dena
German Energy Agency

dena-BACKGROUND PAPER

# Making money with smart electricity consumption

Demand Side Management (DSM): Introduction and practical experiences in Germany

CNREC
国家可再生能源中心
CHINA NATIONAL RENEWABLE ENERGY CENTRE

# Imprint

**Publisher**
Deutsche Energie-Agentur GmbH (dena)
German Energy Agency
Chausseestrasse 128 a
10115 Berlin, Germany
Tel: +49 (0)30 66 777 - 0
Fax: +49 (0)30 66 777 - 699
E-mail: info@dena.de
Internet: www.dena.de

**Authors**
Carolin Schenuit, dena
Lukas Vogel, dena

**Printed by**
schöne drucksachen GmbH, Berlin

Photo credits cover picture: ©shutterstock.com/tonton

Date: 12/2018


Supported by:

Federal Ministry
for Economic Affairs
and Energy

on the basis of a decision
by the German Bundestag

# Contents

# Foreword

China has had a challenging history of electricity shortage and forced electricity curtailment. To date, in some parts of China, industrial electricity consumers would still be asked to reschedule their production in peak-demand seasons. On the other hand, China also faces challenges in integrating the installed renewables into the power system. A flexible power demand is one of the key components in a complex renewable energy system. Demand side management (DSM), therefore, may potentially create a profitable industry and contribute to efficiency improvement, cost reduction, and pollution mitigation of China's electricity sector. China is quickly installing advanced metering infrastructure (AMI), which could provide tremendous opportunities in developing and utilizing DSM resources.

Today, China lags behind other countries in utilizing DSM. The power demand side is still adopting one-way regulation by administrative means such as orderly power consumption. Institutional barriers, including the lack of competitive electricity market and the absence of mature business models, are preventing the commercialization of DSM. In order to fully recognise the potential of smart grid, China needs to push forward the reforms to establish an open access power market with clear price signals, so the DSM resources can compete with power generators on equal terms.

Although China's DSM programs have high potential to succeed, they require substantial efforts in resolving key issues as the programs' funding mechanisms, pricing, and relationship with electricity industry reform. This paper provides an introduction to DSM in Germany: it gives an overview of the different markets for DSM in Germany, and it shares experiences from two pilot projects in the south of Germany. This report demonstrates a joint collaboration between the Deutsche Energie-Agentur (dena) – the German Energy Agency – and CNREC which is supported by the German Federal Ministry for Economic Affairs and Energy (BMWi) and Children's Investment Fund Foundation. The close cooperation between international experts enhances the quality of the work and provides invaluable implications for China's energy transition.

Wang Zhongying
Acting Director General, Energy Research Institute under NDRC
Director, China National Renewable Energy Centre (CNREC)

# 1 Introduction to Demand Side Management (DSM)

The targets of national and European energy and climate policy are necessitating radical changes to the electricity supply system in Germany. The expansion of renewable energy sources, and the resulting increase in fluctuating power input, are creating an increasing need for more flexibility in the electric power system. One option for providing more flexibility in the electric power system is to match electricity consumption more closely with electric power generation – so-called 'demand side management' (DSM).

Demand side management (DSM), also known as cross-sector load management, involves targeted management of the demand for electricity by switching loads on and off on the basis of price signals. It can help to integrate fluctuating renewable energy sources into the electric power system, balance out production and demand fluctuations, provide valuable compensation and balancing energy and relieve overloaded grid sections. At the same time, DSM opens up a new source of income for companies. This is because electricity consumers – above all, industrial and commercial users – can market their flexible loads in various market segments.

Large, energy-intensive companies that administer their own balancing group can even market their flexible loads themselves, to a certain extent. Loads of smaller size can be marketed in association with other companies through a pooling system. In this case, the tasks of establishing and marketing the pool are carried out by a specialised service company (aggregator).

In the following, the term 'demand side management' will be defined, as well as individual DSM potential, and the markets for DSM will be described.

## 1.1 Definition of DSM

It is not easy to give a single definition of the term 'demand side management'. Depending on the country or institution, it has various unclear boundaries with similar concepts such as demand response, demand side integration or load management, which are often used as synonyms or sub-categories of one another. To a certain extent, the type of marketing (e.g. measures involving the electricity grid) or even the type of signal (e.g. external, automated intervention) are included in the definition. In the current market environment, and in the context of the goal to open up as many markets for DSM as possible, it seems sensible to define the term as openly as possible.

For general use, the following definition suggests itself:

> *Demand side management involves actively, individually switching or influencing electricity loads in response to an external price signal or a contractually agreed switching signal.*

Additionally, it must be considered whether flexibilisation of operational (in-house) electricity generation plants such as CCGT power stations, CHP plants or emergency power aggregates should also be included under DSM. At large- and medium-sized industrial facilities especially, in-house electricity producers are often available, which are often more easily exploited for flexible marketing than consumption processes. If a company is considered as an enclosed unit, then the load at the grid transfer point is decisive from the perspective of the electricity provider as well as the grid operator. Nevertheless, it is immaterial whether load variations are provided by decreased/increased electricity loads or increased/decreased in-house power genera-

tion by the company. In an extended sense, therefore, DSM also includes in-house electricity generation processes, since in the process of unlocking DSM potential these can also serve as a springboard for the consumption processes, which are often harder to market.

## 1.2 DSM potential

The term 'DSM potential', too, is mostly used unclearly, which results in large discrepancies between definitions in research and literature, as well as in public discussion. For a company, the mere technical possibility of controlling a process does not in itself mean that this process can also be marketed flexibly. In principle, each operational process is often susceptible to control, in the sense of increasing and reducing its power consumption. However, the marketability of a process is dependent on a multitude of other factors, as the following illustration makes clear.

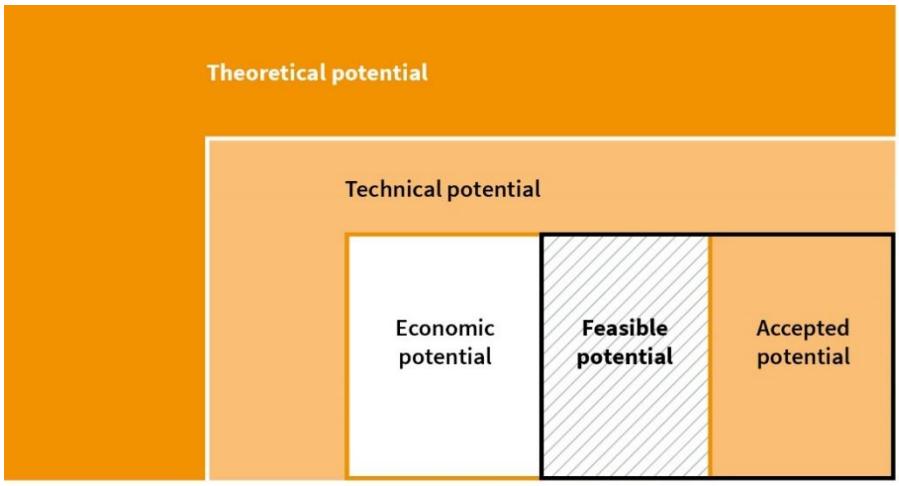



Figure 1: DSM potential

The term most widely used in this context is **theoretical DSM potential**, which refers to the long-term flexibilisation of a process, including replanning production and, if necessary, acquiring new operating resources.

