LCNF Tier 1 Close-down Report

Honeywell I&C ADR: Demonstrating the functionality of automated demand response

SSET1004

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Project Title

Honeywell I&C ADR: Demonstrating the functionality of automated demand response

Project Reference

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Contents

Appendices

List of Tables

List of Figures

Executive summary

Project scope

Automatic Demand Response (ADR) technologies, implemented in commercial buildings, are expected to support distribution network operators (DNOs) to deliver a cost effective transition to a low carbon future. The Honeywell ADR system, not previously trialled in the UK, enables reduction/shift of electricity load from buildings through their existing building management systems (BMS). This project was developed to demonstrate an end-to-end solution for building owners to automate load shed in response to a signal from a DNO.

Aims

1 Furnish all data required for a DNO to quantify the benefits of the ADR system;
2 Drive rapid enrolment by providing required hardware, software, consulting and training to the participating building owners enrolled on the programme;
3 Demonstrate interoperability of systems and by adhering to the standards and open protocols, ensuring long term lifecycle of assets;
4 Demonstrate compliance to various elements pertaining to cyber security;

Activities

This project implemented and demonstrated basic ADR functionality in commercial buildings. Three building owners were recruited as trial participants, each willing to test the Honeywell ADR system. A framework for customer engagement was developed iteratively during the project to identify potential participants, engage with them to obtain sign up to the trial and manage their participation. The ADR system was installed by Honeywell at each participant's premises and tested by carrying out individual and aggregated load shed events. Honeywell collated data to monitor the performance of the system. Imperial College used this data to evaluate ADR system performance in the trial, create models to predict future performance and analyse the potential value to a DNO.

Outcomes of the project and key learning

A framework for customer engagement was developed which can be used and evaluated in future trials. The framework covers engagement required from the first meeting through to agreement of load shed strategies. Work after this can be deemed as the technical integration/ installation of equipment. It is broken into three stages, shown with average resource requirements (man hours) and recommended time allowance in a project plan:

1. Customer acquisition –13 hours (50-70 days)
2. Facility audit –12 hours (15 days)
3. Agreement of Peak Load Shed Strategy –13 hours (14-16 days)

The average cost in terms of DNO staff resource required to engage a customer up to agreement of load shed strategies for this trial was £480. As a result of the trial, the documentation provided to participants on ADR was simplified and the sign up process was streamlined so only one contractual agreement is now required instead of a two step process with separate agreements to authorise ADR site surveys and ADR event participation.

A review of compliance with security standards confirmed the system and hosting facility met Southern Electric Power Distribution's (SEPD) information security standards, with some recommendations for further security controls identified. Technical demonstration of load shed was achieved for each building, with an absolute maximum aggregated load shed of 188kW from all three sites, achieved by a manual signal via the ADR Gateway at a time specified by SEPD. The load available for shedding in any building changes given the time of day/year, since load reduction is primarily based on control of Heating Ventilation and Air Conditioning (HVAC) systems. Modelling by Imperial College based on trial results estimated an aggregated peak load shed of at least 460kW (summer) and 100kW (winter) could be expected from the three buildings studied, indicating that ADR at these study sites will be most effective in managing constraints in peak periods during the summer.

Imperial College also assessed the potential value of ADR. The net present value of the cost of ADR was estimated at between £56,700 and £97,000 per building over 30 years, based on deployment as per this trial in 20 buildings. Estimates of network reinforcement costs were used to calculate the minimum levels of demand reduction that ADR in this cost range must achieve to make it a financially viable alternative to reinforcement. Minimum levels were then compared to expected summer and winter load shed from the buildings studied as above. This indicated that the expected reductions in summer load from the three individual buildings studied would exceed the minimum, making ADR viable if network reinforcement is driven by demand peaks in summer, rather than winter.

Imperial College also assessed the additional network observability (in terms of visibility of power flow) that can be obtained through the ADR system. Results from the trial highlighted that the real time demand profile data available for buildings with ADR can be used with existing network data to improve the accuracy of estimated power flows in HV feeder sections and corresponding network voltage profiles. With only three buildings, the increased observability was very

localised. However, a greater concentration of ADR customers on a single feeder could provide considerable benefits.

Conclusions and future work

As a technical demonstration, the project – and success criteria – were focused on delivery of a functional ADR system. The aims to advance the system's TRL level from 8 to 9 through a small scale trial and to define a working process for customer engagement were fully met as above.

The results indicate ADR has considerable potential to reduce load and provide wider benefits to DNOs. However, conclusions are very tentative due to the small sample size and require validation through further trials. This trial has been an essential first step in creating a platform for systematically testing:

- the cost, effectiveness and value for money of stages in the customer engagement process
- ADR's technical potential
- the commercial/social limits on exploiting this potential

Now the technology can be considered 'proven', testing of these aspects of ADR will be carried out under the NTVV project on a wider sample (30 buildings) to provide a more robust evaluation of the commercial viability of ADR in a free or supported market.

Intellectual property

The project made use of existing products available on the market on commercial terms. It did not require the development of new products. As such no Relevant Foreground intellectual property (IP) has been registered for this project. Relevant products and suitable alternatives are available on the market to other network operators.

The main benefits and knowledge delivered by the project relate to learning around deployment of ADR in the UK and engagement of commercial customers in ADR trials. Details necessary to allow the project to be replicated by other GB DNOs are set out in this close-down report. Any additional information required can be requested through jenny.1.rogers@sse.com.

1 Project background

Honeywell Building Solutions' Automated Demand Response (ADR) technology is in use in the USA, Asia, Australasia and China to undertake a number of processes based around the reduction of kW electrical load on a network or at specific large, high kW usage complexes at times of peak demand. This Tier 1 Pilot project will trial the above solution on a UK HV/LV network, to ascertain whether it can effectively help manage and reduce the constraints we are likely to find, as we move into a low carbon economy.

However, before a DNO can use such technologies to manage the network, it is important to ensure that the communication and automated aggregation of the load shedding systems proposed have the functionality to produce and monitor the desired load reductions.

SEPD ran this pilot project on Honeywell's ADR innovative technologically advanced solution, to answer the following questions;

1. Can the proposed ADR solution produce an aggregated figure of despatchable demand?
2. Can it reduce/shift peak loads in facilities (& therefore the network)?
3. What data can be collated and what value is it to a DNO and how will it be securely stored?

This Tier 1 Pilot project will demonstrate the feasibility of the above solution and will provide valuable learning for all DNO's in the UK. The learning from this trial may also feed into SEPD's TVV Tier 2 LCNF submission, if approved.

2 Scope and objectives

This Tier 1 Pilot project has been developed to demonstrate an end-to-end solution for building owners to automate load shed in response to events managed by the DNO;

- Furnish all data required for a DNO to quantify the benefits of the ADR system;
- Drive rapid enrolment by providing required hardware, software, consulting and training to the participating building owners enrolled on the programme;
- Demonstrate interoperability of systems and by adhering to the standards and open protocols, ensuring long term lifecycle of assets;
- Demonstrate compliance to various elements pertaining to cyber security;

3 Success criteria

A. Demonstrate and report on ADR delivery capabilities across multiple business sites & Facilities;
    - Can the proposed ADR solution deliver an aggregated figure of despatchable demand?
    - Can the technology reduce loads on the network via a signal from the DNO?
    - How much can the load be reduced in the trial buildings?
B. Develop a framework for customer enrolment that can be analysed and developed as part of the TVV/ other LCNF T2 submissions;
C. Provide 'Observability' of the HV/ LV network via ADR;

4 Details of the work carried out

Automatic Demand Response (ADR) technologies, implemented in commercial buildings, are expected to support distribution network operators (DNO's) deliver a cost effective transition to a low carbon future. This project implemented and demonstrated the basic ADR functionality in 3 commercial buildings. The project was a pilot study designed to provide a foundation for a comprehensive set of trials to be carried out in the New Thames Valley Vision (TVV) Tier 2 project.

4.1 Method trialled

Figure 1 below shows an overview of the method trialled.

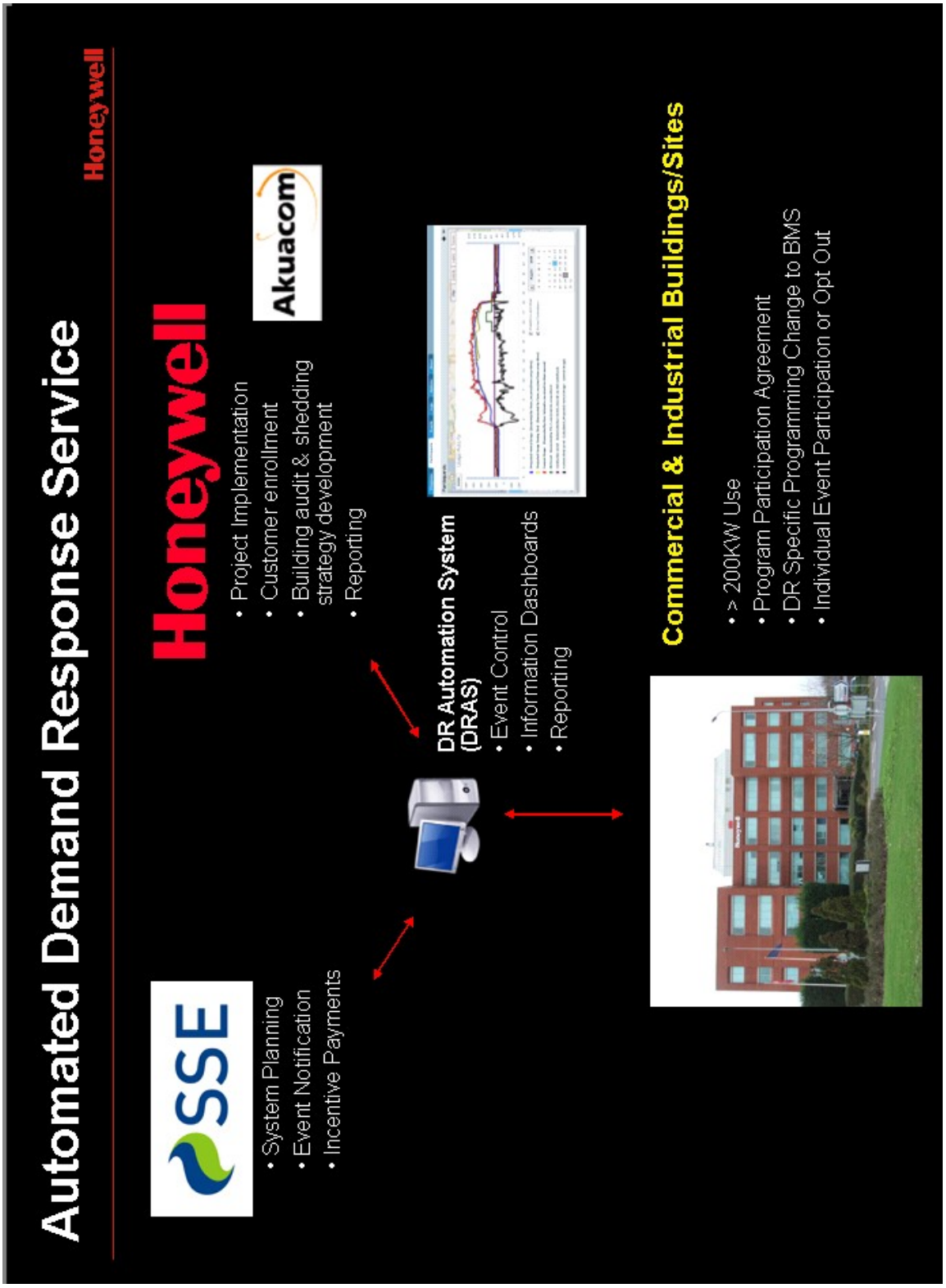


Figure 1 *Overview of trial concept*

4.1.1 The Honeywell ADR system;

Figure 2 shows the basic schematic layout of the ADR system, including the following key elements:

- Demand Response Automation System (DRAS) – Cloud based server & back up server – Server based in US for secure data storage
- DRAS Licence (Honeywell Akuacom) – For use of systems
- DR Gateway – Site interface between Building Management System (BMS) and DRAS. The physical box that sits at the customers' building and both reaches out to the cloud server looking for events, and sends the instruction to the BMS (Building Management System, existing technology at customer site) to activate load shedding strategy
- BMS Software modifications – programs that are added onto the existing BMS for load shedding. The Honeywell equipment then sends a signal to the BMS to activate the load shed upon request.
- Main Electrical meter interface – where the Honeywell system monitors the kW usage
- Localised Internet connectivity – if this is not available on site, it is organised by Honeywell

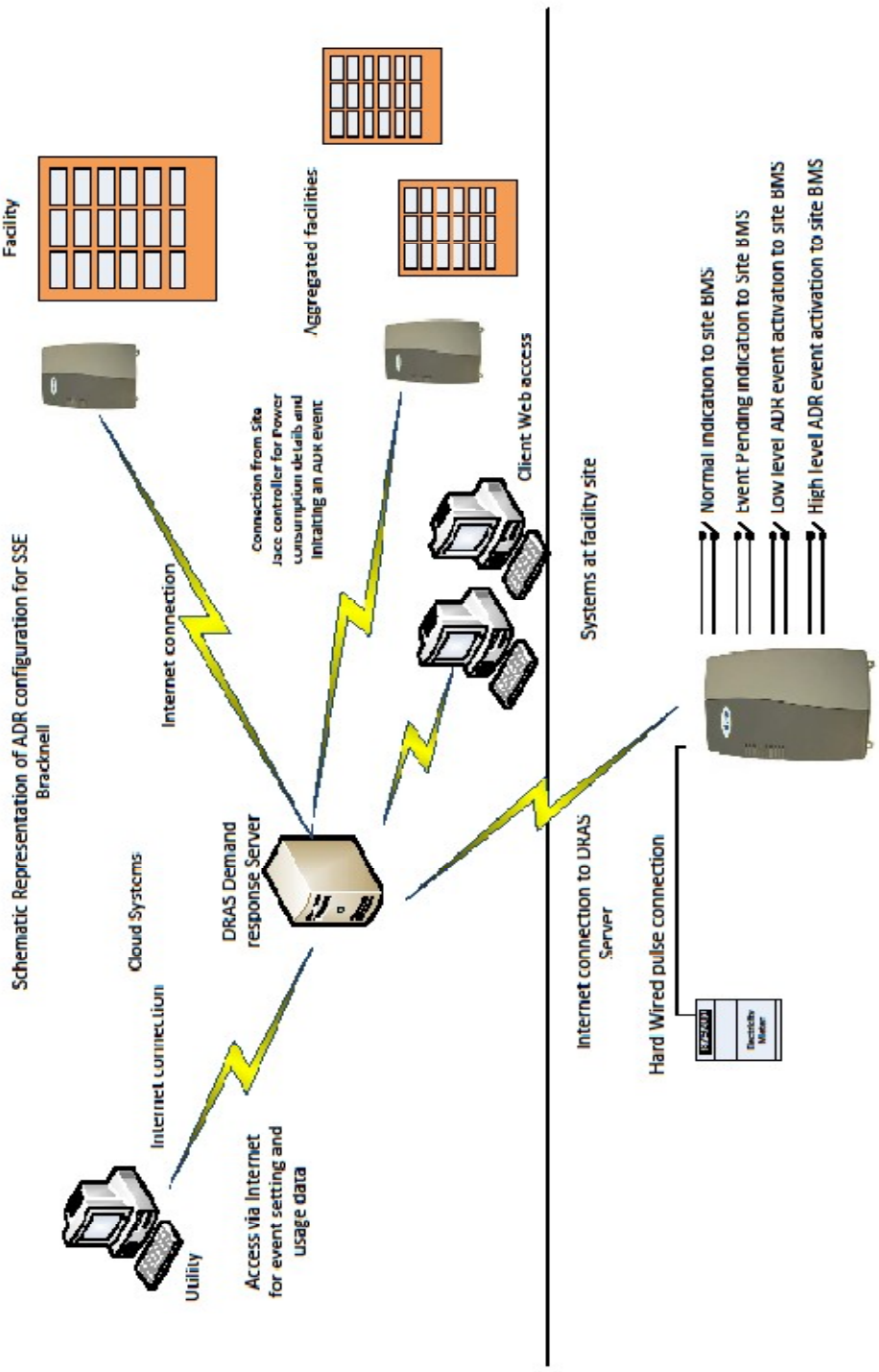


Figure 2 *Schematic layout of ADR system*

The above ADR system sits on a SaaS (Software as a Service) platform, linked via secure internet connections. The Operator (DNO) can log in and view real time (<15 minutes) loads on individual sites and monitor the aggregated loads. The Operator can also look back at the results of load shedding events in data and/ or graphical form. Customers can view their own site's load profile and actively participate (either by allowing load shedding events activated by the DNO or, if they want, by activating their own strategies, via the secure internet connection, once signed in).

4.1.2 Non-domestic Peak Load Shedding Strategy (PLSS)

The Honeywell ADR system reduces customer demand by initiating a Peak Load Shedding Strategy (PLSS). Typical commercial loads that a PLSS would reduce include:

- Reducing the output of Air Handling Units (AHU's), Fan Cooling Units (FCU's) etc;
- Adjustment of non-critical internal environmental conditions;
- Localised temperature set-point adjustments;
- Reduced motor & pump loads, via Variable Speed Drives (VSD) settings;
- Space pre-cooling or heating, prior to initiation of the event;
- Turning off non essential pumps eg. ornamental lake fountains;
- Reducing non-essential lighting, within compliance settings;
- Isolation of lighting zones (e.g. near windows);
- Pre-cooling refrigerated units prior to initiation of the event;
- Turning off external sign lighting.

Tailored PLSSs are devised for each site based on individual audit and analysis of energy consumption. PLSSs are designed to maintain a safe and acceptable environment in which building occupants can effectively continue their normal activities. PLSS for this trial were therefore based on prime HVAC plant and Lighting Controls, leaving Safety Systems, Computer Suites etc out of the strategy. This No/Low Impact approach provides reassurance for customers that an ADR event will not affect their organisation's operation or directly impact on occupants.

This approach enables the ADR provide to reduce the peak load and spread the actual load profile, or reduce it. For instance, a building can be pre-cooled or pre-heated prior to a planned ADR event, so that its internal environment remains within the agreed comfort band for the event duration. Whilst this approach could result in an additional load outside of the peak load period, it will enable us to either switch off or reduce the actual load during an event i.e. shift load. If VSD or inverter controls are fitted to the main AHUs fans and pumps, the AHUs and pumps electrical

consumption can be reduced to provide a minimum level of fresh air and pumping flow rates, or the pumps can be turned off.

Sign lighting, feature lighting, such as fountains and internal lighting can be either switched off or in specific areas, such as those adjacent to a source of natural day light, can be tuned to reduce consumption whilst maintaining the overall safety luminaries' levels.

This trial looked to prove that such strategies can deliver a reduced load profile when initiated, and that the ADR system can aggregate and collate data from a number of sites, to show the actual savings an ADR Event has delivered. The trial therefore aimed to prove the concept that this method can enable DNOs to reduce the Peak loads on a wider and broader level, giving more network headroom during the times when the load exceeds the norm or is raised to an unacceptable level.

An example of a PLSS can be seen in Appendix I.

4.2 Trialling methodology

The methodology for this project was to recruit three commercial building owners as trial participants willing to test the Honeywell ADR system to demonstrate proof of functionality in the UK. A framework for customer engagement was developed iteratively during the project to identify potential participant customers, engage with them in order to obtain sign up to the trial and manage their participation. The ADR system was installed by Honeywell at the three participants' premises and tested by carrying out individual and aggregated load shed events. Honeywell collated data to monitor the performance of the system. Imperial College used this data to evaluate the ADR system performance in the trial, create models to predict future performance and analyse the potential value to a DNO.

4.2.1 Trial participants

A key aim of this project was to develop a framework for customer engagement. The section below explains how we acquired customers for the trial; learning from this process and the resulting framework are described in Section 5 (Project Outcomes). The selection criteria for participants were that they should be electricity customers in the same geographic area fed from the same primary substation and, if possible, the same feeder (for this project we had one customer on feeder E8L5 and two on E7L5). It was also necessary for participants to be receptive to involvement in a research trial. No specific criteria in terms of load profile or composition were set since the aim of the trial was to demonstrate proof of functionality in a range of building types/organisations. A further rationale for this was to maximise the likelihood of identifying three participants in the same area as quickly as possible.

Three customers were recruited, the rationale for their selection and participation is set out below:

1. **Bracknell Forest Council** (TVV project partner): one of their sites was selected as representing a typical public sector building, which was both inefficient and had old technology installed. The premises will soon be refurbished and they again were keen to understand how load could be reduced without impacting employees and the general public.

2. **Bracknell & Wokingham College** (Bracknell Forest Council contact): selected as representing the educational element in a local community. They have recently moved into a purpose built, energy efficient building with modern HVAC plant and because the site contained an engineering facility, they were very keen to participate and understand if a PLSS could be developed that would not impact on their fee paying students.

3. **Honeywell House** (TVV project partner): representative of a typical commercial building with HVAC plant, much like those within the various local Business Parks around Bracknell. As the Building is fully occupied and is due to have its BMS & Control system upgraded, this application could be interfaced with both the old and new technology.

4.2.2 Site preparation and on site works

Following customer sign up, site survey, preparation and system installation was undertaken by Honeywell. In advance of site installation works Honeywell undertook Risk Assessments and produced Method Statements for the installation & commissioning team to utilise (Please see Appendix II for RAMS relating to B&WC and BFC). This team also familiarised themselves with the Customer's H&S policy and any relevant data from the customer's facilities team regarding restricted access, environmental and noise pollution issues.

