Executive Summary - Designing a Market Solution for Rapid Demand Response in Kenya

A report from the EUROstar project UMEME 24/7
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This is an executive summary of the Market Solution report written as part of the EUROstar project UMEME 24/7 which aims at developing and testing a demand response system to improve the power supply in Kenya. One aim of the project is to suggest proper market institutions that together with the technical solution make up a business solution for demand response.

The aim of this summary is to convey knowledge developed in the research project and to make it possible for a broad target group to bring the ideas to life. As such, the target group ranges from business entrepreneurs and researchers to interest groups and policy makers.

The electricity supply in Kenya is challenged by a rapid growing economy and consequently a rapidly rising demand for electricity. Reliable electricity supply is generally considered as one of the critical factors for an economy to develop. Cognizant of this, Kenya has invested considerably in production and transportation of electricity and has ambitious plans for future investments in the electricity sector. However, rapidly rising demand due mainly to growing economy and ambitious connectivity goals, among others, render such supply side efforts inadequate to ensure reliable supply of electricity in the country. Inadequate and unreliable power supply has forced businesses in the country to invest in costly off-grid backup generators Trajectories of future demand and supply of electricity suggest potential instabilities in supply of electricity both in short and long run

In practice, the frequent imbalances are solved by switching-off entire substations and leaving large areas without on-grid power. In this report we have described a demand response system as well as market institutions that aim at using available off-grid generators more efficiently. Instead of switching off entire substations we suggest a demand response solution involving backup generator owners based on consumer consent in a way that improves on-grid sale as well as electricity reliability. The existing off-grid backup generators allow for rapid on-grid demand reduction, however, the suggested solution may equally well be used for other demand response resources such as intelligent control of cooling systems.

To get more knowledge about how the challenges described above are perceived by the consumers and electricity stakeholders in Kenya, and thus what the possible solutions may be, the project has visited Kenya twice: one in December 2012 with primary focus on the technical aspects of a potential solution and another in January 2013 with primary focus on the economic aspects of a solution. The two trips to Kenya included 21 field visits and interviews with: Industry (African Cotton, Alpha Knits, General Plastics), Retail/Service Industry (Nakumatt Supermarkets, Westgate Mall, CBRE, Knight Frank, three Sarova hotels in both Nairobi and Mombasa), Public Institutions (Mombasa Harbour, Mombasa Airport), Generator Companies (Car and General, Aggreko, Blackwood Hodge), TSO (Kenya Power) Power producers, (Lake Turkana Wind Project, Aggreko), Knowledge Institutions (Strathmore University, KIRDI, Growth Africa), Intergovernmental organisation (UNIDO). There has been and is on-going communication with several of the visited institutions including DNV KEMA Energy and Sustainability who did an extensive feasibility study for the Lake Turkana Project.

From the field visits we can conclude that electricity consumers in Kenya are challenged by the current situation with large numbers of power fluctuations and blackouts. Interviewed consumers reported that such unreliability is costly primarily in terms of production loss and equipment damages. Consumers reflected a real need for improvements and as such they appear to be positively inclined towards a solution that could help the situation.

Our interviews indicate that consumers are better able to imagine the 'Island Mode' scenario (where an entire firm is switched off) than the 'Reduction Mode' scenario (where partial installations within a firm are switched off). This could be related to the fact, that Island Mode scenario is already known to them, as this is practically what currently happens every time there is a blackout - but without the compensation scheme, which would be part of the added value of the UMEME solution. The Reduction scenario may demand more 'selling' and should clearly show how it would not compromise the consumer's business/production/service.

The two main barriers for businesses to engage with an UMEME solution are:

1) Technology investments and return on investment and
2) Lack of trust in KP (and whether they would actually compensate businesses for demand response).

The UMEME Technical Solution

The UMEME solution that was presented to the stakeholders for them to comment consists of three components:

- A monitoring and prediction system, that map demand response (from the end users with a demand response contract) on the electricity grid.
- Remotely controlled switches that can activate the demand response immediately if necessary.
- Market institutions (e.g. contracts and price-setting mechanisms) that provide sufficient incentives for end-users to participate

These three components make up the demand response solution. The operation may be made easy accessible by a web application where the TSO request and demand reduction in the relevant parts of the grid and get prices as well as executing the demand response directly.

Figure 1 illustrates an operational scenario in four steps:

1. The TSO request reduced consumption in a given region of the grid (a job).
2. Based on the stated minimum compensation and consumption profiles, an auction computes the compensation and cost of activating the reduced consumption available for the job.
3. If the TSO accept the suggested plan, the selected end-users (or contract holders) are disconnected.
4. After the job has been solved the compensation to the selected end-users is settled.

