

CITIES AND THE GLOBAL POLITICS
OF THE ENVIRONMENT

Series Editors: Michele Acuto,
Joana Setzer and Elizabeth Rapoport

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**LOW CARBON URBAN
INFRASTRUCTURE
INVESTMENT IN
ASIAN CITIES**

Edited by
**Joni Jupesta and
Takako Wakiyama**

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Cities and the Global Politics of the Environment

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More than half of humanity lives in cities, and by 2050 this might extend to three quarters of the world's population. Cities now have an undeniable impact on world affairs: they constitute the hinges of the global economy, global information flows, and worldwide mobility of goods and people. Yet they also represent a formidable challenge for the 21st Century. Cities are core drivers not only of this momentous urbanisation, but also have a key impact on the environment, human security and the economy. Building on the Palgrave Pivot initiative, this series aims at capturing these pivotal implications with a particular attention to the impact of cities on global environmental politics, and with a distinctive cross-disciplinary appeal that seeks to bridge urban studies, international relations, and global governance. In particular, the series explores three themes: 1) What is the impact of cities on the global politics of the environment? 2) To what extent can there be talk of an emerging 'global urban' as a set of shared characteristics that link up cities worldwide? 3) How do new modes of thinking through the global environmental influence of cities help us to open up traditional frames for urban and international research?

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Low Carbon Urban Infrastructure Investment in Asian Cities

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FOREWORD

This book is the product of a two-year APN project, *Low-Carbon Urban Infrastructure Investment in Asian Cities: Shanghai, Jakarta and Yokohama*, which explored a new funding mechanism for urban infrastructure investment that engages multiple stakeholders in public-private partnerships. The project involved several researchers from UNU-IAS, the Institute for Global Environmental Strategies (IGES), Fudan University (China) and Bogor Agriculture University (Indonesia). This book aims to showcase the role that cities can play in the green growth agenda by making smart urban infrastructure investments in low-carbon buildings and other types of physical infrastructure, by using financial incentives and taxes, by fostering renewable energy supplies and by raising societal awareness of sustainable lifestyles.

This book covers a wide range of approaches to green investment that have been utilized in three cities, including risk analysis, cost-benefit analysis, integrated assessment modelling analysis and input–output analysis. An additional chapter describes the smart city initiative in Yokohama and explores the possibilities for technology transfer to slums in India.

As a think tank, one of the missions of UNU-IAS is to promote a more sustainable future through policy-oriented research focused on sustainability and particularly on sustainability's social, economic, and environmental

dimensions. This book is in line with this mission and serves the international community by making valuable and innovative contributions to high-level policymaking and by informing debates within the UN.

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SERIES EDITORS' PREFACE

One of the core rationales for establishing *Cities and the Global Politics of the Environment* was that of inspiring greater collaborative work on the impact of cities on national, regional, and international affairs. Jupesta and Wakiyama's *Low Carbon Urban Infrastructure Investment in Asian Cities* does just that. This collection looks across complex regional boundaries such as those of Southeast and East Asia, and provides a concerted effort towards a better appreciation of the governance of a low-carbon infrastructure for cities in Japan, China, Indonesia, and beyond.

Issues of low-carbon investment, smart city developments, and impact assessments on the political-economic dynamics underpinning low-carbon transitions have become increasingly crucial in the past years. Jupesta and Wakiyama's collection is in this sense timely and well placed to speak to the growingly critical centrality of cities in sustainable futures. These questions have emerged even more centrally on the global governance agenda after the outcomes of the new Sustainable Development Goals (SDGs) in September, and the Paris climate negotiations at COP21 in December 2015. Critically, the collection reminds us, by looking between new and emerging powerhouses, as well as developed and fast-developing world, how the demands for sustainable infrastructure in the SDGs will apply universally, in diverse contexts like Yokohama and Jakarta, and call upon both policymakers and academics to further decentre our appreciation of urban policy and politics.

From this more "global" angle, once again key in the titles of this series, *Low Carbon Urban Infrastructure Investment in Asian Cities* asks us to look at global urban developments "from the East", remembering

the more-than-local impacts of unplanned infrastructure on the future of cities. As Jupesta and Wakiyama remind us at the outset of the book, cities now play a key role in green growth agendas and we cannot disregard how much of regional, international politics, not just local, will be played in the streets of urban settlements the world over.

Michele Acuto
Joana Setzer
Elizabeth Rapoport

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Introduction

Joni Jupesta, Takako Wakiyama, and Ambiyah Abdullah

1.1 GREEN INVESTMENT IN ASIAN CITIES

The concept of “green growth” is tied to the “green economy for sustainable development and poverty reduction,” the first theme of the Rio+20 United Nations Conference on Sustainable Development (UNCSD). Furthermore, formulating strategies for making cities and human settlements inclusive, safe, resilient, and sustainable has emerged as one of the 17 Sustainable Development Goals. To effectively achieve green growth, developing a low-carbon society should occur at multiple levels: international, regional, national, and subnational. The Asia Pacific region, the site of rapidly growing populations and economies, can show the global impact of sustainable development partly because this region includes a key advanced economy, Japan, and two key emerging economies, China and Indonesia.

The UN concluded that 50% of the world’s population lives in cities (2008) and that this percentage will increase to 60% by 2030. Furthermore, cities account for 90% of the population growth, 80% of the wealth creation, and 60–80% of the energy consumption and greenhouse gas (GHG) emissions across the globe. Thus, it would be most effective to begin building a low-carbon society by developing low-carbon cities.

Across Asia, several approaches have previously been employed to low-carbon cities, particularly in the transportation, building, and waste management sectors. Several cities in Japan, China, and Indonesia have already invested in initiatives aimed at developing low-carbon/green cities. Cities require intensive urban infrastructure development to accommodate rapid and substantial growth. However, as a result of the financial constraints on local governments, funding urban infrastructure projects has become a critical issue. Plans to overcome these constraints may prove critical to achieving low-carbon development pathways.

Against this background, this book, which is based on the Asia-Pacific Network for Global Change Research (APN) funded project, explores a new funding mechanism that engages numerous stakeholders in public-private partnerships. The private and public sectors should work hand in hand to foster green investment. As economic and political power has shifted to cities and megacities, particularly in the Asia Pacific region, local economic development has been successfully employed in numerous cities as a strategy to address issues involving uneven growth and extreme poverty (SDSN 2013). Cities also play a critical role in national growth and in generating environmental externalities. Cities account for 70% of all public direct investment and 50% of all public procurement. Moreover, cities offer economies of scale for measures designed to address climate change adaptation (OECD 2014).

1.2 METHODOLOGY AND APPROACHES TO ADDRESSING GREEN INVESTMENT IN ASIAN CITIES

This research project uses explorative qualitative and quantitative approaches to define, measure, and monitor green investment at the city scale in Jakarta, Yokohama, and Shanghai and in certain slum areas in India. Several methods were applied in this study, including risk analysis, cost-benefit analysis, integrated assessment modelling, input-output analysis, and comparative analysis. Chapter 2 examines the effect of feed-in tariff (FIT) and other renewable energy investment policies; we examine variations in expected returns and risks under different FIT conditions. We also study investment returns and risks by examining net present value (NPV) and internal rate of return (IRR) measures using the discounted cash flow (DCF) method. The DCF method is used as an investment analysis and evaluation model. NPV estimates future cash flows, and IRR can determine investment benefits by estimating the rate of operating revenues

against investment. Larger revenues from business gains and faster returns from revenues result in higher IRR. In the case of solar photovoltaics (PV), IRR values that exceed 10% before tax and 7–8% after tax are preferred.

Chapter 3 presents a combined qualitative and quantitative analysis. The qualitative methods used in the study include literature and comparative analyses. Information was identified and collected, and the necessary comparisons were made by means of the literature review. First, main international green codes (i.e., LEED, BREEAM, and CASBEE) are presented and China's Green Standards (i.e., the Evaluation Standards of Green Building) are introduced—and green building development trends in China are described—in the literature review. Research objectives, questions, and frameworks are reasonably determined from the results of the literature analysis. The goal of employing quantitative methods is to quantify the incremental costs of green buildings and to compare the relation between subsidies and incremental costs. The incremental costs of green buildings per unit floor area can be calculated using the initial cost and unit floor area of a sample building.

The results presented in Chap. 4 were generated from the ExSS (Extended Snap Shot) nonlinear programming model, which uses the GAMS (General Algebraic Modeling System) v 23.3 that is supported by various technical, economic, and social parameters (Dewi et al. 2010; Dewi 2012). The back-casting method was engaged first to determine a set of desirable goals and then to determine how to achieve these goals, which involved (1) setting a framework, including the base year (2005) and target year (2030), the environmental target, the target area, and the number of scenarios; (2) describing and quantifying socioeconomic assumptions; (3) exploring energy technologies to achieve low-carbon targets; (4) estimating GHG emissions for the base and target years; and (5) analysing low-carbon measures that can achieve low-carbon city targets. The projection scenarios developed in this study include business as usual (BaU) and mitigation scenarios; BaU scenarios envision development paths and associated GHG emissions without considering mitigation efforts, whereas mitigation scenarios envision development paths to achieve low-carbon city targets.

Chapter 5 examines the economic impact of low-carbon investments in renewable energy sectors in Yokohama from 2005 to 2011. In this study, we conducted an accounting multiplier analysis to determine the impact of changes in low-carbon investment in renewable energy from 2005 to 2011. Chapter 6 examines a case in Japan (Yokohama) and summarizes the

traits that are typically relevant to four representative city sectors: energy, waste, transportation, and water. The paper also examines policies in these sectors, including regulations, standards, planning and administrative directions, economic measures, voluntary actions, and environmental ethics. The chapter later discusses possible applications of the concept to the context of developing countries—and particularly to slum areas in India—and then presents an example of how concepts from smart city (SC) development may be applied in the energy sector in slum areas in India. Finally, the chapter elaborates upon the opportunities for the application of SC concepts in developing countries and introduces the leapfrogging model.

1.3 THE FOCUS OF THIS BOOK

This project will be used as guidance that shows how cities in select countries play a key role in the green growth agenda by stimulating growth through smart investment in urban infrastructure: by building physical infrastructure, by using financial and tax incentives, by fostering renewable energy supplies, and by increasing societal awareness of sustainable lifestyles. The roles of cities should also include systematic institutional governance that improves coordination among involved institutions (national and local governments, local communities, academics, and industries).

As for Asia, lessons learned from the three cities examined in our study show that unplanned and unstructured urban growth will significantly increase economic, social, and environmental costs. Funding for low-carbon infrastructure projects in cities may be generated by incentivizing low-carbon technologies such as solar PV and by fostering clean development mechanisms (CDM) and energy efficiency measures through market mechanisms and/or policy interventions such as those employed in Yokohama, Shanghai, and Jakarta. These findings correspond with the findings of the New Climate Economy Report that some cities may serve as powerful evidence that more compact and connected urban development based on mass public transportation can generate cities that are economically dynamic and healthier and that generate fewer GHG emissions.

Chapter 2 first identifies the risks associated with investing in renewable energy and the financial methods that may be used when promoting renewable energy sources (Sect. 2.2). Second, the chapter analyses the current status of global warming action plans and strategies that are

designed to promote renewable energy sources using Yokohama as a case study (Sect. 2.3). Third, it describes the methodology and data used for the investment risks and returns analysis (Sect. 2.4). Fourth, it describes the outcomes of renewable energy investments by focusing on solar PV in both the residential and commercial sectors (Sect. 2.5). Yokohama, the second largest city in Japan, offers more opportunities for installation of solar PV than other renewable sources such as wind energy sources, which require regulation and large-scale land acquisition. In fact, solar PV represent more than 80% of the installed capacity of renewable energy sources in Yokohama, whereas wind sources constitute only 10% and hydro sources account for 3% (as of 2011). Thus, in this study, we focus on solar PV investments. Investment challenges faced under the current FIT system in Japan are presented as examples of other risks (Sect. 2.6). The last section includes a discussion and conclusion.

The increase in the number of new green buildings shares represents just a small component of the overall growth trend in the building sector in China in recent years. For instance, in 2003, newly constructed buildings covered a total area of 3892 million metres², whereas newly built green buildings (including all 1-star, 2-star and 3-star green buildings) covered a total area of 83 million metres², which accounts for only 2% of the total building area. Chapter 3 addresses research issues such as the causes of the current status of green building, the barriers and problems associated with green building development, and the possible solutions to such problems. Research methods are designed to address these research questions.

Chapter 4 presents the results of a modelling study on the 2030 Low-Carbon City Scenario for DKI Jakarta. The study aims to identify development paths that will allow DKI Jakarta to become a low-carbon city by 2030. As the energy sector accounts for 89% of all GHG emissions generated in DKI Jakarta, the study focuses on this sector. Particular emphasis is placed on the selection of energy technologies that are necessary to achieve low-carbon city status. The results of the study may be used as an information source to help prepare development strategies, policies, and plans for DKI Jakarta.

Rather than assessing the environmental and social impacts of renewable energy investments, Chap. 5 assesses the economic effects of renewable energy investment in Yokohama. To determine the impact of renewable energy expansion in Yokohama, we assess economic transactions using the city input-output table.

Chapter 6 includes a policy analysis for Yokohama and the possible application of this analysis to developing countries. The chapter also examines policies in related sectors in terms of regulations, standards, planning and administrative approaches, economic measures, voluntary actions, and environmental ethics. The analysis on SCs in Japan reveals that such cities evolve over decades through steady urban development. The study finds that SC concepts may be applied to cities in developing countries, including informal settlements. Emphasizing informal settlements can be a key for leapfrogging directly to SC development.

Renewable Energy Investment Risk Analysis for Low-Carbon City Development in Yokohama

Takako Wakiyama, Ambiyah Abdullah and Joni Jupesta

Abstract The chapter identifies the risks and costs related to renewable energy investments in general and then analyses the risks and returns associated with renewable energy investment using Yokohama as a case study. The role of the government in setting clear policy targets, in providing financial support, and in introducing new and innovative policies proves essential to minimizing renewable energy investment risk. This chapter qualitatively and quantitatively examines the status of policies and financing policies used to promote renewable energy. As part of a financing study, this chapter explores the effectiveness of feed-in tariff (FIT) systems and supplemented tax policies.

2.1 INTRODUCTION

Renewable energy technologies represent a key instrument for providing sustainable energy services and for contributing to the reduction of CO₂ emissions (Monkelbaan 2013; UNEP/GRID 2009). Since the Kyoto Protocol was signed in 1992, various policies for promoting the installation of renewable energy have been introduced internationally (Lipp 2007; Solangi et al. 2011). Renewable energy sources increase the availability and reliability of domestic energy supplies, limit price volatility and the foreign

exchange flow risks that are associated with domestic energy imports, and decrease CO₂ emissions by replacing conventional fossil fuel energy sources (IPCC 2007, 2012; Mitchell et al. 2006).

Renewable energy is often derived as independent energy sources that differ from conventional centralized energy systems (Carrasco et al. 2006). For instance, conventional electricity supplied through thermal and nuclear energy generation in Japan has been dominated by regional electricity companies that own large-scale energy facilities (FEPC 2014). However, as renewable energy sources are typically sited at local production facilities, increasing attention has been dedicated to local contexts with respect to the construction, management, and operation of such energy supply systems at the city or prefecture level (Hiremath et al. 2008). The OECD (2012) notes that renewable energy production involves new sources of revenue that support key public services and infrastructure and local employment and business opportunities. Renewable energy facilities could be promoted as locally and individually owned facilities. Cities and local governments thus can play a key role in promoting renewable energy production.

The benefits associated with renewable energy production are increasingly recognized and global investments in renewable energy have increased over the past decade, reaching \$270.2 billion in 2014 (FS UNEP 2015). However, to meet the 2-degree target, an average of \$1.6 trillion in green investments is required every year through 2040 (WB 2012; IEA 2010). At the same time, there are economic, social, political, and geological risks and uncertainties associated with renewable energy investments that are not associated with conventional energy sources (Beck and Martinot 2004; FS UNEP 2015; MOEJ 2014b). Therefore, to promote renewable energy supplies, electricity market reforms, innovative financing schemes, and additional low-carbon policies are important factors to mitigate low-carbon investment risks and make renewable energy investments more attractive to investors (OECD 2011). However, before proceeding with any such reforms, three questions must be addressed: What financing methods are available? What are the risks and returns that can be expected from renewable energy investments, and what policy interventions may effectively reduce such risks while increasing returns. Under current market structures, power plant investment decisions are made by private investors based on power generation costs (Fagiania et al. 2013; The Economist 2011; CPI 2011). To further increase installed renewable capacities, establishing supportive financial policies will help strengthen market competitiveness levels until such technologies become cheaper in the market and public awareness regarding sustainable energy supply and energy security issues is enhanced.

This chapter first identifies the risks associated with renewable energy investments and the financial schemes that may be applied to promote renewable energy production (Sect. 2.2). Second, it examines the current status of global warming action plans and strategies that promote renewable energy sources by using the city of Yokohama as a case study (Sect. 2.3). Third, it describes the methodologies and data used for the analysis of the investment risks and returns (Sect. 2.4). Fourth, it discusses renewable energy investment outcomes with a focus on solar photovoltaics (PV) in both the residential and commercial sectors (Sect. 2.5). In this study, we focus on investment in solar PV. Challenges associated with investments made under the current feed-in tariff (FIT) system are presented as other types of risks using a case study in Japan (Sect. 2.6). The last section presents a discussion and conclusion (Sect. 2.7).

2.2 RENEWABLE ENERGY FINANCING RENEWABLE ENERGY INVESTMENT RISKS AND COSTS

2.2.1 *Barriers to Accelerating Renewable Energy Investments*

One of the barriers to accelerating investments in renewable energy involves the pricing of renewable energy, which is more expensive than other forms of electricity generation. In the case of Japan, the cost of generating electricity using renewable energy—and using solar PV energy in particular—remains high compared with other energy sources (Table 2.1). The emission abatement cost of solar PV exceeds 50,000–100,000 JPY/t-CO₂ (MOEJ 2010; CAS 2009). However, in the long run, renewable energy may reduce electricity generation costs (Sims et al. 2003). Although generating electricity using fossil fuels may be less costly at present, there is a risk and uncertainty that these costs may escalate in the coming years and a regulation may restrict

Table 2.1 Energy generation costs as of 2010 (JPY/kWh)

<i>Nuclear</i>	<i>Coal</i>	<i>Oil</i>	<i>LNG</i>	<i>Hydro</i>	<i>Onshore wind</i>	<i>Geothermal</i>	<i>Small hydro</i>	<i>Solar</i>	<i>Mega solar</i>
8.9–	9.5–	22.1–	11.5–	10.6	9.9–17.3	9.2–11.6	19.1–	33.4–	30.1–
	9.7	23.7	11.9				22	38.3	45.8
	(2.5)	(1.1)	(2.1)						

Source: Cost evaluation committee (CAS 2012)

The capacity factor of coal and LNG thermal power generation is 50%

investment on newly establishing fossil power plants. For instance, social costs might increase, which are associated with climate policies, regulations, and CO₂ countermeasures such as the introduction of carbon pricing policies including carbon taxes and emission trading schemes (Vithayasrichareon and MacGill 2012).

According to calculations by the governmental cost evaluation committee, solar PV generation costs are expected to decline from 28.7 JPY/kWh in 2010 to 18.1 JPY/kWh by 2030, whereas coal plant costs may slightly increase from 9.5 JPY/kWh in 2010 to 10.3 JPY/kWh in 2030 by including CO₂ countermeasure costs (CAS 2012). The electricity generation costs of coal plants include current fuel prices of 4.4 JPY/kWh and social costs of 3.2 JPY/kWh as of 2010 (CAS 2012). On the other hand, in the case of solar PV, fuel and social costs remain at zero JPY/kWh, and if construction costs decrease to 150,000 JPY/kW (more than half the price of current construction costs), generation costs can be reduced by 9.9 JPY/kWh. However, under current conditions, renewable energy sources remain expensive compared to fossil fuel sources. Therefore, financing and risk mitigation policies are required to increase renewable energy's competitiveness (Grubb and Newbery 2007).

Other barriers to promoting renewable energy investment involve the technical and financial risks associated with the construction, operation, and maintenance of renewable energy facilities. These risks are related to common infrastructural investment risks such as landownership, environmental impact assessment, and cash flow, as shown in Table 2.2. Table 2.2 identifies potential investors at each stage of renewable energy investment—from construction to operation and maintenance—and the investment-related risks at each stage.

Under construction period of renewable energy facilities, investors including power companies face risks such as completion delay risk and financing as common risks of infrastructure investments. Following the construction of renewable energy facilities, electricity producers can generate returns by producing and selling electricity, whereas investors can begin enjoying future cash flows generated from producing and selling electricity. However, at the operation stage, electricity producers and investors face unique risks associated with the electricity market: price, quantity, and regulation risks (Grossa et al. 2010; Fagiania et al. 2013). For instance, prices and quantities are supplied through an electricity market. Price risks are associated with electricity, fuel, and carbon price uncertainties. Renewable energy purchase prices are determined based on equilibrium supply and

Table 2.2 Renewable energy business risks and measures

	<i>Potential investors</i>	<i>Major risk items</i>	<i>Potential risks</i>
Construction of facilities	Investor: Private company	Land risk Environmental impact assessment risk Grid connector risk Completion delay risk Financing risk	Land ownership changes/ contract termination/restoration expenses of expiry, etc. Respond to resident complaints regarding landscape issues and noise/radio interference caused by transmission and distribution equipment/effects on the ecosystem Additional cost burdens and delayed completion due to line interconnection or system connection failures/cost overruns Insufficient funds and temporary budget overruns due to incorrect projections of project costs
Operation and maintenance	Investor: Private company Loan: Bank, lease company	Technology and equipment performance risk Operational risk Electricity generation capacity and cash shortage risk Interest rate risk Output control risk	Deterioration or failure of power generation equipment/repair cost changes Pause or decline in power generation levels associated with operational, maintenance, and management defects Cash flow fluctuations in accordance with output declines due to a rise in panel surface temperature, dust and sunshine duration in solar PV due to changes in wind direction and wind speed via wind power generation Borrowing rate increase Electricity company output controls or limits
Force majeure	Investor: Private company, private equity, pension fund, insurance company, investors Loan: bank, leasing company	Disaster risk	Accidental equipment damage (typhoon, lightning, etc.) or equipment damage due to natural disasters (fire, etc.)

Source: Terabayashi and Ando (2013) and MOEJ (2014b)

demand in a market through competitiveness with other sources of energy such as fossil power generation (Miera et al. 2008). Therefore, when renewable energy prices are high, demand drops, and prices decrease, which means that suppliers may find it difficult to earn returns on their renewable energy investment. In addition, quantity risks are a different type of risk related to the uncertainties associated with renewable energy costs that are influenced by electricity demand levels (Menanteau et al. 2003a, b).

2.2.2 *Risk Mitigation Approaches*

As discussed above, one barrier to the deployment of renewable energy in energy markets is related to risks involved with investment returns due to future short- and long-term uncertainties of the market price (Finon 2013; Varadarajan et al. 2011). However, price, quantity, and regulation risks embedded in renewable energy sources are to some extent controlled by policies, and electricity market competitiveness levels can be improved by introducing financial systems. There are three main ways to increase competitiveness and to mitigate the market risks of renewable energy in the electricity market through financial support. The first one is to put values on carbon such as by creating a carbon tax that increases the price of fossil fuels by imposing tariffs as surcharges on electricity prices. The second is regulating renewable energy purchases based on a fixed price or certain amount (Cory et al. 2009; Haas et al. 2004). Quantity-based systems such as the renewable portfolio standard (RPS) and price-based systems such as FIT systems are methods used to promote renewable energy purchases. The third one is subsidies and funds to support the initial stage of technological deployment.

2.2.2.1 *Renewable Portfolio Standard*

Under quantity-based RPS systems, future renewable energy generation targets could be established (Jaccard 2004). Quantity risks can be neutralized to some extent. However, prices are established through a market mechanism based on supply and demand. Thus, it is difficult to mitigate price risks in RPS markets (Suwa and Jupesta 2012; Fagiania et al. 2013; EC 2004). In the case of Japan, power companies are required to purchase a certain amount of renewable energy but the required target amount of renewable energy is not so high (approximately only 1 % of total power supply). With such low target amount, the RPS price is low at 7–8 JPY/kWh. Only waste energy can cover the market cost at 6.8 JPY/kWh, while the generation

costs of solar PV and wind power remain higher than the market cost at 19.5 JPY/kWh and 11.5 JPY/kWh, respectively (Nishio et al. 2007; CAS 2012). These figures indicate that solar PV and wind sources of energy are more expensive than waste energy sources. In RPS markets, less expensive technologies such as waste and wind power sources are preferred over other energy sources. Therefore, if targets are not established in a sector, the installation of renewables focuses only on cheaper forms of power generation. With the introduction of RPS, electricity generation from wind power and waste biomass energy increased from 0.9 to 2.6 GW (from 2.2 to 4.3 TWh in the electricity generation) and from 1.3 to 2.3 GW (from 1.4 to 4.6 TWh in the electricity generation), respectively, from 2004 to 2011 (METI 2012a, b). However, the RPS approach can present risks when governments make policy and regulatory changes that affect future RPS targets.

