Transforming Utilities: Turning Data into Intelligence with Data Analytics

Vanesa Čačković, Željko Popović
Ericsson Nikola Tesla did.
Zagreb, Croatia
e-mail: vanesa.cackovic@ericsson.com
e-mail: zeljko.popovic@ericsson.com

***Abstract*—Data analytics is an important part in solving the challenges faced by transforming utilities. The introduction of smart meters and smart grids is leading to the convergence of information and communications technologies and utilities. Data analytics can be a powerful tool to create major improvements in efficiency and customer experience or it can even bolster service innovations. The deployment of data analytics is a necessary move as infrastructures, particularly electric grids, are expected to transform from more or less linear energy systems into networked, distributed systems with a multitude of market participants and management models in play. The grids simply become too complex to handle without large-scale data analytics.**

Keywords-data analytics; utilities transformation; smart metering; smart grid.

I. INTRODUCTION

Data analytics is a broad term frequently heard in the utility industry together with the phrase big data. In theory, analytics is simple: data delivered from devices, sensors, and meters throughout the grid is being analyzed and used to create an intelligence in order to inform and improve operator responses to a given situation. Most of the analysts agree that analytics solutions and big data have gone from hype to work [1][2][3][9][11]. It is becoming a foundation for decision-making and a business priority among the world's organizations. Big data is a term describing large amounts of data, collected from variety of sources, analyzed with the purpose of creating new intelligence and building business advantages. It brings faster results, a new depth to analytics and an unprecedented predictive power. Data analytics solutions are primarily used for three things: increasing customer experience, efficiency and growth. They are used as powerful preventive mechanism as well as corrective mechanism for real-time and near real-time control and management. A data-enhanced customer experience provides a deeper understanding of users and an increased customer experience through high performance services, fast feedback and customized offerings. Data-driven efficiency means taking advantage of the information available within the organization, in order to work smarter and reduce costs. Growth, finally, is about innovations and new revenue streams sparked by big data [4].

The utilities industry is transforming. Electrical grids, water and gas pipes are examples of infrastructures that are expensive to build and maintain, and are often heavily regulated and considered 'natural monopolies'. Market conditions vary significantly between countries in terms of competitiveness and private/public ownership, but in general, the sector has particular ways of conducting business. Simply put, utility businesses have been built around energy resources and have had generation, transmission and energy retail flowing from the center in a one-way, linear build-up. Consumers have had little influence on service and pricing. Today, there is a new situation for utilities companies: market mechanisms are changing, competition is increasing and pricing is becoming increasingly complex. There are a number of factors that contribute to the market transformation and call for big data solutions. Some of the most important drivers include:

1. Regulatory pressure: Governments are under pressure to improve energy efficiency, and their actions have consequences for energy companies. Regulations like the European Union's 2012 Energy Efficiency Directive and the US Energy Policy Act of 2005 put pressure on energy companies to become more efficient and reduce their environmental impact. Utilities are also incentivized to utilize their assets in more effective ways. This is done through value-based assets management, including deployment of sensors and analysis of the financial impact of outages.

2. Consumers become producers: The relationship between utility companies and consumers is becoming increasingly complex. The combination of decentralized generation and storage options with demand side flexibility can further enable consumers to become their own suppliers and managers for (a part of) their energy needs, becoming producers and consumers and reduce their energy bills. Decentralized renewable energy generation, whether used by consumers for their own use or supplied to the system, can usefully complement centralized generation sources. Where self-consumption exhibits a good match between production and load, it can help reducing grid losses and congestion, saving network costs in the long-term that would otherwise have to be paid by consumers. If consumers generate their own electricity from onsite renewable energy systems, they consume less electricity from the grid. This will affect how network tariffs are calculated. Network tariffs should be designed in a cost-reflective and fair manner while supporting energy efficiency and the renewable energy objectives and being simple and transparent for consumers Those dramatic changes in market mechanisms push energy

 ISBN: 978-1-61208-484-8

companies to find ways to manage distributed generation and net metering using the data analytics to help manage all new relations, power flow and business models.

