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METHOD FOR EVALUATING SMART GRID CONCEPTS AND PILOTS

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Abstract: this paper describes the challenges of and requirements for the evaluation of smart grid concepts and pilots. It proposes the use of load forecasting techniques to unravel the effect of smart grid concepts on the consumers’ load, using the results that the various pilot projects bring forward. Load forecasting techniques make it possible to define the input-output relationship between the smart grid input and the change in the consumers’ load profile. This is essential, as a uniform way to evaluate pilots requires that the results are generalized based on specific input assumptions. Consequently the results can be fit into the methodological approaches applied for the estimation of the costs and benefits of smart grids, providing an equivalent method to assess different pilot concepts, from a system perspective. The proposed evaluation method is illustrated by describing two different smart grid concepts and their pilot set-up.

Keywords: demand side management, distributed energy resources, load forecasting, smart grids.

INTRODUCTION

Worldwide a large number of smart grid pilots are initiated. Up to 2012 already 281 smart grid pilots are set up across 30 European countries, accounting for a total investment of €1.8 billion [1]. As there are various categories of benefits and beneficiaries of smart grid functionalities, pilot concepts are generally unique in a specific setting. To identify costs and benefits involved in smart grid pilots, frameworks are developed to define the impact for the entire electricity system and society, providing amongst others formulas for the monetization of benefits of smart grids, for its different functionalities [2], [3].

In [4] the societal costs and benefits associated with a large scale introduction of smart grids in the Netherlands are quantified, based on the various functionalities of smart grids. In [5] the potential of smart grids in the Netherlands is studied from the perspective of network operators, in this case the possibility to control flexible loads is used to optimize the utilization of the grid. Both studies, [4] and [5], assess the implications of introducing smart grids over a longer period, until 2050 and 2040 respectively. Over this length of time, data is hard to predict on core issues, such as (i) the energy production mix (e.g. penetration of renewables) and (ii) the energy demand (e.g. penetration of different loads). Therefore, a scenario-based methodology is applied in both studies to address the uncertainties related to long term (load) forecasting. It is estimated that by implementing smart grids in the Netherlands costs savings for society as a whole can vary between 35% and 67% [4], depending on the scenario for the future energy system. Amongst others, smart grids lead to costs savings due to (i) avoided grid investments, (ii) avoided grid losses, (iii) more efficient use of and (iv) avoided investments in central generation capacity, and (v) reduced imbalance. In [5] it is estimated that due to smart grids investment costs for network operators can be reduced with 45% to 72%, also depending on the scenario for the future energy system.

Important input factors for both studies are, besides the scenarios, assumptions with respect to energy savings and load shifting capacity of residential households due to the introduction of smart grids. In [4] it is assumed that due to smart grids there will be 4% energy savings, 4% daily peak shaving and 16% incidental peak shaving (12 hours per year), and in [5] it is assumed that 10% of the future residential electricity demand is flexible and on top of that there is the flexibility of heat pumps and Electric Vehicles (EVs). In both studies the flexibility is used to reduce the peak, which means that e.g. 10% flexibility results in 10% peak reduction. These assumptions regarding the available flexibility at residential households are based on literature studies.

The results of the smart grid pilots initiated in the last couple of years should be used to validate these assumptions regarding the flexibility available at residential households. Using the pilot results as an input for the previously described scenario-based methodologies, provides a uniform approach to evaluate different smart grid concepts and pilots. This makes it possible to compare the output, i.e. the smart grid benefits, of different pilots under similar conditions, and validate the assumptions done e.g. in [4] and [5]. Despite the large number of smart grid projects initiated worldwide, still there is not much known about what is the mobilized flexibility in the different pilots, and what exactly is the behavior of this flexibility. In [1] and [6] overviews are provided of the set-up and current status of the various smart grid pilots initiated worldwide.

A uniform evaluation approach is required as a lot of smart grid initiatives are generally unique in a specific setting. Furthermore, there are various approaches used to influence electricity consumption, e.g. dynamic pricing schemes are applied (time of use, critical peak pricing, real time pricing or critical peak rebate), feedback on consumption is provided, enabling technology is used, or automation is applied [7]. Some studies give already a general impression about the unlocked flexibilities due to the introduction of e.g. dynamic pricing schemes, see also [8] and [9]. In this case, the unlocked flexibility is defined as the percentage of peak reduction and/or the percentage of energy savings. However, to fit the pilot results into the scenario-based methodologies to estimate the benefits of smart grids, the results need to be generalized based on specific input assumptions. Therefore, it is important to find out, (i) *what* the flexibility is, and (ii) *how* the flexibility is being deployed. Both these aspects of flexibility will be discussed in this paper. Consequently, a method is proposed to evaluate the results that the various smart grid pilots generate. Finally, the approach is illustrated by describing two different smart grid concepts, and their pilot set-up, namely (i) PowerMatching City, and (ii) Your Energy Moment (Jouw Energie Moment).

EVALUATION OF PILOT RESULTS

As described before, the benefits of smart grids depend on future developments in the electricity system, therefore different scenarios are used to define these benefits. If a scenario-based methodology is applied as a uniform approach to compare smart grid concepts, identical scenarios should be used as an input for the evaluation of the results of different pilots. To this end, pilot results should be generalized on (i) *what* the flexibility is, and (ii) *how* the flexibility is being deployed. Generalizing results based on *what* the flexibility is, means that, e.g. if a pilot only focusses on the flexibility of EVs, its future impact should be generalized based on the expected penetration rates of EVs, or if the flexibility of the heat pump is only measured during winter periods, results should be generalized for every season. As for the second point, generalizing results based on *how* the flexibility is being deployed, it is important to know which 'signals' are used for the flexibility optimization. There are various categories of benefits and beneficiaries of smart grids and flexibility can be used in different ways. For example, energy suppliers and network operators can both stimulate load shifting to optimize load profiles based on energy market prices or peak loads in the network, respectively. When defining the benefits of smart grids it is important to know how the load is shifted over time. Consequent step, is to unravel what will be the impact of future developments in the power system on these signals: on the usage of the flexibility.

To this end, simulation models must be used to predict load changes based on input data, using the metered data of the pilot [9]. These simulation models should define the basic physical relationship that exist between the change in the consumers' electricity use and the factors that determine that change. To do so, load forecasting techniques can be used, such as artificial neural networks, fuzzy logic, support vector machine or multiple regression.

Once load profiles for pilot projects participants and non-participants can be generated, statistical methods can be used, to isolate the impact of the adaption of a specific pilot concept. A combination of simulation models and statistical methods is suitable to address changes in participants electricity use due to the pilot concept and address factors unrelated to the program but do have an impact on the load, e.g. weather circumstances [9]. This makes it possible to quantify the flexibility available at the consumer, as a result of the implementation of a specific pilot concept, for any scenario for the future energy supply.

In the full paper an extensive analysis will be provided of the application of the approach described in the previous part for evaluation of two pilot recently launched in the Netherlands, namely (i) PowerMatching City, and (ii) Your Energy Moment.

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