Sustainable energy solutions for South African local government

A practical guide
Smart Grids

What are Smart grids?
A smart grid is an electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end-users. Smart grids co-ordinate the needs and capabilities of all generators, grid operators, end-users and electricity market stakeholders to operate all parts of the system as efficiently as possible, minimising costs and environmental impacts while maximising system reliability resilience and stability. (EIA 2011)

Rationale for smart grid technology
The world’s electricity systems face a number of challenges, including growth in demand, the integration of increasing numbers of variable renewable energy sources and electric vehicles, the need to improve the security of supply and the need to lower carbon emissions. Smart grid technologies offer ways not just to meet these challenges but also to develop a cleaner energy supply that is more energy efficient, more affordable and more sustainable. (EIA 2011)

Overview
The smart grid is a component of the smart city concept related to electricity distribution. In 2011, the International Energy Agency (IEA) published a roadmap for the deployment of smart grids. It defines the smart grid and its rationale (see textbox).

Basic technical aspects
A principle of electrical grids is that the power supply must always match the demand. If the supply exceeds the demand, electricity is wasted. If the demand exceeds the supply power outages can occur.

A conventional electricity grid is characterised by the one-directional flow of power from a few large power stations through transmission and distribution grids to the consumers. The grids have substations that reduce the voltage of the electricity gradually to the needs of the consumers (see Figure 8 below). The one-directional flow in the grid requires only simple metering of consumed power. The grid operators balance supply and demand on the basis of their practical experience.

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1 EIA (2011) Technology Roadmaps Smart Grid
The introduction of electricity generated from renewable sources (wind and solar) makes it more difficult to balance supply and demand in the grid. Renewable energy from wind and solar is variable and provided by many large and small suppliers who are often at the same time consumers of electricity. The management of a grid with many variable suppliers is more complicated and requires timeous information on the performance of the power generators and the demand of customers. Information is gathered by linking the electricity grid to the ICT network that provides supply data from generators and demand data from customers at short time intervals. A smart grid is therefore a combination of the electrical grid and the ICT network.

In addition to integrating renewable energy, smart grids have advantages such as enabling demand side management by the electricity grid operator, increasing efficiency in power use and in turn reducing greenhouse gas emissions. A Smart Grid is characterised by:

- Integration of the electricity grid with an ICT network;
- Decentralised power supply through many large and small generators;
- Bi-directional and smart meters transmitting data on the flow of electricity at short intervals;
- Different types of storage for electricity, including battery banks and electric cars;
- Ability to quickly respond to changes in supply and demand, e.g. through switching on additional suppliers or demand side management;
- Network grid instead of hierarchical grid; and
- Steering the grid with the assistance of a powerful IT system.

The transformation of a conventional grid to a smart grid is costly and typically implemented incrementally when the need arises or when the benefits exceed the costs.

Although the smart grid has many benefits, the technical need for it arises when many decentral power generators using variable sources of energy and storage facilities are integrated into the electricity grid. Figure 10 shows 'smarter grids' as a component of an electricity supply system with a high share of renewable energy. Other components of such a supply system are gas-fired power station and energy storage to complement variable power supply through wind and solar sources.
In 2013, the International Renewable Energy Agency (IRENA) published a study on Smart Grids and Renewables. It found that at low penetration of up to 15% capacity no smart grid technology is required. At medium level penetration of up to 30% some smart grid technology is needed, while at higher than 30% penetration smart grid technology is necessary for reliable grid operations.

An example in the study is Denmark where in 2013, more than 30% of power was produced by wind. Smart grid technology was needed to integrate weather forecast data into grid operations.

Another example is Germany that has achieved 25% renewable energy penetration (mainly wind and solar PV) before starting major investment into the grid. In order to move towards 50% penetration substantial investments into upgrading the grid are under way.

1 IRENA (2013) Smart Grids and Renewables – A Guide for Effective Employment
2 Pers. comm. with Tobias Bischof-Niemz, head of CSIR Energy Centre, Pretoria
3 Heinrich-Boell-Stiftung (ed.) (2014) Energiewende 2.0
What is a Smart Meter?

