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Business models for distributed generation in a liberalized market environment

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Abstract

The analysis of the potential of emerging innovative technologies calls for a systems-theoretic approach that takes into account technical as well as socio-economic factors. This paper reports the main findings of several business case studies of different future applications in various countries of distributed power generation technologies, all based on a common methodology for networked business modeling and analysis.

Keywords: Distributed generation; Technological innovation; Networked business modeling; Business case analysis

1. Introduction

The successful introduction into society of innovative technologies generally depends on a wide variety of technological as well as socio-economic factors [1]. Accordingly, there is a consensus now in many areas of complex systems engineering that requirements specification and analysis should take into account both technical and business requirements [2–5].

Emerging distributed power generation technologies, variously referred to as distributed generation (DG) or distributed energy resources (DER), are no exception to this rule. The analysis of their future potential calls for a systems-theoretical approach that involves analysis of their general technical characteristics [6], consideration of the broader strategic contexts and scenarios in which technologies will function [7,8], and of the business models [9] that are to make innovative technologies economically sustainable beyond their research and development stage. The contribution of this paper is to consider the economic side of the introduction of new DG technologies, by investigating business requirements and models for different forms and applications of DG.

Like many industries, the power and utility sector is no longer characterized by a linear value chain [10]—from generation, transmission, and distribution to the final customer. Instead, value chains are now becoming more complex value constellations in which enterprises are collaborating and competing in networks [9,11]. In the power sector, this is caused by a combination of factors, including the steady progress of distributed generation technologies, the increasing penetration of advanced information and communication systems and technologies (that, like the Internet and Web, are usually also distributed and tend to lead to decentralization) to manage an increasingly complex grid, and on top of this the ongoing industry restructuring and market liberalization in many countries. As a result, DG technologies must be economically analyzed in terms of *networked* business models that are sustainable in a liberalized market environment.

We have developed a systematic methodology for constructing and assessing such new networked business models [5,9,12–14], called BusMod, and applied this to a number of different case studies and scenarios where DG technologies may be successfully applied in the future. The present paper discusses the key findings of these studies, which cover the economic potential of DG for dynamic demand response at peak hours packaged as a new business service, the market feasibility of small-scale local producers of renewable power, the usage of DG in grid balancing services, and in the active management of distribution networks.

In Sections 2–5, we present the major, qualitative and quantitative, results from four different case studies on DG business models from, respectively, Spain, Norway, The Netherlands and the United Kingdom. In Section 6, we outline some of the methodological background of the employed BusMod methodology for networked business modeling and analysis. Section

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7 summarizes the key socio-economic conclusions for DG and some suggestions for further research.

2. Case study A: distributed generation energy services to shift demand in peak hours

2.1. Case introduction

The Spanish electricity market is fully liberalized since the 1st of January 2003. This liberalization resulted in 40,000 small customers changing supplier over the whole of 2003. Moreover, a strong increase of customers changing supplier took place during the first 2 months of 2004, which resulted in 60,000 additional customers changing supplier. So, 100,000 customers changed their supplier in just over 1 year since the liberalization of the market took off.

The energy consumption in Spain has experienced an accumulated increase of 34% between 1996 and 2002, and this trend is expected to continue for several years to come, at about a 4% increase per year. The currently installed electricity generation capacity is 56,000 MW, but the available peak capacity is 35,000 MW. This situation, together with the increase in consumption, resulted in some days in 2003 in which the demand was equal to the available generation capacity, so that some curtailment actions had to take place.

Several alternatives exist to solve the power shortage problem, such as increasing the generation capacity, reducing the consumption by increasing the efficiency of the equipment, managing the demand, or a combination of these mechanisms. In Spain, this trend has led to installment of additional generation capacity: 40,000 MW of combined cycle power plants and 50,000 MW of additional wind generation. However, the combined cycle plants increase the external dependency on gas, and wind generation faces the well-known problems of intermittence and of forecasting difficulties.

Therefore, it is of interest to investigate alternative business scenarios that aim to influence the demand in a market-compatible fashion. The business idea here is that the electricity bill that a customer has to pay can be reduced by shifting part of the demand to low price periods, and furthermore by using own generation when the prices of the electricity are high. At the same time, this load shifting will yield the additional benefit of reducing the needed capacity that must be available at peak periods.

2.2. Business scenario

The success of this demand management scenario requires the involvement of several different actors. First of all, there should be an aggregator, a supplier that within this scenario has several responsibilities and roles:

- Grouping customers and participating in the wholesale market to get the lowest possible prices.
- Shifting and managing the movable loads of the customers to hours with a low electricity price.
- Planning the use of the distributed generators when the associated cost is lower than the market prices.

Thus, the key role of the aggregator is that it acts not just as an Electricity Supplier, but as a company that *provides a bundle of services* to the final customers, with the objective of achieving lower prices for them. Second, as major actors (actually a market segment) we have the customers, who in this business scenario are enterprises that not only consume electricity at the planned hours, but also own and maintain local distributed generation capacity. Finally, other actors are necessary to complete the scenario, in order of importance: a regulator, the Distribution System Operator (DSO), the Transmission System Operator (TSO), the Conventional Generator (CG) and the Market Operator (MO). Our studies show that the regulator is another key actor in this DG/DER scenario, being in charge of collecting the taxes related to the promotion of distributed generation, renewables and demand-oriented measures.

The demand shifting scenario itself is general and applicable to many regions and countries. For numerical calculations of the feasibility of the business model, however, it has to be specialized to a specific situation, in the present case to the framework for electricity regulation in the Spanish market and its status of full liberalization.

The Spanish market, although fully liberalized, currently does not show a reduction in the price of the energy generation market (unlike the UK and other countries). As a consequence, the profit margin for the suppliers is small. This may be due to the short time elapsed since full liberalization was put into operation, and to the fact that most generation in Spain is controlled by just a few companies, thus reducing the possibilities for competition. This situation of low price volatility reduces the opportunities for load shifting at this moment in Spain compared to other countries, but even under these conditions our business analysis shows the potential of the scenario.

2.3. Business analysis

The analysis has taken into account three different types of DG technologies that could be used for generating electricity: MicroHydraulic, PhotoVoltaic and MicroTurbine. Every one of these has different characteristics, such as investment cost, expected lifetime, and availability. The data used for the base-case of the scenario are those shown in Table 1.

Based on the above business model characteristics, we performed calculations concerning the expected feasibility of the demand shifting scenario as a potential energy service. One result of these calculations is that load shifting will reduce the electricity bill of a final customer by 15%, taking into account the current situation of the Spanish market. These savings are expected to be higher with a more mature electricity market. The reduction in the electricity bill, nonetheless, is on average not enough to fully pay the planning and control services to be provided by the aggregator. This means that a demand shifting service should not be independently positioned as a key income source; rather, the revenue of the aggregator is to be claimed from the *complete bundle* of services offered: electricity supply, aggregation, scheduling and metering.

The use of DG to cover own consumption in peak hours is not *in itself* profitable for the customer due to the under-utilization