LOW COST INTELLIGENT OUTAGE MANAGEMENT

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1. Introduction

The City of Ekurhuleni (CoE) is the industrial hub of Gauteng, contributing 8.8 % of the national economy. Strengthening its industrial competitiveness is a priority for the CoE. Africa's largest and busiest airport also fall within its boundaries. It is home to approximately 3.5 million people, with 18.7% of the approximately 1 300 000 households in CoE being informal dwellings. Currently there is a backlog of 115 375 informal dwellings that are not yet supplied with electricity. Supplying electricity to the informal settlements forms an important component of the pro poor focus of the current term of Council (City of Ekurhuleni, 2019).

A reliable distribution network is vital to ensuring that customers receive a high standard of electricity supply with minimal power outages. Numerous challenges to achieving this exist, which include, inter alia, aging infrastructure and illegal connections overloading the network. An important component of managing the reliability of the distribution network is to be able to identify potential problem areas and frequently failing distribution equipment.

Municipal customers affected by power outages are negatively impacted in several ways ranging from revenue lost by businesses through to the inconvenience of a home without electricity. Municipalities also lose revenue over the duration of a power outage.

To respond to a power outage as soon as possible, in order to minimise downtime, it is desirable to have automated notifications of power outages. Additionally, reliable statistics on power outages can be used to identify circuits experiencing frequent outages so that remedial action can be taken.

SCADA is a solution that can, inter alia, meet the requirements described in the above paragraph. However, SCADA is costly and for South African municipalities faced with a high demand to expand service delivery to customers lacking basic services expenditure on an item of this nature can be seen as a luxury.

The need for a cost effective and efficient system for alerting staff to power loss events so that they can be rapidly responded to, as well as displaying current power outages and logging power loss and return events was identified by the CoE: Energy Department.

The Energy Department investigated the feasibility of implementing automated notifications of power outages, as well as recording of power outage statistics, using existing modems used as a metering communication medium for remote metering together with open source software, available at no cost.

The implementation of the system, and the benefits obtained will be discussed in the following section.

2. Discussion

2.1. Factors influencing adopted solution

The coverage provided by the installed base of meters being remotely read was deemed to be acceptable for the intended purpose for the following reasons:

- Key customers and large business customers are all metered remotely.
- Residential complexes with bulk connections are metered remotely which will provide notifications of area outages in residential areas surrounding the complexes.
- Modems with the capability to generate notifications of power loss and return events could be retrofitted to sites to be monitored within the existing contract with the remote metering service provider.

Suitable open source software, for which the necessary in-house skills to develop a system to geographically display received power loss events and to log received power loss and power return events was available.

2.2. Power loss and return event alerting

Currently a total of 10 724 sites are remotely metered. Of these sites 1 153 are equipped with modems capable of generating notifications of power loss and return events. The distribution of the remotely metered sites and sites with modems capable of generating notifications of power loss and return events between the nine Distribution Business Units (DBUs) within the CoE Energy Department is shown in Figure 1.

