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Market integration of local energy systems: Is local energy management compatible with European regulation for retail competition?

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ABSTRACT

The growing penetration of distributed energy resources is opening up opportunities for local energy management (LEM) – the coordination of decentralized energy supply, storage, transport, conversion and consumption within a given geographical area. Because European electricity market liberalization concentrates competition at the wholesale level, local energy management at the distribution level is likely to impose new roles and responsibilities on existing and/or new actors. This paper provides insights into the appropriateness of organizational models for flexibility management to guarantee retail competition and feasibility for upscaling. By means of a new analytical framework three projects in the Netherlands and one in Germany have been analysed. Both the local aggregator and dynamic pricing projects present potentials for retail competition and feasibility of upscaling in Europe.

1. Introduction

In the European Commission, parallel attention is given to the introduction of competition in the electricity sector and the ambitious targets for sustainability. The process of electricity sector liberalization was formally finalized in 2007, inciting competition in the wholesale and retail electricity markets and the unbundling of network activities. The retail competition markets in Europe are largely based on an assumption of centrally managed electricity systems, whereas wholesale markets are increasingly coordinated or merged [1]. Starting in 2015, all interconnected European power exchanges are coupled, which represents a large step towards the creation of a European internal energy market, the European Energy Union [2].

With regard to sustainability, achieving the ambitious 2020 and 2030 European climate targets relies on both the market penetration of large- and small-scale renewables and the deployment of energy efficiency measures [3]. The recently established Energy Union strategy strongly supports a new market design that would support the integration of higher shares of renewable energy and foster energy efficiency measures contributing to demand moderation [4]. Especially Germany can be recognized with favourable policies for renewables with priority connection and priority grid access for generation units that produce electricity from renewable sources [5]. The supportive feed-in-tariffs in Germany have incentivized the widespread installation of small solar panels in the residential and commercial sector with in 2014, 38 GW capacity of solar PV installed, with more than 60% located at low voltage levels [6]. Other examples of rapidly developing residential solar PV segments are found in Belgium, where 1 in 13 households has a PV system, but also in for example Greece and the United Kingdom [6]. Further, Denmark in particular has seen an increased penetration of decentralized combined heat and power (CHP) [7–9]. Previous analysis showed that liberalized electricity markets hindered the

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adoption of small CHP units in other places like the United Kingdom (UK), due to the discrimination of the liberalized electricity market towards smaller electricity generators [9]. For many CHP plants in the UK it would only be beneficial to sell electricity to a third party, providing lower pricing schemes than the actual electricity markets [8]. Differently, regulation in Denmark supported adoption of CHP units by allowing aggregations of those units to bid in the Danish electricity markets. Analysis showed the economic viability of using electric flexibility from CHP units for national balancing purposes and therefore improving the overall integration of wind power in the sector [7].

At the distribution grid level new challenges are arising due to the penetration of electric vehicles (EVs), especially in Norway and the Netherlands [10]. To respond to these changes in supply and demand, system operators and suppliers have started to develop new strategies for handling a more decentralized system. Among the more radical solutions is *local energy management* (*LEM*) – the coordination of decentralized energy supply, storage, transport, conversion and consumption within a given (local) geographical area. Combined with automated control and demand-side management strategies, local energy management, especially with the use of local heating production, holds the promise to significantly increase the efficiency of energy use, reduce carbon emissions and enhance energy independence [7,9,11]. Many of these benefits have already been realized in the context of numerous local energy projects initiated worldwide [12,13].

As countries across Europe seek to effectively and efficiently manage the large-scale integration of distributed energy resources, it is important to consider the effect of actor roles and responsibilities for managing the electric flexibility from resources locally in the regulatory context of energy retail competition. Different authors have expressed the difficulties associated with the unbundling of network and market functionalities [14,15]. For example, due to the fact that the DSO is a monopoly party, it is generally not allowed to trade electric flexibility with end-users.

