SAMSET SCOPING REVIEW

URBAN ENERGY TRANSITION IN THE GLOBAL SOUTH

Xavier Lemaire | Daniel Kerr

November 2014 – Revised June 2016

UCL ENERGY INSTITUTE

SAMSET
Supporting Sub-Saharan Africa's Municipalities with Sustainable Energy Transitions




FOREWORD

SAMSET (Supporting African Municipalities in Sustainable Energy Transitions) is a research-action project which aims to support energy transition in medium-size African municipalities in Ghana, Uganda and South Africa.

This scoping review aims to synthetize elements of research that have been conducted related to low carbon transition within municipalities in the Global South; it attempts to establish how the findings could be useful for African municipalities.

Five topics have been researched: municipal planning, municipal waste and energy, transport, buildings and energy, electricity and peri-urban energy. A particular focus of research has been the articulation between the informal and formal sector, which is a major issue in African municipalities.

Xavier Lemaire & Daniel Kerr

More information on the SAMSET project can be found on:

SAMSET website: http://samsetproject.net/

SAMSET blog: https://samsetproject.wordpress.com/

For the purpose of citation, this document can be referenced as: Lemaire, X. and Kerr, D. (2016) *SAMSET Scoping Review – Urban Energy Transition in the Global South,* UCL-Energy Institute – SAMSET.

TABLE OF CONTENTS

TOPIC 1

MUNICIPAL PLANNING

Particularly in South East Asia, the lack of clearly-defined policy boundaries with regard to national and municipal authorities for urban energy planning has been observed to be a barrier. Identifying the boundaries of urban governance, for example the limits of the remit of sub-national government administrations or municipal authorities, as well as in which areas the national government wishes to retain some level of centralised control, is important for laying the foundation for a more sustainable urban planning process.

However, as stated in Friend et al. (2014) "the sectoral interests of government departments are often a disincentive to collaborate around shared 'urban' issues". For example, the development of new urban plans in Thailand is mandated to involved several local administrations, but the process has rarely been implemented due to the lack of incentive to co-ordinate objectives, and therefore potentially constrain a local administration's potential to urbanise further. (Rode et al 2014, Duranton & Puga 2013, Allen 2009)

A major problem in developing countries with regard to urban energy planning is a lack of capacity in project implementation and governance of energy projects within the municipal authorities responsible. The interlinking effects between energy concerns and urban development planning have often been overlooked in city development strategies in the developing world. This has been observed in both SE Asia (Todoc 2008), in East Asia (Okata & Murayama 2010) and in Sub-Saharan Africa (Nissing & van Blotting 2010, Borchers, Euston-Brown etc. 2008). Capacity development in municipal authorities, and the empowerment of municipal authorities in implementing energy projects in their local spheres, has been shown to be a key step in implementing sustainable urban energy planning (SALGA 2015). For example, the implementation of an Energy Integrated Urban Planning (EUIP) methodology has reaped benefits in both Philippine and Vietnamese cities (Todoc 2008).

The methodology is designed to be interrelated with other planning sectors, and to generate benefits across society, for the whole population of the city, whilst respecting local conditions (for example demands and constraints).

The EUIP methodology comprises of six activities in the production of a strategic urban energy plan:

1. Socioeconomic analysis
2. Energy and environmental analysis
3. Stakeholder analysis
4. Problem analysis
5. Options finding
6. Strategy and action plan definition

The Mexican case for energy/urban transition also highlights the capacity issues faced in urban planning in developing countries. Paez (2010) analysed the planning processes of a number of municipalities in Mexico with regard to the implementation of sustainable energy projects, as well as sustainability concerns in urban planning and development in a post-petroleum urban model. Mexican energy sources, particularly in cities, are heavily biased towards petroleum products, in part due to the country's indigenous petroleum production capacity. In addition, the constitutional conditions in the country dictate a high degree of centralisation in energy planning, with federal agencies being in majority responsible for planning at all levels. This has constrained the development of an independent capacity in local, state and federal district government organs for sustainable energy planning and urban planning. Critical factors that were found to be missing in terms of urban planning procedures in the majority of cases include legislation to apply bioclimatic criteria in urban planning and legislation to increase urban density, rather than urban dispersion. (World Bank 2016, Jabareen 2015)

Empowering the local authorities (for example, city councils, city development agencies etc.) in a city for the implementation of sustainable urban energy planning has also been shown to be more effective for the local energy development of a city than relying on top-down, national-scale energy planning. A useful case for this can be found in Roy (2009), focusing on Dhaka, Bangladesh. A combination approach of identifying a conventional strategic framework for the city and locally-informed model of sustainable urbanisation was used in order to produce a more locally-informed approach to sustainable urban planning in the city's communities.

Local stakeholder involvement was a key factor in the approach detailed in Roy (2009), particularly in the context of new urban development planning. With Dhaka following the model of a number of developing megacities of having a highly-developed urban core and a distributed catchment area, combined with the local issues of having significant agricultural production in potential expansion areas for the city, integrated land-use planning with stakeholder involvement was identified as a useful tool in order to effectively plan the city's further expansion. (Roy 2009)

Following on from this, as well as the necessity of involving municipal authorities in the urban planning process, the need for stakeholder and citizen participation has often been overlooked in urban planning in developing countries. Participation has often had little meaning in the planning process, with functions often amounting to little more than announcing decisions to the affected public. Variation within countries is not uncommon in this regard, for example in Indonesia where both open and inclusive processes and tightly-controlled processes in planning are both evident. Indonesia has also traditionally been quite dependent on external consultancy for technical and non-technical inputs, which undermines the development of local planning and policy capacity. (Friend et al. 2014)

Stakeholders at all levels can contribute a significant amount to policy development and planning within a developing city (WHO 2010). In summary, stakeholders' roles can include:

- Developing and writing policy for the city (for example, national and municipal governments),
- Enabling project delivery (for example, energy service companies),
- Implementing projects (construction firms etc.),
- Participation in public consultation and service receipt from the city (end-users),
- Enabling knowledge sharing (for example, academic institutions in the city).

Stakeholders must be aware of the effects that constructing and developing policy for the urban area in question can have. Disempowerment of the local populace and municipal government can result in limited buy-in from these representatives, hampering policy roll-out and project delivery.

Such activities must be undertaken carefully, with comprehensive review and consultation with affected parties, to avoid this effect.

The constraints on institutional development mentioned above have also been present in African cities and municipalities. For example, in South Africa, widely varying levels of institutional capacity exist, but a number of constraints to implementation are cross-cutting in the sector.

Particularly in the South African context, the dominance of the national energy department, as well as the over-arching dominance of the national utility ESKOM in the energy planning process, has led to a lack of consideration for the issues in other government departments. In addition, the traditional approach of ESKOM in particular has been to focus on electricity supply and distribution; with their income dependent on electricity consumption, the diversification of supply sources and ownership, as well as other demand-side factors, are not easily integrated into their strategy. The building of capacity for sustainable energy approaches into all government departments was seen as a key outcome in improving sustainable energy consideration in South Africa's urban planning. (Tait 2015, Kruger & Tait 2015)

Financing constraints and a lack of financial independence are also a widespread factor in municipal authorities in developing countries. Inflexibility in procurement procedures, as well as restrictions on market participation for municipal authorities (for example, in emissions trading) can hamper the ability of local governments to participate in energy project financing. This has been shown to be evident in both developing African and South East Asian cities. The financial means of local governments have been a major barrier to project implementation, with industrial development and population movements often outpacing the means of the local authorities to provide sufficient infrastructure. This is evident, for example, in terms of the growing informality of housing in developing cities. (Derashkan 2011)

The importance of local involvement has been demonstrated in Sub-Saharan Africa also, particularly in East African countries such as Kenya. Completion rates for projects have been shown to be correlated to the level of stakeholder and beneficiary involvement in the planning process. For example, in the 1999-2002 planning period for Mombasa, projects from the poverty eradication commission for the city far exceeded other projects in terms of successful completion of objectives, through the involvement of stakeholders, notably the actual project beneficiaries (Kithiia & Dowling 2010).

Another recurrent theme in the available literature is the need for a systems-based approach to sustainable urban planning, considering all available factors and their intersections. A successful example of this is Curitiba, Brazil. Through a combination of an efficient transport system and a holistic approach to city planning, numerous benefits have been achieved for the city, including improvements in air quality, the addition of green space, and decreasing traffic congestion. (Keirstead, Samsatli & Shah 2009, Ernst et al 2016, ICLEI/GIZ 2013, Sakieh et al. 2016)

A number of planning processes were used in the achievement of these goals, including land use zoning and the creation of mixed-use zones, and the combination of strategic transport corridors and the encouragement of high-density growth in proximity to these. (Kithiia & Dowling 2010, Friend et al. 2014,UN-HABITAT/ICLEI 2009, World Bank/AUSAid 2012, Bontenbal 2009, Sivakumar 2013)

REFERENCES FOR MUNICIPAL PLANNING

POLICY & STRATEGY

Bontenbal, M.C. (2009) Strengthening urban governance in the South through city-to-city cooperation: Towards an analytical framework. *Habitat International*, Vol. 33, pp. 181 – 189.

Bunning, J. (2014) Governance for regenerative and decarbonised eco-city regions. *Renewable Energy*, Vol. 67, pp. 73 – 79.

Cheng, H. & Hu, Y. (2010) Planning for sustainability in China's urban development: Status and challenges for Dongtan eco-city project. *Journal of Environmental Monitoring*, Vol. 12, pp. 119 – 126.

Friend, R. et al. (2014) Mainstreaming urban climate resilience into policy and planning; reflections from Asia. *Urban Climate*, Vol. 7, pp. 6 – 19.

Jabareen, Y. (2015) City planning deficiencies & climate change – The situation in developed and developing cities. *Geoforum*, Vol. 63, pp. 40 – 43.

Khirfan, L., Momani, B. & Jaffer, Z. (2013) Whose authority? Exporting Canadian urban planning expertise to Jordan and Abu Dhabi. *Geoforum*, Vol. 50, pp. 1 – 9.

Lo, K. (2014) China's low-carbon city initiatives: The implementation gap and the limits of the target responsibility system. *Habitat International*, Vol. 42, pp. 236 – 244.

Derashkan, F. (2011) *On sustainability in local energy planning*. Doctoral thesis, Division of Energy Efficient Systems, Department of Energy Sciences, Faculty of Engineering, Lund University, Sweden.

Ramadan, E. & Feng, X. (2004) Urban planning: a tool for urban poverty alleviation in Sudan. *Chinese Geographical Science*, Vol. 4, No. 2, pp. 110 – 116.

Rasoolimanesh, S.M., Badarulzaman, N. & Jaffar, M. (2012) City Development Strategies (CDS) and Sustainable Urbanization in Developing World. *Procedia - Social and Behavioral Sciences,* Vol. 36, pp. 623 – 631.

Roy, M. (2009) Planning for sustainable urbanisation in fast growing cities: Mitigation and adaptation issues addressed in Dhaka, Bangladesh. *Habitat International,* Vol. 33, pp. 276 – 286.

Sakieh, Y. et al. (2016) Evaluating the strategy of decentralized urban land-use planning in a developing region. *Land Use Policy*, Vol. 48, pp 534 – 551.

SALGA (2015) *Voice of Local Government Issue 16*. Pretoria, South Africa Local Government Association. Available at: http://www.salga.org.za/Documents/Documents%20and%20Publications/Voice%20Magazine/Voice%20Magazine%20Issue%2016.pdf

UN-HABITAT/ICLEI (2009) *Sustainable Urban Energy Planning: A handbook for cities and towns in developing countries*. New York, UN-HABITAT. Available at: http://www.unhabitat.org/pmss/listItemDetails.aspx?publicationID=2839

Wamsler, C. & Brink, E. (2014) Interfacing citizens' and institutions' practice and responsibilities for climate change adaptation. *Urban Climate*, Vol. 7, pp. 64 – 91.

World Bank/AUSAid (2012*) Sustainable Urban Energy and Emissions Planning Guidebook: A Guide for Cities in East Asia and Pacific*. Washington D.C., World Bank/Vienna, AUSAid. Available at: http://documents.worldbank.org/curated/en/2012/01/17193899/sustainable-urban-energy-emissions-planning-guidebook-guide-cities-east-asia-pacific

Zia, H. & Devadas, Z. (2007) Energy management in Lucknow city. *Energy Policy*, Vol. 35, pp. 4847 – 4868.

Agudelo-Vera, C. et al. (2011) Resource management as a key factor for sustainable urban planning. *Journal of Environmental Management*, Vol. 92, pp. 2295 - 2303.

