A Practical Guide to

Demand-Side Bidding

International Energy Agency Demand-Side Management Programme
Task VIII: Demand-Side Bidding in a Competitive Electricity Market

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Foreword

The move towards competitive electricity markets has led to many changes in the way that electricity is traded. One result of these changes is that the demand-side can now actively participate in the market place, rather than being simply 'price takers'. This has paved the way for Demand-Side Bidding (DSB). DSB offers consumers the opportunity to receive financial rewards for making short-term changes to their electricity consumption profile. By rescheduling loads or agreeing to short-term interruptions to their supply, consumers can help to ensure a balance between electricity supply and demand and to maintain the quality and security of electricity supply.

However, many DSB schemes fall short of their objectives. A project was therefore set-up under the IEA Demand-Side Management Programme to evaluate existing DSB schemes, and to develop guidelines for the development of new schemes and enhancements to existing schemes. This project, entitled ' Demand-Side Bidding in a Competitive Electricity Market'[1], focussed on the way electricity is traded, the opinions of market participants towards DSB, and the opportunities for DSB schemes within electricity markets.

The project consisted of three stages, each examining a different aspect of DSB. In Stage 1, the focus was on gathering information about current DSB schemes, and the views towards and experiences with these schemes. The findings showed that a wide range of DSB schemes was available, but with the vast majority targeted at large consumers. The opportunities for consumers became the main focus of Stage 2 of the project, which gathered information about the electrical loads available for DSB, the incentives needed to make participation in DSB attractive, and the technologies required to implement DSB. The emphasis of the final stage of the project, Stage 3, was the technical rules associated with the provision of DSB products.

This guide draws on the results and findings of the whole project in order to provide practical advice to those organisations most likely to be involved in setting up and implementing DSB schemes. However, it is important to note that DSB needs to evolve to ensure that it keeps pace with the inevitable changes that occur as electricity markets continue to develop.

This guide represents the final publication of the project. There are a number of other publications from this project that present the findings of the different Stages, and the reader is encouraged to refer to these documents if more detailed information is required on any of the aspects covered in this guide. A full list of these publications is provided in the Appendix.

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[1] Task VIIII of the IEA Demand-Side Management Programme.

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Contents

1 Introduction

1.1 Who is this guide intended for?

This guide provides practical advice to those organisations most likely to be involved in setting up and implementing Demand-Side Bidding (DSB) schemes. In many instances this will be a specialist company who can combine knowledge of the way in which electricity markets function, with both a good understanding of the end consumers of electricity, and the necessary metering and telecommunications technologies required to make DSB happen. We shall use the term ***Aggregator*** to define such a specialist company. Much of the emphasis of the guide will be directed at describing and developing the role of the aggregator. However, the guide will also be of interest to the many others who will participate in DSB, either through an aggregator or directly through their own actions. In particular these will include:

- Transmission System Operators (TSO), who are responsible for maintaining the quality and security of supply of the transmission network;
- Local Network Operators, who are responsible for maintaining and operating the network used to deliver electricity to customers' premises within a specific geographic area (these are also sometimes referred to as Distribution Network Companies);
- Market Operators, who provide the platforms for the trade of electricity;
- Suppliers, who are licensed to sell electricity to customers (these can also be referred to as Retailers);
- Regulators / Governments, who introduce policies to encourage and facilitate demand-side participation; and
- Large consumers who may be interested in directly implementing and participating in DSB.

1.2 Use of this guide

The guide introduces the steps that need to be taken in order to ensure that Demand-Side Bidding schemes are successful. It shows how to gain an understanding of the opportunities for DSB in the electricity market and indicates the factors that need to be taken into consideration when implementing new DSB schemes.

The guide falls naturally into two parts - Sections 1, 2 and 3 providing background information about the concept of DSB and why it is important in the operation of competitive electricity markets; with the remainder of the guide discussing a step-by-step approach to DSB and providing examples of DSB in operation.

Section 2 starts with a definition of DSB. It then goes on to discuss the relationship between DSB and Demand-Side Management, and introduces the benefits of DSB. Those readers unfamiliar with the topic of DSB should start with this section in order to obtain an overview of the subject. Section 2 also introduces some important terminology that will be used throughout the guide.

Section 3 discusses the drivers for DSB, providing a background to why DSB is important and to whom. It then goes on to introduce the concept of aggregators and makes the case for their crucial role in implementing DSB.

Section 4 introduces the step-by-step implementation of DSB, whilst sections 5 to 11 describe each of these steps in more detail. The step-by-step approach is illustrated by building up complete examples of DSB in operation. Additional examples are provided in section 12, to provide a wide overview of current, and possible future, DSB practice.

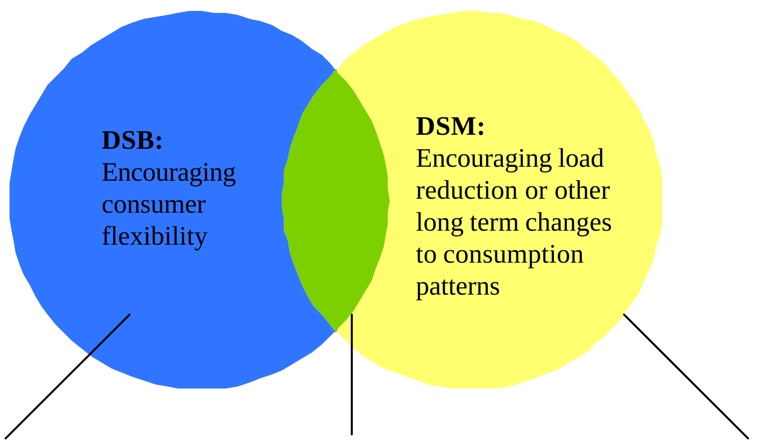
2 Demand-Side Bidding

2.1 What is Demand-Side Bidding?

Demand-Side Bidding (DSB) is a mechanism that enables consumers to actively participate in the trade of electricity by offering to undertake changes to their usual pattern of consumption in return for financial reward. The financial reward can be in the form of reduced electricity prices or via a direct payment for electricity they have 'not consumed' or even an availability payment for the promise of being available to make a consumption change at an agreed time.

2.2 What is the relationship of DSB to DSM?

Although closely related, DSB is very different to Demand-Side Management (DSM). The main difference between these arising from the impact the two have on the demand profile of consumers; DSB involves short-term discrete changes to demand profiles whereas DSM involves sustainable and permanent changes to demand profile. The diagram below summarises the differences and similarities between DSB and DSM.



DSB

- Market driven
- Involves short term, discrete actions by the consumer
- Improves market efficiency
- Consumers given the opportunity to earn money in the energy markets
- Potential energy efficiency and environmental benefits

Overlap

- Shared control, monitoring and communication technologies
- Cross fertilisation of ideas and opportunities

DSM

- Mostly regulatory driven
- Involves sustainable and permanent changes to demand profile
- Results in long term benefits for the environment, for utilities, and for consumers
- Cost savings for consumers

Figure 1. Definition of Demand-Side Bidding

2.3 What are the benefits of DSB?

DSB is all about involving the Demand-Side (the actual consumers of electricity) in the processes of setting prices and maintaining the quality of supply. This is done through encouraging and rewarding the Demand-Side for flexibility in its use of electricity (both when and how much).

DSB has several important implications in terms of the overall efficiency of electricity supply, both from an economic and an environmental point of view. In the short term, avoiding the need to call upon expensive, reserve generators reduces overall market costs. In the long term, reducing both the size of networks and the number of generators required may result in lower costs. Almost always, reserve generators will be less efficient, and produce higher CO_2 emissions, than base load plant. There is also an added energy penalty in starting them up and holding them in a state of readiness. DSB can thus be regarded as a means of optimising overall system energy efficiency, by reducing the need for such plant.

2.4 Important Terminology

In order to be able to use this guide effectively, it is important that the reader is familiar with the following important terms that are used throughout this document:

Important terminology

DSB buyer

The person who accepts the Demand-Side Bid. For example when a System Operator accepts a DSB to help him react to a loss of a generator he is the 'Buyer' of that DSB

The 'need' of the buyer

The reason for accepting a Demand-Side Bid

DSB product

A DSB product is the technical specification of a Demand-Side Bid (typically the size duration of load and response time) that is required by the ***Buyer*** to meet his ***needs***.

DSB provider

This is the end user or consumer of electricity who agrees to modify his normal pattern of consumption to help the DSB ***Buyer*** meet his ***needs***.

The 'process' of the provider

The process or consumption pattern which can be interrupted or modified by the ***provider*** in order to make and deliver a Demand-Side Bid. For large consumers this will often be an industrial process. However, the term will also be used for other types of consumption. For example, in a domestic context the 'process' might be electric space heating or the operation of washing machines.

3 Drivers for DSB

3.1 Overview of Financial Drivers

There are many drivers, or motivating forces, behind the implementation of DSB schemes. Amongst the most important are:

- Regulation / legislation / government
- Needs of Transmission System Operators
- Needs of Local Network Operators
- Needs of Suppliers
- Costs of Consumers

Regulation / legislation / government

Regulation and legislation play a vital role in enabling the demand-side to actively participate in the electricity market. However, whilst a suitable regulatory framework is a prerequisite for DSB, it is, of itself, only a weak driver. DSB will not happen unless the various participants gain from DSB.

Needs of Transmission System Operators

The Transmission System Operator (TSO) has the responsibility to maintain system security and quality of supply. Traditionally TSOs have looked to generators to help them achieve this, but in a competitive market there can be advantages to looking to the Demand-Side. Incentives may be placed on the TSO by the Regulator to encourage use of the Demand-Side. However, in most cases the TSO can do its job without DS participation.

Needs of Local Network Operators

There are times when demand on local networks exceeds the capacity of particular supply points. Usually conventional short term solutions, such as supplying from an alternative supply point, can be found. Long term there may be pressure to build new capacity, which might include local generation, to alleviate the problem. However, a responsive, flexible, demand-side could avoid the need for such actions and provide a more cost effective solution. New needs will also arise as local Embedded Generation, often of a less predictable nature (such as wind farms), takes an increasing role in local network behaviour.

Needs of suppliers

In competitive markets it is generally the case that suppliers must purchase sufficient power to meet their customers' requirements at all times, or else face financial penalties. Such penalties will usually depend upon the time of day reflecting the demand on the system and the availability of generation capacity. Customers who have the ability to be flexible in their usage patterns of electricity can be particularly valuable to suppliers, in helping suppliers avoid periods of high penalties.

Markets for bulk purchase of electricity also generally have a time of day element to prices, and again consumers who can be flexible in their usage patterns can help drive down costs for the benefit of the supplier and all its customers.

Costs of consumers

Consumers of electricity are naturally interested in purchasing electricity at the lowest cost and DSB can help them to achieve this. However, in the vast majority of cases electricity is something to be used as and when needed, be this for a large industrial concern or individual domestic households. Some consumers will, due to the nature of their process, have more ability to change their consumption profiles than others, but in all cases this will be a distraction from their normal business.

Furthermore, in most cases, individual consumers use too little electricity to make them of interest to purchasers of Demand-Side Bids. Certainly to compete with generators of several Megawatts, Demand-Side Bids should ideally also run into Megawatts.

Thus, generally speaking, individual consumers are not strong drivers behind the implementation of DSB. The one exception to this is very large industrial consumers for whom electricity forms a large part of their overall production costs. Here they might be sufficiently motivated to take the initiative and develop DSB themselves, but even in this case there is likely to be a skills and knowledge shortage to do so successfully.

3.2 Business opportunities – the role of aggregators

As we have seen, there are economic drivers for DSB from the point of view of many of the participants in competitive electricity markets. However, for most it can be far removed from their normal day to day activities. This is especially so in the case of consumers, the very people who DSB is aimed at.

This then provides a business opportunity for parties who are not directly involved with the buying and selling of electricity, or with maintaining system security. Someone who has, or can develop, the expertise to make it happen – to become, in effect, the prime driver behind Demand-Side Bidding. Such a party is generally known as an Aggregator or a Consolidator (the term Aggregator will be used throughout this guide) – the term arising because of the general requirement to form a single Demand-Side Bid made up of loads from several consumers.

