INTEGRATING DER MANAGEMENT SYSTEMS INTO INDUSTRIAL ENERGY MANAGEMENT – DEPLOYMENT RESULTS

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ABSTRACT

The energy transition is leading many Commercial and Industrial (C&I) customers to re-evaluate their energy and sustainability objectives and programmes. Energy Management enabled through recent IT capabilities as well as Distributed Energy Resources (DER implementation and Demand Side Response (DSR) are now essential components of a C&I energy strategy and also a value adding opportunity.

This paper highlights the opportunity for combined implementation of advanced Energy Management, DER management systems (DERMS) and DSR in behind the meter C&I situations. The paper works from the EC OPTIMSED project and its 'Factory 4.0' vision and objectives. The paper draws out the results of development and implementation of real time and historic energy dashboards, two DSR service opportunities available in the UK market and an analysis tool for annualized value of DSR and DER implementation.

The paper concludes that emerging IT and DERMS technological solutions are a good fit for the C&I market; that configurability and extensibility for DER, DSR and Dashboards is particularly valuable given the ongoing changes in the energy sector; that integration of energy/DER/DSR with factory production scheduling; and that modest but clear financial benefits area available from the demonstrated use cases and several other use cases.

INTRODUCTION

Energy consuming industries have clear objectives in energy management including cost efficiency and sustainability objectives (e.g. carbon intensity of inputs and operations). New energy management strategies are emerging including focus on the energy hierarchy (starting with efficiency and progressing to introduction of new energy technologies), corporate Power Purchase Agreements (PPA) with renewable generators and on-site implementation of Distributed Energy Resources (DER). At the same time the energy sector is transitioning along the decentralization–decarbonization–digitalization pathway, including flexible approaches to integrating clean energy technologies into distribution systems.

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DER Management Systems (DERMS) have emerged as a key component of the evolving smart, flexible power system and the requirements for DERMS are crystalizing [1]. These requirements address new Distribution System Operator tools for flexibility as set out by industry bodies EURELECTRIC and EDSO [2]. Industry analysts [3] have already projected the application of DERMS to owners and operators of energy assets and fleets including energy intensive industries with large flexible energy demand and low carbon technology deployments.

This paper presents the results of the EU OPTIMISED [4] project within which a major goal was integrating (normally utility, front-of-the-meter) DERMS capabilities with 'behind-the-meter' factory Energy Management Systems capability. This includes high resolution energy data capture, analytics, Demand Side Response (DSR) and DER grid and market integration. The project successfully demonstrated new technologies for DERMS implementation in the C&I sector including integration of multiple energy metering / control points in the factory environment with open standard Internet of Things (IoT), cloud DERMS implementation and energy market interaction through available APIs and Web Services. The wider goals included extending the functionality and applicability of DERMS solutions in the Commercial & Industrial (C&I) sector to address emerging requirements and corporate sustainability objectives.

C&I DERMS SYSTEM IMLPEMENTATION

A DERMS was implemented for behind-the-(electricity)- meter (BTM) operation within the factory environments at Goimek (Spain) and Laing O'Rourke (LOR, UK). The factory operators specified that monitoring and management of energy should focus on four energy Key Performance Indictors (KPIs) for each of the factory demonstrations. These KPIs features in online/real-time and offline application development and demonstration as well as in integration to other factory management systems:

- Energy consumption (kWh)
- Energy purchase (£)
- DSR benefits (£/kWh and £/kW)
- Carbon content (gCO2-total and gCO2/kWh)

The implemented DERMS system is illustrated in Figure 1. The system implementation centres on the SGS Comms Hub component that integrates and manages a number of data sources. A number of utility (e.g. DNP3), IoT (e.g. RabbitMQ) and IT (e.g. REST) interfaces and protocols were implemented to enable energy metering data, energy market data and factory systems data exchange. A historical, time-series data base is implemented to support the energy dashboard and offline analysis model. Energy metering from tens of factory locations are concentrated at a RTU to maintain consistency of integration with front-of-meter utility DERMS implementation preferences.

DSR programme and DER management applications are hosted on the SGS Core system component. Integration to the factory production simulation and optimization functions are through the information backbone (Message Oriented Middleware) utilizing RabbitMQ.

