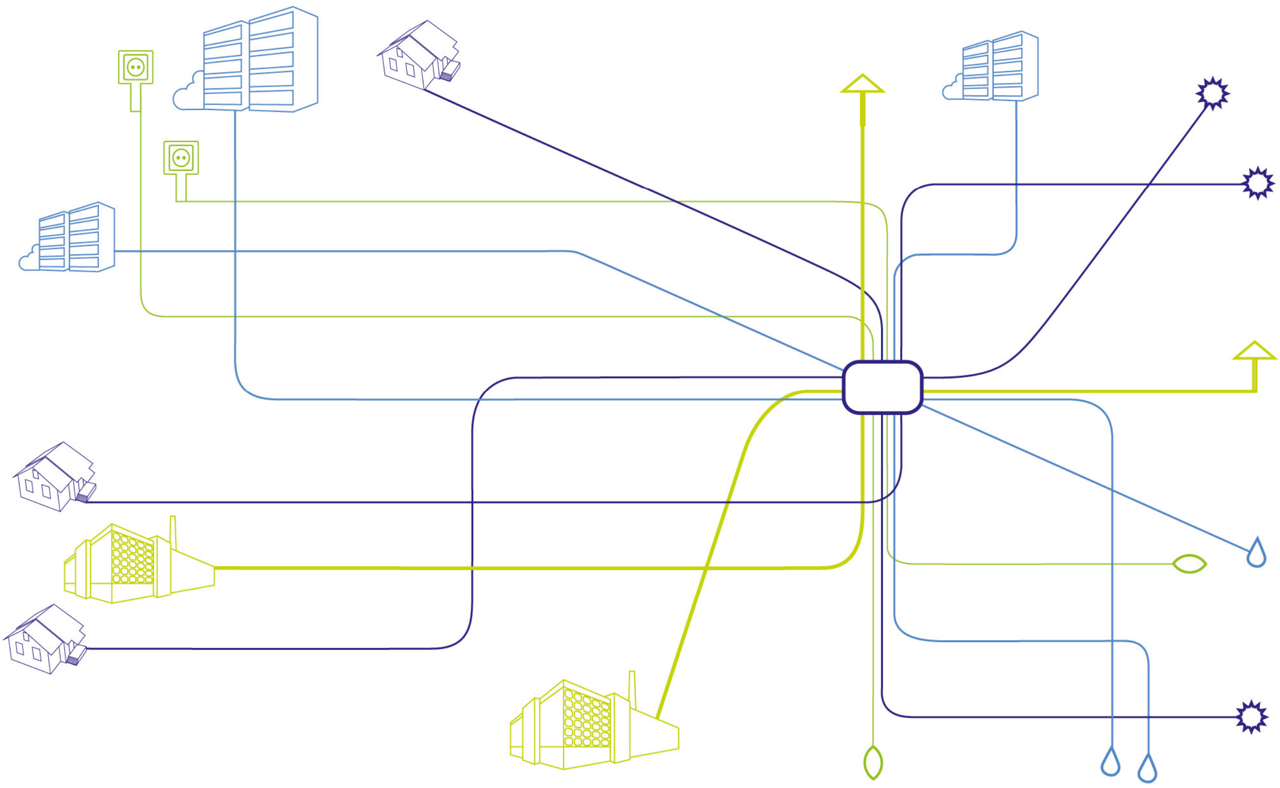
Blue Globe Report

Smart Energies #18/2013

EDRC

European Demand Response Center



cyberGRID GmbH, BRIMATECH Services GmbH,
Austria Power Grid AG, Graz University of Technology

PREFACE

The BLUE GLOBE REPORT shows the competence and variety of approaches chosen by Austrian industry and research in striving to come up with solutions for the central tasks of the future. The Climate and Energy Fund has made it its strategy to provide specific impulses through long-term subsidy programs, programs to create an excellent starting position for Austrian companies and institutions in international competition.

Each year the Climate and Energy Fund has a budget of up to 150 million euros for promoting sustainable energy and transport projects in line with the climate protection goals. These funds are used to support ideas, concepts and projects in the areas of research, mobility, and market penetration.

The Climate and Energy Fund's BLUE GLOBE REPORT informs about project results thus supporting the application of innovation in practice. In addition to technological innovations in energy and transport it also discusses social topics and the scientific base for political planing processes. The BLUE GLOBE REPORT is made available to the interested public via the www.klimafonds.gv.at website and invites readers to a critical discussion.

The current report documents the results of a project from the „ Neue Energien 2020 " research program with the goal of providing the scientific basis for increasingly important decisions on climate adjustment measures and as such constituting a solid basis on which stakeholders can base their decisions.

We are the right partner for whoever decides to take a sustainable part in the future. The Climate and Energy Fund promotes innovative solutions for the future!

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EDRC

European Demand Response Center

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cyberGRID GmbH

BRIMATECH Services GmbH

Austria Power Grid AG

powered by klima+energie fonds

Dieses Projekt wird aus Mitteln des Klima- und Energiefonds gefördert und im Rahmen des Programms „NEUE ENERGIEN 2020“ durchgeführt.

List of EDRC Project Partners:

Partner no.	Partner name	Partner short name
1	cyberGRID GmbH	cyG
2	Graz University of Technology – Institute for Energy Economics	TUG
3	Austria Power Grid AG	APG
4	BRIMATECH Services GmbH	BRI

List of LOIs:

No.	Name
1	Donau Chemie
2	Smurfit Kappa Nettingsdorfer
3	Marienhütte Graz
4	Noske Skog
5	Unibail rodamco
6	UKH Graz
7	UKH Klagenfurt

Das Forschungskonsortium bedankt sich beim BMVIT für die Förderung des Projekts und die hervorragende Betreuung während der gesamten Laufzeit. Großer Dank gilt auch den Industriepartnern und Interessensvertretungen, ohne deren Input die Umsetzung des Projekts undenkbar gewesen wäre.

Abbreviations:

ACER	Agency for the Cooperation of Energy Regulators
APCS	Austria Power Clearing & Settlement
APG	Austrian Power Grid
BG	Balance Group
BGR	Balance Group Representative
BNA	Bundesnetzagentur Deutschland (German Federal Network Agency)
BRP	Balance Responsible Party
C & I	Commercial and Industrial
CAM	Control Area Managers
CEER/ICR	International Confederation of Energy Regulators
CPP	Critical Peak Pricing
CSA	Clearing and Settlement Agents
CSP	Curtailment Service Provider
CSR	Balancing Group Representatives
DER	Distributed Energy Sources
DLC	Dynamic Load Control
DoE	Department of Energy (USA)
DOW	Description of Work
DR	Demand Response
DRM	Demand Response Management
DSM	Demand Side Management
DSO	Distribution System Operator
EAF	Electric Arc Furnace
EDRC	European Demand Response Center
EE	Energy Efficiency
EEX	European Energy Exchange
ENTSO-E	European Network of Transmission System Operators for Electricity
EPACT	Energy Policy Act of 2005 (USA)
ETP Smart Grids	European Technology Platform Smart Grids
EURELECTRIC	Union of the Electricity Industry
EXAA	Energy Exchange Austria
FCDM	Frequency Control by Demand Management
FFE/FfE	Forschungsstelle für Energiewirtschaft
GAVE	Großschönau As Virtual Energystorage
ICT	Information and Communication Technology
ISO	Independent System Operator
IT	Information Technology
LOI	Letter of Intent
MW	Megawatt
NTP	National Technology Platform

PTR	Peak Time Rebate
RES	Renewable Energy Sources
RTP	Real Time Pricing
SW	Software
SWOT	Strengths, Weaknesses, Opportunities, Threats
TOU	Time of Use Pricing
TSO	Transmission System Operator
UCTE	Union for the Co-ordination of Transmission of Electricity
USP	Unique Selling Proposition
VPP	Virtual Power Plant
WKO	Austrian Economic Chambers (*Wirtschaftskammer Österreich*)
WP	Work Package

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PART I: USE CASES AND BUSINESS MODELS (CYBERGRID GMBH)

1 Abstract

1.1 Setting

An affordable and secure supply with electric power is one of the fundamentals of our modern society. But the increasing use of fluctuating renewable energy sources (RES) like small hydro, wind power and photovoltaics lead to higher cost for end consumers and may cause a reduction of the security of supply. Demand response used in smart grids business models has the potential to minimize these disadvantages in an economic and efficient way. The improved utilization of the existing infrastructure can reduce the investment requirements in “conventional” generation infrastructure (coal, gas, heavy fuel oil (HFO), nuclear) and enhance the integration of new RES in the power grids.

Developments in demand response vary substantially across Europe reflecting national conditions and triggered by different sets of policies, programs and implementation schemes[1]. In general, large commercial and industrial clients are the main target of demand response programs. As the size of the load is larger, the ratio between outcome and effort increases and profitability grows. Furthermore, demand response technology brings many benefits to industrial and commercial clients. The optimization of production and the significant potential for lowering electricity bills represent incentives for these customers to participate. On the other hand, the demand response company needs a good knowledge of industrial loads and specific market industry to successfully identify appropriate loads.

Demand response programs were traditionally used for energy efficiency and conservation with reliability-driven load management programs used occasionally for emergency situations which sometimes disrupt the success of these actions as electric prices were taken as a given[2]. With electricity systems in Europe changing, many more opportunities arise for demand response companies. Intensive integration of smart meters, renewable energy sources, electric vehicles and other new technologies will go hand in hand in the future demand response market.

1.2 Solution

In the scope of the project, a concept for an integrated EDRC scheduling/negotiation framework was developed. The main barriers facing demand response companies in Europe are still deregulated markets with different levels of openness for demand response market participation. In the developing European demand response markets, aggregation

[1] Torriti et al. 2009. Demand response experience in Europe: Policies, programmes and implementation.

[2] Charles river associates, 2005. Primer on demand side management.

companies are also facing risks, especially those arising from institutional and regulatory barriers. Furthermore, the dispersed European market makes it hard for independent aggregators to pursue marketing and enrollment activities throughout Europe. An analysis of business models indicated that a technology provider model could be suitable for the implementation of demand response solutions into European power markets. An independent technology provider might be preferred by established utilities as a partner to realize smart grids and demand side management business models.

Considering the above mentioned facts, the implementation of virtual power plants (VPP) based on demand response in Austria will be a step towards a smart power supply, reducing costs for small and medium-size end consumers as well as industries, while also improving the integration of RES to reduce CO_2-emissions in Austria. And the investigations and surveys conducted for the EDRC-project confirmed there is a need for a new type of virtual power plants.

From a technological point of view, the main challenge is the realization of a dual-VPP concept, which combines the existing business model of VPP resource aggregation for electricity markets, peak capacity markets or balancing markets with a VPP that provides services for distribution grid operation i.e. active power control of loads and generators. The dual-VPP will be able to provide active control by curtailment of loads or generation in order to assist the DSO in maintaining a secure operation.

1.3 Advantages

The resulting benefits of the developed solution are expected to be cost reductions for network integration as well as additional benefits for generators and consumers on the electricity market. Another important social effect is the principle of learning, flexibility and adaptation for future development. This includes new market opportunities for involved industry partners such as markets for VPP-related products. On the other hand there will be alternative applications (e.g. Demand Response) for several different other market participants (e.g. electricity utilities or market aggregators).

Enabling a higher share of renewable based distributed generation units allows regions to use locally available resources. This results in an increasing number of local projects (e.g. biomass and PV units), requiring local manpower and knowledge for construction and operation and generation of jobs in the area of renewable energy technologies (“green jobs”).

2 Introduction

In this section we provide descriptions of existing business models for Demand Response that are currently in practice in the US or in Europe. In the US, the demand response market is maturely developed, while in Europe the market is still more dispersed. According to Nilson[3], in the US, the DSM-process was institutionalized in "rate base cases" before Public Utility Commissions, whereas in Europe the processes were less formal. Furthermore, in countries with fast growing economies, like Asia, the concept of demand response management became quite natural and attractive as the resources needed to "fuel" the expansion had to be economized.

Developments in demand response vary substantially across Europe reflecting national conditions and triggered by different sets of policies, programs and implementation schemes[4]. Europe's leading countries in demand response development are France, UK and Ireland. Other European countries, however, have shown significant development in this area but are not fully developed yet. The main barriers facing demand response companies in Europe are still deregulated markets with different levels of openness for demand response market participation. Since demand response participation in a deregulated European market is more complex and country-specific, not all business models operable in the US can also work in Europe.

It is very important to choose a suitable business model that allows demand response integration. *"Whenever a business enterprise is established, it either explicitly or implicitly employs a particular business model that describes the design or architecture of the value creation, delivery, and capture mechanisms it employs. The essence of a business model is in defining the manner by which the enterprise delivers value to customers, entices customers to pay for value, and converts those payments to profit[5]."*

One of the main tasks when choosing the right business model is the identification of stakeholders' needs and their alignment for collaboration. In his work, De Jonge[6] stresses the importance of bringing several actors together when establishing demand response activities. He states that the value of demand side management and smart grids in general will rise when offering more than one function at the same time. Furthermore,

[3] Hans Nilson, 2007. Demand side management (DSM): A renewed tool for sustainable development in the 21st century.

[4] Torriti et al. 2009. Demand response experience in Europe: Policies, programmes and implementation. P.1

[5] Teece, 2010. Business models, business strategy and innovation. p.1

[6] De Jonge, 2010. Business models for demand side management; p.5

experimentation with multifunction solutions in combination with the involvement of several actors is crucial for the success of smart grids and demand side management.

The identification of EDRC stakeholder needs is the main task for the second work package. In addition, viable business models for the EDRC were identified from all the business models described in this section, based on an extensive market survey that included all stakeholders needed in establishing the EDRC.

3 Business models

Based on existing practices in the US and Europe, we hereby present demand response business models in practice.

In this report a business model is defined as a description of entailed activities, main incentives and customers. Here we are not concerned about how to deal with possible competition, but we focus on the main factors for each business model to work in its environment. For each business model we try to provide main positive and negative aspects, mentioned in existing literature or explained in stakeholder's interviews.

Literature classifies demand response business models differently. *"There is no single right way to distinguish different types of business models[7]"* For example, De Jonge[8] has chosen his research to classify business models by their functions in three groups. The first business model refers to a DSO where demand side management is used for peak shaving. The second business model represents the case of a business-responsible supplier, where demand side management is used for integration of large-scale renewable energy sources. The third business model classified by De Jonge applies to the aggregator using flexibility for economic load management where economic benefits are a result of the ability to raise demand during times of low energy prices and lower demand during periods of high energy prices.

In the table below, different investigated functionalities of demand side management classified by De Jonge are underlined:

[7] Weill et al. 2005. Do some business models perform better than others? A study of 1000 largest US firms. p.6

[8] De Jonge, 2010. Business models for demand side management; p.32

Table 1: Value and interest of Demand side management by De Jonge6

Function	*DSO*	*Program responsible supplier*	*Consumer*	*Aggregator with access to the spot market*
Peak shaving	Efficient use of the grid and delay upgrades	O	O	O
System services: • Support distributed generation • Improve voltage quality	Reliability of supply and market facilitation	*Predictability distributed generation*	Reliability of supply and application of distributed generation	More predictable distributed generation
Integration of large central renewable energy sources	O	Lower cost related unbalance and reserve capacity investments	Sustainability	O
Economic load and storage management	O	O	O	Earn money with economic load management
Offer new consumer services	Market facilitation	New market an possibility for differentiation	New benefits like information services how to save electricity	New market

Furthermore, the International Energy Agency (IEA) [9] uses a somewhat different classification. They have chosen three business models based on assessing the benefits of distributed energy resources and of optimizing this value. Their business models differ in terms of actors as well as technology. A summary of their classification in three business models is presented in the table below.

Table 2: Classification of business models by IEA9

Business model	Aggregator	Customers	DER technology
1	electricity supplier	medium commercial and industrial	flexible demand, wind
2	electricity and gas supplier	small residential	CHP
3	energy service company (ESCO)	medium commercial	CHP and flexible demand

[9] IEA, Integration of demand side management, distributed generation, renewable energy sources and energy storages; p. 54

In our analysis, we based the presentation of demand response business models on existing classifications, but extended the view based on more factors. For better transparency we classified them in four groups. The first group represents market models based on the way a demand response company enters the market. The second group classifies demand response companies based on their main source of revenue while the third group presents market models based on the type of customers involved.

3.1 Market entry

For the first classification of market models we used a classification used by Thomas et al.[10], extending it according to our observation in the European markets. Thomas et al. refer to these models as models of customer participation. Here we will refer to it as classification based on market entry, to make a clear distinction with our third group which is based on customer type. "Market entry" refers to the channels pushing demand response to the market.

Thomas et al. describe three market models:

1. Traditional utility model
2. CSP or Aggregator model
3. Customer-provisioned model

Based on our observation in European markets, we added two more business models:

4. Utility service provider
5. Technology provider

The role of basis technology providers differs from the first four models since the technology provider does not participate in demand response markets. However, the model was added to make clear distinction from the utility service provider.

First, we will present the most common business model, the curtailment service provider (CSP) model. Next, we present the traditional utility model, the utility service provider and the technology model. Here the distinctions are explained. Finally, we briefly touch upon the customer-provisioned model.

[10] Thomas, Chris et al., *An Assessment of Business Models for Demand Response*, GridWise Architecture Council. 2008, 7.

3.1.1 Curtailment service provider / Aggregator

The curtailment service provider, also referred to as independent aggregator, is the most common market model pursued by demand management companies. According to Thomas et al., aggregator firms take advantage of existing demand response programs and seek out businesses to participate in them. They replace the functions provided by utility account representatives and bring in the resources of their own centralized control facilities. Since these companies do not have public obligations as regulated utility, not as much information is available about the specifics of their programs.

According to Ikaheimo, an aggregator's activities include the following:

1) Study of which customers can provide profitable demand response.
2) Active promotion of demand response service to customers.
3) Installation of control and communication devices on the customer's premises.
4) Offering financial incentives to customers to provide demand response.

A widespread view is that demand response can be more easily activated by the help of an intermediate company[11]. According to Cappers et al.[12], Demand Response vendors provided load control and communication/notification technologies to utilities on a fee-for-service basis in load management programs. In recent years this changed with Curtailment service providers being remunerated on a pay-for-performance basis. These efforts are often characterized as a move toward “outsourcing” DR services, which in some cases are driven by the utility's need to meet aggressive demand-side reduction goals.

[11] Ikaheimo et al., 2010. DER aggregator Business: The finnish case; p.1

[12] Cappers et al. 2009. Demand Response in U.S. Electricity Markets: Empirical Evidence

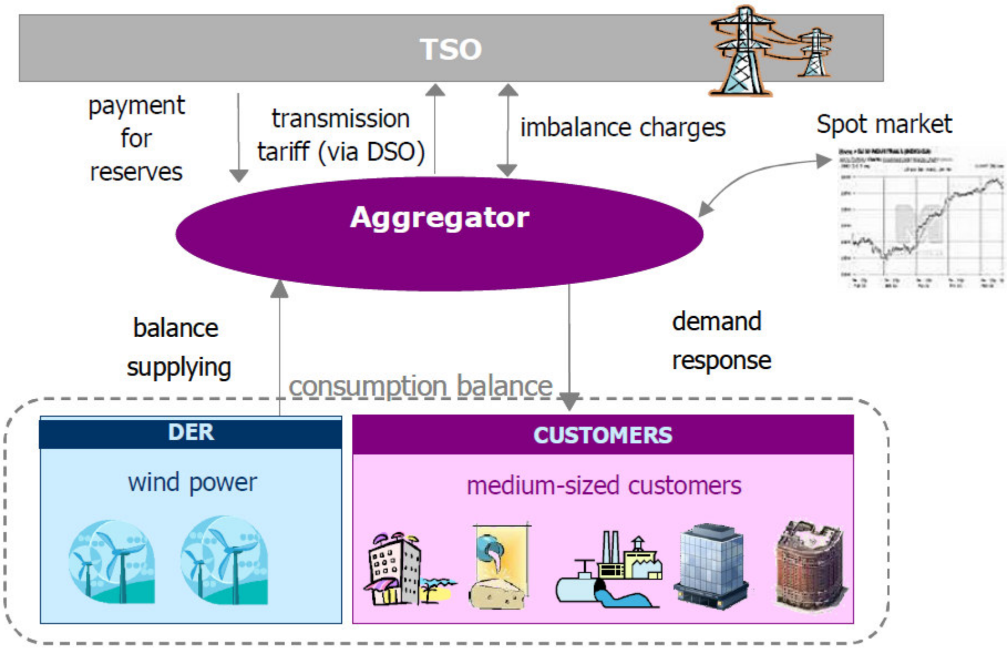

Figure 1: Money flows in Aggregator business model; source: Ikaheimo et al.

According to DER aggregator, a retailer can also assume the full role of an aggregator, taking advantage of his existing customers. This business model is referred to as the retailer model. Furthermore, the authors identify another model, where the party responsible for the balance indeed acts as the aggregator for customers whose retailers belong to this balance portfolio. In addition, they list another model[13], where the aggregator is a company without any existing relationship with customers as far as electricity business is concerned. However, they might entertain a relationship in another field, such as facility management.

Here, when we refer to the Aggregator we mean an independent company acting as a curtailment service provider as defined above, with its core business being demand response.

[13] Ikaheimo et al., 2010. DER aggregator Business: The Finnish case; p. 14

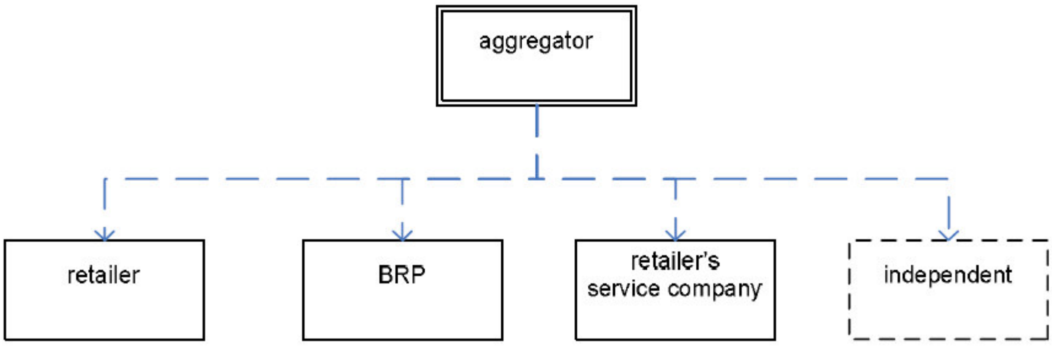

Figure 2: Aggregator business models classified according to aggregator's identity Source: Ikaheimo et al.

Ikaheimo et al.[14] further states that the benefit of the aggregator model compared to the retailer model is that the aggregator is not limited to a certain group of customers, with whom he maintains a retail contract. However, the disadvantage is that he has to first come into agreement with several retailers to take advantage of this. Furthermore, there is a problem with supplier-switching, should the customer switch to a retailer who has not signed a service contract with the aggregator. An independent aggregator is additionally challenged with finding the method of neutrally determining the energy provided by the retailer or aggregator, especially for dynamic tariffs.

Furthermore, according to De Jonge[15] in case of a program responsible supplier, the flexible load will be used to act upon their energy program and to balance supply and demand on a national level. On the other hand, an aggregator with access to spot markets will use demand-side management for economic load management. The analysis of different goals and interests from actors reveal the existence of opposite interests during the day.

According to Moran&Suzuki[16], one of the most important advantages of engaging independent aggregators is leveraging their marketing expertise. However, being a new entrant to the market comes with disadvantages. The authors also say that as new entrants, CSPs incur substantial up-front costs such as marketing costs to enroll customers in a DR program, back-office and communications network infrastructure costs and other costs.

Here, the independent aggregation company bears all the risks related to these activities.

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[14] Ikaheimo et al., 2010. DER aggregator Business: The finnish case p. 25

[15] De Jonge, 2010. Business models for demand side management; p.4

[16] Moran&Suzuki , 2010. Curtailment Service Providers: They Bring the Horse to Water…Do We Care if It Drinks? p. 5, p.23

In the US, where demand response aggregators have been participating in the electricity market for many years, the aggregation companies found ways to avoid some of these risks. For instance, by enrolling customers and managing curtailment activities, independent aggregators are bearing the risk of underperformance. For example, Moran&Suzuki evaluated aggregation-driven demand response programs in California and identified that instead of having to pay penalties for underperformance, aggregators will lower the risk by withholding future payments to underperforming customers.

In the developing European demand response markets, aggregation companies are also facing risks, especially those arising from institutional and regulatory barriers. The dispersed European market makes it harder for independent aggregators to pursue marketing and enrollment activities throughout Europe. The observation of the EU market shows demand response aggregators being smaller, and usually running operations only in their home country. Like in the US, European demand response aggregators have started to find new ways to overcome this risk of inability to access markets. The utility service provider model explained below is one of the approaches to eliminate part of the risks and costs that independent aggregators are facing and to align interests with existing market players.

3.1.2 Traditional utility model

The traditional utility model is a business model involving the utility signing up individual firms to participate in demand response. According to Thomas et al.[17], this model works most clearly in non-restructured states where the relationship between the utility and their larger customers has not yet evolved.

"Traditionally, DSM programs were confined to energy efficiency and conservation programs with reliability-driven load management programs being used occasionally to manage emergency situations. Electric prices were taken as a given when designing such programs, hampering the eventual success of all such efforts.[18]"

"Within several European countries there are long standing arrangements or programmes to harness the largest and most energy intensive industrial customers in DR, through interruptible tariffs or time of day pricing, and some system operators make use of large

[17] Thomas, Chris et al., *An Assessment of Business Models for Demand Response*, GridWise Architecture Council. 2008, 7.

[18] Charles river associates, 2005. Primer on demand side management. p.4

avoided loads as part of their system balancing activities[19]" However, according to Toritti et al. these activities represent poor substitutes for the benefits that would arise from a more comprehensive approach to demand response.

Furthermore, according to Torriti et al., these programs are typically not based on accurate price signals that serve as the basis for dynamic pricing options. They are based on discrete timing and pricing of interruption, where payment mechanisms vary between countries.

Recent developments have changed demand response systems in various countries. The focus now is on more sophisticated technology and programs also including commercial and residential customers.

Below we present an overview of some European load management examples according to Torriti et al., expanding them with few other cases observed on the market. This market experience provides a good basis for integration of new demand response systems.

Sweden

In Sweden, studies on demand response showed that most Swedish industries are able to face reductions between 30 minutes and 3 hours per day. Auctions were arranged for reserve capacity up to 2000 MW. This provided a basis for further development toward more market-oriented demand response.

Finland

In Finland, interruptible programs have been used as disturbance reserve for several years. Companies have annual contracts with the national electricity transmission grid operator.

France

Electricité de France created a program called Tempo tariff making use of different prices according to the weather. Customers can adjust their consumption either manually or by selecting a program for automatic connection and disconnection of separate water and space-heating circuits. Furthermore, France recently opened its market to individual demand response aggregators.

Norway

[19] Torriti et al. 2009. Demand response experience in Europe: Policies, programmes and implementation. P.1

In Norway, several programs have been undertaken with the objectives of strengthening the grid capacity. The demand response program facilitated the reduction of the peak load from commercial end-users by 4,5%, with the energy savings amounting to about 15%.

UK

In the UK, specific demand response programs have been in place for some years. In the industrial and large commercial sectors, energy-intensive users are able to sign Time of Use and/or interruptible contracts with suppliers. The system operator can contract such large users directly as part of their network balancing activities. Furthermore, the UK opened its market to individual aggregators with ancillary services such as short-term operating reserve (STOR).

The Short Term Operating Reserve (STOR) provides additional active power from generation and/or demand reduction[20]. There are two types of the STOR service: Committed, and Flexible. Committed service providers work to offer service availability in all of the required availability windows in each season. Upon accepting the tender, the TSO National Grid commits to buying all services offered. Flexible service providers, on the other hand, are not obliged to offer services in all availability windows, and the National Grid is not obliged to accept and buy all the services offered. STOR is procured via competitive tender with three tender rounds per year. If the tender is accepted, the STOR provider receives compensation in form of availability payments and utilization payments.

Ireland

In 1993, Northern Ireland Electricity implemented direct load control of storage and water heating using radio teleswitches. This has been successful as allowed for the coordination of load management with control of generation. It has promoted change in tariffs and working practices. System-led load control programs[21] in Ireland include Winter Peak Demand Reduction Scheme (WPDRS), the Powersave program and the Short time active reserve (STAR) program.

WPDRS was introduced by EirGrid in 2003. Customers able to reduce their electricity demand between 17:00 h and 19:00 h can earn payment for their reduction. Payments include a reliability payment which is based on the difference between baseline and committed level, and a profile payment.

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[20] Found on : http://www.nationalgrid.com/uk/Electricity/Balancing/services/

[21] Found on: http://www.eirgrid.com/operations/ancillaryservicesothersystemcharges/demandsidemanagementdsm/winterpeakdemandreductionschemewpdrs/

The powersave scheme encourages large and medium-sized customers to reduce their electricity demand on peak power days. In return, participating customers are paid on the basis of kWh reductions achieved during a powersave event. A powersave event may be called at any business day of the year and for any time of day where customers will be notified before the event.

The STAR scheme, previously known as the 'Interruptible Load' scheme, has been running for over 20 years. Electricity consumers are contracted to make their load available for automatic short term interruptions, occurring 10 to 20 times a year. This service provides the TSO with 'reserves' that are utilized in the event of the loss of a large generating unit. Here, contracted industries receive payments for load availability, while it is their responsibility to pay for equipment installation.

Italy

Interruptible programs represent 6,5% of peak power. Here, large industries are required to reduce their load to predefined values and face penalties if they fail to do so. Load shedding programs initiate automatic load shedding in emergency situations. There is a real time program and a 15 minute notice program. Furthermore, the energy regulator integrated a mechanism for calculating the price of energy designed to shift consumption to periods of lower and cheaper loads.

Spain

In Spain, system-led programs are shifting from classical to market-grounded programs. Direct load control has been in place in Spain since 1988. About 200 large industrial consumers have been able to choose special tariffs on a voluntary basis. The Spanish TSO can request these industries to limit the demand during periods of time varying from 45 min to 12 h, upon the condition that the TSO informs industrial consumers in advance.

3.2 Utility service provider/ Partnership model

Due to fragmented and deregulated European demand response markets, demand response companies are finding new ways for market participation. The partnership model upgrades the traditional utility model. This model entails the role of a utility as an aggregator in partnership with a demand response company. The utility provides access to customers and markets, while the demand response company provides technology and the expertise. Again, this model differs from a basic technology provider model since the risks, the expertise and benefits are shared between the two or more actors.

By aligning the interests of the utility and the demand response company, much of the risk for both, aggregator and utility, are eliminated. At the same time, many of the benefits are preserved. By cooperating with the demand response specialist, the utility can still concentrate on its core business. In addition, the costs incurred by the independent aggregator for operation activities, such as the network operation center (NOC), are eliminated since the utility already has these operations in place.

Furthermore, the transition to demand response integration is facilitated due to the utility's past experience with the traditional utility model. On the other hand, the demand response company participating with a utility in such a model has to be prepared to adapt to the rules that apply to the utility, especially the regulation for establishing such a structure. However, in some cases such as the mandatory participation in a balancing group, the described participation can further facilitate market entry. A similar situation applies to easier participation in electricity markets.

3.2.1 Technology provider

A technology provider is a company developing demand response technologies and selling it to utilities. Doing so, the technology provider itself does not participate directly in demand response markets. Utilities buying this technology then follow the utility model. From the technology provider's point of view, this model allows him to focus solely on developing technology in exchange for potential revenues from participating in the electricity market. The loss of potential revenue is usually partly compensated by pay-for-service revenues.

Another disadvantage of the technology model is that these are off-the-shelf products. In the case of the European markets, the needs of different markets and utilities vary significantly. In this case, the technology bought by a basic technology provider might not be appropriate for specific needs. On the other hand, there are many markets in demand response where the technology itself might be sufficient.

3.2.2 Customer-provisioned model

The third model of participation described by Thomas et al.[22], is customers purchasing and provisioning demand response technology and processes for themselves. This model is called customer-provisioned model and does not refer to utilities but to customers directly.

An example provided by Thomas et al. describes large national retail chains with their own internal corporate policies regarding demand response as a way to manage operating costs, and who develop and manage participation in programs at a national level. In the US, firms

[22] Thomas, Chris et al., *An Assessment of Business Models for Demand Response*, GridWise Architecture Council. 2008, 7.

like Wal-Mart and Target carefully monitor the operations of their stores in real-time across many variables. If the temperature in a freezer in a Target store in New York is abnormally high, the control center in Minneapolis knows about this and contacts the store manager. The same aggregation of information can be and is being used for demand response purposes. However, these companies incur most of the costs of the independent aggregator such as the operating center and other operational and installation costs. The author identifies that as US standards become clearer, and telemetry and control costs decline, smaller and smaller customers will be able to provision and maintain their own demand response.

Since demand response technology in the customer-provisioned model entails the role of internal optimization, this model is appropriate for large European companies as well. Here, the deregulation of the markets and the slow demand response development in some parts of Europe, do not play as much a significant role as with other market models. More and more large retail chains in Europe are interested in demand response technology.

3.3 Revenue models

The second division of market models was done on the basis of different sources of revenue. The profitability factor of demand response is very important; however it is not the only benefit deriving from demand response activities. Increased efficiency and better response to market needs brings about many benefits. Looking at financial benefits for instance, customers benefit from bill saving. Electricity consumers in general, distribution system operators and transmission system operators benefit from increased reliability, lowering their financial cost of peak capacity and allowing certain investments to be avoided or delayed. Furthermore, the market in general benefits from lower electricity prices. This happens when productions costs are lowered as a result of expensive peak power plants running at reduced levels. Lower production costs show in lower wholesale electricity price which in longer term is reflected in retail prices. These benefits are important in order to be a market driver in demand response. Here however, we focus only on the benefits for a demand response company from different revenue programs for participation.

Demand response programs were traditionally used for energy efficiency and conservation with reliability-driven load management programs used occasionally for emergency situations which sometimes disrupt the success of these actions as electric prices were taken as a given[23]. With electricity systems in Europe changing, many more opportunities arise for

[23] Charles river associates, 2005. Primer on demand side management. p.4

demand response companies. Intensive integration of smart meters, renewable energy sources, electric vehicles and other new technologies will go hand in hand in the future demand response market.

Balancing renewable energy sources

"On-grid renewable capacities will have to account for 40% of European generation capacities in 2020: such a high share will require new ways of balancing electricity[24]"

According to De Jonge[25], there are three different trends visible in the electricity market leading to several problems:

- The increasing use of distributed generation (DG) to the distribution grid.
- The increasing use of large-scale intermittent sustainable energy sources
- Increasing demand of electricity caused by electric vehicles, the application of heat pumps and other.

"Deploying demand response resources at appropriate locations would allow generation to operate at a lower cost as the congestion is reduced and also transmission network investment can be postponed while maintaining the existing level of security.[26]" Here, demand side management can help to integrate these new sources of energy more efficiently, prevent the necessity of huge investments and make electricity markets more competitive.

Demand side management is used for the integration of large central renewable sources in case of reliability responsive programs (dispatchable) presented below.

Demand response participation programs

Apart from changes in electricity markets, constant development in demand response technologies can also be observed. Technological development in combination with lowering costs, opens additional opportunities for participation in new revenue programs. Currently, not all markets are available in every country in Europe, however significant development can be observed.

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[24] Capgemini, 2008. Demand response: A decisive breakthrough for Europe; p. 5

[25] De Jonge p.10

[26] Yousefi et al. 2011. Congestion management using demand response and FACTS devices. p.1

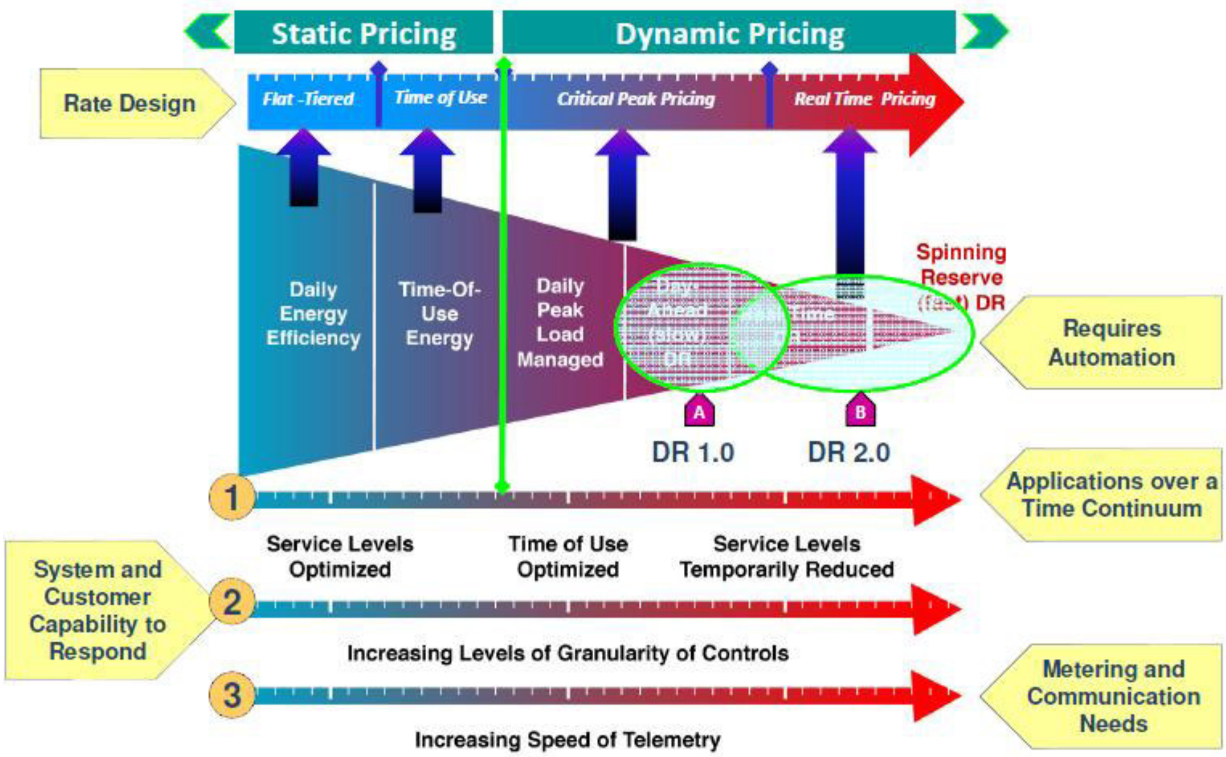

Figure 3: Development of DR markets, Source: Levy et al.[27]

Even if the markets offer many demand response participation programs, it is not expected for a demand response company to participate in all markets. *"As part of their business strategy, some aggregators may specialize on certain services, based on its customer base, technological level, cost considerations, etc., or try to maximize the value of distributed energy resources by attempting to offer as many services as possible"*[28].

The IEA[29] identified that in all the countries investigated (see table below), demand response is present to some extent. The most common DR scheme is the time of use tariff (ToU) or the real-time pricing. Moreover, interruptibility power contracts for industrial customers, considered within indirect load control initiatives, have been widely deployed for power balancing in most countries, at least in Europe and the USA. Furthermore, the IEA identified the best known type of DR that is commonly used in participating countries to be the load shedding. It helps the transmission system operator in case of critical situations, such as avoiding a blackout (congestion management) or restarting the system after one.

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[27] Levy et al. 2011. Demand response. NARUC webinar. p.10

[28] Ikaheimo et al., 2010. DER aggregator Business: The Finnish case p. 16

[29] IEA, Integration of demand side management, distributed generation, renewables energy sources and energy storages;

Table 3: Integration of DSM, DG, RES and storages: Flexibility in the electricity demand. (Source: IEA)

Type of DR	Country	Note
Time of use	Finland	Retail and network ToU, usually for customers over 10 to 15MWh per year
	Italy	Night&Day tariffs for residential customers
	Spain	Compulsory above 50kW, otherwise optional
	Austria	
	Netherlands	
	USA	
	Korea	Industrial and commercial consumers
Real-time pricing	Finland	Some suppliers are offering this form of pricing for small customers if customer has an hourly meter [11]
	Italy	For large and medium consumers
	Spain	For large consumers
	Netherlands	For large consumers
	USA	Exists and is viewed to increase
Curtailment and direct load control programs *	Italy	Interruptible load deals with VHV grid large customers (by 7% of country peak load)
	USA	Most of the DR programs are of this type
	Austria	
* : Does not include emergency curtailment programs that exist in all the participating countries		

Furthermore, Levy et al. conducted investigations of demand response options in US markets. In their 2010 FERC Survey program, they found that 79% of demand response companies participate in four revenue programs.

- Most common demand response participation is direct load control,
- second is interruptible load,
- following by emergency demand response
- and load as capacity resource.

Other, less common participation programs are seen in the table below.

Table 4: Demand response options in the US. Source: Levy et al.[30]

	2010 FERC Survey Program Classifications[1]	Description
1	Direct Load Control	Sponsor remotely shuts down or cycles equipment
2	Interruptible Load	Load subject to curtailment under tariff or contract
3	Emergency Demand Response	Load reductions during an emergency event Combines direct load control with specified high price
4	Load as Capacity Resource	Pre-specified load reductions during system contingency
5	Spinning Reserves	Load reductions synchronized and responsive within the first few minutes of an emergency event
6	Critical Peak Pricing w/Control	Combines direct load control with specified high price
7	Non-Spinning Reserves	Demand side resources available within 10 minutes
8	Regulation Service	Increase or decrease load in response to real-time signal
9	Demand Bidding and Buyback	Customer offers load reductions at a price
10	Time-of-Use Pricing	Average unit prices that vary by time period.
11	Critical Peak Pricing	Rate/price to encourage reduced usage during high wholesale prices or system contingencies
12	Real-Time Pricing	Retail price fluctuates hourly or more often to reflect changes in wholesale prices on day or hour ahead
13	Peak Time Rebate	Rebates paid on critical peak hours for reductions against a baseline
14	System Peak Response Transmission Tariff	Rates / prices to reduce peaks and transmission charges

79%

In addition, Thomas et al.[31] divide demand response revenue sources in dispatchable and non-dispatchable, as presented below:

- **Dispatchable:**
  Also called „reliability responsive programs“, where demand is reduced to cope with electricity peaks and grid stability.
  - Direct load control
  - Contractually interruptible/curtailable supply
  - Capacity market programs
  - Ancillary services

[30] Levy et al. 2011. Demand response. NARUC webinar. p. 19

[31] Thomas, Chris et al., *An Assessment of Business Models for Demand Response*, GridWise Architecture Council. 2008, p.5

- **Non-dispatchable:**
  Non-dispatchable demand response revenue sources are based on price incentives, where demand is reduced according to tariff structures.

  - Time of Use pricing (TOU)
  - Real Time Pricing (RTP)
  - Critical Peak Pricing (CPP)
  - Peak Time Rebate (PTR):
  - Price-triggered automatic load reduction
  - Emergency DR

Below, different revenue models are described according to the above presented classification used by Thomas et al.

3.3.1 Dispatchable

Dispatchable programs (reliability responsive programs) are programs where demand is reduced according to instructions from a control center[32]. Load reduction is triggered on reliability reasons or when prices are too high. Orders are usually dispatched by utilities, load serving entities or grid operators. In return, demand response companies are usually compensated based on load reduction compared to the baseline. If demand response companies fail to deliver the service, they sometimes face penalty charges.

Direct Load Control
Direct load control is a program in which the operator remotely shuts down electrical equipment such as air-conditioning or water heating[33]. Some examples of these programs are available in the explanation of the traditional utility model.

Load curtailment
Interruptible or curtailment service is a curtailment program where incentives are given to large customers who agree to reduce their load in case of congestion. Some examples of these programs are available in the explanation of the traditional utility model.

Capacity market programs
In capacity market programs, customers offer load curtailment for replacement of traditional reservation. Services are usually compensated based on availability payment.

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[32] Thomas, Chris et al., *An Assessment of Business Models for Demand Response*, GridWise Architecture Council. 2008, p.5

[33] US department of Energy, 2006. Benefits of demand response in electricity markets and recommendations for achieving them.

Chapes, Goldman and Catan[34] were investigating demand response in US electricity markets and identified that as the demand response market in the US developed, curtailment service providers gravitated from energy payment for load reduction to incentive-based demand response programs like capacity market and request for emergency resources. Since these markets provide upfront and ongoing reservation payment for committed load reduction, risks for both, customer and aggregator, are lower.

Similar to the US, the capacity market is one of the more promising markets in Europe for demand response companies.

Ancillary services:

Ancillary services ensure the reliability and support of transmission of electricity, including regulation and frequency response, spinning reserve, non-spinning reserve, replacement reserve, and reactive supply and voltage control. In ancillary services programs, a demand response company receives payments for providing load reduction for system balancing. As for other programs, ancillary service characteristics depend on each country. Depending on technology capabilities, demand response companies are usually capable of participating in tertiary reserve markets, some even in secondary reserve markets. The ancillary services market differs from other programs due to necessity to react faster and need to be available all the time.

3.3.2 Non-dispatchable

Non-dispatchable programs are the ones where demand is reduced according to tariff structures, providing incentives to end-users to manage their usage. This is also referred to as "*Price-based demand response*". Here, dynamic pricing is evolving. If the price varies in time, customers can respond to the price with significant changes in energy use which reduces their electricity bills. Customers increase usage to take advantage of lower-priced periods and avoid consuming when prices are higher. Here, participation is not binding.

Programs involving demand response to price signals are not widely available in developing and transition economies at this time[35]. However, the European market for dynamic pricing is developing.

***Time of Use pricing (TOU)*:**

In Time of use pricing, prices differ according to levels for peak and off-peak periods. The periods are set according to daily price variations that entail electricity costs.

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[34] Cappers et al. 2009. Demand Response in U.S. Electricity Markets: Empirical Evidence. p. 23

[35] Charles river associates, 2005. Primer on demand side management. p. 15

***Real Time Pricing (RTP)*:**
In Real Time Pricing, retail prices vary in real time to reflect the wholesale market. According to Thomas et al.[36], customers on peak time pricing programs are usually informed of the hourly prices either hourly or a day ahead, so consumption can be planned. This program gives the most accurate price signal and represents the biggest incentive to reduce peak usage, but it requires active participation.

***Critical Peak Pricing (CPP)*:**
In critical peak pricing, as the name suggests, prices are increased during system peak periods. These peaks usually refer to high temperature summer season or winter season when electricity is used for air conditioning or heating, respectively. An example of such a model is the demand response program in Ireland called WPDRS (Winter peak demand response scheme). More about these programs will be explained in the section below. The duration of load reduction can be fixed or variable.

***Peak Time Rebate (PTR)*:**
According to Thomas et al., in a peak time rebate program, customers are credited for reductions in consumption (compared to customer-specific baseline normal usage) during specified system peak periods. Instead of raising prices during high cost periods, Peak time rebate provides a credit or rebate for each kWh of reduced usage. Here it is required that a baseline of normal usage is set for each customer for each hour.

***Price-triggered automatic load reduction*:**
Price-triggered automatic load reduction entails automatic shutdown of loads according to customer wishes and not triggered by the utility.

***Emergency DR*:**
Emergency DR is a program where customers are paid to voluntarily reduce load when there is an emergency situation.

3.4 Resources

A demand response company can specialize in aggregation of different types of customers. Here, different technologies are needed for different types of loads. Some loads can only be operated manually or for some duration, or the installation of automatic operation equipment is not yet financially viable.

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[36] Thomas, Chris et al., *An Assessment of Business Models for Demand Response*, GridWise Architecture Council. 2008 p.5

For larger loads more expensive control and communication technology can be used and a different approach must be taken in marketing with different types of customers[37]. Furthermore, according to DER Aggregator, customers of demand response companies differ in expectations, legal aspects and also different degrees of negotiations.

Here we divide customers into households, commercial and industrial customers and distributed generation.

3.4.1 Households

Households are usually targeted by independent aggregators. Since the household consumption is relatively small to other types of customers, usually a lot of households are needed to participate in demand response programs. In Europe, it is not common for aggregators to target households, while in US household electricity consumption is usually larger, allowing for aggregation.

Households differ in other aspects as well, not just size of the load. According to Ikaheimo et al., households do not only make decisions based on economic contemplations but also pay attention to environmental values, and they have usually even less understanding of energy issues than real estate managers in small commercial and industrial enterprises.

Although households are currently not the main target of demand response companies, this is expected to change significantly for at least two reasons. First, the variable costs for connecting the individual customer are expected to decrease in the future, bringing financial viability for connecting households. Second, there is a definite growing trend in small renewable energy generation on a household basis and a possible integration of electric vehicles. These trends are an especially important factor in Europe. According to De Jonge[38], apart from existing household appliances the future scenario for the year 2030 is that there will be a 100 % penetration of electric vehicles and heat pumps. This means that there will be an extra peak load caused by charging electric vehicles and using heat pumps.

3.4.2 Commercial and industrial customers

Large commercial and industrial clients are **usually** the main target of demand response companies. Their main benefit is size. As the size of the load is larger, profitability grows. Furthermore, demand response technology brings many benefits to industrial and commercial clients. The optimization of production and the significant potential for lowering

[37] Ikaheimo et al., 2010. DER aggregator Business: The Finnish case p. 15
[38] De Jonge, 2010. Business models for demand side management p. 36

electricity bills bring many incentives for these customers to participate. On the other hand, the demand response company needs a good knowledge of industrial loads and specific market industry to successfully identify appropriate loads. Also, for successful load curtailment of more complex loads, there is a need for a more intelligent technology.

Commercial customers include:

- shopping centers and supermarkets,
- universities and schools,
- office buildings,
- hospitals,
- hotels, etc.

Industrial customers include:

- pulp, paper
- water treatment plants,
- mining and minerals,
- iron and steel,
- chemicals,
- cold storages,
- etc.

3.4.3 Distributed generation

Distributed generation (DG) is small capacity power generation including renewable resources and combined heat and power units.

Distributed generation (DG) involves a large number of generation technologies usually between 1 and 50 MW[39]:

- small turbines with a steam cycle
- small turbines with an organic Rankine cycle (ORC),
- gas turbines,
- micro turbines,
- diesel- or gas-fuelled reciprocating engines,
- Stirling engines,
- fuel cells (high and low temperature),
- photovoltaic systems,
- wind turbines.
- Small hydro turbines.

Furthermore, the IEA identifies three characteristics:

- In most cases these resources are located at places far away from the network or on a weak network, thus increasing connection costs.
- Non-controllability also comes with additional costs to cover the risks due to the fluctuation in generation.
- Usage of energy storage as part of the distributed energy systems offers several benefits for managing the fluctuations in energy use or generation.

"Several models for the future electricity system recognize the fundamental fact that with increased levels of distributed generation and active demand-side penetration, the distribution network can no longer act as a passive appendage to the transmission network. The entire system has to be designed and operated as an integrated unit. In addition, this more complex operation must be undertaken by a system where ownership, decision-making and operation are also dispersed[40]".

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[39] IEA, Integration of demand side management, distributed generation, renewable energy sources and energy storages; p.25

[40] IEA, Integration of demand side management, distributed generation, renewable energy sources and energy storages; p.25

4 Market and impact assessment

4.1 Market assessment for demand response solutions in Austria

The potential market for DR applications can be assessed by observing the markets in the USA. The DR business in the USA is well developed due to very supporting market rules since DR is a part of the US electricity supply strategy.

According to Energy Information Administration statistics, the sum of summer peak loads in the US was about 768 GW and the annual consumption was 4.016 TWh in 2010[41]. The annual peak load reduction is published to be 33,2 GW in 2010, with 20,8 GW coming from energy efficiency programs and 12,5 GW coming from load management. Total expenditures of utilities for demand side management (DSM) programs were about 4.220 million USD in 2010, of **which 1044 million USD are direct expenditures for load management[42].** An assessment of the benefits of DR in the USA is shown in Table 5.

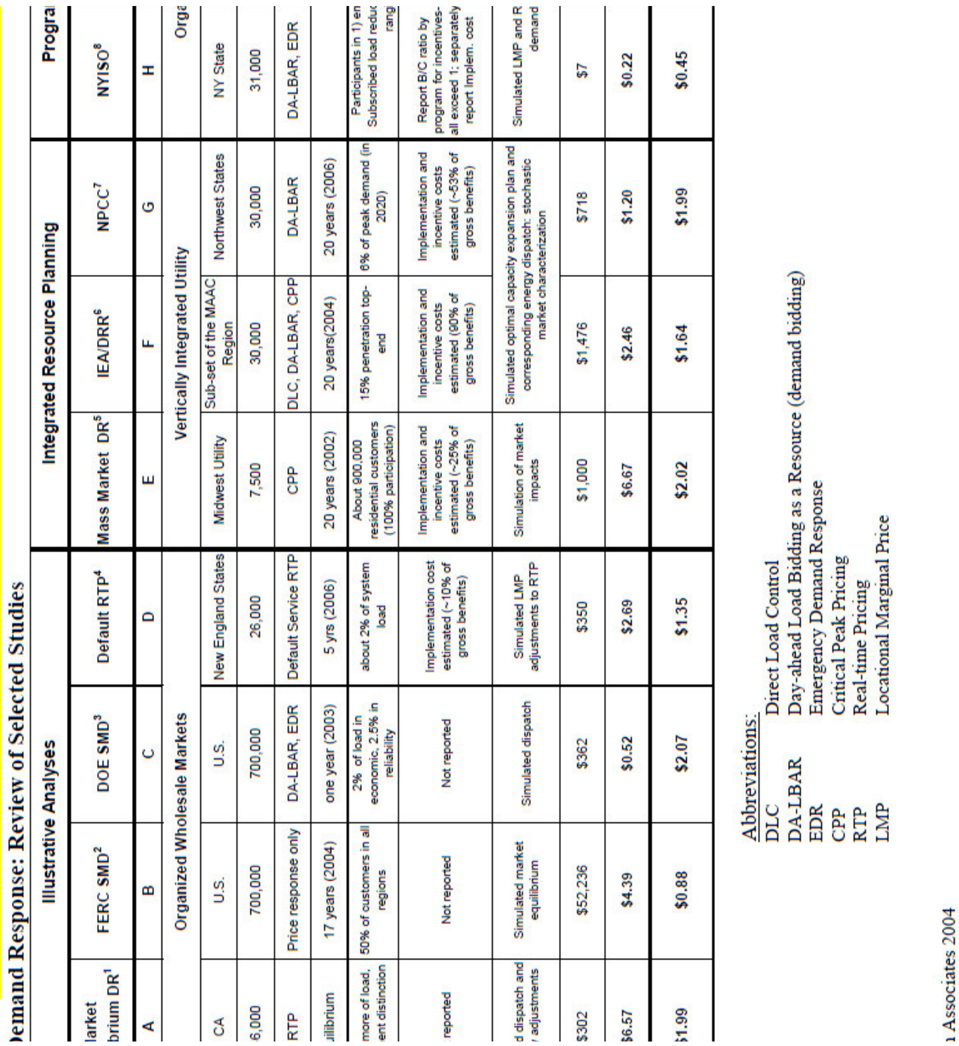
In 2010 the ENTSO-E countries had a (winter) peak load of about 557 GW and an annual consumption of 3.408 TWh[43] which represents 72% of US values in terms of load, and 85% of US values in term of consumption. Austria had a peak load of 10,76 GW and a consumption of 68,3 TWh in 2010, which represents 1,4% respectively 1,7% of US values.

[41] U.S. Energy Information Administration: *Electric Power Annual 2010*, http://www.eia.gov/electricity/annual/

[42] These values only consider large utilites.

