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Demand Response Services: Economic Pre-Feasibility Model and Case Studies for Austria

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1 Abstract

With this discussion paper we want to answer the question, whether the participation at the energy balancing market could be an interesting field of business for innovative energy service provider (ESPs) and what the key parameters are to assess the economic pre-feasibility of demand side management (DSM) measures, taking Austria as an example.

This discussion paper gives an overview on the potential of demand side management in Austria, it describes the balance energy market and products relevant for demand response (DR) services. Based on that the feasibility of new innovative DSM services will be analysed using case studies of the cement industry and office buildings as case studies.

As a result of energy policy developments, with the goal to increase the share of energy production from renewables, the need for balancing of production and consumption in electricity grids has increased. Balancing energy may either come from centralized production sites, from decentralized DSM measures or distributed energy generation (both potential sources also labeled as flexibilities). The energy balancing market is highly regulated but it is open for new participants which fulfill specific technical pre-qualification requirements like minimum power, time restrictions etc. The so called "tertiary control" was selected as the most appropriate market to verify the feasibility for new business cases for ESPs.

To assess the pre-feasibility for new business models we developed a simplified DR-revenue model which is based on average prices and a DR-revenue model with product prices. Revenues are in the range of 2.500 EUR per MW and year for the case that switchable power is offered for 1 hour daily. For the case that power is offered for one product on weekdays and weekend (4 hours per day), and time slots with the highest prices are selected, revenues can go up to 24.000 EUR per MW of switchable power.

In two case studies revenues are calculated to test feasibility of the developed revenue models as well as to reveal prospects for new business models. In the first case study, 2 cement companies with a switchable power of 5 MW are modeled with the result, that revenues vary from appr. 6.000 EUR/year to 25.000 EUR/year depending on the number and duration of switchings. Case study 2 includes calculations of potential revenues for a medium sized office building with ventilation and cooling. Due to high requirements for comfort in the building, revenues are below 100 EUR/year for ventilation and 750 EUR/year for cooling.

From this pre-feasibility analyses we conclude that potential revenues for individual DR-projects are most likely not sufficient to cover CAPEX and OPEX expenses of the DR-measure, project transaction cost as well as expected financial returns for the ESP and the flexibility providers at current energy balancing market price levels in Austria.

However, business cases may turn out to be financially viable with higher capacity prices as it is the case in most economies with high energy demand

growth rates e.g. in many Asian, Arab and developing countries. Also subject to further investigations, economies of scales through project aggregation and standardization could result in a positive business case. Furthermore, investigating other capacity markets such as the secondary control with a max of 30 seconds response time may prove to be profitable.

2 Introduction

In 2008, the European Commission presented an ambitious legal package on energy efficiency, climate protection and the use of renewable resources. Broadly known as 20-20-20-goals, the European Union committed itself and its Member States to increase energy efficiency by 20%, to reduce greenhouse gases by 20% and to increase the share of renewable energy sources to 20% of total energy consumption. These goals should be achieved by 2020.

Within this context, a strong increase of renewable energy sources can be observed in Europe. This increase has significant effects on the present but even more on the future energy market.

Electricity production from wind turbines, located far-off from consumers, and from a large number of small and big sized photovoltaics sites, distributed all over Europe lead to high fluctuations in the grid and cause the necessity to transport large amounts of energy over long distances. Furthermore, uncertainties of production forecasts rise dramatically even though reliability of prediction models improve constantly. Consequently, a highly controversial discussion about dealing with these new requirements has started.

However, production and consumption in electricity grids have to be balanced all the time. Increasing shares of fluctuating supplies from renewable energy sources in our electricity networks will result in a growing demand for balancing energy, power and related services from different sources.

Balancing energy may either come from centralized energy production side, which is still dominating the balancing energy market, or from the energy demand side where demand response (DR) or demand side management (DSM) resources can stem from either distributed generators or switchable loads in various end-use sectors.

This discussion paper gives an overview on the potential of demand side management in Austria. It describes the balance energy market and products relevant for demand response services. Based on that the feasibility of new innovative DSM services will be analysed using the examples of the cement industry and office buildings as case studies.

3 Motivation and main research questions

For innovative Energy Service Providers (ESP) the participation in the energy balancing market may open up additional business opportunities that complement or even replace revenues from energy savings. However, since new business models need to draw on reliable information, several questions arise before entering the energy balancing market:

- What is the economic rationale behind balancing electricity markets?
- **What are the key parameters to assess economic feasibility as a first step to explore these options?**
- And how do such new business models comply with the existing regulatory framework?

With this discussion paper we aim to answer these question with a focus on helping ESP to conduct feasibility studies for the development of new business areas by their own. ESPs should be able to assess the order of magnitude of possible revenues, costs and relevant technical, legal, and other framework conditions.

4 Overview on the DSM potential in Austria

For Austria, only a few studies on the DSM potential exist either focusing on industry or on households. A summary of publications can be found in Moser 2015. However, the picture is still not very clear. The reason for this is the high dependency on a large number of influencing factors. Oberhofer summaries these factors which may influence the DSM potential directly or indirectly (Oberhofer 2013; adapted and translated, Fig. 1):

