A Framework for Distributed Grids for Municipal Solid Waste Management in South Africa

Llewellyn van Wyk

CSIR

ABSTRACT

A framework for the structural reform of solid waste management is proposed based on the use of distributed grids which encompass a collection of microgrids operating together within distribution networks. The paper explores the concept with regard to municipal solid waste management. A survey of distributed grids in the energy sector is conducted. The components are used to produce a systems diagram. Municipal solid waste (MSW) management is analysed at a systems level and the component parts for a distributed grid for MSW management are identified. The paper is limited to exploring a framework for distributed municipal solid waste management. The paper finds that many of the required component parts are already in place. The paper finds that waste loads at designated municipal waste sites can be significantly reduced, while also creating a new economic sector that supports job creation. The report finds that a public/private partnership is a prerequisite for distributed grids. An enabling policy and regulatory environment is required to ensure effective management.

Keywords: Infrastructure, municipal service delivery, municipal solid waste management, distributed grids

1 INTRODUCTION

Despite trillions of Dollars in annual investment in global infrastructure many foundational systems are deteriorating (McKinsey Global Institute 2016:1). Infrastructure commentators claim that investment in infrastructure is insufficient and the investment needs are only growing steeper: an estimated average annual investment of $3.3 trillion through to 2030 is required just to support current economic growth projections (excluding maintenance backlogs) (MGI 2016:1). It is not surprising therefore that critical infrastructure systems are eroding (MGI 2016:1). The poor condition of infrastructure not only undermines the quality of life of communities, but also undermines the performance of companies and their ability to grow the economy (KPMG 2009:5). KPMG found that 77 percent of global executives surveyed fear there will not be enough infrastructure investment to support the long-term growth of their organisations (2009:13).

There are at least two primary causes of public sector under-funding: first, the finance model is dependent on borrowing to fund infrastructure development and the cumulative impact of successive borrowing has negatively affected countries debt-to-GDP ratio, especially so for developing countries (Williams 2017); and secondly, the urban growth model is based on continuous expansion – known as urban sprawl – requiring continuous extensions to and upgrading of infrastructure megagrids. This perfect storm of challenges has, as Beske and Dixon (2018) note, broken apart a 70-year-old suburban growth model shaped around car-focused, relatively affluent, and dispersed development. They argue that demographic and economic trends suggest that these dynamics will grow more disruptive over the next two decades.

The circumstance regarding infrastructure in South Africa is no different: municipal infrastructure was rated as ‘D+’ overall in the SAICE 2017 Infrastructure Report Card for South Africa largely due to the increased demand placed on infrastructure from a growing urban population, the ageing condition of infrastructure, under-investment, and lack of proper maintenance (SAICE 2017:9). Yet the 2017/18 budget for capital spending and transfers of R173.5 billion (11 percent of total spending) is only marginally more than the budget for interest payments of R169.3 billion (National Treasury 2017:iv).

Solid waste management, one of the infrastructure systems covered in the SAICE Report Card, is assessed in four categories namely: waste collection in the major urban areas (rated ‘C’); waste collection in other areas (rated ‘D’); waste disposal in metro areas (rated ‘C+’); and waste disposal in other areas (rated ‘D-‘) where ‘C’ is satisfactory for now and ‘D’ is at risk of failure (SAICE 2017:7).

The focus of this paper is the management of municipal solid waste (MSW) which typically consists of all solid waste generated within the municipal area although household waste is the dominant contribution. Household waste comprises of an organic fraction (food and garden waste) and a non-organic fraction (paper, plastic, glass, metal, builders rubble, ash, sand, grit, batteries, e-waste, paint, thinners, etc.). About 108 million tonnes of waste was generated in South Africa in 2011 of which 98 million tonnes were disposed of at landfill sites (SAICE 2017:25). These resources are valued at about R25.2 billion per year

(DEA 2016:12). However, landfill sites are under pressure in South Africa with some areas having exhausted their landfill capacity (DEA 2011:15). In addition, many of the landfill sites are not licensed (estimated at 64 percent for general waste) although this improves to 100 percent for hazardous waste, health care risk waste storage, recycling facilities and transfer stations (SAICE 2017:25; DEA 2011:15).

This pressure on disposal has supported an increased focus on alternative disposal methods away from landfilling to recycling and waste-to-energy initiatives. Whereas only 10 percent of all waste was recycled in 2011, mainstream recycling has increased to 54 percent currently with scrap metal the best performer (at 80 percent) and eWaste the worst (at 14 percent) (SAICE 2017:25). A number of benefits arise from recycling including an improvement in recovery rates from between 3-5 percent for hand pickers at landfill sites to 75 percent for kerbside collections, and an increase in jobs from 6 jobs per 10 000 tons of waste in landfill to 36 jobs per 10 000 tons for recycling (WasteGroup 2018).