Off-site, Honeywell set up a specific DRAS Server for the Pilot project (cloud computer that enables SaaS access, monitors, activates ADR Events and stores building data). The ADR equipment installed on site communicates with this server. Prior to carrying out physical works on a site, a meeting with the customer IT provider was arranged as it is vital to have full cooperation of this department as without a live network port the system will not operate. Once this work was complete, Honeywell carried out testing and commissioning. General site activities are detailed below (Box 1), followed by more detail on testing and commissioning phases (Box 2):

Box 1 - Honeywell scope of works

- Honeywell engineer will carry out a Survey at engineering level of all plant that can be automatically load shed for the purposes of Demand Limiting, this will include 2 levels of reduction medium and High. Items included but not limited to. Chilled water plant, Pumps both heating and cooling, terminal heating units, main AHU fans either stopped completely or speed reduction if applicable.

- Honeywell engineer will develop an appropriate demand reduction strategy for the building which will be tailored and approved with the building engineering manager

- Installation of a pulse output from the incoming meter will be required for the usage data transmitted to the DRAS server; this will be arranged by Honeywell and installed at a time and date agreed with the customer. The contact will be fitted by the meter supplier as directed by Honeywell.

- A small approx 500mm x 600mm enclosure to house the web interface controller will be mounted in a location agreed with the building management but local to a suitable BMS interface, all BMS, Network and meter pulse cables are terminated at this location.

- Following the confirmation that a network point is available Honeywell will attend site with a test application and verify that the network port is live and passing data to the server

- An electrical contractor will be employed to install the interface enclosure and install the wiring to the meter and BMS controller

- Honeywell will enlist the involvement of the site BMS contractor to carry out modifications to the control system if there is no BMS installed or there is not a regular contractor currently carrying out the control maintenance we will review what controls would be best suited to the current installation and advise.

- At the completion of the electrical installation and the BMS modifications the Honeywell engineer will carry out the commissioning of the ADR interface and initiate a demand reduction to test the operation of the system, at this time a log on and password for the customer access to the system will be issued and a demonstration of how to log on and view information available from the system also an understanding of the events and how to initiate an event in isolation. Also the procedure to opt out if required.

The installation process included an additional requirement for the main electrical meter to be connected into the customers BMS. This was surprising, given that the Building Regulations and the building Energy Performance Certificates would require this information logged locally. This requirement has a direct impact on installation, as Honeywell are unable to undertake their works until this connection is in place. The issue in future will be raised at survey stage, to enable customers to organise this with their energy supplier, to minimise down time.

Box 2 - Test and commissioning schedule

- Once agreed a network point is configured to the required parameters
- A network test is then carried out using a DRAS interface controller connected only to the network, not to the building BMS system. This is to verify the correct port settings and is operated for an hour, using simulated electricity pulses which are confirmed via the DRAS server.
- A simulated event is then initiated to confirm the function of the DRAS output. Again, this is carried out in isolation and not connected to the site BMS system.
- The PLSS is then uploaded onto the clients existing BMS, either by Honeywell's installation team, or via the clients BMS service company or supplier (the latter option was found to reduce issues over ownership & fault finding) and an ADR Event tested and commissioned t by the customer's BMS supplier.
- During the ADR Event, Honeywell will inspect the systems being controlled, to confirm the actions are as expected and this will be checked again at the end of the Event, to ensure all systems go back to their original or planed status.
- Further checks are undertaken to ensure the data from the DRAS dashboard has identified and logged the Event's data correctly.
- The customer is then issued with an ADR Account, with specific individual logon and passwords, for each clients use.
- The customer is advised that the works are now completed and with their agreement, a further aggregated ADR event is scheduled, to commission the whole ADR system.

4.2.3 Trial load shed events

Two individual trial load shed events were run for Honeywell House, followed by a trial of an aggregated load shed event for all three buildings. In each case, a PLSS was initiated for one hour between the hours of 15.00 and 20.00, For the purpose of the trial, each ADR Event was activated by request, from Honeywell. Agreement and participation of the customers was ensured by scheduling events in advance, to provide transparency and help maintain their cooperation. Customers were notified of the time and duration of the planned event at least two working days in advance by phone. We ran the event and monitored the ADR Event via the DRAS client Web browser (this web resource records kW data from the building and feeds it into the system). It's also possible to access historical data including a 10day rolling average load profile. Each customer decided not to tell building occupants that an ADR Event was scheduled and then asked if anyone noticed any changes or undue impact following the event. Formal building occupant surveys are not within scope of this project however, this will be explored further during further trials to understand impacts.

4.2.4 Data analysis

Imperial College were commissioned to carry out data analysis work on this trial and to inform the TVV project. The following assessments were carried out:

(a) Analysis of performed ADR trials,
(b) Analysis of ADR capabilities,
(c) Analysis of ADR enabled network observability enhancements and
(d) ADR cost-benefit analysis.

(a) Analysis of ADR trials included the audit of proposed demand response strategies, equipment and devices involved and expected demand response contributions. The received data and data downloaded from Demand Response Automation Server (DRAS) were used to assess building demand response capability. The aggregated demand response of all three buildings was also estimated.

(b) ADR modelling included development and calibration of thermal model of buildings. Calibration of the models developed was based on actual ADR trials making use of the actual hourly weather data, outdoor temperature, solar radiation, wind speed and relative humidity. To inform development of the TVV project, the model was then used to assess the capability and limitations of HVAC system based ADR schemes, assess the application of ADR for network management purposes and to recommend further trials.

(c) The potential for ADR to increase the observability of the HV network was analysed by assessing the reduction in uncertainty in voltage and power flow profile that ADR power

measurement enables. For this purpose, actual HV network data and associated power measurements available in the three buildings were used in the analysis of network observability based on state estimation modelling.

(d) ADR installation and operation cost and potential benefits associated with reducing distribution network peak demand and avoiding corresponding network reinforcement were assessed. Imperial developed a framework for cost-befit analysis for ADR application in distribution networks.

5 The outcomes of the Project

5.1 Framework for customer engagement

A key outcome from this trial is the development of a framework for customer engagement which can be used and evaluated in future trials. The framework was developed based on learning from customer engagement activities during this trial. These activities and associated learning points are described below, and the framework itself is presented at the end of this section.

5.1.1 Customer engagement activities during trial

Stage 1 - Customer acquisition:

For the trial, potential participant customers were identified opportunistically through existing contacts (SEPD's project partners for TVV – Honeywell and Bracknell Forest Council) and sampling (contacts of initial participants – SEPD were introduced to Bracknell and Wokingham College by the Council). Recruitment of each customer was achieved through one-to-one engagement to identify relevant staff in the organisation, explain the principles of ADR, scope and purpose of the trial and the potential benefits, as well as the requirement for participants to permit utilisation of their data for trial evaluation. No financial incentive was offered to participants. The primary incentive was the reputational benefit of participation in a trial of smart grid technology which could reduce energy consumption, carbon emissions and local disruption (through reduced need for reinforcement works).

Customers expressing interest were presented with an ADR Agreement. Signing this agreement permitted Honeywell access to the customer's site to carry out initial surveys and gained a commitment from them to participate in ADR Events in principle. The initial agreement used for this project was taken directly from Honeywell's US experiences (see Appendix III for an example agreement).

The one-to-one engagement method was used on the basis of Honeywell's worldwide experience of customer recruitment, which has indicated this is the most successful method. However, it is

very labour intensive and required significant time and effort from SEPD and Honeywell staff to progress from initial engagement to implemented installation. The steps required at each location are described below highlighting the efforts required to reach agreement and installation:

1. Bracknell & Wokingham College
    a. The initial contact was given to the project team by the local authority
    b. An initial meeting was set up with only DNO presence to give an introduction to the project and to explain the benefits and risks to them.
    c. At this stage there was an obvious interest from the facilities manager however, the proposal then had to be 'sold' internally to a senior director (in this case, the principal).
        i. This is the first stage of customer sign up that causes some delay due to the availability and interest of staff at this level.
    d. Following initial sign on from senior management, the team went into further detail about the project and handed the customer the installation agreement covering both the physical installation and the trials proposed.
        i. This is the second potential 'bottle neck' as the document needs to be reviewed by legal teams. In this case the document was turned around in approximately two weeks. This wasn't a delay that was factored into the project plan and is therefore a valuable piece of learning from the project.
    e. Once Legal sign off was complete another meeting took place to sign the installation agreement and to organise site audits.
    f. This process took approximately 2 months from first meeting to signed agreement and from this we estimate that approximately 3-5 on-to-one meetings, as well as various e-mail engagements to reach this point.

Breakdown of man hour estimates to acquire customer (cost per hour consistent with SEPD bid submissions)

Table 1- *SEPD Costs, Bracknell & Wokingham College. Breakdown of man hour estimates to acquire customer (cost per hour consistent with SEPD bid submissions)*

Bracknell & Wokingham College			
Task	**Time (hrs)**	**Real time (weeks)**	**Cost to DNO (£)**
SEPD - Project management	8	4	592
SEPD - Commercial resource	2	1	132
SEPD - Legal resource	1	1	74
Total	**11**	**6**	**798**

2. Bracknell forest Council – Time Square
    a. Bracknell Forest Council were initially engaged via with SEPD via the Tier 2 TVV project. When this ADR pilot project opportunity became available they were keen to be a part of it.
    b. At this stage a senior director put the project team in contact with the building manager.
        i. As the senior team were already involved it reduced the delay in getting this approval as unlike Bracknell & Wokingham College, we had a top down approach. This cut out the potential delay of receiving the correct senior level 'buy in'.
    c. The document did however, still need to go through legal review which took approximately 4 weeks and is another reminder that time needs to be built into any project plan to allow for this if it were to be rolled out on a wider scale.

Table *2* - *SPED Costs, Bracknell Forest Council. Breakdown of man hour estimates to acquire customer (cost per hour consistent with SEPD bid submissions)*

Bracknell Forest Council			
Task	**Time (hrs)**	**Real time (weeks)**	**Cost to DNO (£)**
SEPD - Project management	4	3	296
SEPD - Commercial resource	1	1	66
SEPD - Legal resource	1	4	74
Total	**6**	**8**	**436**

3. Honeywell – Honeywell House
    a. Honeywell are a partner on the TVV Tier 2 project. As such, the customer acquisition element of the project is not as applicable.
    b. However there was learning regarding the agreement as it gave both organisations an opportunity to structure the installation agreement and work out any issues at an early stage. This is covered in more details in section 9.

Table *3* *– SEPD Costs, Honeywell House. Breakdown of man hour estimates to acquire customer (cost per hour consistent with SEPD bid submissions)*

Honeywell House			
Task	**Time (hrs)**	**Real time (weeks)**	**Cost to DNO (£)**
SEPD - Project management	N/A	N/A	N/A
SEPD - Commercial resource	2	1	132
SEPD - Legal resource	1	1	74
Total	**3**	**2**	**206**

Stage 2 - Facility audit:

Following the customer sign off, a Honeywell Energy Specialist undertook a site audit survey, collecting details of the site Asset Schedule, energy consumption data, BMS Manufacturer and any relevant operational details such as operating hours, specialist processes, Critical Plant, Critical Temperatures etc. This survey identifies all plant that can be automatically load shed to limit demand. A site survey typically took 1-2 days and write-up between 2-4 days. It is expected

that one week minimum should be allowed in an ADR project plan to allow time to conduct the relevant works.

Obtaining energy consumption data in records of electrical and gas consumption proved difficult. To alleviate this potential delay, customers were asked to provide Honeywell with direct access to their half hourly demand (HHD) electrical data and this resolved the issue.

Stage 3 - Peak Load Shed Strategy (PLSS) and PLSS Agreement:
Honeywell then created a PLSS for each site by analysing the typical load profile from the HHD with the Asset register, occupancy schedule and relevant processes. By assessing the potential load variations and operational structure of the M&E plant, a PLSS that still fitted within the operational load profile for the site was developed and tailored.

The PLSS was then presented to the participant as a report, including standard information on the principles and benefits of the ADR system. As we progressed with this format, we found it contained too much information for most customers. The content has therefore been reduced to a simplified schedule, outlining the nominated plant, the PLSS strategy and brief description of the process. A final 'Sign off' section was also added to the initial report, so that both parties could refer to a controlled document, and potentially modify it as time progressed and they became more comfortable with the low impact on their business and site occupants

Including customers in the decision making process for the PLSS led to the finding they actually wanted to see an ADR Event live. This may help to gain their support and involvement in developing future PLSS's that can enhance and improve the kW reduction being delivered on their site.

The final phase was for Honeywell to present the PLSS to the Customer in a report format, which provided an open conversation piece. When Honeywell outlined all the details on the PLSS, it was clear that Facility/Building Managers were confused by all the data. The report format was modified to a simplified schedule outlining the nominated plant, the PLSS strategy and a brief description of the process. Information on the load reduction elements was reduced and is now just shown as an indicative value. This approach helped the customer focus on what was involved, not the complexity of the PLSS. We also added a final 'Sign off' section to the report, so that both parties could refer to a controlled document and potentially modify it as time progressed and they became more comfortable with the low impact on their business and site occupants. This makes it clear to all parties what has been agreed and when.

5.1.2 Framework for customer engagement

Based on the experiences above, the following framework has been devised for use in future trials. It provides a starting point for DNO's to understand the level of effort required to implement ADR technology. This can now be evaluated and refined as part of future trials.

The Framework covers engagement required from the first meeting through to agreement of the PLSS. Work after this can be deemed as the technical integration/ installation of equipment. It is broken into three stages:

4. Customer acquisition
5. Facility audit
6. Agreement of Peak Load Shed Strategy

Table 4 – *Framework for Customer Engagement (continued overleaf)*

Stage	Engagement / Task	Description	Responsibility (DNO/ Hon/ Customer)	Physical Time Allowance (hours)	Project Plan (real) Time Allowance (working Days)	Cost to DNO (£)
1	**Initial Meeting**	Introduction to the project and ADR (this is typically with facilities management)	DNO	2	n/a	148
1	**Internal Sale**	If the customer is interested at this stage, it is important that senior staff in the organisation are aware of the potential benefits for later sign off	Customer	2	5-10	n/a
1	**Secondary Meeting**	This is where finer details and expectations can be set. The project team introduce the ADR agreement. This is the Honeywell install agreement that also includes a section regarding the trial	DNO, Hon	2	5-10	148
1	**Legal/ Commercial Review**	Customer to gain approval from their respective legal/ commercial teams	Customer	4	30-40	n/a
1	**DNO/ Honeywell Legal/ commercial Review**	As Above for DNO/ Hon	DNO/ Hon	1 (L) + 1 (C)		140
1	**Completion Meeting**	To agree final agreement and organise on site visits from Honeywell for the 2nd stage	DNO, Hon	1	5	74

2	**Pre Site Visit (handover)**	This is a handover session where the ADR audit process is fully explained and site safety rules are set out by the customer	DNO, Hon	3	5	148
2	**Presentation and Discussion of RAMS**	Productions and agreement of Risk Assessments/ Method statements for on site works	Hon	1	5	n/a
2	**Facility Audit**	Audit of all on site plant to identify despatchable demand	Hon	8	5	n/a
3	**Production of Audit Report**	Honeywell engineer compiles report of despatchable demand and potential PLSS	Hon	10	3-5	n/a
3	**Presentation of report and intro discussion to PLSS**	Meeting with customer to agree the level of disruption acceptable vs benefits gained	Hon, DNO	1	5	74
3	**PLSS Rework**	Prepare final PLSS using customer feedback	Hon	1	1	n/a
3	**PLSS Agreement**	Final agreement of PLSS (no legal or commercial input required)	DNO, Hon	1	5	74
			Totals	37	89-102	8,132

5.2 Technical demonstration of ADR

5.2.1 Technology integration – BMS system interconnectivity

The project has demonstrated successful technical integration of the ADR system with BMS systems in the UK. Honeywell testing of the ADR system has indicated that it is compatible with at least 99% of BMS systems. However, prior to this trial it had not been used in the UK. The trial has demonstrated compatibility with three manufacturers and system types (Table 5). Since the Bracknell and Wokingham College system is a relatively unusual make/model (demonstrated by low market share), this result supports Honeywell's claim of near universal compatibility.

Table 5 – *Trial participant BMS systems*

Customer	Manufacturer	System/Type	HQ Address	Estimated UK Market Share (Honeywell)
Bracknell & Wokingham College	Automated Logic	Web Ctrl – BAC Net	Automated Logic Corporation 1150 Roberts Blvd. Kennesaw, GA 30144	0.5%
Bracknell Forest Council	Trend	IQL	Albery House, Springfield Road, Horsham, West Sussex RH12 2PQ	15%
Honeywell	Honeywell	Excel 5000 + IRC	Arlington Business Park, Bracknell RG12 1EB	35%

All trials were operated according to open protocols, under the OpenADR specification (Version 1.0) as defined under the Lawrence Berkeley National Laboratory standards (http://openadr.lbl.gov/).

5.2.2 Cyber security compliance

SEPD reviewed the Honeywell ADR system in terms of potential cyber security risks during the trial. This exercise involved consideration of the components introduced, their interactions with existing systems and Honeywell's approach to managing cyber security risks. The key outcomes from the review are set out below, showing how cyber security risks have been addressed and what additional controls DNOs may want to introduce.

5.2.2.1 Components

The Honeywell ADR system for building management consists of components installed at 3 trial sites, a web accessible interface for read-only access to device status, and a process flow to request "shed" events. The core components of the Honeywell platform are hosted in a Honeywell owned and operated data centre with distributed components installed at the trial sites. No new equipment was installed at SEPD's premises, and no new connectivity or applications were required to access Honeywell's web interface.

5.2.2.2 Review of Honeywell compliance

Honeywell's data centre underwent a SAS70 audit which certified that the site was suitable for the storage and management of financial systems. This certification was up to date with no significant findings in evidence. Additionally Honeywell completed an SEPD security self-assessment questionnaire with regards to the system and the hosting facility and these provided confirmation that the site met SEPD's information security standards.

The Honeywell web portal was subjected to rigorous vulnerability assessments and penetration tests and has passed these with no significant issues.

The ADR system has been subject to a comprehensive risk assessment which reviewed the possibility of malicious and accidental user activity impacting on the normal operation of the systems and reviewed the potential for harm. The risk assessment found that there were significant risks in the operation of the system and that adequate controls were in-place for the management of information security risks to the system.

5.2.2.3 Design considerations relevant to cyber security

As the ADR system does not have any direct connectivity to SEPD there are no risks to SEPD systems, and any residual risk is purely reputational if the ADR system was shown to be compromised in some way. The ADR trial focused on shedding load from equipment that did not have a significant HSSE impact such as lighting and building temperature.

Load shed requests have to be actively accepted by the participating site, and load shedding is performed slowly over a period of time giving operators plenty of opportunity to override an unwanted shed. Shedding strategies are pre-programmed into units at the trial sites so an ADR shed request is only responded to in one of a number of pre-determined ways.

Data privacy issues were reviewed, but as the ADR is connecting to commercial premises there are no considerations under the Data Protection Act. Control signal data should always be considered confidential an as such is encrypted over public networks to prevent interception,

interference, or replay attacks. The ADR system is capable of sending emails and SMS messages to alert operators of potential problems.

5.2.2.4 Cyber security incident resolution and recommendations

During the trial period a security alert was issued against a component used in the ADR system and installed at client sites. Honeywell responded quickly to this, providing advice on how to reduce any possible risks and quickly producing an updated firmware to apply to the devices. It was noted that there were no contractual controls in-place between Honeywell and SEPD to deal with this process. A key learning point is that the contracts put in place between SEPD and equipment / service providers should include clauses pertaining to how the supplier notifies SSE of a potential problem and how this should be fixed.

5.2.3 Analysis of ADR load shed capabilities

Imperial College conducted analysis of the load shed strategies and events undertaken during this trial. The following section provides context for the analysis of the ADR trial and presents findings from this work.

5.2.3.1 Load shed events from individual buildings

The conducted audits of the three buildings Honeywell House, Bracknell and Wokingham College and Bracknell Forest Council's Time Square revealed that several different ADR strategies might be feasible to be implemented. The corresponding hardware, software and communication were implemented to enable the ADR, which functionality was then demonstrated through dedicated trials. The goal of the trials was to validate ADR communication and operability. In total, five ADR trials were carried out, three for Honeywell house and one for each of the other two buildings. The ADR trials were synchronised which permits the analysis of aggregated performance of buildings. Demand of each building was recorded over several months including the days of the ADR events. This data was used to assess level of demand response delivered by the ADR.

Controllable Devices and their ADR characteristics

ADR installed and tested in the three buildings is based on control of the building electrical equipment with Heat Ventilation and Air Conditioner (HVAC) playing a major role. The available demand response that can be offered to support network management is limited not only by the installed capacity of the associated equipment but also by operating patterns of the devices driven by outdoor weather condition and internal building requirements.

In this context, the available demand response contribution from a group of buildings at a particular point in time is likely to be lower than the maximum contribution that individual buildings would be able to deliver due to difference in building physical characteristics and diversity of HVAC system operation.

The type of HVAC system installed will be also an important factor in determining the amount of flexible demand response that may be delivered. Two different HVAC systems were identified in the Buildings participating in the trials: Variable Air Volume and Fan Coil systems. Variable Air Volume is installed in Honeywell House and B&W College Buildings while Fan Coils are installed in BFC's Time Square Building.