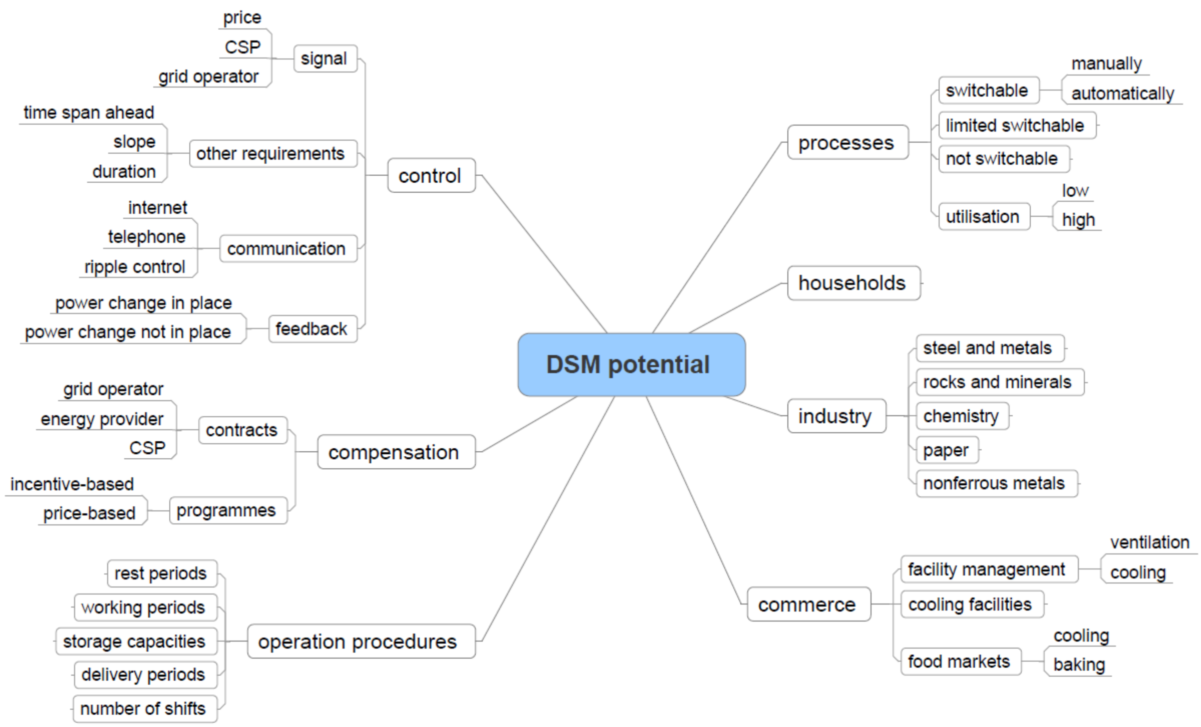

Fig. 1: Influencing factors for DSM potential (Source: Oberhofer 2013, adaptded)

Without going into details, the following Table 1 gives a rough overview on the demand response potential in Austria as a function of maximum duration of switched power. Data were taken from Berger et al. 2013, compiled by Moser 2015.

Branch	**DR potential [15 minutes]**	**DR potential [60 minutes]**
Paper and printing	68,3 MW	70 MW
Steel and metals	97,9 MW	95 MW
Nonferrous metals	20,1 MW	20 MW
Chemicals	28,8 MW	30 MW
Rocks and minerals	93,1 MW	85 MW
Wood processing	46,7 MW	50 MW
Food and tobacco	19,6 MW	15 MW
Mechanical engineering	13,1 MW	5 MW
Textiles and leather	7,0 MW	5 MW
Service sector: hospitals	115,8 MW	0 MW
Service sector: waste water treatment	6,4 MW	0 MW
Service sector: cold stores	4,9 MW	5 MW
Service sector: facility management	390,0 MW	0 MW
Total	**843,5 MW**	**380 MW**

Table 1: Demand response potential in Austria, derived from a bottom-up calculation (Source: Berger et al. 2013, in Moser 2015)

The figures reveal, that the potential declines significantly with the increase of the duration of switched power. For the development of feasibility studies for ESPs more detailed data are necessary. As this goes beyond the scope of this discussion paper, it is recommended to consider Moser 2015 and Bruyn et al. 2015 for additional references.

5 Energy balancing market

The balancing energy market is a highly regulated market, which is still dominated by a few market participants, usually big energy providers. This market is divided up into sub-segments with very specific technical requirements and market rules.

In order to balance deviations between electricity production and consumption within the control area (since 2012: whole Austria), 3 different mechanisms are in place (Fussi et al. 2011):

- Primary control, frequency containment reserves (FCR)
- Secondary control, frequency restoration reserves (FRR, further divided in automated FRR, aFRR, and manual FRR, mFRR; mFRR is procured together with RR)
- Tertiary control, replacement reserves (RR)
- (Unintentional deviation [Un.D.])

If imbalances in the electricity grid occur that lead to a variation of the 50 Hz frequency, primary control is started automatically with the aim to stop the increase or decrease of the frequency. Secondary control starts simultaneously with the primary control and replaces primary control if the imbalance exceeds 30 seconds. Secondary control brings the frequency back to 50 Hz. If imbalances are still in place after a few minutes, tertiary control is activated and replaces secondary control.

5.1 Selection of balancing market segment for ESPs

5.1.1 Technical Requirements

All control mechanisms have their own technical requirements and market-based procurement mechanisms. The following Table 2 gives an overview on the Austrian balancing energy market and selected technical requirements for the prequalification.

	Power (2013)	time until fully in place	duration		tender conditions, minimum power
FCR	+ 66 MW - 66 MW	within 30 seconds	up to 15 minutes	auto	power plants; min. +/- 2 MW (pos. and neg.)
aFRR	+ 200 MW - 200 MW	with PRL, max. within 5 minutes	50 Hz within 15 minutes	auto	power plants or other systems; +/- 5 MW (pos. or neg.)
mFRR	+ 180 MW	10 minutes		manually	power plants or other systems; from +/- 5 MW up to +/- 50 MW
RR	+ 100 MW - 125 MW	10 minutes		manually	power plants or other systems; from +/- 5 MW up to +/- 50 MW

Table 2: Prequalification according to ENTSO-E Policy 1

In a first step the technically appropriate sub-segment for ESPs was selected. As the main features for the sub-segments are the response time and a minimum level of switchable power, primary and secondary control had to be classified as not appropriate for the time being. The primary control market can only be accessed by power plants. The secondary control market is open for other systems but reaction time is very short (5 minutes) and activation is fully automated. Hence, secondary control seems not to be appropriate for starting new businesses. However, in the medium term secondary control is a very interesting market.

For all these reasons the analysis focuses on the tertiary balancing electricity market, including the reserves for the failure of the biggest power plant (manual Frequency Restoration Reserves – mFRR), which are part of the secondary control by definition but traded together with the tertiary control. due to their reduced technical requirements.

