Chapter 8

What is the Flexibility Potential in the Tertiary Sector?

Ulrich Reiter and Martin Jakob

Abstract Demand side management (DSM) is seen as a promising, cost-effective measure to cope with high shares of intermittent renewable energy in the electricity grid system. As the regulatory framework in Europe is changing in favor of opening up new market opportunities for DSM, the question is answered, which potentials are effectively available in the tertiary sector today and in the future. Results in this study are based on empirical data gathered from services companies. The collected data is of high quality and rich in detail and is of utmost importance for relevant model-based analyses. Additionally, the discussed acceptance rates of new technology or behavioral trends have a high impact on the results of the model analyses.

8.1 Introduction

8.1.1 Overview of Demand Side Flexibility Markets

Demand side management is seen as promising, cost-effective measure to cope with high shares of intermittent renewable energy in the grid system. As the targets for renewable energy generation are set, the future potentials and needs for flexibility markets remain currently unclear. One of the main expectations toward the REFLEX project¹ is to shed light on the need of flexibility provision in the future with high shares of renewable electricity generation.

Until recently, the regulatory framework in most European countries was designed in a way that mainly industrial units were able to participate and offer demand flexibility on the wholesale market (Vallés et al. 2016; Dufter et al. 2017). Additionally, in some countries, utilities are able to reduce electricity demand from specific appliances in the residential and services sector to limit demand in certain peak hours

¹See www.reflex-project.eu.

U. Reiter (✉) · M. Jakob
TEP Energy GmbH, Zurich, Switzerland
e-mail: Ulrich.Reiter@tep-energy.ch

based on local grid codes (Vettori et al. 2017). However, given the need for more flexibility in the future (Alizadeh et al. 2016), the country specific regulatory authorities are obliged to open up the market system for additional market participants (European Parliament and the Council of the European Union 2012).

As the market for DSM from the services and residential sectors are only at their infancy in many European countries (Smart Energy Demand Coalition 2017), the information on the DSM potentials and market acceptance in the services and residential sector is scarce. There is a need to better understand and determine barriers and thresholds, potentials, and drivers, as well as specify a concrete inception of DSM to estimate the full potential of services sector DSM applications.

The process of better understanding the market situation can be supported by the recent development of the technological progress. In recent years, better measurement and control systems have been developed for a facilitated DSM implementation, commonly summarized as smart grids (Behrangrad 2015). By gaining further insights into specific demand profiles from different applications and sub-sector use cases, additional knowledge can be gained on the expectations and boundary conditions from service sector market participants.

8.1.2 Overview of Tertiary Sector and Potential Applications, Regulatory Environment

So far there is an insufficient amount of data available about many areas of the European service sector to define the effective electricity demand (measured hourly and sub-hourly load profiles) and the contemporaneous DSM potential. Although there is some information available on generic load profiles from specific applications (Jakob et al. 2014), only few reports have published the DSM potential from services sector companies and appliances (VDE 2012). In practical terms, it remains unknown which facilities have already been included in DSM markets and what willingness or readiness is dormant in facility operators to govern over specific facilities. Furthermore, it has not been clearly identified which obstacles and restraints are crucial to companies to decide to participate in the DSM market or not.

In order to empirically answer these questions for multiple European countries, a survey directly aimed at companies in the service sector was performed, to determine whether there is potential to increase the share of controllable loads.

This chapter will describe the state of the current aptitude of an implementation of DSM into the tertiary market and explain the implications. Thus, the focal point is laid on research questions concerning sector- and key aspects of an optimized usage of electric power at peak times.

There are several technologies on which DSM would be particularly effective, as they consume, comparatively, large amounts of energy and due to the nature of their functionalities, they are meant to be used for long periods of time. Such technologies comprise air conditioning, cooling, and refrigerating and ventilation systems used

in different tertiary sub-sectors such as wholesale or retail trade companies, hotels and restaurants or office-based companies (e.g., Gils 2014; Grünewald and Torriti 2013). As the use and the potential interruption due to DSM of such appliances are usually not process- or income-relevant, and therefore have only limited impact on company operations, they are considered as suitable for DSM application.