Chilled water is produce by chillers (hot water requirements are met by gas boilers) which is then distributed via Variable Air Volume or Fan coil systems. The chillers remove heat from the liquid through a compressor evaporative cycle. Chillers are composed of compressor, condenser and expansion valve. Compressors could be reciprocating, scroll screw driven or centrifugal. The chillers are operated by electrical motors, representing the major electricity consumption of the chillers. Generally, demand for chilled water fluctuates with the outdoor weather variability. Consequently, chillers do not normally operate at full capacity for most of the time (strictly, the part load operation of chillers will also have an effect on the Coefficient of Performance). Another source of demand response in HVAC systems are Air Handling Unit (AHU) that manage air exchange, through operating fans tat are driven by variable speed electric motors.

In summary, the amount of demand response enabled by chillers and air handling units are determined, to a large extent, by building heat / cooling demand that will be in turn driven by outdoor conditions, which is a key feature of the demand response based on HVAC system. In summer time, for example, the potential contribution of chillers to ADR may be very significant and hence the corresponding amount of flexible demand available for network management is potentially also significant. On the other hand, in winter only the AHU may be in operation (potentially operating at less than 100% power while chillers may not be in use at all) the amount of flexible demand available may be significantly lower. In addition to weather conditions which affects directly the HVAC system operation, some other loads such as lighting, may have a significant impact on the HVAC consumption and consequently to the comfort levels. Hence, the actual performance of ADR system installed, together with the impact on indoor temperature and air quality, will be comprehensively tested and analysed in further trials. Furthermore, application of ADR strategies based pre-cooling and lighting control will be also considered in future trials.

5.2.3.2 Description of ADR Events Implemented

As the majority of implemented ADR strategies (Table 6) are related to control of HVAC equipment, mostly with Chillers, Air Handling Units and Fan coil units, and given that these devices contribute most significantly to the amount of flexible demand potentially available for network control, our analysis focuses on HVAC.

We also note that ADR can be in exercised in discrete lumps, by for example switching off the equipment, or continuously by changing settings on the operating points.

Table 6 - *Applied load shed strategies*

Equipment	**Strategy**	**Honeywell House**	**B&W College**	**BFC Time Square**
Chiller	Switch off	•	•	•
AHU	Fan speed reduction	•	•	
AHU	Switch off	•	•	
Fan Coils	Switch off			•
Peripheral HVAC equipments	Switch off	•	•	•
Lifts	Switch off		•	

Controlling Chillers

As highlighted above, weather conditions will drive the requirement for chilled water, and this will drive the total electricity consumption of chillers. In order to provide flexibility in demand response that may be made available, it will be important to control the chillers individually (rather than having them all off or all on). This will enable the delivery of ADR of different magnitudes and different durations. For example, on a warm summer day, when the three chillers would need to operate, several ADR strategies may be implemented: switching off all chillers for very short time or switching one chiller for longer period of time, while maintaining the comfort levels in both cases. As the implemented ADR equipment can provide this flexibility, further trials will need to be conduced understand the relationship between the magnitude of demand response that may be available across different durations of ADR exercises.

Controlling AHU

Air Handling Units could be switched off when they provide fresh air and ventilation to zones at times when there are no activities. The viability of this strategy is assessed during the site audit and the presence of CO2 monitors will ensure that the exercise of the AHU based demand response would maintain the required air quality (applied in areas / rooms that are not used). The scope of this ADR strategy will be subject to examination through further trials.

Controlling AHU Fan speed reduction

Variable Air Volume systems supply air conditioner demand and can operate efficiently while part loaded. In this case, the ADR strategy would involve de-loading the Variable Air Volume through reducing the speed of AHU fan. The speed reductions could be 30-50% but generally not below the minimum operation limit i.e. 30 percent of the peak design. Estimation of the corresponding

amount of demand response will be determine by the actual operating point and the reduction in speed. It is important to keep in mind that the speed reduction will affect comfort levels, temperature and air quality. Understanding the relationship between the magnitude of demand response, reduction of speed and the impact on the comfort levels will need to be investigated in further trials.

5.2.3.3 Honeywell House trials

Three different ADR trials were carried out at Honeywell House Building. The first one was in the Summer of 2011 (Figure 3), the second one in Winter 2012, (Figure 4), and the third one in Spring 2012, (Figure 5). The differences in demand among these trials days are attributed to different weather conditions as shown in the same Figures.

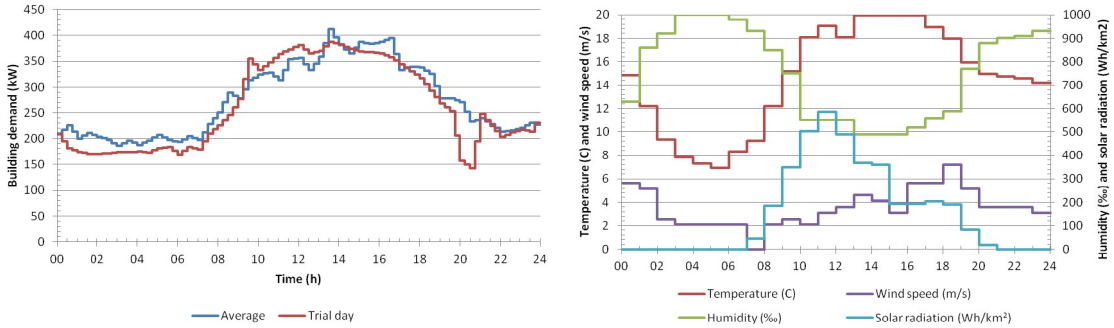


Figure 3 - *Honeywell house demand (left) and weather conditions (right) during the trial -Summer 2012; trial period 19.30-20.30*

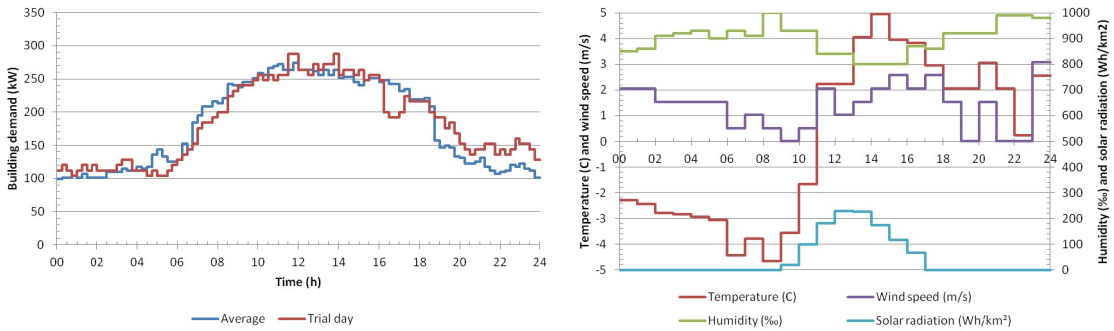


Figure 4 - *Honeywell house demand (left) and weather conditions (right) during the trial in Spring 2012; trial period 16.00-17.00*

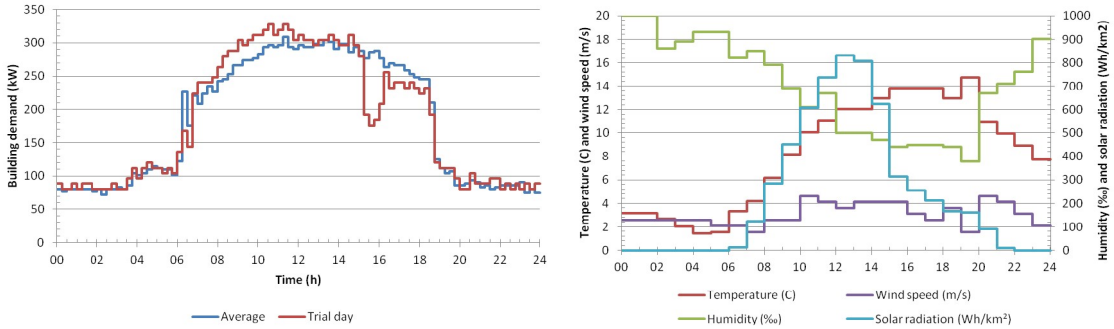


Figure 5: Honeywell house demand (left) and weather conditions (right) during the trial in Spring 2012; trial period 15.00-16.00

In the first trial, the overall building demand throughout the day was greatest given the temperature profile. On the other hand, the estimated demand responses in the first and third trail are similar (93.6 kW in the first trial and 92.0 kW in the third), as the trials were conducted in different periods of the day. The demand response obtained in the first trial would be greater if the ADR was exercised earlier, as the chillers loading is generally driven by the outside temperature. Demand response in the second trial conducted during winter season is significantly lower at 45.3 kW given that heating is provided by natural gas. Table 7 shows the installed capacity of equipment for generic demand response strategies and total for the building. Sign plus denote that not all capacity is accounted for.

Table 7 - *Installed capacity of equipment used in demand response strategy*

Strategy	Equipment	Demand response strategy	Nameplate rating (kW)
A	AHUs	Reduce the duct static pressure (DSP) of AHU 1&2 by at most 20%	170
B		Switch off the kitchen staff changing room AHU & restaurant AHU	7.2+
C		Reduce the speed of fans on the conference rooms' AHU	9.8
D	Chillers	Switch off chiller 1 & 2 and associated pumps	+
E		Switch off chiller 3 and associated pumps	7.4+
F	Boilers	Switch off all boilers	3.7+
G	Heating pumps	Switch off all listed pumps	+
Total nameplate rating			**198.1+**

Table 8 shows the minimum, average and maximum demand response during trials. Significant 15-min demand response variability, about 40%, is observed during ADR trials lasting one hour.

Table 8 - *Demand response characteristics of Honeywell House trials*

Trial	Minimum (kW)	Average (kW)	Maximum (kW)
Summer 2011	68.8	93.6	112.6
Winter 2012	32.0	45.3	50.7
Spring 2012	69.3	92.0	109.3

The main ADR strategies tested involved Chillers and AHU, as a part of Variable Air Volume system. Execution of Honeywell House ADR trials at different times of the year shows the correlation between the amounts of demand response available and weather conditions. This effect is shown in Table 8 between spring and summer trials (major demand response) and the winter trial (lower demand response). Summer and spring demand response were similar because the summer event was at 19:00 hours when outdoor temperature was naturally reducing at the end of the day, in contrast to trial conducted in the spring event. It is clearly important to evaluate individual contributions of ADR strategies and their correlation with outdoor conditions.

5.2.3.4 Bracknell & Wokingham College

The ADR trial of Bracknell & Wokingham (B&C) College is depicted in Figure 6. The B&C College demand response is around 48 kW. In this building a Variable Air Volume HVAC system is installed.

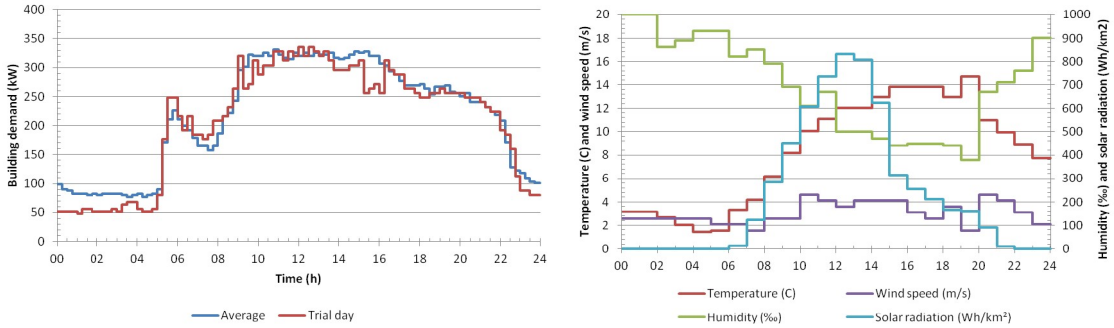


Figure 6 *- B&W College demand (left) and weather conditions (right) during the trial on Spring 2012; trial period 15.00-16.00*

Table 9 - *Installed capacity of equipment used in demand response strategy*

Strategy	Equipment	A/M*	Demand response strategy	Nameplate rating (kW)
A	AHUs	A	Reduce maximum speed of VFD to 70%	45.9+
B		A	Reduce maximum speed of VFD to 50%	45.9+
C		A	Switch off AHU's 3 & 5	7.1
D	Chillers	A	Switch off one chiller and lock the speed of both primary loop & CB pumps to a maximum speed of 70% prior to DR.	66.1+
E	Lifts	M	Switch off one of the triplex lifts	35.3+
F	Extract fans	A	Switch off non-critical extract fans	2.6
G	Toilet extract fans	A	Reduce fan's speed of toilet extract to 70% at most	2.9
H	DX split units	A	Switch off DX split units	2.5
I	Ground source heat pump	A	Switch off ground source heat pump	35.1
Total nameplate rating				**243.4**

*A/M – Auto/Manual demand response strategy

Table 10 - *Demand response characteristics of B&W College ADR trial*

Trial	Minimum (kW)	Average (kW)	Maximum (kW)
Spring 2012	48.0	56.7	72

Bracknell & Wokingham College has a Variable Air Volume system for air conditioning and the ADR strategies are based on controlling Chillers and reducing the speed of the Air Handling Units. Due to the small scale nature of this ADR trial, it is difficult to assess the demand response variability across different seasons and time of the day; the trial data are therefore supplemented through modelling and simulations (although these need further verification). Although this building is significantly larger than Honeywell building, B&W College provided a lower contribution to demand reduction, which may be caused by a number of reasons including differences in activities and occupancy.

5.2.3.5 Bracknell Forest Council's Time Square Building

ADR trial of Bracknell Forest Council's Time Square (BFC's Time Square) building is depicted in Figure 7. The BFC Time Square demand response is around 11.2 kW. In this building fan coil HVAC system is installed.

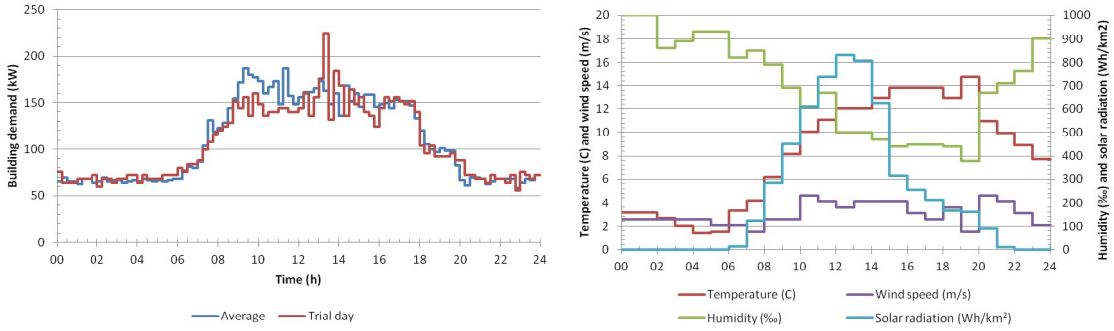


Figure 7 - *BFC's TS Building demand (left) and weather conditions (right) during the trial in Spring 2012; trial period 15.00-16.00*

Table 11 *- Equipment used in demand response strategy*

Strategy	Equipment	Demand response strategy
A	Fan coil units	Shut down fan coil units in open areas by about 38 units
B		Shut down fan coil units in open areas by at most 82 units
C	Chillers	Switch off one chiller and lock the speed of CW pumps to a maximum speed of 70% prior to DR
Total nameplate rating		

Table 12 *- Demand response characteristics of BFC's TS ADR trial*

Trial	Minimum (kW)	Average (kW)	Maximum (kW)
Spring 2012	4.0	16.7	22.7

The single trial conducted in BFC's Time Square Building, suggests that this building offers the lowest demand response among the three (Table 12). This may be driven by the type of HVAC system design and the ADR strategy chosen: the demand response involved switching off fan coils. It is however early to conclude that ADR involving Variable Air Volume offers higher demand response potential than fan coil based systems.

5.2.4 Assessment of ADR value to a DNO

In order to assess the value of ADR to a DNO using data from this small scale trial, modelling was performed to extrapolate results in more detail. It should be noted that the statistical significance of this modelling is low due to the small sample of sites and events – future trials will allow validation of these initial findings. The following modelling exercises were performed by Imperial College using information from Honeywell's DRAS system and network data from SEPD.

5.2.4.1 Objectives of modelling

The purpose of the ADR modelling and simulation undertaken was to complement the data obtained in trials carried out and, for the TVV T2 project, to highlight the effects that are critical for assessing the capability and limitations of HVAC system based ADR. The results of the latter work are presented in Appendix IV. Furthermore, this work was also used to propose further in-depth ADR tests and trials which would be needed to provide a more robust assessment of the value of ADR.

One of the key features of the HVAC based ADR strategies is that the available demand response for the use for the distribution network management (by network operators) is inherently determined by the weather conditions, particularly outdoor temperature and level of solar

radiation. This is critically important for understanding the impact of demand response on the comfort levels. In this context, different control strategies could be examined and applied, from scheduled demand responses ahead of real time (in which case pre-cooling / heating strategies may be applied) to real-time demand control. The amount of power that may be potentially available for control, will however depend on the duration of demand response (load reduction) and understanding this relationship will be essential for the application of ADR to support distribution network management and the provision of services to facilitate more efficient operation of the generation system at the national level (e.g. wind balancing).

5.2.4.2 Model Calibration

Modelling of power demand of the three buildings considers key relevant parameters including building construction, building thermal loads, HVAC system characteristics and weather conditions. Building construction characteristics such as materials, total area, volume, number of floors, area covered by windows etc define the building thermal mass and inertia, which will determine the building response to HVAC equipment based ADR control strategies. In the buildings in which ADR was installed, two different systems are used, namely Variable Air Volume and Fan coils, which have different demand response capabilities.

The building models were developed using real data from ADR trials and a number of assumptions associated with HVAC system operation and implementation of ADR strategies. The model parameters were then tuned with data generated in the ADR trials.

Table 13 shows strategies that are implemented and the key assumptions taken for the simulation of the ADR trials.

Table 13 - *ADR Strategies simulated*

Strategy	Description	Simulation	Assumption
A	Air Handling Units (AHU) shed	27.4 kW	The air circulation is reduced due to reduced AHUs operating point to 30%.
B	Chillers shed	33.4 kW	Chillers switched off
C	Switch off of peripheral equipment	S_1=7.2 kW S_2=2.9 kW S_3=3.7 kW	These strategies have modest impact on the overall demand response system and comfort
Total	**Total load shed**	**74.7 kW**	

The developed model matches reasonable well the actual performance of the ADR trials as illustrated in the figures below.

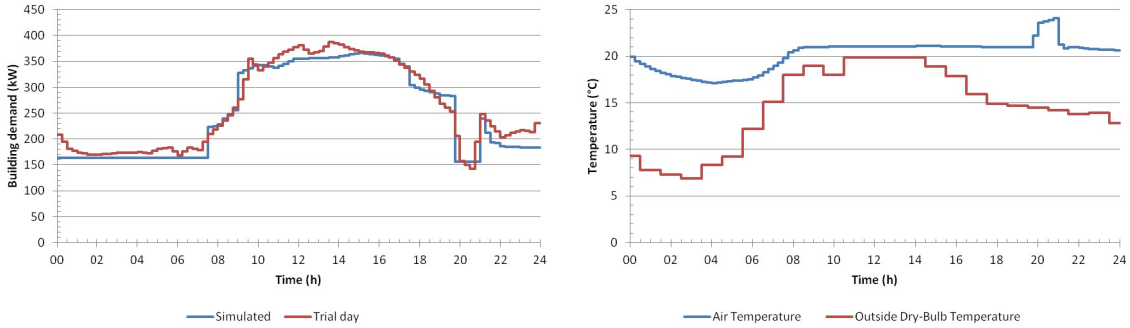


Figure 8 - *Simulation of ADR trial with calibrated Honeywell house building model (left) and estimation of indoor temperature (right)*

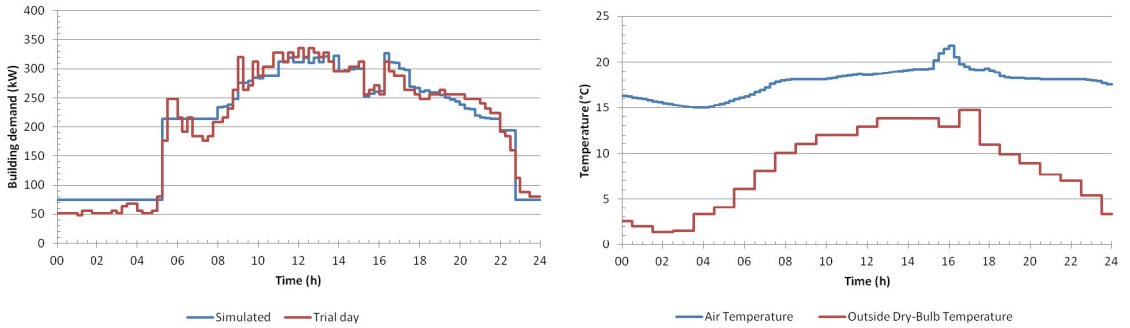


Figure 9 *- Simulation of ADR trial with calibrated B&W College building model*

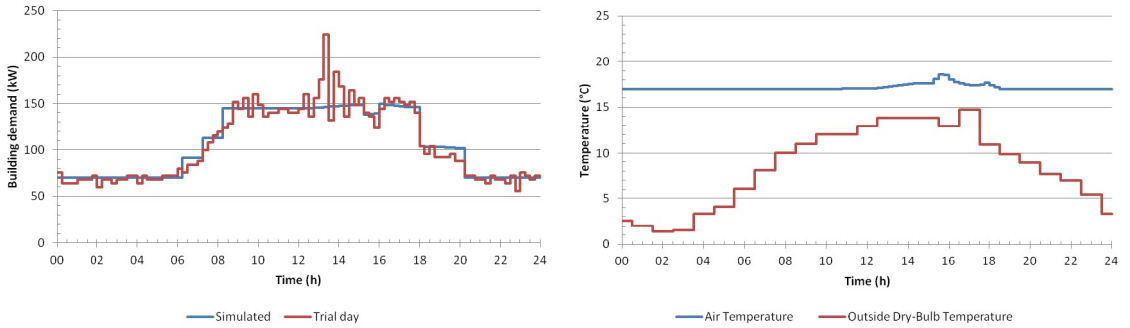


Figure 10 *- Simulation of ADR trial with calibrated BFC's TS building model*

We observe that exercising ADR will impact on the indoor conditions and potentially comfort levels in buildings. Understanding of this relationship will be an important part of future trialling in this area.

