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DSM Spotlight

The Newsletter of the International Energy Agency Demand-Side Management Programme

ieadsm energy efficiency

Task 24 The US Joins via The Consortium for Energy Efficiency

Even though the first and maybe largest global research collaboration on behaviour change in DSM is winding down after seven fruitful years, IEA DSM Task 24 was lucky to add a new participant to the nine countries that have funded it in the past. The Consortium for Energy Efficiency (CEE) (http://www.cee1.org/behavior), is the United States and Canadian consortium of gas and electric efficiency program administrators. Ten sponsor organisations, including some of the largest utilities in the US and Canada, joined forces, with support by the US Department of Energy, to become Task 24's latest member. The National Expert is Kira Ashby, the Senior Program Manager of the CEE Behavior Program, and we have been working very closely since early 2018 with her and our Project Partner, the See Change Institute (SCI) in California.

There are many reasons why it is excellent news that CEE / US has joined DSM Task 24:

- The US is the largest energy-producing and –using country in the world and has the greatest potential for behaviour change and energy efficiency.
- North American utilities thus have the greatest access and power (literally and figuratively) to create real,

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Task 16

Testing the Concept of Simplified M&V for Energy Efficiency Projects

Measurement & Verification (M&V) is a prerequisite to assess the quantitative outcomes of energy, water and CO_2 saving measures. This applies both for 'in-house' (or 'do-it-yourself') implementation as well as through outsourcing to an energy service provider (ESP). Besides assessing physical savings, M&V is also the basis for translating savings into monetary units and deriving verifiable future energy savings cash flows for energy efficiency financing or other purposes.

In practice, however, M&V (if pursued at all, particularly in the case of in-house implementation) often encounters difficulties with the availability of relevant data, the lack of a clear M&V plan and the needed resources to follow it up. Furthermore, accuracy of savings estimations is almost always complicated by a lack of comparability between 'Baseline' and 'Reporting Periods' because either the facility, energy prices or climate conditions deviate from one another

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lasting change, leading to massive energy savings and improving efficiency and their customers' lifestyles and homes.

- The US has long provided in-kind support to Task 24, via our SCI project partners who developed the excellent Subtask 9 "Beyond kWh" tool to help standardise evaluation of behavioural interventions.
- We also undertook our greatest field pilot, the award-winning Energy Connect program with the largest health network in North America, Atrium Health. Task 24's Operating Agent, Dr. Sea Rotmann, was part of an expert group that included ACEEE's Behavioural Programme Director, Dr. Reuven Sussman, and energy and behaviour experts from the US and Canada. Our pilot showed that the Task 24 method of bringing "Behaviour Changers" together to collaborate using a collective impact approach really works. Some pilot healthcare facilities are trending towards almost 20% energy savings by fostering culture and behaviour change with their facilities management team and building operators (you can read the report here: http://www.ieadsm.org/wp/files/IEA-DSM-Task-24-Subtask-11_CHS-case-study_FONTS.pdf).

It is, therefore, excellent to finally provide the US with a specific Task 24 research project, which was chosen by the CEE sponsors after our first workshop in San Francisco in April 2018. The topic is probably the most difficult of all (and similar to what was chosen by our Austrian participants – see the Austrian Final Report here: http://www.ieadsm.org/wp/files/Task-24_Final-Status-Report_Austria.pdf) - How to prove that behavioural interventions actually change behaviours. In more detail, our research project will survey evaluation techniques, methods and approaches that have worked in other countries and different disciplines, including the credibility of evidence for behaviour change and persistence of behaviour and energy savings after programmes end. This will also include some examples of intervention and evaluation methods for hard-to-reach customers.

The research methodology involves:

- An in-depth analysis of the CEE Program Inventory on behavioural interventions that have used credible evaluation methods, studied persistence or were aimed at hard-to-reach customers.
- An in-depth analysis of almost 60 Task 24 case studies and which looked at similar themes or provided credible evaluation methods and outcomes.
- Interviews with all CEE sponsors and selected Task 24 experts.

Hands-on activities at the Consortium for Energy Efficiency sponsors' first workshop in San Francisco in April 2018.