In process and economic terms, DSM is considered to be suitable for two types of clients in the services sector: on the one hand side for large companies, which have elevated loads and consumption of electricity in overall terms. Likewise, larger enterprises will have an energy management system (EMS) as well as an energy manager at their disposal and are therefore open to optimize energy demand and related costs. On the other hand, smaller companies with low demand loads and less information on energy demand could be aggregated by service companies, thus making available untapped potentials in a cost-effective manner. However, even companies of large scales may encounter further restraints and obstacles to overcome. Companies generally refrain from change, avoid investments, and fear disturbance of work flow and quality.

Furthermore, there are favorable as well as inhibitory regulatory frameworks which are influencing the take up of DSM in different countries (Smart Energy Demand Coalition 2017). To access and participate in the DSM market, the following main condition needs to be fulfilled (among others): The regulator needs to adjust the market regulations to allow consumer to participate in demand response (DR) programs. Companies need to fulfill various regulations and technical standards to be eligible to participate in the ancillary services market (Arteconi et al. 2012).

As introduced above, the general set-up for this framework on EU level is defined by the Article 15.8 in the European Energy Efficiency Directive (European Parliament and the Council of the European Union 2012). However, looking at country levels, these regulations vary strongly and are not fully implemented yet (Smart Energy Demand Coalition 2017). To get a grasp on the different market statuses, the empirical study was conducted in countries where the market design is at different stages. Whereas in Switzerland and the UK, market regulations for DR options are already in place (Smart Energy Demand Coalition 2017), other countries such as Poland or Germany are lagging behind. In Germany, the Electricity Network Fee Regulation Ordinance (Bundesregierung 2011b) aiming at the avoidance of load fluctuations, incomplete aggregator-models impeding pooling is one of such inhibitory frameworks. Also, the market is not accessible without having to undergo complex qualification processes.

To conclude, currently there are potential cross-sectional technologies at hand, and partial previous experiences from test cases (Klobasa et al. 2006), as well as regulatory facilitating conditions (Bundesregierung 2011a) which allow for increasing DSM participation of service sector companies. Notwithstanding favorable regulatory frames, there is barely space to access DSM's profitable potentials. Only time will show the willingness and readiness at an enterprise level, as well as its practical, usable potentials.

8.2 Data Collection Methodology

8.2.1 *Research Questions*

To better understand the DSM potential from service sector companies in Europe, an empirical study was implemented to address the following research questions:

- Which technologies of service sub-sectors seem most promising for demand side management?
- Which conditions and barriers affect the realization of the DSM potential in the short- and mid-term?
- What energy efficiency potentials are untapped and therefore indirectly influencing the potential DSM implementation to reduce energy costs of enterprises?
- What expectations are in the market toward returns and profitability of DSM?

8.2.2 *Empirical Survey Introduction*

A comprehensive survey was designed and addressed toward selected stakeholders from four countries, namely, the UK, Italy, Poland, and Switzerland (see also Reiter et al. 2020). The survey was prepared based on a similar survey already implemented in other projects (e.g., Wohlfarth and Klobasa 2017). This country selection was chosen, as different regulatory environments and their impact on DSM participation are of interest.

The focus of the survey was set on four specific service sub-sectors to include wholesale and retail, hotels and restaurants, private office-type companies, and public administration. Each sub-sector sample contained at least 75 data sets, adding up to 300 data sets at minimum per country. However, due to data availability on potential survey participants and the market structures within the different countries, the number of effective survey participants varies for sub-sector specifications.

In total, 1,200 complete data sets were collected by a specialized contractor using phone interviews and optional online finalization of the survey. With this data set, a first broad overview of DSM potentials in different European countries can be gained. Due to the limited number of samples per sub-sector, the uncertainty of the processed results needs to be considered in the future implementation of such. An overview of the sample sizes is given in Table 8.1.

The survey questions were structured into four different main energy-related categories:

- General information on the enterprise related to energy demand (e.g., energy reference area, annual energy consumption and costs, etc.).
- The enterprises' relation to energy efficiency (e.g., past or future investments into energy efficiency, energy audits, or similar).

