Analysis of the European energy system

under the aspects of flexibility and technological progress

Call: H2020-LCE-21-2015

Grant Agreement Number: 691685

Deliverable

D2.2 Report on survey findings

Empirical study on DSM potentials and survey of mobility patterns in European countries

Deliverable type:	Report
WP number and title:	WP2: Data Warehouse and model coupling
Dissemination level:	Public
Due date:	Month 18 – 31 October 2017 (extension granted to Month 20 – 31 December 2017)
Lead beneficiary:	ESA[2]
Lead author(s):	Ulrich Reiter (TEP), Francesca Fermi (TRT), Katharina Wolfarth (ISI)
Reviewer(s):	Steffi Schreiber (TUD), Francesca Fermi (TRT)

This project REFLEX has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691685.

Document history

Version	Date	Author/Editor	Description
0.1	11.12.2017	Ulrich Reiter	Initial version
0.2	04.01.2018	Ulrich Reiter	After internal revision
1.0	05.01.2018	Claudia Hawke	Published version

Table of contents

List of tables

List of figures

List of abbreviations

DR	Demand Response
DSM	Demand Side Management
EMS	Energy Management System
EnSYS-FlexA	Flexible Nachfrage als wichtiger Beitrag zur Energiewende und Baustein in der Energiesystemanalyse (Flexible Demand as important contribution to the Energiewende and module of energy systems analysis - project acronym EnSYS-FlexA)
GDP	Gross Domestic Product
StromNEV	German Electricity Network Fee Regulation Ordinance (Stromnetzentgeltverordnung)

Executive Summary

In this deliverable the data gathering regarding electricity demand side management measures and mobility patterns is described, including the presentation of first results of the data analysis. These two different aspects of the energy system are under special focus due to the following reasons. On the one hand, quality data is of utmost importance for relevant model based analyses. Therefore, specific attention must be put on model input data and its foundation on empirical or measured data. On the other hand, the impact of new technology or behavioural trends has a high impact on the actuality of the model analyses. In the task 2.4 we are looking at two of these trends which are considered as relevant in the future for the further development of the energy system:

- Demand side management (DSM)
- Mobility pattern

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 regulatory framework in Europe is changing in favour of opening up new market opportunities for such measures, the question raises, which potentials are effectively available. Besides the DSM potential in the industry sector which is already addressed in many countries, the information on the DSM potentials and market acceptance in the services and residential sector is scarce. Therefore, an empirical study regarding the DSM potential in the services sector is included in the REFLEX project and the design of the study and the first results are presented in chapter 1 of this deliverable.

Mobility is one of the main drives for increasing energy demand and CO_2-emissions in the past and is expected to grow in the future. Therefore, the electrification of mobility is one of the main goals in Europe to bring down CO_2-emissions. However, also behavioural trends towards a shared economy can help reduce emissions. In chapter 2, the findings on such trends are described to give insights in the expected development of car sharing mobility and an increased use of bicycles.

1. DSM survey

1.1. Introduction

With the rise of new, more efficient means to harvest renewable energy and humanity's ever-increasing hunger of electric energy, one of our main concerns has not changed since the upcoming of the use of it; the ability to effectively store electric power.
The project's intent was to find the potential of demand-side management (DSM) in major stakeholders in peak energy usage as promising utilizers of such initiation.
This report presents the methods and results of a qualitative stakeholder survey to further determine barriers and thresholds, potentials and drivers, as well as designate a concrete inception of DSM.
The study is focusing on the tertiary sector, to increase know-how and data on service companies and their potential contributions to DSM from different technologies applied. While the DSM potential from the industry sector is better understood and better technologies have been developed for a facilitated DSM implementation, such as smart grids (Behrangrad, 2015), the expectations and boundary conditions from service sector market participants is widely unknown and therefore untapped. So far there is an insufficient amount of data available about many areas of the European service sector to estimate the current DSM potential. 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 restrains are crucial to decide to participate in the DSM-market or not.
In order to empirically answer these questions, a survey directly aimed at companies in the service sector was performed, to determine based on the findings whether there is potential to improve taxable loads.
The selected stakeholders include subordinates such as, aggregators, network operators, energy providers, technology suppliers and the Federal Network Agency, among others, but also sector agents like trading companies, bureaus and hotels. They were selected across four nations; the UK, Italy, Poland and Switzerland. Additionally, data from the EnSYS-FlexA project on similar data for Germany is available as model input for the REFLEX project but not part of the data description and deliverable D2.2.
Ultimately, this report will describe, first-hand information on the state of the current aptitude of an implementation of DSM into the market and explain the implications. Thus, the focal point is laid on research questions concerning sectors 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 without breaks in between. Such technologies comprise air conditioning, cooling and refrigerating and ventilation systems.

DSM can be suitable for two types of clients: on the one hand side for bigger companies, which have elevated loads and consumption of electricity. Likewise, larger establishments will have an energy management system (EMS) as well as an energy manager at their disposal. On the other hand, smaller companies with non-process related technologies (e.g.

heat pumps, etc.) 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 restrains and obstacles to overcome. Companies generally refrain from change, avoid investments and fear disturbance of work flow and quality.
Furthermore, there will be inhibitory *regulatory frameworks* such as the German StromNEV (Electricity Network Fee Regulation Ordinance aiming for the avoidance of load fluctuations), incomplete aggregator-models impeding pooling. Also, the market is not accessible without having to undergo complex qualification processes.
To conclude this introduction, currently there are potential cross-sectional technologies at hand, and partial previous experiences as well as facilitating condition are present. Notwithstanding, due to 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.

1.2. Methods

In total, 1200 complete data sets were collected by a contractor (GfK[1]) from corporations of four service sectors. The survey was prepared by TEP Energy and Fraunhofer ISI based on similar surveys for other projects. A set of data counts as complete when a survey participant has answered all posed questions concerning a domicile (location) of a company. At maximum, three domiciles per concern or per international enterprise respectively are permitted to participate (or one domicile of a company respectively).

1.2.1. Selection of samples

The focus was set on four specific service sectors to include wholesale / retail, hotels and restaurants, private office-type companies, and public administration. Each of which contained at least 75 data sets, adding up to 300 data sets at minimum per country. The following selective criteria have to be paid attention to, when selecting possible corporations from tertiary sector, which are to be surveyed by the contractor:

- Economic sector / sub-sector
- Host country
- Size of company (number of employees)

Economic sector
Based on the country structure of the service companies and the available address data, the distribution between sub-sectors and countries varies (see Figure 1). This is of importance to understand and consider differences for calculating country wide DSM potentials and find analogies for estimating DSM potentials of countries not considered in the survey directly.

[1] GfK is an international market research company with country offices in Switzerland, United Kingdom, Poland and Italy.

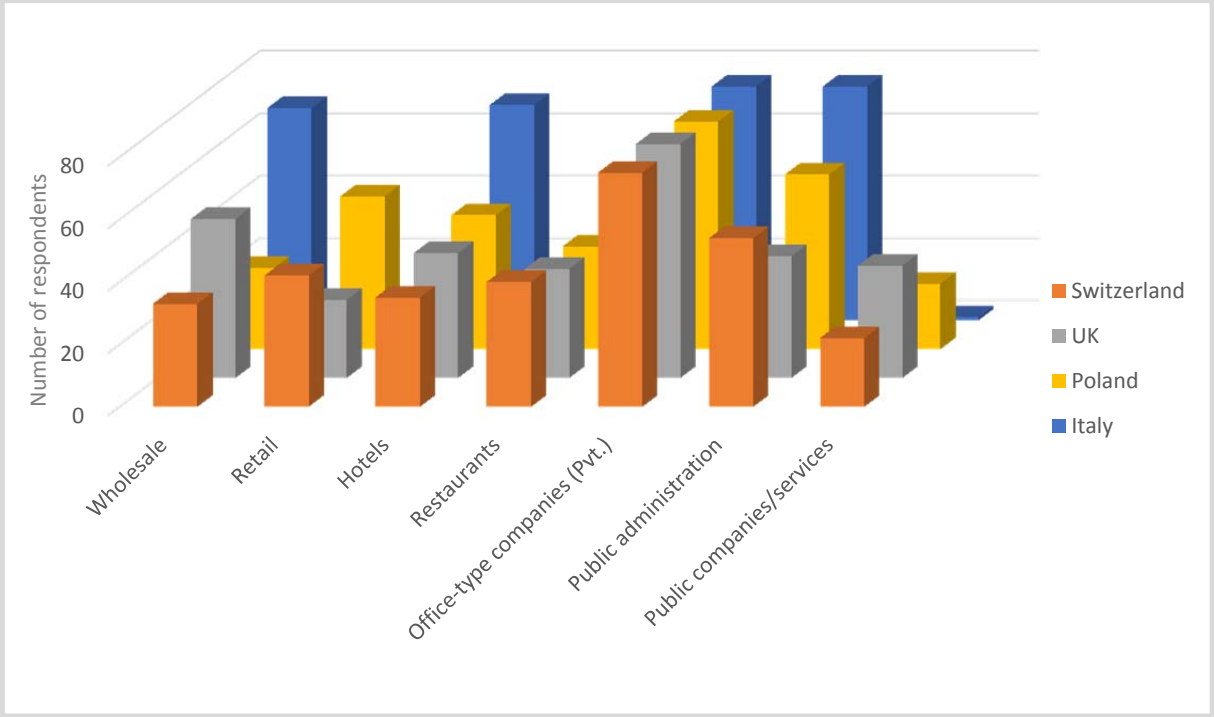

Figure 1 Number of respondents per country and sub-sector (Wholesale and retail trade; hotels and restaurants; office type companies with privately-owned office-type companies include banking and insurance companies. The public administration encompasses office-type buildings. The public companies and services are comprised of healthcare, education and schools, and culture).

Host country

To access and participate in the DSM market, the two following main conditions need 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 fulfil various regulations and technical standards (Arteconi, Hewitt, & Polonara, 2012) to be eligible to participate in the ancillary services market.

The general set-up for this framework on EU level is defined by the Article 15.8 in the European Energy Efficiency Directive (European Energy Efficiency Directive, 2012). However, looking at country levels, these boundary conditions vary strongly and are not fully implemented yet. 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 (Thies, Murray, Dong, & Bortolotti, 2014), other countries such as Poland or Germany are lagging behind (ibid.).

Size of company

Regarding the size of the company, different approaches are expected to be implemented in terms of energy efficiency and DR. While the specific energy demand per employee and sub-sector varies, and given the limited number of samples possible, only two group-sizes were defined to distinguish between market participants. While service companies with few employees often dominate specific sub-sectors, the overall energy demand and therefore the DSM potential is rather lower (exceptions exist) as compared to large companies with high energy demand.

Table 1 Overview of sample sizes.

	Bureaus		Public sector	Trade				Hotel, restaurants		Total
Number of enterprises	Private	Public	Health/Education	Retail	Wholesale	Of which (Food)	Of which (Non-food)	Hotels	Restaurants	
United Kingdom (UK)	75	39	36	25	51	*14*	*63*	40	35	**301**
Switzerland	75	54	22	42	33	*16*	*63*	35	40	**301**
Italy	75	75	1	7	68	*21*	*58*	69	8	**303**
Poland	73	56	21	49	26	*13*	*62*	43	33	**301**
Total	**298**	**224**	**80**	**123**	**178**			**187**	**116**	

1.2.2.Survey design

The questions of the survey can be categorized into four different main energy related topics:

- General information on the firm
- Energy efficiency
- DSM solutions
- Decision processes

First, there needed to be collected some *general information* on the building or the site in order to be able to put the results into an appropriate context. Questions about the general information include the number of employees, energy reference area, annual electricity consumption, building standard and others. Other pressing questions include whether companies are prepared for DSM, e.g. if the electric power usage is measured on time intervals less than an hour, or if they preferably look for energy efficiency improvements, or whether they are utilizing or planning of implementing energy management systems until 2018.

Next, the questions focused on their relation of the company towards *energy efficiency*, such as the companies' commitment to energy audits, expected investment or refurbishment measures.

The third topic is focusing on evaluating the technological readiness of companies towards *DSM solutions*, the acceptance of DSM and the willingness to install the technologies that go alongside with load management (e.g. company allows for DSM, is already participating, what are drivers and hurdles, economic expectance, among others). Depending on the use of DSM options already today or not, participants were asked which technologies they have installed on site, which of them they are already integrating in their DSM contract and which other installations could be used for DSM.

Finally, the questions about the *decision processes* were raised, 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.

1.3. Results

The results of the stakeholders will be explained for all countries in an overview and thereafter for each country independently. The most relevant and telling histograms are described and further elaborated upon in the subsequent subchapters. 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 towards future use of DSM in the services sector.

1.3.1. Overview all countries

Samples based on power usage

One first indication towards the readiness of services companies towards DSM acceptance and therefore varying price signals is the incorporation or use of flexible tariffs already today. Flexible tariffs are giving a price signal for customers to either reduce their electricity consumption at high price levels or to increase demand at low price levels. However, the majority of the companies participating in the survey are signing full supply contracts with only little or no transition to flexible or variable price signals (see Figure 2).

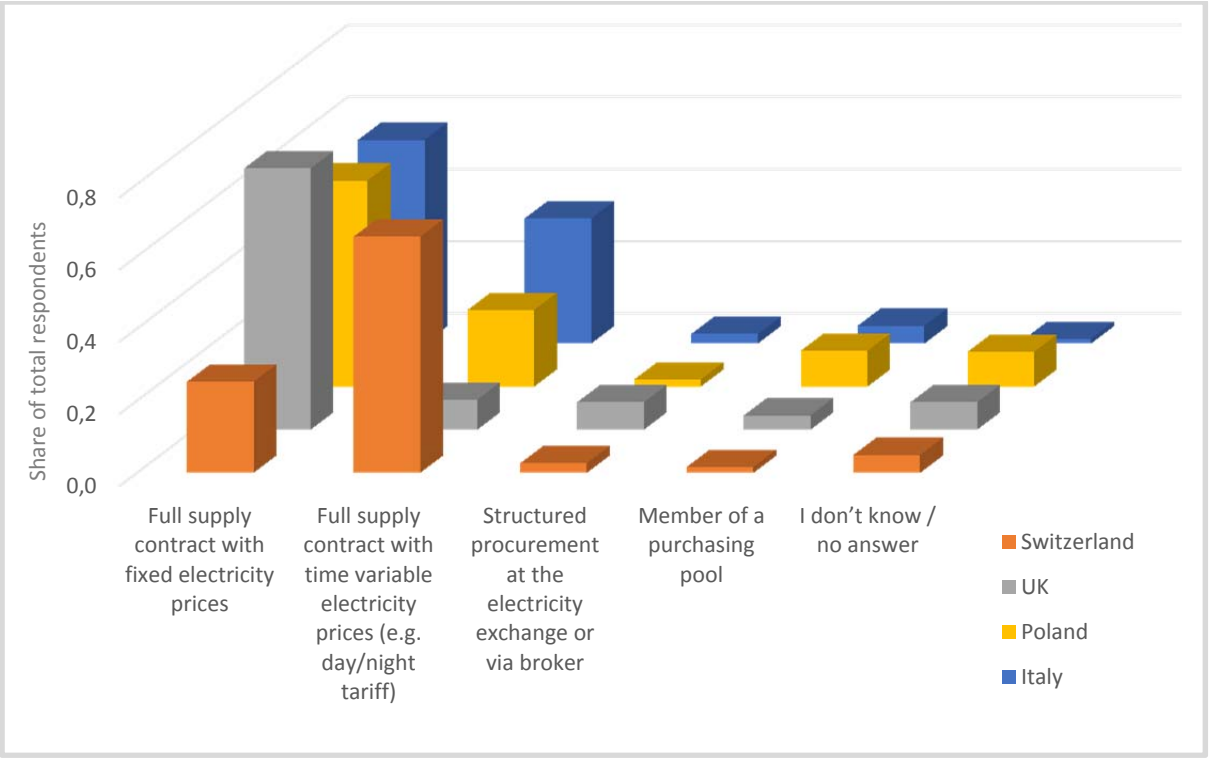

Figure 2 The figure displays the share of respondents specifying their tariff structures within the individual countries. The majority of the companies are fully supplied with either fixed electricity prices or with time variable electricity prices.