- A smart meter is a type of electricity meter that can record when and how much electricity is consumed. Smart meters are required for Time of Use tariffs.
- Smart meters can separately record bi-directional flows of electricity. This is necessary if power is exported to the grid by embedded generators.
- Smart meters can ensure more accurate electricity bills.
- Smart meters come with monitors, allowing customers to better monitor their electricity usage.
- Smart meters are capable of two-way communication between the meter and the utility. This enables the utility to remotely read information off the meter, detect power outages and meter tampering and to send information to the meter and customer.  
- Smart meters can be integrated in advanced metering infrastructure (AMI), which is an integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities and customers.

What is Advanced Metering Infrastructure (AMI)?

Advanced metering Infrastructure (AMI) is the collective term to describe the whole infrastructure from a smart meter to the two-way-communication network to control centre equipment and all the applications that enable the gathering and transfer of energy usage information at short time intervals. The installation of an AMI is looked upon as a bridge to the construction of smart grids, and smart meters are an integral part of the AMI.

An AMI is required to capture the full benefits of smart meters. It requires setting up a communication network and IT infrastructure at the utility that can handle large amounts of data submitted by the smart meters. Costs associated with hardware, software, installation, training and vendor deployment support for an AMI system need to be considered.

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2 www.eskom.co.za/CustomerCare/SmartPrepayment/Pages/default.aspx
3 For more details on smart meters and AMI see: SEA (2015) Smart Metering: Overview and Considerations for South African Municipalities
A study by GreenCape\(^4\) noted that municipalities that are already implementing smart metering are paying anything between R1 500 and R8 500 per meter compared to a conventional meter\(^5\) that can cost them as little as R400 for a post-paid or under R1 000 for a pre-paid meter.

**The NRS 049:2008 – Advanced metering infrastructure for residential and commercial customers**, specification has been drafted and published to create a standard specification for advanced metering infrastructure (AMI) systems in South Africa. An NRS 049 compliant smart metering system essentially has the following characteristics:

- Bi-directional communications from the central server to meters and devices and from these devices back to the central server.
- Customers are able to have a portable customer interface unit in their premises that can read information off a meter and receive information from the utility.
- The ability to control up to two relays for load control (such as hot water cylinder and a swimming pool pump).
- Be capable of remote load disconnect for revenue protection of the utility\(^1\).

**Figure 14: Typical AMI system complying with the NRS 049-1**

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1. SEA (2015) Smart Metering: Overview and Considerations for South African Municipalities

4. GreenCape, Economically Viable Smart Grids within Western Cape Municipalities, Summary Report 2013/14

5. Conventional meters include the currently common meters such as disc meters for billed customers and prepaid Standard Transfer Specification (STS) meters.
**Smart Grid and Smart Meter Policies**

In 2013 the South African National Energy Development Institute (SANEDI) drafted a Smart Grid Vision 2030⁶ that was developed as part of the South African Smart Grid Initiative (SASGI).

‘An economically evolved, technology enabled electricity system that is intelligent, interactive, flexible and efficient and will enable South Africa’s energy use to be sustainable for future generations.’⁷

The SASGI sought to address challenges of the aging South African electricity infrastructure to achieve policy objectives set out in the National Energy Act (34 of 2008) and in the National Climate Change Response Policy White Paper (Department of Environmental Affairs, 2011). These objectives included:

- Ensure uninterrupted supply of energy to the country;
- Promote diversity of supply and energy resources;
- Facilitate effective management of energy demand and its conservation;
- Promote appropriate standards and specifications for the equipment, systems and processes used for producing, supplying and consuming energy;
- Ensure collection of data and information relating to energy supply, transportation and demand;
- Provide for optimal supply, transformation, transportation, storage and demand of energy that are planned, organised and implemented in accordance with a balanced consideration of security of supply, economics, customer protection and a sustainable development.⁸

Government Regulation (GN) 773, published in terms of section 35 of the Electricity Regulation Act, became effective in 2008. It established norms and standards for electricity reticulation services in order to:

- Maintain the quality of electricity supply;
- Ensure the stability of the electricity network, and;
- Minimise electricity load shedding and avoid blackouts.⁹

The Regulation stipulated the roll out of smart metering to all customers with a monthly consumption of 1,000 kWh and above, and for a time of use (TOU) tariff to be applicable to these customers by 1 January 2012. The TOU tariff is very high at peak consumption time motivating customers to shift consumption to other times of the day. The main objective of this Regulation was demand-side management at a time of anticipated electricity supply shortages but it also demonstrated the intent to move towards smart grid infrastructure. The timeframe of the regulation has not been met.