The Aggregator will have the expertise to:

- Understand consumers' processes and consumption patterns
- Understand the needs of the buyer of a DSB product
- Aggregate loads from several consumers to give a useful DSB product
- Enter markets or negotiate directly with buyers
- Provide the necessary communications and controls

The role of the Aggregator could be fulfilled by a group within a Transmission System Operator or Supplier, or by a totally independent organisation. Arguably being a part of the TSO might compromise the working of a competitive market (in the same way that TSOs are often not allowed to be owners of generators).

Aggregators have an important, perhaps even fundamental, role in the implementation of successful DSB schemes. However, in order for such parties to have sufficient incentive to become involved, the income derived from the DS Bid needs to more than offset the costs incurred in setting up the scheme. Determining the costs and benefits associated with implementing and participating in DSB are discussed further within the step-by-step descriptions of implementing DSB (see Sections 4 and 9 of this Guide).

The role and activities of aggregators will be a recurring theme throughout this guide. There can be other routes to successful DSB schemes, but understanding the role of the aggregator will enable others (such as a TSO who wishes to promote DSB) to better achieve their aims.

4 Implementation of DSB

As we have seen in Section 3, the successful implementation of DSB schemes requires someone who has the knowledge and expertise to understand both the needs of the 'buyer' of a Demand-Side Bid and the 'processes' and consumption patterns of the 'providers' of Demand-Side Bids [2]. We have referred to such a person as an Aggregator.

The rest of the guide is written as if it were aimed solely at potential Aggregators. This brings out the full extent of what is required to successfully implement DSB. Other interested parties will readily be able to identify tasks that they can undertake themselves.

The flow chart on page 9 sets out the step-by-step process required. Each of Sections 5 to 11 deals with one of these steps, illustrating it with examples as appropriate. More examples are then provided in Section 12, each being discussed in the same step-by-step manner.

Some steps are more essential than others. In particular, no DSB scheme can be implemented without steps 1, 2, 4, 5, and 7.

Steps 3 and 6 are to do with looking beyond the obvious – seeing if there are better, wider ranging, more cost effective measures that can be used, and adapting the DSB scheme accordingly. Where steps 3 and 6 are used there will be the need to revisit some of the previous steps, to define new products, select different metering and communications technologies, and refine costings. This may result in involving groups of consumers who would have initially seemed to be unlikely candidates for DSB, but will ultimately provide cost effective ways of encouraging Demand-Side participation, to the benefit of the market as a whole.

[2] See "Important terminology" on page 4 for a reminder of the definitions of such terms as 'needs', 'buyer', 'provider' and 'process'

Flow Chart

Section 5	**Step 1: Identify needs of buyer(s)** There may be an existing basic ‘product’ But may also identify new products
Section 6	**Step 2: Target provider(s)** Understand process & range of ‘needs’ that could be met
Section 7	**Step 3: Adapt Product** Marry actual ‘needs’ of buyer to ‘process’ of provider
Section 8	**Step 4: Define CMC Technologies** What are the Control, Monitoring and Communications requirements?
Section 9	**Step 5: Make Business Case** Define costs & benefits & costs of the generator alternative
Section 10	**Step 6: Refine Selection of Product** Adjust business case to find best match
Section 11	**Step 7: Implement** Establish bid mechanisms and negotiate contracts

5 Step 1: Identify the needs of the buyer

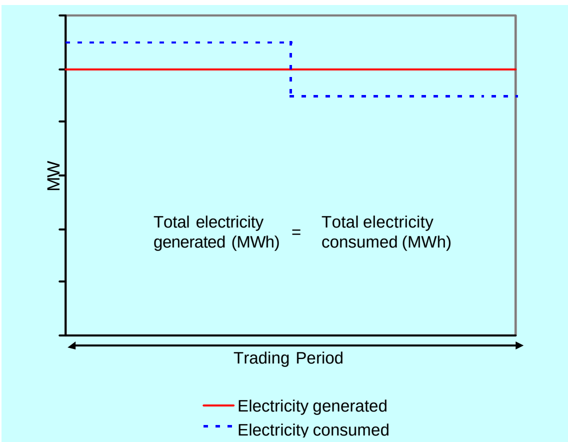
The first step in developing a DSB scheme is to identify and understand the needs of the 'buyer'. These differ from buyer to buyer and will also vary from country to country. We will now explore how these needs arise and what the differences can be.

Although competitive electricity markets treat electricity as though it were any other commodity whereby supply and demand are met at the optimum cost, electricity is not like any other commodity. For economic reasons, it cannot be stored in bulk when supply exceeds demand, and when supply is insufficient to meet demand it is not simply a case of a percentage of demand going unsatisfied as would be the case with a commodity such as wheat or oil. Instead actions need to be taken to prevent the entire network becoming unstable and eventually causing complete collapse and black-out. Therefore, governments and or regulators place responsibilities on both system operators and certain market participants to ensure that supply and demand are kept in balance.

Whilst electricity must be kept in balance at all times (i.e. on a second by second basis), for practical purposes it is not traded on a second-by-second basis in liberalised electricity markets. Rather trades are settled over a longer time interval, the length of which depends upon the market regulations in force. For example, in the UK electricity is traded across half-hourly time intervals, whereas trades in Scandinavian countries and in Spain are based on hourly intervals. Thus, market participants such as Suppliers and Generators are given the responsibility of balancing supply and demand over these trading periods or otherwise face financial penalties (such participants being defined as 'balancing responsible'). In addition to this requirement for market participants to be in balance across trading periods, there is also a requirement for balance to be maintained in real time as demonstrated in the following simple example.

Consider the situation where the demand of a single consumer is met by the output of a single generator, as indicated in the diagram on the right.

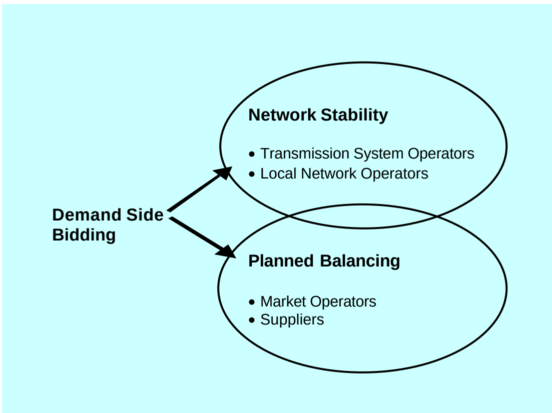
Although the total amount of electricity generated over the Trading Period is the same as that consumed (i.e. the area under the generation curve = the area under the demand curve), generation and demand are not in balance on a second-by-second basis.



Thus even with all market participants in balance across all trading periods, there is a requirement for the system to be kept in balance in real-time. There is also a requirement for the system to be kept in balance if a generator fails or if an unexpected variation in demand occurs. The responsibility for these actions fall on the Transmission System Operator, who is also responsible for managing network constraints that arise on the transmission network. Similar responsibilities are also placed on Local Network Operators who maintain the security and quality of supply of their local network.

Therefore, actions to maintain supply and demand in balance can be divided into two basic categories:

- those undertaken to maintain balance in real-time to prevent system imbalance and ultimately network failure; and
- those undertaken to balance supply and demand over a trading period for the purpose of avoiding imbalance charges.



It is difficult to provide a definitive split of DSB into these two categories and there is an area of overlap between the two categories.

Although there is some degree of overlap, the use of these two categories provides a useful means of describing DSB products. Network Stability is primarily concerned with avoiding imbalances caused by *unpredictable* events such as the sudden loss of a generator or an unexpected increase in demand. Planned balancing, however, is essentially associated with the financial aspects of energy trading, and in particular, securing contracts for the amount of electricity *predicted* to be consumed or generated over a trading period. The distinction between predictable / unpredictable events does become blurred at the edges. For example, measures taken for the purpose of alleviating transmission network constraints are primarily the responsibility of the Transmission System Operator and are undertaken to avoid certain parts of the network being overloaded, i.e. to maintain network stability. However, such constraints do not readily fit the description of 'unpredictable' events, as the TSO may often be aware of network constraints several hours (or even days) before they occur. Additionally, the TSO often plays a key role in planned balancing activities. This is particularly the case when the financial implications of imbalance are insufficient to encourage the market participants themselves to avoid any imbalances between their contracted and metered volumes.

We shall now look at the 'needs' that arise for 'buyers' in each of these two categories in some depth. The aim here is not to present a definitive list of all of the 'needs' of all of the potential 'buyers', but rather to give a flavour of what might be important. One example for each of the two categories will be introduced. These will be built up into full case studies over subsequent chapters.

5.1 Network Stability

The Transmission System Operator maintains a secure and stable transmission network at all times using a variety of different services. Whilst the exact operational procedures followed by TSOs does vary from country to county, the broad principles followed are similar.

Similarly Local Network Operators (or Distribution Companies) are responsible for maintaining and operating the local networks that supply electricity directly to consumers. Electricity distribution networks were designed primarily for top-down power flows from the transmission network to consumers. However, the increasing amounts of embedded generation places an increasing burden on Local Network Operators to manage and operate their networks effectively and prevent power problems such as reverse power flow, excessive fault levels and voltages outside statutory limits.

To illustrate Network Stability 'needs' in more depth, we shall concentrate on the 'needs' of the Transmission System Operator. These needs fall into several categories:

- Frequency Stability
- Reactive Power & Network Voltage Stability
- Transmission Constraints

System frequency is a continuously changing variable that is determined and controlled by the instantaneous balance between system demand and total generation. The system frequency is consistent throughout an interconnected system.

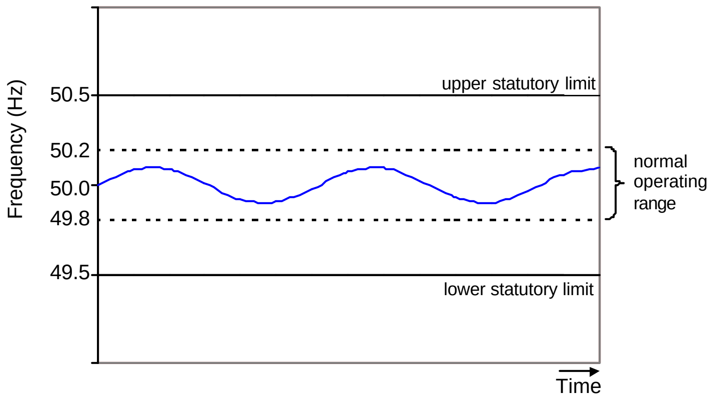
Reactive Power describes the background energy movement in an Alternating Current system, arising from the production of electric and magnetic fields. Reactive power is required to maintain system voltage within the statutory range. Since this varies with location (depending upon local generation and demand) reactive power flows must be controlled on a local, zonal, basis.

Transmission constraints are 'bottlenecks' that occur on the network, which arise when the required quantity of electricity cannot be delivered over the constrained part of the network because it is already operating at full capacity. Such constraints usually arise when areas of demand do not coincide with areas where generation is predominant.

To date the area of Demand-Side intervention being most successfully applied is in the area of system frequency control and it is this area that we will concentrate on here.

Frequency Stability

The frequency of any transmission service must be maintained within a specified narrow band by maintaining a careful balance between demand and generation.



For example, the frequency in the UK must be maintained between 49.5Hz and 50.5Hz.