Additionally, these results can be closely linked to the installed infrastructure (e.g. smart meters and the time resolutions of demand metering, see Figure 3) and the availability of such price schemes. Depending on the market regulator, such dynamic price schemes are already today possible. Additionally, the availability of smart meters is needed to technically

allow for DSM. Depending on country policies, smart meters are already widely in use or not at all.

Interestingly is the case of Italy. In Italy, a first smart meter rollout took place in the years between 2001 and 2006 with the installation of approx. 30 million devices. However, looking at the feedback from the survey participants (see Figure 3), either utilities do not use such devices for metering on hourly levels, or it is technically done but the services companies do not know about it. Therefore, utilities and electricity providers need to increase their efforts to introduce supply contracts, including flexible price signals to allow the market to adapt to additional chances and risks of such price schemes.

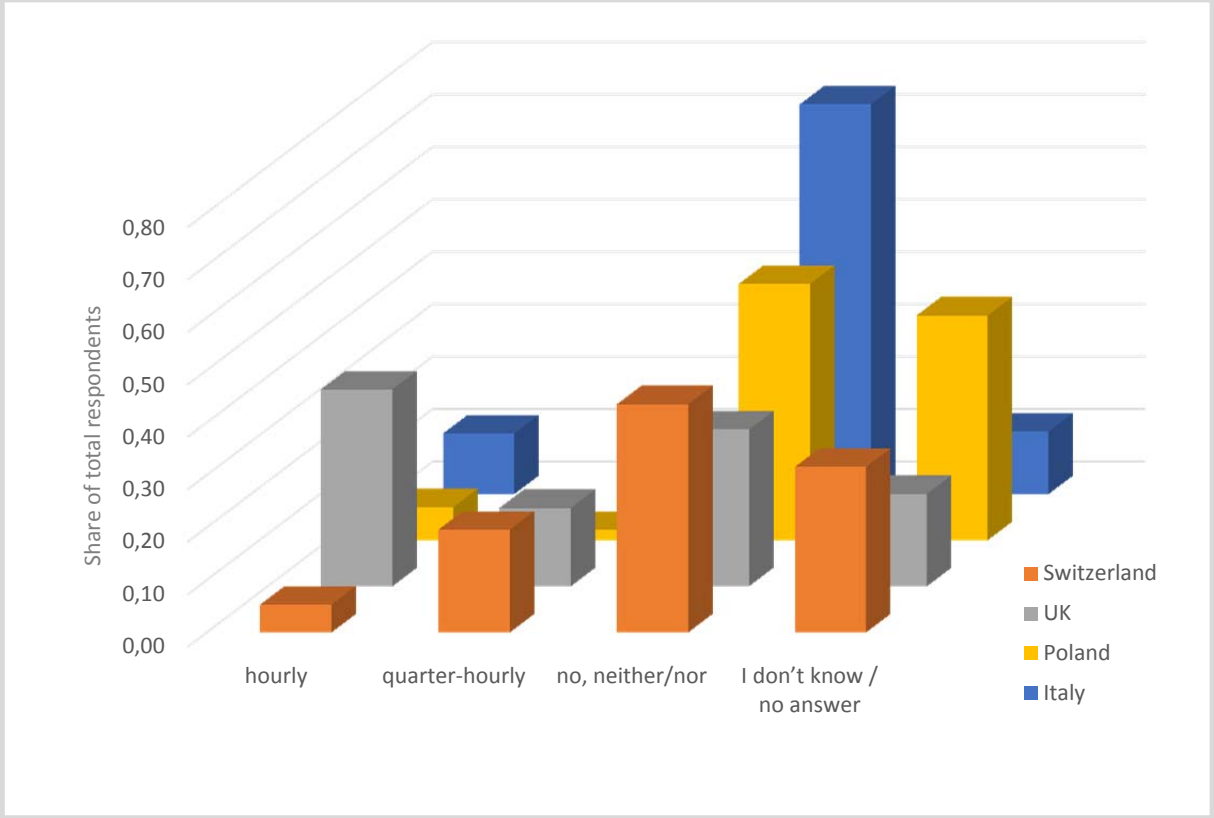

Figure 3 Share of respondents defining the time resolution of the metering system (either hourly, quarter-hourly or not at all).

Besides the questions on current state of electricity demand and its metering, the perception of energy efficiency and potential measures are of relevance to understand the importance of energy costs for the current and future behaviour of the companies. In the survey, companies were asked if they had conducted an energy audit in the past three years (see Figure 4). Most companies in the four countries did not have an external energy audit, disclosing a potentially high potential for energy efficiency measures or higher DSM potentials to be implemented.

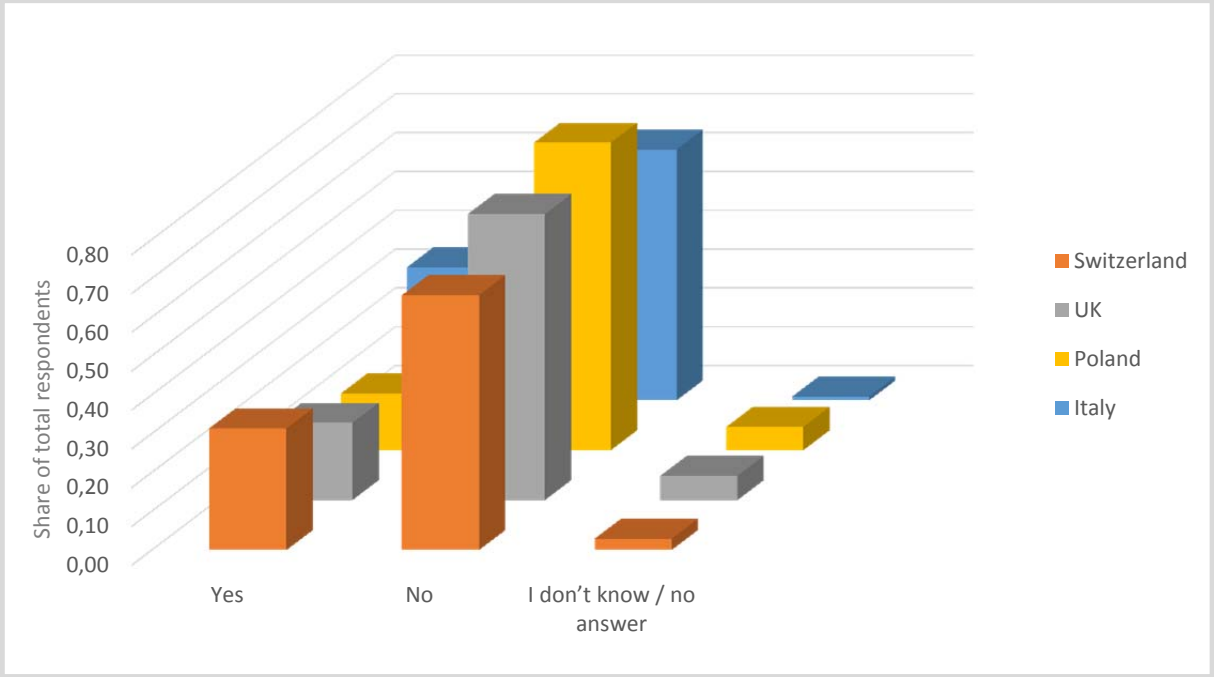

Figure 4 Share of respondents which have conducted an energy audit in the past three years.

In terms of planned and future energy efficiency improvements, the answers vary between countries only slightly. Between 32 % (Switzerland) and 42 % (UK) of the companies are less likely to invest in energy efficiency measures in the coming five years (Answers “no” or “rather not”, see Figure 5). Companies which are planning to invest in energy efficiency, are more heterogeneously distributed and opt between “only limited measures” (e.g. replacing lights) and “specific measures” (up to 25 % of the respondents in case of Switzerland).

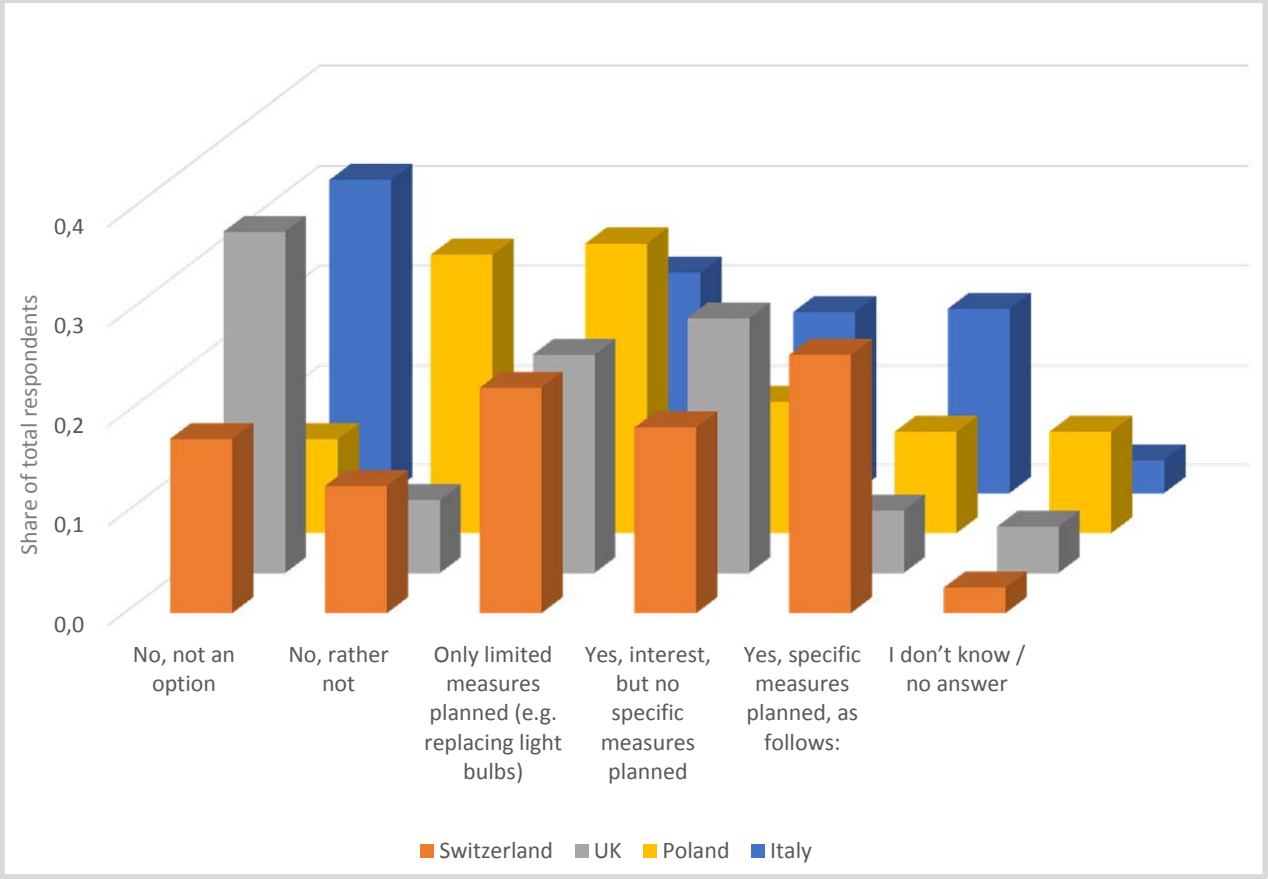

Figure 5 The shares of companies planning to invest in energy efficiency measures in the coming 5 years.

The Figure 6 reveals how few of Europe's companies have so far adopted load management and thus provides insight on the potency of a DSM implementation. The general understanding and notion of DSM's and DR's versatility has certainly improved over the years (Thies, Murray, Dong, & Bortolotti, 2014). However, almost independent of the regulatory framework in the countries investigated, similar shares of tertiary companies are participating in DSM as of today.

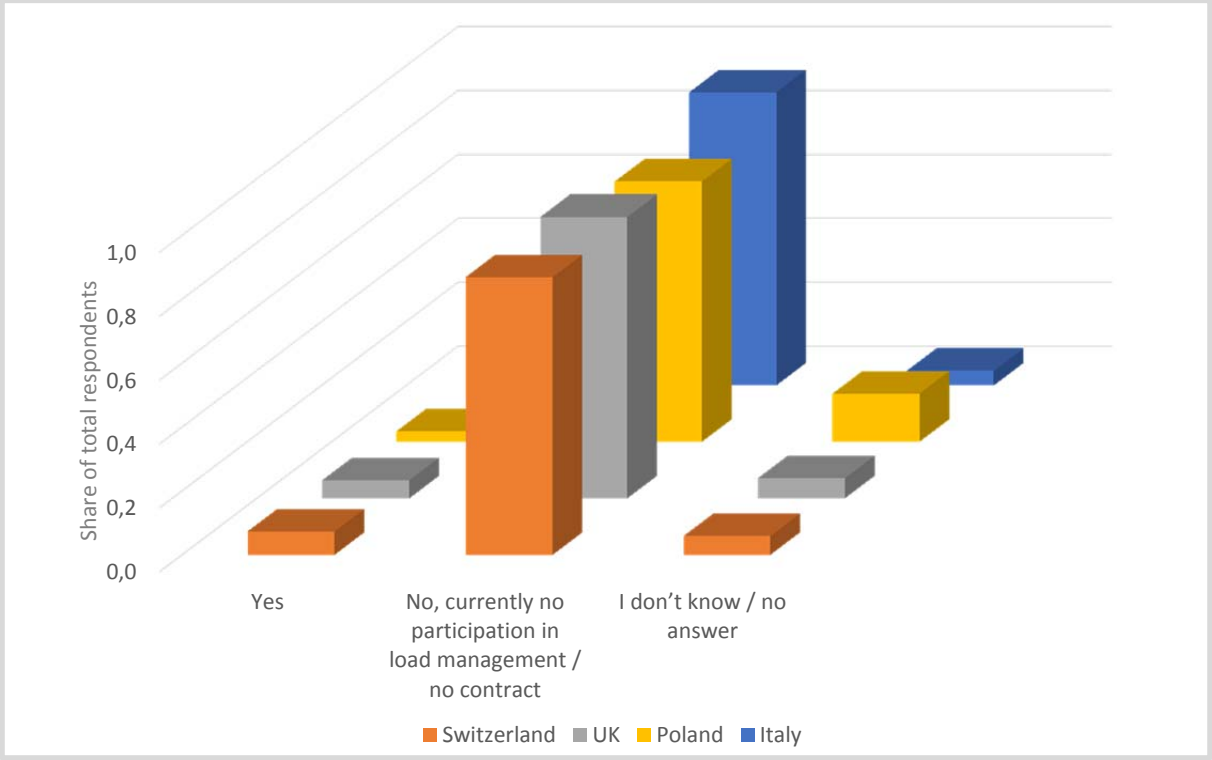

Figure 6 Ratio of companies carrying out load management or not.

According to the respondents, depending on the annual energy consumption, one can see those companies with very high energy demands conduct energy audits most frequently. However, only a minor share states that such audits were performed on mandatory base (see **Table 2**).

Table 2 Number of respondents reasoning why they have conducted an energy audit

	Switzerland	UK	Poland	Italy
Voluntary energy consultation	61	25	21	65
Energy consultation within energy management system	12	9	4	11
Mandatory energy audit for large enterprises due to directive or legal requirement	15	16	12	27
I don't know / no answer	2	10	5	1
Total	90	60	42	104

Given the expectation that larger consumers benefit the most from energy efficiency and/or a DSM implementation, additional efforts are needed that also companies with smaller energy demand look closer at the potential savings by improved energy efficiency or DSM implementation. However, the majority of large scale energy consumers (i.e. those most benefitting from its participation) are currently not involved in DSM.
Not surprisingly, a link between the companies having performed energy audits in the recent three years and those most likely to plan energy efficiency measures within the next five years was observed.

