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Low Carbon Green Growth Strategies and Sustainable Development for Mega Cities: A Case Study of Kolkata

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Abstract

Megacities in India are historically major economic growth centres and Kolkata is the oldest and the most densely populated mega city in India. With the increase in sustainable city discourse, an assessment of sustainable discourse, an assessment of sustainable development challenges and probe into possible green growth strategies in Kolkata city, provides some useful insights which are of general relevance as well. Sustainable development priority assessment for Kolkata highlights practical issues that go beyond just green growth. So, this paper starts with flagging broader multidimensional challenges of sustainable development, using multiple indicators as suggested in the literature based on empirical assessments. The present study realizes its importance for final negotiations towards implementation with city-scale development decision makers. The study also presents a well-defined boundary for green growth. Using sector wise database available from official sources, results show the green growth potential of each sector compared to a baseline. The potential is based on effective and efficient technology deployment. However, behavioural responses also highlight the possibility of increase in overall demand for energy services with introduction of efficient technologies. This study summarizes practical issues in grabbing the opportunities for green growth in the context of a fast growing developing country aiming at sustainable development.

Keywords: Low Carbon Growth, Green Growth, Sustainable Development, Energy, Policy, Megacity

JEL Classification: Q01, Q56, Q58

Paper Classification: Research Paper

Context

Broad definition of Sustainable Development, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED[1], 1987; Bojo, Mäler, & Unemo, 1992) provides enough opportunity for working out

[1]World Commission on Environment and Development

diverse solutions. Three pillars of Sustainable Development (SD) represent economic, social and environmental goals. Prioritization of various goals can be time, place and context dependent, so multiple trajectories of future growth paths can meet Sustainable Development Goals. Sustainable Development Goals (SDGs) list goals and targets to achieve sustainable development by 2030, addressing issues ranging from employment generation, poverty reduction, health improvement to environmental issues (UNDP, 2015). Environmental goals include sustainable cities with clean and affordable energy, climate actions with a special focus on reduction of per capita negative environmental impacts of cities, increase in the number of cities and human settlements aligning their goals towards adopting and implementing integrated policies and plans that focus on inclusion, resource efficiency, mitigation and adaptation to climate change (UNDP[2], 2015). However, prioritization among multiple goals is context dependent and path dependent. Past methodology- development and evidence based research in India (Roy, Bhowmick & Dolui, 2014; Roy, Shyam Roy & Deb, 2012; Roy, Chatterjee & Basak., 2008) have demonstrated that relative prioritization of goals would depend on the relative achievements of each study unit through time: be it nation, state or district within a state. Green growth can be considered as 'niche' (Grin, Rotmans & Schot, 2010) as it is planned to address simultaneously all three goals as compared to usual economic growth (GDP) oriented or social goal (HDI) oriented growth agenda. Low carbon growth (LCG) can be considered as a 'niche nested within green growth' that addresses the carbon emission component of environmental issues. If low carbon growth agenda has to emerge as a dominant growth trajectory (Roy, Ghosh, Ghosh & Dasgupta, 2013), then it is important to identify the connection with larger goal of sustainable development and the right nesting/protection strategy for various sustainability transition experiments. This will provide chances of emergence and survival of low carbon growth pathways, so that it may play an evolutionary role in the longer run.

Megacities in India are historically major economic growth centres. Kolkata, a major mega city in eastern region of India needs special attention due to its geographical position. Kolkata is one of the coastal mega cities of India which is situated 7 meters above mean sea level. This oldest megacity (the Kolkata Metropolitan Area or KMA) has 1888 sq km area with a population of 14.11 million as per Census 2011, which is the highest population density in India. By 2030, population of Kolkata can reach upto 23 million (Government of India, 2012). Kolkata is characterized by a fast growing and changing population density due to migration, floating population, rising building stock and physical infrastructure. The infrastructure needs of the city are enormous. It is predicted that a capital infusion of Rs.109 billion is needed in the next two decades just to meet human development goals. A projected growth rate of 6 to 7 per cent for Kolkata provides both challenges and opportunities for a new development strategy. Further, economic growth may be achieved through expansion of urbanization, new building constructions, extension of transport, drainage, sewerage network, water supply network, power supply enhancement through extended generation and transmission network and municipal service expansion. Against this backdrop, the objective of this paper is to assess low carbon green growth strategies for mega cities with a case study of Kolkata, India.