[43] ENTSO-E: *Statistical Yearbook 2010*, https://www.entsoe.eu/resources/publications/general-reports/statistical-yearbooks/

Table 5: Review of studies about the benefits of DR in the U.S.A. [44]



...emand Response: Review of Selected Studies

	Illustrative Analyses				Integrated Resource Planning			Progra...
...larket ...brium DR[1]	FERC SMD[2]	DOE SMD[3]	Default RTP[4]	Mass Market DR[5]	IEA/DRR[6]	NPCC[7]	NYISO[8]
A	B	C	D	E	F	G	H
Organized Wholesale Markets				Vertically Integrated Utility			Orga...
CA	U.S.	U.S.	New England States	Midwest Utility	Sub-set of the MAAC Region	Northwest States	NY State
6,000	700,000	700,000	26,000	7,500	30,000	30,000	31,000
RTP	Price response only	DA-LBAR, EDR	Default Service RTP	CPP	DLC, DA-LBAR, CPP	DA-LBAR	DA-LBAR, EDR
...ilibrium	17 years (2004)	one year (2003)	5 yrs (2006)	20 years (2002)	20 years(2004)	20 years (2006)	
...more of load, ...ent distinction	50% of customers in all regions	2% of load in economic, 2.5% in reliability	about 2% of system load	About 900,000 residential customers (100% participation)	15% penetration top-end	6% of peak demand (in 2020)	Participants in 1) en... Subscribed load reduc... rang...
...reported	Not reported	Not reported	Implementation cost estimated (~10% of gross benefits)	Implementation and incentive costs estimated (~25% of gross benefits)	Implementation and incentive costs estimated (90% of gross benefits)	Implementation and incentive costs estimated (~53% of gross benefits)	Report B/C ratio by program for incentives- all exceed 1; separately report implem. cost
...d dispatch and ... adjustments	Simulated market equilibrium	Simulated dispatch	Simulated LMP adjustments to RTP	Simulation of market impacts	Simulated optimal capacity expansion plan and corresponding energy dispatch: stochastic market characterization		Simulated LMP and R... demand
$302	$52,236	$362	$350	$1,000	$1,476	$718	$7
$6.57	$4.39	$0.52	$2.69	$6.67	$2.46	$1.20	$0.22
...1.99	$0.88	$2.07	$1.35	$2.02	$1.64	$1.99	$0.45

Abbreviations:
DLC Direct Load Control
DA-LBAR Day-ahead Load Bidding as a Resource (demand bidding)
EDR Emergency Demand Response
CPP Critical Peak Pricing
RTP Real-time Pricing
LMP Locational Marginal Price

...Associates 2004

If assumed, that the market potential of DR is relative to the peak load of a power system, and Europe will establish a supporting legal framework for DR like in the U.S., then the market potential for DR can be assessed by a linear relation (see Table 6).

Table 6: Assessment of market volume (turnover) for DR
(calculated with an exchange rate of USD:EUR=1,25:1)

	peak load	direct expenditures for DR	
	GW	million USD p.a.	million EUR p.a.
USA	768	1044	

[44] Benefits of demand response in electricity markets and recommendations for achieving them - A report to the United States Congress pursuant to section 1252 of the energy policy act of 2005. Washington: U.S. Department of Energy, 2006. http://eetd.lbl.gov/ea/ems/reports/congress-1252d.pdf

ENTSO-E	557	757	606
Austria	10,76	14,6	11,7

Furthermore, US figures take a DR capacity of 12,5 GW respectively 1,63 % of peak load into consideration. Many studies state that about 5 % of the annual peak load could be addressed by DR programs[45], which is three times higher.

With this approach, an annual market volume of about 600 to 1800 million EUR can be assessed for DR solutions within ENTSO-E, respectively 12 to 36 million EUR in Austria.

4.2 Competitors in the demand response aggregation business

Between the competitors we have to differentiate between:

(A) existing demand side management (DSM) companies like EnerNOC,

(B) large companies like SIEMENS and Honeywell or Schneider Electric

(C) new competitors who are not yet acting in the market, but could be able to develop competing technologies within the next 3 years

(D) large industrial plants (like paper mills) that offer curtailment capacity directly on the power markets but are facing availability issues since not participating in an aggregators pool

But at the moment, the main competitor for demand response business in Europe is still the investment in traditional power generation.

4.2.1 Companies already in the business

As a major example **EnerNOC** has to be mentioned, a US based company that is already trying to enter the European marketplace (via UK). EnerNOC was founded in 2001 and is a large provider of energy management equipment and demand response services for commercial, institutional, and industrial customers, as well as electric power grid operators and utilities. The company focusses on Anglo-Saxon countries. At the end of 2011, they

[45] Gutschi, Stigler: *Potenziale und Hemmnisse für Power Demand Side Management in Österreich*, 10. Symposium Energieinnovation, Technische Universität Graz, 2008.

managed 7.100 MW at 11.400 consumer sites, with annual revenues of about 287 million USD in 2011.

EnerNOC's literature suggests that their business model looks as follows:

- They primarily focus on simple load capacities in industrial or commercial sites like HVAC, boilers, lights (load and generation).
- Through an end-user survey, EnerNOC determines the peak shaving potential at the customer's facility, and receives a commitment for the peak shavings from the end user.
- EnerNOC installs the necessary monitoring, switching and communications hardware and connects it to its network operating center, free of charge to the customer.
- The customer will experience significant power savings through the agreed upon peak shaving activities.
- EnerNOC sells the non-used peak capacity to the utility company and that is their major source of revenue.
- Based upon an agreed peak shaving target between the end user and EnerNOC, EnerNOC gives a small bonus to the end user for exceeding the target.
- Due to the nonexistence of capacity markets, this business model will not work in central Europe in the next years.

Other US-based players on the electricity market that are providing demand response solutions like Cpower, Comverge etc. focus on residential and commercial customers.

4.2.2 Established technology corporations

Large corporations like SIEMENS, Honeywell or Schneider Electric are developing scalable smart grid technologies:

- Mainly DSM projects in the area of controlling residential loads are developed by large corporations in order to create high numbers of new applicable hardware components. Therefore, industrial and commercial demand response projects are rare.
- These large corporations have strong lobbying abilities and are very well connected within the energy industry and legal decision makers.
- Long-term and trustful business relationships and strong resources of those players enable fast international market entry.

4.2.3 New Competitors

Smart Grid R&D projects are beginning to develop within Europe. New market participants mainly arise in countries with supporting market rules, e.g. France. In the area of demand response a few regional demonstration systems are known. But no competitor on the market has yet gained a significant market penetration.

- It is hard to predict which kind of competing technologies we will have to face in the future. But according to our current knowledge, very few companies are trying to enter the European market and have proper technological solutions. KIWIPOWER is a demand response service provider located in the UK who is still looking for feasible technologies in order to be able offering their services.
- All new competitors within Europe face the same legal and regulatory challenges.
- Business opportunities of new companies strongly depend on their network within the energy industry and have to be analyzed individually as soon as activities can be recognized.

New competing companies in the European market are:

- **Entelios** (Germany), founded in 2010, is the main competitor on the German market.
- **Energy Pool** (France) has joined a strategic partnership with Schneider Electric.
- **Actility,** which is also of French origin, started as an independent aggregator but is now additionally trying to launch a parallel business as technology provider for utilities.
- **KIWIPower** (UK)
- **EnerNOC** (UK)
- **Voltalis** (France)

4.3 Impact assessment

An affordable and secure supply with electric power is one of the fundamentals of our modern society. But the increasing use of fluctuating renewable energy sources (RES) like small hydro, wind power and photovoltaics lead to higher cost for end consumers and may cause a reduction of the security of supply. Demand response used in smart grids business models has the potential to minimize these disadvantages in an economic and efficient way. The improved utilization of the existing infrastructure can reduce the investment requirements in “conventional” generation infrastructure (coal, gas, heavy fuel oil (HFO), nuclear) and enhance the integration of new RES in the power grids.

High energy costs are one of the main challenges of heavy industries in Europe. The increasing use of demand response will provide a possibility for medium and larger consumers to reduce electricity costs by generating income from participation in DR aggregator pools.

Furthermore, a new entrant to the electricity economy has to pay great attention to regulatory requirements. Changes in technical and market rules will be required in order to run a virtual power plant business model without the need of additional subsidies, minimizing electricity costs for end consumers.

Considering these facts, a new VPP based on demand response in Austria will be a step towards a smart power supply reducing costs for small and medium size end consumers as well as industries, while also improving the integration of RES to reduce CO_2-emissions in Austria.

In the following, the impacts of demand response implementation on the environment and the power system will be assessed referring to a study of Capgemini Consulting, VaasaETT and Enerdata presented in 2012[46.] The study investigates the effects of demand response (DR) in the residential, commercial and industrial segment with the scope of the EU27. It is considered to be a main reference in the European smart grid community.

The potential for DR in 2020 is estimated under two scenarios: In the moderate forecast scenario the current status of regulation in each country is thought to continue until 2025. The dynamic scenario considers the best case of DR development with a supporting regulatory framework and implementation of smart meter technologies in all countries. Both scenarios are compared to a technical potential.

The study investigates nine types of demand response offers focusing on peak load reduction and energy savings. The results for the EU-27 and Austria are listed in Table 7.

Table 7: Impacts of DR in EU-27 as well as Austria within 10 years, assessed by Capgemini, VaasaETT and Enerdata in 2012

Scenario	Peak saved	CAPEX avoided in peak power plants	CAPEX avoided in grid investment	Consumption saved p.a.	Electricity bill saved p.a.	Emissions saved p.a.	
	GW	*million EUR*	*million EUR*	*MWh*	*mill. EUR*	*kt_{CO2}*	
Forecast	46,4	18 567	9 284	19,5	2 713	13 675	EU-27
Dynamic	60,8	24 325	12 162	70,4	10 371	49 306	
Technical potential	91,7	36 664	18 332	164,4	21 562	102 513	

[46] *Demand Response 2012: Assessment of DR potentials in EU-27 within 10+ years. Methodology, Results, Discussion & Recommendations.* An abstract of the study can be downloaded from the news site of the SGP2012: http://www.corpevents.fr/sgparisnews/news-fev2012-capgemini.html

Forecast	0,9	360	180	134	19	93	Austria
Dynamic	1,21	485	243	1.099	162	769	
Technical potential	1,76	703	351	2.285	337	1.600	

Because the above mentioned study focuses on the demand side and does not take into consideration the improved integration of renewable generation into the distribution grid derived from the implementation of VPP technology, the emission savings presented in **Fehler! Verweisquelle konnte nicht gefunden werden.** stand as minimum values.

For instance the "reduced economic potential" for additional hydropower in Austria was assessed by Pöyry[47] with 17.900 GWh in an average year. This would be equivalent to emission savings of 7.160.000 $tCO_{2\text{-eq}}$ per year[48]. The overall emission savings caused by the feasible development of RES is about **4.200.000 $tCO_{2\text{-eq}}$** per year, as shown in Table 8.

Often, the development of additional electricity generation from RES is limited by the distribution grid. The implementation of VPP technology in Austria will contribute to reducing grid restrictions and thus support the utilization of the Austrian RES potential.

[47] *VEÖ: Wasserkraftpotentialstudie Österreich, Endbericht*, 05.05.2008, http://www.energiestrategie.at/images/stories/pdf/36_veo_08_wasserkraftpotenzial.pdf

[48] calculated with 400 $t_{CO2\text{-eq}}/GWh_{el}$ as recommended by FFG resp. Umweltbundesamt

Table 8: Status and planned (feasible) development of electricity generation from RES in Austria[49]

	Status quo, 2011	Planned increase until 2020	Sum until 2020	Emission reduction due to increased RES utilization[48]
	GWh/a	GWh/a	GWh/a	t_{CO2-eq}/a
Hydropower (subsidised) Hydropower (total)	988 37.142	4.000	41.142	1.600.000
Wind power	1.883	4.000	5.883	1.600.000
Photovoltaic	39	1.200	1.239	480.000
Biomass, Biogas	2.489	1.300	3.789	520.000
Sum	41.553	10.500	52.053	4.200.000

A study[50] by AIT, Vienna University of Technology and different Austrian network operators published in 2008 show that smart grid technologies can increase the possible share of distributed generation to be integrated into distribution grids in a range from 40% to 110%, depending on grid topologies. These values confirm that the implementation of smart grid and VPP technology has a significant potential to contribute to the planned targets of RES development in Austria.

[49] Sources: Bundesgesetz über die Förderung der Elektrizitätserzeugung aus erneuerbaren Energieträgern (Ökostromgesetz 2012); E-Control: *Betriebsstatistik 2011*; E-Control: *Ökostrom-Einspeisemengen und Vergütungen in Österreich, Gesamtjahr 2011.*

[50] Österreichisches Forschungs- und Prüfzentrum Arsenal (pub.): *DG DemoNetz – Konzept, Aktiver Betrieb von elektrischen Verteilnetzen mit hohem Anteil dezentraler Stromerzeugung – Konzeption von Demonstrationsnetzen*, im Auftrag des Bundesministeriums für Verkehr, Innovation und Technologie, Wien, Juni 2008.

5 Innovative business concepts

5.1 The *dual*-VPP

The investigations and surveys of the EDRC-project showed there is a need for a new type of virtual power plants (VPP). VPPs are often considered a technological problem which comes along with non-technical challenges related to suitable business models, market organization, customer awareness etc.

From the point of view of **technology**, it is the challenge to combine two types of concepts for virtual power plants (VPP):

(A) There are virtual power plant concepts which focus on trading on selected power markets. These VPPs use curtailment of aggregated loads, generators and “unused” capacities like emergency power supplies as “resource” which can be delivered to different customers like TSOs or power traders. These VPPs do not consider technical constraints in the distribution grid. There are some suitable business models for these VPPs, but most European countries do not recognize them, or even support them with the national rules for power markets.

(B) On the other hand there are technically orientated VPP concepts which try to manage loads and generation in distribution grids in order to keep the power quality parameters within the tolerable limits. These VPP concepts are part of the smart grid idea, nevertheless there are no suitable business models fitting into the regulatory framework in most European countries so far.

The concept explained in the following chapter aims at describing a so-called “***dual*-VPP**”, which is capable of satisfying both topics: making business on selected power markets and support the distribution grid operator with active management of loads and distributed generators at the same time. Depending on grid topology and structure of loads and generators, many different technical frameworks and boundary conditions for the operation of such a dual-VPP may appear. The possibilities and limits of the concept have to be evaluated in additional research projects.

The second challenge arises from the **efforts of increasing electricity production from renewable energy resources (RES)** and thus, the increasing impacts of RES on the existing distribution grids. This situation can be found in Austria as well as many other European countries. If the distribution grid cannot collect additional feed-in from distributed generators, the DSO requires payment for grid reinforcements from the generator in order to be authorized to connect to the grid. This approach causes high additional costs for the generators. In many cases, the DSO can decide to utilize smart grid solutions (e.g. reactive power control) in order to prevent the high costs of grid reinforcements. Reactive power control is free of charge with respect to the generated electricity, but is limited in terms of providing additional grid capacities. In some cases it can affect the thermal limit of power lines since reactive currents will increase.

In addition to the reactive power control, active power control can also be applied. Active power control can prevent voltage increase as well as excess thermal limits via monitoring of significant points in the grid. The main disadvantage of active power control is that it can cause high opportunity costs related to non-generated electricity. The opportunity costs of inhibited generation are related to the nominal power of the generation unit. The investor has to consider this effect in order to determine the optimal size of the generation unit. This issue is also relevant to new consumers connecting to the grid.

Besides issues concerning voltage levels and thermal limits in the normal switching status, the concept can also be applied in unusual switching status, respectively in the case of congestions.

The active power control via a VPP can deal with many problems in distribution grids but still it has to deal with **high opportunity costs, especially if generation from RES with high feed-in tariffs are curtailed**. These opportunity costs are too high to be covered by any known business model operating within the current market rules, which is the third challenge to be addressed by the proposed concept.

From a technological point of view, the main objective is the realization of a dual-VPP concept, which combines the existing business model of VPP resource aggregation for electricity markets, peak capacity markets, or balancing markets with a VPP that provides services for distribution grid operation i.e. active power control of loads and generators.

A simplified flow-chart of the proposed *dual*-VPP concept is shown in Figure 4. Distribution grid operators, electricity trading platforms, and resources continuously communicate with the *dual*-VPP in order to provide information about the situation in the grid (congestions, voltage levels etc.) and requested active control, the demand from the market side and the status of the resources (full operation, part load operation, standby, switched off, etc.). Using this information, the *dual*-VPP starts to solve any grid problems by executing the DSOs request for active and reactive management, thus balancing this action in non-critical grid areas if required. In the second step, demand from the power market will be satisfied by modifying load or generation of resources. The active controls in the distribution grid as well as the curtailment of resources are both closed loop control algorithms. Thus, the performance of the resources has to be monitored.

The performance of the resources as well as the fulfilment of the DSOs' request and the market demand is reported to a database. According to contracted prices or dynamic market prices, the accounting module of the *dual*-VPP calculates the client's costs (DSO, power trader etc.) and the revenues of the resources, which were produced by the operation of the *dual*-VPP.

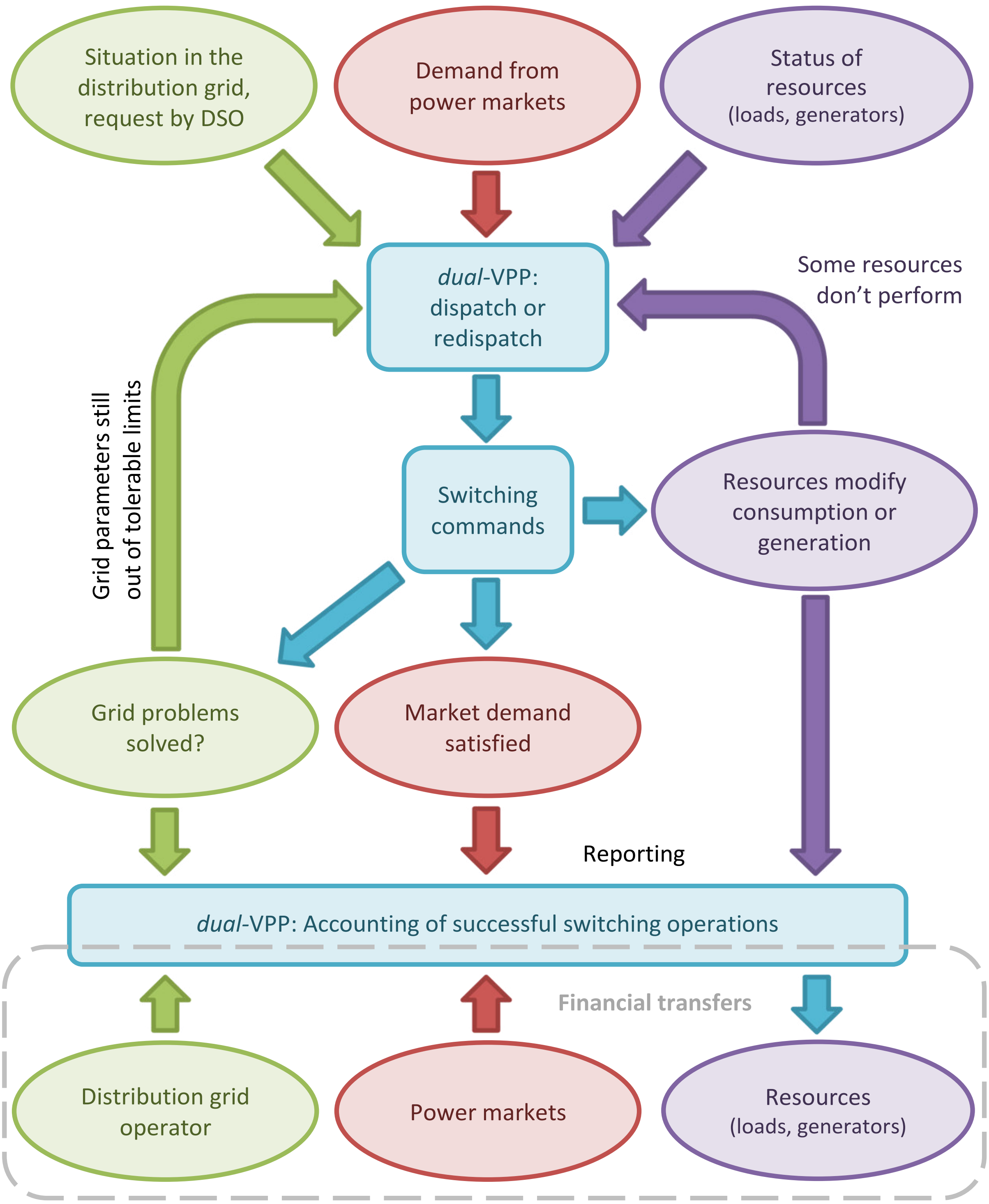


Figure 4: Schematic concept of *dual*-VPP operation (copyright: cyberGRID GmbH)

The possible influence of the distribution grid on the operation of the "trading part" of the *dual*-VPP is explained in Figure 5. In most grid areas no problems are to be expected. In those areas the *dual*-VPP can act without any restrictions. But in some areas the grid might be in a semi-critical state, where a change of (A) generation or (B) load is not allowed. In such cases, the *dual*-VPP is only allowed to act against the critical situation, e.g. increase loads in an area with too much generation or vice versa. Furthermore the grid might fall into critical states where any curtailment operation is not allowed in that area until the operational parameters of the grid returned into safe limits. But in most critical situations in the distribution grid, the *dual*-VPP will be able to provide active control by curtailment of loads or generation in order to assist the DSO in maintaining a secure operation.

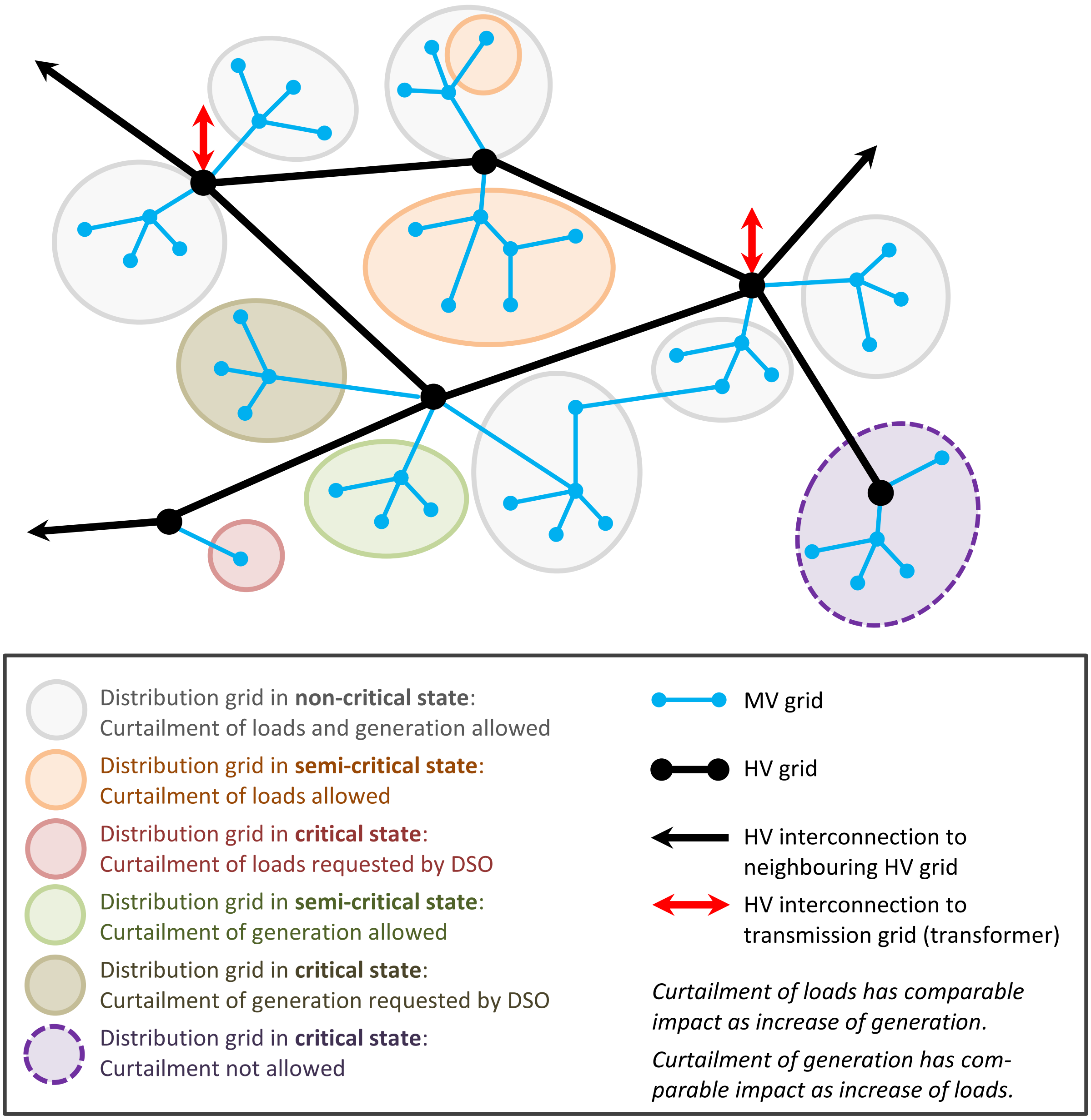


Figure 5: Schematic explanation of the possible influence of the distribution grid on the operation of the *dual*-VPP (copyright: cyberGRID GmbH)

The resulting benefits are expected to be cost reductions for network integration as well as additional benefits for generators and consumers on the electricity market. Another important social effect is the principle of learning, flexibility and adaptation for future development. This includes new market opportunities for involved industry partners such as markets for VPP-related products. On the other hand there will be alternative applications (e.g. Demand Response) for several different other market participants (e.g. electricity utilities or market aggregators).

Enabling a higher share of renewable based distributed generation units allows regions to use locally available resources. This results in an increasing number of local projects (e.g. biomass and PV units), requiring local manpower and knowledge for construction and operation and generation of jobs in the area of renewable energy technologies ("green jobs").

5.2 Concept for software solution

The concept for the fully automated software solution is described in the following using the example of a software solution developed and owned exclusively by cyberGRID GmbH.

An advanced ICT solution aggregates a variety of demand response capabilities (C&I) into a clean energy asset that acts like a conventional peaking power plant.

cyberGRID **Demand Response** (DR) proprietary **Network Operations Center** (NOC) software is designed according to the latest open source Java EE specifications and IEC 62541 (OPC Unified Architecture). Advanced computer algorithms to predict, classify, manage and optimize DR-NOC infrastructure are realized in the software package. It supports fully automatic, semi-automatic and notification-based load control.

Figure 6: Screenshot of the cyberGRID dashboard (copyright: cyberGRID GmbH)

5.2.1 Functional modules

The cyberGRID software package consists of several modules in order to cover the full functional chain of a demand response solution.

cyberCOM – the library of communication drivers that enables DR-NOC to establish a two-way communication with the registered devices (smart meters, data loggers, RTUs, PLCs, etc.) and systems (SCADA, building management systems, local controls, etc.) to exchange metering data, time stamps, set points, commands, price signals, alarms, notifications etc.

cyberBASE – employs algorithms for calculating the characteristic curve for activation, resources (resource facilities and facility devices), consumption. The characteristic curve for the whole activation (aggregation) is determined by summation of all individual characteristic curves of associated resources. All characteristic curves are calculated continuously and simultaneously. They enable an up-to-date and immediate display on the web page for activation control.

cyberSELECT – runs a very fast optimization procedure, based on evolutionary optimization algorithms, and automatically prepares the optimal package of resources to be used for scheduled activation. It boosts the efficiency of the activations and reliability of the DR-NOC's overall operation.

cyberREG – algorithm which calculates the deviation of current capacity from desired capacity. In the case of deviation, cyberREG requests the cyberSELECT to update the activation schedule such that it compensates for the resources which had originally been scheduled for the activation, but are not performing as expected.

cyberARCADE – an innovative three-dimensional monitoring view of demand response curtailment phase, with dynamic presentation of current status from each activated resource, represented by a dedicated **cyberTOWER**. It represents an important informational value to the operator of the demand response NOC, providing a complete demand response pool at a glance for supervision.

cyberWALL – an innovative two-dimensional monitoring view of demand response activation, with static presentation of nominal capacity and duration of each selected resource, framed in the activation profile. It carries an important informational value to the operator of the demand response NOC and can serve as a background to trend and historian.

cyberCONNECT – the interface between the client and the control center. Due to the DR-NOC's requirements our key emphasis is the reliability of performance and communication channels across the network. It supports direct and automatic activation of loads and gen-sets. It brings real time measurements into the DR-NOC database via secure and reliable communication, using the Internet and/or GPRS. Third party automation or SCADA systems managing industrial or commercial loads can be connected and intelligently managed by the DR-NOC.

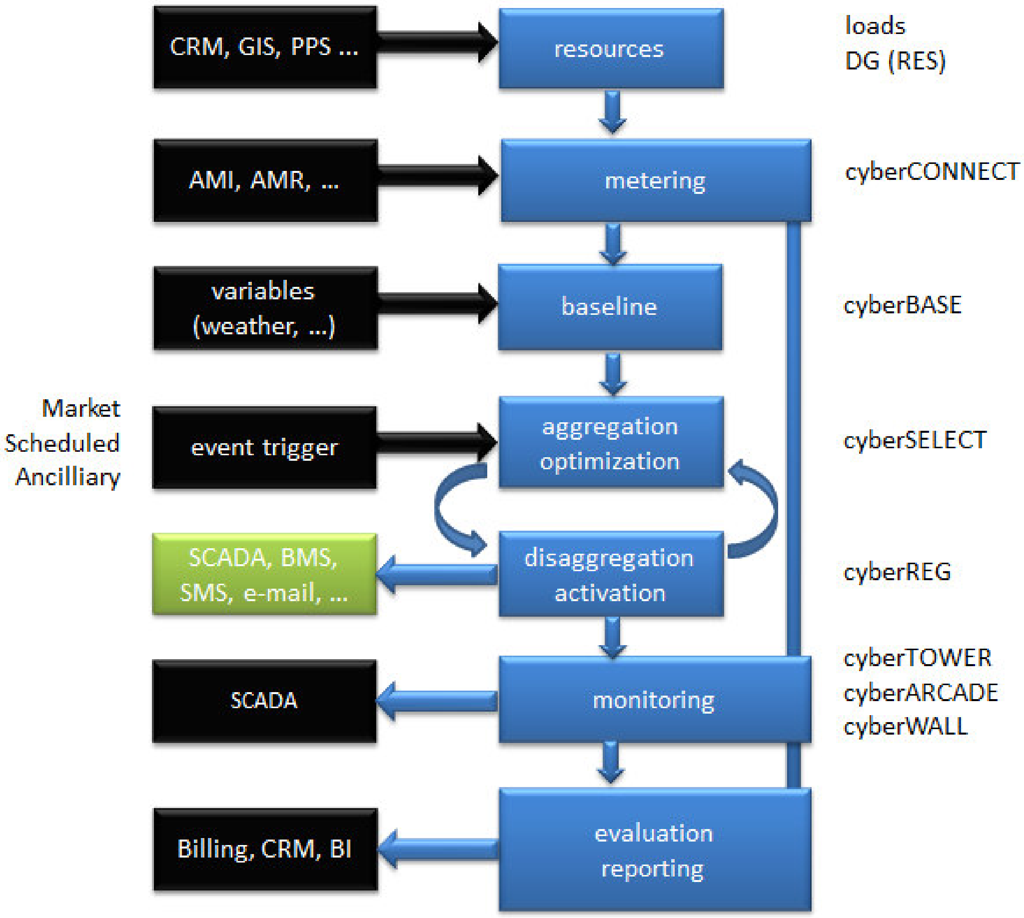


Figure 7: Flow chart of the functionalities in the cyberGRID software concept (copyright: cyberGRID GmbH)

5.3 Concept for a hardware solution

In general there are many different combinations of hardware and software solutions for metering, communication and power plant dispatch utilized in European utilities. Most of these combinations have grown over decades and are adapted to the special needs of a certain utility, thus showing a unique architecture. In most cases, a demand response technology provider will have to adapt to the existing system components, especially for communication, switching and resource dispatch but also for billing. Nevertheless, in the interviews carried out in the frame of the EDRC project many utilities showed interest in an "overall solution" which also includes a hardware unit for remote meter reading and resource control.

This additional hardware functionality can be provided by the cyberCONNECT cabinet. This box realizes a hardware solution for transmission of resource metering data, distributed data storage in case of communication problems, remote switching abilities and additional alarming features. Communication between the cyberCONNECT cabinet and the demand response network operation center can be done via Ethernet or GSM/GPRS-networks, thus providing redundant communication methods.

Figure 8: cyberCONNECT connection capabilities

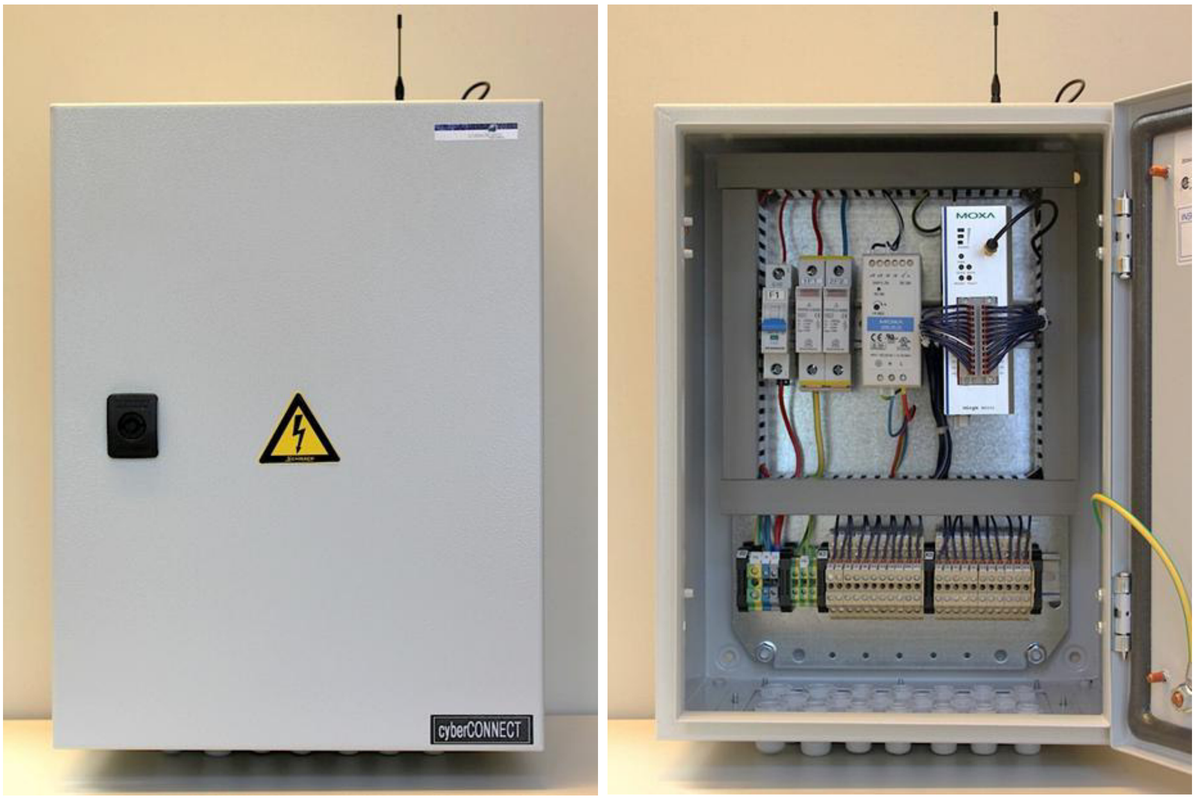


Figure 9: Example of the cyberCONNECT cabinet (ver. 5312)

PART 2: STAKEHOLDERS, USER NEEDS AND BUSINESS MODELS (BRIMATECH SERVICES GMBH)

6 Executive Summary

Power systems are designed to meet a peak demand condition, which means that 10% of electric infrastructure has been built to meet peak demand which occurs less than 1% of the time. Together with issues such as increasing consumption of electricity, ageing infrastructure, environmental issues and public resistance against new projects, also in Austria the pressure to solve these issues through demand side solutions has been growing steadily over the past years. More importantly, demand response (DR) will play a pivotal role in smart grids and markets of the future. The aim of the European Demand Response Center (EDRC) project was to research and explore possibilities of DR in Austria and to derive recommendations for the establishment of an EDRC based in Austria.

The report at hand covers Brimatech's contributions to the EDRC research project. Brimatech's main tasks in the first Work Package were the identification of relevant stakeholders and user groups and the identification of stakeholders' and users' needs. The main task in the second Work Package was the research of possible business models. From a methodological point of view, activities included desk research, numerous interviews (51 in total), a quantitative survey, a stakeholder workshop, value chain analysis and the assessment of drivers and barriers of the EDRC business models.

Focus on the consumer side was put on heavy industry in the two Austrian regions of Upper Austria and Styria. Large plants (selection criteria: > 250 employees) from energy-intensive industry branches were investigated. These branches were: paper, cardboard and pulp; mining, industrial rocks and minerals; iron and steel, non-ferrous metals; chemical industry; glass, ceramics, cement; rubber and plastics.

70 companies in total were contacted and out of these, 16 participated in in-depth interviews that were approximately one hour long and followed up by a quantitative questionnaire. Furthermore, 20 short interviews were conducted via phone. Points of contact were personnel responsible for matters of energy management onsite, namely energy managers and/or plant managers.

Interest and willingness to participate in demand response (DR) systems on the side of industry was considerable with many companies having made experience with load management in the times before the liberalisation of the Austrian electricity market starting 2001. Before the unbundling of functions on the electricity markets, utilities had used the opportunities to shave peak loads in their distribution networks through the direct load management at some big industrial sites. This factor must not be neglected when looking at DR solutions such as EDRC, since energy managers have knowledge both about internally switchable loads and also experience with load management and its implications for internal processes.

Analysis resulted in an actual economic potential of 156 MW at the investigated sites.[51]

Industry Sector	Co. No.	Shiftable Loads (MW)	Frequency	Duration	Response time
Paper, Cardboard, Pulp	1	-	-	-	-
	2	18	daily	2 hrs	15-60 min
	3	-	-	-	-
	4	3-4	anytime	unlimited	<1 min
	5	25	daily	2x4hrs per day	5-15 min
	6	6	3-5x a week	2-3hrs	5-15 min
Iron & Steel	7	27	3-5x a week	15 minutes	< 1 min
	8	24	repeatedly per week	3-5 hrs	< 1 min
	9	10	repeatedly per week	depending on orders	15 min
Chemical Industry	10	-	-	-	-
	11	15	uncertain	winter: minutes to hours; summer: hours to days	3-5 days
Rubber and Plastics	12	-	-	-	-
	13	-	-	-	-
Glass, Ceramics, Cement	14	9,5	repeatedly per week	2-6hrs	17 hrs
	15	17	daily	4-5hrs	15-30 minutes
	16	0,7	depending on orders	depending on orders	<1 minute
Mining	17	not known	not known	not known	<1 minute

Table 9: Shiftable loads, response time and frequency/duration of load shedding by industry branch

The confluence of technical potential, relative ease of implementation and willingness to participate by specific companies make the industry branches of paper & cardboard, iron & steel, chemical industry and the cement industry the most interesting consumers to involve in DR in Austria. Paper and cement mills in particular are often part of large international companies that avail of know-how regarding DR from their plants in other countries.

The European Demand Response Center (EDRC) as a decision support system can be utilized by various stakeholders for various applications. These different possibilities of market integration in Austria were investigated in Work Package 02. Use cases encompass the three identified overarching benefits of DR systems, which are the enhancement of infrastructure and reliability (e.g. through deferment of investments, support of grid stability),

[51] It is important to note that this is *not* the *technical* potential for DR in Austria overall, but confined to the actually achievable load shift in those companies investigated.

the management of electricity costs and the reduction of environmental impact caused by electricity usage.

Regarding the implementation of EDRC in Austria, the following use cases can be distinguished:

- Provision of tertiary reserve
- Reduction of balancing costs/integration into balancing groups
- Grid stability/congestion management/peak load management
- EDRC as a tool for utilities
- Integration of EDRC into energy management systems
- Emergency protection
- Trading on spot markets
- Cross-border exchange

The three first use cases mentioned, namely provision of tertiary reserve, reduction of balancing costs/integration into balancing groups and grid stability were looked at in more detail in the project. While project partner APG focused on the provision of tertiary reserve, Brimatech looked at the use cases of reduction of balancing costs/integration into balance groups and local grid stability at DSO level in more detail. This aspect, namely that DR touches both upon network and market issues was seen as problematic by stakeholders involved since this topic cannot be easily resolved in the area of unbundled electricity markets and needs an overarching regulatory framework.

The Austrian system of balancing groups was analyzed in detail and the conclusion was reached that a seamless integration into balance group is possible. EDRC would not act as a stand-alone actor/balance group on the market, but cooperate with an already established balancing group and enable it to take on the role of “aggregator” or “flexibility operator” that can utilize EDRC for various purposes (reduction of balancing costs, tertiary reserve market etc.). Balancing group representatives that were interviewed showed considerable interest in EDRC, in particular due to the growing amount and degree of variance of the energy input from renewables and the general interest in having flexible capacities available. Besides the prime requirement of reliability, a close cooperation with EDRC is necessary. This includes cooperation regarding the acquisition of DR customers, information exchange within the DR system and collaboration to integrate EDRC software in the BGR software.

Other important stakeholders in this model are the suppliers (“prosumer”), namely industry. A prerequisite for their participation is the transparency of the EDRC system. Benefits for industry include a more flexible participation on the tertiary reserve market which is not limited by the need to fill the four-hour timeslots by oneself. The involved balance group would have to contain a considerable pool of large industrial customers in order to fulfil these criteria. Furthermore, a side-effect for the BG would be the possibility to offer new pricing models based on improved BG management which could turn out to be a considerable advantage on the very competitive market for large industrial customers.

At the moment, DR is not a high priority topic for distribution system operators (DSOs). DSOs use ripple control in order to switch night storage heaters and also offer special network tariffs to this end. Historically, load management was employed for example in Styria, in order to release the load on certain critical power lines. All DSOs shared the view that the liberalisation of the electricity market had complicated the use DR in a DSO context.

However, a need for advanced DR solutions is likely to arise for localised DSO issues in the years to come and it is probable that this solution will cover both network and market aspects. DSOs estimate that a timeframe from 5 to 10 years is likely and that DR “definitely makes sense in the long run”, according to one DSO representatives. At the moment though, the pressure is not big enough and economic incentives for DSOs are missing. Most importantly, the current regulatory framework is considered a barrier to implementation.

7 Introduction

7.1 The EDRC project

7.1.1 Situation and Main Challenges

Power grid systems are designed according to peak demand conditions. It is estimated that over 10% of the electric power infrastructure has been constructed in order to meet peaks in electricity demand that occur less than 1% of the time accounting for 46.8 billion € worldwide.

The main challenges of electricity systems are:

- Increasing consumption and increasing share of distributed RES
- Underinvested ageing infrastructure with long lead times for new projects
- Environmental issues and global warming
- Public resistance against new projects (transmission lines, nuclear, coal, etc.)

Demand side actions will be an important tool to address challenges of managing the imbalance between electric supply and demand. Thus reducing demand during critical peak hours resulting in a diminishing need for construction of new energy supply infrastructure.

7.1.2 Project aims

Research needed to focus on commercial, market, technology, environmental and social issues. Interdisciplinary project partners in the EDRC project therefore are: cyberGRID GmbH (group of energy and technology experts from Austria, Switzerland, Germany, Slovenia and Serbia), Austria Power Grid (TSO, control area manager), BRIMATECH (Experts for bridging markets and technologies) and the Graz University of Technology (Institute for Electricity Economics and Energy Innovation).

The aim of EDRC was to explore and analyze the possibilities – both technical and commercial – of such an intelligent network of consumers, producers and actors of the energy supply industry and to derive recommendations for the further development of the system. Main outcome of this project was in-depth knowledge of what to do in order to realize a European Demand Response Center with its origin in Vienna, which features novel services for the energy industry, but also causes additional value for consumers/producers and covers the environmental aspects of Europe's NewEnergy2020 goals.

7.1.3 Scope of the Report

The project team decided to focus on Austria and on large industry as possible participants of EDRC. For this reason, the regional focus was put on the provinces of Upper Austria and Styria, where most of the heavy industry in Austria is based.

A validation of results as well as the involvement of cross-border interactions and players was achieved through the inclusion of international experts from six of Austria's neighbouring countries in a workshop organized by the project team and further activities (see Confidential activity report (Endbericht – Tätigkeitsbericht).

This report contains a description of activities conducted by Brimatech in Work Package 1 and 2 of the European Demand Response Center Research Project. A detailed account of activities follows.

7.2 Brimatech: Work performed in Work Package 1

7.2.1 Goals of Work Package 1 (All Partners)

The objectives of this work package were to research and analyze a role-and-process model of actors in the energy sector, to explore overall architecture to implement this model and enable running the data services and communication efficiently. In WP1 the conceptual base for the project was provided. In the following Work Packages, the project team drew upon these results to analyze potential business models and infrastructure of the European Demand Response Center (EDRC).

7.2.2 Brimatech Tasks in Work Package 1

Brimatech's first task consisted of the identification of relevant stakeholders and user groups involved in the provision of an EDRC. This is a key issue as energy consumers, energy producers, grid system operators, traders, power exchanges and settlement institutions and other stakeholders along the value chain may have not only divergent, but opposing interests in the system which are important to be clearly stated early in the project.

The second task consisted of the identification of stakeholders' and users' needs. An in-depth review of the needs and requirements of the different relevant stakeholder groups along the European Demand Response Center value chain were conducted and relevant stakeholders interviewed.

7.2.3 Timeline of Work Package 1

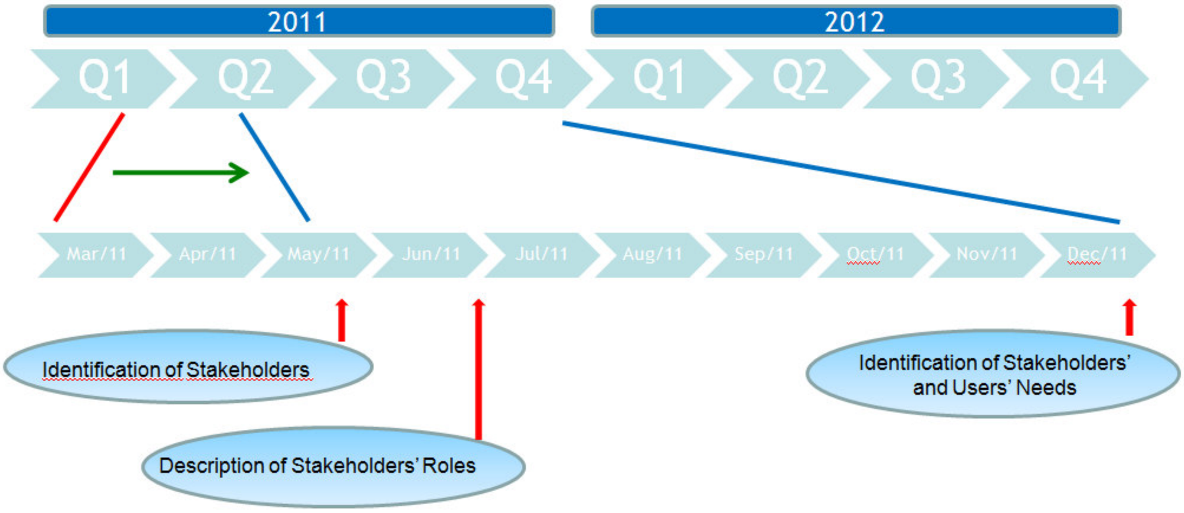


Figure 10: Time schedule of WP02 (Brimatech)

7.2.4 Activities, Methodology and Limitations

In order to identify the user needs and requirements in demand response solutions, following research was undertaken.

Desk research: In order to identify the pool of companies to be contacted, a literature and internet research was conducted.

Interviews: The identification of challenges, user needs and requirements were derived from semi-standardised face-to-face and telephone interviews conducted with potential users (identified in task “Identification of relevant stakeholders and users groups” (see “830011_BRI_WP 1_Report.pdf”). Besides, in cases where it was not possible to conduct an extended interview (e.g. due to low interest by the interview partners, time constraints), short interviews focusing on the most important aspects were conducted.

Matrices: Emphasis was put on the investigation of available and shiftable loads. They were identified and analyzed on the basis of the matrix developed (see Annex,). The matrix was filled in by the interviewers based on the information gained in the interviews and completed with subsequent phone calls with the interviewees.

In order to assure consistency, an interview guide (see Annex) and a reporting template (see Annex) were developed. The figure below shows a rough illustration of the interview structure, following the SPIN approach:

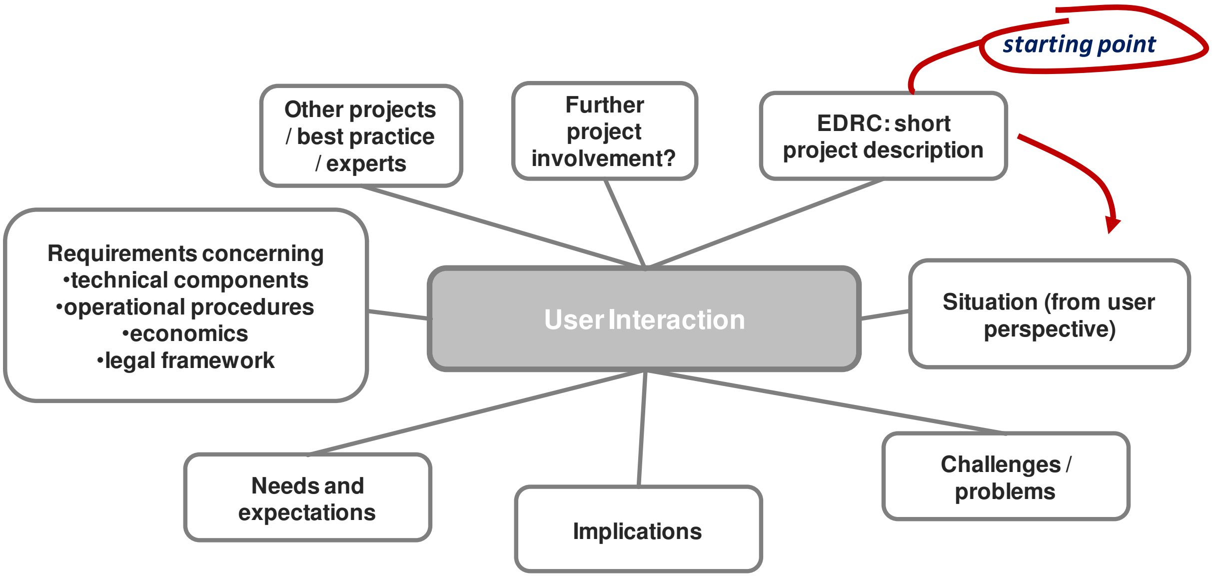


Figure 11: Interview Structure (SPIN approach)

Following the SPIN approach of Neil Rackham[52] the empirical needs analysis is structured along the main parts:

- Situation analysis
- Problems (challenges) faced currently
- Implications of these difficulties
- Needs and expectations resulting out of the current situation and challenges.

Originating from selling of complex high-tech products, this approach pays attention to the valid identification of needs and expectations based on the actual current situation. Disclosing related problems and the impacts they entail helps recognizing the real needs of future solutions.

[52] Rackham, *SPIN Selling*.

7.3 Brimatech: Work performed in Work Package 2

7.3.1 Goals of Work Package 2

The overarching goal of WP2 is the identification and analysis of possible business models for EDRC. In order to achieve this, the needs and expectations of all EDRC stakeholders were investigated. On the one hand, seller (industrial and commercial consumers and RES) requirements were investigated on a sociological and economical level. On the other side, the buyer (TSOs, DSOs, Utilities, Balance Groups) side was analyzed as well as technological and regulatory aspects.

Additional scientific goals were the approximate assessment of cost structure and competitiveness of demand response and the assessment of the impacts of demand response on the Austrian electricity system.

7.3.2 Brimatech Tasks in Work Package 2

As stated in the description of work, Brimatech's focus in Work Package 2 was the identification and analysis of possible business models.

To this end, Brimatech conducted value chain analyses, a description of possible business models, business case considerations and a driver and barrier assessment. During interviews and workshops with the identified stakeholders of the value chain, possible business models were developed, where all stakeholders and their interactions were identified. On basis of these business model suggestions, financial and other benefits for the main stakeholders and users were identified.

For a detailed description of the activities and methods used see chapter 7.3.4. Results will be displayed in the following chapters of this report.

7.3.3 Timeline of Work Package 2

The following chart depicts the timeline of the 2nd Work Package of this project.

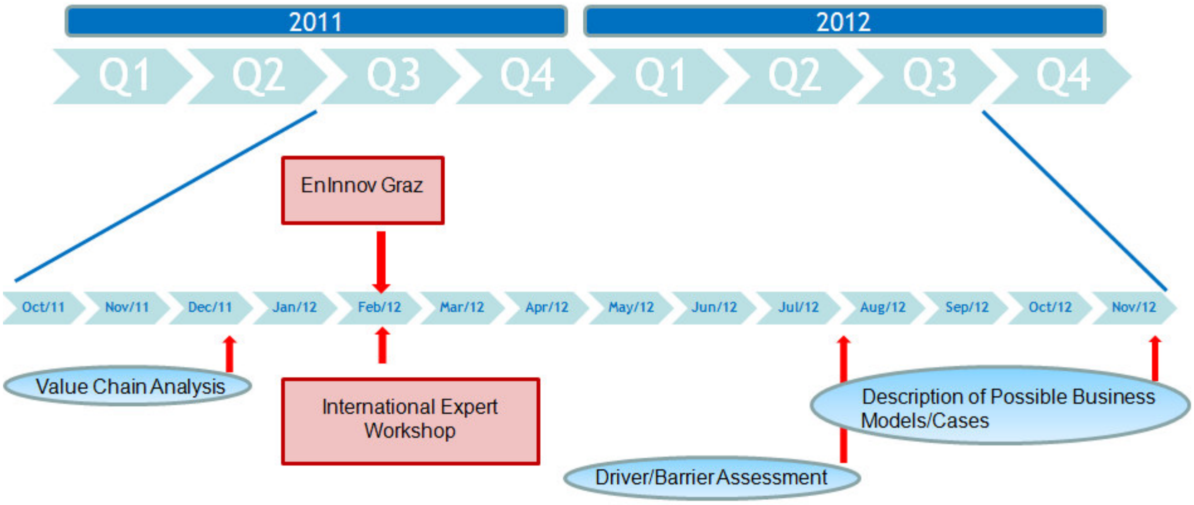


Figure 12: Time schedule of WP02 (Brimatech)

7.3.4 Activities, Methodology and Limitations

The tasks described above called for the following activities:

- **Value chain analyses**: basis for the value chain considerations were the stakeholder groups identified in work package 1. By interviews and workshop results these groups were more closely analyzed, focusing on interactions necessary between these groups, data and revenue exchanges between them, thus finding their roles in the EDRC Value Chain.

- **Description of possible business models and business case considerations**: results of the analysis of user needs and stakeholder groups helped fine-tuning business model considerations. Result is a detailed description of the single partners necessary to provide services.

- This description displays the role of the main partners, resources necessary and how resources need to be exchanged amongst the key players in the value chain, interactions, benefits but also possible drawbacks arising (e.g. monetary, etc.), the role of third parties, organisational, technical or legal barriers that need to be overcome and recommendations for actions needed for the successful provision of services (**driver and barrier assessment**).