Participants of the survey were asked if they can imagine that external companies are allowed to control appliances to participate in DSM. The majority of the participants in all

countries is stating that such interaction is hard to imagine or even not at all to imagine (see Figure 7). Particularly the UK appears to disapprove of this possibility, together with Italy.

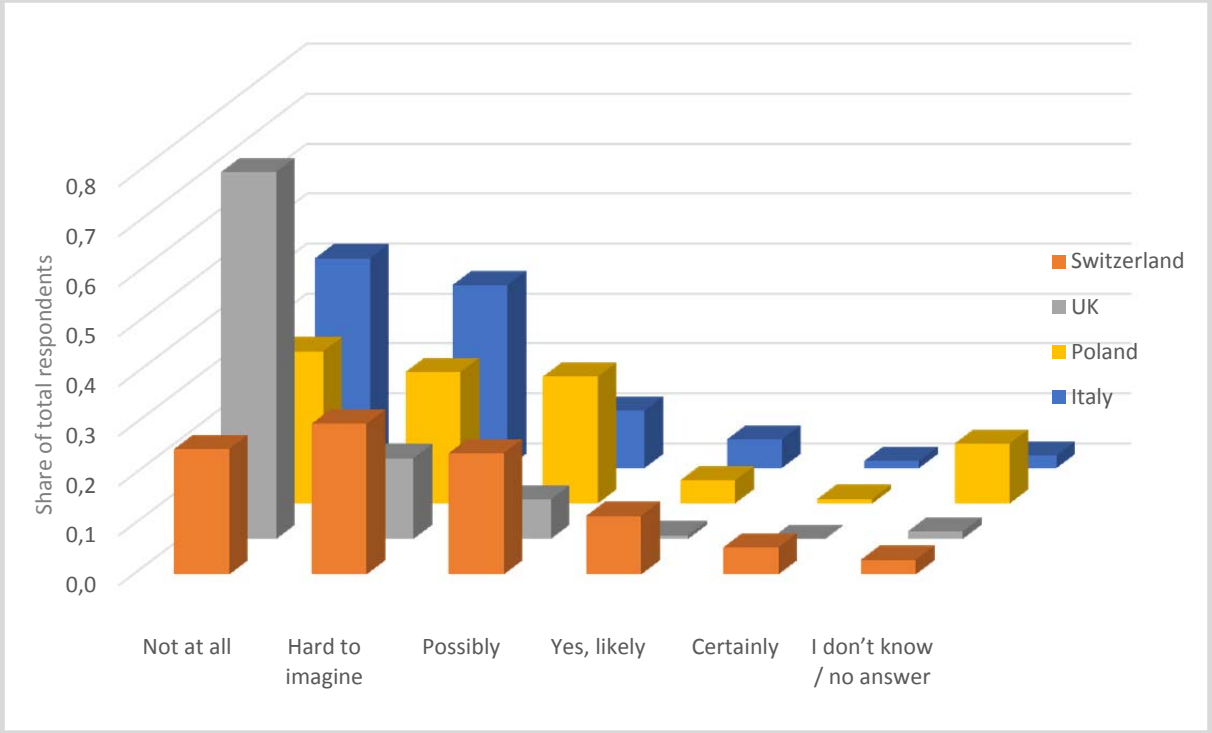

Figure 7 Share of answers if the control of appliances by an external service provider can be imagined or not.

However, companies in Switzerland and Poland do show a certain interest in DSM and can (partially) imagine allowing for external controls. At the moment and based on the answers in the survey, it remains unclear what the relevant boundary conditions are for such differences and which regulations or market conditions need to be changed for higher acceptance of external controls. The risk perception as one of the expected drivers does not give a clear picture (see Figure 8), and is not homogeneously distributed compared to the acceptance of external controls.

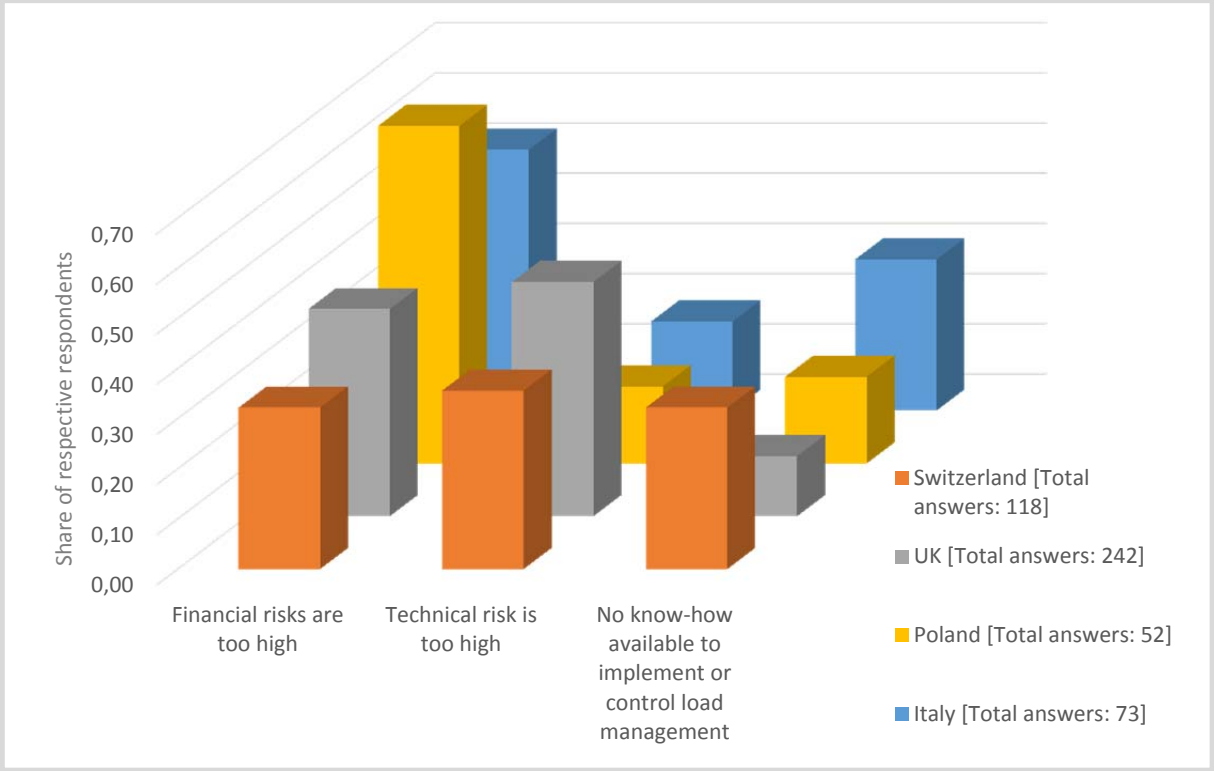

Figure 8 Share of respondents giving reasons why DSM is not seen as option (in relation to the total number of answers stating that risks are too high, displayed in the legend of the graph).

Warren et al. stated in 2013 in their review of demand-side management policy in the UK that *it is clear from the review that utility financial incentives and regulatory support are key determinants of the success of a DSM policy*. In order to encourage participation in DSM mostly monetary incentives are usually offered (ibid.). Therefore, participants were asked, which kind of incentives they would expect if participating in DSM. Although for some countries, only few companies had a clear expectation, it is surprising to see that a majority of the respondents are willing to participate in the financial risk of DSM operations (see Figure 9). By asking for a fixed share rather than a fixed fee for participation in DSM, the DSM operator or aggregator can transfer parts of the financial risk associated with the DSM offering to the client. Only in Italy, the interest in a fixed fee is higher as compared to receiving a fixed share of the revenues.

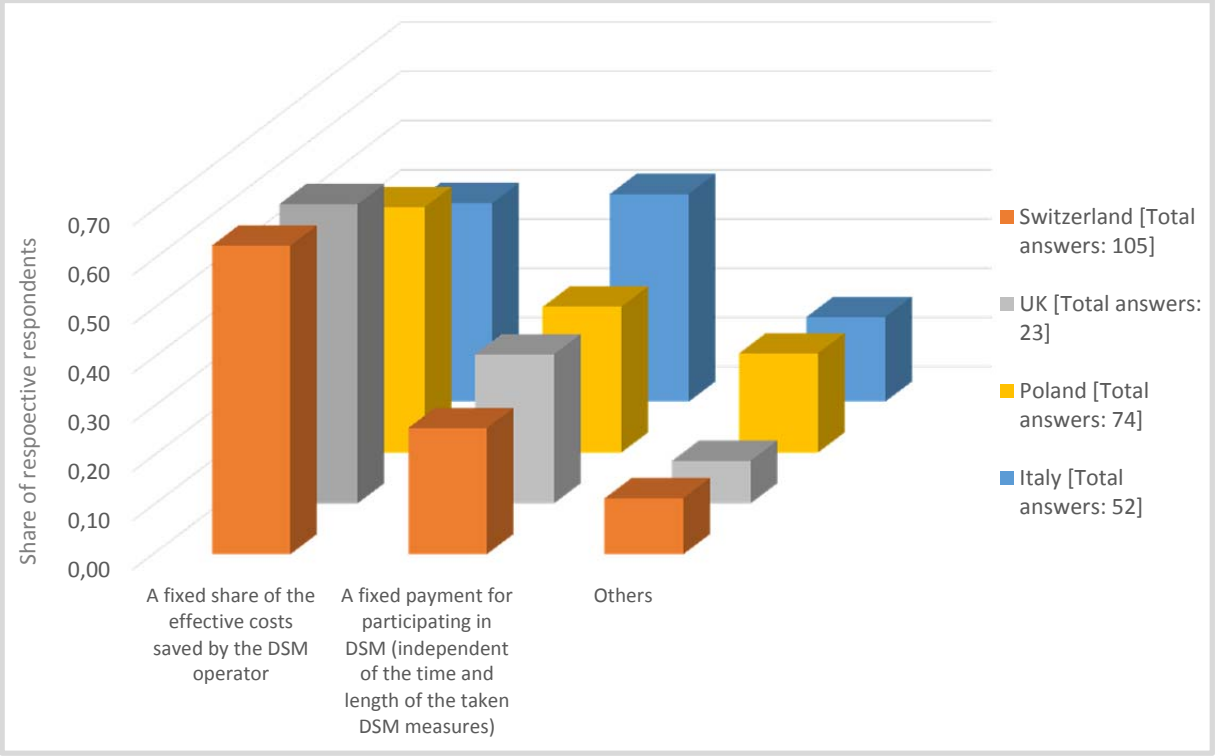

Figure 9 Share of respondents stating their preferred revenue scheme for DSM (with either a fixed share of saved cost by DSM or a fixed payment for the participation of DSM. Number in brackets in the legend is the total number of respondents for this question).

Requesting a fixed share of the costs saved would leave the companies more freedom to handle appliance operation, and might spark yet more interest in investing in energy conservation to save costs in the long term. A fixed payment for participating in DSM would not create any of such motivation, rather binding companies more to the specificities of DSM operations defined by the operator. Other companies don't agree with either and offered suggestions of their own, which are not discussed further.

In addition, compared to the effectively used remuneration schemes for DSM, the expectations are strongly deviating. Although the number of companies already today participating in DSM is small (see Figure 6), some indications can be used for further discussion. Although on small numbers, the fixed payment scheme seems to dominate besides other- more individual schemes (see Figure 10). Only in Switzerland with 8 out of 21 respondents, a large share of DSM participants is receiving a fixed share of the effective costs saved. In the UK and Poland, more companies receive a fixed amount of money for their participation in load management.

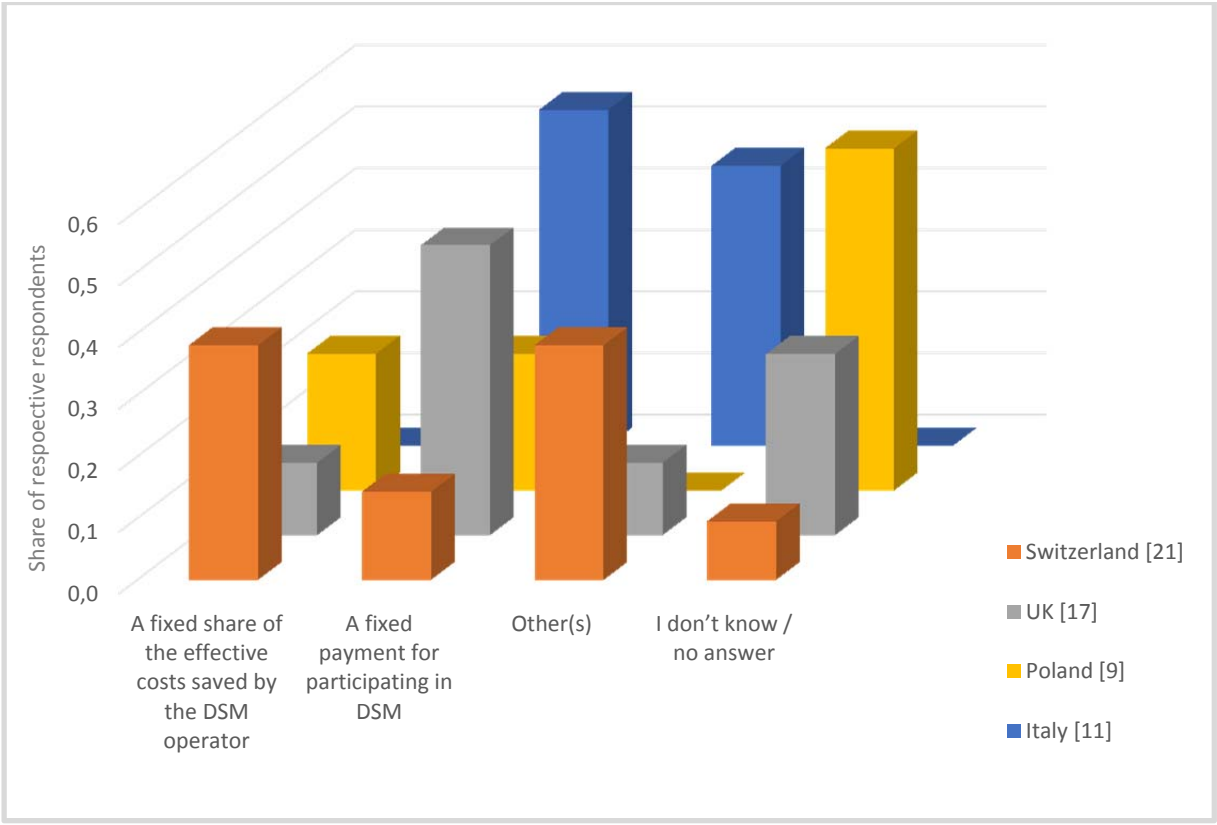

Figure 10 Share of respondents which effectively received remuneration (system with either a fixed share of saved cost by DSM or a fixed payment for the participation of DSM. Number in brackets in the legend is the total number of respondents for this question).

To estimate the future potentials of DSM, it is of high interest which appliances are operated in the different companies and in which conditions these appliances are operating. Therefore, respondents were asked, which appliances they operate and if they would allow for external control.