2.2.2.2 *Green Power Certificate*

Green power certificates are other method to promote renewable energy. The differences between RPS and the green certificates are that while RPS is imposed to power suppliers, the certificate is used by the energy consumers who are willing to purchase cleaner energy or trade such as under emission cap and trade programmes. For instance, Tokyo metropolitan employs a green power certificate under its cap and trade system (Tokyo Metropolitan Government 2010). A mandatory emissions trading scheme, the Tokyo cap and trade programme was initiated in 2011 and imposes total greenhouse gas (GHG) emissions reductions on companies that consume fuel or electricity quantities totalling more than 1500 kl of crude oil per year. These companies are required to reduce GHG emissions independently or otherwise trade emissions by purchasing green power certificates or by helping small- to medium-sized enterprises to reduce energy use levels. In another example, Yokohama introduced the “Y partner system” as a way of collecting funds for wind power generation purposes, wherein a company donates funds for wind power generation by purchasing green power certificates.¹ When using renewable energy supplied from a power company, users pay a premium on environmental value-added electricity by purchasing green power certificates.

However, there are certain identified drawbacks of green power certification in Japan (Suwa and Jupesta 2012). Green power certification in Japan imposes no obligations on users and thus differs from a quota pur-

chasing system and cannot be used to ensure the quantity to be purchased. In addition, purchasing green power certificates are largely treated as donations in Japan (Shimizu 2009). Thus, excess company donations cannot be treated as write-offs for tax purposes.

2.2.2.3 *Feed-in Tariff*

The FIT price-based system offers electricity producers long-term fixed prices on electricity generated through renewables, which can help reduce price risks by ensuring long-term cash flows at fixed prices. In Japan, long-term fixed prices are determined by estimating the average generation cost of each renewable energy technology based on projections made by governmental expert committees² in Japan (METI 2012a, b). After the Fukushima nuclear accident in 2011, discussions on increasing renewable energy sources emerged in Japan. The FIT system was implemented in July 2012, and installed capacity levels of renewable energy have rapidly increased since that time, particularly in the case of non-residential solar power generation installation. Following the introduction of FITs, the installed capacity of solar PV increased to about 11.9 GW (9.1 GW of non-residential (more than 10 kW) solar PV) over two years from July 2012 to July 2014.³ However, total hydro, wind, solar, and geothermal electricity generation levels reached only 0.097 TWh⁴ in 2014. The renewable energy ratio in the total electricity generation is at 10%.

2.2.2.4 *Tax Policies and Subsidies*

In addition to cost reduction strategies to increase competitiveness of renewable energy, renewable energy requires not only an FIT system but also a system that mitigates upfront costs. The greater the scale of the installed capacity, the greater the upfront costs. Policy options such as tax deductions and subsidies or financing mechanisms (in combination with risk mitigation efforts to increase access to funding for upfront costs) are necessary to ensure that investment returns can be generated over a reasonably short period of time.

Numerous studies have examined the effects of price- and quantity-based systems that have been employed to increase renewable energy supplies (Ayoub and Yuji 2012; Buckman 2011; del Río and Gual 2007; Menanteau et al. 2003a, b; Muhammad-Sukki et al. 2014; Pizer 2002), although the effectiveness of FIT systems and of associated funding policies as risk mitigation tools have not been assessed in details. This chapter assesses the effects of FIT and related policies in a city-scale case study.

These policies are analysed by examining whether FIT systems mitigate risks and increase the returns on renewable energy investment and whether financing policies can enhance risk mitigation efforts. Thus, in the following section, we examine the effects of solar PV investment policy interventions at the city level using Yokohama as a case study.

2.3 CASE STUDY ON YOKOHAMA, JAPAN

Yokohama is a government ordinance–designed city with a population of 3.7 million and boasts the second largest urban population in Japan after Tokyo. Yokohama has experienced trends involving population growth and increased total CO₂ emissions. Total CO₂ emissions generated from Yokohama in 2010 reached 18.841 Mt-CO₂. Shares of total emissions by sector are as follows: energy conversion (18.8%), industry (14.8%), households (23.1%), commercial (19%), transportation (21.6%), and waste (2.8%) (Fig. 2.1). Household emissions represent the largest share among the other sectors and have a high rate of increasing CO₂ emissions. Household emission sources include electricity (60.7%) and city gas (26.8%). The commercial sector also shows the highest degree of basic year emissions rate increases among the sectors due to an expansion of total office building floor space (a 42.5% increase from 1990 levels), and 72.1% of all emissions are generated from electricity and 20.5% are generated from city gas sources. Yokohama has promoted renewable energy use to combat global warming and to achieve the targets set by the city government (City of Yokohama 2011).

In recent years, numerous cities have formulated climate change and low-carbon action plans and have increased their annual budgets to accommodate such plans that complement the increased funds provided by national and subnational governments at the prefecture and city levels. For instance, beginning in 2014, the renewable energy installation promotion fund (as a part of regional green new deal fund) was created at the prefecture and city levels to enhance the deployment of environmentally friendly technologies and projects, including renewable energy and energy-efficient technologies.⁵ The fund was designed to increase the installed capacity of renewable energy under the revised green new deal fund initiated from 2014. In the case of Yokohama, the size of the climate change action funds grew from 1.1 billion JPY in 2008 to 5.1 billion JPY in 2013 (MOEJ 2014a).

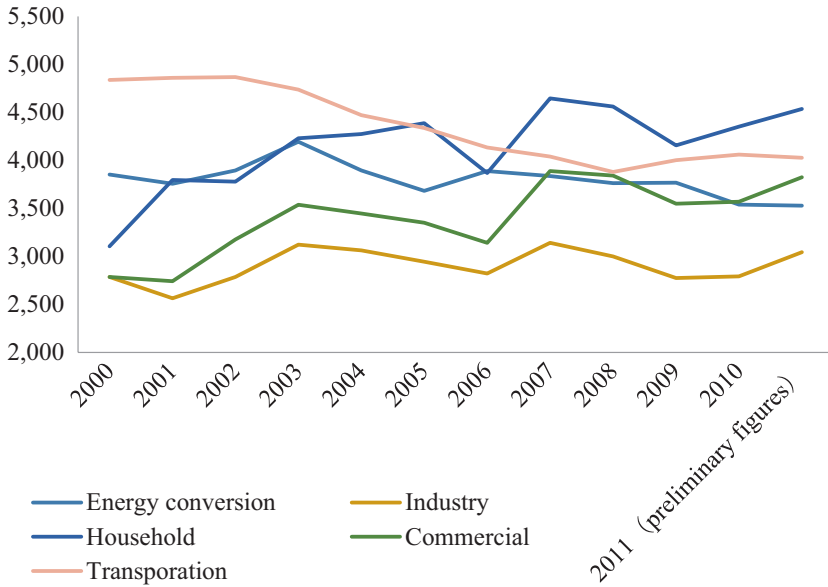


Fig. 2.1 Yokohama total energy consumption levels. Source: City of Yokohama, Climate change policy headquarters (<http://www.city.yokohama.lg.jp/ondan/plan/ghgmissions/>)

As the second largest city in Japan with high population density, Yokohama presents opportunities for solar PV use which enable installation at rooftops and walls of households, offices and factories as opposed to other forms of renewable energy such as wind, which typically involve regulation and large-scale land acquisition (Kanagawa 2012). In fact, solar PV constitutes 47% and waste 46% of the share of installed renewable energy capacity in Yokohama, whereas wind and small hydro account for only 2.1% and 0.5%, respectively (as of 2014) (City of Yokohama 2015). In addition, Yokohama set up the Global Warming Action Plan towards 2030 to increase solar PV by installing it at 15% of single-family houses (0.32 MW), 15% of complex housings (0.13 MW), 15% of factories (0.032 MW), and 15% of offices (0.005 MW) in Yokohama city by 2030 (City of Yokohama 2014a).

2.4 DATA AND METHODOLOGY

To analyse the effects of FIT and other policies on renewable energy investments, this paper examines the differences between expected returns and risks under various FIT conditions. It also analyses investment returns and risks by examining net present value (NPV) and internal rate of return (IRR) measures using the discounted cash flow (DCF) method. The DCF method is used as an investment analysis and evaluation model (Kettunen et al. 2011). The NPV can be used to estimate future cash flows, and the IRR can be used to determine investment benefits by estimating operating revenue rates against investments. The larger the revenues from business gains and the faster the returns from revenues, the higher the IRR value obtained. In the case of solar PV, an IRR value that exceeds 10% before tax and 7–8% after tax is preferred (METI 2012a, b).

The NPV of the renewable energy project is determined as follows:

$$\text{NPV} = \sum_{t=1}^T \frac{\text{CF}'}{(1+i)^t} - I \quad (2.1)$$

where CF is the cash flow of solar PV, I the investment, i the interest rate, and t the time.

IRR is calculated by determining the discount rate through which NPV becomes 0 [Eq. (2.2)]. In other words, the interest rate return on investment is plus or minus 0. A comparison between the interest rate and the IRR of the discount rate can serve as an indicator of investment decisions.

$$\text{NPV} = I - \sum_{t=1}^T \frac{\text{CF}'}{(1+\text{irr})^t} = 0 \quad (2.2)$$

Although NPV and IRR can be used to assess future investment returns, NPV calculations are designed to serve as projections of only one scenario and of one possible future expectation. However, in the business world, there are numerous components of future cash flow uncertainty (Blyth et al. 2007; Fleten et al. 2007; Yang et al. 2008). Thus, the Monte Carlo method can be used to evaluate various values rather than only one value of expectation and thus can evaluate NPV by using a system of random numbers for simulations.

The Monte Carlo method can also be used to determine distributions as a whole through various parameters and to reveal investment risk and return probabilities (Froot et al. 1993). Thus, we use Monte Carlo discount cash flow simulations and estimate the stochastic distribution of NPV and IRR by assessing the uncertainty, risk, and return levels of a project investment.

2.4.1 *Household*

This paper first focuses on household investments in solar PV and the risks and returns from such investments. To estimate NPV and IRR values, a cash flow balance sheet for solar power generation is constructed for April 2013 to March 2032 with a monthly base based on a household rooftop form of solar PV installation (a 20-year duration). In this case study, the household analysis examines the risk and return probabilities associated with solar PV investment. The investment benefits of solar PV installation include saving the costs associated with electricity fees as well as revenues from renewable energy surpluses sold to an electricity company after the renewable energy generated is utilized for household energy purposes. As basic data for estimating cash flows, the current average installed capacity of Kanagawa Prefecture (4.62 kW in 2013) is used (Yokohama is the capital city of Kanagawa Prefecture). Solar module costs, including ancillary equipment (99,000 JPY) and installed costs (75,000 JPY), are estimated at 464,000 JPY per kW (the average cost of the module in Japan as of 2012).

Under the FIT system, electric power has been sold at a fixed rate of 42 JPY/kWh for 10 years as of 2012 for households (less than 10 kW capacity)⁶ (Asano 2013). In this case study, we assume that the FIT application was submitted and registered in 2012, with operations beginning in April 2013.⁷ The profit probability level is estimated for 20-year lifetime duration of solar module while the FIT time period is only for 10 years. Subsidies required for solar PV installation differ across cities. In 2013, the Yokohama city government provided subsidies of 50,000 JPY to support the initial cost for each household in addition to national subsidies, which are calculated by multiplying installed capacity levels by 15,000 JPY in cases in which installation fees exceed 410,000 JPY. By including subsidies in this study, the total initial investment cost for 4.62 kW solar PV in 2013 is estimated to be 2.02 million JPY.

For the estimation of NPV for future cash flows associated with solar electricity generation, the following uncertainty factors and risks are considered: monthly average solar insolation in Yokohama, monthly household

electricity demand, and monthly electricity price levels. There are three models to estimate the forecasted data: a stochastic model, a regression model, and a non-parameter model such as the multi-agent system and advanced neural network models. In this study, estimations of these data for periods up to 2032 are simulated using the mean-reverting process of a stochastic process model (Huisman and Mahieu 2003; Shenoy and Gorinevsky 2015; Daniels and Jonge 2003). We assume that electricity prices and electricity demand converge at constant prices over the long term [Eq. (2.3)].

$$S_{t+1} = S_t \times e^{\alpha(\log b - \log S_t) + \sigma \varepsilon} \quad (2.3)$$

Where S_{t+1} is the estimation of electricity prices and electricity use, a is the regression rate (converges to b over a period if there is no change), b is the regression level, σ denotes volatility, ε is the standard normal distribution, and \log is the natural logarithm.

To simulate future electricity prices via the mean-reverting process, historical data are used from April 2002 to March 2013. Electricity demand data are extracted from statistics on the city of Yokohama, and electricity price data are extracted from the Tokyo Electricity Generation Company (TEPCO), as electricity in Yokohama is provided by this entity. Monthly electricity prices can be influenced by future changes in basic electricity fees, fuel cost adjustment system unit prices (JPY/kWh), renewable energy promotion levy unit prices (which were in effect from November 2009 to September 2014),⁸ and PV power promotion levy under excess electricity purchasing scheme (which become in effect from August 2012).⁹ Thus, electricity prices are calculated by including these fees and by estimating the future costs of these fees. In addition, solar power generation levels depend heavily on solar insolation levels. For this reason, this paper uses the Japan Meteorological Agency observation data for solar insolation levels in Yokohama, and it simulates solar insolation levels until 2030 using historical data for 2002 to 2009. Finally, we estimate the monthly solar insolation range and average. The beta distribution of the optimum data assumption with parameters for Yokohama is used and has a minimum value of 1.70, a maximum value of 6.18, an alpha value of 1.68, and a beta value of 2.07. In this analysis, we also compare the risks and returns of 42 JPY/kWh FIT fixed rate in 2012 with 38 JPY/kWh FIT fixed rate in 2013.

2.4.2 *Commercial Sector*

In the case of commercial sector solar power generation, the cash flow analysis is constructed differently from that employs for the household sector. We assume that a company creates an electricity generation enterprise as a sole business and that there are thus no profits from other forms of business within a company. Investment decisions made in a company are determined by considering various factors (e.g., based on the benefits that may result from investment and on the amounts and durations of returns from investment on the installation of solar power generation facilities).

For our NPV calculations, we estimate the yearly investment depreciation on 50 kW of solar generation. Solar insolation is also estimated for up to 20 years using the same mean-reverting process used for the household data. Future cash flows are calculated for 2013 until 2032. In case of the commercial sector (more than 10 kW capacity of solar PV), the FIT time period is 20 years. For the FIT calculations, as in the same setting with households, we assume that FIT was registered in FY 2012 and that investments began in April 2013. We also calculate NPV and IRR values for a fixed rate of 40 JPY/kWh for more than 10 kW capacity in 2012 using a 20-year base period. In the analysis, the risks and returns for different FIT rates (40 JPY/kWh in 2012 and 36 JPY/kWh in 2013) are compared.

Moreover, This paper estimates the impact of tax exemptions with/without green tax cuts. For cash flow calculations involving solar PV in private companies, we first construct a balance sheet for solar PV generation businesses. With regard to tax policies promoting renewable energy, FY 2012 tax system revisions are designed to promote environmentally related investments and to create a system that allows for the immediate depreciation of PV and wind power generation systems that have been approved (MOF 2012). On a national level, green investment tax cuts allow a company to claim either special depreciation (common depreciation plus 30% depreciation) or immediate depreciation of the acquisition cost of renewable energy facilities (100%). In the case of small- and medium-sized enterprises, tax reductions equivalent to 7% of the acquisition cost of solar power generation equipment can be applied up to a limit of 30% of corporate tax¹⁰ (CAS 2010). In this case study, this paper compares normal depreciation and immediate depreciation to examine the effect of tax policy.

Generally speaking, tax policies are designed to offset future surplus taxable income with net operating loss carry forwards from previous periods

(i.e., where tax losses have occurred) (Orihara 2015). With the tax reforms instituted in 2011 in Japan, the development of net operating loss carry forwards has been amended from seven years to nine years (80% of net operating losses can be carried forward) (PWC 2012). Losses carried forward effectively reduce future tax burdens. Thus, since they are treated as temporary differences in the tax effects of an accounting system, the amounts can be appropriated to the profit and loss income statement as the adjusted amount of corporate tax for the period that is based on the effective tax rate of the net operating loss carry forwards and according to deferred tax assets. This tax policy can prove highly effective, particularly when there are transferred benefits from real estate and business activities, insurance maturity processes, sales gains, or other temporary profits recurring profits. When a business makes no profit, it is possible to produce a net operating loss carry forward.

As for subsidies of solar PV installations of more than 10 kW, both Yokohama and Kanagawa Prefectures currently do not offer any subsidies for commercial solar power investments. Thus, in this analysis, two conditions are analysed with/without tax policies (normal and immediate amortization) to assess the effectiveness of green tax cuts as well as risks and returns from commercial solar PV investment.

2.5 SOLAR PV INVESTMENT RESULTS

2.5.1 *Household*

The analysis results show that to mitigate solar module investment costs while minimizing risk, a longer provision term of 20 years of fixed FIT prices proves effective although the fixed price is used only for 10 years for households under current FIT system. This paper sets up three scenarios: (1) 20 years' FIT fixed payment; (2) 10 years' FIT fixed payment and 20' years solar PV use; and (3) no FIT fixed price and 20 years' solar PV use. In the first scenario with a 20-year FIT cash flow calculation at FIT price of 42 JPY/kWh, cash returns will begin in August 2027, 14 years from initial investment. As for IRR, when using a monthly discount rate of 0.25 %, the results show a monthly IRR of 0.33 %, which is higher than the discount rate (Table 2.3). From the base case, a Monte Carlo simulation is run 1000 times with random trial numbers to create 1510 forecasts at the 95 % confidence level. As a result, the IRR forecasting probability range generates a mean value of 0.27 %, a minimum value of 0.06 %, and a maximum value of 0.51 %, and more than 50 % of the IRR probability

value exceeds the discount rate. Risk and return ranges can be generated from solar insolation rate probabilities in a range from 1.70 to 6.18 kW/m² with future electricity use and price changes. As for NPV, a household can acquire 187,027 JPY in profits over 20 years in the base case. The maximum NPV is 737,412 JPY, and the mean is recorded at 49,442 JPY (Fig. 2.2 and Table 2.3)

In addition, NPV and risk ranges are affected by the FIT fixed price. For a 2013 fixed FIT price of 38 JPY/kWh, the probability of achieving returns is 40%, which is more than 10% lower than the 2012 price of 42 JPY/kWh fixed FIT rate (Table 2.3). Moreover, the Yokohama case study results indicate that if module prices are reduced to one-half of current levels, 97.64% profits and 2.48% risk reductions can be expected per household with 20 years fixed payment at FIT 42 JPY/kWh. Thus, to reduce risk and increase returns, either there should be solar PV construction cost reductions or the high fixed FIT rates should be maintained.

Next, we consider the case wherein solar power generation is used for 20 years, but the FIT fixed payment is terminated in 10 years at the rate of 42 JPY/kWh. When the FIT mechanisms continue for only ten years and the other ten years do not include fixed FIT prices, the IRR is reduced to 0.31% in the base case. In the simulation analysis, the range of risks and potentials is 0.17% for the mean, -0.07% for the minimum, and 0.48% for the maximum. As for NPV, a household can acquire 145,073 JPY in profits over 20 years in the base case. The maximum NPV is 623,701 JPY, and the mean is recorded at -158,426 JPY (Fig. 2.3 and Table 2.3). Returns can be generated with a probability of only 10%. In this scenario, there is no returned payment from FIT fixed payment after ten years. However, if a household continues to use solar PV to generate electricity for personal electricity use after the FIT termination, there are still benefits to use the solar PV such as reducing electricity fees for electricity usage and CO₂ emissions.

The last scenario is the case wherein there is no FIT, but the solar PV is installed for personal electricity use in a household. The result indicates that a household can acquire 79,779 JPY in profits over 20 years in the base case. The maximum NPV is 303,377 JPY, and the mean is recorded at -364,450 JPY (Table 2.3).

In case of CO₂ emissions, the same effects can be found for the 20- and 10-year FIT fixed payment scenarios (scenario one and two) or no FIT scenario (scenario three) by installing solar PV on the rooftop in a household. The accumulated CO₂ emissions for 4.62 kW of installed capacity

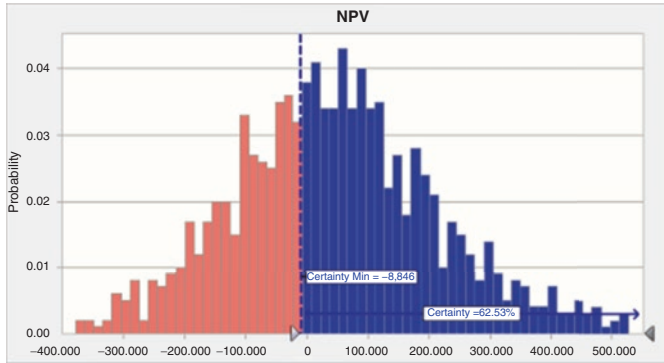


Fig. 2.2 Household NPV distribution for FIT of 42 JPY/kWh for a 20-year period. Source: Author

over 20 years are expected in a range of 34,094 to 37,770 t-CO₂ per household from business as usual (BaU). The CO₂ emission reductions are estimated using the amount of electricity generation from solar PV per household simulated by the Monte Carlo model and CO₂ emission intensity from electricity as of 2014 (0.464 kgCO₂/kWh). The accumulated electricity fees estimating from the amount of electricity generated from solar PV decline over 20 years range from 1.93 million to 3.48 million JPY by means of household FIT system installation.

2.5.2 Commercial Sector

The commercial cash flow analysis results show that the IRR base case for investing in 50 kW of solar PV falls below the 3% discount rate at 2.2% and 2.1% for immediate and normal depreciations, respectively, in case of 40 JPY/kWh fixed payment for 20 years (Table 2.4). In the simulation, the IRR value exceeds the discount rate by more than 20% and by less than 20% in the cases of immediate depreciation and normal depreciation, respectively. In terms of NPV, immediate depreciation ranges from roughly -6.36 million to 5 million JPY and normal depreciation ranges from -6.81 million to 4.24 million JPY, although the base case presents a negative value (Fig. 2.4). The probability of generating positive revenues over 20 years is 20% in the case of immediate depreciation and 10% in the case of normal depreciation. However, the tax policy

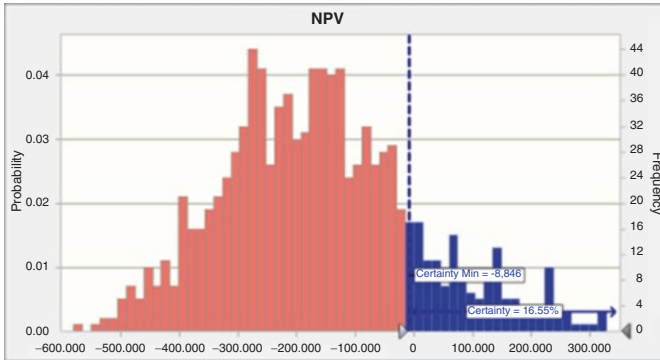


Fig. 2.3 Household NPV distribution with an FIT of 42 JPY/kWh for a 10-year period. Source: Author

effects differ across company financial conditions and cash flow balances. In addition, with 100% immediate depreciation effects, initial year taxes can be reduced, and it is notable that depreciation rates are zero after the initial year, thus increasing taxes.

This paper also analyses the impact of fixed FIT price changes. It compares the FIT prices of 40 JPY/kWh for 2012, 36 JPY/kWh for 2013, and 32 JPY/kWh for 2014. The results indicate that IRR in the base case is reduced to 0.7% at the 36 yen/kWh FIT rate with normal depreciation (2.1% for the 40 yen/kWh FIT rate). When the FIT rate is reduced to 32 JPY/kWh, the IRR value is -0.8% in the base case. In the simulation, the IRR value exceeds 3% in 40 JPY/kWh with more than 10% probability, but the probability value declines to less than 10% at 36 JPY/kWh. For the NPV, although the 40 JPY/kWh simulation ranges from -6,628,302 to 3,037,176 JPY, this range is lower profitability under 36 JPY/kWh, from -8,693,496 to 97,576 JPY.

The economic and environmental effects of solar PV installation are also considered. Total electricity generation levels for a solar PV installed capacity of 50 kW range from 877,913 to 1,342,964 kWh over 20 years and can therefore offset electricity use. CO₂ reductions over 20 years can be achieved within a range of 407,351 to 623,135 t-CO₂ using the amount of electricity generation from solar PV in a company cash flow simulated by the Monte Carlo model and CO₂ emission intensity from electricity as of 2014 (0.464 kgCO₂/kWh).

