

Smart cities in Japan and its application in developing countries

Noriko Kono¹, Aki Suwa², Sohail Ahmad³

Abstract

Smart cities, smartization and improved efficiency in managing utility like electricity, gas, water, waste, and transportation, are presently one of the most important keywords to city development. The concept is often thought as a panacea for the present global issues and inefficiencies, such as growing energy consumption, food wastes, rapid urbanization, industrial pollutions, endangered biodiversity, and traffic problems. Developed countries have discussed the concept profoundly these years in the context of green innovation, green economy, or green new deal.

Also, rapidly industrialized cities in developing countries are promoting smart cities. Nikkei BP (2011) estimates the smart cities makes the market potential of 52 trillion US\$ by 2030, and most of the estimation came from developing industrial countries. Though the interests to smart cities are quite high, little literature has been published in the fields of urban planning and international development. This paper treats the smart cities as an important trend proceeding to the historical thresholds of urban planning such as streetcar city, dispersed city, linear city, and smart growth city.

The traits of smart cities has summarized in four representative aspects: energy management, waste management, water management, and transportation. Energy management includes: electricity smart grid with distributed power sources, and diverse energy sources including solar, wind, and hydrogen. Waste management includes: 3R and material cycle economies. Transportation includes: EVs and Hybrid cars, Non-motorized transport (NMT), and car sharing system. Finally Water includes: renewable energy sources for water facilities and looping water use. The authors compared these trends with Indian slum situation and discussed the application to these sites.

Through the analysis of a smart city in Japan, many new attempts are being pursued. However, some challenges exist due to well-established existing infrastructure and solid urban systems of Japanese cities. On the other hand, the great potential was found in developing country cities. Specifically in energy sector, through microgrids

¹ PADECO Co., Ltd. Shin-Onarimon Bldg. 6-17-19 Shinbashi, Minato-ku, Tokyo 105-0004 Japan
Email: nkono@padeco.co.jp

² Email: Ahmad@ias.unu.edu

³ United Nations University Institute of Advanced Studies (UNU-IAS)6F International Organizations Center Pacifico-Yokohama 1-1-1 Minato Mirai, Nishi-ku Yokohama 220-8502 Japan Email: suwa@ias.unu.edu

financed by microcredit system, slum areas could leapfrog to the most advanced smart cities. Introducing smartization of cities, slums or the poorest areas could be one good example where smart cities shifts could fit into.

1. Introduction

Smart cities, or smartization of cities, would be the most important buzzword for development field. The concept is thought as a panacea for the present global issues and inefficiencies, such as growing energy consumption, food wastes, rapid urbanization, industrial pollutions, endangered biodiversity, and traffic problems. Developed countries have discussed the concepts profoundly for these years in the context of green innovation, green economy, or green new deal. Also, rapidly industrialized cities in developing countries are promoting this concept.

Japan, where most of the related technologies patents exist, has been working hard to promote the environmental technologies, such as solar batteries and electric vehicles. These shares are now closely to 70 % and it is important for Japan to keep the edge as one of the most advanced countries for the model of smart cities. However, difficulties lie in many aspects, and most of the barriers are reputational and institutional, not technological (METI 2012).

This paper first examines policies of smart cities in Japan and summarized their typical traits relevant to representative fields. The paper also examines these policies in terms of regulations, standards, plan and administrative directions, economic measures, and voluntary actions and environmental ethics. Next the paper discusses the possible application to developing countries, especially in slums in India. Then it discusses how to lay microgrids in slum areas in both technological and financial aspects. Finally it presents a model for application of SC to developing countries.

2. Definition of SC and Case of Japan

2.1 The recent definitions of SC

According to Fukuchi (2009), a member of Nomura Research Institute-NRI, which has been involved in smart city research in the early stage, the definition of Smart City has not been established necessarily. In the literature of NRI define the smart city as "*A city which possesses an integrated infrastructure that supports urban life by the power of ICT, at the same time it contributes to sustainable growth as well as decreases the demerit of urbanization.*" However, this concept has not been established on where and how much the smarter a place should be.

According to Aida and Morozumi (2011), who are forerunners of smart grid, whereas the micro-power network for the entire power grid, and smart grid power

network and is including the entire side and demand-side network power, with respect to Smart City, presented a diagram like Figure 1.

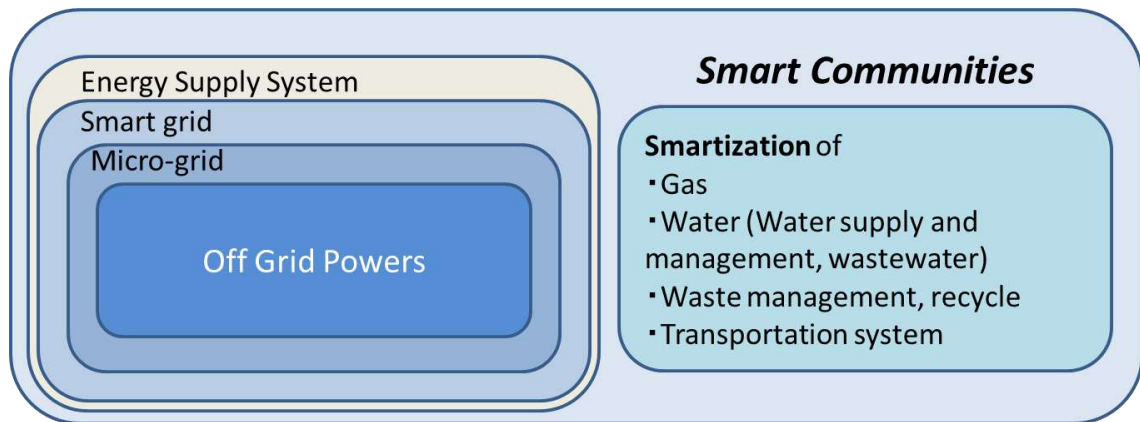


Figure 1: Smart Grid and Smart Communities

Source: Aida and Morozumi. 2010. Smart Grid Textbook. Tokyo: InPress Japan.

Although SC has advanced without standardization until now, in 2011, as for the smart city infrastructure evaluation-index international standardization domestic preparation committee and standards authorization innovation technical research association (IS-INOTEK) which are organized in the Japanese company and economic organization of 20, installation of the subcommittee within ISO was approved aiming at standardization. On the other hand, France and the World Bank agreed to put the SC criteria for selection in Global City Indicator as a standard of ISO at the period (Mochizuki, 2012).