Observations

The simulations carried out demonstrate that the available demand response for the use for the distribution network management (by network operators) will be influenced by the weather

conditions and understanding of the impact of demand response on the comfort levels is hence critical. Furthermore, the amount of power that may be potentially available for control may depend on the duration of period in which load reduction is needed. Understanding this relationship will be a key part of future trials.

Note – Imperial College also ran modelling exercises were beyond scope of this small scale trial. This work was funded by the TVV T2 project however, in context of this report, does add value and will need to be investigated in the T2 project. This additional information and modelling can be found in Appendix IV.

5.2.5 Enhancing network observability by ADR enabled power measurements

The key objective of this section is to discuss the potential benefits of ADR in increasing the observability of the HV network enabled by the presence of real time measurements in buildings equipped by the ADR technology. Generally, real time measurements in HV networks are only available in 33kV/11kV Primary substations. Power flows in HV feeder sections and corresponding network voltage profiles that are relevant for the real time operation and network management as well as planning of network reinforcements, can only be estimated with relatively large error margins.

In this context, for the two feeders that supply the three buildings in which the ADR equipment was installed, we carried out case studies to assess the benefits of the ADR enabled power measurements in enhancing the network observability by increased accuracy of the network power flow and voltage profile estimates. Power flow profiles, with the 15-min resolution, in the first feeder sections of feeder F7L5 and feeder F8L5, taken at the Bracknell Primary are available (through existing SCADA system), together with the demand profiles taken in 15 minutes intervals at the 3 sites with ADR. These measurements, together with the feeder network data and estimates of power consumption at the distribution substations supplied for the two feeders are used to assess the network voltage profile and accuracy improvements in voltage and power flow estimates.

The case studies performed examine the benefits of ADR enabled measurements additional installed at load points on state estimation. For the purpose of this analysis we applied conventional Weighted Least Squares based state estimation technique. We demonstrate that additional enabled measurements enabled by ADR reduce uncertainty in voltage magnitudes and the power flows in sections in close neighbourhood. We however observe that although considerable, the benefit of the presence of additional power measurement is local in character.

Observability improvements in Bracknell feeder E7L5 enabled by ADR installed in BFC Time Square Building - The feeder topology is presented in Figure 11, with the location of the BFC Time Square Building indicated (busbar 10).

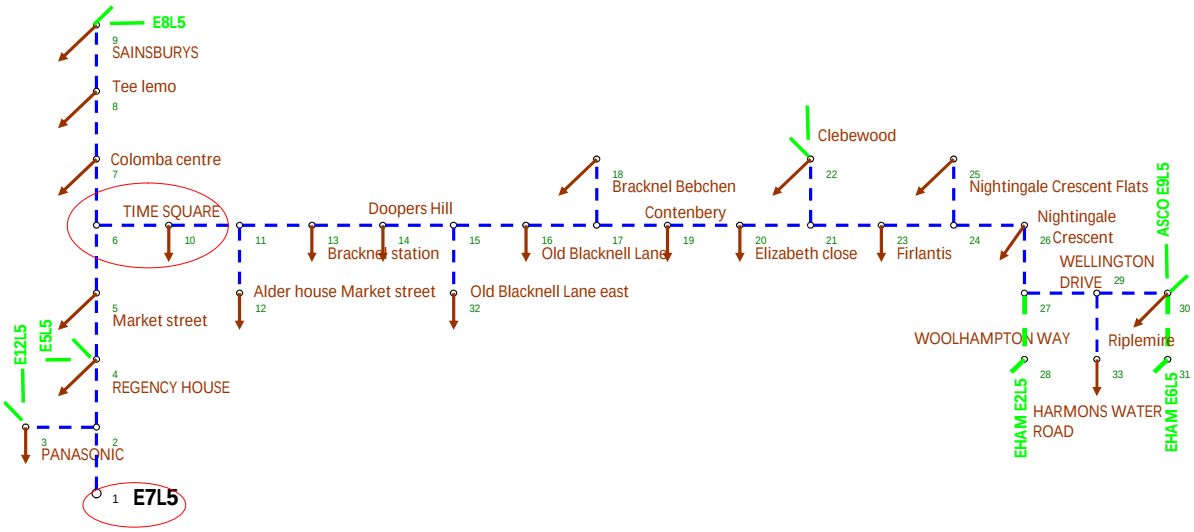


Figure 11 *- Network topology of feeder F7L5 - The demand profile on the Bracknell Feeder E7L5 and of the BFC Time Square Building for the period under consideration (24/06 - 15/07 – 2012) is given in Figure 12.*

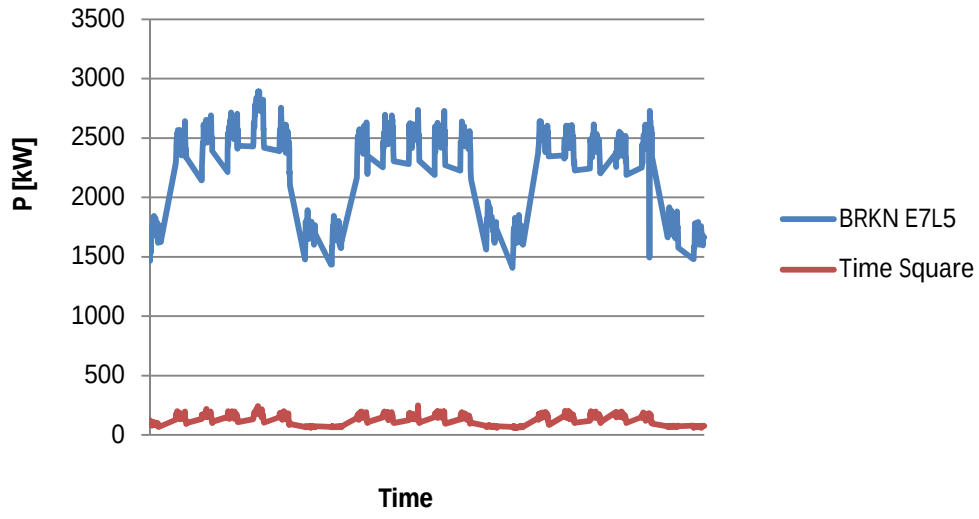


Figure 12 *- Power profile in the period from 24/06/2012 to 15/07/2012*

The demand of the BFC Time Square Building varies quite significantly. Deviation from the mean is found to be about +/- 65%, and we assumed that similar variation of load would characterise all other distribution substations on this feeder, which was used as input to the state-estimation.

We analysed possible variations / uncertainty in voltage magnitudes and power flow across the feeder considering two cases:

(1) Assuming that the only available measurement is voltage and power in the fist section of the feeder in the Bracknell primary (with no power measurement in BFC Time Square Building available)
(2) Considering that power measurement in the BFC Time Square Building is available, together with the measurement in the first feeder F7L5)

The expected uncertainties in the voltage estimates are presented for the both cases in Figure 13. The voltage uncertainty can reach 2.45% around its expected value, if only measurement in Bracknell primary is available. Having accurate information of power consumption enabled by ADR can significantly decrease the uncertainty in voltage magnitude in the surrounding areas. As it can be seen in Figure 13, the presence of measurement in the BFC Time Square Building reduces the uncertainty in voltage magnitude for about 50% (from 2% to about 1%). Although considerable, the benefit of this power measurement on voltage uncertainty is local in character. The observability improvement reduces significantly with the distance from the ADR enabled measurement (busbar), which is expected given that the contribution of the BFC Time Square Building load to the total feeder load is relatively small.

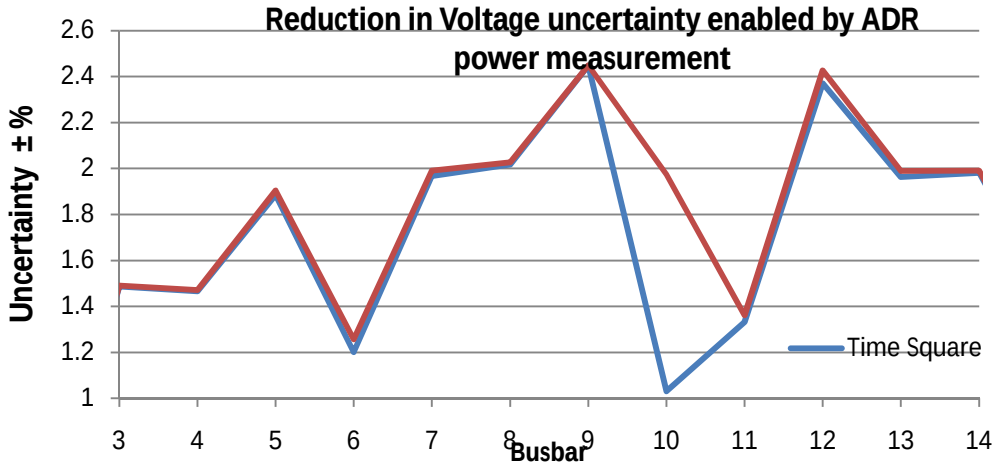


Figure 13 - *Reduction in uncertainty in estimates of voltage magnitudes enabled by ADR Power measurements*

Figure 14 presents uncertainty in Power flow for the examined feeder may be larger than 30%.

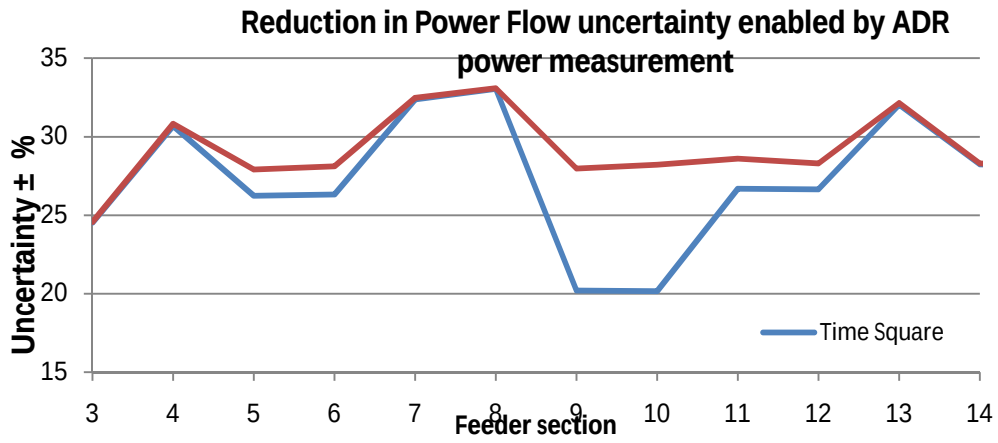


Figure 14 *- Reduction in uncertainty in Power flow estimates enabled by ADR power measurements*

The additional information about the consumption at BFC Times Square Building reduces uncertainty on the power flow sections connected to this node for about 30%. It also has beneficial influence on neighbouring feeder sections. We however observe that although considerable, the benefit of the presence of additional power measurement is local in character.

Observability improvements in Bracknell feeder F8L5 enabled by ADR installed in Honeywell House and Bracknell & Wokingham College - The feeder topology is presented in Figure 15 with indicated locations of Honeywell House (node 6) and Bracknell & Wokingham College (node 17).

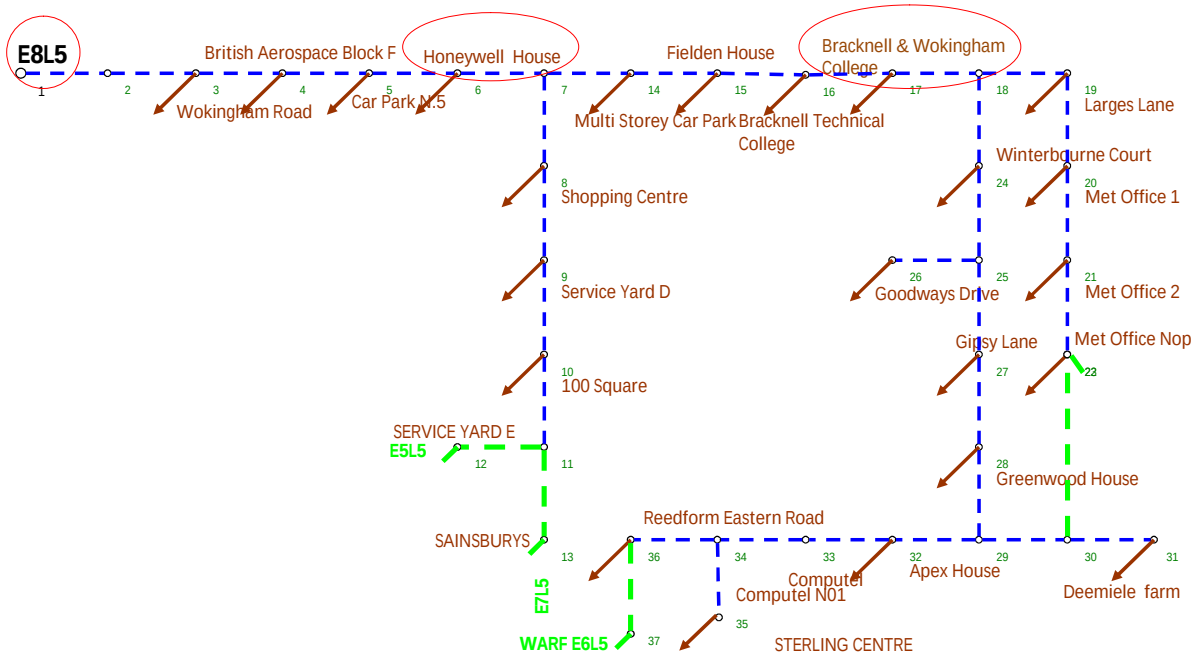


Figure 15 *- Network topology of feeder F8L5*

The demand profiles in the two buildings and the first section of the feeder for the period under consideration are presented in Figure 16.

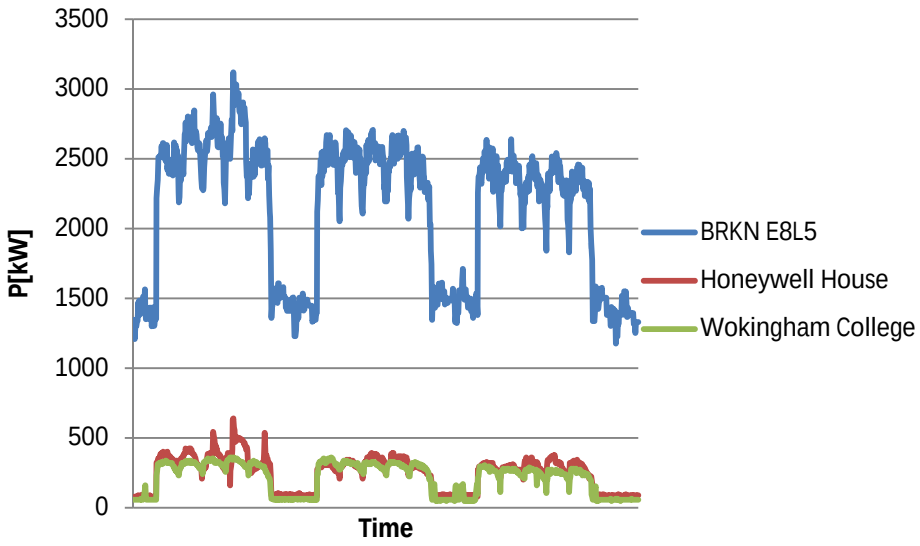


Figure 16 *- Power profile in the period from 24/06/2012 to 15/07/2012*

For the three case studies are examined

(1) Only voltage and power accurate measurements at the primary of the feeder are available

(2) In addition to (1) measurement of power at Bracknell & Wokingham College is available (busbar 17).

(3) In addition to (2) measurement of power at Honeywell House is available (busbar 6).

The expected uncertainties in the bus Voltage estimates are compared for all three cases in Figure 17. The estimated voltage is expected to vary up to 2.46% around its estimated value. ADR enabled power measurements can significantly decrease uncertainty in voltage profile. As demonstrated in Figure 17, the uncertainty in voltage profile for nodes where additional measurements are available reduces for more than 30%. Although considerable, the influence of additional power measurement is local in character.

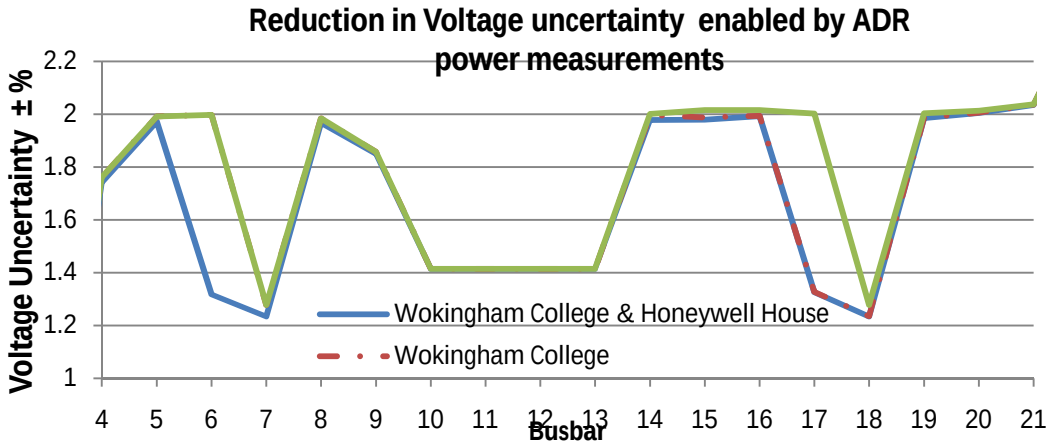


Figure 17 - *Reduction in uncertainty in estimates of Voltage magnitudes enabled by ADR power measurements*

Figure 18 presents uncertainty in Power flow for examined feeder for the three case studies.

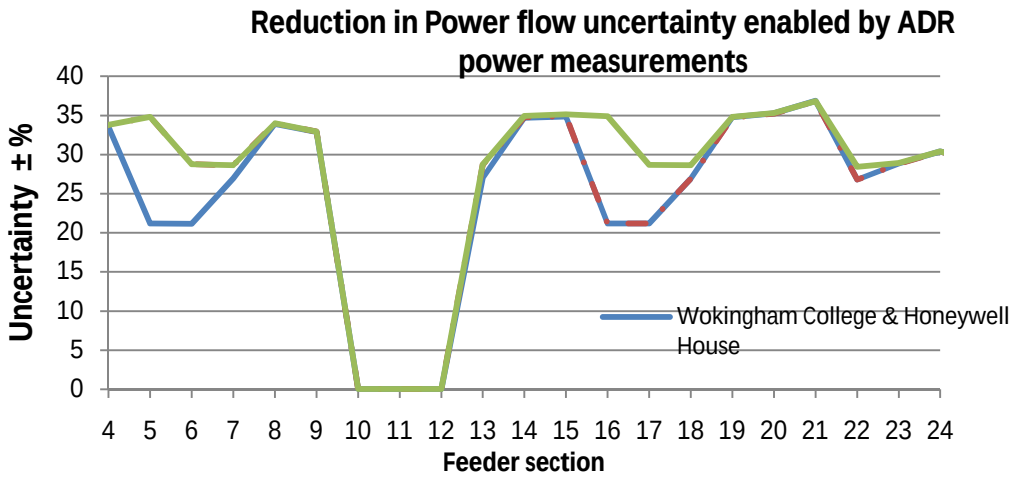


Figure 18 - *Reduction in uncertainty in Power flow estimates enabled by ADR measurements*

Note that the uncertainty of power flow estimates for feeder sections 10, 11 and 12 is close to zero as these sections represent NOPs (no power flow and inexistence of any load on their ends).

We observe that the ADR enabled measurements at busbar 6 and 17 reduce uncertainty in the power flow in sections connected to these busbars for about 40 %. These measurements also have beneficial influence on the neighbouring feeder sections. Although the benefits are considerable, the influence of the power measurement in the two buildings on the power flow uncertainty is local in character.

Overall, we note that the presence of ADR power measurements will reduce uncertainty in HV network voltage and power flow profiles, and hence improve network observability and bring corresponding benefits to both real time operation and network planning processes. However, we note that these benefits are likely to be local, and hence wider use of ADR in future could very significantly improve network observability and hence enhance efficiency of network operation and investment.