Table 8.1 Overview of sample distribution and number of participants from each service sub-sector

Number of enterprises	Bureaus		Public sector		Trade		Hotels/restaurants		Total
	Private	Public	Health/education		Retail	Wholesale	Of which (food ^a)	Of which (non-food ^a)	
UK	75	39	36		25	51	14	63	301
CH	75	54	22		42	33	16	63	301
IT	75	75	1		7	68	21	58	303
PL	73	56	21		49	26	13	62	301
Total	298	224	80		123	178			1,206

^aDouble selection possible
Source Data based on survey results

- Focus on DSM solutions, available technologies, and enterprises' know-how on implementation.
- How enterprises structure their decision processes regarding energy demand and related costs and investments.

From the general information on energy-related aspects of the enterprise, relevant knowledge on the importance of energy demand and costs is gained to derive indicators on relevance and potential clustering for DSM options (see above). Besides information on the energy reference area or the annual energy consumption and costs, further questions were addressing the number of sites and employees, the building standards of the rented or owned premises. Other pressing questions include whether companies are prepared for DSM, i.e., if the electric power usage is metered on hourly or sub-hourly levels, and the type of supply contracts. Both aspects are relevant for DSM implementation in the sense that enterprises need to cope with price signals and related chances and risks for the annual electricity bill.

The second category of questions focused on the enterprises' relation toward know-how on energy demand and energy efficiency. Survey participants were asked, if energy audits were conducted in the recent past and if efficiency improvements were implemented in the past or planned for the near future. As efficiency measures are seen as complementary opportunity compared to demand side management measures to reduce the strain on the electricity grid, the enterprises' commitment in the near future to one or the other will influence the available potential of DSM.

The third category of questions was focusing on evaluating the general acceptance of DSM and available know-how as well as the technological readiness of enterprises toward DSM solutions, and the willingness to install the respective control devices that go alongside with load management. Depending on the use of DSM options already today or not, survey participants were asked about available technologies on site, which of them they already integrated in their DSM contract and which other installations need to be excluded from DSM. To estimate the potential length of DSM measures in terms of temporally shift, companies were also asked about opening hours and times when service interruptions would not be accepted.

Additionally, the economic costs and benefits are of interest for enterprises in the evaluation of DSM participation. Therefore, a set of questions was directed toward expected revenues from DSM participation as well as expected payback times for related investments.

The last category of questions addressed the decision processes of enterprises; to understand the position of the respondent within the firm and which decision levels need to be addressed to realize investments in energy efficiency or DSM. The decision pathway within a company is highly influential on the probability of—and the relevance for implementing DSM measures.

8.2.3 *Issues Encountered Regarding Empirical Data*

As introduced above, the sample size per country and sub-sector is limited given the available financial resources. Therefore, the significance of the results in terms of statistical analysis could be increased in further work. However, as for modeling purposes and to understand market barriers and drivers as well as to evaluate first DSM potentials, the survey is highly relevant.

As from other empirical studies in the energy sector known (Klinke et al. 2017), the difficulty remains to reach the staff member with relevant know-how on the enterprises' energy topics. Usually, such information on energy managers or similar are not published in organigrams and therefore difficult to collect. By conducting phone interviews, a querist can ask for the relevant person in an enterprise which is increasing the likelihood to collect relevant information for the survey. This approach, however, is limiting the number of potential sample participants as it declines a mass mailing.

8.3 Survey Results and Derived Flexibility Potentials

The results of the stakeholder survey will be explained for all countries in an overview. More detailed results per country can be found under (Reiter et al. 2020). Therefore, the most relevant and telling histograms and results are described and further elaborated upon. Alongside the descriptive statistics, the technological equipment of each of the four surveyed countries are each outlined below and offer a clear insight about how feasible the implementation of DSM is so far and what are potential contributions toward future use of DSM in the services sector.