**Technical DSM potential** is the presently available capacity of a process that can be technically flexibilised. Technical DSM potential, therefore, also includes existing production processes. Often these cannot be changed in the short term, limiting flexibilisation, which means that the technical DSM potential of a process is generally lower than the theoretical DSM potential.

Other subsets of technical DSM potential are the **economic DSM potential** and the **accepted DSM potential.** The economic DSM potential is defined as the DSM potential that is commercially marketable under present market conditions, taking into account all marketing and opportunity costs. On the other hand, the accepted DSM potential is the potential that is considered viable for flexible marketing from the individual company's subjective viewpoint. There can be definite economic DSM potential that the company does not approve for marketing, e.g. because it involves processes critical for quality, or because the company has reservations regarding certain marketing channels, for example if they involve external interventions in their own production process.

The **feasible DSM potential** is the intersecting set of accepted and economic DSM potential, and as such represents the actual extent of flexibility that a company considers for flexible marketing, and which can also be marketed economically under the given market conditions.

## 1.3 Markets for DSM

Large, energy-intensive companies that have highly professional processes for energy provision can basically market their flexible loads themselves. With smaller loads, marketing is best undertaken in association with other companies via a DSM marketer's pool.

At present, the following marketing opportunities for demand side flexibility exist in Germany (see also illustration below):

- Balancing energy: Marketing as balancing energy to equalise imbalances between load and power generation through the balancing power market, which is based on a tendering process.
- Interruptible Loads Ordinance: Marketing targeted on/off switching of loads to stabilise grid operation according to § 18 of the Ordinance on Interruptible Loads (AbLaV), e.g. as part of grid congestion management.
- Spot market: Participating in the Intraday spot market of the European Energy Exchange (EEX), in which the acquisition of electricity is postponed to times when electricity prices are lower.
- Compensation energy: Marketing power to balancing group managers as balancing group compensation energy, to compensate for short-term deviations from schedule.

With the exception of the AbLaV ordinance, these market segments are not configured with an eye on the large degree of heterogeneity in consumption processes, but primarily with an eye on power generating units (above all, large-scale power plants). Only in recent years have they been opened up for flexible loads to participate. The following section gives a brief description of the market segments named above, their importance for DSM in practice, and the perspectives for DSM in the future.

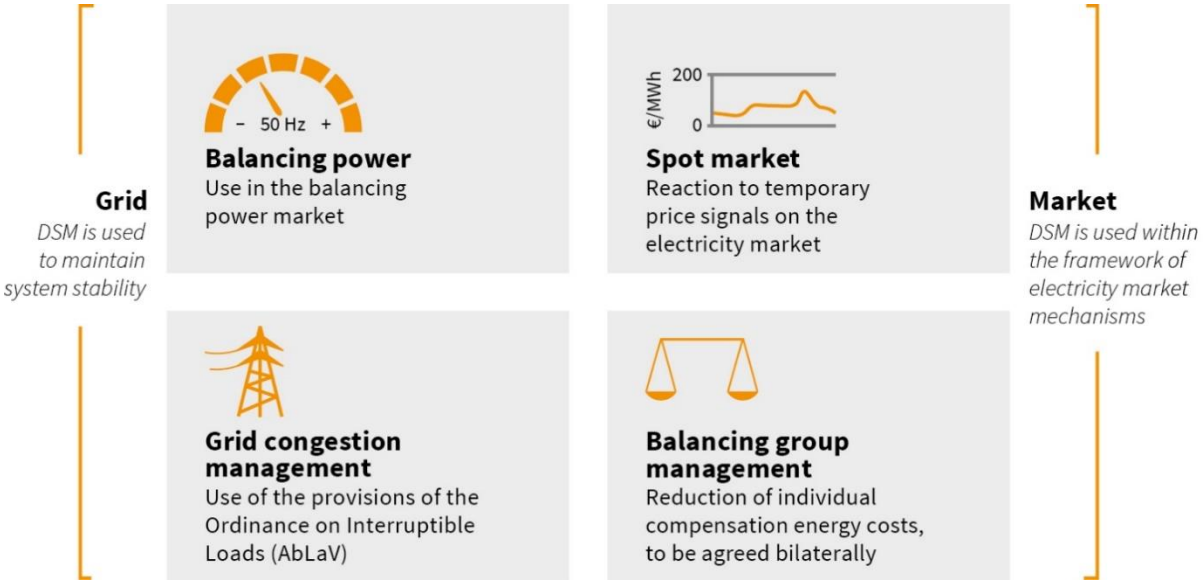



Figure 2: DSM market segments

### 1.3.1 Balancing power market

Balancing power is an important ancillary service that serves to maintain system stability, and in particular to control frequency in the electricity grid. This means that the amount of electricity produced must always equal the amount used. Basically, balancing these volumes is achieved within the framework of the trading activities on the electricity market, but in reality discrepancies can naturally occur between the amounts of

electricity traded and the actual amounts of electricity consumed, which must then be equalised at short notice.

The differences between planned volumes and actual volumes that are left over above the balancing group level are equalised by the transmission system operators (TSOs) with the help of balancing power. The essential reasons why balancing power is needed are:

- **Load noise:** Load fluctuations as a result of uncontrollable behaviour on the part of many different grid users.
- **Power plant outages:** Technical outages of power stations cannot entirely be ruled out.
- **Forecast errors with renewable energy sources:** The actual volume of renewable electricity generation differs from predictions.
- **Load forecast errors:** Unexpected events lead to deviations from the load forecast.
- **Jumps in schedule:** Since electricity trading only takes place in quarter-hour blocks, the start-up and shut-down ramps of power stations and the stages of the schedule must be equalised with the aid of balancing energy.

