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Smart meter communication standards in Europe – a comparison

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ABSTRACT

Smart grids and smart meters are central for the integration of distributed, renewable electricity generation. For smart grids to operate smoothly, technology standards are essential. In Europe, a multitude of different standards have been developed, making standard selection a complex task for electric utilities. With this paper we make three contributions: firstly, we identify 17 wired and wireless communication standards for smart metering in Europe. Secondly, we develop and describe a comprehensive set of technical and non-technical criteria for standard selection. Finally, we compare the existing standards against these criteria. We find that none of the standards is superior in all aspects, resulting in major trade-offs for decision makers. Moreover, we reveal the competing nature and missing interoperability of standards, which makes a seamless integration of smart grids across different regions difficult and poses major challenges for the development of complementary smart grid technologies.

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1. Introduction

Smart grids are a central element of the ongoing energy transitions as they facilitate the integration of distributed, renewable electricity generation [1–3]. Smart meters are household meters with two-way communication technology. They are often considered the first step in building a smarter grid [1].

For large numbers of smart meters to operate smoothly, technology standards for data exchange are essential [4–7]. Standards can be expected to enable interoperability, reduce costs through economies of scale and create mass markets [6,8]. More generally, common standards facilitate the diffusion of new technologies and the development of entire technological fields [9,10]. Classical examples are technology standards for computers [11] or mobile phones [12].

In emerging technological fields, it can be very challenging to arrive at a common standard and the literature on standardization reports many cases of firms and governments struggling about standards. The battle of VCR standards with VHS winning over Sony's Betamax [13], the success of Blu-ray in the case of high definition DVDs [14] or the struggle of IBM, Apple and Sun for dominance in the field of IT platforms [11] are prominent examples.

Also in the case of smart grids, different standards are associated with different strategic interests. Technology providers such as Landis+Gyr, Echelon or Connode, utilities such as Enel, ERDF or Iberdrola and even governments are involved in standard development [10]. Today, 17 different smart meter standards exist in Europe. What makes this situation even more challenging is that the entire energy sector is currently changing – as a consequence of market liberalization and the recent rise of renewable energies in many countries. In fact, the ongoing transformation of the energy sector can be viewed as a sustainability transition [15], which depends on the simultaneous development of complementary technologies, including new renewable energies, energy storage, energy efficiency and smart grids.

In this situation of general uncertainty about sector development and many competing standards, utilities have a hard time choosing a smart meter standard. Standard selection depends on the intended use of smart meters and on different criteria such as costs, data rates, robustness or standard openness.

A comprehensive review of technical and non-technical criteria for smart metering and a comparison of standards against these criteria are still missing. So far, scholars have provided in-depth analyses of the performance of individual standards such as PRIME, G3, GSM, DLMS/COSEM or oneM2M [16–21]. Existing studies also discuss the applicability of standards from other domains for smart metering [21–23]. Other studies discuss the opportunities and challenges of smart meters and smart grid communication in more general terms [24,25]. Existing reviews take a broad perspective, comparing communication standards independent of their application. They survey communication standards used for several smart grid applications [5,7,26] and they only focus on technical criteria.

In this paper we specifically focus on communication standards used for smart metering and we compare them against technical and non-technical criteria. In doing so, we make three contributions: firstly, we identify standards used for smart meter communication in Europe. Secondly, we provide a comprehensive review of technical and non-technical selection criteria relevant for smart metering. Finally, we compare the identified standards against these criteria. The results provide utilities and other stakeholders with greater transparency for standard evaluation and selection.

This paper is structured as follows: we start by introducing the technological field, including a description of the main use cases. In Section 3, we then describe the methodological approach for the identification of standards, the review of criteria and the comparison of standards against these criteria. Section 4 introduces the criteria for the comparison. The results of the comparison are described in Section 5. Section 6 discusses the findings and concludes.

2. Smart meter technology

2.1. Use cases of smart meters in smart grids

The main purpose of household electricity meters is billing – meters are the cash registers for utilities. *Smart meters* are equipped with two-way communication technologies. In the first place, two-way communication enables automatic, remote (instead of manual) meter readings for utilities [21]. This saves manual reading efforts and enables utilities to send regular (e.g. monthly) bills based on actual consumption rather than on estimates.

Detailed information about electricity consumption from smart meters can also help utilities to identify and stop fraud (energy theft). Smart meters provide information on actual consumption in intervals between one day and 15 min. An analysis of this data enables utilities to identify irregular consumption patterns [5] that are indicators for fraud [27]. Moreover, the two-way communication allows utilities to remotely disconnect meters [21,24] not only in cases of fraud or unpaid bills but also in emergency situations (e.g. risk of a black-out).

With the aid of smart meters utilities can also provide consumers with real-time information on their electricity consumption. This consumption data can be displayed on so-called in-home displays, consumer internet portals or mobile apps [28] that help consumers to identify energy saving potentials [24]. Studies have shown that consumers reduce their energy consumption by 5–15% when they use such displays and portals [28,29].

Beyond these consumer-oriented use cases, smart meters can also help utilities to integrate increasing amounts of distributed, renewable energy production in the electricity grid. Especially fluctuating electricity production can lead to imbalances between demand and supply. Utilities typically have little information of what is going on in the distribution part of the grid. Smart meters can help monitor and provide near-real-time information on actual distributed production and consumption [24].

Moreover, smart meters can enable utilities to influence demand as they allow introducing flexible tariff schemes or other advanced demand response measures. Today, the electricity price for households is mostly the same every day and throughout the day. In some cases, a lower tariff applies during the night. With smart meters utilities can change pricing schemes anytime and remotely [21]. In some cases, utilities might not want to rely on consumers' reaction to price incentives. Instead, they might seek to control industrial, commercial and household loads directly. For such demand response programs utilities need to know how much load is available for them to reduce and they need to verify the actual reduction of loads. Smart meters can provide this transparency and proof [24].

Finally, smart meter communication can be used in even more advanced cases connected to other domains such as transport, comfort, security or healthcare. The communication channel to the meter could be used to remotely manage heating or ventilation or to send alarm signals in case of emergencies. Each of the above-described use cases has particular requirements in terms of quantity, speed, latency and reliability of data transfer. A central step when choosing a communication technology standard is therefore to select and specify the applications for which smart meters shall be used.