Results of these tasks are a description of partners to provide innovative services. Further it was shown if and how the single partners can benefit by contributing to the innovative system.

In this project, an iterative research approach was chosen:

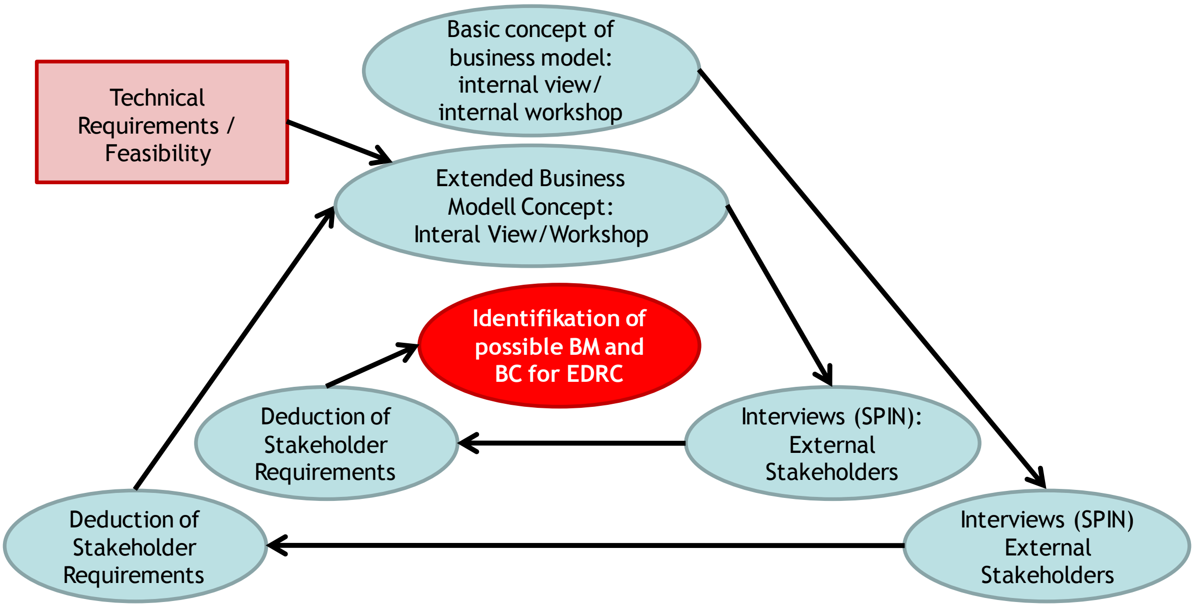


Figure 13: Overview of Methodology

According to this depiction, research and surveying phases took place alternately to internal phases of research. On the one hand, the core idea of the European Demand Response Center was sharpened up and the technical feasibility investigated, which on the other hand is constrained by market requirements, needs and barriers (political, organizational, financial, technical, etc.). The different points of views are accounted for by taking different perspectives into consideration (project-external and project-internal viewpoints, different stakeholders).

The methods used were:

- Intensive interaction/exchange with WP 3: technical requirements
- Literature and internet research
- Problem-centered interviews
- Questionnaires
- Workshops

Interviews with the stakeholder group of the potential prosumers took already place in Work Package 1. The additional perspectives of further stakeholder groups were captured through further interviews (see below).

Limitations

Despite undertaking a total of 51 interviews, concrete data to formulate a detailed business model was not easy to obtain. Therefore the project team drew upon proxy indicators to reach a quantification of the business model. Still, through the large amount of input through interviews and workshops, a detailed architecture of the business model and use cases could be achieved.

7.3.5 Overview of Interviews

A total of 15 interviews were held that covered all stakeholders relevant to this work package. Each of these interviews was approximately one hour long and often included more than one interviewee. These interviews were held in additions to the 16 in-depth and 20 short interviews held with industry in the context of WP01. This results in an overall number of **51 interviews** overall, which includes 31 in-depth interviews and 20 short interviews.

Stakeholder Group	Number of interviews	No. of interviewees
Transmission System Operator	*ongoing consultation with project partner APG*	
Regulator (E-Control)	2	4
Distribution System Operator	5	5
Balance Group Representative	5	9
Energy management system providers	1	2
Eurelectric (network & markets)	2	2

Table 10: WP02 – Overview of Interviews

The focus was put on both balance group representatives and distribution network operators. These were identified as the two prime stakeholders in any demand response offering.

The range of interviews conducted was also of great value to disseminate the EDRC project and engage directly with stakeholders.

7.4 Definitions and Important Terms

The term "Demand Response" can be used in different ways. This section highlights some of the differences with regards to technical terms and presents the working definition used in this report.

Demand Response (general definition)

"Changes in electric usage by end-use customers from their normal consumption patterns in response to changes of grid conditions over time, like incentive pricing designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized."[53]

„Demand Response is a series of programs sponsored by the power grid, the most common of which pays companies (commercial DR) or end-users (residential) to be on call to reduce electricity usage when the grid is stressed to capacity." [54]

The following table analyzes the above mentioned definitions by splitting them up according to their core elements:

	Provider	**Load Shifting**	**Implementation**	**Incentive**	**"Consumer"**
DoE	End-use customer	Change electricity use	Tariff program	Changes in the prices over time; incentive payments, high market prices, grid reliability	Times of high wholesale market prices or when system reliability is jeopardized
European Commission (Paolo Bertoldi)	Companies End-users	Reduce electricity usage	Series of programs	Grid is stressed to capacity	(sponsored by the) power grid

Table 11: Comparison of Definitions of Demand Response

Another definition of DR comes from the German Research Center for Energy Economics (FFE):

"*Demand Response ist eine kurzfristige und planbare Veränderung der Verbraucherlast als Reaktion auf Preissignale im Markt oder auf eine Aktivierung im Rahmen einer vertraglichen*

[53] Department of Energy, USA (http://energy.gov/)
[54] Definition according to the European Commission (Paolo Bertoldi)

Leistungsreserve. Diese Marktpreise oder Leistungsabrufe werden durch ungeplante, unregelmäßige oder extreme energiewirtschaftliche Ereignisse ausgelöst.“[55]

The above mentioned definitions illustrate that slightly differing concepts exist for the term “demand response”. Different emphases are put on the aspects of pure energy storage, energy production and active intervention through switching a system. A clear definition of terms with regards to the project is needed:

Demand Response (working definition)

“Demand Response” (DR) is the process of managing energy consumption that is typically employed to

(1) Create incentives for consumer to save electricity costs (shifting of energy usage from peak times to off-peak times.
(2) Enable Transmission System Operators (TSOs) to save costs in the areas of energy balancing/capacity market and redispatch (along with an increase in energy efficiency)

This definition is used throughout this report, whenever Demand Response (DR) is mentioned.

Aggregator/Flexibility Operator[56]

According to the Smartgrids Technology Platform Austria, “flexibility operator” refers to “a general role that pools small flexibilities/customers/network users in order to make use of them in the grid or on energy markets. The concept is often referred to as aggregator, but in this case the name should underline the general role concept of “using flexibility”. According the description of the role concept the roles of the flexibility operator might be performed by existing market roles like energy suppliers, aggregators, DSOs etc...”

Prosumer

The general understanding of “prosumer” refers to an entity that both consumes and produces energy. More specifically, in the context of EDRC we understand prosumer as a “consumer that becomes resonant with the energy market through systematic actions and reactions that aim to increase personal or collective benefits.”[57] The word “personal” in this definition refers to (mainly monetary) motives by large industrial customers.

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[55] “Demand Response is a short-term and projectable change of the load as reaction to price signals on the market or as part of an activation within a contractual power reserve. These market prices or load activations are caused by unplanned, irregular or extreme events of an energy economics nature.”
[56] NTP Austria, „Geschäftsmodelle im Smart Grid als Voraussetzung für eine erfolgreiche Marktüberleitung“. Presentation at the Smart Grids Week, Bregenz, 2012
[57] Shandurkova, et. al, “A Prosumer Oriented Energy Market. Developments and future outlooks for Smart Grid oriented energy markets”, Halden, 2012, 36.

8 Market Overview

This chapter comprises the characterisation of the market environment of EDRC with a special emphasis on Austria, a detailed description of the structure and relevant regulatory framework. Examples of DR integration into electricity markets from other countries are presented to investigate different possibilities of EDRC market integration.

8.1 Market Environment

8.1.1 Unbundling of the Austrian Electricity Market

In order to analyze the integration of EDRC on the Austrian electricity market, it is important to understand recent developments and the transition from an integrated utility model to a market open to full competition.

Through the accession to the European in 1995, Austria had to adapt European rules concerning the liberalisation of the electricity market. The idea that lies behind the European regulations is that electricity can circulate freely within the common European market, just like any other good.[58]

Initially, the policy to liberalise electricity and gas markets was based on the will to put European industry in a better competitive position compared to the USA and Japan. Consequently, industry (paper, chemical industry, machinery and heavy industry) was one main driver behind the liberalisation process.

Full liberalisation of the Austrian market was put into effect via the law regarding the deregulation of energy (Energieliberalisierungsgesetz 2000, BGBl I 121/2000). The electricity market was liberalised on 1 October 2001 and the gas market one year later on 1 October 2002.[59]

Cornerstones of the regulation of the European energy market were the following elements:[60]

Non-discriminating access to the distribution network

In order to counteract the monopoly status of vertically integrated companies that own a transmission network, several unbundling measures were undertaken. The operation of networks and the production and distribution activities were separated both functionally and

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58 E-Control. *Zehn Jahre Energiemarkt-Liberalisierung in Österreich*. Wien, 2011, 16.
59 Ibid., 22.
60 Ibid., 18-21.

legally in three steps ("drei Liberalisierungspakete"). A detailed account of stakeholders that resulted from this unbundling process can be found below.

This regulation was also made necessary through the potential monopoly of vertically integrated electricity companies. Third parties must be granted network access without discriminating against them.

Cross-border energy exchange

This is another cornerstone of the liberalisation. Not only markets within each country were liberalised, but also the flow of energy across borders was put into focus. In order to achieve a single European energy market, single initiatives were launched. Issues of cross-border exchange include congestion management, capacity allocation and issues related to tariffs.

Institutional network

Member states are obliged to oversee and control all of these regulatory measures independent of politics and industry. The organisation of transmission systems operators (TSOs; European Network of Transmission System Operators for Electricity) – ENTSO-E was regulated and the Agency for the Cooperation of Energy Regulators (ACER) founded.

All of these regulatory measures are overseen by the European Commission. In Austria, regulatory aspects are overseen by the E-Control.

The E-Control evaluates the developments 10 years after the liberalisation of the electricity market as positive. They state that increased efficiency and better services for customers were achieved.[61] Demand Response solutions, such as EDRC, are a possible further step in this direction.

However, due to historical reasons the Austrian electricity industry is characterised by a high proportion of shares held by the state or provinces and also vertical and horizontal entanglement. This has not changed much in the years after the liberalisation and also has implications when thinking about integration EDRC on the Austrian electricity market, as well be demonstrated below.[62]

Before the unbundling of functions on the electricity markets, utilities used the opportunities to shave peak loads in their distribution networks through the direct load management at some big industrial sites. This is an important factor for EDRC since the cooperation with these actors is required in order to be successful. Load management, however, is not possible in the same way nowadays due to the regulatory framework after unbundling.

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[61] E-Control, *10 Jahre Energiemarkt-Liberalisierung*, 5.
[62] Ibid., 6.

Building on these historical experiences with load management can be an advantage for EDRC. It means that a considerable number of today's industrial customers have experience with load shifting. Interviews conducted in Work Package 1 confirm this.

8.2 Structure of the Austrian Electricity Market

The unbundling that has taken place on the Austrian electricity market has resulted in a differentiated structure of the market. The analysis of business models requires an understanding of these structures and main players involved. Research on this is summarised in the following and also in Chapter 10.

8.2.1 Stakeholders on the Austrian Electricity Markets in the Context of EDRC

In a first approximation, players on the Austrian electricity market can be grouped into four categories.

Electricity supply & networks	**Consumers & Prosumers**	**Trading & Services**	**Regulators & Lawmakers**	**Interest Groups and further Stakeholders**
Balance Group System				
TSO DSOs Utilities	Households Medium/ commercial customers Large/industrial customers	Energy Exchanges Energy Traders Service Companies	E-Control Government /Ministries	Österreichs Energie WKO Eurelectric

Table 12: Overview of Stakeholders on the Austrian Electricity Market

Each of these stakeholder groups is briefly described below. The first two stakeholder groups, namely "electricity supply & networks" as well as "consumers & prosumers" are from a regulatory point of view affiliated through balance groups.

8.2.2 The Austrian Balance Group System

A balancing group consolidates suppliers and consumers into a virtual group in which the supply and demand are balanced. All market players are obliged to join a balancing group. Hence, the balance group system is highly relevant since also EDRC has to be part of a balance group. EDRC has to be integrated into the balancing group system in one way or the other.

The following shows a schematic overview of the Austrian balance group system:

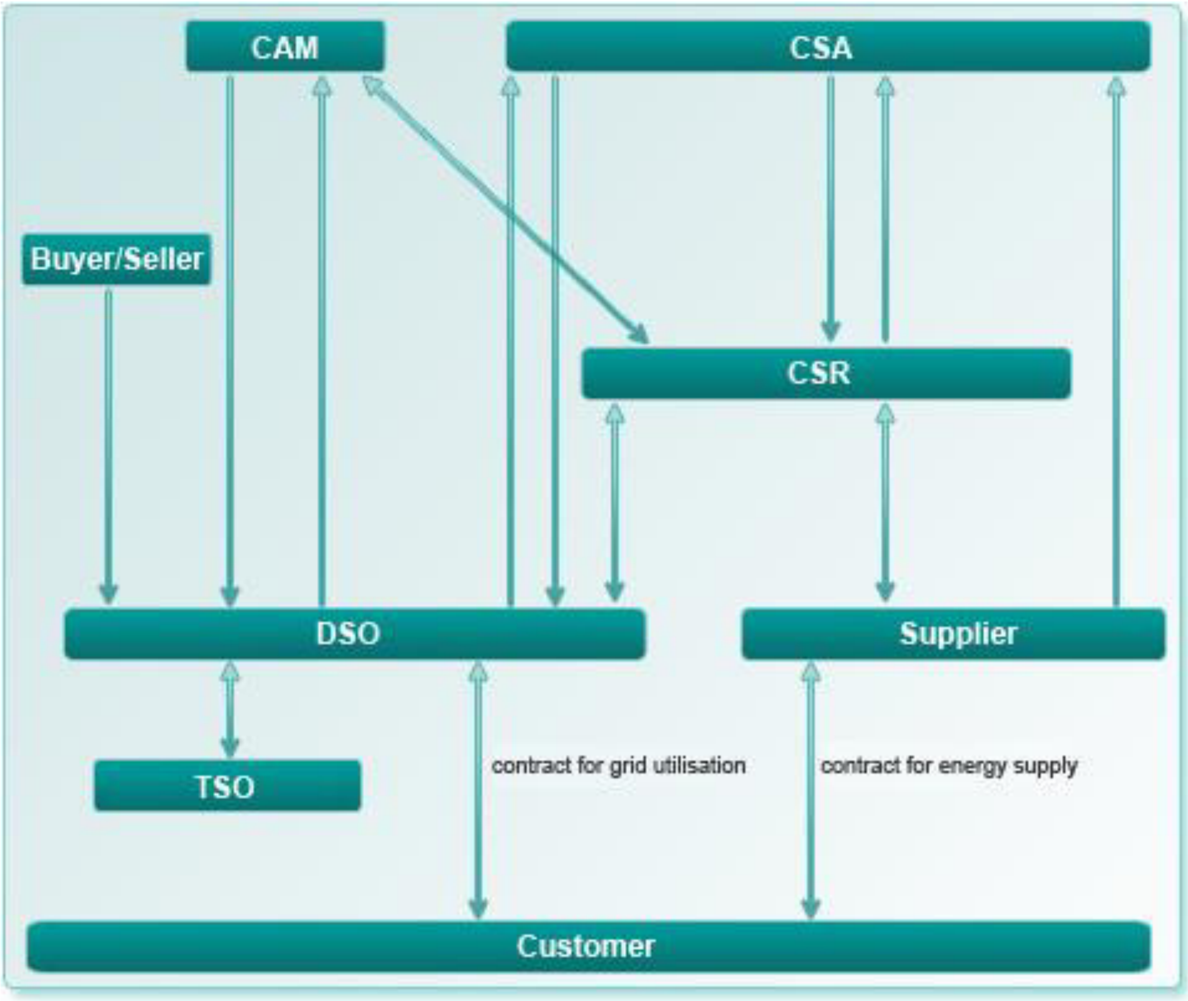

Figure 14: The Austrian balance group system[63]

Main actors and their functions are described in the table below and an in-depth discussion of this topic can be found in Chapter 10.

[63] (accessed on 2 October 2011).

Actor	Description / Tasks
CAM - Control Area Manager	*CAM calculates in advance how much electricity will need to cross the control area boundaries to fulfil the supply contracts in place.* The CAM: • Continuously measures demand within the control areas. • Transmits these meter readings to the clearing and settlement agent, • Bills the clearing and settlement agent for the balancing energy required.
CSA - Clearing and settlement agents	*CSA calculate the difference between the balancing group representatives' forecasts and actual flows metered by the system operators.* • Bill the balancing group representatives for the balancing energy required. • Pay the control area managers for the balancing energy required. • Obtain offers of balancing energy from generators and compile merit order lists on the basis of these bids.
TSO - Transmission system operators	*The transmission system operators (TSOs) are responsible for performing the functions of a network operator and for transiting electricity.*
BGR - Balancing group representatives	*A balancing group consolidates suppliers and consumers into a virtual group in which the supply and demand are balanced. All market players are obliged to join a balancing group.* BGR fulfil these tasks: • Obtain day-ahead consumption forecasts from all the suppliers in their balancing group. • Send these forecasts to the clearing and settlement agent. • Pay the clearing and settlement agent for the balancing energy. • Bill the suppliers for the balancing energy require.
DSO - Distribution system operators	*DSOs are obliged to transport electricity in accordance with the existing contracts between generators and withdrawers.* They: • Conclude system access contracts with their customers. • Deliver electricity to their customers. • Meter consumption and attribute it to the balancing groups responsible for it. • Transmit consumption data to the clearing and settlement agent.
Suppliers	*Suppliers are responsible for delivering electricity to their customers.* Tasks are to: • Conclude supply contracts with their customers. • Notify their balancing group representative of their customers' day-ahead requirements. • Bill their customers for the power they consume.

Actor	Description / Tasks
Generators	*A generator is a natural person, legal entity or partnership that generates electricity.* • Generators conclude contracts with electricity suppliers or OeMAG (the green power clearing and settlement agent).
Electricity wholesalers	*An electricity wholesaler is a natural person, legal entity or partnership gainfully selling electricity. An electricity wholesaler performs no transmission or distribution functions either inside or outside of the network in which it operates.* • Conclude contracts with generators. • Conclude contracts with electricity suppliers and/or other electricity wholesalers or traders

Table 13: Main actors on the Austrian electricity market: main role and tasks

Balancing Energy/Ancillary Services[64]

A balance between the production and consumption in a control area is always necessary in order guarantee a stable grid frequency. This is a task of the Control Area Manager (CAM). Deviations from this balance are compensated through so-called reserves which can be activated in both directions (increased/reduced generation). There are three different kinds of reserves:

Primary Reserve

In order to compensate imbalances in production and consumption of energy within seconds and to stabilize the frequency, a primary reserve is needed. The primary reserve held by APG amounts to +/- 70 to 80 MW.

Secondary Reserve

Secondary reserve is activated when primary reserve is unloaded. Secondary reserve is activated when the influence on the network lasts more than 30 seconds or is expected to last for more than 30 seconds.

Tertiary Reserve

If the deviation in the control area lasts for more than 15 minutes, tertiary reserve is activated. Tertiary reserve is activated when secondary reserve is freed up again in order to be available for further calls. In control area of APG, tertiary reserve is activated manually.

Market maker auctions are done separately for weekends (Saturday, Sunday) and week following (Monday to Friday). Within these two timeframes, six products are distinguished: 0-4 am, 4-8 am, 8-12am, 12-4pm, 4-8pm, 8pm-0am. This results in 12 products in the market maker call for bids. Furthermore there are short-term auctions that do not contain a performance price.

Pre-qualification

In order to participate on the balancing market, certain pre-qualifications have to be met. This topic is dealt with in detail in PART 3.

8.2.3 Trading & Services

As pointed out in the introduction and the DOW, the EDRC project is not focused on the energy markets. However, it must not go unnoticed that in principle also other markets can

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[64] http://www.apg.at/de/markt/netzregelung (accessed on 2 Oct. 2012).

be addressed through demand response in general and also potentially the EDRC. [65] The leading energy exchange in Europe is the EEX.

Theoretically, also spot markets could be addressed through EDRC. A large part of electricity is traded via bilateral and long-term contracts. The day-ahead trade at the EEX has a volume of about 30% of the overall electricity consumption at any given time. Consequently the turnover in the intraday market is significantly smaller since this market addresses the imbalance between unplanned or inaccurately forecasted incidents. Price differences are at times considerable, and interesting price structures could be utilized through EDRC.[66] These theoretical aspects were reaffirmed in Brimatech's interviews with BGRs, who stressed their general interest in this concept.

8.2.4 Regulators & Lawmakers (E-Control[67])

E-Control is the regulator of the Austrian electricity market. Since the liberalisation of the Austrian electricity market in 2001, E-Control has had the role of drawing up and enforcing market rules. In detail, E-Control has "*the job of strengthening competition and ensuring that this does not compromise security of supply and sustainability. To act even-handedly in the interests of all market participants, regulators must be politically and financially independent.*"[68]

Energie-Control Austria (E-Control) was established in 2001 and on 3 March 2011, E-Control was transformed into a public authority. Its tasks and duties are laid down in the *E-Control-Gesetz* (E-Control Act).

8.2.5 Interest Groups and further Stakeholders

Österreichs Energie[69]

Österreichs Energie is the advocacy group for the Austrian electricity industry. Important in the context of EDRC are the activities of Österreichs Energie with regard to the representation of its members regarding energy policies, where a close cooperation between national and international political decision makers is taking place. Österreichs Energie is involved in the development of the legal, regulatory, technical and economic framework conditions on the electricity market, where it works together with ministries and regulatory authorities.

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[65] Serafin von Roon and Thomas Gobmaier, *Demand Response in der Industrie – Status und Potenziale in Deutschland*. Forschungsstelle für Energiewirtschaft – FfE. 2010.
[66] Ibid.
[67] http://www.e-control.at
[68] http://www.e-control.at/de/econtrol_en/company (accessed on 10 Nov. 2011).
[69] http://oesterreichsenergie.at/positionspapiere.html (accessed on 10 Nov. 2011).

The Austrian Technology Platform Smart Grids ("Technologieplattform Smart Grids")[70]

The National Technology Platform Smart Grids is a consortium of important stakeholders on the Austrian electricity market. The aim lies in bundling competences and expertise in order to support the energy- and cost efficient electricity system of the future. The platform was founded in 2008 with the aim of addressing issues regarding Smart Grids in Austria. The goals of the platform are the positioning of Austria as a leading market when it comes to Smart Grids. Networking among the most important actors, research and development activities as well as demonstration and market implementation of smart grid technologies are another aim of the platform.

International stakeholders

Relevant international stakeholders in the context of DR are:

- CEER – Council of European Energy Regulators

CEER is the "Council of European Energy Regulators" through which the energy regulators cooperate at an international level to share best practice. The main aim is to facilitate the creation of a single, competitive, efficient and sustainable internal market for gas and electricity in Europe.

- ICER – International Confederation of Energy Regulators

The International Confederation of Energy Regulators (ICER) is a framework for cooperation between energy regulators from around the globe

- ACER - Agency for the Cooperation of European Energy Regulators

"The Agency for the Cooperation of Energy Regulators (ACER) is the European Union body created by the Third Energy Package to further progress on the completion of the internal energy market both for electricity and for natural gas."[71]

- ENTSO-E – European Network of Transmission System Operators for Electricity

The European Network of Transmission System Operators for Electricity (ENTSO-E) is an association of Europe's transmission system operators (TSOs) for electricity. ENTSO-E's mission is to promote important aspects of energy policy at the European level. It represents all European TSOs on both market and technology related issues.

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[70] http://oesterreichsenergie.at/nationale-technologieplattform-smart-grids.html , http://www.smartgrids.at/ (accessed on 11 April 2011).

[71] http://www.acer.europa.eu

- ETP Smart Grids – European Technology Platform Smart Grids

The ETP is an initiative by the European Commission to boost the competitive situation of the EU regarding electricity networks in general and smart grids in particular.

- EURELECTRIC – Union of the Electricity Industry

EURELECTRIC is the sector association which represents the common interests of the whole electricity industry at pan-European level, plus its affiliates and associates on several other continents.[72]

8.3 Demand Response Service Offerings and Data Models

This section gives an overview of the different possibilities of market integration of DR systems taking into account various market environments. The USA and UK are mentioned as examples for the markets where DR systems are successfully being operated. Details of these programs are analyzed in order to derive conclusions for the market integration of EDRC. The last mentioned aspect is further elaborated in chapter 10.

8.3.1 Three Basic Demand Response Service Offerings

According to Thomas[73], who elaborates these cases for the US-American market, there are three basic models of demand service offerings:

Traditional Utility Model

This model works best in markets that have not been restructured and electricity is not bought from third party suppliers. This model has also been in place in Austria before the liberalisation of the market. The background is that integrated utilities have developed DR in order to manage capacities. These programs largely represent what is known as load management ("Lastenmanagement") in Austria. In this model, the utility runs the program, sends signals to participating prosumers and also pays these. These utility-run programs often worked on the basis of predetermined rates or discounts, as opposed to programs that are based on real-time market prices.

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[72] http://www.eurelectric.org/about-us/
[73] Thomas, Chris et al., *An Assessment of Business Models for Demand Response*, GridWise Architecture Council. 2008, 7. These examples refer to the US-American market.

CSP – Curtailment Service Provider, or Aggregator Model

This model entails the role of an independent aggregator that brings in facilities of its own control infrastructure and operates in a deregulated landscape. Examples of such CSPs or aggregators are described further below.

According to Thomas[74], these two models fall either into the "dispatchable" or the "non-dispatchable" model:

- Dispatchable („reliability responsive program")

Here, demand is reduced according to instructions form a control center with the main aim of addressing peak capacity shortage and grid reliability. Customers are usually paid by kW saved. Programs can fall into one of the following categories:

  - Direct load control – equipment is automatically switched
  - Contractually interruptible/curtailable supply – Large customers are compensated through rate discounts or credits for agreeing to shut down when called upon during system emergencies
  - Capacity market programs – load reductions are bid into capacity markets
  - Ancillary services – curtailments are bid into wholesale markets

- Non-dispatchable

Here "demand is reduced according to tariff structures that provide inducements to end-users to manage their usage and 'flatten' load shapes"[75]. Incentives can be either dynamic price and is a reflection of time-varying electricity prices on the wholesale markets (day-ahead or real-time). Different configurations of non-dispatchable models are briefly mentioned below:

  - Time of Use pricing (TOU): prices are pre-set at different levels for peak and off-peak periods
  - Real Time Pricing (RTP): prices fluctuate to represent wholesale market prices
  - Critical Peak Pricing (CPP): "prices are increased substantially during system peak periods or during declared system emergencies"
  - Peak Time Rebate (PTR): "customers are credited for reductions in consumption during specified system peak periods"
  - Price-triggered automatic load reduction
  - Emergency DR: customers are paid to reduced loads in emergency situations

[74] Thomas et al., *An Assessment of Business Models for Demand Response*, 5.
[75] Ibid., 5.

Customer provisioned model

This model refers to usually large customers, such as retail chains, purchasing their own demand response soft- and hardware in order to manage operating costs. In the USA, large firms utilize such technologies and have set up control centers in order to participate on the markets via DR.

8.3.2 International Examples: UK and USA

UK – Frequency Control by Demand Management (FCDM)

In the United Kingdom, FCDM is in use as a tool to control network stability. FCDM is an automated system controlled by the network operator in order to fulfil the task of keeping the frequency at a constant level. This is a fully automated system that cuts off customers once the frequency drops below a certain threshold. Customers are prepared to interrupt their demands for up to 30 minutes. Statistically, customers engage in FCDM 10 to 30 times per year.

Besides the fully automated interruption and the sole goal of maintaining network stability, another key difference between DR and FCDM is that the latter one is not operated through an independent flexibility operator, but by the network operator directly.[76]

USA – Demand Response

DR has been an important tool to curtail peak demand in the USA in the past 40 years. In the 1970s, utilities in the U.S. implemented load management and interruptible/curtailable tariffs, „both of which were in essence call options in which the customer sold the right but not the obligation for the utility to curtail or shed some of the customer's load in exchange for an upfront payment (in $/kW-month or a bill credit for participation) or a per kWh discount for the non-firm electricity consumption".[77] Drivers of this development were the increasing prevalence of air condition and spikes in consumption associated with this, as well as the insight into costs caused by peak loads.

Electricity restructuring led to the intention of creating regional, competitive wholesale electricity markets in the 1990s. Problems in these restructured markets, for example concerns during system peak demand conditions, led to the realization that demand response is a tool needed also in these new markets. An important step in establishing commercial demand response operations in the U.S. was the Energy Policy Act of 2005 (EPACT):

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[76] http://www.nationalgrid.com/uk/Electricity/Balancing/services/frequencyresponse/ (accessed on 5 December 2011).

[77] Peter Cappers, Charles Goldman, and David Kathan, *Demand Response in U.S. Electricity Markets: Empirical Evidence,* Berkely National Laboratory, 2009.

Through the Energy Policy Act of 2005 (EPACT) regarding the participation of demand response in wholesale markets, such as energy, capacity and ancillary services, were eliminated. [78]

Figures for the year 2008 show that the potential for peak load reduction in the U.S. through DR was about 38,000 MW (incentive-based programs), with an additional 2,700 MW coming from DR programs with time-based retail rates.[79]

To a very large extent, DR is executed through aggregators on the U.S. electricity markets. The flexibility generated through the role of the aggregator is then sold on the market. The main advantage of the aggregator is the large pool of capacities, which is not possible if participating on the energy market as a single company. Furthermore, aggregators can have a wider range of companies participating in DR since they are not bound by their customer base in the same way as utilities are. The overhead is smaller as well, which guarantees more attractive options for the customers.

These aggregators usually also have a relatively large number of small companies in their portfolios. Pricing takes place through annual premium for the capacity that is being held available. On top of this, the aggregator pays the participating company the actual price for each megawatt that is being sold on the market. In the perception of participating industries, it is the annual premium for reserving the capacity which is the profitable part of the contract since there are not that many DR events per company per year.

Currently, the outlook of the demand response industry is seen as very positive, in particular under the impression of current developments of increased RES feeding into the electricity system.[80]

The following list shows the most important DR players in the U.S.:[81]

- Badger Meter
- Comverge
- Cooper Industries
- CPower
- Echelon Corp.
- Energy Connect
- Energy Curtailment Specialists

[78] Kappers et al, *Demand Response in U.S. Electricity Markets: Empirical Evidence*.
[79] Ibid.
[80] For example: Jeff Osborne, and Dilip Warrier, *A Primer on Demand Response: The Power Grid: Evolving from a "Dumb" Network to a "Smart" Grid*, 2007, 6.
[81] Osborne, *A Primer on Demand Response*, 4*2. Jussi* Ikäheimo, Corentin Evens, and Seppo Kärkkäinen, *DER Aggregator Business: the Finnish Case*, 2010.

- Energy Response
- EnerNoc
- ESCO Technologies (Aclara)
- Evonic New Energies
- Fextricity
- Itron
- North America Power Partners
- PowerSecure

Example: ENERNOC

As an example of a non-European aggregator already actively working in DR, Enernoc's business model shall briefly be portrayed. Enernoc is one of the leading companies offering in C&I DR response and energy efficiency in the U.S. According to its own figures, more than 400,000 MWh of industrial EE have been achieved.[82] In the field of DR, the application lies in emergency, peak shaving and ancillary services.

Enernoc cooperates with utilities and offers consulting services for these in a range of areas (DLC, Dynamic Pricing, TOU, Interruptible Tariffs, C&I DR) and turnkey solutions in the area of C&I DR as outsourced offering. In the turnkey C&I DR approach, Enernoc claims, there are no penalties for customers but at the same time performance of the system is guaranteed.[83]

The following shows the features of Enernoc's outsourced program:[84]

[82] Brad Davis, *Commercial & Industrial Demand Response: An Overview of the Utility/Aggregator Business Model,* ENERNOC (Pacific Northwest Demand Response Project), 2011.
[83] Ibid.
[84] Ibid.

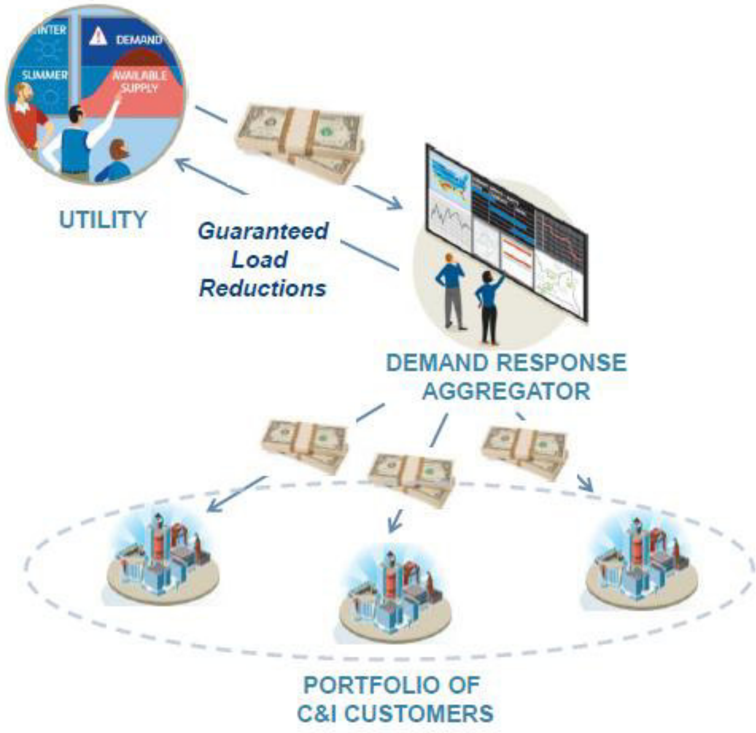

Figure 15: Feature's of Enernoc's outsourced program

This depiction demonstrates the basic principle: money flows from the utility to the DR aggregator (Enernoc), who then pays participating C&I customers for their load reductions, after deducting Enernoc's fee. Enernoc sees its role as shielding businesses form under-performance penalties while at the same time guaranteeing performance to utility. While utilities contribute employee knowledge and customer relationships, Enernoc manages and maintains the resource. Customised curtailment plans and no-cost participation increase the market penetration. Utilities sign one contract with the aggregator, and the utility can control branding and messaging. [85]

In detail, Enernoc offers the following value proposition: [86]

- Customers typically receive quarterly payments for availability, and event-based payments based on energy reductions
- Contract terms can be structured to meet specific customer needs
- Curtailment options are tailored to avoid negative impact on business operations
- Service provider manages the installation and pays for all auditing and equipment costs

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[85] Davis, *Commercial & Industrial Demand Response*, 2011.
[86] Ibid.

- Service provider handles program administration and event execution, and accepts all risks of non-performance
- Customers have access to web portal displaying real-time and historical information on energy use, including multi-site aggregation data, which can be used to improve overall efficiency

A key ingredient for Enernoc is a diverse portfolio, which guarantees that utilities' needs can be met. In order to achieve consistence performance, Enernoc mention the following key factors: "a technology platform that enables automated dispatch of multiple events simultaneously, with real-time visibility into performance. End-use loads are continuously monitored to ensure capacity availability. Each site's capabilities are thoroughly tested prior to event dispatch, including acceptance tests and notification tests. The composition of the "portfolio" ensures reliable delivery." [87]

Who benefits from Enernoc's model?

Utilities do not have to go "from door to door" but Enernoc makes contact with customers and thus administration is outsourced. According to an analysis done by Thomas Weisel Inc., "utility payouts to the aggregator range from $30,000 to $150,000 per MW per year, with an average payout in the order of $70,000 to $90,000 per MW (or $70–90 per kW) per year." [88]

The aggregator, in turn, goes out and enrols residential or C&I customers in demand response programs and pays them a portion of the utility payout for agreeing to provide demand response and/or a payment for actual demand response provided. The ratio paid out to end users depends on the capacity committed, the type of demand response program enrolled in, regional demand/supply and capacity actually delivered when called on by the utility. Demand response aggregator gross margins can range between 30% and 65%, after deducting payouts to program.[89]

Since C&I customers typically offer more capacity curtailment, with the potential to include multiple sites under a single contract, the sales process is more relationship-driven and can deliver more "bang for the buck." [90]

Assuming on average a C&I customer is worth 1MW per year in terms of demand response capacity, they can earn about $40,000 per year assuming the demand response aggregator retains half the average $80,000 per MW the utility pays out. For small, low-margin businesses that can afford to curtail load when called upon by the utility savings of such magnitude act as a huge incentive to enroll in demand response programs. For larger C&I

[87] Davis, *Commercial & Industrial Demand Response*, 2011.
[88] Osborne, *A Primer on Demand Response*, 27.
[89] Ibid, 27.
[90] Ibid, 27.

customers who can offer 2–3MWs, incentive payouts can be as large as $20,000–30,000 per quarter.[91]

8.3.3 Demand Response projects in Austria

To the knowledge of the project team, DR projects in Austria have focused mainly on low to medium voltage grids with a focus on the integration of RES that were mostly small-scale. The following projects involve DR to some degree:

- Smart Distribution Grid Biosphärenpark Grosses Walsertal
- Smart Infrastructure Salzburg
- Smart Microgrid Murau
- Smart Infosystems Vöcklabruck
- Smart Services für den Großraum Linz
- Smart Community Großschönau

Foci of these projects are not listed in detail in this report and are available at http://www.klimaundenergiemodellregionen.at/ and http://www.energiesystemederzukunft.at/.

Two projects dealing particularly with DR in the Austrian context are GAVE (Großschönau als virtueller Energiespeicher) and Smart Response which were both carried out by the Vienna University of Technology.

GAVE

This project looked at the efficiency and user acceptance of automated load management. Private, public and C&I customers participated in the project (http://energyit.ict.tuwien.ac.at/index.php/de/projekte/gave). This experiment took place in the rural community of Großschönau where mainly small consumers of electricity can be found and hardly any large consumers.

SmartResponse

The Smart Response Study (http://energyit.ict.tuwien.ac.at/index.php/de/projekte/smartresponse) analyzed causes for and issues in the context of the missing implementation of DR in Austria. Results of this interdisciplinary project were consisted of recommendations to enable DR solutions in Austria.

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[91] Osborne, *A Primer on Demand Response*, 27.

Since large industrial customers were at the focus of this project, their needs and requirements were looked at in detail in WP01 of the EDRC research project. Results are presented in the following chapter.

The results of research conducted in this chapter form the basis of Chapter 10. There, the approaches described here are elaborated into eight distinctive use cases for EDRC, two of which are investigated in detail.

9 Needs and Requirements: The Potential for Demand Response Systems in Austria

9.1 Selection Criteria and Selected Industries

9.1.1 Energy-intensive Branches in Austria

A high potential for DR technologies is given in those industry branches, where the following two criteria are met. First of all, a large amount of electrical energy needs to be consumed and secondly, energy costs need to represent a significant part of overall production costs. An analysis of Austrian industries from this perspective was provided by the Graz University of Technology and showed that the following industries have a high potential for DR technologies:

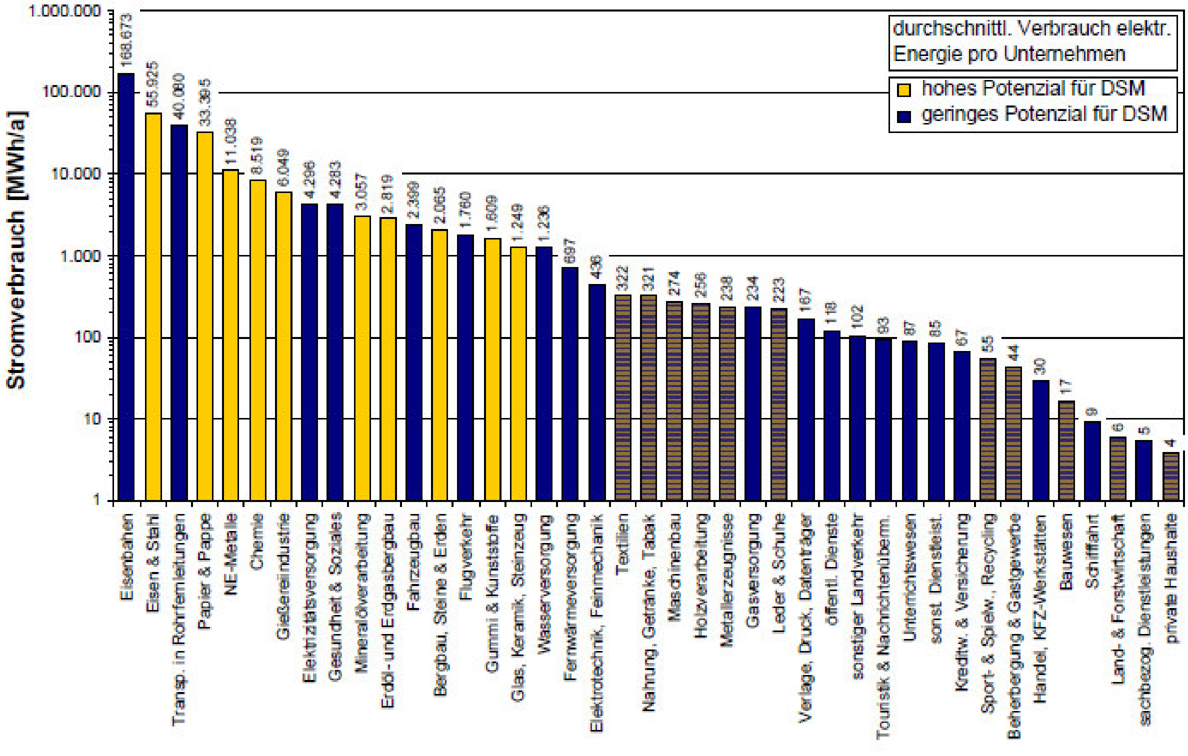

Figure 16: Potential for demand side management (DSM) in Austria[92]

[92] Christoph Gutschi, *Interdisziplinäre Beiträge zur Effizienzsteigerung im Energiesystem durch Energiespeicherung und Kraft-Wärme-Kopplung*, PhD Thesis, Graz 2007.

The analysis concluded that the following industries have high potential for demand response technologies:

- Paper, Cardboard, Pulp
- Mining, Industrial Rocks and Minerals
- Iron and Steel, Non-ferrous Metals
- Chemical Industry
- Glass, Ceramics, Cement
- Rubber and Plastics

Consequently, companies from these branches were selected as first contact points for expert interviews about the potential of DR technologies in Austria

9.1.2 Size of Companies

Only companies with more than 250 employees were contacted to make sure that the companies identified within a specific energy-intensive industry are correspondingly "big" companies resulting in high energy consumption.

9.1.3 Identified and Contacted Companies

Research in the database of the WKO (Austrian Chamber of Commerce) resulted in a list of companies to be selected due to their fulfilment of the above mentioned criteria (Annex, page **Fehler! Textmarke nicht definiert.**). Companies from the industry "mining, industrial rocks and minerals" were identified in all Austrian provinces due to the fact that only one company in Styria and Upper Austria fulfilled the determined criteria. In all companies, the relevant contact person was identified. Usually it was the site's energy manager that was contacted for an interview or in case of the absence of such a position the interview was held with the plant manager.

All contacts, totalling 70 companies, were contacted via email, explaining the study and asking for an interview. In a second step, the contact persons identified were contacted via telephone in order to fix a date for a face-to-face or telephone interview. Result of this step is a list of the companies that could be reached via telephone.

Accordingly, out of the 70 companies contacted, 16 companies were willing to take part in the study - most showing interest in demand response systems, whereas 18 companies explicitly showed no interest in the study and demand response systems correspondingly. The following chapters explain in detail the results of this analysis.

	No of Interviews	
Industry Branch	**Short interviews**	**Problem-centered interviews**
Paper, Cardboard, Pulp	5	6

Mining, Industrial Rocks, Minerals	6	0
Iron, Steel, Non-ferrous Metals	2	3
Chemical Industry	2	3
Glass, Ceramics, Cement	0	3
Rubber and Plastics	5	1

Table 14: Number of interviews by industry branch

Reasons not to Participate

As pointed out above, there were a few companies that did not agree to be interviewed for the EDRC research project. Looking at the reasons for non-participation is important for the analysis of the potential for DR technologies in Austria.

Since target interview partners usually were in senior positions at their companies, such as energy managers or plant managers, it is unsurprising that a few decided not to participate in lengthy interviews due to busy schedules. However, the project team usually could reach these persons for short telephone interviews.

Apart from this, following reasons for non-participation were mentioned:

One paper producing company is already actively engaged in DR. They have set up their own balance group and participate on the electricity market by buying and selling loads.

In the case of a large Austrian salt producing company, the interference with the production process through DR technology is not possible. Salt production is a continuous process that – at this particular site – is constantly fed through a 50 km brine pipeline running from the mine to the plant.

Interest in DR by companies that engage in the processing of rubber and plastics, for example via injection moulding or extrusion, was very low to non-existent due to the fact that it is very hard to disrupt these processes, not least due to consequential costs through additional waste.

Some companies were not willing to participate in an interview since they have already put a lot of effort in optimization of energy usage internally and were not willing to discuss DR systems further. However, this does not mean that they are against DR in principle and could be interested in participating in such a system once it is up and running. Resistance to interference with internal processes by outsiders is an aspect that must be considered in any DR system.

9.2 Paper, Cardboard and Pulp

9.2.1 Analyzed Companies

This table gives an overview of the interviews that were conducted in the pulp, cardboard and paper industry:

Province	Company
Styria	7 Companies
Upper Austria	4 Companies

Table 15: Paper, cardboard, pulp: companies

9.2.2 Demand Response Potential

In general, the paper and cardboard producing industry shows a big interest in the participation in DR systems. The main assemblies, which are the paper/cardboard machines, cannot be drawn upon in DR systems since the interference with production processes would be too significant.

However, it is possible to use the machines producing base materials in the processes, namely pulp or pressure grinders, but also augers. These are suited very well because reaction times are relatively quick. Switching can take place about 15 minutes after notification. Furthermore, one paper producing company mentioned an additional condenser/turbine that could be used and would have a reaction time of less than one minute. Summing up the switchable loads of the four pulp/paper/cardboard producing companies results in about 50 MW.

The time periods for which these can be switched vary. While the mentioned steam turbine of Company C can theoretically be switched for indefinite periods of time, the switching of the other assemblies is dependent on production processes and the capacity utilization in respective plants. Capacities at Company B (11MW) could be switched once daily for 2 hours and capacities at Company D (25 MW) two times daily for 4 hours. As pointed out above, it is not clear at this stage how often MM Karton would be able to switch loads as this depends on production cycles, but they could switch it 2-3 hours at a time.

One aspect that has to be kept in mind is that investments in storage facilities could become necessary in the paper and cardboard industry when participating in DR systems. If, for example, a pulp grinder is switched off at a certain time, then there has to be enough ground pulp on stock to feed the production process of paper/cardboard.

9.3 Mining, Industrial Rocks and Minerals

9.3.1 Analyzed Companies

This table gives an overview of the interviews that were conducted in the mining, industrial rocks and minerals industry:

Province	Company
Lower Austria	1 Company
Upper Austria	3 Companies
Salzburg	1 Company
Vorarlberg	1 Company

Table 16: Mining, industrial rocks and minerals: companies

Quarries

A number of mining, industrial rocks and minerals companies were contacted, as shown in the table above. However, despite the fact that these industries were shown to have significant potential from theoretical point of view, interest to participate in a problem-centered interview for the EDRC was low. Therefore, no detailed data could be obtained. The short interviews conducted point towards a resistance towards interference with internal processes.

Salt works

There is very little potential for demand response systems in this industry in Austria. It is not possible to disrupt the flow of the brine, which is pumped into the plant directly from the mine. The subsequent process of extraction of salt from the brine can also not be disrupted as it is highly integrated. These facts were made clear by the responsible manager in a short interview.

9.3.2 Demand Response Potential

Despite the significant potential for DR technologies in this industry, there seems to be a considerable resistance towards these technologies in the area of mining, industrial rocks and minerals. Apart from saltworks – where it is not possible to interfere in internal processes with DR technologies – efforts to convince responsible managers in this industry would have to be undertaken in order to unlock the potential for DR.

9.4 Iron and Steel, Non-ferrous Metals

9.4.1 Analyzed Companies

This table gives an overview of the interviews that were conducted in the iron &steel and non-ferrous metals industry:

Province	Company
Styria	4 Companies
Upper Austria	1 Company

Table 17: Iron and steel, non-ferrous metals: companies

9.4.2 Demand Response Potential

There is both a significant potential and interest for the application of DR technologies in the iron and steel industry. The two steel production companies in particular showed a big interest in participating in DR technologies and mentioned their EAFs as the items that can be used to this end. Main advantages of EAFs from a DR point of view are that they can be switched off with almost no delay and that they have a high connected load.

The two electric arc furnaces of Company G and Company F alone could provide 51MW of power with one minute response time. This is a significant potential. Very importantly, managers at both plants are very interested in participating in demand response systems. They stress that other parts of the mill, like the rolling mill, could be utilized as well, but that this is not the desired first option and would not be that easy technically. Before the liberalisation of electricity markets in Austria, both companies were actively involved in systems to cut off peak loads.

Company K is interested in the participation in DR technologies in principle, but further investigations internally would have to be carried out to give an indication of the possible extent of involvement. As mentioned, in the 90ies a system to cut off peak loads was operated at Company K. The pressing plant and the rolling mill are the two assemblies that could be used in DR systems.

With less than one minute, reaction times are very short for the steel plants surveyed. Both could switch their loads multiple times during the week, with Böhler preferring shorter switching times (15 minutes) and Company F longer intervals (hours). Company K's loads can be switched very often and for long time periods – depending on utilization, which is hard to predict.

9.5 Chemical Industry

9.5.1 Analyzed Companies

This table gives an overview of the interviews that were conducted in the chemical industry:

Province	Company
Carinthia	1 Company
Styria	1 Company
Upper Austria	1 Company

Table 18: Chemical Companies: Industry

9.5.2 Demand Response Potential

Key personnel interviewed at the respective plants were very interested in DR systems. There is significant potential in the chemical industry for demand response systems. Although the potential in one plant (Company M) is momentarily low, future plans to extend facilities there point towards increased potential in the future.

As noted, Company N has significant potential as well. Here, up to 15 MW could be switched of ammonia production. The potentially long switching times – from hours to days – could be very interesting within a demand response system. However, switching is preferred to take place in the warmer months of the year since equipment (compressors in particular) is more likely to get damaged when it is cold.

9.6 Glass, Ceramics, Cement

9.6.1 Analyzed Companies

This table gives an overview of the interviews that were conducted in the glass, ceramics and cement industry. In fact, interviews conducted here were all focused on cement industry.

Province	Company
Styria	1 Company
Lower Austria/Styria	1 Company
Upper Austria	1 Company

Table 19: Glass, ceramics, cement: companies

9.6.2 Demand Response Potential

From the interviews it was clear that there is a very high potential for DR technologies in the glass, ceramics and cement industry. Companies showed a high willingness to participate in such a system and even started preliminary investigations into their own potentials. Cement mills in particular are "predestined" as assemblies to be used in DR systems. Their advantages are that they can be switched off immediately, have a relatively high connected load of up to 10 MW per site and can be turned off for hours at a time.

Reaction times in the cement industry are usually short (less than 15 minutes), only one plant required a notification of more than six hours. The frequency of switching is not easy to predict in the cement industry, often mills are very busy between March and October. However, on average it is possible to shed loads two or three times a week for blocks of up to 5 hours.

9.7 Rubber and Plastics

9.7.1 Analyzed Companies

This table gives an overview of the interviews that were conducted in the rubber and plastics industry.

Province	Company
Styria	1 Company
Upper Austria	6 Companies

Table 20: Rubber and plastics: companies

9.7.2 Demand Response Potential

For the companies surveyed in the rubber and plastics industry, results are similar to those obtained in the packaging industry. The potential for the rubber and plastics industry seems to be low. This is due to the processes involved, which are extrusion and injection moulding. These processes cannot be stopped easily and if they are interrupted, then the problem of waste arises, which is very costly to dispose of. To sum it up, the potential for DR systems in the rubber and plastics processing industry is very low.

9.8 Summary of Potential for Industrial Demand Response in Austria

Paper & cardboard, iron & steel, chemical industry and the cement industry are the first industries that should be looked at when thinking about demand response systems in

Austria. There was considerable interest by leading companies in respective industries. Moreover, several of these companies gathered experiences with load shedding in the 1990ies before the liberalisation of the Austrian electricity market. They evaluated these experiences primarily positive. Furthermore, certain paper companies and cement mills that are part of international corporate groups know of their sister companies participating in DR or frequency response systems elsewhere in Europe and the World.

Main motivations for participating in DR systems are monetary incentives, possible other consideration such as contributing to grid stability and gaining an image as environmentally friendly company are not important to industry.

Only in very few cases is automated switching an option for industry players. They want to be control and have the final say over whether or not a certain machine is switched on and off.

The table below gives an overview of the loads that can be shifted in the companies surveyed. Please note that interviewed persons at the respective plants was often not in a position to give exact indications as to the frequency and the duration of shifting since these are also dependant on factors such as capacity utilization in a narrow sense and thus the economic situation overall.

Industry Sector	Co.	Shiftable Loads (MW)	Frequency	Duration	Response time
Paper, Cardboard, Pulp	1	-	-	-	-
	2	18	daily	2 hrs	15-60 min
	3	-	-	-	-
	4	3-4	anytime	unlimited	<1 min
	5	25	daily	2x4hrs per day	5-15 min
	6	6	3-5x a week	2-3hrs	5-15 min
Iron & Steel	7	27	3-5x a week	15 minutes	< 1 min
	8	24	repeatedly per week	3-5 hrs	< 1 min
	9	10	repeatedly per week	depending on orders	15 min
Chemical Industry	10	-	-	-	-
	11	15	uncertain	winter: minutes to hours; summer: hours to days	3-5 days
Rubber and Plastics	12	-	-	-	-
	13	-	-	-	-
Glass, Ceramics, Cement	14	9,5	repeatedly per week	2-6hrs	17 hrs
	15	17	daily	4-5hrs	15-30 minutes
	16	0,7	depending on orders	depending on orders	<1 minute
Mining	17	not known	not known	not known	<1 minute

Table 21: Shiftable loads, response time and frequency/duration of load shedding by industry branch

10 EDRC Business Models

This chapter summarises Brimatech's findings regarding possible business models for an EDRC based in Austria. After describing general possibilities, i.e. use cases, for the integration of EDRC on the Austrian electricity market, two cases were selected together with the project consortium and described in detail. These cases are the integration of EDRC in the balance group model and the possibility to draw on EDRC in the context of network stability. A third use case, namely the provision of tertiary reserve, was dealt with by APG in more detail. However, the use case of addressing balance group management could also be drawn upon to address the tertiary reserve market, as will be shown below.