Japan aims "measurement standard," for related products, while France and the World Bank aimed at "operating standards," which plans the state of the residents and administration in SC. In Japan, SC definition focuses on technical ones and in the West, the focus rests on soft elements, such as management and business mode.

2.2 Ecological implication of SC

The World Bank Urban group summarized a book called "Eco2 Cities: Ecological Cities as Economic Cities," meaning that a good city is both economically and environmentally (ecologically) feasible city. By this literature, in future cities, while it is important to connect linking artificial city infrastructure by using the advanced technology such as smart grids, it is also important to link new infrastructure to existing ecosystem.

Ecological implications such as looping and cascading the materials could strengthen the smart city ideas. For example, cascading of the water use: using graywater as other uses, should be appeared in modern water use. Also, looping waste

management by using the heat, wastewater, ashes, and so on could be one other option (Suzuki et al., 2010).

Chinese smart cities always refer to the ecological parts when referring the smart cities. Thus, this paper also includes these ecological concerns of the smart cities, referring to the efficiency in ecosystem.

SC definition can be a city which has efficient system in energy, waste, water and transportation by smartization and technological innovation and which become low carbon as well as ecologically feasible.

2.3 The four categories of SC

Aida and Morozumi (2010) has identified five areas; electricity, gas, water, waste management, and transportation systems. Moreover, the four pilot study areas of Japan has the projects of smartization of electricity, gas, transportation infrastructures and some cities broaden the areas to water and waste. In this paper, the definition looks at several important infrastructure sectors of SC.

Though the definition of the term smart cities, or smart communities, fluctuates presently, it is possible to gather some requisites. Through literature reviews, authors have summarized the typical traits of smart cities in four sectors.

Table 1. Traits of Smart Cities

	<i>Energy</i>	<i>Waste</i>	<i>Transportation</i>	<i>Water</i>
Special Traits	<ul style="list-style-type: none"> • Smart grid system with distributed power sources • Ene-farm (self powerplant from hydrogen) • Hydrogen reuse system • Co generation 	<ul style="list-style-type: none"> • 3R (reuse reduce recycle) policies • Co generation at the source • Bio energy made from solid waste 	<ul style="list-style-type: none"> • Using EVs and Hybrid cars for leveling off the peaks • Car sharing or other volunteer car shares programs ...make private property as public property 	<ul style="list-style-type: none"> • Renewable energy sources for water facilities (solar power, wind power etc) • Looping water use would be another solution (use of graywater)

3. Yokohama Case

3.1 Minato Mirai 21, Dawn of City-Smartization

Yokohama is one of the first Westernized cities in Japan and it had developed as a leading industrial city since the opening of Yokohama Port in 1858. During 1980s, it finished environmental enhancement in the CBD by industrial relocation to the suburbs and serviced its industry. Especially, Minato Mirai 21 is a project planned and built for the long period (approximately 50 years), as it is started as one of the "6

big declarations of Yokohama" in 1965. The establishment of the "utility tunnels" in the district can be called as the dawn of city smartization. Electric wires and telephone wires (optical fibers), waterworks, sewage, and garbage collection tubes are laid underground together, and community-central-heating-and-air-conditioning institution is managed by utility tunnel, which is energy-saving.

The electric power cable in utility tunnels is transformed by substation facilities within a power line from two plants in the CBD in Yokohama 500,000V, 154,000V, 66,000V, 6,600V, and 100-200V, and the electricity of voltage corresponding to each scale is sent to consumers. The space for substations was provided and what is called "smart power transmission" has been started since the start of the 1990s (Kishida and Uduki, 2008). Yokohama was the first runner of SC when the word did not exist yet in the world.

3.2 Global Warming Mitigation Policies in the Context of SC in Yokohama

By the "green innovation" determined by the Cabinet in 2009, "New growth industry strategy: towards bright Japan," the Ministry of Economy, Trade and Industry selected four "next-generation energy and a social system demonstration area" in 2010 and has tackled the promotion of smart-izing of the cities in Japan.

Yokohama was chosen, as one of the domestic four pilot study areas, along with Kitakyushu, Keihanna university town, and Toyota, and many ingenious industries of each city has followed. SC of Yokohama has the feature of the point which is a big city, the advantage of various industrial accumulation is employed efficiently and traffic infrastructure, and covered smart-ized item of each building comprehensively (Sasaki, 2012).

In this paper, developed countries' infrastructure maintenance as global warming policy of Yokohama was examined in the context of SC. In order to take a closer look, it was divided into four elements of energy, waste, traffic, and water and it analyzed by dividing into three policy fields: 1. Regulations, Standards, Plan and Administrative Directions Regulations, 2. Economical means, 3. Voluntary actions and Environmental ethics.

Table 2 describes the regulations, standards, plan and administrative directions. Energy sector is represented by the measure of smart grid and Yokohama Smart City Project (YSCP) Plan made in 2009 is in response to specification of the next-generation energy and the social system demonstration enterprise of the Ministry of Economy, Trade and Industry centering on three areas (Minato Mirai21 area, the Kohoku new town area, and the Kanazawa area) of the city.

There was The Great East Japan Earthquake in 2011, and the concerns of the stable supply of energy in and outside the country is very high, and the measure attracts attention from different parts of the world. The duty of the city in YSCP is to specifically distribute 6 billion yen of "the next-generation energy fund" from the

Ministry of Economy, Trade and Industry to participating companies (Toshiba, Meiden-sha, Nissan, etc.). Yokohama is performing control of a board of governors or a joint session in the YSCP promotion conference. The city plays a facilitator's role in this plan.

Waste category is characterized by citizens' cooperation at G30 plan, which is a general waste disposal master plan for 2003 - 2010. This plan is aimed at reducing the waste to be incinerated. At the "Yokohama 3RMu(dream) plan" from 2011, reducing the total amounts of waste including resources are mentioned.

Transport sector's emphasis is put on the modal shift. The goal setting was made in 1997 of 15-minute from every station plan, and station power, which is to make more amenity in the vicinity of every stations. This aim is completed 88.4% in 2006.

In the scope of YSCP, Yokohama smart mobility defines the various projects including promotion of EV, and promotion of paratransit. Although the means of transportation not using motor power [Non-motorized transport=NMT] promotion is encouraged, goal setting of the modal split for NMT is not performed. NMT promotion is on-going as the social experiment of community cycles. The Yokohama Bay Bike enterprise is undertaken by funding of NTT DOCOMO for three years during 2011 to 2014.