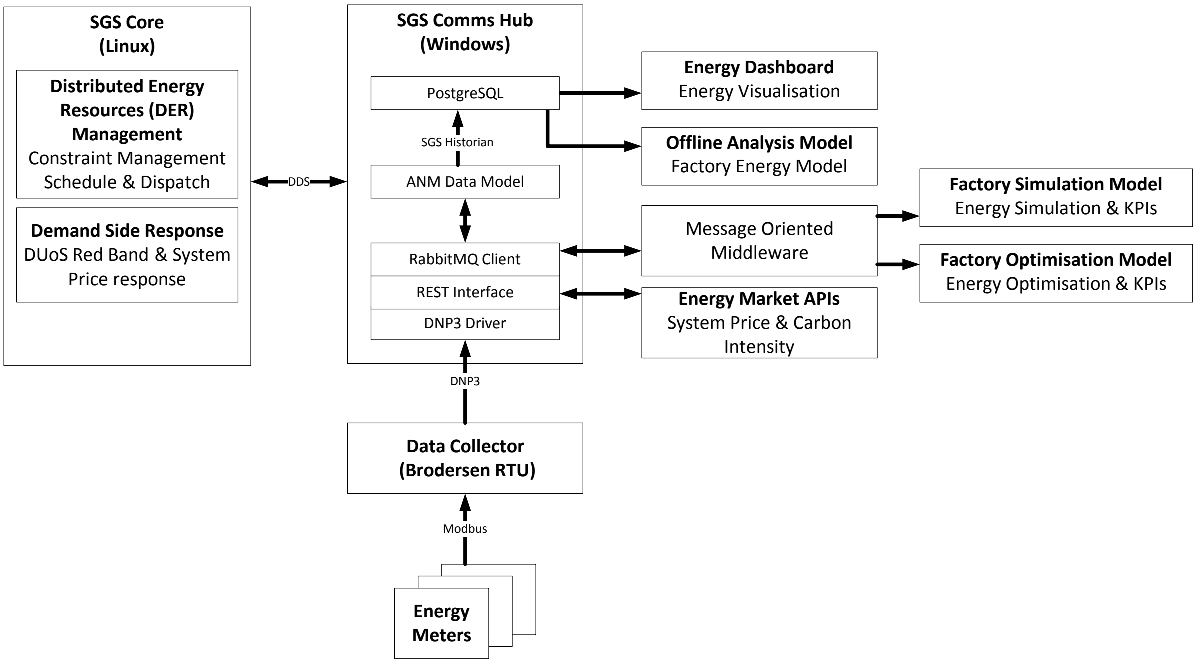

Figure 1 – Distributed Energy Resources Management System (DERMS) implementation architecture at the Laing O'Rourke OPTIMISED demonstrator.

DERMS IMPLEMENTATION RESULTS

Several interesting results from DERMS implementation energy dashboards, DSR and offline analysis are illustrated through the following three result sets. The results are presented for a section of the Laing O'Rourke (LOR) factory in the UK.

Results: Real-time DSR Activation

DSR activation events were demonstrated based on two distinct opportunities in the UK electricity market[1]:

1. **Distribution Use of System (DUoS) Red Band Reduction** – network charges reduction service with the value to the customer (dependent on charge pass through arrangements from LOR's energy supplier)
2. **Balancing System Price Response** managing electcrical demand away from peak real-time price periods (dependent on value sharing arrangements with LOR's energy supplier)

The DUoS Red Band period activates between 16:00-19:00. Typically, energy offset from real time DSR or pre-scheduled DSR demand in factories is recouped in a rebound period after the DSR activation. The Balancing System Price response is based on a £90/MWh activation threshold. The power capacity for response was set arbitrarily for the demonstration but would be set according to survey of responsive load equipment and also possible day-by-day preferences of the factory operations management.

Figure 2 shows a one-hour (two 30-min settlement periods) duration System Price DSR event in the

[1] The structure of demand response and flexibility services is changing in the UK, as with other electricity markets, as the penetration of DER and the general level of customer response increases. The DSR schemes demonstrated in the OPTIMISED project are already subject to change. This creates a premium to easily configurable and re-configurable DER and DSR capabilities.