- A mini literature review with over 100 peer-reviewed papers from the scientific literature.
- Two international workshops at the largest behaviour change conferences (BEHAVE and BECC) and collecting expert feedback.

The work will be presented in a final US report and policy brief at the end of 2018. This will conclude the IEA DSM's Task 24 and work on behaviour change (for now).

This article was contributed by Sea Rotmann, the IEA DSM Task 24 project manager. For more information on this DSM Task visit http://www.ieadsm.org/task/task-24-phase-2/.

or the savings are small in relation to the overall consumption of the facility, which is observed at the utility meters.

Due to the inherently complex nature of energy efficiency projects, energy managers, project developers, ESPs and (potential) ESP customers, and financiers may decide not to bother. To avoid such a decision, IEA DSM Task 16 on Competitive Energy Services examined the concept of simplified M&V methods. The Task experts believe that this simplified approach could make M&V accessible for in-house and smaller performance-based ESP projects, which often skip M&V. The experts also want to encourage the introduction of M&V methodologies for individual retrofit measures where they are not common practice and full-scale M&V approaches are not suitable.

Measurement & Verification

In addition to selecting a calculation method, the verification intervals need to be defined, for example, whether the M&V is done on a once-off basis (resulting in a flat rate without subsequent testing of the results of the electricity, heat, water or CO_2 saving measures) or repeated on a periodic basis (e.g., annually). To ensure proper implementation and effectiveness of the energy saving measures with a focus on the simplified verification of individual measures, DSM Task 16 experts have defined additional quality assurance instruments (QAI).

Quality Assurance Instruments (QAI)

The concept of QAI is to assure the functionality and quality of a particular saving measure. Their role is to verify that a specific saving measure has been implemented correctly and that it is performing according to specifications. QAIs, however, cannot determine the exact quantitative outcome of electricity, heat, water or CO_2 saving measures, which is typically subject to a number of external and dynamic parameters like utilization of the facility or climate conditions that may change over the course of the project cycle.

For simplified M&V approaches DSM Task 16 proposes to use (simplified) savings calculations to determine savings cash flows and to back these up with QAIs as a 'safeguarding mechanism'. The concept is applicable for saving measurements as well of course. For each electricity, heat, water or CO_2 saving measure, individual QAIs should be devised. Below are two examples to illustrate saving calculations in combination with QAIs:

- The savings of a thermal insulation measure are quantified through a heat-demand calculation before and after the measure. The implementation quality is verified using a blower-door-test and a thermographic analysis of the building after the retrofit.
- For a street or indoor re-lighting project, the power demand by the system is measured in short once-off tests before and after the retrofit to verify the power savings. If the reduction in power demand is multiplied by previously measured or deemed operating hours, a figure for the energy savings over time can be calculated and factored into a flat-rate remuneration. Additionally, compliance with the illuminance specifications is measured.

The selection of QAIs as well as their exact design will depend on the specific requirements of the project scope and the parties involved. QAIs can either be specified in-house by a facility manager, by an ESP client or by an ESP as part of the competition of solutions during the procurement process or the detailed project design. You can learn about more combinations of simplified M&V calculations and QAIs in the DSM Task 16 paper, *"Simplified measurement & verification + quality assurance instruments for energy, water and CO_2 savings. Methodologies and examples"*.

Simplified M&V Combined with QAIs at Work

The case study below is one of several illustrating best practices in industrial applications detailed in the DSM Task 16 paper noted above.

Opel Vienna: Optimization of compressed air and heat supply in powertrain manufacturing

Opel Vienna GmbH (formally General Motors Powertrain Austria) is GM's largest powertrain manufacturing site with an annual production of about 1.5 million motors units. In 2011 and 2013 Opel implemented saving measures to reduce compressed air and heat energy demand. To allow for a feed-in installation of the heat recovered from three compressors, the temperature level of the facilities heat supply system had to be reduced to 85°C, which required some unforeseen additional work.

