Smart Demand Side Management: Storing Energy or Storing Consumption: It´s Not the Same

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It is expected that energy systems with a high share of intermittent renewable electricity generation (fed in at a range of network levels) will require a high proportion of low-load conventional peak load generation and have high residual load gradients. A strategy to deal with these characteristics is the transition to an energy system with more flexible components. On the supply side, the relevant technical options include the use of more flexible generators, more long-distance transmission, energy storage and demand response (DR).

Demand response includes pure changes in the volume of demand such as load shedding (or the increase in load to absorb surplus power) and the quantity-neutral load shifting. However, that kind of load shifting can be interpreted as storing consumption. The technical vision of consumption storage includes the preference-based control of individual devices, which, in addition to the extent of the temporal shift, also takes account of the resulting monetary returns (price advantages). Sufficiently low equipment costs, ease of usage, a high time resolution of the market system and modern information technology for the transmission of price signals are prerequisites for the implementation of this technological vision.

This kind of load shifting is not entirely visionary, as radio-based peak load shaving was developed in the US in the 1970s. Today there are numerous products with negative power supply which are traded as ancillary services, making it possible for large industrial customers to generate revenues with load shifting. Contemporary potential analyses of load shifting are focused on these technical processes and their potential to shift significant loads over hours. In addition to these large-volume - long-time shifting options, there may be significant cope for the coordinated shifting of many small loads by short periods. In many applications, like refrigerators, a shift of load by 10 minutes is costless. In addition, consumption storage also offers the advantage of low degradation and lower capital requirements in comparison to conventional hydro or chemical energy storage.

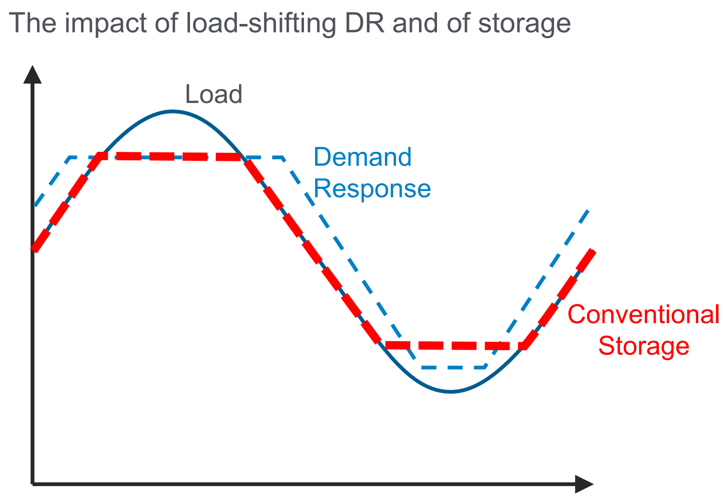
What is the potential of load shifting? Which methods are applicable to analyse it? How does a rational consumer select the devices for load shifting and how does he program them? What are the effects of a series of rational load shifts in a system with conventional generation? Can a huge number of consumption storages be coordinated by markets to act as a single virtual storage? None of these questions is trivial to answer, but the answers are essential to evaluate load shifting technology.

In our article, we design a micro-founded model of load shifting by a rational consumer. The consumer selects devices and programs that balance the shifting quantity and time depending on the price development. To model the cost of load shifting, it is assumed that there is a specific indifference time zone for the use of an electrical device. In a variety of applications this will not be the case - e.g. watching live television, but in other cases, consumers would not care exactly when a washing machine finishes, as long as the clothes are dry enough at ironing time. Similarly, the insulation of refrigerators allows for a slightly longer gap before starting the cooling compressor without increasing the spoiling risk. Outside this indifference zone – beyond the indifference threshold time – there is an increasing cost of delay (or anticipation – some activities can be brought forward).

We show in our analysis how the optimal device mix can be determined from assumptions about the distribution of indifference threshold times and power consumption of electrical devices. With the optimal selection of devices, the cost of load shifting can be derived. Under simplifying assumptions, an analytical expression for the cost of load shifting can be deduced as a function of the shifted load and the shifting time. In this context, the value of lost load can be regarded as a limiting case for the cost of unlimited shifting time and it can be used for calibration.

With this approach, the optimal DR consisting of shifting quantity and time can then be determined for a given pattern of prices over time. Characteristic of load shifting is the indifference between storing a large quantity for a short time and storing a small quantity for a longer time. In this sense, consumption storage is limited in its capacity by two dynamic components: 1. the storage time and 2. the load that is available for shifting. This basically distinguishes load shifting from energy storage, which has a fixed capacity over time.

To analyse the effect of load shifting in a fully coordinated market system, a simplified model of load



shifting was then embedded in a simple electricity system model. One typical result is shown in the Figure. The underlying load is shown by a continuous line, and the effect of energy storage (the thick dotted line) is to remove load peaks (by discharging) and displace them into load valleys (when charging takes place). In contrast, shifting consumption leads to a different pattern, shown by the thin dashed line. As the load level falls, so does the shifting potential available. Therefore, a "part of the load" that has been displaced from the peak must reappear "on the way from peak to valley". This is reflected in the load pattern as a "landslip" on the slopes of the peak. Whether this also leads to an increase in the load gradients may well depend on parameter values. As expected, this "landslip" effect intensifies as the load valley deepens.

These analyses show that, even under conditions of optimal coordination through a system of markets, this kind of load-shifting has some properties that differ from those of simple energy storage. Furthermore, it can be expected that energy and consumption storage are not necessarily substitutes for each one another, but that DR might be efficiently complemented by conventional energy storage to fill the valleys in loads more smoothly.

Overview of Special Student Events

During the 40th IAEE International Conference a special program for student delegates was offered to allow for networking within the student community; starting on Sunday evening with a "Happy Hour" reception and followed by a Student Breakfast Meeting on Monday morning with roughly 45 attendees. IAEE Student Representative, Fabian Moisl, presented the benefits of an IAEE student membership such as a free subscription to the IAEE's publications, reduced conference fees and scholarships to attend IAEE conferences, access to IAEE's job market database and much more. Dr. Peter Hefele presented on the Konrad Adenauer Foundation (KAS), which sponsored the Breakfast Meeting and the Happy Hour.

Four excellent papers were presented during the IAEE Best Student Paper Award Session on Monday afternoon. The award was given to Nathalie Hinchey, PhD Student at Rice University, for her paper titled 'The Impact of Securing Alternative Energy Sources on Russian-European Natural Gas Pricing'.

The final student event was a casual get-together at Makansutra Gluttons Bay hawker center where students had a chance to experience local food, network and socialize with fellow students of their academic fields.