5.1.2 Energy balancing market volume

In 2014 appr. 24 mio EUR (in 2013 appr. 30 mio EUR and in 2012 appr. 20 mio. EUR) were spent for tertiary control. 65% (86% in 2013) of the costs derive from expenses for power reserves and 35% (14% in 2013) had to be spent for energy. The following Table 3 gives an overview on the volume:

[MEUR]	2013	2014
Primary control	**13,31**	**13,42**
... power reserves	*13,31*	*13,42*
... called energy	-	-
Secondary control	**124,47**	**159,55**
... power reserves	*62,84*	*40,31*
... called energy	*56,49*	*106,55*
Power plant failure reserve	**14,31**	**6,86**
... power reserves	*14,24*	*6,86*
... called energy	*0,07*	-
Tertiary control	**14,97**	**17,31**
... power reserves	*10,86*	*8,95*
... called energy	*4,12*	*8,36*
Unintended deviation	**4,81**	**5,99**

Table 3: Annual expenses for control power and energy (Source: APG)

5.2 Overview on market rules and products

5.2.1 Market rules

The balancing market is a liberalized energy market with clear market rules, which are well documented. Tendering for the tertiary control market is organized by APG (Austrian Power Grid AG) since 1.1.2012. Thus, detailled market information can be found on www.apg.at.

5.2.2 Prequalification

In a first step, tenderers have to gain accreditation as a supplier of control energy. They have to meet specified technical criteria in order to guarantee the required quality of primary, secondary, or tertiary control. However, tenderers may only participate in one of the three markets and may - in that case - prequalify only for one control energy type. Prequalification criteria are documented in the Operation Handbook of ENTSO-E Policy 1. The prequalification is valid for 3 years. Before entering the market, a Framework Agreement with detailed legal arrangements has to be signed by both partners, the tenderer (supplier of control energy) and the control area manager. This first step is completed with the registration in the tendering system (TTS) of APG.

5.2.3 Tenders for tertiary control power

All three control energy types are tendered separately with different conditions and different products.

In the tertiary control energy two products are tendered:

- Market maker, where the control power with power prices is in focus, and
- Day-ahead, where only energy prizes can be bid.

The total volume put out to tender normally is:

- +280 MW (demand exceeds energy production, e.g. in the case of a power plant breakdown),
- -125 MW (energy production exceeds demand, e.g. in the case of unpredicted wind power production).

Tenderer are required to offer blocks between 5 and 50 MW. However, blocks must not only be power plants, which still dominate the balancing energy market but also aggregates of smaller units, be it smaller production or demand units. In any case, tenderer must fulfil the prequalification requirements and have a signed framework agreement with APG.

Market maker tender

Tenders for market maker take place every Wednsday from 9.00 to 15.00 for the following weekend (Saturday and Sunday) and - in an extra tender - for the following week (Monday to Friday). 6 different product time slots can be selected. In total, 12 different products are available:

- Weekend, 0.00-4.00 (each day)
- Weekend, 4.00-8.00 (each day)
- ...
- Weekend, 20.00-24.00 (each day)
- Weekdays, 0.00-4.00 (each day)
- ...
- Weekdays, 20.00-24.00 (each day)

This means that when offering for weekdays, 8.00-12.00, offered power has to be guaranteed from 8.00-12.00 from Monday to Friday. Offers can be placed for positive or negative control power.

Furthermore, offers have to include the size of the block, a power price and an energy price.

Acceptance of bids are based on the power price, if offers have the same power price, the offer that was placed first will be given preference. Successful tenderers are obliged to hold the reserved power available for the specific product. Activation of control power has to take place only on demand of APG within 10 minutes.

Market maker offers are integrated in the merit order list that includes both day-ahead offers and market maker offers. As long as the day-ahead tender is not closed, energy price can be changed. Prices can only be reduced in case of positive control energy and it can be increased in case of negative control energy.

Day-ahead tender

Day-ahead products are tendered daily from Monday to Friday. Bidding closes at 15.00 on the previous day.

Products of day-ahead tender are identical with those of the market maker tenders, apart from being only valid for one single day. Offers consist of the size of the block and an energy price.

Acceptance of bids are based on the energy price (merit order list including offers of market makers). In case of positive control energy (additional energy production or reduction of demand necessary) the lowest energy price will win the bid. In case of negative control energy (reduction of energy production, additional demand necessary) the highest energy price will be successful.

Calling tertiary control power

All bids are ranked according to the merit order list, including energy prices from market maker and day-ahead tenders. If necessary, the bid with the lowest energy price will be called in the case of positive control power, in the case of negative control power, the bid with the highest energy price will be called. Minimum duration of control power is 15 minutes.

5.3 Empirical findings

Prices differ significantly between working days and weekends, between time slots and between positive and negative power.

5.3.1 Aggregated data (tertiary control)

In the following Table 4 the weighted average prices per time slot are displayed for the years 2012, 2013, 2014 and partly for 2015.

weighted average price per time slot [EUR/MWh]		**2012**		**2013**		**2014**		**2015 (until week 14)**	
		Mo-Fr	Sa-Su	Mo-Fr	Sa-Su	Mo-Fr	Sa-Su	Mo-Fr	Sa-Su
accepted power price	Peak +	10,77	2,54	10,00	1,60	4,78	1,14	5,50	0,62
	Off-Peak +	3,13	1,64	4,77	1,43	2,01	0,95	0,98	0,42
	Peak -	1,21	4,73	2,33	15,12	2,29	10,41	2,33	5,15
	Off-Peak -	5,25	8,82	10,45	17,88	9,29	13,52	9,91	9,59
Accepted day-ahead energy price	Peak +	n.a.	n.a.	393,21	343,81	486,73	460,28	410,47	367,82
	Off-Peak +	n.a.	n.a.	369,33	339,60	470,86	438,83	381,17	343,66
	Peak -	n.a.	n.a.	-64,26	-73,86	-124,60	-144,44	-196,41	-227,38
	Off-Peak -	n.a.	n.a.	-72,39	-74,25	-136,30	-144,83	-203,26	-215,94
Actual day-ahead energy price	Peak +	172,93	162,65	139,97	120,65	202,51	168,02	202,41	141,42
	Off-Peak +	152,03	127,77	133,44	112,12	179,48	170,58	191,27	140,29
	Peak -	1,00	3,48	-29,67	-32,79	-74,80	-76,77	-134,16	-127,12
	Off-Peak -	-8,70	-10,17	-36,19	-35,04	92,01	-73,62	-124,04	-120,49

Table 4: Accepted and actual prices for power and energy (Peak ... 8-12, 12-16, 16-20; Off Peak- ... 0-4, 4-8, 20-24; Source: APG)

In the following Table 5 costs for tertiary control are further divided into manual frequency restoration reserves (mFRR) and replacement reserves (RR) subdivided for power and energy.