Water sector also has shown the policy of reserving the remote reservoir for years. The Waterworks Bureau submits the environmental accounting report every year. The guideline of environmental accounting is followed to the Ministry of Environment Plan and they include environmental preservation cost, the environmental preservation effect, and economic effects. The trial calculation is made by yen terms and t-CO2.

Table 2: Regulations, standards, plan and administrative directions

	<i>Energy</i>	<i>Waste</i>	<i>Transportation</i>	<i>Water</i>
Regulations, standards, plan and administrative directions	Smart grid (YSCP plan)	Yokohama G30 plan 2003-2010 3R dream plan 2011-	Promotion of Non-Motorized Transport ,smart mobility plan, 15-minute anywhere plan, and Station Power	Reservation of remote reservoir, Calculation of cost benefit environmental accounting

Table 3 explains the economic measures of Yokohama. Energy includes the Yokohama Green Power Model Project promoted by the city's own funding. YGP model project collected monitor households from the YSCP pilot study area and the

companies introduced HEMS and PV to these households. The charge systems in household waste are not introduced in Yokohama. However, the city charges the bulky wastes for a long time.

Transportation category introduces 100 yen buses on weekends and holidays. The buses run along the tourists' stops and they are all municipal buses. The discount system is hard among each line as seven private companies exist in the city, but the statistics say that 100 yen buses promote the transit usage.

Water system uses the step-up charge system based on the idea that daily use water should be used in low rate. As the system charge more to the people who use more, it is said to get demand management.

Table 3: Economic Measures

	<i>Energy</i>	<i>Waste</i>	<i>Transportation</i>	<i>Water</i>
Economic measures	Yokohama Green Power Model Encouraging the local industry to enter YPORT	No charge on plastic bags Bulky waste	100 yen bus, Support for community cycle project	Charge system Yokohama Water Company

Table 4 illustrates the voluntary actions and environmental ethics. Energy sector elaborates on the lectures on introduction on HEMS. Action Plan for G30 articulates on citizen partnership in recycling and separating, and the city officials are very satisfied with the results. Transportation sector has the visibility in the voluntary community cycle project Hama-chari, which was run by the NPO. There is an NPO that promotes the transit usage as well. Water sector include various citizen participated events to enlighten the importance of saving water, which was participated by many interested citizens.

Table 4: Voluntary actions and Environmental ethics

	<i>Energy</i>	<i>Waste</i>	<i>Transportation</i>	<i>Water</i>
Voluntary actions and environmental ethics	Lecture on introduction of HEMS	Action Plan for G30	Hama-Chari	Vaporization heat Practical use of a hydrogen hybrid truck

3.3 Summary and Challenges in Yokohama

Previously it explains that in Yokohama, there are the balanced policies in four sectors (energy, waste, transportation, and water) in three policy fields (1. regulations, standards, plan and administrative directions, 2. economic measures, and 3. voluntary actions and Environmental ethics). The city has many innovative plans

and regulations as well as well organized environmental education system and environment-conscious citizens. Given the fact that Japan is one of the most industrialized nations in the world, Yokohama is among the best smartized cities in the present world.

On the other hand, difficulties are found in this city. These are: the measures against surplus electric power at the time of photovoltaics spread, the storage battery / EV practical use by the side of demand, solar cell power generation control by AMI, demand regulation capability grasp by demand response, construction of the micro grid which held down cost, and difficulty to the large cost reduction by electric power supply increase in efficiency. These problems are raised because the present system of Yokohama or cities in Japan is too systematized or institutionalized to adapt a new system.

4. Conditions of India

4.1 Slums in India

According to 2011 census, India's urban population was 377 million, about 32 percent of total population of India (Census-of-India, 2011). About one-fourth of the urban population (≈ 93 million) live in 49,000 slums spread across the country (NBO 2010). Slums are the manifestation of housing poverty. The proliferation of slums and severe housing shortages (over 24 millions) give a panoramic view of the housing poverty (NBO, 2007). Various government reports show growth of slum population, housing shortages and urban poverty (head count) across the states are severe and pathetic conditions.

Table 5 presents changes in slum characteristics during 2002 and 2009 based on nationally-representative survey. In the span of six years (2002 to 2009), housing conditions have not improved radically; nevertheless, incremental changes have been noticed in almost all housing indicators, for instance, proportion of households living with more than three persons per living room decreased from 32 to 28 %. Though there is a slightly bright side in the change, but there still exist a number of challenges to overcome as international living standards.

Table 5: Changes in housing conditions of slum households, 2002 – 2009

Indicators	2002	2008-09
Consumption expenditure (INR)	2929.97	3924.3
Living space per member (m ²)	5.84	6.92
Households with more than three persons per living room (%)	52.72	42.92
Structurally bad dwelling (%)	24.28	23.54
Separate kitchen (%)	30.08	39.04
Tap as a drinking water (%)	78.72	77.23

Own toilet (%)	21.45	31.22
Motorable access road (%)	44.26	45.85
Sample size (\approx)	6,130	8,273
(% of total)	14.64	14.68

Source: NSSO 2004; NSSO 2010

Note: A slum is a settlement with a collection of poorly built tenements, mostly at temporary nature, crowded with inadequate sanitary and water facilities in unhygienic conditions. Such an area was considered as a “slum” if at least 20 households lived in that area (NSSO 2010).

4.2 The four elements of infrastructure

To analyze slum household characteristics, a few indicators were selected from energy, water, waste and transport sectors. Although indicators are not comprehensive, it can give a fair idea about position of slum households in Indian context. Moreover, this is only a source at household level in urban India. The next section describes the each category in detail.

Table 6 presents three types of slums notified slum, non-notified slum and squatter. A comparison between non-slum and slum shows that slum households are relatively in poor condition. The table identifies the conditions of electricity, water service, and waste management. For example, though there are provisions of 95.5 % electricity of non-slum households, only 91.5 % slum households have electricity. Over 31 % of slum households have only temporary wiring.

74 % of non-slum households use tap/bottle water as a major source of drinking water and corresponding value for slum households is 77.3%.

Notably, 43.5% of slum households have access of drinking water within dwelling unit or premises, while 74.7% in non-slums. In same pattern, almost 29 % of slum households do not have garbage collection arrangement and while non-slum households 24.4%.