### Balancing power products

There are three different types of balancing power, which differ in terms of their properties and speed of activation. In July 2018, a new regulation of the German Federal Network Agency (BNetzA) came into force, which shortened the tender periods and product time slices and, in part, harmonised them.

| | **Primary balancing power (PBP)** | **Secondary balancing power (SBP)** | **Minute reserve (MR)** |
|---|---|---|---|
| Tender period | Weekly | every calendar day | every calendar day |
| Time of tender | usually Tuesday of the previous week | start of tender: 7 days before day of provision<br>end of tender: day before provision, 8am | start of tender: 7 days before day of provision<br>end of tender: day before provision, 10am |
| Product time slice | entire week | 4-hour time slice | 4-hour time slice |
| Product differentiation | one offer for positive and negative PBP | one offer each for positive and negative SBP | one offer each for positive and negative MR |
| Minimum offer | 1 MW | 5 MW<br>exception: from 1 MW under certain conditions | 5 MW<br>exception: from 1 MW under certain conditions |
| Pooling | permissible in the same balancing zone | permissible in the same balancing zone | permissible in the same balancing zone |

Table 1: Overview of balancing power products

The various types of balancing power are accessed in stages. In other words, when discrepancies occur, primary balancing power (PBP) is used first, but since its capacities are limited, it is then supplemented by using secondary balancing power (SBP). After that, in turn, minute reserve (MR) kicks in, replacing the two other balancing powers for a longer period until balance is restored by the trading market or balancing group equalisation.

**Primary balancing power (PBP)** reacts to deviations of grid frequency within 30 seconds, and at present is mostly provided by conventional power stations which, above a certain size, are obliged to offer primary balancing power. Recently, the first systems providing PBP from battery parks have started appearing here and there.

**Secondary balancing power (SBP)** must be provided at full power within five minutes. This, too, is provided primarily by conventional power stations, but recently some consumption processes with good information and control connections have already been able to provide it as well.

**Minute reserve (MR)** is made available within 15 minutes and can be offered by considerably more providers thanks to its longer advance notice period and currently smaller time slices.

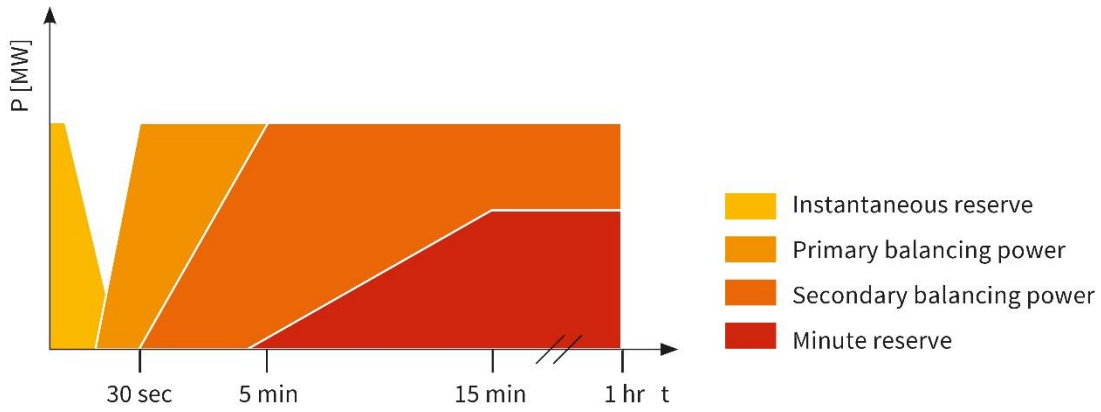



Figure 3: Temporal allocation of balancing power products

There are positive and negative deviations of electricity grid frequency, which means that there are positive and negative products for both SBP and MR. For a power station, positive balancing power means that it offers to ramp up its electricity generation and feed more power into the electricity grid when it is called for. For an electricity consumer, it means that he offers to reduce his load when it is called for. Correspondingly, for an electricity producer, negative balancing power means producing less electricity, while for a consumer it means drawing more electricity from the electricity grid. Separate positive and negative products exist for SBP and MR. At present, PBP can only be offered symmetrically (i.e. positive and negative to the same extent).

### Tendering of balancing power

The transmission system operators collectively tender their need for balancing power via the internet platform www.regelleistung.net. The conditions for tendering in these markets are frequently adjusted by the Federal Network Agency, above all in order to open up the markets to new providers such as flexible loads, enabling their participation. In order to be able to participate in the individual markets, each participating technical facility must first be **prequalified.** Prequalification involves providing evidence to the TSO that the

facilities are technically capable of satisfying the requirements of the individual balancing power types. Subsequently, providers can offer their prequalified facilities amongst the normal tenders. An aggregator who wants to bundle several technical facilities into a virtual power plant must also prequalify. As part of this, the capacity of its IT systems and evidence for the accessibility of the balancing power on offer are tested. Moreover, the balancing power quantities tendered depend on the forecast requirements stipulated by the TSOs. At present, primary balancing power is tendered on a weekly basis, secondary balancing power and minute reserve by the calendar day. For both secondary balancing power and minute reserve, there are currently 6 time slices of 4 hours each. Primary balancing power is tendered permanently.

In the tenders for SBP and MR, two price elements are offered: a capacity price and an energy price. The capacity price specifies the price on offer for providing capacity over the time slice. The energy price indicates the price for actually accessing the capacity in €/MWh. The surcharge is based on the capacity prices offered, which are then paid to the providers surcharged for providing their capacity in the period on offer. The actual release orders, on the other hand, are transacted according to the merit order of the energy prices offered. This means that the services with the lowest energy prices are accessed first, and that providers with higher energy prices do not have to provide balancing power until the need becomes greater. In the case of PBP, only the capacity price is offered. The remuneration is therefore independent of the release orders that are actually transacted.

### Players' roles in balancing power marketing

To date, balancing power has mainly been provided by conventional power stations. In the future course of the energy transition, however, it is predicted that this pool of providers will become smaller. At the same time, the demand for system-stabilising actions by renewable power stations and consumers will increase. Marketing flexible loads as balancing power raises various questions about players' roles, and the transaction processes occurring between the players. The illustration below shows which connections, and therefore interactions, exist between players' roles.

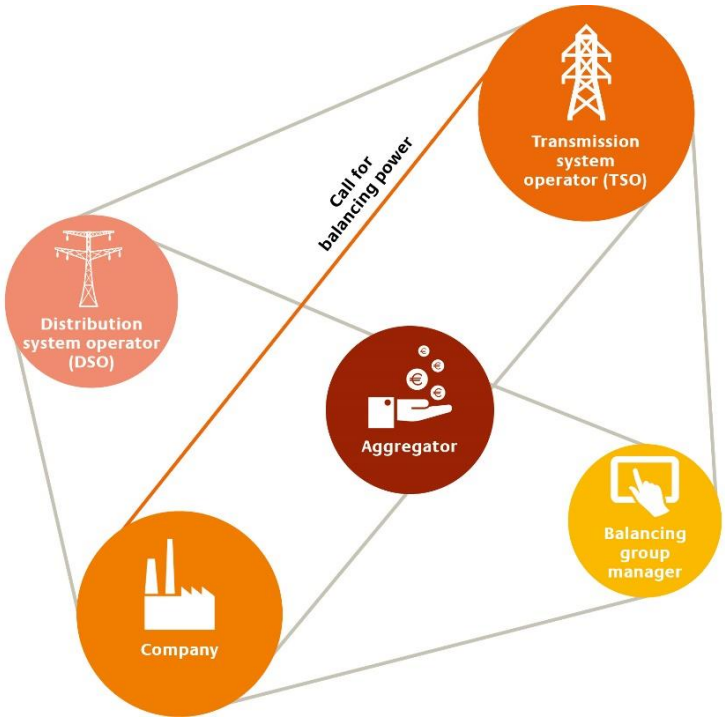



Figure 4: Overview of players

**Balancing group managers**

The supply of customers with electrical energy takes place within the framework of balancing groups. A balancing group is a virtual electricity or gas volume account, in which all extractions and inputs are recorded and balanced. The balancing group manager is responsible for ensuring that the capacity balance of the balancing group is equalised in every quarter-hour measuring period. This 'capacity balance' offsets the sum of extractions against the sum of inputs.

