DEVELOPING AND IMPLEMENTING A TARIFF ASSESSMENT TOOL USING EXCEL AND A BOTTOM-UP APPROACH (BIG DATA)

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ABSTRACT

The development of hourly electricity consumption metering in distribution grids provides several new opportunities for network companies if they have the tools to utilise the large quantity of hourly data that they collect. This paper presents the development of a software model tool that can harness a large quantity of data produced with an hourly resolution at an individual-consumer level. It has many applications within analyses focused on the distribution grid. The software model has three key advantages compared to other tariff revenue calculation models: its set-up is capable of dealing with a variety of different measurement formats, it can handle a significant amount of hourly data from every single end-customer rather than needing to rely on standard consumption curves, and its interface is simple to use for technical and non-technical staff alike. In this paper, we present the tool itself and several areas where the tool has been applied, including in revenue assurance, tariff assessments, temperature normalisation, and distributed generation impact assessment. Several developments in the market, such as increased hourly metering and changing customer behaviour, will increase the number of applications of this tool in assessing future revenue levels and scenarios for distribution grid companies.

INTRODUCTION

As computing power reaches strengths that allows for the time-effective processing and analysis of very large quantities of data, opportunities are opening up in many sectors to be able to utilise this as a competitive and efficiency advantage, not least within the electricity distribution sector. Measuring hourly data over a period of time grants many possibilities to assess how changes at the end-customer system level can impact the system as a whole, as well as customers and stakeholders. Tariff changes and future scenarios for the energy sector can be analysed and the impact this can have on individual stakeholders through to the electricity market considered. Being able to use and analyse this data can serve as a key tool to analyse the impact of possible future changes within the distribution sector. One of the bigger barriers in this process, however, is the use of different measuring systems with different customer segments and substations.

This tool has been successfully applied to a variety of client projects, from basic quality assurance to tariff structure analysis. A recent example is a revenue assessment for a Swedish electricity distribution company under different scenarios across their entire customer base – with hourly data this amounted to over 750 million rows of data for one calendar year.
In the following sections, the analysis tool is first presented and then several applications briefly described. The potential for future work with this tool and big data is highlighted in the latter part of the paper.

ANALYSIS TOOL

The big data software environment used to read in, structure and perform the calculations is Lavastorm Analytics Engine (LAE) [1]. LAE was initially developed for the telecommunications sector, however is today being used in several other sectors. LAE was specifically chosen for this paper as it is capable of managing large volumes of data and different data formats.
In designing the user interface, Microsoft Excel was chosen due to general client preferences and for its accessibility for a variety of users, from IT experts to business controllers not versed in computing. It is from Excel that both inputs and parameters are imported and to which the final results are printed back. An overview of this relation between Excel and LAE is shown in Figure 1.

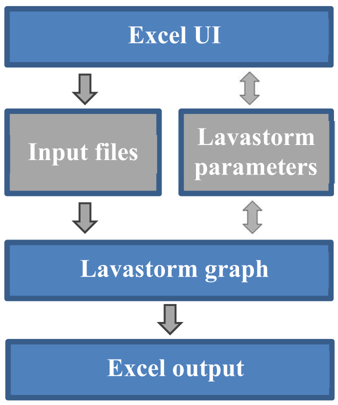

Figure 1 Schematic overview of the relationship between MS Office (Excel UI) and LAE (Lavastorm graph). A double pointed arrow means there is two-way communication (read/write)

By using a bottom-up approach, the analyst has a markedly improved accuracy in terms of assessing different possible changes to tariff structures, and a wide variety of scenarios. Using historical data one can avoid the need for general assumptions to be applied to a

category of end-customers, such as standard consumption curves, but rather collect and use individual end-customer data to get results that are likely more accurate than those based on assumptions.
As the use of meter data increases, being able to simulate scenarios that can take into account changes at an individual end-user level will be an effective tool for distribution grid companies. By revealing the added value in data, it is possible to assess different scenarios and quantify sensitivities and risks, and to enable a more efficient use of available resources.

AREAS OF APPLICATIONS

The model can support a wide range of parameters variables such as penetration levels of distributed generation, colder/warmer temperatures (which affects consumption that is temperature-sensitive), change in electricity usage (energy efficiency), different rate plans (e.g. subscription fee, power tariff fee and time-differentiated power fee/subscription fee). An additional possibility is to include high-voltage consumer rate plans in the simulations.
In this section we aim to show how the software tool developed can facilitate both technical and business analyses and address many challenges faced by distribution companies.

Revenue Assurance

Measuring the quality and accuracy of current practices can provide several opportunities for improvements which are possibly within easy reach of stakeholders. By comparing billing data with actual data and ensuring that revenue caps are met can highlight simple adjustments without the need for more expensive and bigger changes.

Challenge
Did revenue levels reach the revenue levels expected with the current rate plans? Is the billing data correct considering the underlying consumption and rate plans? If not, where did the error occur?

Model Application
With the hourly meter data in hand, it is possible to evaluate the status and electricity consumption of every customer in each customer segment, apply the relevant tariff, and then compare the value of the expected revenue with the realised value. This process should be able to identify possible errors that exist within the current billing framework and verify that customer bills are correct.