Table 6 Typologies of slums with characteristics, 2009

	notified slum (1)	non-not ified slum (2)	squatter (3)	all-slum (4=1+2 +3)	non-slu m (5)
household (#)	3,957	3,553	763	8,273	48,085
Household have electricity (%)	94.19	89.36	87.42	91.49	95.51
If yes dwelling with conduit wiring (%)	33.3	22.17	16.94	27.19	42.41
If yes dwelling with 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)*				18	21
Electricity Payment (median) (INR/month)*				150	200
Payment to SEB (%)*				84.6	75.84
Tap/bottle water as a major source of drinking water(dw)	83.04	74.19	61.21	77.27	73.93
Water within dwelling unit or premises (%)	49.47	34.64	54.07	43.52	74.74
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	18.7
No arrangement (%)	21.49	35.13	36.96	28.77	24.37

Notes: Sources: NSSO (2010); * these figures is calculated from Desai, S. and R. Vanneman (2009); SEB: State Electricity Boards

Figure 2 shows the maximum distance to the place of work normally travelled by each household. Despite poor living conditions and low income of the slum households, most slum households travel relatively more than the non-slum households. Figure 2 also reveals that high proportion of non-slum households are in less than 1km travel, while the number of slum households that travel more than 1km are about 7 point bigger than non-slums. It can conclude that slum households are located near workplace. It also shows a great burden on mobility on slum households, given their low income and accessibility of job.

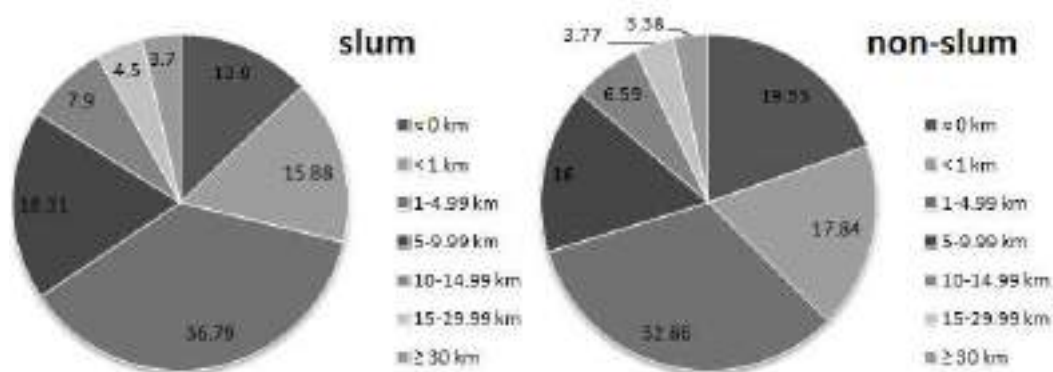


Figure 2: Maximum distance to the place of work normally travelled by any earner of the household

Source: NSSO 2010

Table 7 shows the firewood dominant as a fuel for cooking and kerosene for lighting in slum households from “Indian Human development Survey” a multipurpose household survey conducted by the University of Maryland and National Council of Applied Research. This survey is also based on nationally-representative survey. In non-slum, dominant form of fuel for cooking was LPG and Kerosene for lighting (Desai and Vanneman, 2009). According to the survey, 6.9 % of slum households

and 8 % non-slum households use their dwelling as residential cum commercial. It should be also noted that 37.2 % slum dwellings are bad ventilation while only 14.6 % of non-slum households are badly ventilated.

Table7: Fuel and energy use by slum and non-slum, 2005

Variables	Slum		non-slum	
	mainly cooking	mainly lighting	mainly cooking	mainly lighting
Number (#)	725		13,818	
Firewood (%)	45.69	0.41	21.38	0.14
Dung (%)	24.68	0	9.56	0.09
Crop residue (%)	0.55	0	1.3	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, S. and R. Vanneman (2009)

Table 8 summarized the Indian slum conditions in India and summarized the four sectors in infrastructure: energy, waste transportation, and water. The slums can have the potential that they do not have proper system of anything. In other words, it could have some possibility, if guided properly.

Table 8: Slums condition in four sectors

	Energy	Waste	Transportation	Water

Special Traits of Slums	<ul style="list-style-type: none"> - There is a serious issue of energy security, limited hours of electricity supply - Households are connected with centralized grid system -LPG are used as cooking energy, however, significant proportion of households also use firewood and other traditional solid fuels for cooking energy. 	<ul style="list-style-type: none"> - No proper system of waste management - Hardly any effort by local government for waste management. - Significant proportion of slum household livelihood depends upon the recycling of waste (an informal way). - Liquid waste (storm, drain and sewerage) management are in pathetic condition, needed great attention for better physical condition. 	<ul style="list-style-type: none"> -Most of the slum dwellers are pedestrians, however, low percentage of them also use bicycle and public transportation for mobility. - They also use hawker cart for their informal economy. 	<ul style="list-style-type: none"> - No regular water supply (w/s). - Community based w/s system available only for few hours in a day (say 2-3 hours daily). - They also use hand-pump for water, however, there is no satisfaction over the quality of water.
-------------------------	---	---	---	--

5. Application to India

5.1 Energy use in the poorest urban conditions

Previous section has shown that Kerosene and biomass are the main energy sources for cooking purpose in majority of households in Indian slums. This section illustrates the energy use in slums or in the poorest urban conditions. Kerosene is a standard fuel for cooking, but biomass is another source especially when poor do not have access to Kerosene. Kerosene is supplied with subsidized price, for ration card holders and often difficult to have a ration card especially to new migrants. Biomass, on the other hand, do not need such proof, but burning of biomass often causes severe air quality problems, used both indoor and even outdoor when smoke generated in one time for cooking.

A closer look will reveal more characteristics on the fuel composition for households. Table 9 demonstrates different income level seems to influence on the choice of energy carriers. It shows biofuel is commonly used as a cooking fuel in low income level households than those with higher income. Electricity usage for cooking is highly limited both for low and high income groups. Electricity is

widespread for high income groups for lighting purpose, with less usage by lower income households (Reddy and Srinivas, 2009). Also Table 7 in page 11 shows fuel composition comparison between slum and non-slum for mainly cooking purpose. Firewood and biomass (e.g. dung) are more commonly used in slum area than non-slum area. LPG, on the other hand, is more used in non-slum area than in slum.