10.1 Product Description and Positioning

- **European Demand Response Center**

Input for the EDRC are prices on reserve markets, costs for the storage of semi-finished goods, ramps of aggregates, possibilities of load shedding of aggregates as well as fines in the case of non-compliance. The output is different services/use cases for market participants.

- **Regional focus**

The regional focus of the analyses in this project is put on Austria. The main stakeholders in the project are large industry, DSOs, TSOs, regulator, electricity traders, utilities and balancing groups.

- **Who is the prosumer?**

The focus of the project is large industry. Prosumers were evaluated via their electricity usage/1000€ of production. Depending on their relative electricity consumption, also smaller companies can profit from such a DR system. Apart from the energy-intensive sectors of industry, also those sectors that participated in the project via a LOI were investigated.

General benefits of DR, which comprise the enhancement of infrastructure and reliability, the management of electricity costs and the mitigation of environmental impact caused by electricity usage, are well understood in principle.[93] The possible implementation of these advantages in the Austrian context is described below.

The following shows the expected development of DR solutions in terms of customer base in the future and thereby also gives an indication of the development potential of EDRC.

[93] Osborne, *A Primer on Demand Response*, 2.

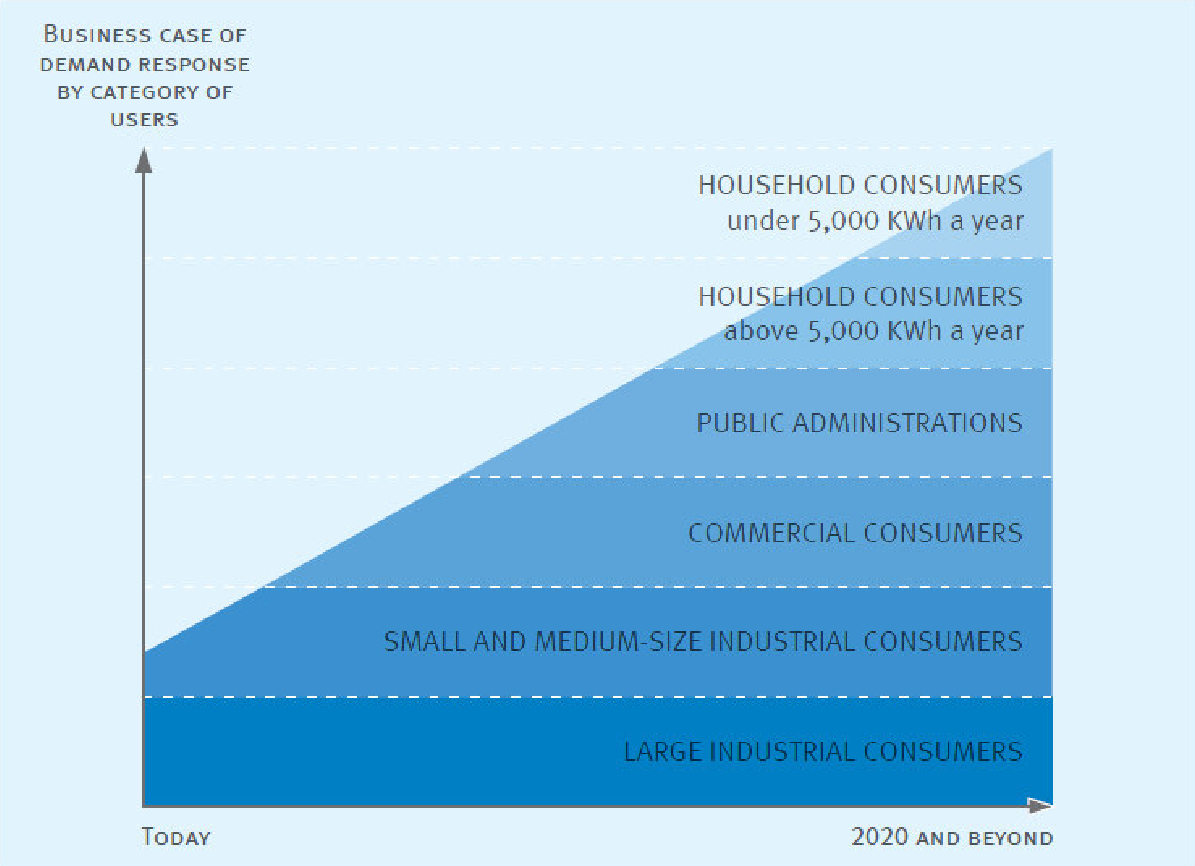

Figure 17: Development of the European DR market (Source: Eurelectric)[94]

10.2 Possibilities for the Market Integration of EDRC

As a basis for analysing possibilities for the integration of Demand Response systems on the Austrian market, relevant literature as well as DR applications in other countries were screened. This analysis resulted in an overview of markets that can be addressed by DR technologies and the definition of use cases. Literature research was complemented by information gathered in the stakeholder interviews.

This section gives, first of all, a brief description of the main advantages of DR systems. This is followed by an overview of the possible conflicts between market and network aspects in DR systems. Last but not least the different use cases of the DR business model are presented.

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[94] Eurelectric. *Views on Demand-side Participation: Involving Customers, Improving Markets, Enhancing Network Operation,* Brussels, 2011.

10.2.1 Advantages of Demand Response

Why demand response? The advantages of DR are reflected in the table of use cases further below. In relevant scientific literature, the following benefits of DR systems are described:[95]

DR to enhance infrastructure and reliability

- Through DR systems, the need for investments regarding generation, transmission and/or distribution can be deferred.
- DR can be used to fulfil criteria of operating and planning reserves as a resource for use in planning and procurement activities.
- DR is able to support grid reliability, easing congestion and delivery constraints and to improve local and regional reliability. Furthermore, emergency system needs can be met.
- Integration of intermittent RES can be supported through DR.
- In conjunction with enabling technologies, DR can provide customer service benefits, such as outage management and power quality management.
- Controlled outages during power system emergency situations can be decreased.

Management of electricity costs

- DR can give customers an opportunity to have greater control over their energy use, and enable more effective response to dynamic tariffs and prices which reflect the time-varying cost of energy. Providing electricity service can encourage some consumers to adjust their usage and, in the aggregate, lower overall wholesale electricity costs for all customers.
- DR can enhance market efficiency and help mitigate wholesale market power.

Reduction of the environmental impact caused by electricity usage

- DR can reduce electricity use during peak periods when the least efficient generation are usually operating. Thus, it can reduce greenhouse gas and other air emissions.
- DR via permanent load shifting can help integrate intermittent, non-peak time, renewable resources into the electric grid and benefit the system load factor.

10.2.2 Market and Network: An Area of Conflict?

The division between network and market is very important in the context of EDRC – in particular in the light of the liberalisation of the market and the separation of market roles.[96].

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[95] Osborne, *A Primer on Demand Response*, 2.
[96] Bundesnetzagentur, *"Smart Grid" und "Smart Market". Eckpunkte der Bundesnetzagentur zu den Aspekten des sich verändernden Energieversorgungssytems,* Bonn, 2011.

Network operators are focused on the provision of network capacities (kW) while energy (in terms of kWh) is the field of activity of the other market actors.

However, current developments in the ICT sector, which are applied in projects such as EDRC, will allow further automation in the energy sector. This will also allow end users to participate in the energy markets and as a consequence new service offerings are expected to enter the market.[97] EDRC is one of these new service offerings and is currently confronted with a “conflict of roles” on the energy markets.

In Austria, load management (“Lastenmanagement”) was practiced up to the liberalisation of the markets and had a focus on network stability. In the future, the German BNA expects that the more market driven model of DR will play a more important role but stresses that also network topics have to be taken into consideration.

10.2.3 Overview: Demand Response Business Cases for Austria

This section describes the various use cases that were identified for DR systems in Austria. Not all of these use cases were looked at in detail for the EDRC business model, but three of them were selected for a more detailed analysis. The use case “provision of tertiary reserve” was investigated by project partner APG; Brimatech analyzed the use cases “Reduction of balancing costs” and “Grid stability, congestion management, peak load management”.

The use cases are based on the interviews that were conducted with various stakeholders, relevant literature and discussions within the EDRC project team. Each of the use cases is described briefly below and the most important elements of each use case are analyzed in Table 22 below.

1. **Provision of tertiary reserve**

The energy saved through load shedding can be offered on the tertiary reserve market. The tertiary reserve market is addressed since response times required in primary and secondary reserve are not achievable within the EDRC project, as concluded in Work Package 1.

For obvious reasons, Austria’s TSO APG is the prime stakeholder in this context. Important issues related to this use case, such as the necessity to adapt prequalification rules, are detailed in PART 3 of this report.

2. **Reduction of balancing costs - integration into balance groups**

For balance groups, demand response technologies can be used to minimize the required balancing costs. By embedding DR technologies into forecasting tools used by balance groups, the forecasting required for each balance group can be improved and thereby

[97] “Ibid., 8.

savings in balancing costs achieved. The stakeholders who are most interested in this case are the balance group representatives (BGR). Furthermore, the integration of DR into a balance group is a key aspect of any business case.

3. **Grid stability, congestion management, peak load management**

Since the liberalization of the electricity market in Austria, vertically integrated utility companies that also include network operations are an aspect of the past. Network operators are mainly responsible for grid stability. However, they are currently not allowed to directly switch large industrial consumers without fairly complicated legal constructions. This is clearly stated in the market rules and also expressed in the perception of DSOs. The following questions arise: In the current regulatory framework, is the implementation of EDRC for DSOs feasible? What steps would have to be undertaken in order make it feasible?

4. **Tool for Utilities**

Apart from the above system-level applications of DR technologies (provision of tertiary reserve/grid stability/balancing) DR may also be considered as a tool for utilities. From the interviewed utilities' point of view, DR technologies could be of particular interest to create new and more attractive pricing structures for large and very large customers. The idea behind this is to reduce the share of electricity that is bought at peak price by employing intelligent DR technologies and consequently being able to offer more attractive pricing to large consumers.

5. **Integration into energy management systems**

Existing energy management systems for large plants could be extended to also include networked DR functionalities.

6. **Emergency protection**

DR technologies could play an important part in emergency protection systems of the electricity system. Here again, the DSOs will be the main stakeholders.

7. **Trading spot market (e.g. EEX, EXAA)**

The energy saved through load shedding could be offered on the energy spot market, such as the EEX.

8. **Cross-border Exchange**

Cross-border exchange is also administered by the TSO and shed loads could be employed to participate on this market.

The overview on the following page displays the most important facets of each use case. Relevant players differ by use case and so will have differing interests, requirements and needs towards DR systems.

#	Use Case	Product/ Service/ Software	Competition	Stand-alone/ possibility to cooperate	Possible Partner(s)	Revenue	Customer	Relevant Stakeholders	Comments
1	*Tertiary Reserve*	Service	Other bidders on the tertiary reserve market (generators)	Aggregator/ Cooperation with balancing group	Balancing groups	Market price tertiary reserve	APG; heavy industry	APG, Balancing Groups; E-Control	Barriers: regulatory framework;
2	*Balancing costs / balancing group*	Service/ Software for balance group management	None known	Software for BG, possible cooperation with the balancing group's SW provider	Software providers; balancing groups	Reduction of balancing costs	Balance groups; heavy industry	Balance group; forecasting software provider; E-Control	
3	*Grid stability, congestion/ peak load management*	Service for DSO	None known	Stand-alone/ or other SW providers	DSOs	Currently unknown due to regulation	DSO; heavy industry	DSO	Issue: current market model/ market rules
4	*Tool for Utilities*	Software/ Service	None known	Cooperation with Utilities	Utilities	Dependent on the possibility to reduce the share of spot prices in overall electricity costs	Utilities (heavy industry)	Utilities	
5	*Integration into energy management systems*	Software embedded in energy management systems	Energy management software	Cooperation with producers of energy management software	Providers of industrial energy managem ent systems	Licensing	Energy manage-ment system provider	Energy management System Provider	

#	Use Case	Product/ Service/ Software	Competition	Stand-alone/ possibility to cooperate	Possible Partner(s)	Revenue	Customer	Relevant Stakeholders	Comments
6	*Emergency Protection*	Service/ Software	None known	Cooperation with DSO	DSO	annual usage fee	DSO	DSO	
7	*Trading spot market/ (EEX; EXAA)*	Stand-alone Software	EEX/ EXAA participants	Participation in balance group	Balance group; Utilities	Depending on prices on market	Heavy industry	BGR; EXA; EXAA	Setting-up or participation in a balance group Barrier: regulatory framework
8	*Cross-Border Exchange*	Service	Utilities	Possibility to cooperate with balance group	Balance group, APG	Market prices (intra-day)	TSO of another control area	CSA; E-Control	

Table 22: EDRC Use Cases

Use cases 1-3 are the focus of this part of this report. In order to see how the integration of EDRC on the Austrian market could take place, complex interactions of different actors in the Austrian balance group system and on the wider electricity market have to be investigated.

10.3 Business Case: Reduction of Balancing Costs – Integration of EDRC into Balance Groups

As described in the overview regarding use cases (Chapter 10.2.3), the basic idea behind this use case is the reduction of balancing costs on the side of BGR and thereby providing positive effects for balance groups, industry and the Austrian electricity system as a whole. Furthermore, the integration of EDRC into an existing balancing group is an important aspect since it would greatly facilitate the market entry of EDRC. In fact, it was decided in project-internal workshops that such integration should be the goal since a stand-alone EDRC solution (aggregator/flexibility operator) would face very high barriers for market entry.

The first type of balance group that was investigated was producing “green” electricity. BGs with a higher level of RES are more often confronted with the issue of intermittent energy generation and therefore may have more issues regarding balancing. The second type of balance groups were the ones without any particular focus on green electricity, but with a considerable portfolio of industrial customers. Challenges regarding DR, such as the requirements regarding communications infrastructure, protocols, and processes that have to be installed, apply to both categories of balance groups.

10.3.1 Value Network

The depiction below gives a schematic overview of a possible integration of EDRC within a balance group. The two circles signify two balancing groups, where the one on the left hand side (Balance Group A) cooperates with EDRC. The main role of EDRC in this model is to counter unscheduled power flows through load shifting by participating companies, thereby decreasing costs of balancing power for the balance group and the electricity system as a whole.

As pointed out, a key element in this model is the close relationship between EDRC and the BGR, as opposed to a stand-alone aggregator/flexibility operator.

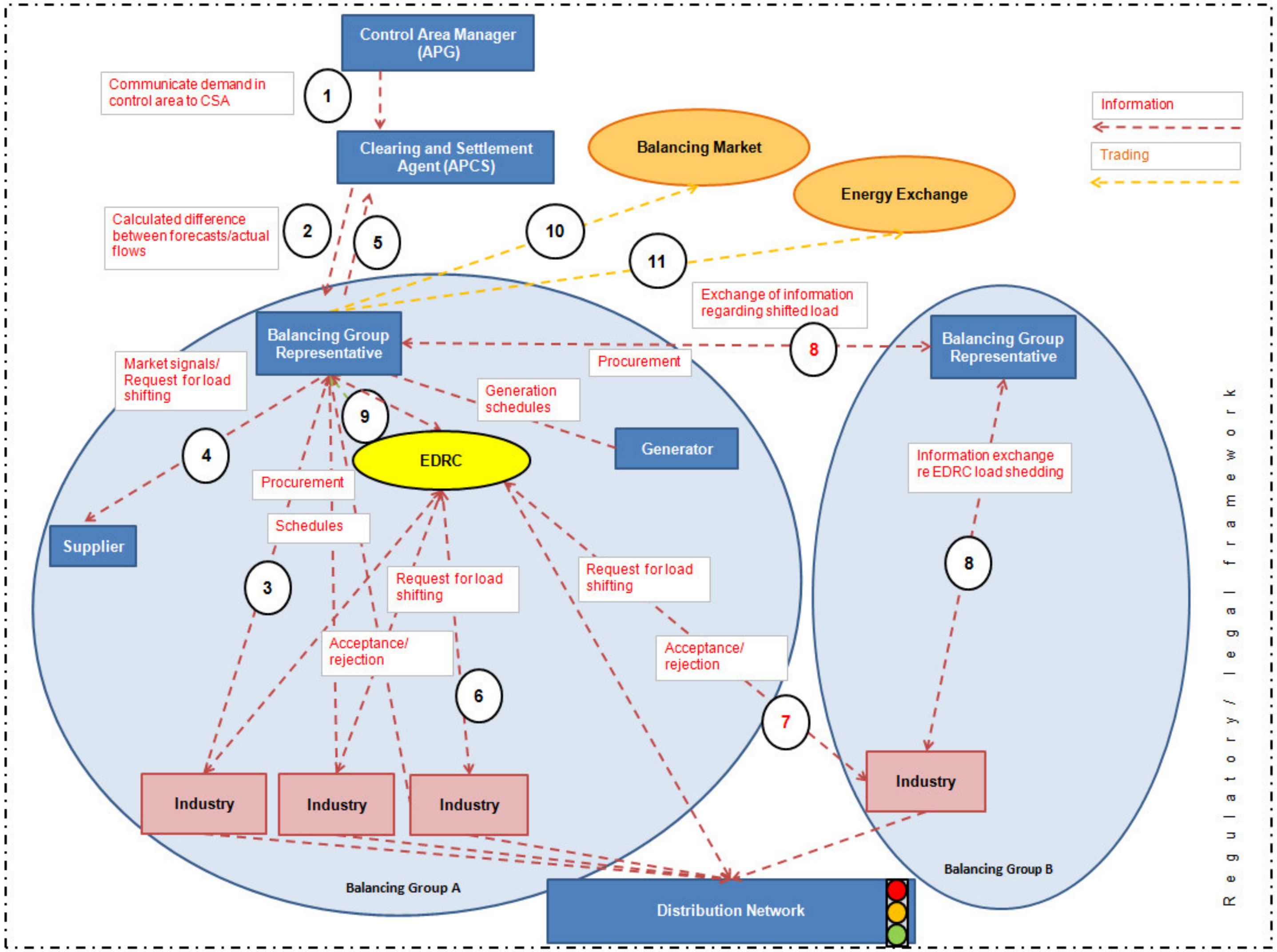

Figure 18: Integration of EDRC into a balancing group

10.3.2 Process Description

Steps 1-5 describe measures that are undertaken within the regular balance group system, while the subsequent steps describe processes related to the integration of EDRC and new emerging possibilities within the BG. When looking at the chart, the pivotal roles of both the BGR and EDRC become obvious.

Step No.	Description	Stakeholders Involved
1	The CAM passes on the actual electricity usage within the control to the CSA. In the case of Austria, these functions are fulfilled by APG and APCS.	CAM, CSA
2	The CSA (APCS) then calculates the differences between actual consumption and the consumption that had been forecasted by balance group representative (BGR). This information is passed on to the BGR.	CSA, BGR
3	Heavy industry submits their consumption schedules to the BGR day ahead. These reports are then aggregated by the BGR and combined with information obtained from generators of electricity.	Industry, BGR
4	Just as industry does, generators provide information to the BGR about their schedules day ahead.	Generators, BGR
5	Step number five is the information exchange between BGR and the CAS, where the information gathered in the above steps 3) and 4) is passed on to the CAS.	BGR, CAS
6	EDRC sends requests for load shedding to the participating industrial plants. These send back the confirmation/rejection message. This exchange can be done by phone or email.	EDRC, Industry
7	From a strictly regulatory point of view, EDRC can also access loads outside the respective balance group. In this chart this is step 7, where a request for load shedding is sent to an industrial plant outside the BG and, as in step 6, either a confirmation or rejection of load shedding takes place. However, it is important to note that this step is **not** permitted in the context of current regulations/pre-qualifications for tertiary reserve energy. Furthermore, this step seems to be difficult to implement in reality, even though it is allowed from a regulatory point of view. The interviewed BGR in particular strongly expressed the view that such a course of action would be perceived as "unwanted intervention".	EDRC, Industry
8	Due to the design of the balance group system, which makes it necessary to forecast energy usage and pass information on to the CSA and for internal balancing in general, it is necessary to exchange information between balance groups A and B.[98]	CSA

[98] E-Control, *Sonstige Marktregeln Strom, Kapitel 3: Fahrpläne*. (accessed on 11 May 2012 at http://www.e-control.at/de/marktteilnehmer/strom/marktregeln/sonstige-marktregeln).

	This point correlates to step 7) and is unlikely to be feasible in reality.	
9	Step number 9 symbolises that the load has been shed and is now at the disposal of the BGR.	
10	The BGR can now theoretically utilize the load in a number of ways. From the BGR's point of view, the shed load provides additional flexibility, i.e. the added value to manage the balancing group in a more efficient manner. As pointed out during this report, this is (and will become) particularly important with the increased stochastic production of renewable energy. Furthermore, through active information exchange between EDRC and the BGR, there is the possibility to utilize this energy as balancing energy.	BGR, Balancing Market
11	In the same way, the BGR could also act actively on energy exchange markets. However, this is a theoretical possibility that is not investigated further in this report.	BGR, Energy Exchange
12	The DSO has to be included in the architecture of EDRC to make sure that the distribution network is not put under stress.	BGR, DSO

Table 23: Balancing Costs – Stakeholders and Processes

10.3.3 Stakeholder requirements

The most relevant stakeholders in this business model are the balancing group representatives, industry, the distribution network operators and of course EDRC. Their requirements, which have been surveyed in interviews, are reported below.

Balance Group

A key requirement for BGR is that EDRC is run in a manner that is compliant with all current Austrian energy market regulations. Two points can be distinguished here: First of all, for the case of balance group management the current regulatory framework is not violated through EDRC. Secondly, the possibility of using EDRC on the tertiary reserve market must not involve the procurement of loads from another balance group, since this is not allowed by regulations regarding pre-qualifications for tertiary reserve (see PART 3).

Another key requirement on the side of the BGR is the reliability of EDRC. This was emphasised by all BGRs. Some BGRs reported that they had already made the experience of cooperating with large industrial companies that wanted to shed loads in order to participate on the tertiary reserve market. These single plants were not able to fulfil requests for load shifting and thus cooperation was not carried out for very long. In turn, this means that the pooling achieved through the EDRC has to overcome this issue by being able to supply energy whenever requested, even if single companies are not able to fulfil requests.

Besides the prime requirements of regulatory compliance and system reliability, a close cooperation with EDRC is necessary. This includes cooperation regarding the acquisition of

DR customers, data/information exchange within the DR system and collaboration to integrate EDRC software in the BGR software.

The switching undertaken by the customer must be transparent, traceable and verifiable. EDRC must be able to prove to the BGR that load shedding has taken place. This aspect requires the involvement of the DSO, who is in charge of meter readings. Thus, data information exchange between the EDRC system (through the BGR) and the DSO involved is necessary.

Another important requirement for some BGRs is the source of energy. Suppliers of green electricity need to be certain that energy obtained from the EDRC system will be green as well. This means that, first of all, no diesel aggregators or similar must be used in the production of electricity. Leaving the issue of diesel aggregates aside, it became clear during the investigations that the participation of "green" balance groups in EDRC may not be easily possible. From a marketing point of view it may be difficult to integrate EDRC into such a balance group at all since the energy "source" would be large industry (Chapter 10.3.5). These viewpoints may be upheld by customers irrespective of the real positive environmental impact of EDRC.

EDRC

The two main relationships of EDRC are with industry and with the BGR. Installation of equipment onsite and setting up of a central IT infrastructure are key requirements for any DR system. Furthermore, two-way information exchange with the BGR is a key requirement. In order for the DR system to work, the pool of companies has to be larger than the energy actually needed. Last but not least, the cooperating BGR must have sufficient numbers of large industrial customers. However, in this research it was not possible to determine the composition of balance groups with regards to relevant industry sectors (see Chapter 9) due to confidentiality reasons.

Distribution Network Operators

DSOs are not directly affected by this EDRC market model and due to their status as natural monopolies they do not have an immediate economic interest in this use case.

However, it is very important to note that DSOs have the responsibility for the physical side of the electricity system and therefore the integration of EDRC in the market must take DSOs into account.

While the actual location of plants does not play a role for TSOs, DSOs and network stability could be directly affected by actions taking place in their network.

In the depiction of the business model, this is symbolised by the stop light. It is suggested at this stage that schedules for possible load shedding are sent to the DSO day ahead under the assumption of “worst case scenarios”, i.e. the maximum load that may be shed in a certain time period.

Industry

The entire EDRC system relies on the availability of a pool of participating industrial companies. Analysis performed in Work Package 1 of the EDRC project showed that in principle there is a considerable economic potential of 156 MW in the two Austrian regions surveyed, but successful implementation will depend on meeting industry requirements, too.

A key requirement is the installation of equipment on site. From industry’s point of view, it is crucial that the aggregator is absolutely transparent in its dealings with the customers. DR experience on the American markets suggests that providing detailed load curves on the amount of energy that was requested by the DR provider and the amount of energy that was supplied by the company is important. Further it must be kept in mind that companies that do not have experience with DR may have to receive training for DR and have to adapt to the system first. In particular, this is true for medium-sized non-multinational companies. A dialogue between the DR aggregator and the participating companies should take place each month in order to define the number of DR events that can be realistically achieved by the company in the upcoming month.

10.3.4 Data Exchange

The following figure shows an overview of data exchange that needs to take place in the EDRC system. It is based on information gathered in interviews with stakeholders and project internal discussions.

The diagram of the information exchange below shows untouched information channels in black while those influenced by the EDRC architecture are displayed in red. To exemplify the position of the EDRC, only two customers are depicted in the graph.

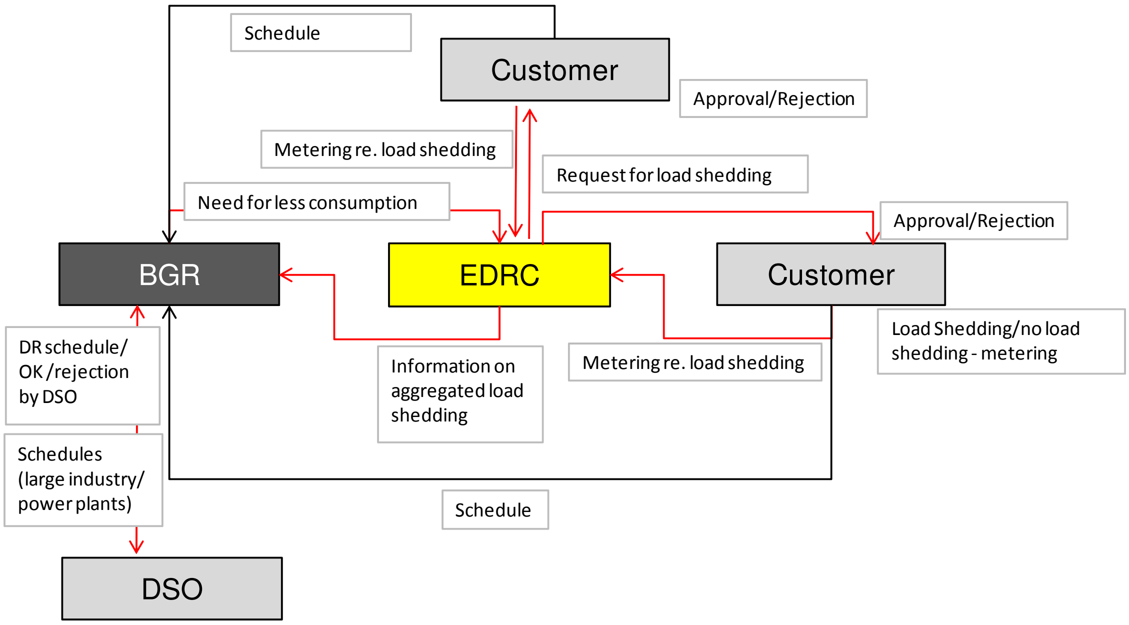

Figure 19: EDRC information exchange

Industrial companies' transmission of schedules of electricity consumption to the BG remains untouched.

Information exchange between BGR and the EDRC is twofold. The first step is the communication of a need for reduction in electricity usage to the EDRC. It is the role of the EDRC to then "intelligently", i.e. through utilization of the core EDRC IT solution, send out requests for load shedding to industrial customers. While the request from the EDRC can be transmitted electronically, for example through integration of EDRC software into existing software of balance groups, the request to the industrial customers should happen either through email or phone call. This fact was stressed by interview partners and is also evident from a legal point of view. A fully automated demand response is not the goal of EDRC:

- Possibility to reject request

The system architecture involves the possibility to reject the demand for load shedding. If an industrial company is not able to shed loads, it has the possibility to deny that request. This option is important since industry is not willing to participate in a mandatory system. No penalties apply when not fulfilling a request.

- Damage of equipment.

If equipment were switched automatically and it were damaged in that process, the question of liability would arise, the most probable outcome being that the switching party is responsible. This is a further reason to put the last decision in the hands of the industrial companies who have the detailed technical know-how needed to avoid damage by switching loads.

Information about fulfilling/not fulfilling the request is communicated to EDRC and on the basis of incoming information from the companies, new requests for load shedding are sent out the pool of participating companies.

After receiving feedback from these companies and actual real-time metering data, feedback about the load shifting is sent to BGR.

10.3.5 Benefits

General benefits of DR systems for the electricity system overall have been reported in chapters 8.3 and 10.2.1 of this report and can be summarised in three categories: [99]

- **Enhance infrastructure and reliability**
    - Deferment of the need for investment in generation, transmission, and/or distribution by decreasing peak demand
    - Serve the need for operating/planning reserve
    - Assist in maintaining grid reliability (congestion, delivery restraints)
    - Interaction with intermittent RES
    - Provide customer service benefits, such as power quality management
    - Decrease controlled outages (emergency situations)
- **Manage electricity costs**
    - Potential to provide customers with greater control over their energy use
    - Flexible DR tariffs can encourage customers to adjust usage;
    - Increase of market efficiency and mitigation of wholesale market power
- **Reduce the environmental impacted caused by electricity usage**
    - Reduction of greenhouse gas and other air emissions
    - Integration of RES into the electric grid

These benefits were discussed and evaluated together with interview partners. The following comprises a summary of the benefits for each stakeholder involved in the use case at hand:

Industry

The paramount benefits for industry are monetary benefits. These, first of all, stem from the reduction in balancing costs in the balancing group which is then passed on to industry.

Secondly, when taking a look at the participation on the tertiary reserve market, going through an aggregator/flexibility operator offers several benefits. Possible penalties in the case of not supplying the energy as planned can be avoided since the BGR takes on the role of shielding industry from risk while at the same time this risk is offset through pooling

[99] Thomas et al., *An Assessment of Business Models for Demand Response,* 2.

services by EDRC. Through access to professionalised pooling services, more time slots on the tertiary reserve market become available and thus the overall profitability is increased.

Last but not least, advanced software infrastructure and the service offered means that companies that already participate directly on the tertiary reserve market can outsource this aspect and thereby reduce internal operational costs.

BGR

From the BGR's point of view, the main benefit is the access to additional sources of energy, flexibility and the improved management of the balance group. Immediate monetary benefits are created through a service fee and the reduction of balancing costs. The DR service offering could be branded as a utility's own service, thereby attracting new customers. By handing over DR services to EDRC as a specialised entity, the BGR gains access to a service provider that is able to handle the demand response program. This is a full-time commitment that requires specialised staff and software.

According to the interviewed BGR, large industrial customers fairly often change their electricity suppliers. This is a very competitive market and therefore the inclusion of DR in a balancing group would be an excellent way to market this balancing group/utility and attract new customers. This point was specifically highlighted by balance group representatives.

10.3.6 Barriers

The possible barriers for EDRC were investigated in the interviews with the stakeholders and also discussed within the project team. Barriers can be categorised into technical, organisational/regulatory and other barriers.

Technical barriers

No technical barriers for the implementation of EDRC have been identified in the interviews.

Organizational and regulatory barriers

The regulatory framework could pose challenges for the introduction of the EDRC system. The following factors have to be taken into account.

In terms of balance group management, no regulatory barriers have been identified and EDRC could be installed as described in this report. However, from an organisational point of view, the above sketched possibility to access loads outside of a balance group may not be possible. Even though this is permitted from a regulatory point of view, this will not be easy to implement in reality. Balance group managers emphasised that they would be opposed to another balance group interfering with their own balance group and they think that such an action is not feasible in reality. Furthermore, such an action is not allowed in the technical prequalification for the tertiary reserve market.

Due to these organisational limitations, the pool that is available for EDRC is limited to large industrial customers in each balance group (the detailed composition of which was not disclosed in interviews due to reasons of confidentiality). And the question of the needed size of the virtual pool of companies participating to EDRC has to be reversed in this case into how many are available at all.

Other barriers

It is not easily possible for suppliers of green electricity to participate in the proposed EDRC system. Even though DR systems as a whole are not damaging to the environment, the perception of customers of green electricity may be different. Therefore, suppliers/balance group representatives of green electricity can be expected to be very cautious when it comes to participating in DR systems. Unfortunately, this barrier means that DR is unlikely to be applied to green balance groups in the near future.

An issue in terms of marketing DR to companies is the perceived uncertainty of the actual return from such a system. This could pose a serious barrier to the implementation of the system since it is not easily possible to give such an estimate initially while customers would need an exact figure.

Energy prices are currently fairly high in Europe. Higher energy prices would drive the further development of DR technologies and their implementation.

10.3.7 Resources Needed

This section describes the cost drivers of the EDRC systems. Cost drivers of the system fall into the following categories:

- Framework requirements
- One-off investments
- Ongoing operation

Framework requirements comprise the market environment of EDRC, which, first of all, consists of prices for electricity and balancing costs.

The proposed business model envisages a balance group representative who collaborates closely with the service provider EDRC. Therefore, service fees for these two entities have to be considered as ongoing costs. Furthermore, one-off investments such as equipment and investments in industry have to be taken into account.

Resources needed are summarised along these three categories in the table below. Particularly important aspects are described in more detail below the table, with a focus on cost drivers in industry which vary by industry branch.

Type of Cost Driver	Cost Driver	Main Stakeholder(s) Affected	Description
Framework	Electricity Price	System/ Industry	The price of electricity affects the economic viability of the EDRC system overall. It is assumed that electricity is an important cost factor in industry production,
Framework	Balancing Costs	System/ BGR	The percentage of balancing costs in electricity prices is an important influencing factor in the EDRC system. The savings in balancing costs have to be high enough in order to make the system viable and of interest in the first place.
One-off	Equipment cost (Hardware)	EDRC/Industry	Installation of equipment at industrial sites (DR meters & communication system); mostly available already in large industry.
One-off	EDRC initial costs	EDRC	Development, marketing and implementation costs, introduction to initial customer base,
One-off	Installation of EDRC (Software)	EDRC/BGR	One-off costs of installing EDRC in a BG
One-off	Adaptations, e.g. storage facilities	Industry	Depending on industry branch, storage facilities may have to be built in order to be able to participate in DR systems
Operational costs	Service fee	BGR	Ongoing costs for the balance group representative are the EDRC service fee, the dedication of personnel resources to the liaison with EDRC as well as clearing and settlement
Operational costs	Demand response operation	EDRC	For EDRC, ongoing costs are customer acquisition for DR, customer care and consulting services for customers, as well as hardware maintenance/repair, and software updates
Operational costs	Workers on stand-by (Loss of production)	Industry	Potential additional costs through workers on stand-by during load shedding (decrease in workforce productivity)

Table 24: Description of EDRC Cost Drivers

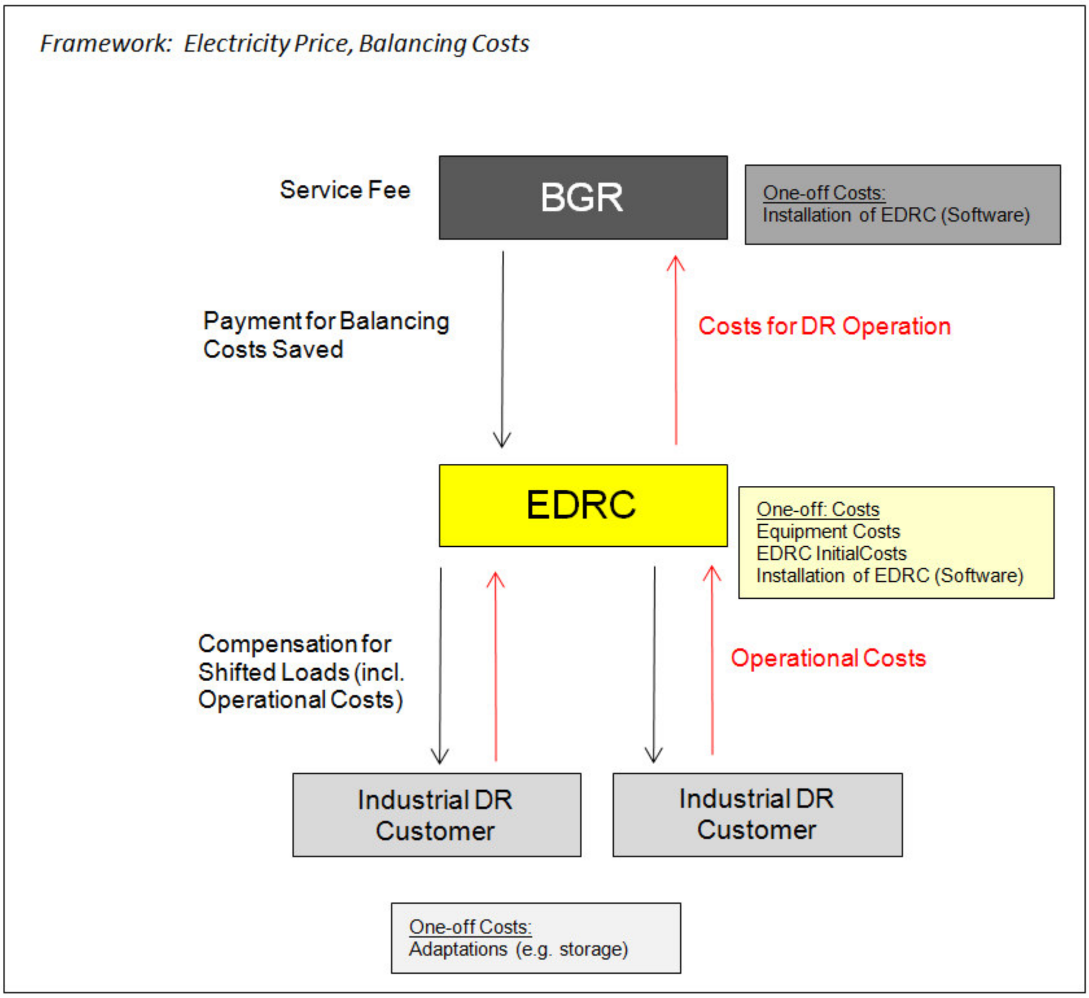

Figure 20: Revenue and Cost Flow

The entire EDRC system is based on savings in the cost of balancing energy by shifting loads of large industrial customers. After deduction of a fee to cover its own operational costs (personnel dedicated to work together with EDRC, clearing and settlement), these savings are then passed on to EDRC. After EDRC deducts its service fee, the participating companies receive their compensation for shifting loads according to their contribution.

Revenue	Stakeholder	Description
Savings in Balancing Energy	BGR	The main revenue source is saved balancing costs.
Operational/Management Fee	BGR	After deducting an operational fee for personnel resources dedicated to EDRC, savings are passed on to EDRC.
Service Fee	EDRC	After a deduction of a service fee, revenues are passed on to customers.
Compensation for shifting loads	Industrial Customers	Customers receive compensation for their load shifting. Compensation depends on the amount of loads shifted.

Table 25: Description of EDRC Revenue Streams

As an alternative the BGR may pay the Service Fee to EDRC and take care of clearing and distributing the savings to industrial customers. It will be a matter of the contractual relationships of the three main actors to stipulate which scheme is preferred.

Balancing costs and electricity price

The first cornerstone of the industrial DR system is the electricity price paid by industry. In interviews, no detailed data on actual contracts could be derived but the price paid by industry can be approximated by looking at wholesale market prices, which in reality are fairly close to the actual price paid for by industry. The wholesale market price plus a mark-up by utilities, the size of which was determined in interviews, serves as a basis here. Furthermore, balancing costs, their impact on the BG group, and pricing need to be taken into consideration.

Investments and ongoing costs in industry

The following briefly describes cost drivers by the investigated branch of industry. These, first of all, concern the need to expand storage facilities in some cases. Furthermore, additional personnel costs that may arise from load shifting have to be considered. These costs cost comprise both one-off investments and ongoing costs.

- Cardboard, Pulp and Paper

Two principal modes of electricity generation for EDRC, namely generation via turbine and generation via load shifting, can be distinguished here. This industry sector is the only one where active additional power generation is possible.

In the case of power generation, no direct investment costs are necessary since everything is already installed on site.

When interrupting production processes of e.g. wood chips, it is important to have the necessary storage facilities. Three out of five companies said that this would not be an issue for them. The remaining two companies indicated the need to invest in storage facilities in order to participate in an EDRC system.

- Chemical Industry

The chemical plant investigated utilizes electrolysis. Since this process does not involve intermediate products to be stored, no additional storage facilities need to be installed. DR would be achieved by gradually decreasing production when the circumstances allow.

- Glass, Ceramics, Cement

The investigated cement industry does not require any storage facilities to be built. The cement mills that can be switched would produce less cement from clinker, hence requiring less storage on the output side. The storage of clinker, which is the input to these mills, would not have to be expanded at the mills investigated.

- Iron & Steel

Due to the production process in the iron & steel industry and the electric arc furnaces (EAF) that can be switched for DR purposes, the question of storage does not arise. However, interviews indicate that an operation on stand-by is very expensive due to personnel costs and the possible impact on production.

As interview partners were not able to give details about personnel costs and impact on production, assumptions across all industry branches were made in the calculations.

Service fees

For offering services to the BGR and industry, the DR operator is reimbursed through service fees. As has been noted by some interview partners, the electricity utilities in general and their trading/balance group representatives' roles in particular are moving towards the role of a service provider. This contrasts the former of role of fully integrated utilities (supplier and network).

10.3.8 Cost drivers

This section presents an estimation of the feasibility of the proposed EDRC business model. The data presented here was derived from interviews and secondary research with the aim of a deriving a maximum indicative cost for EDRC.

Electricity Price

The price of electricity used in the calculation of the business model is based on data published by E-Control.[100] This data stems from a survey of 300 commercial and industrial enterprises that is being conducted by E-Control every 6 months. Since all of the surveyed industrial plants have a consumption of more than 10 GWh per year, the electricity price drawn upon in the calculation is derived from the second table below. As the number of full-load hours is not known for all companies, the electricity price used in calculations is the arithmetic mean (total), which is marked in orange below. Hence, the average price for electricity is assumed to be 5.7 Cent/kWh, which equals 57 € per MWh.

Analysis	**Full-load hours < 4.500 h/a***	**Full-load hours > 4.500 h/a***	**Total**
Median	6,24 Cent/kWh	6,00 Cent/kWh	6,16 Cent/kWh
Arithmetic Mean	6,25 Cent/kWh	5,97 Cent/kWh	6,16 Cent/kWh
Standard Deviation	0,69 Cent/kWh	0,58 Cent/kWh	0,67 Cent/kWh
Number of Companies	154	80	234

Table 26: Electricity Price: Annual Consumption < 10 GWh

Analysis	**Full-load hours < 4.500 h/a***	**Full-load hours > 4.500 h/a***	**Total**
Median	5,96 Cent/kWh	5,64 Cent/kWh	5,67 Cent/kWh
Arithmetic Mean	5,97 Cent/kWh	5,61 Cent/kWh	5,68 Cent/kWh
Standard Deviation	1,05 Cent/kWh	0,64 Cent/kWh	0,75 Cent/kWh
Number of Companies	21	83	104

Table 27: Electricity Price: Annual Consumption > 10 GWh

Analysis	**Full-load hours < 4.500 h/a***	**Full-load hours > 4.500 h/a***	**Total**
Median	6,19 Cent/kWh	5,83 Cent/kWh	6,00 Cent/kWh
Arithmetic Mean	6,22 Cent/kWh	5,79 Cent/kWh	6,01 Cent/kWh
Standard Deviation	0,74 Cent/kWh	0,63 Cent/kWh	0,72 Cent/kWh
Number of Companies	175	163	338

*Full-load hours: h/a Annual Consumption / Demand

Table 28: Electricity Price: Total

[100] http://www.e-control.at/de/industrie/strom/strompreis/industriestrompreise/energiepreis

Balancing Energy

Detailed data regarding the cost of balancing energy could not be obtained in interviews. Only the balance group "Ökostrom" publishes its balancing costs, so these figures were used for calculation.

Balancing Energy (BE)	Sum 2011		
	Austria total		
	MWh	**EUR**	**BE-Price €/MWh**
BE acquisition by Öko-BGR	343,241	23,171,781,01	67.51
BE export by Öko-BGR (negative algebraic sign)	-312,349	-8,296,030.79	28.58
Balance	30,892 MWh	14,245,750.23	

Table 29: Balancing Costs Öko-BG (2011)[101]

The table above shows that an average price of 67.51 € per MWh was paid by the Öko balancing group for balancing energy.

Industry investments

The importance of industry investments has been outlined above (see section 10.3.7). A quantification of these investments is not possible at this point since no sufficient data could be obtained in interviews.

Demand response potential

The basis for the calculation of the business model is the economic potential as evaluated in this research project. Focus on the consumer side was put on heavy industry in the two Austrian regions of Upper Austria and Styria. Large plants (selection criteria: > 250 employees) from energy-intensive industry branches were investigated. The industry branches of paper/cardboard/pulp, iron & steel, chemical industry and cement are showed particular interest in participating in demand response systems and offer significant potentials. Companies in the selected two provinces and the mentioned industry branches offer a potential of 156 MW of loads that can be shifted for DR purposes. It is important to emphasize that these 156 MW are the economic potential as evaluated in this research project, whereas the technical potential for all of Austria is in the range of 400 MW.[102]

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[101] http://www.oem-ag.at/oemag/statistik/ausgleichsenergie/2011_sum.jpg (accessed in November 2011)

[102] Christoph Gutschi, *Interdisziplinäre Beiträge zur Effizienzsteigerung im Energiesystem durch Energiespeicherung und Kraft-Wärme-Kopplung*, PhD Thesis, Graz 2007.

However, in order to evaluate this load in terms of consumption, the duration of switching in MWh has to be taken into account. This figure was arrived at by looking at each plant's potential and the possible duration of load shedding. This was then extrapolated to arrive at the figure of the duration of switching per year for all companies. This analysis resulted in a total amount of 8293 MWh of electricity that are available through DR at the companies investigated in the EDRC project.

Energy consumption by companies

The energy consumption by those companies that showed interest to participate in EDRC is another important indicator. This figure, which amounts to 1.930.000 MWh of electricity used per year (excluding energy generation by companies), is needed to calculate the price of electricity paid overall. It also helps to put the impact of DR solutions into perspective.

10.3.9 Revenue Schemes and Indicators

The following assumptions form the cornerstones of the calculation of the business model:

- The Öko balance group (Öko-BG) invests in EDRC in order to minimize their balancing costs.
- The DR potential that the Öko-BG can draw upon is 8293 MWh. It is assumed that this entire energy is used internally, i.e. to reduce the amount of balancing energy needed by this BG and therefore generating savings for the balancing group. The price paid for balancing energy is 67.61 Euro per MWh.
- By reducing the balancing groups' need for balancing energy through EDRC, the price paid for those 8293 MWh is no longer 67.61 Euro per MWh but the average price paid for electricity by industry, namely 57€. Therefore, the savings through EDRC consist of the difference between 67.61 € per MWh (balancing costs) and the regular energy price of 57€, i.e. 10.61€ per MWh.

The table below summarises the calculation:

	Amount	**Industry Price**	**Costs (normal)**	**Balancing Price**	**Costs (Balancing Energy)**	**Savings through DR**
	MWh	€ / MWh	€	€ / MWh	€	€
Electricity consumption	1.930.000	57	110.010.000			
DR potential	8.293	57	472.701	67,51	559.860	87.159

Table 30: Savings through EDRC

The third line of the table shows that a total amount of 1.93 million MWh were consumed by these companies and that they paid 110 million Euro for this energy.

Assuming that all of the 8,293 MWh of DR potential can be shifted from phases of high pricing (balancing energy – 67.51€ per MWh) into normal pricing (57€), the economic advantage of the DR system is 87.159€ per year.

It is assumed that every participating company has to invest 50,000 Euros in terms of storage facilities or other adaptations of production processes. Hence, these investments total 500,000 Euros which results in an annual amortization of 33,333 Euros (15 years).

Annual Costs	
Investments by companies (annual amortization 15 years)	33,333 €

Table 31: EDRC Annual Costs

Hence, the 87,159 € saved every year can only be achieved by annual investment costs of 33,333€, which means that the net savings come to 53,826€ per year.

Consequently, an indicative figure for the maximum annual cost of EDRC for this use case is 50,000€.

10.3.10 SWOT Analysis

Strengths of this business model lie, first of all, in the fact that the approach answers a need of balance groups brought about by the development of their market environment. The increase of renewable energy sources (RES) and resulting difficulties in forecasting electricity production make it desirable for BGRs to gain flexibility via demand response. Furthermore, this general trend is expected to increase in the years to come and shiftable loads in industry are one way of dealing with this. As mentioned, the past experience and general willingness of plant managers and companies' energy managers are favourable for the proposed EDRC solution.

In any case, EDRC requires integration into balance groups in one form or the other. The mode proposed here has several advantages. First of all, integrating EDRC into a balance group – as opposed to founding its own BG – means that market entry is facilitated to a great extent. Teaming up with a BG significant in size, gives EDRC instant credibility on the market and access to the respective BG's company portfolio. The BG, on the other hand, is able to gain access to the advanced IT infrastructure of EDRC, more flexibility regarding production/consumption of energy and through this is able to offer a more competitive package to customers.

This flexibility can be exploited in a variety of ways, such as on the tertiary reserve market, for internal purposes and potentially also on other electricity markets.

Despite the general willingness of industry to sign up to DR programs, a potential **weakness** lies in the needed effort to come to contractual arrangements with industry. This issue is not confined to this particular approach but inherent to all DR programs. This aspect needs to be addressed by dedicated marketing activities and by offering individually tailored solutions. Raising awareness was already achieved in this research project, thereby preparing the ground for market entry.

Opportunities of expansion are given against the backdrop of the increasing role of intermittent RES. While taking one BG as a starting point, the expansion to other BG might be feasible. Furthermore, the creation of an EDRC BG is a viable option.

Risks remain in the development of the electricity market and electricity prices as well as the question whether enough industrial companies will actually participate. The last mentioned aspect is not easy to ascertain from the “outside” since BG do not to disclose their customers due to reasons of confidentiality.

10.4 Business Case: Grid Stability/Peak Load Management

10.4.1 Smart Grid, Demand Response and Distributions System Operators

Network stability at the DSO level is increasingly challenged through the growing percentage of energy from renewable sources, such as wind and photovoltaic generation. This problem is of particular pertinence in Germany[103], but is also gaining momentum in Austria. Besides active reaction towards market signals, e.g. through variable tariffs, also the generation will have to increasingly react to market signals and network constraints.[104] Austrian DSOs across the board confirmed these findings and stated that the integration of RES is becoming more and more a challenging for them. Furthermore, certain Austrian regions in particular in the East of the country witness a rapid expansion of large scale wind farms.

However, a general challenge regarding EDRC in this context is the status of DSOs as "natural monopolies". Due to this, DSOs operate in a highly regulated framework which would have to be adapted in order to allow them to take an active role within DR systems.

DR can be an important tool for the integration of renewable energy sources. Issues of grid stability (regional) could be solved through DR technologies and possibly also some issue of transmission (losses) by enabling increased local sourcing.

When looking at EDRC in the context of DSOs and the proposed focus on large industry, a quick overview of network levels is important:

- Level 1 (380 kV, 220 kV)
- Level 2 (transformation from Level 2 to Level 3)
- Level 3 (110 kV)
- Level 4 (transformation from level 3 to level 5)
- Level 5 (1kV-36kV)
- Level 6 (transformation between Level 4 and Level 7)
- Level 7 (1kV and below)

Larger customers are usually connected to Level 3 or Level 4 and are only few in numbers. Every network is characterized by a dominance of small customers, although large customers can be significant in terms of electricity usage and therefore are important to network stability.

On the network side, TSOs are currently the main parties involved in DR activities in Europe and the role of DR at the level of DSOs is not entirely clear at the moment. Discussions

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[103] Bundesnetzagentur, *"Smart Grid" und "Smart Market". Eckpunkte der Bundesnetzagentur zu den Aspekten des sich verändernden Energieversorgungssytems,* Bonn, 2011.
[104] Ibid., 10.

mainly revolve around the topic of “Smart Grids”. Developments with regards to Smart Grids, e.g. smart meter rollouts at the household level, shall not be repeated in detail in this section but possible roles of DSOs in Smart Grid/DR architecture will be discussed and drivers and barriers expressed by Austrian DSOs analyzed.

Advantages of DR for DSOs within the Smart Grid include grid control and supervision, demand and generation forecast, outage management and grid optimization. Both new system services for planning (long term) and operation (short term) are expected to be benefits for DSOs. While planning of the grid development usually follows the estimated demand, the inclusion of DR could result in an optimized grid development that avoids “oversized, infrequently used distribution assets”[105] by including long-term demand flexibility. In order to make this possible, however, new arrangements between DSOs and suppliers/large customers would be necessary.

According to Eurelectric, these new agreements “will allow DSOs to optimize investments in distribution assets. As a result, demand flexibility will deliver firm capacity”.[106]

Eurelectric envisages that DSOs will act as market facilitators by keeping the role of ensuring the security, integrity and quality of supply while at the same time “enabling the offering of market products. When market products are not compatible with distribution grid security standards, new DSM system services will be required. Therefore, new agreements between DSOs and suppliers/large customers will allow DSOs to solve grid constraints through demand flexibility”.[107]

Since the liberalisation of the Austrian electricity market in 2002, the role of the DSO focuses on the transport of electricity according to existing contracts between generators and withdrawers, in return for regulated system charges. They have to “take any action necessary, under the prevailing technical circumstances, to maintain network stability. In particular, they must make long-term investments to maintain the operability of their networks.”[108]

Their tasks are:

- Conclude system access contracts with their customers.
- Deliver electricity to their customers.
- Meter consumption and attribute it to the balancing groups responsible for it.
- Transmit consumption data to the clearing and settlement agent.

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[105] Eurelectric. *Views on Demand-side Participation, Brussels, 2011*.
[106] Ibid.
[107] Ibid.
[108] Ibid.

Against this backdrop, the EDRC architecture and adaptations needed for DSOs were discussed with DSOs.

The interviewed DSOs included players from the two regions that are at the focus of this project, namely Upper Austria and Styria, as well as Burgenland, Vienna and Salzburg. The viewpoints from both rural and urban regions as well as industry-dominated and household dominated regions were captured in interviews.

10.4.2 Demand Response and Distribution System Operators in Austria

The idea of the electricity network as a “copper plate” that is able to transport electricity anywhere without any constraints is becoming increasingly challenged. According to the DSOs investigated, there are network reserves available in Austria at the moment, but the situation is expected to become increasingly problematic. For future applications, there is a consensus that DR system should address both network and markets and shift between the DR functions outlined in the table below. The Austrian National Technology Platform Smart Grids (NTP Smart Grids) suggests a “layer model”, where DR could be used for different purposes depending on the status of the network. Network states and their corresponding DR functionality are:

Network state	**DR Function**
Normal operation	Market-based energy services *Unlimited function of all market mechanisms*
Need for optimization	Market-based system services *Market-based optimization according to physical restraints*
Infringement of safety values	Services to ensure network operation *Temporal and local restrictions of market mechanisms*

Table 32: Network States and DR Function (NTP Smart Grids)[109]

Interest in DR systems on the side of Austrian DSOs is given but an implementation in the near future seems to be unlikely. The issue of balancing usage and production is perceived to become more relevant in five to ten years, and at the moment projects are in the research or pilot phase and usually focus on small prosumers rather than large industry.