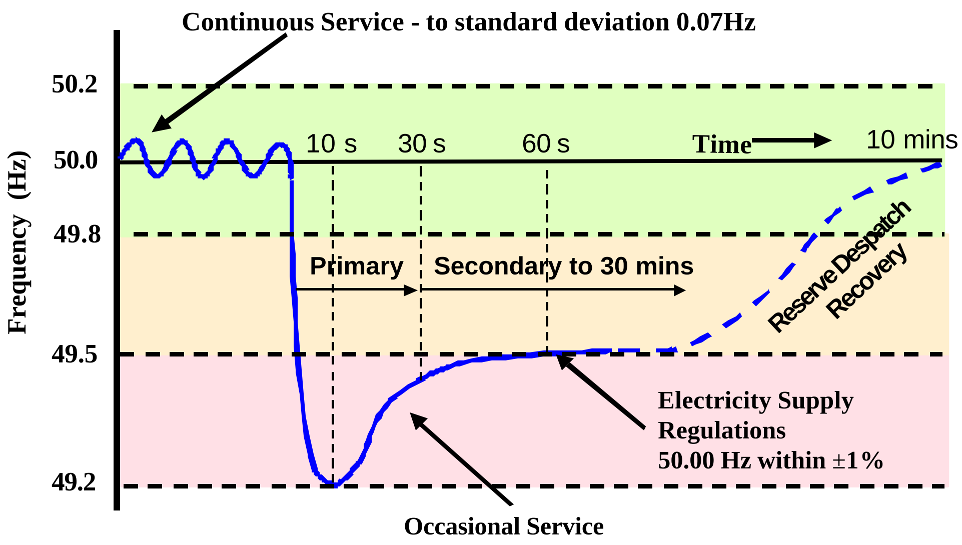
- If generation output is less than demand – frequency will start to fall.
- If generation output is greater than demand – frequency will start to increase.

Fluctuations within this narrow band are normal and are readily dealt with by synchronous generators through their automatic governing systems. In the UK this normal fine tuning of the system frequency by generators is known as “Continuous Service”.

A sudden larger drop in frequency, due to either a failure in a large generator or a sudden unexpected increase in demand, is harder to deal with and requires more active intervention. Again, in the UK, the TSO has traditionally turned to the generators for corrective action, but is now increasingly looking to the Demand-Side to provide more cost effective solutions, since a drop in system frequency can be just as effectively averted by a reduction in demand as it can by increasing the output of a generator [3].

In the UK, a response to a sudden large fall in frequency is known as “Occasional Service”. The graph below shows a typical required response, with fast acting “primary” response, being supplemented by slower acting “secondary” response and then ultimately being replaced by “reserve”.

[3] In networks with large controllable hydro plant – such as much of Scandinavia - it is still the case that generators are the most cost effective response to large sudden changes in frequency



The TSO will have a defined set of parameters, covering the size of the loss of generation (or increase in demand) and the time-scales over which corrective action must be taken.

In the UK these volumes and times scales are as shown below:

Description of service	**Loss of generation / increase of demand**	**Frequency requirements**
Continuous Response	up to 300 MW	Maintained within the normal operating limits of 50.2 Hz to 49.8 Hz.
Response to abnormal event	300 MW to 1000 MW	Minimum 49.5 Hz. Restored to 49.8 Hz after 30 seconds.
Response to significant event	1000 MW to 1320 MW	Minimum 49.2 Hz. Restored to 49.5 Hz after 60 seconds.

The TSO will have various 'products' (both Generator and Demand-Side) that he can buy to meet his statutory requirements. Thus (using the UK terminology from the graph above) there will be products for:

- Primary response
- Secondary response
- Reserve (categorised as both fast and standing)

The TSO will define these products in terms of volumes, reaction times (notification periods) and duration of service provision. Volumes will of necessity be large (MWs). This is to ensure that by purchasing a manageable number of such products, the TSO can make an adequate response to the sudden large volume changes that cause such frequency drops.

Historically the products would have initially been defined with the generators in mind, and so will often have response times and durations that are specifically suited to the characteristics of generators.

However, the Demand-Side may well be able to offer different characteristics that would still be attractive to the TSO. These may, in some cases, be even more attractive than the generator response. Thus there may be scope for defining new products with the TSO, to help him meet his ‘needs’ in the most cost effective manner.

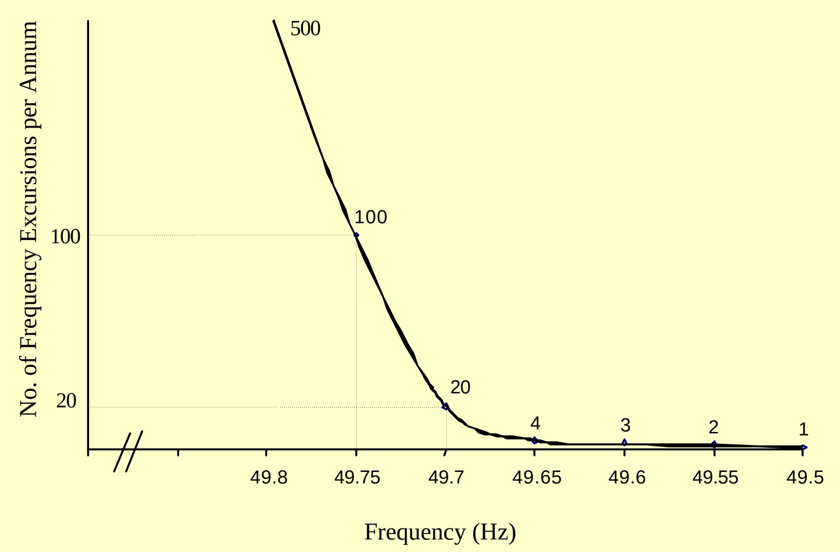
Example 1: Fast Acting Frequency Response – UK

As we have seen, in the UK the TSO must respond to a sudden loss in frequency within a prescribed time period. Various products have been defined in order to help achieve these requirements. One such product is a ***Commercial Frequency Response – initiated by Low Frequency Relays***. This product can be provided by either generators (typically generators in a state of readiness – spinning but not on-line) or by the Demand-Side. The particular basic commercial frequency response product that is suitable for the Demand-Side has the characteristics of:

- Response delivered in full within 2 seconds
- Minimum volume 3 MW
- Duration of change 30 minutes

In reality, the response of demand to a frequency relay is instantaneous (within micro-seconds), giving a clear advantage to the Demand-Side over Generators.

How often the service is called upon will depend upon the setting of the relay, as shown below. The price of the 'product' might vary to reflect this. More likely is that an Aggregator would have several 'providers', each being paid the same. Frequency trips would be set at different levels to provide a progressive change in demand as the frequency falls. The setting of the relay would then be varied throughout the year, from site to site, to give each 'provider' a similar number of trips per year.



5.2 Planned Balancing

In the case of ‘Network Stability’, discussed in the previous section, it is usually obvious who the ‘buyer’ of a DSB product is, i.e. whose ‘needs’ the DS Bid is meeting. In the case of ‘Planned Balancing’ this is often not the case. In many cases some form of market mechanism will be in operation where the actual ‘buyer’ will be invisible to the ‘provider’ of the DSB.

In this case we could simply summarise the ‘needs’ of the buyer as one of reducing the overall cost of electricity. However, there are specific needs that can be identified and in order to do this we need to understand some of the basics of how electricity markets operate. This we shall now discuss using the Scandinavian market as an example.

An interesting subset of ‘Planned Balancing’ is where the ‘buyer’ of the DS Bid is the electricity supplier of those same consumers who are actually providing the DS Bids. In this case transactions can take place outside of the market mechanisms. This will be returned to later after we have developed the initial market based example.

Market liberalisation in Scandinavia

During the 1990s, the process of market liberalisation took place in all of the Nordic mainland countries (Norway, Sweden, Denmark and Finland). Centrally planned, monopolistic systems, have been broken down into areas that could be subject to competition (i.e. generation and supply), and areas of natural monopoly (transmission and local networks) where regulation is required to encourage economic efficiency. Suppliers lost their exclusive rights to supply customers in their franchise area and consumers became free to choose their electricity supplier. Generators, were no longer obliged to supply their areas with long-term stable electricity prices and were subjected to competition.

Under the new arrangements, participants can now purchase and sell electricity directly between each other via bilateral contracts, as well as undertake market based trades for both long-term contracts (e.g. forwards contracts) and shorter term contracts.

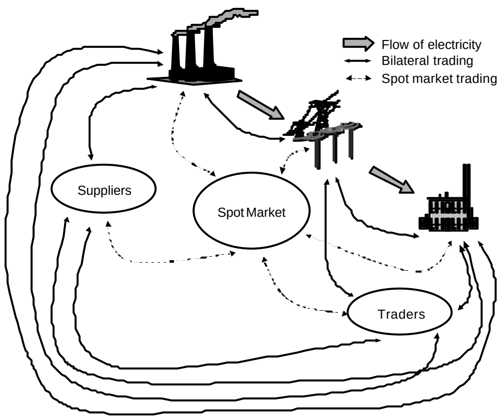
Building on the pre-liberalisation co-operation that existed between the generators and transmission operators across Scandinavia, a common electricity exchange has been developed, known as Nord Pool, on which players from Norway, Finland, Sweden and Denmark can trade in electricity. This includes a day ahead Spot market known as Elspot.

The trading process is designed to encourage participants (generators, suppliers, traders, network owners and some large consumers) to be self-balancing. However, whilst power flows freely between the Nordic countries the market is not totally without borders – a generator has to be balancing responsible in the country where the electricity is fed into the national network, whilst a supplier has to be balancing responsible in the country of consumption.

Each day is split into 24 hourly trading periods.

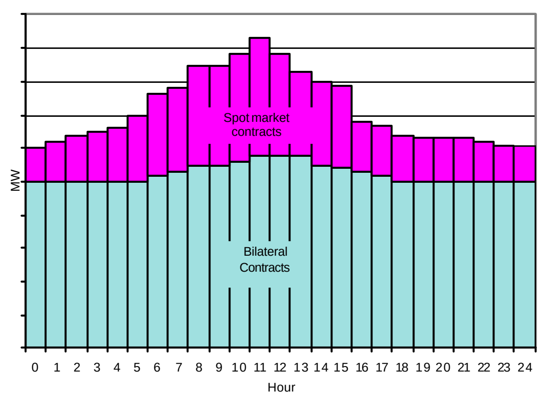
For each 1 hour trading period

- Generators aim to have contracts in place for all the electricity they expect to generate
- Suppliers aim to have contracts in place for all the electricity they expect their customers to consume
- Traders aim to balance total electricity purchases with sales
- Balancing responsible customers[4] aim to have contracts in place for the electricity they expect to consume
- Network owners aim to have contracts in place to cover expected network losses



Approximately 30% of the annual energy consumed in Norway is traded in the spot market, the remaining 70% is traded bilaterally.

Market participants normally have a portfolio of bilateral contracts and long term market based trades to cover a large proportion of their expected requirements. However, it is not possible to determine in advance the exact volume of electricity that will be required. This will vary with such factors as the weather and, in the case of industrial consumers, production schedules.



[4] Balancing responsible customers are those that opt to buy their electricity directly, for example via bilateral contracts or from the markets. Other customers, will prefer to place contracts with an electricity supplier, who will agree to meet their electricity requirements for a pre-determined price.

Therefore, some final adjustment of volumes will always be required near to the time of delivery. This is normally done through the spot market.

Failure to make such market based adjustments, will result in a mismatch between an individual participant's contracted and metered volumes for that trading period. They will then incur an imbalance charge. In Norway, overcoming such imbalances is the responsibility of Statnett, the Transmission System Operator, who organises a real time (or balancing) market to physically balance generation and consumption. The TSO also manages the financial settlement of imbalances after the day of trading.

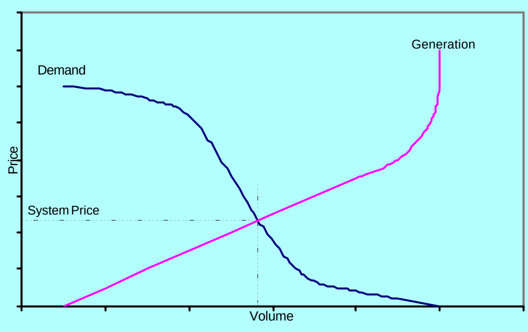
There are essentially three choices for avoiding imbalance charges:

- Purchase 'top-up' requirements on the spot market; or
- Reduce electricity requirements to a level covered by long-term contracts; or
- Avoid electricity use altogether and sell back any excess contracted electricity to the spot market.