Table 2.4 Monte Carlo simulation results: IRR and NPV forecast values

	IRR		NPV	
	<i>Immediate amortization</i>	<i>Normal amortization</i>	<i>Immediate amortization</i>	<i>Normal amortization</i>
Base case	4.1 %	5.4 %	2,027,561	1,596,096
Mean	4.3 %	6.0 %	2,424,052	1,908,257
Median	4.3 %	5.8 %	2,385,502	1,889,248
Mode	–	–	–	–
Standard deviation	1.0 %	2.8 %	1,950,528	1,772,726
Variance	0.0 %	0.1 %	3,804,557,599,868	3,142,556,063,614
Skewness	0.0755	0.4924	0.0832	0.1995
Kurtosis	2.87	3.42	2.84	3.00
Coeff. of variability	0.2407	0.4757	0.8047	0.9290
Minimum	0.9 %	–0.3 %	–3,982,245	–2,856,827
Maximum	7.6 %	19.3 %	8,899,546	8,443,521
Range width	6.7 %	19.7 %	12,881,791	11,300,349
Mean std. error	0.00 %	0.1 %	61,681	56,059

Source: Author

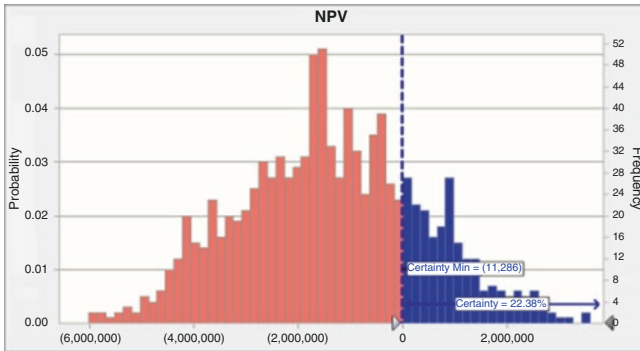


Fig. 2.4 NPV distribution for 20-year immediate amortization for an FIT of 40 JPY/kWh. Source: Author

2.6 CHALLENGES

The current Japanese electricity system employs a centralized energy generation system that is dominated by ten regional electricity companies (FEPC 2014). Regional electricity companies independently prioritize certain energy sources based on costs and profits. Thus, to some extent, in promoting renewable energy, companies that produce electricity employ their own energy balance strategies, which affect renewable energy promotion levels in Japan. In addition, under the current grid system, only limited electricity surpluses in a region can be traded with other electricity companies due to limitation of transmission capacity (Komiya and Fujii 2014), and electricity companies must thus manage their own electricity generation capacity levels and stabilization of electricity supply (MOEJ 2009).

To further promote renewable energy installation while increasing the ratio of renewables in the electricity energy system, Japan must identify ways of mitigating risks resulting not only from prices and quantities but also from the FIT system and policy changes. Two years after the introduction of the FIT system, a gap was found between actual installed solar power generation levels and the number of registered FIT applications.¹¹ Although nearly all the registered capacities of less than 10 kW solar PV have begun operations (83% had been installed by July 2014), most registered capacities managing more than 10 kW have not yet begun operations (only 14% has been installed). Investors typically wait for low solar panel prices to maximize solar power business profits, which may imply that when registering FIT to ensure the fixed FIT price in the early part of the year which is higher than in the later part of the year, companies expect cost declines and wait for lower prices in a solar panel module with learning effects (Nemet 2006; Zwaan and Rabl 2003).

An FIT system policy change was instituted in April 2014 when the government revised rules on the registered government approval capacity of FIT.¹² Installation capacity levels under FIT system increased from 9.8 GW in March 2014 to 13.2 GW in September 2014 for more than 10 kW solar PV.¹³ Although renewable energy installed capacity increased from 1.9 to 2.9 GW for six months from March to September 2014 in Kyusyu area, the excess capacity of expecting renewable energy generation was revealed. The Kyusyu electricity power company realized that—although a maximum electricity demand level within the Kyusyu electricity power company was 16.71 GW—the registered government-approved renewable energy capacity exceeded maximum

demand levels at 17.55 GW in March 2014.¹⁴ In response to the increasing trend in the expected renewable energy, on 21 September 2014, the Kyusyu electricity power company suspended additional renewable energy to connect to the electricity grid (METI 2014a).¹⁵ Other electricity companies also suspended renewable energy purchases and limited their renewable electricity connection levels to grid systems (METI 2014c). In October 2014, the government announced that renewable energy suppliers required not only authorization to sell renewable energy to electricity companies but also approval for the connection from Ministry of Economy, Trade and Industry (METI), which limited renewable energy installation capacities.

These challenges are rooted in solar power generation that involves issues of voltage suppression. Decentralized renewable energy is difficult to control, which requires fluctuation control in voltage and frequency adjustment for balancing energy demand and supply (Kyusyu METI 2011). If higher voltage electricity is transmitted with overcapacity, voltage levels across regions will increase and break down power conditioner functioning in a manner that reverses electricity flows (MOEJ 2009). Addressing this connection problem would involve building additional infrastructure, such as output control systems, storage batteries, pumped hydropower storage, and power grid enhancements, to avoid limiting renewable energy installation via connection capacities (METI 2014b, 2015). In addition, there are emerging discussions on future electricity equilibria, on energy trade-offs between fossil fuel and nuclear and renewable energy sources, and on prioritization concerns.

2.7 CONCLUSION

This analysis indicates that solar energy sources will enjoy an increase in the probability of returns over 20 years for both the household and commercial sectors, which will depend, however, on the rate of FIT schemes and on installation costs. The Yokohama case study results indicate that if module prices are reduced to one-half of current levels, 97.64% profits and 2.48% risk reductions can be expected per household. For the commercial sector, in comparison to FIT fixed prices, the IRR differs in that the IRR in the base case is reduced to 0.7% at the 36 yen/kWh FIT rate with normal depreciation (2.1% for the 40 yen/kWh FIT rate). When the FIT rate is reduced to 32 JPY/kWh, the IRR value is -0.8% in the base case.

The result could be used to guide policies employed in other cities and countries. Risks and returns from renewable energy investments are heavily dependent on FIT rates, solar module prices, and solar PV usage periods. If households continue to use solar PV for personal electricity use, investment gains will increase. Although profits may not return, there are benefits in terms of electricity fee reductions and declines in CO₂ emissions, which are the same as those found for both the 20- and 10-year FIT scenarios. The same implications could be applied to the commercial sector. In addition, for the commercial sector, in comparing tax policies, we found that tax policy effects depend on company financial conditions. Recently, although FIT rates have declined in Japan, total solar module costs have declined over a matter of years, which may shorten return periods while increasing renewable energy investment and operation returns.

However, we are also aware of limitations within FIT systems, frameworks, and policies (e.g., regulation changes). Although FIT schemes are believed to mitigate price risks while delivering on long-term government promises, when such beliefs are in question, policy changes to FIT systems may be used to adjust market conditions in a country.

NOTES

City of Yokohama. Yokohama Wind Energy (Japanese). <http://www.city.yokohama.lg.jp/kanky/ondan/furyoku/>

Data source is Procurement Pricing Committee. Ministry of Economy, Trade and Industry (Japanese). http://www.meti.go.jp/committee/gizi_0000015.html

Feed-in tariff publication of installed capacity database. Ministry of Economy, Trade and Industry (METI) (Japanese). http://www.fit.go.jp/statistics/public_sp.html

Calculated from electricity power generation statistics published by the Agency for Natural Resources. http://www.enecho.meti.go.jp/statistics/electric_power/ep002/results.html#headline2

MOEJ (2015c). About renewable energy installation promotion fund (Japanese). https://www.env.go.jp/policy/local_re/funds4.html

METI FIT website http://www.fit.go.jp/statistics/public_sp.html

In the FIT system in Japan before April 2014, there was no obligation on time periods for solar PV to be installed after it was registered.

TEPCO 2103. Notice of renewable energy power generation promotion levy unit price and solar power promotion generation promotion levy unit price (Japanese) <http://www.tepco.co.jp/e-rates/individual/shin-ene/saiene/pdf/20130401.pdf>

- TEPCO press release 2012 (Japanese). http://www.tepco.co.jp/cc/press/2012/1205626_1834.html
- Green investment tax cuts, METI http://www.enecho.meti.go.jp/category/others/green_tax/greensite/green/
- Registered government-approved FIT is renewable energy capacity at the registration level. The capacity has not been installed. In case of solar PV, there was no obligation to obtain land certificate for a site to be installed and to install it in a specific time period since it was registered before April 2014.
- Registered government-approved renewable capacity (more than 50 kW of solar PV) must operate within 180 days following approval. Otherwise, permits are cancelled under the revised rule (METI 2014b).
- Feed-in tariff publication of installed capacity. Ministry of Economy, Trade and Industry (METI) (Japanese). http://www.fit.go.jp/statistics/public_sp.html
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Analysis of Economic Incentive Policies for Promoting Green Building Development in China

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Abstract In the process of creating a resource-saving and environmentally friendly society, promoting green buildings is emerging as a key objective of sustainable development strategies in China. This chapter focuses on policies with economic incentives for green buildings within a context of low-carbon sustainability. In introducing domestic and international green building coding systems and using data on 104 green building projects in China, we examine current green building economic incentives and local economic policies for selected case studies conducted in Suzhou and Shanghai. We find that total subsidies are sufficient for two-star green buildings but are insufficient for three-star green buildings at both the national and local levels. Barriers to the development of green building are also discussed. We also address our main question regarding why green building label designations are typically allocated at the design stage rather than at the operation stage. Policy recommendations are made to promote green building in China that involve improved integration of subsidy schemes, energy performance contracts (EPCs), carbon trading mechanisms, and carbon taxes based on our research results.

3.1 INTRODUCTION

Approximately 15 million people will be added to the urban population in China every year between 2000 and 2030 (de Oliveira et al. 2012), which means that there will be greater demand for urban dwellings. While economic development and social changes in China have accelerated as a result of urbanization, rapid urban development has also increased resource and energy demand and has accelerated environmental degradation at unprecedented levels. More critically, as large quantities of fossil fuels are consumed due to the process of urbanization in China, billions of tons of greenhouse gases (GHGs) and pollutants are emitted into the atmosphere every year, contributing to serious problems—climate change and air pollution. GHG and pollution emissions will increase with patterns of urban expansion and with ongoing improvements in living standards.

Approximately 2 billion square meters of new buildings (over 90% of these are urban) appear each year, and approximately 21 billion square meters of new buildings are expected to be constructed by 2020 in China to match urban growth (World Bank 2001), which is equivalent to the current building area of the EU-15 (Ecofys 2006). With improved living conditions, an ongoing increase in Chinese buildings' energy consumption levels will occur until 2050 (Qiu et al. 2007). Energy usage in the building sector accounts for 28% of all energy consumption in China (Jiang and Keith 2013). In total, 95% of the 43 billion square meters of buildings in China consists of high energy consumption buildings, and 80% of all new buildings do not adopt (or only adopt a few) energy-saving measures (Jiang et al. 2013). One core objective of China's "Twelfth Five-Year Plan" is to ensure long-term sustainable urban development. Promoting green building development is the main goal of this plan. According to the "The National New Urban Planning 2014–2020" document, the proportion of green buildings in the set of all new buildings will increase from 2% in 2012 to 50% in 2020 (MOHURD 2014).

Green buildings are also addressed in other countries' sustainable development strategies. Several famous green building codes have been issued and implemented, such as the Leadership in Energy Environment Design (LEED) scheme in the USA, the Building Research Establishment Environmental Assessment Method (BREEAM) in the UK, and the Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) in Japan. These green building coding systems have significantly enhanced green building development not only in these three countries but also in other countries. Table 3.1 provides a general overview of the LEED, BREEAM, and CASBEE systems (Wang and Jiang 2006; Tian 2009; Huiling and Burnett 2008).

Table 3.1 Overview of green building coding systems employed in the USA, the UK, and Japan

<i>Name</i>	<i>Country</i>	<i>Issue time</i>	<i>Building types</i>	<i>Rating standards</i>	<i>Standards</i>
LEED	USA	1995	<ul style="list-style-type: none"> • Commercial buildings • Public Buildings • New buildings 	Four-star	Construction, water, energy and environment, materials and sources, indoor environment and innovation
BREEAM	UK	1990	<ul style="list-style-type: none"> • New buildings • Existing buildings 	Four-grades of	Management, energy, traffic, pollution, materials, water resources, land use, ecological value, physical and mental health
CASBEE	Japan	2003	<ul style="list-style-type: none"> • New buildings • Existing buildings 	Five-grades of	Energy consumption, resource reuse, local environments, indoor environment

3.1.1 Energy Conservation Legislation in China's Building Sector

The “Northern Residential Building Energy-saving Design Standards,” which were issued in 1986, mark the beginning of energy-saving building development in China. Since their creation, a series of energy-saving standards have been issued by the Ministry of Construction and by local governments. These standards include mandated energy-saving objectives for the building sector. For example, energy consumption in all new and refurbished public buildings¹ must be reduced by 50 % relative to public building energy performance levels of the 1980s under GB50189-2005 standards (Chinese Construction Ministry 2005). Some local municipal governments have also issued their own energy efficiency design standards for buildings by referring to the national standards and by considering local realities. For instance, the Beijing government issued the “Beijing Public Building Energy Saving Design Standards,” which came into effect in June 2006. The Beijing standards are designed to meet the energy-

¹Public buildings refer to non-residential buildings, for example, offices, shopping malls, hotels, schools, hospitals, with the exception of factories and plants, as outlined in GB50189-2005.

saving objective of a 65% reduction in energy consumption levels in relation to energy use levels in the same public building sector in the 1980s (Beijing Construction Bureau 2005).

All standards and codes related to energy conservation in China's building sector and their states of implementation are presented in Table 3.2 (Liang 2007).

Table 3.2 Current energy conservation standards/codes in the Chinese building sector

No.	Title	Status
1	Energy Consumption Data Collection Standard Construction (JGJ/T154—2007)	Implemented
2	Civil Building Heating, Ventilation and Air Conditioning Design Specification (GB50736—2012)	Implemented
3	Design Standard for the Energy Efficiency of Civil Buildings—Heating in Residential Buildings (JGJ26—95)	Implemented
4	Design Standard for the Energy Efficiency of Residential Buildings in Hot Summer and Cold Winter Areas (JGJ134—2010)	Implemented
5	Design Standards for the Energy Efficiency of Public Buildings (GB50189—2005)	Implemented
6	Standards for the Lighting Design of Buildings (GB50034—2004)	Implemented
7	Code for the Design of Heating, Ventilation and Air Conditioning (GB50019—2003)	Implemented
8	Technical Specification for the Energy Efficiency Retrofitting of Heated Residential Buildings (JGJ129—2000)	Implemented
9	Standards for the Energy Efficiency Inspection of Residential Buildings (JGJ/T 132—2009)	Implemented
10	Technical Specifications on Ground Radiation Heating (JGJ142—2004)	Implemented
11	Technical Specifications on Solar Water Heating Systems of Civil Buildings (GB50364—2005)	Implemented
12	Building Water Supply Drainage and Heating Engineering Code for the Acceptance of Construction Quality (GB50242—2002)	Implemented
13	Code for the Acceptance of the Construction Quality of Ventilation and Air Conditioning Engineering (GB50243—2002)	Implemented
14	Standard Operation Management of Air Conditioning and Ventilation Systems (GB50365—2005)	Implemented
15	Code for the Engineering Technology of Ground Source Heat Pumps (GB50366—2005)	Implemented
16	Code for the Construction and Acceptance of Building Energy Saving Engineering (GB50411—2007)	Implemented

(continued)

Table 3.2 (continued)

<i>No.</i>	<i>Title</i>	<i>Status</i>
17	Cold Storage Air Conditioning Engineering Technologies (JGJ158—2008)	Implemented
18	Urban Heating System Evaluation Criteria (GB/T50627—2010)	Implemented
19	Technical Specifications on Sun Shading Building Engineering (JGJ 237—2011)	Implemented
20	Technical Regulation Urban Geothermal Heating Project (CJJ 138—2010)	Implemented
21	Thermal Design Code for Civil Buildings (GB50176—93)	Implemented
22	Technical Index of Tianjin City Residential Building Energy Saving Design	To be issued
23	Technical Specification for Public Building Energy Saving Reconstruction	To be issued
24	The Thermal Environment of Residential Design Standards	To be issued
25	Technical Specification for Centralized Heating Systems of Room Temperature Control and Heat Metering	To be issued
26	Meteorological Parameter Standard for the Energy Efficiency of Buildings	To be issued
27	Technical Specification for Centralized Heating Systems for Room Temperature Control and Heat Metering	To be issued
28	Effects of Standard Whole Life Cycle Building Sustainability Assessments	To be issued
29	Specification for Energy Saving in Town Heating Systems	To be issued

3.1.2 *Green Buildings in China Today*

Green building promotion has become a major issue of building development in the context of low-carbon sustainability since the 1990s. In recent years, various countries have formed their own green building assessment systems for supporting green building development based on local realities. The “Evaluation Standards of Green Building” (hereafter referred to as “the Green Standards”) came into force in China in 2006 (Ministry of Construction of China 2006), which indicates that China has taken formal steps to promote green building development.

Two main types of buildings (i.e., residential and public buildings) are addressed under the Green Standards. The Green Standards present the following six measures for assessing standards under their evaluation system: land saving, outdoor environments, energy saving and energy performance, water saving and utilization, material saving and utilization, and indoor environment quality and operations management. Each

category includes various items. A total of 40 items are allocated to residential buildings, and 43 are dedicated to public buildings. Green buildings are divided into three levels/grades (i.e., one-, two- and three-star) based on the number of standard items met. Tables 3.3 and 3.4 provide information on residential and public building evaluation standards presented in the Green Standards (Ministry of Construction of China 2006).

When residential or public buildings meet the standards presented in Tables 3.3 and 3.4, green building labels/certificates can be issued. Green labels include one green label/certificate for the design stage and another green label/certificate for the operational stage (Fig. 3.1). The green design label is awarded for the completed design of a project that meets the standards, and the green operations label is awarded for a project that meets the standards after at least one year of operation.

Furthermore, the Ministry of Finance and the Ministry of Housing and Urban–Rural Development of China (MOHURD) jointly presented

Table 3.3 General Green Standards requirements for residential buildings

<i>Level/grade</i>	<i>General requirements (40 items)</i>					
	<i>Land-saving and outdoor environments</i>	<i>Energy saving and utilization</i>	<i>Water saving and utilization</i>	<i>Material saving and utilization</i>	<i>Indoor environmental quality</i>	<i>Operations management</i>
★	4	2	3	3	2	5
★★	6	3	4	4	3	6
★★★	7	4	6	5	4	7

Table 3.4 General Green Standards requirements for public buildings

<i>Level/Grade</i>	<i>General requirements (43 items)</i>					
	<i>Land-saving and outdoor environment</i>	<i>Energy saving and utilization</i>	<i>Water saving and utilization</i>	<i>Material saving and utilization</i>	<i>Indoor environmental quality</i>	<i>Operations management</i>
★	3	5	2	2	2	3
★★	5	6	3	3	4	4
★★★	7	8	4	4	6	6



Fig. 3.1 Three-star green labels for buildings in China. (a) Three-star green label for the operation stage (b) Three-star green label for the design stage

the “Action on Accelerating the Implementation of the Development of Green Building in China (hereinafter referred to as ‘the Action’)” in 2012 (Ministry of Finance and the Ministry of Housing and Urban–Rural Development 2013). The Action states that economic incentive policies, standards and evaluation systems improvements, and technological development processes should be addressed when promoting green building development in China. The Action requires that all new public buildings receiving government investments (at any level) must meet the Green Standards after 2014. The Action also presents a plan for creating 1 billion square meters of new green building space in 2015 and for increasing the green building share to 30% of all new buildings by 2020. By December 31, 2013, 1446 buildings were officially identified as green buildings (both green design and green operations), and the total green building area covered 162.7 million square meters. Among these buildings, 1342 cover an area of 150 million square meters, and 92.8% of all green buildings were certified as green buildings at the design stage. A total of 104 buildings covering an area of 12.8 million square meters (representing 7.2% of all green buildings) were awarded green labels at the operation stage.

A subsidy scheme is also set in place under the Action, which awards subsidies only to green operation buildings. The average subsidy awarded by the central government is 45 yuan²/m² for two-star green buildings and 80 yuan/m² for three-star green buildings in China. In addition to the central government’s subsidy scheme, local governments also sometimes issue their own subsidy schemes to promote the development of local green buildings (Table 3.5).

²The reference exchange rate between yuan (i.e., CNY) and USD is 6.27 yuan =1 USD.

Table 3.5 Subsidy schemes of five provinces and cities in China for green buildings.

<i>City/province</i>	<i>Subsidy scheme</i>
Shanghai	Average 60 yuan/m ² for two- and three-star green buildings. Maximum of 6 million yuan for a single project.
Tianjin	Maximum of 10% of project investment for the green building subsidy.
Xi'an	5 yuan/m ² for one-star green buildings, 10 yuan/m ² for two-star green buildings, and 20 yuan/m ² for three-star green buildings.
Shandong	15 yuan/m ² for one-star green buildings, 30 yuan/m ² for two-star green buildings, and 50 yuan/m ² for three-star green buildings.
Jiangsu	15 yuan/m ² for one-star green buildings, 25 yuan/m ² for two-star green buildings, and 35 yuan/m ² for three-star green buildings.

Under current policies covering green buildings, including economic policies, green building quantities and areas have increased significantly since 2008 (Fig. 3.2). By the end of 2013, 704 projects had been awarded green building certificates, and the total green building floor area covered 86.9 million square meters. There are 648 green building projects (79.3 million square meters) at the design stage and 56 green building projects (7.6 million square meters) at the operation stage. Compared to 2012 levels, the number of green buildings increased by 81.0%, and the total floor area increased by 112.3%. The number of one-star green buildings increased by 90.1%, and the corresponding floor area increased by 143.2%. The number of two-star green buildings increased by 115.6%, and the corresponding floor area increased by 121.4%. The number of three-star green buildings increased by 10.6%, and the corresponding floor area increased by 19.4% (The Eleventh Session of the China 2014).

Of the 704 green buildings identified, 61 were approved by the Science and Technology Promotion Centre of the Ministry of Housing and Urban–Rural Development. A total of 180 green buildings were approved by the City Science Studies of China. The remaining 463 green buildings were approved by local authorities. Green buildings have been built in 28 provinces and cities throughout China since 2008 (Fig. 3.3) (Chinese Construction News and Tianjin Daily 2013).

However, this expansion of new green buildings represents a much smaller trend compared to recent overall building sector growth trends in China. For instance, the total new constructed building area was 3892 million square meters in 2003, but the total constructed green building

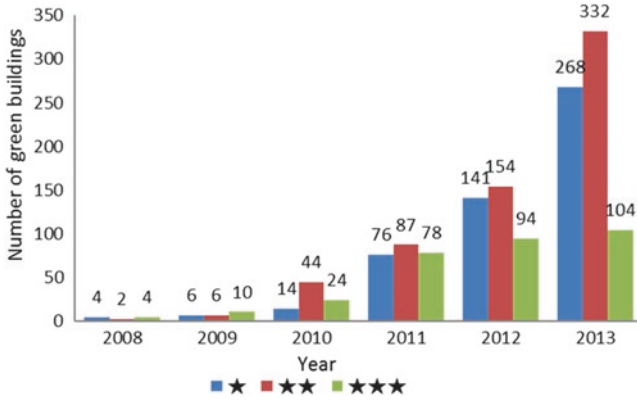


Fig. 3.2 Number of green buildings in China between 2008 and 2013

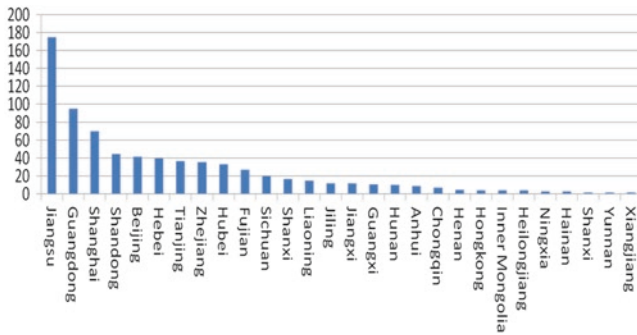


Fig. 3.3 Number of green buildings in 28 provinces and cities in China in 2008–2013

area (including all one-, two-, and three-star green buildings) covered 83 million square meters, accounting for only 2% of the total building area in 2003 (National Bureau of Statistics of China 2014; The Eleventh Session of the China 2014). This chapter seeks to answer the following questions: What led to the current green building situation? What barriers and problems are there in green building development? How solutions can be worked out to overcome these barriers? Our research methods are designed to answer these questions.

3.2 METHODS

In comparison to “normal” buildings, green buildings can maximize resource conservation (e.g., savings on energy, water, and materials), facilitate environmental protection, and reduce pollution while also ensuring the healthful, comfortable, and efficient use of space for occupants over the entire building life cycle (Chinese Construction Ministry 2006). Green buildings have thus had a positive external impact by reducing energy consumption and water use levels, by reducing pollution levels, and by improving indoor and outdoor environments at different life cycle stages (Liu 2006). Green building construction and operation costs, which are mainly borne by developers, are typically higher than those of other buildings because of the nature of positive external benefits. However, most external benefits are enjoyed by occupants, not by developers. In turn, developers are presented with few incentives to develop green buildings. To address this situation, policies such as subsidies, tax exemptions, and other economic incentives should be designed and implemented to comprehensively support green building design, planning, land use, material development, construction, operation, maintenance, renovation, and demolition over the life cycle.