However, the EDRC focus on large prosumers appeals to DSOs: they clearly see the advantage of switching a few large consumers rather than many small ones. As mentioned earlier, load management was a topic before the unbundling of integrated utilities. Load shedding in the 1990ies was less complex than it is going to be in the future since load curves are increasingly becoming more complicated due to stochastic production.

[109] NTP Austria, „Geschäftsmodelle im Smart Grid als Voraussetzung für eine erfolgreiche Marktüberleitung“. Presentation at the Smart Grids Week, Bregenz, 2012.

In a sense, load management is still done by DSOs but only through ripple control and mainly heat pumps are being switched (at night). Currently, these interruptible tariffs do not apply to industry. In critical situations customers are switched off via frequency dependent relays.

10.4.3 Drivers

One main argument for utilization of DR technologies for network purposes is the delay of infrastructure investments. While this is expected to become a very relevant topic in the future, currently no quantifiable information could be given by DSOs. For those networks that were looked at, no immediate bottlenecks that could be resolved through EDRC were identified. General optimization of network construction through DR is highly dependent on investment cycles.

While the issue of the transport of electricity over long distances poses challenges for transmission systems, at the local level the main challenge is the increased regional production, mainly on a small-scale level (e.g. household). DR could fulfil the function of network stabilization at different network levels.

For example, balancing voltage locally could happen either at local nodes or via industry, if more than one consumer/producer is connected to a node. In doing so, EDRC could be used for optimizing network utilization which would have large repercussions on the market model (see below). The issue of network utilization is already apparent at the level of medium voltage, where small hydropower plants cannot be utilized in the most efficient manner.

10.4.4 Barriers

As can be seen, there are numerous options for the utilization of DR for DSOs is thinkable. However, a variety of barriers have been identified make such a utilization of EDRC unlikely in the near future. In particular, current regulations do not allow DSOs to access EDRC services. In short, adaptations of the market model have to be take place because of DSOs status as “natural monopoly” acting in a regulated environment.

While switching of consumers takes place in emergency conditions, further activities are not feasible. Under the current regulation, contractual arrangement between DSO, EDRC, utilities and industry would have to be reached in order to make the DR system work. It is almost impossible for DSOs not to break rules under current conditions, be it market regulations or also data protection and laws regarding calibration.

DSOs could take on the role of flexibility operator in a Smart Grid infrastructure, but are most likely to do so whenever the system is in the red zone (see above). However, this would require a redesign of the market model.

Possible adaptations in the crucial relationship between DSOs and utilities are listed below:

Object of Agreement	Purpose	Responsible Actor	Service/Product Provider
Provide customers with information on energy consumption & related cost	Enhance customer awareness and their active role in electricity markets	Supplier	Supplier
Balance of demand/supply in the transmission grid	Optimize demand and supply to balance the grid	TSO	Balance responsible party
Balance of demand/ supply portfolio at balance responsible level	Optimize demand and supply to ensure global system flexibility	Balance responsible party	Supplier/large customer
Security congestion management (short-term)	Operate the grid within the security standards	DSO	Supplier/large customer
Firm capacity management (long-term)	DSO planning purposes; optimize demand and supply with a view to using assets most efficiently	DSO	Supplier/large customer
Voltage control	High quality of service	DSO	Supplier/large customer

Table 33: Examples of potential future agreements between suppliers and DSOs[110]

Two questions in particular need to be resolved. First of all, it is the question of who pays for the arising costs when DSO switches a customer. Through market regulation, it has to be clarified how and by whom these costs are covered. Secondly, the question of pricing network stability and coupling this with network tariffs needs to be addressed in future market designs.

[110] Eurelectric. *Views on Demand-side Participation,* Brussels, 2011.

11 Conclusions and Recommendations

The background of the EDRC project was to address current and future challenges of electricity systems – such as increasing consumption of power and the increasing share of distributed RES, underinvested ageing infrastructure with long lead times for new projects, environmental issues and global warming and public resistance against new projects (transmission lines, nuclear, coal, etc.) – through demand side actions. This part of the report focused on the possible architecture of such a system in Austria, taking all key players into account and focusing on large industry as participating prosumers.

A range of use cases for demand response in Austria are thinkable: the provision of tertiary reserve; balance group management (reduction of balancing costs/integration into balancing groups); grid stability/congestion management/peak load management; EDRC as a tool for utilities; integration of EDRC into energy management systems; emergency protection; trading on spot markets; cross-border exchange.

Analysis showed that the most promising of these cases are the "provision of tertiary balancing energy" and the "integration of EDRC into balancing groups". The issue of providing tertiary balancing energy was mainly investigated in the third part of this report by project partner APG. These three use cases cover the three main parties which could have interest in DR systems, namely balance group representatives, TSOs and DSOs.

The use case "integration of EDRC into balance groups" for the purpose of managing balancing energy (unscheduled power flows) and associated costs, is a promising prospect. Balance group representatives regard this to be an interesting option, not least because this would have a positive effect on electricity prices for customers. One challenge for balancing groups with a focus on green electricity could be the perceived industrial focus of EDRC.

An indicative figure for the maximum annual cost of EDRC for this use case is 50,000€. Interviewed balance group representatives stressed their need for fast responding power generation/curtailment, which will increase in the future and is likely to draw upon demand response solutions. Therefore, investing in DR solutions now would secure balance groups a first mover advantage with significant potential to expand DR activities into areas outside of large industry. Furthermore, DR and its potential to create attractive prices for large customers could be significant given the very competitive nature of this market. EDRC provides noteworthy marketing potential when used by the balance group/utility as part of its branding strategy. The potential of EDRC to shield businesses from underperformance, while at the same time guaranteeing performance to balance groups, provides significant benefits to these two stakeholders groups.

As regards the use case "grid stability/congestion management/peak load management" there are several issues yet to be solved. Currently, DR is not a high-priority topic for DSOs.

Some of the DSOs use ripple control in order to switch night storage heaters and also offer special network tariffs to this end. Historically, load management was employed for example in Styria, in order to release the load on certain critical power lines. All DSOs shared the view that the liberalisation of the electricity market had complicated the use DR in a DSO context.

However, a need for advanced DR solutions is likely to arise for localised DSO issues in the years to come and it is probable that this solution will cover both network and market aspects. DSOs estimated that a timeframe from 5 to 10 years is a likely for such a need and that DR "definitely makes sense in the long run", according to one DSO representative. At the moment though, the pressure is not big enough to look at the application of DR for DSOs and, most importantly, the current regulatory framework is a barrier to implementation. Economic incentives for DSOs are missing.

Regulatory rules and incentives are the only way to alter DSOs activities. Therefore, the new grid codes should be designed to facilitate new grid services such as DR and combined tariffs between utility and DSO may be a possible solution.

In terms of strategy, an expansion to other prosumers, marketing activities for raising awareness of balancing groups and efforts for the adoption of the regulatory environment seems advisable.

While the focus in this project was on very large consumers, an expansion to small and medium-size industrial consumers and commercial consumers, would be beneficial. In particular, it is large cold storage facilities that could be addressed as next steps.

In marketing DR to balancing groups/utilities, the focus should be put on the innovative approach of EDRC that allows the reduction of balancing costs and hence the design of more attractive pricing models. This unique selling proposition (USP) would allow balancing groups to attract customers in the very competitive market of large commercial and industrial consumers while contributing positively to the electricity system as a whole.

In the long run, the electricity market will have to adapt to changes taking place in terms of new energy sources and specific measures to also promote demand response. Currently, stakeholders perceive uncertainty/absence regarding demand response solutions in Austria. Clear regulations that facilitate the use of DR technologies seem to be necessary, which concern both pre-qualifications for the provision of reserves on the balancing market as will be illustrated below (PART 3), and finding new arrangements between utilities and DSOs that allow for monetary incentives to participate in DR systems. Network tariffs should be designed so that the development of DR systems and services is facilitated.

PART 3: DEMAND RESPONSE FROM THE TSO'S PERSPECTIVE (AUSTRIAN POWER GRID AG)

12 Control Reserve in Austria

12.1 Abstract

From a TSO point of view DSM DR could be used in the three following electricity market fields: procurement of control reserve, redispatch agreements and emergency delivery. The possibility to use pooled controllable loads exists also for the counter-trade concept. At the moment the most promising field is the use of DR in the balancing market - in a first step especially in the tertiary market due to the existence of capacity payment (EUR/MW) and very lucrative prices for the procurements. All market participants that fulfill the prequalification requirements are entitled to participate in the individual tenders. This would also include consumption sides as there is no difference between increase in generation and decrease in consumption as both cases result in a positive tertiary control reserve. The basic idea is to aggregate several individual units to a virtual power plant (VPP) and thus increase the potential significantly. This way would facilitate TSOs goal of ensuring more competition in order to avoid market power and at the same time potentially decrease the costs of procurement.

In the report different ways to integrate VPPs in the Austrian balance group model were analyzed. In a first step pooling within a balancing group has been analyzed. The liquidity and availability of units (power) could be increased by making a pooling of pools which are located in the different balancing groups. However, only limited ways of implementation seem feasible considering the current market rules. To facilitate DR integration still some obstacles need to be removed. The remaining main challenges on the way to implement the VPP concept are: monitoring issues, communication interfaces to ensure real-time measurement (data exchange) and estimation of a virtual base line of a consumer in question. Besides that, it is of crucial importance to sharpen the awareness of the potential participants that there is the possibility to DR beside their ordinary business.

12.2 Detailed overview

The current situation in the Austrian markets for load-frequency-control is summed up in Table 34.

Table 34: Characteristics of the Austrian markets for load-frequency control reserves

Ancillary Services	Procurement volume	timeframe	products	Prequalification
Primary control	+/- 76 MW	Weekly tender	Mon-Sun: base products	
Secondary control	+/- 200 MW	Weekly capacity tenders and daily energy tenders	Weekly / 4-weekly products. Mon-Fri: peak and off-peak, Sat-Sun: base	Energy to be available 5 minutes after request
Tertiary control	+ 100MW/ - 125 MW (+180 MW to cover outage of the biggest unit	Weekly capacity tenders (market maker) and daily energy tenders	Mon-Fri and Sat-Sun blocks of 4 hours	Energy to be available 10 minutes after telephone call

13 Possibility of Demand Side Management usage from a TSO perspective

From a TSO point of view DSM could be implemented in the following three fields of electricity market design:

- procurement of control reserve
- redispatch agreements
- emergency delivery

13.1 Procurement of control reserve

All market participants that fulfill the pre-qualification requirements are entitled to participate in the tenders for tertiary control reserve. This also includes consumption sides as there is no difference between increase in generation and decrease in consumption as both cases result in a positive tertiary control reserve. The prices of the market-maker tenders (reservation of unit capacity) are currently very lucrative and could be an incentive to participation of demand-side management. On the other side, the goal of a TSO is to ensure more competition in order to avoid market power and try to decrease the costs of procurement. Implementation within the concept of a tertiary control could be seen as the initial step of DSM integration, as it is the easiest way to move forward (requirements for the product and reaction time are not that restrictive in comparison to the other types of reserve – such as a secondary or primary control). After a successful implementation in the tertiary section, DSM could be extended to the secondary- energy market where the faster reaction times are expected.

13.2 Redispatch agreements

An additional possibility for the usage of demand-side management would be in cases when the network system security has to be guaranteed. In such a case, mainly due to the voltage problems or unforeseen contingencies (outage of power plants, transmission lines etc.), the secure system operation could be jeopardized. One of the most important measures to solve network congestions close to the real-time is redispatch. With the activation of those kinds of remedial actions the production (usually in the bigger generation units) is altered upwards or downwards. This change leads to the redistribution of power flows in the network and maintenance of the secure operation state of the entire system.

Controllable load-units could also be used for such a purpose. One important aspect which is to be considered is the dispersion of loads (usually connected in the different network nodes and also on different voltage levels) and lower level of efficiency when it comes to actual energy delivery.

Redispatch measures could be paid either in a market-based way (price for activation depends on the actual day-ahead/intraday price which is usually increased for some surcharge) or a contractual way (price has been calculated based on the marginal cost of the unit in question).

13.3 Emergency delivery

As the last resort measure to maintain the transmission network stability and system security (and avoid complete black-out), TSOs are allowed to start the emergency delivery contracts. One of those contracts is considered to be a so-called “load-shedding” agreement where system operators can disconnect a certain level of load from the network with the goal to stabilize the system frequency or local voltage. Demand-side could play also an important role here.

14 Tertiary control

In the subsequent paragraphs the preconditions for the participation in the tertiary control tenders, organized by APG, are separately explained by means of commercial and technical preconditions. Furthermore these technical requirements are divided in the three criterions: ramps, connection and monitoring.

14.1 Commercial preconditions for participations at MM-auction

The bidder has to confirm that the unit which is to be used for the delivery of tertiary energy belongs to one registered commercial balance group within the control area of APG.

The validity of the prequalification is limited to three years. All costs which are incurred during the prequalification process are to be covered by a bidder.

14.2 Technical preconditions for participation

14.2.1 Defection of the ramp function for the fulfilment of tertiary energy delivery

In the prequalification requirements it is requested that the total available tertiary control power (MW) in a bidder's pool has to be activated in the case of a need within **10 minutes**. The same is valid for the deactivation. It means that this dynamic has to be ensured by a bidder when making the decision about portfolio of units which are to be activated within the pool. The total activated tertiary control which is requested by the transmission system operator (TSO) is defined as the difference between the current set point of the pool (without request) and the new set point (10 minutes after request). The set point without request usually contains commercial schedules which are built upon the different long-term supply contracts (for the end-consumer) and "fine-tuning" on the day-ahead (power exchange) and intraday markets.

At the moment no mandatory ramp is stipulated, just a nominal ramp is defined. This fact makes it easy for a potential pool of many small units to be built as no too much effort has to be put into the generation of a special ramp. At the moment the energy resulting from up- as well as down-ramping is settled as balancing energy. From the TSO point of view, the ramp should be defined in such a way to avoid fast changes of generation and/or load units which happen at the same period of time (usually in quarter-hour or full hour periods for the settlement of schedules). Therefore, some kind of linear ramp could be introduced in the schedule for tertiary control activation which has to be followed by the balancing group in question. On the other side, such a ramp could be regarded as discriminatory as the speed of the set point change depends on the unit which provides tertiary energy (e.g. gradient is sharper for the hydro power plants in comparison with thermal units).

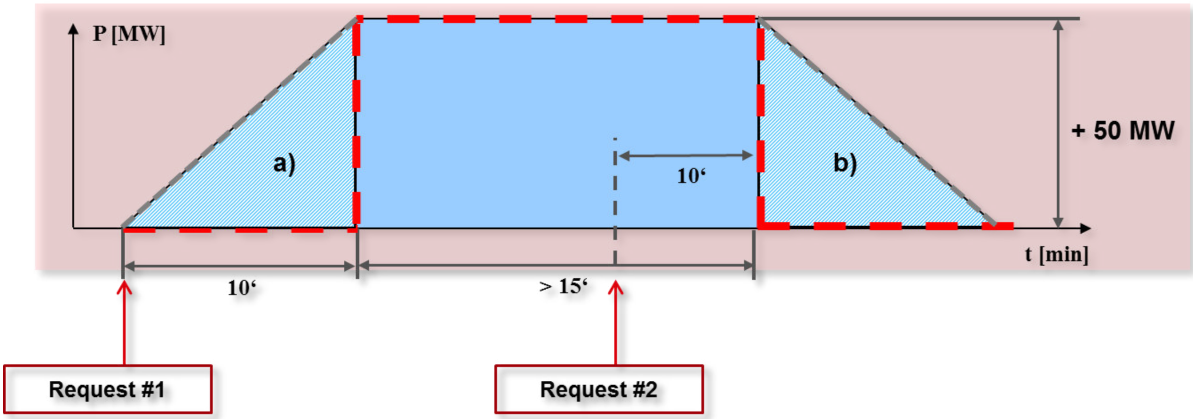

Figure 21: Scheduling of tertiary control requests

Besides that, the minimal activation time is 15 minutes while the maximal activation could last up to four hours. If a bidder was awarded also for the next tendering product (the following four hours), it could happen that this delivery could be prolonged, i.e. could last more than four hours. The bidder is also informed 10 minutes before the start of deactivation.

The information about the request of energy activation/deactivation is given to a bidder by phone. In the future it is foreseen to introduce a fully-automated MOT (merit-order-tool) where the activation and deactivation signals will be send electronically. Those will contain the information about the requested power (MW) as well as the latest point of time (H+10’) when the working point of a unit (or pool of the units) has to reach the requested value (new set point).

14.2.2 Connection of the different units in the pool (“light-technical solution”)

The bidder has to provide information (connecting grid operator; metering point) about the network connection for the energy production and/or consumption. The connecting TSO defines the specification for the data exchange. Costs which will occur due to the implementation (and/or modification) of such interfaces are to be borne by a bidder in question.

Exchange of online real-time measurements between a technical unit (or a central connection point of a bidder) and connecting TSO has to be performed via standardized IEC protocol. It is also necessary to ensure the availability of the data communication channel to a bidder also for the time periods when his bids are not awarded. In such a case the transmission of zero values is foreseen.

14.2.3 Monitoring of the energy delivery and data exchange

For a bidder pool the following data sets are requested by the connecting-TSO:

a) Static data sets for a technical unit: nominal power, maximal power, minimal power, maximal value of the ramp rate (defined as the fastest possible change of power increase/decrease). All those values are to be transferred only once to the TSO. The values have to be adapted accordingly by the bidder in case of technical unit parameters change;

b) Online values of the pool in the time resolution of at least 1 minute: real-time production/consumption, set point, activated tertiary control.

The data for the individual participating units for 15-minute periods are to be archived by the bidder, at least for the period of 6 months, and to be sent to the connecting-TSO on request.

The online measurements have to be transferred continuously with time stamp. The resolution of the values has to be from 2sec to maximum 1 minute. It is also necessary to set the thresholds on such a way that the data transfer occurs by 1% change of measurement band (but at least by 1 MW change). It has to be ensured that, with the real-time data transfer from technical units and/or pools of units, any possibility for the misuse of the concept is avoided.

15 Analysis of Integration of DSM within the Balance Group Model

The implementation of DSM in the Austrian Balancing Group (ABG) model could take place in different ways. Below the implementation of three potential models has been analyzed.

It must be emphasized that the following presents an integration into the balance group system that focuses on the provision of tertiary reserve and is therefore different from the model presented in PART 2 of this report, where the focus was on the internal management of the balance group.

15.1 Model 1: Pooling of units within one Balance Group

The concept of units pooling which are located in one Balancing Group is already foreseen in the technical prequalification document. In this sense, the Pool (or Bidder Pool) is defined as the group of technical units which are used for the delivery of Tertiary control and organized inside only one Balancing Group in the control area of APG. The units which are aggregated on such a way have to prove requested dynamical aspects of prequalification (ramp rates). The entire concept of units' coordination inside the Pool has to be provided to TSO, based on his request.

15.2 Model 2: Pooling of units between different Balance Groups (with a special Balance Group of a bidder)

The most sophisticated way of the demand-side management pool integration within BG model is one where the supplier, which takes part at market-maker (MM) tenders, **needs** to establish a separate Balancing Group covering (some of) the above mentioned pools. This newly established Balancing Group acts as a quasi-virtual-pool aggregator. Its main task is, based on the optimization process, to provide the aggregated bids to TSO (bids of the Virtual Pool). Those bids could be created with the combination of the different technical units (located in the different balancing groups) and are based on the actual availability of those units during the certain time period as well as their price of activation.

For example, at the diagram shown below, TSO activates, via the MM-Bidder, 3 pools which are commercially situated in the 3 different balancing groups.

As the energy delivery actually occurs over the MM-Bidder BG, the following commercial schedules shall be created by the MM-Bidder:

- BG1> MM-Bidder: 10 MW
- BG2> MM-Bidder: 60 MW
- BG3> MM-Bidder: 30 MW
- MM-Bidder>APG TRL: 100 MW

BG1 shall need to pay the costs for the deviation in case the energy is not delivered (for example in pool 1). The balancing group of the bidder (MM-Bidder) could be seen as the typical trading (transit) group, as it commercially “receives” the energy and “forwards” the same amount to TSO.

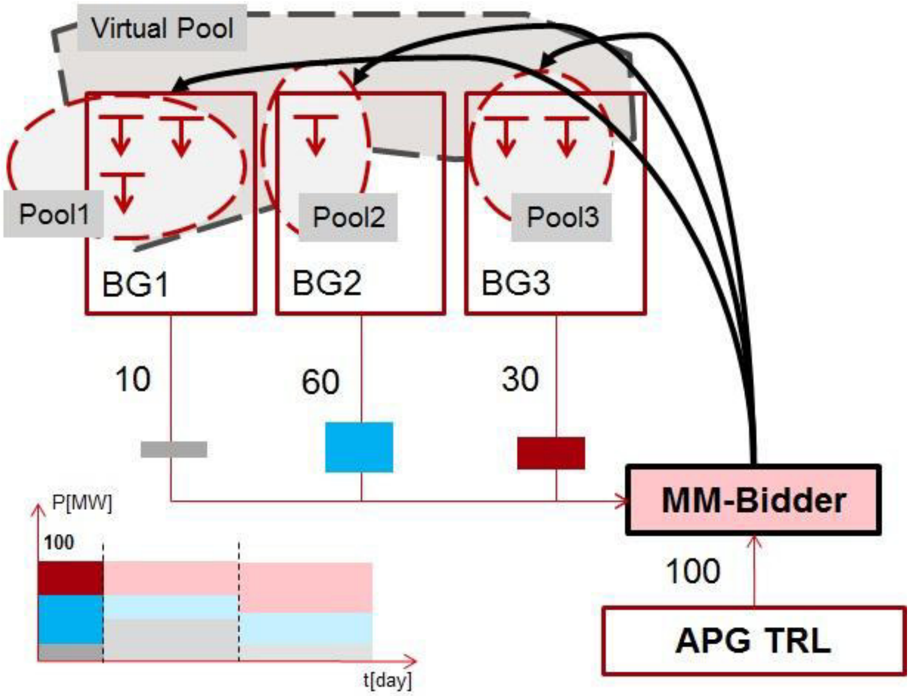

Figure 22: Pooling of units between different Balance Groups

This concept is currently not implemented and requires additional changes of the prequalification procedure as well as the analysis when it comes to the data sets which are to be transferred from units/pools towards the TSO.

15.3 Model 3: Pooling of units between different Balance Groups (without a special Balance Group of a bidder)

The solution which has been also discussed for the implementation is the one without the necessity to establish the special ("transit") Balancing Group of the bidder (MM-Bidder). In such a case, TSO would need to receive the exact information about the activation of every single unit within the pool (quasi merit-order of a virtual pool). It would also be necessary to know in which balancing group this unit is commercially located. This model has not been analyzed into details due to following disadvantages:

- complexity (more aggregators with the different set of units in the control area);
- low-level of transparency;
- non-legal entity towards TSO (as there is no need to establish a special "MM-Bidder" BG).

The last point could be seen as an advantage for the aggregator as he does not need to set up a separate Balance Group, but needs to be the contact person towards the TSO.

This concept is currently not implemented and requires an additional feasibility analysis.

16 Overview of the experience in the other countries

16.1 Spain: Red Electrica

Red Electrica actively uses DSM, but at the moment the focus is primarily on interruptibility services and industrial demand management. Besides the fact that these services are based on bilateral agreements (no in a market based way) these are provided by individual large industry. Thus they don’t really fit in the DSM concept of EDRC where the core idea lies in the aggregation of several small units.

16.2 Slovakia: SEPS

In Slovakia there is a possibility to procure the tertiary control (over tenders) also from the consumers’ side. The price of the reservation is limited and approved by Regulator on the yearly basis. Currently there are two bigger units (connected to the 110KV and 220kV level) which provide this type of reserve (called ZNO/ZVO for the upward/downward regulation).

16.3 Czech Republic: CEPS

Demand-side management is actively used by the Czech Transmission System Operator (CEPS) since 2005. The special product has been designed for such a purpose (called ZZ30 - „load change within 30 minutes“). In order to sign the contract (no tender) with CEPS, the units have to fulfill certain technical preconditions (ramps: load change of at least 10MW in the 30’ interval). In a case of non-compliance with the request sent by CEPS, penalties are foreseen (10% lower payment per non-activation). Due to the low-activation and interest of the market, there will be no contract ZZ30 foreseen for 2013 onward.

17 Conclusions and challenges from the TSO's perspective

From a TSO point of view DSM DR could be used in the three following electricity market fields:

- procurement of control reserve,
- redispatch agreements and
- emergency delivery.

The possibility to use pooled controllable loads exists also for the counter-trade concept. At the moment the most promising field is the use of DR in the balancing market. In a first step DR could be implemented especially in the tertiary market due to the existence of capacity payment (EUR/MW) and very lucrative prices for the procurements. All market participants that fulfill the prequalification requirements are entitled to participate in the individual tenders. This would also include consumption sides as there is no difference between increase in generation and decrease in consumption as both cases result in a positive tertiary control reserve. The basic idea is to aggregate several individual units to a virtual power plant (VPP) and thus increase the potential significantly. This way would facilitate TSOs goal of ensuring more competition in order to avoid market power and at the same time potentially decrease the costs of procurement.

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19 Annex I: Meetings with international experts

19.1 Minutes of the meeting with REE

Venue: Vienna, Austria
Date: 27.06.2012

Participants:
REE: Andres Sainz Arroyo
APG: Florian Pink

Findings:
Main focus of DSM in Spain is on the interruptibility service and industrial demand management.

- interruptibility service: is a demand management tool which gives a rapid and efficient response to the needs of the electricity system in emergency situations. It consists on reducing the active power demanded to a required residual power level (firm power level), in response to a power reduction order issued by Red Eléctrica de España, as system operator, to consumers subscribed to this service.
- Industrial demand management:
  - REE enable a higher flexibility of the demand through the management of 10 % of the national demand.
  - Flexibility power that REE can interrupt on critical moments (between 2.000 and 2.500 MW)
  - Load shape adaptation
  - Shift of the demand from the system peak to the system off-peak
  - 155 providers of the interruptibility service provide flexibility and load shape adaptation to the system in critic moments.

19.2 Minutes of the meeting with SEPS

Venue: Bratislava, Slovakia
Date: 26.09.2012

Participants:
CEPS: Andrej Pukac, Jaroslav Martincek, Peter Rihak
APG: Milan Vukasovic

Findings:

- Generators > 50 MW must be able to provide the ancillary services; For the consumers it is voluntary;
- For the consumers there is the specially designed product (called ZNO/ZVO for the upward/downward regulation): 30' after call to respond with the full requested power;
- Product is defined in the grid code: minimum power 5 MW/maximal power 50 MW;
- Consumer RTU has to be remotely connected to the dispatching control system according to SEPS standards;
- Power must be remotely activated/deactivated with the dispatching control;
- Prequalification test must be performed by so-called certification test;
- Certificate is valid 25 months – it is issued by certification authority and approved by SEPS;
- Currently two big industrial consumers are prequalified (both independent BGs);
- They provide tertiary control to SEPS for many years;
- No small consumers or households;
- Based on the estimation by SEPS, the biggest part of the requested power is provided on the yearly level (tender in September); smaller parts are procured on the monthly level; daily level: fine-tuning
- Price for procurement – constrained and approved by Regulator;

19.3 Minutes of the meeting with CEPS

Venue: Prague, Czech Republic
Date: 30.08.2012

Participants:
CEPS: Jaroslav Kaspar; Vclav Tomasek; Richard Kabele
APG: Milan Vukasovic

Findings:

- DSM at ČEPS since 2005:
  - study showing the potential >100MW available within one hour after activation request;
- Mainly large-scale industry (cement works, paper mills, mines,…)
- Definition of special reserve (ZZ30 – „load change within 30 minutes“)
- Prerequisites for providing of ZZ30:
  - Proof of ability to change load at lest of 10MW until 30 min – according to the NC in CZ
  - Operational planning in D-1 – schedule needs to be sent (more unit base than portfolio based)
  - Online communication (measurement, activation signals): everything is fully automatized; CEPS sends signal for the activation;
- No tendering, contract (price) is the same for all providers
- Operational usability is low (2 hours / day, high energy prices, low reliability) – 3 consumers are prequalified only 1 performs correctly;
- In case of non-compliance with the request, penalties are foreseen (10% lower payment per non-activation);
- Since 2009 newly organized balancing market (energy only); the market is similar to ID internal market; only that CEPS acts as a single buyer;
- No contracts ZZ30 foreseen for 2013 onward

For APG the central questions to implement Demand Response in Austria are:

- What are the requirements, from TSO point of view, for any potential participant who provides Demand Response (DR) services?
- How can they been integrated in the current market structure, especially taking into account the currently applied commercial Balancing Group (BG) structure within Austria?

FINAL REPORT

EDRC –

European Demand Response Center

Univ.-Prof. Mag. Dipl.-Ing. Dr. techn. Heinz Stigler

Institute of Electricity Economics and Energy Innovation
Graz University of Technology

DI Daniel Hütter

DI Andreas Schüppel

Dr. Christoph Gutschi

Dr. Christoph Huber

NEUE ENERGIEN 2020

PART 4: Potential allocation and simulation of possible impacts in Austria (Graz University of Technology)

PART 4: Potential allocation and simulation of possible impacts in Austria (Graz University of Technology)

1 Demand-Side Management Basics

There are two different methods for Demand-Side Management (DSM). One method being the reduction of consumer-sided load, the other being a short term unscheduled increase in generation. It is also possible to increase the amount of delivered energy.

The purpose of unplanned load management is to maintain system stability, which can be refunded by the grid operators, or to gain profits for the company applying this DSM method. To achieve such an overall load shift a company can either interfere with the operational process flow, if no penalties result from the loss of production, or by shifting process independent loads. Both measures will, if used correctly, increase the system stability and furthermore increase the total efficiency of the system (e.g. by reducing the needed balancing energy). The methods for load shifting described are shown in Figure 1.

Figure 1: Possibilities for consumer load management

Depending on size and branch of an industrial company several options to save money through the use of DSM-methods occur. Beside the financial gains for the company, using DSM will affect the overall security level of supply and may even lead to a decrease in energy prices. Lower energy prices can be the result of DSM if it is used appropriately, meaning if a company can shift its load from times of peak load to off-peak-times. Lower energy prices can be passed down to all end consumers which leads to lower production costs for the company itself and therefore strengthens the position of an industrial company.

1.1 Positive and negative aspects of DSM

Advantages of a reaction of consumers to critical or unpredictable situations in the electricity system:

- **Fast and uncomplicated:** Certain industrial load shifts are prepared for specific assignments and can therefore react very fast if needed. The most important requirement is the existence of an appropriate contract with the DSM supplying company.

- **Reduced capacity demand from power plants:** Through the use of DSM investments in transmission lines or energy-producing-facilities can be postponed. Additionally the use of existing power plants can be more efficient. The entire electricity system needs to be able to handle the annual peak load (in addition to certain reserves). This annual peak load can be reduced through DSM which aside from reducing the demand for the entire electricity system also leads to a homogenisation of the load curve. This result in a more efficient use of power plants (compare Figure 2).
- **Low costs:** The electricity sector has very high costs when it comes to the construction of new infrastructure. The implementation of DSM on the other hand can be rather cheap and has under normal conditions rather short payback-periods.
- **Higher efficiency and environmentally friendly:** The use of DSM leads to generally more efficient electricity system. This results in a reduced demand in primary energy carriers. The more efficient use of energy-producing facilities leads to a reduction of emissions and therefore has a positive impact on the environment.

Possible disadvantages of a consumer reaction to an unpredictable situation in the electricity system:

- **DSM may send wrong price signals:** Through the re-dispatching of demand and production and the simultaneously occurring shift of the resulting cost to the network tariffs (costs for DSM are rolled off on the network tariffs) the information of congestion is lost for the free market. This may even result in wrong congestion-signals for the market because congestions won't be detected under certain circumstances. The implementation of DSM can therefore result in negative effects on certain congestion-situations.
- **No long-term solution for capacity problems:** DSM may provide short term solutions for problems in energy-production or energy transportation but cannot replace long term development of net or power plant development strategies.

2 Possible designs for Demand Side Management

The following applications for DSM-measures in the transmission grid of continental Europe can be identified:

- Balancing energy market
- Peak load reduction, especially if energy production capacity is secured
- Avoidance of peak prices for energy consumption
- Minimization of balancing energy costs in a balance group
- Removal of predictable network congestions
- Emergency measure for securing the system stability in exceptional situations

2.1 Balancing energy market

The three different balancing energy markets in Austria, primary-, secondary- and tertiary-reserve, are open to every participant of the electricity-economy since 2012. The tertiary-reserve market is especially attractive for DSM due to its relatively long lead time. One of the things which need to be discussed is the "form" of the supplied power, which should have a ramp-like shape. Table 1 shows the current conditions in Austria's balancing energy market.

Table 1: Overview over the balancing energy markets in Austria (Austrian Power Grid AG, 2011c)

Balancing energy market	Contract volume	Duration of offer	Possible products	Prequalification
Primary	± 76MW	Weekly (minimum size 1MW)	Weekly Monday to Sunday	(Austrian Power Grid AG, 2011a)
Secondary	± 200MW	Weekly from 2012	Week/4 week Products separated into peak and off-peak as well as weekdays and weekends	(Austrian Power Grid AG, 2011b)
Minute (Tertiary)	+100MW/-125MW additionally 180MW to prevent the shutdown of the largest generation unit	Weekly (Market Maker) as well as daily for the next day	Market Maker: Weekdays or weekends in blocks of 4 h (power- and energy payment) Daily (only energy payment)	(APCS, 2004) is no prequalification constraint at all

2.2 Peak load reduction

The most important use of DSM is to reduce load in peak load times (see Figure 2). These few peak hours in a year create a demand for supply reserve, leading to high specific fixed costs. For example, the costs for a combined cycle gas power plant with an installed capacity of 400 MW are approximately 280 mio. €. These costs need to be compared to the costs of shifting certain load-intensive processes (e.g. grinding process in a cement plant) from peak load times to off-peak times. Since peak load hours make up only a small proportion of a year, this shift should be rather uncritical for the company, depending on their process structure. The building material industry qualifies very well for peak load reduction as the demand in building material is significantly higher during summer times whereas the peak load hours mainly occur during winter.

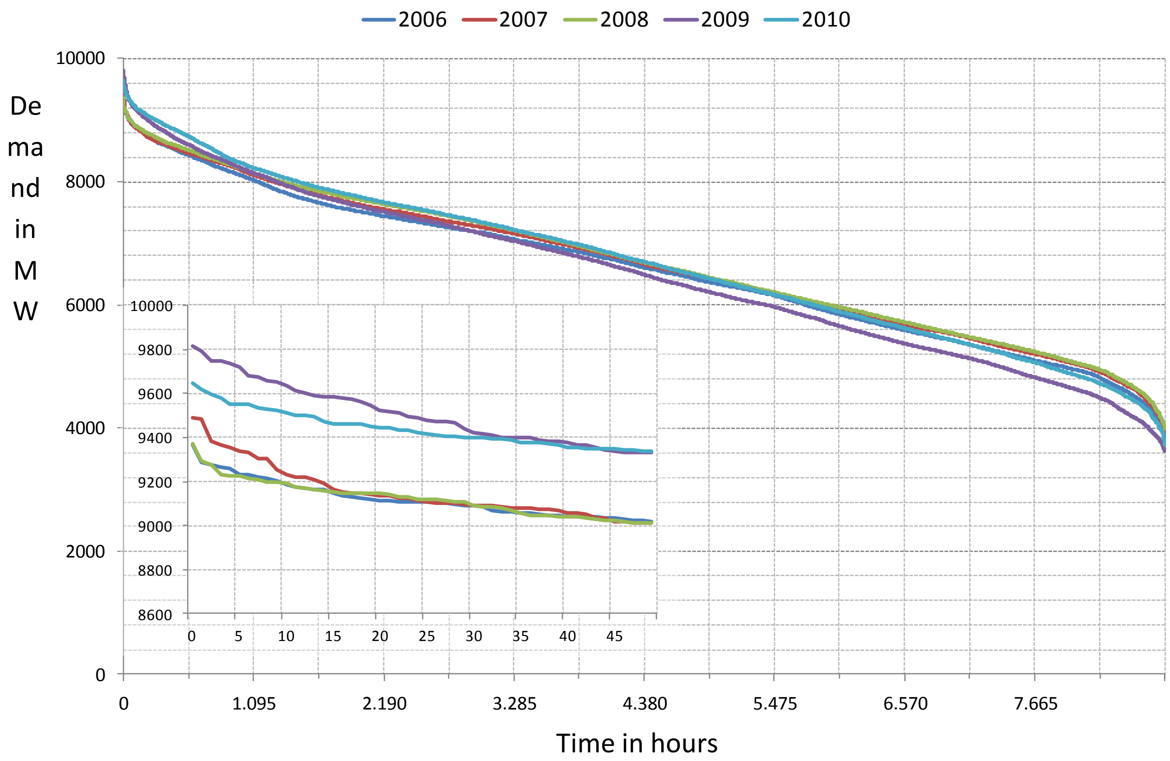


Figure 2: Demand curves for the years 2006 to 2010 (source ENTSO-E)

2.2.1 Current peak load situation in Austria

Figure 2 shows the consumer's electricity demand in Austria for the years 2006 to 2010. It is obvious that for a limited period of the year the demanded power is very high, a more detailed perspective is provided in the enlarged part of the diagram. For the year 2009 there is a demand increase for the 40 highest peak load hours of approx. 449 MW. These 40 hours are distributed over 12 days. In general there is to see an absolute peak of 500 to 600 MW for about 20 days in a year from 2006 to 2010. This circumstance promotes the use of DSM for the reduction of peak load. Figure 3 shows the distribution of the 88 hours with the highest load situation in a year. Figure 4 and Table 2 show at which hours of the day those peaks occur.

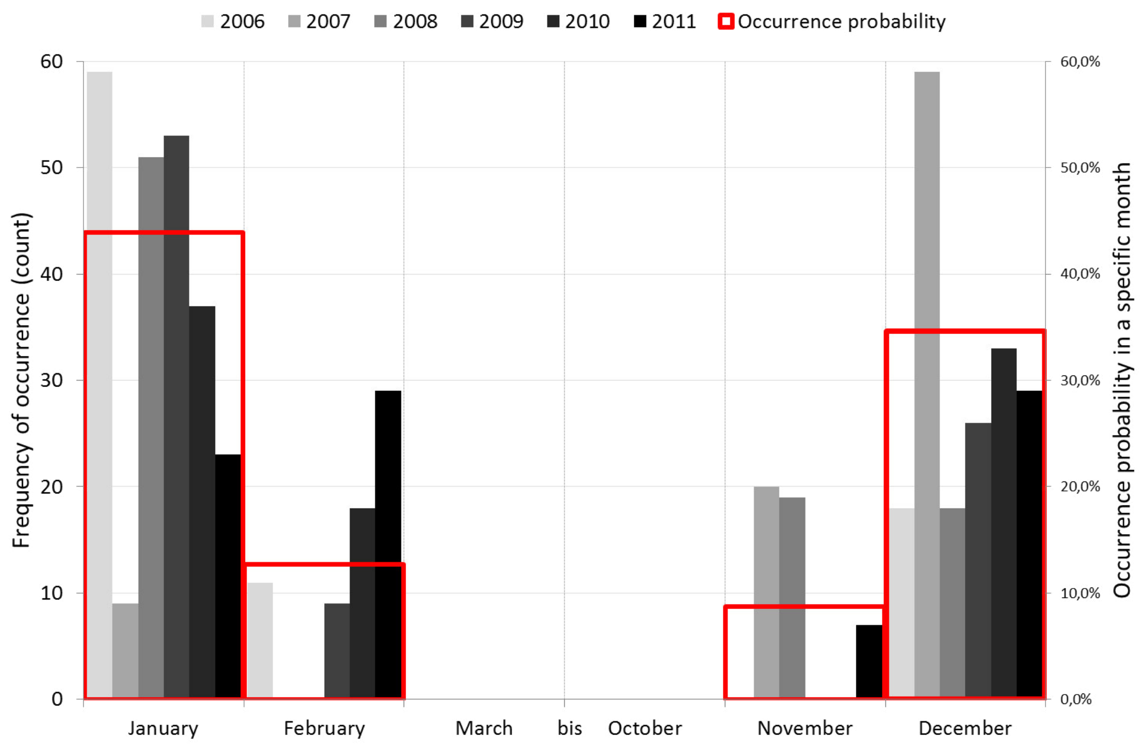


Figure 3: Peak load situation in Austria from 2006 to 2010 monthly categorisation (data source: ENTSO-E)

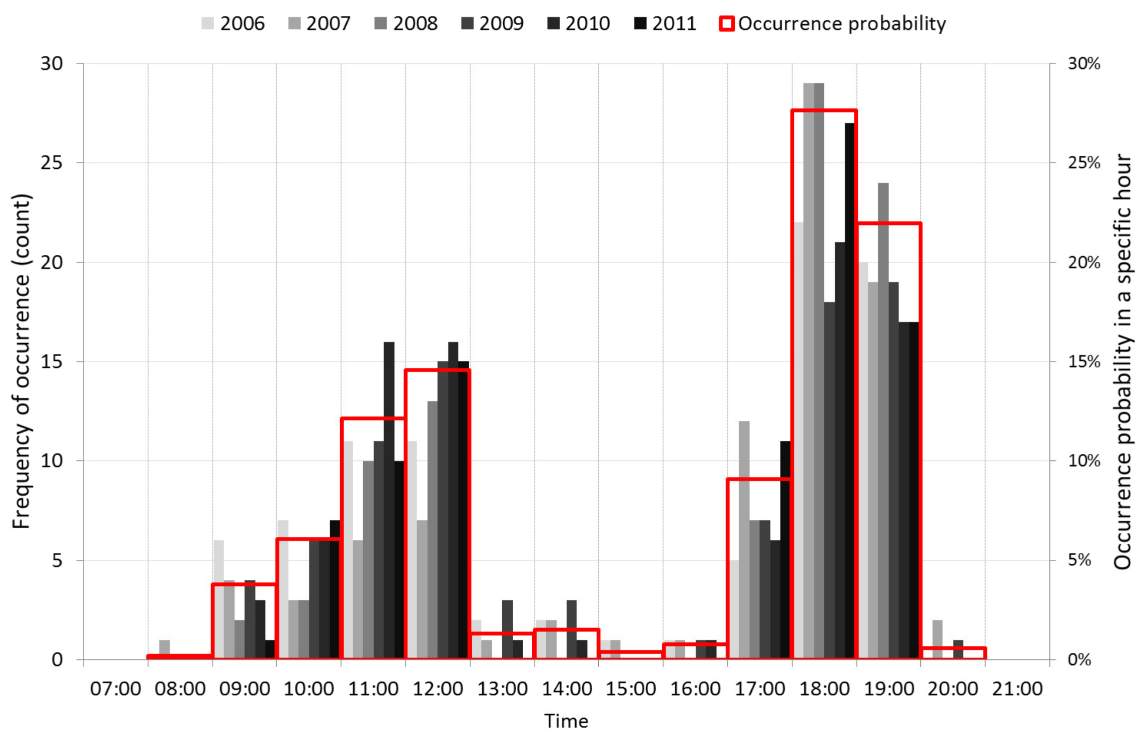


Figure 4: Peak load situation in Austria from 2006 to 2010 hourly categorisation (data source: ENTSO-E)

Table 2: Overview over the possibility of peak load occurrence categorised after months as well as hours (red frame in the diagrams above)

Month	Possibility	Time	Possibility	Time	Possibility
January	47%	7	0%	14	2%
February	9%	8	0%	15	0%
March	0%	9	4%	16	1%
October	0%	10	6%	17	8%
November	9%	11	12%	18	27%
December	35%	12	14%	19	23%
		13	2%	20	1%

2.3 Avoiding price peaks for energy demand

On the continental European energy market very high peak prices can occur in extreme situations. During the winter months with a high demand and a reduced production from hydro-power plants, relatively high energy prices may result during peak hours. This is a problem for load intensive companies, because their electricity bill matches the hourly market price. As a result, it can be useful for certain big companies to reduce their load during peak times. The decision to reduce load depends on the opportunity costs for the reduced production as a result of the load reduction. These costs depend on a variety of factors. For example, the loss of production capacity can become extremely expensive if it results in a delay of delivery leading to high penalties. In certain industries a reduction of load isn't possible due to the nature of the production process, which would lead to high opportunistic costs, as would be the case in the NE-metal producing industry. An entirely different situation is given when you look at the Stone- und Earth-industry as well as paper-, iron- or metal producing industry. Ideally certain production steps can be shifted from peak times into off-peak times, especially those steps which produce a commodity which can be stored for later usage (see chapter 3.2). Through that method high peaks in energy prices should be avoided. In addition, if the company owns a generator, unused energy can be sold on the market. This is also true for back-up generators.

Over the last years the promotion of fluctuating renewable energy producers (e.g. wind- or solar power) on the Austrian and German energy market has led to situations where the price for energy drops drastically or the renewable energy didn't find a buyer on the market. These situations lead to an interesting new possibility for the use of DSM. The drop in energy-prices enables companies with the possibility for DSM to shift their production into these times so they can produce a storable commodity at very low prices.

2.4 Reduction of balancing energy

Another possibility for DSM is the reduction of balancing energy demand in a balancing group. The "Ökostrombilanzgruppe", a balancing group responsible for the fluctuating renewable energy production, isn't exactly predictable when it comes to production. This unpredictability often leads to a certain demand of balancing energy, which is paid by all customers. The balancing energy needed could be reduced by the coordinated reduction of demanded power from the companies in the EDSL-program, resulting in a cost reduction for everyone. On the other hand during times of predicted green-power production commodities can be produced at low prices. Additionally through building a pool of industrial electricity consumers, the short peak in balancing energy demand can be absorbed to a certain degree by the use of DSM.

2.5 Grid congestions and emergency situations in the grid

Often the saturation of the demand is not an issue when it comes to generation capacity, but the problem is the transportation of the energy. A method to avoid grid congestions is redispatch, where the power plant schedule according to the market is altered, leading to a less cost efficient use of power plants. This method leads to new costs, so called redispatch-costs. These can be minimized through the use of DSM if it is possible to avoid congestions through the use of DSM and the companies capable of providing DSM for redispatch-purposes are taken into consideration. Another grid situation which could be prevented by the use of DSM is the danger of a blackout. A blackout can occur if the sum of the actual generation can’t saturate the actual demand or an infeasible net situation occurs. This results in a frequency drop throughout the entire grid. If the situation of a frequency drop occurs, the control mechanism described above (primary control reserve …) are activated. If those mechanisms can’t provide enough power or fail otherwise the frequency drops even further until the point is reached where electrical machines go off the grid to prevent damage to themselves. Resulting in a breakdown of the electricity system, a so called black out. In such extreme situations contracted companies can drop their load to prevent black outs and therefore provide additional safety to the entire grid, or at least bigger parts of the grid.

3 Versions of DSM-measures

As shown in Figure 1, there are different possibilities how an industrial company can implement DSM. It is necessary to mention that the most important requirement is that the DSM-measure won't affect the output of the entire production cycle.

3.1 Temporal load shifting

The most common and easiest method for load shifting is ripple control. But since this is no inner-industrial method it won't be discussed any further at this point. Next to ripple control the voluntary load dropping of customers is a method of direct load reduction. The chronological activation of DSM-measures is a method to counter grid congestions even though these measures can under certain circumstances result in extremely high costs for the company.

Most industrial companies don't show significant consumption peaks but rather flat day/night-consumption-characteristics. This means, that a load shift can only be interpreted as a delay in production. This can be seen a possibility for the company if the current order situation is bad. In some rare occasions the gain through selling the commodity can be less than not producing it and selling the saved energy.

The potential for DSM is especially high in energy-intensive industry branches. Industry branches qualify for load shifting due to their structure. In comparison to small customers or business-customers, industrial customers have a higher total consumption separated amongst many switchable machines which can be used for load shifts. A detailed analysis of the production schedule needs to be made in order to evaluate the DSM-potential of a certain company. In some companies machinery with a very high specific demand can be found such as electric arc furnaces, which can be switched off for a short period of time. Taking energy service storage into account the potentials for DSM can be raised even further in certain companies. Other methods of reducing or shifting loads is to change the production plans, which is only possible for companies not working on 3/3 shifts, as well as the temporary shutdown of the entire production. The two methods discussed are to be seen as very expensive due to the loss in creation of value. Additionally technical issues, such as start-up and shut-down times of machinery have to be taken into consideration when investigating the use of DSM. The potential and willingness to participate in short term production disruption is likely to be higher in companies with a currently bad order situation.

3.2 Energy service storage

A cheap and easy method for consumer sided load management in industrial companies is using energy service storages. These will be explained on basis of some examples. Excluding production processes such as electric arc furnaces, electrical energy is rarely directly used. In most cases it is used for a service, the so called "energy service". Electricity is used to create services by either transforming it into another form of energy (such as cooling, creating air pressure, lighting) or in production processes where a certain good or material is brought from one form to another (for example grinding, reforming, shredding and so on). The newly created commodity can then be used by a follow up process. As example, breaking up rocks can be the energy service in a quarry, the resulting crushed rocks can be stored for further use. The storage itself functions as energy service storage. Another example would be a refiner, which is used in the paper industry for creating wood fibre out of wood chips. The demanded energy for this process depends on the quality of the fibre, but can range from 1 to 2 kWh per kilogram of fibre, which makes this process very energy intensive. The power-demand of such a refiner can sum up to several MW. As it was the case for creating crushed rocks, the fibre can be stored for later use.

Through the possibility of storing energy services, energy consumption can be decoupled from the time the commodity itself is needed. Instead of storing electrical energy the energy service is stored. Such storages are common in certain industries because different parts of the production cycle need different times for production of the corresponding good. Almost all production chains have a limiting link, which slows down the whole process, as can be seen in Figure 5. This is often the case because this part is described by extremely high investment costs in comparison to the rest of the production chain. While the limiting part of the process is permanently running, other parts of the production are temporarily on halt due to overcapacity (Gutschi & Stigler, 2006).

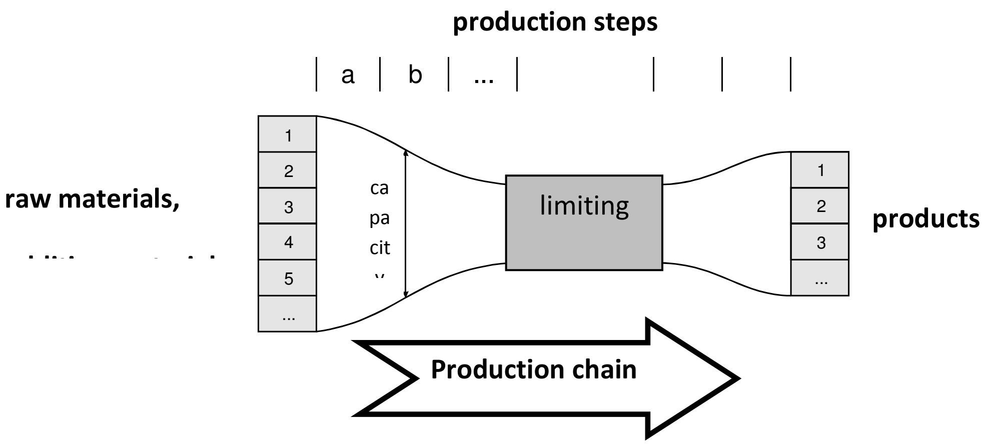


Figure 5: Symbolic representation of different production capacities in a production chain (Gutschi & Stigler, 2006)

In most cases storages are installed throughout the production process to prevent a shutdown of the entire process cycle from a malfunctioning machine. For example, it is necessary to keep a rotary kiln running continuously whereas the parts of the process before and after the kiln can store their corresponding products. Through the efficient use of the commodity storages as energy service storages load shifts can be achieved, resulting in a reduced peak load. As a result we see an organisational method to prevent peak loads. It has to be said at this point, that companies will only participate if there is a certain financial benefit resulting from their actions.

3.2.1 Circumstances promoting or demoting energy service storages

If peak load management can be achieved through energy service storages depends on many different factors, which mainly influenced by the branch of the company. But there are also company-specific conditions, such as configuration of the equipment or the organisational configuration of the company as well as the economy, spatial and social environment. See (Gutschi & Stigler, 2006).

Positive effects on DSM through energy service storages:

- Storable products or semi-finished goods
- Possibilities of storing goods during the production process at reasonable costs
- Partial overcapacities in the production cycle or low capacity utilisation of certain parts of the production equipment
- Possibilities of short term production disruption
- Little or no production during weekends or night time
- Production of commodities with little time pressure or innovation pressure
- Order situation below average

Negative effects:

- Production process organized to demand only base load
- Coupled products which result of originally storable products, which will be used in latter products with low efficiency
- Good order situation due to good economic situation
- Environmental restrictions like noise protection
- Collective contracts which prohibit a transition to flexible working hours
- Branches where costs for electricity demand make up only a small proportion of the entire costs
- Goods with high deadline pressure
- Perishable goods like food or pharmacy-products
- Materials which need instant processing
- A lack of general knowledge of how to change production processes

3.3 Increase of production from customer generation

The opposite way of managing load is by increasing customer generation. This can be done by increasing the power of the generation to its maximum at those times when there is no need to have the generator run at full capacity. Such situations may occur during times of high peaks because at these times the prices are high enough for this method to pay off.

3.4 Activation of backup generators

Backup generators function as safety-equipment in manufacturing companies or in hospitals, where a disruption of the power supply simply isn't acceptable. As for manufacturing companies, examples would be the automobile production, electronics or the chemical industry. Additionally cement production needs undisrupted power supply for its rotary kiln as long as it is hot If power supply would fail the kiln would deform due to the heat and high mass. This would then lead to massive costs. This capacity of backup generators can be used if they can be activated from outside the company. Considering the fuels needed to operate these generators there should be no boundary to the use of backup generators. Another benefit arises from using backup generators for power supply, if the generator is needed in the company itself, it is already running so the start-up time is reduced to zero. Additionally through the constant use of the backup generator the overall efficiency rises and the owner constantly receives information about the current condition of the generator. Considering these facts, the backup generator will get more economic.

3.5 Controlling the use of DSM-Measures through comparison of scheduled load and actual demand

According to the law a schedule is the precise information about the timetable of demand and production, meaning that the average load value for generation and demand will be built for each period of measurement. A balancing group on the other hand is a virtual fusion of customers and suppliers to a group where there needs to be a balance between generation and consumption.

All members of the balancing group need to tell their schedule for either demand or generation between one to thirty days before the actual generation or demand do occur to their corresponding head of the balancing group. If there are short term deviations, changes to the schedule can be made on basis of quarter hours. The schedules for every balancing group will then be given to a balancing group coordinator, which has to give the information on basis of a quarter of an hour to the control zone manager if demanded. Who can then use this information gathered to ensure system stability. If a deviation occurs, balancing energy will be required, and if there is a contract with a company regulating the use of DSM, the control zone manager can verify if the contracted company participated according to their contract.

4 Potentials for customer sided load management in Austria's industry

There are different reasons qualifying industrial companies for DSM measures. On the one hand equipment with a high consumption could be switched off or the time of their use shifted, on the other hand customer generation or backup generator could be used.

4.1 Technical potentials in the industry

Especially equipment or companies showing a high peak load qualify for DSM. Table 3 shows some industrial sectors which qualify for DSM thus having a high potential. A high consumption alone does not necessarily mean that peak load management can be applied. So each company has to be tested, considering the individual situation, in order to evaluate the potential for DSM.