Ceron-Palma, I. et al. (2013) Towards a green sustainable strategy for social neighbourhoods in Latin America: Case from social housing in Merida, Yucatan, Mexico. *Habitat International*, Vol. 38, pp. 47 – 56.

Dowling, R., McGuirk, P. & Bulkeley, H. (2014) Retrofitting cities: Local governance in Sydney, Australia. *Cities*, Vol. 38, pp. 18 – 24.

Ho, C. et al. (2013) Low carbon urban development strategy in Malaysia – The case of Iskandar Malaysia development corridor. *Habitat International*, Vol. 37, pp. 43 – 51.

Kernaghan, S. & da Silva, J. (2014) Initiating and sustaining action: Experiences building resilience to climate change in Asian cities. *Urban Climate*, Vol. 7, pp. 47 – 63.

Kithiia, J. & Dowling, R. (2010) An integrated city-level planning process to address the impacts of climate change in Kenya: The case of Mombasa. *Cities*, Vol. 27, pp. 466 – 475.

Kostevsek, A. et al. (2013) Conceptual design of a municipal energy and environmental system as an efficient basis for advanced energy planning. *Energy*, Vol. 60, pp. 148 – 158.

Puppim de Oliveira, J.A. (2013) Learning how to align climate, environmental and development objectives in cities: lessons from the implementation of climate co-benefits initiatives in urban Asia. *Journal of Cleaner Production*, Vol. 58, pp. 7 – 14.

Sperling, J.B. & Ramaswami, A. (2013) Exploring health outcomes as a motivator for low-carbon city development: Implications for infrastructure interventions in Asian cities. *Habitat International*, Vol. 37, pp. 113 - 123.

UNEP (2007) *Liveable Cities – The Benefits of Urban Environmental Planning*. New York, UNEP. Available at: http://www.unep.org/urban_environment/PDFs/LiveableCities.pdf

UNEP GER12 (2011) *GREEN Economy – Cities: Investing in energy and resource efficiency*. New York, UNEP. Available at: http://www.unep.org/publications/contents/pub_details_search.asp?ID=6219

Wamsler, C., Brink, E. & Rivera, C. (2013) Planning for climate change in urban areas: from theory to practice. *Journal of Cleaner Production*, Vol. 50, pp. 68 - 81.

WHO (2010) *Why Urban Health Matters*. Geneva, WHO. Available at: http://www.who.int/world-health-day/2010/media/whd2010background.pdf

World Bank (2007) *Principles and Practice of Ecologically Sensitive Urban Planning and Design: An Application to the City of Hai Phong, Vietnam*. Washington D.C., World Bank. Available at: https://openknowledge.worldbank.org/handle/10986/7719

Zanon, B. & Verones, S. (2013) Climate change, urban energy and planning practices: Italian experiences of innovation in land management tools. *Land Use Policy*, Vol. 32, pp. 343 – 355.

ENERGISATION AND ENERGY TRANSITIONS

Brandoni, C. & Polonara, F. (2012) The role of municipal energy planning in the regional energy-planning process. *Energy*, Vol. 48, pp. 323 – 338.

Ernst, L. et al. (2016) Sustainable urban transformation and sustainability transitions; conceptual framework and case study. *Journal of Cleaner Production*, Vol. 112, Part 4, pp. 2988 – 2999.

ICLEI/GIZ (2013) *Green Urban Economy: Conceptual basis and courses for action*. Bonn, ICLEI. Available at: http://www.iclei.org/fileadmin/PUBLICATIONS/Global_Reports/ICLEI-GIZ_Green_Urban_Economy_Study_2013.pdf

Marcotullio, P. & Schulz, N. (2009) Urbanization, increasing wealth and energy transitions: Comparing experiences between the USA, Japan and rapidly developing Asia-Pacific economies. In Droege, P. (ed.) *Urban Energy Transition – From Fossil Fuels to Renewable Power*, 2009. Available at: https://app.knovel.com/web/view/swf/show.v/rcid:kpUETFFFR3/cid:kt00627EY3/viewerType:pdf/root_slug:urban-energy-transition?cid=kt00627EY3&page=1&b-toc-cid=kpUETFFFR3&b-toc-root-slug=urban-energy-transition&b-toc-url-slug=urbanization-increasing&b-toc-title=Urban%20Energy%20Transition%20-%20From%20Fossil%20Fuels%20to%20Renewable%20Power

Nissing, C. & von Blottniz, H. (2010) An economic model for energisation and its integration into the urban energy planning process. *Energy Policy*, Vol. 38, pp. 2370 – 2378.

Nissing, C. & von Blottniz, H. (2010) Renewable energy for sustainable urban development: Redefining the concept of energisation. *Energy Policy*, Vol. 38, pp. 2179 –2187.

Paéz, A. (2010) Energy-urban transition: The Mexican case. *Energy Policy*, Vol. 38, pp. 7226 – 7234.

Schwaiger, B. (2012) *Energy management as a first step toward integrated urban planning in Ukrainian cities*. 48th ISOCARP Congress 2012, Perm, Russia, 10-13 September 2012.

Shaalan, I. (2013) Sustainable urban transformation in small cities in Egypt: a UN-Habitat perspective. *Journal of Cleaner Production*, Vol. 50, pp. 200 – 204.

Todoc, J.L. (2008) Integrating Energy in Urban Planning in the Philippines and Vietnam. In Droege, P. (ed.) *Urban Energy Transition – From Fossil Fuels to Renewable Power*, Ch23.

World Bank (2013) *Energizing Green Cities in Southeast Asia: Applying Sustainable Urban Energy and Emissions Planning*. Washington D.C., World Bank. Available at: http://documents.worldbank.org/curated/en/2013/09/18272908/energizing-green-cities-southeast-asia-applying-sustainable-urban-energy-emissions-planning

URBAN DESIGN

Allen (2009) *Sustainable Cities or Sustainable Urbanisation?* London, University College London. Available at: https://www.ucl.ac.uk/sustainable-cities/results/gcsc-reports/allen.pdf

Awuah, K.G.B. et al. (2014) Benefits of urban land use planning in Ghana. *Geoforum*, Vol. 51, pp. 37-46.

Okata & Murayama (2010) Tokyo's Urban Growth, Urban Form and Sustainability. *Megacities*, Vol. 10, pp. 15 – 41. Available at: http://www.thecandlelightclub.com/Sakura%20in%20Old%20Tokyo/9784431992660-c1.pdf

Rode, P. et al (2014) *Accessibility in Cities: Transport and Urban Form*. London, London School of Economics. Available at: http://2014.newclimateeconomy.report/wp-content/uploads/2014/11/LSE-Cities-2014-Transport-and-Urban-Form-NCE-Cities-Paper-03.pdf

World Bank (2016) *Central America Urbanisation Review – Making Cities Work for Central America.* Washington D.C., World Bank. Available at: http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2016/06/08/090224b0843a73b3/1_0/Rendered/PDF/final0report.pdf

IIASA, GEA Background Paper (2009) *Relationships between form, morphology, density and energy in urban environments*. Luxemburg, International Institute for Applied System Analysis. Available at: http://www.iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/GEA_Energy_Density_Working_Paper_031009.pdf

ECONOMIC MEASURES AND MODELLING

Duranton, G. & Puga, D. (2013) *The Growth of Cities*. Paris, Organisation for Economic Cooperation and Development. Available at: https://www.oecd.org/eco/growth/Growth_of_cities_Duranton.pdf

Keirstead, J., Samsatli, N. & Shah, N. (2009) *SynCity: An integrated tool kit for urban energy systems modelling*. Washington D.C., World Bank. Available at: http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/336387-1256566800920/6505269-1268260567624/Keirstead.pdf

Kruger, W. & Tait, L. (2015) *Implementation of the municipal energy efficiency and demand side management programme in South Africa*. Cape Town, University of Cape Town. Available at: http://www.mapsprogramme.org/wp-content/uploads/EEDSM-Implementation_Final_.pdf

Puppim de Oliveira, J.A. et al. (2013) Green economy and governance in cities: Assessing good governance in key urban economic processes. *Journal of Cleaner Production*, Vol. 58, pp. 138 – 152.

Sivakumar, A. (2013) *Modelling urban energy systems: Disaggregate activity-based models of demand*. Available at: https://www.bartlett.ucl.ac.uk/energy/news/documents/aruna-sivakumar

Tait, L. (2015) Evaluating the electrification program in urban settlements in South Africa. Cape Town, University of Cape Town. Available at: http://www.erc.uct.ac.za/sites/default/files/image_tool/images/119/Papers-2015/15-Tait-Evaluating_urban_electrification.pdf

Zhou, Y., Li, Y.P. & Huang, G.H. (2014) Integrated modelling approach for sustainable municipal energy system planning and management – A case study of Shenzen, China. *Journal of Cleaner Production*, Vol. 75, pp. 143 – 156.

TOPIC 2

MUNICIPAL WASTE AND ENERGY

WASTE TO ENERGY

One of the most persistent factors associated with the success or failure of waste to energy projects in developing cities is the social acceptability of waste-to-energy measures. This applies to a variety of waste-to-energy technology options, including landfill incineration and municipal waste-to-biogas digesters. Besides the potential usage of landfill gas as an energy resource, collecting this hazardous material is a key factor in waste management in the developing world. Landfill gas explosions are a common risk factor in new landfill projects, and the solubility of contaminants in landfill gas can be a major environmental issue, as noted for example in the conveyance of vinyl chloride compounds into groundwater sources.

There have been a number of measures to address this catalogued in the literature, notably in terms of cases in China. Zheng et al. (2014) details a wide variety of policy measures to further the development of both incineration and biogas technologies in the country. The 2007 National Programme on Climate Change in China extended the industrialisation of municipal solid waste incineration technologies, and laid a number of ground rules for the development of new incineration plants to address the concerns of previous projects, including siting new incinerators away from economically developed areas or where land is scarce. Minimum utilisation targets were also set under this plan, incentivising the sustainability improvement of the municipal solid waste management regime. (Aleluia & Ferrão 2016)

Economic and environmental sustainability of municipal waste-to-energy projects have been the critical factors in project success or failure in the majority of cases, particularly in South East Asian cases. Economic sustainability is also a key factor in majority of African cases, although the availability of currently-poorly managed municipal waste contributes to the effective economic sustainability of some African projects. (Oteng-Ababio 2013, Kurniawan et al. 2013)

The technology options appropriate for waste-to-energy applications in developing countries are often dependent on the prevalent composition of the municipal waste in the relevant context. This dictates a localised and context-specific approach, with a number of cases (for example, Oteng-Ababio 2013 Giza and Cairo cases) demonstrating the dangers of direct technology transfer from Western or more developed contexts.

SUSTAINABLE WASTE MANAGEMENT

To date there have been a number of barriers identified to the sustainable management of municipal solid waste in African cities. These fall into four main categories:

- Institutional and regulatory barriers
- Natural/physical barriers
- Operational barriers
- Socio-economic barriers

Institutional and regulatory barriers can include policies being poorly focused and lacking strategies for action, as well as a weak regulatory framework. Natural/physical barriers include the ease of availability of dumping grounds, the unplanned nature of a city's urban form, and the nature of the municipal waste the city produces. Operational barriers mainly focus on the organisations responsible for municipal waste management in the city, including limited scope of operations, poorly-paid and under-skilled staff, and unsuitable/obsolete equipment. Socio-economic barriers include insufficient funding for municipal waste management, a negative public attitude and an unsuitable investment climate for new operations in the sector (Ezeah & Roberts 2012).

Recommendations based on a survey of the above barriers in Abuja, Nigeria (Ezeah & Roberts 2012) focused primarily on the policy and regulatory environment for municipal waste management in the city. Weaknesses in the regulatory environment and the lack of a clear strategy for realisation of waste management policies have damaged the effectiveness of waste management activities in the city. The lack of participation of the private sector in waste management operations has also led to a rise in informal sector operations in the city, which are often unsustainable and can be illegal. Liberalisation of the waste sector and encouraging private sector participation was recommended to improve the sustainability of waste management.

There are, however, cases where top-down operations implemented by a national government or government agency have resulted in significant improvements in the sustainability of waste management operations. “For example, Malaysian projects involving incineration of municipal solid waste and refuse-derived fuel projects have proven reasonably successful, for example the RDF pilot plant in Sermenyih, Selangor” (Kadir et al. 2013). However, there have remained significant challenges to the construction of larger-scale waste-to-energy projects in Malaysia. According to Kadir et al. (2013) these include: ‘health risks associated with the emissions of toxic organic compounds and metals from stack, complications caused by disposal of inorganic residue and difficulty of monitoring facilities after the preliminary test burns have been conducted’.