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The results – heat savings of 2 GWh/a or 140,000 EUR/a, which represents 33% of the baseline demand supplied by district heat and were verified by a heat meter installed with the heat recovery system. The total savings investment was 550,000 EUR with a payback time of 3.2 years. An additional beneficiary was the district heat supplier "Fernwärme Wien", who could lay off a boiler needed just to supply the higher temperature level in Opel's heat supply network.

Food for Thought

Simplified approaches should be seen as additional M&V options as they are not meant to replace utility meter based or other comprehensive M&V methodologies that are suitable, feasible and desired by the project stakeholders.

There are a number of reasons to opt for simplified M&V methodologies, including:

- For smaller scale energy performance contracts (EPC), combinations of EPC, energy service contracts (ESC) and other energy service projects, the initial and periodic time and effort may be prohibitively high or just not desired for various reasons. The same rationale may apply to in-house implemented projects. In this context, simplified approaches can open up the option for performance-based smaller scale energy service projects or in-house implemented projects, which is a prerequisite for evaluating savings cash flows.
- Projects involving an external energy service provider (ESP) when energy-savings measures are implemented in-house often only require a very light M&V programme, so perhaps a M&V is not even conducted. In these cases, simplified approaches can be a reasonable compromise between no M&V and a comprehensive approach.

The Need for More Discussion and Work

DSM Task 16 participants want to broaden the discussion on the awareness, acceptability and added value of the simplified M&V approaches both for in-house implemented projects as well as in energy service markets. They invite feedback, in particular concerning the proposed combination of simplified M&V approaches backed by QAIs. It will also be valuable for the work to better understand from a financing institution's perspective if these simplified approaches are sufficient or not even an issue as long as cash flows are secure.

An area identified as needing more work is how best to estimate and quantify the possible sources and margins of error resulting from simplified methods. Knowing these error margins would make it possible to discuss the costs and benefits of the precision of different kinds of M&V strategies as well as formulate some rules of thumb on the type of approach that would be most effective for different size and type of projects.

Last but not least, it should not be forgotten that so-called non-energy-benefits (NEB) like increased productivity or comfort, better air quality or a green image may constitute bigger added values than the energy savings by themselves. If this hypothesis holds true, we should put more focus on factoring NEBs into the business case than trying to quantify savings too precisely (provided implementation decisions are based on economics). In other words, to make meaningful contributions towards energy policy goals, actors will need to open up from narrow energy perspectives and join forces with other project drivers.

This article was contributed by Jan W. Bleyl, IEA DSM Task 16 Operating Agent, and highlights the detailed work described in the paper, "Simplified measurement & verification + quality assurance instruments for energy, water and CO_2 savings. Methodologies and examples" (http://www.ieadsm.org/wp/files/Bleyl-et.al_Simplified-MV-QAI_ECEEE_140327.pdf) by Jan W. Bleyl, Energetic Solutions, Austria; Markus Bareit, Swiss Federal Office of Energy (SFOE); and Peter Sattler, sattler energie consulting gmbh, Austria. If you have questions or comments on this work contact Jan W. Bleyl at EnergeticSolutions@email.de.

Australia

The DSM Canary in the Coal Mine - The imperative to develop a Social Licence to Automate DSM

Australia's energy sector is in a profound period of change. In particular, Australia's electricity sector is being transformed through the closure of aging coal-fired generators and increasing levels of renewable energy.

The existing national Renewable Energy Target (RET) of 20% renewables will be met by 2020, driven initially by wind. More recently, through State based targets and the rise of consumer driven action on climate change, Australia now has installed 1.84 million PV systems across Australia, with a combined capacity of over 7.8 gigawatts combined. In 2017 alone an additional 1.1 GW of small scale solar was installed, which now means that 25% of dwellings have a solar installation.

An Energy Market in Crisis

Unfortunately, despite an abundance of natural resources, this transition to distributed renewable generation, combined with outdated electricity market rules, has resulted in Australia lurching toward an energy crisis that has seen a decade of rising energy prices and a potential threat to the reliability of electricity.

Energy policy has been a poisoned chalice for the revolving door of Australian Prime Ministers and Energy Ministers in the last decade, as the government struggles to tackle the energy trilemma, in particular, price. Australia has one of the highest prices for electricity in the developed world.