8.3.1 *Participation Interest in DSM*

Currently, 58 companies from the survey are participating in DSM which is a participation rate of approximately 5%. In Switzerland, with favorable regulations, the participation rate is slightly higher with 7% overall, whereas in countries with less favorable conditions (e.g., Italy or Poland) the participation rate is in the range of 3.0–3.6%. Interestingly, in all countries, not only large size companies participate in DSM but also small companies with annual electricity consumption below 50–100 MWh per year. In average, 4% (or 26 out of 658) of the companies with an annual electricity demand of below 100 MWh are participating in DSM (cf. Table 8.2). With increasing demand, the share of DSM participants is also increasing. From the companies which estimate their annual electricity demand from 100 MWh up to 1 GWh, 7% are participating in DSM operations and 16% of the companies with an

Table 8.2 Willingness of companies to participate in DSM aggregated for different demand classes

Annual demand (rows) \ Participation in DSM (columns)	Yes		No		I don't know		Total number
	No	[%]	No	[%]	No	[%]	
Below 100 MWh	26	4	600	91	32	5	658
Between 100 MWh and 1 GWh	12	7	149	87	10	6	171
Above 1 GWh	9	16	43	78	3	5	55
Not defined	11	3	263	82	48	15	322
Total	58	5	1,055	87	93	8%	1,206

The last column indicates the total number of companies classified in the respective demand category
Source Data based on survey results

electricity demand larger than 1 GWh per year also include DSM operations. Additionally, 3% of the companies which did not specify their annual electricity demand are also participating in DSM operations. However, based on the available answers, it remains unclear why the companies decided to participate in DSM.

From the participants which did not participate in DSM measures at the time of the survey (in total 1,055 respondents), 254 stated that they possibly can imagine to participate in DSM operations in the future (see also next paragraph) and 749 do not see their company participating in DSM and 52 companies remained undecided. The 749 participants which cannot imagine to participate in DSM could indicate which reasons lead to such decision (multiple selection, cf. Table 8.3). Highest risks are evaluated as financial risks with 28.2% (or 211 out of 749 respondents), technical

Table 8.3 Risk perception of companies aggregated for different demand classes for different risk categories

Annual demand (rows) \ Risk categories (columns)	Financial risks high		Technical risks high		Not enough incentives		Sample size
	No	[%]	No	[%]	No	[%]	
Below 100 MWh	112	25	94	21	117	26	449
Between 100 MWh and 1 GWh	34	35	34	35	19	20	97
Above 1 GWh	6	23	12	46	4	15	26
Not defined	59	33	36	20	27	15	177
Total	211	28.2	176	23.5	167	22.3	749

The column "sample size" indicates the total number of companies classified in the respective demand category

Source Data based on survey results

risks with 23.5% (176 out of 749), and 22.3% (167 out of 749) state that DSM does not provide enough incentives in their view. 215 respondents out of 749 gave additional reasons which were not further grouped.

The results indicate, that the risk perception of mid-sized companies with an annual demand between 100 MWh and 1 GWh is with 20–35% slightly higher in average as compared to small-sized companies with approx. 21–26% (annual demand below 100 MWh) and large companies (annual demand above 1 GWh). However, for 46% of the large companies the technical risks seem to be high which is highly relevant for potential integration into DSM operations. As such companies offer larger DSM potentials due to their energy demand, dedicated measures would be needed to address such risks. Additionally, for 22.3% DSM has too little incentives to be seen as attractive alternative to, e.g., more energy efficiency or doing nothing.

8.3.2 Available Technologies

To derive the DSM potential in the services sector, a distinction is made between the technical potential and the market potential. The technical potential is defined by the installation rate or availability of DSM feasible technologies in companies, including their potential decline in the future. This technical potential is limited not only by the availability (i.e., grid connection), but also the use and importance for the companies' core business. Different owner interests and limitations are of high relevance to understand potential load shifting directions (positive or negative, cf. Michaelis et al. 2017) and shifting hours, during which the demand side flexibility would be available for grid operators. This market potential is further influenced by the willingness of companies to make available such sources to grid operators based on economic considerations (e.g., revenues, risks and chances). In the following, the results of the survey regarding these main aspects will be introduced and explained in more detail.

The technical potential of installed appliances varies strongly between the countries surveyed (cf. Fig. 8.1). The highest numbers of appliances available are cross-sectoral technologies such as ventilation and air conditioning systems. For other appliances such as cooling rooms, freezers, or refrigerators among others, Switzerland seems to have a generally higher equipment rate in general which is almost double as compared to the other countries investigated. From the survey it remains unclear if this is a result of a selection bias (i.e., which companies participated in the survey) or if structural differences between the countries effectively exist. Independent of these considerations, the DSM potential per country and appliance is estimated.