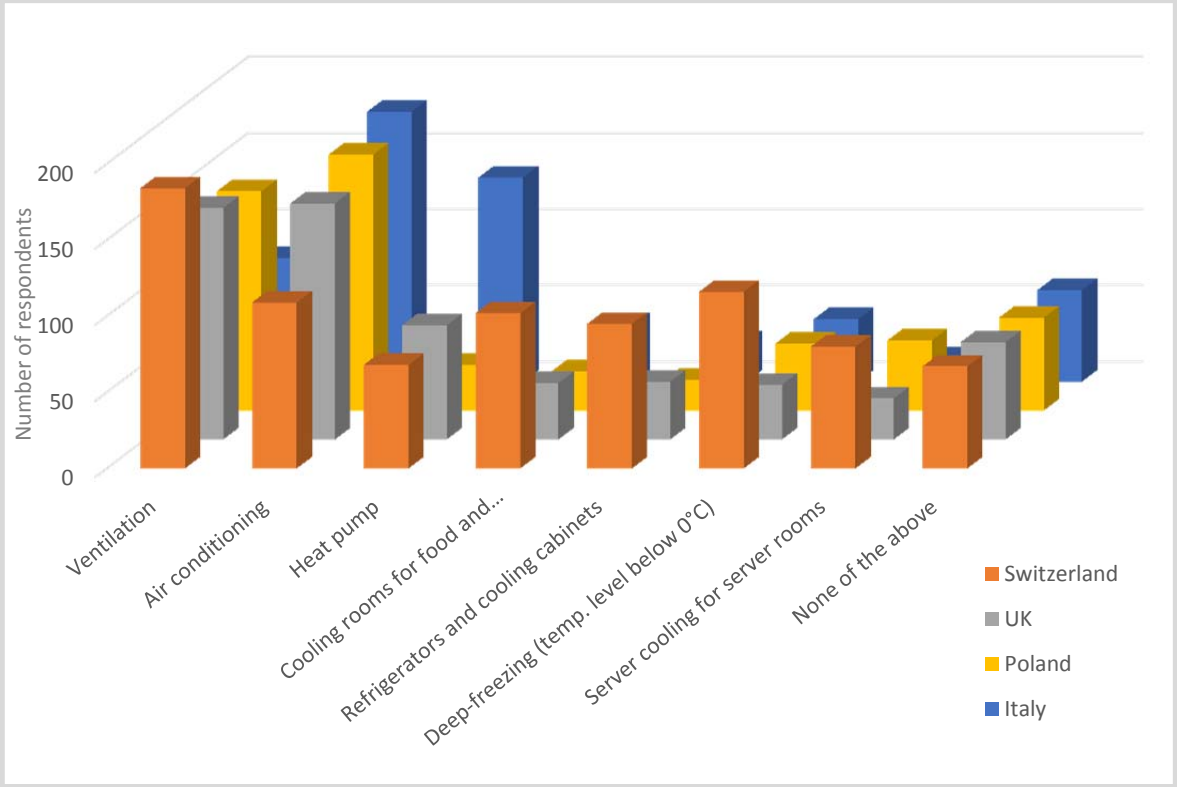

Figure 11 Effective numbers of different appliances installed in the four countries (multiple answers allowed).

Depending on the sub-sectors, some service specific appliances are installed but also other service-overlapping appliances are available and even in higher total numbers (see Figure 11). All of the above-mentioned appliances are grid connected with a reasonable installed capacity and therefore interesting for DSM operations in general terms. According to the survey, ventilation and air conditioning are the most commonly installed appliances. Depending on the specific conditions on site, these appliances offer flexible load shifting potentials for upward and downward flexibility (Michaelis, et al., 2017).

Respondents were asked about the age of the installed equipment to better understand the potential development of increasing DSM options. It is expected that equipment which has not yet reached the end of life, will not be replaced in the short term. Moreover, companies are usually not ready to update new appliances shortly after installation, with the aim of keeping the system simple and additional configurations are supposedly time consuming and not always cheap to deal with. On the other hand, equipment which is already at the end of lifetime or beyond, offers the potential for fast introduction of DSM ready appliances. It is found that the age distribution varies strongly between countries (see Figure 12).

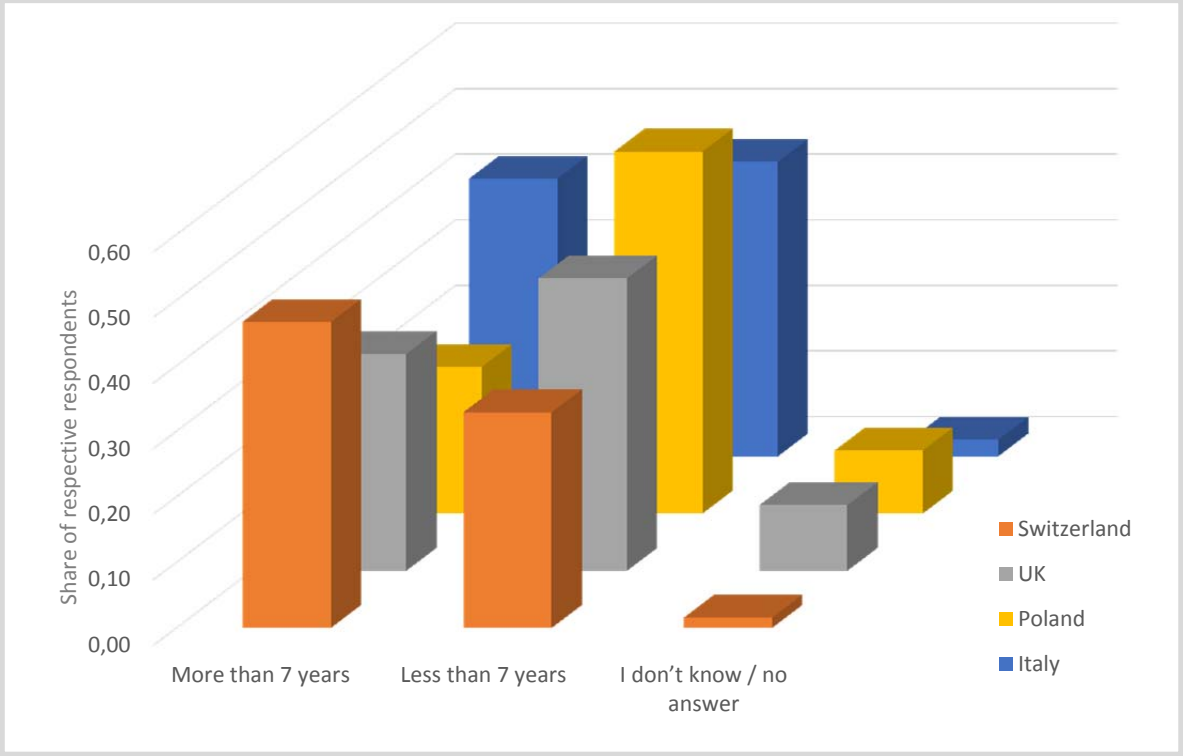

Figure 12 Share for age distribution of installed equipment on site.

Poland shows the highest share with equipment younger than seven years and therefore, additional flexibility from such installations in the coming years is expected to be limited. On the other scale, Switzerland shows the highest share of equipment older than seven years and therefore one can expect a faster growth rate of DSM ready appliances in case such equipment is available at the market at reasonable costs.

By asking about the decision processes and the purchasing structure of energy and the related topics within companies (see Figure 13) one tries to better understand the relevance of associated costs.

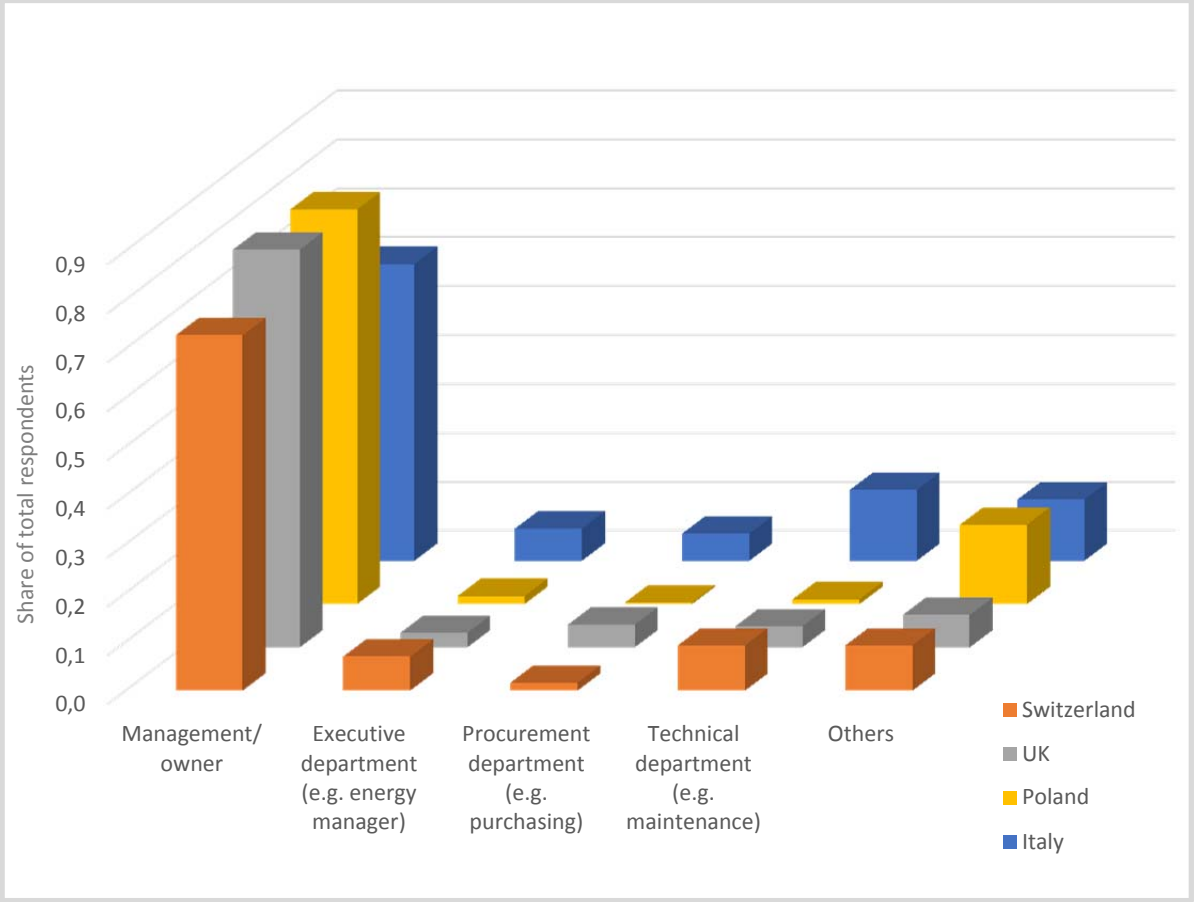

Figure 13 Share of respondents defining where the responsibility for energy management lies within each company.

The large majority of companies manage their energy administration at the highest decision level (exec. management or owner). Depending on the size of the company this is offering fast decision processes (e.g. small companies) or rather low relevance in case of large companies if no specific departments are responsible. Specialist with direct connection to energy demand and costs are usually more oriented towards new and innovative systems (i.e. DSM) and therefore more open to incorporating such flexibility options (Klinke, Reiter, Farsi, & Jakob, 2017).

Given this overview and comparison of responses between countries, we will describe country specific results in more detail in the following. Depending on the sub-sectors and distribution of respondents from the sub-sectors the answers vary strongly between countries. However, these differences are the base for the adjustment of model input for other countries considered in the REFLEX model exercise.

1.3.2.United Kingdom

Companies were asked for their average surface size used which is relevant to provide their specific services. For the UK the available data is almost equally distributed between companies with surfaces below 800 m^2 sales surface (in total 40) and above (in total 47) (see Figure 14 for companies with one or more than one site).

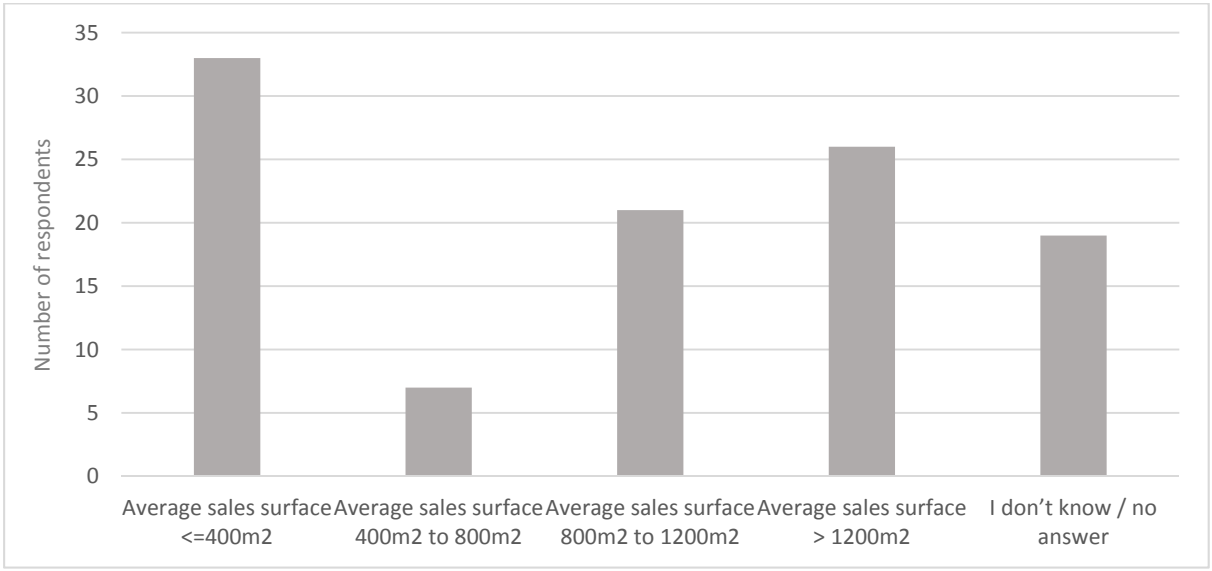

Figure 14 Number of respondents specifying their average **sales area**, which is heated and/or cooled and used for providing services but not open areas, measured at the work locations in the UK.

For other sectors, the distribution of space used for providing services is not as equally distributed as in the trade sector. For office type companies, a majority of the companies (in total 84) is using less than 800 m^2 whereas only 37 % (in total 50) respondents occupy more than 800 m^2 office space.

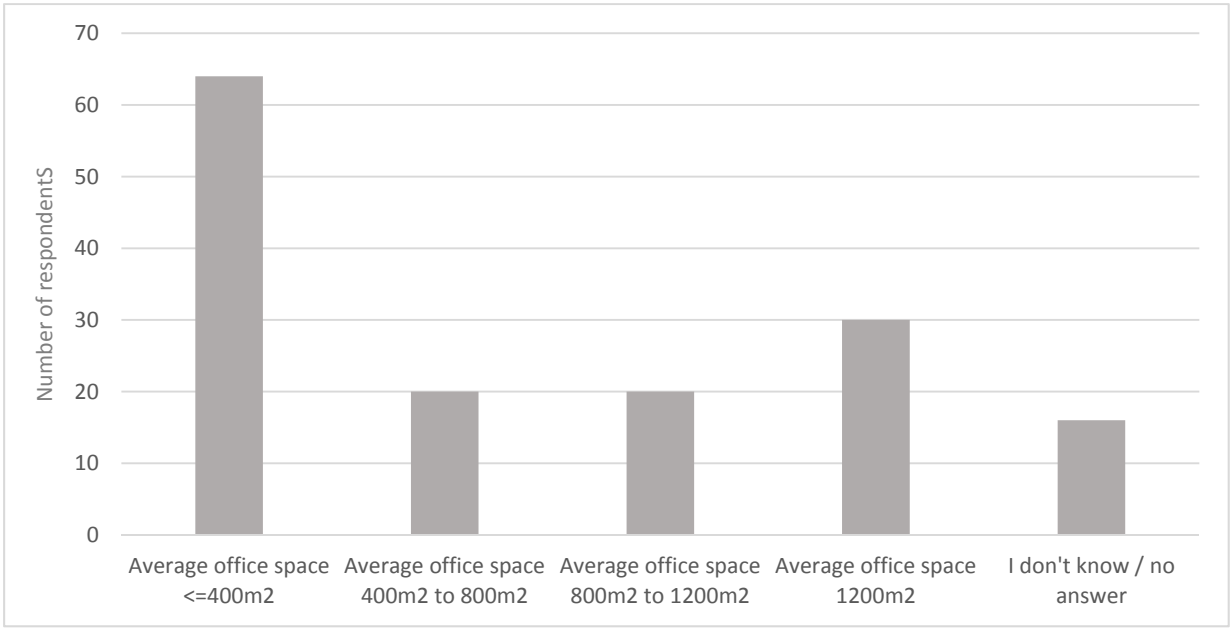

Figure 15 **Office space**, which is heated and/or cooled and used for providing services but not open areas, measured at the work locations in the UK.