[MEUR]		2013	2014	2015 (until week 14)
Total cost tertiary control market	mFRR	14,31	6,86	1,70
	RR	14,97	17,31	5,81
Total cost tertiary control market, power	mFRR	14,24	6,86	1,70
	RR	10,86	8,95	2,06
Total cost tertiary control market, energy	mFRR	0,07	0,00	0,00
	RR	4,12	8,36	3,76

Table 5: Costs for tertiary control (Source: E-Control)

A more detailed analysis focuses on the selection of time slots with low, medium and high prices for tertiary control power. This is of high strategic relevance for the development of business cases as specific switchable processes are critical in some time slots but are uncritical in others. Another dimension is the availability. For example, switchable loads are sometimes not available at weekends, since companies might be closed at this time.

average weekly price for power reserves [EUR/MWh]	Mo-Fr (+)	Sa-Su (+)	Mo-Fr (-)	Sa-Sa (-)
low [< 2]	0-4	0-24	n.a.	n.a.
medium [2-10]	4-8 12-16 20-24	n.a.	8-24	n.a.
high [> 10]	8-12 16-20	n.a.	0-8	0-24

Table 6*: Average weekly prices for 2013 (Source: APG 2014; own calculations; 0-4 … from 0 to 4 o'clock)*

It is easy to observe that positive control power (reducing loads or producing additional energy) has a high price from 08.00 to 12.00 and 16.00 to 20.00 on weekdays, but not on weekends. Negative control power (switching on loads or reducing energy production) has a high price between 00.00 and 08.00 on weekdays and the whole weekend.

Just to give a descriptive example: Considering a company that does not run on weekends, it would not be reasonable to bid for the negative control power in this time slot. Personnel would have to be available without any productive work causing unnecessary extra costs. On the other hand, if machines (loads) are running on partial loads during this time, tenders for negative control power on weekends could be of high interest. Depending on the available storage, load could be increased without any significant extra costs.

However, some additional information have still to be considered. The switching of loads may cause extra costs due to an increased demand for maintenance. Hence, the number of orders to switch loads is very low. For example, in 2013 positive control power was only demanded about 100 times, negative power only 4 times, which could be used to calculate a call-off probability for further evaluations.

6 Pre-feasibility study for new business models for ESPs

6.1 Simplified DR-revenue model with average price

In order to assess the feasibility of new business models for ESP, we subsequently develop a simplified DR revenue model of the tertiary balancing electricity market in Austria, which was selected as suitable for DR-resources, mainly due to the required maximum response times. To calculate potential revenues we have identified i) availability of DR-potentials, ii) typical capacity prices and iii) revenues from energy as main independent variables. Potential revenues can then be compared to implementation cost and for revenue sharing between end-users and ESP to assess and to pre-structure possible business models.

The simplified calculation of the potential revenue is based on average prices for capacity reserves and it assumes a switchable power of 1 MW.

Revenues consist of a capacity component (assumed power * duration of availability * capacity price) and an energy component (in case of request of power; power * duration * energy price). Based on an analysis of actual balancing energy market data for 2013 and for simplicity reasons, revenues for energy are calculated as a proportional share of power revenues.

The major independent variables are:

- Capacity price [EUR per MW*h]
- Availability of DR-potential [h per year]
- Additional revenues (e.g. from energy; calculated as percentage from revenues from power component; appr. 15% in 2013) [EUR]

Revenues [EUR per year] = **Capacity price** [EUR per MW*h] * **Availability** of DR-potential [h per year] + **Additional revenues** [EUR per year]

If we look at 2013, an average power price of appr. 6 EUR per MW and hour for positive and 9 EUR per MW and hour for negative balancing power could be gained. However, price varies to a large extent from appr. 0,50 to 17 EUR per MW and hour (weekly average capacity price, E-Control). For a first estimation of possible revenues the above formula was applied and some specific points were highlighted:

- 1 hour per week
- 1 hour per day
- 4 hours per day (1 product on weekdays and 1 product on weekend)
- 8 hours per day (2 products on weekdays and 2 products on weekend)

In the following Fig. 1 revenues for an average capacity price is illustrated:

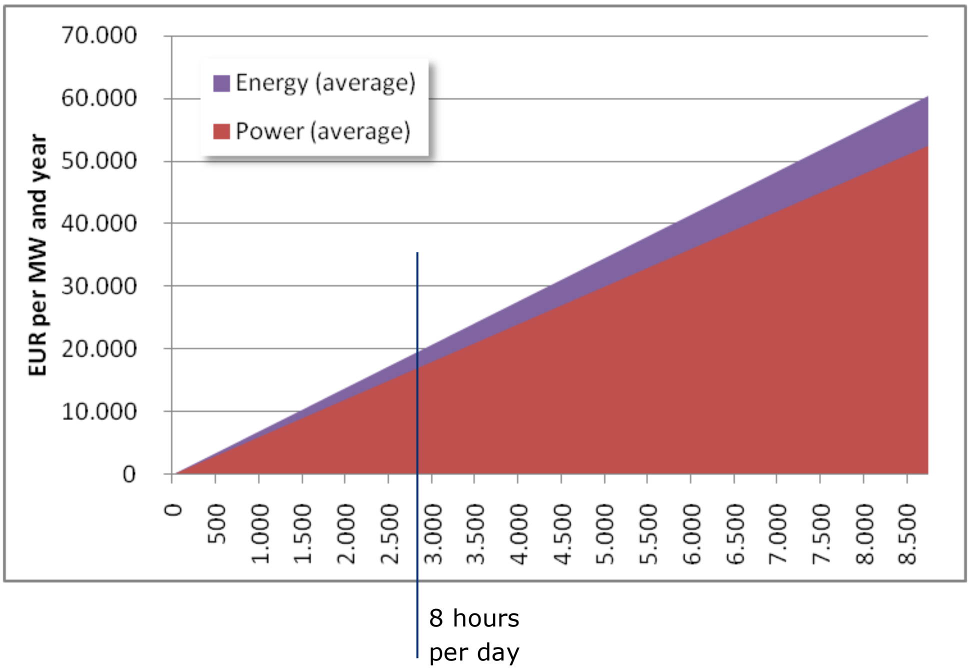

Fig. 2: Potential revenues for positive tertiary control as function of annual hours (Source: own calculation)