When spot market prices are relatively low, the first option will be favoured. However, as spot market prices increase, as has occurred recently in Norway, the second two options become more relevant.

Spot Market Price

The spot price depends on a number of factors, but is predominantly affected by the availability of generation compared to the demand for electricity. Generally, the higher the demand for electricity and the lower the availability of generation then the higher the spot market price for electricity.

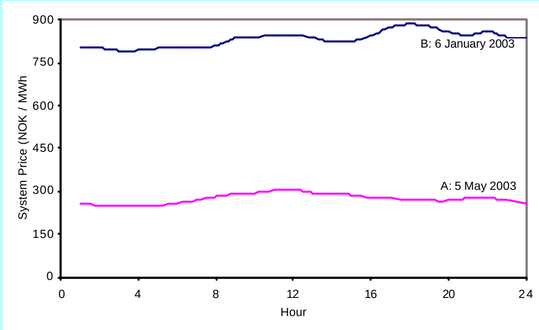


The price on the spot market is determined by the intersection of the aggregated generation and demand curves for each trading period. The demand curve shows how responsive the demand is to price signals. It will often be very steep showing that demand will be similar across a wide range of prices, unless active demand participation is encouraged.

Variations in Spot Market Prices

Spot market prices vary both within each day and seasonally reflecting the variation in demand (and to a lesser extent generator availability).

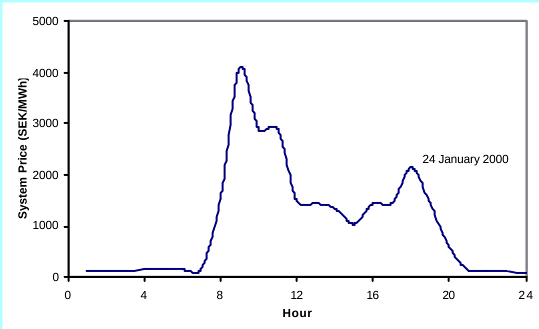
Norway 2003



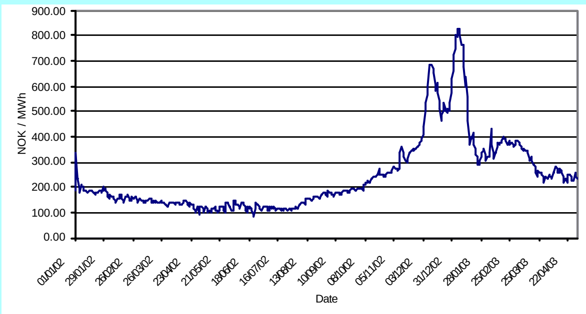
Here we see two daily spot market price variations for Norway. Curve A shows little incentive for the demand-side to manipulate loads due to the low spot price, whilst curve B shows that significant savings could result from avoiding the high cost periods.

(Actually "system price" is shown which is the Nordic wide spot price. Norwegian spot prices will include local transmission constraint costs on top of the system price).

Sweden 2000



The graph on the right shows an example of the variation in hourly spot prices that can, on occasion, occur within a single 24 hour period.



Here we see that spot price can vary widely across the seasons. The graph shows the average daily spot price for Norway. This was generally in the range 100 – 200 NOK / MWh over the period January 2002 to April 2003. However, over the winter period (December 2002 to January 2003), there was a dramatic (four-fold) increase, with prices rising to over 800 NOK / MWh.

Thus in terms of Demand-Side Bidding, we can see different types of 'need' emerging – one where prices remain high for several days at a time and another where prices fluctuate widely within the day, but not necessarily from day to day. The most cost effective response from the demand-side may vary from situation to situation.

Example 2: Planned Balancing – Norway

Market Mechanism – Dealing with high spot prices

The Nordic spot market is known as Elspot. This is a day-ahead physical-delivery power market based on bids for the purchase and sale of power contracts of one-hour duration (or multiples of one hour) that cover all 24 hours of the next day.

The deadline for submitting bids for the following day's delivery is 12 am (noon). Bids are for purchase and sale of hourly contracts using three different bidding types: hourly bids, block bids and flexible hourly bids that cover all 24 hours of the next day.

Hourly Bid: A sequence of price / volume pairs for each specified hour.

Block Bid: A block bid for several consecutive hours with a fixed bidding price and volume. A block bid must be accepted in its entirety.

Flexible Hourly Bid A sales bid for a single hour with a fixed price and volume. The hour is not specified, but instead the bid will be accepted in the hour with the highest price, given that the price is higher than the limit set in the bid.

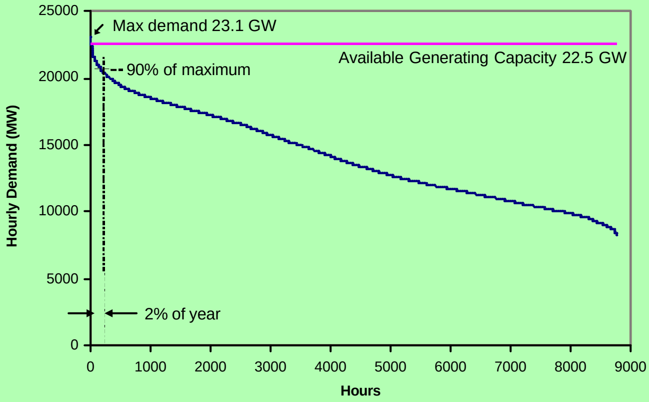
In order to participate on the spot market, participants need to have a licence / concession, which means they are obliged to have contracts in place to cover their generation / consumption or otherwise face imbalance charges (i.e. they are 'balancing responsible').

Participants who have already secured the right to consume electricity via bilateral contracts or over-the-counter trades are able to sell this electricity back on the spot market in direct competition with electricity sales from generators.

As with all Elspot bids, a Demand-Side Bid is defined in terms of the volume of electricity (MW), the time period (i.e. the trading periods to which the volume bid applies) and the price. The minimum bid size on the spot market is 0.1MW, which theoretically makes participation possible for a reasonably large proportion of industrial and commercial consumers. The fees involved in participating directly on the market tend to make this viable only for power intensive consumers who consume large amounts of electricity, i.e. of the order of several MWs. The fees required for participation on Elspot include an entrance fee and an annual membership fee. Participants are also required to provide financial security equivalent to the net purchases over the previous 4 weeks.

A load duration curve is a useful way of illustrating the potential for DSB products on the spot market, and shows the number of hours that the demand in each of the hourly trading periods exceeds a certain level.

The graph on the right shows the load duration curve for Norway in 2001. The graph shows that the maximum demand (23.1GW) actually exceeds available generation capacity (22.5GW), which means that Norway has to rely on imports to meet its peak power requirements.

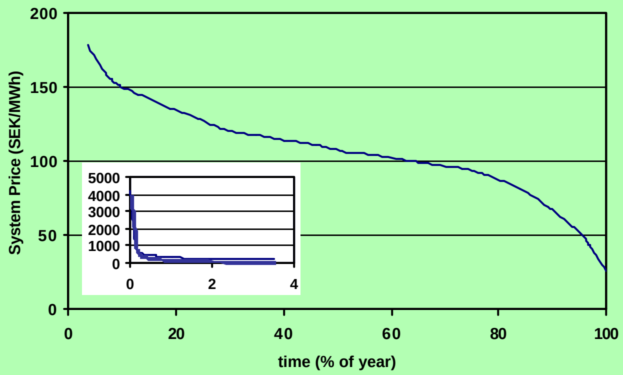


Load duration curve for Norway, 2001

However, Norway cannot rely on its neighbouring countries (Sweden, Finland, Denmark) during peak periods, as they typically also experience their peak demand at the same time as Norway.

The graph above is also useful for demonstrating the number of hours per year that peak demand conditions occur. For example, the graph shows that demand exceeds 90% of the maximum for less that 2% of the year (i.e. for less than 160 hours), therefore, generation plant used to meet this peak will be used for only a few hours, and as a result, spot prices for these limited number of hours would be expected to be high.

This is illustrated more dramatically by a price distribution curve, which show the number of hours per year that the price exceed the plotted values. The graph on the right is a typical annual Swedish Spot Price distribution curve. The inset shows how the price can rise dramatically to over 4000 SEK / MWh compared to prices of between 50 and 150 SEK / MWh for the bulk of the year.



Direct and Indirect participation

Conceptually it is easy to see how a single large consumer could bid back some or all of his contracted 'right to consume' into the Spot Market. He would then simply avoid, or reduce, consumption during the period related to the bid. Such DSB participation can be seen to be direct participants in the Planned Balancing mode of DSB.

In the case of a Supplier this is less straight forward. A Supplier cannot directly reduce his 'right to consume', but rather has to rely upon his customers – the end consumers – to do this for him. In general he will have many customers, some of whom will be better able to make adjustments to their patterns of use than others. Consumers willing or able to curtail their electricity consumption could assist their electricity supplier in one of three ways:

- Enabling the supplier to avoid high pool prices for top up electricity requirements (i.e. one consumer / group of consumers curtail their demand in order to ensure that the demand of another consumer / group of consumers is satisfied.
- Enabling the electricity supplier to 'make money' by selling electricity back to the electricity spot market when prices make such actions favourable.
- Enabling the supplier to avoid imbalance charges if one consumer / group of consumers was expected to consume more electricity than had been expected at the time of gate-closure on the spot market, which can be up to 36 hours before the time of delivery.

Consumers willing to assist their supplier would then be rewarded either via a reduced price for purchase of electricity or a direct payment for actually curtailing their demand.

Here the Supplier becomes in effect an aggregator, taking 'bids' from some of his customers to either offset demand of his other customers or bid back into the spot market. His customers then become indirect participants in DS Bidding.

An independent aggregator could also fulfil a similar role, allowing end users to indirectly participate in DSB. The buyer of the DS Bid might then be a supplier – with the Aggregator helping his group of end consumers search for the supplier offering the best deal.

6 Step 2: Targeting providers

DSB involves demand reduction bids by consumers – the providers of Demand-Side Bids. However, a demand reduction is not equivalent to *'negative'* generation because there will always be some impact of a demand bid on the 'process' of the consumers. It cannot be over emphasised that DSB is not core business for the provider, and thus he will only be interested in participating if:

i) DSB has little or no impact on his process

ii) And / or DSB provides a significant income stream or reduction in costs

The greater the cost benefit, the more disruption to his process the DSB provider will be prepared to accept.

How closely a Demand-Side Bid resembles negative generation will depend very much upon the processes involved (i.e. the type of electrical load used to provide the Demand-Side bid). This will affect:

- the time(s) during the day when the load can be safely interrupted
- the length of time that the demand bid can be sustained
- the interval required between demand reduction bids
- the impact on electricity demand after the event has occurred
- the amount of notification required before a bid can be activated

The last item (notification) can have parallels with generator operation, but the others tend to be much more restrictive for the Demand-Side than for generators. Such issues greatly affect the ability of consumers to participate in DSB, and must be taken into consideration when setting up any DSB scheme.

As we have seen, the buyer of a DSB product generally wants to purchase large volumes (MW) of electricity so that the DS Bid will have a significant impact on meeting his needs. Thus, the ideal provider is usually a large single consumer. However, there are often few suitable large consumers. For DSB to reach its full potential, ways of enabling smaller customers to participate are desirable. Thus we have two basic types of DSB provider:

1. Large single customers
2. Groups of smaller customers who:
    - have similar processes
    - can be combined into a single large DS Bid
    - can use similar control, communications and metering technologies

Aggregators have an obvious (and indeed essential) role to play with the smaller consumers, where a number of loads are aggregated together into a single large DS Bid (hence the name “aggregator”). However, the expertise that an aggregator will have in making DSB run smoothly, will be of value in helping even the largest, single consumer to participate in DSB.

The impact of a DSB on a provider will vary with the type of process involved. Some types of process make it easier to participate than others, but, with a bit of ingenuity and the right incentives, there are a wide range of processes that can be used.

We shall split the types of process which can be used for DSB into three:

1. Those that require no change to the process
2. Those that require a change to the operation of the process
3. Those that require a change to the process

6.1 No change to process

Here the process can simply be interrupted. The energy that would have been used is either:

- Avoided (lost production)

Or

- Used later to compensate

The latter has implications for the returning load – this might cause a follow-on problem from the one that the DS Bid has just avoided.