The annual electricity demand is a good indicator to analyse the importance of energy demand and DSM in terms of potential for future improvements. As the Figure 16 illustrates, most of the companies (or 70 % of the UK respondents specifying demand) use less than 100 MWh electricity per year. However, a large share (31 % of the total UK respondents) does not know the approximate energy demand of the company on site. As the selected respondents are the ones responsible for energy topics within the firm according to their own statements, these figures are somewhat surprising. If basic information on energy is not easily available for a reasonable number of companies, this indicates that the importance of energy related issues is low within the company and therefore, more information is needed to raise awareness for topics such as energy efficiency and DSM.

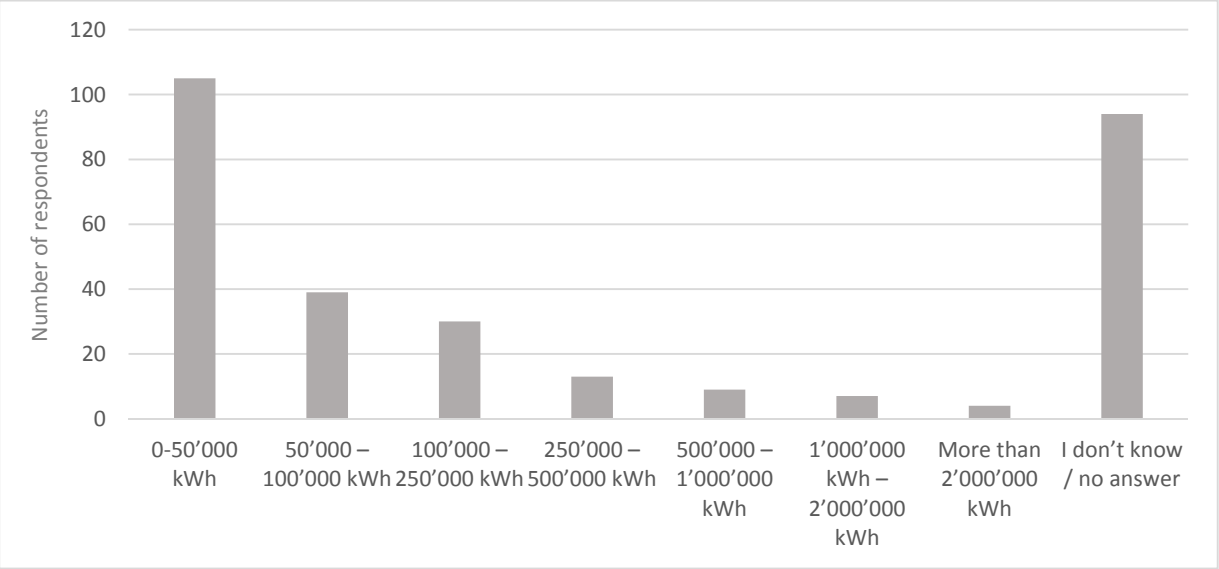

Figure 16 Number of respondents defining electricity demand for 2016 in the UK.

From the 17 companies already today participating in DSM measures in the UK, seven companies use less than 100 MWh electricity per year. Four companies consume between 100 and 250 MWh per year and five companies above 500 MWh (with two companies not knowing how big their electricity consumption was). Therefore, first movers seem to exist also with small energy demands (below 100 MWh) which are interested in adopting DSM.
In line with the findings on electricity demand and independent of the size of the companies (cross-sector), only few companies use an energy management system as of today (see Figure 17). Additionally, approximately 70 % of the respondents state that the company does not plan to implement such system in the coming year.

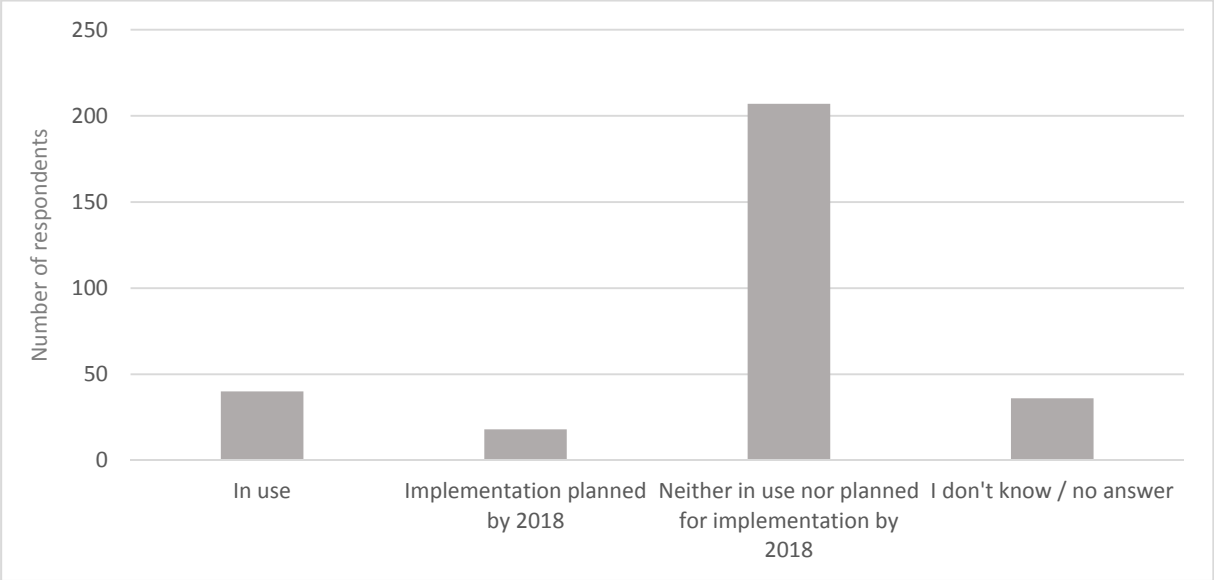

Figure 17 UK companies to plan on implementing energy management systems by 2018.

Also included in the survey was the possibility to state personal suggestions of what other technologies the respondents consider as important to be included in load management. The most frequently named by 13 companies in the UK were computers and printers, and three companies added uninterruptable power supply systems (UPS). These answers are interesting to see, since such technologies are usually not foreseen for DSM use due to their main functionality and operational hours.

Additionally, respondents were given the opportunity to name three crucial criteria for the decision-making of whether to invest in energy efficiency or in generation of energy for their company. In the UK, by far the most commonly named factors were the saving potentials (being named 245 times) and closely followed by the price of such energy efficiency investments (being named 217 times). As companies stated that efficiency investments are hardly foreseen for the coming years, it is somewhat surprising since energy efficiency improvements often are economic feasible, even with low to medium depreciation periods.

1.3.3. Italy

Companies were asked for their average surface size used which is relevant to provide their specific services. For Italy, the share of companies with small sales areas below 800 m^2 (in total 50) is dominating compared to companies with sales areas above 800 m^2 (in total 20) (see Figure 18 for companies with one site).

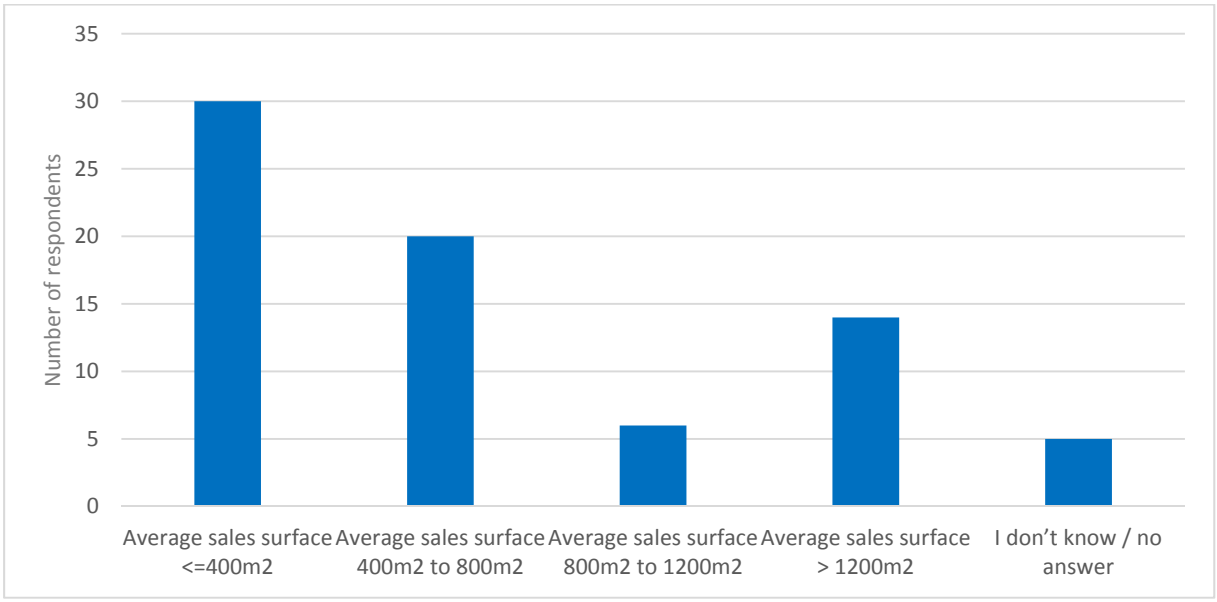

Figure 18 Average **sales area**, which is heated and/or cooled and used for providing services but not open areas for companies in Italy.

For office buildings, the distribution of space used for providing services is even more unequally distributed. For office type companies, a majority of the companies (in total 141) is using less than 800 m^2 whereas only 6 % (in total 9) respondents occupy more than 800 m^2 office space (see Figure 19).

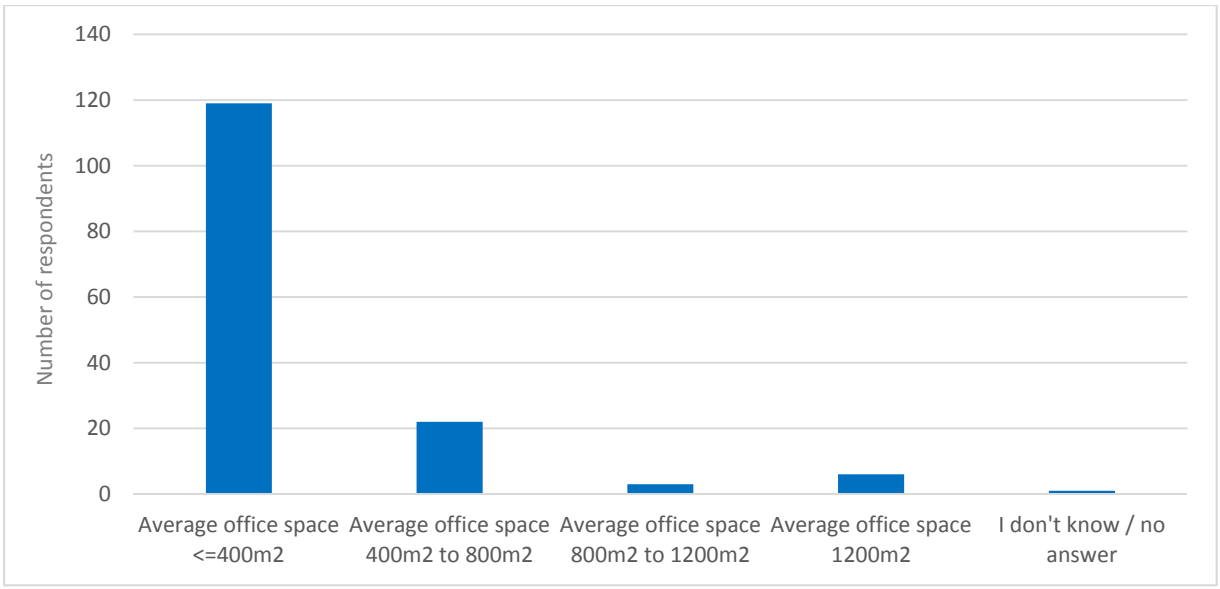

Figure 19 Number of respondents defining average energy reference area of **office buildings**, which is heated and/or cooled and used for providing services but not open areas for companies in Italy.

The companies with less than 100 MWh electricity demand per year dominate in the survey, representing 84 % (in total 231 respondents) of the sample size considering only companies stating their electricity demand (see Figure 20). The share of companies not knowing their electricity demand is approx. 10 % of the total number of respondents.

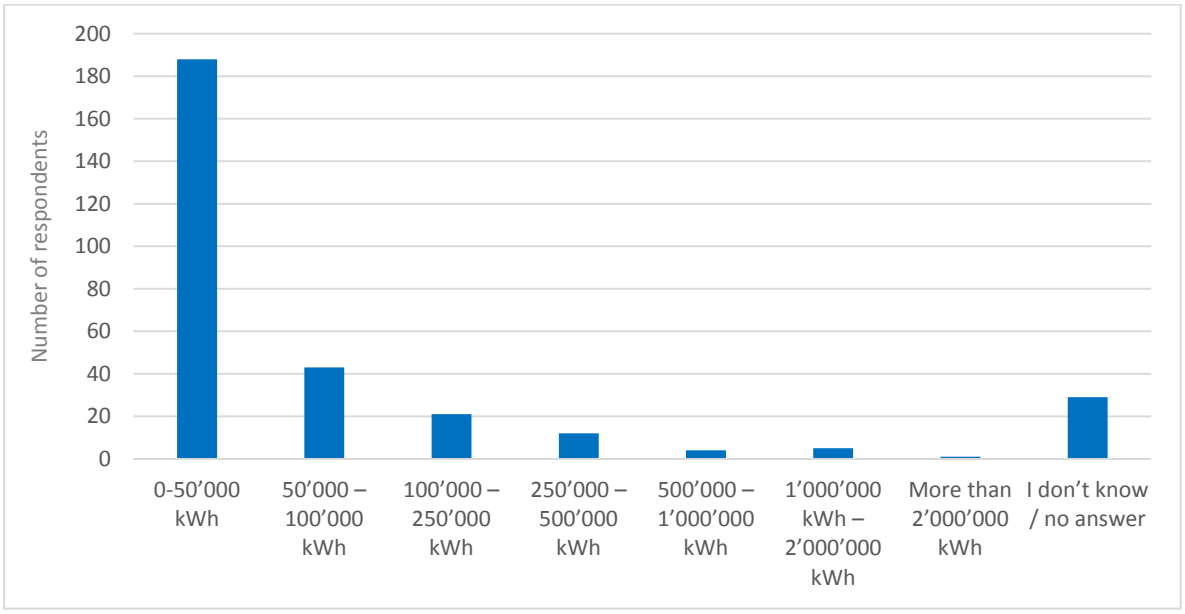

Figure 20 Number of respondents defining electricity demand for 2016 in Italy.

In Italy, eleven companies already participate in DSM as of today. From these eleven companies, eight have an energy demand of less than 100 MWh per year and can therefore be considered as small energy consumers. As in the UK, these companies seem to be early adopters of such market options, since the effective gains seem to be relatively small and energy does not seem to be of major relevance (see Figure 21). Only two companies with an energy demand between 100 MWh and 500 MWh also participate in DSM (one company did not state the effective electricity demand but is participating in DSM).
The large majority of companies in Italy does not have a plan as for 2018 to tackle energy management systems; once again leaving the opportunity to implement DSM.