Notably in African cities, there exists a persistent disconnection between formal waste management services and the operations conducted by the informal sector. A number of cases in West Africa (for example, Nigeria and Ghana) have shown the limitations of a centralised state operator model, with this position being incompatible with the socio-economic and physical realities of the country contexts. A lack of local capacity and insufficient financial investment has heightened the need for alternative approaches, at a more local scale and taking the specific context of the waste regime into account. Notably in Ghanaian cities, for example the capital Accra, informal waste collection services have performed better than the municipal authorities in areas with high population densities and a non-conducive spatial layout. A study of a number of varying-income areas of Accra discovered that upwards of 60% of respondents in middle-income areas used the services of informal-sector waste operations. The continued existence of the informal sector in waste management services in developing cities, despite often hostile regulatory environments and competition from public and private entities, denotes a gap in services that has not been addressed by the public and private sectors.

Therefore, the integration of informal and formal sectors can lead to a more sustainable waste management regime. Oteng-Ababio et al. (2013) offers a wide array of case studies of successful and unsuccessful efforts to integrate the informal and formal waste service sectors, covering a number of developing country contexts. (Ezeah & Roberts 2012, ESMAP 2012, Kasseva & Mbuligwe 2000, Kurniawan et al. 2013, Cheng & Hu 2010)

Key features of the successful case studies include:

- Organisation of the informal sector actors into a formalised entity, for example a union or trade organisation. A successful case of this was in Belo Horizonte, Brazil, with the formation of the Waste Picker's Association (ASMARE). The formation of the association and its integration into the city's formal waste management activities in 1993 guaranteed the informal sector workers rights to work in the city, and access to suitable facilities to more effectively operate.

- Organisation of informal workers' cooperatives to more effectively service under-serviced communities, for example low-income and informal settlements. In Mozambique, the capital Maputo's municipal authorities embarked on a joint project with GIZ (then GTZ) to improve waste collection, recovery and disposal. The organisation of the city's informal sector waste workers into cooperatives with the support of the programme increased the efficiency of their activities, and a higher standard of waste service was provided to the areas previously serviced by the informal sector operators. 45% of the low-income areas of the city had coverage by municipal collection services at the end of the program, with employment provided for over 250 workers.

- Lack of recognition for informal sector activities and the relationship between this and unsustainable waste management practices. An example of this in in Egypt, where the effectiveness of informal sector municipal waste workers was not considered in the reforms of the Cairo and Giza municipal waste collection systems in the 1990s. Contracts were awarded to multinational corporations, and a transfer of standard Western waste management technology and policy options was branded a failure, with companies regularly failing to meet a recycling quota of 20%, compared to the 70-80% achieved by the informal sector operations.

- Accessing organic waste to operate landfill gas-to-electricity projects. Both California and South Africa have experienced issues with accessing landfill gas for different reasons. Legislative difficulties in the Californian Energy Act of 1994 prohibit the distribution of landfill gas via pipeline off-site, meaning all generation from landfill gas has to be performed on-site, often increasing costs and hampering efficiency. Illegal dumping/littering affecting the volumes of landfill waste has been a problem for a number of South African municipalities in the sector, for example Ethekwini (formally Durban) municipality. These illegal or unregulated activities affect the amount of landfilled waste in the municipality, and therefore the amount of landfill gas produced.

REFERENCES FOR SUSTAINABLE WASTE MANAGEMENT

SUSTAINABLE WASTE MANAGEMENT AND POLICY

Aleluia, J. & Ferrão, P. (2016) Characterization of urban waste management practices in developing Asian countries: A new analytical framework based on waste characteristics and urban dimension. *Waste Management*, available online 21 May 2016.

Asian Institute of Technology/United Nations Environment Program (2010) *Municipal waste management report – Status-quo and issues in Southeast and East Asian countries*. Pathumthani, AIT. Available at: http://www.rrcap.ait.asia/Publications/MW_status_quo.pdf

ESMAP (2012) *A Primer on Energy Efficiency for Municipal Water and Wastewater Utilities*. Washington D.C., ESMAP. Available at: http://www.esmap.org/sites/esmap.org/files/FINAL_EECI-WWU_TR001-12_Resized.pdf

Ezeah, C. & Roberts, C.L. (2012) Analysis of barriers and success factors affecting the adoption of sustainable management of municipal solid waste in Nigeria. *Journal of Environmental Management*, Vol. 103, pp. 9 -14.

Ezeah, C. & Roberts, C.L. (2014) Waste governance agenda in Nigerian cities: A comparative analysis. *Habitat International*, Vol. 41, pp. 121 - 128.

Kadir, S.A.S.A. et al. (2013) Incineration of municipal solid waste in Malaysia: Salient issues, policies and waste-to-energy initiatives. *Renewable and Sustainable Energy Reviews*, Vol. 24, pp. 181 – 186.

Kasseva, M.E. & Mbuligwe, S.E. (2000) Ramifications of solid waste disposal site relocation in urban areas of developing countries: a case study in Tanzania. Resources, *Conservation and Recycling*, Vol. 28, pp. 147 – 161.

King, M.F. & Gutberlet, J. (2013) Contribution of cooperative sector recycling to greenhouse gas emissions reduction: A case study of Ribeirão Pires, Brazil. *Waste Management*, Vol. 33, pp. 2771 – 2780.

Kurniawan, T.A. et al. (2013) City-to-city level cooperation for generating urban co-benefits: the case of technological cooperation in the waste sector between Surabaya (Indonesia) and Kitakyushu (Japan). *Journal of Cleaner Production*, Vol. 58, pp. 43 – 50.

Melikoglu, M. (2013) Vision 2023: Assessing the feasibility of electricity and biogas production from municipal solid waste in Turkey. *Renewable and Sustainable Energy Reviews*, Vol. 19, pp. 52 – 63.

Oteng-Ababio, M., Arguello, J.E.M. & Gabay, O. (2013) Solid waste management in African cities: Sorting the facts from the fads in Accra, Ghana. *Habitat International*, Vol. 39, pp. 96 - 104.

Wang, L. et al. (2004) Emission reductions potential for energy from municipal solid waste incineration in Chongqing. *Renewable Energy*, Vol. 34, pp. 2074 – 2079.

Yang, N. et al. (2012) Greenhouse emissions from MSW incineration in China: Impacts of waste characteristics and energy recovery. *Waste Management*, Vol. 32, pp. 2552 – 2560.

Zheng, L. et al. (2014) Preferential policies promote municipal solid waste (MSW) to energy in China: current status and prospects. *Renewable and Sustainable Energy Reviews*, Vol. 36, pp. 135 – 148.

ECONOMIC AND TECHNICAL MODELS

Arafat, H.A. & Jijakli, K. (2013) Modeling and comparative assessment of municipal solid waste gasification for energy production. *Waste Management*, Vol. 33, pp. 1704 – 1713.

Chakraborty, M. et al. (2013) Assessment of energy generation potentials of MSW in Delhi under different technological options. *Energy Conservation and Management*, Vol. 75, pp. 249 – 255.

Gunamantha, M. & Sarto (2012) Life cycle assessment of municipal solid waste treatment to energy options: Case study of KARTAMANTUL region, Yogyakarta. *Renewable Energy*, Vol. 41, pp. 277 - 284.

Johari, A. et al. (2012) Economic and environmental benefits of landfill gas from municipal solid waste in Malaysia. *Renewable and Sustainable Energy Reviews*, Vol. 16, pp. 2907 –2912.

Nixon, J.D. et al. (2013) Evaluation of options for energy recovery from municipal solid waste in India using the hierarchical analytical network process. *Energy*, Vol. 59, pp. 215 – 223.

Rentizelas, A.A., Tolis, A.I. & Tatsiopoulos, I.P. (2014) Combined Municipal Solid Waste and biomass system optimization for district energy applications. *Waste Management*, Vol. 34, pp. 36 – 48.

Suberu, M.Y., Bashir, N. & Mustafa, M.W. (2013) Biogenic waste methane emissions and methane optimization for bioelectricity in Nigeria. *Renewable and Sustainable Energy Reviews*, Vol. 25, pp. 643 – 654.

Sufian, M.A. & Bala, B.K. (2006) Modelling of electrical energy recovery from urban solid waste system: The case of Dhaka city. *Renewable Energy*, Vol. 31, pp. 1573 – 1580.

Udomsri, S., Martin, A.R. & Fransson, T.H. (2010) Economic assessment and energy model scenarios of municipal solid waste incineration and gas turbine hybrid dual-fueled cycles in Thailand. *Waste Management*, Vol. 30, pp. 1414 – 1422.

Xydis, G., Nanaki, E. & Korodeos, C. (2013) Exergy analysis of biogas production from a municipal solid waste landfill. *Sustainable Energy Technologies and Assessments*, Vol. 4, pp. 20–28.

ENERGY FROM MUNICIPAL SOLID WASTE

Abila, N. (2014) Managing municipal wastes for energy generation in Nigeria. *Renewable and Sustainable Energy Reviews*, Vol. 37, pp. 182 – 190.

Abu-Qudais, M. & Abu-Qdais, H.A. (2000) Energy content of municipal solid waste in Jordan and its potential utilization. *Energy Conservation and Management*, Vol. 41, pp. 983 – 991.

Ali, G. et al. (2012) Green waste to biogas: Renewable energy possibilities for Thailand's green markets. *Renewable and Sustainable Energy Reviews*, Vol. 16, pp. 5423 – 5429.

Bidart, C., Fröhling, M. & Schultmann, F. (2013) Municipal solid waste and production of substitute natural gas and electricity as energy alternatives. *Applied Thermal Engineering*, Vol. 51, pp. 1107 - 1115.

Cheng, H. & Hu, Y. (2010) Municipal solid waste (MSW) as a renewable source of energy: Current and future practices in China. *Bioresource Technology*, Vol. 101, pp. 3816 – 3824.

Cheng, H. et al. (2007) Municipal solid waste fuelled power generation in China: A case study of waste-to-energy in Changchun city. *Environmental Science Technology*, Vol. 41, pp. 7509 – 7515.

Gebreegziabher, Z. et al. (2014) Prospects and challenges for urban application of biogas installations in Sub-Saharan Africa. *Biomass and Bioenergy*, Vol. 30, pp. 1 – 11.

Jain, S. & Sharma, M.P. (2011) Power generation from MSW of Haridwar city: A feasibility study. *Renewable and Sustainable Energy Reviews*, Vol. 15, pp. 69 – 90.

Mbuligwe, S.E. & Kassenga, G.R. (2004) Feasibility and strategies for anaerobic digestion of solid waste for energy production in Dar es Salaam city, Tanzania. *Resources, Conservation and Recycling*, Vol. 42, pp. 183 – 203.

Mustafa, S.S., Mustafa, S.S. & Mutlag, A.H. (2013) Kirkuk municipal waste to electrical energy. *Electrical Power and Energy Systems*, Vol. 44, pp. 506 – 513.

Ofori-Boateng, C., Lee, K.T. & Mensah, M. (2013) The prospects of electricity generation from municipal solid waste (MSW) in Ghana: A better waste management option. *Fuel Processing Technology*, Vol. 110, pp. 94 – 102.

Olugasa, T.T., Odesola, I.F. & Oyewola, M.O. (2014) Energy production from biogas: A conceptual review for use in Nigeria. *Renewable and Sustainable Energy Reviews*, Vol. 32, pp. 770 – 776.

Shi, Y. et al. (2013) Garden waste biomass for renewable and sustainable energy production in China: Potential, challenges and development. *Renewable and Sustainable Energy Reviews*, Vol. 22, pp. 432–437.

Singh, R.P. et al. (2011) An overview for exploring the possibilities of energy generation from municipal solid waste (MSW) in Indian scenario. *Renewable and Sustainable Energy Reviews*, Vol. 15, pp. 4797 – 4808.

Surendra, K.C. et al. (2014) Biogas as a sustainable energy sources for developing countries: Opportunities and challenges. *Renewable and Sustainable Energy Reviews*, Vol. 31, pp. 846 – 859.

Tsai, W.T. & Chou, Y.H. (2006) An overview of renewable energy utilization from municipal solid waste (MSW) incineration in Taiwan. *Renewable and Sustainable Energy Reviews*, Vol. 10, pp. 491 – 502.

Udomsri, S., Martin, A.R. & Martin, V. (2011) Thermally driven cooling coupled with municipal solid waste-fired power plant: Application of combined heat, cooling and power in tropical urban areas. *Applied Energy*, Vol. 88, pp. 1532–1542.