Calculated with the average price in 2013 a revenue of appr. 20.000 EUR per MW could be gained for positive balancing power if switchable power is offered for 8 hours per day, though a time span that is very implausible in practice.

Reducing the duration of offering switchable power reduces potential revenues as well. Fig. 3 also shows variety of revenues in the case of applying high and low prices.

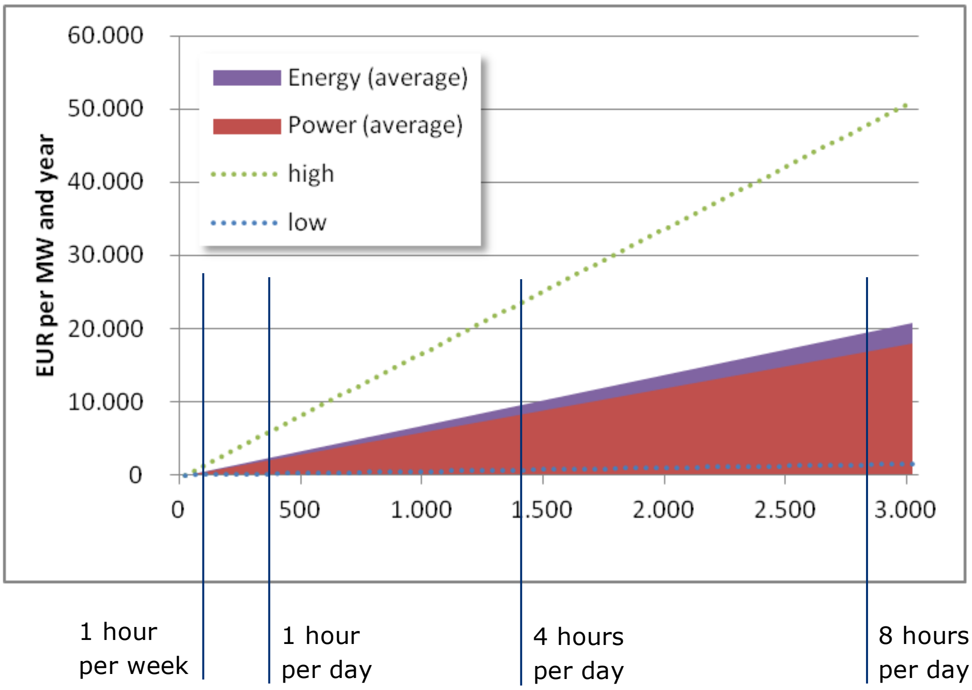

Fig. 3: Revenues for positive control energy for different duration of switching (Source: own calculation)

If switchable power (positive balancing power) of 1 MW is offered only 1 hour per day, revenues are only appr. 2.500 EUR/year on the basis of average prices, but assuming a high price of 17 EUR per MW and hour, the revenue reaches 7.000 EUR/year. For the according figures of 4 hours per day (i.e. 1 product for weekdays and 1 product per weekend), revenues go up to appr. 10.000 EUR/year and even to 28.500 EUR/year, when considering a high price. If low price is applied for this case, only 840 EUR/year could be gained. For negative balancing power (i.e. switching power on), average revenues are 50% higher.

6.2 DR-revenue model with product prices

The revenue model with product prices is structured along the balancing market model in Austria, considering weekdays, weekend and time slots.

As shown in the former chapters, prices show a high variation, depending on the product. Prices for products were classified to low (up to 2 EUR per MW and hour), coloured in red, medium (between 2 and 10, orange), and high (> 10, green). This view is not only helpful to demonstrate the variability of prices but also to select products that seem appropriate for the business under consideration. For example, if a process can easily be switched on during the night, 4 products seem to be beneficial: weekdays and weekends, negative control power, 0-4 and 4-8. Prices were between 13 and 20 EUR per MW and hour. On the other hand, switching off the same processes on weekends would not make so much sense as prices are below 2 EUR per MW and hour (Table 7).

Average price for power reserves 2013 [EUR/MWh]	**Mo-Fr (+)**	**Sa-Su (+)**	**Mo-Fr (-)**	**Sa-Sa (-)**
0-4	1,92	1,43	14,84	19,45
4-8	5,48	1,42	13,84	21,73
8-12	11,46	1,43	2,22	14,14
12-16	7,33	1,43	2,26	16,56
16-20	11,09	1,95	2,51	14,65
20-24	6,73	1,43	2,66	12,47

red … low price, orange … medium price, green … high price

Table 7: Average prices for all 24 products (Source: E-Control, own calculation)

Just to give an overview on the effect of different prices the following Table 8 shows revenues from one product (4 hours per day), calculated with product prices.