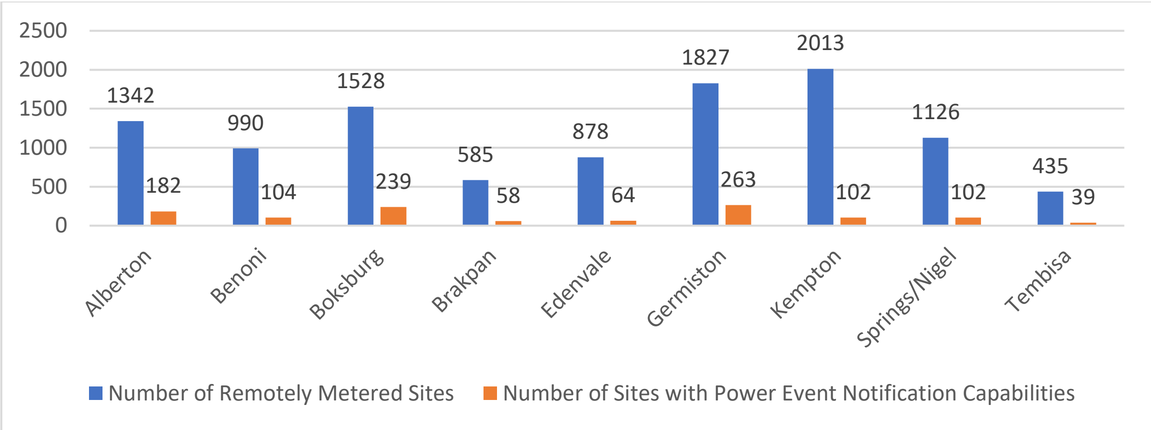

Figure 1: Distribution of Remotely Metered Sites and Power Event Notification Capabilities between DBUs

The modems installed at the sites that are monitored by the system can provide a “last gasp” notification, before powering down, of a power loss event that has occurred. When a power return event occurs, the modem is powered back up and provides notification of the power return event.

The notifications are received by the remote metering service provider, who then sends the following notifications to the Energy Department:

1. SMS notifications to staff whose cell phone numbers have been included in the notification list.
2. Email notifications to staff whose email addresses have been included in the notification list. An example of the content of an email notification is shown in Figure 2.
3. A HyperText Transfer Protocol (HTTP) Post request to an Energy Department HyperText Preprocessor (PHP) server for further processing.

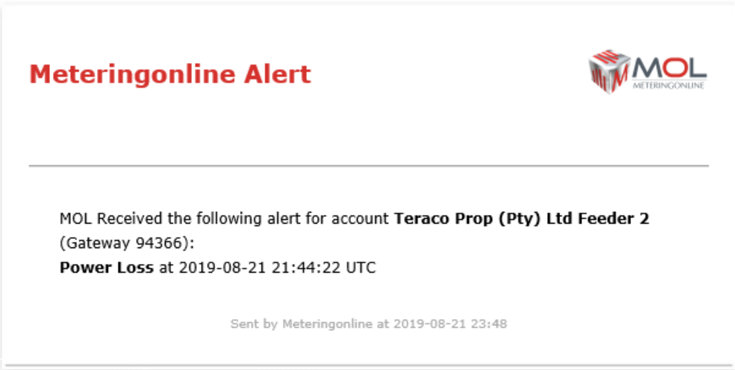

Figure 2: Email content of a power loss notification

2.3. Display and logging of Power Loss and Return Events

The display and logging of the power loss and return events is accomplished using a PHP server together with a script supplied by the remote metering service provider to process the HTTP Post request sent to CoE, as well as the following open source software:

1. A PostgreSQL database, an open source relational database (Postgresql.org, 2019), for the processing and logging of the power loss and return events received via PHP together with PostGIS, an open source spatial database extender for PostgreSQL (Developers, 2019) to spatially enable the PostgreSQL database.
2. GeoServer, an open source server for sharing geospatial data (Geoserver.org, 2019), to publish the spatial data.
3. Leaflet, an open source JavaScript library for publishing interactive maps (Leafletjs.com, 2019), to display the map showing current power outages.

The HTTP Post request parameters are processed by the supplied PHP script residing on the PHP server and the status (power loss or return) of the site/s for which the event/s occurred is updated within the PostgreSQL database.

The update triggers a stored procedure which then logs the event after assigning a sequential (per site) event number to the event and, if a power return event, calculating the power outage duration and classifying the power outage in accordance with Figure 3 for interruption durations longer than 3 seconds and as a voltage dip for interruption durations less than or equal to 3 seconds.

4.3.2 Classification of unplanned interruptions

4.3.2.2.1 Momentary interruption events: Unplanned interruptions of LV and MV circuits that are longer than 3 s but less than or equal to 5 min shall be classified as momentary interruptions.

4.3.2.2.3 Sustained interruptions: Unplanned interruptions of LV and MV circuits longer than 5 min shall be classified as sustained interruptions.