Section 2 provides a brief description of methods applied in this study with literature review highlighting gaps in the literature. Section 3, present results from an assessment of how Kolkata is performing in terms of sustainability goals and what can be the possible priorities to attain them. Section 4 narrates technological options to realise the hidden low carbon potential at the scale of the city. This makes good techno-economic sense for the context under study. It explores if

[2]United Nations Development Programme

sustainable development priorities of the city can be delivered through green growth agenda. The narrative is followed by a short discussion that shows the additional strategies that are needed to allow low carbon green growth agenda to be successful and to evolve as a dominant development trajectory consistent with Sustainable Development Goals. Section 5 provides discussion and scope for further research.

Past Studies and Methodology

Due to the growing trend of urbanization, it is expected that, by 2050, two-thirds of the world population will be in urban areas (World Bank, 2015; UNDP, 2015) It is also expected that urban areas will comprise 70 per cent of the world's Gross Domestic Product and has therefore economic, social and environmental importance. Even in cities of India, likely impact of extreme climate and environmental risks are expected to increase (Revi, 2008). Against this backdrop, assessing how various city development programmes are addressing climate action becomes imperative. However, as economic growth centres, cities cannot ignore the contestation among multiple goals of sustainable development and it remains to be seen how within the federal structure issues get resolved at a city scale. A large variety of literature has addressed the issue of sustainability indicators but here we review only those relevant with our study goal. To comprehend the implication of present and future path of development diverging viewpoints have emerged (UN 2003), one of those is the three pillars approach. The three- pillar approach to sustainable development tries to simultaneously address economic, social and environmental systems where each pillar is important on its own, however, they are interconnected as well (Hanley, Shogren & White, 1997). Thus, they need to be considered simultaneously. Indicator based sustainable development assessment is essential for the analysis as it allows for both a top down aggregate view and a bottoms up detailed description for sustainable pathway (Roy *et al.*, 2008; Ness, Piirsalu, Anderberg & Olsson, 2007; Moldan, Janouskova, & Hak, 2011; Morse, McNamara, Acholo & Okowoli, 2001; Koichiro & Aris, 2012). Indicators are unit free. Comparison and identification of performance for each component over time, in the context of sustainable development is also possible. Moreover, the indicator provides an idea of whether the economic development is consistent with social and environmental issues (Wallis, Graymore & Richards, 2011). Thus, an assessment of sustainable development challenges brings forth the issues which go far beyond economic growth indicators. Roy *et al.* (2008) used Composite Sustainable Development Index (CSI) in the country context and the same can also be applied in the city context. Composite Sustainable Development Index is an integrated measure of sustainable development. It considers numerous dimensions of social, economic and environmental aspects for sustainability evaluation (Hizsnyik & Toth, 2010). The method and results of Composite Sustainable Development Index (CSI) analysis used in this study to identify the challenge of sustainable development are summarised in the following section 3. The relative performance of progress of Kolkata, a district within the state of West Bengal, towards sustainability has been assessed.

In order to construct the CSI, a 'baseline' or 'benchmark' is formulated to measure the relative deviation of each district in West Bengal in terms of sustainability performance. The goal of the study is to assign numerical values and determine the relative positions of the districts in West Bengal in relation to the 'benchmark'. Conceptually, the study has taken the average performance level of all districts of West Bengal as the benchmark. To construct the benchmark, the study has considered the concept of 'Representation Index' (RI) from the existing literature (Pscharopoulos & Woodhall, 1985). The Composite Sustainability Index for each district has been developed. The indices are pure numbers and may be compared over time and space. The districts that indicate a positive CSI value may be assessed as districts that are on the path towards

achieving sustainability. While negative CSI value districts can be considered deviating from the sustainability and in need of policy interventions. The objective of every district should be to achieve continuous and consistent positive CSI value.

Eleven social (e.g., access to safe drinking water, crime etc.), nine environmental (malaria, dengue etc.) and three economic indicators; NDDP[3] Invested capital, road length[4] were considered. Data used are from all secondary sources of official statistics. Based on a detailed analysis of each indicator, a list of issues of concerns has been prepared for each district. An issue of concern is when a district has been performing poorly and has therefore been deviating away from the sustainability pathway.