The internationally accepted waste management hierarchy comprises a number of options for waste management namely (in order of preference): waste avoidance and reduction; re-use; recycling; recovery; and treatment and disposal as the last resort (SAICE 2017:25). Although recycling is legislated in South Africa, recycling activities are largely executed by the private sector with notable results for tyres, paper and packaging.

2 LITERATURE REVIEW

Commentators and economists generally share the view that a substantial boost over current investment is required to overcome infrastructure backlogs, and interventions are therefore primarily focused on developing a range of funding models and instruments (World Bank 2018; MGI 2016:17; KPMG 2009:7). Other interventions include improving the productivity performance of the construction industry itself, and improving the planning, project management, and operational capabilities of government agencies and other stakeholders that are charged with carrying out infrastructure builds (MGI 2016:17). Technology interventions seldom feature as a potential solution and when it does, it is limited to the greater use of Information and Communication Technologies (ICT) (MGI 2016:17).

The development of microgrids and distributed grids however is highlighting a potential alternative approach to the provision of some municipal infrastructure services most notably electricity generation and reticulation. A distributed grid is not a single technology, but rather, a system of systems – or an ecosystem – that can be applied by multiple stakeholders over a range of spatial scales. This development has prompted interest within the CSIR to evaluate the extent to which distributed grids could be applied conceptually to other bulk municipal services including potable water treatment and reticulation, waste water treatment and reticulation, and municipal waste management and disposal.

Microgrids have rapidly emerged as a viable alternative to a centralised grid in electricity generation and reticulation. In the electricity sector a microgrid is a localised group of electricity sources and loads (sinks) that typically operates connected to and synchronous with the traditional centralised electrical grid (macrogrid), but can disconnect and maintain operation autonomously as physical and/or economic conditions dictate (Berkely Lab 2018). Microgrid definitions focus primarily on two features: as a locally controlled system; and as a function both connected to the traditional grid (megagrid) or as an electrical island (Berkely Lab 2018).

There are two major types of microgrids namely ‘customer grids’ or true grids which are wholly on one site, and ‘milligrids’ which involve a segment of the legacy regulated grid (Berkeley 2018).

There are cogent benefits to be derived from microgrids, i.e. improved energy efficiency, minimisation of overall energy consumption, reduced environmental impact, improvement of reliability of supply, network operational benefits such as loss reduction, congestion relief, voltage control, or security of supply and more cost efficient electricity replacement (Berkely Lab 2018). More critically, microgrids can coordinate all these assets and present them to the megagrid in a manner and at a scale that is consistent with current grid operations, thereby avoiding major new investments that are needed to integrate emerging decentralised resources (Berkeley Lab 2018).

Electricity microgrids comprise of four basic components as shown in Figure 1, i.e. local generation (solar, wind turbines, small hydro, biomass, and thermal energy sources); consumption (users); energy storage (electrical, pressure, gravitational, flywheel, batteries, and heat storage technologies); and point of common coupling (connection between microgrid and macrogrid) (Berkeley Lab 2018).

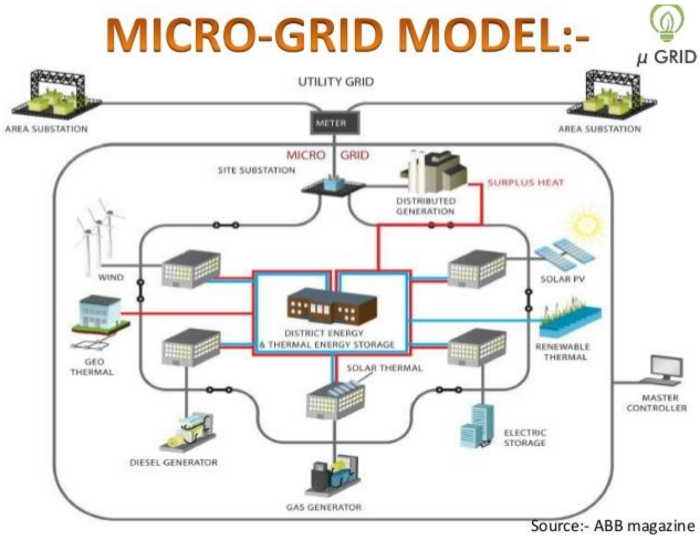

Figure 1: Electricity Microgrid Model (Windpower 2015)

Electricity microgrids have been made possible by the rapid development of renewable energy (RE) equipment, reducing costs of RE equipment over time, and a reduction in electricity prices. As a consequence global microgrid capacity had reached 20,766.2 MW in the fourth quarter of 2017 (Navigant Research 2017:3). Due to the structure of the grid most of the investment for this capacity came from institutional and private sector investors (Navigant Research 2017:3).