In total, 561 companies stated that their working areas are partially or fully ventilated. From these 561 companies, 429 companies estimate that more than 10% of their total floor area is ventilated. In average, 55% of the floor area is ventilated according to these companies.

Fig. 8.1 Overview of the number of installed energy demand devices, potentially available for DSM operation (*Source* Data based on survey results)

Additionally, the number of survey participants allowing for external control of their ventilation system gives an indication on the potential market uptake rate for DSM services per country and sub-sector. From the 561 participants with ventilation systems installed, 87 stated a positive acceptance of external control for their ventilation device in the future and 24 participants stated that their ventilation system is already included in a DSM system. On the other hand, 395 participants denied DSM participation and 55 participants gave no answer. Therefore, additional 15% of the ventilation systems installed, could be included into DSM measures in the short- to mid-term.

The equipment rate of air conditioning systems and heat pumps,² offers DSM potential for different seasons and time instances. Demand for air conditioning is largest in summer, often correlating with peaking solar photovoltaic electricity generation (Müller et al. 2019). Therefore, the DSM potential is mainly available in case of applying specific cooling strategies during such periods. Heat pumps in winter can offer upward flexibility (power-to-heat) as well as downward flexibility (load shedding) (cf. Michaelis et al. 2017), in combination with heat storage devices (e.g., heating water tanks) or through the thermal mass of buildings.

In the survey, 609 companies state that they run air conditioning systems on site. From these 609 companies, 332 also include ventilation systems and 108 companies (from 609) run heat pumps. In total, 120 companies run all three devices (i.e., ventilation, air conditioning, and heat pumps) and 188 companies run air conditioning systems and heat pumps on site. Importantly, 251 companies indicate, that the air

²In southern countries (e.g. Italy), heat pumps are often sold as reversible heat pumps and therefore used as heating device in winter and air conditioning system in summer (Nowak and Westring 2018).

conditioning system is a centralized system which is more likely available for DSM operations. With these 251 centralized systems, 222 systems are used to cool more than 10% of the floor area- and in average 58.5% of the floor area of each site. From the 251 centralized systems, 11 systems are already included in DSM operations and additional 39 companies could imagine to opt for DSM in the near future. In total, 20% of the centralized air conditioning systems could be available for DSM in the short- to mid-term.

307 companies indicated in the survey, that they run heat pumps on site for heating or hot water purposes. From these 307 heat pumps installed, 15 systems are included in DSM operations as of today and additional 55 companies indicate that they would allow for external control of their heat pumps to be used in DSM operation. In total, 22.7% of the installed heat pumps could be integrated in DSM operation in the short- to mid-term. Additionally, from the 94 companies which run heat pumps as well as centralized air conditioning systems (see above), only 4 companies opt for external load controls in both systems, limiting the potential for annual DSM operations with such appliances to very small numbers. However, as the potential for operating one of the devices under DSM is higher for either heat pumps or air conditioning systems, it remains open what barriers cause such behavior as from technological and risk perception, similar acceptance rates to combine heating and air conditioning systems in one DSM system are expected.

As more specific devices such as refrigerators or cooling cabinets are not commonly installed in all sub-sectors investigated, the available number of installed appliances is smaller as compared to cross-sectoral appliances introduced above.

In total, 203 companies run cooling rooms, from which 129 cooling rooms are larger than 10 m² (max. size is 2,500 m² and in average 109 m²). 10 cooling rooms are already today included in DSM operations, whereas additional 37 companies indicate their willingness to allow for external control in the near future. Therefore, 23% of the cooling rooms would be available for DSM operations in the near future. Additionally, 76 companies indicate that they operator refrigerators connected to a centralized system, from which 8 are already included in DSM operations today and 21 would be potentially available in the near future. Therefore, approx. 38% of centralized connected refrigerators are potentially available for DSM operations. Finally, 96 companies run freezer rooms and 141 run smaller systems such as chest freezers. Approx. 40% of the freezer rooms are larger than 10 m² and therefore offer reasonable DSM potential in terms of installed cooling capacity. Two freezer rooms are already operated under DSM system and 12 additional freezer rooms could be available in the near future (approx. 37% of the installed systems). From the 141 smaller freezing systems, 29 systems are connected to a centralized chiller. Three of these systems are already connected to DSM and additional three systems could be connected in the near future. Therefore, 20% of the centralized systems would be available for DSM, however, in overall terms, only a limited potential of freezer units is available for DSM operations.