6 Performance compared to original project aims, objectives and success criteria

Section 5 has demonstrated how this project met the scope and objectives in terms of demonstrating an end-to-end solution to automate load shed through three functional installations at sites with a range of BMS systems and load characteristics. It has also furnished data which has been used in combination with modelling techniques to provide an initial quantitative assessment of the benefits of ADR (further information provided in Section 8). The ADR system as deployed in the trial has also been reviewed for compliance with cyber security requirements, showing satisfactory compliance and a number of recommendations/considerations to be taken into account in future trials. Overall, the trial has advanced the TRL of the ADR system from 8 (Technology completed and ready for deployment through test and demonstration) to 9 (Technology deployed); while in use in other countries, the system was successfully deployed for the first time in the UK in this trial.

A brief summary of the extent to which success criteria have been met is provided below:

1. **Demonstrate and report on Auto DR delivery capabilities across multiple business sites & Facilities:**
    a. Can the proposed ADR solution deliver an aggregated figure of despatchable demand?
    b. Can the technology reduce loads on the network via a signal from the DNO?
    c. How much can the load be reduced in the trial buildings?

Proven load reductions have been demonstrated – an absolute maximum aggregated load shed of 188kW was achieved by a manual signal via the ADR Gateway at a time specified by SEPD. Analysis of the load shed events shows the ADR system can provide a despatchable demand figure however, confidence in the level of despatchable demand that can be delivered needs to be further investigated to be proven as a deferral of traditional network reinforcement methods (due to the small sample of trial sites and events). As detailed above, the load available for shedding in any building will change given the time of day/year. Modelling based on results from this trial estimated an aggregated peak load shed of at least 460kW (summer) and 100kW (winter) could be expected from the three buildings studied. This estimate is very tentative, being based on such a small sample, but the approach used in this project can be extended with further trials and modelling to provide a more robust quantification of despatchable demand.

2. **Develop a Framework for Customer Engagement that can be analysed and developed as part of the NewTVV/ other LCNF T2 submissions;**

As a result of this project SEPD has created a Framework for Customer Engagement. As detailed in Section 5, an iterative approach was taken to develop and refine processes for customer engagement by working closely with the participants to gain qualitative feedback on the trial process. This approach has informed development of a formal framework for customer engagement with estimated timed stages and costs, based on DNO, Honeywell and customer experiences of the trial. The approach to evaluating this framework that will be taken in the Tier 2 TVV project is described in Section 9. The average cost in terms of DNO staff resource required to engage a customer up to PLSS agreement for this trial was £480. Section 8 below provides assessment of ADR implementation costs based on Honeywell's activity. This section shows that based on a 20 building costing, it is estimated that the net present value of ADR is between £56,700 and £97,000 per building over 30 years.

3. **Provide 'Observability' of the HV/ LV network via Auto DR;**

Section 5.2.5 describes the nature of additional observability that can be obtained through the Honeywell ADR system. The trial has highlighted that potentially useful information may be available, but that the increased observability is very localised. With a greater concentration of ADR customers on a single feeder this would be greatly improved.

The quotation below is a key observation from the Imperial College analysis presented above is:

> *"Overall, we note that the presence of ADR power measurements will reduce uncertainty in HV network voltage and power flow profiles, and hence improve network observability and bring corresponding benefits to the real time operation and network planning processes."*

In summary, as a technical demonstration, the project – and success criteria – were focused on delivery of a functional ADR system. The aims - to advance the system's TRL level from 8 to 9 through a small scale trial and to define a working process for customer engagement were fully met as above. This has been an essential first step in creating a platform for systematically testing:

- the cost, effectiveness and value for money of stages in the customer engagement process
- ADR's technical potential
- the commercial/social limits on exploiting this potential

7 Required Modifications to the Planned Approach during the Course of the Project

The planned approach was followed with only one key modification. We added additional value by engaging Imperial College to assist with review and analysis. This has provided academic rigour in assessment of the potential of ADR to deliver an aggregated figure of despatchable demand based on trial results and initial quantification of benefits.

The selection of Imperial College for this work was based on a pre-established relationship with SEPD through the TVV Tier 2 LCNF project. It was recognised that analysis of this Tier 1 project would not only add value to the trial by maximising the learning from the trial load shed events, but also feed directly into development of wider trial strategies.

8 Significant variance in expected costs and benefits

8.1 SEPD Project costs

There were no significant variance in cost to the overall project and the final close down spend on the project is £260,277 from a budgeted £260,000. As noted above the key change from initial plans was to hire an external resource (Imperial College) to add independent academic rigour to the project to ensure that it would be as valuable as possible to UK DNO's. This has provided greater learning from the trial than initially envisaged at project inception.

Table 14 – *Cost variance*

Cost	Predicted £k	Actual £k	Variance £k	Variance (%)
Contractor (Honeywell)	**219.9**	219.9	0	0
Project Management	**27**	23	-5	11.5
Overheads	**3**	3	0	0
Contingency	**10**	15	+5	50
Total	**260**	260.2	+0.2	<1%

Project Management – The 11.5% variance in this section was due to work being completed during the acquisitions stage being completed with less resource than was initially expected as trial participants were acquired during with the assistance of previous relationships. More detail can be seen regarding this in Section 5.1.

Contingency – The 50% variance in this cost was due to the need for additional data analysis in the latter stages of the project. The project team employed Imperial College to help assess the value of ADR to a DNO and to give further independent rigour.

8.1.1 Honeywell costs

Honeywell were contracted to provide all physical elements of the project and encountered some issues which impacted on these costs during the lifecycle of the project. These were not passed on to SEPD due to the small scale of the pilot, so did not affect SEPD's overall project cost.

However, a qualitative overview of the areas of increase and causes is provided below to inform potential future trials.

- The prime area of additional cost incurred was due to the length of time it took to identify the right person within the organisation and then proceed with the recruit of those Customers, as well as the requirement to have the Supplier undertake the electrical meter connections. These costs were not accounted for within this project and will require due consideration for future ADR trials.

- The time scale was further elongated by the fact that some customers wanted their Legal team to amend agreement T&C's, which meant Honeywell needed to involve their Commercial team, before gaining final sign off. Combining the SSE and Honeywell T&C's (as in the Customer Engagement Framework developed) will minimise the effort required by Legal and Commercial teams and reduce the time scale.

- Another source of additional costs related to an incumbent BMS provider charging a significant amount for a small scale amendment to the BMS. To alleviate this issue in the future, Honeywell would undertake a further evaluation on the cost verses benefit analysis to include the potential risk of problem solving, should an issue occur if Honeywell had programmed the BMS themselves.

8.2 DNO expectation of benefits

The project set out to demonstrate the functionality of ADR in a proof of concept trial. There were no planned changes to incentive payments or expected savings in revenue (allowed for in DPCR5 settlement) due to the scope and scale of the trial. Data from the trials supplemented with modelling exercises have been used by Imperial College to undertake an initial analysis of the value of ADR at this scale, which can be used to inform future work.

8.2.1 ADR Cost benefit analysis

Imperial College developed a framework for assessing the value of ADR in commercial buildings in reducing the need for distribution network reinforcement. This framework and implications based on data from this trial are presented below.

An ADR scheme will break even when the cost of ADR enabled reduction of network reinforcement cost equal to the cost of avoided network reinforcement. This can be expressed through a simple relationship involving three variables:

- Cost of ADR installation (A, expressed in £)
- Demand response for network peak demand reduction enabled by ADR (R, expressed in kW)
- Distribution network benefit enabled by peak demand reduction, or avoided cost per each kW of peak demand reduction (B, expressed in £/kW);
- The ADR will break even when R = A / B.

In other words, if the building with ADR capability installed can reduce distribution network peak demand for more than R, then investing in ADR is justified (note however that consideration of benefits of ADR in providing other services, such as reserve and balancing are not in the scope of this project, but will be considered in Tier 2 TVV project). Therefore, R represents the minimum distribution network peak demand reduction that ADR should be able to facilitate, for the ADR solutions to become cost effective. Table 15 presents the components of ADR cost (A): there are three key categories of cost (1) site-specific costs (audit and installation costs), (2) fixed costs of installing ADR in 20 buildings (off site equipment and support structure cost) and (3) refresh cost (involving server replacement, support and software licences renewal etc)

Table 15 *- ADR cost based on operating licence for up to 20 buildings;*

Category	Value
Site specific cost • Undertake recruitment process for new Customer • Undertake Commercial process for Terms & Conditions' (T&C's) sign off • Produce Risk Assessments & Method Statements (RAMS) for site survey & sign off • Undertake site survey & identify Building Management System (BMS) control strategy • Collate ½ hr data, Asset Register & Gas Consumption to form Base Line – Review • Test internet connection for compliance • Customer to instruct Supplier to provide pulsed output from main Electrical meters • Design Peak Load Shedding Strategy to fit with BMS Control, or identify Programmable Logic Controller (PLC) route • Produce Site Report and identify Low and Medium strategies plus other relevant information • Gain agreement on which Peak Load Shedding Strategy (PLSS) to implement and sign off • Produce RAMS for site access & installation programme • Produce Health and Safety (H&S) File for site team compliance • Write PLSS programme appropriate to BMS language • Upload onto BMS (with 3rd Party service provider (SP), if required) • Supply, install & commission ADR Gateway/s • Test ADR system through Demand Response Automation Server (DRAS) • Commission ADR site installation • Undertake training programme for Customer	£34,351
Fixed costs (off site equipment and support structure cost for 20 buildings) - Design and develop the DRAS Operating Programme for SSE (Web based) - Obtain specific DRAS Operating Licence – Statement on Auditing Standards (SAS) No. 70 Certification & compliancy - DRAS Hosting framework – SaaS (Software as a Service) - DRAS Maintenance programme & software updates - Customer training & On line support	£446,925
Refresh cost	0 – 10%

Based on a costing for 20 buildings, it is estimated that the net present value of ADR cost is between £56,700 and £97,000 per building over 30 years.

In order to estimate the benefits of distribution network peak demand reduction i.e. component B, a set of HV representative networks characteristic for the area of ADR trials is used. Designed representative networks[1] satisfy the network security standard ER P2/6. Parameters of representative networks, shown in Table 16, are calibrated against the actual GB distribution systems.[2] [3]

Table 16 - *Representative network characteristics*

Representative network	Consumers per km^2	Load density (MVA/km^2)	Distribution sites per km^2	HV network density (km/km^2)
Semi-Urban	3,145	3.28 – 4.79	7.3 – 10.5	4.4 – 5.9
Urban	13,500	13.27 – 16.04	32.5 – 42.5	11.2 – 12.8

Network reinforcement cost is evaluated for a set of peak demand increases for which assets requiring upgrade is identified. Those assets are costed and supply cost curves are derived i.e. reinforcement cost of each representative network is estimated as a function of peak demand. The asset upgrade unit cost data is based on cost approved by Ofgem (2008) and used in the recent distribution price control review. Table 17 shows an excerpt from the list of cost items.

1 C.K. Gan, P. Mancarella, D. Pudjianto, G. Strbac, "Statistical appraisal of economic design strategies of LV distribution networks", *Electric Power Systems Research*, Vol: 81, pp. 1363-1372, Jul 2011.

2 C.K. Gan, N. Silva, D. Pudjianto, G. Strbac, R. Ferris, I. Foster, M. Aten, "Evaluation of alternative distribution network design strategies", 20th International Conference on Electricity Distribution (CIRED), 8-11 June 2009, Prague, Czech Republic.

3 ENA and Imperial College, "Benefits of Advanced Smart Metering for Demand Response based Control of Distribution Networks", April 2010.

Table 17 *- Network equipment cost (in 2011 sterling pound)*

Asset	Units	Cost (£k)
11/0.4 kV ground mounted transformer	#	14.8
11/0.4 kV pole mounted transformer	#	3.3
HV overhead line	km	39.4
HV underground cable	km	93.2
EHV/11 kV ground mounted transformer	#	425

Rate of reinforcement cost per peak demand kW is estimated for various peak growth rates. Range of rate of reinforcement cost for semi-urban and urban distribution networks, excluding low voltage network component, is estimated at £395/kW to £730/kW as shown in Table 18 (in this analysis we assume that ADR in commercial buildings may offset cost of reinforcement in HV and EHV networks)

Table 18 *- Representative networks reinforcement cost (excluding LV network cost)*

Representative network	Reinforcement cost (£/kW)
Semi-Urban	535 – 730
Urban	395 – 455

Therefore, minimum distribution network peak demand reduction per building i.e. component R can be estimated. It is in range of 78 – 246 kW (as presented in Table 19).

Table 19 - *Range of minimum peak demand reduction (per building) needed for ADR installations to be justified*

Offsite refresh cost	Representative network	Break even ADR enabled peak demand reduction (kW)
0%	Semi-Urban	78 – 106
	Urban	124 – 144
10%	Semi-Urban	133 – 182
	Urban	213 – 246

Estimated capabilities of demand response of the three buildings during winter and summer periods are shown in Table 20 (note that these are only estimates, and that additional trials will be required to confirm how closely and consistently actual capabilities match these estimates).

Table 20 - *Estimates of peak demand reduction capability enabled by ADR*

Building	**Peak reduction capability (kW)**	
	Winter	**Summer peak**
Honeywell House	50-80	110-220
B&W College	40-80	220-260
BFC Time Square	10-50	130-150

If the network reinforcement are driven by winter peaks, it may not be justified to install ADR as the contribution to peak reduction presented in Table 20 is less than the minimum required presented in Table 19. Note that the lower capability of ADR based peak demand reduction in winter is driven by the use of natural gas for buildings heating, rather than electricity. If however the network peaks occur in summer, network reinforcement would be driven by summer peaks and ADR is likely to be beneficial. However, this may depend on the duration of network peak demand period and the ability ADR to maintain peak demand reduction for required period of time without compromising on comfort levels, as discussed.

Furthermore, the prospect of a wide rollout of ADR solutions will drive ADR cost significantly down making it more attractive. Moreover, ADR could provide additional services, such as reserve and balancing service to support real time system management, and could also reduce the need for peaking plant. If ADR could access these benefits, it would make ADR solutions more commercially attractive.

9 Lessons learnt for future projects

Through this small scale trial of ADR in Bracknell, we have proven that ADR can reduce peak loads in UK buildings and we have developed a Framework for Customer Engagement as a result of negotiations with customers. The project has also allowed some initial cost benefit analysis of ADR although because the results presented are based on a very small sample, further work is required to provide a more accurate quantification. For example, it is expected that there would be economies of scale in wider deployment. Given that the scope of this project was limited to the installation and demonstration of basic ADR functionality, a comprehensive set of trials is now needed to determine the capabilities, limitations, potential roles and value of various ADR schemes in providing support to distribution network management and facilitating integration of low carbon generation in the UK. Key learning points relating to various aspects of the trial are set out below, followed by more specific recommendations for future trialling based on Imperial College's assessment of next steps required.

9.1 Customer Engagement and Participation

- The trial showed the value to DNOs of engaging with a local Council. The support received from Bracknell Forest Council in this trial provided numerous opportunities to publicise the project to the community and show that SEPD was managing the network in a way that provides the energy people need without the need for unnecessary disruption. The good relationship established with the Council has opened many doors for the project for example a council director introduced the project team to the right contact at Bracknell & Wokingham College. The College were very receptive as a result of this recommendation.

- Customers will most likely require a participation incentive in the future for large scale ADR deployment and participation. This learning is based on informal feedback from Bracknell & Wokingham College. At this stage they are more than happy to be involved from a publicity perspective however, if there are no direct savings on overall energy use they would work with SEPD to investigate incentives and incentive structures. This will be an important part of the TVV Tier 2 project.

- The individual ADR Agreements take longer to get signed off than originally envisaged. All agreements need legal sign off however, as there is no direct incentive to participate, sign off may not take top priority with customers' legal departments and may take a number of weeks to completion. The trial showed the stage from signed agreement to "signed off" audit report could be 6-8 weeks, whereas 3-4 weeks were allowed in the project planning stages. In addition, it was found that while the key contact at the

participant site may be enthusiastic about deploying ADR on their site, their direct reports may not be quite as keen, initially. Participation in this ADR trial was often driven by senior directors however, at times the staff running the buildings struggled to find time to help with audits and implementation. This is also something that needs to be considered in the timeline in future projects.

- Following on from the point above, since the individual Agreements (trial sign up and PLSS approval) took longer to get signed off than envisaged, they will be combined in future trials and the effect of this on the overall time required for trial sign up will be evaluated.

- It became apparent that the actual level of kW reduction agreed within the PLSS is somewhat dependent upon the person making the decision & their status within the Company/Building. Initial observations suggest that if the decision is taken by staff members at a sufficient level of seniority, no one will question the strategy or the impact, if any, encountered. This suggests ADR will be most effective in reducing load if trials receive management sponsorship at the highest level, a premise which could be investigated in future trials. It also indicates that design of any incentive should consider the type and value of incentive that would gain support from management staff.

- We also found that customers asked what other customers were doing. This interest in could be an opportunity to achieve greater kW load shed from ADR Events by promoting interaction between customers. It could be possible to evaluate the effects of sharing ADR best practice or creating a League Table, on the basis of a % Load Reduction, (as a maximum would be unfair on customers with smaller loads). The demand for, and effect of such initiatives may be investigated in the TVV T2 project.

- It is evident that an ADR Event can actually save energy, as well as change the load profile, this is however, totally dependant upon the time of an Event i.e. an ADR Event is scheduled for 4:30-5:30 in a commercial building, on a Friday night. When the event is completed, the building occupancy is actually significantly less than during the rest of the week, so it would be possible to change the occupancy time schedule to allow for this situation and not restart the HVAC plant & selected equipment from the PLSS. This approach can only work if programmed into the BMS and validated with the Building's FM team, but it does show the potential to make savings, as well as a change in peak load.

- For ADR Events to be effective, it is necessary to gain access to a valid load reduction. Level of potential load reduction was not a criterion for trial participation, however the

variation in potential load shed for the three buildings studied in this trial and the costs involved in recruitment and ADR deployment suggest this approach may not be cost effective in future wider trials. It may be necessary to select participants on the basis of best available load reduction.

- During the evaluation phase Honeywell were asked for information on the ambient conditions prevailing at the time of an ADR Event, by Imperial College. Unfortunately, this data is only available from the BMS, which Honeywell (and therefore Imperial College) do not have access to. As a result Honeywell are investigating the viability of altering the ADR system data to include temperature and the system will be updated if viable.

- When analysing the load profile data, Honeywell found evidence of a Customer exceeding their Maximum Demand (MD) allowance. This type of information could enable the DNO and supplier to work on a resolution. This data will also be useful to DNOs if site profiles change significantly, as the DNO can identify where this is occurring and where to apportion costs, if a single Customer has exceeded their MD profile.

- In this trial actual programming of the ADR event onto the BMS was done by at least one incumbent BMS provider. The trial showed providers may see this as an opportunity to charge for this service. Discussions during the trial suggested early engagement to build relationships with BMS providers might affect their approach to providing this service.

- In the future, the PLSS may require additional parameters for different event durations – e.g. different times of day may require entirely different load shedding strategies, for the reasons discussed in Section 5.

- For SEPD, working with other parties involved in this trial on a partnership basis, rather than the normal Customer/Supplier arrangement, developed open discussion and lead to mutual respect. However, as a DNO, we also found we are not traditionally set up for dealing with all T&C's expected and required by the ADR supply industry. Similarly, the industry is not necessarily set up for this 'Learning' type of Project, where the end might not deliver against an expected set criteria. Feedback from Honywell suggested it might prove valuable for the DNO's to develop a standard form of contract, or work from one already developed.

- Using one-to-one engagement and 'word of mouth' was effective for a proof of concept trial with a very small sample requirement. Its effectiveness for a larger trial both alone

and in combination with other methods including presentations at events/groups and website promotion should be evaluated. It was easy to identify a very small number of participants for whom potential reputational benefits were sufficient incentive. The pool of participants with this mindset may not be large enough for a wider trial and the need for an incentive should be explored. Secondly, the role of an incentive can be evaluated – as these participants accepted no and low impact PLSSs without an incentive, use of incentive to drive acceptance of PLSSs with a higher level of impact could be considered.

- Using the information regarding the steps and time taken to acquire customers we have calculated the cost it took to get to sign up stage. It is important to remember that as this is a small scale trial, the estimates are based on a limited sample. However, it provides a valid indicative cost to a DNO associated with recruitment for this type and scale of trial.