Annual revenue for power reserves per product 2013 [EUR per MW and h]	**Mo-Fr (+)**	**Sa-Su (+)**	**Mo-Fr (-)**	**Sa-Sa (-)**
0-4	2.290	1.706	7.101	9.307
4-8	6.549	1.704	6.623	10.395
8-12	13.703	1.705	1.062	6.766
12-16	8.768	1.705	1.083	7.925
16-20	13.263	2.329	1.199	7.007
20-24	8.050	1.708	1.274	5.965

Table 8: Potential annual revenues for 1 MW and 4 hours per day (Source: own calculation)

For the calculation of total revenues with product prices the following formula can be used. Independent variables are:

- Switchable Power [MW]: on/off; reduction or increase of power

- Availability per product of DR-potential [hours]: 1 to 4 h
- number of weeks: 1 to 52 weeks
- number of days of product: 1 to 5 d (weekday products); 1 to 2 d (weekend products)
- Capacity price (per product) [EUR per MW*h]
- Additional revenues (e.g. from energy; calculated as percentage from revenues from power component; appr. 15% in 2013) [EUR]

Total revenues [EUR per year] = Σ(**Switchable Power** [MW] * **Capacity price** [EUR per MW*hour] * **Availability per product** [h] * **number of weeks** * **number of days of product**) + **Additional revenues** (e.g. from energy) [EUR per year]

Revenues are calculated as the sum of revenues for specific products (with specific capacity prices) or for part of products. Revenues from energy are calculated as share of the revenues from power capacity.

This formula does not only help to calculate potential revenues with more realistic data, it also allows to focus on strategic issues. Companies interested in participating in the energy balance market can find opportunities that fit best to their internal processes. For example, companies that run their aggregates all day long during the whole week may focus on products with the highest price for switching off. In another case, where personnel is around all the time but some aggregates only run for a short time, morning time (0-8) or weekends could be used to switch them on for a good capacity price. Which products fit best for a specific company has to be analysed case by case.

6.3 Costs for the implementation of DSM

According to Gruber et al. 2014 costs for the implementation of DSM can be divided into initial costs (investments), variable costs, and fixed costs.

Kreuder et al. (2013) conducted a comprehensive survey on the cost of demand response for industrial processes and cross-sectional technologies.

6.3.1 Investment costs

Investment cost are divided into plant-independent investments (e.g. the development of a demand response strategy) and plant-dependent investments. The survey comes to the result, that for most companies 6.000 EUR seems to be realistic for the development of a demand response strategy. Additional expenses of 3.000 EUR have to be forseen for the investment in a communication box that allows to receive commands from a demand-response-aggregator. With such a communication box, plants can be switched from an external entity. Plant-dependent investments usually involve costs for control technology, which is, however, sometimes already installed and costs for further technical equipment, like frequency converters or dimmable ballasts. Costs were estimated to be in the range of 6-9 EUR per kW for frequency converters and 100 EUR per illuminant. In addition, measurement devices to monitor current power consumption would cost about 1.000 EUR plus 1.000 EUR for programming the integration of measurement equipment into central control devices.

6.3.2 Fixed costs

Annual fixed personnel costs were estimated by 2.000 to 5.000 EUR. Due to assumed learning effects, personnel costs should be reduced significantly in the second year of operation. Data exchange costs may vary to a large extent, Kreuder et al. (2013) assumes that no additional costs occur.

6.3.3 Variable costs

These costs derive from the fact that, according to the survey mentioned above, most industrial businesses indicated to decide at will, whether plants are switched off or not for every activation of demand response. Based on average costs of 50 EUR per working hour and a time of 10 minutes, personnel expenses are estimated to be around 8 EUR per activation of demand response.

6.4 Aggregation of DSM services

Due to strict requirements for the pre-qualification to trade power and energy on the energy balancing market, it is obvious that a direct participation will only be feasible for very few companies. Particularly the minimum of 5 MW of switchable power and the need to bid for at least 4 hours a day for all weekdays or weekend seem to be very restrictive for most interested parties. However, regulation allows for aggregating DSM services. There are already market players that are able to aggregate distributed power. Aggregators have to apply for pre-qualification and can then act as normal market players.

Aggregation of switchable power will be necessary for participation in the energy balancing market, but it has to be considered, that additional costs are associated with aggregation activities, which further reduce profits.

7 Case studies

Within IEA DSM Task 16 two case studies will be used to test the suitability of the DR revenue model on the one hand and the feasibility of the participation of ESPs in the balancing market on the other hand. The first case study deals with the Austrian cement industry, where reliable company data are published (Berger et al. 2013) that can be used for the analysis.

7.1 Case study 1: cement industry

Industrial processes are included in DSM for a long time. Traditionally, large industrial companies with high electrical loads and processes, which can be switched off or on within a short period of time, were contacted directly by grid operators in case of a need to balance energy production with demand.

For the development of business cases we focus on industrial processes that do not tackle core production processes. There are only a few companies in the Austrian cement industry, whereby all of them use similar facilities that are technically appropriate for DSM. However, cement production companies usually focus on the reduction of peak power loads.

Berger et al. (2013) documents 2 cement companies with respect to DSM potential. Mills (raw mix mills and cement mills) are the most appropriate units in cement production process. It is recommended to focus on cement mills since they are not directly linked to the production process. This means that cement mills can be switched off as long as the storage for raw cement is not full (Table 9).

	power	max. duration	frequency	time ahead
raw mix mill 1	2 MW	4 h	20 times per year	1 hour
cement mills 1	3 MW	4 h	40 times per year	1 hour
raw mix mill 2	2 MW	1 h	daily	1 hour
cement mills 2	3 MW	2 h	daily	1 hour

Table 9: Technical data for case study 1 (Source: Berger et al. 2013)

Depending on the operation schedules of the companies, different strategies can be appropriate. If skilled personnel is available during the weekend but mills only run sporadically, it might be reasonable to offer negative balancing power, i.e. to switch on aggregates. During weekdays time slots should be selected with the highest price. For the case study the following data are assumed (Table 10):

Variable	Case study 1a	Case study 1b
Strategy	(1) positive balancing power Mo-Fr 16-20; (2) negative balancing power Sa-So 8-12	(1) positive balancing power Mo-Fr 16-20; (2) negative balancing power Sa-So 8-12
Capacity price (average)	6 EUR per MW and hour (+) 9 EUR per MW and hour (-)	6 EUR per MW and hour (+) 9 EUR per MW and hour (-)
Capacity prices (products)	(1): 11,09 EUR per MW and hour (2): 14,14 EUR per MW and hour	(1): 11,09 EUR per MW and hour (2): 14,14 EUR per MW and hour
Duration	4 h	1 h
Power	5 MW	5 MW
Availability per product	4 h	1 h
Number of weeks	10 (10 switchings on weekdays, 10 switchings on weekends)	52
number o days per product	(1): 1 day (2): 1 day	(1): 5 days (2): 2 days
Revenue (average price)	**3.450 EUR**	**14.352 EUR**
Revenue (product price)	**5.803 EUR**	**25.036 EUR**

Table 10: Calculation of revenues for case study 1 (Source: own calculation)

It is obvious that potential revenues differ to a large extent depending on the assumed power prices and on the specific framework conditions. Considering related costs, case study 1a does not seem feasible while case study 1b could gain revenues suggesting the development of a detailed business case. However, in any case more specific analysis will be necessary taking all framework conditions into consideration.