Figure 3: Unplanned power outage classification based on duration (Standardization Section, Eskom, 2007)

PostGIS is used to add spatial geometry to the relevant tables within the PostgreSQL database thus allowing the data to be geographically located. The Geoserver publishes the spatial data through connecting to the PostGIS database via a Store and using Styles to control the appearance of the various geospatial layers published. Leaflet is then used to display the map in a web server.

A map (Figure 4) of the current power outages (overlaying the installed base of remotely read meters) can be displayed in any web browser from within the CoE ICT network using an intranet URL.

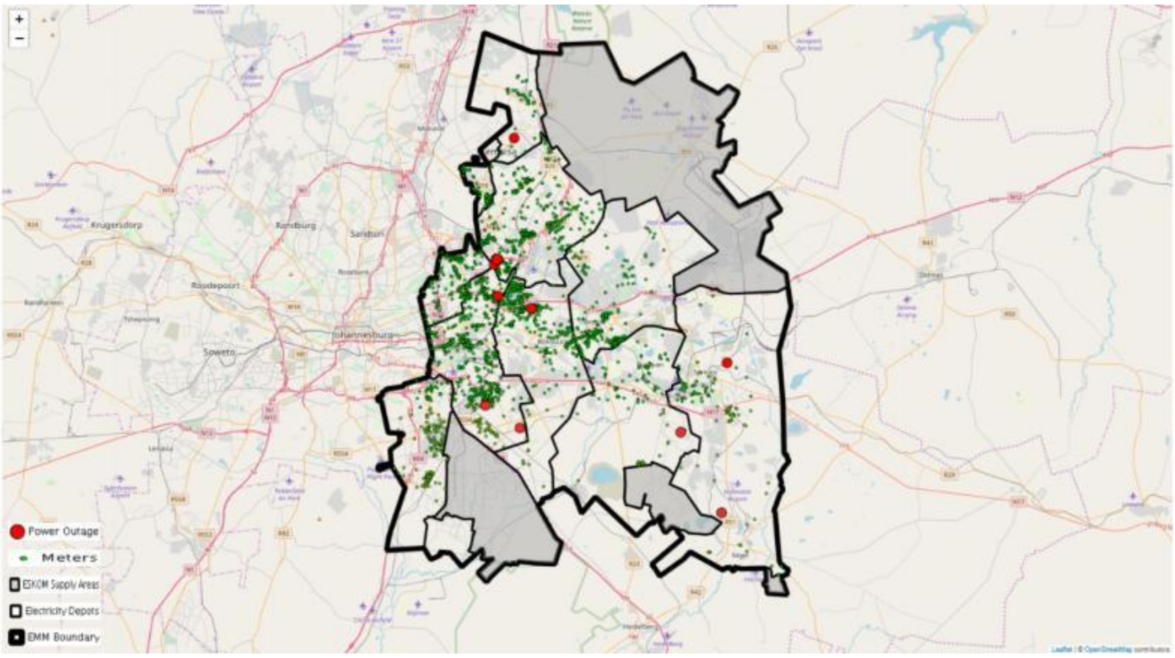

Figure 4: Current Power outages

2.4. Reporting on and Business Intelligence from power loss and return events

Reporting on power loss and return event history is achieved using MS Excel (Figure 5). The spreadsheet is automatically updated through a data connection to the PostgreSQL database when the spreadsheet is opened and updated every 5 minutes while the spreadsheet is open. The spreadsheet can then be used to analyse and report on the data.