Table 21 – *Customer engagement cost per MW load shed (see Section 5 for details)*

Building (company)	kW Shed	Cost to DNO	Cost per MW load shed (£k)
Bracknell & Wokingham College	56	798	14.250
Bracknell Forest Council	11	436	39.636
Honeywell	70	206	2.943
Overall	**137**	**1440**	**10.511**

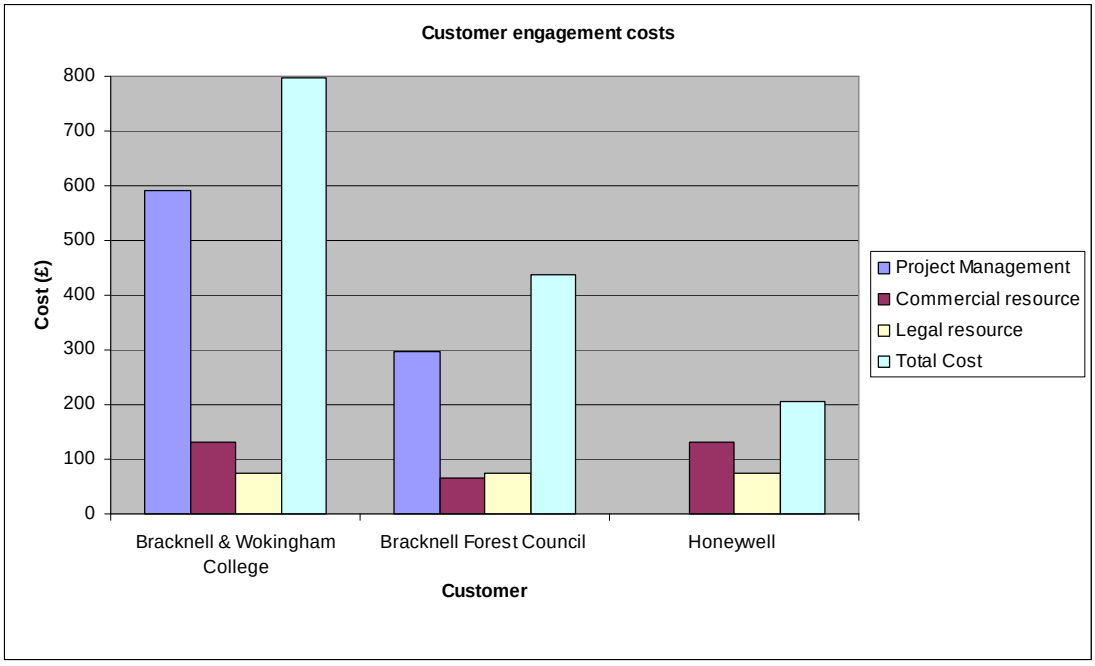


Figure 19 – *Customer engagement costs*

9.2 Cyber Security

While the ADR system was not found to present any undue cyber security risks during this project, we have identified a number of recommendations for additional controls which should be considered in future ADR trials:

- The contracts put in place between SEPD and equipment / service providers should include clauses pertaining to how the supplier notifies SEPD of a potential problem and how this should be fixed.

- Require strong authentication to the Honeywell portal in order to minimise the possibility of attack by external parties.

- Email notifications from the ADR system should be digitally signed to reduce the possibility of spoofed mails being used to interfere with ADR operation

- Opt out messages should also be digitally signed to address the risk identified in the Honeywell Cyber Security plan of participants claiming not to have sent an opt-out (this may eventually impact a customer's tariff)

As part of the deployment of equipment to customers participating in the ADR trial, vendors should include recommended security options for ensuring that ADR equipment, if compromised, does not provide additional access to the customer's network.

Finally, SSE Corporate security has recommended the use of Security Procurement Language[4] in all contracts relating to control systems – this should be applied to the Honeywell ADR system. The Cyber Security Procurement Language for Control Systems project was established in 2006. It was an initiative that DHS (The Department For Homeland Security) sponsored together with Idaho National Laboratory, the Multi-State Information Sharing and Analysis Centre, and private industry. The purpose of the project was to summarise security principles that should be considered when designing and procuring control systems products and provide examples of language to incorporate into procurement specifications. By utilising the SPL DNOs would be able to build the necessary level of assurance in to contracts required to give assurance in the procurement of control systems, including for notification of issues and timelines for patch delivery.

[4] http://www.us-cert.gov/control_systems/pdf/FINAL-Procurement_Language_Rev4_100809.pdf

9.3 Future trialling required

The trials conducted suggest that different buildings offer different levels of demand response, which may be driven by different types of HVAC system design (for example Variable Air Volume vs. fan coils) and the ADR strategy chosen. Now that basic functionality has been proven, it is important to analyse the contribution of different ADR strategies and understand and quantify the main factors influencing the level of demand response that may be available.

In particular, given that ADR is based on control of the buildings HVAC systems, this should include trials aimed at establishing the impact of outdoor weather conditions (temperature profiles, humidity, solar radiation), constraints imposed by the design of HVAC systems and equipment used, building insulation levels and building thermal inertia, activities taking place in the building. In this context, it will be particularly important to understand how the amount of available demand response changes across different weather conditions and seasons, the time over which demand response may be required, and the amount and duration of the demand payback while monitoring the indoor temperature and air quality relevant for maintaining in-door comfort levels.

Following the analysis of the ADR implemented and actual trials conducted, recommendations for future work include:

- Assessment of the demand response availability as a function of season, time of day, weather condition and duration of the demand response exercise including the intensity and duration of payback effect. This should include assessment of the individual contribution of different ADR strategies to

- Understand and demonstrate the impact of ADR on comfort levels, which may require measurements of indoor temperature and potentially air quality

- Assessment of predictability and despatchability of ADR, as this is critical for DNOs to incorporate ADR into network management

- Further cost benefit analysis to fully understand the potential value of ADR. This should cover site specific and site non-specific costs including DNO requirements and system control interfaces.

As well as technical and economic evaluation of ADR, further work should include analysis of the Framework for Customer Engagement developed from this trial. This should include investigation of the following questions:

- Are the defined stages appropriate – are additional stages required or can any be brought together to reduce the length of time it will take the project team?
- Are the materials used at each stage appropriate – for example can legal/ commercial documents be simplified to make reviewing and approval easier for the end customer?
- How do customers experience the engagement process – what is the retention rate at each stage and what are the reasons for continued participation or drop out at each stage?
- Are the estimated timescales accurate?

9.4 Likelihood of large scale deployment

One of the prime objectives a DNO will have when considering an Automated Demand Response (ADR) application will be to assess its potential effectiveness against the major capital investment & local disruption required to replace or upgrade and reinforce a constrained network. If the network only reaches near capacity or becomes constrained at specific times or during major events as the peak loads occur, the actual network may not require any reinforcement, if the peak loads can be controlled, shifted and/or reduced.

The likelihood of wider deployment of ADR will depend on the temporal and spatial distribution of peak loads. As shown in Section 8, ADR is most likely to have the greatest benefits for networks experiencing summer peaks.

10 Planned implementation

While the TRL of ADR has advanced, the trial deployment demonstrated in this project needs to be supplemented by further research before ADR can be adopted as a Business As Usual (BAU) solution to network peak reduction. SEPD will continue to work with Honeywell and Imperial College to undertake further trials of ADR under the TVV project, based on the recommendations above. The wider scale implementation proposed under TVV is intended to determine the feasibility of taking ADR to BAU. This will not just further stretch and test the technology, but also look at the commercial arrangements needed to make this solution viable in the future.

In summary, it will be essential to develop and demonstrate:

(a) The capability to ***predict*** the amount of ADR available as a function of time over which demand response may be required including the amount and duration of the demand payback. This prediction should ideally cover various time-scales, from minutes to hours ahead. It may be desirable that the ADR systems installed within individual buildings carry out this task;

(b) The capability to ***optimise*** the dispatch of a *portfolio* of individual ADR schemes to achieve a particular demand response objective that may include peak demand minimisation or demand response aimed at supporting energy balancing task at the national level. This could be conducted by the DNO or by ADR aggregators through carrying out Virtual Power Plant type functionality.

(c) The capability to ***incorporate*** ADR within distribution network management system and support network *operation* both under normal and outage conditions. It may be appropriate that, for example, the available ADR resources is utilised through automatic actions, triggered by particular events (e.g. loss of a primary transformer)

Other Considerations

For ADR to be introduced as a technology that can be implemented as a tool that DNOs can use as a deferral and/ or alternative to traditional reinforcement methods, there will need to be considerations/ developments in the following areas;

- **Commercial arrangement** – New commercial arrangements will need to be developed to facilitate an open market in ADR. This pertains to the relationship between the DNO and the customer. There will need to be defined incentives for customers to participate

that are easily accessible and administered. This is something that will be further investigated in the TVV T2 trial.

- **Customers** – At present customers are very aware that reducing energy will save them money by reducing operational costs. However, there is no knowledge of the downstream benefits of peak shifting/shedding. If this solution were to become a success we feel that awareness of ADR and DSR would need to be raised. It is thought that this would increase take up and reduce engagement times.

  We also feel that if there was a direct incentive to the customer, engagement times would be reduced as it would be seen as a greater priority. The type and level of incentive required will need to be further investigated in future trials.

- **Framework for Customer Engagement** – To be proven as a cost effective solution future trials will need to be heavily focussed on the time and effort required to acquire customers. The Framework for Customer Engagement is a starting point that can be utilised by all DNOs to develop in order to create a model that can be used across the UK.

11 Intellectual property

The following tables lists all physical components and knowledge required to replicate the outcomes of this project, showing how the required intellectual property (IP) can be accessed by other GB DNOs. Further detail relating to any knowledge item is available from SHEPD on request by contacting the project manager jenny.1.rogers@sse.com

Table 22 – *Components required for project replication*

Component	**Products used in project or commercially available equivalents**	**IP ownership and availability**
Automated demand response system	Honeywell ADR system	Honeywell Commercial product available for purchase

Table 23 – *Knowledge products required for project replication*

Knowledge item	**Application**	**IP ownership and availability**
Methodology for trial deployment of ADR system on GB network in commercial buildings	Deployment of ADR in commercial buildings	SEPD Closedown report Sections 4.2, 5.1 and 9.1 and Appendices I, II & III
Customer Engagement Framework	Engagement of commercial customers for an ADR trial	SEPD Closedown report Sections 5.1 and 9.1
Commercial Agreement for ADR	Engagement of commercial customers for an ADR trial	SEPD Closedown report Appendix III
Cyber security issues associated with ADR and controls	Deployment of ADR in commercial buildings	SEPD Closedown report Sections 5.2.2 and 9.2

Item	Description	Owner	How benefits will be shared	Notes
GB network impacts of ADR	Understanding of the potential range of load shed and factors affecting load shed from three typical UK commercial buildings, also learning regarding additional observability of network provided by ADR system, detailed in sections 5.2.3-5.2.5.	SEPD	Published in Closedown Report	
Cost/benefit analysis of ADR to a DNO	Understanding of cost of ADR and load shed required for Method to provide benefits over network reinforcement, detailed in section 8.2.	SEPD	Published in Closedown Report	Per building cost of ADR is background IPR owned by Honeywell
Safety Considerations	Safety risks and issues and appropriate controls associated with implementing ADR in commercial buildings, detailed in Risk Assessments and Method statements.	SEPD	Examples published as Closedown Report Appendix	Methodology is background IPR owned by Honeywell
Load Shed Strategies	Examples of the applied load shed strategies used.	SEPD	Examples published as Closedown Report Appendix	Methodology is background IPR owned by Honeywell

Appendix I

Example Peak Load Shedding Strategy Report

HONEYWELL

ADR load shedding strategy

for

Bracknell & Wokingham College, church road building

2nd March 2012

Honeywell

Executive Summary

Introduction

Honeywell Building Solutions UK (Honeywell) would like to thank Bracknell and Wokingham College for inviting us to design a load shedding strategy to reduce the electrical demand on the network in line with the Thames Valley Vision Automated demand Response Programme funded by Ofgem.

Honeywell is pleased to present the load shed strategies for the facility located at Church Road, Bracknell, Berkshire, RG12 1DJ.

The Results

From the results of the Audit Honeywell has recommended 7 Electrical Load Reduction Measures which include:

- Chiller reduction
- Limiting AHU fan speed
- Switching of DX split units
- Switching of ground source heat pump
- Switching off AHUs
- Switching off extract fans
- Switching off one of the triplex lifts

By implementing this strategy, Honeywell estimates that Bracknell and Wokingham College will reduce their load by a minimum of 41.35 kW.

TABLE OF CONTENTS

Honeywell

1.0 Honeywell Approach

1.0 Honeywell Approach

The primary objective of this report is to develop an ADR (Auto demand response) load shedding strategy to reduce the building's grid electricity consumption during network peak periods. A number of different load shedding strategies were investigated to support this objective and those considered favourable have been selected for inclusion in the overall solution.

The site analysis was conducted over a period of 5 days and the approach was for Honeywell Building Solutions to gain the required understanding of the various system locations, configuration, design and operation of the mechanical plants/equipments under review. The building's load profile and load shedding strategies developed on the following pages are based on the data gathered, site survey and the discussions with the on-site facility management team.

1.1 Summary of assumptions made by Honeywell Building Solutions

Conversion factor for CO_2 emissions used for grid supplied electricity is 0.5246 kg/kWh and 0.1836 kg/kWh for natural gas based on Carbon Trust green house gas emission factors for 2011.

Assumption on the building's time schedule for the general HVAC (Heating, ventilation and air-conditioning) system has been as follows

Mondays – 0600hrs to 1700hrs
Tuesdays to Thursdays – 0700hrs to 2115hrs
Fridays – 0700hrs to 1700hrs
Minimal usage during weekends and public holidays

1.2 Summary of information provided.

The half hourly electricity consumption data was retrieved from the utility provider, Eon while the gas consumption data was obtained from an excel spreadsheet provided by the college's facility management team.

We have used for electricity a unitary cost of £0.08767 per kWh as the daytime rate, £0.05579 per kWh as the night time rate and £0.02211 per kWh as the unitary cost of natural gas in 2011. Please note that these figures exclude VAT and other charges incurred in 2011.

2.0 Site Description

2.0 Site Description

2.1 Site summary

Bracknell & Wokingham College, church road building was constructed in 2009. The building is a type 4 glass curtain building on a concrete frame structure; consisting of approximately 12,098 m^2 of air conditioned space spread over seven (7) floors with part of the lower ground floor and roof space as the plantroom.

The B&W College, church road building currently accommodates about 1,500 full time/part time students and about 250 staff. The building comprises of mixed accommodation which consists of general and specialist teaching areas, public services, laboratories, engineering workshops, IT support rooms, beauty salon, specialist computing training rooms, meeting rooms, staff offices, a sport hall and catering facilities. The building is occupied during the week with operational hours between 07:00 to 22:00 and occasionally on Saturdays.

2.2 Energy system summary

The energy consumed at B&W College, church road building is in the form of natural gas and grid-supplied electricity. Electricity is supplied to the building on an 11 kV grid connected system to an internal substation located on level P, adjacent to the LV switchroom. The voltage is stepped down to 400 volts, 50Hz at the substation and then linked to the main switch gear on a ring main unit, three phase supply. The building incorporates a standby generator to support essential loads in the event of an electrical power failure.

Some of the building load which consumes electrical energy include: lightings, electric motors, kitchen equipments, air handling units, ground source heat pumps, workshop equipments, air cooled water chillers, split units, IT equipments, laboratory equipments, air compressors and office equipments.

Natural gas is also supplied to the building to serve the domestic hot water boilers, LPHW central boilers, laboratories and kitchen equipments. The college's heating requirement is met by low pressure hot water (LPHW) system.

The heating requirement for the college is served primarily from two ground source heat pump system and supplemented by gas fired condensing boilers. The heating demand for the building is met by means of radiators, air handling units, unit heaters, under floor heating system and trench heating system. The supplementary plant has been provided to assist the ground source heat pump when the system is unable to meet the building's heating demand.

The ground source heat pump also provides chilled water for the air handling units and chilled beams and is supplemented by two chillers located externally on the roof top. Both systems are operated and controlled by the building management system (BMS).

2.3 HVAC description summary

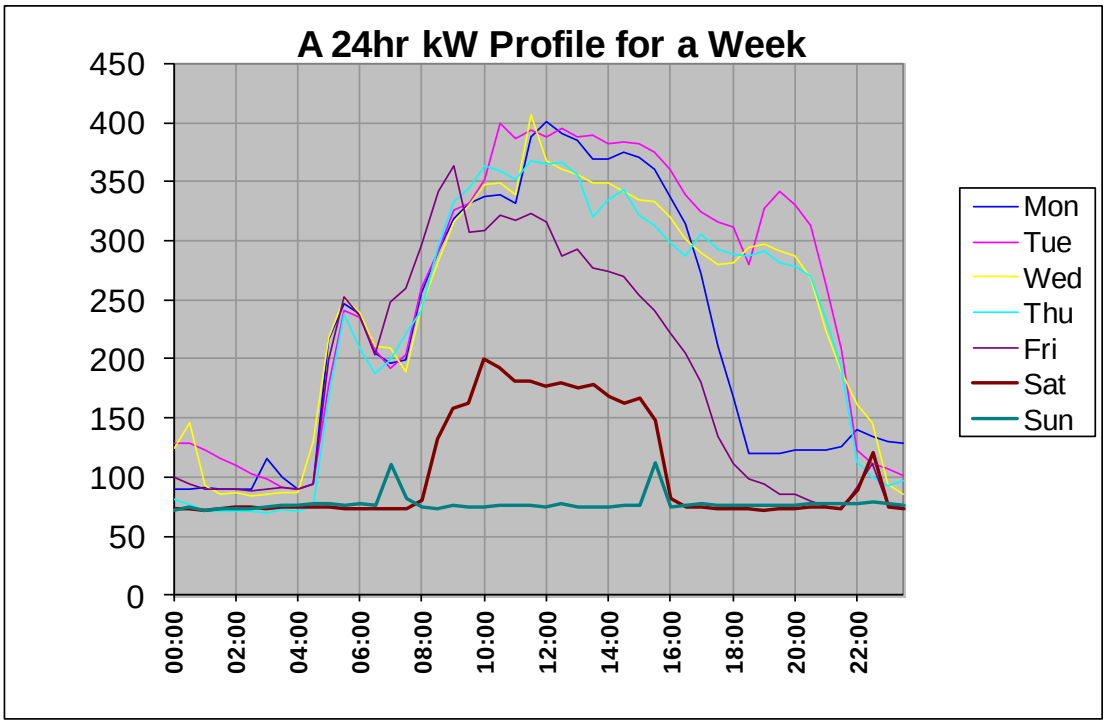
Two air handling units are used to provide tempered fresh air to the main areas of the building. AHU1 serves the north wing of the building and AHU2 serves the south wing of the building. In the air handling units, some heat is recovered from the extract air through a built in recuperator (thermal wheel). The air supplied from the AHUs is distributed to the space mostly through liner diffusers located within the false floor. The volume of fresh air delivered to the building is constant irrespective of what is required for thermal comfort.

In addition, the sport hall, commercial kitchen and training kitchen are provided with a supply and extract ventilation from separate modular air handling units located in the external plant area on the 2nd floor. A number of DX splits and VRF units have been installed in the building in areas that requires 24hours cooling or in other areas where chilled beams are unsuitable. Areas where DX split units have been provided includes the server room, hub rooms, room 130-132, drama room, LG05 and LG06. All air conditioning plant is controlled and monitored through the BMS with the out station located in the mechanical plant control panel.

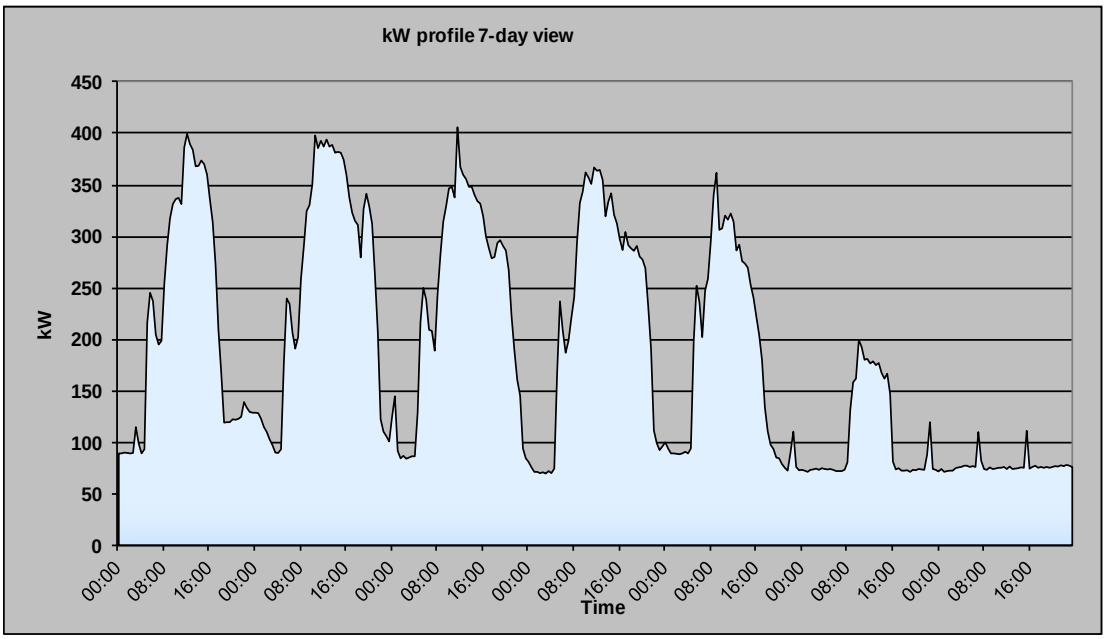
2.4 Energy profile summary

The year adopted for this report is 2011. The electricity and gas consumed during that period was 1,456,613.6 kWh and 958,325 kWh respectively. The resulting CO_2 emission during that period was 940.09 tonnes.

Figure 1 (a & b) below shows the building's electricity consumption on a daily and weekly profile for a week in January 2012. The average base load for the building as seen in both figures is about 75 kW with a peak load of about 400 kW



(a) Daily profile of electricity usage, week commencing from 16th Jan 2012



(b) 7 day view profile of daily electricity usage for a week, commencing from 16th Jan 2012

Figure 1 – Daily electrical energy consumption profile for B&W college building, Churchill

The electricity consumed from April 2010 to January 2012 is shown in figure 2 below. A detailed analysis will be needed to understand the building's usage against the winter and summer session. However from the figure below, it can be seen that the monthly energy consumption relative to the previous year has been on the decrease. This shows that some energy conservative measures are in use to reduce the building's overall energy consumption.