Tariff assessment

As the capacity to measure hourly consumption data increases, different rate plans are increasingly being considered by distribution companies as to how they would affect customers and their own revenue levels. There are several components to each tariff structure which should be considered to find the optimal values to be implemented.

Challenge
How could different rate plans affect revenue levels? Which cost levels of rate plan components would provide same revenue levels as today?

Model Application
In this process it is first necessary to take the historic hourly data for each customer, and apply a reference tariff structure to it, which would likely be the current rate plan assigned respectively to each customer group. Then, the different tariff structures can be applied to this same individual hourly data.
For example, the comparison could be between a subscription fee tariff that a distribution company currently uses, and a power fee tariff that they are considering, can be easily assessed in this process. As shown in Figure 2, this allows for a comparison of revenue levels between the two different tariff structures.

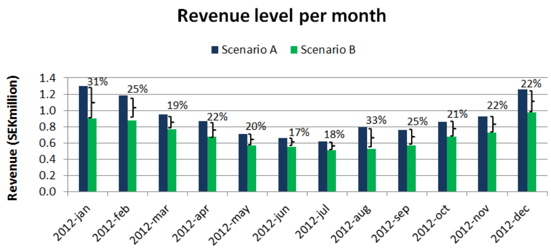

Figure 2 Monthly revenue levels for two different tariff structures, with the percentage difference between them shown, relative to Scenario A

Such rate plans will naturally impact revenue levels, and customers with a weather-dependent load who today pay a twelfth of their fixed yearly bill each month will likely pay a higher portion of their yearly fee in the colder periods of the year.
It is then possible to analyse different cost components and identify which combinations can give sufficient revenue levels. For example in Table 1, there have been six values considered for each of the two different cost components of a power fee tariff – both the power fee (SEK/kW) and energy-usage fee (SEK/kWh) – resulting in 36 combinations.

Table 1 Various combinations of the cost components of a tariff with a power fee and transmission fee and the revenue levels they produce, relative to a reference tariff structure

Power fee (SEK/kW) \ Transmission fee (SEK/kWh)	0.125	0.15	0.175	0.2	0.225	0.25
20	69.3%	76.8%	84.2%	91.6%	99.1%	106.5%
22	71.9%	79.3%	86.7%	94.2%	101.6%	109.0%
24	74.4%	81.9%	89.3%	96.7%	104.2%	111.6%
26	77.0%	84.4%	91.8%	99.3%	106.7%	114.1%
28	79.5%	86.9%	94.4%	101.8%	109.2%	116.7%
30	82.0%	89.5%	96.9%	104.3%	111.8%	119.2%

Further applications

There are several key developments of this model application described, most notably in the assessment of tariffs with time-differentiated power fees and critical peak pricing tariffs. As this model deals with hourly data, both of these tariff structures can be accurately examined using a similar methodology.

Temperature normalisation

Electricity consumption levels can be affected by several external factors that lie well-beyond the control of network companies, not least the effect of weather on load patterns. The extent to which load is weather-dependent varies and is different between different customer segments.
If comparing energy usage and revenue levels for different years, it is important to be able to correct the data for different weather conditions. Whilst all household loads are not weather-dependent, certain customers will be disposed to alter their energy use depending on the temperature outside.

Challenge

What share of consumption of our consumers is weather dependent? How sensitive are the revenue levels of current or proposed tariffs to variations in weather conditions?

Model Application

Rather than depend on general assumptions about customer groups, the model allows for the weather dependency of a specific set of customers to be assessed historically and normalised accordingly.
An example of this; the first step in the analysis is to take the hourly data and assess the weather sensitivity of the load. This process takes all customers in the assessment group and compares the average consumption of each of these consumers in January/February with that in July; if consumption in the colder months is 50% or more than consumption in the warmer month then the load is considered weather-dependent and so can be weather-corrected, or temperature normalised. Temperature normalisation can be done using a method such as that of the Swedish Meteorological and Hydrological Institute with their "Graddagar" ("Heating degree days") method [2]. An example of how this affects the energy volumes considered can be seen in Figure 3.

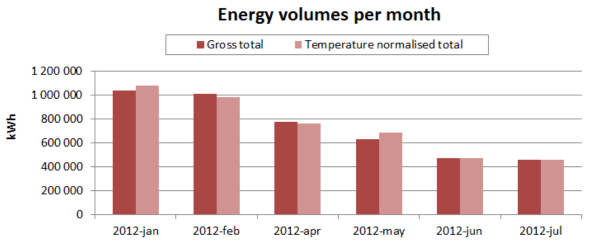

Figure 3 Monthly energy volumes, with and without temperature normalisation

The next step of the analysis can be to then consider the effect of such weather dependency on revenues, and how this can differ between tariff structures or rate plans. Figure 4 shows the results of an analysis considering monthly differences in revenues between two tariff structures, with and without weather correction, for a specific customer group.