	A	B	C	D	E	F	G	H
1	event_number	action_tstamp	site_name	account_number	elec_depot	status	outage_duration	outage_classification
212	16	2018/12/11 16:57:08	Actom (Pty) Ltd	3501974695	Springs	Power Outage		
213	16	2018/12/11 17:01:17	Actom (Pty) Ltd	3501974695	Springs	Power Restored	00:04:09.622	Momentary Interruption
214	17	2018/12/28 14:16:57	Actom (Pty) Ltd	3501974695	Springs	Power Outage		
215	17	2018/12/28 14:39:03	Actom (Pty) Ltd	3501974695	Springs	Power Restored	00:22:05.969	Sustained Interruption
216	18	2018/12/29 14:33:02	Actom (Pty) Ltd	3501974695	Springs	Power Outage		
217	18	2018/12/29 14:33:02	Actom (Pty) Ltd	3501974695	Springs	Power Restored	00:00:00.146	Voltage Dip
218	19	2019/01/07 22:22:45	Actom (Pty) Ltd	3501974695	Springs	Power Outage		
219	19	2019/01/07 23:12:54	Actom (Pty) Ltd	3501974695	Springs	Power Restored	00:50:09.437	Sustained Interruption
220	20	2019/05/03 12:57:16	Actom (Pty) Ltd	3501974695	Springs	Power Outage		
221	20	2019/05/03 13:31:16	Actom (Pty) Ltd	3501974695	Springs	Power Restored	00:33:59.542	Sustained Interruption

Figure 5: Power loss and return event history

A separate worksheet within Excel also shows details of current power outages including the date and time of the power loss and the duration of the current outage (Figure 6).

	A	B	C	D	E	F	G
1	site_number	account_number	site_name	elec_depot	power_status	status_date_time	outage_duration
2	93614302		POD31b: Edenvale Town Supply Sub 2	Edenvale	Power Outage	2019/08/22 10:33:36	0.01:38:07.135
3	15548696	1708105655	Teraco Prop (Pty) Ltd Feeder 2	Kempton	Power Outage	2019/08/21 23:41:32	0.12:30:10.822
4	15682942	3500255682	I & W Van Der Merwe Boerdery	Springs	Power Outage	2019/08/21 21:01:37	0.15:10:06.060
5	15682893	2101071647	Soleprops 39 (Pty) Ltd	Alberton	Power Outage	2019/08/19 22:30:47	2.13:40:55.769

Figure 6: Current power outages

The current power outages can also be visualised spatially within Excel using 3D maps (Figure 7)

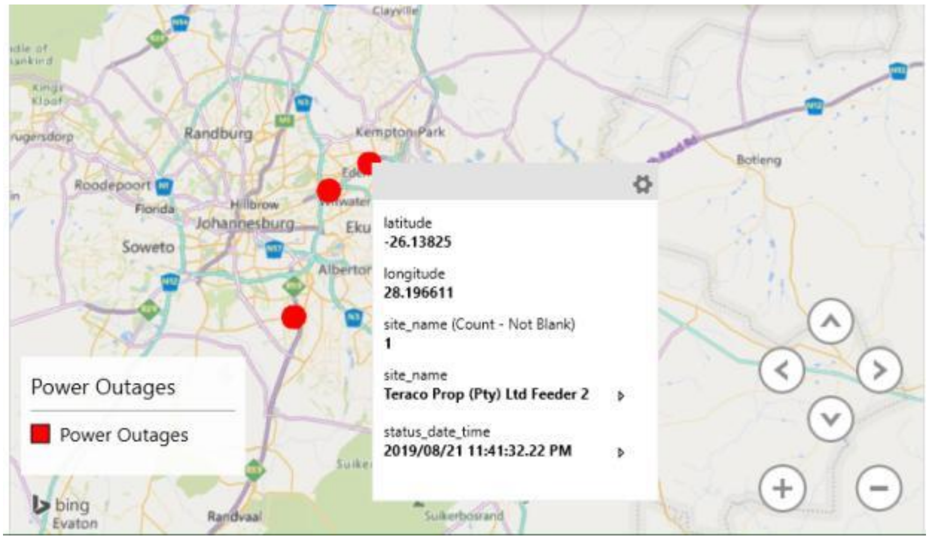

Figure 7: Visualisation of current power outages within Excel 3D Map

Business Intelligence (BI) software, is also used to derive information from the data in the form of dashboards providing readily available visualisations of the information to employees to facilitate planning and decision making. Since the ICT department has indicated that it intends to standardise on Microsoft Power BI as the BI software for CoE Power BI was utilised for this purpose rather than one of the open source alternatives.