Unnikrishnan, S. & Singh, A. (2010) Energy recovery in solid waste management through CDM in India and other countries. *Resources, Conservation and Recycling*, Vol. 54, pp. 630 – 640.

TOPIC 3

TRANSPORT

Sustainability in urban transportation covers a wide variety of measures and technologies. Some broad categories can be determined from the wide-ranging case studies available in the literature. Mass-transit approaches are a common policy and technology mechanism used to promote sustainable urban transport, covering both rapid-transit routes as well as strengthening municipal transport links.

The promotion of alternative fuel use is another broad theme in the sphere of sustainable transport, particularly in biofuel use, with a number of examples in Brazilian cities, as well as some Sub-Saharan African cases (da Silva, Costa & Brondino (2007), da Silva, da Silva Costa & Macedo (2008)). An integrated approach has proven to be the most useful in a number of case studies in the literature, with aggregated approach papers such as Bräuninger et al. (2012) encompassing a wide variety of integrated and specific approaches.

Another point highlighted consistently in the literature is the synergy between transportation planning and urban land use planning in developing cities. Bräuninger et al. (2012) highlights a best practice case of Curitiba, in Brazil. From the 1960s onwards, Curitiba has been implementing an integrated transport city plan, with the city's first bus rapid transit line opening in 1974. Curitiba's city planners saw transport as the backbone of growth for the city, and as such also acquired strategic land before it was developed, providing city-subsidised housing for low-income communities, with already integrated transport links to the main economic zones. Residential and commercial zoning in the city has enabled policies such as parking restrictions in the downtown area to be implemented effectively, encouraging public transport use, and enabling the pedestrianisation of areas of the city centre.

Curitiba's bus rapid transit system is a widely-studied successful case in its own right. The system comprised of 340 routes, with a total network length of 1,100 km as of 2012. Five key urban corridors are complemented by orbital bus routes and feeder routes, maximising accessibility across the city. Advantages to this approach in general include the relatively low infrastructure costs compared to other mass transit measures, as well as flexibility in responding to development. Concentrating development along already existing bus corridors can help to generate travel demand for the system. Operating costs can be further reduced by competitively tendering routes, as is used in the Curitiba case. With a tendering public authority bearing the risk for revenues, effective regulation of fares to achieve the desired social and economic goals of the system is also simplified. The Curitiba system also operates a 'one journey, one ticket' system, with one flat fare required for a journey, regardless of distance or transfers. The design of the system - optimising the interchanges between feeder and trunk services - enables the system to function more effectively. Finally, the municipal authority retains control of fare pricing, enabling the authority to keep fares within the reach of the poorest users.

The context of an urban transport system is widely observed to be the critical factor in designing appropriate responses to the issue of transport sustainability. Godard (2013) compares West and North African transport systems, and observes that whilst similarities exist in the varying country contexts, significant structural differences mean bespoke responses will ultimately achieve greater success than a cross-cutting strategy. North African mass transit systems have provided positive experiences in the sector in recent years, including light rail transit systems in Tunis, as well as tram-based systems in Moroccan and Algerian cities. By contrast, West African (and Sub-Saharan African more generally) experiences in mass transit are limited, with a number of projects envisaged, but few coming to bear. The lack of appropriate institutional arrangements before projects commencing, as well as financial constraints, were determined to be the main constraining factors in the region.

Godard (2013) goes on to note the importance of the paratransit sector in considering the urban transport system of many African cities. Paratransit use has been the dominant public/collective mode of transport in a number of West African cities (with, for example, a 56% share in Yaoundé in 2010), covering modes such as minibuses, shared taxis and motorcycle taxis. The sector is characterised by the driver retaining operational responsibility for the vehicle, and paying a rental (mostly daily rentals) to the owner of the vehicle, keeping the surplus in fares as revenue.

The paratransit sector in many cities is subject to minimum regulation, with public authorities only intervening in terms of licenses and taxes. The sector is in general self-organised, and attempts at further regulating the paratransit sector are not numerous. Godard (2013) uses a case study of Dakar, Senegal, which experienced a World Bank-funded program of minibus fleet renewal from 2005 onwards: "The principle was to introduce regulatory measures which minibus operators could accept to benefit from financial facilities for the vehicle renewal". These include ticket systems for payments, rather than direct payments to controllers, and wages for drivers and controllers instead of direct payments from fare receipts.

Some outcomes from the Dakar World Bank program were the improvement of service, which was determined to be the result of improved operations rather than the vehicle renewal itself. Financial sustainability for the project was indirectly improved through the compensation payment for scrapped vehicles scheme in the city at the time, and Godard draws from this the necessity of direct or indirect subsidies in modernisation of paratransit. Another point highlighted is the lack of urgency in local authorities in adapting to the rapid evolution of the transport sector in general, and the paratransit sector in particular. This has been observed in other cases, such as in Morocco, where reorganisation and modernisation of the sector has been a very gradual process.

Another case study on the interactions between existing paratransit networks and new transportation schemes, particularly bus rapid transit, can be found in Schalekamp & Behrens (2010). Considering the case of South Africa, where a number of cities were/are planning integrated transport networks relying on the introduction of bus rapid transit, these reforms were also used as a mechanism for the reform of the paratransit sector, dominant in terms of market share, but unregulated. "National, regional and local paratransit groups objected to the proposed reforms, on the grounds of insufficient consultation and unclear roles in the new system, as well as concerns about redundancies". The paper highlights the importance of stakeholder consultation in new transport system planning; with the lack of consultation and expectation from municipal authorities that paratransit operators would be formalised and incorporated readily into scheduled public transport services, the paratransit sector was unwilling to cooperate with the goals of the municipal authority. (Jones, Tefe & Appiah-Opuku 2015)

The paper goes on to explore alternative approaches to engaging the paratransit sector in transport reform processes. Using a case study of initiatives underway as of 2010 in the Nelson Mandela Metropole and Cape Town, one recommendation is for paratransit to be part of a wide diversity of public transport initiatives in an urban area, with paratransit operators and bus rapid transit systems operating at different ends of an integrated business. The aforementioned municipalities have plans to stagger the implementation of bus rapid transit into an initial pilot phase, servicing the main urban corridors, which is then able to be used as leverage for the remaining incumbent operators to join a more wide-ranging implementation of the system. Stepped transitions to bus rapid transit integration and paratransit formalisation are also suggested as a means to assist in paratransit sector integration, initially by formalising the paratransit sector, then transitioning to an integrated operating company model, incorporating bus rapid transit services.

The importance of stakeholder engagement in delivering new public transport services is another recurring theme in the literature. This applies across all levels, from underserved communities and other users to paratransit operators to existing mass transit companies. Ibitayo (2010) highlights the importance of community consultation in the viability and sustainability of urban transport services for Lagos, Nigeria, focusing on commuter opinions and experiences. Dirgahayani & Nakamura (2012) also highlights the importance of user consultation in mass transit system design, using a Japanese and Indonesian city as case studies. Horizontal coordination among local stakeholders, for example by achieving coordination among transportation sub-systems (traffic, public transport, road network etc.) is shown to be a determining factor in the effectiveness of an urban transport system, and in the case of Matsuyama, the Japanese city studied, partnerships between local government, operators and citizenry in terms of discussion led to improved service quality and satisfaction.

The implementation of sustainable urban transport strategies is ultimately influenced by the form of the urban area in which the strategies exist. A significant number of factors in terms of urban form affect the development of sustainable transport strategies, including the siting of new residential and commercial areas and the transport links between them, the placement of existing urban zones and the morphology of existing urban sprawl, and the form of the existing road network and its current status. (Ahmad & Puppim de Oliveira 2016)

A particular case highlighting the transport challenges of dealing with unregulated urban expansion is in Olvera, Plat & Pochet (2013), considering the case of Dar es Salaam. Significant demographic growth from the late 1960s onwards, coupled with a lack of urban planning and high informality, led to large increases in the urban area of the city, with the maximum distance from city centre to city edge increasing by over 20km from the mid-1970s to the early 2000s. The radial structure of the existing road network, in conjunction with the concentration of jobs and urban facilities in the central business district, and wide, unplanned dispersion of residential zones, lead to increased pressures on the public transportation of the city.

The growth of unplanned settlements in Dar es Salaam has also pressurised the urban transport system and services, and the lack of capacity in transport services to adequately supply unplanned urban settlements in the city has contributed to economic and social polarisation of these communities.

Zhou et al. (2013) also “investigates the relationship between settlement morphology and transportation energy consumption, using Xiamen Island, China as a case study”. Housing policy in China over the last 30 years, in combination with the rapid urbanisation of the island, have greatly contributed to increases in transport energy consumption for the island’s residents. Using the TRANUS integrated land-use/transport model, separating demand and supply elements and defining activities that require transport, as well as transport options and accessibility, the paper proposes options for reducing both the transport energy consumption and CO2 emissions of the island. These scenarios are centred on the transition from older urban village settlements to newer commercial developments, with appropriate policy support, for example in giving priority to public transport development, and in integrated road construction and planning, in a four-stage network system to increase capacity and free flow of traffic.

The implementation of municipal government policy relating to transport in the Xiamen Island case is key to achieving the goals of the transport system transition. Without appropriate policy support in the form described above, both gasoline consumption and CO2 emissions were projected to be higher than a business-as-usual scenario, due to a greatly increased rate of private car use in the traffic make-up of the system. (Zhou et al. 2013, Godard 2013, Da Silva, Costa & Macedo 2008, Bräuninger et al. 2012, Sadhegi & Hosseini 2008, Sen, Tiwari & Upadhyay 2013)

REFERENCES FOR URBAN TRANSPORT

SUSTAINABILITY IN URBAN TRANSPORT

Ahmad, S. & Puppim de Oliveira, J.A. (2016) Determinants of urban mobility in India: Lessons for promoting sustainable and inclusive urban transportation in developing countries. *Transport Policy*, available online 30 May 2016.

Ariffin, R.N.R & Zahari, R.K. (2013) The challenges of implementing urban transport policy in the Klang Valley, Malaysia. *Procedia Environmental Sciences*, Vol. 17, pp. 469 – 477.

Ariffin, R.N.R & Zahari, R.K. (2013) Towards a sustainable urban transport system in the Klang Valley, Malaysia: The key challenges. *Procedia Social and Behavioural Sciences*, Vol. 85, pp. 638 – 645.

Bräuninger, M. et al. (2012) *Achieving sustainability in urban transport in developing and transition countries*. Dessau-Roßlau, German Federal Environment Agency, available at: http://www.thepep.org/ClearingHouse/docfiles/Achieving%20sustainability%20in%20urban%20transport%20in%20developing%20and%20transition%20countries.pdf

Da Silva, A.N.R., da Silva Costa, M. & Macedo, M.H. (2008) Multiple views of sustainable urban mobility: The case of Brazil. *Transport Policy*, Vol. 15, pp. 350–360.

Doll, C.N.H. & Balaban, O. (2013) A methodology for evaluating environmental co-benefits in the transport sector: application to the Delhi metro. *Journal of Cleaner Production*, Vol. 58, pp. 61-73.

Godard, X. (2013) Comparisons of urban transport sustainability: Lessons from West and North Africa. *Research in Transportation Economics*, Vol. 40, pp. 96-103.

Hidalgo, D. & Huizenga, C. (2013) Implementation of sustainable urban transport in Latin America. *Research in Transportation Economics*, Vol. 40, pp. 66-77.

Liaquat, A.M. et al. (2010) Potential emissions reduction in road transport sector using biofuel in developing countries. *Atmospheric Environment*, Vol. 44, pp. 3869-3877.

Lindholm, M. (2010) A sustainable perspective on urban freight transport: Factors affecting local authorities in the planning process. *Procedia Social and Behavioural Sciences*, Vol. 2, pp. 6205 – 6216.

Qureshi, I.A. & Lu, H. (2007) Urban Transport and Sustainable Transport Strategies: A Case Study of Karachi, Pakistan. *Tsinghua Science and Technology*, Vol. 12, Iss. 3, pp. 309-317.

Sohail, M., Maunder, D.A.C. & Cavill, S. (2006) Effective regulation for sustainable public transport in developing countries. *Transport Policy*, Vol. 13, pp. 177 – 190.