3. Increase in price volatility: The increase of intermittent energy sources like wind and solar has resulted in more fluctuations in energy access over time. The volatility is elevated further with the growing influence of power markets. By introducing smart meters, consumers can adjust their energy use in relation to the fluctuating prices. These fluctuations are now becoming normal; but handling those demands require sophisticated data analysis.

4. Threats against the service delivery: Utilities are among the most critical infrastructures in society. Major incidents such as geopolitical events and natural disasters can cause severe damage to vital systems, in turn threatening markets, security, and people’s lives. We all rely on energy infrastructure, and the increased level of these threats calls for improved resilience and intelligence.

5. Aging infrastructure: Around the globe, utility infrastructure is growing, and with aging technology comes increased vulnerability and a lack of interoperability with newer systems. Old infrastructure requires ongoing optimization to remain functional and cost effective [5].

Implementation of Distribution Grid Optimization Analytics described in this paper proposes using existing utility data fetched from several sources of smart metering network to achieve better visibility and easier monitoring of the end-to-end electricity network. It is important to state that analytics engine used here is real near time which enables users to act on the identified situation immediately. Another important aspect of this implementation is that the data model internally used by this analytics system is based on metadata which enables modelling of any kind of network elements, communicating over any communication technology in any type of network (electricity, water, gas networks with smart meters, routers, repeaters etc. communicating over power line communication, RF Mesh, 3G or any). So, the same concept could be applied for different types of utility networks.

This paper presents the typical current situation in European utilities regarding implementation of analytics methods based on industry research and commercial implementations experience together with possible benefits for implementing analytics and big data solutions.

The paper is structured in following way: Section I gives an introduction to the subject, Section II describes the Traditional utilities approach to data, Section III explains the Data Analytics Potential, Section IV gives an overview of the Implementation Use Case, while Section V gives the Conclusion of the paper.

II. TRADITIONAL UTILITIES APPROACH TO DATA

Today utilities only make use of existing data to a limited extent. Decisions are based mostly on historical data from internal data sources and sometimes combined with external source, for example weather data. Usage of real time data is limited to pilot projects and small scale initiatives. Utilities often do not use all valuable data they have access to. Major analysts estimate that around 5% of existing data is being used for some specific purpose, while the rest is not processed at all. For example, a smart meter can be seen as a sensor that can help to visualize “the health” of power grid and communication. Only small percent of data one smart meter is capable of storing and sending is being fetched and that is primarily for billing purposes. The fact that a utility collects data does not necessarily means that it is making use of the data. Everyday operation and maintenance routines often mean handling of various excel files coming from different data sources and is not being done in real-time manner. Databases are also often updated by hand.

Utilities approach can be described as “one problem/one system” approach which means that single problems are handled using single dedicated applications. Links between systems are loose or missing. This means that many utilities still lacks synchronized databases and use many redundant databases (data silos). However, efforts to integrate those separate data systems can be already seen for most of energy companies.

Today’s utilities usually have some business intelligence tools in place and have insight into some areas of their operation. Those tools used by utilities are mostly standard reporting tools and obsolete forecasting models.

However, utilities are aware of the changes in the energy landscape and available data sources. They see that conversion of operation and information technologies brings massive volume of data. Some utilities have started pilot projects to investigate the use cases for big data other than accurate billing. It is clear that utilities will have to invest in new technologies for data management to unlock true potential of new data sources. They need to re-build their data architecture model and redefine data use cases.

Data management is not new for utilities. For example, traditional supervisory control and data acquisition (SCADA) systems [6] are in place for a while now, but the volume and velocity of data in smart grid is something which they are not prepared for. The main difficulty that they will have to overcome to start implementing big data technologies refers to expertise, infrastructure, and perception of risk (business value recognition).

Handling a tremendous amount of data from the grid, smart homes, in-house data bases or social networks requires big data processors with enormous storage capacity and specialized ICT services. Most utilities do not have that. They also complain about the shortage of people specialized both in energy industry and big data.