Figure 8 shows the interruption rankings by DBU in terms of number of interruptions over the period since implementation, 14 December 2017 until 22 August 2019, while Figure 9 shows the same statistics for the month of June 2019 against the backdrop of the total number of interruptions over the period in Figure 8.

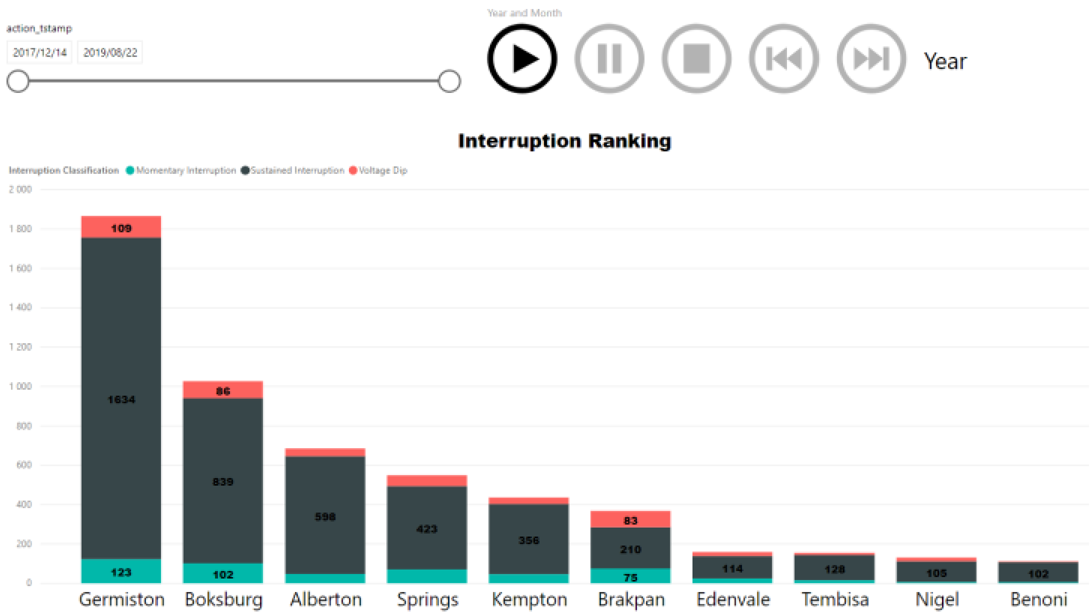

Figure 8: Interruption ranking by DBU for number of interruptions from 14 December 2017 to 22 August 2019

