A Review of ICT Considerations in Actual AMI Deployments

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Abstract. As transitioning to Advanced Metering Infrastructure (AMI) begins to make more sense for Energy companies and actual deployment projects are increasing, field players need to effectively answer a set of business and technical challenges posed either as tradeoffs or as investment feasibility / viability problems. This review aims to provide an overview of current offerings and solutions sought, relevant to the business / technical challenges faced as well as future opportunities identified for work in this section.

Keywords: Energy companies, utilities, metering infrastructure, advanced metering infrastructure, AMI, ICT, smart grids.

1 Introduction

Recent technology advancements as well as regulatory directives (e.g. 2006/32/EC) have motivated Energy companies' interest in transforming their infrastructure to a Smart Grid.

Smart Grid can be defined as one that uses information and communications infrastructure technology to manage grid information flows to make the power grid observable, controllable, automated, and integrated [1].

2 Current Situation

2.1 Legacy and Advanced Metering Reading

As of today, legacy energy consumption meters are manually polled at large regular intervals to produce each customer's bill; the sampling frequency does not exceed quarter yearly field measurements. As a major breakthrough, advanced metering reading (AMR) enables more frequent automatic measuring of consumption, aggregation and upload to central information systems in a non-interactive manner. This way, more fine grained measurements are available to energy retailers, so that future needs are predicted more accurately, distribution systems can be better tuned and energy theft is tracked.

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2.2 Drivers to Transition

Since transitioning to AMR entails a large scale infrastructure transformation, it is prudent to extensively study and quantify the available alternatives optimizing the transition strategy based on the following factors:

- Regulatory demands: Constraints set by market regulation are hard and constitute the baseline of the transformation strategy. For example UK, Canada and Australia governments have already set relevant deadlines to their energy markets.
- Transformation business case: Deploying a smart metering infrastructure may not increase sales but will allow energy companies to leverage on the technology enablement so as to achieve:
    - Costs reduction (meter reading, accuracy errors elimination, energy theft limitation, etc.)
    - Enablement of advanced marketing campaigns for encouraging customer loyalty, based on usage patterns
    - Economies of scale by turning off low priority devices in an ad-hoc manner (provided that customer consent has been acquired) and shifting their operation when cost of energy production is lower
- Funding: Built into the business case, funding for AMI installation is considered as a decisive factor for kicking-off a transformation project (US has already awarded more than $600M to Smart Grid projects).
- Technology maturity: Feasibility of implementing the transformation is dependent on technology maturity and on specific company demands / operating model;

2.3 Challenges Related to AMI Deployments

AMI deployment feasibility studies need to convincingly provide an approach to the following key technology sectors:

- Communications Infrastructure: Data network supporting the communication between smart meters and the centralized management system.
- Network Operations: Maintaining a large number of metering nodes (management and operation) requires deployment of functionalities new to energy companies (like NOC).
- Sophistication of Metering Equipment: The services that metering equipment provide may extend beyond the requirement of measuring and transmitting the results to a centralized system. Of course the level of sophistication directly affects the integration and operation (maintenance) cost of the devices.

3 Future Developments

As evident from the above, the ICT infrastructure component of a smart grid constitutes a critical factor of the deployment, introducing a different operating environment from what utilities have been used to until now. As identified in [1], four emerging trends influence the way the smart grid will be build, operated and controlled:

1. Shift from centralized to peer-to-peer control
2. Shift from centralized to distributed energy resources: A traditional consumer may become a supplier, providing excess renewable energy production to neighbors on an ad-hoc basis
3. Shift from few dumb end points to many smart end points
4. Shift from low data volumes / slow response times to high data volumes with low latency (periodic legacy meter readings vs real-time measurment aggregation and monitoring) Challenges faced by companies will be driven by the above factors.