Often this category includes:

- Large loads
- Processes where electricity costs are a high proportion of the production costs (and therefore operators are interested in deals that will reduce this cost)
- Processes which can safely be interrupted at little or no notice required

There is inevitably a cost involved as production is affected. However the costs involved with making the DS Bid are small (these will be discussed further at steps 4 & 5)

6.2 Change to operation of the process

This can occur in two ways:

i) Fuel substitution

This can be a long term change to the operation of the process (lasting for several hours with no deterioration in the quality of the process). It typically involves:

- Running standby generators
- Switching fuels in duel fuel boilers

ii) Within process storage

This covers such areas as:

- Cold store warehouses – where the warehouse is slightly overcooled prior to the DS Bid taking effect and then allowed to warm up during the interruption itself.
- Fabric storage – e.g. over cooling the fabric of an air-conditioned office prior to the DS Bid, and again allowing warm up during the interruption.

Such within process storage can only be for a limited period – minutes or hours rather than for several hours or days, or else the effect on the process would become noticeable.

In both of the above categories (substitution and within process storage) there is no change to the production or delivered level of service. The add-on costs for making the DS Bid are, however, generally higher than where no change to the process is involved, since additional levels of process control are required to implement the bid.

6.3 Change to process

This will almost always involve some form of dedicated storage that would otherwise not be present, examples being:

- Storage heating (replacing direct electric resistance heating)
- Ice storage (supplying air-conditioning loads)
- Product or raw material storage (allowing down stream processes to continue whilst up stream ones are interrupted)

All such examples require investment to be made prior to DS Bidding becoming established, and requires a certain amount of economic and market stability (repeatability rather than non volatility) to make any such investment worthwhile. It does, however, represent the area with probably the largest potential for DS Bidding.

On occasions the investment will have already been made as part of an existing (prior or ongoing) DSM scheme. DSB would then build on this to add flexibility and market responsiveness.

Example 1: Fast Acting Frequency Response – UK

***Commercial Frequency Response – initiated by Low Frequency Relays*.**

Continuing with our first example, we need to target consumers who can provide large loads at little or no notice.

i) Cement manufacture

Two such processes that cover both criteria directly, are the crushing and milling phases of cement production. These consume large, predictable and steady electricity loads, and can be easily interrupted and restarted. Fuel cost is a high proportion of what is essentially a low value bulk commodity, and the manufacturers are receptive to ways in which their costs can be reduced. There is natural storage both upstream and down stream of the process and typically production does not need to be at maximum capacity 24 hours per day. There is thus little or no cost to interrupting supplies, providing overall production targets can be met, and as such represents the ideal DSB provider.

In the UK, Yorkshire Electricity Special Markets (recently acquired by Gaz de France) developed the first Demand-Side frequency response service using cement companies. Now, in total, thirteen sites offer a maximum instantaneous load reduction of 110MW.

ii) Cold store warehouses

Whilst large single consumers can be ideal for DSB, there are few suitable ones. Many large consumers produce high value products where the process is ‘king’ and any interruptions to the electricity supply are far from welcome. Thus it is also worth looking elsewhere for DSB providers.

Cold stores have predictable steady demands for cooling / refrigeration. Whilst individual refrigeration compressors will cycle on and off throughout the day, aggregating the loads from several compressors, across several warehouses, will give a significant steady load.

The stored produce in the warehouse represents a large thermal mass and temperatures remain stable for some time after an interruption in the refrigeration supply. Operating the cold store at a slightly lower temperature than normal enables the process to be interrupted for longer – giving a useful opportunity for DSB.

The process is similar from warehouse to warehouse and so control and communications technology can be duplicated. The questions are then whether the infrastructure for DSB can be provided cost effectively, and whether ***fast acting frequency response*** is the most appropriate product. These questions will be returned to later in steps 4, 5 & 6.

Example 2: Planned Balancing – Norway / Sweden

Dealing with high spot prices

Continuing with our second example, we need to target consumers who can respond to price signals by modifying their normal consumption pattern. Typically, day ahead predictions of demand and spot prices are used. As we will see, responses, in terms of length and volume of interruption, will vary from situation to situation.

In some cases there is a clear need for an aggregator. In others arguably an aggregator is not required at all. However, expertise will be required in such areas as forecasting of prices (e.g. predicting periods of system peak demand), and market entry rules (e.g. a consumer changing from supplier to direct market participation) and often an aggregator will be best placed to provide this.

Details of examples in this area tend to be confidential and so the following discussion is, in part, generic rather than specific.

i) Direct participation of a large single consumer – Norway

Some consumers opt to become ‘balancing responsible’ and therefore choose to participate directly on the spot market. This is only likely to be the case for energy intensive customers, who are able to make bids that are typically of several MWs in size.

One specific example is where Spot Prices are expected to remain consistently high for several days. This happened in Norway during the winter of 2002 / 2003. Here some industrial consumers felt it was actually more economically beneficial to suspend production, temporarily lay off workers, use the time for annual maintenance if necessary, and sell back their pre-bought power to the spot market.

In this instance the preceding discussion about the type of process is irrelevant – a total suspension of production for several days at a time being possible in most, if not all, large industrial plant.

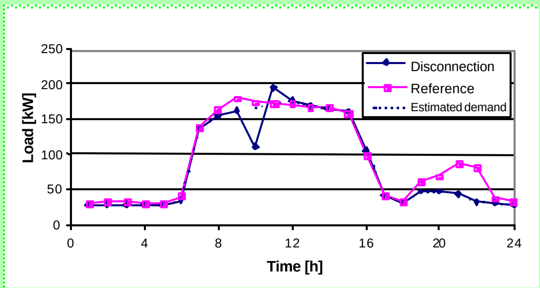
ii) District heating & industrial water heating - fuel substitution - Sweden

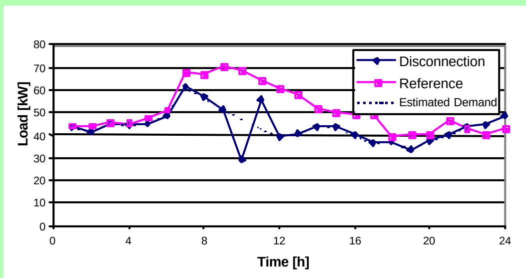
The more general case is where spot prices vary through the day, with high prices for a few hours at a time. This results in a requirement for processes that can be modified or rescheduled within the day to avoid those peak hours. One type of highly flexible load, where interruptions can range from hours to days, is large scale water heating. A large proportion of cities in Sweden are heated by district heating. These systems can often use different energy sources (bio-fuel, oil, electricity) in different boilers. Similarly large industrial and commercial customers will also produce hot water using dual fuelled boilers. When spot prices are low (typically when there is a wide margin between demand and hydro-electricity generation capacity) electricity will be used. When spot prices rise to levels where the cost of running, for example, an oil fired boiler would be lower, the oil fired boiler is brought on-line.

In principle, the providers could again participate directly on the Spot market, and this is indeed the case where the boilers are owned by large energy companies. However, in many cases electricity will be purchased from a supplier at a price that follows the spot market price. In this case the supplier becomes, in effect, the aggregator and can choose whether to use the resulting non-consumption to keep a balance with his other customers or bid back into the spot market.

iii) Indirect participation - Electric space heating in schools – Norway

A similar example, with slightly different consequences for the provider's process, is space heating in schools. Electric boilers are again used, but this time there is no alternative fuel source available. Any interruption to the supply will result in a change in the normal operation of the process (i.e. a change in the space heating), the thermal mass of the building maintaining comfort through the period of the interruption. The graphs below show the effects of interrupting the boiler supply for one hour from 9-10 am, at two different schools.





In both cases the demand increases to above that of the reference case when the supply is returned. This process recovery is important in determining whether or not the demand reduction is worthwhile, or simply creates a new problem later. Nevertheless, this type of interruption, which is cheap to implement, and for limited periods has little or no noticeable effect on the process (the comfort of the occupants) can prove valuable to a supplier trying to balance his full portfolio of customers at the lowest cost.

7 Step 3: Adapt product

Sometimes it will be possible to adapt DSB products to widen the range of DSB providers. The best way to describe this is through illustration with an actual example.

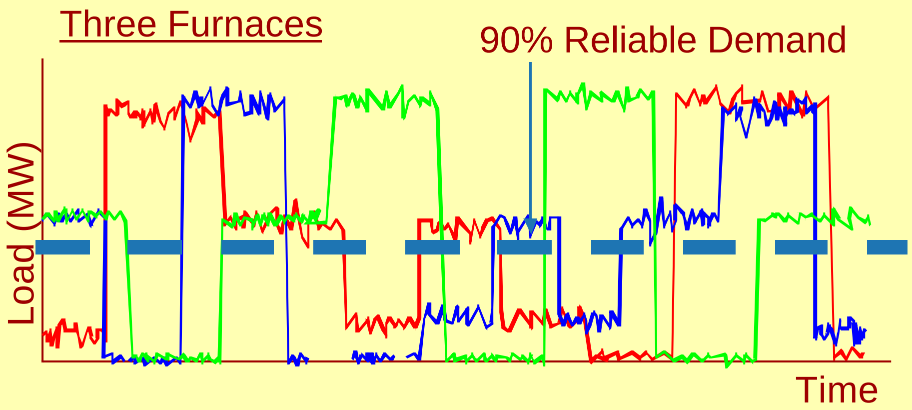
Example 1: Fast Acting Frequency Response - UK

Commercial Frequency Response - initiated by Low Frequency Relays.

Continuing with our first example, in step 2 we saw that the UK Cement Industry is an ideal 'provider' of fast acting frequency response DS Bids. There are, however, few such industries and the 'needs' of the TSO are greater than can be provided from the one source. Other large industries have also been successfully targeted, although in this case the product has been adapted to meet the capabilities of the provider, whilst still meeting the needs of the buyer.

Steel works – arc furnaces

Arc furnaces are also capable of instantaneous shut down with no adverse effect on plant. Individual arc furnaces have very high, but irregular, patterns of electricity usage, fluctuating from zero demand to over 50 MW within a half-hour. This makes them, as individual plant, unsuitable for frequency response. However, the net load of several arc furnaces, when aggregated together, can provide a predictable load as shown.



The manner of providing this "probabilistic" DS Bid to the TSO is very similar to the "firm" demand of the Cement Works. However, the actual DSB product has been modified to make it more attractive to the steel companies - the required duration of the interrupt having been reduced from 30 minutes after an event to only 15 minutes.

Yorkshire Electricity Special Markets grouped together a number of arc furnaces in this way, and are able to guarantee to the TSO that a firm load of around 100 MW is almost always available for interruption.

8 Step 4: Define CMC Technologies

Invariably control, metering and communications (CMC) technologies are required in order to make DSB happen. There will be costs involved with providing these technologies and these must be defined before a business case for DSB can be made.

In very general terms making and delivering a DS Bid involves:

Making the Bid
e.g. specifying times when consumption could be altered, volumes involved & prices

⇓

Proving load is available
e.g. monitoring consumption ahead of DSB implementation

⇓

Receiving notification to modify consumption

⇓

Controlling process to modify consumption

⇓

Monitoring change in load

⇓

Receiving end notification
e.g. when normal process operation can be resumed

⇓

Process Recovery
e.g. Control of plant restart

⇓

Communicating result of DSB
e.g. settlement process

The actual details of each of these items will vary from DSB product to DSB product. In some cases sophisticated electronics and associated software is required, in others it might involve little more than a phone call. The remainder of this section discusses the CMC requirements for the examples previously introduced.