One of the important tasks of the balancing group manager is to forecast the quantities of electricity that each electricity producer will generate in its balancing group or that each electricity consumer will need. These forecasts – the so-called schedules – must be compiled precisely for each quarter hour as part of schedule management and supplied to the transmission system operator in question for the following day. If balancing power is provided by flexible loads in its balancing group, then the balancing group manager becomes responsible for various actions, e.g.:

- Opening up the balancing group for the provision of balancing power
- Carrying out adjustments to the schedule after a TSO accesses balancing power

**DSM marketer/aggregator**

Most DSM marketers are principally active as electricity suppliers or direct marketers and develop DSM marketing as a new business area. DSM marketers who do not offer electricity supply always need a bilateral agreement with the relevant balancing group manager in order to be able to market a consumer's flexibility as balancing power. For the most part, the electricity supplier exercises a dual function as balancing group manager as well. In the case of demand side management, the tasks of DSM marketers include for example:

- Support in identifying flexible electricity loads
- Merging the loads of different companies in a pool
- Marketing the pool, taking part in the TSO tenders
- Activating companies' prequalified facilities if balancing power is called for

As mentioned in the above description of balancing power markets, often the requirements of specific marketing channels cannot be met by individual processes alone (an example is minimum capacity). Thus it makes sense to offer various processes from one company or several together. This procedure is called **pooling** and may involve the collective marketing of several loads that, individually, are not available throughout the entire period of an balancing power order, or that, individually, do not reach the threshold minimum capacity for participating in the balancing power markets, for instance.

Usually a DSM marketer or pool operator is responsible for marketing the pool. This stakeholder integrates additional processes in the pool, keeps capacity in reserve to secure individual processes, and undertakes the marketing of the pool, e.g. on the balancing power market. In this way, it serves as a link between different providers of flexibility and consumers, e.g. the TSOs. Pooling of loads is basically possible for all marketing channels, although many other marketing channels such as spot marketing place lower demands on stakeholders and do not make pooling necessary. Pooling can help market even smaller processes that are otherwise difficult to market.

**Distribution system operators**

Flexible loads are usually connected to the electricity grid at the distribution grid level. The distribution system operator (DSO) must guarantee that the balancing power can be provided via the distribution grid. It issues the so-called connecting grid operator's declaration of confirmation (DSO confirmation), which a company requires in order to be prequalified to supply balancing power.

**Transmission system operator**

The TOSs are responsible for the secure operation of the transmission grid. One of the ways they achieve this is by using balancing power. In the context of DSM, the essential duties of transmission grid operators are:

- Prequalifying flexible loads for supplying balancing power
- Tendering the forecast demand for balancing power
- Accessing the balancing power in cases of frequency deviation

**Companies (load owners)**

In their function as so-called 'load owners', companies can tap into potential new revenue by marketing flexible loads and contribute to the stability of the electricity grid by providing balancing power. In the case of large companies with their own balancing group this marketing can be carried out independently, or it can be achieved with the aid of a DSM marketer (pool operator)

## Significance of balancing power for DSM

For DSM, balancing power is currently the most highly remunerated form of marketing, and therefore of interest to many operations. Moreover, the remuneration system is attractive, since if a very high energy price is chosen orders are received only rarely, and remuneration is provided via the capacity price for the willingness to flexibilise loads. For a provider, therefore, it is partly within their control to achieve a low frequency of orders, and thereby have to make fewer adjustments to their consumption processes. At the same time, the technical demands and IT expenditure involved in taking part in these markets are too high for many consumption processes. Particularly with regard to connecting control technology, most consumption processes require upgrading before they can participate in the balancing power market. For consumption processes, the marketing channels considered are mainly SBP and MR. The crucial demands for companies when marketing SBP and MR are:

- **The volume of controllable capacity** At present, the minimum quantity of SBP or MR required for participation in the market is 5 MW. However, by bidding together with other consumption facilities or producers (so-called pooling), processes with smaller outputs can also share in tendering.
- **IT and control technology connections of processes** Ideally, to be marketed as balancing power the processes must be centrally controllable and, in the case of SBP, also capable of remote control. Usually this presupposes that a master process control system is available centrally, and that individual processes are connected to it. Remote control can then be carried out without technical complications. However, the capacity for remote control can lead to high levels of internal resistance within the company, since external interventions in its own operating procedures are not desired.
- **Length of advance notice before access** With MR the capacity offered must be supplied in full within 15 minutes; with SBP the period is 5 minutes. For many consumption processes this is only possible to a limited extent, or not at all.
- **Predicted operational status of the individual process at the time of tender** Many companies are quite capable of flexibilising their processes even at short notice, depending on the current level of utilisation. In

order to market balancing power, however, they must be able to forecast a definite operating status of their processes at a point in the future when they wish to offer the balancing power, to ensure that the required adjustment can be made. For many processes this is not possible. Particularly with SBP, where the lead time for the forecast is one week, this requirement often prohibits balancing power marketing.

**Perspectives for DSM on the balancing power market**

Many factors support a greater increase in the participation of consumption processes in the balancing power markets. For example, in recent years the requirements for minimum tender volumes have already been reduced. The current consultation process of the Federal Network Agency and the targets of the law on the further development of the electricity market passed in July 2016 (Electricity Market Act) are aimed at increasing access to balancing power markets for new providers and flexible consumption processes. At the same time, energy management systems are becoming more widespread in companies, and the IT connection of individual processes is being more intensively promoted, so that the requirements for balancing power marketing are increasingly being created. For many smaller processes, however, the cost of balancing power marketing is very high and, by contrast, the expected yield too little.

### 1.3.2 DSM marketing on the spot market (Intraday)

Marketing consumption processes on the electricity spot market involves adjusting the electricity load to the electricity price at short notice. In the future, as a result of the expansion of renewable energy sources and the parallel decline of conventional power plant capacities, increasing scarcity scenarios with high price spikes are predicted in the electricity market on the one hand, and surplus scenarios with very low or even negative electricity prices on the other. Adjusting consumption to the current electricity price can therefore contribute to optimising a company's electricity procurement costs.