3.1 Metering Equipment Sophistication

It can be easily established that the more intelligence built in a device, the more capabilities and flexibility is provided. At the same time, increasing the complexity of metering devices leads to increased CAPEX (for acquiring the device) but also OPEX (for operation and maintenance). The right level of sophistication should be a result of current needs as well as planning for future expansion (the device selection is a delicate process, since the cost of replacing them for complying to future needs would be enormous). For acquiring the maximum flexibility the chosen devices should:

- Follow open (and commonly adopted) standards as far as integration is concerned
- Be firmware-upgradable over the network (soft-update), for implementing changes avoiding the cost of field visits
- Be modular expandable; if update over the network is not possible, modular expansion may be a decent approach to limiting extra costs and possibly avoiding on-site visits (customer may acquire the expansion and install it with the support of service line)
- Provide alternative [physical] interfaces. More than one interfaces (even if not used) may be considered for providing flexibility through alternatives.

3.2 Communications Infrastructure

Business decisions on communications infrastructure involve evaluation of the following options:

- Build a private network, owned by the energy company
- Lease an existing network, from a telecom carrier, for example. Internet may be considered as a candidate as well, provided that performance and security risks are assessed and mitigated appropriately
- Build and share a common network with other utilities: this option seems more appealing if also collocation of companies' metering devices is considered

In order to decide on the above, the utility needs to study the economic models associated with each of the above options, building a business plan and evaluating the impact of each decision to the company's CAPEX / OPEX.

On the technologic side of the ICT infrastructure, different paradigms can be identified for achieving connectivity and reliable transmission of data from metering devices to the central management systems and / or to peer devices. Implementations should consider using one or more of the following media for connecting a metering device to the company's network:

- Landline internet connection (e.g. existing ADSL)
- Wireless connection over a telecom operator's network: GSM / UMTS / WiMax
- Wireless connection to other device: Forming a dense network of stand-alone nodes each equipped with a radio interface may allow for creation of an ad-hoc private network (message routing can be implemented using any of available algorithms, e.g. the one presented in [3]).
- Data over power lines: Metering data can be transmitted using the existing power line towards distribution station.

3.3 Network Operations

Efficiently managing network applications and monitoring of end devices operation requires adoption of a framework, especially since the utility is expected to deploy millions of devices in the field. Service assurance and availability metrics (e.g. 99.999% availability) need to be tracked by NOCs (Network Operating Centers) which will either have to be built from scratch or result as an extension of an existing department. Paradigms of such frameworks may be reused, leveraging on telecom experience, for example using eTOM (enhanced Telecom Operations Map [4]) or ITIL (IT Infrastructure Library [5]).

Implementing the framework processes and deploying the required applications, NOC can obtain an end-to-end view of the services deployed over the network and additionally will be able to implement service provisioning and commissioning activities.

3.4 Meter Data Management – Application Architecture

Meter data management (MDM) solutions provide data storage and management and act as an intermediate between the metering system and various business applications such as the company billing platform, executive forecasting, customer service, customer relations, operation and support.

Aside from the functionalities deployed, application architecture needs to be carefully studied and defined, taking into consideration the following:

- Definition of data model: The data model adopted should be open and covering all modeling requirements of the company's operation (e.g. CIM – Common Information Model, is such a model developed by DTMF [6]).
- Design the integration interfaces and decide on implementing (or customizing) an enterprise service bus for service delivery. The design should consider all involved systems (e.g. Billing, Customer Care, Operations, etc.) and sensor capabilities.

4 Conclusions

From the above it is evident that the transition of any traditional energy company towards an advanced metering infrastructure is the next required evolutionary step. The change implies a business transformation, since energy companies are called to deal with extensive IT operations, which may have not been the case in the past. In this context, utilities will need to deploy or revitalize existing communications infrastructure by taking a holistic approach considering different aspects such as specific present and future functional requirements, network ownership and management approach.

As a consequence, it seems unlikely there will ever be a single paradigm-fits-all smart grid communication solution because of the fact that utilities vary greatly in requirements and constraints, based on internal structure, geography, population demographics, local regulation, and economics.

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