A total of 104 green buildings are selected as research samples in this study to explore the economic incentives for green building development in China. The cities of Suzhou and Shanghai are used as case studies for assessing local economic policies. In particular, data from the following sources are used: the Chinese Society for Urban Studies (CSUA), the China Green Building Council (CHINAGBC), and the China Association of Building Energy Efficiency (CABEE). The 104 samples are located in 22 Chinese provinces and cities. The data also include information on building names, building types, identified green star features, floor areas, initial investment costs, and operational cost savings.

We conduct both qualitative and quantitative analyses. The qualitative method employed in the study involves a literature review and comparative analysis. Information collection, identification, and comparisons are conducted by means of a literature review. First, major international green codes (i.e., LEED, BREEAM, and CASBEE) are presented, China’s Green Standards (i.e., the Evaluation Standards of Green Buildings) are introduced, and green building development conditions in China are described in the literature review. Our research objectives, questions, and framework are formed based on the literature analysis.

The quantitative method is designed to quantify the incremental cost of green buildings and to also compare the relationship between subsidies and incremental costs. Green building incremental costs per unit of floor area can be determined from the initial cost and floor areas of the sample buildings. The equation used is:

$$C_i = C_o / S \quad (3.1)$$

Where C_i is incremental cost (yuan/m²), C_o is the initial cost (yuan), and S is the floor area (m²).

The total green building subsidy for the two case studies (i.e., Suzhou and Shanghai) is calculated using the following equation:

$$S_t = S_c + S_l \quad (3.2)$$

Where S_t is the total subsidy (yuan), S_c is the central government subsidy (yuan), and S_l is the local government subsidy (yuan).

For Suzhou, the local subsidy is the sum of subsidies from the Jiangsu provincial government and Suzhou municipal government. For Shanghai, the local subsidy is equal to the municipal government subsidy. To further identify differences between two- and three-star green buildings, the quantitative analysis also examines reasons behind differences in the quantity of design- and operation-stage green buildings within the sample.

3.3 RESULTS

3.3.1 *Current Chinese Central Government Economic Policies*

Green buildings have had the following positive external impacts: decreased energy consumption and water use, lower pollution outputs, and improved indoor and outdoor environmental health over the life cycle period. However, green building developers cannot ensure all the external benefits—and particularly monetary benefits—leading to economic externality issues for developers. As the market can only reflect a producer's internal revenues and costs, developers are not guaranteed profits from external green building benefits, which is also considered a form of market failure in the promotion of green building development.

When market failure occurs, the government can intervene with certain policies and regulations. In particular, externality policies are designed to address this form of failure and are normally divided into mandatory policies and economic incentive policies. Typically, mandatory policy enforcement can occur via laws and regulations that help achieve specific goals. However, the negative results of mandatory policies may limit flexibility or lead to further market failure. Economic incentive policies can also be divided into tax policies (e.g., a tax (e.g., Pigouvian tax³) on non-green building developers and subsidies for green building developers). Current central and local government subsidies designed to promote green building development in China are a common type of economic incentive policy, which is the focus of this study. The analysis subsequently assesses subsidy schemes and incremental costs of green buildings at both the national and local levels and then compares the subsidies and incremental costs of elected green buildings for the two case studies.

3.3.2 *Subsidies and Incremental Costs of Green Buildings*

To promote energy conservation and green building development, the Ministry of Finance and the Ministry of Housing and Urban–Rural Development issued a policy entitled the “Action of Accelerating the Development of Green Building in China” in 2012 (Wang 2013), which provides subsidies for two- and three-star green buildings in the Chinese building sector. The following subsidy scheme is employed: 45 yuan/m² for two-star green buildings and 80 yuan/m² for three-star green buildings (MOHURD 2013).

Using Eq. (3.1) and data for the 104 sample buildings, the average incremental costs for green public and residential buildings are presented in Table 3.6.

According to the Action, average national subsidies for green buildings are established as follows: 45 yuan/m² for two-star green buildings and 80 yuan/m² for three-star green buildings. Based on the study results, actual incremental costs in China are 93 yuan/m² for two-star green buildings and 224 yuan/m² for three-star green buildings. Clearly, central government subsidies (i.e., Ministry of Finance and the Ministry of Housing

³A Pigouvian tax is applied to a market activity that is generating negative externalities and is intended to correct inefficient market outcomes by being set to equal the negative externalities.

Table 3.6 Average incremental costs of green buildings in China

<i>Building type</i>	<i>Green building level</i>	<i>Average incremental cost (unit: yuan/m²)</i>
Public	One-star	25.32
Public	Two-star	82.71
Public	Three-star	337.69
Residential	One-star	42.85
Residential	Two-star	103.03
Residential	Three-star	110.91
Average incremental cost of two-star green buildings		93
Average incremental cost of two-star green buildings		224

and Urban–Rural Development of China) do not cover real incremental costs. Instead, current national subsidies cannot effectively encourage and support green building development in China. In addition to the national subsidy scheme, local governments issue and implement subsidy schemes in cities and provinces. The total subsidies for green buildings are required to integrate national and local government subsidies. To further evaluate local green building economic incentive policies, we present two case studies and a corresponding analysis.

3.3.3 Case Studies

Following the Action, a series of local economic incentive policies were issued by local provincial and city governments in 2012. Subsidies under local policies differ based on local climatic conditions and economic development patterns in provinces and cities.

Based on the quantity of green buildings in different cities among the 104 sampled buildings, Suzhou and Shanghai are ranked first and second, respectively, insofar as having the largest number of identified green buildings is concerned. Therefore, two cities are examined as case studies for exploring subsidy schemes of green building development at the local level.

Case 1: Suzhou

Jiansu province, where Suzhou is located, issued the “Building Energy Management Measures of Jiangsu Province.” The policy outlines the following subsidy standards for green buildings: 15 yuan/m² for one-star green buildings, 25 yuan/m² for two-star green buildings, and 35 yuan/m² for

three-star green buildings in Jiangsu province (Feng 2013). At the same time, Suzhou established its own municipal subsidy procedure entitled the “Green Building Implementation Plan.” Under this plan, the following subsidy procedure is employed: 15 yuan/m² for two-star green residential buildings, 25 yuan/m² for two-star green public buildings, 35 yuan/m² for three-star green residential buildings, and 50 yuan/m² for three-star green public buildings.

The total subsidy for green buildings in Suzhou is thus equal to the total subsidy amount from the central, Jiangsu provincial, and Suzhou municipal governments. Moreover, total subsidies for green buildings in Suzhou are determined using Eq. (3.2): 95 yuan/m² for two-star green buildings (i.e., $45 + 25 + 25 = 95$ yuan/m²) and 140 yuan/m² for three-star green buildings (i.e., $80 + 35 + 25 = 140$ yuan/m²).

Based on the results of Eq. (3.1), real incremental costs of green buildings in Suzhou are 41 yuan/m² for two-star green buildings and 246 yuan/m² for three-star green buildings. The total subsidy (i.e., 95 yuan/m²) covers the incremental cost of two-star green buildings. However, the total subsidy (i.e., 140 yuan/m²) does not cover the incremental cost of three-star green buildings.

Case 2: Shanghai

Shanghai was the first Chinese city to implement the Green Standards. The country’s first green building label was awarded to a Shanghai building in 2008. A total of 94 green building labels were issued between 2008 and 2013. According to the Shanghai municipal government’s policy titled “Supporting the Building Energy-saving Projects in Shanghai,” subsidies for both two- and three-star green buildings amount to 60 yuan/m² (Liu 2006). After adding central government subsidies using Eq. (3.2), the total subsidy amounts to 105 yuan/m² for two-star green buildings ($45 + 60 = 105$ yuan/m²) and 140 yuan/m² for three-star green buildings ($80 + 60 = 140$ yuan/m²).

Based on the results of Eq. (3.1), real incremental costs of green buildings in Shanghai are 41 yuan/m² for two-star green buildings and 381 yuan/m² for three-star green buildings. Therefore, as in Suzhou, the total subsidy (i.e., 105 yuan/m²) covers the incremental cost of two-star green buildings, but the total subsidy (i.e., 140 yuan/m²) does not cover the incremental cost of three-star green buildings.

A comparison between subsidies and incremental costs for the two cities is presented in Fig. 3.4.

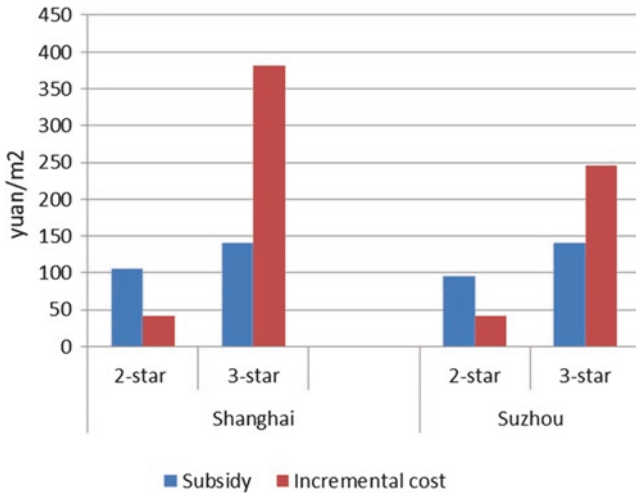


Fig. 3.4 Subsidy and incremental cost for green buildings in Shanghai and Suzhou cities

3.3.4 Number of Design- and Operation-Stage Green Buildings

As noted in Sect. 3.1, two types of green building labels are awarded, one at the design stage and the other at the operation stage. We compare the number of labels awarded to further determine differences between design- and operation-stage development conditions. By January 2013, 742 green building labels had been awarded in China, and the total green building area reached 75.81 million square meters. The assessment results show that 694 green labels have been awarded for the building design stage (two- and three-star labels with a total area of 70.66 million square meters) and that only 48 green labels have been awarded for the operation stage (two- and three-star labels with a total area is 5.15 million square meters). Figure 3.5 shows the difference between the quantities of green labels allocated for the design and operation stages. Figure 3.6 presents the green building area difference for the two stages as well.

Clearly, design-stage green buildings are more plentiful and cover a larger area than operation-stage green buildings. As noted in the introduction of Sect. 3.1, 80% of energy use in a building's life cycle is affected by the operation stage, and more economic and environmental benefits can

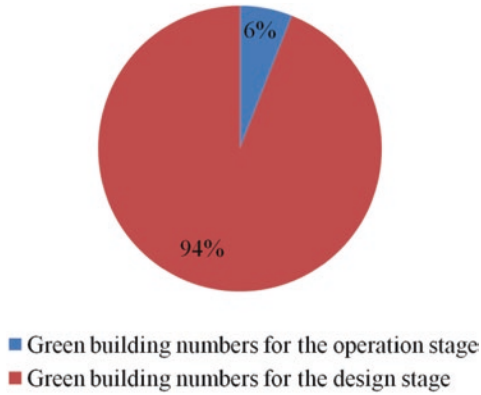


Fig. 3.5 Number difference of green buildings for design and operation stages

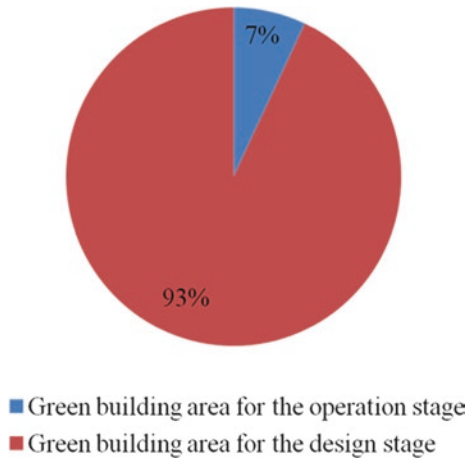


Fig. 3.6 Area difference of green buildings for design and operation stages

be achieved at the operation stage. The substantially lower number and area coverage of certified green building at the operation stage than at the design stage and the issue of subsidies discussed in Sects. 3.2 and 3.3 raises critical questions: What factors contribute to this situation? How can developers be encouraged to obtain green building status at the operation stage in China?

3.4 DISCUSSION

3.4.1 *Barriers to Green Building Development in China*

The literature review reveals numerous problems associated with Green Standard implementation (MOHURD 2013). For example, in existing green buildings, 30% of sun-shading systems do not work due to design flaws, 6.7% of renewable facilities are no longer used, only 10% of materials are reused, and 20% of tools are not maintained regularly—and all these results are obtained after only one year of operation. Other problems associated with green buildings include indoor environments and water-saving systems that do not meet standards and plants that have died due to watering system failures. These issues mean that some green buildings are no longer “green,” as they do not meet Green Standards during operation periods.

In addition to the issues presented above, Wang (2013) also notes two main reasons for the discrepancy between design- and operation-stage green buildings:

- The term of approving the green label for the design stage is much shorter than at the operation stage.
- Green label awarding processes are more complicated at the operation stage.

For these two reasons, developers must face more technical and financial risks to obtain green labels for buildings at the operation stage (Wang 2013); in addition, these two reasons also explain why fewer green labels are awarded at the operation stage than at the design stage.

As numerous new green buildings have only operated for one or two years, they require more time to fully meet low-carbon and “green” operation targets, which is understandable in light of the issues presented above. Although the speed of green building growth has been high in recent years, Yao and Wu (2014) describe the constraints on green building development in China as follows:

- Securing Green Standards and green labels during the operation stage is difficult and complicated.
- Three-star green building awards are more difficult and costly to obtain than two-star green building awards.

- Three-star green building subsidies are inadequate.
- Developers are less aware of the benefits (e.g., profits from energy and water savings, staff productiveness improvements) of green buildings at the operation stage, and insufficient information is available for raising developer awareness.

To overcome the current barriers to green building development in China, national and local subsidy schemes must be made sound and feasible. The first solution may involve improving the subsidy scheme for three-star green buildings. Based on the analysis presented above, national subsidies and the subsidies offered in Shanghai and Jiangsu are clearly inadequate for three-star green buildings. The central government (i.e., the Ministry of Finance and the Ministry of Housing and Urban–Rural Development) and local governments must update subsidy procedures and substantially enhance subsidy levels to eliminate barriers related to the incremental costs of three-star green buildings. Simultaneously, the process of approving and identifying two- and three-star green labels at the operation stage must be simplified, and costs must be reduced. Furthermore, more information and training must be provided by the government for building developers to raise their awareness of green building benefits (e.g., economic, environmental, and health benefits).

In addition to these means of improving subsidy schemes, other economic incentive policies such as the energy performance contracts (EPCs), carbon trading mechanisms, and carbon taxes described below may also be considered.

3.4.2 *Energy Performance Contract*

Because developers must invest more in green buildings than in traditional buildings, the main challenge facing developers involves incremental costs. Although economic incentive policies and subsidy schemes in particular have been developed to promote the development of green buildings in China, barriers remain nonetheless. In addition to insufficient subsidies for three-star green buildings, other problems include the following: (1) technological risks involving the utilization of new equipment and technologies for energy saving in buildings and (2) financial risks involving investments in new technologies and equipment. However, we also note that investments (i.e., incremental costs) in green buildings can be paid back by reducing energy water usage costs and in the management of certain phases of the green building life cycle.

An EPC allows professional energy service companies to participate in the energy management of green buildings for a profit. In brief, the EPC constitutes a collaborative effort between professional energy service companies and developers that is designed to reduce technological and financial risks during green building development (Lu and Fan 2012). Typically, energy service companies invest in energy-saving equipment and technologies and secure profits from energy savings made during the building operation phase to pay back investments. In other words, a portion of the incremental costs can be managed by energy service companies rather than by developers. In addition to partly sharing incremental costs, more importantly, companies can engage professional support for energy savings at the design, technology selection, and equipment operation and maintenance phases of the operation stage. Thus, the EPC may significantly reduce the risks facing developers by allowing professional companies to become involved. More importantly, developers and energy service companies can form contracts based on market principles.

Based on the description presented above, the EPC may serve as a means to overcome the problems and barriers associated with China's current subsidy procedures. However, we found that no EPCs had been created among the 104 green building projects examined and that there were only a few cases of EPC implementation in Chinese green building projects. The two main obstacles appear to be as follows (Sun 2008; Wang et al. 2008):

- EPCs still constitute an emerging energy management approach in China. Limited regulations and implementation experiences constitute the most significant barriers thus far. Professional energy service companies are not afforded sufficiently supportive government policies (such as tax exemptions for green building involvement).
- The financial risks faced by energy service companies differ from those faced by green building developers. Most energy service companies have been established only in recent years, and enterprise credit evaluation systems created by banks for these companies have not yet been fully formed, which makes it difficult for these companies to obtain credit guarantees from banks. Furthermore, most of these companies are small Chinese businesses, making it more difficult for them to obtain business support from banks.

3.4.3 *Carbon Trading and Carbon Taxes*

Under the “cap-and-trade” principle, certified carbon reductions are traded in a carbon market (Hepburn 2007). Carbon trading schemes might help developers overcome the investment barriers described in Sect. 3.5, as the costs and risks of employing technologies and knowledge can be significantly reduced. Li et al. (2009) also note that investors can pay off their initial extra costs within a manageable risk range by using carbon reduction credits granted via green building project implementation. Partners such as developers, energy companies, and even real estate management companies could enjoy the benefits under the Chinese building sector carbon trading mechanism.

China has made efforts to establish and promote domestic carbon trading markets. For instance, seven demonstration carbon trading centers have been built in Chinese cities (e.g., Beijing, Tianjin, Shanghai) since July 2008, and more carbon trading centers are slated to be built in the future.

However, as a new trading mechanism, such markets have limitations that must also be addressed. According to a report by Wen (2011), real carbon trading contributions from the building sector are limited, and the following three main obstacles prevent the current carbon trading scheme from being developed further to more fully accommodate China’s building sector (Wen 2011):

- All carbon reduction projects executed in carbon trading centers are voluntary carbon reduction activities. Without market-based incentives, most developers are not motivated to initiate carbon reduction projects.
- The carbon trading mechanism is based on “cap-and-trade” principles, and China has not set any caps on carbon emissions thus far at any level. No carbon trading schemes can be imposed without emission caps.
- Green building carbon trading projects are difficult and costly to implement.

As an environmental tax, a carbon tax might be implemented together with subsidy themes, EPCs, and carbon trading mechanisms. This study shows that decreasing carbon taxes on businesses related to green buildings can enhance green building developer competitiveness levels while

reducing their incremental costs. The Chinese government has previously implemented an environmental tax for pollution prevention (Jun and Michel 2009). Similar tax policies that promote green building development may be designed as well (e.g., a tax exemption can be offered to developers, energy service companies, and others involved in green building development).

3.5 CONCLUSIONS AND POLICY IMPLICATIONS

China is the largest energy consumer and emitter of carbon emissions in the world. The building sector is one of the most energy-intensive sectors in China. Energy conservation and environmental protection have become central priorities of the national sustainable development strategy, and green building promotion constitutes a key task as part of this strategy.

Green buildings have had positive external benefits (e.g., energy and water saving, pollution reduction, indoor and outdoor environmental improvements) over their life cycles. However, building developers cannot enjoy all the potential external benefits and must bear incremental costs. This form of market failure must be mitigated, mainly through economic policies. Subsidies have formed an integral part of Chinese central and local government strategies to promote green building development. In this study, 104 green buildings in 28 provinces and cities are used as research samples to explore the incremental costs of green buildings and for drawing comparisons between current subsidies. In conducting an additional analysis at the local level, Shanghai and Suzhou are taken as case studies. From the study results, we find that total subsidies are sufficient for two-star green buildings, but are insufficient to encourage the development of three-star green buildings at both the national and local levels, which suggests that it would be costly for developers to build three-star green buildings, but that it would be profitable for them to build two-star green buildings.

Additional study results show that green labels awarded at the design stage far exceed those awarded at the operation stage, largely because it is more complicated and costly to secure green building labels at the operation stage than at the design stage under the current Green Standards. Environmental and economic benefits that can be achieved at the green building operation stage are overlooked, which may be mitigated by simplifying and lowering the costs of green label allocation at the operation stage.

In addition to improvements to subsidy procedures, our analysis shows that addressing problems and barriers associated with green building development in China will involve the introduction of several economic incentive policies. Such policies may involve the introduction of EPCs that allow energy companies to participate and the adoption of carbon trading mechanisms and carbon taxes that make green building developers more competitive in the market.

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Low-Carbon City Scenarios for DKI Jakarta Towards 2030

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Abstract This study presents the results of a modelling study on greenhouse gas (GHG) mitigation actions through which the DKI Jakarta energy sector may achieve “Low-carbon City in 2030” targets. The study assesses the effect of future GHG emission levels in DKI Jakarta and ways in which the DKI Jakarta provincial government may reach reduction targets by up to 30% below the baseline level in 2030 through the Provincial Action Plan (RAD GRK). Using a back-casting approach, an energy development path is developed based on desirable goals, and we then seek ways to employ it.

The results of this study show that energy demand in DKI Jakarta has increased significantly, particularly as the result of increasing activity in the transportation and industrial sectors. Future energy city demand levels will be determined by population growth, economic development, transport demand generation, and end-use technology trends. Future energy supplies will correspond with future demands and decision-making regarding the energy supply mix and regarding technologies. Under the business as usual (BaU) scenario, final energy demand levels from 2005 to 2030 are estimated to increase 4.5 times from 6.7 mtoe (5.5% of total consumption in Indonesia) to 27.9 mtoe, whereas primary energy supplies will increase from 11.3 mtoe to 50.1 mtoe. Under mitigation scenarios, final energy demand levels from 2005 to 2030 are estimated to increase 3.5-fold from

6.67 mtoe to 23.33 mtoe, and primary energy supplies will increase from 11.3 mtoe to 50 mtoe.

4.1 INTRODUCTION

DKI Jakarta, the capital city of Indonesia, is one of the world's megacities, with a population of 10 million living on 662 km² of land area and 6977 km² of sea area (Widodo 2013). DKI Jakarta is a coastal city ($\pm 40\%$ of land area falls below sea level) located in a tropical region with dry and rainy seasons. Several rivers that flow across the city combined with low topographical features make Jakarta prone to flooding during the wet season and when high sea tides occur. In addition, a lack of water level control infrastructure, deforestation in areas surrounding DKI Jakarta, and complex socioeconomic problems also indirectly trigger flooding events. These conditions render the city vulnerable to the effects of climate change, and particularly to the rise of sea levels and rainfall intensities. The term "city" is used to refer to the province of DKI Jakarta.

The city's population grew by 1%/year from 2005 to 2010. The city contributes significantly to the national economy. Generating a GDP of approximately 396 trillion rupiah (at constant prices in 2000) in 2010, DKI Jakarta accounts for 17% of Indonesia's GDP value. The GDP value increased by 6.5%/year from 2005 to 2010. The main contributors to the city's GDP include the tertiary/commercial (73%) and secondary/manufacturing industries (15%) (Widodo 2013). The city is characterized by high motorized vehicle (cars and motorcycles) density levels and by limited public transport infrastructure. Population growth, economic characteristics, and transportation conditions have resulted in high GHG emission levels, that is, 3.84 tons of CO₂e per capita (2005), with the energy sector accounting for 89% of total GHG emissions. As a comparison, during the same year, national GHG emissions measured 3.01 tons of CO₂e per capita (RAD GRK DKI Jakarta 2012).

In response to these conditions and to general climate change issues, in 2010, the Governor of DKI Jakarta announced "non-binding commitments" to reduce GHG emissions to 30% below the baseline emission level () in 2030. To achieve reduction targets, the government of DKI Jakarta developed a mitigation action plan entitled the RAD GRK in 2012. This mitigation action plan complements mainstream international development concepts, that is, low-carbon development

(LCD). LCD tracks a development path that will lead to socioeconomic development with low-carbon emissions. LCD concepts can be implemented at the national level as well as at the regional, city, community, and corporate levels. Although DKI Jakarta has not formally sought to achieve LCD, the mitigation action plan under the DKI Jakarta RAD GRK is in line with efforts that will lead to the achievement of low-carbon city targets.

This report presents the results of a modelling study on a low-carbon city scenario for DKI Jakarta until 2030 and identifies development paths to allow DKI Jakarta to become a low-carbon city by 2030. As the energy sector accounts for 89% of all GHG emissions in DKI Jakarta, the study focuses on the energy sector. Particular emphasis is placed on selecting energy technologies that are relevant to achieving low-carbon city targets. The results of the study may be used as a source of information for the preparation of development strategies, policies, and plans for DKI Jakarta.

4.2 DESIGN AND METHODS

The tool used in this study is a non-linear programming model ExSS (Extended Snap Shot) that employs GAMS (General Algebraic Modelling System) v 23.3, which is supported by various technical, economic, and social parameters (Dewi et al. 2010; Dewi 2012). Figure 4.1 shows the structure of the ExSS tool, with input parameters, exogenous variables, and variables between modules. The figure shows that population and economic developments serve as a driving force for energy demand and, correspondingly, GHG emissions. Important residential parameters include household sizes (number of persons/household), energy service demand levels, technology efficiency levels, and efficient technology share levels. Important transportation parameters include trip generation demand levels, trip distances (annual km-passenger or ton-km) for each mode of transport, industrial and commercial activity growth levels (for freight transport), technological efficiency levels, and efficient technology share levels. Important industrial parameters include shares of industrial subsector outputs, energy service demand levels, technological efficiency levels, and efficient technology share levels. Important commercial sector parameters include floor space/output and commercial output share levels.