Business model transformation will mean step by step adoption of new data management technologies for more informed decision making. The transformation will be based on 3 pillars:

- Emergence and adoption of new data sources
- Integration of new types of data
- Changes in data consumption model

With the emergence of smart grids, utilities will start exploiting new data sources (grid sensors, smart meters, and electric vehicles) to optimize their business and provide better customer services. Utilities will be also forced to

 ISBN: 978-1-61208-484-8

improve customer interaction building on social media and various web data.

Utilities are used to dealing with simple and structured data limited in volume and velocity. Collection, storage, and processing of M2M data from sensors and meters will pose a challenge for energy companies who have no in-home big data capabilities. However, the greatest difficulty will be to integrate those structured data with unstructured one which is totally new to utilities [1][7].

Business model transformation will be based on connecting traditional and new data sources, tapping new data, and integrating smart meter, smart grid, transaction, and geospatial data as shown on Figure 1.

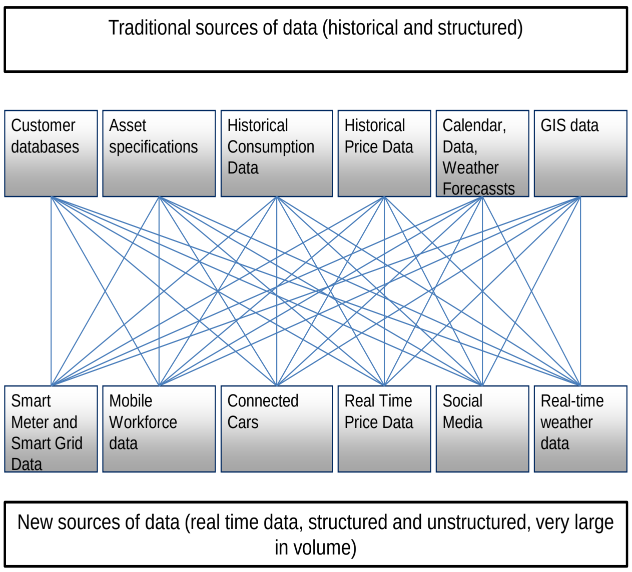

Figure 1. Data-business model transformation

Big data in the utilities sector will be dependent on a much larger number of nodes than for example in telecoms, demanding lots of machine power and powerful analytic models. Smart meters are not the only components of smart grids that can generate useful data for utilities companies.

In the transformation, period utilities will not be using the full potential of available data. Utilities will leverage data potential only to some extent, mainly using just smart meter data on commercial scale. Starting from reporting, billing and settlement, they will test new technologies and use cases. After choosing the most successful ones, they will start adding new sources of data to their data management systems and build up their analytics capabilities.

The development pace of data management systems will differ by country, energy market participants and technology.

Utilities will start with analyzing structured data. Many pilot projects, especially involving smart meter data have already been kicked off. Utilities will lag behind with adoption of analytical tools for processing unstructured data. It seems that cost approach will be the biggest challenge which will have to be overcome to enable moving to a truly data-driven model.

Cloud computing may be the answer for utilities hesitancy in deploying advanced analytics solutions. Some utilities have already moved part of their processes to cloud environment, however, a majority of those cases are non-mission critical processes.

III. DATA ANALYTICS POTENTIAL

There is evidence that analytics is quickly becoming an extremely important component of many utilities' overall IT/OT strategy. From predictive maintenance to customer engagement (CE), from energy efficiency optimization to grid optimization and beyond, analytics solutions are evolving rapidly and promise to dramatically alter the utility IT landscape in years to come. In a study commissioned by C3 Energy, the consulting group McKinsey and Company found that the potential annual savings per meter, through utility analytics solutions, could approach $300 [2].

By implementation purpose analytics solutions can roughly be divided into three categories:

1. Distribution Grid Optimization Analytics
2. Customer experience analytics
3. Business Intelligence analytics

1. Distribution Grid Optimization Analytics:

Smart grid data analytics can support a myriad of use cases, but in order to fully maximize the benefits of smart grid deployments, analytics solutions that support operational improvements are necessary. Grid optimization analytics can leverage data from smart meters and other grid-sensing devices, as well as through asset monitoring data, to optimize the operation of the transmission and distribution networks and asset performance [2].