Table 9: Energy carrier mix for various end users (2004-2005)

End use	Energy carrier	% Of households using various energy carriers		
		Low income	Middle income	High income
Cooking	Biofuels	81.1	61.8	31.8
	Kerosene	8.0	5.2	4.5
	LPG	8.5	31.3	61.2
	Electricity/others	2.2	1.7	2.6
Lighting	Kerosene	29.1	15.2	6.1
	Electricity	69.5	83.1	93.6
	Others (including no lighting households)	1.4	1.7	0.3
Total households (million)		68.3	107.6	29.5

Source: International Institute of Population Studies 2003, adopted by Reddy and Srinivas, 2009

As also demonstrated by Table 10 on typologies of slums with characteristics, it is rather surprising that the slum households have relatively high electricity accessibility, though most of the slums in Delhi are unelectrified. Even when there is a certain degree of accessibility to electricity, Transmission and Distribution (T&D) losses are generally large. For the OECD countries, the T&D losses are normally less than 10%, while the rate is more than 30% as average in India (Joseph, 2010). In India, one of the main reasons for the loss is attributed to power theft (Dhingra, et al, 2008). But some of the residents of slums acquire electricity through hooking or through paying contractors, thus the high access rate to electricity is sometimes characterized with illegal wiring.

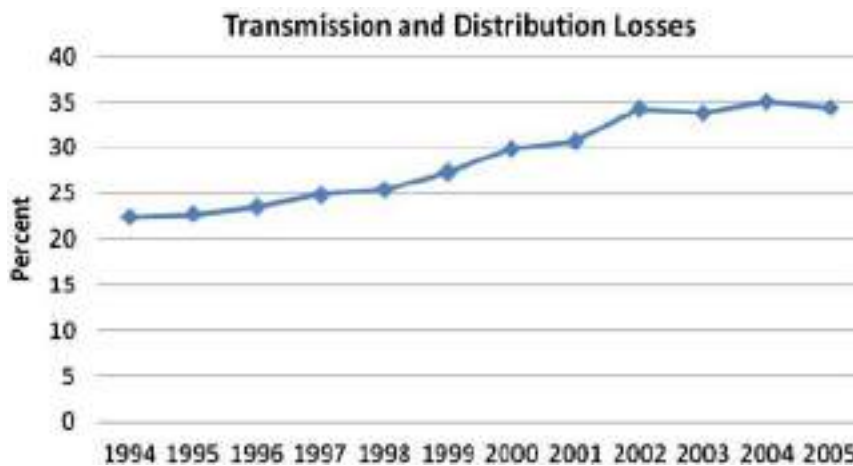


Figure 3: Average Transmission and Distribution Losses.
 Source: All India Electricity Statistics, General Review. Central Electricity Authority: Delhi, 1994–2006, adopted from Joseph, 2010

5.2 Electricity in the poorest areas

As electricity, at the point of its use, do not emit harmful substance, it has potential to provide environmental and health benefits to the urban residents. Electricity, however, is not officially available in the most of the Indian slums as seen. When available, no matter if legal or illegal, electricity is generally used for lighting (Reddy and Srinivas, 2009). Using electricity for other purposes than lighting may be a too expensive option, since cooking and heating normally require higher caloric values, potentially leading to higher prices to be paid if electricity is used for those purposes. However, if electricity tariff is set as low as the slum dwellers may be able to pay, they may be encouraged to use electricity for multiple ends.

Currently, necessary political commitment, business interest and technological infrastructure are all absent to legally provide electricity to slum. These setbacks mean that there is a need to formulate a strategy to make the utilities and others to invest into the areas where normally neglected from commercial operation. It is also important to create a framework where these investments can be collected back in a sufficiently short period.

One way of doing this may be to focus on microgrid. Microgrid is generally referred as an aggregation of electrical generation, storage and loads. The generators in the microgrid may be micro turbines, 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 static switch can disconnects the grid from the main grid, so that it can operate in isolation. Microgrid demonstrates its primal features as enabling stable operation in the time of faults and other network disturbances. When the microgrid is separated from the main grid, microgenerators are supposed to sustain sufficient power quality within the grid. It comprises low voltage distribution

systems with integration of diverse energy sources, such as photovoltaic, wind, biomass, biofuel and fuel cell together with distributed storage such as flywheels, advanced power electronic conversion and control capabilities (Agrawal and Mittal, 2011). Thus renewables, such as solar and biomass, can be the energy sources for microgrids electricity, and environmental benefits are larger if the microgrid electricity is sourced from renewables.

Also, microgrid can be operated with smart grid gadgets. Once connected to smart meters to a central control system, households can be provided with a real-time view of the amount of energy consumption. More importantly, it creates more advantage to the grid owners to have improved energy management and control over the energy production/consumption. The smart meters are particularly associated with better charging mechanisms as they are supposed to identify non-technical losses on T&D on the grids, thus it has a potential to work against power theft (Depuru, et al, 2011).

While the concept of microgrid has been developed in case of emergency and power interruption in the main grid, there is a growing interest in applying the system as an effective solution of providing electricity to the areas that have been long unelectrified. Currently focuses are much more on its application in rural areas, where the distance from urban areas prohibits connection to main grids. One of the social entrepreneurs, Mera Gao Power (MGP), for example, started to provide extremely low cost lighting and mobile phone charging services to the households in Uttar Pradesh, through building and operating village-wide photovoltaic microgrids. Households will be given two LED lights and a mobile-charging point with a cost of 25 rupees (US\$0,46) per week, and MGP is expecting that their investment in each microgrid collected back in around 18 months (de osta, 2012).

Funding agencies, such as US AID is also strongly focusing on microgrid provision in rural areas of developing countries. (US AID and microgrid in India).

5.3 Financing the microgrids

The microgrid has also a large potential in slums to connect the residents to electricity. As stated, the microgrid is an islanding electric infrastructure requiring relatively inexpensive investment than the main grid. Possibly combined with smart grid devices, the microgrid has a better chance to deliver electricity in specific areas in the urban areas of developing countries, as well as giving the utilities and investors the chances to control over technical and non-technical losses on T&D.

