“Innovative Business Models for Market Uptake of Renewable Electricity unlocking the potential for flexibility in the Industrial Electricity Use”

Flexible Industrial Demand Assessment

Case Studies Summary

Public version

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Introduction

The report summarizes the results of demand response audits (DRA) at the premises of different energy intensive companies in various European countries for various business models, which were conducted as a part of the IndustRE European project.

Depending on the particular market design and regulation, several relevant business cases for flexible industrial demand (FID) can be identified. The identified business cases can be grouped in four categories: 1) Electricity Bill Reduction, 2) System Service Provision, 3) Balancing Service Contract with off-site variable renewable energy source (VRES), and 4) Electricity Bill Reduction with on-site VRES[1].

The business models are adapted to 6 industrial sectors, which with 403 TWh/year represent more than 10% of the electricity consumption in Europe (Chemicals, non-ferrous metals, cold storage, steel, paper, and water treatment) and 6 target countries (Belgium, France, Germany, Italy, Spain and UK.

Demand response audit

A demand response audit (DRA) is a generic approach for identifying, evaluating, and exploitation of flexibility in a flexible industrial demand (FID). It can be used either for exploitations purposes of existing flexibility in the process, or during the process upgrade to make it more flexible ("design for flexibility").

DRA consists of the following steps: Identification of flexibility in the process, Quantification, and Valorisation[2]. During the **quantification** step, the exact amount of flexibility per flexibility source is modelled. Once the flexibility of the relevant processes is quantified in a flexibility model, the value of the flexibility can be calculated in the **valorisation** phase.

The quantification and valorisation steps can be executed in two ways: by developing tailored models of the identified flexible processes and optimizing them to the chosen business model (the full methodology), or by a four step simplified ProFLEX approach developed specifically to quickly get a sufficiently accurate estimation of the flexibility value[3].

Demand side audits were conducted for the following combinations of industrial sectors, countries and business models:

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[1] For more information, please refer to http://www.industre.eu/downloads/download/business-models-and-market-barriers

[2] A detailed description of the different steps can be found at http://www.industre.eu/downloads/download/adapted-methodology-for-optimal-valorization-of-fl

[3] For more information see http://www.industre.eu/downloads/download/simplified-methodology-for-optimal-valorization-of or https://www.youtube.com/watch?v=w8fsJxXaLyY

1) Germany, (waste) water treatment industry, electricity bill reduction with on-site VRES
2) Belgium, paper industry, balancing service contract with off-site VRES (imbalance business case)
3) UK, cold storage industry, system service provision (reserves) and electricity bill reduction (TOU and day-ahead prices) electricity bill reduction (day-ahead prices)
4) Italy, steel/cast iron industry, electricity bill reduction (TOU and day-ahead prices)
5) France, cold storage industry, electricity bill reduction (day-ahead prices)
6) Germany, chemical industry, electricity bill reduction (day-ahead prices)
7) Germany, non-ferrous industry, electricity bill reduction (day-ahead prices)

The case studies were executed using the full methodology, the ProFLEX methodology, or both methodologies, depending on the data availability and properties of the identified flexible process. Table below summarizes the calculated business cases and indicates which methodology in applied for which audit.

	Chemicals	Non-ferrous	Cold storage	Steel	Water treatment	Paper
Belgium						balancing service contract with off-site VRES full methodology
France			electricity bill reduction ProFLEX methodology			
Germany	electricity bill reduction ProFLEX methodology	electricity bill reduction ProFLEX methodology			electricity bill reduction with on-site VRES both methodologies	
Italy				electricity bill reduction both methodologies		
UK			system service provision and electricity bill reduction ProFLEX methodology			

The first five DRAs from the list were executed by VITO/EnergyVille, whereas the last two (electricity bill reduction in Germany in chemical and non-ferrous industry,) were executed using the ProFLEX methodology by a consultancy company under the supervision of VITO.

The case studies in paper industry in Belgium and in chemical industry in Germany focused on evaluating benefits of having additional flexibility onsite for which significant capital investment was required (design for flexibility), whereas in other case studies, the existing flexibility in the industrial process was evaluated.

The goal was to empower the audited companies with detailed insights in the amount and value of flexibility available on their particular site that was audited, and in such a way facilitate the decision making process.

The reported numbers should be interpreted as an upper bound on the real expected cost savings, as they are obtained under a number of critical assumptions that might negatively affect the obtained business case value. For instance, only the commodity price is considered and not the network tariffs. In some cases, this will affect the total numbers as network tariffs might change as a consequence of providing flexibility. Similarly, the presented evaluation of flexibility is done under the assumption that the prices are known in advance. This is not the case in general for all the business cases, and in particular it is expected not to be the case for the balancing service contract with off-site VRES business model. Although some prices are well predictable, the ultimate operational flexibility value will depend on the price forecaster used in the process control system, in which an optimization of the process schedule is determined.