To achieve this kind of flexible marketing, it is necessary for a company to include corresponding conditions for flexible marketing in their electricity supply contract with their electricity provider. For example, this can be achieved if the company makes an agreement with the electricity provider not to operate certain predefined processes at times of high price spikes, and to receive a rebate on the electricity price in return. In return, the electricity provider's risk due to price spikes is lower. The provider can reduce its own procurement requirements accordingly, instead of having to buy expensive volumes of electricity or sell volumes of electricity that have been procured long in advance, even at high prices, and have now become available.

In contrast to the strictly regulated balancing power markets, these bilateral agreements between companies and electricity providers can be freely negotiated and are basically not subject to any technical limitations.

**Significance of marketing on the spot market (Intraday) for DSM**

The majority of electricity price components are fixed for the electricity consumer, and not subject to the volatility of the electricity trading price. This category includes, for example, grid fees or reallocation charges such as those of the Renewable Energy Sources Act (EEG), which have to be paid per MWh independently from the point of consumption. Depending on individual exemptions, the fixed components – such as those for private households – can account for up to two thirds of the electricity price. As a result of this, the present incentives are currently too small for most companies to orient their consumption processes strongly towards the current electricity trading price. Additionally, the current electricity trading prices as a whole are at a very low level.

**Prospects for marketing on the spot market (Intraday)**

Nevertheless, since it is relatively easy to implement, flexible spot marketing is a sensible addition to their electricity supply contract for many companies, which can open up the prospect of more flexible marketing channels for them in future. In the long term, as a result of the further expansion of renewable energy sources and a shrinking conventional power plant fleet, volatile electricity prices must increasingly be expected. Additionally, free pricing has been adopted as a fixed goal in the Electricity Market Act (EnWG); in other words, these price fluctuations should also not be influenced from outside. Rather, they should send out a signal that there is a demand for flexibility.

### 1.3.3 Compensation energy in balancing group management and DSM

The electricity market in Germany is made up of a lot of individual balancing groups, in which electricity consumers and electricity producers are connected through trading technology. Each of these balancing groups has a balancing group manager, who is often also an electricity supplier for consumers, unless the latter are themselves active on the energy exchange. The balancing group manager aggregates the schedules and forecasts of their balancing group members and ensures that the balancing group is always in equilibrium through electricity trading. That means that the balancing group is always consuming as much electricity as it is producing or has purchased, and that surplus volumes of electricity are promptly sold on the energy exchange. If, through deviations from forecasts, imbalances arise in the balancing group that the balancing group manager cannot correct through short-term trading, the transmission system operator charges the balancing group manager compensation energy for these discrepancies. Compared with balancing power (see above), which ensures a physical balance in the electric power system, compensation energy is primarily a financial balancing measure. In relation to DSM, the balancing group manager has the option of putting countermeasures in place within the balancing group to avoid compensation energy costs.

Like spot marketing, in contractual terms this functions by means of a bilateral agreement between the balancing group manager and the company consuming the electricity. The company thus enables the balancing group manager to adjust consumption or production at short notice in order to equalise the balancing group.

**Significance of compensation energy marketing for DSM**

At present, compensation energy prices are mostly relatively low, which means that balancing group managers have incentives to set up structures for DSM measures in their balancing group only to a minor extent. However, as with spot marketing, the technical hurdles associated with these forms of marketing are minor, which means that with corresponding financial incentives, providing compensation energy can definitely become an attractive option for companies.

**Prospects of compensation energy marketing for DSM**

In the Electricity Market Act (EnWG), promoting balancing groups and boosting incentives for balancing group commitments are mentioned as a clear aim to reinforce system stability. For this reason, at the end of 2015 the Federal Network Agency already launched a discussion process on the further development of the compensation energy system, which initiated the establishment procedure for adjusting the compensation energy system. It is probable that compensation energy prices will rise as a result, e.g. through a penalty for balancing group deviations or higher prices for compensation energy on the TSO side. This would create a greater incentive for balancing group managers to increasingly exploit flexibility options within their balancing group, and also to secure DSM potential in contracts.

### 1.3.4 Grid congestion management

Grid congestion management refers to locating and eliminating grid congestion in the transmission grid. In the long term, this occurs mainly as a result of electricity grid adjustments and upgrades. In the short term, it is mainly due to interventions in power station deployment by the transmission system operators (redispatching).

It can, therefore, transpire that electricity transmission capacities are inadequate to transmit volumes of already purchased electricity. This can happen if a high level of electricity generation from conventional and renewable power stations in northern Germany coincides with a very high level of demand for electricity in southern Germany. Large quantities of electricity must then be transported from north to south. Particularly between Bavaria and Thüringen, at present this can lead to very heavy loads on power lines, up to overload level. For this reason, the TSOs must intervene in the situation to make sure the lines are not overloaded and avoid subsequent damage. In the example given, for instance, it would be feasible to connect conventional power stations in southern Germany that would otherwise produce little or no electricity, or to downscale production at the power stations feeding in from northern Germany.

**Significance of grid congestion management for DSM**

DSM currently plays a very subordinate role in grid congestion management in Germany. The main reason for this is that at present sufficient power generating plants and flexibility are available on the market, and therefore loads must be downscaled for redispatch only in exceptional cases. At present, TSOs do not envisage using DSM for long-term grid congestion management, i.e. as an alternative for expanding the electricity grid.

**Prospects of grid congestion management for DSM**

Until now, the remuneration mechanisms for redispatch measures have operated on the basis of marginal costs. This arrangement was overturned by a judgement of the Düsseldorf higher regional court in spring 2015 and is currently being altered. It is to be expected that the compensation payments for these interventions to date will increase in future and will not only be based on marginal costs, but also on lost income. In other electricity markets, such as the PJM market in the north-east of the US, DSM measures are already successfully participating in long-term grid congestion management on capacity markets even now, as an alternative to electricity power lines in congested regions.

## 1.4 Current market situation for DSM

DSM is hardly known in large areas of the industry and is used only partially in energy-intensive industries. For a wider distribution of DSM, it is vital that discrimination-free access to existing and future markets be available. In addition to these regulatory aspects, further testing of technical challenges in companies, along with the associated explanations, are particularly needed.

In recent years the markets for flexibility have developed significantly. There are many marketers who form pools and bid together; the entry conditions for DSM on the balancing energy market have been and are being improved; flexible electricity supply contracts can be concluded because of the increasing competition; and energy management systems (EMS) are becoming more widespread in companies. At the same time, the low level of wholesale electricity prices and the price spread only result in minor incentives for industry to

flexibilise its electricity consumption.[1] In the medium term, it is expected that conventional power plant capacity will disappear from the market and significant market price signals will emerge in connection with the further expansion of renewable energy sources. Steps in this direction include, for example, the start of the capacity reserve in 2017 and Germany's gradual withdrawal from nuclear energy by 2022.