There is surely a problem of financing the microgrid in slum areas. Investing into these difficult areas may require, at least high social motivation, but also a skillful strategy to ensure return on investment. Collecting funds back from slum dwellers is a particularly difficult task for microgrid investors, as slum dwellers' willingness to pay could be a critical barrier. In rural areas, dwellers usually have higher sense of residentialship in their area, no matter how poor or not. In slums, on the other hand,

residents see their dwelling as temporally, particularly in non-notified slums and squatter settlements thus it is highly difficult to expect them to invest into upfront cost for the lasting facilities. The legal status of the slum dwellers has been recognized as one of the major problems, and allowing them secure tenure status, regardless of permanent or temporally, is recommended to secure their accessibility to cleaner energy. In addition to giving them tenure status, it is possible to reduce the initial costs burden through installment payment. The suppliers have to reach out to the poor customers, breeding trust and integrate them as part of business portfolio and encourage them to be willing for legal connections (Dhingra, et al, 2008).

It is quite difficult to expect the existing utilities to take up the microgrid business. It has been well documented that Indian government adopted the Electricity Act 2003, which introduced significant changes to the electricity industrial structure. The background to the enactment of the act is a number of challenges that the Indian electricity industry were facing. In India, the electricity industry had been dominated by the State Electricity Boards (SEBs), vertically integrated monopolies, for decades. The SEBs are in a severe financial difficulty, to the extent they are lack of funds to even invest into maintenance of the currently available infrastructure (Bhattacharyya, 2005, Dubash and Rao, 2008; Joseph, 2010). Pouring money into the new microgrid in high risk areas would be out of their financial capability. New energy and electricity entities with viable financial capacity are required for investment into microgrid for the poors.

Microgrid shall find a better partner through social entrepreneurship. Social entrepreneurship is process whereby the creation of new business enterprise leads to social wealth enhancement so that both society and the entrepreneur benefit (NYU Stern, 2005). Social entrepreneurs usually apply practical, innovative and sustainable approaches to benefits society in general, with an emphasis on those who are marginalized and poor (Schwab Foundation, 2005). In general, majority of existing 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 through creating business models on the microgrids in slums. One of the social entrepreneurs' successes has been demonstrated as a case of Grameen Shakti, which provided solar powered facilities in Bangladesh with soft loans through installment. With the affordable price set, the installed number of Grameen Schakti's Solar Home System has risen from around 230 in 1997 towards more than 520,000 in 2010 (Asif and Barua, 2011). Its innovative business model and operational framework can be seen as a benchmark to be applied to other countries.

Foreign aids, majority of which are focusing on rural electrification, may also have to pay more attention to slum electrification. Urban air quality can be improved significantly, once microgrid is available to slums. There is an increasingly wider recognition that there is a strong linkage between global climate change (GCC) and local air pollution (LAP). Options to mitigate GCC may show strong co-benefits in

terms of less LAP and vice versa. Policies neglecting these co-benefits may be sub-optimal, as the co-benefit approach is to cope with the global and local emission control at the same time, where strategic design of policies is indispensable. Also, the international attention is moving more to integrate wider areas and measures to optimise the policy effects. Thus mitigating the slum air quality also needs to be placed in the context of urban co-benefits policy formulation (UNU-IAS, 2012). In addition, the microgrid will enhance accessibility and availability of electricity that would definitely ensure environmental sustainability in slums that is one of the key Millennium Development Goals (MDG).

An analysis demonstrated that mere top-down and technology focused approaches have limitations in making people willing to pay for electricity. Social elements, such as local norms, trust and sometimes sanctions, seem to work better for ensuring compliance (Winther, 2012). Nevertheless, the combination of technological solution, together with enhanced social contexts, would create an environment where cleaner energy may be accessed by the slum dwellers. The microgrid funded by social investors has a very large implication for slum/urban environmental benefits, through air quality improvement, and social benefits via energy and electricity provision to the poors. The role of the national government to play is ever more important, for the development of policy on the slum dwellers' accessibility to cleaner energy. The local government shall be equally imperative to encourage and cooperate with social groups and entrepreneurs to establish new business models for providing clean electricity, as also seen in Japan where the Yokohama city government' smart community initiative and its liaison with new business enterprises demonstrate.

6. Conclusions

6.1 Traits of Urban Development in Different Level of Nations

In this paper, the policy measures against global warming by Yokohama were considered from a viewpoint of SC, and each measure was analyzed in four categories and three fields. Here in conclusion, how to transfer SC to developing country cities is taken into consideration based on the experience of Yokohama in international development. Table 10 shows this image summarized by literature and interviews on each country-level situation: the poorest country cities, fairly-developed country cities, and advanced nation cities.

In this Table, it notes that there is a tendency for the cities of fairly-developed country to experience the peak of the Environmental Kuznets Curve (EKC) in their process of economic development. EKC was described on x-y coordinate, where x-axis is represented by the GDP per capita and the y-axis is shown as the environmental pollution level. It is said that it is shown with inversed U-curve, where the pollution increases as the GDP increase, peaks at the mid-income level, and decreases as the GDP approach to the highest point.

It can be said that technical innovations by efficiency are needed in the increase in efficiency using new technology, such as explosive increase in energy demand, excessive wastes and insufficient processing, increase in traffic and its involved externalities, and increase in water demand. Also the demanders' side needs environmental ethics to change their behaviors. It is important for developing countries to reach the SC situation like developed countries soon enough.

Table 10: Different Type of City Development in Different 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 is a serious issue of energy security, limited hours of electricity supply - Households are connected with centralized grid system -LPG are used as cooking energy, however, most households also use firewood and other traditional solid fuels for cooking energy 	<ul style="list-style-type: none"> - Hardly any effort by local government for waste management. - Significant proportion of slum households livelihood depend upon the recycling of waste (an informal way). -Poor liquid waste (storm, drain and sewerage) management 	<ul style="list-style-type: none"> -Most of the slum dwellers are pedestrians, however, low percentage of them also use bicycle and public transportation for mobility. - they also use hawker cart for their informal economy. 	<ul style="list-style-type: none"> - No regular water supply (w/s). - community based w/s system available only for few hours in a day (say 2-3 hours daily). - They also use handpump for water, however, there is great level of unsatisfaction over quality of water.
Mid-level courtiers	<ul style="list-style-type: none"> - In urban areas, it is begun to ensure a stable supply of electric power. -Improvement in the concern about pluralization of energy source. - Gap with farm villages. 	<ul style="list-style-type: none"> - In urban areas, it is begun to carry out fixed recovery. - There is also a place where intravenous business is realized. - Gap with farm villages. 	<ul style="list-style-type: none"> - Correspondence of the increase in the means of transportation with much GHG discharge by private cars. - Aggravation of traffic congestion or air pollution. 	<ul style="list-style-type: none"> - In urban areas, stable supply of water. - uncertainty in sanitation. - Gap with farm villages.
Developed	<ul style="list-style-type: none"> • Smart grid system with distributed power sources • Ene-farm (self powerplant from hydrogen) • Hydrogen reuse system • Co generation 	<ul style="list-style-type: none"> • 3R (reuse reduce recycle) policies • Landfills are less GHG emitting than combustion 	<ul style="list-style-type: none"> • Using EVs and Hybrid cars for leveling off the peaks • Car sharing system or other volunteering car shares programs ...make private property as public property 	<ul style="list-style-type: none"> • Renewable energy sources for water facilities (solar power, wind power etc) • Looping water use would be another solution (use of graywater)