From the 168 server rooms, 128 are larger than 10 m², with reasonable cooling demand. Four of these cooling systems for servers are stated to be included in DSM

operations as of today whereas 31 would be available in the near future. Therefore, 27% of such cooling devices could be potentially integrated into DSM operations.

Overall, it was found that reasonable shares of the installed appliances could be made available for DSM operations in the near future due to the willingness of companies to allow for external control of their appliances. The shares of available systems range from 15% of the installed appliances (ventilation) up to 38% (refrigerators).

8.3.3 *Derived Flexibility Potentials (S-Curve)*

Future load management potentials can be directly linked to the market diffusion of control systems ready for DSM. However, as historic data on such market diffusion is scarce, such technology roll-outs need to be seen in the framework of the higher-level scenario definition. Therefore, to define the potential uptake of DSM ready appliances and their integration into DSM operations, the shares of available DSM systems as of today are used as starting point. Based on the findings above for the additional shares of companies willing to participate in DSM operation and including assumptions on country specific uptake rates of DSM control units as well as exchange rates of non-DSM-ready appliances, so-called S-curves are derived. These S-curves describe the development of installed demand capacity in time which is potentially available for DSM and which is considered in the model exercise to describe the available flexibility potentials and their integration into the market system. These DSM potentials are used as input to the scenario analyses to allow for additional flexibility in the electricity system.

In the REFLEX Mod-RES and High-RES centralized scenarios (cf. Chapter 2) it is assumed that no further incentives or dedicated policy measures are introduced to stimulate the participation in DSM. The share of flexible technologies (referred to as “smart share”) is thus mainly dependent on the willingness of companies and households to participate in DSM. In general, the smart share for the flexible appliances in the tertiary sector is deduced from the survey as indicated above. As the model calculations are run on country bases, the country specific uptake is also relevant (cf. Table 8.4).

To adjust for the higher-level scenario definition, different acceptance rates for smart share technologies are applied. In the Mod-RES scenario, in the mid-term, i.e., until 2030, it is assumed that all companies will participate in DSM that are willing to allow an external company to exploit their DSM potential as of today. These are the companies that answered the respective question with “possible,” “yes, likely,” or “certainly.” When other incentives or regulations become available, assuming that in the long-term future, i.e., 2050, all companies will participate DSM that are today not absolutely against an external company exploiting their DSM potential (i.e., also including the companies which answered with “hard to imagine”). With the three data points resulting from the survey, a logistic S-curve could be fitted that reflects the smart share in the different countries for all future years (cf. Fig. 8.2).

Table 8.4 Participation rate of companies already using DSM and willingness of non-DSM users to allow for external control units

	Do you participate in DSM (yes)?	Would allow external access for purpose of DSM?		
	(%)	Yes or likely (%)	No or unlikely (%)	No answer (%)
UK	6	8	78	8
PL	3	25	46	26
IT	4	18	72	6
CH	7	35	51	7

Source Data based on survey results

Fig. 8.2 Country specific fitted S-curves for “smart readiness” (Data source Fraunhofer ISI and TEP Energy)

For the residential sector, it is assumed that all new installed appliances for which smart control has no effect on performance or consumer comfort, such as heat pumps, will be DSM ready from 2025 onwards. With the diffusion of new installations over time, the smart share increases (cf. Table 8.5).