[1] One important exception here is the optimisation of grid fees in the form of peak load management, which is being used in many parts of industry as a result of the strong financial incentives.

# 2 dena's DSM pilot projects

Over the period from 2013 to 2016, the Deutsche Energie-Agentur (dena) – the German Energy Agency – carried out two pilot projects addressing the topic of demand side management in two south German federal sates, Bavaria and Baden-Württemberg. The projects were linked to political discussions about expanding the transmission grid, which would enable better connections between north German power generation centres and south German load centres, and opening up balancing power markets in 2011, with the associated revenue-generating potential for companies.

The aim of both pilot projects was to help companies in Bavaria and Baden-Württemberg to identify existing potential for flexible loads and market these commercially. At the same time, the practical experience was intended to determine how the development of a market for DSM in Germany could be supported. To this end, DSM potential was investigated cross-sectorally in companies from the small and medium-sized, industrial and commercial sectors. Subsequently the companies were helped to test the commercial marketing possibilities for the flexible loads identified and, if necessary, to implement them.

## 2.1 Baden-Württemberg Pilot Project Demand Side Management

From July 2014 to December 2016, dena undertook a pilot project for DSM in Baden-Württemberg with the support of the German Ministry for the Environment, Climate and the Energy Industry.

Baden-Württemberg is one of the most highly developed industrial regions of Germany, and therefore the issue of utilisable flexiblisation potential plays a major role there. The Baden-Württemberg 2020 energy concept envisages increasing the share of renewable energy sources in electricity generation to at least 20 per cent. As a result of the decommissioning of nuclear power stations from 2018 (Phlippsburg, with 1.4 GW, closed in 2018, and Neckarwestheim, with 1.3 GW, will close in 2022), plus the gradual transfer of coal-fired power stations to the climate reserve, the region has lost a lot of its conventional generation capacity. At the same time, because of its economic strength, Baden-Württemberg needs large quantities of electricity. In this context, analysing the possible contribution DSM potential can make to companies in this federal state is of particular interest.

### Project participants

The Baden-Württemberg pilot project Demand Side Management had an interdisciplinary design. To supplement the practical approach with both scientific and political perspectives, dena incorporated several different players.

**Project advisory board:** The project advisory board served as a central controlling authority, supporting the project technically by involving technical authorities, grid operators, professional associations and research institutions, and discussing needs for developing content with regard to regulatory and process-related topics. It was composed of representatives from the Ministry of the Environment, Climate Protection and the Energy Sector Baden-Württemberg, the Bavarian State Ministry for Economic Affairs and Media, Energy and Technology, the Federal Network Agency, the grid operators, and various associations. The associations represented were the German Association of Local Utilities e.V., the Baden-Württemberg Association for the Energy and Water Industries e.V., the Regional Association of Baden-Württemberg Industry e.V., and the German Chemical Industry Association e.V.

**Accompanying scientific research:** To supplement the market-oriented and legal perspectives, the pilot project was given scientific support by the Fraunhofer IPA. The aim of this was to analyse the current frameworks for DSM, identify market integration challenges, and develop suggested solutions for opening up further markets.

**DSM marketers:** DSM marketers play a central role in the utilisation of DSM potential. They support companies in their analysis of potential and enable even smaller companies to market their load transfer potential by merging flexible loads in so-called pools. As part of the pilot project, several DSM marketers drew up commercial offers for the identified DSM potential, gave interested companies ongoing advice, and partly assisted with the implementation of the DSM marketing process.

**Companies:** One of the aims of the project was to analyse the load transfer potential of Baden-Württemberg companies and assist the companies in marketing it. To this end, dena recruited companies from a wide variety of sectors to take part and assisted them with the identification and subsequent analysis of their DSM potential. In this way, by considering real operational requirements, facilities and processes, it was possible to gain important insights for further market development.

## 2.2 Bavarian Pilot Project Demand Side Management

From 2013 to 2016, dena carried out the Bavarian Pilot Project Demand Side Management, funded by the Bavarian Ministry of Economic Affairs and Media, Energy and Technology. The aim of the pilot project was to help Bavarian companies identify existing load transfer potential and market it successfully. With the help of the insights gained through the project, solutions for the identified problems and practical help for the implementation of demand side management were developed in association with other market players.

### Project participants

During the pilot project, various industrial companies from Bavaria were recruited as project participants, helped to identify their flexibility potential, and assisted with the possible marketing of this potential by dena and the direct electricity marketers involved in the project.

In parallel with this practical process, an expert project advisory board accompanied the project. The project advisory board was composed of industrial companies, DSM marketers, technology providers, council services, transmission and distribution system operators (DSOs), the Federal Network Agency, the Bavarian Ministry of Economic Affairs and Media, Energy and Technology, associations, the Research Centre for Energy Economics (FfE) and representatives of dena.

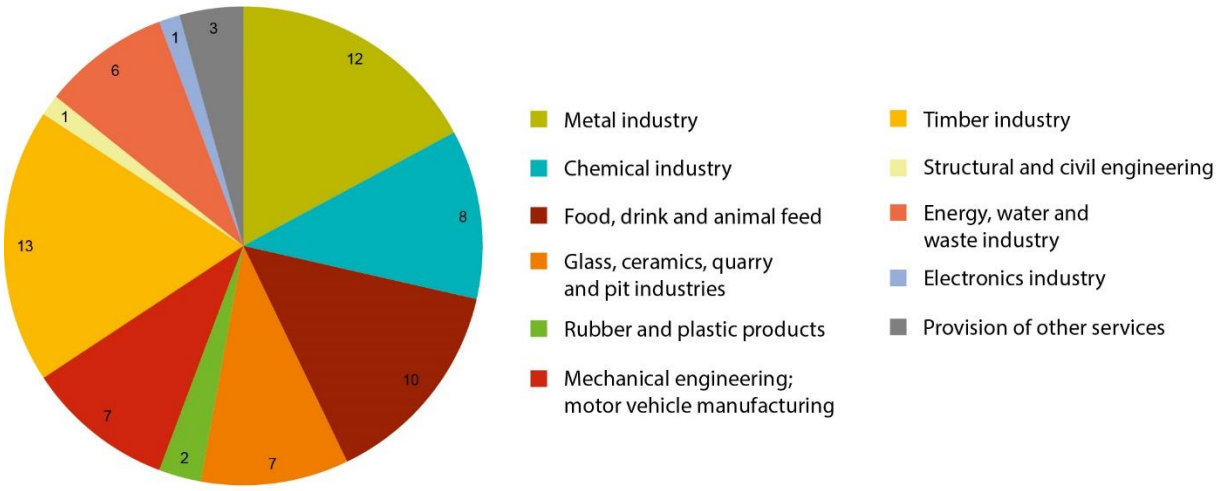
## 2.3 Findings of the pilot projects

In many companies, there is potential for DSM. Marketing channels for this potential are also generally available. However, the frameworks for flexibility in the various market segments are still very demanding and tailored towards companies in the energy industry such as power station operators. This hampers more widespread participation in the market by companies lacking equivalent expertise.