Because the internal market policy process imposes constraints on how the electricity system can be organized, there may be conflicts between these flexibility management approaches and market regulation. The aim of this paper is to give insight into the compatibility of the organizational structure for flexibility management with the European electricity retail competition context. This is done through analysis of different real-life LEM cases and their organizational structures, comparing them to the traditional organizational structures and possibilities for retail competition and lastly discussing the aspect of scalability of those projects.

We analyse four cases – three Dutch and one German case – drawing both on publicly available material such as [16–20] and interviews with involved project partners and managers.

The paper is structured as follows. Section 2 describes background information on organizational structures for flexibility management, together with the framework for flexibility management used in this analysis. Section 3 describes the method used to analyse the cases, and Section 4 presents the results of the analysis. This is followed by a discussion and conclusions in Sections 5 and 6.

2. Background

2.1. Organizational structures and electricity market integration

The organization and coordination of energy transactions on local electricity distribution level has been explored by numerous scholars for different local energy management concepts. Some analyses focus only on electricity and refer to the terms smart grids, virtual power plants and microgrids [21–24]; and others include thermal and chemical energy carriers with multi-energy carrier systems and refer to the terms energy hubs or smart energy systems [11,25]. As described in the introduction, in this paper we define local energy management (LEM) as *the coordination of decentralized energy supply, storage, transport, conversion and consumption within a given (local) geographical area.*

This paper aims to present the possibilities for integration of local energy systems into the traditional regulatory context of Europe. Specifically, the focus here is on the aspect of electricity management integration and therefore this paper leaves out the integration of heat or gas supply due to the fact that deserves analysis by itself see Fig. 1 for a conceptual presentation. In the figure, the aspect of electric flexibility is presented as central. Electric flexibility can be defined *as a power adjustment with a specific size and direction, sustained at a given moment for a given duration from a specific location within the network*[26]. Due to the fact that for reliability of supply a constant balance between supply and demand is required, the role of electric flexibility and the management thereof is crucial. This flexibility can be used for multiple purposes, ranging from network congestion management, supply portfolio optimization and renewable integration. In this research, the aspect of flexibility management is analysed from an organizational perspective instead of a technical perspective only. This organizational structure can provide insights in whether a flexibility management method is closely related to the traditional organizational structures to manage flexibility in the electricity sector in Europe.

2.2. Framework for flexibility management

When discussing organizational structures and their impacts on the arrangements of (electricity) markets, the theory of institutional economics is relevant. The Williamson framework represents how economic transactions are embedded in layers of formal organization, governance and informal institutions [27]. Künneke proposed a technical counterpart of this framework, which has been further elaborated by other researchers [28,29]. This comprehensive framework shows how technical and economic transactions are embedded in their technical and economic environment. For example, for economic transactions, the rules for (spot) market design provide the possibilities for actors to bid in the markets. Alternatively, from a technical perspective, operational control mechanisms manage the way in which technical transactions take place in real-time. Annex 1 presents the techno-economic framework. For the analysis in this paper the framework has been adapted to focus on the management of flexibility in electricity systems and provide insight into the most suited design for the European context. The framework includes three layers, a techno-institutional layer, an economic layer and an operational layer. Flexibility management is defined as the application of the four flexibility management variables; *the division of responsibilities* (***who***) *for specified management of flexibility of appliances* (***what***) *by specific means* (***how***) *and for specific time-dependent system purposes* (***why***), and two organizational variables, *the* ***number of actors*** *involved and the* ***nature of transactions***. Fig. 2 presents the framework used to analyse the LEM cases in this paper. The next

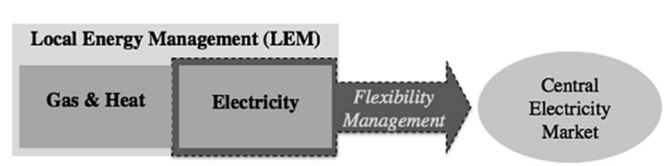

Fig. 1. The emphasis on electric flexibility management in this work.