Yet there are a variety of different factors that are contributing to price rises in Australia. The Australian Clean Energy Council identify the following reasons:

- A lack of national energy policy beyond 2020. This means that business does not have the necessary certainty to invest in the new infrastructure needed to replace the old power plants that are retiring.
- Rising network costs, now half the Australian electricity bill, was driven by meeting peak capacity, especially between 2007-2014.
- Increased charges by energy retailers for winning and billing customers.
- Decreased competition by the larger retailers, who also operate a large proportion of generation (Gen-tailers) and make up a quarter of electricity bills.
- Complicated consumer information which makes it hard for people to easily understand the options they have available and make smart choices to reduce their bills.

Gas has also seen a similar explosion in price (pun intended), caused by the export of gas and reducing the amount of gas available for local supply. In some cases, this means Australian gas is cheaper to buy overseas than back home. As the main

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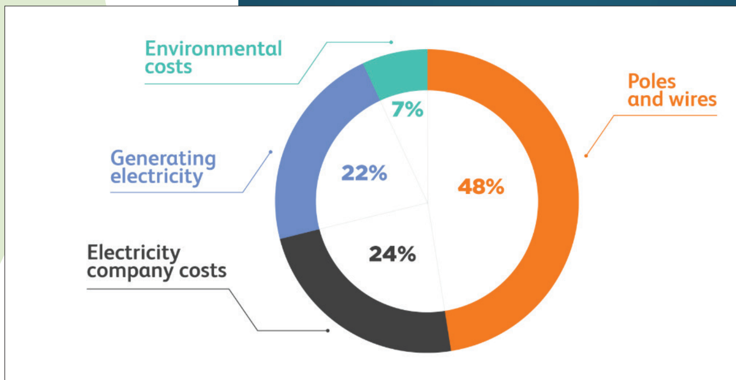

Australians pay for four main things in their power bills.

Source: [CEC] Clean Energy Council, "Lifting the Lid on Prices"

fuel for peaking plant, which is the last entrant and price setter in the wholesale market, this has also contributed to increased electricity prices.

Exacerbating the political debate on energy policy is the role of renewable energy. Australia has an abundance of solar, wind and hydroelectric resources, yet renewables have become the scapegoat of the energy crisis, blamed for reliability issues and price increases.

The political pressure intensified in September 2016 in South Australia when a 1 in 50 year storm (which are only predicted to increase) crippled the transmission infrastructure resulting in a cascading system fault that left all of the state without power for hours and parts of the State without power for days.

South Australia has led the renewable energy charge in Australia, with a generation mix that is now pushing 50% renewable energy, and hence several vested interests, including politicians, were quick to lay the blame at the feet of wind power alone, playing in to the hands of those claiming that reliability and stability services can only be provided by existing coal fuelled generation. In reality, the inability for a system to respond to sudden loss of traditional generation (coal plants were on the ends of those downed lines), reliance on transmission interconnectors to other states that became overloaded and the lack of other services that could be provided by DSM were just as important as the inability for wind farms to ride through faults.

Ignoring the politics, the rise in renewable energy will have consequences in one of the longest distribution networks in the world. Deployment of wind and other large scale renewable projects will continue, but it is penetration of solar that is likely to have the biggest impact on the sun-baked Australian grid. The Australian Energy Market Operator (AEMO) is forecasting minimum operational demand to plummet over the next 20 years. For example in South Australia (often seen as our own canary in the coal mine for energy transition in Australia) it is predicted to cross over to negative net demand from around 2029 when generation from rooftop solar is forecast to exceed total demand on the grid while peak demand is forecast to continue to rise.

The Australian energy sector is at a crossroad, but through crisis comes opportunity, and there is now a growing momentum to find solutions that drive down energy prices and ensure reliability without sacrificing carbon emissions.