Example 1: Fast Acting Frequency Response - UK

***Commercial Frequency Response - initiated by Low Frequency Relays*.**

We have developed our first example to look at three types of provider. The CMC technologies for each will now be discussed. In each case the services of an Aggregator are employed.

i) Cement manufacture

Making the bid	The UK TSO procures its Frequency Response services through bi-lateral contracts. In this case, these are negotiated on behalf of their customers by the Aggregator. The contract will stipulate volumes and will also agree a price for availability. The Aggregator has a portfolio of consumers offering this service. All of these consumers notify the Aggregator of their load schedules for those processes available for frequency control. The aggregator totals these offers of availability and relays them to the TSO by the week ahead of the availability being offered. Offers can be refined a day ahead, for example to cover production problems at the plant. Great efforts are taken to reassure consumers that DSB availability will have as little impact on their business as possible. Consumers can automatically undeclare their availability at any time, by pushing a button at their plant. Production schedules and combined offers of availability are conveyed to the relevant parties by email.
Proving load is available	Actual availability is monitored continuously. The control room is in constant communication with both the consumers and the TSO, via dedicated telephone lines (a leasing charge is paid for the lines to the phone company, rather than a call time based charge). Pulses from a power meter at each process are relayed to the control centre. These are converted into MW and summed to give the total availability
Receiving notification to modify consumption	Supply frequency is constantly monitored, so that the aggregator is constantly aware of the likelihood of frequency control being activated However, no actual notification is given.

Controlling process to modify consumption	Because frequency can fall so rapidly, the load reduction is controlled by frequency sensitive relays, which operate in microseconds. These are connected to circuit breakers of the piece of plant that the customer has agreed to allow to be tripped.
Monitoring change in load	See 'proving load is available' above
Receiving end notification	The frequency trips are automatically reset after 30 minutes. During a disconnection, consumers can manually over-ride the frequency trip if process demands dictate.
Process recovery	Processes are restarted manually once the relay has reset itself.
Communicating result of DSB	Currently sites are only paid for availability. There is currently no penalty for not delivering the demand reduction.

Example 1: continued

ii) Steel works – arc furnaces

The CMC Technologies for use with arc furnaces are the much same as for the cement industry discussed above, although there are a few slight differences in detail.

Proving load is available	Here a calculation is included, at the aggregator's monitoring centre, to account for the variability in demand from the furnaces. Thus the on-line value presented to the TSO refers to the 'probable' load available rather than the actual load.
Receiving end notification	The frequency trips are automatically reset after 15 minutes.

Example 1: continued

iii) Cold Store Warehouses

Cold store warehouses are not currently active DSB participants in the UK, although it is an area known to be under consideration. The information presented here is thus, to some extent, speculation about what CMC Technologies could be used.

As we saw in step 2 (Targeting Providers) this is a case of aggregating a large number of small loads that behave in similar manners, to provide a single large Demand-Side Bid. Thus the role of the aggregator is again crucial and will build on the experience of the larger consumers discussed above.

Making the bid	Contracts will be negotiated in a similar manner to that for the larger consumers. Predicting the load available to offer load availability schedules would probably be more automated, based on known energy use with weather and product loading / unloading corrections.
Proving load is available	Again continuous monitoring of load is desirable. In view of the larger numbers and smaller individual loads involved, compared to the cement and steel industries, less cost on metering and telecoms is justified and low cost metering solutions are required.
Receiving notification to modify consumption	No notice given as response must be automatic.
Controlling process to modify consumption	It may be necessary to lower the normal temperature set point slightly to make the warehouse available for frequency trips. This would be done through the normal refrigeration compressor control / energy management package. The frequency response itself must be virtually instantaneous, and so again frequency relays must be used.
Monitoring change in load	See 'proving load is available' above

Receiving end notification	The likelihood is that the energy management system would restart the compressors automatically after the agreed interruption period.
Process recovery	Some staggering of load would be desirable at the end of the interrupt period. This would again be arranged automatically through the compressor management system.
Communicating result of DSB	As for cement manufacture.

Example 2: Planned Balancing – Norway / Sweden

Dealing with high spot prices

i) Direct participation of a large single consumer - Norway

Making the bid	This will be in-line with the normal day to day process of the provider (i.e. the same as purchasing electricity from the spot market). Bids are submitted by 12:00 on the preceding day, usually via the Internet.
Proving load is available	Elspot is a physical market, therefore participants must have metering for electricity delivered to or taken from grid – the current requirement is for hourly metering. However, the metering is there to show use after the event, rather than to prove that load is available. It is the consumer's contracts for purchase of electricity that prove that he has load available to sell. This is a major difference between 'Planned Balancing' and 'System stability'.
Receiving notification to modify load	System price notification is sent out by 13:30 on the preceding day. If the bid was lower than the system price – the bid is 'accepted' and the provider must react (i.e. 'deliver' his non-consumption) If the bid was higher that the system price – the bid is not accepted.
Controlling process to modify consumption	Manual
Monitoring change in load	Time of use metering (hourly)
Receiving end notification	Part of notification of system price
Process recovery	Restarted manually
Communicating result of DSB	The market operator will compare all of the provider's contracts to buy and sell electricity (i.e. his long term bilateral contracts less his DSB) with his actual metered consumption for each hourly trading period. This is part of the normal monitoring and settlement process.

Example 2: Continued

ii) District heating & industrial water heating – fuel substitution – Sweden

Making the bid	We shall assume indirect DSB participation (via a supplier). The supplier will then estimate loads required as part of his normal purchasing for all of his customers. He will match this against spot prices and known fuel substitution costs to determine when non-consumption will be available from fuel substitution.
Proving load is available	Time of use (hourly) metering will be required to prove that the energy use of the supplier's customers matches his contracts to purchase electricity on their behalf. Again, as with case of the single large consumer, it is the contracts to buy electricity that determine the validity of the DSB.
Receiving notification to modify load	Supplier will notify his customer (i.e. the DSB provider) of times when electricity use should be interrupted and fuel substitution should take place, through a schedule of spot prices. Such notification will be via the internet or email or even automated radio tele-switching.
Controlling process to modify consumption	Manual or automated reaction to schedule of spot prices.
Monitoring change in load	Hourly metering
Receiving end notification	Part of spot price notification
Process recovery	Not applicable
Communicating result of DSB	Supplier's contracts to buy and sell electricity compared with total user metering in the normal balancing and settlement process. The end user will often have a supply contract that follows the spot price and settlement will then be against the hourly meter readings.

Example 2: Continued

iii) **Indirect participation - Electric space heating in schools – Norway**

Making the bid	The supplier will estimate loads required as part of his normal purchasing for all of his customers. He will then estimate the change in load both during and after the interruption and determine whether a short term interruption of 1 hour of so will reduce his overall costs. He will then adjust his normal Spot Market bids accordingly.
Proving load is available	Hourly metering is assumed, but as with the other ‘Planned Balancing’ cases, it is the supplier’s contracts to buy electricity that determine the validity of the DSB. In this case the most likely scenario is that the supplier will simply buy less on the spot market at the time of the DS Bid.
Receiving notification to modify load	Disconnection will be automated (e.g. tele-switch)
Controlling process to modify consumption	In the simple case discussed here, there is no control of the process over and above that of normal space heating temperature control. Additional benefit could arise by slightly overheating the space prior to disconnection (which would reduce the increase in demand at the end of the interruption).
Monitoring change in load	Hourly metering
Receiving end notification	Automated (as notification of interruption).
Process recovery	See controlling process
Communicating result of DSB	Supplier’s contracts to buy and sell electricity compared with total user metering in the normal balancing and settlement process. End user rewarded with lower price than normal supply contract.

As we have seen every Demand-Side Bid will involve some form of Control, Monitoring & Communications technology. This will vary from product to product and from provider to provider, reflecting the nature of the process involved. Generally the CMC technologies are currently available. However, as with all other electronics based technologies, these are constantly improving. Thus technologies that may currently only be economically feasible for large consumers may soon have reduced in cost to enable wider Demand-Side participation. The availability of CMC technologies is not seen as major barrier to DSB.

9 Step 5: Make Business Case

For a DSB product to become successful it must:

- Make savings for the 'buyer'
- Produce a net income for the 'provider'
- Make money for the Aggregator

The Buyer's Perspective

A DSB product is bought as an alternative to purchasing electricity from a generator. The DSB product must therefore cost less than the generator alternative or be able to provide additional benefits.

Example 1: Fast Acting Frequency Response – UK

Commercial Frequency Response

The TSO will aim to have a portfolio of both Generator and Demand-Side 'Products' available, to help him meet his frequency response requirements. The price that DSB will attract is then comparable to that for the Generator service. Few generators will be able to respond as quickly as a Demand trip, and thus, depending upon the amount of cover the TSO requires, the Demand-Side may attract a slight premium price over the closest generator option.

Example 2: Planned Balancing – Norway

Dealing with high spot prices

In this case the invisible buyer / provider relationship of the market makes no distinction between generation and non-consumption (DSB). The lowest bid secures the sale.

The Provider's Perspective

The net income to the provider will arise through:

- Income from the DSB

Less the

- Costs involved with making and delivering the DS Bid (CMC Technologies)
- Cost of any loss or change in production and any additional expenditure from recovery

Often the costs involved with making and delivering the DS Bid will be shared with the Aggregator.

It is also important to minimise the impact on the normal operation of the 'provider' – it is not his core business and, even if it makes him some money, any perceived nuisance may go against implementation of DSB.

Example 1: Fast Acting Frequency Response – UK

Commercial Frequency Response – initiated by Low Frequency Relays

In each case the income is via an availability payment (£ / MW) paid by the TSO for each half hour trading period that the provider declares his plant available for interruption.

The costs will vary from provider to provider as discussed below.

i) Cement works

In the case of the cement works, there is no direct cost due to loss of production (the plant does not normally run 24 hours per day), although any knock-on effects on shift patterns / overtime payments of workers should be taken account of.

The major costs of CMC Technology are the Frequency Relays, the electricity meters and the dedicated phone lines to communicate the meter output to the Aggregator's headquarters. However, these costs were (in this instance) met by the Aggregator.

ii) Steel Works – arc furnaces

In this case, interruptions to supply will cause disruption to the normal process and will result in some cost (lost production, holding upstream feed). In some cases this cost can be minimised by using the down time for maintenance. Arc furnaces have for many years been used to working with supply interruptions, as a way of reducing their maximum demand charges (these were based on their demand at times of peak network loads).

CMC Technology costs as for Cement Works

iii) Cold Store Warehouses

If it is necessary to lower the normal temperature set-point slightly to make the Warehouse available for frequency, then this will result in a slight increase in the electricity used by the refrigeration compressors. This cost will be readily predictable from existing consumption patterns.

The costs of CMC Technologies are perhaps the deciding factor for this application. The large numbers of low loads that require to be aggregated requires a low cost metering solution that can be duplicated at every site. Similarly a low cost frequency relay is required. Currently it is believed that these costs are too high to make this an attractive DSB example. The advent of low cost time of day metering and internet based data gathering may change this perception in the near future.

Example 2: Planned Balancing – Norway / Sweden

Dealing with high spot prices

i) Direct participation of a large single consumer - Norway

In this case the decision to be made is whether to close the plant for several days to avoid the expected very high seasonal peak spot prices. Complete closure will obviously have costs associated with loss of production, although it might be feasible to use the down-time for annual maintenance. Thus the costs to be considered are:

- Loss of income due to loss in production, offset by any essential annual maintenance undertaken during close down
- Savings in production worker wages (shift payments)
- Income from resale of electricity into the Pool
- Savings arising from avoiding purchasing electricity at the high spot prices.

As a direct market participant (for purchase of electricity) much of the CMC Technology will already be in place.

ii) District heating & industrial water heating - fuel substitution - Sweden

Here we have assumed indirect DSB participation via a supplier. It is further assumed that the provider (the operator of the boilers) will have a supply contract that follows the spot price. The provider will thus avoid high electricity prices by switching fuels, but he will have to pay for the fuel used in the alternative boiler. In this case the provider can clearly see when he will make savings (a direct comparison between the fuel cost of running the alternative boiler and the equivalent cost of electricity), and by how much.

iii) Indirect participation – Electric space heating in schools – Norway

The provider (the school) will be rewarded with a lower price than normal supply contract. Furthermore, tests have shown that the electricity used on a day with a supply interruption of an hour or so, is lower than that on a day with no interruption. Thus there should be no problem convincing the provider that savings will be made. The down side is whether there will be any noticeable loss in comfort. Again tests suggest that this will not be the case.

