CONTRACTING FLEXIBILITY SERVICES

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Overview

The penetration of renewable energy sources is increasing and is expected to keep increasing throughout the developed world. The Danish electric power system, which is the focus of this work, is a particularly interesting case with a wind penetration of 25 % today and an expected 2020 penetration of 49,5 % [1]. The replacement of conventional power plants with non-dispatchable renewable energy sources causes a major challenge for the electricity system: the central power plants do not only deliver power but also provide ancillary services ensuring a reliable and secure electric power system. It is therefore evident that in a grid with high penetration of renewables, alternative sources of ancillary services must be found [2]. One solution is the *smart grid* concept where demand-side devices with flexible power consumption take part in the balancing effort. The Danish TSO, Energinet.dk, has recently suggested a framework for smart grid in Denmark [3]. A core element in this framework is to let an *aggregator* manage a portfolio of flexible demand-side devices and utilize the accumulated flexibility in the liberalized electricity markets, including the ancillary service markets, on equal terms with conventional power plants.

To substantiate and structure such flexibility aggregation, a legally binding contract between aggregator and consumers is crucial. Such *flexibility contracts* are the focus of this work. The work is based on experiences from the US demand-response programs where flexibility contracts currently exists between aggregators and large-scale consumers [4]. In the American electric power system, demand-response is mainly concerned about peak load reductions a few hours per year and primarily addresses larger power consumers with loads above 100 kW. The main contribution of this work is to extend the American event-based flexibility contracts for larger-scale consumers, to the Danish case which is significantly different. In the Danish system, the goal is to utilize the flexible consumption, not only for load reduction in a few critical hours each year, but to aggregate and trade the flexibility in a more continuous manner through the electricity markets. Further, the goal in the Danish smart grid vision is to control not only large-scale consumers, but also smaller consumption devices such as domestic heat pumps and electrical vehicles. This is the motivation behind this work which seeks to extend the American flexibility contracts to also include smaller consumption devices and to prepare the ground for more continuous flexibility operations. The end result is a flexibility contract template emphasizing the key elements in writing flexibility contracts. This contract template serves as a powerful tool for manufacturers of devices with flexible consumption as it can be used to examine the possibilities of selling smart grid related services to an aggregating entity. In cooperation with the industry, the flexibility contract template developed in this work has already been applied to two specific cases: a flexibility contract for supermarket cooling systems and a flexibility contract for a domestic heat pump. In both cases, the flexibility contracts are concerned with the devices' inherent thermal flexibility.

Methodology

Figure 1 illustrates the aggregator's role in the Nordic electricity markets: by controlling a number of residential, commercial, and industrial consumers, the accumulated flexibility can be sold in the existing transmission system markets and possibly in future distribution system markets. This architecture is interesting because the aggregator operates the portfolio of flexible consumers on market terms in competition with the conventional power plants and not just as a last resort in case of system contingencies. This is believed to improve the efficiency, economy and sustainability of the electrical grid.

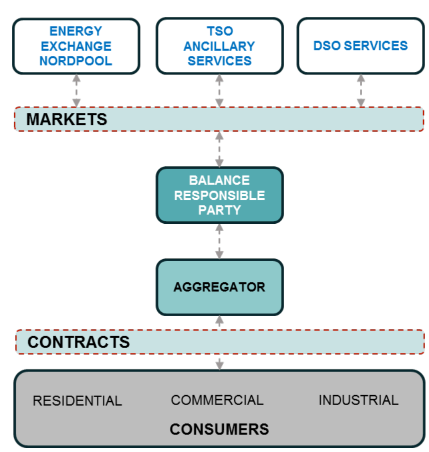

Figure 1: Flexibility in the liberalized electricity market.

To act as a competitive player on the electricity markets, the objective of the aggregator is to manage a portfolio with many flexible consumers controllable at low marginal costs; on the other hand, the consumers have little or no market understanding and are mainly concerned about reliable and affordable electricity. In such a bilateral relationship between parties with different access to information and where one party is carrying out some task or effort on the behalf of another party, there is a risk that the objectives of the parties are misaligned. This information asymmetry produces a need for communication and transparency between consumer and aggregator which must be assured through a legally binding flexibility contracts. Further, this contract must assure sufficient incentive for both parties to participate in accordance with the contracted conditions while maintaining individual rationality [5].

As a basis for the flexibility contract constructed in this work, an analysis of different flexible consumption devices and their characteristics is made for both smaller and larger consumers. This analysis combined with experiences drawn from the American demand-side programs is used as a foundation for constructing the contract template. Further, interviews are conducted with two Danish companies that currently operate flexible consumption, to gain from their experiences.

Results

The result of this work is a flexibility contract template serving as an overview of the components that the aggregator and consumer must agree upon. The template can be used as a comprehensive check list to ensure that all relevant issues have been covered in the aggregator/consumer relationship for a given consumer type. To provide an idea of the content of the flexibility contract template, a selection of some of the key components of the template is presented in Table 1.

A main result of this work is the construction of two settlement poles: *flat rate* and *flex rate*. Flat rate refers to consumers receiving a compensation independently on the aggregator's utilization of the flexibility. As an example, flat rate could be a fixed discount on a domestic heat pump that is remotely controlled by an aggregator. On the contrary, flex rate refers to payments that depend on the utilized flexibility. As an example, flex rate could be an aggregator sharing its revenue with the consumers comprising the portfolio. We refer to the two regimes as poles to illustrate that a flexibility contract can be at one of the poles: fully flat or fully flex, or it can be a flat/flex mix, depending on the risk averseness of each consumer.

Table 1 – Introduction to the Flexibility Contract Template

1. Legal Contracting Parties:	
Consumer and aggregator data. Contract terms, scope of services.	Aggregator and consumer company name, address etc. Contract start and end date. Description of flexibility service, that the consumer allows the aggregator to utilize in the electricity market.
2. Specifications of the flexible consumption device:	
Device type, available capacity, reaction time, technical duration.	Type of device, control parameters, minimum and maximum capacity available. Response time and maximum time duration that the device can sustain flexible operation.
3. Availability Constraints:	
Time specific constraints, comfort constraints, overrule rights.	Daily, weekly, seasonal constraints. Maximum allowable number of activations per day. List of specific overrule rights and potential costs associated. User comfort settings, for example temperature bands.
4. Financial Data	
Compensational regime, determination of compensation.	Flat rate or flex rate: payment per month, fixed payment per utilized kWh, specific share of aggregator market revenue. Specifications of baseline determination.
5. Consumer and Aggregator Obligations	
Required hardware on-site, consumer liabilities.	Responsibility and payment for instalment of additional communication, control, and sensoring equipment. Responsibility and payment for underperformance. Allocation of financial risks.

Conclusions

In this work, we examined the legal bindings between an entity called an aggregator and consumers with flexible loads. Based on experiences from American demand-side programs and based on case studies from the Danish electric power system, we developed a flexibility contract template that encompasses the main issues that must be covered when a consumer with a flexible load allows an aggregator to manage its flexibility. The template has already been presented to several component manufacturers, and two specific cases of the template have been developed: an industrial case with a supermarket cooling system and a residential case with a domestic heat pump.

References

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