Table 8.5 Assumed participation in DSM (i.e., “smart share”) in the residential sector in the years 2020, 2030, 2040, 2050, based on the diffusion of new appliances/systems

	2020 (%)	2030 (%)	2040 (%)	2050 (%)
Heat pumps	6	25	58	75
Electric vehicles	3	9	22	31
Air-conditioning	3	9	22	31

Data source Fraunhofer ISI and TEP Energy

Table 8.6 Classification of countries regarding their DSM acceptance/participation

Country group	Assigned countries
“high acceptance”	Belgium, Denmark, Estonia, Finland, Netherlands, Sweden, Norway, Switzerland
“high potential acceptance”	Austria, France, Germany, Latvia, Luxembourg, Poland , Slovenia
“medium acceptance”	Cyprus, Czech Republic, Spain, Greece, Hungary, Italy , Portugal, Slovakia, Romania, Bulgaria, Croatia
“lower acceptance”	Ireland, UK

In the High-RES scenario, the smart share for all sectors is increased to 99–100%, to align for the higher-level scenario definition. This assumption implies that not only new installations are equipped with smart control systems but also existing installations are retrofitted. Additionally, since empirical data is only available for four countries, country-analogies are used to derive the potential DSM development for all EU-28 countries, Norway and Switzerland (cf. Table 8.6).

Therefore, for each country group, the respective smart share rate is implemented in the model FORECAST (cf. Chapter 3).

8.3.4 *Lessons Learned and Issues Identified for Modelers*

As for all modelers, the difficulty remains to understand and interpret the given dataset correctly in the way the survey participant has made available his information. There might be open data points or misinterpretations from the survey participant in regard of the questionnaire on the one hand and on the other hand potential over-interpretations of the answers through the modeler. Therefore, one has to be careful, not to derive trends or extrapolations from the dataset which are not accurate or misleading.

A cross-section of market actors for each investigated sub-sector was targeted in terms of size (number of employees) and market profile. Especially the size of the company is of relevance for the project, as for the applied models in the REFLEX project, energy demand projections are linked to such indicator (e.g., energy demand per floor area and floor area per employee). However, information on these indicators from the selected companies is a result of the survey, and therefore, a skewed sample is likely to be achieved, varying across countries. Given the uncertainties due to small sample size and sample structure, in a first approach, no corrections for different size classes were included in the design of the S-curves for DSM potentials. Therefore, further corrections are necessary in terms of sample- and market structure to accurately describe the respective DSM potentials.

Additionally, further assumptions are needed to translate the available technical potential into an applicable DSM potential in the future. With further information and the introduction of pre-installed DSM control units in cross-sectoral appliances

such as ventilation or heat pump systems, the use rate of DSM is likely to increase. However, questions and indicators for such trends were not part of the survey and need to be defined by the modelers. Therefore, besides the companies which have indicated their interest in participating in DSM operations in the short- to mid-term, additional potentials need to be estimated and included in the model calculations for the long run until 2050.

8.4 Conclusions and Recommendations for Further Research

With the survey-based approach to collect empirical data on available DSM technologies as well as the readiness of companies to engage in DSM, the basis was set to better understand the DSM potentials from services sector companies.

The empirical study to investigate the DSM potential of services sector companies improves the knowledge base on the availability of suitable DSM devices and the willingness of companies to make the respective appliances available for flexibility needs of the grid. The survey is giving an overview on the current situation of DSM integration which is highly market depending and the perceived risks and opportunities of companies to interact in DSM markets. There is a substantial potential for DSM to be implemented in the near future given the high installation rate of DSM-affine appliances (e.g., heating, ventilation, cooling, etc.). An adequate number of companies can imagine to carry out and benefit from load management, even participating in the financial risks associated with such measures (Reiter et al. 2020). Some more analysis will be carried out on the dataset to fully grasp the potential of the given information as input to the model environment addressed in the REFLEX project.

However, as the sample size can be considered as small for market wide analyses and trend estimates, additional efforts are needed to provide further empirical data on different kinds of DSM aspects in the services and residential sectors.