3 RESEARCH METHODOLOGY

In determining an appropriate research methodology for the paper, consideration was given to the key characteristic of the research problem i.e. assessing the replicability of electricity microgrids for other municipal bulk services, in the case of this paper, municipal solid waste management.

This study makes use of a systematic literature review (SLR). This research methodology has been used by other researchers working in comparable fields with a similar desired outcome (Walter, Cullman, von Hirshhausen, Wand and Zschille 2009; Kitchenham, Brereton, Budgen, Turner, Bailey, and Linkman, 2009).

Siddaway (2014:1) defines a SLR as a review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyse data from the studies that are included in the review. Kitchenham (2007:3) describes a SLR as a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest. Reasons for undertaking a SLR include (Kitchenham 2007:3):

- To summarise the existing evidence concerning a topic area of phenomenon of interest;
- To identify any gaps in current research in order to suggest areas for further investigation; and
- To provide a framework/background in order to appropriately position new research activities.

The literature review appraises the critical points of current domain knowledge and methodological approaches adopted in this domain with a view to summarizing the current body of knowledge on microgrids and developing generally accepted microgrid systems. A list of keywords is used such as ‘microgrids’, ‘distributed grids’, and ‘infrastructure’.

The research design relies on empirical studies, using existing data obtained from case studies and technical assessments. In this sense the empirical design is archival, making use of recorded facts but without direct observation of the facts, which may come from primary and secondary sources.

Having established the microgrid system requirements the study is able to assess the replicability of microgrids for municipal solid waste management.

4 FINDINGS AND DISCUSSION

Waste is defined in the National Waste Management Strategy (NWMS) as any substance, whether or not that substance can be reduced, re-used, recycled and recovered that is surplus, unwanted, rejected, discarded, abandoned or disposed of; which the generator has no further use of; that must be treated or disposed of; or that is identified by the Minister as a waste (DEA 2011:13). The NWMS acknowledges that one of the challenges of waste management is the absence of a recycling infrastructure which will enable the separation of waste at source and diversion of waste streams to material recovery and buy back facilities (DEA 2011:15). The NWMS further notes that only a few waste treatment options are available to manage waste and are therefore more expensive than landfill costs (DEA 2011:15).

Two of the NWMS's goals directly enable a distributed grid (although it is unlikely that this was in the authors' mind when it was drafted): the first is the promotion of waste minimisation, re-use, recycling and recovery of waste; and the second is to grow the contribution of the waste sector to the green economy (DEA 2011:16).

These two goals form the foundation of a distributed grid: firstly, converting waste into an economic resource; and secondly enlarging the waste management sector to include a network of public/private partnerships. Distributed grids depend on an intermediate structure between the producer (generator) and the municipality (collector) for its operation.

There is sufficient evidence to indicate that this layer already exists in certain waste streams. Data by Plastics South Africa indicates that there were 204 active recyclers in South Africa towards the end of 2016, up from 176 in 2009 (PlasticsSA 2017). The results from their 2016 survey confirmed that there is a growing awareness of recycling and public pressure to recycle resulting in more post-consumer and post-industrial plastics being made available for reuse (PlasticsSA 2017). They note that recycled tonnages have grown by 35 percent since 2011 with a growing number of organisations and consumer groups becoming actively involved in upstream collection efforts (PlasticsSA 2017). They note further that the recyclers provided formal, permanent employment to 6 140 staff and supported the informal employment of 51 500 waste pickers and collectors (PlasticsSA 2017).

The South African Waste Sector 2012 report (DST 2013:11) found that the private sector was already engaged in the handling of a wide range of waste which would suggest that a key component for distributed waste grids is already in place.

The NWMS constructs a waste management hierarchy which is useful to consider when conceptualising a distributed grid for municipal waste management (Figure 2).

Figure 2 Waste Hierarchy (NWMS 2011:18)

A distributed grid would essentially construct a network of private sector capacity – the country wide infrastructure to enable re-use and recycling referred to in the NWMS (2011:19, 22) – across and within each of the steps in the hierarchy. The grid would operate at a number of scales similar to the electricity microgrid from individual households to (sub)urban blocks, precincts, and to the city. This new operational network will amend the role of the municipality by shifting more of the management functions to the private sector with the public sector exercising an oversight and governance role.