India has accepted a position to move towards a low carbon economy without compromising on its developmental priorities. As new investments are expected to flow in to meet developmental aspirations, energy demand will increase. The big question is how development can progress without jeopardising environmental and green house gases (GHGs) emissions. For identifying the boundaries of green growth, the study uses decomposition analysis which is a simple, flexible methodology in energy use pattern and energy-related gas emissions analysis (Oh, Wehrmeyer & Mulugetta, 2010, Roy, 2000; and Ang, 2004). The decomposition method uses the Kaya Identity (Kaya, 1990; Kaya & Yokobori, 1993; IPCC[5], 2014). The conventional three factor decomposition tries to capture effects on emissions or energy consumption on the overall activity level (output effect), the activity mix (structure effect) and the impact of technological advancements to reduce energy use per unit of activity growth (intensity effect).

What is the best way to promote Low Carbon Green (LCG) growth in the city scale? There is great uncertainty in this issue due to lack of enough evidence and detailed data. A huge effort was made to collect necessary information at city scale and finally a database has been prepared using both downscaling of top down data and bottom up information to create baseline information providing energy use of major sectors. Using sector wise database available from official sources, results are derived to show which economic sector has, how much green growth potential compared to a baseline or consumption as usual (Gouldson, Kerr, McAnulla, Hall, Colenbrander, Sudmant, Roy, Sarkar, Ghatak, Chakravarty & Ganguly, 2012).

City scale studies covering both sustainability assessment and green growth scope are almost non-existent as per our search and knowledge. Past attempts in the context of Kolkata (Roy *et al.*, 2008; Roy *et al.,* 2011) have been to address either sustainable development or low carbon growth possibility (Gouldson *et al.,* 2012); the current article tries to combine both the aspects and to identify the challenges and opportunities of sustainable development. This study is therefore, a humble contribution in the literature on sustainability issues of megacities.

Sustainable Development Challenges for Kolkata

An assessment of sustainable development challenges for Kolkata district brings forth the issues which go far beyond green growth indicators such as GHGs emissions. So, the study starts with flagging broader multidimensional challenges of sustainable development (SD), based on empirical findings, using components of the Composite Sustainable Development index (Roy *et al.,* 2008).

[3]Net District Domestic Product

[4]For detailed list please refer to Roy et al., 2008

[5]Intergovernmental Panel on Climate Change.

Kolkata has shown positive growth since 2001 with respect to economic indicators, e.g., Net District Domestic Product and in 2012 the Gross Domestic Product was 1.5 trillion INR (Gouldson *et al.*, 2012). While GDP is rising, per capita energy demand is also rising. However, it is lagging behind in invested capital flow indicator and in several social and environmental issues. Even today, access to piped water supply is available for 80% only, diarrhoea records are increasing and medical facilities in proportion to rising population pressure is relatively worsening (World Bank, 2015). It has performed poorly with respect to social indicators like crime and environmental indicators like malaria and dengue.

Gradually environmental issues are demanding higher priority with worsening relative quality. Composite Sustainable Development Index based assessment clearly shows that for sustainable development economic priority if a faster flow of invested capital share is required, attention needs to be on correcting adverse sex ratio, besides controlling crime and vector borne diseases (Roy *et al.*, 2012). Residential sector is an important end user of electricity in India. Taking a cue from electricity usage pattern in residential sector till 2010 (Figure 1a), a rising appliance usage pattern is expected in the next couple of decades (in high economic growth phase), with increasing income, lifestyle change and urbanization (Roy & Pal, 2009). The previous study (Roy *et al.*, 2011) on energy efficiency potential achievable through advanced technology adoption in KMA, also explored that there is scope for diffusion of efficient (Figures 1b, 1c) appliances where 'baseline' implies the existing consumption as usual case and 'best practice' implies the most energy efficient path (for example, all appliances are substituted by their most energy efficient counterparts). Among all the appliances in Figure 1a, refrigerator showed the highest growth in the last ten years in KMA as a refrigerator became almost indispensible part of households' durable asset stock in megacities (Roy *et al.*,2011). This trend is expected to continue in future. Thus, the study explored that at 'best practice level', the savings potential of refrigerator is 62 per cent (702 million Watt) for hundred per cent urbanised area and 38 per cent (429 million Watt) for semi urbanised area of KMA compared to 'baseline' level. Figures 1a, 1b and 1c are based on the detailed information of energy consumption and appliances ownership pattern, collected from randomly selected 1600 households in KMA in 2009-2010.