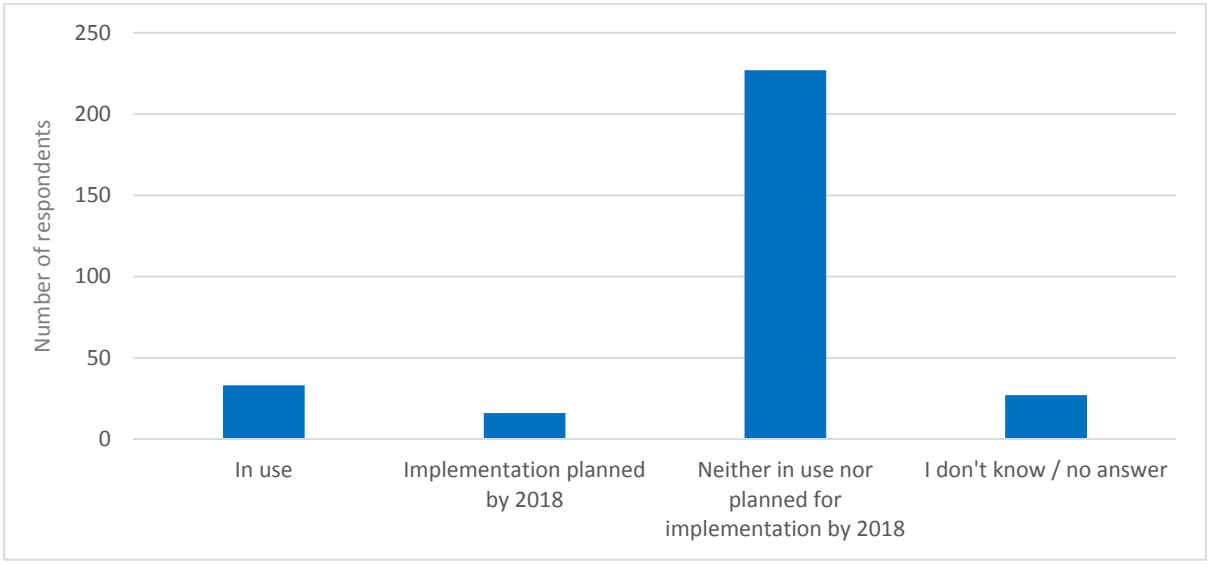

Figure 21 The distribution of Italian companies to plan on implementing energy management systems by 2018.

1.3.4.Poland

Companies were asked for their average surface size used which is relevant to provide their specific services. Concerning Poland, the share of companies with small sales areas below 800 m^2 (in total 58) is dominating compared to companies with sales areas above 800 m^2 (in total 17) (see Figure 22 for companies with one site).

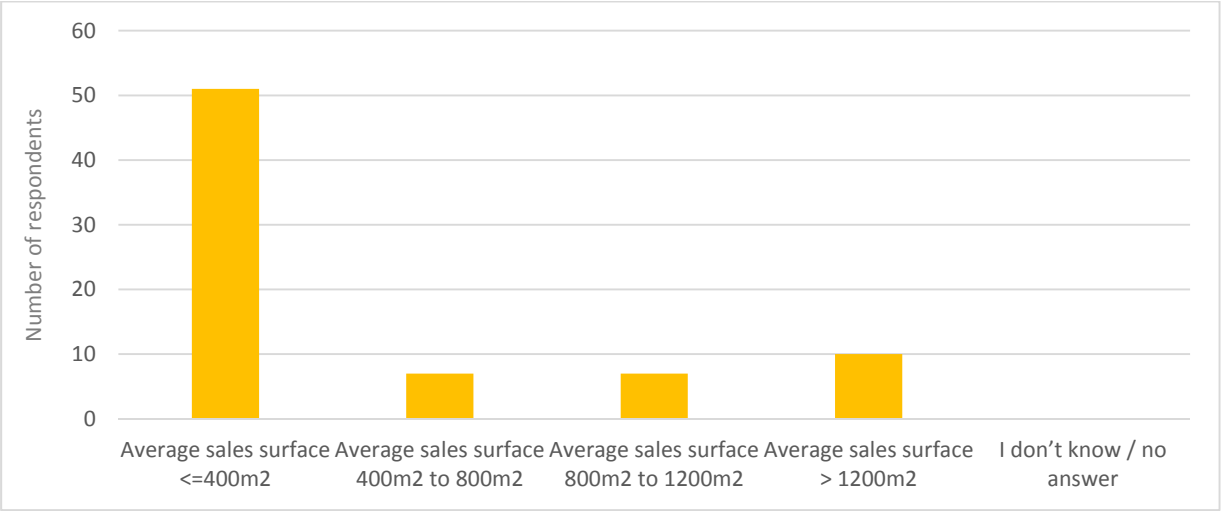

Figure 22 Average **sales surface** as reference energy area in Poland.

Relatively speaking, Poland's companies in perspective with the companies of the other countries, the Poles have the smallest offices per company. Almost 70 % have a smaller reference area than 400 m^2 (see Figure 23).

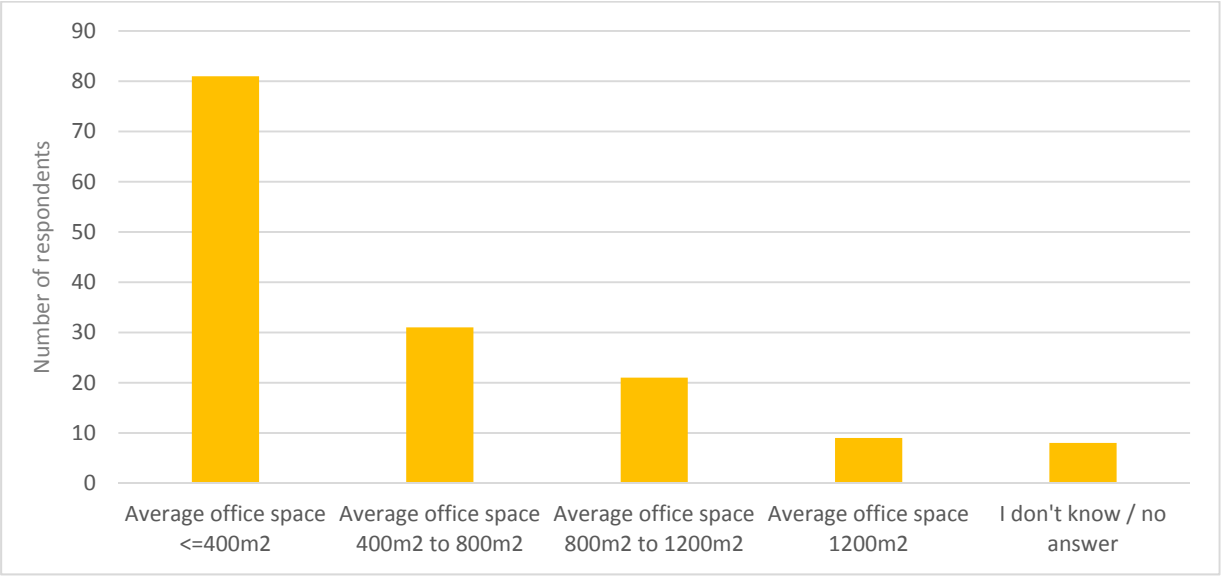

Figure 23 Average energy reference area of **office buildings** in Poland to be heated and/or cooled and used for providing services.

The companies with less than 100 MWh electricity demand per year dominate in the survey, representing approximately 90 % (142 companies in total) of the sample size (see Figure

24). However, more than 50 % of the respondents did not know their approximate annual electricity consumption expressing a low interest in such information.

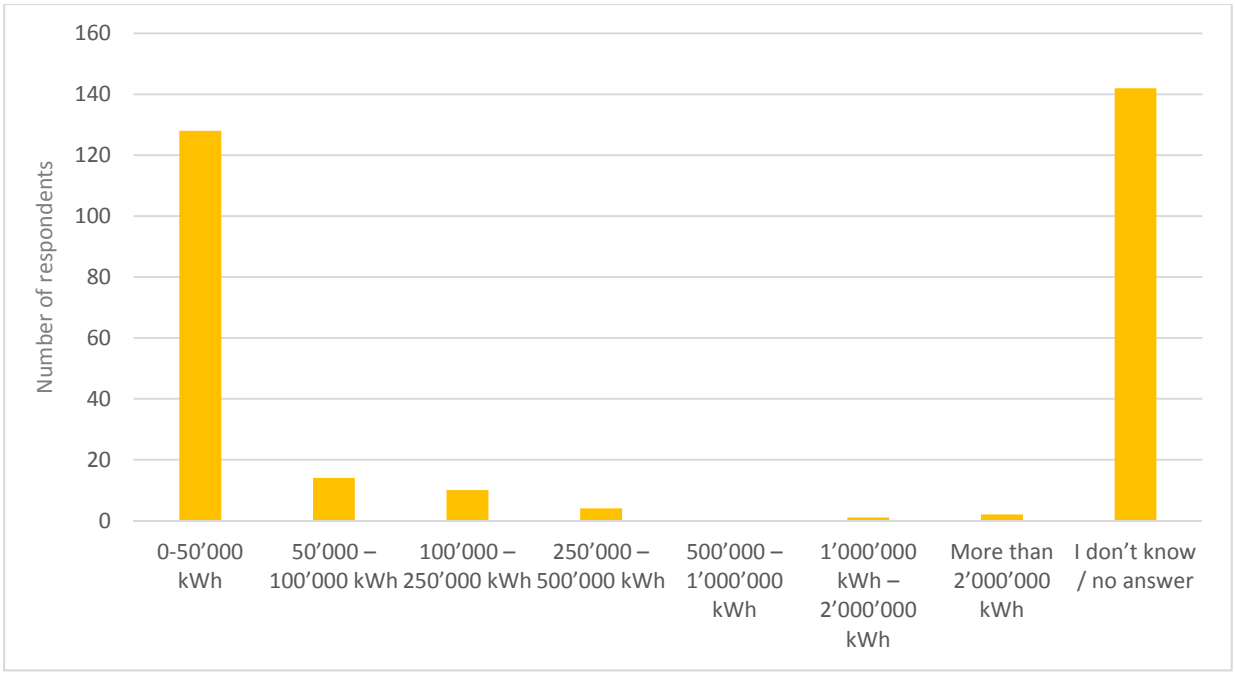

Figure 24 Number of companies defining their electricity demand in 2016 in Poland.

In Poland, nine companies already participate in DSM as of today. From these nine companies, four have an energy demand of less than 100 MWh per year. Only one company specified an energy demand between 100 MWh and 250 MWh and one company an electricity demand of 1-2 GWh also participating in DSM (three companies did not state the effective electricity demand but are participating in DSM). As in the other countries, energy and electricity demand do not seem to be of high relevance for the survey participants, since a majority has no energy management system implemented (see Figure 25).

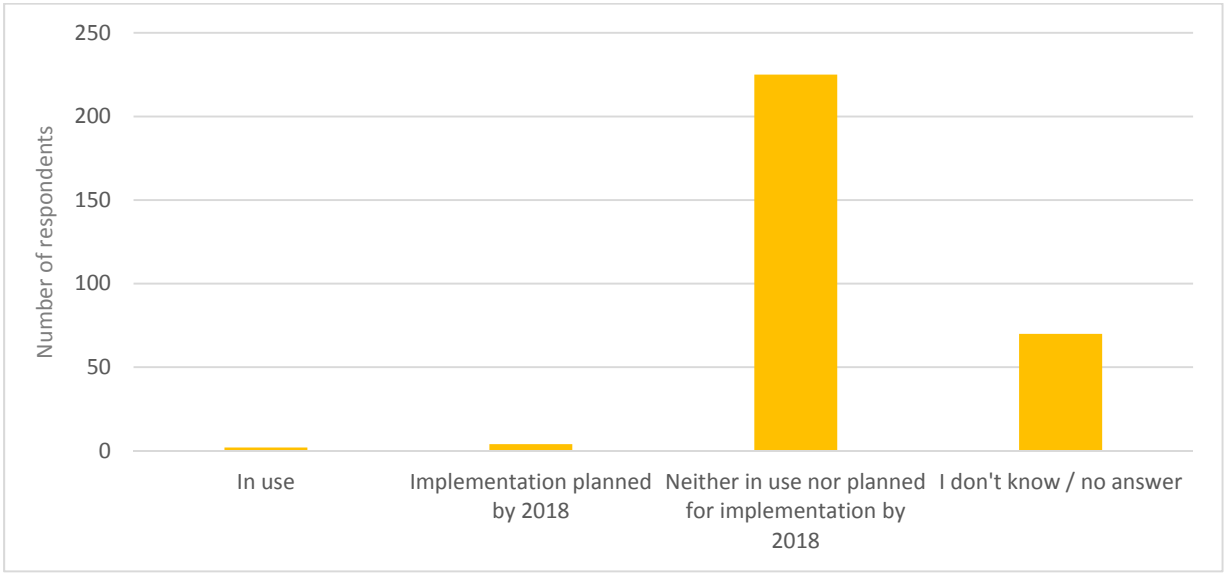

Figure 25 The share of Polish companies to plan on implementing energy management systems by 2018.

The low interest in energy management systems in Poland also corresponds to the information given on the annual electricity demand. Since less than 50 % of the companies know about their approximate electricity demand, energy related topics seem to have low priority.

1.3.5.Switzerland

Companies were asked for their average surface size used which is relevant to provide their specific services. Concerning Switzerland, their answers have been more diverse than those of other countries. The share of companies with small sales areas below 800 m^2 (in total 44) are slightly dominating the number of companies with sales areas above 800 m^2 (in total 30) (see Figure 26 for companies with one site).

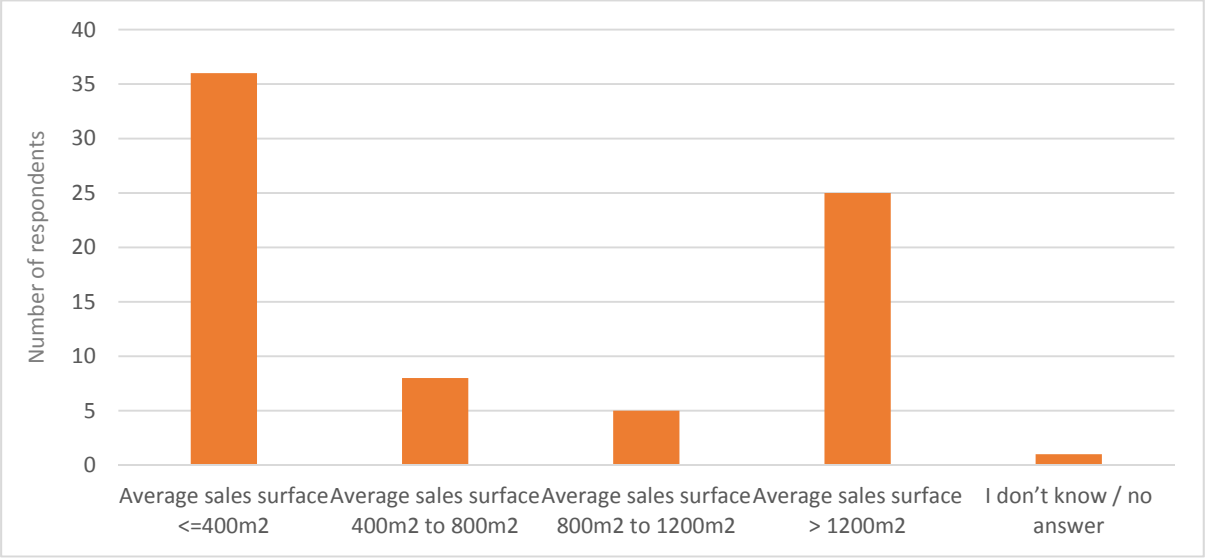

Figure 26 The total **sales area** in Switzerland.

Concerning office buildings, the distribution of space used for providing services is not as unequally distributed as in companies based in other countries. For office type companies, the majority of the companies (in total 108) is using less than 800 m^2 whereas a fourth (in total 39) of all respondents occupy more than 800 m^2 office space (see Figure 27), which is much more than those of other countries. To put it in perspective, that is six times more companies than the numbers of companies in Italy.