6.2 Laying Smart Grid in International Settings

The power network of the present developed countries is at the zone A: concentrated type supply where the supplier (major electric power companies) has mainly participated in electric supply. The present U.S. policies are represented by the zone B: large-sized demanders (manufacturing industry) and restrictive suppliers' participation. Although there are small suppliers participation by solar and wind powers in Europe or Asia, zone C is still only advantageous to large-sized suppliers in terms of regulations and technologies.

Both zone B and the zone C are insufficient as new generation smart grid and to be distinctive as new deployment in Japan, not only the large suppliers, but the small suppliers, to be able to take full advantage of ICT technology and legal system (you can freely buy and sell electricity). The zone D should be aimed in order to be ahead of any other country (Kato, 2010).



Figure 4: The four type of Smart Grid Conditions
 Source: Kato 2010

6.3 Planning Smart Cities in International Settings

In this paper, in relation to SC at large, a development model as shown in Table 6 is proposed using the model of the above smart grid model. In this model, x-axis: concentration vs distribution, and y-axis: demand person, and a supplier scrutinize the plane model (x-y coordinates) of separation vs one (one-way vs both directions). Concentration vs distribution, a service supplier, and a city resident are separation vs one. The model which applies and takes into consideration the quantity of each activity (z axis) on x-y coordinates was considered.

In the poorest country, an active mass is zero or that our country performs international cooperation on the occasion of the city development which goes to a fairly-developed country although it is very small, and thought that development in SC could be performed by what is called leapfrogging.

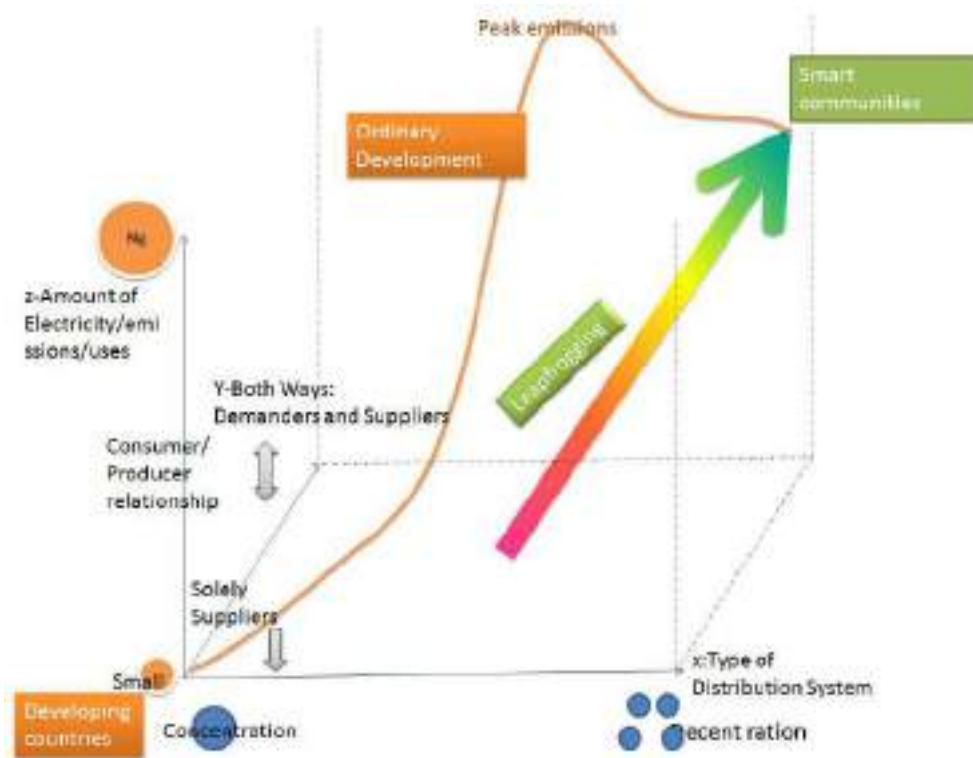


Figure 5. Model of Leapfrogging
 Made from Kono, Suwa, Armad 2012

7. References

- Agrawal, M., Mittal, A., 2011, Micro grid technological activities across the globe: A review, *IJRRAS*, 72, pp147-152.
- Asif, M., Barua, D., 2011, Salient features of the Grameen Shakti renewable energy program, *Renewable and Sustainable Energy Reviews* 152011, pp5063-5067.
- Bhattacharyya, S.C., 2005, The electricity act 2003: will it transform the Indian power sector?, *Utilities Policy* 132005, pp260-272.
- Brian Bahor, Michael Van Brunt, Keith Weitz, and Andrew Szurgot, 2010, Life-Cycle Assessment of Waste Management Greenhouse, Gas Emissions Using Municipal Waste Combustor Data.
- Census-of-India, 2011, Provisional Population Totals Paper 2 of 2011 India Series 1, Office of the Registrar General & Census Commissioner, India. Data Product No. 00-004-2011-Cen-BookE.
- da Costa, 2012, Indian villagers' lives transformed by new energy delivery system, *OurWorld* 2.0, <http://ourworld.unu.edu/en/indian-villagers-lives-transformed-by-new-energy-delivery-system>.
- Depuru, S.S.S.R., Wang, L., Devabhaktuni, V., 2011, Electricity theft: overview, issues, prevention and a smart meter based approach to control theft, *Energy Policy* 392011, pp1007-1015.
- Desai, S. and R. Vanneman, 2009, "National Council of Applied Economic Research, New Delhi. India Human Development Survey IHDS, 2005 [Computer file]. ICPSR22626-v5." Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor]: 06-22.
- Dhingra, C., Gandhi, S., Chaurey, A., Agarwal, P.K., 2008, Access of clean energy services for the urban and per-urban poor: a case-study of Delhi, India, *Energy for Sustainable Development*, 74, pp49-55.
- Dubash, N.K., Rao, D.N., 2008, Regulatory practice and politics: lessons from independent regulation in Indian electricity, *Utility Policy* 162008, pp321-331.
- Ethan Goffman, 2010, Smart and Smarter, *E Magazine*, July/August 2010.
- Freund and Vine, 2010, Aging, Mobility, and the Model Transportation: Approaches to Smart Community Transportation, Fall, 2010 --*American Society on Aging* 34 477 pp, 76-81.
- Fukuchi 2011, Smart city in Japan and in the world, Tokyo: Nomura Research Institute-NRI.