The Energy Efficiency Council (EEC) of Australia has identified a number of critical activities that need to occur:

1. Unlock the power of demand response
2. Improve electricity network regulations
3. Implement fair and efficiency electricity tariff structure
4. Strengthen and extend energy efficiency certificate schemes
5. Improve governance
6. Urgent support for manufacturers
7. Transform offices
8. Inform and protect home buyers and renters
9. Reduce governments energy bills
10. Improve standards for appliance, buildings and vehicles

Many of these measures require traditional deep energy efficiency to reduce consumption in offices, government buildings and the manufacturing sector. However, it is increasingly critical for

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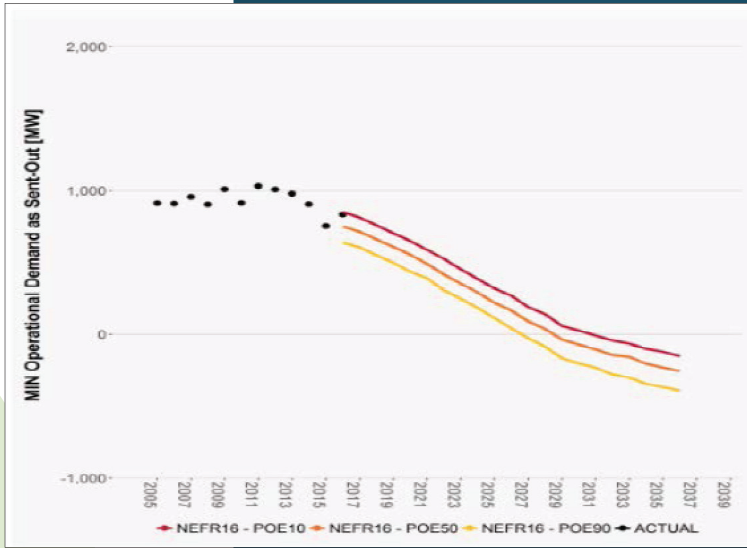

AEMO forecasts South Australia's minimum demand to be less than zero well before 2036.

Source: [ARENA] Australian Renewable Energy Agency – UTS - Institute for Sustainable Futures, "Demand Management Incentive Review", 2017

Australia to unlock the power of DSM to also provide a cost effective solution to unreliability through demand flexibility that also helps to promote renewable energy.

DSM Late to the Party

Unfortunately, despite early good intentions of a recent Demand Management Incentive Review sponsored by the Australian Renewable Energy Agency (ARENA) that states "Demand management … options are intended to have equal opportunity alongside conventional supply side options to satisfy future requirements", DSM has been largely neglected in the Australian National Energy Market.

Several national strategies (e.g., the Demand Management Incentive Scheme and Demand Management Innovation Allowance in 2015) for energy efficiency have been developed, however, many proposed actions haven't been implemented, and Australia's rate of energy efficiency improvement has continued to fall behind other developed economies.

The gap in balanced incentives for DSM has likely cost energy consumers hundreds of millions dollars or more through unnecessarily high electricity bills due to excessive generation and network infrastructure spending.

DSM in the Spotlight

In recent years, DSM has had a revolution in Australia, and the most high profile response to the crisis was the introduction of the Reliability and Emergency Reserve Trading (RERT) scheme. The 3-year trial commenced last summer to address (real and perceived) issues of reliability after the sudden withdrawal of the aging coal fired plant in Victoria and the South Australian blackout.

AEMO Managing Director and Chief Executive Officer Audrey Zibelman said, "These demand response projects will help manage spikes in peak demand in a cost effective way using our existing electricity infrastructure and clever new technology. It is clear that demand response has untapped potential to manage demand during extreme peaks in Australia, just as it does in other countries".

These type of emergency interventions are important transitional measures but have been criticised for requiring costly subsidies to relatively few participants. Australia must continue to implement recommendations to set up markets that allow all energy users to sell demand-response for emergency capacity, frequency response and low-cost capacity during periods of peak demand.

The potential for DSM in Australia is enormous. Research from ClimateWorks Australia has found that voluntary demand response measures could reduce commercial and industrial (C&I) electricity demand in the industrial sector on Australia's east coast by as much as 42% during peak periods. C&I measures alone would reduce overall peak demand by over 10%, or 3.8 gigawatts.