### 2.3.1 Participating industries und processes

In the course of the pilot projects it was possible to identify a large number of suitable processes in the companies. Potential for DSM in machine processing, as well as cooling and heating processes, was established with particular frequency. Another important finding was that DSM potential is not sector-specific. It can be found in almost all sectors, regardless of the size of the company. However, whether DSM potential can be exploited in practice depends not only on the processes, but also on the persons involved, the business structures and the economic frameworks.

**Overview of sectors and number of participating companies:**




**Overview and number of process types:**

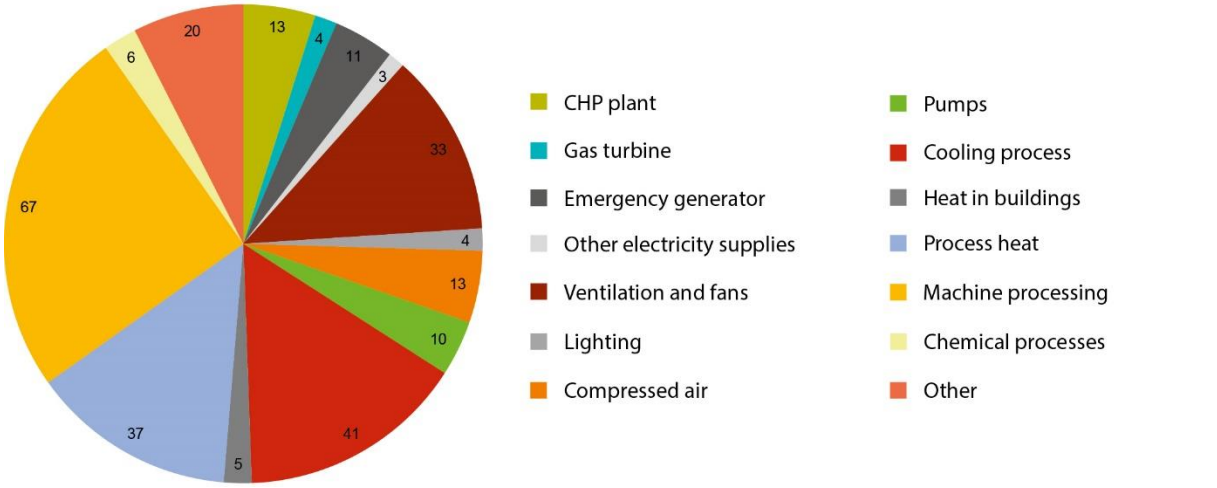



Figure 5: Overview of industries and processes involved in the Baden-Württemberg and Bavarian Pilot Projects Demand Side Management

**Practical example: Stuttgart Airport markets balancing energy**

Stuttgart Airport was the first company to market flexible loads as part of the Baden-Württemberg Pilot Project Demand Side Management. In addition to its own power generating plants (CHP plants) and emergency

generators, the company also has a number of energy storage options. These include heat and cold reservoirs. As part of a potential analysis, the control and savings potential of the emergency generators, air conditioning systems and cogeneration plant was tested. The use of cooling and ventilation systems is particularly well suited for DSM, since they can be temporarily switched off without noticeably compromising their cooling capacity. Since 16 December 2015, the airport has initially been providing 3.2 MW of balancing power from emergency generators through the virtual power plant run by EnBW Energie Baden-Württemberg AG.

### 2.3.2 DSM Roadmap

As part of the Bavarian Pilot Project Demand Side Management, dena has developed a roadmap that provides an overview of the challenges involved and concrete recommendations for action.

- The challenges of the **information and data situation** are connected with informing companies about marketing possibilities for DSM and gathering process-specific energy data in companies to establish existing potential for flexibility.
- Challenges in the **energy industry** primarily consist of the challenges of the existing regulatory provisions of the flexibility markets.
- **Business management challenges** include necessary costs for exploiting and marketing DSM in companies and comparing costs with achievable revenues.
- **Technical challenges** arise if industrial processes are intended to be deployed and operated flexibly.
- In addition to these challenges, there are also open questions in the area of DSM which come under **research needs.**

The roadmap (see Figure 6) derives recommended courses of action from the experiences gained in the pilot project in order to better exploit Germany's available DSM potential. The overarching aim of the roadmap is to describe the need for action so that anticipated future requirements for flexibility can also be exploited by flexible loads. The challenges described are based on the experiences of the participating companies and DSM marketers in the development and marketing of flexibility, backed up by the research accompanying the project and the experiences and assessments of the project's advisory committee. The derived recommendations for action are the result of discussions of the challenges and consideration of suitable routes to solutions within this broad stakeholder group.