**Implementation**

Some municipalities have embarked on the procurement and installation of smart meters. Smart meters are commonly used by large industrial and commercial customers that are being billed on a time-of-use (TOU) tariff. Residential smart metering is not common but some municipalities plan to introduce residential TOU tariffs that require smart metering.

Smart metering projects have been implemented in Johannesburg, the City of Tshwane, and the Nelson Mandela Bay Municipality. EThekwini Municipality is piloting smart meters for customers that are small scale electricity generators (SSEG) e.g. have roof top PV installations.

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⁷ SANEDI (2013) p. 21
⁸ SANEDI (2013) p. 15
⁹ SANEDI (2013) p. 16
The main drivers of smart meter initiatives have been to improve collection of revenue for electricity and addressing electricity theft in low income areas. Eskom and a number of municipalities have responded through the installation of smart meters. However, as this is linked to social problems it is questionable if expensive technology is most effective in addressing them. Research by Eskom (Eskom 2015) and GreenCape\(^\text{10}\) make a compelling case for a strategic approach to these issues before investing in expensive technology.

Eskom has reported the results and lessons of several of their own pilot projects and research in a report to COGTA (Eskom 2015)\(^\text{11}\). Important aspects and recommendations to municipalities are summarised below.

In South Africa smart meter initiatives have been undertaken to address the growing revenue challenges of electricity utilities (municipalities and Eskom) due to:

- A culture of non-payment;
- Dissatisfaction with service delivery, which may include electrical utility related services;
- Alternative energy supply options;
- Rising electricity tariffs;
- Lack or inefficient utility processes to effectively manage revenue collection; and
- Aging infrastructure and lack of maintenance on low voltage (LV) networks.

Utilities are therefore looking for innovative and technological solutions that could assist them reverse the negative trend. It is apparent that the revenue management problem needs to address people, process and technology aspects. The initial step of any project must be a thorough analysis of the problem that includes the root cause.

Immense gains can be made with revenue management without buying a single smart meter just by reviewing and tweaking existing processes and practices. Identifying and addressing people and process related shortcomings provides a critical foundation on which to successfully deploy smart metering. There is no technological solution that can resolve people (culture and attitude) and process related problems. In addition a utility should conduct an open smart meter readiness assessment of its organisation and network.

Eskom has developed a Smart Strategy for the installation of AMI infrastructure in its networks. Its implementation needs to be incremental because of high costs and flexible because of complexity, anticipated technological changes and risks, such as customer resistance and revised business processes.

Any smart meter project needs to consider the following aspects for successful implementation

- Customer change management;
- Staff training and buy-in;
- Automated data capturing process linked to billing system;
- Established and verified customer, meter and network data;
- Assessed and if necessary repaired infrastructure;
- Trained and competent installation teams;
- Calibrated and tested devices (meters need to be recalibrated every 10 years); and
- IT, telecommunications infrastructure and back-end integration.

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\(^{10}\) GreenCape, Economically Viable Smart Grids within Western Cape Municipalities, Summary Report 2013-14, GreenCape, Developing Smart Grid Business Cases, Guidelines for Western Cape Municipalities, 2013-14.

\(^{11}\) Report was compiled in collaboration with GreenCape and SEA.
A range of smart meters exists with different capabilities and prices. The meters should be carefully matched to the communities’ needs and the capabilities and skills of the municipality to support the meters post the initial go-live. The Figure 16 indicates types, capabilities and costs of smart meters.

Based on their analysis of several pilot projects, recommendations to municipalities planning the roll-out of smart meters include:

- Municipalities need to conduct a thorough smart metering readiness assessment prior to commencing any roll-outs. Municipalities will need assistance in developing their smart grid visions / roadmaps and these should be guided by the high level national Smart Grid Vision.

- The project should invest significant effort into planning, designing, testing, integrating with the existing systems, processes and pilot meter rollouts. Only once a level of confidence has been obtained then a more aggressive rollout strategy should be executed.

- A smart meter programme should include demand response capabilities on the meter itself to reduce the maximum load during periods of stress on the national grid.

Generally it is recommended that a national smart grid strategy should be developed and supported by updates to the Grid Code.
Support Organisations

SANEDI
www.sanedi.org

GreenCape
www.greencape.org

Eskom
www.eskom.co.za