The Aggregator's Perspective

A pure Aggregator – one who has no supplier interests – is only involved as a business opportunity. His income must then exceed his costs.

Example 1: Fast Acting Frequency Response – UK

Commercial Frequency Response – initiated by Low Frequency Relays

The Aggregator's costs include:

- The investment costs associated with establishing a control centre. This is where the measured loads are aggregated and communicated to the TSO
- The cost of recruiting suitable providers
- The cost of negotiating contracts with the providers
- The cost of negotiating contracts and adjustment of 'product' details with the TSO

It is also likely that – to minimise the impact on the provider – he will bear the investment cost of providing the CMC Technologies, and also pay the line rental for the communications link.

His income will come from taking a share of the availability payments paid by the TSO to the provider. Exact details of costs and benefits are necessarily commercially confidential. All that can be said is that in the UK a successful business has been in operation for several years in this area.

Example 2: Planned Balancing – Norway

Dealing with high spot prices

i) Direct participation of a large single consumer – Norway

In this case it is possible that that no aggregator is used. However, the expertise of an aggregator may be valued in helping the consumer enter the market and become comfortable with the mechanisms involved. The aggregator may then be rewarded with a one off payment, or may take some share in the savings.

In the case where the Aggregator is the supplier, he has greater flexibility in making money as he can either use the DS Bid for his own Balancing needs, or offering the DS Bid to other purchasers.

Example 2: Planned Balancing – Norway / Sweden

Dealing with high spot prices

ii) District heating & industrial water heating - fuel substitution – Sweden

iii) Indirect participation – Electric space heating in schools – Norway

In both of these examples we have assumed DSB participation is through a Supplier. This, as previously noted, is necessarily the case for the space heating in schools, but optional for the fuel substitution case.

The costs to be borne by the Supplier (or shared with the end user or an independent aggregator) are the CMC Technology costs associated with remotely scheduling and controlling the consumers' process (e.g. radio tele-switching or internet technology).

Income will derive from:

- bids on the spot market
- or avoiding further spot market purchases
- or avoiding other balancing payments

Hourly metering will be required to compare the Supplier's contracts to buy and sell electricity with the total consumption of his customers. Metering is often the responsibility of the Local Distribution Network Operator (not the supplier).

10 Step 6: Refine Selection of Product

Again, this is perhaps best illustrated by way of building on the examples described above. In particular we noted that the initial product selection for the Cold Store Warehouse example does not (currently) result in a convincing business case for fast acting frequency response. Might it then be better able to provide an alternative product?

Cold Store Warehouses – selection of DSB product

Alternative System Stability Products

One of the major barriers to providing ***fast acting frequency response*** is the high cost of providing the frequency relays. However, the TSO also requires slower forms of response to help the system recover after an sudden fall in frequency. In the UK the TSO has defined his needs in terms of a variety of products, some with notice periods as long as 20 minutes. An example of this type of frequency response will be outlined as a separate example later.

Metering costs – to prove the available load to the TSO – are still likely to be high for the relatively large number of small loads that would have to be aggregated. Thus System Stability products may not be the best choice.

Planned Balancing Products

Conceptually, there are many similarities between the Cold Store Warehouse example and the Electric Space Heating in Schools example. Loads can be interrupted for significant periods with little or no effect on the process of the provider (be that a space heating temperature or a cold storage temperature). There will be process recovery implications at the end of the interruption, although in both cases managing the ‘fabric’ storage by over cooling (warehouse) or over heating (school) could reduce this.

The details of the ‘needs’ of the purchaser (the supplier / aggregator), CMC Technologies, and the Business Case, will be as discussed for the Electric Space Heating in Schools example.

11 Step 7: Implement

We have now:

- identified the needs of the buyers of Demand-Side Bids - defining basic DSB products and why they are important (i.e. the problems that they will help to overcome);
- identified suitable providers of DS Bids;
- defined the necessary Control, Monitoring and Communications (CMC) Technologies to implement a DS Bid;
- established a positive business case for all of the players – buyers, providers and aggregators – refining the matching of product to provider as required.

All that remains is to put it all into practice. Depending on the DSB product this will involve:

- negotiating contracts between buyers, providers and aggregators;
- providing the financial guarantees for entering market mechanisms;
- purchasing and installing the CMC Technologies at both the providers' premises and, where appropriate, the central control room of the aggregator.

12 Case Studies

A number of case studies were built up as we progressed through the step-by-step guide. These are summarised in the two tables below.

Network Stability - Fast Acting Frequency Response Initiated by Low Frequency relays

Provider	**Country**	**Size of provider**	**Comments / Effect on process**
Cement Works	UK	Large	No change to process – short duration interrupt of firm capacity (process has intrinsic storage capacity)
Cold Store Warehouses	UK	Small	Aggregation of several small loads. Change to operation of process – within process storage
Arc furnaces	UK	Large	Aggregation of several furnaces to give a probabilistic load. No change to process – short duration interrupt

Planned Balancing - Dealing with high spot prices

Provider	**Country**	**Size of provider**	**Comments / Effect on process**
Large single user	Norway	Large	Total plant shut down
Industrial / commercial water heating	Sweden	Medium / large	Change to operation of process – fuel substitution
Space Heating e.g. Schools	Norway	Medium / Small	Change to operation of process – fabric storage
Cold Store Warehouses	UK	Small	Aggregation of several small loads. Change to operation of process – within process storage

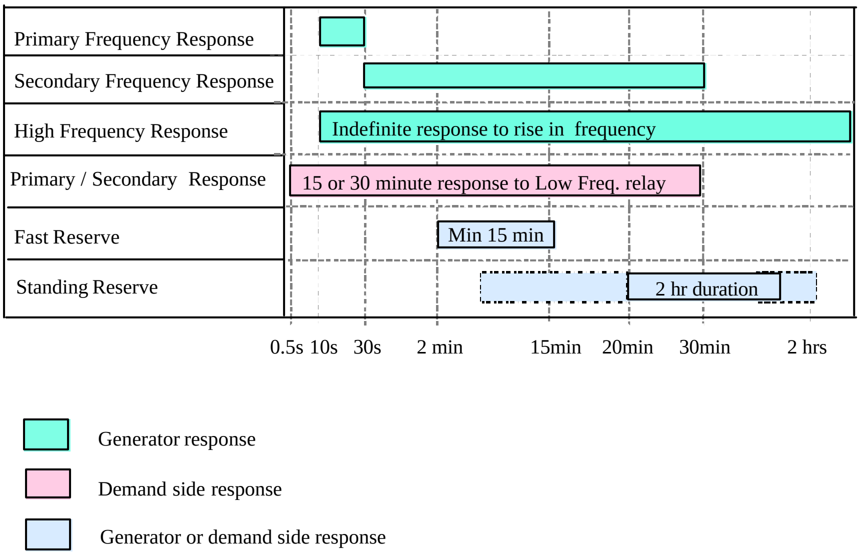
Cold storage warehouses are included in both lists – the most cost effective at present being the Planned Balancing application. It should be noted, however, that the two categories of DSB – Network Stability and Planned Balancing – are not mutually exclusive. A simple example would be where a large industrial consumer closes down his plant completely for a day or two, to sell back contracted electricity on the spot market during times of very high spot prices (Planned Balancing); whilst declaring his availability for short term frequency trips for the rest of the year (Network Stability).

We shall now discuss two more case studies - one more from each of the two categories of DSB - the aim being to provide a good coverage of current DSB applications.

Standing Reserve (System Stability) - UK

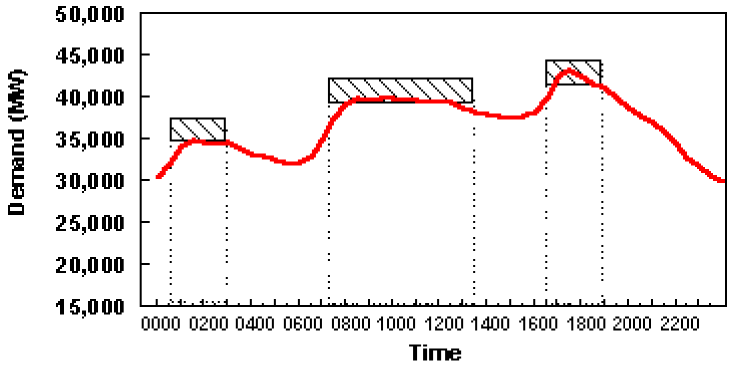
STEP 1: Identify the needs of the buyer

As we saw in section 5.1, the TSO in the UK purchases various services that he calls upon to respond to a sudden loss in frequency. The initial response is fast acting and lasts from 30 seconds (for a primary generator response) to up to 30 minutes for secondary responses (including the demand response activated by low frequency relays). The TSO then calls on other services to help the system recover. Typical reaction times and durations are shown below for the range of services required.



Standing reserve is provided by both the generators and the demand-side. It requires a response time of between 5 and 20 minutes, and must be capable of being sustained for at least 2 hours.

The need for standing reserve is a function of the system demand profile, and varies across the year, the time of week and time of day. To reflect these variations, the TSO splits the year into five seasons, for both working and non-working days, and specifies the periods in each day that Standing Reserve is required. These periods are referred to as Availability windows. For any service to be acceptable to the TSO, the Standing Reserve must be available for at least three periods of each week. Bids must be over 3 MW.



Typical times of the day when Standing Reserve is required

STEP 2: Target Providers – Water Companies

Water companies have many large pumps for pumping both fresh water and sewage. As essential services, many pumping stations are provided with standby generators, to maintain the service in the event of a power cut. Standby generators are ideal for providing Standing Reserve as they can be started automatically with only a small amount of notice. There is also an advantage to the water company, over and above any payments for providing standing reserve, as these generators must be run from time to time to prove their reliability.

One UK water company, in collaboration with an aggregator, has aggregated a number of small standby generators together to provide 15 MW of useful reserve.

STEP 3: Adapt Product – Not Applicable

STEP 4: Define CMC Technologies

Making the bid	The UK TSO procures its Standing Reserve services through a competitive tendering process conducted annually. In this case, the tender is submitted on behalf of the water company by the Aggregator, who will advise on expected prices. The tender will stipulate volumes, speed of response and duration of service.
Proving load is available	The total load available from the start of the 20 minute warning period is monitored at the control room of the aggregator. This continues throughout the period of the contracted load change.
Receiving notification to modify consumption	Notification is via an electronic interface: TSO ⇨ Aggregator ⇨ Standby Generators

Controlling process to modify consumption	Standby generators are started automatically and are brought on-line gradually over the 20 minute notification period. The start-up procedure includes automatic synchronisation with the supply network.
Monitoring change in load	See 'proving load is available' above
Receiving end notification	Automatic electronic notification.
Process recovery	The close-down procedure of the standby generators includes disconnection from the grid and (if necessary) reconnection of the normal supply.
Communicating result of DSB	Payments are made for both availability and use. Aggregator submits both claims on behalf of his clients.

STEP 5: Make Business Case

Buyers perspective

The TSO will choose the lowest tender to meet his needs in the most cost effective manner.

Provider's perspective

The Water Company will need to be assured that:

- Fuel costs will not exceed income
- Maintenance costs will not increase (or will be covered by payments)
- There will be little or no interference with day to day business

Aggregator's perspective

The Aggregator will bear the costs of:

- Installing communications technologies
- Interfacing with standby generator controls
- Installing and / or remote reading of meters
- Submitting tenders

His income will be a share of the availability and use payments to the provider.

STEP 6: Refine Selection of Product – Not Applicable

STEP 7: Implement

Aggregator to install CMC technology, submit tenders and negotiate contracts.

Domestic response to price signals (Planned Balancing) – various countries

A number of countries are actively looking at the feasibility of encouraging flexibility in the domestic use of electricity. The following is based on some of these experiences.