Table 3: Processes and equipment with high power input in different branches

Branch	Equipment with high demand	Barriers
Oil and chemistry	Electrolysis, electro-chemistry, condensers, pumps, stirrers, blowers, cooling aggregates, air liquefiers, stationary engines	
Rubber and plastics	Industrial furnaces, condensers, pumps, stirrers	
Paper and fibre	Machines for pulp wood and paper, pumps, condensers, blowers, backup generators, hocks	Partially long start-up times
Iron and steel	Steel-mills, electric arc furnace, curing oven, annealing furnace, induction hardening, pan furnace	
Agriculture and forestry	Stationary engines, blowers, engines work on discontinuous basis, IR-heating lamps	DSM effective only in case of large concerns; spoilable goods
Non-iron metals	Electro-chemistry, electric furnaces, thermal treatment furnaces, induction hardening, steel-mills	
Trade	Ovens, cold store, air-conditioning	Low power, spoilable goods
Gastronomy and hotel business	Air-conditioning, lighting, canteen kitchen, cold stores, washing machine	Spoilable goods, energy service is part of the product
Ironware	Induction hardening, electrically heated ovens for temperature treatment, steel-mills, engines for mechanical treatment, galvanisation	
Stone and earth	Industrial ovens, breaker mills, mills, grinders, mixers, micro strainers, blowers , drivetrains for rotary kilns	
Food	Pumps, condensers, stirrers, cooling, washers	Spoilable goods
fabrics	Stationary engines, dryers	

Wood treatment	saws, compactors, blowers, dryers	
Vehicle construction	Industrial ovens, backup generators, pressurised air	
Engineering	Stock removing machinery, presses, steel-mills, laser cutters	
Infrastructure and supply	pumps, condensers	
electronics	Air-conditioning	Sensitive production equipment
mining	Breaker mills, steel mills, micro-strainers, (percolating water-)pumps, blowers, charging of electric vehicles	
Lumber mills, composite panel industry	presses, wood chip machinery, saws, blowers	
Glass and ceramics	Electro ovens, backup generators	Glass melt must not cool down
Foundry	Electro ovens, steel-mills	Delays in heating must be short (30 min)
Meat market	Cold stores	Spoilable goods
Paper processing, print and graphics	Printing press	High deadline pressure, low power
Milk products	cooling	Spoilable goods
bakery	Electrically heated ovens, cooling	Spoilable goods, deadline pressure
Construction industry	mixer	Concrete must be processed quickly
clothing	Washers, dryers, looms, electric irons	Low power
mills	Crushing mill	
households	Night-storage heater, domestic hot water tank, heat pump	

Not all the companies or industrial sectors qualify equally for DSM measures. Table 3 should only give a good overview over the numerous possibilities.

The potential of some promising industrial consumers and branches will be described in the following subchapters. Other further information is given by BRIMATECH. Notice that only some examples of promising industries are shown. To get an overview about the potential in a specific company you have to identify the process flow in detail. Therefore we have no figures of the potential, but qualitative analyses of possible machines or processes. The following points are based on (Gutschi C. , 2007).

4.1.1 Potential of cement industry

The cement industry does have one of the most promising potentials for DSM. The best fitting application for the cement industry may be the peak load reduction. The production of cement needs, depending on the quality, lots of electrical energy but some steps of the process can be stored easily. Figure 6 shows a typical process flow in the cement industry. As can be seen the limiting process is the around the clinker production. The steps before and after that can store their products. The main problem in the cement industry is that most of the production sites do have very small stocks. There was no need to store semi-finished goods when the production sites where plant. Now it's not as cheap to install stock as if it would have been plant under construction. But an analysis of TU Graz (Gutschi & Stigler, 2006) led to the result that specific costs for building storages in the cement industry is cheaper than building a new plant. The calculation does have some boundaries which can be read in the paper. The only constraint which has to be proven for each industrial site is if the grinding capacities are enough to produce in stock.

The high potential of the cement industry got early identified by Yorkshire Electricity (1996). In cooperation with 13 cement sites 110 MW negative capacities got collected which was used for frequency control. This shows the potential of the cement industry and its possible fast response to a call for reducing their demand (Hull) (IEA).

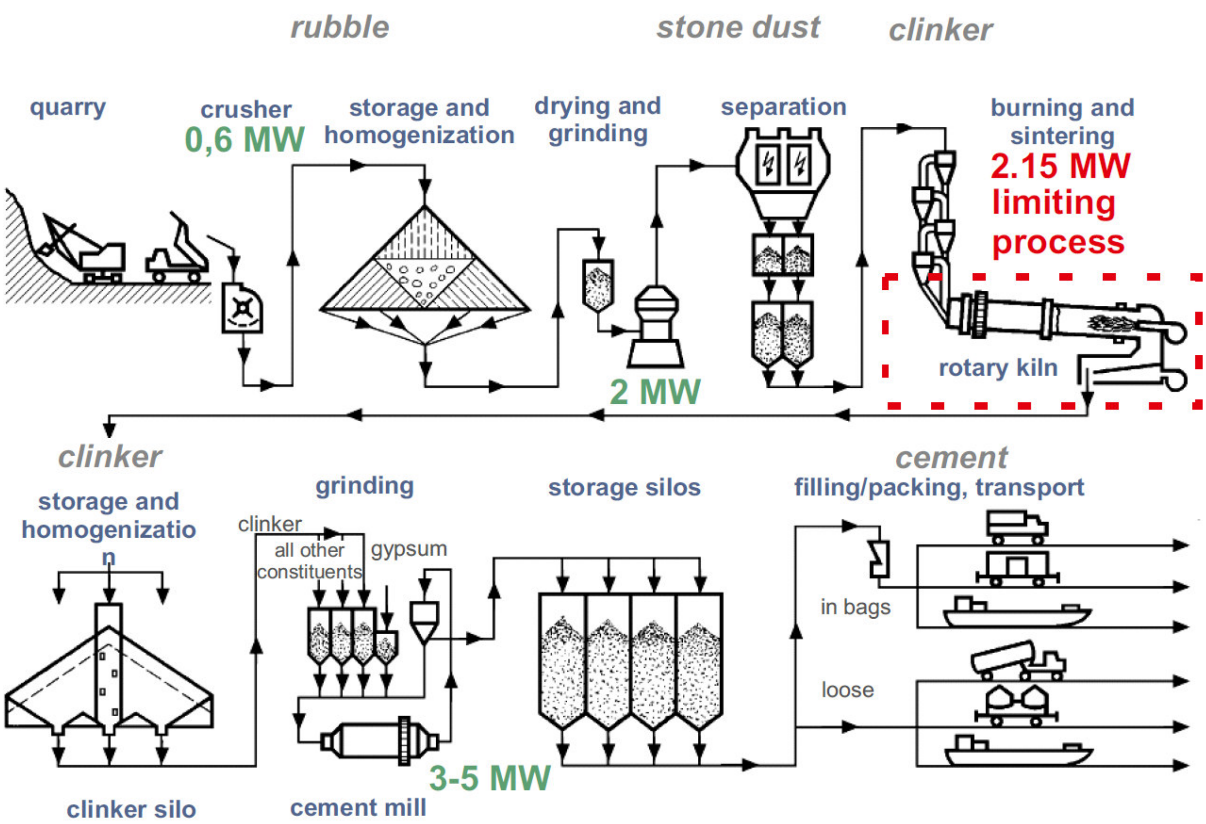


Figure 6: Basic process chain in the cement industry (source: based on (VDZ- Verband deutscher Zementwerke, 2005))

4.1.2 Potential of paper industry

Another promising industry is paper and pulp cause of the big machines which are used there. In Austria about 500,000 t of paper is produced per year. This production leads to an energy demand of about 600-700 GWh and a capacity peak of 90-100 MW. A high amount of the needed electrical energy gets generated in directly at the industrial site by power-heat cogeneration. Wood grinder and refiner do have the highest potential in the paper industry. A typical wood grinder does have demand of 3-5 MW. This was confirmed in our interviews as well. One industrial site does have about five of these wood grinders. Refiner does have a demand of about 15 MW. These energy intensive machines bring much better results in producing wood fibres than chemical solutions, but also need more energy. The wood fibres already get stored cause if there is a problem with the refiner or wood grinder the production of paper can't stop. Therefor a storage is installed which could be used for DSM. The storage of those fibres is limited to about 24 h. If they get stored for a longer time, there is a loss in quality and the paper may don't get white (Gutschi & Stigler, 2006). The time where those fibres could be taken out of the storage is far long enough for all possible applications of DSM.

4.1.3 Potential of stones and earth industry

As can be seen from Figure 7, the stone and earth industry counts to the most energy intensive branches in Austria. Another positive effect for DSM in this branch is that there are some big machines which can produce more than instantly is needed for production. The overproduction can be stored in a hopper so that the limiting process runs all the time. The smaller the stone pieces are which are produced, the higher is the need for energy and capacity to get it. Especially the cement and chalk production are energy intensive. The most Mills and breaker mills do need the most power in the stone and earth industry. But also separator, sieves, band-conveyors and blowers need lots of energy. These are normally machines without much electronic parts, so they can switch on and off easily nearly without preparation time. Energy costs are a major part of the production costs in this branch. Therefor the application as peak load reduction, where the energy price is high, could be the best fitting application for the stone and earth industry. In the winter period there often less need for stones and earth, so the capacities can be shifted in this time of the year where prices are high. That the capacity isn't used to capacity can also be seen in Gutschi (Gutschi C. , 2007). Over the whole year the energy consume of stones and earth industry is the opposite of the general demand. There we have peaks in summer and less demand in winter. This is because of the building sector, which is weaker in the winter period. With little costs storage silos can be build which can help to save a lot of money for the company and help to keep the electricity system save and cheap for all consumers. In some cases not even a storage building is needed. Products can be stored simply on ground, so that space is the only thing needed. The bigger the product the easier the storage, because small parts shouldn't stick together. The demand in this sector isn't as high as for example in the paper industry, but reasonable for DSM measures.

4.1.4 Further possible potentials

The easiest way to get potentials in the industry is to look where due to historical reasons overcapacities are installed. Even if the process steps with installed storages have not a great potential itself, the aggregate of lots of such processes can have an effect. The main aim of EDRC project is to find potentials of different ranges and combine them to one sellable product. In some cases also the installation of storages in an effective process chain can help to reduce the energy costs by an amount which justifies the storage. New industrial sites normally are optimized to have a great number of use hours, where DSM makes not as much sense as by existing equipment.

4.1.4.1 Chemical industry

There are several possible processes in chemical industry that could fit for DSM. For example the Chlorine-Alkali-Electrolysis has a high potential because of the energy intensity of the process and the ability for fast response to a call. There are three different methods of Chlorine-Alkali-Electrolysis and all of them are energy intensive. There is not the greatest potential in Austria, but in Europe several sites could help to keep the system safe by delivering control energy. Another possible application is the production of Calciumcarbit.

4.1.4.2 Iron and steel

In iron and steel industry the most energy intensive applications are electric ovens especially arc furnaces. The electric power of arc furnaces is about 30 to 40 MW. These devices can be switched on and off easily with respect to downstream processes. By shifting maintenance there is a high potential to switch these ovens within the week. A constraint in this case is that the oven is not needed all the time, so the capacity is not used 100 % of time. If this is given, the production loss is higher than possible earnings with DSM.

Even electrolysis processes due to producing non-iron metals like copper and zinc and galvanic processes do have a significant potential for DSM. As already mentioned the industrial site should be visited in such cases to find out how much potential is available for what range of time.

4.1.4.3 Production of technical gases

The element breakdown of air in its main parts azote, oxygen and argon is energy intensive. The first step is to clean the air from contaminant like dust or carbon dioxide. The cleaned air is set under high pressure of about 200 bar and gets cooled down to -193°C before it gets rectified. After that the elements are stored as a fluid in tanks. These tanks could be used as storage and would be a good chance to use DSM. Big sites do have a need for power of about 10-15 MW, which means they have enough potential for industrial DSM.

4.1.4.4 Compressed-air system

Many industrial processes need compressed-air. This process can cause up to 25 % of the energy use of a company. Normally a compressor puts air in a vessel and by putting more and more in the air gets compressed. Normally these vessels are oversized so the compressor only works 50 % of the time. If the companies are able to charge the vessel in times of low load and use the stored air in peak load times it would be an easy way for DSM. You can get a reduction of the energy costs and help that the system does not need as much power plant in peak hours. Another positive effect of this is that the operating cycles decrease which may leads to longer lifetimes of devices. Another possible application is to use these compressors for control energy because of the fast response and the normally big variation time. So if there is an intelligent control system, compressed-air systems could be used for positive and negative control energy with really low response times.

4.1.4.5 Cold air storage

The use of air conditions in large scale and also in small scale for domestic use can be seen as a potential for DSM. If cold air is produced in a large effective industrial site and stored there. The cold air can be transported in pipes like heat in winter. The storage gets his load in off-peak hours and gives it to industrial or domestic users when they need it. Even in large companies where the air condition needs more than 1 MW power the potential can be seen as high enough.

These are just some of much possible potential for DSM in industry. Every big industrial site has to be visited and individual decisions for DSM measures have to be done.

4.2 Overview over the potential in different branches

A high demand in electricity of a branch or energy-intensive processes is a hint that DSM measures can be applied well. It is to be expected, that the effects are stronger in larger companies in comparison to smaller companies.

The highest incentive for customer load management can be found in branches where the costs for demand of electricity make up a big part of the entire production costs. This can be described by the proportion of electricity demand to gross value added or production value.

Figure 7 shows the electricity demand for each unit of gross value added[1] for most economic branches in Austria. Due to the financial crisis, leading to non-representative results, the year 2007 (one year prior to the crisis) was picked as it shows the unadulterated conditions in the industrial sector. The figure shows the typical electricity-intensive branches such as mineral-oil processing, paper and card board, iron and steel, mining, stones and earth as well as chemistry, as those industries are the ones with the highest specific use of electrical energy. After the branches energy-supply/district heating-supply, which can't be used for load management, the branches glass, ceramics and cement as well as rubber and plastics, are those branches where potential for customer load management exists. Additionally DSM can be of use in connection with energy service storages, in some not so energy intensive branches, but in this case the branch itself needs to be properly investigated.

[1] According to Statistik Austria, the gross value added is a measurement for the economic output of a company or a branch and includes the sales revenues incl. subventions not including intermediate inputs, taxes and dues

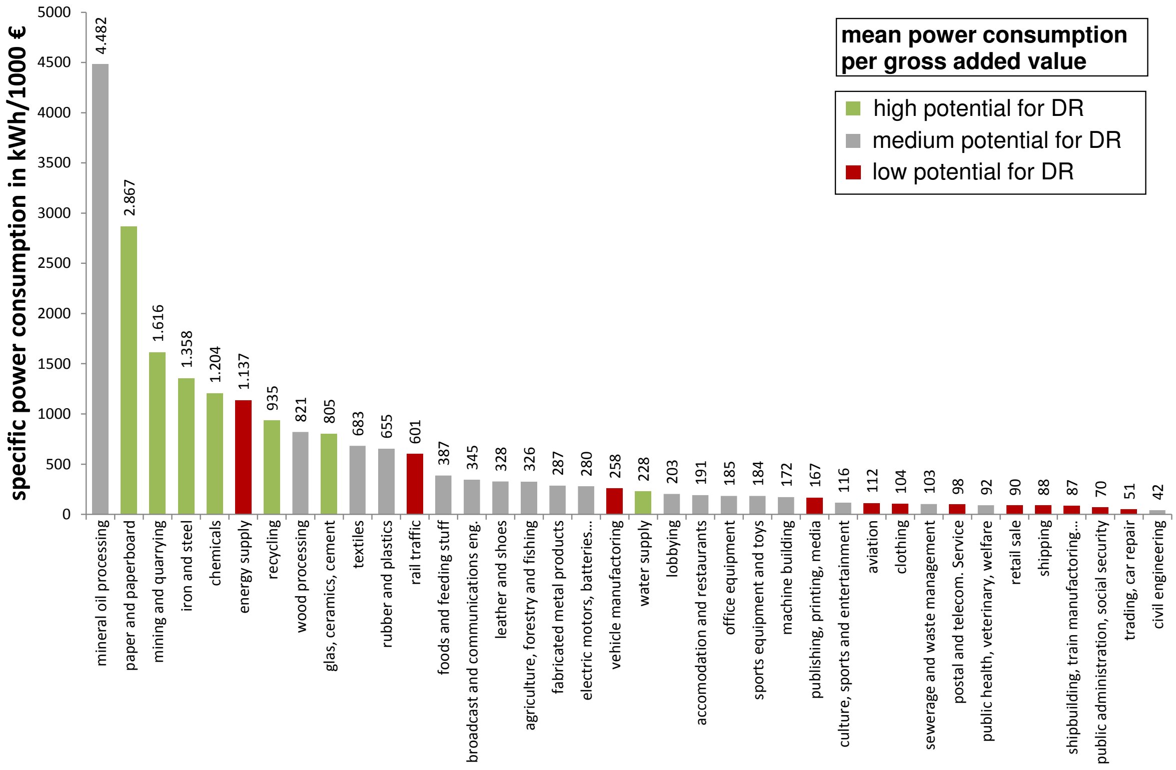


Figure 7: Estimation of the electricity intensity of Austria's economic branches in relation to their gross value added for the year 2007, numbers on basis of data from Statistik Austria

To analyse the efficiency of energy service storage the value added in a company as well as the intermediate inputs need to be considered, summing up to the gross production value[2]. To investigate the aspect of tied capital, Figure 8 shows the average specific electricity demand as a quotient of the used electrical energy and the production value for most economic branches in Austria. This figure confirms which was said about using energy service storages.

In regard to energy service storages the following branches are of high importance:

- Paper and card board
- Mining, stones and earth
- Iron and steel
- Chemistry
- Glass, ceramic and cement

[2] According to Statistik Austria the production value can be calculated on basis of the sales revenues, the activated internal labour, the acquisition of for resale intended goods or services as well as under consideration of the supply change of done and undone products an commodities as well as services which are intended to be resold.

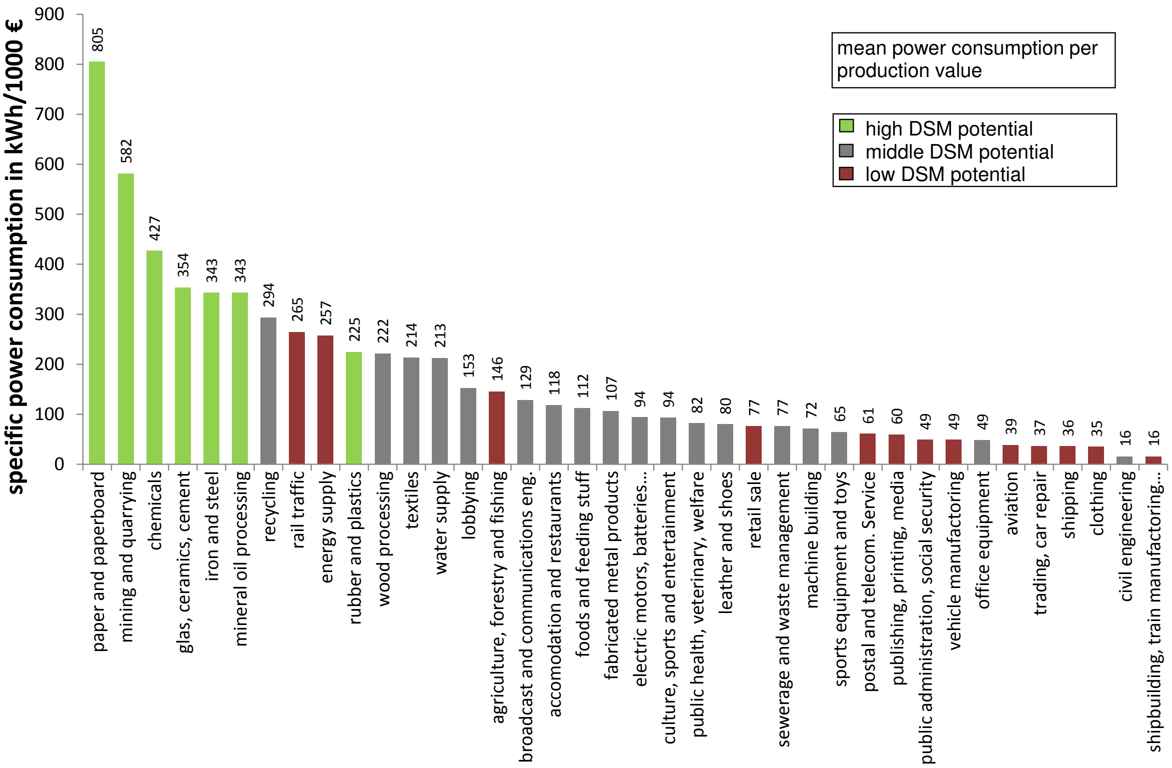


Figure 8: Estimation of the electricity intensity of Austria's economic branches in relation to their gross production value for the year 2007, numbers on basis of data from Statistik Austria

Chapters 4.3 and 4.4 show those Styrian and Upper-Austrian companies with the most relevant DSM-potential. These provinces were chosen by the project manager, Mr. Korsitzke (cybergrid). Due to the fact that many energy intensive industries from many different branches reside in these two provinces the potential for all of Austria can be derived from the results. Another factor for choosing only two provinces was that for this study only a limited amount of time was provided.

From Figure 9 the potential for DSM per sector allocated from interviews and up scaling. Because of less knowledge and interviews the sector stones and earth has a little potential, but we predict that if DSM measures get more popular, the potential in this sector will be far higher.

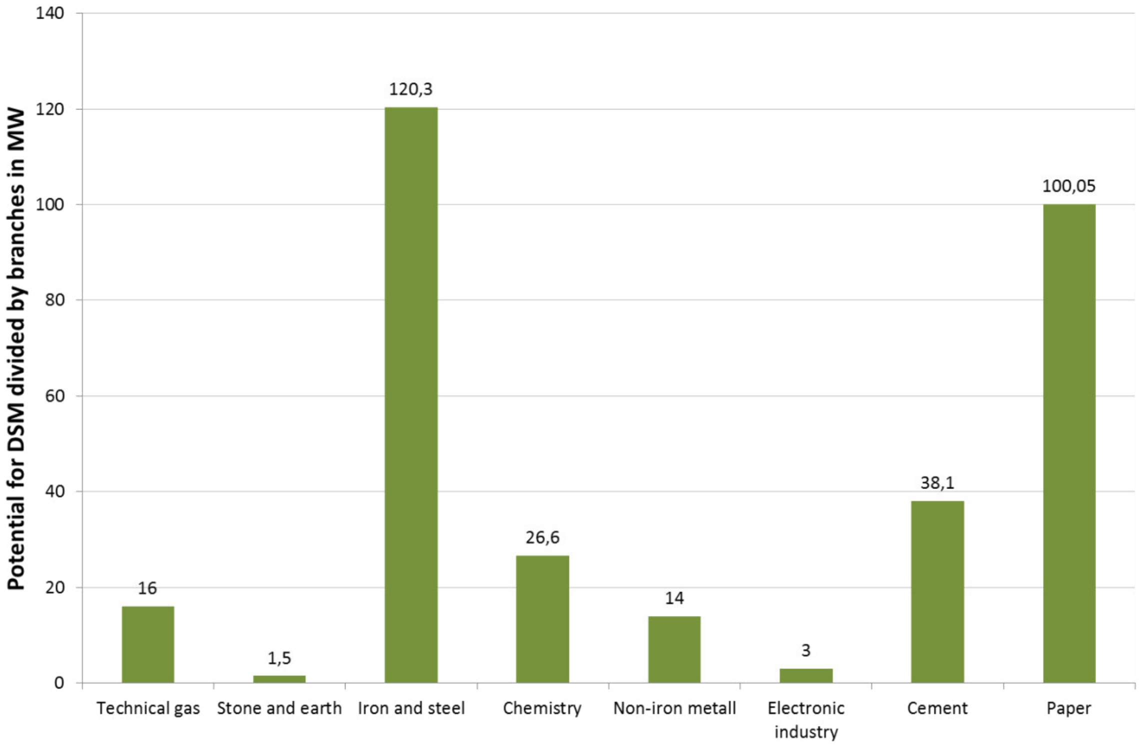


Figure 9: Overview of the potential distribution to different branches. Data combined from interviews and up scaling.

4.3 Relevant Companies in Styria

Styria itself has always been an industrial-region. Especially the region of Upper-Styria has a high amount of heavy industry. With approximately 1400 companies this region accounts for as much as 15 billion Euros. This sums up to 37% of the gross domestic product of this region and to about 18 % of Austria's total industrial production (2006). Figure 10 shows the 68 biggest Styrian industrial companies categorised by branch.

The most energy-intensive branches in Styria are:

- Paper industry
- Metal production and processing
- Stones and earth
- Cement industry
- Engineering and vehicle construction

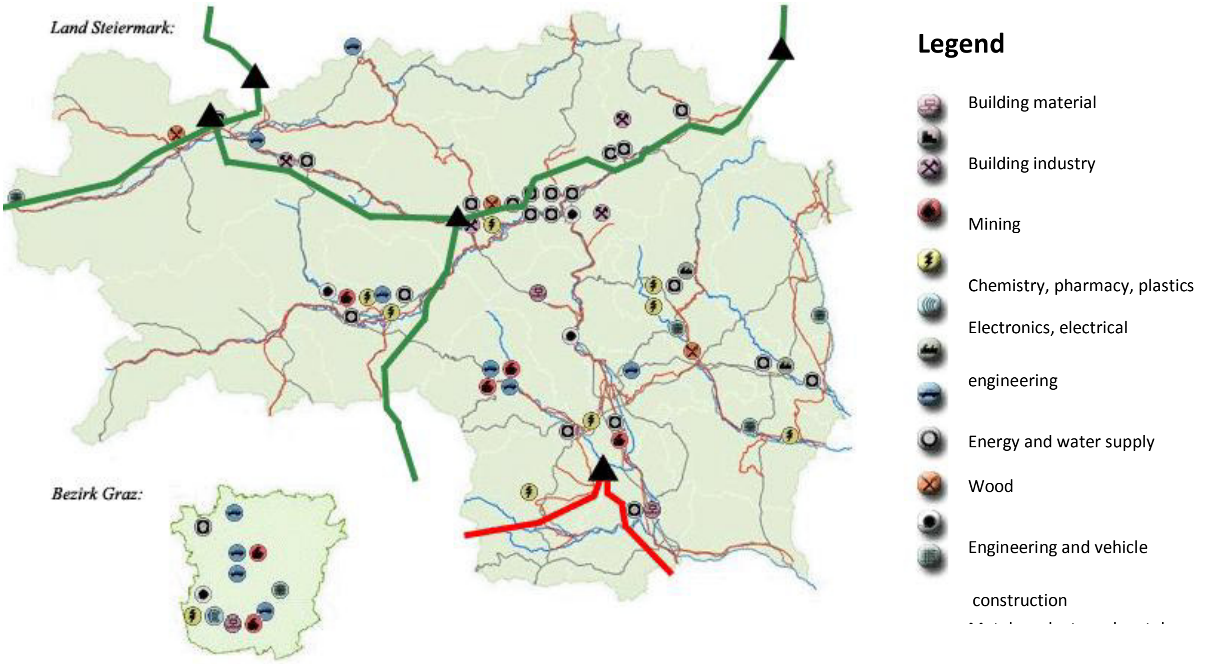


Figure 10: Overview over the 68 biggest Styrian industrial companies, categorized by branches (IV Steiermark und Wirtschaftskammer Steiermark, 2006)

Figure 10 shows the most relevant companies when it comes to DSM-potentials in Styria, categorised by branch.

Table 4: Overview over the most relevant companies qualifying for DSM

Paper	Stone and Earth	Cement	Metal production and products
Sappi Austria Produktions-GmbH and Co KG	Wolfram Bergbau- und Hütten-GmbH NFG KG	Wietersdorfer und Peggauer	Böhler Schmidetechnik GmbH & Co KG
Mayr-Melnhof Karton GmbH & Co KG Werk Frohnleiten	RHI-AG (vormals Veitsch-Radex)	Lafarge Perlmoser	BOEHLERIT GmbH & Co KG
Norske Skog Bruck	VA-Erzberg-Gesellschaft	Klöcher Basalt Werke	Böhler Edelstahl GmbH
Zellstoff Pöls AG	Porzellanfabrik Frauenthal GmbH	Schotter und Betonwerk Karl Schwarzl Betriebsges.m.b.H	Böhler Bleche GmbH
		Pronat Steinbruch GmbH	voestalpine Austria Draht GmbH
			voestalpine Bahnsysteme GmbH
			voestalpineStahl Donawitz GmbH
			voestalpine Tubulars GmbH & Co KG
			Alpenländische Veredelungsindustrie (Marienhütte)
			Andritz AG
			Magna-Steyr-Fahrzeugtechnik

4.4 Relevant companies in Upper Austria

Major electricity consumers in Upper Austria are the Voestalpine AG, the fibre producer Lenzing AG as well as the aluminium processing company Austria Metall AG and Austria Alu Guss GmbH in Ranshofen. Due to the complicated process-structure of the Lenzing AG, this company's potential for DSM is rather small. Considering the size of Voestalpine AG, it has to be assumed, that their energy management potential is well used and therefore the resulting potential for DSM would be rather small.

The most relevant companies, according to their DSM potential, are shown in Table 5 and are categorized in the corresponding branches.

Table 5: Overview over the most relevant companies for DSM purposes in Upper Austria

Paper	Stones and Earth	Glass, ceramics and cement	Metall production and products
UPM Kymmene Austria GmbH	Salinen Austria	Gmundner Zement Produktions und Handels GmbH	voestalpine AG
SCA Grapic Laakirchen	Poschacher Natursteinwerke GmbH & Co. KG	Eckelt Glas GmbH	Austria Metall AG
Nettingsdorfer Papierfabrik AG & Co KG	Schärdinger Granit Industrie AG	Kirchdorfer Zementwerk Hofman GmbH	SAG Euromotive GmbH & Co KG
Tann-Papier Ges.m.b.H.			Amag rolling GmbH
Chemistry			Amag extrusion GmbH
Lenzing AG			Austria Alu-Guss GmbH
			MEPURA Metallpulver GmbH
			Miba AG
			SGL Carbon GmbH & Co

4.5 Experiences on basis of discussion with industrial companies

To gain experience considering the willingness to discuss as well as their general incentive for DSM measures and test the developed questionnaire, interviews between TU Graz, Brimatech and relevant companies were held. Because of data protection no company names will be mentioned at this point.

These interviews resulted in the information, that due to the very intense competition and the ever rising energy- und economy awareness and also because of the financial and economic crisis; the general awareness for efficient and economic use of electrical energy is getting stronger. The companies interviewed gave a positive feedback on the project EDRC.

The companies try to use their process-cycles and energy-consumers or customer generation at highest logistical and economic efficiency. The more production processes make up the cycle the smaller the incentive of a company to accept controlled load shifts. The incentive to accept load shifts is higher if the company can perform them themselves at times of need, for example if a shift is needed the company will receive a call. This ensures that companies still got full control over their production cycles. Also the acceptance for less frequent but longer lasting shut downs is higher than for more frequent shut downs with shorter durations. This shows that the potential for peak load reduction is higher than for balancing power supply.

The rules for load management are known to the participants. Primarily peak load guards for a reduction of grid costs are being used. Very large energy consumers nowadays already have an appointee for load management who actively participates on the day-ahead electricity market and even on the balancing energy market. These companies therefore show a reduced potential for participating in the EDRC program. Higher still unused potentials can be found aside the paper and steel industry for example in energy intensive medium sized companies.

Due to the many variations of production equipment in each company, a comparison of different companies even in the same branch is very difficult, calling for an individual concept for each company. A rather large uncertainty factor for companies is the punishment if the arranged measures regarding DSM cannot be fulfilled. It is absolutely necessary for each company to know the consequences in advance and if it’s possible to avoid punishment by pooling up. The idea of pooling up with other customers was well received.

If the company has a good order situation there is rather little incentive to risk production output because of load management, even if it would be possible.

Ensuring minute-precise ramps while changing the load will be hard to achieve or rather impossible from a technical angle of view. A predefined change of the average power demand in 15 minute periods seems to be easier to realise.

Another barrier is the complexity of the process including the balancing group itself. The rules and correlations in a balancing group need to be explained to the appointee for energy management participating in the EDRC program, in order to ensure success.

The conclusion of those two “test-interviews” can be summarized as follows. The incentive to participate in DSM measures basically exists, but you have to consider all the aspects of every company anew. Additionally it is of utmost importance that the idea and rules behind the EDRC program are communicated in a more than sufficient manner.

Further interviews were held by Brimatech, CyberGrid and APG with promising companies which partly signed a letter of intent. These results are shown in detail by Brimatech.

5 Description of the simulation model ATLANTIS

ATLANTIS is a techno-economic model of the electricity industry in Continental Europe (former area of the UCTE) – a synchronous area with a net installed capacity of about 750 GW by the end of 2011 and annual consumption of approximately 2,600 TWh in 2011 (ENTSO-E, 2012). A major part of the scenario model is a database of the most important facilities and companies in the investigated area.

Based on the comprehensive database, ATLANTIS is a simulation model which is close to reality in technical matters but is also able to give an explanation of the economic behavior of electricity markets. The technical part of the model includes all necessary elements of the physical system, e.g. the synchronous transmission grid (400 kV and 220 kV levels), about 10,000 existing individual power plants as well as final consumption of electricity geographically downscaled to about 2,500 grid nodes.

The economic part of the model covers electricity trade by using market models like net transfer capacity (NTC) based zonal pricing and a European-wide market coupling between countries, as intended by the European Union. Major European power producers are described by simplified balance sheets and income statements.

5.1 Global input parameters

In addition to the master data which represents the Continental European electricity system until today, future scenarios up to 2050 can be built by adding projected or fictitious power plants, transmission lines, transformers and grid nodes. In the course of this project, about 10,000 additional power plants have been modelled, which either replace existing units at the end of their operation, or offer additional production capacities (especially in case of renewable energy sources). These supplemental units are sited in locations of units which are replaced by them or, in case of RES, in locations of appropriate potential of primary energy sources.

Besides the physical parameters included in the modelled power plants, transmission lines and transformers as well as final consumption, economic parameters and market data have to be considered within the simulation. These parameters include assumptions for future fuel prices, CO_2 price, inflation, NTCs, investment costs, learning curves, operation and maintenance costs of power plants and many more.

5.2 Assumptions of energy and environmental policies

To define all those input parameters needed for a scenario simulation using ATLANTIS, certain developments regarding energy and environmental policies have to be assumed. For the EDRC project, a “green” scenario was chosen to show the effects of DR measures like reduction of CO_2 emissions even at a high level of renewable generation in the electricity system.

The assumed scenario's main target is to reduce CO_2 emissions by forcing renewable energy sources in the electricity generation mix, and by simultaneously decreasing fossil generation capacities. The actual development derives from the 450 ppm scenario of the World Energy Outlook 2010 (International Energy Agency, 2010).

Another target of the European Union which is represented in this scenario is to reach higher end-user efficiency. This is represented by a rather slow demand growth until 2030, compared to actual growth rates. Countries in Eastern Europe will experience a rather strong growth of economy and average wealth leading to a higher demand. Due to this, the Continental European total demand of electricity increases in this scenario.

Both generation capacity and peak load increase in this scenario. The proportion of renewable energy sources for electricity production is increasing and the absolute as well as relative amount of thermal generation capacity is decreasing, thus satisfying the general idea of the 450 ppm scenario. The generation capacity almost doubles between 2006 and 2030, reaching a total of more than 1,000 GW.

The price for oil is also based on the 450 ppm scenario of the WEO 2010 (International Energy Agency, 2010). The oil price experiences an increase until 2020 where its peak is reached. From there on the price stays the same until 2030. This development can be explained by the general rethinking process towards a more eco-friendly environment, which this scenario is based on, leading to a reduction of fossil fuel demand, thus resulting in lower oil prices.

5.3 **Program flow**

Figure 11 shows the flow chart of a scenario simulation. Based on the predefined scenario, the calculations are performed on an annual and, respectively, monthly base. Every month is furthermore divided into a number of peak and off-peak periods. The monthly load duration curve is discretized by the means of the corresponding periods. At the beginning of every simulated year, the calculation starts with a system adequacy check for winter and summer peak load, which also considers physical load flow restrictions. The physical load flow is calculated using a DC-OPF (DC optimized power flow) algorithm. In this initial step, the model proves whether the simulated electricity system is able to handle the annual peak load hour. If not, the model automatically builds a new gas-fired CHP plant to cover the missing generation capacities, using an "optimal" placement algorithm. This step is repeated until the amount of generation capacities is sufficient, and no lines are overloaded.

In the next steps, the dispatch of power plants is calculated by minimizing the total generation costs, using different market models. More precisely, a zonal pricing algorithm under consideration of net transfer capacities (NTCs) at cross border lines is applied, followed by a DC-OPF calculation to proof whether the market results can be realized without violating the (n-1) criterion[3]. In case of a violation, power plants are redispatched to resolve the limiting congestions, still trying to keep the total generation costs as close to the optimal dispatch as possible.

Fluctuating generation like hydro power or wind power is considered by the long-term average generation in the particular month. A power exchange where the modeled companies trade generation surpluses is calculated parallel to the dispatch. When the utilization of the power plant park is determined, fuel demand and CO_2 emissions of each period are calculated.

Finally, the required retail price of electricity for each country is calculated considering "second best" regulation. The dynamic simulation of different scenarios over time shows the effects of changing climatic conditions on power production, electricity exchange and network utilization.

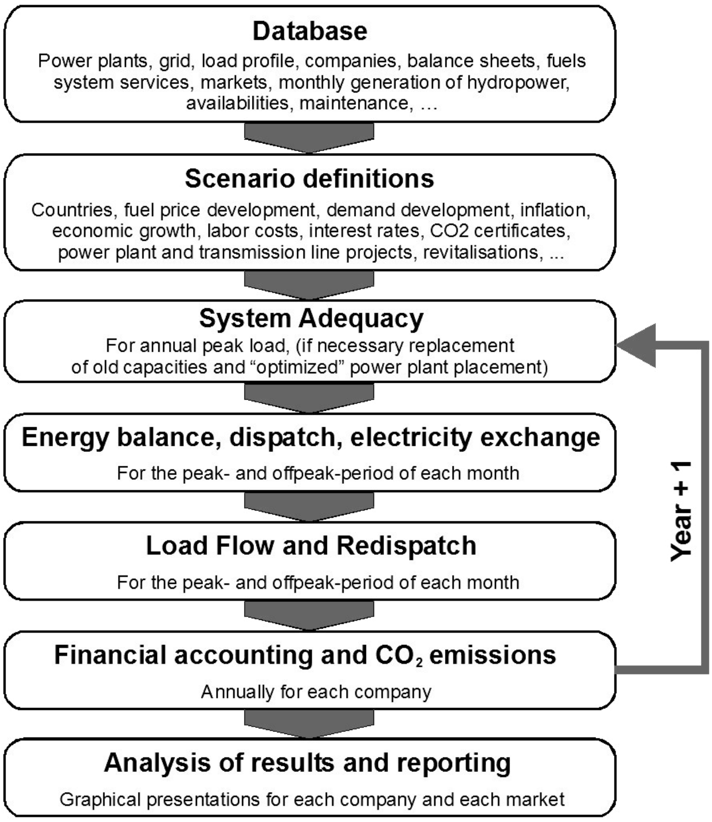


Figure 11: Flow chart of the ATLANTIS scenario model . source: (Gutschi, Jagl, Nischler, Huber, Bachhiesl, & Stigler)

5.4 Adjustment of ATLANTIS for project EDRC

To be able to simulate effects of demand response, some additional functionality has to be added to ATLANTIS. Final consumption of electricity is one of the major components in the

[3] The (n-1) criterion is evaluated by reducing the thermal limits of all transmission lines to 70 %, which is generally known as a good approximation.

electricity system. Due to this, hourly load curves per country of 2006 (ENTSO-E, 2012) have been implemented in ATLANTIS to represent the behaviour of end customers as good as possible (for example, see Figure 14 on page 34). Duration curves are derived from these hourly load curves and discretised to reduce simulation time. To be able to consider effects especially in times of highest loads, a peak load period containing 10 % of the highest loads in every month has been simulated in addition to the usually simulated periods[4]. The development of electricity consumption is modelled by scaling the load curve of 2006 by the factor of increasing or decreasing annual demand.

To consider DR on an hourly basis, a mechanism to include hourly changes in electricity demand has to be implemented into ATLANTIS. Therefore, a tool to include the statically assumed DR measures (see chapter 6.2.1) has been introduced for this project. Because the load curve of 2006 is statically implemented in ATLANTIS, there is no need to integrate DR measures in ATLANTIS dynamically.

Final demand is simulated in an aggregated way, considering that distribution grids are constructed in radial topology and connected at their roots to grid nodes of the ultra-high voltage transmission grid. Thus, the underlying distribution grids can be abstracted by connecting all power plants directly to transmission grid nodes and by concentrating the final consumption within the distribution grids to a total demand per transmission grid node. While the assignment of electricity consumption to grid nodes is based on population densities for the common final demand, a new assignment has to be found for DR measures in application case one (chapter 6.1). In application case two (chapter 6.2), the total DR potential is concentrated to only one grid node, depending on the simulated showcase.

[4] Usually the load curve is divided by a ratio of 30/70 for peak times and 80/20 for off-peak times in accordance to time.

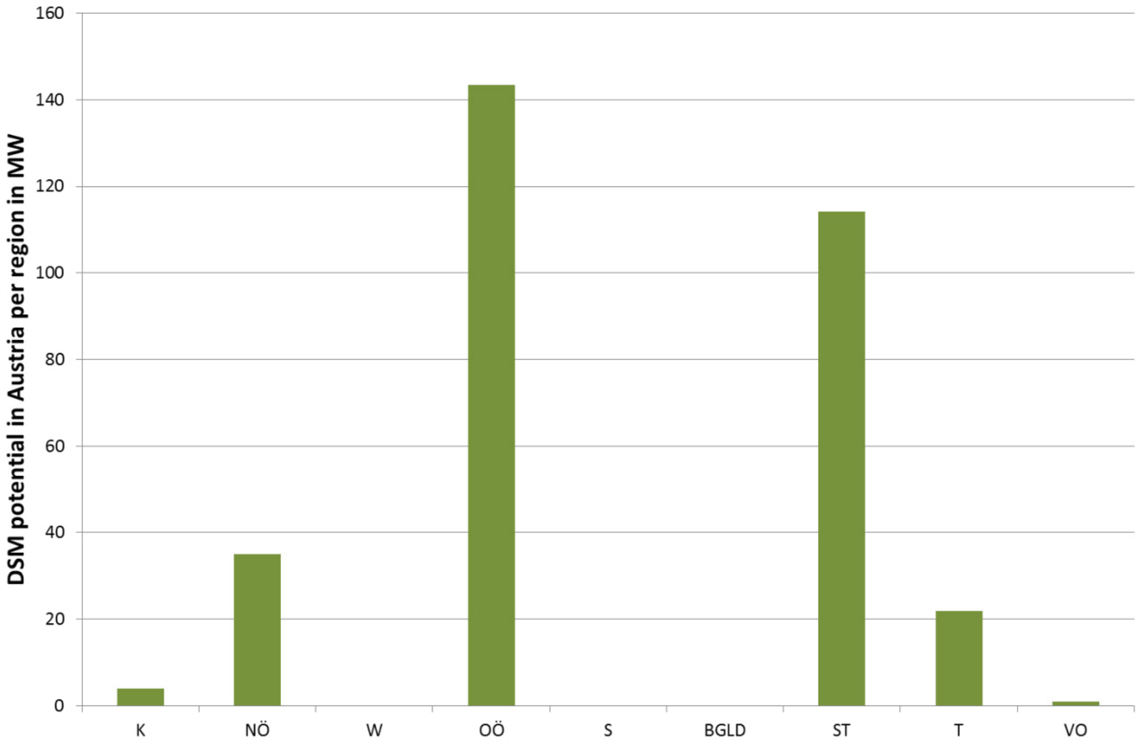


Figure 12: DR potential of different regions in Austria
(K…Carinthia, NÖ…Lower Austria, W…Vienna, OÖ…Upper Austria, S…Salzburg, BGLD…Burgenland, ST…Styria, T…Tyrol, VO…Vorarlberg)

Figure 12 shows the DR potential of all regions in Austria. Upper Austria and Styria hold the highest potential of DR measures in Austria by far. Thus, the distribution shown in Figure 12 needs to be taken into account. Assuming that areas showing a high concentration of industry come along with a higher population density, a combination of the DR potential distribution and population density was chosen to be a sufficient approximation to assign DR measures to grid nodes. A rising potential of DR measures (as shown in Figure 13) is taken into account by scaling the DR measures of 2006 up to the corresponding year. This is done equally to the scaling of final consumption.

6 Scenarios of EDRC

Within the EDRC project we simulate two different promising applications of DSM with ATLANTIS. Firstly a reduction of peak loads, as described in chapter 6.1. In this case old, inefficient and expansive power plants which operate just a few hundred hours a year should be replaced by DSM-measures. In theory, the price of electricity at the energy market should decrease. An industrial company has the advantage, that if they shift a part of their electricity use to off peak times, they gain the price difference between peak price and off peak price as additional profit. In addition the electricity system becomes safer for all consumers. The second application is the reduction of redispatch. Redispatch is a second best solution in plant usage because of physical constraints in the transmission grid. The different simulations with ATLANTIS in this case should show how many of these inefficiencies can be eliminated by DSM.

The third application is a calculation without ATLANTIS to find out how much additional profit from tertiary control market can be expected. These additional profits are an estimate because of less available data and less predictability of this market.

6.1 Peak load application with ATLANTIS

The most promising application for DSM is to reduce the peak load, where prices at the energy market are rather high. The price depends on the last plant (which also is the most expensive plant in comparison to the other plants used) in use for covering the actual consumption. In extreme peak load times (app. hundred hours a year), prices are far higher compared to the rest of the year. In these hours, old and inefficient plants are used which therefore only run for some hundreds hours a year. This doesn't result from a need for energy, but because there is a lack in capacity. The most important thing for the electricity system is to ensure that demand and generation is as equal as possible at every moment. A reduction in peak load can help to reduce overcapacities and to operate other capacities at a more efficient level. Therefore the first application within the EDRC project is for reducing the peak load. The peak load application shouldn't be seen as a form of saving energy. It's just a time shift of demand. Leading to a reduction of consummation during peak load hours and resulting in an increase in consummation some hours later. In our approach a few hours does mean 2-5 hours later.

6.1.1 Technical parameters of DSM applications for peak load reduction

The interviews yielded the amount and the technical specification of DSM. This seems to be the minimum technical potential, because not all industrial sites could be visited and the feedback given from carried out interviews wasn't always 100% perfect.

Where no interviews were held, we adjusted and scaled corresponding data from our interviews to fit the industrial site's parameters. For example, if a company in cement industry with 1 Mio tons of annual production does have a potential of 10 MW and another one with 500,000 tons does have 5 MW potential a scaling factor of 1 MW potential per 100,000 tons of annual production can be derived. In similar ways we did an approximation for different branches in a more conservative way. Summing up the DSM potential from our interviews and scaling for non-interviewed industrial sites result in an amount of 320 MW for the year 2012. This is similar to the results from the PhD thesis of Mr. Gutschi (Gutschi C. , 2007). For ATLANTIS we adapted our load duration curve of 2006 with a DSM potential of 300 MW and added an annual increase of 1.2 %. This can be seen in Figure 13. From the information gather in our interviews we know, that approximately two thirds (200 MW) can be shifted once a day for each day from Monday to Friday. The other 100 MW can be shifted once a week. Because of a lack of information, you can't predict which day in a week will have the highest peak load. Therefore we spread out these 100 MW evenly on each working day which leads to an increase of potential of 20 MW each day, resulting in a daily potential of 220 MW. These figures apply to 2006 and also have this up scaling factor of 1.2 %.

A second simulation with an optimistic potential has been done. Here we assumed that industry do have far more potential, but does not know it. This potential was assumed with 1,000 MW, which means 840 MW a day in 2006. The load curve adaption in this case was completely different, but all other assumptions where the same.

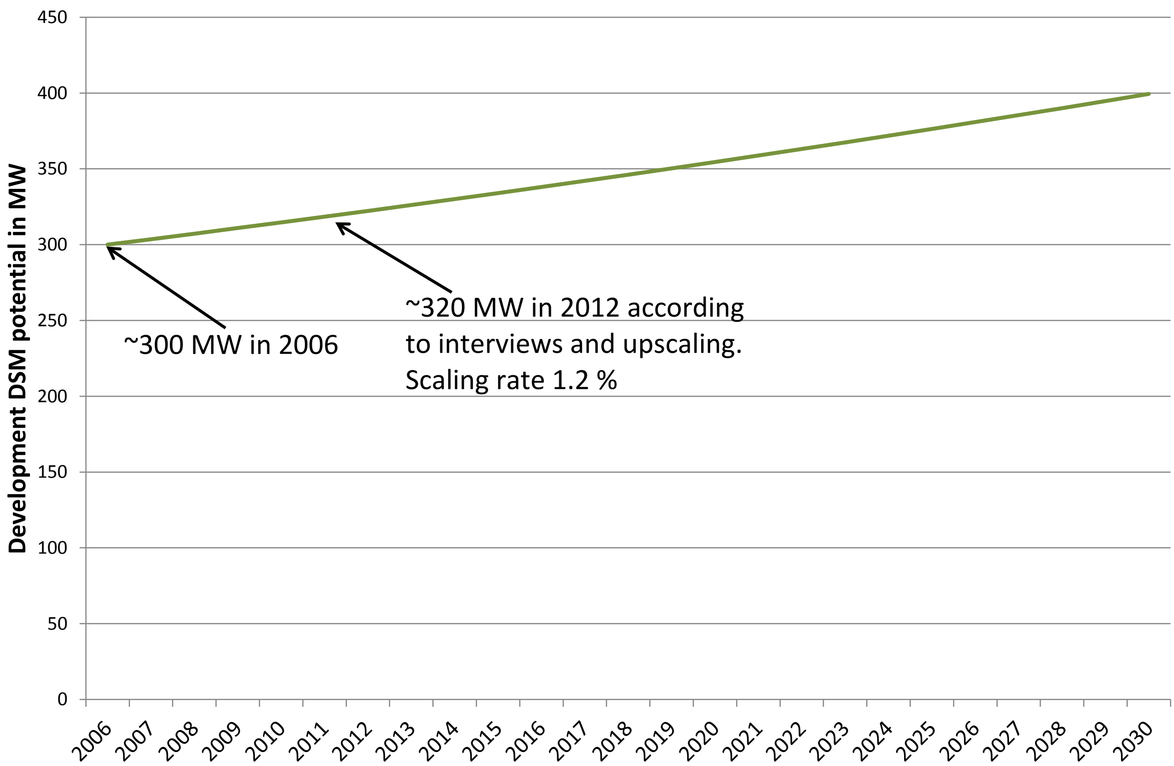


Figure 13: Development of DSM potential in Austria

6.1.2 Input parameters of Simulation

The simulations are based on the consumption data of 2006 from ENTSO-E (ENTSO-E). The consumption data is in chronological order and has to be sorted to a load duration curve. In Figure 14 you can see an example of the unmodified load duration curve of Austria (week 3 in 2006). In Figure 15 you can see the example of a peak load case adaption of the load curve (week 3 in 2006). The example shows week three in year 2006. Because of the static realization of demand, this demand curve and also the DSM potential is just scaled up by factors for the simulation until 2030.

Because of the simulation duration until 2030, it is necessary to give respect to the impact of increasing PV installations in the next years. This calls for an adaptation of the load curve for 2020 until 2030. The changes made in the load curve can be seen in Figure 16. It shows week 26 in 2020.