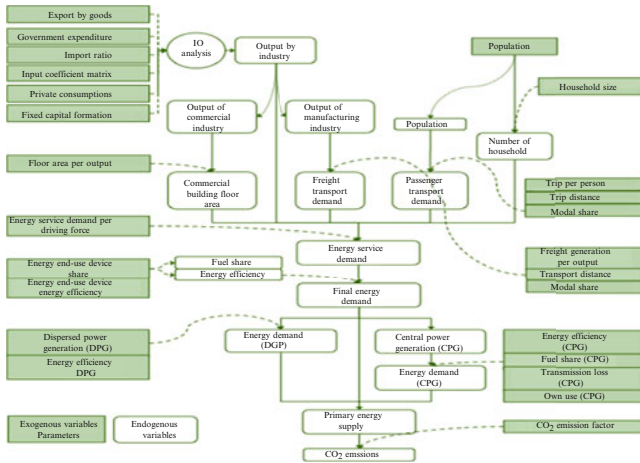


Fig. 4.1 Overview of the Extended Snapshot Tool calculation system (Dewi et al. 2010)

Our method is based on the back-casting approach and was developed to identify ways to meet desirable goals: (1) setting the framework: base (2005) and target years (2030), environmental targets, target areas, and number of scenarios; (2) describing and quantifying socioeconomic assumptions; (3) exploring energy technologies for low-carbon measures; (4) estimating GHG emissions for the base and target years; and (5) analysing low-carbon measures that can be used to meet low-carbon city targets. Projection scenarios developed for this study are BaU and Mitigation scenario (CM) scenarios. The BaU scenario envisions development paths and associated GHG emissions without considering CM efforts. The CM scenario was developed to envision development paths to achieving low-carbon city targets.

Over the last decade, the city's population grew by 1% p.a. and the economy grew by 6.5% p.a. Therefore, the projection (2005–2030) assumes that the population will continue to grow at the same rate (1% p.a.) and that the economy will grow at a slightly faster rate (7% p.a.). Figure 4.2 presents the population by age group and GDP output for 2005 and 2030. The figure shows that the main contributors to the city's economy include the tertiary industry (commercial) followed by the secondary industry

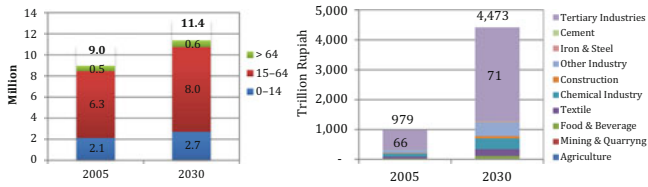


Fig. 4.2 Projected population (by age group composition) and GDP output

(manufacture). The commercial sector will grow at a faster rate relative to other sectors, and therefore the share of this sector will increase from 66% (2005) to 71% (2030). Although this sector accounts for a high share of GDP output, the energy intensity level of the commercial sector is lower than that of other sectors. Therefore, final energy demand growth in the commercial sector is assumed to be lower than that in other sectors.

The projections for both the BaU and mitigation scenarios use the same socioeconomic indicator assumptions. All the assumptions of socioeconomic indicators used in this study are described in Table 4.1. As shown in the table, the city's population increases 1.3-fold, GDP increases 5-fold, passenger transport demand levels increase 3.9-fold, and freight-transport demand levels increase 3.8-fold. All these parameters eventually affect energy demand projections and associated GHG emissions.

In this study, the mitigation scenario is limited to energy technology options that can be used to achieve low-carbon city targets. Other options that might lead to GHG emission reductions (e.g., lifestyle changes) are not considered in this study. In developing these energy technology options, mitigation options in RAD GRK for DKI Jakarta are used as a reference. The options are limited to GHG emission reduction from energy consuming activities, that is, from the transportation, industrial, commercial, and residential sectors.

GHG emissions from the power sector are indirect emissions resulting from electricity consumption. Mitigation actions taking the form of electricity efficiency measures will eventually mitigate emissions from power generation that fall outside of DKI Jakarta's jurisdiction. Therefore, energy technology options that can reduce CO₂ emissions in the power sector are not examined in this study. Thus, the energy technology options considered in this study include:

Table 4.1 Socioeconomic variable (ExSS modelling input parameters)

<i>Socioeconomic parameter</i>	<i>Base year 2005</i>	<i>Target year 2030</i>	<i>Ratio 2030/2005</i>
Population, millions	8.9	11.4	1.3
Number of households, millions	2.2	2.85	1.3
GDP (at constant prices in 2000), trillions IDR	474	2347	5
GDP per capita, millions IDR	53	206	3.9
Gross output, trillions IDR			
– Primary	5.2	18.8	3.6
– Secondary	305	1250	4.1
– Tertiary (commercial/floor area)	594	3367	5.3
Passenger-transport demand, billions psg. km	49	192	3.9
Freight-transport demand, billions ton km	15.8	61	3.8

- deployment of energy-efficient devices in the transport, industry, and commercial/residential sectors,
- transport fuel change from oil fuels to low-carbon emitting fuels (biofuel and gas),
- transport mode changes (private to public), that is, MRT/mono rail, train/double track, bus-way,
- non-motorized transport increase (bike or walk) through infra-structural improvements,
- motor efficiency improvements through flue gas monitoring,
- traffic management (parking management, freight transport scheduling, etc.), and
- promotion of eco-driving.

4.3 RESULTS AND DISCUSSION OF ENERGY SECTOR DEVELOPMENT AND GHG EMISSIONS

DKI Jakarta's energy demand levels will increase significantly, particularly due to increasing transportation and industrial activity. Energy consumption in 2005 reached 6.67 MTOE (5.5% of all energy consumption in Indonesia). Future energy consumption in DKI Jakarta will depend on factors such as population growth, economic development, transport

demand generation, and energy technology mix schemes that will be deployed in the future. Energy supplies correspond with future energy demand levels and energy mix and technological decisions that address future energy demand. Future GHG emission levels will be determined by the magnitude of energy activities (on both the demand and the supply sides) and by technology mix schemes employed in energy activities. The ExSS modelling simulation, which presents snapshots of population, GDP, energy demand, and GHG trends for the base and target years, is shown in Fig. 4.3 and Table 4.2. Snapshots of the parameters shown in Fig. 4.3 are presented as a ratio of future values (2030) compared with base year levels (2005).

A snapshot of the final energy demand under BaU and CM projections on energy demand (by type and sector) for 2030 is presented in Fig. 4.4, while a snapshot of the energy supply mix and corresponding sectoral GHG emission trends is presented in Fig. 4.5. A snapshot of final energy demand levels in DKI Jakarta shows that under the BaU scenario, final energy demand levels from 2005 to 2030 are estimated to increase 4.1-fold from 6.67 mtoe (5.5% of total energy consumption of Indonesia) to 27.54 mtoe, whereas primary energy supplies will increase from 11.29 mtoe to 49.2 mtoe from 2005 to 2030. Under the CM scenario in the same period, demand is estimated to increase 3.5-fold from 6.67 mtoe to 23.33 mtoe, whereas the primary energy supply mix level will increase from 11.3 mtoe to 41.53 mtoe. Future

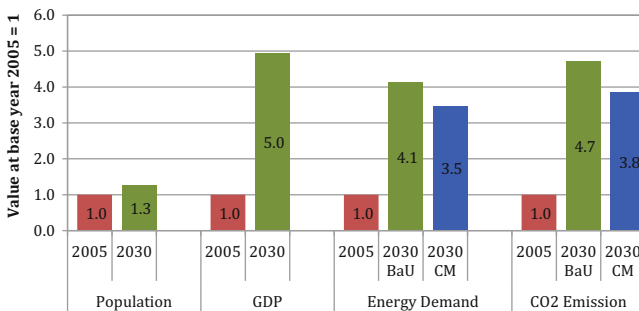


Fig. 4.3 Future population, GDP, energy, and CO₂ emission values

Table 4.2 Estimation of scenario quantification for the base (2005) and target (2030) years

<i>Parameter</i>	<i>Base year (2005)</i>	<i>BaU 2030</i>	<i>CM 2030</i>
Energy demand (ktoe)	6672	27,537	23,224
– Passenger transport	1701	6875	5235
– Freight transport	625	2403	2194
– Residential	1518	5705	5299
– Industrial	2337	9303	7766
– Commercial	491	3252	2730
Energy demand/capita (toe/cap)	0.7	2.4	2.0
Energy intensity (toe/million IDR)	14	12	10
GDP growth rate	6.5%	6.9%	6.9%
Energy demand growth rate		6.1%	5.3%
Energy elasticity		0.9	0.8
CO ₂ emission (kton-CO ₂)			
– Total sectoral energy	29,992	141,534	115,235
Passenger transport	5272	21,313	13,735
Freight transport	1917	7369	5389
Residential	8834	41,118	36,410
Industrial	8749	35,645	29,288
Commercial	5219	36,089	30,413
– All energy sources	29,992	141,534	115,235
Coal	4	15	13
Oil	10,062	37,349	26,437
Gas	4750	18,763	16,732
Electricity	15,176	85,407	72,053
Carbon intensity			
– Tons of CO ₂ per capita	3	12	10
– Tons of CO ₂ per million IDR	63	60	49

GHG emissions from the energy sector are determined based on the magnitude of activities in both the demand and supply sides of the energy sector and by technology mix approaches used in the sector. Under the BaU scenario, GHG emissions associated with energy used on both sides will increase from 30 ktons of CO₂e (2005) to 143 ktons of CO₂e (2030), with major contributors including the power generation (61%), transportation (20%), industrial (14%), residential (5%), and commercial sectors (0.4%). Under the mitigation scenario, the GHG emission level will be 26 million tons of CO₂ in 2030, which is

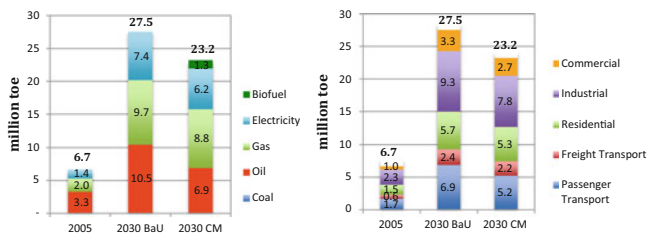


Fig. 4.4 Snapshot of overall city energy demand (by energy type and sector)

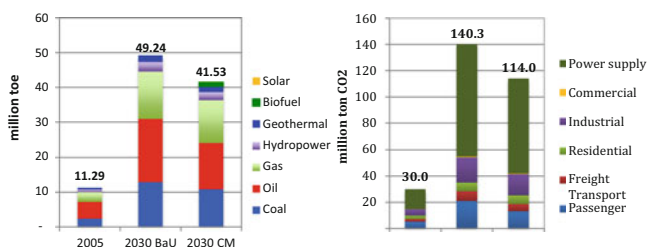


Fig. 4.5 Snapshot of energy supply mix levels and corresponding sectoral GHG emission levels

lower than BaU levels for the same year. GHG emission levels associated with energy used on both the demand and supply sides for the base year, the BaU scenario, and the CM scenario are presented on the right hand side of Fig. 4.5.

The share of sectoral consumption by energy type from 2005 to 2030 will change slightly, that is, consumption in all sectors will decrease, although not in the commercial sector, which will experience an increase from 7% to 12%. As shown in Fig. 4.6, oil dominates energy supply (accounting for 49% of total energy supplies in 2005, with the remaining 51% shared by natural gas 30% and electricity 21%). Oil is used primarily for transportation, whereas gas (natural gas and LPG) is largely used in the industrial and residential sectors. In 2030, under the BaU scenario, the distribution of energy use by type will be similar to that in 2005, although oil fuel consumption in the residential sector will no longer exist and will be replaced by gas (natural gas/LPG) and electricity. The share of oil will decrease to 44% and the share of electricity will increase to 27%.

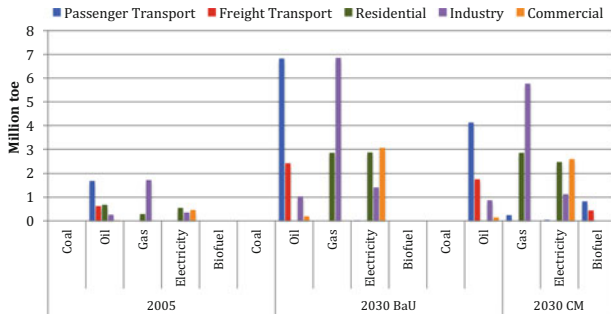


Fig. 4.6 Energy consumption of each energy type by sector

GHG emissions from DKI Jakarta's energy sector are attributed to fossil fuel combustion activities in the transport, industrial, commercial, and residential sectors. There are also indirect GHG emissions from electricity consumption due to GHGs that are emitted from power generators. In the context of GHG emission inventory and mitigation actions, power generators fall outside of DKI Jakarta's jurisdiction. Although some of these power plants are located in the city, they are integrated with other power generators that supply the regional grid (Jawa Madura Bali or JAMALI). As DKI Jakarta uses electricity from the JAMALI grid, GHG emissions resulting from electricity consumption in the city are determined using the GHG emissions factor for the grid. By sector (aside from the power generation sector), the industrial and residential sectors were the most significant GHG emitter, followed by the transport and commercial sectors in 2005 (see the right hand side of Fig. 4.7). The left hand side of the figure shows that the main contributor to GHG emissions generated in power plants is electricity consumption in the city. However, it is notable that these emissions are distributed across sectors and electricity consumers.

Figure 4.8 presents a projection of GHG emissions from the energy sector under the BaU 2030 scenario and shows that most GHG emissions are generated by power plants as a result of electricity consumption in the city. However, it is notable that these emissions are distributed across various sectors and electricity consumers. By sector (outside of power generation sectors), the residential sector is the largest GHG emitter followed by the commercial, industrial, and transport sectors (see the right hand side of Fig. 4.8). The right hand side of Fig. 4.8 shows that the electric-

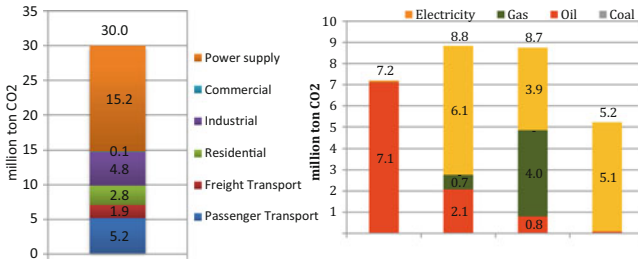


Fig. 4.7 GHG emissions from the energy sector in DKI Jakarta in 2005

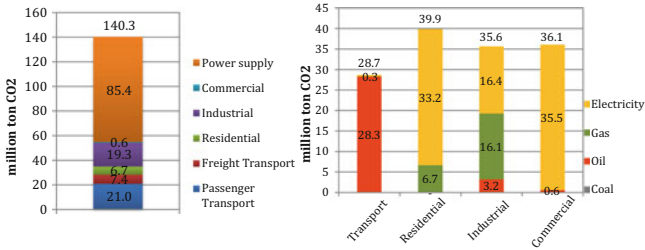


Fig. 4.8 GHG emissions from the energy sector in DKI Jakarta under BaU 2030 conditions

ity sector is the largest contributor of GHG emissions. Emissions appear in the commercial, residential, and industry sectors. Emissions from the transport sector result almost exclusively from oil combustion.

Based on sectors and forms of fuel use in the energy sector, mitigation actions are primarily designed to reduce energy consumption levels by means of efficiency measures for various energy end users (industrial, commercial, residential, etc.) that decrease GHG emitting fuel use (biofuel, natural gas, and LPG) in various subsectors (transport, industry, and power) and that limit energy consumption by shifting transport modes for passengers and freight transport sectors. By implementing various GHG emission mitigation measures in all sectors, GHG emissions in 2030 will decrease by 19% from 140.3 million tons of CO₂ to 114 million tons of CO₂. As shown in Fig. 4.9, all forms of mitigation result in 26 million tons of CO₂ emission reduction. These actions are discussed in greater detail in the following section.

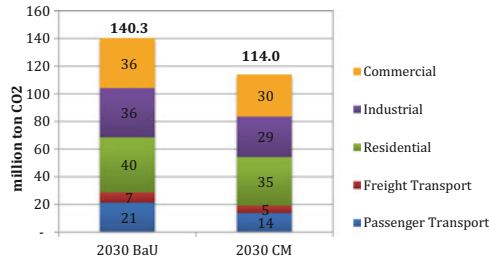


Fig. 4.9 Energy sector GHG emissions in DKI Jakarta in 2030

Transport mitigation results in the highest degree of emission reduction (i.e., 7 million tons of CO₂ from passenger transport and 2 million tons of CO₂ from freight transport), followed by the industrial (7 million tons of CO₂), commercial (6 million tons of CO₂), and residential sectors (5 million tons of CO₂). This mitigation involves improvements in transport infrastructure, transport management, regular emissions testing (enforcing more efficient vehicle use), energy-efficient vehicle deployment (best available technology (BAT)), the mode of transport shifting from individual vehicles to mass public transport (MRT, bus-way, bus-feeder, train, mono-rail), and eco-driving promotion. Changes in the transportation distribution of city and cross-border passenger and freight transport from 2005 to 2030 are presented in Figs. 4.10 and 4.11.

There is also a shift in energy use from oil fuel to zero- or low-GHG emitting fuels, such as biofuels and gas (natural gas and LPG). Figure 4.9 shows that the share of oil will decrease to 37%, and the share of electricity will increase to 27% (similar to that in the BaU scenario). This change results from replacing kerosene (beginning in 2007) with natural gas/LPG and electricity (lighting and rice cooking) in the residential sector, and oil fuel will be replaced by biofuels and natural energy sources (CNG/LPG) in the transportation sector.

In terms of energy efficiency measures, assumptions in efficiency improvements in each sector compared with current devices are presented in Table 4.3. Efficiency measures are expressed in terms of the penetration share of BAT within the technology (device) mix on the end-user side. These mitigation actions will lead to lower energy consumption levels in 2030 compared to those under the BaU scenario as the result of energy efficiency measures.

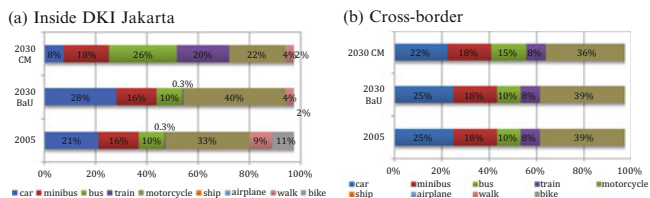


Fig. 4.10 Share of passenger transportation mode distribution (a) Inside DKI Jakarta, (b) Cross-border

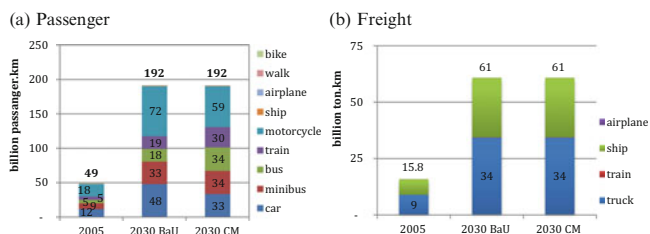


Fig. 4.11 Transportation mode distributions of passenger and freight transport (a) Passenger, (b) Freight

Table 4.3 End-user energy efficiency measures for DKI Jakarta

Sector	Penetration share of BAT	Efficiency improvements in BAT compared to the current device	Remarks
Industry	30 %	10–20 %	In the model, this efficiency improvement varies, depending on the type of device (not sectoral aggregate)
Commercial	30 %	15–20 %	
Residential	40 %	10–15 %	
Transport	10 %	10–15 %	

Note: An industry sector penetration share of 30% denotes that in 2030 technology (devices) used in the industry will account for 30% of BAT and 70% of current technologies (less efficient)

Mitigation in the industry sector mainly involves the deployment of energy-efficient devices (BAT), and of electric motors and direct heat devices in particular. Mitigation in the residential sector mainly involves the deployment of energy-efficient devices (BAT), and air conditioners, electric motors (water pumps), and lighting (LED). Mitigation in the

commercial sector mainly involves the deployment of energy-efficient devices (BAT) in government and non-government buildings, and of air conditioners, vertical lift/escalators, electric motors, and direct heat devices in particular. The deployment of BAT devices in non-government buildings is carried out through Green Building Codes (voluntary programme by association). BAT device deployment in government buildings is implemented through a mandatory programme (e.g., Energy-Efficient Building Codes).

CM scenarios for DKI Jakarta's energy development path have been explored using the Provincial RAD GRK of DKI Jakarta (2012) as reference material. This development is expected to afford DKI Jakarta low-carbon city status in the future. Details on GHG emissions reduction efforts for each mitigation measure are summarized in Fig. 4.12. As shown in the figure, the main GHG emission reductions result from the implementation of end-user energy efficiency measures in the industrial, non-governmental building, and residential sectors and by fuel switching in the transport sector.

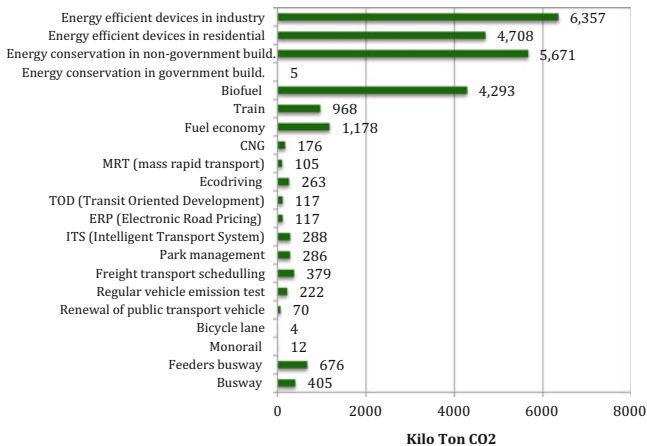


Fig. 4.12 Breakdown of GHG emissions reduction emission reductions to be achieved in 2030

4.4 CONCLUSION AND REMARKS

ExSS GAMS modelling was conducted to explore the development paths for DKI Jakarta that will lead to low-carbon emission development in the energy sector by 2030. These development paths are expected to earn low-carbon city status for DKI Jakarta in the future. No specific definition regarding the number of low-carbon cities currently exists.

GDP growth measures used in this modelling study will result in a five-fold increase in GDP in 2030 in comparison with 2005 levels. There will also be shift in sectoral GDP product levels, where the commercial (tertiary industry) share will increase from 66% to 71%, which is in line with the expectation that a capital city like DKI Jakarta will rely more heavily on its commercial sector than its manufacturing industry and other sectors. Notably, energy intensity levels found in the commercial sector are not as high as those found for the manufacturing sector. Thus, such a shift will decrease growth rates for energy demand. Electricity is the main energy type used in this sector. Mitigation actions in this sector and in other sectors that use electricity (industry and residential) can only be applied to the end-user side, as mitigation on the power generation side falls outside of DKI Jakarta's jurisdiction.

Mitigation actions for DKI Jakarta have been explored using the Provincial RAD GRK of DKI Jakarta (2012) as reference materials. The selected mitigation actions will result in emission reductions of 26 million tons of CO₂ in 2030 relative to BaU scenario emissions levels. This reduction is equivalent to 19% of the BaU level for 2030. For purposes of comparison, the RAD target is 30%. Although reduction percentages resulting from mitigation approaches used in the study are lower than the RAD levels, they are similar to the RAD targets in terms of the magnitude of GHG emission reductions. The percentage difference is likely attributable to higher BaU levels found in this study that resulted from higher economic growth assumptions compared with those used for the RAD. The high BaU GHG emission results are also attributable to additional parameters related to energy consumption (e.g., changes in economic growth will affect lifestyle habits that involve high levels of energy consumption, more electricity devices in households, moving from conventional cooking devices (gas-fuelled) to modern electric stoves).

The sector with the greater potential for emission reductions is the transport sector, followed by the industrial, commercial, and residential sectors. Regarding specific types of measures, the main contributor to emission reductions involves the implementation of end-use energy efficiency measures in the industrial, non-governmental building, and residential sectors and in implementing of fuel-switching mechanisms in the transport sector.

The ExSS model may be used to evaluate mitigation actions and to explore city-scale energy development paths in relation to low-carbon emission targets in other cities with sufficient socioeconomic data, IO table/SAM energy data, and other data that are of relevance to energy matters.