For the Distribution Grid Optimization Analytics it makes most sense to include the analytics solution from the very start, with the rollout of smart meters. If so, the analytics solution can be powerful tool to track the rollout progress. Main benefits of using analytics in parallel with the rollout are reducing times for detecting and fixing faults, decreasing number of needed field interventions, increasing quality of service, improving network visualization and decreasing the operational cost of the network in general. After the rollout is finished, with the analytics solution already in place, the same system can be used for further distribution grid optimizations (for example, Demand Response Management System (DRMS), energy data forecasting/load forecasting, various visualization tools etc.).

2. Customer experience analytics:

The business-to-consumer model is being challenged by forms of energy production that allow private individuals to become energy producers. Wind farming, solar energy, the unloading of surplus energy from electric vehicles into the grid, or other forms of distributed generation (the ability for consumers to sell power) all complicate the transaction of energy and payments. This in turn demands more from billing and charging systems. Data analytics is necessary for dealing with the complex customer relationships following from distributed generation. It can also provide the foundation for new services that address new customer

 ISBN: 978-1-61208-484-8

needs. Smart meters and smart home appliances provide new opportunities to invent solutions that build customer engagement and grow revenue. They can track consumer behavior on different appliances, and combine that information with weather data, pricing information and other variables to create solutions that save energy and money for users. Data analysis can be used to mitigate price volatility on the consumer level, through better management of the risks associated with a portfolio of commercial and physical assets. These types of data-driven innovations help to build new services, improve billing and charging algorithms and ultimately build engagement among customers in the long term. They can help to transform utility companies' businesses beyond distributing and selling electricity.

Like telecoms, the utilities industry is a sector where timing is vital. The intricate network of assets needs continuous monitoring and support, especially as many infrastructures are aging, and ongoing optimization becomes a way of prolonging their life. Data analytics solutions can give companies early warning services, detecting signs of problems that may affect customer experience in advance. The aim is to optimize everyday performance and prevent issues through effective fault management. There is also a customer care dimension to experience issues. Through analytics solutions, companies can identify the underlying issues that lead to customer complaints. It becomes possible to drill down into each customer's usage history and find the root cause of issues, making it possible to explain and resolve bad experiences.

3. Business Intelligence analytics:

Broadly, business analytics are used to guide business planning and identify inefficient business processes. Within the utilities sector, business analytics have historically been used for financial and production planning applications to analyze historical data and provide information to business users around a set of predefined key performance indicators via reports, dashboards, and web portals. Typical applications include financial and compliance reporting, demand forecasting for energy trading, and customer operations. Today, armed with a multitude of new data generated by smart grid technology deployments, utilities are trying to understand the potential for business intelligence (BI) data analytics applications beyond those provided by traditional BI tools. BI analytics can leverage smart meter data and asset monitoring data to improve the efficiency of M2C operations, enhance revenue assurance, provide greater visibility into system performance and asset utilization, and enable load and generation forecasting for energy trading or production planning activities. The more advanced applications move from a predominantly descriptive approach toward more predictive analytics that will enable utilities to become proactive in their strategies [2].

IV. IMPLEMENTATION USE CASE

Implementation of analytics solution as a rollout support is being chosen as an example for this paper since it describes well the usefulness of the analytics solution for utility company as well as help to understand basics and the full potential on one analytics solution.

A. Architecture

Advanced Metering Infrastructure (AMI) is defined as a full measurement and collection system that consist of a meter hardware located at the customer site; communication networks between the customer and a service provider such as an electric, gas, or water utility; and data reception and management systems that make the information available to the service provider. AMI has a variety of specific characteristics that present challenges to the effective management of its communications and head-end systems. The biggest challenges an AMI network faces include controlling and utilizing waves of meter data, building AMI networks to scale, and meeting important requirements including bandwidth, latency, throughput and reliability.