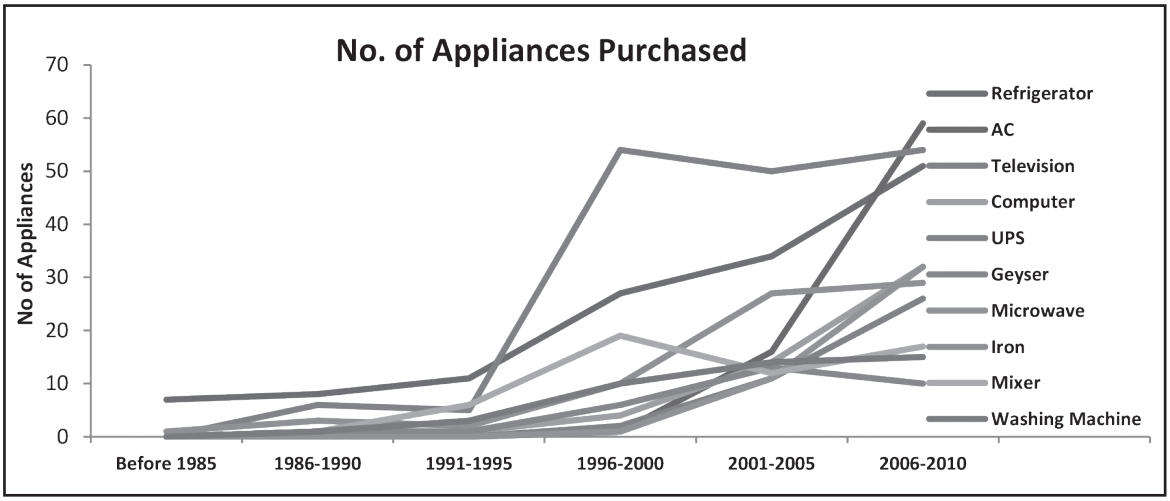


Figure 1a. Demand for Electricity in Residential Sector of KMA

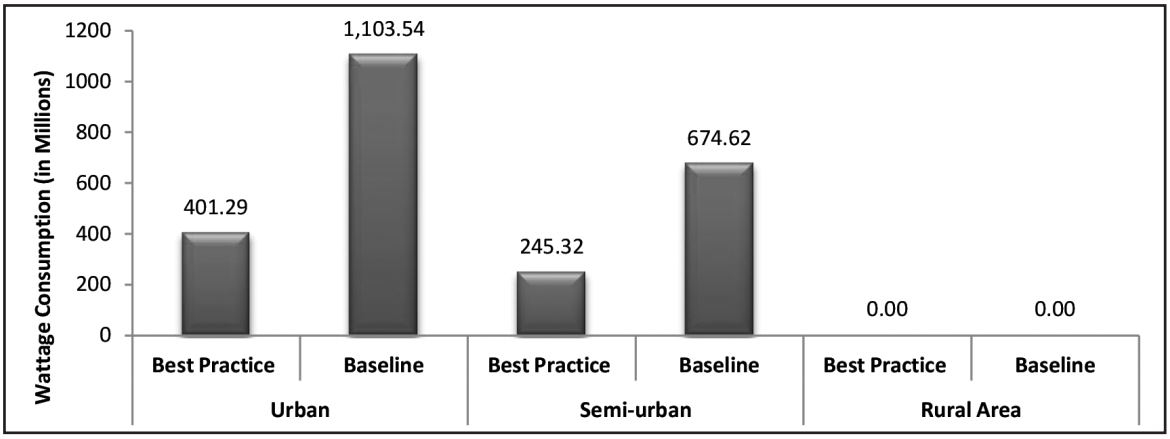


Figure 1b. Refrigerator Wattage Consumption – Baseline vs Best Practice

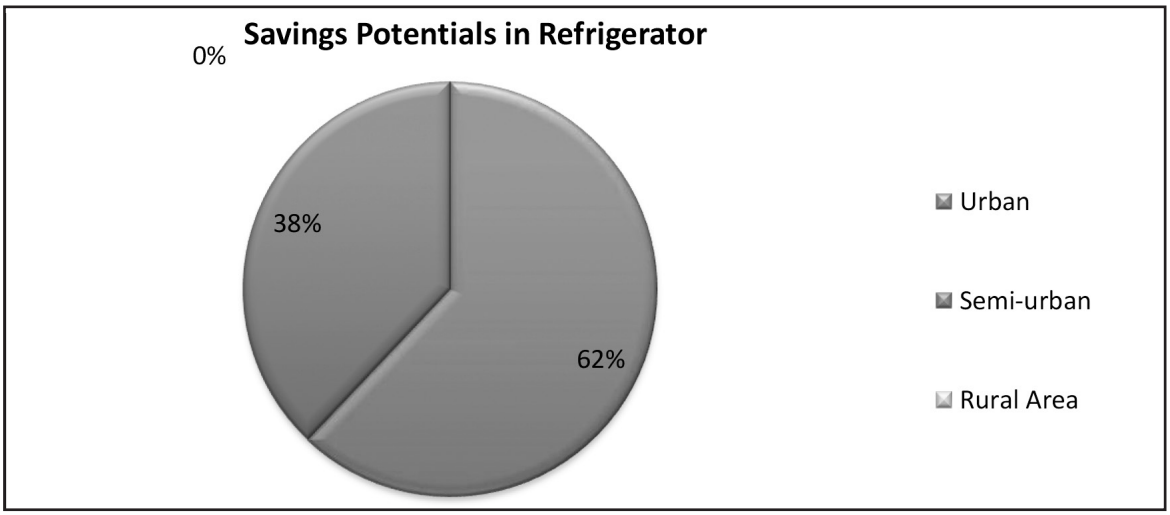


Figure 1c. Savings Potential in Refrigerator in Different Areas

Source: Roy *et al.*, 2011

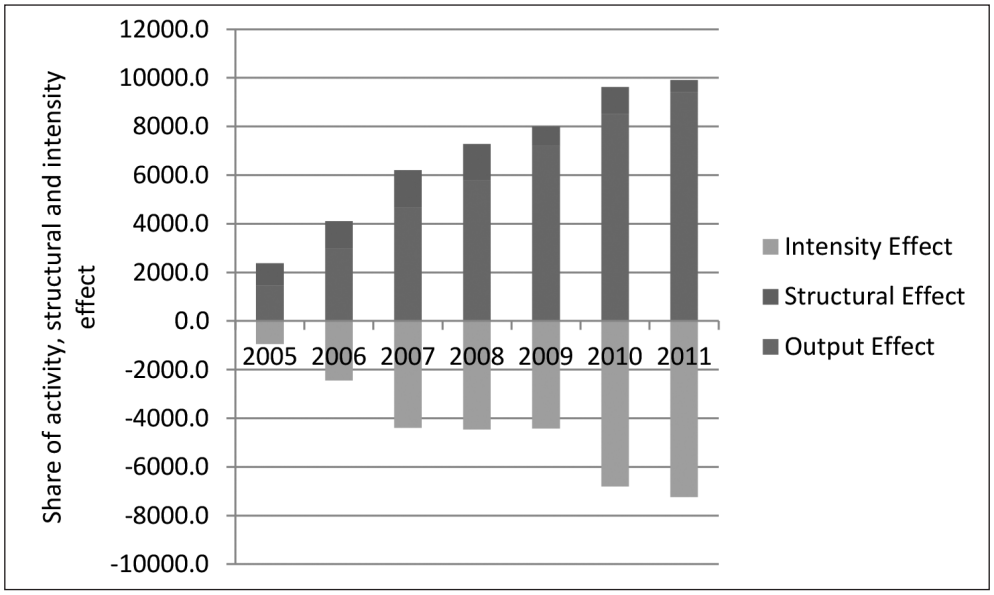
Kolkata has a sub-tropical climate. The summers in Kolkata are warm and humid, May and June being the warmest months while winters are short from December to January. The annual mean temperature is 26.8˚C and monthly mean temperature range between 19-30˚C (IMD, Government of India, 2015). The highest recorded temperature by India Meteorological Department, is 43.5˚C (110.3˚ F) and the lowest is 9˚C (35.6˚F) in Kolkata. The hottest and the coldest months are May and January respectively. In May, the temperature varies from 17.9˚C to 43.5˚ C and in January temperature ranges from 10˚C to 32.8˚C (IMD, Government of India, 2015). The city faced heat wave like situation from 23rd to 27th April in 2009 with the maximum temperature exceeding the average temperature by 4-5˚C. Space cooling demand is expected to increase as an adaptive strategy (IPCC-SAR[6], 1995; Ministry of Power, GOI, 2015; Gupta, 2014).

[6]Intergovernmental Panel for Climate Change- Second Assessment Report (IPCC-SAR).