UN-HABITAT, Candiracci, S., Energy & Transport Policies Section (2009) *Climate change, urbanization and sustainable urban transport in developing country cities*. New York, UN-HABITAT. Available at: http://www.unhabitat.org/downloads/docs/7997_10872_Sara%20Candiracci.pdf

World Bank (2010) *Republic of Yemen: Urban Transport in Sana'a Strategy Note*. Washington D.C., World Bank. Available at: http://documents.worldbank.org/curated/en/2010/09/14106644/yemen-republic-urban-transport-sanaa-strategy-note

Zhao, P. (2010) Sustainable urban expansion and transportation in a growing megacity: Consequences of urban sprawl for mobility on the urban fringe of Beijing. *Habitat International*, Vol. 34, pp. 236 – 243.

POLICY AND REGULATION FOR URBAN TRANSPORT

Dhakal, S. (2003) Implications of transportation policies on energy and environment in Kathmandu Valley, Nepal. *Energy Policy*, Vol. 31, pp. 1493 –1507.

Gordon, C. (2012) The challenges of transport PPP's in low-income developing countries: A case study of Bangladesh. *Transport Policy*, Vol. 24, pp. 296 – 301.

Timilsina, G.R. & Dulal, H.B. (2011) Urban Road Transportation Externalities: Costs and Choice of Policy Instruments. *World Bank Res Obs*, Vol. 26(1), pp. 162 - 191.

Kunchornrat, J., Pairintra, R. & Namprakai, P. (2008) Sustainable energy management in urban transport: The public's response of road congestion pricing in Thailand. *Renewable and Sustainable Energy Reviews, Vol.* 12, pp. 2211–2226. http://dx.doi.org/10.1016/j.rser.2007.04.014

Kutzbach, M. (2009) Motorization in developing countries: Causes, consequences and effectiveness of policy options. *Journal of Urban Economics*, Vol. 65, pp. 154 – 166.

Ong, H.C., Malia, T.M.I. & Masjuki, H.H. (2012) A review on energy pattern and policy for transportation sector in Malaysia. *Renewable and Sustainable Energy Reviews*, Vol. 16, pp. 532–542.

Sadhegi, M. & Hosseini, H.M. (2008) Integrated energy planning for transportation sector—A case study for Iran with techno-economic approach. *Energy Policy*, Vol. 36, pp. 850–866.

Sen, A.K., Tiwari, G. & Upadhyay, V. (2013) Strategies of state and local government in management of urban transport problems – A case of Delhi. *Research in Transportation Economics*, Vol. 38, pp. 11 – 21.

Sohail, M., Maunder, D.A.C. & Miles, D.W.J. (2004) Managing public transport in developing countries: Stakeholder perspectives in Dar es Salaam and Faisalabad. *International Journal of Transport Management*, Vol. 2, pp. 149 – 160.

Takiguchi, H. & Mizuno, O., Global Environment Facility (2012) *Investing in Sustainable Transport and Urban systems – The GEF Experience*. Washington D.C., GEF.Available at: http://www.thegef.org/gef/sites/thegef.org/files/publication/gef_transportBrch_nov2012_r3.pdf

Vanderschuren, M., Lane, T.E. & Korver, W. (2010) Managing energy demand through transport policy: What can South Africa learn from Europe? *Energy Policy*, Vol. 38, pp. 826–831.

FORMALISATION AND USER CONSULTATION

Dirgahayani, P. & Nakamura, F. (2012) Fostering partnerships towards sustainable urban mobility from the national to local level: Matsuyama, Japan and Yogyakarta, Indonesia. *IATSS Research*, Vol. 36, pp. 48 – 55.

Ibitayo, O.O. (2012) Towards effective urban transportation system in Lagos, Nigeria: Commuters' opinions and experiences. *Transport Policy*, Vol. 24, pp. 141 – 147.

Jones, S., Tefe, M. & Appiah-Opuku, S. (2015) Incorporating stakeholder input into transport project selection – A step towards urban prosperity in developing countries? *Habitat International*, Vol. 45, Part 1, pp. 20 – 28.

Rahman, M., Timms, P. & Montgomery, F. (2012) Integrating BRT Systems with Rickshaws in Developing Cities to Promote Energy Efficient Travel. *Procedia - Social and Behavioral Sciences*, Vol. 54, pp. 261 – 274.

Salon, D. & Aligula, E.M. (2012) Urban travel in Nairobi, Kenya: analysis, insights, and opportunities. *Journal of Transport Geography*, Vol. 22, pp. 65–76.

Schalekamp, H. & Behrens, R. (2010) Engaging paratransit on public transport reform initiatives in South Africa: A critique of policy and an investigation of appropriate engagement approaches. *Research in Transportation Economics*, Vol. 29, pp. 371 – 378.

URBAN FORM

Chen, H., Jia, B. & Lau, S.S.Y. (2008) Sustainable urban form for Chinese compact cities: Challenges of a rapid urbanized economy. *Habitat International*, Vol. 32, pp. 28 – 40.

da Silva, A.N.R., Costa, G.C.F. & Brondino, N.C.M. (2007) Urban sprawl and energy use for transportation in the largest Brazilian cities. *Energy for Sustainable Development*, Vol. 11, No. 3, pp. 44 – 50.

Olvera, L.D., Plat, D. & Pochet, P. (2003) Transportation conditions and access to services in a context of urban sprawl and deregulation. The case of Dar es Salaam. *Transport Policy*, Vol. 10, pp. 287 – 298.

Zhou, J. et al. (2013) Exploring the relationship between urban transportation energy consumption and transition of settlement morphology: A case study on Xiamen Island, China. *Habitat International*, Vol. 37, pp. 70-79.

MODELLING, INDICATORS AND FRAMEWORKS

Bertolini, L., le Clercq, F. & Kapeon, L. (2005) Sustainable accessibility: A conceptual framework to integrate transport and land use plan-making. Two test-applications in the Netherlands and a reflection on the way forward. *Transport Policy*, Vol. 12, pp. 207 – 220.

Jones, S., Tefe, M. & Appiah-Opoku, S. (2013) Proposed framework for sustainability screening of urban transport projects in developing countries: A case study of Accra, Ghana. *Transportation Research Part A*, Vol. 49, pp. 21 – 34.

Miranda, H.d.M. & da Silva, A.N.R. (2012) Benchmarking sustainable urban mobility: The case of Curitiba, Brazil. *Transport Policy*, Vol. 21, pp. 141 – 151.

Nkurunziza, A. et al. (2012) Examining the potential for modal change: Motivators and barriers for bicycle commuting in Dar-es-Salaam. *Transport Policy*, Vol. 24, pp. 249 – 259.

Santos, A.S. & Ribeiro, S.K. (2013) The use of sustainability indicators in urban passenger transport during the decision-making process: The case of Rio de Janiero, Brazil. *Current Options in Environmental Sustainability*, Vol. 5, Iss. 2, pp. 251 – 260.

Shiau, T-A. & Liu, J-S. (2013) Developing an indicator system for local governments to evaluate transport sustainability strategies. *Ecological Indicators*, Vol. 34, pp. 361 – 371.

Charles, M.B. et al. (2011) Transport energy futures: Exploring the geopolitical dimension. *Futures*, Vol. 43, pp. 1142–1153.

El-Fadel, M. & Bou-Zaid, E. (1999) Transportation GHG emissions in developing countries - The case of Lebanon. *Transportation Research*, Part D4, pp. 251-264.

Katheler, R.M., GTZ (2002) *Urban transport and poverty in developing countries*. Bonn, German Technical Cooperation GmbH (GIZ). Available at: http://www.gtkp.com/assets/uploads/20091127-182046-6236-en-urban-transport-and-poverty.pdf

Lefèvre, B. (2009) Long-term energy consumptions of urban transportation: A prospective simulation of ''transport–land uses'' policies in Bangalore. *Energy Policy*, Vol. 37, pp. 940–953.

Mraihi, R., ben Abdallah, K. & Abid, M. (2013) Road transport-related energy consumption: Analysis of driving factors in Tunisia. *Energy Policy*, Vol. 62, pp. 247–253.

Poumanyvonga, P., Kanekoa, S. & Dhakalb, S. (2012) Impacts of urbanization on national transport and road energy use: Evidence from low, middle and high income countries. *Energy Policy*, Vol. 46, pp. 268–277.

Shakibaei, S., Alpkokin, P. & Gunduz, U. (2011) Oil rich countries and sustainable mobility: Challenges in Tabriz. *Procedia Social and Behavioural Sciences*, Vol. 20, pp. 171 – 176.

TOPIC 4

BUILDINGS AND ENERGY

The broad spectrum of measures to address energy concerns in buildings in urban areas of developing countries can be split predominantly into measures affecting construction and planning of buildings, and demand-side measures affecting the users of buildings. Sustainable construction and operation of buildings, the carbon content of buildings materials in new and existing buildings, thermal energy performance of buildings and planning for new and existing construction in terms of densification and energy consumption patterns of residents have all been identified in the literature as factors affecting the overall energy consumption attributable to buildings (Jiang et al. (chair), 2009, Heravi & Qaemi, 2014, Kadian, Dahiya & Garg, 2007).

Demand-side measures examined in the literature include improved energy efficiency of appliance stock, as well as the importance of user behaviour on building energy performance (Ouyang & Hokao 2009), covering energy efficiency gains from changes in personal behaviour, and energy consumption patterns in different housing types. The behavioural analysis measures have also been shown to be cross-applicable over differing country contexts, and within different regions of the same country (Ofori, 2007, Mousa 2015).

Another distinction in the literature exists in the separation of measures addressing the energy efficiency of buildings and measures addressing the carbon production and content of buildings and buildings materials. Carbon reduction measures and measures that address energy efficiency are not necessarily cross-applicable in terms of strategy and policy development (Koizumi, 2007, UN-HABITAT, 2010, Chen et al. (2015).

The relationship between urban form, building energy consumption and carbon emissions is determined to have a significant effect. Qin & Han (2013) for example examines evidence from Beijing, China, on the relationship between planning parameters; for example population density, land use, accessibility to public transport, and balance between jobs and housing, and household carbon emissions. The paper analyses 1,227 households in three high-carbon and two low-carbon neighbourhoods in the city, determining a number of conclusions based on these planning parameters. Higher building density areas in the city generally used less energy for cooling and heating per building area, and the study also noted the association with greater use of low-carbon transport modes, for example public transport, of high building density areas. The paper goes on to note the association between transport energy consumption and land use planning, with mixed land-use areas shortening commuting distances, increasing the employment/population ratio and balancing the jobs/housing mix. Better access to employment locations resulting from mixed-use zoning can also help to reduce carbon emissions, through reducing transport carbon emissions. This paper highlights again the interconnected nature of urban planning and strategy, with building planning affecting transport energy consumption, as well as affecting the energy end-use patterns of behaviour of building users.

Mandatory energy efficiency codes for new buildings can assist in reducing building stock energy consumption and carbon production. Liu, Meyer & Hogan (World Bank/ESMAP, 2010) provides a number of case studies on early adopters of building energy efficiency codes in developing countries, and also goes into detail on strategies for mainstreaming building energy efficiency codes, and global cooperation and knowledge exchange to achieve this. Studying China, India, Mexico and Egypt as examples, the paper summarises the four programs, noting the successful and unsuccessful examples among them. (Chandel, Sharma & Marwaha 2016)

Experiences from the programs are separated into key conditions for the successful implementation of energy efficiency codes. These include political commitment and incentives to energy efficiency, government oversight and regulation of the construction sector, compliance capacity of the supply chain for energy efficient materials, and financing mechanisms for energy efficiency improvements. Finally, a key lesson that the paper highlights is the importance of setting incremental targets for energy efficiency program implementation in buildings, starting with realistic goals, and consciously taking note of compliance cost and the effect on the construction sector and market of the program.

Liu, Meyer & Hogan (World Bank/ESMAP, 2010) goes on to detail international assistance strategies for mainstreaming building energy efficiency codes in developing countries, most notably in terms of financing and supporting the effectiveness of regulation and oversight in government. Incremental cost financing, and bridging the gap in financing common in low and lower-middle income countries, is noted to be a critical issue, with the authors recommending targeting market segments where economic benefits are greatest, and enforcement is most likely to be effective. The paper also recommends knowledge exchange in terms of policy assistance for developing countries, streamlining building law and permitting process, as well as strengthening compliance and enforcement infrastructure for building energy efficiency, for example by involving nongovernmental entities for regulatory processes. (Kuo, Lin & Hsu 2016)

Thermal energy consumption in the developing world has been significantly affected by the rapid urbanisation experienced in many countries (Monkkonen 2013). Barnes, Krutilla & Hyde (2004) examines the urban household energy transition, characterising it with a typology of energy usage. The pattern begins with high woodfuel utilisation, through the use of "transition" fuels such as kerosene or charcoal, to implementing LPG and electricity usage for household energy needs. The paper examines Hyderabad's urban transition as a case study, particularly policy mechanisms that affected the transition to modern fuels the urban population has undergone. In particular, subsidies for fuel purchasing for poorer communities led to increased use of LPG in households, through government-operated networks, which in turn led the fuel-wood sector, operating on market principles and largely unregulated, to replace its residential customer base with commercial customers, supplanting low-quality coal as their fuel of choice.