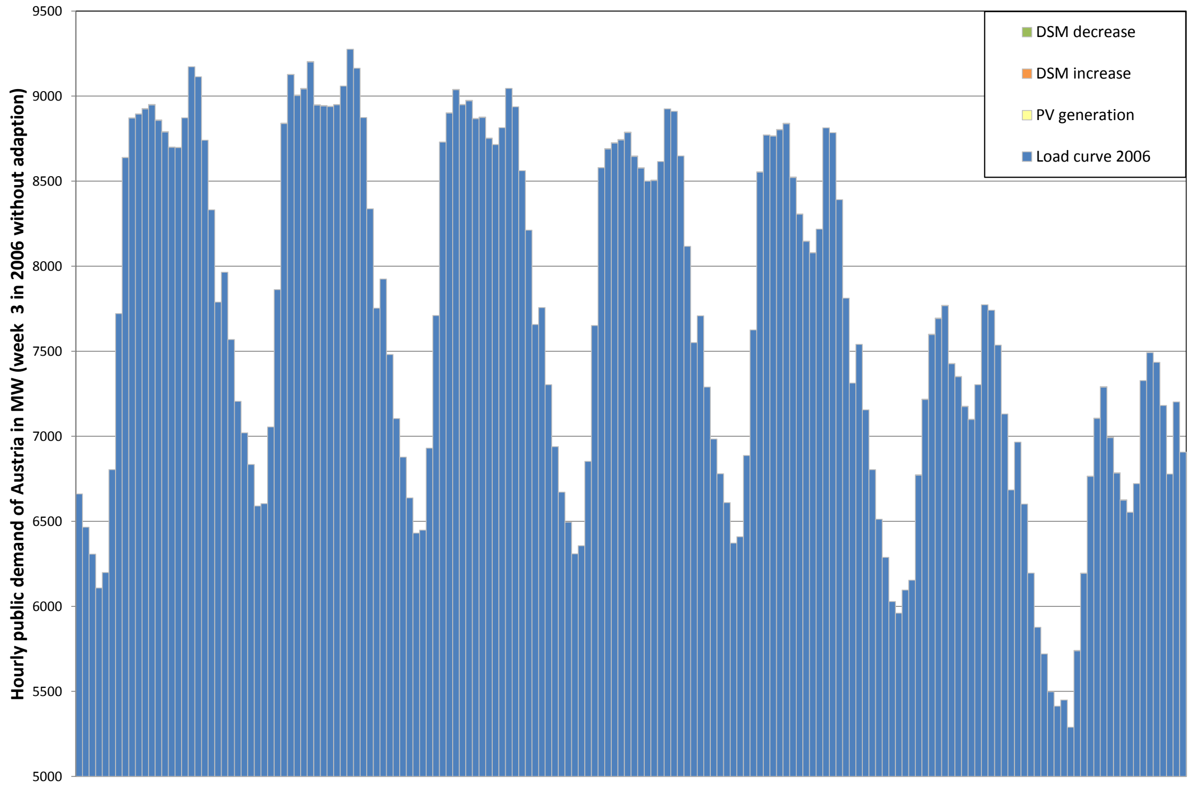


Figure 14: Unmodified load curve of Austria 2006 (ENTSO-E)

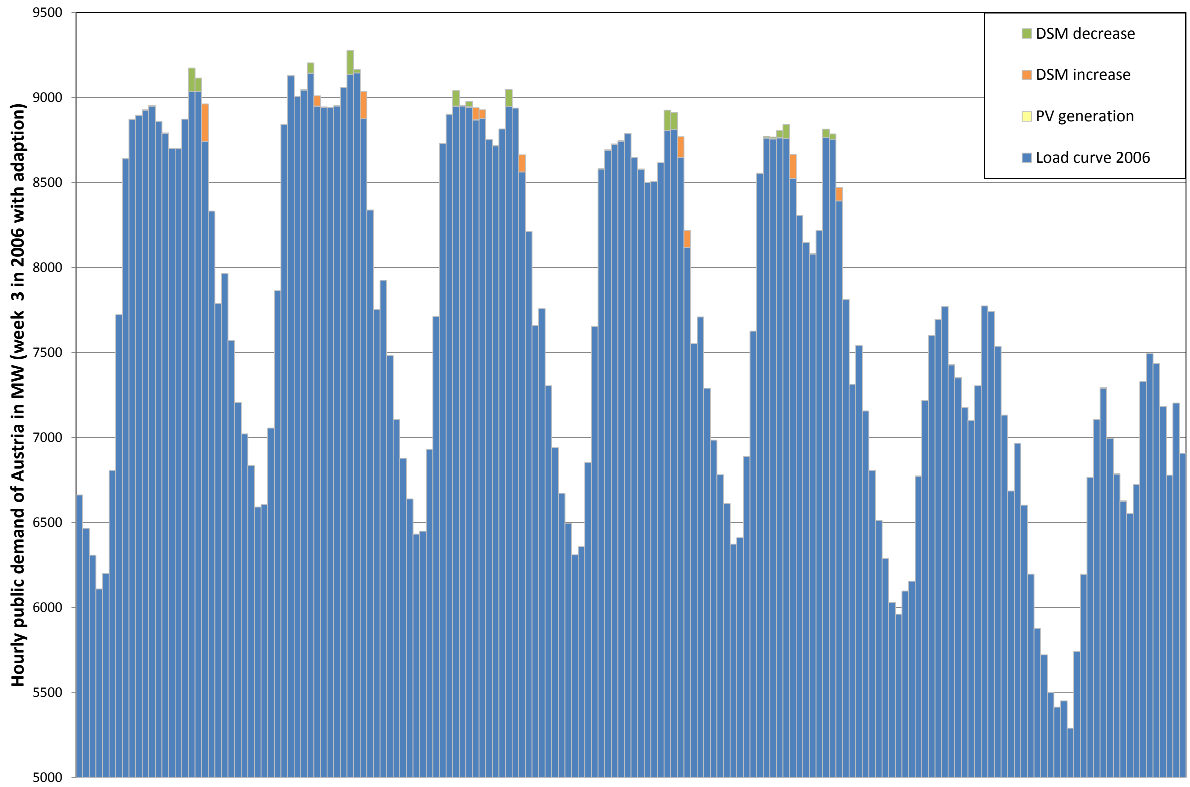


Figure 15: Load curve of Austria 2006 with DSM adaption (week 3 in 2006 – Austria; case 300 MW)

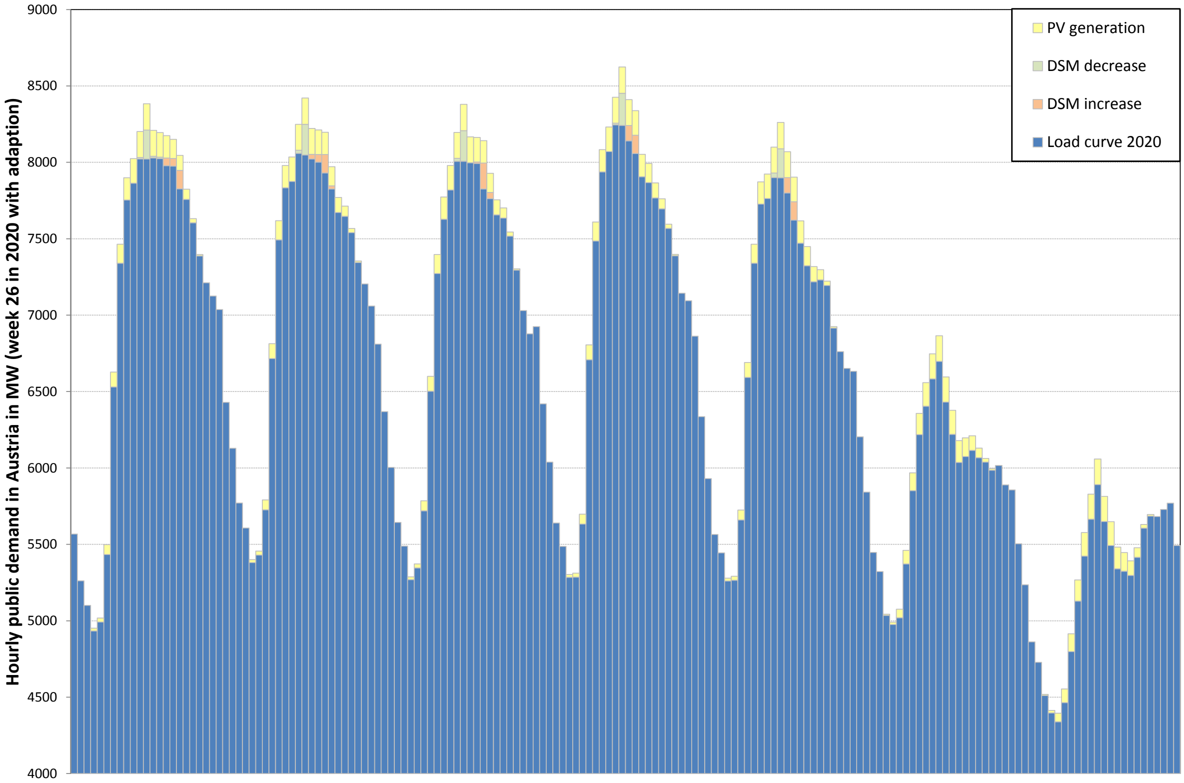


Figure 16: Adapted load curve with respect to PV generation (week 26 in 2020 – Austria; case 300 MW)

A constraint of the peak load application is that the reduced demand has to be used within 2-4 hours after the reduction (300 MW case). This constraint results from our interviews and the fact that not every company is allowed to produce during night time. Even if the night would be optimal to shift the load to, it isn't realistic and therefore not considered in this project.

In the 1,000 MW case the time gap can be up to five hours. To handle this amount of DSM it's necessary to increase the gap, otherwise there would be no real effect because the potential couldn't be used in an efficient way.

6.1.3 Simulation results

There are several effects which are investigated within the simulation model ATLANTIS. These are the impact on the load duration curve, the power generation in Austria, the CO_2 emissions, the changes in production costs and the import-export balance of Austria.

In Table 6 you can find the abbreviations according to the cases simulated for the application of peak load reduction.

Table 6: Abbreviation overview of the cases for the application for peak load reduction

Abbreviation	Description
BASE	Reference scenario used to compare results to "business as usual"
SLS	Adaption of the load curve from the point of view in 2006 (no respect to PV generation); in addition "case 300 MW" or "1.000 MW" is added to clarify the amount of DSM

SLSPV	Adaption of the load curve beginning in 2020 with respect to PV generation); in addition case "300 MW" or "1.000 MW" is added to clarify the amount of DSM

6.1.3.1 Load duration curve

The load duration curve LDC shows the hourly demand of a consumer, region or country, sorted by the demand. In our case, it is the LDC for Austria 2030. As an example you can see from Figure 17 the LDC for 2030 as an outcome of our ATLANTIS simulations. For clarity reasons the Y axis is not set zero. In the lower left corner there is a zoom of the hundred highest demand values of the LDC. As can be seen from zoom, the highest peak load hours can be reduced by approximately 3 %. In the case of 220 MW possible load shift per day. We also did a simulation with a DSM potential of 840 MW per day. But our simulations showed that if the supposed potential is too high there is no more reduction. The breakeven point is about 4-5 % of the peak load in the case of a static optimized load curve for a certain amount of load reductions. If you try to implement more DSM under the given constraints, old peaks disappear and new ones occur which leads to a nearly similar load duration curve as before which means that for a high amount of DSM the time shift duration needs to be increased.

Figure 17: Load duration curve /with adaption for Austria for 2030 (ATLANTIS)

6.1.3.2 Power generation in Austria

An interesting aspect of the application for peak load reduction is the power generation in Austria. In this interpretation we have two different figures (case 300 MW). In Figure 18 you can see the entire generation in Austria except pump-storage. They are not included in the interpretation because of their ability to be a consumer as well as producer. The different levels in Figure 18 represent the different demand situations in the years 2010, 2020 and 2030. The assumptions for the simulation which cause the higher demand for 2020 and 2030 are described in Chapter 0. As a result of the higher demand, the production (or import) has to increase. A slight difference in generation can already be seen in Figure 18. Gas fired plants contribute the most to these differences. The high contribution of gas fired plants calls for a separate consideration, which is shown in Figure 19. Gas-fired power plants often set the price in the electricity systems, due to the fact that they are the last operating plant in the merit order. If there is a load shift, it is likely that a formerly needed plant isn't used anymore. This could also lead to lower generating costs, which is described in 6.1.3.4.

A possible case is that imported electricity is cheaper than generation in Austria and if there are enough net capacities, this could also be a reason for turning down the generation in Austria. The analysis of import and export can be read in chapter 6.1.3.5. The figures for the case 1,000 MW are located in the annex.

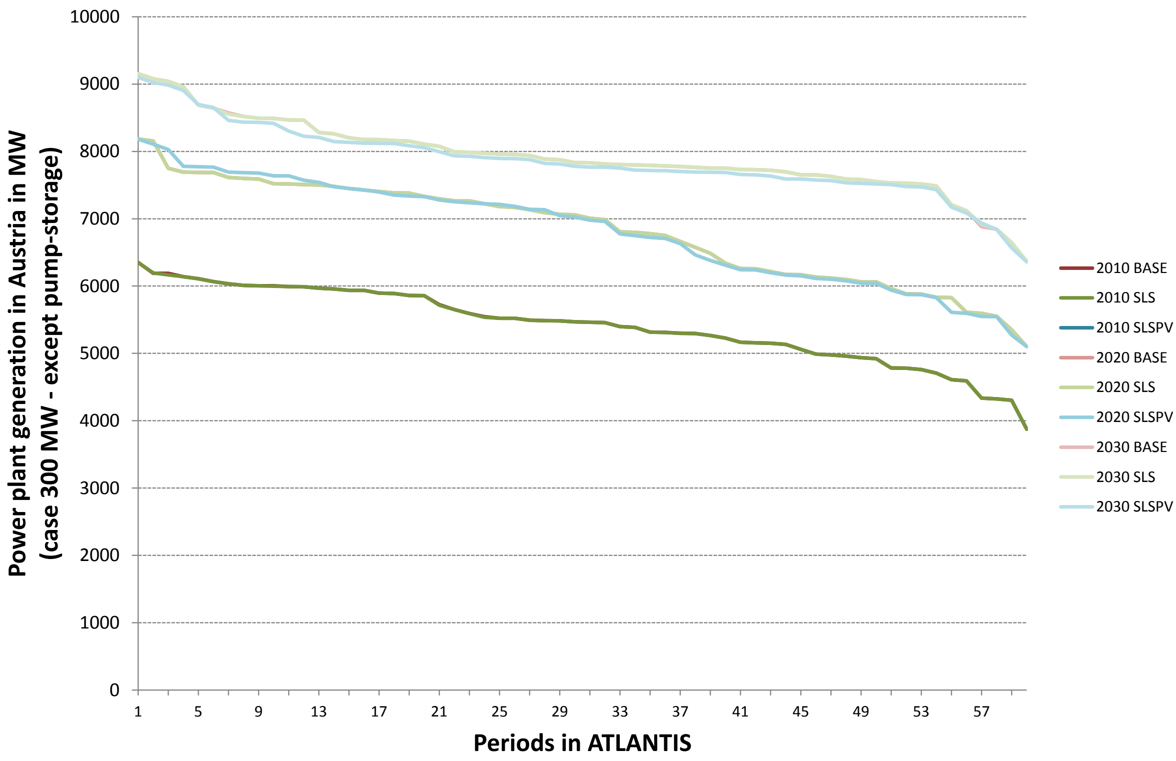


Figure 18: Overview of generating in Austria in case 300 MW (except pump-storage)

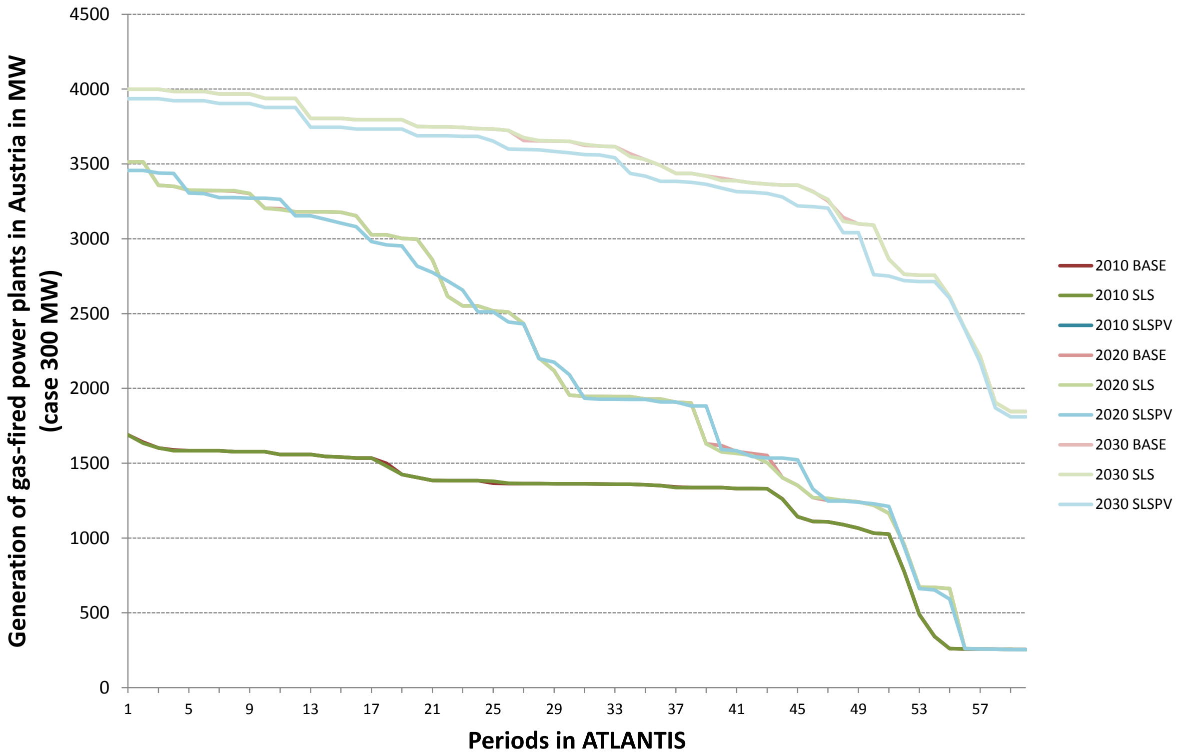


Figure 19: Generation of gas-fired power plants in Austria (case 300 MW)

6.1.3.3 CO_2 emissions

Figure 20 shows the CO_2 emissions of different thermal technologies in Austria. Because of the small differences in generation also the CO_2 emissions do not vary much. In case of SLS 300 MW the CO_2 emissions nearly remain the same as in BASE. In case of SLSPV 300 MW there can be seen a reduction between 1 and nearly 3 % of CO_2 emissions. This reduction comes from shifting peak load in off-peak hours. In off-peak times the plant mix in Austria is lower than in peak hours. The simple shift without respect to the installed PV and its generation in the next 20 years does not lead to high significant findings. But if attention to the PV generation is paid, there can be seen the supposed reduction of CO_2 emissions.

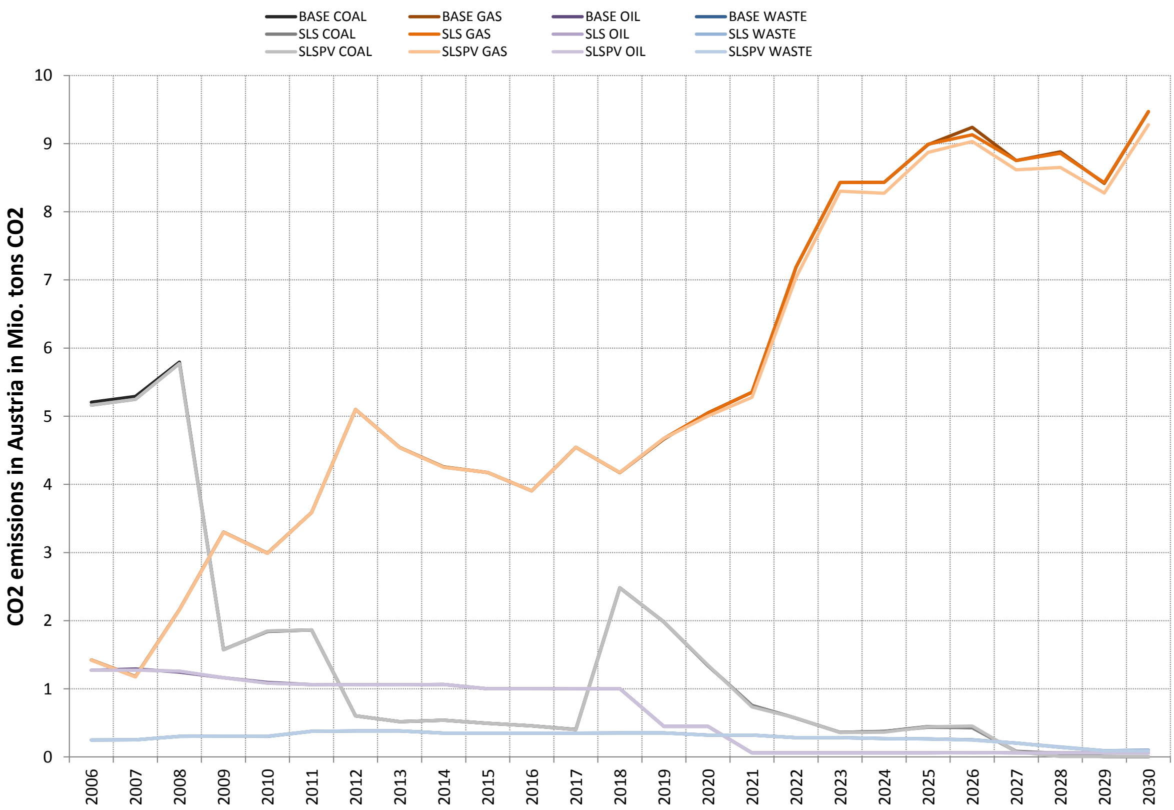


Figure 20: CO_2 emissions of thermal power plants

6.1.3.4 Changes in production costs

The changes in production costs can be seen in Figure 21. The case with an adapted load curve for PV-optimization was simulated from 2020 to 2030. As can be seen, the PV adaption leads to far better results compared to the case without the adaption. The main difference is the reduction of the peak from about 11 am to 2 pm through the PV generation. As a result more DSM is left to cut the peak in the evening, which leads to lower generation costs. The Figure includes the generation costs itself as well as the differences from import and export. This is the result of the simulation model ATLANTIS and represents a possible solution under given constraint (see Chapter 5). The lower generation costs derive from a more effective electricity system, because there is less need for old, ineffective and cost intensive generation capacities. The lower generation costs could be a benefit for the producers and for the consumers as well and may lead to lower electricity costs for all consumers. Also costs for import of energy are included in this examination. The only case where the electricity system gets more expansive is the case 300 MW potential in 2025 because of high import rates. The 300 MW case with PV adaption does show a reduction of costs like all other cases in this year do.

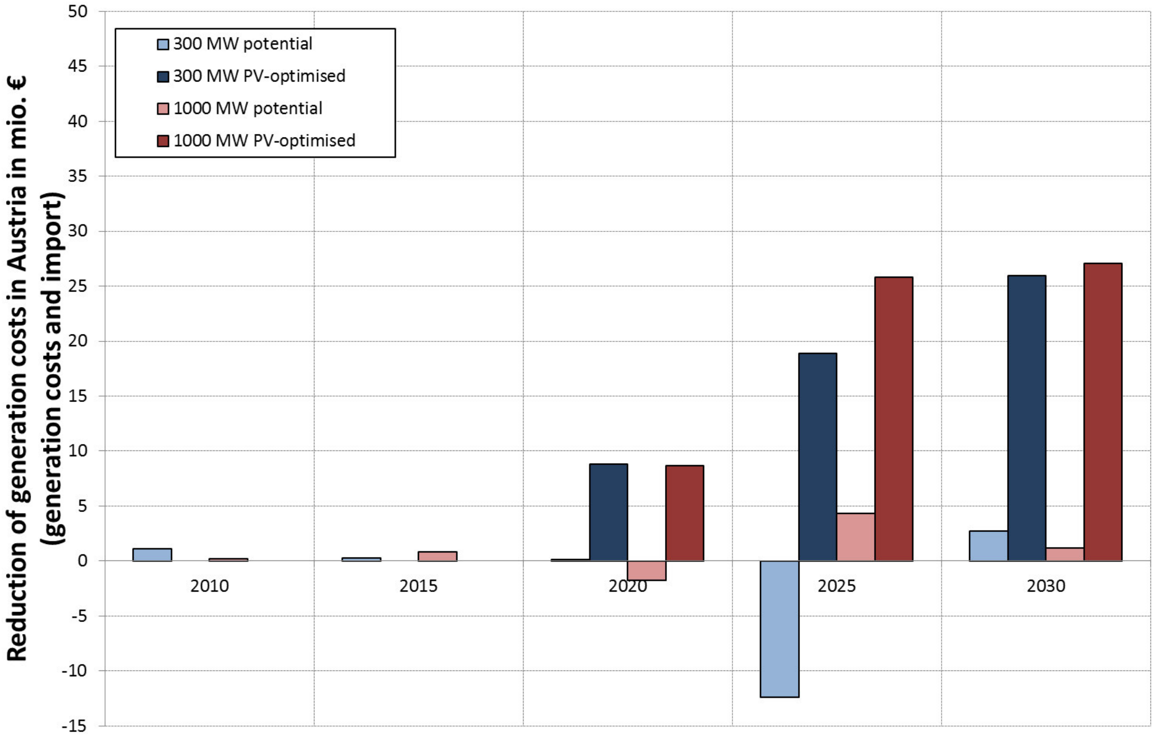


Figure 21: Reduction of production costs in Austria

6.1.3.5 Import-export balance

Every adaption in demand leads to a variation in generation or in import/export balance. This can be caused by different prices on the energy market or by different net situations which can enable more or less import/export. In Figure 22 the import/export of Austria from 2010 to 2030 can be seen. This is an outcome of ATLANTIS with the preconditions of the simulation and without any DSM measures.

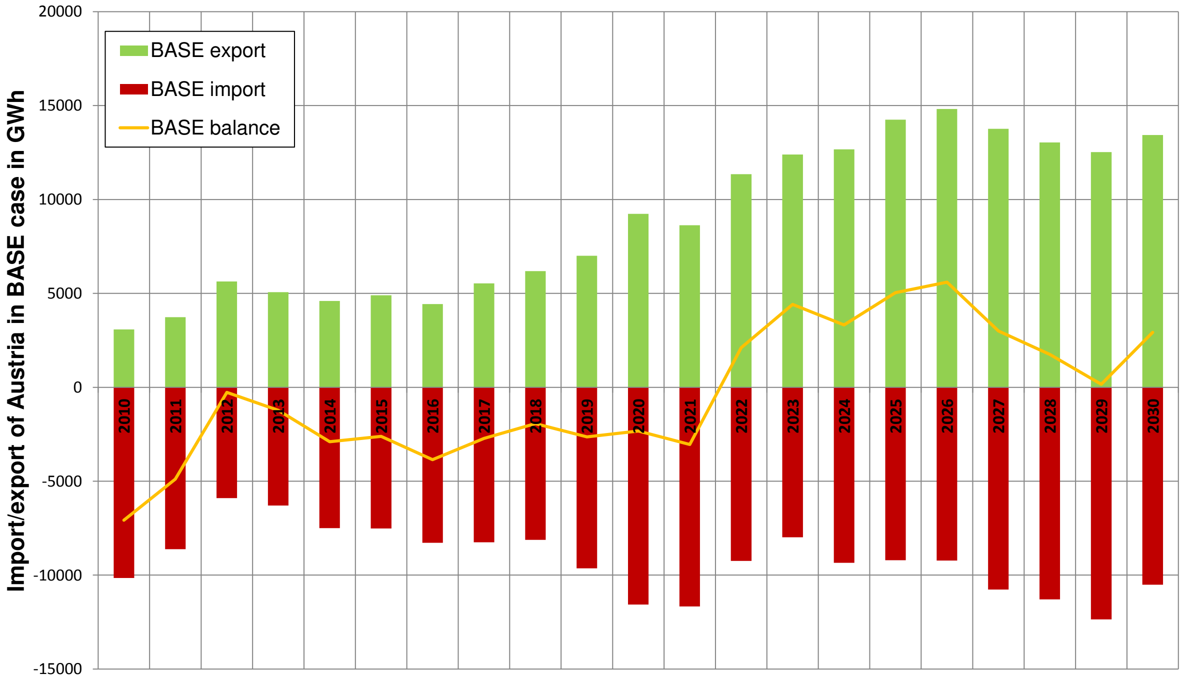


Figure 22: Energy import/export simulated in ATLANTIS for the BASE case

In comparison to Figure 22, in Figure 23 the changings to the BASE case can be seen. Because of simplicity only the changings in balance between import and export is shown. As can be seen is the SLS 300 MW case nearly the same as BASE. In case SLSPV 300 MW a trend to less export (more import) can be seen. This is because of the shift of demand from peak hours to off-peak hours. In these hours energy often gets imported because of lower generation costs in countries around Austria. But on balance Austria remains an exporter from 2022 to 2030 same as in BASE case (except SLSPV 300 MW in 2029).

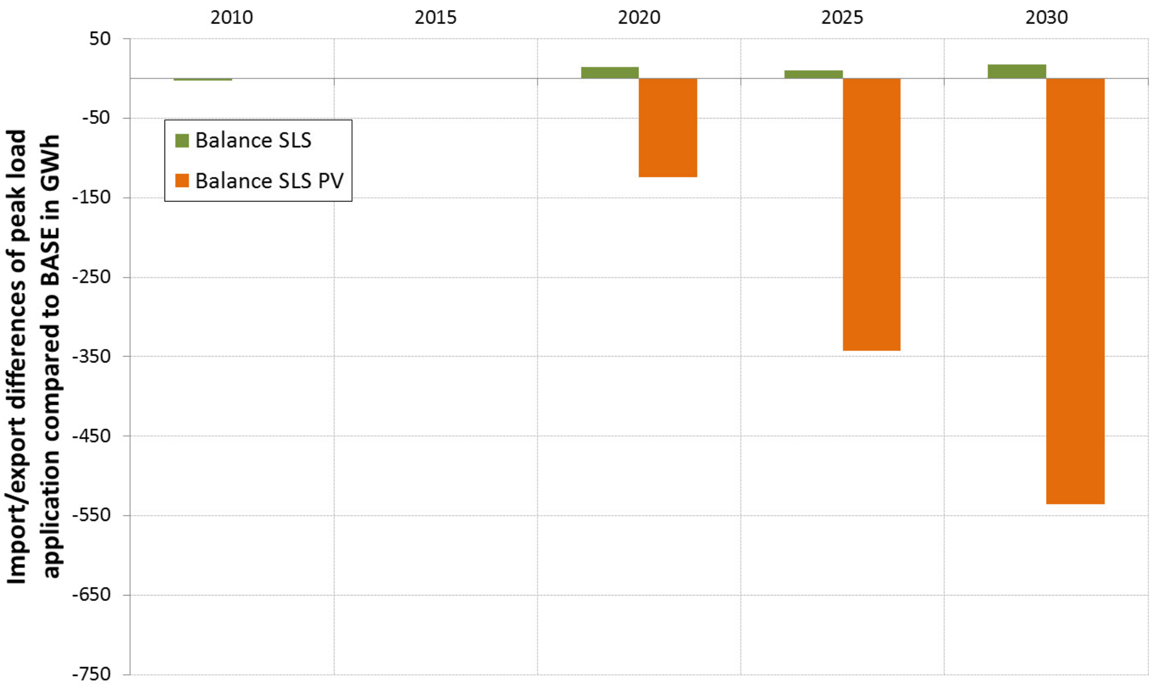


Figure 23: Changings in import export compared to BASE case for SLS 300 MW and SLSPV 300 MW

6.2 Showcase: Possible redispatch reduction as an EDRC application

Another promising application for DSM is to reduce the need for redispatch. The term redispatch describes the alteration of a cost optimal dispatch of power plants according to the market as a result of physical constraints. The grid, especially the transmission grid, is not able to transfer the generation to the places where high load occurs. As a result the congestion of a transmission line can cause a change in the power plant schedule. If the plant generates less than it should from an economic point of view, it is called negative redispatch. Otherwise, if generation from an expensive plant has to be increased, it's called positive redispatch. Because of the low variable generation costs and the high degree of eco-friendliness, renewable energy sources shouldn't be the victim of (negative-) redispatched at all. The main aim is to discharge the transmission grid that RES don't have any constraints for their generation. The second aim is to reduce the costs for redispatch.

6.2.1 Technical parameters of DSM application for redispatch reduction

For redispatch reduction, we assumed to have just one concentrated potential for DSM at one node. Now we can identify the different impacts of DSM on different nodes. One requirement being, that the selected node does indeed prove capable of providing any DSM at all. A further constraint for node selection from our side was that the generation structure at that nodes are predominantly renewable. In the end we took five nodes located in Lower Austria. Their locations vary from Lower Austria's border to Burgenland, Styria to Upper Austria.

6.2.2 Input parameters for the simulation

The first step was to analyse the generation structure of the different nodes in Austria. The main criteria's to choose a node were DSM potential and RES generation. Our investigation lead us to five different nodes, all of them located in Lower Austria. As an example the parameters for the node Ternitz 220 kV is shown in Figure 24.

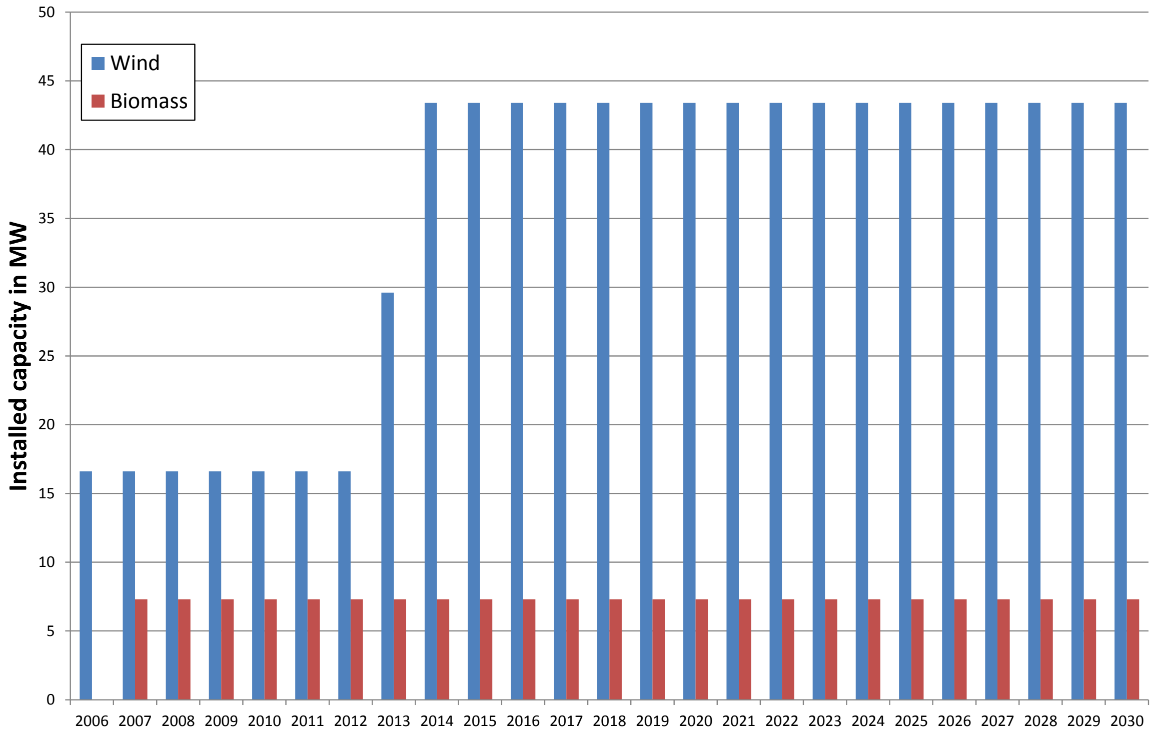


Figure 24: Installed capacity at example node Ternitz (220 kV)

The nodes resulting from this first analysis were Bisamberg (220 kV), Sarasdorf/Stixneusiedl (400 kV), Ternitz (220 kV), Ybbsfeld (220 kV) and Wallsee (220 kV). The corresponding graphs of the installed capacity at those nodes can be found in the annex.

Two different cases for the application “possible redispatch reduction” were simulated:

The first one considers a DSM potential of 40 MW at one node. In order to meet the parameters of the 40 MW case, the load curve with a DSM potential of 300 MW needs to be scaled down to 40 MW. The procedure is the same for all other simulations with a DSM potential other than 300 MW. The simulation is an iterative process where one node after the other receives a DSM potential of 40 MW. After that, the results of the different simulations get compared to the base simulation which is without any DSM influence. This represents a rather conservative point of view regarding the DSM potential.

For the second simulated “possible redispatch reduction” case a potential of 200 MW was considered. The procedure was the same as above. For this case, the load curve with 1,000 MW gets downscaled to fit the 200 MW potential. This is the optimistic case for possible redispatch reduction.

6.2.3 Simulation results

There are several effects which are investigated within the simulation model ATLANTIS. These are the impact on the redispatch variation by using DSM at different nodes, CO_2 emissions and the different usage of plant types in Austria.

6.2.3.1 Redispatch variation by using DSM at different nodes

In the first step the changes in negative redispatch at the example nodes have been investigated. As Figure 25 shows, the generation structure at these nodes has no influence on the variation of redispatch. This means that DR can influence the need for redispatch independent from the place of occurrence. Because of less redispatch of renewable energy sources, there is no significant improvement by DR. The highest variation by means of redispatch can be observed on gas fired power plants. Compared to RES these units cause higher costs of redispatch for the electricity system. Therefore the redispatch of these units will be reduced first. In the year 2015 in Figure 25 there is an increase of negative redispatch. This positive change in negative redispatch happens just in 2015 because of changes in the plant mix. In the following years a reduction of negative redispatch is the same like in the years before.

But there is not necessarily a decrease in negative redispatch because of DR. In the case of 200 MW DR potential concentrated at one node the simulation leads to an increase in negative redispatch which can be seen in the annex. This increase occurs because of the high value of shifted DR at one node which means that not every amount of DR can be handled at one node (split makes more sense).

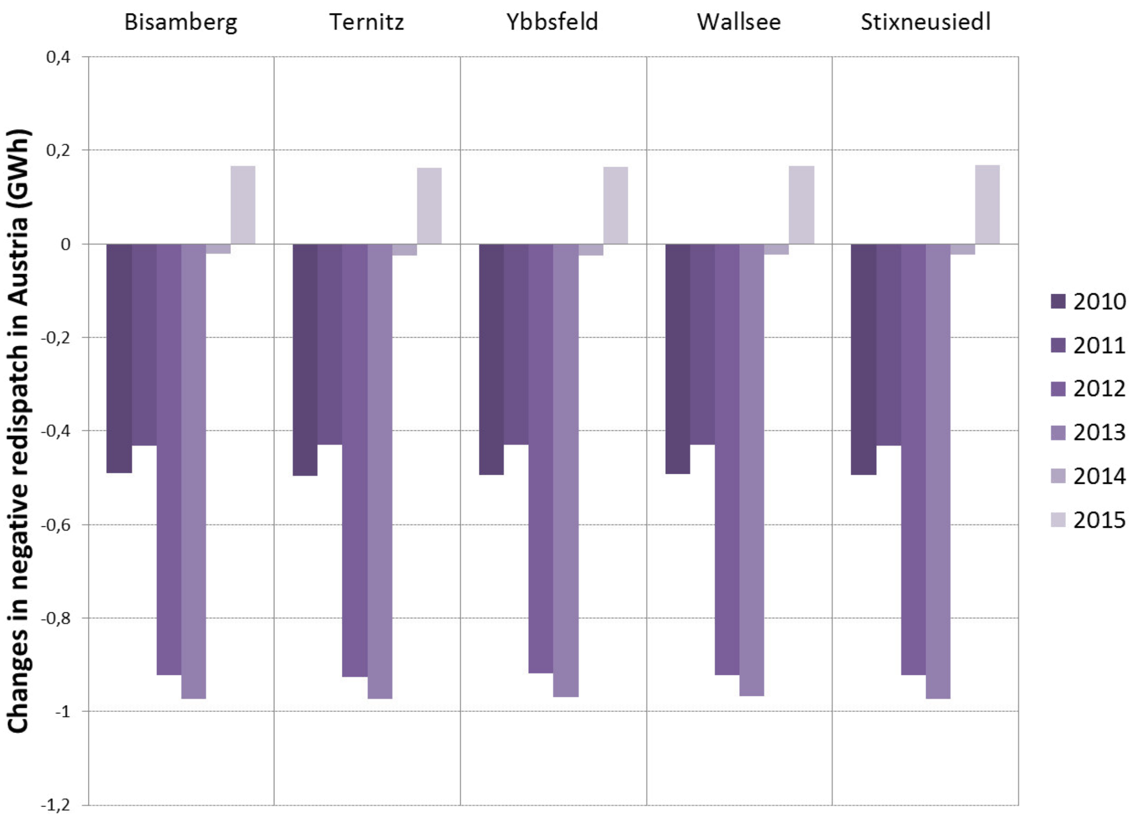


Figure 25: Changes in negative redispatch at different showcase nodes in Austria between 2010 and 2015

6.2.3.2 CO_2 emissions

Also in the case of possible redispatch reduction a reduction of CO_2 emissions can be seen. The absolute emissions for the generation of electricity in Austria are about 6-7 million tons of CO_2. The variation of reduction in different years is a result of different grid situations and generation structures. Possible impacts can be if new plants are built in this time or old plants stop operating. Also price variations at the energy market or a different generation structure in neighbour countries can vary the energy mix and thus the CO_2 emissions. Also the changings in redispatch from emission intensive technologies to “greener” energy sources is a part of this reduction. A reduction of CO_2 emissions can be seen every year until 2030.

Figure 26: CO_2 emissions at the showcase test nodes

6.2.3.3 Different usage of plant types in case of DSM

At all a lower use of power plants occurred in the showcase. This is the result of shifting load from peak hours, where Austria produces energy competitive to its neighbouring countries, to off-peak hours where our neighbouring countries do have a cheaper energy mix in the observed time frame from 2010 to 2015. Because of international trade and available grid capacity import is cheaper in certain hours where a raise of load occurs because of DR. The range of reduction in Austrian generation is about 100 to 200 GWh per year, which means less than 0.3 % of annual production. The main part of this reduction is given by gas-fired power plants which are usually the last traded units in the electricity system. Figure 27 shows the reduction of generation of all power plants in Austria. About 90 % of this reduction is seen by the operation of gas-fired power plants. In our case, by looking at these five nodes, the reduction of generation seems to be independent from researched nodes just like the redispatch variation.

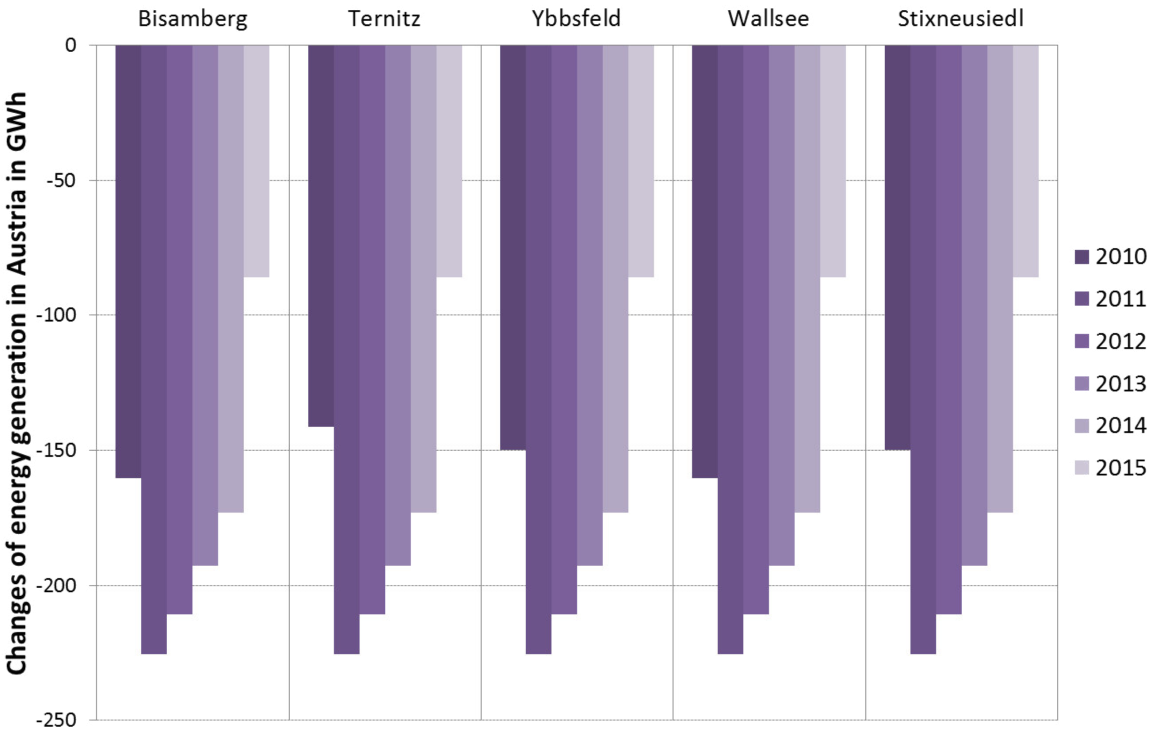


Figure 27: Changes in generation in Austria (all plant types) in GWh

6.3 Application of DSM for the control energy market

The third promising application for large scale DSM in industry is the control energy market. Since 2012 the APG is responsible for the primary-, secondary and tertiary control energy market in Austria. As a partner of EDRC project, the details concerning the market can be taken from APGs final report.

6.3.1 Technical parameters of DSM applications for control energy market

Because of the short response time and the automatic call up, DSM is not suitable for the primary and secondary control market. An external interrupt (f.i. from a TSO) is not acceptable for an industrial company. Such an interrupt can cause massive damage on the production machines or in a worst case scenario even on human beings (depending on the contact of humans with production machines).

As a result a DSM application only makes sense for the tertiary control energy market (Market Maker MM), which is the only control energy market considered in the EDRC project. The call for tertiary control energy comes manually by the TSO. In the case of EDRC it is possible that not the company itself gets contacted, but the aggregator which coordinates a certain number of companies. He then calls the corresponding companies which will then change their actual consumption.

The first idea for this application was that industrial sites can either reduce or raise their consumption of energy/capacity. Outcome result of the interviews was that a raise of the consumption can't be achieved as easily as someone might think. Normally such companies operate near their physical maximum of consumption, which renders an additional demand increase difficult. As a result, only a reduction of production is a possible solution (e.g. gas turbines) for DSM in this analysis. That's why we analyse positive (reduction of consumption) and negative (rise of consumption) redispatch with DSM statistically, but possible earnings are calculated only for the positive case.

The tertiary control energy market with its prequalification terms is described by the APG as the specialist for this market in Austria.

6.3.2 Preparing data for the calculation

In the following analysis of the control energy market only the type "Market Maker" is considered, which is described in detail by the final report of APG. For the calculation of possible gains from DSM use on the control energy market, two components are important. The first one is the power price. The company will get this money independently from whether they had to contribute or not. All bids which get collected at a certain time/date get sorted by the bid price from low to high. The bids (in MW) get added until a certain amount of positive and negative tertiary control energy is reached. The last bid can be split or APG accepts more than the minimum amount for a product (pos. /neg.). All bids made without sales tax in €/MWh.

The second one is the energy price. The accepted tenderer of power price auction have to bid for the energy price. Possibly the most expensive accepted tenderer in the power price auction could offer for the lowest energy price. The energy price bids get sorted into the daily merit order and called from lowest to highest energy price. A tenderer can correct the energy price bid all the time if this leads to lower costs for the electricity system.

As already mentioned since 2012 the APG is responsible for the entire Austrian control energy market. Until 2012 this was, to a certain part, the duty of the APCS. Therefore only limited data for our calculations could be obtained. We do have the results of the power price auction and the energy prices for calls from the APG for 2012. Unfortunately we have less data from the years before 2012. The energy price data with calls (time/date/duration/price) and an average of power prices can be downloaded from APCS homepage (APCS, 2012). So the time series for the calculation of possible earnings at control energy market is very short which needs to be considered when it comes to the reliability of the results.

6.3.3 Bid structure at tertiary control energy market (Market Maker)

As an outcome of the interviews and further investigations only the positive tertiary control energy market seems to prequalify for a use of DSM. In a similar way to the peak load application and the reduction of redispatch, only a time shift of demand can be achieved by this application. There is no sort of energy saving. As already mentioned, the earnings for capacity are independent of being called to deliver or use energy.

6.3.3.1 Capacity price

In the main part of this report only the positive tertiary control market gets described in detail – which is called "Ausfallsreserveleistung ARL" in Austria. From Figure 28 you can see the development of the positive capacity prices from January to September 2012. Unfortunately that's the entire time series available for the statistical evaluation of the capacity price. Therefore the results are just an estimation of possible earnings. As you can see in Figure 28 there is a peak in March and/or April which couldn't be investigated in detail because of non-existent data.

ARL is defined as supply to the control area of APG. This supply can be provided by power plants or by consumers. Power plants which do not operate at 100 % of their possible generation (at least for the time slot of the bid) can increase their output for to fulfil the contract for ARL. Consumers and especially industrial consumers often have two options to provide positive tertiary control energy. Mostly the reduction of their demand is the preferred solution. A second possibility is to increase the customer generation if possible.

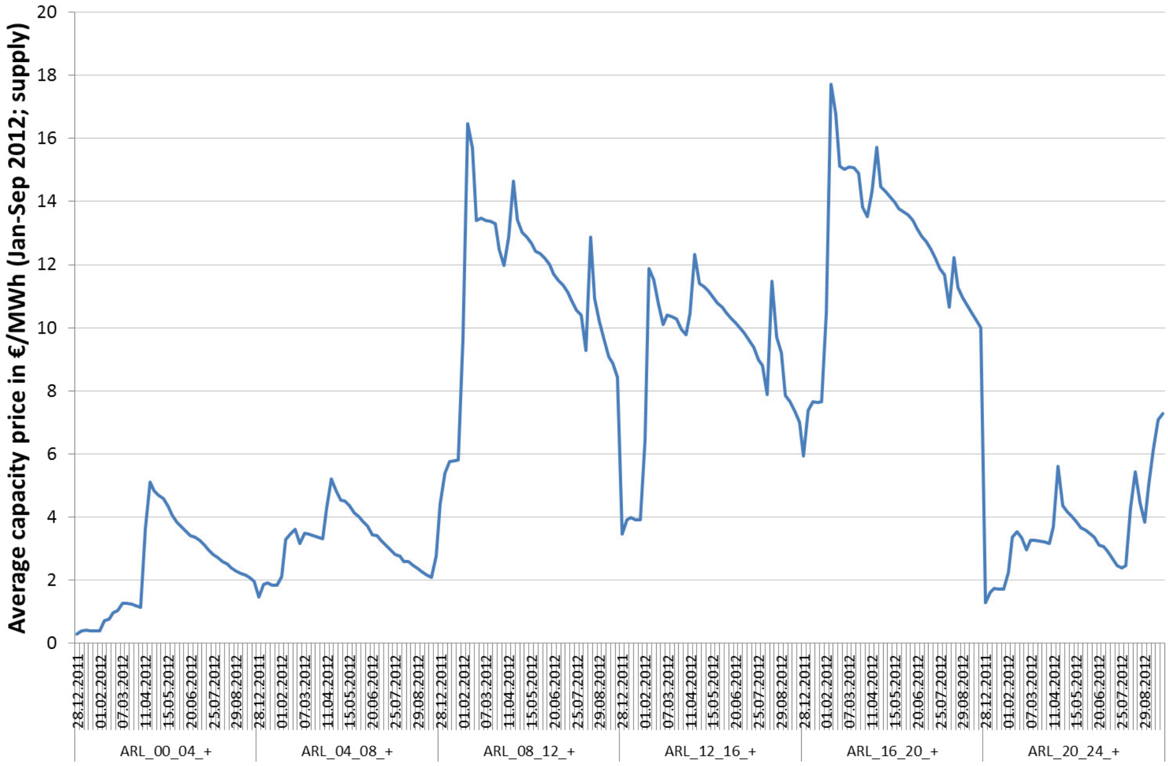


Figure 28: Average capacity price for the supply of energy/capacity (positive)

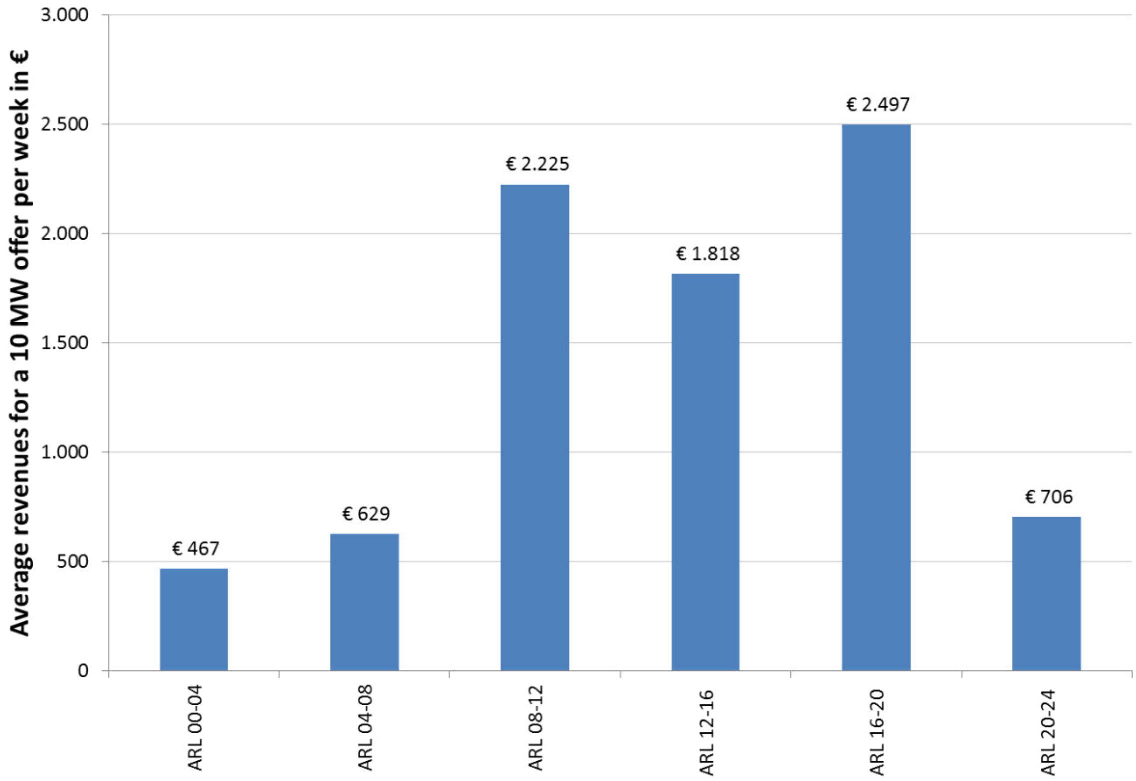


Figure 29: Average revenues for the minimum bid of 10 MW at positive tertiary control market (Mon-Fri)

Figure 29 shows the average earnings for providing capacity at the positive tertiary control energy market (ARL) for the Market Maker auction from Monday till Friday. The time slots for the single bids always have duration of four hours. For example a bid from 4 to 8 am means that from Monday till Friday the bidden capacity has to be available for a call at the given time. If the capacity is not available, the bidder can be punished. As can be seen in Figure 28 there is a big time variation in possible earnings. The further calculations will be done with the average revenues from Figure 29.

6.3.3.2 Energy price

The second part of a Market Maker bid is the energy price. There is no connection between capacity and energy price. A low capacity price does not imply that the bidder gets called. After being accepted in the capacity auction, every successful bidder has to give up a bid with his energy price. Until the delivery time and date he can change his bid but only if it's an advantage for the system. If you have to actually provide tertiary control capacity doesn't depend on your capacity price, in this regard only the energy price matters. The bids get sorted from lowest to highest in case of supplying energy and from highest to lowest in case of using additional energy. Depending on the need for control energy the bids get called in this order.

The database for this analysis is better than the one we had for evaluating the capacity price. The data are from APG for 2012 Jan-Oct (APG, 2012) and from APCS (APCS, 2012) for 2011. This amount of data is not enough for a statistical significant analysis, but enough to get an overview over possible earnings.

In Figure 30 you can see the count of positive and negative tertiary control energy calls in 2011. In Figure 31 you can see the same for 2012.