7.2 Case study 2: office buildings

The integration of buildings into smart grids is regarded as an option with a very high potential for DSM (Meisel et al. 2012). The core idea is to use thermal capacities in buildings for DSM. Especially buildings with established central building control systems are well suitable for this purpose. The only investment would be the installation of additional sensors. In the study mentioned above, calculations of scenarios are based on a number of 20.000 buildings in Austria, whereby all of them could basically be used for DSM.

Based on information from Kreuder et al. (2013) ventilation is seen as the most suitable demand response technology, followed by refrigerating machines, electric lighting, heating circulation pumps, heat pumps and hot water preparation.

The following case study 2 calculates potential revenues from balancing energy market for a hypothetical, however realistic, office building. Beside ventilation and cooling, heating with heat pumps, which are only availible in a few cases, seems to be the most interesting technology. Hence, the case study only estimates revenues from ventilation and cooling. According to Berger et al. (2013) ventilation and cooling can be switched off for 15 minutes 2 times per day. Klobasa (2007) assumes that ventilation and cooling can be switched off for 1 h per day. Since most office buildings only are used on weekdays, weekend products cannot be included in this case study. In terms of cooling it has to be considered, that aggregates only run in the warm season of the year (appr. 500 h). For our case study it is assumed that ventilation and cooling can be switched off for 15 minutes, 2 times per day.

The following assumptions (Table 11, Table 12) were made for case study 2 (Table 13):

office building	
area	15.000 sqm
ventilation	
specific energy consumption	15 kWh per sqm
full load hours	4.000 h
power	56 kW
cooling	
specific power	30 W per sqm
full load hours	500 h
power	450 kW

Table 11: Technical data for the office building (Source: e7)

	power	max. duration	frequency	time ahead
ventilation	56 kW	15 min	2 times daily	5 minutes
cooling	450 kW	15 min	2 times daily	5 minutes

Table 12: Technical data for DSM for case study 2 (Source: Berger et al. 2013, e7)

Variable	**Case study 2a Ventilation**	**Case study 2b Cooling**
Strategy	(1) positive balancing power Mo-Fr 8-12; (2) positive balancing power Mo-Fr 16-20	(1) positive balancing power Mo-Fr 8-12; (2) negative balancing power Mo-Fr 16-20
Capacity price (average)	6 EUR per MW and hour (+)	6 EUR per MW and hour (+)
Capacity prices (products)	(1): 11,46 EUR per MW and hour (2): 11,09 EUR per MW and hour	(1): 11,46 EUR per MW and hour (2): 11,09 EUR per MW and hour
Duration	15 minutes	15 minutes
Power	56 kW	450 kW
Availability per product	15 minutes	15 minutes
Number of weeks	52	15
number o days per product	(1): 5 day (2): 5 day	(1): 5 days (2): 5 days
Revenue (average price)	**50 EUR**	**404 EUR**
Revenue (product price)	**94 EUR**	**759 EUR**

Table 13: Calculation of revenues for case study 2 (Source: own calculation)

Even though the case study building is not a small office building, revenues are very low. Aiming for a revenue at the same level as a single cement company from case study 1 it would be necessary to aggregate 30 office buildings. The main reason for this disparity lies in the comfort parameters in buildings which should not be affected. Therefore available power can only be switched off for a very short period of time. Further research is needed to verify existing figures or to develop new strategies with higher potential for demand response.

8 Conclusions

Which conclusions can be drawn from the insights into the energy balancing market, the potential revenues and the case studies?

With a potential revenue for one single company from only a few hundred EUR/year up to a level of 25.000 EUR/year, calculated in 2 case studies with realistic technical framework conditions, it is quite clear that new business models for energy service providers cannot be recommended at this stage.

These revenue potentials would need to cover all CAPEX and OPEX expenses of the DR-measure, project transaction costs as well as expected financial returns and risks for the ESP and the flexibility providers (or energy cost savings). Although we did not model concrete numbers on the cost side, we conclude that potential returns are not sufficient to drive business development for individual projects at current price levels.

The following framework conditions have to be considered:

- Only a few companies in Austria have a switchable power of 1 MW or more.
- There is no guarantee that the potential revenue will be achieved in reality. Market rules are transparent and quite simple but without long time experience (like competitors have) on that specific market reliable assessments of probability to win tenders cannot be provided.
- Costs associated with the implementation of DR (investment costs, variable costs, fixed costs) reduce potential profits significantly.
- It is obvious that due to existing rules (pre-qualification) but also to expected amendments, a direct participation in the energy balancing market will not be a realistic option for companies. As a result of the points mentioned above, an aggregator would be necessary. Hence, costs for aggregation (transaction costs) reduce profits further.
- DSM is usually not part of the core business of companies and it implies risks. In cement industry maintenance cycles may be reduced and premature failures of machines could cause high costs. For office buildings, comfort must not be reduced in any case. This means that elaborated monitoring systems have to be in place as well as sophisticated control algorithms.

However, there are only a few practical examples for DSM in Austria and Europe. Data for case studies were taken from literature but there are some doubts that figures represent reality. For instance it is not clear, why ventilation or cooling systems in office buildings can only be switched off once per day. From a technical point of view, both, ventilation and cooling systems could be switched off any time when comfort conditions are on the upper edge.

9 Recommendations and Outlook

What can be recommended from the results of the discussion paper?