Overview of the results from the case studies

Different sources of flexibility were identified on the audited sites. Emergency generators, refrigeration system (the cold storage part of the process) and battery charging station were the identified sources of flexibility in the two audited cold storage sites. Depending on the site, flexibility source, and business model, the estimated normalized flexibility value ranges from 2,5 €/MW/h to 7,21 €/MW/h. The most promising gains were estimated for the case of emergency generators providing system services.

In cast iron plant, a source of flexibility was found during the site visit in the thermal inertia of an induction furnace, which was not expected by the customer and consequently not indicated up front in the questionnaire. The flexibility value for the electricity bill reduction business case is estimated to be around 3-4% of the flexible process's energy costs or just below 1% of the total energy costs of the plant.

In waste water treatment plant, two different sites were analysed: one with on-site variable renewable generation (wind), and the other without VRES. Flexibility was found in aggregation of flexibility from aggregation of a number of different smaller processes and in own CHP production. The value of combined flexibility of the aggregated demand response and own CHP production was estimated to be around 3% of the total electricity costs for the considered waste water treatment plant with no VRES if the electricity bill reduction business case is considered. The value of flexibility of the second site for the electricity bill reduction with on-site VRES business model is estimated to be 1-2% of the total electricity costs.

The flexibility source in non-ferrous plant was identified in a possibility to shift a discontinuous (batch) process of alloy melting in time. The process could provide flexibility by partially shifting the batch production from peak electricity cost time instances to low cost instances.

The anticipated net savings, after taking into account the increase in electricity demand due to shifting (to keep the process warm), are estimated to be lower than 1% of the total plant's electricity costs.

The audited paper producing company already had rich experience in providing demand response. Demand flexibility in the process originated from historical over-dimensioning of the process, and a product storage capacity between the chemi-thermomechanical pulping and the paper mills and was already offered to the system through different business models (system service provision and electricity bill reduction), with more business models being under consideration for implementation (balancing service contract with off-site VRES). Therefore, for paper industry, feasibility of electric boilers under the current market conditions was examined. This was an example of utilisation of the demand response audit methodology for "design for flexibility". The feasibility of electric boilers was analysed under the balancing service contract with off-site VRES conditions. In other words, the audit was done under the assumption that an electricity boiler is used next to the gas boilers to produce heat at moments when the imbalance price is beneficial compared to the gas price. If electricity boiler is fired in response to the real-time imbalance prices to correct the electricity imbalance, the estimated upper bound on the yearly savings due to utilisation of electric boiler are expected to be around 1,5% of the total energy costs. Depending on the requirements on return on investment in paper industry, possible consequences on the electricity network tariffs due to addition of the electric boilers, and the shorter expected lifetime of electric compared to gas boilers, this might result in a positive or negative investment decision.

The flexibility in the audited chemical industry was found in the liquefaction process of the air separation unit in combination with the gas storage, for which additional investment would be needed. This is another example of utilisation of the methodology for the purposes of "design for flexibility". The value of flexibility due to process extension is estimated for the electricity bill reduction business model. Although the estimated yearly flexibility value was large in absolute value, it amounted only to just above 1% of the additional investment costs for making the process flexible. The required minimal flexibility value to justify the investment was set to be around 5% of the additional investment costs, and the analysis resulted in a negative business case for this particular investment.

Conclusions from the case studies

The case study results give some inspiration for the flexible process in a certain industry branch. The case studies are chosen to cover a large number of industrial processes, countries, and business models, but are not necessarily representative to generalize the conclusions to the whole industry branch. It was not the ambition of the case studies to draw generic conclusions on the total flexibility or flexibility value per industrial sector or country from these executed seven cases studies. The ambition was rather to show the width of applicability of demand response audits and inspire and empower the industries to make decisions about participation in demand response mechanisms.

The particular flexibility value will vary significantly from plant to plant, depending on the particular electricity contract, chosen business model, regulation in the country in which the plant is situated, and the peculiarities of the flexible industrial process under consideration. For an automated flexible process, the additional investments to provide flexibility are often limited to minor changes in software. Nevertheless, if additional hardware components are required, the additional costs may become significant and impact the expected return on investment.

The flexibility value is in majority of cases expected to increase further if a combination of several business models is considered, or if a combination of different flexibility processes is offered by means of one or more business models.

In general, it was observed that it is easier to get the demand response related topics on the agenda of a certain company if the electrical power costs as a percentage of the company's operational costs are significant, in most cases if they are higher than 10%.

It happened several times during the identification step of the demand side audit that a source of flexibility was found in a process which was not indicated up front as flexible in the questionnaire. This confirms the need for external parties (consultants, specialized audit companies) who can help the industries to identify the presence of flexibility. Further, it confirms that external parties can play an important role in making the industries aware that there is an electricity cost savings potential which they were not aware of and consequently where they were not looking for.