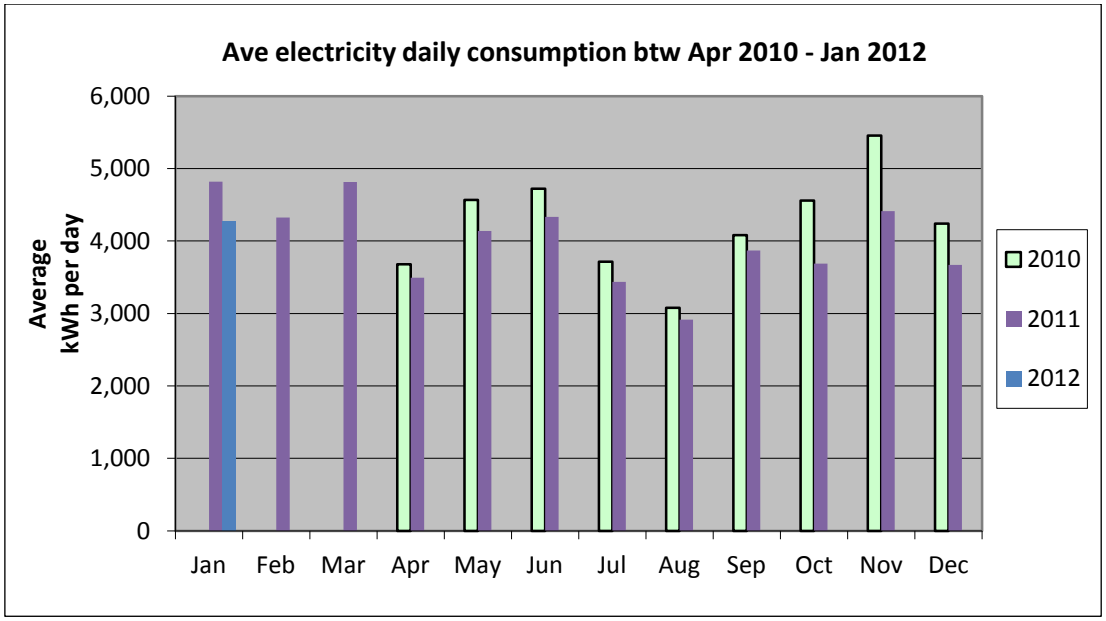


Figure2 – Daily average electrical energy usage by months

3.0 ADR Overview

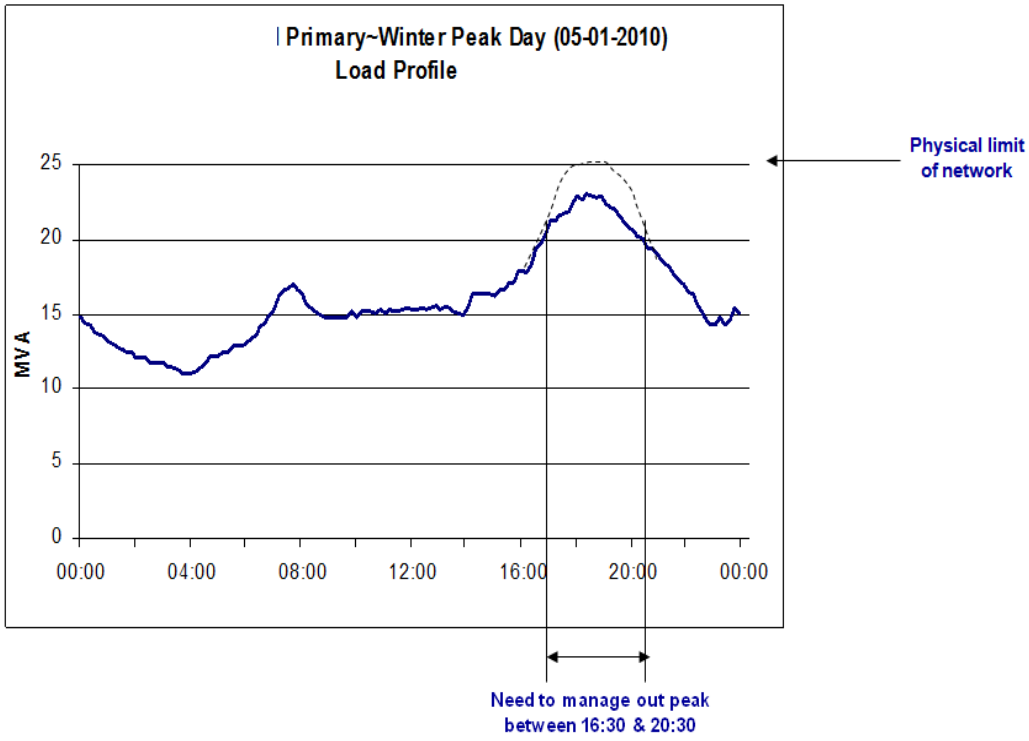
3.0 ADR Overview

3.1 What is ADR and Why is it Important?

Automated Demand Response (ADR) is a Smart Grid technology that can be employed by a Distribution Network Operator (DNO) to reduce electricity demand peaks on their supply networks.

The recent advances in computer based technologies and the proliferation of electrical appliances in our homes and offices along with population growth, has introduced new and larger loads on local electricity networks which were originally specified and built many years ago when demand was much simpler. These new loads are now causing networks to approach their maximum capabilities, posing expensive and disruptive infrastructure upgrade decisions for DNOs to make such as building larger sub-stations and the laying of new, higher capacity cables in the roads.

The diagram below shows the load profile of a Sub-Station in Bracknell that is supplying the local community. This is the demand profile for the 5th January 2010.



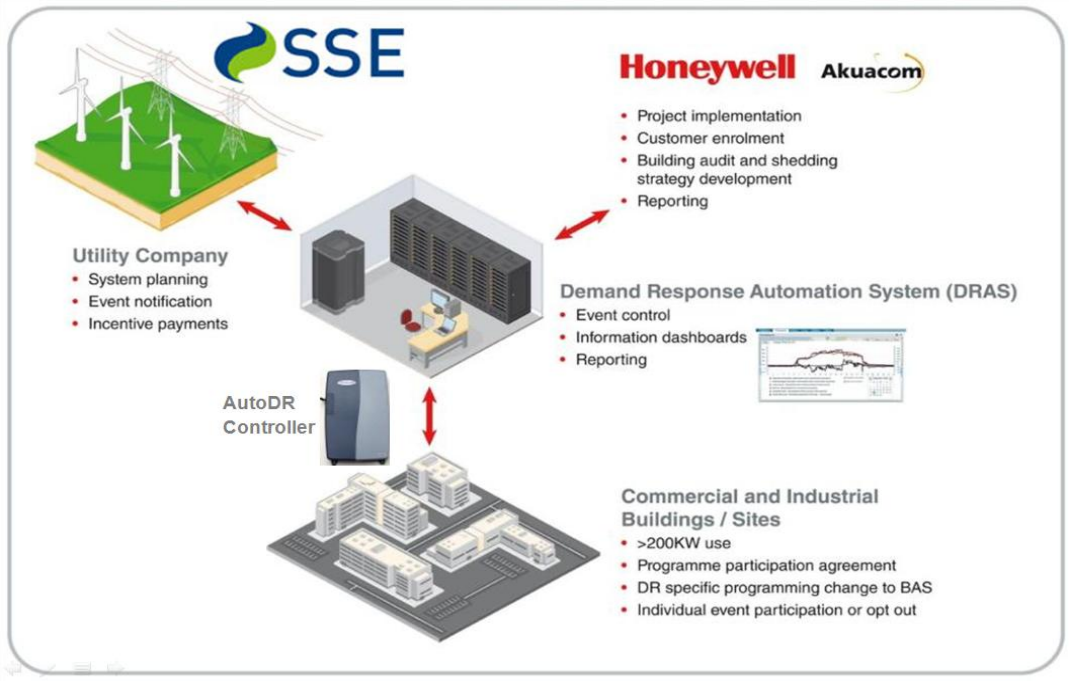
Obvious within this graph is a significant peak in demand between 16:30 and 20:30. This peak is a result of the overlap between the demand required by businesses during operational hours and the demand required by the home lives of our communities. The risk in the future from the introduction of further new electricity consuming technologies such as electric vehicles and heat pumps, is that this demand peak will increase and exceed the physical limit of the network resulting in supply interruptions.

It is important to note that the DNOs would always prevent demand shortages and ensure security of supply, today by investing in larger capacity plant and infrastructure. This would be at the cost of the DNO and this cost would have to be passed on to the consumer, potentially increasing the cost of energy in the long run.

Automated Demand Response (ADR) is a technology that postpones the need to install new capacity. ADR enables the DNO to reduce and move the electrical load on the network during peak periods, ensuring security of supply without the need for expensive and disruptive new infrastructure upgrades.

3.2 How Does ADR Work?

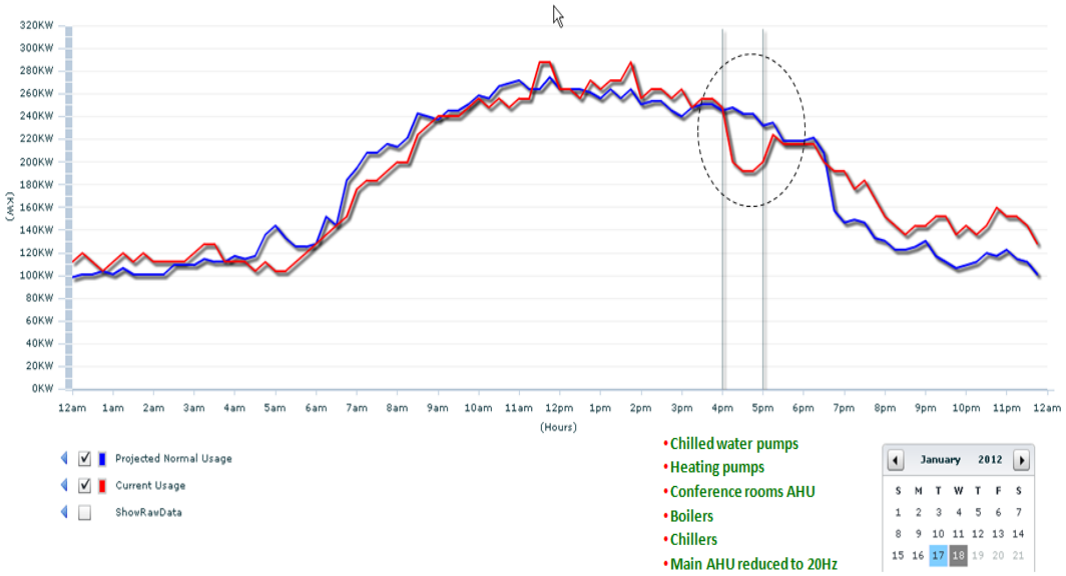
SSE owned Southern Energy Power Distribution (SEPD) is the DNO in your area. When SEPD identifies a peak demand event is going to happen they can employ ADR to reduce electricity consumption in a concerted fashion across buildings on their network. To enable this, an ADR Gateway device installed in each building enrolled on the ADR programme, identifies an action signal via the internet on SEPD's cloud-based Demand Response Automation System (DRAS). This initiates an "Electricity Load Shedding Strategy" programmed into each building's Building Management System (BMS) and pre-agreed electricity using areas are turned down and off. Only areas that have no or minimal impact on the building occupants are accessed. These include adjusting frequencies on air handling units, turning off lights in unoccupied offices and turning off pumps in ornamental lakes for example. At all times the building owner retains complete control by having to confirm participation or not prior to any event.



The result of a Load Shedding Event on a Commercial building with a maximum demand of 290kW is shown on the diagram below. You can clearly identify the load shed between 4 and

5pm where the Shedding Strategy was able to reduce the demand by 45kW. Information on the electricity use of each building along with the consumption profile during an event is accessed via a web portal to provide a complete audit trail.

	Base		Actual		Shed	
	Average(KW)	Total(KWH)	Average(KW)	Total(KWH)	Average(KW)	Total(KWH)
Entire Day	196.908	3396.666	192.812	3326	4.097	70.666
	Average(KW)	Total(KWH)	Average(KW)	Total(KWH)	Average(KW)	Total(KWH)
During Event	241.334	241.334	196	196	45.334	45.334



3.3 What are the Benefits?

- A greater understanding of your energy usage
- Ability to forecast your energy consumption and/ or control it
- Greater comfort conditions for building occupants
- Green Energy Reductions – Not fossil fuel generation
- Marketing – High profile Ofgem funded project
- Major Government Initiative – Recognised demand response as a vital technology for the future
- Manage CO2 emission reduction
- Maximises future revenue opportunities
- High Level Blue Chip involvement and resource
- No Impact to business
- Free Installation and Commissioning of a cutting edge proven technology currently unavailable on the UK market.

Honeywell

4.0 Demand Strategy

4.0 Demand Strategy

4.1 Load shed Strategies

4.1.1 Demand responds strategy 1

– Reduce the speed of both supply and extract fans on AHU 1 & 2 to 50% at most.

4.1.1.1 DR Strategy 1A

– Reduce the speed of both the supply and extract fans on AHU 1 & 2 to 70% during low shed level.

DEMAND RESPONSE SOLUTION RECOMMENDATIONS	
Strategy	Reduce maximum speed of VFD to 70% during low shed level.
Strategy details	Limit or decrease fan's variable frequency drive (VFD) via BMS to reduce fan power consumption.
kW reduction	30.13 kW
Energy usage system	AHU's 1 & 2
Estimated cost savings	
Implementation time	15:00 to 20:00
Hours of operation	07:00 to 21:15
Cautions	There will be less airflow for some areas that may cause ventilation rates to drop below the required level. Hence, its impact on various areas has to be studied.

S. No	VFD	AHU Name	AHU Location	Commissioned supply flow rate (m^3/s)	Estimated current consumption (kW)	Estimated consumption @ 70% speed (kW)
1	YES	AHU_1	6^{th} floor roof top north wing	13.693	27.44	9.41
2	YES	AHU_2	5^{th} floor roof top south wing	9.722	18.42	6.32
Total					**45.86**	**15.73**

*Lock the speed of the LPHW pump supplying the radiators prior to DR strategy 1A

4.1.1.2 DR strategy 1B

– Reduce the speed of both the supply and extract fans on AHU 1 & 2 to 50% during medium shed level.

DEMAND RESPONSE SOLUTION RECOMMENDATIONS	
Strategy	Reduce maximum speed of VFD to 50% during medium shed level.
Strategy details	Limit or decrease fan's variable frequency drive (VFD) via BMS to reduce fan power consumption.
kW reduction	40.13 kW
Energy usage system	AHU's 1 & 2
Estimated cost savings	
Implementation time	15:00 to 20:00
Hours of operation	07:00 to 21:15
Cautions	There will be less airflow for some areas that may cause ventilation rates to drop below the required level. Hence, its impact on various areas has to be studied.

S. No	VFD	AHU Name	AHU Location	Commissioned supply flow rate (m^3/s)	Estimated current consumption (kW)	Estimated consumption @ 50% speed (kW)
1	YES	AHU_1	6^{th} floor roof top north wing	13.693	27.44	3.43
2	YES	AHU_2	5^{th} floor roof top south wing	9.722	18.42	2.30
Total					**45.86**	**5.73**

*Lock the speed of the LPHW pump supplying the radiators prior to DR strategy 1B

4.1.2 Demand responds strategy 2

– Switch off the AHUs that supplies tempered air to the training kitchen and sports hall.

DEMAND RESPONSE SOLUTION RECOMMENDATIONS	
Strategy	Switch off AHU 3 & 5 completely
Strategy details	Switch off AHU 3 & 5 via BMS during load shedding periods
kW reduction	7.06 kW for the 1st hour & 2.74 kW subsequently
Energy usage system	Training kitchen and sports hall AHUs
Estimated cost	
Implementation time	15:00 to 20:00
Hours of operation	07:00 to 17:00
Cautions	None

S. No	VFD	AHU Name	AHU Location	Commissioned flow rate (m^3/s)	Estimated current consumption (kW)	Estimated consumption during DR (kW)
1	YES	AHU_3 (Sport hall)	3rd floor roof top south wing	1.928	2.74	0.00
3	YES	AHU_5 (Training kitchen)	3rd floor roof top south wing	-	4.32	0.00
Total					**7.06**	**0.00**

Note:

- At the time of visit, the time schedule for AHU3 (Sport hall) was Mon – Fri: 0700hrs to 1700hrs.

- Time schedule for AHU 5(Training kitchen) was Mon – Fri: 0830hrs to 1600hrs.

4.1.3 Demand responds strategy 3

– Switch off one chiller completely and limit CB pump's speed to reduce cooling load.

DEMAND RESPONSE SOLUTION RECOMMENDATIONS	
Strategy	Limit or reduce chiller demand
Strategy details	Switch off one chiller and lock the speed of both primary loop & CB pumps prior to DR.
kW reduction	0.00 – 27.58**
Energy usage system	Chiller beams and AHUs
Estimated cost	
Implementation time	15:00 to 20:00
Hours of operation	07:00 to 21:15
Cautions	Lock the chilled beam pump's speed prior to DR. Please refer to note below

S. No	VFD	Name	Location	Commissioned temp set point (^{O}C)	Estimated current Consumption (kW)	Estimated consumption during DR (kW)
1	YES	Chiller 1	6th floor roof top north wing	Flow = 6 Return = 12	0.0 - 38.5**	0.0 – 38.5
2	YES	Chiller 2	6th floor roof top north wing	Flow = 6 Return = 12	0.00 – 27.58**	0.00
Total					**0.00 – 38.5****	**0.00 – 38.5**

** The power consumed by the chillers will vary depending on the demand. During site survey on the 23/02/2012, the power consumed by the chillers was between 0.34 kW and 38.5 kW as at the time of visit.

Chiller_1 – 7.3kW to 38.5kW
Chiller_2 – 0.34kW to 27.58kW

By shutting off one of the chillers, the chilled water loop system will no longer maintain the chilled water temperature setpoint when the operating chiller reaches its maximum capacity. As a result, the cooling valve on each chilled beam opens wider and request for more chilled water flow to maintain the room's setpoint. Due to this, the chilled beam supply pump will speed up to increase chilled water flow.

However, regardless of the increase in the chilled water flow, the chiller cannot provide any more cooling than its total full-load capacity. Therefore, the more the chilled water flow, the higher the chilled water supply temperature becomes. The pump power increase will not provide more space cooling and therefore the pump speed should be locked at its state prior to DR.

4.1.4 Demand responds strategy 4

– Switch off one of the triplex lifts

DEMAND RESPONSE SOLUTION RECOMMENDATIONS	
Strategy	Switch off one of the triplex lifts
Strategy details	Switch off one lift
kW reduction	11.77kW @ maximum load
Energy usage system	Triplex lifts
Estimated cost	
Implementation time	15:00 to 20:00
Hours of operation	07:00 to 21:15
Implementation analysis	Its impact on occupants comfort has to be studied.

S. No	VFD	Name	Location	Estimated current consumption (kW)	Estimated consumption during DR (kW)
1	YES	Lift 1 (Triplex passenger lift)	Roof top plantroom	11.77	11.77
2	YES	Lift 2 (Triplex passenger lift)	Roof top plantroom	11.77	11.77
3	YES	Lift 3 (Triplex passenger lift)	Roof top plantroom	11.77	0.00
Total				**35.31***	**23.54***

N/B
*Value is at maximum load

4.1.5 Demand responds strategy 5

– Switch off extract fans

DEMAND RESPONSE SOLUTION RECOMMENDATIONS	
Strategy	Switch off extract fans
Strategy details	Switch off all extract fans listed below and reduce toilet extract fans to 70% speed at most during load shedding periods
kW reduction	2.63 kW + 1.9 kW from toilet extract
Energy usage system	Extract fans
Estimated cost	
Implementation time	15:00 to 20:00
Hours of operation	07:00 to 21:15
Implementation analysis	Its impact on the affected areas has to be studied.