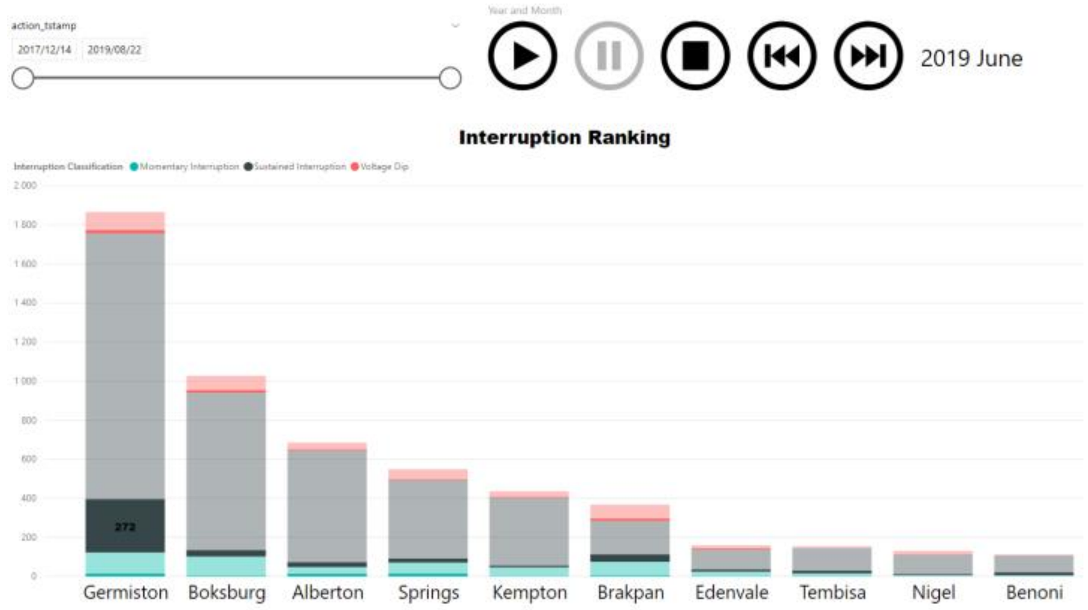

Figure 9: Interruption ranking by DBU for number of interruptions in June 2019

Drilling down on the interruption ranking shown in Figure 8 shows the interruption rankings by site (customer) in terms of number of interruptions over the period since implementation, 14 December 2017, until 22 August 2019. The results are shown in Figure 10.

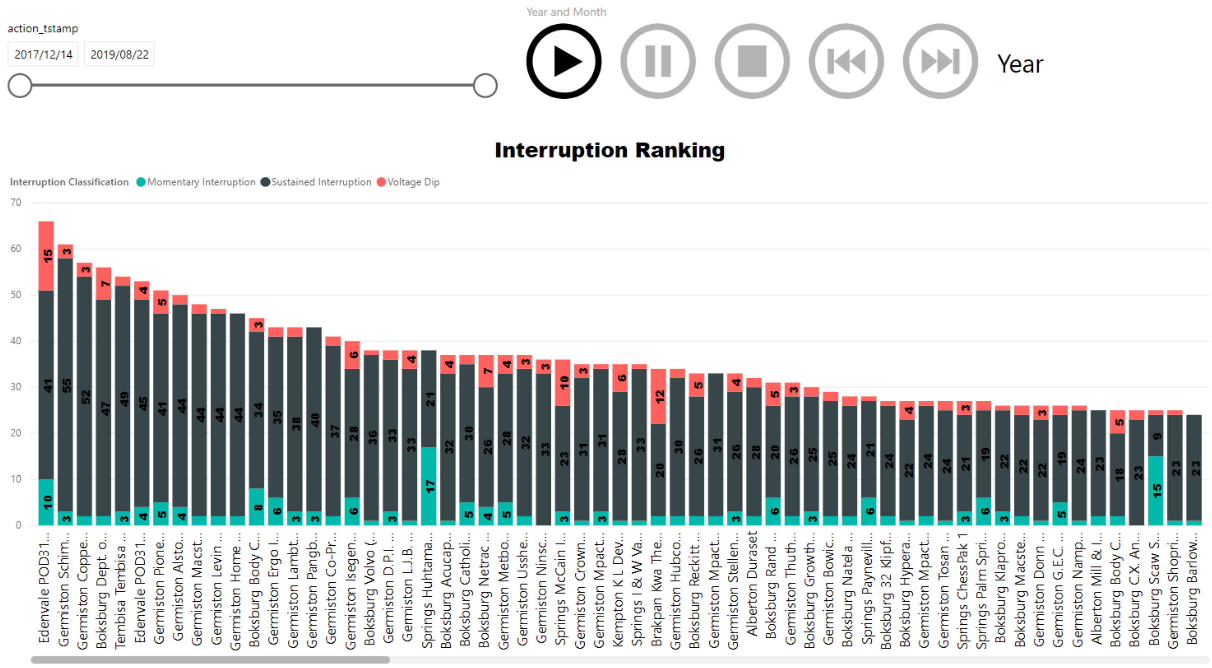

Figure 10: Interruption ranking by site(customer) for number of interruptions from 14 December 2017 to 22 August 2019

The criteria for the interruption rankings can be based on any meaningful measure, e.g. the interruption rankings can be based on the sum of all outage durations per site over a period rather than number of interruptions over a period. Information of this nature assists in identifying problem areas and frequently failing distribution equipment that attention needs to be given to.