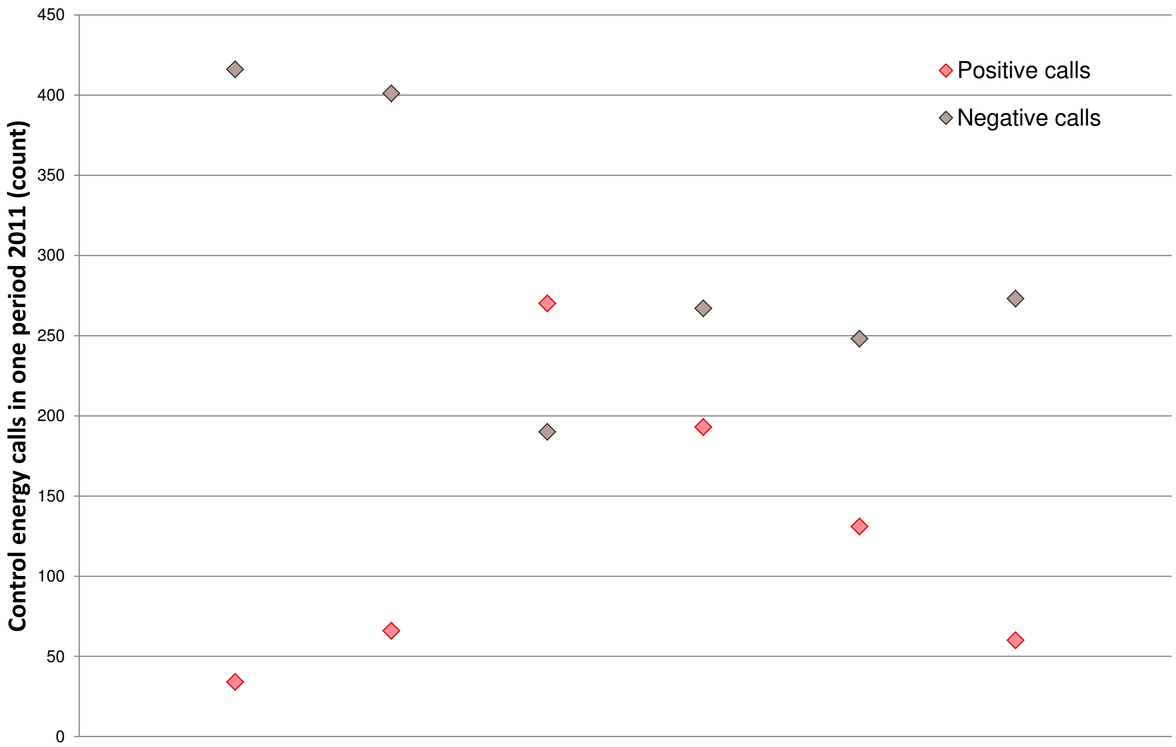


Figure 30: Count of positive and negative tertiary control energy calls 2011 (APCS, 2012)

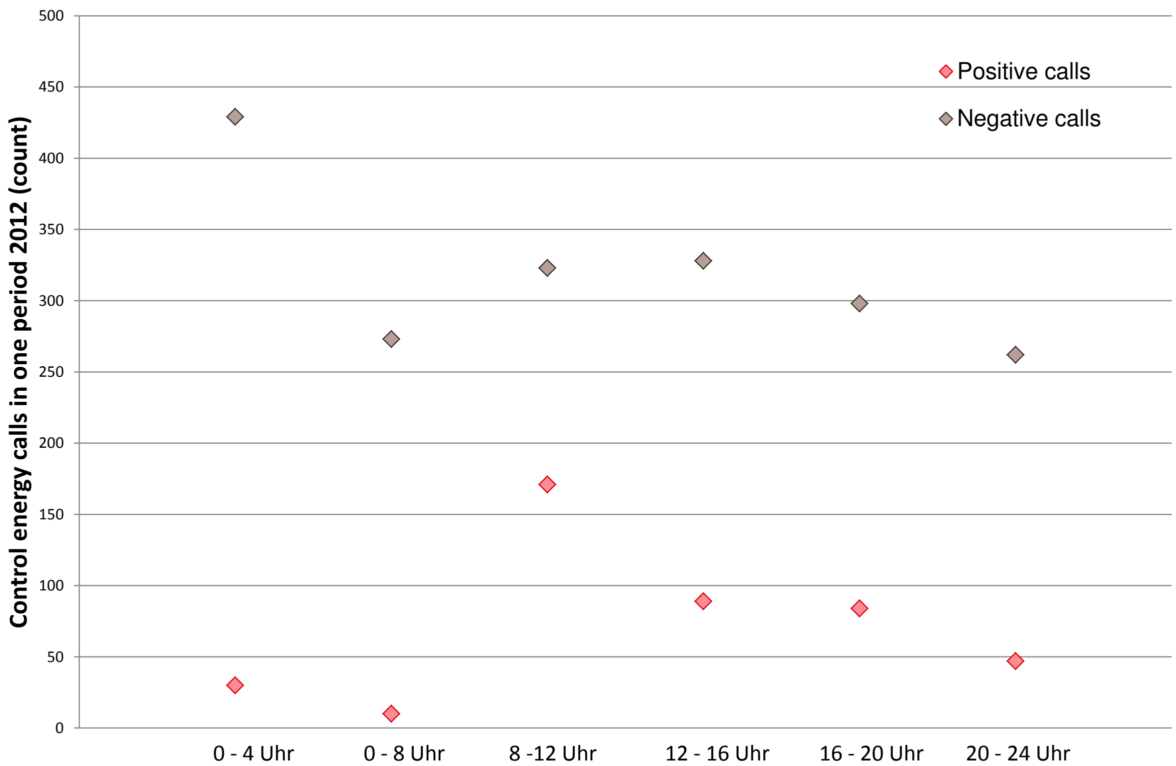


Figure 31: Count of positive and negative tertiary control energy calls 2012 (APG, 2012)

As can be seen negative calls occur far more often than positive calls. Figure 32 and Figure 33 show the price variation of the positive calls (ARL) in 2011 and 2012. For the negative calls (TRL) these price variation are shown in the annex.

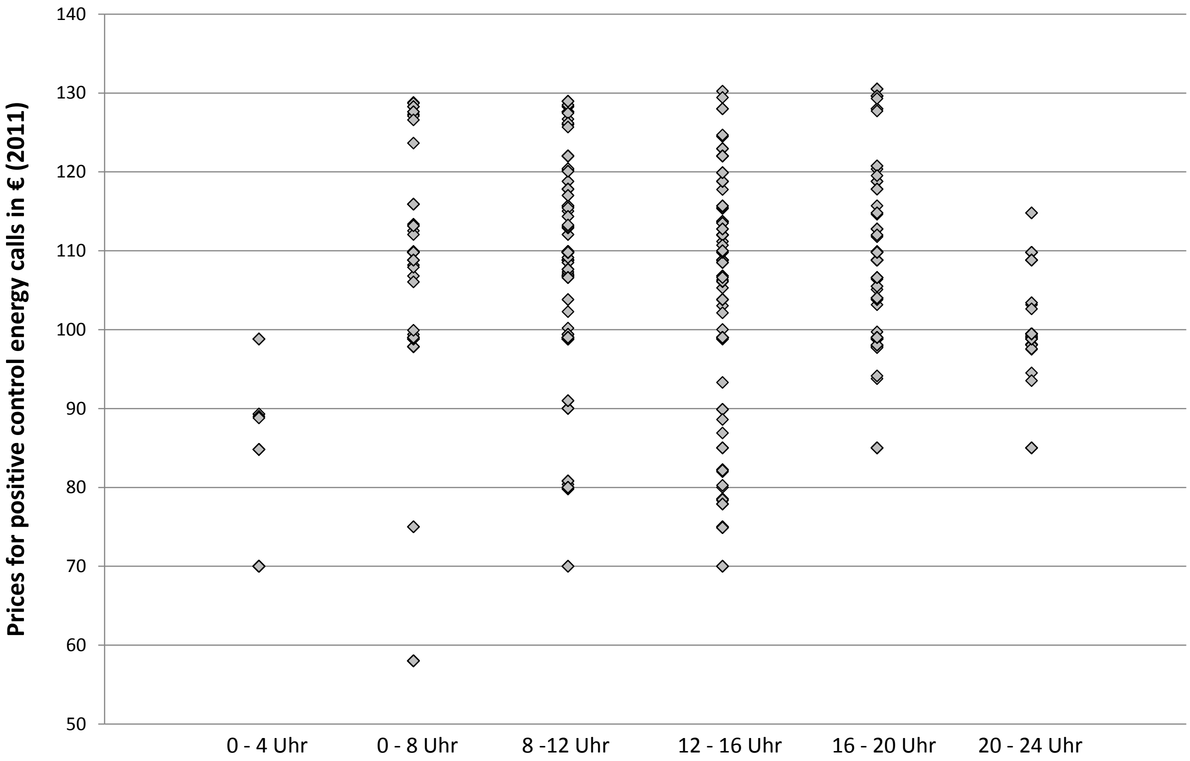


Figure 32: Price variation of positive calls 2011 (APCS, 2012)

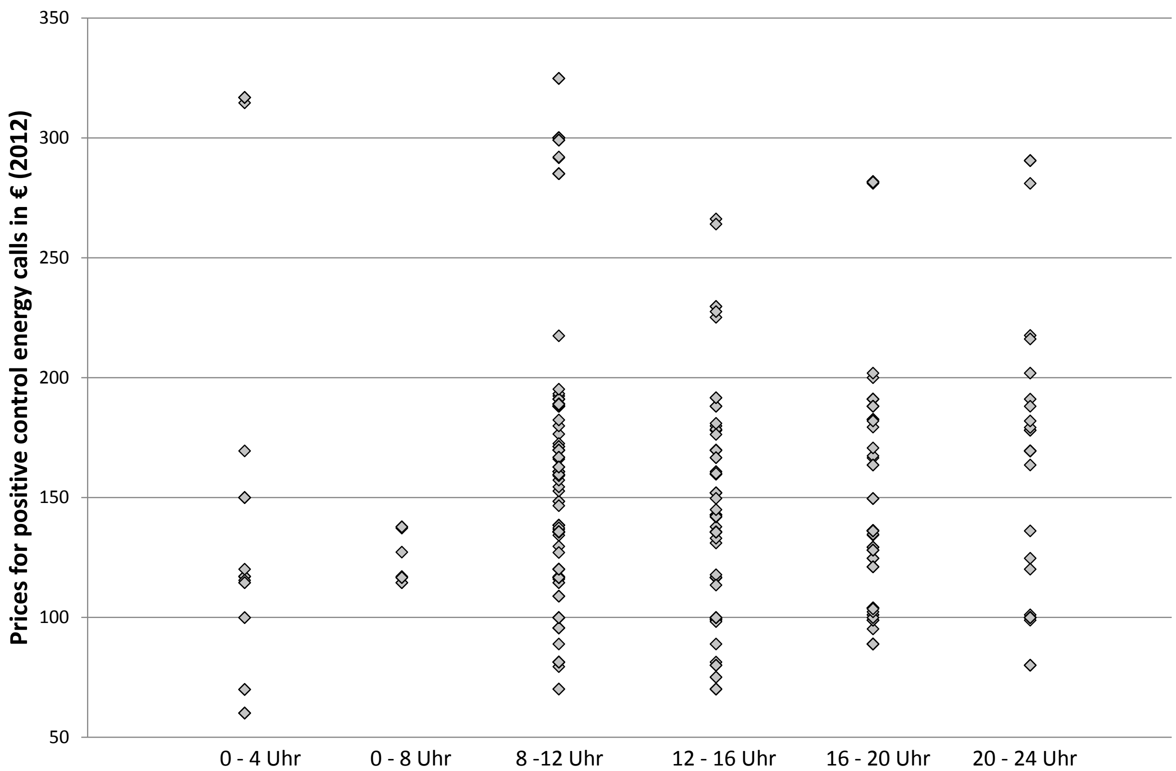


Figure 33: Price variation of positive calls 2012 (APG, 2012)

As can be seen from these figures, the prices in 2012 were by far higher than in 2011. The beginning of the Y axis in Figure 32 and Figure 33 is set up to 50 €, because there were no calls below 50 € for positive calls in the last two years. You will find a calculation of possible incomes in the conclusion.

6.3.4 Possible incomes at control energy market

In the previous chapter the capacity price and the energy price which are possible incomes at the Market Maker market get described. Because of the short time base of available values possible incomes cannot be calculated. It can be seen in Figure 29 which average prices for capacity where achieved in 2012. Out of this data possible average incomes can be derived. The incomes at the energy market depend on the actual situation at the spot market and cannot be calculated in a significant way due to the possibility that no control energy is needed in the call-period. Because of the decoupling of energy and capacity price a bidder who has bid a high capacity price can have a low energy price and therefore be called very often, or vice versa. Another effect which makes this calculation difficult is that every new bidder at the market influences the clearing price. If DR has high capacity costs, there will be no influence on the market. If DR measures are competitive to existing bids, the capacity price will be lower in future than today. There will be further investigations needed to find out the costs for cancelling production in special companies. This figure will be the minimum value for bidding at control energy market. Hence at this point there is no further calculation of possible incomes, but an interested person can calculate his possible incomes because of the data from the previous chapter.

7 Conclusion

There is definitely high potential in Austrian industry for DR. This is one of the results of the interviews and the up scaling of DR potential in Austria. The up scaling is based on the fact that most of the different industrial sites of one branch do have similar potentials. A high DR rate can help to keep the electricity system safe and cheap for the future. DR can support power plants especially in times of peak load. But because of less knowledge and experience with DR, companies often have concerns or do not see the potential. They fear interrupts in the process chain and therefore companies often are not open minded for DR measures. That’s why the most promising way to implement DR in large scale will be to talk to people and analyse their demand and process chain. After that is has to be decided which application in which dimension of power can be done at an industrial site. The pivotal question will be how fast different business models for different branches or processes will be developed to assure companies to do DR. Another restriction is if a company has a good order situation there is rather little incentive to risk production output because of load management, even if it would be possible.

The simulations in the report for the application peak load reduction are based on the assumption that in 2012 320 MW DR is available (interviews, up scaling). For the application of redispatch reduction just 40 MW are assumed in the main part of the report, but this

40 MW are concentrated at one node. As can be seen from our results out of ATLANTIS, a decrease of costs for the supply of all customers occurs as well as ecological benefits because of reduction of CO2 emissions in most of the simulations. Also one effect is that the use of old plants for peak load hours can be limited. But DR response does not replace new plants; it is a measure to operate existing plants in a more efficient way.

In case of tertiary control energy market (Market Maker) the data were not satisfactory for a statistical analysis. The possible earnings are fluctuating a lot over a year. Even if there definitely is a potential for this application further investigations will be needed. But there are processes in industry which fulfil the prequalification conditions and do fit for this application.

There are also other stakeholders which could have an interest in DR in industry. These are for example transmission system operators (TSO) and distribution system operators (DSO). They may have a support out of DR in critical grid situations, are able to influence the load flow over the national borders or they can reduce their peak load demand (DSO pays for the maximum load a fee to the TSO).

The findings of the EDRC project could be an input for dissertations at the Institute of Electricity Economics and Energy Innovation. The dissertation topics are capacity markets and capital stock in the electricity system. Therefore DR has an impact on these topics and this work can be used as a base. Parts of this work were published at the "8. Internationale Energiewirtschaftstagung" in Vienna in February 2013 (Hütter, Schüppel, & Stigler, 2013).

The results of the ATLANTIS simulations in the main part of this report are only valid under the given input parameters. The most important input parameters are derived from the 450 ppm scenario of World Energy Outlook 2010 (International Energy Agency, 2010) (e.g. fuel prices), the National Renewable Energy Action Plans in case of development of generation of renewable energy sources in Europe and the Ten Year Net Development Plan for the transmission grid. The main findings in regard to the use of DR measures are:

- A cost benefit for the whole electricity system
- Lower CO_2 emissions in comparison to a system operating without DR
- Power plants can be operated in a more efficient way
- The European context of DR should be considered in further investigations

Another result is that possible effects do not increase linear with an increased DR potential. The results with an about three higher DR potential as in the main part (results are in the annex), do not show greater effects for the electricity system. The main advantage of such a high potential could be a higher availability of DR potential when it is needed.

8 Next steps

Further steps of this project should be to set the focus from Austria to the entire European region. The interdependencies between countries all across Europe were just a small part of the EDRC project. Therefore a detailed analysis with DSM in all countries with respect to their individual industries and especially to their demand variation during the day, week and year are important.

A further research of possible applications and stakeholders (interviews) should be done as well. More interviews with different stakeholders and with operators of industrial sites are necessary. The image of DSM measures should be changed and brought to relevant companies. Often companies do have a misimpression of what DSM is, what its advantages could be and how to set it up in their special production process.

A more practical approach would be a large scale prototype or commercial use of a system that aggregates many DSM-suppliers to one pool. Such systems could help to support the grid as well as to operate the existing power plants in a more efficient way. The benefits of a large scale system may lead to less need for new power plants, a more ecological way of generating electrical energy and to a safer system for all users.

9 Annex

9.1 Additional information to application peak load reduction

9.1.1 Load curve adaptions in the case 1,000 MW

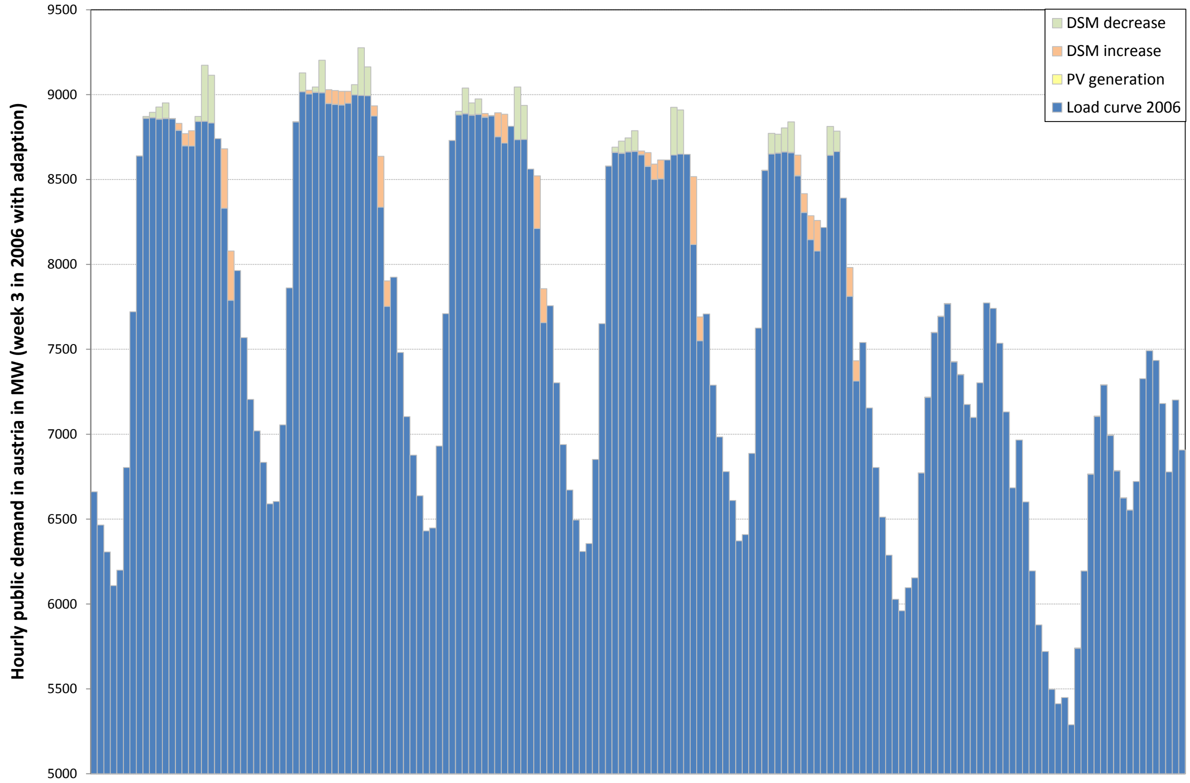


Figure 34: Load curve of Austria 2006 with DSM adaption (week 3 in 2006 – Austria; case 1,000 MW)

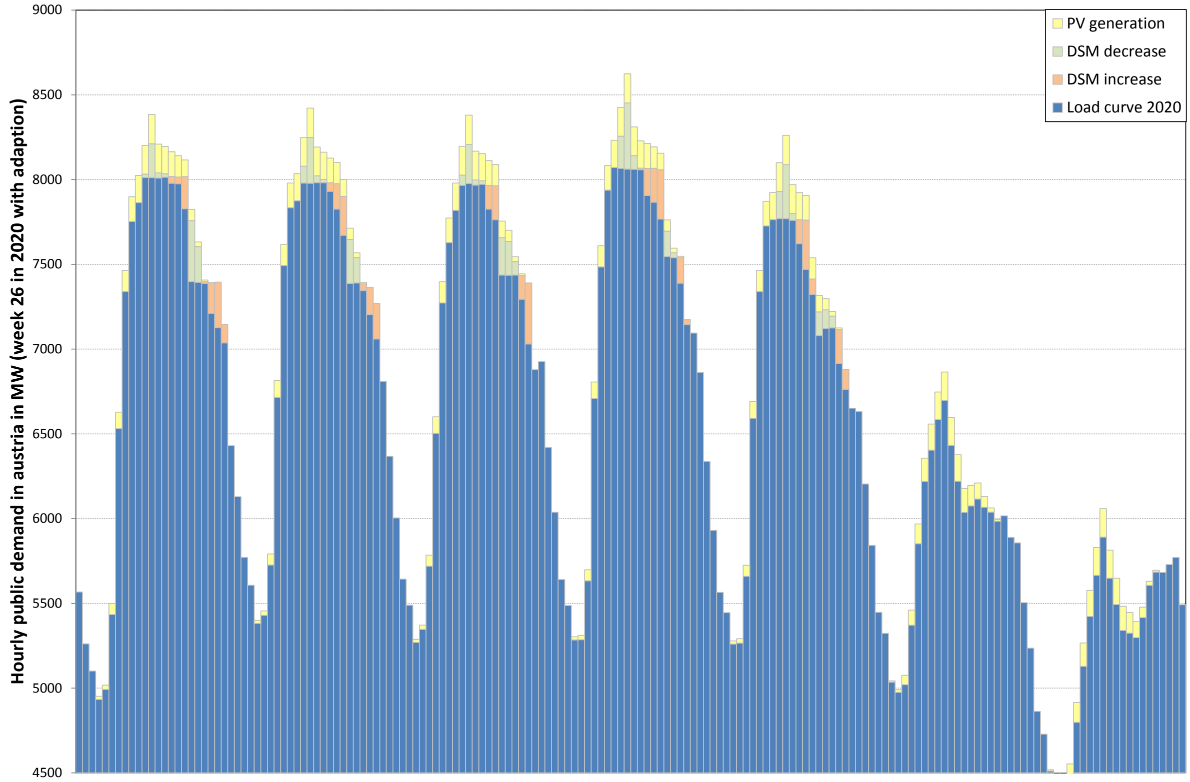


Figure 35: Adapted load curve with respect to PV generation (week 26 in 2020 – Austria; case 1,000 MW)

9.1.2 Generation in Austria in case 1,000 MW

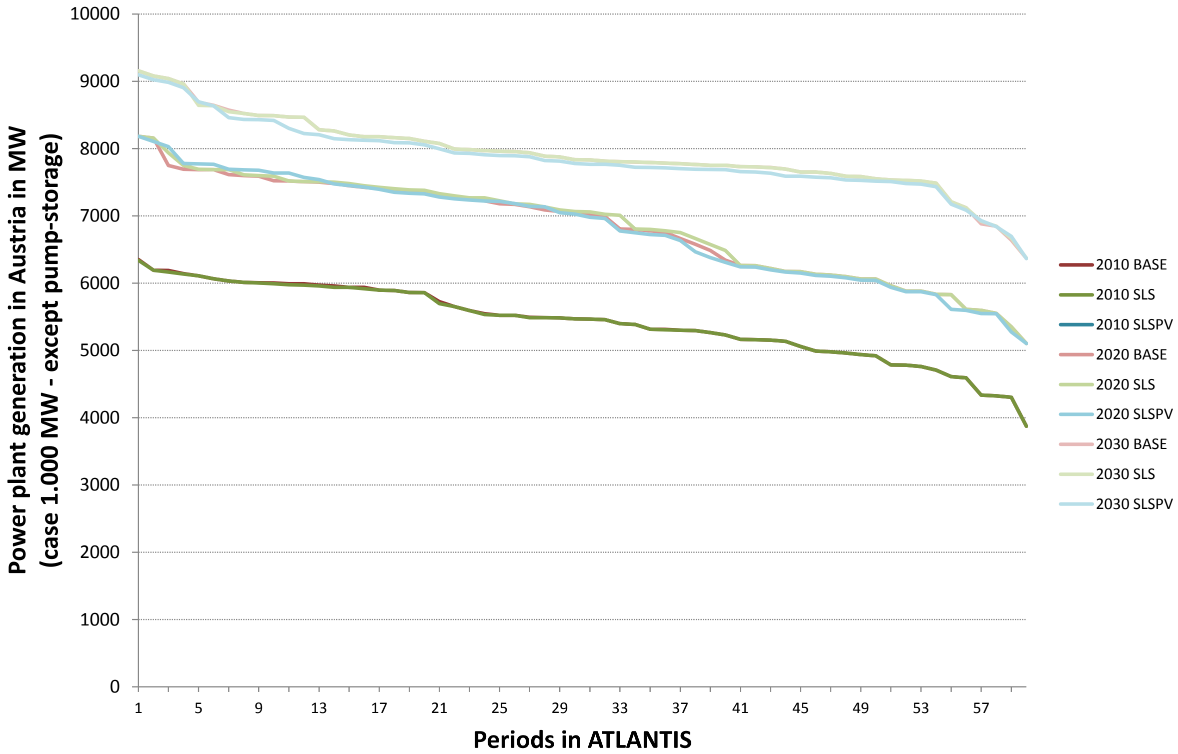


Figure 36: Overview of generating in Austria in case 1,000 MW (except pump-storage)

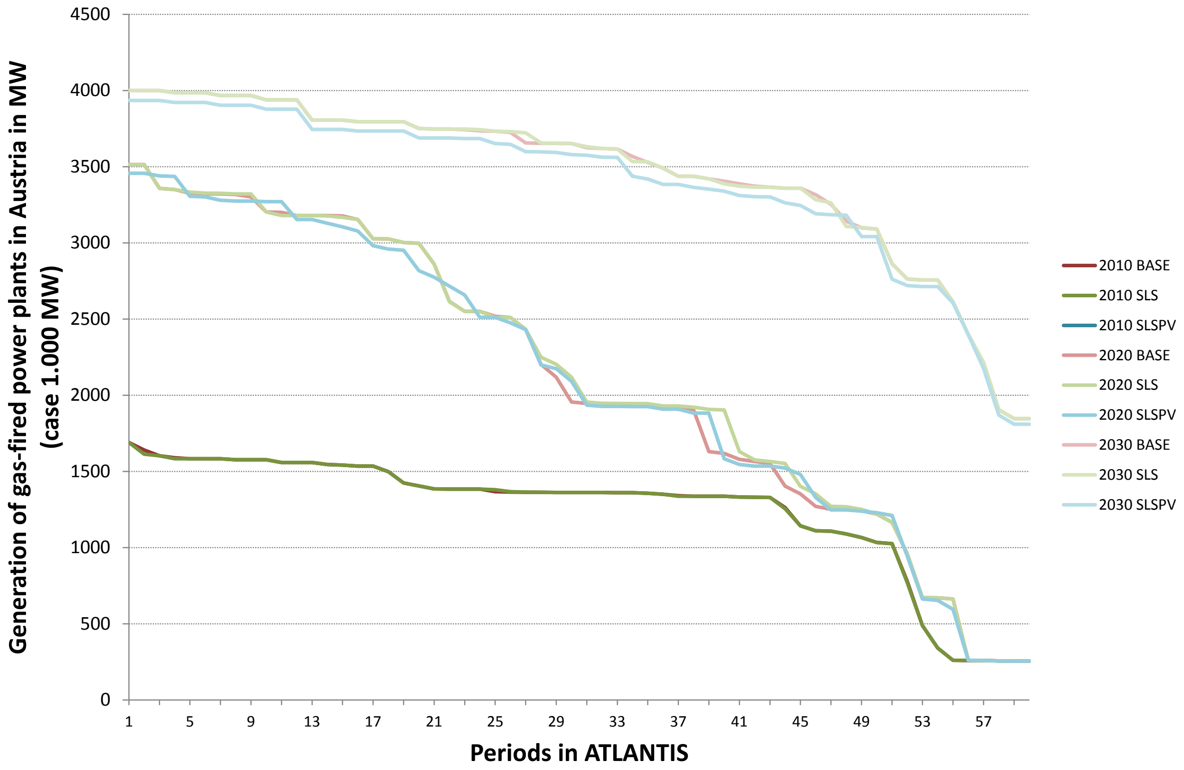


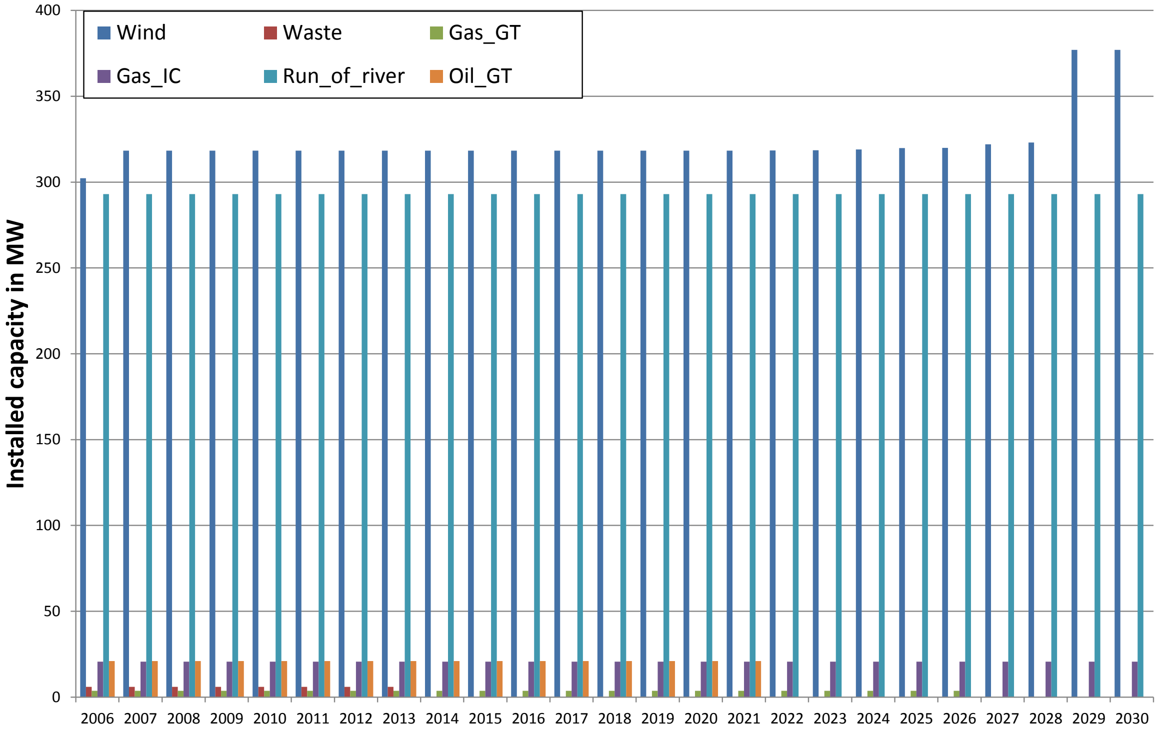
Figure 37: Generation of gas-fired power plants in Austria (case 1,000 MW)

Figure 38: Changings in import export compared to BASE case for SLS 1000 MW and SLSPV 1,000 MW

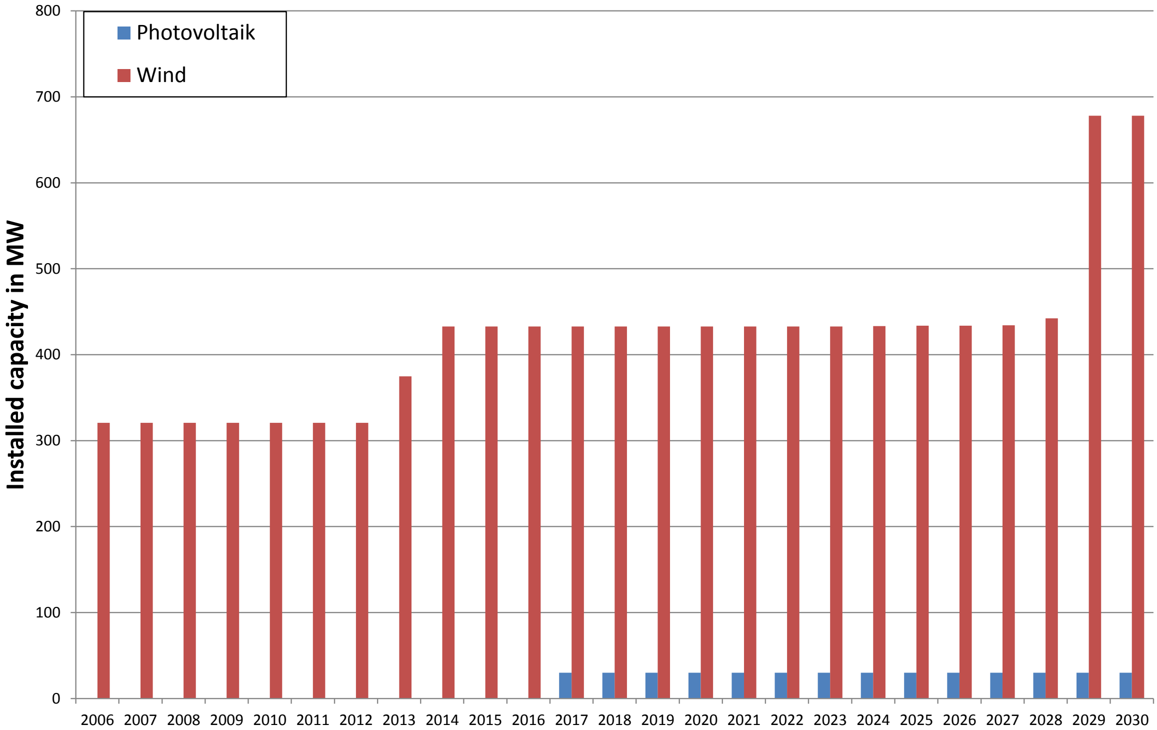
9.2 Additional information to application redispatch reduction

9.2.1 Generating structure of used nodes

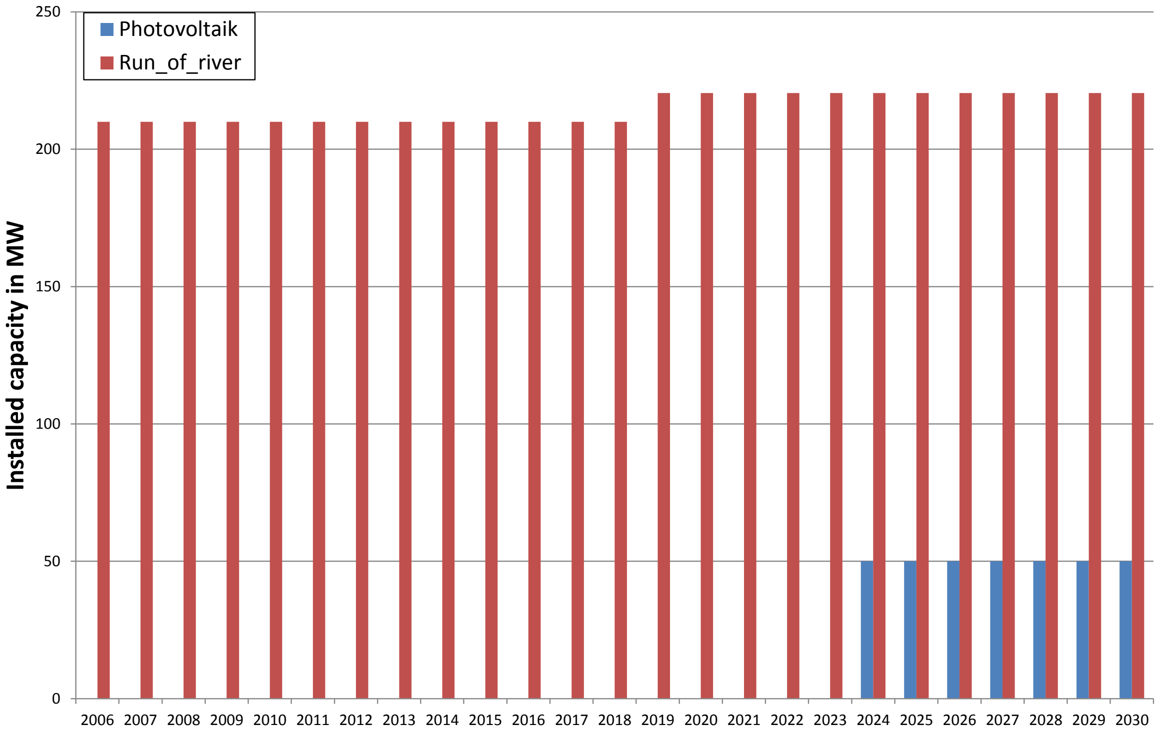
9.2.1.1 Node Bisamberg (220 kV)



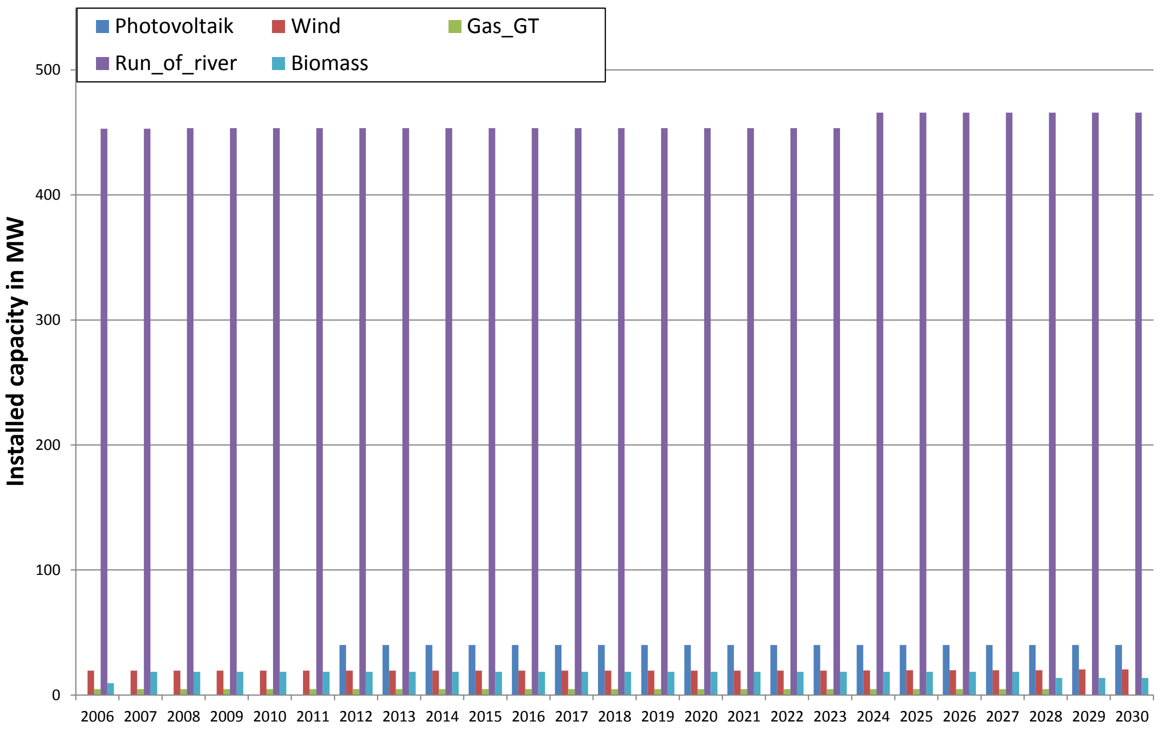
9.2.1.2 Node Stixneusiedl (400 kV)



9.2.1.3 Node Wallsee (220 kV)



9.2.1.4 Node Ybbsfeld (220 kV)



9.2.2 Redispatch variation by using DSM at different nodes (DSM potential 200 MW a day)

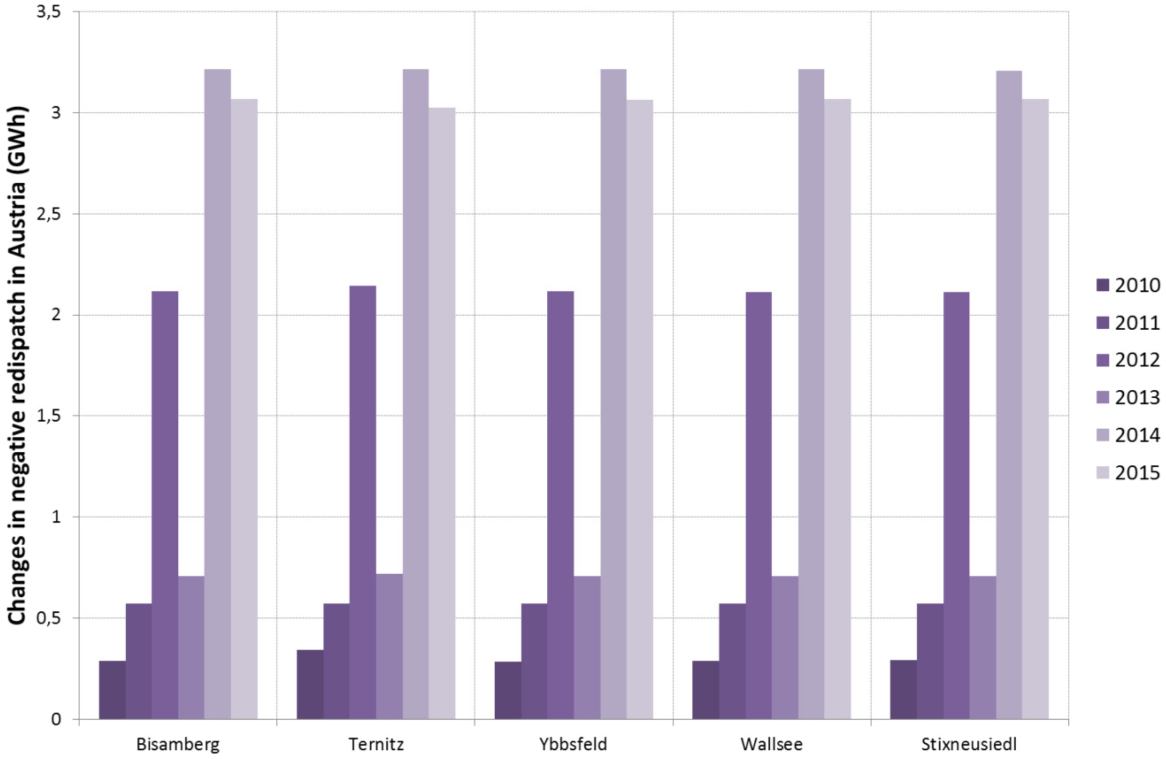


Figure 39: Changes in negative redispatch at different showcase nodes in Austria between 2010 and 2015

9.2.3 Reduction of CO_2 emissions (DSM potential 200 MW a day)

Figure 40: Reduction of CO_2 emissions in case 200 MW at different showcase nodes

9.2.4 Changes in generation in Austria (DSM potential 200 MW a day)

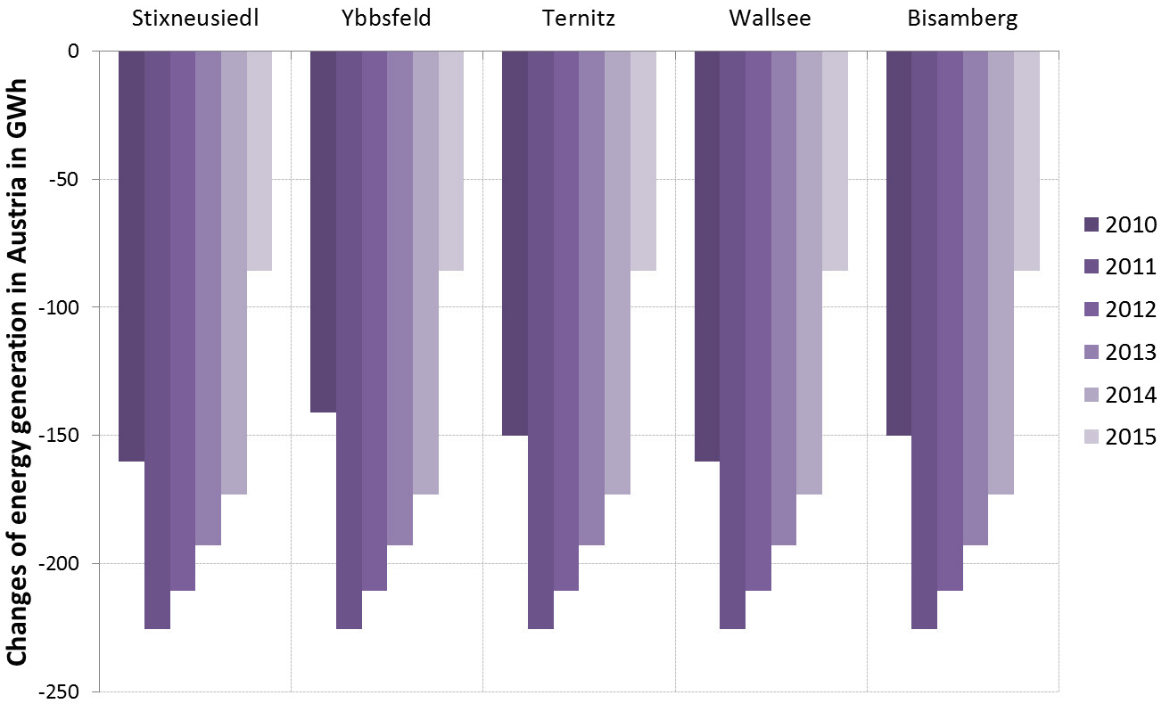


Figure 41: Changes in generation in Austria (all plant types) in GWh

9.3 Additional information tertiary control energy market

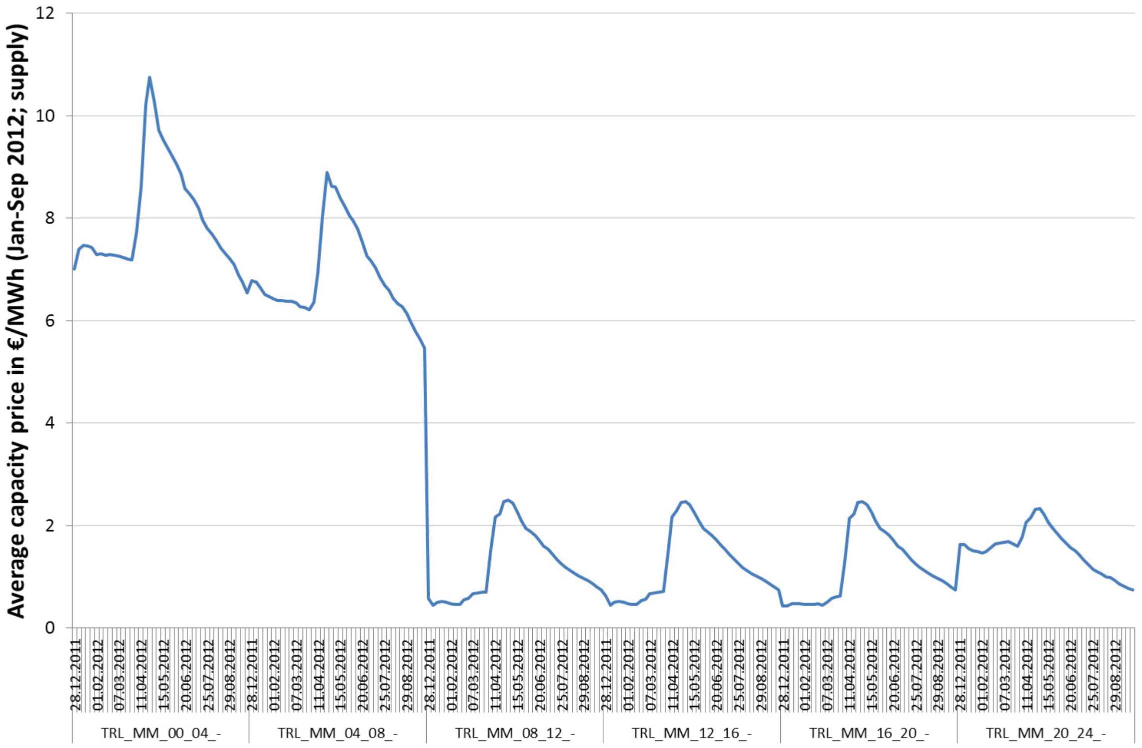


Figure 42: Average capacity price for the supply of energy/capacity (negative)

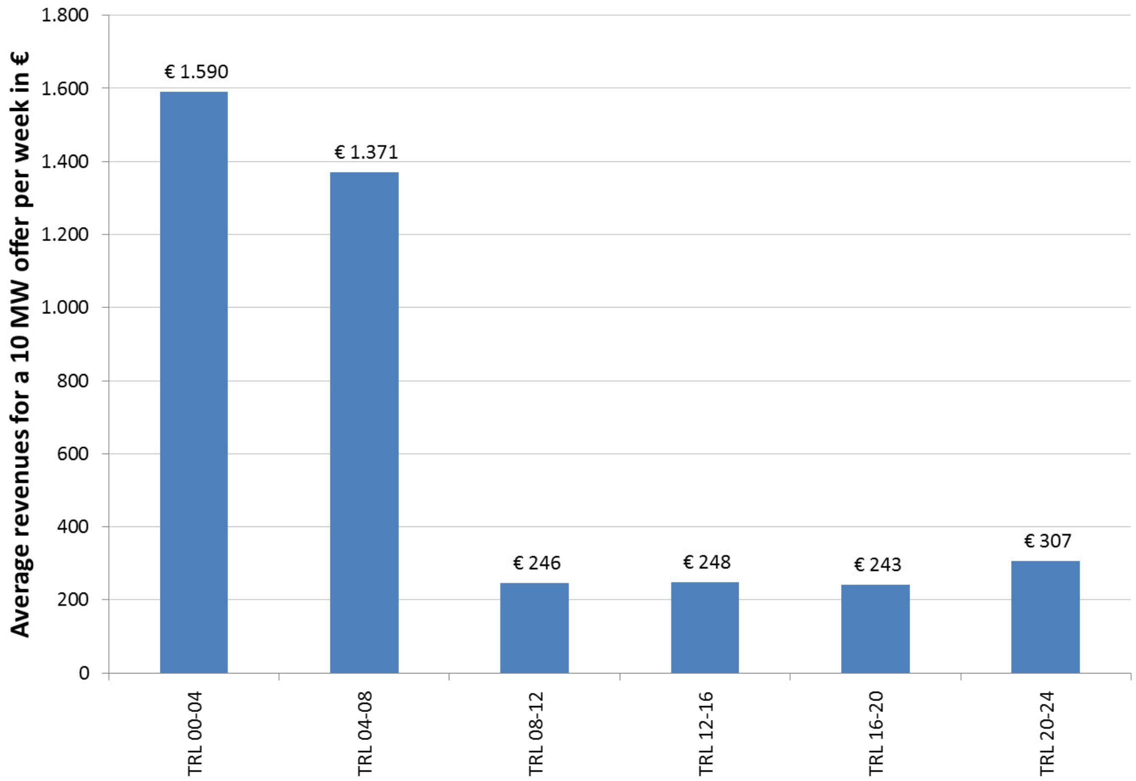


Figure 43: Average revenues for the minimum bid of 10 MW at negative tertiary control market (Mon-Fri capacity price)

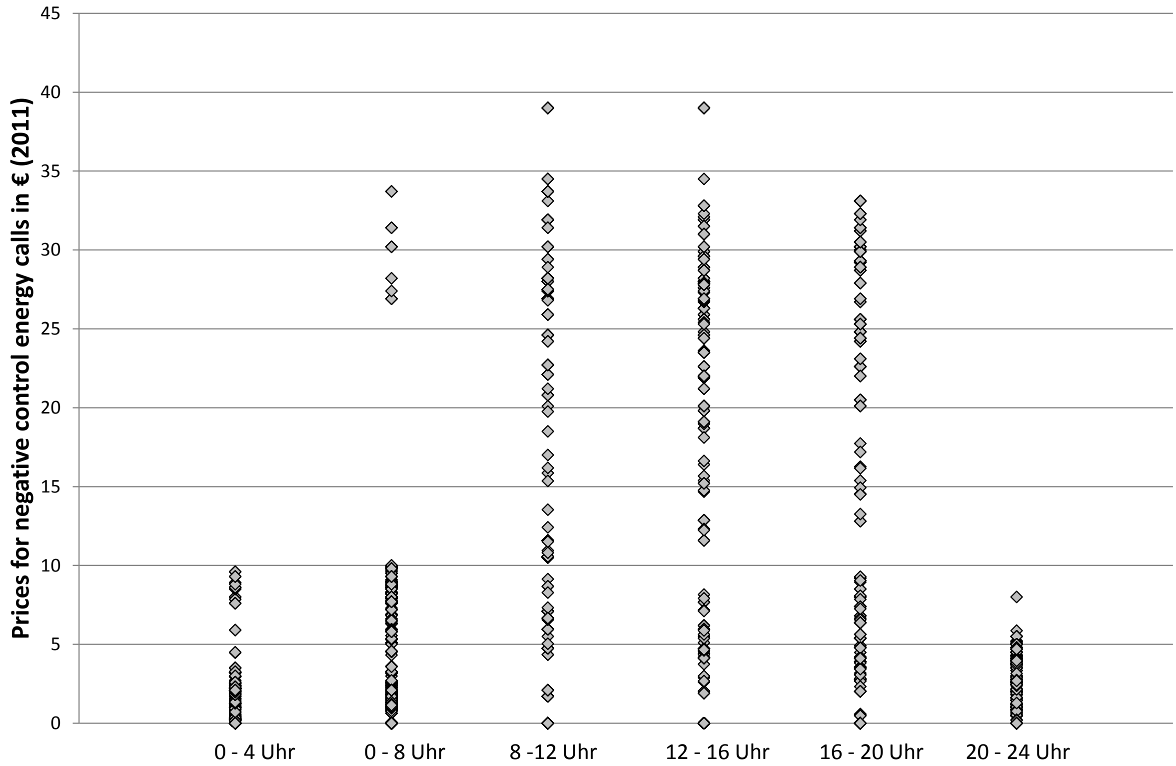


Figure 44: Price variation of negative calls 2011 (APCS, 2012)

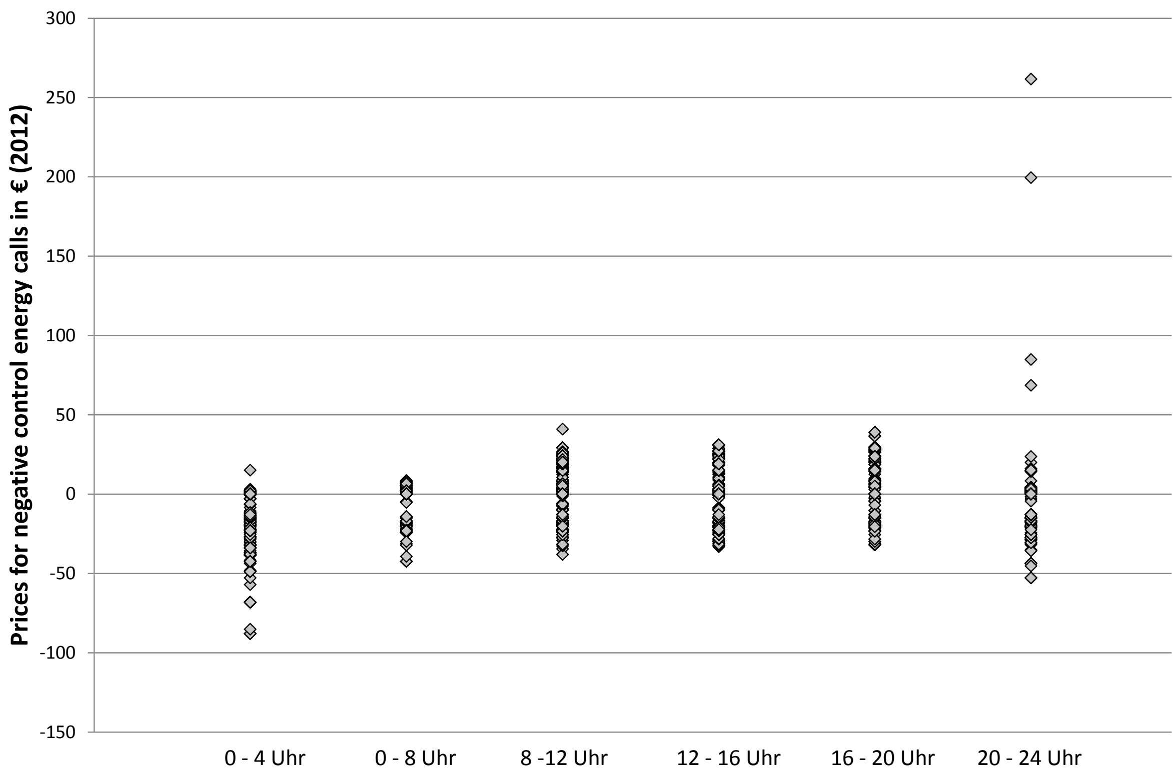


Figure 45: Price variation of negative calls 2012 (APG, 2012)[5]

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[5] As you can see from Figure 45 that is was possible in 2012 to use energy because of stability and get paid for this use (negative price as energy bid)

11 List of tables

12 Literaturverzeichnis

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