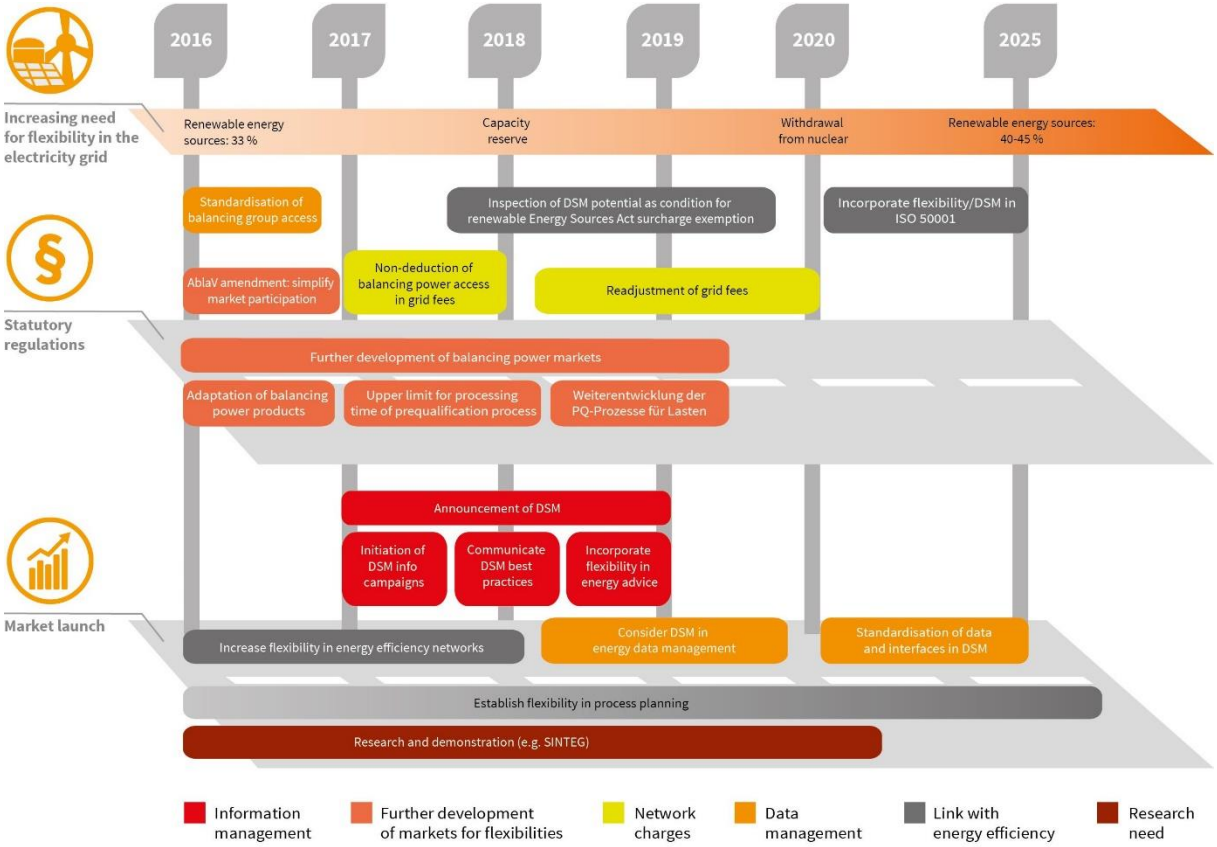



Figure 6: DSM Roadmap

### 2.3.3 Need for action

The challenges arise in various fields. On the basis of the experiences of the Bavarian Pilot Project Demand Side Management, and in close consultation with the project advisory committee, dena has extrapolated recommended courses of action for each area of activity, in order to meet the challenges of exploiting and marketing DSM potential.

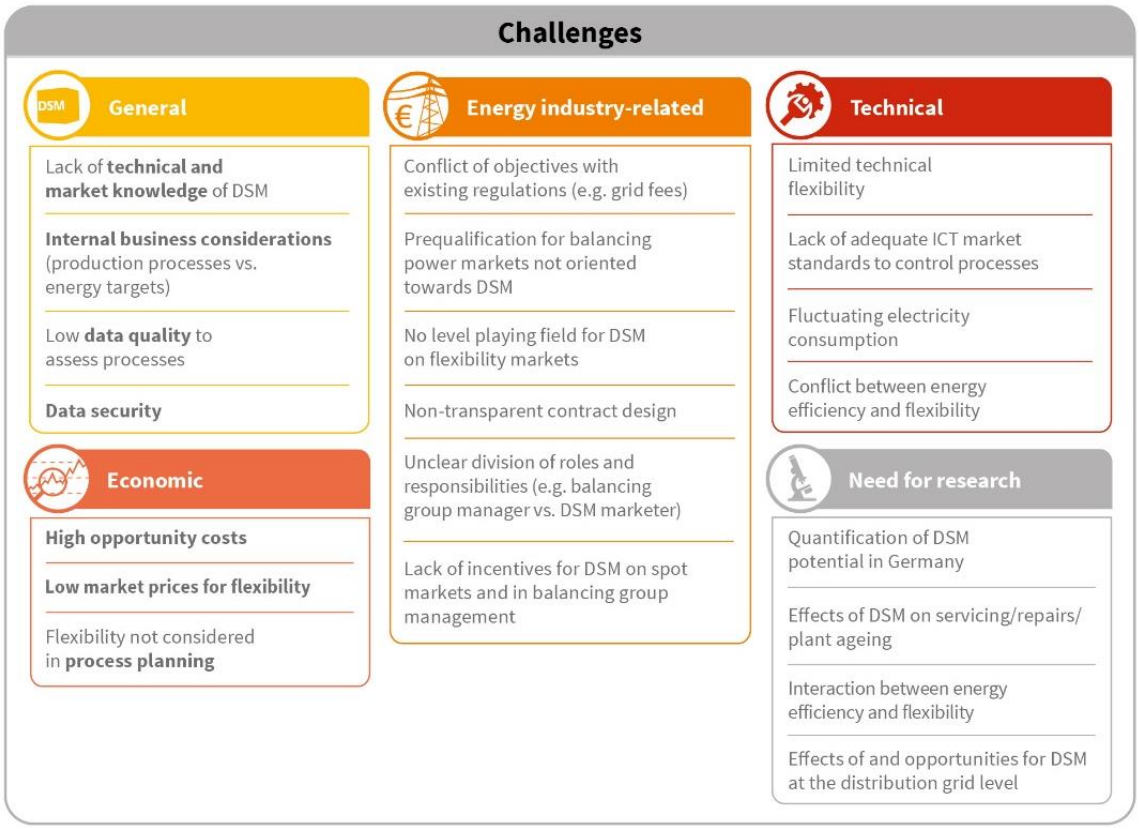



Figure 7: Overview of DSM challenges from the Bavarian Pilot Project Demand Side Management

Based on the experience of the Bavarian Pilot Project Demand Side Management, the following picture of the current market situation in Germany emerges: DSM is hardly known in large areas of the industry and is used only partially in energy-intensive industries. For a wider distribution of DSM, it is vital that discrimination-free access to existing and future markets be available. In addition to these regulatory aspects, further testing of technical challenges in companies, along with the associated explanations, are particularly needed.

In recent years the markets for flexibility have developed significantly. There are many marketers who form pools and bid together; the entry conditions for DSM on the balancing energy market have been and are being improved; flexible electricity supply contracts can be concluded because of the increasing competition; and energy management systems (EMS) are becoming more widespread in companies. At the same time, the low level of wholesale electricity prices and the price spread only result in minor incentives for industry to flexibilise its electricity consumption. In the medium term, it is expected that conventional power plant capacity will disappear from the market and significant market price signals will emerge in connection with the further expansion of renewable energy sources. Steps in this direction include, for example, the start of the capacity reserve in 2017 and Germany's gradual withdrawal from nuclear energy by 2022.

The most important recommended courses of action for further exploiting DSM potential in Germany are:

- Carrying out **information campaigns on DSM** for industrial companies and integrating the topic of DSM in exchanges of ideas with **energy efficiency networks**.
- Aiming to achieve a **level playing field,** in other words the same market access requirements for all flexibility options and dismantling existing barriers to market entry.

- **Reviewing grid fees systems, in the short term particularly special grid fees,** from the perspective of their desired effect in the context of providing flexibility and developing DSM.
- Adopting **obligatory DSM potential tests** in the BAFA list of requirements for exemptions from the Renewable Energy Sources Act surcharges and, prospectively, as a standard in energy audits according to DIN EN ISO 50001.

# Figures

# Tables

www.dena.de/en

dena
German Energy Agency