Using the electricity microgrid model as shown in Figure 1, a modified distributed grid flow diagram based on a typical municipal solid waste management system as depicted in the Municipal Solid Waste Tariff Strategy (DEA 2012:6) can be constructed where the red box indicates the area of operation of distributed grids (Figure 3). As is the case with electricity microgrids, MSW distributed grids also comprise of four basic components as shown in Figure 3, i.e. local generation; on-site sorting, separation and storage; collection by various stakeholders including informal waste pickers; reclamation, recycling, reuse, and sale. As indicated in Figure 2, it is the remainder that is finally disposed of for either waste-to-energy conversion, or to landfill.

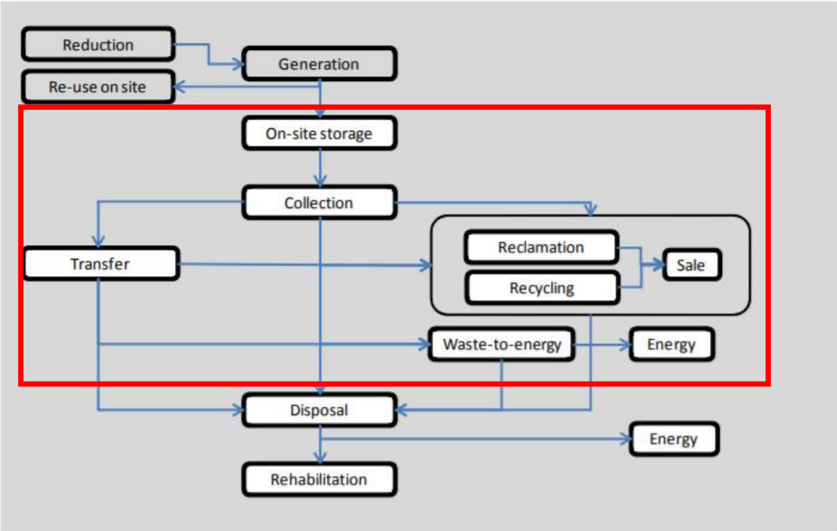

Figure 3 Distributed Municipal Waste Grid Framework (DEA 2012:6)

Growing the role and responsibilities of the private sector will stimulate job creation and broaden participation by SMEs and marginalised communities as indicated in Goal 3 of the NWMS (2011:27). A distributed grid gives greater effect to 'Goal 5: Achieving integrated waste management planning' (NWMS 2011:29): whereas Goal 5 envisages the function to be solely that of municipalities, a distributed grid will assume many of those functions. This will in turn have an impact on 'Goal 6: Ensure sound budgeting and financial management for waste services' (NWMS 2011:30). Experience with microgrids in the electricity sector has demonstrated that creating additional capacity through the private sector has reduced public sector expenditure on electricity generation and distribution.

A significant difference between an electricity distributed grid and a municipal solid waste distributed grid is the value proposition to the household: whereas investing in private RE generation offers cost savings over time (payback period) to the investor, a similar incentive is not immediately obvious in the solid waste distributed grid. This could alter if disposal tariffs increased and/or households received payment for the waste

5 CONCLUSION AND FURTHER RESEARCH

The paper finds a strong conceptual correlation between the structure of electricity microgrids/distributed grids, and a possible distributed structure for municipal solid waste management. The paper finds that an enabling environment already exists: the South African policy environment is strongly supportive of the foundational elements of distributed grids for municipal solid waste management while a robust private sector waste management capacity already exists suggesting that the economic opportunity has been identified.

The paper finds that sufficient evidence exists to demonstrate both the economic and job creation contribution potential of distributed grids for municipal solid waste management. However, financial incentives will need to be put in place to encourage households to participate in a distributed grid. This may be a combination of increased municipal waste disposal tariffs and potential income from waste collectors. The paper finds that electricity microgrids have added additional resource capacity to the national grids at no expense to the public sector. The paper expects that a similar outcome can be expected for the municipal solid waste service.

The paper finds that institutional arrangements will need to be remodelled to facilitate the establishment of new and extensive public/private partnership arrangements. These arrangements will be based on greater private sector management with municipalities exercising an oversight and governance role.

Electricity microgrids and distributed grids have demonstrated a viable alternative service delivery model, one in which greater responsibility for the provision and management of electricity services is placed in the hands of consumers and private sector service providers. Providing consumers realise benefits from such a model – and there is every reason to believe that solid waste distributed grids will deliver similar benefits as the electricity microgrids – distributed grids for municipal solid waste should be equally viable. If this is the case, distributed grids hold the promise of creating a new infrastructure delivery paradigm that can contribute towards the reduction in service backlogs and future infrastructure development.

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This paper constructs a conceptual framework for the application of distributed grids for municipal solid waste management. The model will need to be further expanded and tested for viability. This will require engagement with all the role players in the waste management sector, and the undertaking of case studies to examine where, and how, this might be working in South Africa and abroad. The value proposition to both individual households and recyclers requires further research.

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