Business cases may turn out to be financially viable with higher capacity prices as it is the case in most economies with high energy demand growth rates e.g. in many Asian, Arab and developing countries. It would most likely be relatively easy to adapt our simplified revenue model to other market frameworks in order to perform pre-feasibility calculations.

Also subject to further investigations, economies of scales through project aggregation and standardization could result in a positive business case. Furthermore, investigating other capacity markets such as the secondary control with a max of 30 seconds response time may prove to be worthwhile, in order to achieve relevant economic business potentials.

- Even though there are no realistic financial incentives for new business models at the moment, there still is the need to further investigate the (realistic and economic) potential of demand response of sectors.
- In any case a close co-operation with aggregators would be crucial for the participation in the energy balancing market. Aggregators have some experience with the implementation of DSM measures (at least from other countries) and they are the experts for the energy balancing market.
- Business models must be developed case by case. Depending on technical preconditions, strategic and organisational framework conditions, potential revenues as well as costs will differ to a large extent.

This paper focused on the pre-feasibility of DR services on the energy balancing market. In future energy systems the importance of flexible power will increase. However, companies with flexible power do not only have the possibility to participate in the energy balancing marktet, flexibility can also be used to reduce energy costs by cutting peak power or using flexibilty to optimize energy tariffs. Flexibility can also help to increase direct use of power from photovoltaics.

10 References

Amann, Christof 2015: Loadschift: Lastverschiebung in Haushalt, Industrie, Gewerbe und kommunaler Infrastruktur. Potenzialanalyse für Smart Grids. Lastverschiebung bei gewerblichen Anwendungen: Lebensmittelkühlung und Dienstleistungsgebäude. Berichte aus der Energie- und Umweltforschung 7f/2015. Wien.

APG 2014: Ausschreibungsdetails für für die Beschaffung der benötigten Tertiärregelreserve bzw. Ausfallreserve in Österreich. Version 1.3 (01.10.2014).

APG 2015: Preisentwicklung Regelenergiemarkt von KW1 2013 bis KW14 2015. (download von: www.apg.at/de/markt/netzregelung/marktforum; 21.04.2015)

Berger, Helmut; Eisenhut, Thomas; Polak, Sascha; Hinterberger, Robert 2013: Demand Response Potential of the Austrian industrial and commerce sector. Final report. Vienna.

de Bruyn, Kathrin; Kollmann, Andrea; Moser, Simon; Schmidthaler, Michael; Amann, Christof; Elbe, Christian; Schmautzer, Ernst; Kraussler, Alois; Reinhofer-Gubisch, Marion; Pucker, Johanna; Frantes, Bettina 2014: Loadschift: Lastverschiebung in Haushalt, Industrie, Gewerbe und kommunaler Infrastruktur. Potenzialanalyse für Smart Grids. Überblick und Zusammenfassung. Berichte aus der Energie- und Umweltforschung 7a/2015. Linz.

Friedl, W.; Suessenbacher, W.; Ennser, B. 2012: Marktbasierte Beschaffung von Regelreserve. 12. Symposium Energieinnovationen, 15.-17.2.2012, Graz.

Friedl, Werner; Suessenbacher, Wilhelm; Ennser, Benedikt 2012: Marktbasierte Beschaffung von Regelreserve. 12. Symposium Energieinnovationen, 15.-17.2.2012, Graz/Austria.

Fussi, Andreas; Schüppel, Andreas; Gutschi, Christoph; Stigler, Heinz 2011: Technisch-wirtschaftliche Analyse von Regelenergiemärkten. 7. Internationale Energiewirtschaftstagung an der TU Wien. IEWT 2011.

Gruber, Anna; Biedermann, Franziska; von Roon, Serafin 2014: The Merit Order of Demand Response in Industry. ENERDAY - 9th Conference on energy economics and technology, Dresden/Germany.

Hettfleisch, Christian; Kupzog, Friederich; Pollhammer, Klaus 2012: Balancing Energy Demand with Buildings. Berichte aus Energie- und Umweltforschung 29/2012. Wien.

Klobasa, Marian 2007: Dynamische Simulation eines Lastmanagements und Integration von Windenergie in ein Elektrizitätsnetz auf Landesebene unter regelungstechnischen und Kostengesichtspunkten. Doctoral Thesis. Karlsruhe.

Kreuder, Lukas; Gruber, Anna; von Roon, Serafin 2013: Quantifying the Cost of Demand Response for Industrial Businesses. In: Industrial Electronics Society, IECON 2013 - 39th Annual Conference of the IEEE. pp. 8046-8051.

Meisel, Marcus; Leber, Thomas; Kupzog Friederich; Pollhammer, Klaus; Ornetzeder, Michael; Haslinger, Julia; Sterbik-Lamina, Jaro; Schiffleitner, Andreas; Stachura, Marek 2012: Lastmanagement für intelligente Stromnetze in Österreich (Smart Response). Endbericht. Vienna.

Moser, Simon 2015: Loadshift: Lastverschiebung in Haushalt, Industrie, Gewerbe und kommunaler Infrastruktur. Potenzialanalyse für Smart Grids. Literaturvergleich. Berichte aus der Energie- und Umweltforschung 7d/2015. Linz.

Oberhofer, Michael 2013: Demand-Side-Management in Österreich. Master‵s Thesis. Graz.

Penya, Yoseba K.; Borges, Cruz E.; Haase, Jan; Bruckner, Dietmar 2013: Smart Buildings and the Smart Grid. In: Industrial Electronics Society, IECON 2013 - 39th Annual Conference of the IEEE. pp. 113-117.

11 List of abbreviations

DR: demand response

DSM: demand side management

ESP: energy service provider

FCR: frequency containmant reserves; primary control

FRR: frequency restoration reserves; secondary control

aFRR: automated FRR

mFRR: manual FRR (procurred together with RR)

RR: replacement reserves; tertiary control

Un.D.: unintentional deviation

ENTSOE: European Network of Transmission System Operators for Electricity

APG: Austrian Power Grid AG

CAPEX: capital expenditures

OPEX: operational expenditures

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