Advanced Metering Infrastructure are systems that measure, collect, and analyze energy usage, and communicate with metering devices such as electricity meters, gas meters, heat meters, and water meters, either on request or on a schedule. These systems include hardware, software, communications, consumer energy displays and controllers, customer associated systems, Meter Data Management System (MDM) and supplier business systems.

The most common architecture used to address the features of smart metering systems is presented in Figure 2. It consists of [11]:

- Smart meters (SM)
- Data concentrators (DC): process data from several meters
- Head End System (HES): central data collection point
- Local area network (HAN, NAN): allows bi-directional communication between the smart meters and a data concentrator
- Wide area network (WAN): allows bi-directional communication between the data concentrators and the head end system.

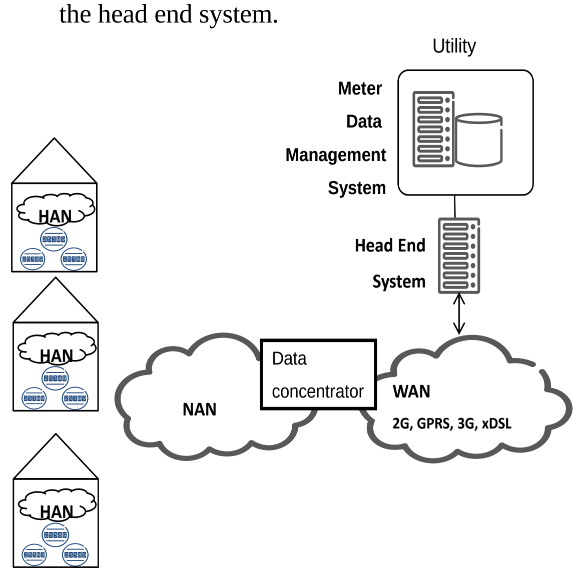

Figure 2. Typical AMI architecture

Though the basic function of the MDMS will include validation and storage of smart meter data, utilities expect additional functionality in support of more business processes across their value chain. Meter Data Analytics (MDA) is an upcoming trend where Meter Data Management (MDM) vendors or ICT vendors are trying to expand their offerings into in order to provide utilities add-on capabilities for data processing, analyzing, and reporting trends that add value rather than just uploading data. MDA enables utilities to avoid forecast failures rather than respond to them.

B. Implementation

Utility company described in this use case is one of the largest electricity distribution companies on the Baltic countries, owning over 640.000 metering points (residential and industrial), 61.000 km of power lines and 22,000 substations. Main motivation for transformation the utility was the fact that all electricity meters need to be remotely readable by 2020 according to EU directive and aging equipment with high maintenance cost. The utility company started an eight-year long transformation project within which integration of new MDMS was included as well as rollout of smart meters and integration of Analytics platform with existing systems. Smart meters help modernize the power grid by providing the ability to remotely monitor and transfer energy consumption and power quality information.

Smart metering also benefits end customers in the form of energy and cost savings, reduced carbon emissions, improved service reliability and improved customer service and responsiveness. To make all of these benefits a reality, utilities need a secure and flexible two-way communications infrastructure to connect and communicate with smart meters.

Collection and transmission of energy consumption data is a continuous process that is done automatically. As the network grows, efficient operation of Smart meter communication network becomes a critical process. Ability to address critical issues in network and also capability to address problems before a failure require innovative tools to support communication personal in their daily work. Analytics platform is a solution for enabling visualization and context development for smart metering data to support power grid management [12]-[17].

The Analytics Platform gathers the data from various data sources (HES, MDMS, GIS, CIS, asset management, etc.) in online mode and does the modelling and processing of data in order to act on newly processed information. During the implementation over 50 candidates for analysis and implementation were identified (so called use cases) which can roughly be divided into three groups: power network operations, smart meter operations and fraud&loss related use cases.