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Economic Impact Assessment on Low-Carbon Investment in Renewable Energy in Yokohama, Japan

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Abstract This chapter examines the economic impact of low-carbon investment on renewable energy sectors in Yokohama via an input–output analysis. The renewable energy sector is aggregated into five detailed categories: solar photovoltaics (PV) residence, solar PV non-residence, hydropower, wind, and other (biomass and others). Two main findings are presented. First, the electricity, wind, and solar PV sectors are backward-oriented sectors that generate indirect effects with other sectors along the supply chain. Second, the simulation scenarios on low-carbon investment in renewable energy sectors in Yokohama from 2006 to 2011 revealed positive economic impacts with regard to increasing economic outputs in Yokohama.

5.1 INTRODUCTION

In March 2011, the Fukushima Daiichi nuclear plant accident occurred after an earthquake and tsunami. The accident highlighted the vulnerability of current energy systems to natural disasters and the economic, social, and environmental risks associated with centralized energy generation facilities and with dependency on particular energy sources (Vivoda 2012; Moriarty and Honnery 2012). Since that time, public

awareness of sustainable energy supplies and energy security has increased in Japan. Through the development of sustainable and resilient energy sources, the role of renewable energy has been highlighted (Huenteler et al. 2012; JETRO 2013). In this regard, the Fukushima nuclear accident resulted in the following key lessons. First, renewable energy sources are not only low emission sources but also decentralized energy sources that allow for energy to be generated in various locations, that have fewer environmental impacts, and that improve energy security levels by increasing the share of domestic energy supplies (Panwar et al. 2011; IPCC 2012). Second, energy reduction schemes alone cannot reduce CO₂ emissions triggered by exogenous shocks (Wakiyama et al. 2014). One notable policy transition that occurred after the Fukushima accident involved the introduction of feed-in tariff (FIT) schemes. FIT schemes were introduced in July 2012, and the installed capacity of solar photovoltaics (PV) in particular increased to 11.9 GW from July 2012 to July 2014.¹

However, to further accelerate renewable energy use in Japan, it is important to identify the effects of increased renewable energy use. An assessment of the effects of investments in renewable energy will help policymakers and other stakeholders examine the potential of renewable energy expansion while identifying whether such expansion may have economic, social, and environmental benefits by enhancing economic activities, reducing CO₂ emissions, creating job opportunities, and supplying clean energy (Blasejczak et al. 2014; Caldes et al. 2009; Lambert and Silva 2012).

Renewable energy installations must be designed for local contexts because installed capacities in a given area can change depending on locations, land regulations, negotiations with landowners, and geographic conditions (Kanagawa 2012). In renewable energy development, decisions are made at the local or individual scale and thus differ from processes employed for large-scale power generation entities such as fossil power stations, which are owned by private electricity companies (Burtonb and Hubacek 2007; Swofford and Slattery 2010). Not only electricity companies but also individuals and municipal governments can serve as renewable energy suppliers. This chapter examines the economic impact of investments in renewable energy that may be expected to facilitate low-carbon transitioning and development at the city level based on a case study conducted in Yokohama. This chapter does not assess the environmental and social effects of renewable energy investments, but instead assesses the economic impacts of renewable

energy investment in Yokohama. To determine the impact of renewable energy expansion in Yokohama, economic transactions are assessed using a city input–output table.

This chapter is structured as follows. First, literature reviews of economic impacts related to domestic Japanese renewable energy sectors and corresponding sectors in Yokohama are presented in Sect. 5.2. Second, data and methodologies used in this study to assess the economic impact of low-carbon investments in the renewable energy sectors in Yokohama are presented in Sect. 5.3. Third, our results and a discussion based on input–output analyses on low-carbon investments in renewable energy sectors are presented in Sect. 5.4. Fourth, we present our study’s conclusions in Sect. 5.5.

5.2 LITERATURE REVIEWS

5.2.1 *Economic Effects of Renewable Energy Introduction*

A low-carbon scenario study was conducted in 2004 in Japan, and a report on Scenarios and Actions towards Low-Carbon Societies (LCS) was published in 2007 (NIES 2008). In the LCS study report, mitigation potentials for the country were assessed and identified, and the findings showed that to form a low-carbon society, energy conservation efforts on the demand side and the reallocation of conventional energy systems to low-carbon sources (e.g., renewable energy) on the energy supply side would play a key role (NIES 2008; Skea and Nishioka 2008). The report estimates that in reducing CO₂ emissions by 70% by 2050 from 1990 levels, wind and nuclear power generation could enhance 30% reductions in CO₂ emissions from the 70% reduction target (NIES 2008). However, in reality, although nuclear power generation has been questioned in terms of social security, safety, and cost considerations since the Fukushima nuclear accident, a substantial expansion of renewable energy supplies has not been realized, with a mere increase of 0.62 to 0.84 (10¹⁸J) occurring from 2005 to 2010 (METI 2014).

Numerous studies on the effects of renewable energy investments have been conducted. Such studies have employed input–output tables in examining job creation effects, economic benefits, CO₂ emission reduction outcomes, and energy security levels (IRENA 2013; STFC 2013). In Japan—and particularly following the Fukushima nuclear accident—numerous studies have estimated the effects of renewable energy investment

(Mizumoto et al. 2013; Ishikawa et al. 2012; NISTEP 2013). Such studies can help individuals realize the economic and environmental benefits of expanding renewable energy resources. To assess the effects of renewable energy investment, energy generation systems should be disaggregated into different renewable energy components, as a regular input–output table does not contain detailed information on renewable energy options in the electricity generation and electricity construction sectors. For instance, through an assessment of the effects of renewable energy investment on GDP and CO₂ emissions, Mizumoto et al. (2013) estimate production inducement in the solar cell sector to reach 87.6 billion JPY (2.09 production inducement coefficient) and production inducement amounts in balanced systems to increase to 45.5 billion JPY (2.02 production inducement coefficient) via investments in 10 MW-scale solar PV systems. This study also shows that if Japan were to import 30% of all solar cells within the PV system, the total social value-added amount would be negative (e.g., –0.8 JPY/kWh of net value added). Conversely, with regard to impacts on CO₂ emissions, the value-added cost of reducing CO₂ emissions amounts to approximately 20.5 thousand JPY per tCO₂ of 10 MW solar PV alongside of 139.1 g-CO₂/kWh emissions within the lifecycle of PV system production.

Some studies compare the economic impacts of renewable energy before and after the occurrence of exogenous shocks or policy interventions. Ishikawa et al. (2012) assessed the regional recovery and economic effects of reducing CO₂ emissions by introducing solar PV and wind power generation to the Tohoku area as a replacement for nuclear power generation after the Fukushima accident using various scenarios. Other studies have examined the effects of renewable energy investments in different countries (IEA 2014; Caldes et al. 2009).

However, these studies have largely been conducted at the national level rather than at the city level, which is attributable to the fact that city-level analyses are difficult to conduct because of insufficient data sources and a lack of input–output tables available for many cities. However, as noted in Sect. 5.1, renewable energy is expected to have local effects by generating energy and boosting local production.

5.2.2 *Renewable Energy Policies and Investment in Yokohama, Japan*

To increase installation rates and the dissemination of renewable energy, policies that promote renewable energy is an important instrument.

Depending on which policies are introduced or on how such policies can be designed to promote particular renewable sectors (whether the focus is on solar PV, wind, or biomass), the effects of policy implementation and enforcement on low-carbon development will vary. For the promotion of renewable energy in Japan, subsidy policies and policy interventions for technological diffusion have been implemented (Suwa and Jupesta 2012). As noted above, renewable energy sources can be expected to increase local revenues from the economic effects of investments and energy supplies. Several policies and instruments have been introduced to enhance the deployment of renewable energy at the city level in Japan. Under the Act on the Promotion of Global Warming Countermeasures, which was enacted in 1998, local governments are required to create action plans regarding global warming countermeasures (City of Yokohama 2014).

Yokohama is a government ordinance–designed city with 3.7 million inhabitants, which is the second largest population in Japan after Tokyo. CO₂ emissions in Yokohama increased by 5.197 million t-CO₂ in 2013 from 1990 levels due to an increase in population and per capita CO₂ (City of Yokohama 2015). The commercial and household sectors generate the largest share of CO₂ emissions in Yokohama (4.83 million t-CO₂ and 5.04 million t-CO₂, respectively).

Yokohama established the Regional Promotion Plans for Combating Global Warming in 2001. Simultaneously, to boost renewable energy investment, various funding mechanisms were created. An early initiative that was designed to increase renewable energy installation capacities in Yokohama was a locally sited fund for wind power generation. In 2007, a wind power plant called the “Hama Wind Power” plant was created through considerable investment efforts. The upfront costs for the construction of the wind power plant were financed with Ministry of Economy, Trade, and Industry (METI) subsidies (0.2 billion JPY) and through the issuance of municipal bonds (0.28 billion JPY).² Total construction costs reached approximately 0.5 billion yen, and operation costs reached approximately 50 million yen in 2009. After the design for the wind power plant was developed, Yokohama called for collaborative support from companies to finance and establish the wind power plant. In 2006, a community-based bond called the “Hama windmill bond” was created. Community organizations and local companies participate in publicly issued bond investments, which typically involves collaboration among citizens, businesses, and the government as a result.

In the case of solar PV, the installed capacities of public facilities in Yokohama have increased since 2009 with an increase in public finance.

Funds for solar PV at the city level in Japan are derived from the national government and from regional governments and are distributed to the commercial and household sectors as subsidies either directly or through city governments (City of Yokohama 2011a). The total fiscal budget for renewable energy promotion activities in Yokohama was increased to approximately 302 and 208 million JPY in 2010 and 2011, respectively³ (City of Yokohama 2011b, 2010).

5.3 DATA AND METHODOLOGY

5.3.1 *Data*

In this study, before assessing the economic effects of low-carbon investment on renewable energy generation in Yokohama, we disaggregate the renewable energy sectors (solar PV residential, solar PV non-residential, wind, hydro-power, biomass, and others) from the electricity and construction sectors using an input–output table with cost structure data drawn from Japan’s Ministry of the Environment (MOE) and METI. A detailed description of the sector classification after disaggregation is presented in the Appendix.

The following steps are employed to disaggregate the renewable energy sectors from the electricity and construction sectors presented in the input–output table. First, the percentage share of the installed capacity of each renewable energy technology source. Second, the share of domestic intermediate inputs and of value-added accounts for each renewable energy technology source is determined using the METI cost structure.⁴ Third, major input sectors for each renewable energy technology sources are identified using MOE data.⁵ Fourth, we adjust shares of each major input sector based on the MOE data. We then calculate renewable energy investments in Japan and Yokohama using data drawn from the Ministry of Internal Affairs and Communications, from the MOE, from the METI, and from the city of Yokohama. This analysis derives the Leontief invested matrix based on the 2005 Japan input–output table, and it bases the economic impact analysis of low-carbon emissions on renewable energy. After the extended version of Japan 2015 input–output table including renewable energy sectors is constructed, we apply the coefficients of renewable sectors to Yokohama 2005 input out tables, and the investment data of renewable energy in Yokohama city.

5.3.2 *Methodology*

To examine the economic impact of low-carbon investment on the renewable energy sectors in Yokohama from 2005 to 2011, this paper employs an accounting multiplier analysis using the following equation:

$$X = (I - A^{-1})y \quad (5.1)$$

where X =output; $(I - A^{-1})$ =the Leontief inverse matrix; y =final demand consumption.

Equation (5.1) allows us to determine the impact of low-carbon investment changes in renewable energy sectors from 2005 to 2011 (Δy) on the change in output (Δx) as presented in Eq. (5.2):

$$x = (I - A^{-1}) y \quad (5.2)$$

where Δx = change in output; Δy = change in final demand based on the implementation of low-carbon investments in renewable energy in Yokohama.

5.4 RESULTS

This section presents the results of the input–output analysis by examining the economic structure of investments on renewable energy sectors and the relationship between renewable energy investments and other sectors (as of 2005). National data for this analysis to overview the economic impact structure in Japan (Sect. 5.4.1, 5.4.2). We then present a simulation analysis is used of changes in the economic effects resulting from investments in renewable energy beginning in 2005 in Yokohama city (Sect. 5.4.3).

5.4.1 *Backward Linkages*

Backward linkage analyses show how strong growth in a sector results in the growth of sectors that supply it. In the backward linkage analysis, manufacturing sectors are ranked among the top ten. Growth in these ten sectors will have the greater impact on corresponding supply sectors.

Notably, the backward linkage results of the power dispersion index show that electricity (wind) and electricity (solar PV residence) rank among the top 20 sectors in which backward linkage values exceed the value of 1, which indicates that an increase of one unit in final electricity (wind) and electricity (solar PV residence) consumption will result in an above-average increase in economic activities due to one extra unit of final consumption in any electricity sector. The sectors with strong backward linkage values are regarded as secondary sectors that use inputs from other sectors in their production sectors (see Table 5.1). Other sectors with strong backward linkages include the following: car or vehicle, petrochemical, motor vehicle, and iron and steel, which is not surprising, as the Japanese economy relies heavily on these sectors. In addition, these more capital-intensive sectors require the use of advanced technologies.

However, interestingly, an examination of the backward linkage of electricity (solar PV residence) shows that the top three input sectors that increase demands by producing electricity (solar PV residence) include the following: construction repair, education and research, financial services, and non-ferrous metals (Table 5.2). These results imply that to increase electricity generation (solar PV residence), additional input supplies from sectors such as the construction repair, financial services, and non-ferrous metals industries are required. Surprisingly, this analysis finds that the financial services sector contributes approximately 11% of total major input sector value for solar PV residence electricity generation.

5.4.2 *Forward Linkages*

Forward linkage analyses show how strong growth in a sector leads to growth in sectors that use corresponding sector outputs. The forward linkage analysis shows that the iron and steel, transport, commerce, business services, financial services, and mining sectors represent the top six sectors with the strongest forward linkages (index of sensitivity of dispersion), which indicates that growth in these sectors will have the strongest impact on corresponding usage sectors in comparison with the effects on other sectors. In addition, electricity (thermal power) was found to present a forward linkage (index of sensitivity of dispersion) value that exceeds 1. When a sector generates a forward linkage value that exceeds 1, an increase of one unit of production in the sector will cause an above-average increase in economic activity due to one extra unit of production (see Table 5.3). For instance, the transport sector presents strong forward linkages, which indicates that it

Table 5.1 Top 20 strongest backward linkage sectors

<i>No.</i>	<i>Row/column sector name</i>	<i>Backward linkage</i>
1	Cars or vehicles	1.52
2	Basic petrochemical products and organic chemical products	1.47
3	Motor vehicle bodies and accessories	1.41
4	Iron and steel	1.37
5	Activities not classified elsewhere	1.32
6	Internal combustion engines for motor vehicles and parts	1.30
7	Non-ferrous metals	1.27
7	Machinery for the office and service industries, with the exception of other office machines	1.27
9	Other office machines	1.22
9	Engines	1.22
9	Electronic information and communication equipment, with the exception of radios and television sets	1.22
12	Transportation equipment	1.20
13	Final chemical products	1.19
14	Electronic components	1.17
15	Conveyors	1.16
16	Electricity (wind)	1.14
16	Electricity (solar PV – residence)	1.14
18	Pumps and compressors	1.13
19	Electrical machinery	1.12
19	Synthetic resins, fibres, and medicaments	1.12
20	Special industrial machinery, with the exception of chemical machinery	1.11

Source: Authors

Table 5.2 Major input sectors for electricity (solar PV – residence)

<i>No.</i>	<i>Input sectors</i>	<i>Share</i>
1	Construction repair	0.13
2	Education and research	0.12
3	Financial services	0.11
3	Non-ferrous metals	0.11

Source: Authors

distributes its outputs as inputs to other industries in the Japanese economy, which are used in various sectors as inputs. The strong forward linkage found for electricity (thermal power) indicates that Japanese electricity is heavily dependent on thermal energy. In fact, in Japan in 2005, 60% of the share of electricity supply was thermal, 30% was nuclear, and 0.9% was renewable. Therefore, many sectors use electricity (thermal) as industrial inputs.

Table 5.3 Top ten strongest forward linkage sectors

No.	Row/column sector name	Forward linkage
1	Iron and steel	4.27
2	Transport	4.09
3	Commerce	3.66
4	Business services	3.30
5	Financial services	3.02
6	Mining	2.89
7	Non-ferrous metals	2.49
8	Information and communications	2.43
9	Other business services	2.28
10	Miscellaneous manufacturing products, with the exception of reuse and recycling	2.19

Source: Authors

Furthermore, by measuring backward and forward linkages, sectors within the whole economic structure can be classified into four categories: (1) key sectors (sectors with backward and forward linkages that are larger than 1); (2) backward-oriented sectors (sectors with backward linkages that are larger than 1 but with forward linkages that are less than 1); (3) forward-oriented sectors (sectors with forward linkages larger than 1 but with backward linkages that are less than 1); and (4) non-key sectors (sectors with backward and forward linkages that are less than 1).

Our backward and forward linkage analyses show that within the Japanese economic structure, wind, solar PV residence, and solar PV non-residence electricity generation activities are categorized as backward-oriented sectors. In other words, an increase in renewable energy electricity generation investment can economically enhance the activities of input sectors in Japan. However, major manufacturing industries such as the petrochemical, motor vehicle, and accessory entities are categorized as key sectors. Transport, commerce, business services, financial services, and the mining sectors are categorized as forward-oriented sectors (see Table 5.4) that are used as inputs for other sectors.

5.4.3 *Economic Impact Assessment on Low-Carbon Investment in Renewable Energy in Yokohama*

The effects of investments in renewable energy on production levels serve as important indicators of the economic system, as additional outputs are

Table 5.4 Four sector categories based on backward and forward linkages

<i>No.</i>	<i>Key sectors</i>	<i>Backward-oriented sectors</i>	<i>Forward-oriented sectors</i>
1	Petrochemicals	Cars or vehicles	Transport
2	Motor vehicle bodies and accessories	Internal combustion engines for motor vehicles and parts	Commerce
3	Iron and steel	Electricity (wind)	Business services
4	Non-ferrous metals	Electricity (solar PV – residence)	Financial services
5	Metal products	Electricity (solar PV – non-residence)	Mining

Source: Authors

expected to be generated in Yokohama's economy through additional economic activities involving renewable energy. In this study, we employ simple accounting multiplier analyses using a simulation scenario that reflects changes in low-carbon investments in renewable energy in Yokohama from 2005 to 2011, which is referred to as the output multiplier.

The results reveal that 0.3 million JPY of the additional economic impacts in Yokohama in 2006 from the base year of 2005 is associated with investments in renewable energy (Table 5.5). There was an increase of 2.4 million and 3.4 million JPY in 2010 and 2011, respectively, in relation to 2005 levels. One of the reasons of economic impacts can be observed from transitions of city planning and strategies of Yokohama city since 2008. In 2008, Yokohama was selected as a model environmental city under the national environmental model city framework. That same year, the Act on the Promotion of Global Warming Countermeasures was revised, and under the Act, local authorities were obligated to create local government action plans for combating global warming. In 2009, Yokohama developed a mitigation target in line with the national targets. As part of a short-term goal to disseminate solar power generation and solar heating systems under the Yokohama global warming action plan by 2020, the city created a solar power generation installation target of 5% for single-family houses to generate 94,900 kW, which may also contribute to a reduction of 43,000 tCO₂ and of 8% for offices by installing 17,000 kW that may contribute to a reduction of 6700 tCO₂ (City of Yokohama 2014). From the analysis results, it can be inferred that the effects of actions taken in 2009 appear to have increased investment in renewable energy in 2010, resulting in an increase in outputs from 1.7 to 2.4 million JPY. We also assume that an increase in renewable energy investment economic impacts in 2011 (from 2.4 to 3.4 million JPY) also appeared as

Table 5.5 Economic effects (change in total output) of changes in renewable energy sector investment in Yokohama from 2006 to 2011 (Million JPY)

<i>Year</i>	<i>Change in total output (ΔX)</i>
2006	0.3
2007	0.5
2008	1.1
2009	1.7
2010	2.4
2011	3.4

Source: Authors

a result of emergency-response issues that emerged following the Fukushima nuclear accidents.

5.5 CONCLUSION

The findings discussed above show that electricity (wind, solar PV non-residential and residential) present the strongest backward linkage values, which indicates that an increase in production or investment in these sectors will have positive economic impacts, by increasing the demand for all input sectors (backward). The accounting multiplier analysis shows that low-carbon investment in renewable energy sectors in Yokohama from 2005 to 2011 had positive economic effects on the city. In 2005, the economic impact of low-carbon investment in renewable energy sectors in Yokohama amounted to 0.3 million JPY. This value increased to 3.4 million JPY in 2011.

In this study, we are aware that further improvement of the extended version of input–output model is required, as it cannot measure exports from outside of Japan. In our input–output table, this paper does not consider imported products, as it does not distinguish imported products from domestic products for Japan and Yokohama. For instance, because of the economic impact of investments in the Hama Wind Power Plant in Yokohama, significant economic effects were not anticipated at the manufacturing level in Yokohama, as the plant is a foreign-made wind power generation facility (made in Denmark). It is thus important to determine the domestic impact of renewable energy investment, particularly in the analyses of employment effects. A more detailed study on the effects of low-carbon investment in renewable energy sectors in Yokohama on employment and environmental aspects may be necessary as a complement to this study.

Appendix: Sector Classifications

<i>No.</i>	<i>Sector classifications</i>
1	Agriculture
2	Forestry
3	Fishing
4	Mining
5	Beverages, food, and tobacco
6	Textile products
7	Pulp, paper and wood products
8	Chemical fertilizers
9	Industrial soda chemicals
<hr/>	
10	Other inorganic industrial chemicals
11	Basic petrochemical products and organic chemical products
12	Synthetic resins, fibres and medicaments
13	Final chemical products
14	Petroleum and coal products
15	Miscellaneous manufacturing products, with the exception of reuse and recycling
16	Ceramic, stone, and clay products
17	Iron and steel
18	Non-ferrous metals
19	Metal products
20	Boilers
21	Turbines
22	Engines
23	Conveyors
24	Refrigerators and air conditioning apparatuses
25	Pumps and compressors
26	Other general industrial machinery and equipment
27	Special industrial machinery, with the exception of chemical machinery
28	Chemical machinery
29	Other special machinery for industrial use, n.e.c.
30	Metal moulds
31	Bearings
32	Other general machines and parts
33	Machinery for the office and service industries, with the exception of other office machines
34	Other office machines
35	Electrical machinery
36	Electronic information and communication equipment, with the exception of radios and television sets
37	Electronic components
38	Cars or vehicles
39	Motor vehicle bodies and accessories

(continued)

No. Sector classifications

40	Internal combustion engines for motor vehicles and parts
41	Transportation equipment
42	Precision instruments
43	Reuse and recycling
44	Building construction
45	Construction repair
46	Public construction of rivers, drainage systems, and other systems
47	Public constructions, with the exception of the public construction of rivers, drainage systems, and other systems
48	Railway construction
49	Electric power facility construction (thermal power)
50	Electric power facility construction (hydro power)
51	Electric power facility construction (solar PV – residence)
52	Electric power facility construction (solar PV – non-residence)
53	Electric power facility construction (wind power)
54	Electric power facility construction (biomass and others)
55	Telecommunication facility construction
56	Other forms of civil engineering and construction
57	Electricity (thermal power)
58	Electricity (hydro power)
59	Electricity (solar PV residence)
60	Electricity (solar PV non-residence)
61	Electricity (wind)
62	Electricity (biomass and others)
63	Gas and heat supply
64	Water supply
65	Waste disposal
66	Commerce
67	Financial services
68	Insurance
69	Real estate
70	Transport
71	Information and communications
72	Public administration
73	Education and research
74	Medical services, health, social security, and nursing care
75	Other public services
76	Business services
77	Other business services
78	Personal services and office supplies
79	Activities not classified elsewhere

Source: classified from Japanese 2005 input output table

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NOTES

1. METI FIT database (Japanese): http://www.fit.go.jp/statistics/public_sp.html
2. Yokohama wind power generation (Japanese). <http://www.city.yokohama.lg.jp/kankyo/ondan/furyoku/outline/pdf/leaflet.pdf>
3. Calculated from the Yokohama finance affairs bureau database.
4. Energy and Environment Conference cost committee under Cabinet Office (Japanese): <http://www.cas.go.jp/jp/seisaku/npu/policy09/archive02.html>
5. MOE Environment and Economic Information Portal (Japanese): http://www.env.go.jp/policy/keizai_portal/index.html

Smart Cities in Japan and Their Application in Developing Countries

Noriko Kono, Aki Suwa, and Sohail Ahmad

Abstract Smart city (hereinafter SC) development (i.e., smartization and improved efficiency in the management of utilities such as electricity, gas, water, waste, and transportation) presently represents one of the most prominent terms in city development. The concept is often understood to be a panacea for the pressing global issues and sources of inefficiency (e.g., growing energy consumption, scarce natural resources, waste management issues, rapid urbanization, industrial pollution, endangered biodiversity, and traffic problems). The concept has recently been discussed widely in developed countries within the context of green innovation, green economies, and the green new deal.

Rapidly industrializing cities in developing countries are also promoting the smart city (SC) concept. The Nikkei BP Smart Tech Institute (2012) estimates that the worldwide SC market potential will reach approximately four quadrillion Japanese yen by 2030, and the majority of this value will be derived from developing industrial countries. Although interest in SCs is quite high, few studies focusing on the topic have been published in the fields of urban planning and international development. This chapter treats SCs as one of the most important historical thresholds of urban planning,

along with the well-known streetcar, dispersed, linear, and smart-growth city frameworks (Muller 2004).