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morning (09:00-10:00) where the System price (blue line) rises above the £90/MWh threshold. The DUoS red band response activates in the period 16:00 -19:00 during which a second System Price response event begins and continues to 21:30 in the evening.

The non-DSR factory power consumption is the green line and the mirror DSR response power consumption is the yellow line. The average power consumption in the factory section in this example is approximately 50kW so a 10kW DSR capability is demonstrated.

Figure 2 – Demand Side Response (DSR) events activated from DERMS for a single October 2018 day at the LOR facility.

Results: Factory Production Simulation DSR Schedule

The OPTIMISED factory production simulation model is configured with energy parameters for selected workstations and major piece of equipment. The model calculates a number of production parameters (e.g. service level (due date reliability), staff resource requirements, product processes sequencing, transits between workstations) but importantly applies a number of energy objectives and constraints based on the energy KPIs stated above. Knowing the future production schedule forms a good basis for forecasting future energy demand, as energy consumption in industry is frequently closely linked to the operations taking place on the shop floor.

The model gives production schedulers a holistic view of the factory state in the near future (typically a week) and allows them to assess the effects of different schedules along the dimensions of logistic KPIs (due date reliability, throughput, etc.), costs, and also the energy KPIs. It also allows to quantify the effects taking certain DSR measures would have on, e.g., the logistic KPIs.

Figure 3 shows (for a five day period) the results for a pre-scheduled daily DUoS Red Band energy demand reduction between 16:00 and 19:00 and the scheduled 'rebound', typically later in the evening. This is possible when there is already a scheduled evening work shift at the factory. However, the value of this single DSR service does not justify creating an evening shift simply to avoid the DUoS Red Band period. The pattern of energy consumption after the DSR event does not always match the profile of reduced energy in the DUoS Red Band period because of other factors in the production

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simulation such as the complex, multi-workstation product schedule. It is important to note that, typically, a pre-scheduled DSR event is better for continuity of factory operations and adherence to a preferred production schedule – this is the case that the example illustrates. However, this is not always possible as several DSR services require real-time or close to real-time response.

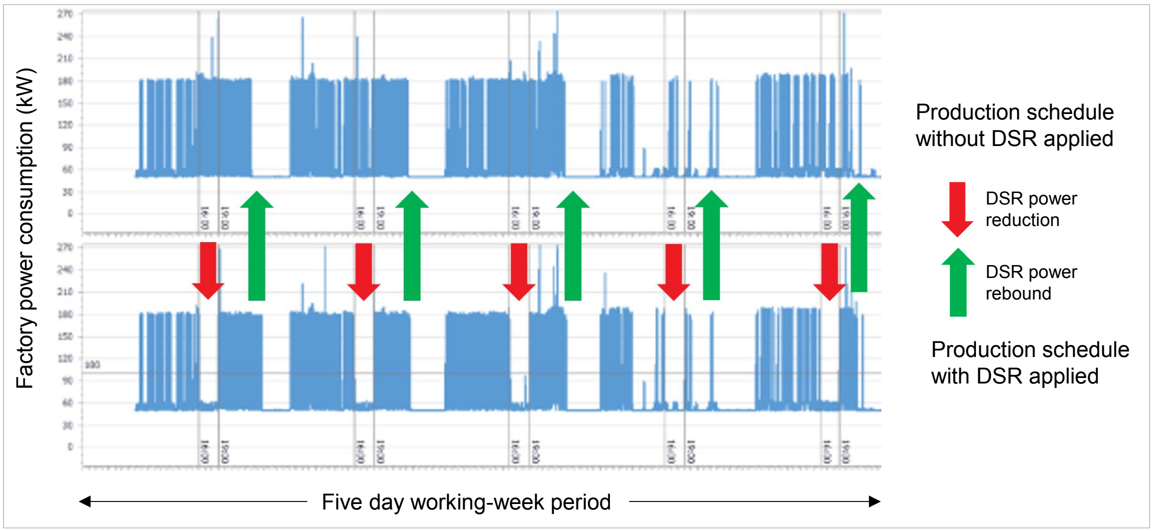

Figure 3 – Five-day Factory Production Simulation with and without energy consumption schedule constraint at DUoS Red Band periods (16:00-19:00).