An innovative cluster of energy start-ups is also poised to take advantage of this revolution in DSM in Australia, developing world leading technical tools for coordinated aggregation. Trials, hosted by networks are already underway, with a focus on precincts (microgrids) and aggregation of retail customers. Australia will need move from trials to fully fledged programs quickly to meet the demands of the energy transition.

Due to this momentum, and in accordance with recommendations by the Australian Chief Scientist in the landmark "Independent Review into the Future Security of the National Electricity Market", the Australian Electricity Market Commission has proposed rule changes to create a mechanism for direct market participation by a customer who can respond to expected wholesale prices. Further, the AEMC is recommending that

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"Like many countries, Australia is grappling with the complex issue of balancing reliability and cost while increasing renewables in the network (the energy trilemma). Demand side management will play a critical role, and like with large scale renewables, the sector must develop a social licence to operate DSM. This will require the blending of social science, technology and policy research. And to do this, Australia must take insights and lessons from around the world, and what better way to start on this journey than by joining the IEA DSM TCP".

TONY FULLELOVE

Australia's DSM Executive Committee member consumers should be allowed to engage multiple retailers (or aggregators) at the same connection point. In practice, this means a customer could sign up for a demand response product from a retailer that is different from their main electricity provider, thus busting open competition for DSM services.

Unlocking this potential for both C&I and residential customers would improve Australia's energy security, and avoid building costly infrastructure needed during peak periods that only take place on a handful of days a year.

Social Licence

There is no greater time for DSM to achieve its potential in Australia; however, technology and regulatory settings alone will not provide the flexible energy system that Australia needs. Reforms to the energy sector and the technology that supports it must engage and reward customers for flexibility in their energy use. Furthermore, this will only be acceptable to communities and governments if it has a safety net in place for "vulnerable consumers" that have peaky loads that can't be shifted.

In a recent survey by Energy Consumers Australia, customer attitudes to demand response depended on how they perceive the reward for being flexible in their behaviour and if technology makes it easier to respond. The largest preference of customers was for reactive measures, relying on traditional approaches of "feedback and advice", indicating that customers may still not understand or trust DSM. Only 21% of customers preferred a proactive system, which allowed management of electricity usage on behalf of customers.

More simply, the industry is yet to develop a "Social licence to Operate" DSM systems in an automatic way that passes through the maximum value from utilities to customers. And without automation, Australia will not be able to combine the benefits of DSM in energy management (wholesale markets) with the fast acting response needed to manage the changing physics of the network.

This Social Licence to Automate in the energy sector is an extremely difficult challenge for DSM, requiring the blending of social sciences, technology and policy research and will require Australia to take insights and lessons from around the world.

Australia could be the proverbial canary in the aging coal mine, with a polarising national debate on how to address the energy trilemma and real network issues that need to be addressed now. Demand Side Management will have a very large part to play, but only if we are able to engage with customers, shape technology that is easy to understand and provide policy outcomes that give us the social license to take advantage of it.

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This article was contributed by Tony Fullelove of Monash University and Australia's IEA DSM Executive Committee member. Australia is the newest member of the IEA DSM Programme.

Industrial DSM & the Power of Demand Response Audits

THE INDUSTRE PROJECT *has analysed the role of demand-side management (DSM) in industry and determined its value as a flexibility source for the electrical system. According to the recent Clean Energy Package agreements, we should expect around 60% of renewables in the electricity mix by 2030. In this scenario, 1,5 b€/year could be saved by making flexible just 10% of industrial electricity demand. In fact, DSM avoids investments in peaking generation capacity and reduces the curtailment of renewable generation. This represents an enticing business opportunity for the industrial sector, which could obtain an economic benefit while helping the electricity system to decarbonise.*

To challenge this theoretical exercise, the IndustRE project analysed the feasibility of multiple DSM business models applicable to the industrial sector. Additionally, a series of case studies were carried out get a feeling from the field on the actual incentives and barriers. This article presents the main findings of an investigation over five countries and six energy-intensive sectors.