This chapter describes SC traits in four sectors: energy management, waste management, water management, and transportation. Energy management includes the electricity smart grid with distributed power sources, hydrogen energy, and renewable energy (including solar, wind, microhydro, geothermal, biomass). Waste management includes 3R and material cycle economies. Transportation includes Intelligent Transport Systems (ITSs), EVs, hybrid cars, non-motorized transport (NMT), and car sharing systems. Finally, water management accounts for renewable energy sources for water facilities and looping water uses. The authors compare these trends with Indian slum conditions and discuss potential applications to India. The chapter also examines such policies within these sectors in terms of regulations, standards, planning and administrative directions, economic measures, voluntary actions, and environmental ethics.

The analysis of SCs in Japan indicates that such cities have experienced steady urban development over recent decades. The study identifies the potential for application of the SC notion in developing country cities, including informal settlements. An emphasis on informal settlements may prove pivotal to leapfrogging processes towards SC development.

6.1 INTRODUCTION

SC development (i.e., the smartization of cities) is considered the most important keyword within the urban development field. The concept of SC is sometimes thought of as a panacea for pressing global issues and inefficiencies affecting cities (e.g., growing energy consumption, scarce natural resources, waste management issues, and rapid urbanization). Such concepts have been discussed in developed countries for several years within the context of the green economy. Rapidly industrializing cities in developing countries are also promoting the concept.

Japan, home to many related technology patents in existence, has promoted innovation in environmental technologies such as solar batteries, storage cells, LEDs, and electric/hybrid/hydrogen vehicles. Patents for solar batteries and EV-operated cars, both of which are key SC technologies, occupy the highest position (Patent Agency of Japan 2009, 2014).

In addition, electric devices and appliances in Japan are among the most energy-efficient devices in the world as a result of the Energy Efficiency Act enacted in 1947. Among these, appliances that are designated energy consumption efficiency standards (the Top Runner Standard) account for

approximately 70% of all energy consumption, and the designation is still increasing in size (as of 2015).

ZEBS, or zero emission buildings, are also being promoted by the Japanese government. As greenhouse gas (GHG) emissions from buildings account for more than 30% of total levels (IPCC 2007), ZEB/ZEH (zero emission buildings/houses) regulations developed in 2010 state that by 2030, all newly built buildings must be ZEBs. Currently, 85% of non-residential buildings and 49% of residential buildings meet the Japanese government's 2011 energy efficiency standards (MLIT 2014).

As Japan represents one of the most important centres for SC development, this chapter first examines a Japanese case (Yokohama) and describes typical features that are of relevance to four representative city sectors: energy, waste, transportation, and water. The chapter also examines policies in these sectors in terms of regulations, standards, planning and administrative directions, economic measures, voluntary actions, and environmental ethics. The chapter then discusses the possible application of SC concepts in developing countries and in Indian slums in particular. Then, it shows how the principal application of SC in slums may be feasible in the energy sector. Finally, this chapter presents ways of applying SC principles in developing countries based on the leapfrogging model.

6.2 DEFINITION OF SC AND THE JAPANESE CASE

6.2.1 *Definition of SC*

According to Fukuchi (2011), a firm definition of SC “has not been established necessarily.” Fukuchi defines a smart city as “a city of high efficiency with integrated infrastructure by leveraging IT to support urban life. It contributes to growth from sustainable cities while seeking to resolve the disadvantages of urbanization.” Fukuchi also states that SC concepts have not established where SCs should be developed or how much “smarter” a place should be.

According to Goda and Morozumi (2011), although a microgrid refers only to the supply side, a smart grid includes both supply- and demand-side networks. The authors also define an SC as a city with a smart grid and with other smart utility systems (Fig. 6.1).

European smart cities are conspicuously known for the EU project “European Smart Cities,” which identifies six elements of an SC: economy, people, governance, mobility, environment, and living (Giffinger et al. 2007;

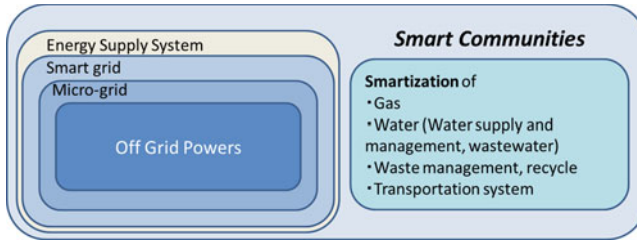


Fig. 6.1 Smart grids and smart communities.

Source: Goda and Morozumi (2011)

Hernández-Muñoz et al. 2011; Batty et al. 2012). These indicators, as in other streams of the literature, include infrastructure and physical environment components (smart mobility, public transport networks, ICT accessibility, etc.) and smart environments (green space, air pollution, energy/water efficiency, etc.).

Interestingly, European SCs emphasize non-physical factors such as smart people, smart governance, and smart living more than Japanese SCs do. Future Internet, an EU alliance that advances Europe’s competitiveness through future Internet technologies, divides Internet technologies into two distinct categories: IoT (Internet operated things) and IoS (Internet operated services). It is believed that through both technologies, new real-life applications and services can be created in SCs (Hernández-Muñoz et al. 2011).

For several years, SCs have expanded without standardization. In Japan, the Domestic Committee for International Standardization and the International Standard Innovation Technology Research Association (IS-INOTEK) created a target for ISO standardization in 2011. However, France and the World Bank agreed to use SC criteria for the selection of Global City Indicators as a standard of ISO (Mochizuki 2012).

In 2012, two ISO TCs (technical committees), ISO/TC268 and ISO/TC268/SC1, were established to discuss the details of ISO for SCs. In 2014, ISO/TC268 introduced ISO37120, proposing “operating standards” of the residents and administration in SCs. On the other hand, ISO/TC268/SC1 proposed ISO37150, focusing on a “measurement standard” for related products of SCs (Smart City Council 2015).

In short, there emerged two kinds of ISOs for SCs: physical and non-physical parts. Japan proposed ISO37150, which focuses on hard and technical factors, while France and WB proposed ISO37120, which focuses on soft factors, such as management and business modelling.

In light of these trends, we refer to SCs in this chapter in terms of technical factors, and we define an SC as “a city with electricity and other social infrastructures that have been improved in terms of efficiency levels via technological innovations and ICT technologies.”

6.2.2 *The Four SC Sectors*

This chapter examines several important SC infrastructure sectors. However, Aida and Morozumi (2010) identified five areas: electricity, gas, water, waste management, and transportation systems. Moreover, the four Japanese pilot studies focus on electricity, gas, transportation infrastructure smartization projects, and some cities have broadened these areas to the water and waste realms (MIAC 2015).

Some critics identify ICT and green infrastructure as separate sectors (Yamamura 2014). ICT, nonetheless, represents the first SC principle. Green infrastructure serves as one of the most important features. As ICT and green infrastructure are extremely relevant, the authors treat them as overarching concepts that are present in each sector.

In terms of green infrastructure, many scholars believe that SCs have not only technocratic but also ecological implications (e.g., material looping and cascading). For example, water use cascading approaches, whereby brown water is used for other purposes, should be employed in modern water use systems (Suzuki et al. 2010). Looping material via solid waste management can help reduce material resources (Suzuki et al. 2010). In addition, Chinese SCs always prioritize ecological factors. Thus, this chapter considers ecological concerns pertaining to SCs with reference to ecosystem efficiency levels and Mother Nature.

From the literature reviews, the authors summarize the typical traits of SCs in Table 6.1.

6.3 THE YOKOHAMA CASE STUDY

6.3.1 *Minato Mirai 21, Dawn of City Smartization*

Yokohama employed European and American state-of-the-art technologies at the end of the nineteenth century when Japan experienced a reopening of the country after its feudal era. Yokohama emerged as a leading industrial city following the creation of the Yokohama harbour port. Environmental improvements in the central business district (CBD) occurred as a result of industrial relocation to the suburbs. The Minato

Table 6.1 Smart city traits by sector

<i>Sector</i>	<i>Energy</i>	<i>Waste</i>	<i>Transportation</i>	<i>Water</i>
Traits	<ul style="list-style-type: none"> • Smart grid system with distributed power sources • Self-managed power plant that uses renewables • Hydrogen reuse systems • Cogeneration 	<ul style="list-style-type: none"> • Collection and management system based on IT • 3R (reuse, reduce, recycle) policies • Bio energy generated from solid waste 	<ul style="list-style-type: none"> • EVs used as batteries for building • ITS • Advanced public transit systems • Advanced NMT systems • Car sharing systems 	<ul style="list-style-type: none"> • Renewable energy sources for water facilities (micro hydro, solar power, wind power, etc.) • Water looping as another solution (the use of grey water)
<i>Overarching sectors</i>				
ICT:	Communication tools, security systems		Green Infrastructure: Open space, parks, wind paths, etc.	

Drawn from Yamamura (2014) and Goda and Morozumi (2011)

Mirai 21 enterprise was planned and built over a long period (roughly 50 years) as one of Yokohama's six major projects implemented in 1965.

Smart city.

The establishment of "utility tunnels" in the district represented the beginning of city smartization processes. Electric wires, telephone wires (optical fibres), and pipes for water, electricity, gas, cable TV, district heating/cooling, and garbage collection were placed in the underground utility tunnel, and the central heating and air conditioning system is also managed by the utility tunnel.

The electric power cable in the utility tunnels is transformed by substation facilities. Electricity of varying voltage levels corresponding to each scale is sent to consumers (Kishida and Uduki 2009). Substation spaces were created and so-called "smart power transmission" systems were initiated in the 1990s. Given these innovations, Yokohama could be identified as a forerunner of SC principles at a time before the term "SC" existed.

6.3.2 SC Policies Implemented in Yokohama

From "green innovations" identified by the Cabinet in 2009 through the "New growth industry strategy towards a bright Japan," the Ministry of Economy, Trade and Industry (METI) selected four "next-generation

energy systems and a social system demonstration area” in 2010 and began promoting SC systems throughout Japan.

Yokohama was chosen as one of the four domestic pilot study areas along with Kitakyushu City, Kansai Science City, and Toyota City, and private sectors in each city took part in the initiative. Compared to the other cities selected, Yokohama boasts high urbanization, various forms of industrial accumulation, efficient traffic infrastructure, and smartized buildings at both respective and comprehensive scales (Sasaki 2012).

Developed country infrastructure maintenance processes with respect to global warming countermeasures employed in Yokohama were examined in the context of the SC notion. For a more detailed examination, we considered four sectors (energy, waste, traffic, and water) with respect to three policy fields: (1) regulations, standards, and planning and administrative regulations, (2) economic means, and (3) voluntary actions and environmental ethics in reference to Imura (2004).

(1) Energy

The energy sector is examined using the smart grid measure, and the Yokohama Smart City Project (YSCP) Plan developed in 2009 is examined in response to next-generation energy specifications and social system demonstration enterprises of METI, focusing on three areas (the Minato Mirai21 area, the Kohoku new town area, and the Kanazawa area) of the city.

The Great East Japan Earthquake of 2011 has raised concerns regarding stable energy supplies in and around Japan, and the measure has attracted international attention. Cities, according to the YSCP, must specifically distribute 6 billion yen from “the next-generation energy fund” from the Ministry of Economy, Trade, and Industry to participating companies (Toshiba, Meiden-sha, Nissan, etc.). The City of Yokohama manages a board of governors and joint sessions at the YSCP promotion conference. The city plays a facilitating role in this plan.

Addressing electric power surpluses has proven challenging. Due to modest rates of photovoltaic (PV) cell coverage, the system extensively uses storage batteries/EVs of the demand side and involves solar cell power generation control via Advanced Metering Infrastructures (AMIs), demand regulation capabilities based on a demand response, and microgrid construction. Difficulties have also been associated with electric power supply cost reductions derived from a single power supplier (Sasaki 2011).

With regard to economic measures, the energy sector includes the Yokohama Green Power (YGP) Model Project supported through the

city's own funding. The YGP model project involves monitoring households from the YSCP pilot study area, and companies have introduced home energy management systems (HEMS) and PV systems to these households.

Regarding voluntary actions and environmental ethics, the energy sector elaborates on lectures on HEMS introduction. Citizen education programmes focused on energy saving and nature conservation are also promoted.

(2) Waste

The waste sector is characterized by the G30 plan, a general waste disposal master plan for 2003–2010. This plan is designed to reduce waste to be incinerated by up to 30%. In 2006, the G30 succeeded in reducing 36% of waste levels compared to 2001 levels. The 2011 “Yokohama 3RMu (dream) plan” focuses on reducing total waste quantities by recycling materials.

The direct charge system for household waste has not been introduced in Yokohama (embedded in a municipal tax), but bulky waste charging systems are in place.

As for voluntary actions, the G30 action plan emphasizes citizen partnerships for recycling and separating, and city officials are largely satisfied with the results.

(3) Transportation

The transport sector emphasizes the development of environmentally friendly modes of transport, for example, public transit and NMT. Regarding public transit usage, the “15-minute walk from anywhere in the city to a transit station” plan, or the “station power promotion” plan, created in 1997 focuses on the development of amenities in the vicinity of every transit station. In 2006, 88.4% of this goal was achieved (City of Yokohama 2006).

In Yokohama, the use of NMTs, transportation that does not involve motor power, is encouraged. The Yokohama government developed the “Yokohama Bicycle Path Creation Policy” in 2007, which aims to develop a new transport option and to ensure safe NMTs. NMT promotion effects have also been conducted as social experiments on community cycling. The Yokohama Bay Bike system conducted experiments from 2011 to 2014. As of 2015, the system is now widely used among citizens and tourists at affordable prices.

Plans for the economic transportation sector have introduced 100-yen buses for weekend and holiday operation. The buses run alongside tourist

destinations and serve as municipal buses. Although the discount system cannot be realized across all seven private companies in the city, statistics suggest that 100-yen buses promote transit usage. Since a pilot study was conducted in 2012, the system has been used heavily in tourist areas by both citizens and visitors (as of May 2015). However, this system relies heavily on well-structured fixed rail transit systems that have existed for decades, and it thus functions as a feeder system.

Regarding the transportation sector, a voluntary community cycle project called the Hama-chari project was run by the NPO from 2003 to 2012. One Non Profit Organisation (NPO) is designed to promote transit system development over the central region. These voluntary and environmentally friendly transport modes support the city's policies.

(4) Water

The water sector has used an excellent system for preserving remote reservoirs for years. The Waterworks Bureau submits an environmental accounting report every year. Environmental accounting guidelines are followed based on the Ministry of Environment Plan, which focuses on environmental preservation costs, environmental preservation effects, and economic effects. Trial calculations are generated in yen and in t-CO₂.

Water systems follow the step-up charge system based on the principle that daily water usage levels should be low. As the system charges those who use more water with higher fees, the demand management system is functional.

Water treatment plants employ several innovative technologies to prevent the development of heat island effects in cities. Wastepipes use microhydraulic power for facility operations, and they are sold to electricity companies.

The water sector manages various citizen-focused events that highlight the importance of water saving, which are frequented by many interested citizens.

6.4 THE YOKOHAMA SC ACROSS FOUR SECTORS AND THREE FIELDS

Table 6.2 describes the Yokohama SC in reference to the four sectors and three fields. Some of the same traits can be found in Table 6.1, and Table 6.2 shows that Yokohama represents one of the most advanced SCs in the world.

Table 6.2 Yokohama SCs in four sectors and three fields

	<i>Energy</i>	<i>Waste</i>	<i>Transportation</i>	<i>Water</i>
Regulations, Standards, and Planning and Administrative Directions	– Smart grid— YSCP plan	– Yokohama— G30 plan 2003–2010 – 3RMu plan 2011	– 100-yen bus in the downtown area – Promotion of non-motorized transport – Smart mobility plan, 15-minute walk from anywhere plan	– Remote reservoir reserves – Cost benefit environmental accounting calculations
Economic Measures	– Yokohama Green Power Model – YPORT support for local industries	– Industrial/ commercial/ office waste and bulky household waste charges	– 100-yen bus – Community cycle project support	– Charge system – Yokohama Water Company
Voluntary Actions and Environmental Ethics	– Energy saving enlightenment – HEMS introductory lecture	– Action Plan for the G30	– Bay-bike	– Micro hydraulic power stations – Treatment facilities with devices that eliminate heat island effects

Source: Created by the authors

6.4.1 The Application of Yokohama's Experiences to the Developing World

The previous sections have shown why Yokohama has emerged as one of the most developed SCs over several decades. It was also shown that the city's remarkable progress has been made possible through robust basic infrastructure development projects implemented over the last 50 years. The previous sections also describe the city's efforts across four sectors and three fields.

Yokohama has successfully contributed to processes of technology transfer to developing countries (particularly with respect to Asia) in collaboration with the Japan International Cooperation Agency (JICA), the World Bank, the ADB, and the UN. The city has also developed the Y Port project, which is designed to transfer accumulated technologies, which are

both private and public, to developing countries. The City of Yokohama has previously worked with the City of Cebu in the Philippines, with the City of Danang in Vietnam, and with the City of Bangkok in Thailand through this scheme, and the city seeks additional international collaborations supported by accumulated knowledge on SCs.

SC concepts, although generally used to refer to technological supply-demand ancillary control, have broader attributes that involve promoting the efficient allocation of energy and environmental resources. Based on this broader understanding, this chapter explores a bold comparison between Yokohama (as an example of a developed city) and cities in India with a focus on how new technologies can contribute to the effective distribution of electricity to the poorest residents.

6.5 PRESENT INFRASTRUCTURAL CONDITIONS IN THE POOREST REGIONS OF INDIA

This section discusses developing world conditions and considers SC application opportunities and bottlenecks with a focus on India. It describes features in four sectors and three fields that can be compared easily with those of the Yokohama case study.

6.5.1 *Slums in India*

According to the 2011 census, India's urban population reached 377 million (roughly 32 % of the total population of India) (Census-of-India 2011). About one-fourth of the urban population (\approx 93 million) lives in 49,000 slums across the country (NBO 2010). Slums are a manifestation of housing poverty. The proliferation of slums and severe housing shortages (over 24 million) offer a panoramic view of housing poverty conditions (NBO 2007). Various government reports describe slum population growth, housing shortages, and severe urban poverty (head count) trends throughout the country.

Table 6.3 describes three types of slums: slums, unidentified slums, and squatter settlements. A slum is a compact settlement with a collection of poorly built tenements that are typically temporary in nature and that are crowded closely together. Slums are characterized by inadequate sanitary and drinking water facilities found in unhygienic conditions within a compact area. Such areas, for the purposes of this survey, were considered "slums" if at least 20 households were found in a given area.

Table 6.3 Slums in India (%)

	<i>Identified slum (1)</i>	<i>Unidentified slum (2)</i>	<i>Squatter (3)</i>	<i>All-slum (4=1+2+3)</i>	<i>Non-slum (5)</i>
Household (%)	7.02	6.30	1.35	14.68	85.32

Source: NSSO (2010a, b)

Areas referred to as slums by respective municipalities, corporations, local bodies, or development authorities were treated as “identified slums.” Only slums in urban areas were examined in this study. If a slum partly covered a sampled urban block, the portion found within the sampled block was considered a slum for the purposes of this survey, provided it contained at least 20 households, which applied to both identified and unidentified slums (NSSO 2010a, b). In addition, households without secure tenure were defined as squatters (whether or not they pay rent), as homeless cases, and as households with no formal agreements adapted to Millennium Development Goal (MDG) monitoring (NSSO 2010a, b).

Using this categorization system, the following section describes Indian slums with regard to the four sectors and three fields of SCs.

6.5.2 *The Four Sectors and Three Fields with Regard to Indian Slum Conditions*

To understand slum household characteristics, following the Yokohama case study approach, the authors examined the energy, water, waste and transport sectors, which formed a comprehensive account of slum household conditions in India. Major utility services used in urban Indian households were identified.

(1) Energy

From the results of the “Indian Human Development Survey,” a multipurpose household survey conducted in 2009, Table 6.4 shows that firewood is used for cooking fuel and that kerosene is used for lighting in slum households (Desai and Vanneman 2009). This survey is also based on a nationally representative survey. In non-slum areas, LPG was found to serve as the main source of cooking fuel and kerosene was used for lighting. According to the survey, 6.9% of slum households and 8% of non-slum households use dwellings for residential commercial activities. It should also be noted that 37.2% of slum dwellings are characterized by

Table 6.4 Fuel and energy use in slums and non-slums of India, 2005 (multiple answers)

<i>Variables</i>	<i>Slum</i>		<i>Non-slum</i>	
	<i>Mainly cooking</i>	<i>Mainly lighting</i>	<i>Mainly cooking</i>	<i>Mainly lighting</i>
Firewood (%)	45.69	0.41	21.38	0.14
Dung (%)	24.68	0	9.56	0.09
Crop residue (%)	0.55	0	1.30	0.04
Coal/charcoal (%)	4.83	0	5.66	0
Kerosene (%)	22.07	27.03	15.25	23.03
LPG (%)	33.38	0	54.11	0.53

Source: Desai and Vanneman (2009)

poor ventilation, whereas only 14.6% of non-slum households are poorly ventilated.

Electricity use levels in slums and non-slums are shown in Table 6.5. The table reveals 95.5% electricity provisions in non-slum households. However, 91.5% of slum households have access to electricity. Although this discrepancy may be considered insignificant, over 31% of slum households surprisingly have only temporary wiring compared to 12% of non-slum households.

(2) *Waste*

Waste management patterns in Indian slums are shown in Table 6.6. One-third of slum households and one-fourth of non-slum household have no access to any garbage collection arrangements. However, in the informal sectors, poor working conditions for garbage pickers, scavengers, and recycling workers are common.

(3) *Transportation*

Figure 6.2 shows the maximum distance to a place of work normally travelled by a resident. The figure shows that despite poor living conditions and low incomes that characterize slum households, slum residents travel more on average than non-slum residents.

Figure 6.2 shows that a high proportion of non-slum households engage in less than one kilometre of travel, and in all but this figure, slum households outnumber non-slum households. This finding challenges traditional views that slum households are located close to workplaces. It also reveals substantial burdens on slum households given the low income and job accessibility levels that characterize them.

Table 6.5 Electricity use in slums and non-slums

	<i>Identified slum (1)</i>	<i>Non-identified slum (2)</i>	<i>Squatter (3)</i>	<i>All-slum (4 = 1 + 2 + 3)</i>	<i>Non- slum (5)</i>
Households with electricity (%)	94.19	89.36	87.42	91.49	95.51
If yes, dwelling with conduit wiring (%)	33.30	22.17	16.94	27.19	42.41
If yes, dwelling with wiring fixed to the wall (%)	41.75	38.46	57.87	41.79	44.87
If yes, dwelling with temporary wiring (%)	24.95	39.37	25.19	31.07	12.77
Electricity hours (median) ^a				18.00	21.00
Electricity payment (median) (INR/month) ^a				150	200
SEB payment (%) ^a				84.6	75.84

Sources: NSSO (2010a, b)

SEB State Electricity Boards

Note: These figures were calculated from Desai and Vanneman (2009)

Table 6.6 Garbage collection in slums and non-slums of India

	<i>Identified slum (1)</i>	<i>Non-identified slum (2)</i>	<i>Squatter (3)</i>	<i>All-slum (4 = 1 + 2 + 3)</i>	<i>Non-slum (5)</i>
Garbage collected by:					
Local governments (%)	62.84	47.26	42.6	54.28	56.92
Residents or others (%)	15.67	17.62	20.45	16.95	18.70
No arrangement (%)	21.49	35.13	36.96	28.77	24.37

Sources: NSSO (2010a, b)

SEB State Electricity Boards

Note: These figures were calculated from Desai and Vanneman (2009)

It can be concluded that slum residents must travel further than non-slum residents. In short, slum residents lack mobility and are forced to travel more.

(4) Water

Table 6.7 identifies water service conditions; 74% of non-slum households and 77.3% of slum households use tap/bottled water as a major source of drinking water. Notably, 54% of slum households do not have access of drinking water within dwelling units or premises.

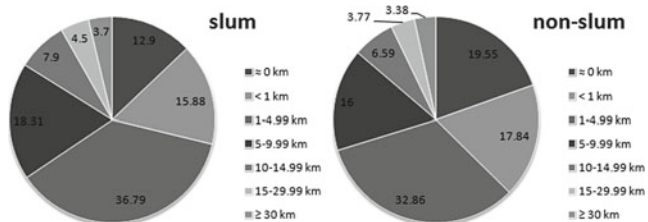


Fig. 6.2 Distances normally travelled to workplaces by any household earner NSSO (2010a, b). Housing Conditions and Amenities in India, Ministry of Statistics and Programme Implementation, Government of India

Table 6.7 Typologies of slums with characteristics, 2009

	Identified slum (1)	Non-identified slum (2)	Squatter (3)	All-slum (4 = 1 + 2 + 3)	Non-slum (5)
Tap/bottled water as a major source of drinking water (dw)	83.04	74.19		77.27	73.93
Distance to the water source (within dwelling units or premises) (%)	49.47	34.64	54.07	43.52	74.74

Sources: NSSO (2010a, b)

SEB State Electricity Boards

Note: These figures were calculated from Desai and Vanneman (2009)

6.5.3 Slum Conditions in Four Sectors and Three Fields

Table 6.8 describes slum conditions in India and the four sectors and three fields of SC, as previously described for the Yokohama case. Slums present potential for improvement, as they do not impose formal systems. In other words, they may employ SC principles if properly guided.