STEP 1: Identify the needs of the buyer

We will again consider the case where a supplier wishes to encourage flexibility of use in order that he might avoid high spot prices and / or balancing charges at particular periods of the day or year. The need can thus be either to reduce peak demand for the few hours of the year where capacity is stretched to the limit and hence prices are very high; or to routinely reschedule use within the day, avoiding periods of relatively high price and using periods of relatively low price.

One problem from a supplier's perspective is that the rules to encourage open competition in most liberalised markets mean that suppliers are discouraged from making the necessary investment in CMC Technologies to make DSB happen. In general consumers are free to change suppliers at only a few weeks notice, potentially making any such investment redundant. One solution would be to separate the ownership of the CMC Technology from the supply of electricity. This topic will be discussed further under making the business case.

There is also much interest in reducing peak demand from the Transmission System Operator (TSO) in several generation limited networks. Whilst this is, strictly speaking (from a liberalised market perspective), a supplier problem, there are obvious security of supply issues for the TSO. Indeed, in view of the competition rules mentioned above, the TSO is better placed to drive the issue forwards. This is one of the areas where the boundary between Network Stability and Planned Balancing becomes blurred, as discussed at the start of section 5. (It could be argued that suppliers might choose to be out of balance at times of very high system demand, in which case it does become the responsibility of the TSO to deal with the problem and to provide a physical balance. However, in so doing, suppliers would be exposing themselves to high and unpredictable balancing charges).

STEP 2: Target Providers – domestic electric heating

In countries with high levels of renewable energy (usually hydro), such as Sweden, Norway and Finland, electricity is often the domestic heating fuel of choice. For example, in Finland there are about 600,000 small houses with electric heating. These consumers are generally charged lower electricity prices during the night and / or summer times. Domestic hot water is usually produced over night and stored in the hot water tank. Space heating is often via direct resistance heating. As with the schools example discussed earlier, interruptions to the electricity supply of an hour or so will have little or no detrimental effect on comfort.

In the UK, particularly in areas where there is no gas supply, there is a significant amount of electric heating. This normally takes the form of storage heating to take advantage of lower priced off-peak electricity (a DSM measure). Here, interruptions can be longer although the opportunity for peak use reduction will be small (since most of the use will not be at peak times).

STEP 3: Adapt Product

Generally the adaptation, if any, is to existing time-of-use pricing structures, to increase their flexibility for DSB. Other adaptations might be to the heating systems, adding a small element of thermal storage for space heating to an otherwise purely direct electric heating system (although this is an adaptation to the providers' process not to the DSB product).

STEP 4: Define CMC Technologies

The large numbers of small users makes the choice of CMC Technologies a major barrier for this application of DSB. Low cost technologies are required. These are now emerging, although as yet there are no well established techniques. The following covers a number of the options currently being investigated.

Making the bid	The supplier will predict usage patterns and decide when it will be most advantageous to him to interrupt supply, taking into account spot prices and the expected demand levels of his other customers. The actual mechanism for making the bid is thus his normal spot market purchase mechanism (either a reduced bid or a negative bid)
Proving load is available	In the general case of the supplier encouraging consumer flexibility, there is no need to prove load is available - it is the contract position of the supplier that is important, and hence how much load he buys or sells on the spot market. Where the TSO is the main driver, the total consumption of a geographical group of houses will be metered (by the local Distribution Network Operator). Assumptions will then be made as to how much of this demand can be interrupted to reduce the system peak.
Receiving notification to modify consumption	The householder must be unaware of the DSB process (or find it unobtrusive), and so interruptions are implemented automatically. A number of systems have been investigated: • Ripple control (e.g. Finland) • Radio tele-switch (e.g. UK) • Internet (e.g. Norway) • TV (e.g. Norway)

Controlling process to modify consumption	In Finland systems simply disconnect supply, and there is no active control of the heating. Norway has investigated changing space temperatures – reducing room set-points for a few hours – rather than giving a hard disconnect In the UK advanced storage heating control has been used to optimise charging periods against time of day electricity prices.
Monitoring change in load	See 'proving load is available' above
Receiving end notification	In same way as start notification
Process recovery	In the Finnish example in particular there is likely to be a slight increase in use after the interruption period (see schools example earlier)
Communicating result of DSB	The householder will receive any benefits of DS participation via the normal householder billing process. However, behind this may lie some complicated calculations as will be discussed below.

Most households are metered with total kWh meters (usually read manually between 1 and 4 times per year), rather than time-of-use meters [5]. Their daily and time-of-day demands are estimated, based on 'profiles' and a metered total supply for a geographical area. Profiles are established consumption patterns based on statistical analysis of a representative sample of the housing stock. Thus, in general, there is no direct way of knowing what an individual house actually consumed at any given time.

Suppliers will have a mix of customers – some with time-of-use (TOU) metering and others whose loads are based on 'profiles'. Thus, for each trading period, the total demand that the supplier must purchase electricity for is the sum of a value that can be (retrospectively) determined accurately (the sum of all TOU metering), and one that can only be inferred (the sum of all the profiled consumers). The profiled sum is reconciled, amongst all suppliers, against the metered value at the major network metering (grid supply) points.
The settlement process, taking account of any DSB actions, is simplest for TOU metered consumers, but has the higher cost in terms of CMC Technology. It is still feasible to reconcile DSB for 'profiled' consumers but requires the establishment of modified 'profiles' to account for the DSB action.

Thus, there are two ways of establishing the results of domestic scale DSB:

[5] Here "time-of-use meters" is used to refer to half-hourly or hourly (depending on the trading period in use in a particular country) kWh meters

1. TOU metering - install TOU metering and the necessary communications to definitively prove DSB action for participating houses
2. Profiles
   - assume profiles for the unmodified consumption (i.e without DSB)
   - predict housing use on a day-by-day basis
   - adjust profile for the modified consumption (following DSB)
   - accept that in sending out a signal to activate the DSB action and cause a change in use pattern, that a change in use actually occurred. This could be statistically based over a large population.

The latter is likely to be the more cost effective, but may require modification to the normal settlement process.

STEP 5: Make Business Case

Buyer's perspective - Supplier

In view of the market competition rules that allow consumers to change supplier at little notice, it is unlikely that a supplier (purely as part of his supply business) will invest in the necessary CMC Technologies to allow DSB to happen. He will thus rely on a "service provider" (who will have contracts with both supplier and customer) as discussed below.

He will, however, benefit from the DSB process by reducing his electricity purchase costs, and will pass on some of these savings to the householder and the service provider.

Buyer's perspective - TSO

In Norway and Finland there are schemes where the local distribution company owns the CMC Technology, and gets paid by the TSO for providing peak demand reductions. Whilst this is successful from a network point of view, there are problems with how to compensate the supplier who may have bought too much electricity to supply his portfolio of households. This problem is being addressed, and Sweden have already developed a model of how this compensation can be dealt with.

Provider's perspective

The householder will benefit from lower electricity prices. He should, however, be unaware of the DSB process, or find it unobtrusive.

Service Provider / Aggregator's perspective

As mentioned above, there is a problem with the supplier making the necessary investment in CMC Technology to make DSB happen. It is likely that this investment will be made by a "Service Provider" who will make money in several ways – only one of which is DSB.

In recent years there has been much interest in the provision of “Customer Services” to households.[6] These can cover a whole range of services such as:

- Remote diagnostics (e.g. white goods, heating systems)
- Remote alarms (security, CO_2 levels, personal wellbeing of the elderly)
- Meter reading (regular, non-manual, could be TOU)
- Customer information (e.g. energy efficiency advice based on meter readings and peer comparisons)

In many, if not most, instances, the income to the “Services Provider” will arise from beneficiaries other than the householder – e.g. an electricity supplier in the case of meter reading, or a manufacturer in the case of white goods diagnostics (especially so if the goods are leased).

Key to this is providing a communications gateway into the home where several services can be provided simultaneously, thus sharing the cost of providing the CMC Technology. The identity of the “Service Provider” could be one of any number of players, including Electricity Suppliers and Aggregators.

STEP 6: Refine Selection of Product

For a number of years radio tele-switching has been used in the UK to stagger the start times for charging domestic storage heaters and hot water cylinders. A recent initiative from the UK TSO has led to tele-switching also being used to provide System Stability services. This is an interesting application since, unlike the other System Stability products the TSO buys, there is no metered proof of available load – simply estimates made from the number of systems in operation, time of day and weather conditions.

It is likely, however, that in most cases Planned Balancing (including TSO instigated peak demand reductions) will be the major use of domestic DSB products.

STEP 7: Implement

The route to implementation is not as clear cut as in the other examples, but will again involve installing CMC technology and negotiating contracts. Who takes the lead in this will vary depending on the circumstances. For example it might be the TSO in a generation limited network, or it might be a Service provider / Aggregator looking for a new business opportunity. A crucial step will be getting agreement on the method of establishing the results of the DSB as discussed at the end of Step 4 on page 54.

[6] See, for example, Task 2 of IEA Implementing Agreement for Demand-Side Management, “Communications Technologies for DSM”

13 Closing Remarks

Demand-Side Bidding is seen as an important component in ensuring that competitive electricity markets behave in an efficient manner. As we have seen, it is all about encouraging flexibility in the use of electricity by the Demand-Side - the actual consumers of electricity. Thus the Demand-Side becomes involved in the processes of setting prices and maintaining the quality of supply, and hence provides a counter to the otherwise dominant role of the generators.

Whilst market efficiency and low electricity prices are important to all consumers, the workings of electricity markets are usually far removed from their day-to-day activities. Consequently DSB can easily be seen as an unwanted distraction. Often, the role of the Aggregator is crucial in providing the necessary impetus to make DSB happen, and much emphasis has been placed in this Guide on this aspect of DSB. The Aggregator may be an independent company or an Electricity Supply Company. In either case, it is he who brings together knowledge of electricity markets, an understanding of the processes of the end consumers of electricity, and the expertise to implement the necessary control, monitoring and communications (CMC) technologies.

The Guide discusses the step-by-step process of making DSB happen, from identifying the needs of the buyer of a DSB product through to implementation. Establishing what CMC technologies are required is a crucial step and one where technologies are constantly improving in terms of increased capabilities and reduced costs. It is highly likely that new opportunities for DSB will emerge as this cost reduction continues, eventually including many smaller consumers as part of ‘customer services’ packages provided by the Aggregator or Supplier.

A number of practical examples of DSB are built-up through the step-by-step guide. These illustrate examples of DSB for both System Stability and Planned Balancing. Additional complete examples are included in Section 12.

Most of the successful applications of DSB to date have been used to cope with abnormal or unusual situations. This is reflected in the examples chosen. System Stability issues are by their nature abnormal, in that they are caused by some unpredicted situation – such as a loss of a major generator or a sudden increase in demand. The successful Planned Balancing examples have tended to be in generation limited networks, where peak demands are reduced for just a few hours per year. A similar scenario exists in network constrained regions where the transmission system is stretched to it’s full capacity for only a few hours per year.

The more general case is where demand-side participants reschedule their electricity use to follow price signals on a daily, or even hourly, basis. In some networks, particularly where there is a high component of dependable and controllable hydro electricity, this is unlikely ever to become important, as witnessed by the very flat spot prices for most of the year in countries such as Sweden and Norway. However, in other markets, within the day variations in electricity prices are common, and end consumers (the providers of DSB) who have the flexibility to respond to price signals, could become very important to Suppliers wishing to minimise their overall costs. The greater use of non-firm generation (wind, solar) could make this demand-side flexibility ever more important in the future.

Thus, the Guide provides an overview of the current status of DSB as well as practical advice on how to implement DSB. However, this, like competitive electricity markets themselves, is a constantly evolving area, and many changes can be expected over the coming years.

Appendix

Task VIII: Demand-Side Bidding in a Competitive Electricity Market – Publications

Market participants' views towards and experiences with Demand-Side Bidding, Version 2, January 2002
Consumer potential for Demand-Side Bidding: National Reports, June 2002
Technologies for Demand-Side Bidding, October 2001
Evaluating the potential for Demand-Side Bidding Schemes, May 2003
The Technical Requirements for DSB: National Reports, 2003