Subsidy mechanisms are an important factor in targeting energy transitions for the poorest consumers, moving away from so-called "traditional" fuels to modern energy services, however the paper also identifies the need to carefully target these subsidies to benefit the poorest. For example in the Hyderabad case, higher-income groups were receiving the majority of the subsidy expenditure by the government, due to the targeting of subsidies directly at the price of LPG and electricity, leading larger consumers to benefit greater from the reductions. In addition, the targeting of subsidies across modern and transition forms of energy was not optimal for reaching poorest consumers, who only benefitted to a great extent from the kerosene subsidies.

The household energy transition is a recurring theme across the literature, particularly the concept of the "energy services ladder", where households' currently utilising traditional energy sources such as fuel-wood transition to more modern energy services, such as LPG and kerosene, through transition fuels, higher in quality than traditional fuel choices, such as charcoal. Sovacool (2011) examines the concept in detail, dividing household energy services into lower, middle, and upper income brackets, and also differentiating energy carriers from energy services, defining services as "benefits that energy carriers produce for human wellbeing". Lower income households are characterised by greater numbers of fuels and carriers, but fewer numbers of services, with middle and upper income households utilising a much broader range of energy services. The author concludes that examining fuel choice in terms of energy services leads to a potential reorientation of priorities for household energy policy, focusing less on raw energy carrier amounts and provision, and more on the services that energy can provide (lighting, heating, cooking etc.).

Rapid urbanisation in developing countries is also changing the makeup of household energy consumption within countries, with a growing disparity being observed between rural and urban areas (Kibwami & Tutesigensi 2016). Miah et al. (2011) for example examines this effect in Bangladesh, noting clear differences in household fuel consumption between rural and peri-urban areas, with rural areas dependant on fuel-wood and other biomass sources, and peri-urban areas having a more diversified energy mix including electricity more often. The key determining factor in the Bangladeshi case in determining household fuel usage was disposable income of the households, with increases in disposable income being linked to improvements in efficiency and sustainability of fuel choices. Other factors included family size, dwelling type and size, and educational status. The authors derive policy recommendations from these conclusions also, suggesting a diversification of priorities for energy policy to focus on the individual needs of economic groups in the country. (Rothwell et al. 2015)

In terms of demand-side measures, appliances are a common theme across the literature to target for energy efficiency improvements. Particularly in warm climates, air conditioning units are a significant contributor to urban energy consumption (Elahee 2014). Koizumi et al. (2010) for example examines the role that the Clean Development Mechanism can play in promoting improved energy efficiency of air conditioners in developing countries. The paper notes for example a difference in average energy efficiency levels in countries with indigenous production capacity compared to those that don't, using case studies of China and Ghana respectively. The sets of barriers to improved energy efficiency in these differing contexts were also determined to lie in different areas. Countries with indigenous air conditioner production capacity were more likely to suffer from financial and business management barriers, whereas countries which import air conditioning units are more likely to suffer from policy and information technology barriers in the diffusion of efficient air conditioners. For example, in the case of Ghana, the potential for efficient air conditioning has largely not been realised, due to a lack of capacity in many government agencies (for example, customs officials), as well as in importers, distributors and consumers to identify the benefits of efficient equipment. (Ofori 2007, Iwaro & Mwasha 2010, GNESD 2013, Chenari, Carrilho & da Silva (2016)

REFERENCES FOR BUILDINGS AND ENERGY

SOCIO-ECONOMIC ANALYSIS AND POLICY

Barnes, D., Krutilla, K. & Hyde, W. (2004) *The Urban Household Energy Transition: Energy, Poverty, and the Environment in the Developing World*. Washington D.C., World Bank/ESMAP. Available at: https://www.esmap.org/sites/esmap.org/files/Rpt_UrbanEnergyTransition.pdf

Chandel, S.S., Sharma, A. & Marwaha, B.W. (2016) Review of energy efficiency initiatives and regulations for residential buildings in India. *Renewable and Sustainable Energy Reviews*, Vol. 54, pp. 1443 – 1458.

Chen, Y. et al (2015) Analysis on the carbon trading approach in promoting sustainable buildings in China. *Renewable Energy*, Vol. 84, pp. 130 – 137.

Chenari, B., Carrilho, J.D. & da Silva, M.G. (2016) Towards sustainable, energy-efficient and healthy ventilation strategies in buildings: A review. *Renewable and Sustainable Energy Reviews*, Vol. 59, pp. 1426 – 1447.

Elahee, M.K. (2014) Energy Management and Air-Conditioning in Buildings in Mauritius: Towards Achieving Sustainability in a Small-Island Developing Economy Vulnerable to Climate Change. *Energy Procedia*, Vol. 62, pp. 629 – 638.

GNESD 2013. Country report (India). *Energy poverty in developing countries' urban poor communities: assessments and recommendations*. Urban and Peri-urban energy access III. Report prepared for the Global Network on Energy for Sustainable Development by The Energy and Resources Institute (TERI). Roskilde, Denmark. Roskilde, GNESD. Available at: http://www.gnesd.org/~/media/Sites/GNESD/Publication%20pdfs/Urban%20Peri-Urban%20Theme/UPEA%20III%20-%20Newly%20Edited/TERI_final.ashx

Heravi, G. & Qaemi, M. (2014) Energy performance of buildings: The evaluation of design and construction measures concerning building energy efficiency in Iran. *Energy and Buildings*, Vol. 75, pp. 456 – 464.

Iwaro, J. & Mwasha, A. (2010) A review of building energy regulation and policy for energy conservation in developing countries. *Energy Policy*, Vol. 38, pp 7744–7755.

Jiang, Y. et al (chair) (2009) *Energy efficiency and urban development (the buildings sector and the transport sector)*. Beijing, China Council for International Cooperation on the Environment and Development, CCICED. Available at: http://www.cciced.net/encciced/policyresearch/report/201205/P020120529358133354649.pdf

Kadian, R., Dahiya, R.P. & Garg, H.P. (2007) Energy-related emissions and mitigation opportunities from the household sector in Delhi. *Energy Policy*, Vol. 35, Iss. 12, pp. 6195 – 6211.

Kibwami, N. & Tutesigensi, A. (2016) Integrating clean development mechanism into the development approval process of buildings: A case of urban housing in Uganda. *Habitat International*, Vol. 53, pp 331 – 341.

Koizumi, S. (2007) *Energy Efficiency of Air Conditioners in Developing Countries and the Role of CDM*. Paris, International Energy Agency. Available at: https://www.iea.org/publications/freepublications/publication/Energy_Efficiency_Air_Conditioners.pdf

Kuo, C-F.J., Lin, C-H. & Hsu, M-W. (2016) Analysis of intelligent green building policy and developing status in Taiwan. *Energy Policy*, Vol. 95, pp. 291 – 303.

Liu, F., Meyer, A.S. & Hogan, J.F. (2010) *Mainstreaming Building Energy Efficiency Codes in Developing Countries: Global Experiences and Lessons from Early Adopters*. Washington D.C., World Bank. Available at: http://www.esmap.org/sites/esmap.org/files/WP_204_GBL_Mainstreaming%20Building%20Energy%20Efficiency%20Codes%20in%20Developing%20Countries_Overview_1.pdf

Monkkonen, P. (2013) Urban land-use regulations and housing markets in developing countries: Evidence from Indonesia on the importance of enforcement. *Land Use Policy*, Vol. 34, pp. 255 – 264.

Mousa, A. (2015) A Business approach for transformation to sustainable construction: an implementation on a developing country. *Resources, Conservation and Recycling*, Vol. 101, pp. 9 – 19

Ofori, G. (2007) Clients' Role in Attainment of Sustainability in Housing: The Case of Singapore and Lessons for Developing Countries. *Journal of Construction in Developing Countries*, Vol. 12, No. 2, 2007. http://web.usm.my/jcdc/vol12_2_2007/1_George%20Ofori%20(p.1-20).pdf

Ouyang, J. & Hokao, K. (2009) Energy-saving potential by improving occupants' behavior in urban residential sector in Hangzhou City, China. *Energy and Buildings*, Vol. 41, pp. 711 – 720.

Rothwell, A. et al (2015) Feeding and housing the urban population: Environmental impacts at the peri-urban interface under different land-use scenarios. *Land Use Policy*, Vol. 48, pp. 377 – 388.

Sovacool, B.K. (2011) Conceptualizing urban household energy use: Climbing the "Energy Services Ladder". *Energy Policy*, Vol. 39, Iss. 3, pp. 1659 – 1668.

Qin, B. & Han, S.S. (2013) Planning parameters and household carbon emission: Evidence from high- and low-carbon neighborhoods in Beijing. *Habitat International*, Vol. 37, pp. 52 – 60.

TOPIC 5

ELECTRICITY AND PERI-URBAN ENERGY

WHAT HAS BEEN WRITTEN TO DATE ON THE TOPIC?

A significant number of papers and articles have been written on the peri-urban situation in Africa, in particular South Africa and East African countries such as Tanzania and Kenya (Scott, Dunn & Sugden 2003; Gaunt et al. 2012; Parsa et al. 2011, Marais & Ntema 2013, Visagie 2008, Menshawy, Ali & Salman 2012). However, the current body of literature covers a wide range of both countries and continents, including South America (World Bank/ESMAP 2008; Bravo, Kozulj & Landaveri 2008), India (World Bank/ESMAP 2008; Dhingra et al. 2008) and South East Asia, particularly Thailand (Winayanti & Lang 2004; Asian Institute of Technology 2008; Shrestha et al. 2008, Hossain 2012).

A large proportion of the literature found for this review focuses on “slums”, as a distinct sub-class of “informal settlements” (Scott, Dunn & Sugden 2003; Asian Institute of Technology 2008). These items most often focus on the poorest segment of the communities they are found in (World Bank/ESMAP 2008), and in majority focus on the Indian sub-continent and South East Asia (Winayanti & Lang 2004; Asian Institute of Technology 2008).

The majority of papers that use the “informal settlements” definition tend to focus on relatively more-established households and communities, although still on an informal, and often illegal basis (Mimi & Ecer 2010; Gaunt et al. 2008; Parsa et al. 2011). The difference in the use of the two terms does not appear to be clearly defined, although clear geographical boundaries in terminology use exist (“slum” most commonly used for India/Bangladesh/Thailand, “informal settlement” for sub-Saharan Africa, Brazil, Colombia etc.).

HOW DO MUNICIPALITIES ELECTRIFY INFORMAL SETTLEMENTS/OTHER NON-ELECTRIFIED AREAS?

There are two primary approaches adopted by municipalities when considering the electrification of informal settlements with the electricity utility carrying out the connections: a blanket electrification approach, where all households in the target area are electrified, or a selective electrification approach, where households are connected only once they've paid a connection fee. The blanket approach generally uses an alternative mechanism to recover the electrification fee after the fact.

The selective approach has some disadvantages, particularly in terms of illegal connections. Under the selective electrification model, there are no disincentives towards continuing to use an illegal electricity connection, which perpetuates the safety concerns, loss in revenue for the utility, and necessity for regular policing and disconnection that entails. Particularly in South Africa, where both models have been operated at various stages, the poorest are often the slowest to acquire formal electricity connections, and there is little incentive to move away from free, if unsafe and unreliable, illegal connections. (Marshall et al 2009)

The blanket electrification approach, in South Africa, has been shown to reduce substantially, if not half, illegal connections. This approach also reduces the costs of making multiple visits to connect households separately. Connection fees are most commonly nominal under this method, with connection costs ranging from R 8,000 – 12,000 (£443 – 670), and normal fees in the region of a few hundred rand. Prepayment meters as used in South Africa allow the distribution companies to recover connection fees over a period of time until the fee is paid. (Gaunt et al. 2008, Visagie 2008, ICLEI 2014).

Many electricity utilities tend to see poor households as a problem, and not as potential clients. A standard approach, when faced with the loss of revenue through illegal connections, is to remove the connections instead of developing innovative methods to increase their client base. The switch to electricity from traditional fuels for many of the poorest households is hindered by high connection and standing charges, and high equipment costs, for example with wiring.

Utilities are often reluctant to provide a new electricity connection, or electricity services more generally, to areas where there is doubt about the legal tenure of properties, and where the dwellings are not considered to be a formal construction. This has been noted to be the case in Brazil previously (Droege (ed.) 2008, ESMAP 2011).