Examples of the use cases are:

1. Use Case (Communication supervision):

Loss of meter data during the collection process may cause issues with billing, as well as disturbances in the distributed energy generation. Upon a data collection failure, it is possible to quickly analyze possible causes by drilling down in the communications network, from a geographical network map down to an individual meter in an apartment house. Regardless where the information come from (multiple systems), it is presented in the same user interface which uses latest usability principles to increase user efficiency and effectiveness. The majority of the faults can be identified and solved either with remote reconfiguration or by deploying field personnel by issuing a work order. Network planning issues are found and can be corrected during normal operation. The method can be used to discover causes for income drops, users complaints, users churn, loss of control of distributed generation figures etc. There might even be regulations which put requirement on fault identification and fault repair which forces the utility company to have an efficient tool to localize and correct faults within a predefined period implying that every saved second means saved money.

2. Use Case (Power Quality Visualization):

Power quality determines the fitness of electric power to consumer devices. Without the proper power, an electrical device (or load) may malfunction, fail prematurely or not operate at all. The complexity of the system to move electric energy from the point of production to point of consumption combined with weather variation, generation, demand and other factors provide many opportunities for the quality of supply to be compromised. Smart meters provide simple power quality measures. Analysis of this information can aid in the detection of anomalies and other emerging adverse conditions in the distribution network, allowing the utility to proactively initiate equipment maintenance, reducing the likelihood of an outage. Power quality monitoring helps in preventive system repairs/ maintenance by identifying areas of poor quality and subsequently acting on those, additionally life of assets could be extended and unplanned service interruptions could be avoided via predictive and pro-active maintenance

3. Use Case (Energy Loss Detection):

Fraud amongst the subscribers is always a risk, including loss of income to unbalance in the power grid. Aggregation and correlation of multiple metering points (e.g. substation vs. aggregated feeder line consumption) makes it possible for the utility to understand magnitude of, and identify possible fraud activity. All information available from different sources is gathered in the same user interface to optimize the user experience and increase the efficiency. An alarm as well as a work order can be issued upon detected (suspected) fraud. The method can be used to reduce the loss of income but also prohibit unwanted unbalance in the power grid.

4. Use Case (Outage management visualization):

Smart meter events such as ‘last gasp’ and ‘power restore’ that provide meter off/on status can be used for improving outage management. Being real time or near real time events, these have an obvious advantage over outage information coming from customers and field staff. Examples of scenarios which could be visualized: Momentary outages and restoration-related events; communication and network interface issue-related events; Events due to planned outages, outages at the lateral, feeder or transformer level, customer disconnects, etc. Effective events processing & analytics engine shall be used to detect outages at the right device level, create proactive tickets, as well as 'power restore' to identify nested outages after large-scale outage restoration. Aim is to help make outages shorter and restoration more reliable. It can also reduce the customer complaints if information about the outage can be handled and in some cases distributed, even before the customers notices the outage.

After integrating described solution utility doubled the back-office engineer efficiency, times for solving faults were cut by half and overall communication quality between SM network elements improved significantly [8].

It has been seen that it would be beneficial to for use this type of Analytics platform also in other parts of utility organizations such as call center and general performance monitoring of the company [18][19].

As an outcome of the integrating the Analytics platform with existing systems and various data streams, it is possible to visualize the network, get communication quality, drill down to root cause, read configuration of devices and have near real time data available. The platform enables proactive and/or fast actions in order to secure needed network quality and meter data availability, supervise network rollout with higher quality, handling big number or smart meters and reduce operating costs. Analytics platform provides a way to collect, aggregate and analyze data in real-time, allowing utilities companies to prevent issues and manage the customer experience.

V. CONCLUSION

Collection and transmission of measurements and events from devices is a continuous process that is done automatically. The variety, velocity and volume of data gathered from and about utility networks are growing day by day. Such trend enables, but at the same time makes it difficult to process the data in order to make accurate, adequate and actionable decisions on managing those networks. Understanding the collected data brings opportunities to acquire new markets, customers and work with efficiency. Many organizations have a lot of data available, but do not have enough experts to leverage big data, and are not recruiting enough talent either. What is equally serious is that many organizations do not have good systems, routines and do not ascribe sufficient importance to data to make insights available to the whole organization.