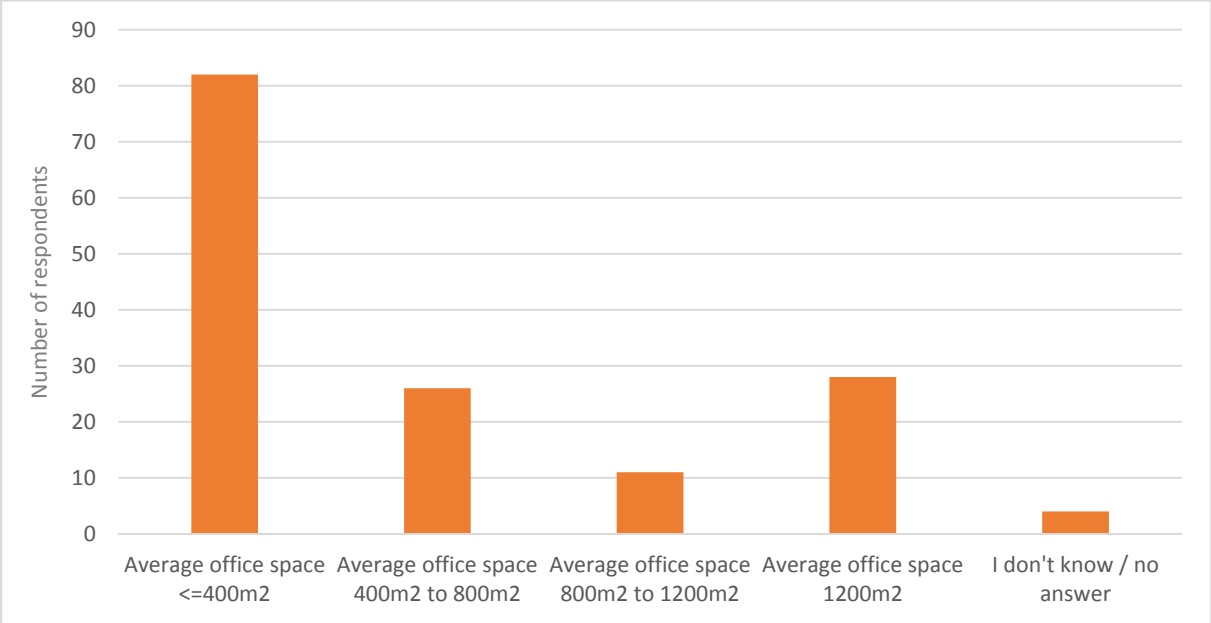

Figure 27 Average energy reference area of **office buildings** in Switzerland to be heated and/or cooled and used for providing services.

Although being much more evenly distributed than other companies, those with less than 100 MWh electricity demand per year dominate in the survey as well in Switzerland, representing 46.8 % of the sample size (see Figure 28).

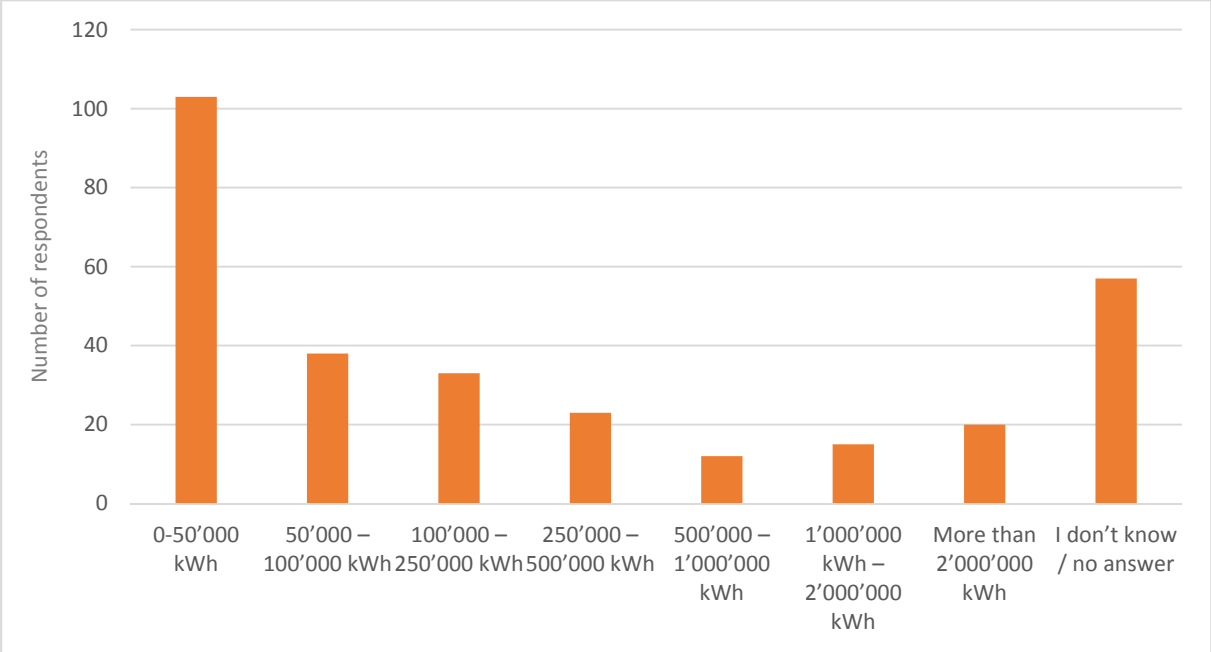

Figure 28 The electric demand in 2016 in Switzerland.

In Switzerland, 21 companies already participate in DSM as of today. Of these 21 companies, seven have an energy demand of less than 100 MWh per year. Four companies participating in DSM use between 100 MWh and 2 GWh of electricity and five companies need even more than 2 GWh of electricity per year (five companies did not state the effective

electricity demand but are participating in DSM). Therefore, different market options seem to be available and addressed, giving various opportunities to participate in DSM in Switzerland. Additionally, a slightly higher share of 12 % of the companies (or 33 of 272 respondents) state that they use an energy management system as of today. However, also 226 companies state that they not plan to implement such system in the coming year, leaving space for improvement.

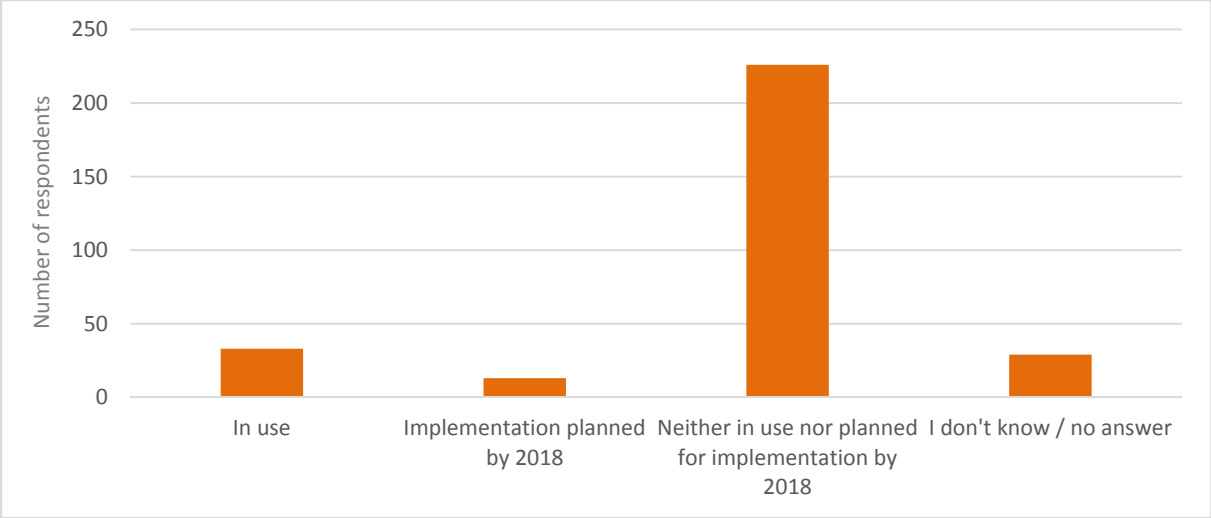

Figure 29 The number of Swiss companies to plan on implementing energy management systems by 2018.

Swiss companies suggested the following appliances to be implemented in load management, which hadn't been mentioned during the survey yet: elevators, photovoltaic and laundry appliances.

The decision-making factors for investing in DSM in Switzerland were more evenly distributed than the ones already mentioned by companies in other countries. Unlike the others they stressed the assurance of security of the company and the time demand of amortisation. Additionally, they emphasized the importance of a balanced cost-income ratio following an investment (being named 94 times) as well as the earnings statement (being named 106 times). Unexpectedly, many claimed their motivation to be purely of having a good consciousness about a clean and healthy environment.

1.4. Summary

According to the figures there is a high potential for the introduction of energy efficiency measures and energy audits in the surveyed countries. The major shares of companies did not conduct energy audits in the last three years and is not interested in implementing energy management systems. Meanwhile 30-40 % of the companies do not plan to invest in energy efficiency in the coming years. Altogether, the interest in optimising and reducing electricity cost seems to be fairly low, although large-scale electricity consumers are reflected in this survey.

Regarding DSM, the current chosen tariff structures do not allow for load management to be implemented yet. This is partially expressing the low interest of companies to participate in DSM measures but is likely to be correlated with the low rate of high resolution electricity measurement needed for DSM. Except for Italy, where the installation rate of smart meters is high, most of the countries did not force a general roll out for smart meters. Therefore, utilities and the regulator need to adapt further to offer more flexible tariffs based on hourly or sub-hourly metering, investing the necessary resources in upgrading metering infrastructure. Additionally, the companies must adapt to more flexible tariff structures, which is risk related and could hence represent an obstacle to companies interested in DSM.
Few companies already today participate in DSM measures and even more, also small energy consumers use such options. Therefore, a potential for spill overs exist to introduce DSM in the services sector.
However, the financial as well as technical risk implications play a crucial part in the implementation of load management. In each of the surveyed countries, these risks were stated most frequently, showing the need for specific risk mitigation options.

1.5. Conclusion

The survey of the four countries serves its purpose as it manages to answer some of the main questions about Europe's energy efficiency measures. The survey is giving an overview on the current situation and the perceived risks and opportunities. 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 carrying out and benefiting from load management, even participating in the financial risks associated with such measures. 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 specific analyses, additional efforts are needed to provide further empirical data on different kinds of DSM aspects in the services and residential sectors.

2.Transport pattern

With reference to mobility patterns and related market potentials, data has been collected and analysed on the following transport related topics in order to support the modelling activities for usage and enhancement of the ASTRA model:

- cycling and pedestrian trips in urban areas
- car sharing mobility

Data on **cycling and pedestrian trips in urban areas** have been collected from several sources: on one hand in some countries national statistics or national mobility surveys report this information, on the other hand the EPOMM Modal Split Tool (TEMS)[2] provide the share of trips by mode for about 465 cities in Europe. Data is available for different years.
The following **Table 3** summarise the data sources analysed.

Table 3: Data sources for cycling and pedestrian trips

Country	EPOMM cities	National statistics/survey
Austria	33	Austria's GHG Inventory 2015 (background data)
Belgium	17	
Bulgaria	19	
Croatia	1	
Cyprus	n.a.	Cyprus Statistical Service. (2010). Short Distance Passenger Mobility Survey 2009
Czech Republic	13	
Denmark	14	
Estonia	2	
Finland	14	WSP Finland Ltd. (2012). National Travel Survey 2010-2011. Retrieved from www.liikennevirasto.fi
France	55	SOeS - Inrets - Insee, enquête nationale transport et déplacements 2008
Germany	165	INFRAS, & DLR. (2010). Mobilität in Deutschland 2008 - Ergebnisbericht. Bonn und Berlin.
Greece	8	
Hungary	8	
Ireland	5	
Italy	37	ISFORT. (2014). La domanda di mobilità degli italiani - RAPPORTO CONGIUNTURALE DI FINE ANNO Dati 2014. Roma.
Latvia	3	
Lithuania	12	
Luxembourg	n.a.	
Malta	n.a.	
Netherlands	36	Centraal Bureau voor de Statistiek. (2015). Personenmobiliteit in Nederland. Retrieved from http://statline.cbs.nl
Norway	51	
Poland	13	
Portugal	21	
Romania	3	
Slovakia	4	
Slovenia	8	
Spain	25	
Sweden	19	
Switzerland	6	
United Kingdom	51	UK National travel survey (2016). Retrieved from https://www.gov.uk/government/statistics/national-travel-survey-2016

[2] TEMS - The EPOMM Modal Split Tool. Retrieved from http://www.epomm.eu/tems/

Data has been elaborated in order to estimate the share of cycling and pedestrian trips at NUTS2 level. Data at city level from EPOMM has been associated to the related NUTS2 zone, integrated where required with average national values for the zones not covered by the sample. National statistics and surveys have been used to integrate and validate the values. The following **Figure 30** provides an overview of the mode share of cycling and walking among countries (estimated on average for the year 2015).

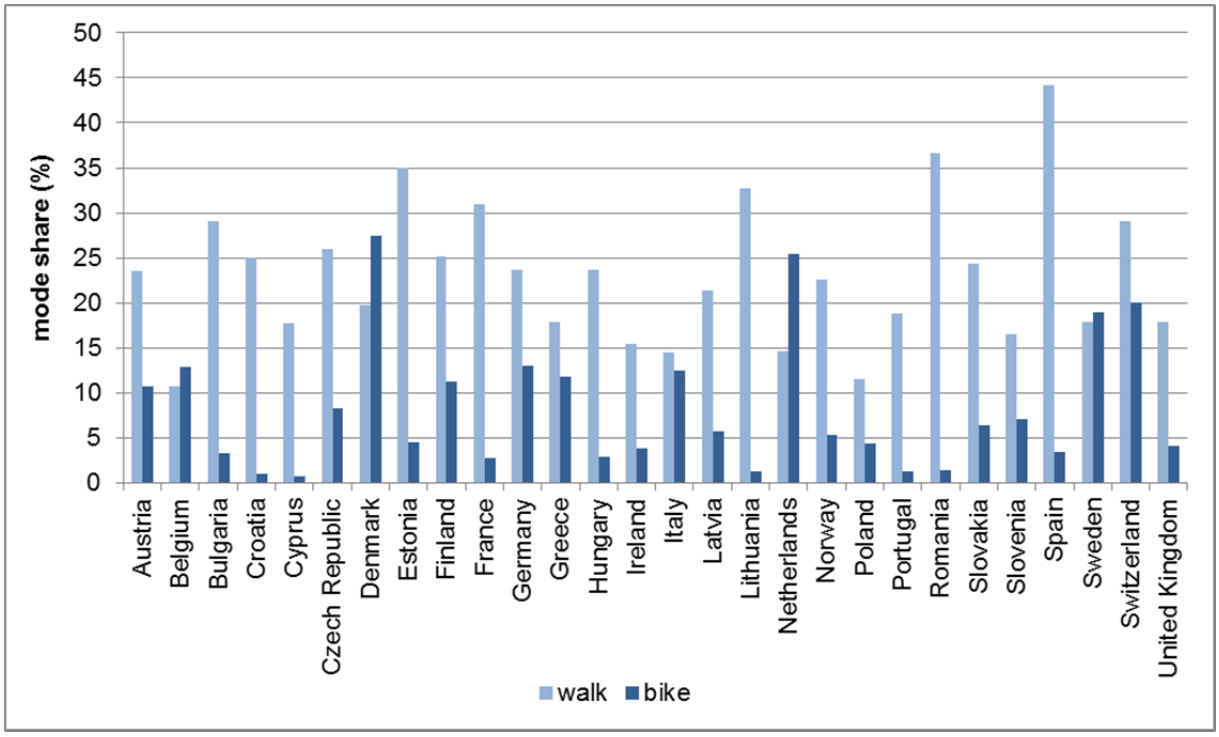

Figure 30 Average cycling and walking mode share by country in 2015.

With reference to **car sharing mobility**, data has been collected and analysed in order to identify the drivers and characteristics of this service showing increasing diffusion in Europe and worldwide.

The exponential growth of car sharing services in the last ten years is mainly due to its capability to extend the benefits of car mobility to individuals without them having to bear the cost and effort of car ownership. Bigger cities are taking advantage of this development which strongly influences traffic congestion and environmental benefits. Even though US can be considered as the pioneer of car sharing development, Europe now represents over 50 % of the global car sharing market with Germany leader in the number of shared vehicles available.

Unfortunately, this remarkable growth is not accompanied by a detail monitoring activity of car sharing development which make problematic the data collection useful to get an overview of the European situation.