Results : Offline Annual Energy Analysis for Operational and Investment Planning

An offline energy analysis model was also developed to support the DERMS / Energy Management platform. The analysis model evaluates the impact of the same DSR programmes and a range of DER interventions (e.g. on-site rooftop solar PV and energy storage). The modelling is based on the captured historical energy consumption data for the factory, energy tariff structure and the DSR programmes. The model operates with half-hourly values for energy, price and carbon making it relatively straightforward to model the operation of DSR and also DG and Energy storage operation at the factory. A 12-month period is modelled (the full calendar year of 2017) where the factory section has a peak demand of 138kW and an annual energy consumption of 568MWh (shown in the baseline in the results tables).

The annual impact of the two DSR programmes is presented in Table 1. This shows the combined effect on energy tariff payments and DUoS charges from DSR action. A modest financial benefit of circa £9000 per annum is available for the configured DSR programmes and responsive demand capacity.

Table 1: Impact of DSR on annual energy baseline results for LOR site.

KPI	KPI Baseline	DUoS DSR Result	Difference	Market Price DSR Result	Difference
Factory Energy Import (MWh)	568	558	-10,	562	-6
Energy Carbon content (kgCO2)	183,693	180,111	-3,582	181,567	-2,126
Energy Tariff Cost (£)	£57,210	£56,101	-£1,109	£50,049	-£7,161
DUoS Network Charge (£)	£4,056	£3,307	-£748	£3,922	-£134

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The projected impact of DER intervention for the same case as in Table 1 above is presented in in Table 2. Solar PV generation and battery energy storage are modelled at various kW capacities with an example result set presented. The combined DSR, solar PV and energy storage system (ESS) benefits are shown with reduced energy import, reduced embedded carbon from energy supplies in factory products and revenue from additional export to the grid. It should be emphasized that that results displayed are for a single analytical case for illustrative purposes – many other combinations and configuration of DSR and DER were analysed as is appropriate.

Table 2: Impact of DER on annual energy baseline results for LOR site.

KPI	Baseline	PV Result	Difference	PV & ESS Result	Difference
Factory Energy Import (MWh)	568	338	-230	672	+103
Energy Carbon content (kgCO2)	183,693	107,033	-76,659	171,385	-12,307
Energy Tariff Cost (£)	£57,210	£32,939	-£24,271	£55,660	-£1,550
DUoS Network Charge (£)	£4,056	£913	-£3,143	£1,180	-£2,876
Energy Production Revenue (£)		£26,966		£26,842	

CONCLUSIONS & OUTLOOK

The implementation of the DERMS in C&I environments and the configuration of DSR, factory production scheduling and the analysis of DSR/DER investment cases show promising opportunities for advanced energy management.

The system architecture implemented demonstrated and exploited the value of modular, extensible, cloud-hosted and IoT enabled infrastructure – all deployable to a wide variety of factory environments.

Demand Side Response (DSR) enablement on the DERMS platform enabled two different UK market DSR services: System Price response and DUoS Red Band (network tariff) response

Energy modelling, simulation and optimization in the factory production management system was enabled through multiple DERMS components and interfaces. The paper presents the results of significant energy consumption changes from factory production simulation.

The granular energy data acquisition enabled high quality offline analysis with DSR and DER implementation planning – the energy, carbon and financial analysis case presented in the paper shows modest but promising value.

There is a promising outlook for DERMS deployment in C&I and this creates a platform for enhanced industrial contribution to the energy transition, integrating with ongoing renewable, energy storage, process electrification and transport electrification programmes. In particular, the extensibility and configurability of the DERMS implementation creates opportunities to manage energy assets and flexibility at a time of change and new opportunities for major energy users. The ability to pre-schedule and also respond in real-time to prevailing on-site, local and national situations and requirements provides the opportunity for significant gains (a subset of which have been demonstrated in this project and reported in this paper).

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