Recommendations adoption

Implementation of the follow-up discussions with audited companies

A structured follow-up process with key respondents from all audited companies was realized by ECI some time after the demand response audit. The goal of the follow-up process was to better understand the likelihood of adoption of the identified flexibility potential and the possible barriers that prevent the audited companies from taking immediate action.

All seven audited companies received upfront a structured questionnaire to facilitate the preparation and internal collection of the different elements and pieces of information for the feedback. Then, a phone interview to go through all topics was scheduled to gather additional clarifications and better understand the reasoning of their feedback answers. The interviews were conducted between September and early December 2017.

Key representatives of each audited company provided detailed feedback on:

- their experiences with the demand response audit process as set up by VITO/EnergyVille
- attractiveness and feasibility of suggested implementations to exploit flexible demand in their processes

- measures that are more likely to be adopted and measures that are not (yet) considered and why
- the internal decision-making process on potential implementations of flexible demand in their industrial processes

In addition, ***for those sites with potential for on-site variable renewable energy generation***, the follow-up discussions have explored the likelihood and challenges for installation of on-site variable renewable energy generation.

Feedback on the VITO/Energyville demand response audit process

Whereas for experienced companies used to do internal energy audits and evaluations, the collection and preparation of the requested information was quite easy and quick to manage, particularly the larger organizations among our case study companies stated that this process was very time consuming and challenging as it involves different departments and people, sometimes even outsourced duties.

Hence the efforts stated to prepare the information and organize the subsequent on-site visits for the case study companies vary heavily: from one to max two man-days for the companies that have relevant experience up to about 10 man-days for the other companies.

The site visit turned out to be the most interesting and useful part of the assessment for most of the case study companies, as many aspects regarding energy usage and flexibility in demand have been only identified on the spot and during the discussion with VITO/EnergyVille.

All companies appreciated the outcome of the assessment as a detailed deep analysis of the site and a clear and precise final report.

Likelihood of recommendations adoption and decision making process

Although in all seven case studies the analysis identified some potential to use industrial flexibility, a short-term implementation of the flexibility potential identified seems rather unlikely. All companies emphasized that they will take this analysis as a starting point to think internally about future ways and will continue to look into exploring their flexible demand opportunities.

The main barrier here is that most companies interviewed require pay-back periods of less than 2 to max 3 years for any larger project, which in the identified business models is currently impossible to achieve due to anticipated investments into mainly control hardware and additional operational expenditure.

Other perceived barriers for a fast implementation of flexibility exploitation measures are:

- Changes in the operational scheme and impact on personnel planning and costs (e.g. necessity to hire additional staff),

- Lack of automated control systems to monitor and adjust the industrial processes according to the optimized flexibility profile,
- Required potential changes in the electricity supply contracts (e.g. to allow purchase on the day-ahead market), which are often taken on a corporate level affecting all sites of a company.

In all investigated companies, projects related to demand response and energy need to show a robust business case to get a chance for later approval. Moreover, a full cost-benefit assessment has to be done, by calculating all necessary CAPEX and anticipated OPEX and putting them in perspective with the potential savings and gains, to meet the required pay-back time.

Final decision is usually on corporate or HQ level and could be made in some weeks to a few months, whereas the actual implementation period of such projects depends on availability of equipment, building permits, delivery and installation schedules, etc., which can take up to 1 to 2 years.

Current implementation of demand side response

Besides the newly identified business models during the demand response audit, some of the audited companies are already exploiting their flexible processes to either respond to time of use tariffs, avoid network peak charges or even to offer reserves to the system operator. In most cases, the exploitation of flexibility is conducted by

- manual following of the tariff zones during the operating time of the day,
- load shedding or load curtailment by switching manually off or reduce the power of some devices, or
- offering capacity (e.g. from over-dimensioning of the processes) to aggregators to provide reserves or balancing.

Integration of renewables

In four out of the seven audited companies, there is already an on-site variable renewable generation source installed or planned to come short-term, mainly for self-consumption, either roof PV panels or on-site wind turbines. However, there were several barriers highlighted that hinder a wider installation of variable renewable energy sources, which are listed separately for PV panels and for wind turbines.

a) Roof PV panels

- Static constraints of the roof structure and significant investment for building reinforcement needed, which makes the pay-back unattractive.
- Limited roof space available and sub-optimal inclination.

- Concerns that insurance companies will raise primes due to higher risks (e.g. fire).
- Renting roof space to external investors for a power purchase agreement (PPA) has currently too long binding periods.

b) On-site wind turbines

- Difficulties in getting permits.
- Changing and uncertain market rules and legal framework (e.g. reduced subsidies and feed-in tariffs, increased levies and taxes).
- Difficulties to nominate anticipated generation output and concerns about imbalance risks.