6.6 APPLICATION TO INDIA

This section focuses on ways of applying SC technology principles in poor Indian neighbourhoods based on energy sector policy measures. Economic measures for realizing SC principles in the Indian context are presented.

Table 6.8 Slum conditions in four sectors and three fields

	<i>Energy</i>	<i>Waste</i>	<i>Transportation</i>	<i>Water</i>
Regulation standards	<ul style="list-style-type: none"> – There are serious energy security issues and limited electricity supply hours. – Households are connected to a centralized grid system. 	<ul style="list-style-type: none"> – Common waste collection by the informal sector. – A degree of local government waste management exists. 	<ul style="list-style-type: none"> – Most slum dwellers are pedestrians. 	<ul style="list-style-type: none"> – No regular water supply (w/s). – Community-based w/s system available only for few hours a day (e.g., two to three hours daily).
Economic measures	<ul style="list-style-type: none"> – Stealing is rampant. – Charge systems are not fixed. 	<ul style="list-style-type: none"> – Most slum household livelihoods depend on waste recycling (informal). – Charges cannot be embedded in property taxes 	<ul style="list-style-type: none"> – Few individuals can afford bicycle and public transportation for mobility purposes. 	<ul style="list-style-type: none"> – Affordability is important. – Charge systems are not fixed.
Voluntary actions	<ul style="list-style-type: none"> – Although LPGs are used for cooking energy, numerous households also use biomass and kerosene for cooking energy. 	<ul style="list-style-type: none"> – Poor liquid waste (storm, drain and sewerage) management systems require urgent attention. 	<ul style="list-style-type: none"> – Hawker carts are used in the informal sector 	<ul style="list-style-type: none"> – Although hand pumps are used for water extraction, water quality levels are unsatisfactory.

Source: Create by the authors

6.6.1 *Energy Uses in the Poorest Settings*

As shown in the previous section, kerosene and biomass serve as the main sources of cooking fuel in most households in Indian slums; although kerosene is a standard cooking fuel, biomass serves as another source, particularly when poor households do not have access to kerosene. Kerosene is supplied at subsidized prices to ration card holders; however, it is often difficult to obtain a ration card, particularly for new migrants. Biomass access, however, does not require such documentation. However, biomass burning frequently results in severe outdoor and indoor air quality problems when smoke is generated during cooking.

A closer examination reveals more household fuel composition features. Table 6.9 shows that income levels appear to influence energy carrier choices, with biofuels more commonly used as cooking fuels in low-income households than in higher-income households. Electricity usage for cooking is highly limited among both low- and high-income groups.

Electricity is often used among high-income groups for lighting purposes and is less often used by lower-income households (Reddy and Srinivas 2009). Table 6.4 presents fuel composition comparisons between slum and non-slum households for cooking purposes primarily. Firewood and biomass (e.g., dung) are more commonly used in slum areas than in non-slum areas. LPG, however, is more often used in non-slum areas than in slum areas.

Table 6.5 shows that slum households enjoy relatively high levels of electricity accessibility, although most slums in Delhi do not have electricity on an official basis. Even when a certain level of accessibility to electricity exists, transmission and distribution (T&D) losses are generally significant. For the OECD (Organization for Economic Cooperation and Development) countries, T&D losses are normally less than 10%, whereas rates exceed 30% on average in India (Joseph 2010). In India, this loss is mainly attributed to power theft (Dhingra et al. 2008). However, some slum residents acquire electricity access by hooking in or by paying contractors, and high electricity access rates are thus occasionally related to illegal wiring (Fig. 6.3).

Table 6.9 Energy carrier mix levels for various end users (2004–2005)

<i>End use</i>	<i>Energy carrier</i>	<i>% of households using various energy carriers</i>		
		<i>Low income</i>	<i>Mid income</i>	<i>High income</i>
Cooking	Biofuels	81.3	61.8	31.8
	Kerosene	8.0	5.2	4.5
	LPG	8.5	31.3	61.2
	Electricity/Other	2.2	1.7	2.6
Lighting	Kerosene	29.1	15.2	6.1
	Electricity	69.5	83.1	93.6
	Other (or no lighting)	1.4	1.7	0.3
Total households (million)		68.3	107.6	29.5

Source: International Institute of Population Studies (2003), adopted from Reddy and Srinivas (2009)

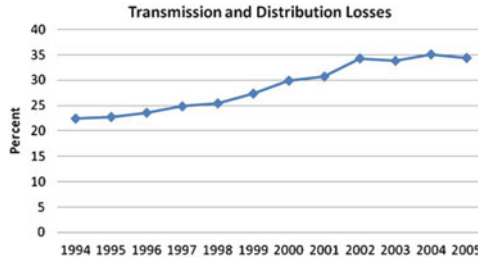


Fig. 6.3 Average transmission and distribution losses. Source: All India Electricity Statistics, General Review. Central Electricity Authority: Delhi, 1994–2006, adopted from Joseph (2010)

6.6.2 *Providing Electricity Through Microgrids in the Poorest Areas*

Since electricity does not emit harmful substances at the point of its use, it can offer urban residents environmental and health benefits. Electricity, however, is not officially available in most Indian slums. When available, whether legally or illegally, electricity is generally used for lighting (Reddy and Srinivas 2009). Using electricity for purposes other than lighting may prove too expensive, as cooking and heating normally require higher levels of caloric consumption, potentially leading to higher prices if electricity were used for such purposes. However, if electricity tariffs are set at low prices that slum dwellers may be able to pay, they may be encouraged to use electricity for multiple purposes.

Currently, the necessary political commitments, business interests, and technological infrastructure are missing with respect to shifting to legal provision of electricity services in slums. Thus, there is a need to formulate strategies to develop utilities and to encourage others to invest in areas that are not normally serviced by commercial operations. A framework must also be developed whereby such investments may be recouped within a sufficiently short period.

Microgrids represent one of the most relevant systems of electricity generation in poor areas. Microgrids are generally referred to as aggregations of electrical generation, storage, and loads. Generators in a microgrid may include microturbines, fuel cells, reciprocating engines, or any of a number of alternate power sources. A microgrid can be a completely self-sufficient network. A device such as a static switch can disconnect the grid from the main

grid, enabling it to operate in isolation. Microgrids boast resilient features that enable stable operations in the presence of faults and other network disturbances. When a microgrid is separated from the main grid, microgenerators are supposed to sustain sufficient levels of power quality within the grid. Microgrids can be low-voltage distribution systems with integration from diverse energy sources (e.g., PV, wind, biomass, biofuel, and fuel cell sources combined with distributed storage features, such as flywheels and advanced power electronic conversion and control capabilities) (Agrawal and Mittal 2011). Thus, renewables, such as solar and biomass sources, can serve as energy sources for microgrid electricity, and environmental benefits are more significant when microgrid electricity is sourced from renewables.

Microgrids can be operated within smart grid contexts. Once smart metres are connected to a central control system, households can be provided a real-time account of energy consumption levels. More importantly, grid owners benefit from improved energy management and control over energy production/consumption levels. Smart metres are associated with better charging mechanisms, in particular, as they are designed to identify non-technical T&D losses in the grids and may thus work against power theft (Depuru et al. 2011).

Although microgrids have been developed for emergency purposes and in case of power interruptions in the main grid, there is a growing interest in using the system as an effective means of providing electricity to areas that have long been unelectrified. Currently, much focus has been placed on its application in rural areas in which long distances to urban areas prohibit connection to main electrical grids. One social entrepreneur, Mera Gao Power (MGP), for example, plans to provide extremely low-cost lighting and mobile phone charging services to households in Uttar Pradesh by building and operating village-wide PV microgrids. Households will be given two LED lights and a mobile-charging point for a cost of 25 rupees (US \$0.46) per week, and MGP is expecting to recoup its investments in each microgrid within roughly 18 months (da Costa 2012).

Funding agencies such as the United States Agency for International Development (US AID) also focus heavily on microgrid provisions in the rural areas of developing countries (US AID and microgrids in India).

6.6.3 *Economic Measures for Microgrid Finance*

Microgrids can also provide slum residents with electricity. As discussed above, microgrids are islanding electric infrastructures that require relatively

inexpensive investments relative to those required for the main grid. In conjunction with smart grid devices, microgrids may be better able to deliver electricity to specific urban areas of developing countries while providing utility companies and investors with opportunities to control technical and non-technical losses in T&D.

There are certainly barriers to financing microgrids in slum areas. Investments in such challenging areas may require not only high social motivation but also skilful strategies for ensuring returns on investments. The collection of funds from slum dwellers can prove to be a particularly difficult task for microgrid investors, as slum dwellers' willingness to pay may constitute a critical barrier. In rural areas, residents typically exhibit a strong sense of residential solidarity, regardless of their income status. In slums, however, residents view their dwellings as temporary, particularly with respect to unidentified slums and squatter settlements. Thus, it is very difficult to expect such individuals to invest in upfront costs for long-term facilities. The legal status of slum dwellers has been recognized as a major issue, and allowing such individuals to secure tenure status (whether permanent or temporary) is recommended to secure their access to cleaner energy sources. In addition to offering them tenure status, it may be possible to reduce initial cost burdens through instalment payments. Suppliers must reach out to poor customers, thereby breeding trust, including them as part of a business portfolio, and encouraging them to make legal connections (Dhingra et al. 2008).

It is difficult to expect existing utilities to overtake the microgrid business. It has been well documented that the Indian government adopted the Electricity Act in 2003, which introduced significant changes to the country's industrial electricity structure. The act was developed in response to a number of challenges facing the Indian electricity industry. In India, the electricity industry had been dominated for decades by State Electricity Boards (SEBs), which are vertically integrated monopolies. The SEBs are experiencing severe financial difficulties and even lack the funds required to invest in the maintenance of existing infrastructure (Bhattacharyya 2005; Dubash and Rao 2008; Joseph, 2010). Investments in new microgrids installed in high-risk areas would extend beyond their financial capabilities. New energy and electricity entities with viable financial capacities are required for investments in microgrids for the poor.

Microgrids may find a better partner through social entrepreneurship. Social entrepreneurship is a process whereby the creation of new business

enterprises results in social wealth enhancement so that both society and the entrepreneur benefit (NYU Stern 2005). Social entrepreneurs typically employ practical, innovative, and sustainable approaches to benefit society overall with an emphasis on those who are marginalized and poor (Schwab Foundation 2005). Generally speaking, most current definitions suggest that opportunities for social change and benefits are explored through social entrepreneurship (Zahra et al. 2009).

Social entrepreneurs are in a good position to provide social benefits by creating business models for microgrids in slums. One successful social entrepreneurial project is the Grameen Shakti project, which created solar-powered facilities in Bangladesh with soft loans through instalment. With affordable prices set, the number of installed Grameen Shakti's Solar Home Systems has risen from roughly 230 in 1997 to more than 520,000 in 2010 (Asif and Barua 2011). Its innovative business model and operational framework can be viewed as a benchmark to be applied in other countries.

Whereas foreign aid largely focuses on rural electrification, greater emphasis should be placed on slum electrification. Urban air quality levels can be improved significantly once microgrids are made available in slums. There is growing recognition of a strong linkage between global climate change (GCC) and local air pollution (LAP) levels. GCC mitigation efforts may have strong co-benefits in terms of lower LAP values and vice versa. Policies that neglect these co-benefits may prove suboptimal, as the co-benefit approach involves coping with global and local emissions control factors in which the strategic design of policies is indispensable. In addition, more international focus is being placed on integrating measures to optimize policy effects. Thus, slum air quality mitigation efforts must also be placed within the context of urban co-benefit policy formulation (Suwa et al. 2012). In addition, microgrids will enhance electricity accessibility and availability, which would ultimately help meet the MDG to ensure environmental sustainability in slums.

Our analysis has demonstrated that mere top-down and technologically focused approaches are limited in terms of making individuals willing to pay (WTP) for electricity. Social factors, such as local norms, trust levels, and occasionally sanctions, seem to work better for ensuring compliance (Winther 2012). Nevertheless, technological solutions informed by social contexts might create environments in which cleaner energy sources may be accessed by slum dwellers. Microgrids funded by social investors present numerous slum/urban environmental benefits (e.g., air quality

improvements) and social benefits via the development of energy and electricity provisions for the poor. National governments play a critical role in the development of policies on slum dweller accessibility to cleaner energy sources. Local governments are equally responsible for encouraging and cooperating with social groups and entrepreneurs in establishing new business models for providing clean electricity, which is shown in the case of the Yokohama government's smart community initiative, through which the government liaises with new business enterprises.

6.7 CONCLUSIONS

In the sections presented above, global warming mitigation policies implemented in Yokohama were examined from an SC perspective, and each measure was analysed across four sectors and three fields. The second section discussed the Indian case and opportunities and barriers to the realization of SC ideals. This section also analysed the Indian situation across the same four sectors and three fields. The third section discussed ways of employing new technologies in the country, with a specific focus on energy factors. The results show that even the poorest areas, such as Indian slums, have the capacity to adopt SC principles.

6.7.1 *EKC and SC Development*

In conclusion, we considered ways of adopting SC principles in developing country cities. Table 6.10 visualizes the literature and interviews on each country-level situation: cities in the poorest countries, in moderately developed countries, and in developed countries. This table reveals a tendency for cities in moderately developed countries to experience an Environmental Kuznets Curve (EKC) peak during processes of economic development. The EKC is shown along the x - y coordinate, where the x -axis denotes GDP per capita and the y -axis denotes environmental pollution and consumption activity levels. The inverted U-curve denotes that pollution levels increase as GDP levels increase, that they peak at the middle-income level, and that they decrease as GDP levels approach the highest point.

It can be concluded that technical innovations are needed to increase the efficiency of new technology use (e.g., increased energy demand, increasing waste levels and insufficient processing, traffic increases and associated externalities, and water demand increases). The demand side must also follow environmental ethics to change behaviours. It is

Table 6.10 Different forms of city development under various economic conditions

	<i>Energy</i>	<i>Waste</i>	<i>Transportation</i>	<i>Water</i>
Slums or the poorest economies	<ul style="list-style-type: none"> - There are serious energy security issues and limited hours of electricity supply. - Households are connected to a centralized grid system. - LPGs are used for cooking energy, however, numerous households also use firewood and other traditional solid fuels for cooking energy. 	<ul style="list-style-type: none"> - No proper waste management system. - Limited local government waste management efforts. - A significant proportion of slum household livelihoods depend on waste recycling (informal). - Poor liquid waste (storm, drain and sewerage) management systems that require considerable attention. 	<ul style="list-style-type: none"> - Most slum dwellers are pedestrians, however, some also use bicycles and public transportation for mobility purposes. - Hawker carts are used in the informal economy. 	<ul style="list-style-type: none"> - No regular water supply (w/s). - Community based w/s system available only for a few hours a day (e.g., two to three hours daily). - Although hand pumps are used for water extraction, water quality levels are unsatisfactory.
Mid-level countries	<ul style="list-style-type: none"> - In urban areas, stable electric power supplies have begun to be secured. - Improvements in concerns regarding the diversification of energy sources. - Gaps between and farming villages. 	<ul style="list-style-type: none"> - In urban areas, fixed recovery programs have been initiated. - Spaces are dedicated intravenous business activities. - Gaps between farming villages. 	<ul style="list-style-type: none"> - Correspondence on an increase in transportation with considerable GHG discharge from private cars. - Aggravation of traffic congestion or air pollution levels. 	<ul style="list-style-type: none"> - Stable water supplies in urban areas. - Uncertain sanitation levels. - Gaps between cities and farming villages.
Developed countries	<ul style="list-style-type: none"> • Smart grid systems with distributed power sources. • Self-managed power plants that use renewables. • Hydrogen reuse system. • Cogeneration. 	<ul style="list-style-type: none"> • Collection and management systems based on IT. • 3R (reuse reduce recycle) policies. • Bio energy generated from solid waste. 	<ul style="list-style-type: none"> • EVs used as batteries for building. • ITS. • Advanced public transit systems. • Advanced NMT systems. • Car sharing systems. 	<ul style="list-style-type: none"> • Renewable energy sources for water facilities (micro hydro, solar power, wind power, etc.). • Water looping serves as another solution (grey water use).

imperative for developing countries to meet SC objectives, as is being undertaken in developed countries.

6.7.2 *Towards Leapfrogging to SCs*

Figure 6.4 shows the four types of SCs in view of electricity T&D patterns. The power network of currently developed countries is shown in zone A: concentrated supplies in which the supplier (major electric power companies) has mainly participated in electricity supply. Current US policies are represented by zone B: large demander (manufacturing industry) and restricted supplier participation. Although small suppliers participate in solar and wind power generation in Europe and Asia, zone C remains advantageous only to large suppliers in terms of regulations and technologies.

However, zones B and C are insufficient. To develop new-generation smart grids and support initiatives as distinctive as those employed in Japan, large and small suppliers must be able to take full advantage of ICT technologies and legal systems (to freely buy and sell electricity). Zone D should be focused upon before any other country (Kato 2010).

In relation to SCs at large, a development model as shown in Fig. 6.5 is proposed using the smart grid model presented above. In this model, the x -axis denotes concentration versus distribution and the y -axis denotes demand levels per person, with a supplier scrutinizing a plane model (x - y coordinates) of separation versus one (one-way versus both directions). Concentration versus distribution, a service supplier, and a city resident

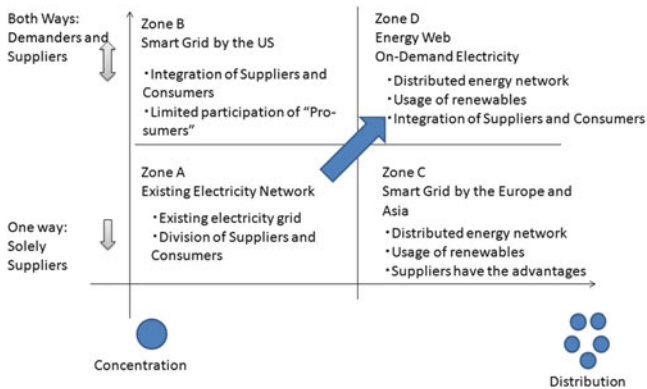


Fig. 6.4 The four smart grid conditions. Source: Drawn from Kato (2010)

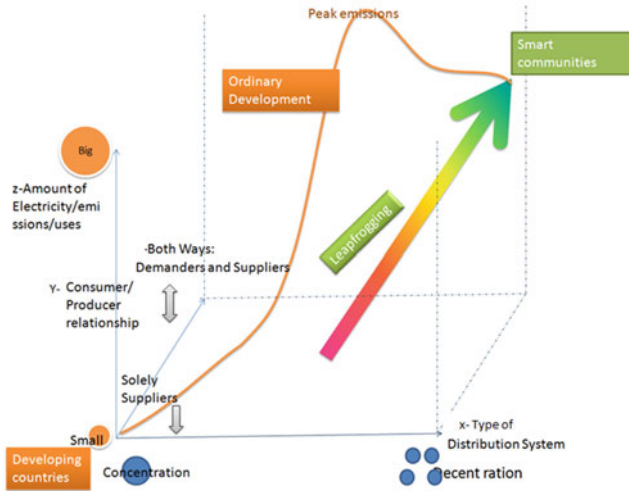


Fig. 6.5 SC leapfrogging model. Drawn from Kono et al. (2012a, b) and from Kono (2012)

are regarded as separation versus one. A model that applies and considers levels of each activity (z -axis) on x - y coordinates was considered.

In the poorest country, active mass levels take a value of zero or a country engages in forms of international cooperation in which marginal city development outcomes are afforded to a fairly developed country, and SC development may occur via leapfrogging effects.

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Conclusions and Ways Forward

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7.1 CONCLUSION

This book presents several case studies on green infrastructure in Asian countries, that is, China, India, Japan, and Indonesia. The following methodologies were utilized: risk analysis, cost–benefit analysis, integrated assessment modelling, input–output analysis, and comparative analysis. Cities are central to achieving low-carbon development targets. Green infrastructure adoption in cities will require transformations in technology, governance, and funding.

Several approaches have previously been employed to create low-carbon cities across Asia. Given their extensive growth patterns, cities require intensive urban infrastructure development. Constrained by local government capabilities, urban infrastructure funding has become a critical issue. Against this backdrop, several development projects are already exploring and examining new funding mechanisms through engagement with various stakeholders (e.g., public–private partnerships). Several cities in China, Indonesia, and Japan have invested in green city initiatives. Among others, the Low-carbon Urban Infrastructure Investment Project for China, Indonesia, and Japan, funded by the Asia-Pacific Network for Global Change Research (APN), attempts to address pathways to green infrastructure investment in these countries at the city level, which is also referred to as a form of smart investment. Through this type of investment, economic growth and greenhouse gas (GHG) emission reductions

can be achieved at the city level. The outcomes will be used as guidance on ways in which cities in selected countries can play a key role in the green growth agenda by stimulating growth through smart investment in urban infrastructure, that is, by building physical infrastructure, introducing financial and tax incentives, ensuring energy supplies, and increasing awareness of sustainable lifestyles, which should involve systematic institutional governance through coordination between involved institutions (national and local governments, local communities, academics, and industries).

With regard to China, the author proposes the following policy recommendations for the city of Shanghai (which are in line with pathways to achieving low-carbon city targets):

1. The Chinese central government and relevant local governments must update current economic incentive policies. The protocol for approving green buildings must be simplified, and costs must be reduced.
2. The energy performance contract may serve as a good tool for involving private businesses.
3. Carbon trading and carbon taxes can be adopted as part of economic incentive policies to promote green building development. Carbon trading schemes such as the Clean Development Mechanism (CDM) can help developers overcome investment barriers, as costs and risks associated with employing technologies and knowledge can be reduced significantly. Investors can pay off initial extra costs within a manageable risk range by selling carbon reduction credits granted for implementing green building projects. In fact, different partners such as developers, energy companies, and even real estate management companies can enjoy benefits under carbon trading mechanisms of China's building sector.

In Japan, Yokohama represents a government ordinance-designated city that displays increasing trends in terms of population and energy consumption levels. In 2007, the city established an execution plan for global warming countermeasures; based on that plan, the city established a 25% reduction target for total GHG emissions by the 2020 fiscal year from 1990 levels as a midterm target and an 80% reduction target for 2050. To achieve these targets, the city initiated a series of activities using various financing methods focused on household and commercial energy

consumption reduction. The case demonstrates that although feed-in tariffs (FIT) and tax policies can help a company mitigate investment risk and achieve returns from business involving renewables, it is dependent not only on the rate of the FIT and on installation costs but also on the framework of the FIT system. Thus, to promote renewable energy investment, further financing mechanisms and incentive mechanisms and a thorough review of the FIT system is needed.

In Indonesia, industrial energy efficiency levels, among others, have resulted in the most significant cuts to GHG emissions in the Jakarta metropolitan area. From an institutional analysis perspective, energy efficiency strategies are insufficient when confronted with a need for more fairness in the pursuit of well-being, which places considerable demands on shared societal resources. These findings complement results presented in the *Towards Green Growth in Southeast Asia* report developed by the Organization for Economic Cooperation and Development (OECD), which indicates that Jakarta's development trajectory must promote inclusiveness, safety, resilience, sustainable energy security, transportation, human health, and settlement services.

As for the Asian region, lessons learned from the three cities show that unplanned and unstructured urban growth will lead to significant economic, social, and environmental costs. Low-carbon infrastructure in cities may be funded through low-carbon technology incentives (e.g., solar photovoltaics (PV)), by fostering clean development mechanisms and by adopting energy efficiency measures through market mechanisms and/or policy interventions, as in the cases of Yokohama, Shanghai, and Jakarta. These findings also correspond with New Climate Economy Report conclusions that some cities demonstrate that more compact and connected urban development that is based on mass public transport can result in the creation of cities that are economically dynamic and healthier and that generate fewer GHG emissions.

7.2 WAYS FORWARD

Studies of cities are becoming more important due to rapid urbanization rates, particularly in the Asia-Pacific region. Infrastructure investments of US\$ 90 trillion by 2030 have become the focus of governments and development funding agencies. Two sustainability agendas created in 2015 are highly relevant to low-carbon infrastructure investments: the post-2015 development agenda and the COP 21st of the UNFCCC. The post-2015

development agenda to be developed in September 2015 in New York will reaffirm the central role of cities as the focus of one of the 17 goals to achieving sustainable development targets by 2030. Low-carbon technology partnerships will also be on the agenda of the 21st COP of the UNFCCC meeting to be held in December 2015 in Paris. This book will serve as an overview of green investment activities prior to 2015 and will support opportunities for developing further sustainable development goals and low-carbon technology partnerships.

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