Data analytics makes it possible to collect real-time data from existing grid elements to gain better control of the infrastructural assets. Ongoing monitoring of resources improves proactive maintenance actions and operations. Data from smart meters and other smart assets helps us to understand asset usage and provides a means of asset lifecycle management. The ability to anticipate issues that could interrupt the provision of service is a value that big data brings to both customer experience and operations. Like many other aspects of running a utilities operation, fault management is an area that is more difficult to handle today without data analytics solutions. Predictive modeling of events that cause outages can be deployed to trigger automated mitigating actions. This is an effective tool to reduce costs and improve customer experience.

REFERENCES

[1] Smart metering in Europe; Tobias Ryberg, Berg Insight research team; www.berginsight.com, [Last access April 2016]

[2] Navigant research: "Smart Grid IT Systems MDMS, CIS, GIS, SCADA, EMS, DMS, OMS, AMS, MWMS, DRMS, DERMS, and Utility Data Analytics Solutions: Global Market Analysis and Forecasts"; published 2Q 2015

[3] Frost&Sullivan: "Data-driven Utilities: Business Intelligence and Analytics to become the Top Investment Area for Energy Companies", October 2013

[4] Industry Transformation - Horizon Scan: ICT & the Future of Utilities; http://www.ericsson.com/news/141211-horizon-scan-ict-and-the-future-of-utilities; [Last access April 2016]

[5] Actionable intelligence Transforming Utilities; Ericsson; http://www.ericsson.com/res/docs/2015/actionable-intelligence-transforming-utilities.pdf; [Last access April 2016]

[6] http://whatis.techtarget.com/definition/SCADA-supervisory-control-and-data-acquisition; [Last access April 2016]

[7] Data-driven Utilities: Business Intelligence and Analytics to become the Top Investment Area for Energy Companies; Frost&Sullivan; October 2013

[8] http://www.ericsson.com/industry-transformation/energizing-estonia/; [Last access April 2016]

[9] Rob Lockhart: "Smart Grid Data Analytics: a New Approach for Utilities"; Gigaom Research, 2015

[10] http://www.metering.com/smart-meter-europe-estonia-utility-deploys-half-of-630k-target/; [Last access April 2016]

[11] GTM Research: "The soft grid 2013-2020: Big Data & Utility Analytics for Smart Grid";

[12] "Functional reference architecture for communications in smart metering systems", CEN/CLC/ETSI/TR, Tech. Rep., ICS 33200; 91.140.01, Ref. CEN/CLC/ETSI/TR 50572:2011 E, December 2011.

[13] J. Kwac, J. Flora and R. Rajagopal, "Household Energy Consumption Segmentation Using Hourly Data", IEEE Transactions on Smart Grid, vol. 5, no. 1, January 2014, pp. 420-430.

[14] G. Chicco, "Overview and Performance Assessment of the Clustering Methods for Electrical Load Pattern Grouping", Energy, vol. 42, no. 1, June 2012, pp. 68-80.

[15] L. Hernandez, et al. "A Survey on Electric Power Demand Forecasting: Future Trends in Smart Grids, Microgrids and Smart Buildings", IEEE Communications Surveys & Tutorials, vol. 16, no. 3, Third Quarter 2014, pp. 1460-1495.

[16] I. S.Bayram, G. Michailidis, M. Devetsikiotis, and F. Granelli,"Electric Power Allocation in a Network of Fast Charging Stations", IEEE Journal on Selected Areas in Communications, vol. 31, no. 7, July 2013, pp. 1235-1246.

[17] A.G. Phadke and J.S. Thorp, "Synchronized Pharos Measurements and Their Applications (Power Electronics and Power Systems)", Springer, 2008, ISBN 978-0-3877-6535-8.

[18] Y. Zhang et al. "Wide-Area Frequency Monitoring Network (FNET) Architecture and Applications," IEEE Transactions on Smart Grid, vol. 1, no. 2, September 2010, pp. 159-167.