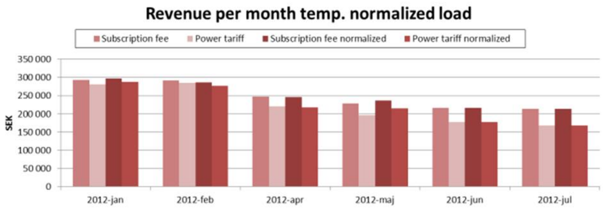

Figure 4 Monthly revenue for different tariff structures and their weather dependency

This process can allow for a basic assessment of how sensitive revenue levels have been to weather conditions, as well as consider how sensitive revenues are under different tariff structures and scenarios.

Changes in customer behaviour

There are many ways in which customer behaviour can vary and develop, both in terms of electricity consumed and patterns of energy use. There are several areas of development that will, if not already, certainly impact distribution companies, for example:

- Demand response
- Distributed generation (DG), e.g. rooftop solar PV panels
- Energy efficiency measures

Challenge

With increased changes at the end consumer level, how do they affect revenue levels? How sensitive are revenues under different scenarios? How does the situation look with different tariff structures, and how can we develop our business to maintain revenue levels?

Model application

As in other applications, the first step is to take the historical consumption data for the relevant customer segments. It would be useful to know which customers already have DG or energy efficiency measures to see how their consumption levels and patterns have changed. In the case of distributed generation, different levels of DG penetration can be assumed across the customer group, with different levels assigned to different segments, and certain production profile assigned to these customers. The different consumption patterns and other challenges that DG can cause for a distribution grid, can be analysed; an example can be seen in Figure 5.

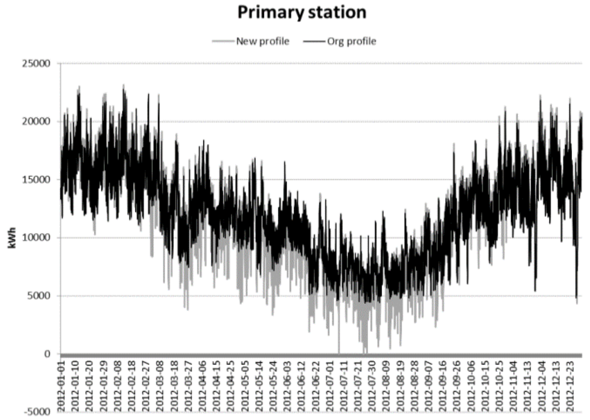

Figure 5 Change in hourly (average) load from the original profile to the new profile for which a certain level of DG has been assumed for different customer segments

In a similar way to DG, the impact of the uptake of electric vehicle charging can also be analysed. Demand response can also be analysed at this individual-customer level. Different types of demand response can be assumed for different customers, and the impact analysed.
The next step in this analysis of changing customer behaviour, as in previous sections, is to analyse how changes in consumption patterns can affect revenue levels, and how robust different tariff structures are to such developments in the market.

Other applications

There are several other areas of application that have not been discussed in the previous sections, two examples would be:

- Data verification, by identifying bad data and errors in meters or other equipment
- Assessment of the number of customers who are on an incorrect tariff, with a higher fuse subscription than their actual fuse size.

FUTURE APPLICATIONS

As the distribution grid continues to develop and new challenges arise, applying this tool can allow distribution companies, and other interested parties, to gain more accurate insights into the effects of such developments. Within the area of analysing tariff structures, critical peak pricing is a more complex area that could be effectively analysed using this tool.
The most notable aspect of all in such a bottom-up approach is that the simulations are not aggregated in any way, but rather performed on each end-consumer's load profile. Hence, any questions arising from changes at this level can be addressed in ways that is simply not possible without measured hourly data.

CONCLUSIONS

As the capacity for measuring the hourly consumption data of households' increases, there are new opportunities to use this data to make more accurate assessments within distribution grids. Making use of this development, the software model tool described here has been created for use in addressing the many challenges faced by distribution grid companies. It has three key advantages over other revenue assessment calculation tools: it can deal with a significant amount of hourly consumer data and reduce the need for assumptions, it can deal with a variety of measurement formats, and its user interface is simple to use by non-technical individuals.
Harnessing the power of big data – the hourly meter data for individual customers – has many areas of application; it allows for more accurate analysis of current practices to ensure that revenue caps are achieved, the sensitivity of revenues to a range of factors such as weather can be considered, future changes to tariff structures, including the level of cost components, can be analysed in depth, and various future scenarios that will affect customer behaviour can be studied. Scenarios can be built from a bottom-up approach, avoiding general assumptions and standard consumption curves about specific consumer groups. The applications are many, and it can be used to address many current and future challenges for distribution companies.

REFERENCES

[1] Lavastorm Analytics, *Analytics Engine* [Online], http://www.lavastorm.com/products/analytics-engine/ [24 March 2014].

[2] SMHI (Meteorological and Hydrological Institute), 2012, *SMHI Graddagar* [Online], Available: http://www.smhi.se/Professionella-tjanster/Professionella-tjanster/Fastighet/smhi-graddagar-1.3478 [24 March 2014].