References

- Alizadeh MI, Parsa Moghaddam M, Amjady N, Siano P, Sheikh-El-Eslami MK (2016) Flexibility in future power systems with high renewable penetration: a review. *Renew. Sustain. Energy Rev.* 57:1186–1193. <https://doi.org/10.1016/j.rser.2015.12.200>
- Arteconi A, Hewitt NJ, Polonara F (2012) State of the art of thermal storage for demand-side management. *Appl. Energy* 93:371–389. <https://doi.org/10.1016/j.apenergy.2011.12.045>
- Behrangrad M (2015) A review of demand side management business models in the electricity market. *Renew. Sustain. Energy Rev.* 47:270–283. <https://doi.org/10.1016/j.rser.2015.03.033>
- Bundesregierung (2011a) Verordnung über den Zugang zu Elektrizitätsversorgungsnetzen (Stromnetzzugangsverordnung - StromNZV), pp 1–14

- Bundesregierung (2011b) Verordnung über die Entgelte für den Zugang zu Elektrizitätsversorgungsnetzen (Stromnetzentgeltverordnung - StromNEV). Bundesministeriums der Justiz Zusammenarbeit mit der juris.de, pp 1–22
- Dufter C, Guminski A, Orthofer C, Von Roon S, Gruber A (2017) Lastflexibilisierung in der Industrie – Metastudienanalyse zur Identifikation relevanter Aspekte bei der Potenzialermittlung
- Gils HC (2014) Assessment of the theoretical demand response potential in Europe. *Energy* 67:1–18. <https://doi.org/10.1016/j.energy.2014.02.019>
- Grünewald P, Torriti J (2013) Demand response from the non-domestic sector: early UK experiences and future opportunities. *Energy Policy* 61:423–429. <https://doi.org/10.1016/j.enpol.2013.06.051>
- Jakob M, Kallio S, Bossmann T (2014) Generating electricity demand-side load profiles of the tertiary sector for selected European countries. *Proceedings of 8th International Conference Improving Energy Efficiency in Commercial Buildings (IEECB14)*
- Klinke S, Reiter U, Farsi M, Jakob M (2017) Contracting the gap: energy efficiency investments and transaction costs. Federal Office of Energy, Bern
- Klobasa M, Erge T, Bukvic-Schäfer A, Hollmann M (2006) Demand side management in dezentral geführten Verteilnetzen. *Elftes Kasseler Symp. Energie-Systemtechnik*, pp 115–146
- Michaelis J, Müller T, Reiter U, Fermi F, Wyrwa A, Chen Y, Zöphel C, Kronthaler N, Elsland R (2017) Comparison of the techno-economic characteristics of different flexibility options in the European energy system. *2017 14th International Conference on the European Energy Market (EEM)*, Dresden, 2017, pp 1–5
- Müller J, Meyer M, Reiter U, Jakob M (2019) Simulation of precooling strategies in office buildings: deriving demand side management potentials. *Proceedings of the 16th IBPSA International Conference*
- Nowak T, Westring P (2018) *European Heat pump market and statistics—report 2018*
- Reiter U, Peter R, Wohlfarth K, Jakob M (2020) Demand side management in the services sector—empirical study on four European countries. In: *Improving energy efficiency in commercial buildings and smart communities*. Springer *Proceedings in Energy*. *Proceedings of the 10th International Conference IEECB&SC'18*
- Smart Energy Demand Coalition (2017) *Explicit demand response in Europe mapping the markets 2017*. Smart Energy Demand Coalition
- The European Parliament and the Council of the European Union (2012) Directive 2012/27/EU on Energy Efficiency (EED). *Off. J. Eur. Union*, no. October 2012, pp 1–56
- Vallés M, Reneses J, Cossent R, Frías P (2016) Regulatory and market barriers to the realization of demand response in electricity distribution networks: A European perspective. *Electr. Power Syst. Res.* 140(June):689–698
- VDE (2012) *Ein notwendiger Baustein: Demand Side Integration, Lastverschiebungspotenziale in Deutschland*. Frankfurt am Main.\
- Vettori A, Iten R, Küng L (2017) *Regulierungsfolgenabschätzung zur Revision Stromversorgungsgesetz (StromVG)*
- Wohlfarth K, Klobasa M (2017) Demand response in the service sector—setting course for energy flexibility and efficiency. *ECEEE SUMMER STUDY Proc.*, pp 1165–1175. <https://doi.org/10.1007/s12053-018-9728-3>

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