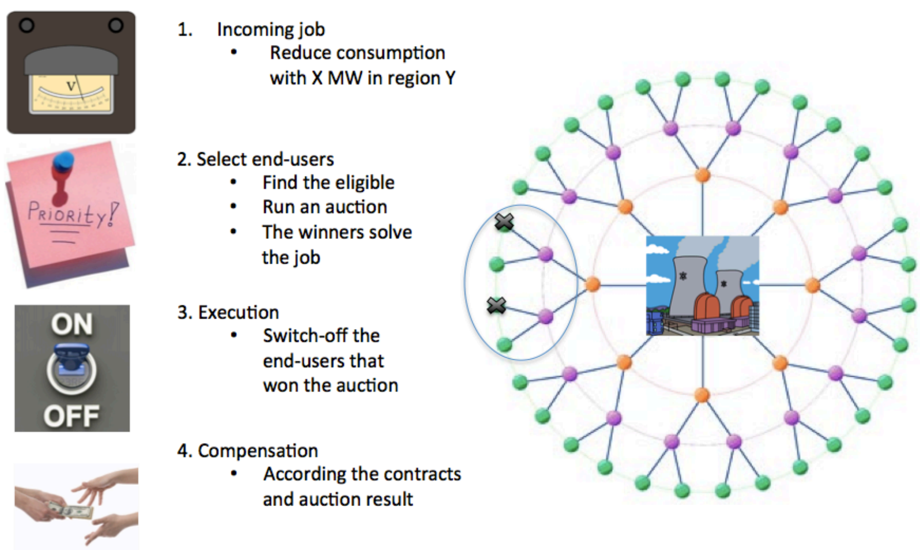

Figure 1: The overall operational scenario

The UMEME Market Solution

The suggested market solution is a demand response system managed by an "aggregator". On one-side, the aggregator signs contracts with end-users that can supply "demand response" and install the required meters and switches. On the other side, the aggregator signs contract with the TSO about using the system to buy and activate demand response.

By nature, the incoming demand response jobs varies a lot both with respect to timing, required reduction and whether the problem is national or local. A national imbalance may be solved by demand reduction from any end-users in the grid, this is unlike a local imbalance that can only be solved locally. Also, demand response offered by the end-users varies a lot among the end-users both with respect to timing and the costs involved in offering the demand response. These basic characteristics of the demand and supply of "demand response" requires a very flexible system that selects end-users and settle compensation levels job by job. The suggested market solution take this into account and involve an auction that selects the set of end-users that can solve a given job and do it cheapest.

The auction settles a single uniform price per demand response job, such that it motivates the end-users to reveal the true minimum compensation rates. Since the true minimum compensation required to operate a private generator is likely to be relatively stable, the end-user can submit bids well in advance and no end-user involvement is required during the actual auctions. This is very much like the so-called add-words auction, where the users submit preferences well in advance and where the auctions are executed automatically as others click on the sponsored link. In the suggested demand response system the TSO type in the job and accepts/rejects the auction result. If the TSO accepts the demand response job the selected end-users are disconnected immediately. This makes the suggested solution a rapid demand response solution.

The solution is well suited for developing countries with less developed electricity markets and with off-grid generators that may be used more efficiently as a part of the on-grid electricity system. Also, in developed electricity markets the increasing use of renewable energy resources requires more rapid end-user involvement. Today the rapid inclusion is bought in advance at inefficient prices. As such the suggested solution may play a role in developing electricity markets and future smart grid solutions. Nevertheless, the value added is probably higher in developing countries, since the value of an additional unit of electric in terms of its contribution to GDP growth is much higher for developing countries as compared to developed countries, as stated in Schramm (1990).

Added Value of The UMEME Solution

In order to measure the value added by the suggested response system, we set up a simple simulation, which has several limitations due to the lack of information in general as well as the lack of a model of the Kenyan power system. Nevertheless, the simulation uses the available information and capture the diversity of the incoming demand response jobs in the context of the suggested demand response solution.

While the exact results from the simulation is questionable due to the limitations laid out above, the interplay between the suggested auction and the contracts used to split the profit between the parties is reflected in the simulation results.

Firstly, the great diversity of the demand response jobs as well as the fluctuating willingness to pay and accept, requires a flexible price setting. This is illustrated by the simulation that clearly shows that the fixed price contracts between the aggregator and the TSO unsuitable.

On the other hand, a lump sum contract is the most flexible and ensures most use of the demand response system. However, settling on a lump sum payment with the TSO is difficult and relies on private information from both the TSO and the end-users. The third type of contract, the markup contract, is reasonable flexible and ensure that the aggregator is left with a positive profit in all cases. Altogether, the simulation results show that distortion introduced by the markup contracts is limited and the difficulties in negotiating a lump sum contract, makes it probably the best choice of contract type.

As a final remark, we conclude that the suggested solution is viable and that the initial attempt to measure the value added, provides insight into the choice of contracts. The result may be used as a first indication of the market potential. However, a number of things has been left out of the analysis, such as social welfare generated by a more stable electricity supply or the value of making more room for renewable energy.