Figure 11 is a spatial visualisation in Power BI of an area outage that occurred on 6 June 2019.

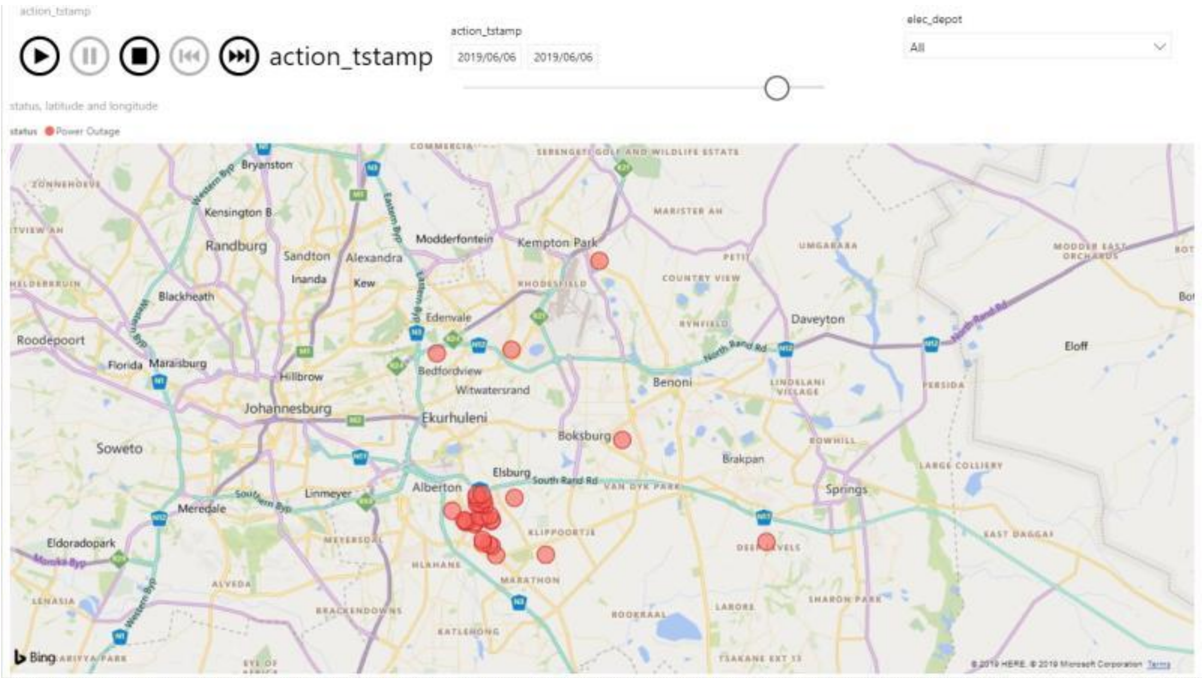

Figure 11: Area outage on 6 June 2019

2.5. Limitation of method used to generate power loss notification

A limitation of the system is that the system cannot distinguish between unplanned or planned power interruptions as the only notification is for the absence or presence of power.

3. Future enhancements

3.1. Extrapolation of received notifications to identify the full extent of an area outage

The possibility of using available data on substation zones together with notifications of power loss events from modems located at check meters on substation feeders, as well as developing GIS based feeder connectivity models, to allow power loss and return events for customers downstream of feeder outages to be reliably logged is being investigated.

3.2. Calculation of estimated energy lost due to a power interruption to a customer

The power loss notification includes the rolling 12-month Maximum Demand for a customer. The value of using this together with the interruption duration in hours and the load factor for the substation zone within which the customer falls to calculate an estimate of the energy lost as a result of the power interruption is being considered.

4. Conclusion

The system has shown itself to be an effective and efficient low-cost method for the display, monitoring and alerting of power loss and return events. It provides the underlying historical data to assist in identifying problem areas that contribute to network downtime thus providing valuable input to contributing to optimal reliability of supply to customers. There is potential to substantially enhance the value derived from the system through further innovation and development.

5. References

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