The formalisation of illegal electricity connections through grid extension and formal metering has also been seen to work in Argentina. Prepayment systems have been introduced by utilities such as Edenor, using a system similar to a pay-as-you-go mobile phone, with a single-use printed code distributed by vouchers at local stores, ensuring easy access. In the trial areas of Buenos Aires where Edenor piloted this model, ninety percent of respondents (from a base of 150) reported that they appreciated the utility's policy of converting illegal electricity connections into legal ones with the provision of a pre-paid electricity meter. Similar positive experiences with slot meters have been found in Nigeria, where it was determined that regular meters led to irregular payments, hence the introduction of slot meters for poorer households, or those with new electricity connections, at the same rate for regular meters. (Droege (ed.) 2008). Formalisation of property rights and the provision of basic urban services (water and electricity) has also been a part of the settlement upgrading process in a number of south-eastern European countries, for example Albania and Greece (Potsiou, 2014).

WHAT IS THE APPROACH TOWARDS INFORMAL SETTLEMENTS?

A number of informal settlement electrification programs have been undertaken to date through central government programs, as well as through government partnering with private organisations. For example, slum electrification programs were included in the Brazilian government's utility upgrade program for Rio de Janeiro, with the main electricity provider in the city, Light Servicos de Electricidad SA, offering a 42% discount on meter installation for low-income residents in favela areas, with an additional option for payment to be carried out through 24 separate US$3 instalments (Scott, Dunn & Sugden 2003).

Particularly in South Africa, in part due to the prevailing political landscape there through the Free Basic Electricity Allowance and policies such as the Guidelines for the Electrification of Unproclaimed Areas, informal settlement electrification has been high on the list of political priorities. This is usually achieved through grid extension to the unelectrified settlement. However, the issue of illegal electricity connections is still a persistent one. ESKOM (the national utility) has also previously received criticism for the unsustainability of its electrification program, due to the very fact it was electrifying “unproclaimed” areas.

However, with the Guidelines for the Electrification of Unproclaimed Areas, illegal settlements acquired a measure of permanence in the eyes of the law, and were able to apply for grid connection in the manner of a formal settlement. The Free Basic Electricity tariffs also do not have an immediate impact on the very poor, as they are not electrified, and subsidy leakage has been identified as a key issue in the program. The South African approach to date has involved thorough community engagement pre-electrification, and flexibility in the regulation of, and technical options for, the provision of grid electricity to the settlement. (Gaunt et al. 2008, Bekker et al. 2008, Singh et al 2014)

In India, the most common (and dominant) method for electrifying new households is through grid extension, particularly in urban and peri-urban areas. However, as is common in Indian cities across most federal regions, the illegality of slum communities in the eyes of the municipal authorities was a key barrier to legal electricity access. A legacy of mistrust between the communities and utility companies due to the prevalent illegal connections also hindered formalisation of access. In Delhi, the Bhalla Factory slum was assisted in overcoming these barriers by a Delhi-based NGO, the Integrated National Development centre for Advancement Reforms and Education (INDCARE Trust). The NGO liaised with both the municipal electricity authorities and the Mihila Housing Trust to arrange microfinance for residents of the slum, and ensure timely repayment of the loans, in order that the community could better afford the high up-front costs of grid connection, and assure the utility of the measure of the community’s financial and physical stability. (World Bank/ESMAP 2008).

WHO IS INVOLVED?

In South Asia, particularly in India, the research into un-electrified communities, informal settlement electricity usage and illegal connections is predominantly done by the electricity utility responsible for the surrounding area or the national/state utility where relevant. Utilities are particularly responsible for the majority of data relating to illegal electricity connections in slum communities, both in terms of non-technical electricity losses and lost revenue. In India particularly, the process between utility and consumer can be a two-way one, with NGOs often acting as intermediaries between co-operatives and informal settlement community groups (World Bank/ESMAP 2008, Shrestha 2008).

In common with the experience seen in India/South Asia, municipal electricity distributors are the main organisations responsible for the majority of research into informal settlement electrification in South Africa. This is evident both in the approach taken to electrifying a settlement, and in the technical options available to the distributor (Gaunt et al. 2008, Visagie 2008). In Senegal, also, the main body responsible for research into peri-urban electrification is SENELEC, that national utility, although this is not their specific aim: for example, the utility considers the entire Dakar region to be “urban” under their designations, making no distinction between the formal and informal settlements present (Fall et al. 2008).

The South American experience appears to be distinct from this, with local and national governments being more involved in the research and decision-making process alike for peri-urban electrification. For example, in Argentina, the national energy policies relating to the poorest sectors of society have included regularisation of electricity users in the Greater Buenos Aires region using an illegal connection. In addition, the development of a “social tariff” for the poorest electricity users in conjunction with EDENOR, a Buenos Aires distribution company, has been undertaken. Government involvement in informal settlement electrification is common in Brazil also, where the national government has been involved through the national energy policy in the provision of energy to, and regularisation of supply to, informal settlements in the country (Bravo, Kozulj & Landaveri 2008, Mimmi & Ecer 2010).

In terms of the decision-making process for choosing informal settlements to electrify, utilities often have the final say. This arises from the need for the utility to provide a viable electricity service to the informal settlement, and recover its costs. Decision-making in terms of electricity pricing policy for informal settlement connections also rests solely with the utility in the majority of cases (Gaunt et al. 2008, Asian Institute of Technology 2008, Shrestha et al. 2008).

A number of cases, particularly in India and South Asia more widely, suggest some collaborative decision-making power with NGOs and community groups, with NGOs often being involved in initial liaison activities and project management with utilities/municipal governments to secure formal electricity connections for the community. Community organisation to lobby for improved services is a particularly common theme in Indian peri-urban electrification to date, for example with the collaboration between the INDCARE NGO and the Bhalla Factory community groups previously mentioned in Delhi. (World Bank/ESMAP 2008, Fall et al. 2008)

The South American experience is that of governments, both local and national, being more involved with the decision-making for slum electrification. This is achieved through policy mechanisms, as well as partnering with electricity utilities in order to electrify and regularise connections in slum communities. Local government organisations are also a key player in Indian peri-urban electrification, as a key precursor to a formal electricity connection in the country is formal property rights, which are regulated by the municipal government. In South East Asia, government policy has been traditionally more focused on land use, rather than direct electricity policies for informal settlement (Lusugga & Kironde 2006). However, the Thai government has instituted electricity tariffs in order to assist the poorest consumers, with a “reduced tariff” for monthly consumers up to 150 kWh being available (Bravo, Kozulj & Landaveri 2008, Shrestha et al. 2008, Dhingra et al. 2008).

WHAT ARE THE CRITERIA TO SELECT AN AREA TO BE ELECTRIFIED?

In South Africa, the government classifies informal settlements for electrification purposes into three categories based on the suitability of the land they occupy for habitation and the projected permanence of the settlement.

Category 3 settlements are those on unsuitable land (such as in dangerous or toxic/otherwise unsafe areas) which need relocation. These are the least likely to be electrified, although well-established Category 3 settlements are considered by the DoE on a case-by-case basis. Category 2 settlements are those not in need of immediate relocation, and are eligible for electrification subsidies if they are not relocated within 3 years of initial assessment. Category 1 settlements are those on suitable land, and likely to go through in-situ formalisation and upgrading, and are immediately eligible for electrification subsidies. The definition of a slum community has also been an important, if non-transparent, factor in the selection for “upgrading” activities undertaken by Egyptian municipal authorities (Gaunt et al. 2008, Menshawy, Ali & Salman 2011).

In Mumbai, India, the Maharashtra state government policy on informal residences was that without legal recognition or proof of residence, public services (such as electricity) cannot be provided to a household. This has led to slum dwellers (often referred to as “pavement dwellers”, living in temporary shacks along the city’s roads) utilising illegal and unsafe electricity connections, resorting often to acquiring night-time electricity from middle men. Concerns raised by the city utility Bombay Electricity Supply and Transport Undertaking (BEST) included the demolition threat of informal settlements, leading to infrastructure losses, and the violation of their own rules that households without proof of tenure should not be supplied with electricity.

This complex situation was eventually resolved to a degree through the participation of the slum dwellers in organisation activities, in a structured manner to demand and acquire electricity access. Members of Mahila Milan, a women’s self-help group, initially negotiated with the BEST, and through collaboration with community-based organisations and NGOs, were able to agree that legal electricity direct from the BEST would be a safer, more reliable and affordable approach to electricity access.

This is a clear example of how community organisation can affect the political standpoint of a government body, as this led to BEST changing its policy for electricity supply for urban poor populations, specifically “pavement dwellers”, recognising their entitlement to electricity service, as the inhabitants recognised the need to organise themselves as a group and comply with the service provider’s preconditions. This model has been successfully replicated in other slum areas of Indian cities, also, as well as influencing the Mumbai Municipal Corporation to introduce a new initiative to reduce the need for “No Objection Certificates” to be issued for other municipal services (water/sanitation etc.) for informal settlements. (World Bank/ESMAP 2008).

In Thailand, a new electricity connection cannot be authorised without the presence of a household registration document, compulsory household registration was introduced in 1956. Popular campaigns for better recognition of the urban poor led to the Thai government beginning to issue temporary registration numbers or “quasi-household IDs” around 1995. These “quasi-household registrations” allow the household to apply for a legal electricity connection with the relevant utility, albeit at a higher deposit level than for fully registered households. The responsibility for applying for the connection still lies with the resident, rather than the utility blanket- or selectively-connecting an area under this system. (Shrestha et al. 2008).

Political factors must also be considered in understanding the selection of communities for electrification. For example, it has been noted in Senegal that the political influence and local community lobbying ability to the national utility and the government affects the ability of the community to obtain electricity. “Peri-urban zones in Dakar that host important religious families, or some traditional chiefs, are more readily electrified” (for example, the Yoff Layene area of the city) (Fall et al. 2008, Marais & Ntema 2013).

Political factors have also been seen to have a significant effect in the electrification of the *bosti* (informal settlements) of Dhaka, Bangladesh. Liaison with the Dhaka Electricity Supply Company to negotiate a legal electricity connection has in many cases been limited to participants in the *bosti* local *somiti*, or savings club, with those who refuse to participate/have been forced out of participation through discriminatory requirements for joining the *somiti*, still being forced to resort to illegal connections through neighbours, due to the prohibitive connection costs experienced in the city.

Patronage and corruption within both the *somiti*, the settlement's governing committee (where all settlement members are encouraged and allowed to participate) and the Dhaka Electricity Supply Company, led to problems when the informal regulation that had existed prior to the central government's "fight corruption" plan tried to be formalised, leading to a crackdown on illegal connections (some of which had been negotiated with other *bosti* by the *somiti*), and a corresponding erasure of regulatory "space" for the informal settlements of the city (Hossain 2012).

WHAT LESSONS CAN BE LEARNED FROM THIS?

There are a number of conclusions to be drawn from the experiences detailed in the literature to date. Firstly, the most common barrier observed to electricity access for informal peri-urban communities is their lack of formal land tenure. The commonality of approach by utilities in requiring a formal right of settlement to inhabited land before providing a formal electricity connection has prohibited many communities from gaining access to legal electricity (World Bank/ESMAP 2008, Fall et al. 2008, Gaunt et al. 2008). It has also been shown that when these requirements are waived, and/or the informal settlements are formalised by the relevant authorities (municipal governments and housing associations, for example), illegal connections and electricity thefts have decreased (Shrestha et al. 2008, Parsa et al. 2008, Menshawy, Ali & Salman 2011, Adil & Ko 2016).

Secondly, tailoring the method used to collect payment for installation of equipment and electricity services to the ability to pay of the community leads to more effective service, and a reduction in electricity thefts. This can be achieved for example by not collecting up-front installation costs, and rather spreading the payment over a longer period (6 months) via the electricity meter/bill. Pre-payment electricity meters have also proven to be superior to standard meters for poor communities, as it allows a greater degree of flexibility in payment for services, a useful factor for the poorest communities with irregular incomes. (Gaunt et al. 2008)

Thirdly, presenting a single community voice to a decision-making agency has also proven to be an effective tool in achieving electricity connection for informal settlements, as well as ensuring the quality and suitability of the connection.

Thorough data collection on the needs of a community pre-electrification is also vital, in tailoring the level of service to the needs of the community and their financial ability (Winayanti & Lang 2004, World Bank/ESMAP 2008, Fall et al. 2008, Bravo, Kozulj & Landaveri 2008).