Assessment of sustainable development priorities for Kolkata (Roy *et al.,* 2012), climate responsive mitigation (Roy *et al.,* 2011) and adaptation strategies for Kolkata city provides us an array of new opportunities that the development authority can aim at in the near term. The focus areas or major needs in brief are: need for new invested capital flow, higher power supply, enhanced access through new water and health infrastructure. The study presents below green growth assessment of the city and tries to cross check if the latter can be nested in the former to have better chance of acceptance, support and survival.

Boundary for Green Growth

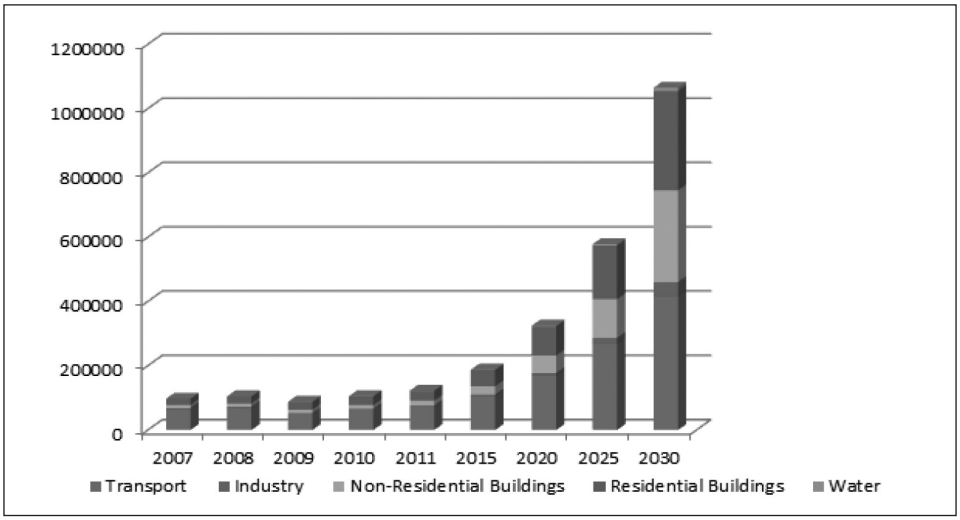
Given these multiple challenges in sustainable development paradigm, understanding the LCG opportunities at city scale can provide an interesting entry point for new directions in developmental process. Sustainability assessment shows there is a need for flow of invested capital to boost sustainable development in Kolkata, so scope of enhanced investment through LCG can be expected to provide a positive incentive for acceptance and support by the city development planners. Figure 2 shows the result of decomposition of GHGs emissions for KMA area into structural, output and intensity effects. Total emissions are energy related, from sectors including Water, Transport, Residential and Commercial Buildings and Industry from 2005-2011. Figure 2 indicates that positive growth of the GHG emissions is mostly from increasing activity levels over time, reflected in growth of domestic output. Sector shares reflected through structural effect is also leading to emissions' growth despite fluctuations. However, it is noteworthy that technological change /progress over time is indeed pulling down the emission growth. It is true that net impact is still pushing up emissions which are mostly driven by activity level and nature of the activities which are energy use intensive.



Source: Estimates based on data drawn from (Gouldson *et al.,*2012) and State Domestic Product and District Domestic Product of West Bengal, 2013-14, Bureau of Applied Economics and Statistics, Department of Statistics and Programme Implementation , Government of West Bengal.

Figure 2. Decomposition analysis of GHGs emission in KMA area

If business as usual trends of energy consumption continues, energy use and carbon footprints in Kolkata will double by 2025, while energy bills will quadruple. Figure 3 shows a projection of Kolkata's energy bills from 2007-2030. Residential buildings and transport sector are the key sectors that will add to the energy consumption followed by non-residential buildings e.g commercial buildings, institutional buildings. Thus, spiralling energy bills in these sectors could therefore, become a major break on development with significant social and economic consequences (Figure 3) (Gouldson *et al.,* 2012).