Goda, Tadahiro and Morozumi Satoshi, 2011, Smart grid textbook, Tokyo: Impress Japan.

Hayashi, Yasuhiro, Okamoto Hiroshi, Hideki Hayashi, Takashi Hamasaka, Tomoko Ina, and Kiyomi Sakamoto, 2010, Smart grid study: A strategy, technology, and methodology. The Japan Electric Association newspaper part.

Hearing with Fujisawa City (February, 2012)

Hearing with Kitakyushu City (December, 2011)

Hearing with Miyakojima City (February, 2012)

Hearing with Saibu gas and Fukuoka City (December, 2011)

Imura, Hidefumi and Kyomin Shimomura and Shunji Matsuoka, 2004, Environment and Development (series international development), Tokyo: Nihonhyoronsha.

Indian Power Sector, 2012, <http://indianpowersector.com/2012/03/ustda-awards-clean-energy-grants-trade-mission-to-india>.

Institute for Global Environmental Strategies, 2011, IGES - YCU Joint Seminar on Low Carbon and Smart Cities Meeting Summary, International Forum for Sustainable Asia and the Pacific 2011 ISAP2011 26 – 27 July 2011.

Ito, Takeshi and Shigeno Ayami, 2011, The business opportunity and subject of Japanese companies in smart grid: Viewing global market. Tokyo: Chiteki-shisan sozo, 2011 April.

Joseph, K.L., 2010, The politics of power: Electricity reform in India, Energy Policy 382010, pp503-511.

Kato, Toshiharu, 2010, Smart grid revolution ---Time of energy web, Tokyo: NTT publication.

Kishida Hiroshi and Uduki Morio, 2009, Strategies of city-planning strategy and project management -- Yokohama Minato Mirai 21, Tokyo: Gakugei Shuppan-Sha.

Kono, Noriko, Aki Suwa, and Sohail Ahmad, 2012, Smart city in Japan and deployment to developing countries. The Japan Society for International Development spring convention Outline under printing.

MacMillan, I.A., 2005,
<http://knowledge.wharton.upenn.edu/index.cfm?fa=viewfuture&id=766>.

Ministry of Economy, Trade and Industry The Agency of Natural Resources and Energy, 2012, Energy saving and alternative energy part, New industrial energy

industry study group Energy new industry creation The huge business which ranks second to a car is produced, Tokyo: Nikkei BP

NBO, 2007, Report of the Technical Group [11th Five Year Plan: 2007-12] on Estimation of Urban Housing Shortage, New Delhi, Ministry of housing and Urban poverty Alleviation, Government of India.

NBO, 2010, Report of the Committee on Slum Statistics/Census, New Delhi, Ministry of Housing and Urban Poverty Alleviation, Governemnet of India.

Nikkei BP, 2011, World Smart City Almanac (Sekai Smart City Soran). Tokyo: Nikkei BP Publication.

NSSO, 2004, Housing Condition in India, Housing Stocks and Construction, Delhi, Ministry of Statistics and Programme Implementation, Government of India,

NSSO, 2010, Housing Condition and Amenities in India, Ministry of Statistics and programme Implementation, Government of Inida,

NSSO,2010, Some Characteristics of Urban Slums 2008-09, New Delhi, Ministry of Statistics and Programme Implementation, Government of India.

NYU Stern, 2005, <http://w4.stern.nyu.edu/berkley/social.cfm>.

Planning-Commission 2011. Press Note on Poverty Estimates. New Delhi, Planning Commission, Governement of India.

Reddy, B.S., Srinivas, T., 2009, Energy use in Indian household sector – an actor-oriented approach, Energy 342009, pp992-1002.

Saito, Yu, 2012, Smart city concept – Smart cities in operation, Hitachi criticism 2012.

Sasaki, Tyuneyo, 2011, Smart city project: "Total solution" by company cooperation, Smart city week 2011 Presentation.

Sato, Tsukasa, 2011, "Viewpoint" Entry strategy Japanese company of smart city with a sudden rise, Renewable energy business review No. 6, Vol.72.

Satterthwaite, David, 2009, The implications of population growth and urbanization for climate change Human Settlements Group, International Institute for Environment and Development IIED, Paper presented at Expert-Group Meeting on Population Dynamics and Climate Change, in Collaboration with UN-HABITAT and the Population Division, UN/DESA 24 to 25 June 2.

Schwab Foundation, 2005, <http://schwabfound.org>.

Sharir, M., Lerner, M., 2006, Gauging the success of social ventures initiated by individual social entrepreneurs, *Journal of World Business* 41(2006), pp6-20.

Simanis, Erik and Stuart Hart, 2008, *The Base of the Pyramid Protocol: Toward Next Generation BoP Strategy*, Cornell University, Center for Sustainable Global Enterprise, Johnson School of Management.

United Nations University - Institute of Advanced Studies (UNU-IAS), 2012, Japan country paper: a working paper submitted to the Ministry of Environment Japan as part of the United Nations University Institute of Advanced Studies project report unpublished.

Suzuki et al, 2010, *Eco2 Cities Ecological Cities as Economic Cities*, World Bank Publications.

Takeyoshi, Ono, 1999, "Use" from "possession": Japan economy in new century. Tokyo: Nihon Keizai Shimbun.

Winther, T., 2012, Electricity theft as a relational issue: A comparative look at Zanzibar, Tanzania, and the Sunderban Islands, India, *Energy for Sustainable Development*, 16(2012), pp111-119.

Zahra, S., A., Gedajlovic, E., Neubaum, D.O., Shulman, J.M., 2009, A typology of social entrepreneurs: motives, search processes and ethical challenges, *Journal of Business Venturing* 24(2009), pp519-532.