WHAT TECHNOLOGIES ARE USED?

Solar energy, either in terms of photovoltaics for electricity generation or solar thermal for heating solutions, has not generally been a considered technology for peri-urban electrification or energy provision. Solar thermal water heaters have been considered as an energy replacement technology for public bathroom water heating in peri-urban areas of Accra, Ghana, but such systems have not yet been implemented (King, Amponsah & Quansah 2012). Local generation can offer the possibility of return to the consumer from the utility through electricity sales, although solar is not considered a viable option for this in many peri-urban areas, due to the urban environment, and also the prohibitive expense of solar electricity in comparison to relatively readily-available grid electricity [Scott, Dunn & Sugden 2004).

The Cape Town City Council in partnership with the non-profit organisation SouthSouthNorth implemented the Kuyasa Income Urban Housing Energy Upgrade Project. This included solar water heaters as part of the retrofitting process performed under the project, along with efficient lighting and ceiling insulation (Clancy, Maduka & Lumampao 2008).

The predominant method used for informal settlement electrification in South Africa is grid connection, generally through a low- or medium-voltage distribution line (230 V – 11,000 V). Network design is determined by the layout and density of dwellings for the most part, and the After Diversity Maximum Demand (ADMD) per dwelling of the area. Department of Energy guidelines in South Africa state that a 20 Amp supply with a design ADMD of 0.8 – 1 kVA is suitable for new electrification projects. Some municipalities install 60 Amp systems immediately however, either for political reasons, or to minimise future visits by the utility for upgrade applications. Prepayment electricity meters are universally used, with measures taken such as using split-type meters to reduce tampering, as any theft on the connection cable is on the household side of the meter. (Gaunt et al. 2008)

In both Mumbai and Delhi in India, the sole approach to a formal electricity connection in recent times has also been grid connection. This has raised numerous issues in terms of land security, security of tenure, and the relevant utility's policies in terms of connection costs and repayment for electricity services (World Bank/ESMAP 2008).

WHAT ENERGY EFFICIENCY MEASURES ARE IMPLEMENTED?

Energy efficiency measures have not been a common feature of informal settlement electrification programs in the majority of situations globally. As part of the COELBA Community Agent Electrification Project in Brazil, a local market for energy efficiency products and distribution/sales of energy efficiency equipment (notably refrigerators) were included in the process of formalising electricity connection for the Barrio de Paz and Barrio Jardim da Mangabiera communities in Salvador. Both communities had high levels of electricity consumption through widespread inefficiencies, as well as high levels of illegal electricity connection. It was estimated in 2008 that the project saves between 26,000 and 44,000 MWh/year of energy, primarily from the refrigerator exchange program implemented as part of the project (World Bank/ESMAP 2008, Jiang 2016).

Supply-side efficiency with relevance to illegal connections is also rare, although a stated aim of the Turkish government's electricity sector liberalisation program was to reduce non-technical losses in the electricity system by reducing illegal connections, and the government of Andhra Pradesh in India also experienced a noticeable drop in non-technical losses through electricity theft following privatisation of the state's utility company (Tasdoven, Fiedler & Garayev 2012).

REFERENCES FOR ELECTRICITY AND PERI-URBAN ENERGY

FINANCING AND SUBSIDIES

Bekker, B. et al. (2008) South Africa's rapid electrification programme: Policy, institutional, planning, financing and technical innovations. *Energy Policy*, Vol. 36, pp. 3125 – 3137.

Dube, I. (2003) Impact of energy subsidies on energy consumption and supply in Zimbabwe. Do the urban poor really benefit? *Energy Policy*, Vol. 31, pp. 1635 – 1645.

Kebede, B. (2006) Energy subsidies and costs in urban Ethiopia: The cases of kerosene and electricity. *Renewable Energy*, Vol. 31, pp. 2140 – 2151.

King, O., Amponsah, R.S. and Quansah, D.A. (2012) Productive Uses of Energy in Enterprises in Slums in Ghana. *International Journal of Social Science Tomorrow*, Vol. 1, No. 5.

Lusugga Kironde, J.M. (2006) The regulatory framework, unplanned development and urban poverty: findings from Dar es Salaam, Tanzania. *Land Use Policy*, Vol. 23, pp. 460 – 472.

Ren, H. et al. (2011) Promotion of energy conservation in developing countries through the combination of ESCO and CDM: A case study of introducing distributed energy resources into Chinese urban areas. *Energy Policy*, Vol. 39, pp. 8125 – 8136.

Shrestha, R.M. et al. (2008) Modern energy use by the urban poor in Thailand: a study of slum households in two cities. *Energy for Sustainable Development*, Vol. 12, No. 4, pp. 5 – 17.

SUPPLY OF MODERN ENERGY SERVICES

Adil, A.M. & Ko, Y. (2016) Socio-technical evolution of Decentralized Energy Systems: A critical review and implications for urban planning and policy. *Renewable and Sustainable Energy Reviews*, Vol. 57, pp. 1025 – 1037.

Asian Institute of Technology (2008) *Energy access in urban slums: a case of Khon Kaen, Thailand*. Pathumthani, AIT. Available at: Available at: http://www.gnesd.org/-/media/Sites/GNESD/Publication%20pdfs/Urban%20Peri-Urban%20Theme/UPEA%20II%20Technical%20Reports/AIT%20final.ashx?la=da

Bravo, G., Kozulj, R. and Landaveri, R. (2008) Energy access in urban and peri-urban Buenos Aires. *Energy for Sustainable Development*, Vol. 12, No. 4, pp. 56 – 72.

Clancy, J., Maduka, O. & Lumampo, F. (2013) *Sustainable Energy Systems and the Urban Poor: Nigeria, Brazil, and the Philippines*. In Droege, M. (ed.) Urban Energy Transition – From Fossil Fuels to Renewable Power, Ch24.

Dhingra, C. et al. (2008) Access to clean energy services for the urban and peri-urban poor: a case study of Delhi, India. *Energy for Sustainable Development*, Vol. 12, No. 4, pp. 49 – 55.

ESMAP (2011) *Improving Energy Access to the Urban Poor in Developing Countries*. Washington D.C., ESMAP. Available at: http://www.avsi-usa.org/uploads/6/7/4/2/67429199/avsi___coelba2.pdf

ESMAP (2012) *Innovative Approaches to Energy Access for the Urban Poor: Summaries of Best Practices from Case Studies in Four Countries*. Washington D.C., ESMAP. Available at: http://www.esmap.org/sites/esmap.org/files/FINAL_EA-Case%20Studies.pdf

Fonesca, J.A. & Schleuter, A. (2013) Novel approach for decentralized energy supply and energy storage of tall buildings in Latin America based on renewable energy sources: Case study - Informal vertical community Torre David, Caracas – Venezuela. *Energy*, Vol. 53, pp. 93 - 105.

Gaunt, T. et al. (2008) *Informal electrification in South Africa: experience, opportunities and challenges*. SEA, Cape Town, South Africa. Available at: http://www.cityenergy.org.za/uploads/resource_116.pdf

ICLEI (2014) Nelson Mandela Bay, South Africa: Embedded energy generation experience in a South African metropolitan municipality. Bonn, ICLEI. Available at: http://www.iclei.org/fileadmin/PUBLICATIONS/Case_Studies/ICLEI_cs_174_NMBM_UrbanLEDS_2014.pdf

Marshall, F. et al (2009) On the Edge of Sustainability: Perspectives on Peri-Urban Dynamics. Brighton, Institute of Development Studies. Available at: http://steps-centre.org/wp-content/uploads/Peri-urban-online-version.pdf

Fall, A. et al (2008) Modern energy access in peri-urban areas of West Africa: the case of Dakar, Senegal. *Energy for Sustainable Development*, Vol. 12, No. 4, pp. 22 – 37.

Visagie, E. (2008) The supply of clean energy services to the urban and peri-urban poor in South Africa. *Energy for Sustainable Development*, Vol. 12, No. 4, pp. 14 – 21.

Winayanti, L. & Lang, H.C. (2004) Provision of urban services in an informal settlement: a case study of Kampung Penas Tanggul, Jakarta. *Habitat International*, Vol. 28, pp. 41 – 65.

FORMALISATION AND ILLEGALITY IN ENERGY SERVICES

Hossain, S. (2012) The production of space in the negotiation of water and electricity supply in a *bosti* of Dhaka. *Habitat International*, Vol. 36, pp. 68 – 77.

Marais, L. & Ntema, J. (2013) The upgrading of an informal settlement in South Africa: two decades onwards. *Habitat International*, Vol. 39, pp. 85 – 95.

Menshawy, A.E., Aly, S.S. & Salman, A.M. (2011) Sustainable upgrading of informal settlements in the developing world, case study: Ezzbet Abd El Meniem Riyadh, Alexandria, Egypt. *Procedia Engineering*, Vol. 21, pp. 168 – 177.

Mimmi, L.M. & Ecer, S. (2010) An econometric study of illegal electricity connections in the urban *favelas* of Belo Horizonte, Brazil. *Energy Policy*, Vol. 38, pp. 5081 – 5097.

Parsa, A. et al. (2011) Impact of formalisation of property rights in informal settlements: evidence from Dar es Salaam city. *Land Use Policy*, Vol. 28, pp. 695 – 705.

Potsiou, C. (2014) Policies for formalization of informal development: recent experience from southeastern Europe. *Land Use Policy*, Vol. 36, pp. 33 – 46.

Singh, R. et al (2014) Electricity (in)accessibility to the urban poor in developing countries. *Wiley Interdisciplinary Reviews: Energy and Environment*, Vol. 4, Issue 4, pp. 339 – 353.

ENERGY EFFICIENCY

Bagheri, F., Mokarizadeh, V. & Jabar, M. (2013) Developing energy performance label for office buildings in Iran. *Energy and Buildings*, Vol. 61, pp. 116–124.

Feng, Y.Y. & Zhang, L.X. (2012) Scenario analysis of urban energy saving and carbon abatement policies: A case study of Beijing city, China. *Procedia Environmental Sciences*, Vol. 13, pp. 632 – 644.

Fujiwara, A. et al (2005) Evaluating Sustainability of Urban Development in Developing Countries Incorporating Dynamic Cause-effect Relationships over Time. *Journal of the Eastern Asia Society for Transportation Studies*, Vol. 6, pp. 4349-4364. Available at: http://www.easts.info/on-line/journal_06/4349.pdf

Jiang, J. (2016) China's urban residential carbon emission and energy efficiency policy. *Energy*, Vol. 109, pp. 866 – 875.

Li, W., Li, L. & Qiu, G. (2013) General Nexus Between Water and Electricity Use and Its Implication for Urban Agricultural Sustainability: A Case Study of Shenzhen, South China. *Journal of Integrative Agriculture*, Vol. 12, Iss. 8, pp. 1341 - 1349.

Tasdoven, H., Fiedler, B.A. & Garayev, V. (2012) Improving electricity efficiency in Turkey by addressing illegal electricity consumption: a governance approach. *Energy Policy*, Vol. 43, pp. 226 – 234.

BEST PRACTICES

Leduc, W.R.W.A. & Van Kann, F.M.G. (2013) Spatial planning based on urban energy harvesting toward productive urban regions. *Journal of Cleaner Production*, Vol. 39, pp. 180 - 190.

Ruet, J. (2006) Optimal timing in the privatisation of a utility in an emerging country: the case of electricity distribution in Delhi. *Energy Policy*, Vol. 34, pp. 2702 – 2718.

Scott, N., Dunn, P. & Sugden, S. (2003) *Barriers to access to modern energy in slums*. Gamos Ltd., Reading, United Kingdom. Available at: http://r4d.dfid.gov.uk/pdf/outputs/R8146.pdf

Tatietse, T.T. et al. (2012) Contribution to the analysis of urban residential electrical energy demand in developing countries. *Energy*, Vol. 27, pp. 591 –606.

MODELLING

Adom, P.K., Bekoe, W. & Adoena, S.K.K. (2012) Modelling aggregate domestic electricity demand in Ghana: An autoregressive distributed lag bounds co-integration approach. *Energy Policy*, Vol. 42, pp. 530 – 537.

Hyman, K. (2013) Urban infrastructure and natural resource flows: Evidence from Cape Town. *Science of the Total Environment*, Vols. 461 – 462, pp. 839 – 845.

This document is an output from a project co-funded by UK aid from the UK Department for International Development (DFID), the Engineering & Physical Science Research Council (EPSRC) and the Department for Energy & Climate Change (DECC), for the benefit of developing countries. The views expressed are not necessarily those of DFID, EPSRC or DECC, or any institution partner of the project.