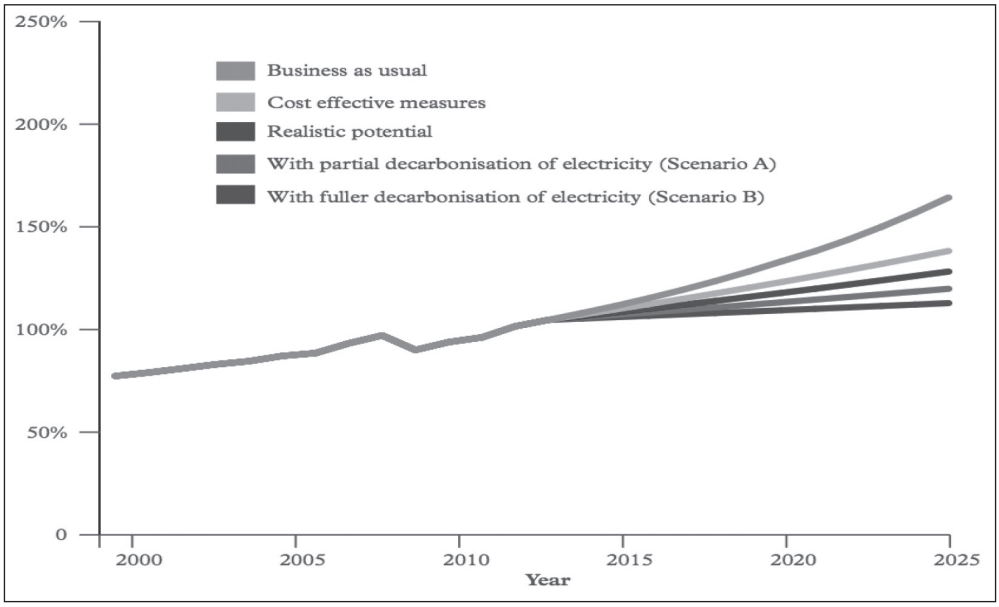
Source: Gouldson *et al.,*2012

Figure 3. Kolkata's Energy Bill in Million Rupees

There are, therefore, enough reasons to justify introduction and deployment of energy saving efficient technologies.

Technology matters: LCG

Energy efficiency gap is one cross cutting area where LCG can be achieved and is also compatible with Sustainable Development Goals. Past research (Roy *et al.,* 2011) shows that high potential for efficient technology adoption exists in residential sector (e.g., Figure 1b and 1c). It is not only refrigeration service, but such gaps between existing appliance stock and best practice appliance available in the market is seen in space cooling, as well as in illumination (household, commercial and institutional buildings, street lighting) services. There is enough scope in Kolkata to grow in coming years in the low carbon way (Figure 4).



Source: Gouldson, *et al.,* 2012

Figure 4. Potential for Low carbon development

These potentials have been estimated under various levels of emission cuts;

Cost Effective – 15.8per cent cut

Realistic Potential – 21.9per cent cut

Decarbonising Electricity Supply:

Partial – 27per cent cut

Fuller – 31.3per cent cut

A whole range of technology deployment has been considered including consumer's readiness to adopt and scale up as well. These technologies are: efficient refrigeration, air conditioning and cooling, electric water heating, lighting, subsidizing solar water heating and solar panels, providing new building standards, car efficiency standards and promoting Bus Rapid Transit (BRT) expansion, non-motorized transport mode, electricity based tram services and expansion of these services. Previous estimate (Gouldson *et al.,* 2012) shows that adopting these energy efficient and low carbon development alternatives by 2025 could secure Kolkata, an investment of INR 200 billion to exploit these cost effective measures across sectors. By following this path, not only will Kolkata be able to save a total energy bill of INR 25 billion a year but also cut its carbon emissions by 15.8 per cent compared to business as usual scenario. This is in tandem with sustainable development goals of the need for invested capital flow in megacity region. Also various health co-benefits and environmental benefits are expected out of LCG.

Behavior and Social Practice

Behavior and social practices are key determinants of transitioning to a low carbon growth