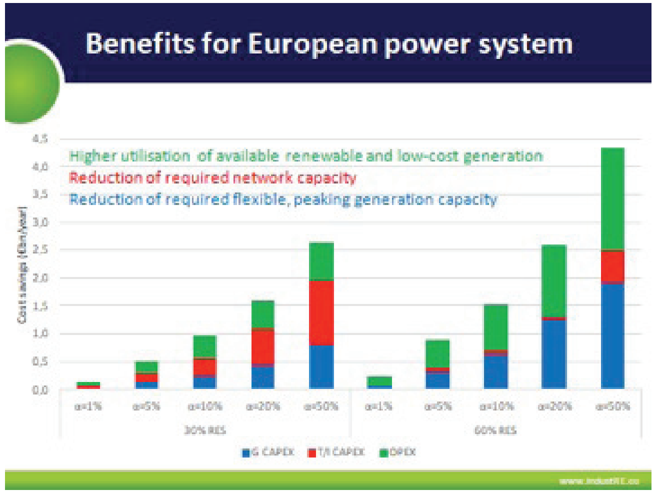
Since 2013, the European Copper Institute (ECI) has advocated industrial DSM as a promising route for deeper integration of electrical renewables. A concept has been developed of wind-powered industrial processes, which led eventually to the IndustRe project described below (www.industre.eu).

This article highlights key results of the demand response audits (DRA) conducted at different energy-intensive companies in six European countries (Belgium, France, Germany, Italy, Spain, and UK) as a part of the IndustRE European project.

As Hans De Keulenaer, the IEA DSM Executive Committee member from the European Copper Institute notes, "Following the spectacular cost reductions of renewables over the past years, the cost-effective integration of renewables into the electricity system is the next challenge. This is where demand-side management can help. Industrial DSM is one of the most promising short-term potentials to make this happen. This requires industry awareness of the flexibility potential in their processes and the business opportunity it brings. One of the most innovative results of the IndustRe project is a fast auditing tool enabling industries to quickly assess this potential."

To test this DRA tool, business case studies for flexible industrial demand (FID) were identified according to market design and regulation, and then were grouped into four business models: 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 .

The business models were then adapted to six 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).



This graph illustrates how 1,5 b€/year could be saved if 10% of the industrial demand becomes flexible, through higher ustilisation of RES and reduction of required peaking generation capacity.

What is a Demand Response Audit?

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

DRA consists of three steps:

1. Identification of flexibility in the process
2. Quantification
3. Valorisation

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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 1) by developing tailored models of the identified flexible processes and optimizing them to the chosen business model (the full methodology) or 2) by using a four-step simplified ProFLEX approach explicitly developed to quickly get a sufficiently accurate estimation of the flexibility value.

In this project, demand-side audits were conducted in the following countries, industrial sectors, and business models:

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)

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)

The DRA Case Studies

	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			

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. The table above summarises the calculated business cases and indicates which methodology is applied for which audit.

The case studies in the paper industry in Belgium and the 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 the 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 the audited

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sites, and consequently to facilitate the decision making process.

The reported numbers should be interpreted as an upper limit 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 the off-site VRES business model. Although some prices are fairly predictable, the ultimate operational flexibility value will depend on the price forecaster used in the process control system, in which an optimisation of the process schedule is determined.