In this direction several resources have been analysed: (STATISTA), (Loose, 2010), (Scott Le Vine, 2014), (Deloitte, 2017), (Fondazione per lo sviluppo sostenibile , 2016). Their findings have been merged together in order to get an overview of car sharing situation in Europe as much detailed as possible. The trend showed in **Figure 31** describes the car sharing growth in terms of number of vehicles and number of users. In 2006 the whole

Europe registered 0.2 million of users while for 2020 15.6 million of users are forecasted. First disaggregated data per country refer to 2009 (**Figure 32**) where Germany was already the undisputed leader with 137000 users and 3900 vehicles for that year.

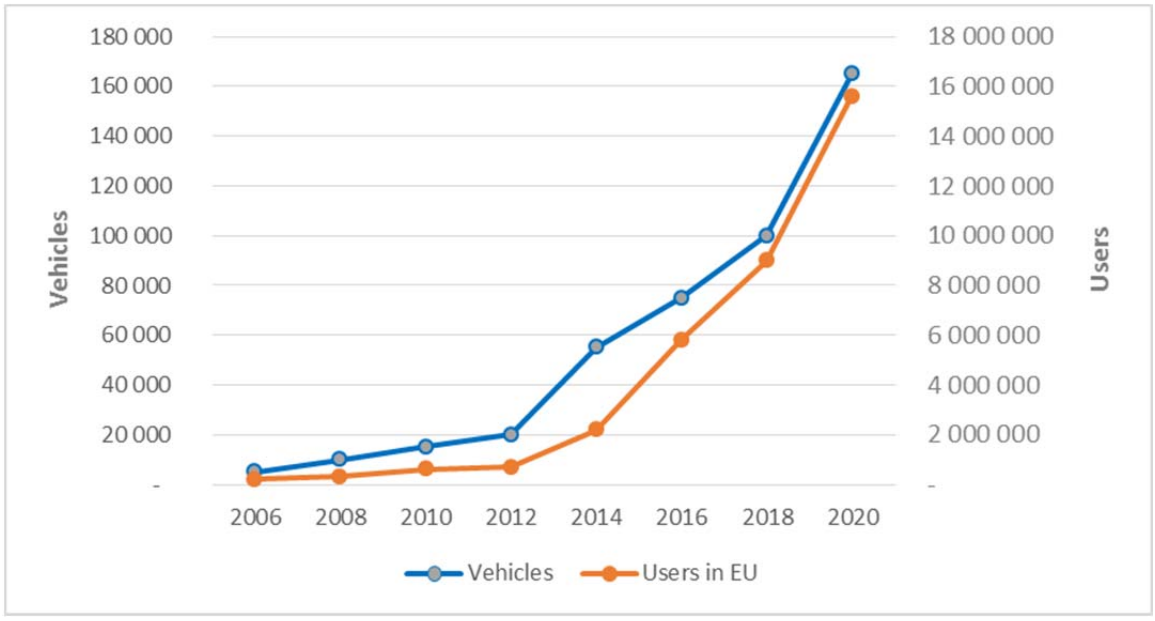

Figure 31 Car sharing trend in Europe (in numbers of total vehicles and users)

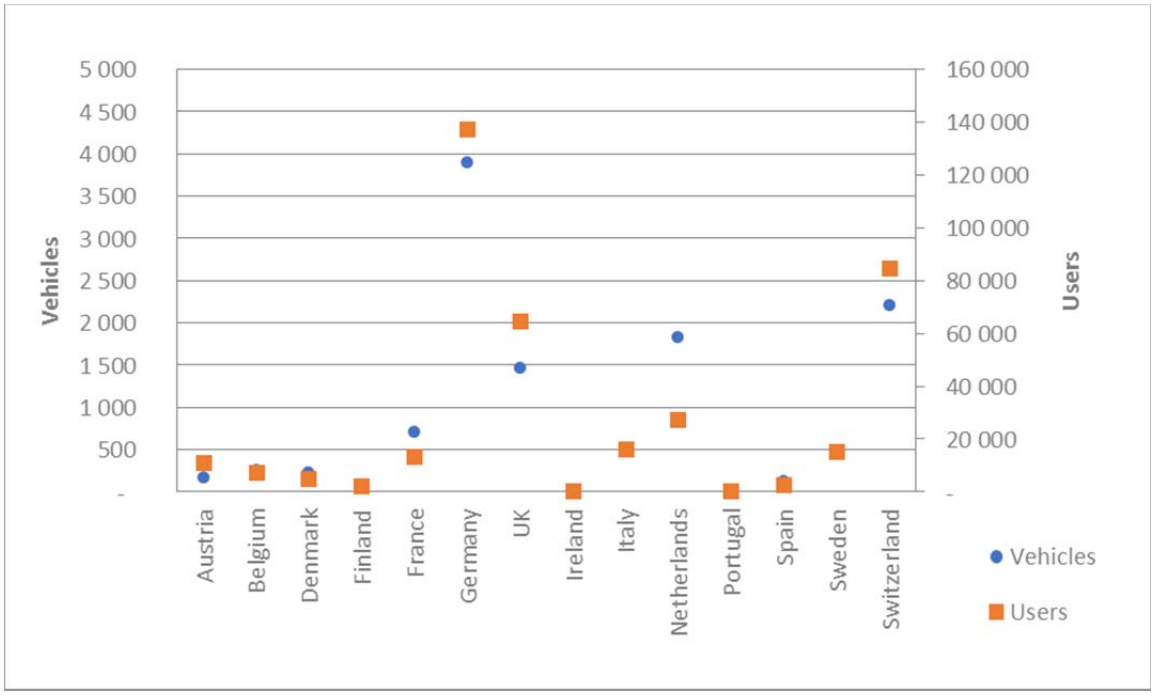

Figure 32 Car sharing in Europe in the year 2009.

In **Figure 33** it is noticeable what market power Germany has in Europe. However, from 2009 to 2014 France and Austria were the country influenced by the biggest growth with a number of vehicles in 2014 almost five times higher than the fleet reported in 2009.

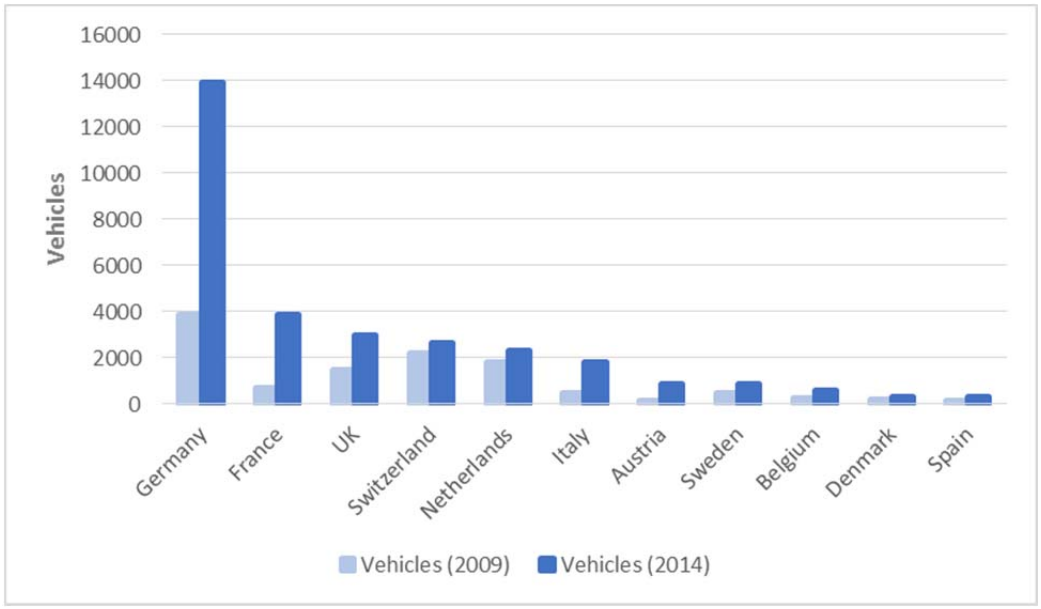

Figure 33 Car sharing vehicle fleet in Europe at 2009 and 2014.

Car sharing programs also help in reducing emissions as a reflection of reduced driving overall. In fact, car sharing members seem not to use cars as much as car owners, despite using public transportation just as much or even less than before car sharing was introduced. On the other hand, in terms of ownership different surveys found that a small but a non-trivial number of respondents either sold or didn't bother to buy a personal vehicle as a result of having car sharing system implemented in his area.

In this context data related to km-travelled and number of trips are important. An example of possible types of data have been extracted for Italy and can be found in **Figure 34** and **Figure 35** where the car sharing fleet and its usage is shown for different years. The increase of the number of rentals (from one thousand in 2011 to more than six million in 2015) was accompanied by an increase of vehicle-km (from eight million km travelled in 2011 to 50 million in 2015). Focusing on trip length, more than 60 % of these movements fall in a distance band between five and ten km. This type of data is useful to get further insights in car sharing market with the aim to understand for which purpose and at which condition car sharing can be considered a competitive mode.

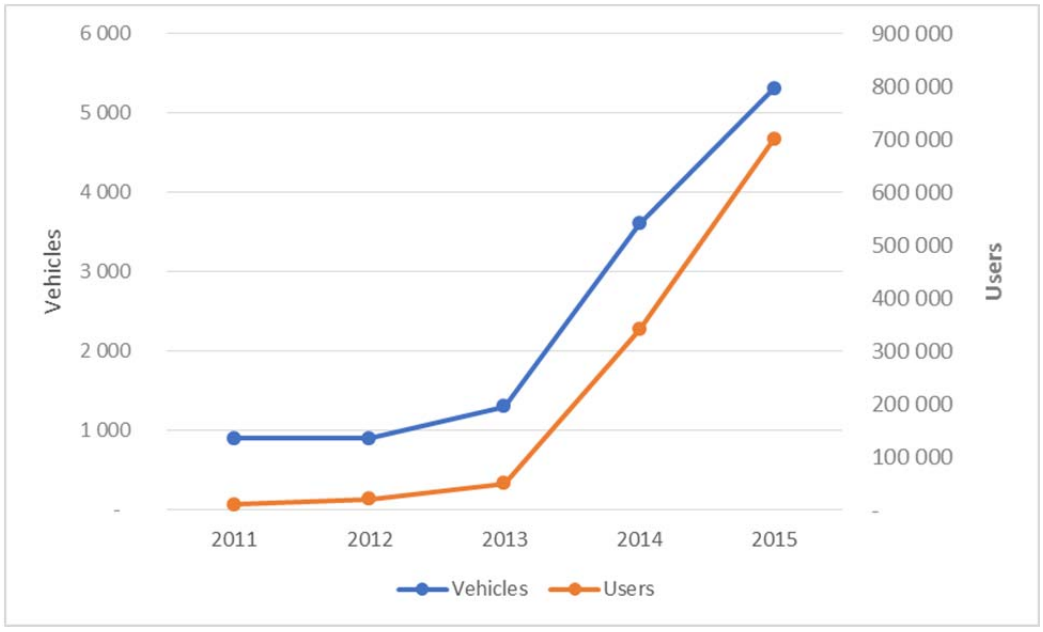

Figure 34 Car sharing trend in Italy.

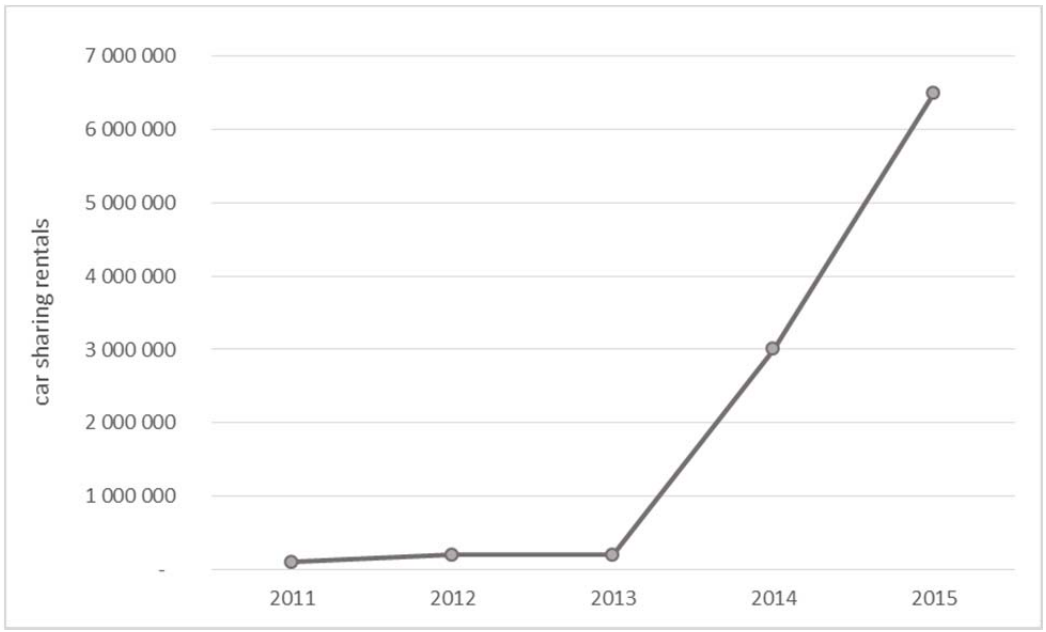

Figure 35 Car sharing rental trend in Italy.

3.Summary and outlook

With this overview on the empirical data gathered in the course of task 2.4, first insights can be provided on the addressed questions. The available data set on DSM and mobility patterns allow the modelling teams in REFLEX to update their input data set with highly relevant and up-to-data empirical data.
With reference to the mobility patterns, data collected allow to implement new features in the ASTRA model to estimate indicators for cycling and walking separately and to simulate the diffusion of car sharing mobility services. With reference to the later, data has been collected and analyzed in order to identify the drivers and characteristics of this service showing increasing diffusion in Europe and worldwide, with an exponential growth in the last ten years. Various sources have been analysed in order to collect data by country and, where possible, to identify future trends in Europe.

References

Arteconi, A., Hewitt, N., & Polonara, F. (2012). State of the art of thermal storage for damand-side management. *Applied Energy*, 383.

Behrangrad, M. (2015). A review of demand side management business models in th electricity market. *Renewable and Sustainable Energy Reviews*, 271.

Centraal Bureau voor de Statistiek. (2015). *Personenmobiliteit in Nederland*. Retrieved from http://statline.cbs.nl

CYPRUS STATISTICAL SERVICE. (2010). *SHORT DISTANCE PASSENGER MOBILITY SURVEY 2009.*

Deloitte. (2017). *Car sharing in europe: business models, national variations and upcoming disruptions .*

(2012). *European Energy Efficiency Directive.*

Fondazione per lo sviluppo sostenibile . (2016). *La sharing mobility in Italia: numeri, fatti e potenzialità.*

INFRAS, & DLR. (2010). *Mobilität in Deutschland 2008 - Ergebnisbericht.* Bonn und Berlin.

ISFORT. (2014). *La domanda di mobilità degli italiani - RAPPORTO CONGIUNTURALE DI FINE ANNO Dati 2014.* Roma.

Klinke, S., Reiter, U., Farsi, M., & Jakob, M. (2017). *Contracting the Gap - Energy Efficiency Investments and Transaction Costs.* Bern.

Loose, W. (2010). *The State of European Car-Sharing.*

Michaelis, J., Müller, T., Reiter, U., Fermi, F., Wyrwa, A., Chen, Y.-k., . . . Elsland, R. (2017). Comparison of the techno-economic characteristics of different flexibility options in the European energy system. *IEEE.*

Scott Le Vine, A. Z. (2014). *Carsharing: evolution, challenges and opportunities.*

STATISTA. (n.d.). Retrieved from www.statista.com

TEMS - The EPOMM Modal Split Tool. (n.d.). Retrieved from http://www.epomm.eu/tems/

Thies, F., Murray, G., Dong, J., & Bortolotti, M. (2014). *Mapping Demand Response in Europe Today.* Brussels: SEDC.

Warren, P. (2013). A review of demand-side management policy in the UK. *Renewable and Sustainable Energy Reviews*, 941 - 951.

WSP Finland Ltd. (2012). *National Travel Survey 2010-2011*. Retrieved from www.liikennevirasto.fi