trajectory. Evidences from Kolkata city show that sufficiently conscious and committed decision makers can achieve larger goal of low carbon growth and can make a difference in final outcome (Roy, Dasgupta & Chakravarty, 2013). Analysis of two case studies on creating operational energy demand shows that if the end user is not consciously guided by a larger goal of reducing carbon footprint and instead focuses on financial balance alone, she/he may not move in the low carbon growth path despite introduction of energy efficient technologies. This is somewhat similar to human decision making under a situation of free deals in the market place (Ariely, 2010). In one case the commercial entity contracted the consultant to introduce efficient lighting and space cooling appliances in the building. Inefficient lighting equipments were all replaced by the efficient ones but overall lighting operational load increased at the end due to increase in the total lighting hours. In energy literature, it is known as 'Rebound Effect'. The 'Rebound Effect' measures change in energy service demand in response to change in energy efficiency since efficiency change gets manifested in implicit price of energy services (Binswanger, 2001; Greene, 1992; Brookes, 1990; Khazzoom, 1980; Chakravarty, Dasgupta & Roy, 2013). The energy efficiency gain can be fully or partially offset by the human behavioral response to implicit price change. With efficiency gain, for e.g., in lighting equipments, same hours of lighting service can be purchased with less energy input/less energy bill. Usually for consumers with unsatiated/ unmet demand rebound is high. In a case study of a large commercial entity (Roy *et al.* 2013a) for lighting services, primary data was collected for before and after stages of efficient lighting appliance implementation and rebound effect was estimated at approximately 488 per cent. That means lighting demand increased by a factor of 4.9 after efficient appliances were deployed. But in a second case study, user wanted to champion the idea of climate responsible lifestyle through conscious goal of achieving low carbon growth in the lighting service, energy efficient lamps were introduced and consciously no additional lighting hours was added and over all energy consumption declined. All these case studies are cited to convey the message that green economic growth would need not only technology deployment strategy but also strategic management of the operational behavior of the end users. It does not imply that with efficiency gain, fuel price needs to go up but supplementary communication strategy to encourage fuel saving behavior might be useful. Low carbon strategy can be promoted as a social good, social norm (Roy & Pal, 2009) and not be left only to market forces.

Discussion and Scope for Future Research

It is very crucial to understand the context of implementation in a fast growing developing country. Sustainable development needs are multidimensional and need all economic, social and environmental issues to be addressed. There is no doubt that clear techno-economic case for faster adoption of efficient and newer technology for LCG in Kolkata exists. Present study shows LCG can address economic concerns towards sustainable development through new investments in new efficient technology deployment. However, implementation of newer techno-economic solutions does affect host of actors who will gain or lose. There is a great information gap among the common individuals about global strategic issues like global warming and its costs and at the local level, unless strategically managed behavioural responses might backfire. Only 55 per cent of those who are well aware about the energy efficiency use energy efficient appliances to reduce their electricity bills and 31per cent individuals are aware about the pros and cons of energy efficiency (Roy *et al.*, 2011), but do not act. The question that remains to be answered is how much more awareness/business cases must be built to increase the percentage of individuals using energy efficient appliances or can the goals be achieved by well-crafted policies? It has been estimated that Asia composes 27% of the world's energy related CO_2 emissions and this is likely to increase by 44% by 2030 (ADB-ADBI, 2013). Keeping the question of sustainable development

in mind, Asia is at the edge of a tectonic shift towards low carbon green growth. Low-carbon green growth includes: (i) reducing energy use, improving resource efficiency, and switching to low-carbon energy alternatives; (ii) preserving and promoting natural resources such as forests and peatlands; (iii) designing and disseminating low-carbon technologies and business models to bolster local economies; and (iv) implementing policies and incentives that discourage carbon intensive practices. (ADB-ADBI[7], 2013). In literature (Kawai & Lee, 2010; Henry & Stiglitz, 2010; Frankel, 2009), it is believed that it will be better if the countries take advantage of low-carbon green growth as early as possible for their long-term sustainable development. For successful implementation of this new approach, five major factors have been identified from multi-country studies. The factors are i) a strong supporting state level framework of the low carbon green growth strategy, ii) formulating and implementing decentralized policies, iii) sector specific energy efficiency improvement with technological innovations, iv) encouraging more and more private sector participation, and v) regional cooperation for better management of financial resources. (Yao & Anbumozhi, 2015).

However, point remains with which the paper started. The other concerns of sustainable development: social and public health concerns would also need attention of the city Governments even if it adopts LCG. Differences in prioritization by various stakeholders of multiple criteria for sustainable development can decrease the speed of the transition to sustainable green economy. There are various opportunities, vast array of technologies but clashing political interests, social norms and business case issues mean that actions are harder to address at city-scale. Training and educational programmes to facilitate faster socio-cultural embedding and change in operational practices are matters that rest with sub national Governments. Besides empirical estimates and evidences, multi-governmental coordination and moreover, the choice of new policy instruments are essential to speed up the implementation of such policies. The current study tries to draw upon the results from various previous studies done independently to round up the story line that single focused green growth strategy can address some economic and environmental issues relevant for sustainable development through selection and deployment of energy efficient technologies. But the study does not analyze which policy instruments can be effective and how other actions need to be combined, implemented at the parallel level /independently to ameliorate multiple concerns of sustainable development of the megacity. This is expected to be true for any city/country. So, future studies need to address the issues of broader sustainable developmental challenges, going beyond the green growth goals. This is even more relevant for developing countries with multiple unfinished agenda.

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