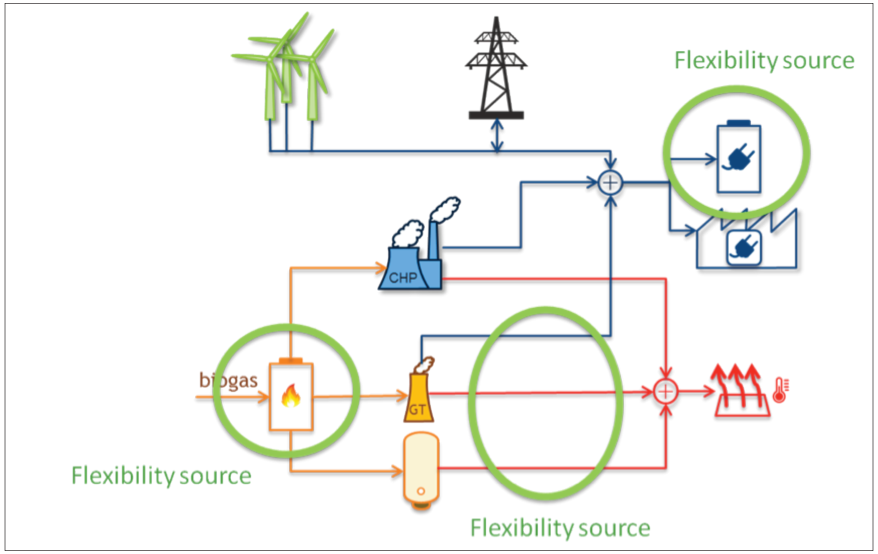
What was Learned

For all 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 €/MWh to 7.21 €/MWh. The most promising gains were estimated for the case of emergency generators providing system services.

In the **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 the **wastewater treatment plant**, two 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 the plant's 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 wastewater 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.

In the **non-ferrous plant**, the flexibility source identified offered the possibility to shift an intermittent (batch) process of alloy melting



For each case study the flexibility options were analysed. This diagram highlights the different energy inputs and flexibility options at a wastewater treatment plant.

from peak electricity cost time. 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.

In the **paper plant** the company already had rich experience in providing demand response, and so the audit was done under the assumption that an electric 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 an electric boiler is fired in response to the real-time imbalance prices to correct the electricity imbalance, the estimated upper limit on the yearly savings is expected to be around 1.5% of the total energy costs. Depending on the requirements on return on investment in the paper industry,

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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 might result in a positive or negative investment decision.

In the **chemical industry**, the flexibility 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 "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 significant 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.

General Conclusions

The case studies offer some inspiration for the flexible process in a particular industry branch. It was, however, never the objective 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 instead to show the breadth 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 specific 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 other hardware components are required, the additional costs may become significant and impact the expected return on investment.

The flexibility value is in the 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 using 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 specific 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 that 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. Furthermore, it affirms 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 that they were not looking for.

Audit Follow-ups

A structured follow-up process with the audited companies was conducted by ECI with the goal to better understand the likelihood of adoption of the identified flexibility potential and the possible barriers that might prevent the audited companies from taking immediate action.

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 is that most of the companies require payback periods of less than 2 year to a max of 3 years for any large project. In the identified business models this 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; and
- 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 the 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

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done by calculating all necessary CAPEX and anticipated OPEX, and putting them in perspective with the potential savings and gains, to meet the required payback time. And, final decisions are usually made at the corporate or HQ level and then onsite implementation can take up to 1 to 2 years.

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 reducing 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 of the seven audited companies, there is already an on-site variable renewable generation source installed or planned that is used mainly for self-consumption; either roof PV panels or on-site wind turbines. However, several barriers were highlighted that hinder a wider installation of variable renewable energy sources. These are listed separately for PV panels and wind turbines.

Roof PV panels

– Static constraints of the roof structure and significant investment for building reinforcement needed, which makes the payback unattractive.

– Limited roof space available and sub-optimal inclination.

– Concerns that insurance companies will raise prices due to higher risks (e.g., fire).

– Renting roof space to external investors for a power purchase agreement (PPA) currently has too long binding periods.

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.

This summary was produced as part of the IndustRE project "Innovative business models for market uptake of renewable electricity unlocking the potential for flexibility in the industrial electricity use". The report was written by Ana Virag from VITO/EnergyVille and Tomas Jezdinsky from ECI. Information about the project is available at www.IndustRE.eu.

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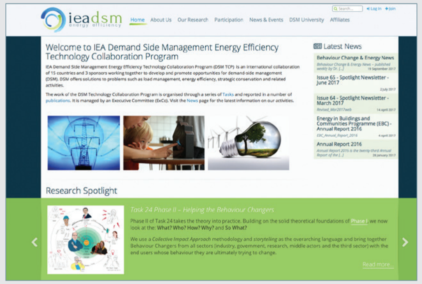

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