S. No	VFD	AHU Name	Fan location	Commissioned supply flow rate (m^3/s)	Estimated current consumption (kW)	Estimated consumption during DR (kW)
1	None	Dark room EF2/02	3rd floor roof top south wing	-	0.30	0.00
2	None	Kilm room EF2/03	3rd floor roof top south wing	-	0.18	0.00
3	None	Dry store EF2/04	3rd floor roof top south wing	-	0.18	0.00
4	None	LG02 EFP 01	LG02	-	0.33	0.00
5	None	LG03 EFP 02	LG03	-	0.33	0.00
6	None	LG04 EFP 03	LG04	-	0.33	0.00
7	None	LG05 EFP 04	LG05	-	0.33	0.00
8	None	LG11 EFP 05	LG11	-	0.33	0.00
9	None	LG03 EFP 06	LG13	-	0.33	0.00
Total					**2.63**	**0.00**

N/B

* Values assumed at 0.8 of nameplate power rating

Extract fans:

1. Dark room EF2/02 – 0.37kW (Nameplate power rating)
2. Kilm room EF2/03– 0.23kW (Nameplate power rating)
3. Dry store EF2/04– 0.23kW (Nameplate power rating)
4. LG02 EFP 01– 0.41kW (Nameplate power rating)
5. LG03 EFP 02– 0.41kW (Nameplate power rating)
6. LG04 EFP 03– 0.41kW (Nameplate power rating)
7. LG05 EFP 04– 0.41kW (Nameplate power rating)
8. LG11 EFP 05– 0.41kW (Nameplate power rating)
9. LG13 EFP 06– 0.41kW (Nameplate power rating)

In addition, limit via BMS toilet extract fan's speed to 70% at most during ADR

1. Toilet Extract TEF/1 – 0.66kW (Ecosmart inverters)
2. Toilet Extract TEF/2 – 3.0kW (Ecosmart inverters)

S. No	VFD	AHU Name	Fan location	Commissioned supply flow rate (m^3/s)	Estimated current consumption (kW)	Estimated consumption @ 70% speed (kW)
1	YES	Toilet Extract TEF/1	6^{th} floor roof top north wing	-	2.40	0.82
2	YES	Toilet Extract TEF/2	5^{th} floor roof top south wing	-	0.53	0.18
Total					**2.93**	**1.00**

4.1.6 Demand responds strategy 6

– Switch off DX split units

DEMAND RESPONSE SOLUTION RECOMMENDATIONS	
Strategy	Switch off DX split units
Strategy details	Switch off all DX split units listed below via the BMS during load shedding periods
kW reduction	2.53 kW
Energy usage system	DX split units
Estimated cost	
Implementation time	15:00 to 20:00
Hours of operation	07:00 to 21:15
Implementation analysis	Its impact on the affected areas has to be studied.

DX split units:

1. G28 – Drama DX split unit
2. Rm 130 – Performance control room DX split unit
3. Rm 131 – Studio room DX split unit
4. Rm132 – AV control room DX split unit
5. LG05 & LG06 – DX split unit

4.1.7 Demand Responds Strategy 7

– Switch off ground source heat pump

DEMAND RESPONSE SOLUTION RECOMMENDATIONS	
Strategy	Switch off ground source heat pumps
Strategy Details	Switch off ground source heat pumps and its ancillary via the BMS during load shedding periods.
kW Reduction	0.4kW – 35.12kW*
Energy Usage System	Ground source heat pumps
Estimated Cost	
Implementation Time	15:00 to 20:00
Hours of Operation	07:00 to 21:15
Performance Implication	

S. No	VFD	Name	Location	Commissioned supply flow rate (m^3/s)	Estimated current consumption (kW)	Estimated consumption during DR (kW)
1	-	Ground Source heat pump	6^{th} floor roof top north wing	-	0.4 – 35.12	0.00
Total					**0.4 – 35.12**	**0.00**

* The power consumed by the ground source heat pumps and its ancillary varies depending on the demand and ground source temperature. During site survey on the 23/02/2012, the system was consuming 9.16 kW at1400hrs.

Ground source heat pump – Heating 126.62kW @ 4.9 COP
Cooling 172.28kW @ 5.4 COP

Ancillary – DAC shunt pump & Dry coolers

4.2 ADR load shed level

√ denotes load shed strategies to be applied

Strategy	Equipment	A/M	Load Shed Strategies	Pending	Load Shed Level	
					Low	Medium
DR Strategy 1A	AHUs	A	Reduce maximum speed of VFD to 70%	-	√	-
DR Strategy 1B		A	Reduce maximum speed of VFD to 50%	-	-	√
DR Strategy 2		A	Switch off AHU's 3 & 5	-	√	√
DR Strategy 3	Chillers	A	Switch off one chiller and lock the speed of both primary loop & CB pumps to a maximum speed of 70% prior to DR.	-	-	√
DR Strategy 4	Lifts	M	Switch off one of the triplex lifts	-	√	√
DR Strategy 5A	Extract fans	A	Switch off non-critical extract fans	-	√	√
DR Strategy 5B	Toilet extract fans	A	Reduce fan's speed of toilet extract to 70% at most	-	-	√
DR Strategy 6	DX Split units	A	Switch off DX split units	-	√	√
DR Strategy 7	Ground source heat pump	A	Switch off ground source heat pump	-	√	√

kW reduction in response to load shed level

Strategy	Equipment	A/M	Load shed strategy	Load Shed Level kW	
				Low	Medium
DR Strategy 1A	AHUs	A	Reduce maximum speed of VFD to 70%	30.13	-
DR Strategy 1B		A	Reduce maximum speed of VFD to 50%	-	41.13
DR Strategy 2		A	Switch off AHU's 3 & 5	7.06[1]	7.06[1]
DR Strategy 3	Chillers	A	Switch off one chiller and lock the speed of both primary loop & CB pumps to a maximum speed of 70% prior to DR.	-	0.00 – 27.58[2]
DR Strategy 4	Lifts	M	Switch off one of the triplex lifts	11.77[3]	11.77[3]
DR Strategy 5A	Extract fans	A	Switch off non-critical extract fans	2.63	2.63
DR Strategy 5A	Toilet extract fans	A	Reduce fan's speed of toilet extract to 70% at most	-	1.90
DR Strategy 6	DX split units	A	Switch off DX split units	2.53	2.53
DR Strategy 7	Ground source heat pump	A	Switch off ground source heat pump	0.4 – 35.12[4]	0.4 – 35.12[4]
Total estimated reduction				**42.35^**	**55.25^**

A/M – Auto / Manual demand shed strategy

1 7.06 kW reduction for the first hour and 2.74 kW until 1700hrs

2 The power consumed by the chillers will vary depending on the demand.

3 The power consumed by the lift will varies depending on the load, maximum power at full load is 11.77kW.

4 The power consumed by the ground source heat pumps and its ancillary will varies depending on the demand and ground source temperature

^ Minimum estimated kW reduction

Appendix II

Example Risk Assessments and Method Statements

BES Ltd.		Author: A Weaver 03.04.12 Method Statement	
		Site:	Bracknell & Wokingham College
Ref:	9128	Location:	LGF Plant Rooms

Note:

Method Statement to be read in conjunction with associated Risk Assessment

Scope of Work	**Electrical & BMS Installation to load control systems**
Hazards Involved	**As Per Risk Assessments**
Personnel Involved	**Project Manager, Installation Electricians**
Plant & Equipment	**Towers, Step Ladders, Hand Tools, 110V / Battery Power Tools**
Access Arrangements	**Access to the site & workplace to be strictly in accordance with authorised routes provided**
Manual Handling	**As Per Manual Handling Assessment –**
Methodology	**See Attached Sheets**
Briefing Arrangements	**Method Statement & Associated Risk Assessments to be briefed to all BES personnel by the BES Project Manager.** **All BES personnel to sign confirmation register.**
Materials Used	**Cat5e, Beldon 6760 & HBS equipment**

Method Statement

Bracknell & Wokingham College

Project Team

The project team outline for the duration of this project will comprise of: -

Alan Weaver - Project Manager
L Canavan - Site Supervisor
S Cox - Electrician Apprentice

Project due to start on 10/04/2012

Additional contacts: Honeywell Control Systems

Tim Watts – Project Engineer: 07974 451324
Dave Smith – Project Manager: 07974 451540

Site Accommodation

Welfare facilities will be available on-site.

Project Planning and Progress

The planned works are to commence on 10/04/12 and will be completed by 10/04/12.

Plant and Equipment

No heavy plant or equipment is required to carry out our works. Hand tools will all be battery operated or 110Volt.

First Aid / Emergency Details

All first aid will be provided by BES Ltd.

Materials and Deliveries

All materials will be brought to site by our operatives.

Scope of Works

LV / SELV / Control Wiring

We install the following aspects;

1.) Mount the ADR enclosure adjacent the basement control panel & close couple.
2.) Cable from the enclosure to the main incoming electrical meter located in the main electrical switchroom.
3.) Install multi-core from ADR enclosure to the control section of the BMS panel & identify.
4.) Review the 240VAC supply with the customer. Cable the required supply from the switchroom DB. Identify a spare DB 6A supply.
5.) As agreed with the IT team we will use one of the existing plantroom network points & patch into the new panel. Provide a local containment from the points to the existing hi-level containment.

Initial Verification

Upon completion of all LV, SELV, and signal 1st fix wiring, cables will be tested in accordance with BS 7671 2008.

A record of there results will be kept for review by the Project Manager and the Client representatives.

All testing should be carried out by competent persons.

2nd Fix Installation

Carry out the 2nd of small power services to LGF Plant Rooms.

Carry out final terminations to all HBS equipment.

Commissioning / Testing

Upon completion of 2nd fix installation, circuits will be tested in accordance with BS 7671 2008.

Circuits will then be energised and final live tests will be carried out in accordance with BS 7671 2008.

A record of there results will be kept for review by the Project Manager and the Client representatives.

All testing should be carried out by competent persons.

Disposal of Materials

All waste materials will be disposed of on a daily basis and removed from site by B.E.S.

Health and Safety

Within BES, Health and Safety is considered an integral part of our method of working and everyone's responsibility. The direct responsibility on site lies with the Project Manager who will ensure that safety procedures are adhered to and all reporting procedures are followed.

BES Ltd.	Risk Assessment Summary Part 1						
Site: **Ref No.:** **Location:**	**Bracknell & Wokingham College** **9128** **LGF, Plant Rooms**						
Work Activity							
Person Exposed	**BES**	Y	**Other Contractors**	N	**Public/Others**	Y	
Any person with a health condition likely to affect capability to report to the Project Supervisor immediately							

Hazard Identification		**Risk Evaluation (Score 1 – 3 Against each Hazard Present)**				
If Present/Requiring Control **If Absent/Not Significant**		**Risk**	**Score**	**Severity**	**Score**	**Risk Number** **Score Multiplier**
		Unlikely	**1**	**Minor**	**1**	
		Possible	**2**	**Moderate**	**2**	
		Likely	**3**	**Serious**	**3**	
1. Mobile Plant	**Y**	**1**		**2**		**2**
2. Moving Machine Parts						
3. Moving Materials	**Y**	**1**		**1**		**1**
4. Falls From Height	**Y**	**1**		**3**		**3**
5. Access Equipment	**Y**	**1**		**2**		**2**
6. Slips, Trips & Falls	**Y**	**1**		**1**		**1**
7. Excavations	**Y**	**1**		**2**		**2**
8. Pressurised Systems						
9. Electrical	**Y**	**1**		**2**		**2**
10. Hot Works/Fire						
11. Explosions						
12. Falling Objects	**Y**	**1**		**2**		**2**
13. Ionising Radiation						
14. Lasers	**Y**	**1**		**1**		**1**
15. Ultraviolet Light						
16. Cold Objects	**Y**	**1**		**1**		**1**
17. Hot Objects						
18. Temperature						
19. Noise/Vibration	**Y**	**1**		**1**		**1**
20. Weather						
21. Lone Working						
22. Confined Space						
23. Restricted Access						
24. Manual Handling	**Y**	**1**		**1**		**1**
25. Hazardous Substances						
26. Micro-Organisms						
27. Veil's Disease						
28. Access to Site						
29. Traffic Control	**Y**	**1**		**2**		**2**
30.						

State Key Risk (Use Risk Evaluation Score For Priorities – 5 + Priorities)			
N/A			
Control Measures – See Risk Assessment Summary Form Attached			
Name:	**A Weaver**	**Signed:**	**Via E-mail**
Position:	**Project Manager**	**Date:**	
APPROVED BY:			
Name:	**Worksafe Partnership**	**Signed:**	**Via E-Mail**
Position:	**H+S Advisor**	**Date:**	

BES Ltd.	Risk Assessment Summary Part 2
Site: **Ref No.:** **Location:**	**Bracknell & Wokingham College** **9128** **LGF, Plant Rooms**
ASSESSMENT FOR:	
SIGNIFICANT RISKS:	**N/A – Minimum Risk**

When considering control measures, consider the following: -

DOCUMENTS, PROCEDURES, INFORMATION, INSTRUCTION & TRAINING, SUPERVISION, ACCESS, ENVIRONMENT, EQUIPMENT, EMERGENCIES, COMMUNICATIONS, COSHH, PPE, OTHER PROCEDURES.

HAZARD	DETAILS OF CONTROL MEASURES
Working / Falls from Height	Ensure permit to work are in place prior to start of task Where there is restricted access steps may be used. Steps must have up to date inspection in place. Ensure that steps are placed on a level and stable ground. Do not overstretch to reach equipment Cables to be kept on drums during installation to avoid trip hazards.
Electricity	Ensure that control panel is isolated when working on live power terminations Permits to work are to be issued for any live testing/commissioning works Ensure permit to work are in place prior to start of task
Occupational Health	Ensure permit to work are in place prior to start of task Operatives to use ear protection during builders works. Ensure gloves are worn during any period where hand held plants are being used
Environmental Issues	Operatives to wear face mask protection during builders works

THE ABOVE CONTROLS HAVE BEEN SELECTED TO PROTECT THE HEALTH & SAFETY OF OPERATIVES & OTHERS WHO MAY BE AFFECTED BY THE WORK. THE CONTROLS HAVE BEEN DESIGNED TO PROTECT AGAINST THE HAZARDS IDENTIFIED ON THE RISK ASSESSMENT SUMMARY FORM PART 1. THESE CONTROL MEASURES MUST NOW BE REVIEWED WITH THE OPERATIVES UNDERTAKING THE WORK UTILISING THE RISK ASSESSMENT REVIEW PROFORMA.

BES Ltd.	**Manual Handling / PPE Requirements** **Risk Assessment**
Ref No.: **Site:** **Location(s):**	**Bracknell & Wokingham College** **9128** **LGF, Plant Rooms**
Assessment For: **Personnel Involved:**	**All BES Operatives**
Preliminary Assessment	**Do the operations involve significant risk of injury?** YES / **NO** **Can the operation be avoided/assisted with the use of lifting aids? (Delete As Appropriate)** YES / **NO**
Overall Assessment	**What is your overall assessment of the risk to health & safety?** **Insignificant** Low Medium High **If not significant, please fill in further details below, if insignificant, the assessment need go no further.**

Questions To Consider (if 'Yes', then state level of risk)	**Level Of Risk**					**Possible Remedial Action**
	Yes	**No**	**Low**	**Med**	**High**	
The Tasks – Do they involve:						
Holding loads away from trunk		X				a) Adopt the correct posture before lifting items b) For larger loads – to be carried by two or more persons c) PPE - Wear boots and hat at all times. Gloves and glasses where required in risk assessment. d) Individuals to be aware of their own personal capabilities
Twisting		X				
Stooping	X		X			
Reaching upwards	X		X			
Large vertical movements		X				
Long carrying distances		X				
Strenuous pushing or pulling		X				
Unpredictable movements		X				
Repetitive Handling		X				
Insufficient rest & recovery		X				
The Loads – Are they:						
Heavy		X				
Bulky		X				
Difficult to hold/grasp		X				
Unstable		X				
Harmful (hot/sharp edges)		X				
The Working Environment Are There:						
Constraints on posture		X				
Poor lighting conditions		X				
Poor walking surfaces		X				
Variations in level		X				
Hot/Cold/Humid conditions		X				
Strong air movements		X				
Individual Capability Does The Job:						
Require unusual capability		X				
Hazard those with a health problem		X				
Require special training		X				
Other						
Is movement/posture restricted by PPE		X				

BES Ltd.	Method Statement Register
Site:	**Bracknell & Wokingham College**

I the below detailed person confirm that I have read, understood and agree to abide by the requirements of Burnham Electrical Services Method Statement and associated Risk & Manual Handling Assessments.

NAME	METHOD STATEMENT REF.	SIGNED	DATE
A Weaver (Project Manager)	9128		
L Canavan (Site Foreman)	9128		
S Cox	9128		

BES Ltd.		Author: A Weaver 13.03.12 Method Statement	
		Site:	Bracknell Forest DC
Ref:	9122	Location:	LGF Plant Rooms & Car Park

Note:

Method Statement to be read in conjunction with associated Risk Assessment

Scope of Work	**Electrical & BMS Installation to load control systems**
Hazards Involved	**As Per Risk Assessments**
Personnel Involved	**Project Manager, Installation Electricians**
Plant & Equipment	**Towers, Step Ladders, Hand Tools, 110V / Battery Power Tools**
Access Arrangements	**Access to the site & workplace to be strictly in accordance with authorised routes provided**
Manual Handling	**As Per Manual Handling Assessment –**
Methodology	**See Attached Sheets**
Briefing Arrangements	**Method Statement & Associated Risk Assessments to be briefed to all BES personnel by the BES Project Manager.** **All BES personnel to sign confirmation register.**
Materials Used	**XLPE/SWA/PVC cable, MK accessories & HBS equipment**

Method Statement

Bracknell Forest DC

Project Team

The project team outline for the duration of this project will comprise of: -

Alan Weaver - Project Manager
L Canavan - Site Supervisor
C Russell - Electrician

Project due to start on 16/03/2012

Additional contacts: Honeywell Control Systems

Tim Watts – Project Engineer: 07974 451324
Dave Smith – Project Manager: 07974 451540

Site Accommodation

Welfare facilities will be available on-site.

Project Planning and Progress

The planned works are to commence on 16/03/12 and will be completed by 16/03/12.

Plant and Equipment

No heavy plant or equipment is required to carry out our works. Hand tools will all be battery operated or 110Volt.

First Aid / Emergency Details

All first aid will be provided by BES Ltd.

P.P.E

The following personnel protective equipment will be used at all times while working in the basement carpark;

Hi Vis Vest/ Jacket
Safety Boots/ Shoes

Materials and Deliveries

All materials will be brought to site by our operatives

Scope of Works

LV / SELV / Control Wiring
Carry out the installation of 1no LV supply wired from LGF plant room to HBS controller sited within LGF Car Park.
Carry out the installation 1no control cable wired from LGF plant room to HBS controller sited within LGF Car Park.

Initial Verification
Upon completion of all LV, SELV, and signal 1st fix wiring, cables will be tested in accordance with BS 7671 2008

A record of there results will be kept for review by the Project Manager and the Client representatives.

All testing should be carried out by competent persons.

2nd Fix Installation
Carry out the 2nd of small power services to LGF Plant Rooms & Car Park

Carry out final terminations to all HBS equipment.

Commissioning / Testing
Upon completion of 2nd fix installation, circuits will be tested in accordance with BS 7671 2008

Circuits will then be energised and final live tests will be carried out in accordance with BS 7671 2008

A record of there results will be kept for review by the Project Manager and the Client representatives.

All testing should be carried out by competent persons.

Disposal of Materials

All waste materials will be disposed of on a daily basis and removed from site by main contractor.

Health and Safety

Within BES, Health and Safety is considered an integral part of our method of working and everyone's responsibility. The direct responsibility on site lies with the Project Manager who will ensure that safety procedures are adhered to and all reporting procedures are followed.

BES Ltd.	Risk Assessment Summary Part 1						
Site: **Ref No.:** **Location:**	**Bracknell Forest DC** **9122** **LGF, Plant Rooms & Car Park**						
Work Activity							
Person Exposed	**BES**	Y	**Other Contractors**	N	**Public/Others**	Y	
Any person with a health condition likely to affect capability to report to the Project Supervisor immediately							

Hazard Identification		**Risk Evaluation (Score 1 – 3 Against each Hazard Present)**				
If Present/Requiring Control **If Absent/Not Significant**		**Risk**	**Score**	**Severity**	**Score**	**Risk Number** **Score Multiplier**
		Unlikely	**1**	**Minor**	**1**	
		Possible	**2**	**Moderate**	**2**	
		Likely	**3**	**Serious**	**3**	
1. Mobile Plant	**Y**	**1**		**2**		**2**
2. Moving Machine Parts						
3. Moving Materials	**Y**	**1**		**1**		**1**
4. Falls From Height	**Y**	**1**		**3**		**3**
5. Access Equipment	**Y**	**1**		**2**		**2**
6. Slips, Trips & Falls	**Y**	**1**		**1**		**1**
7. Excavations	**Y**	**1**		**2**		**2**
8. Pressurised Systems						
9. Electrical	**Y**	**1**		**2**		**2**
10. Hot Works/Fire						
11. Explosions						
12. Falling Objects	**Y**	**1**		**2**		**2**
13. Ionising Radiation						
14. Lasers	**Y**	**1**		**1**		**1**
15. Ultraviolet Light						
16. Cold Objects	**Y**	**1**		**1**		**1**
17. Hot Objects						
18. Temperature						
19. Noise/Vibration	**Y**	**1**		**1**		**1**
20. Weather						
21. Lone Working						
22. Confined Space						
23. Restricted Access						
24. Manual Handling	**Y**	**1**		**1**		**1**
25. Hazardous Substances						
26. Micro-Organisms						
27. Veil's Disease						
28. Access to Site						
29. Traffic Control	**Y**	**1**		**2**		**2**
30.						

State Key Risk (Use Risk Evaluation Score For Priorities – 5 + Priorities)			
N/A			
Control Measures – See Risk Assessment Summary Form Attached			
Name:	**A Weaver**	**Signed:**	**Via E-mail**
Position:	**Project Manager**	**Date:**	
APPROVED BY:			
Name:	**Worksafe Partnership**	**Signed:**	**Via E-Mail**
Position:	**H+S Advisor**	**Date:**	

BES Ltd.	Risk Assessment Summary Part 2
Site: **Ref No.:** **Location:**	**Bracknell Forest DC** **9122** **LGF, Plant Rooms & Car Park**
ASSESSMENT FOR:	
SIGNIFICANT RISKS:	**N/A – Minimum Risk**

When considering control measures, consider the following: -

DOCUMENTS, PROCEDURES, INFORMATION, INSTRUCTION & TRAINING, SUPERVISION, ACCESS, ENVIRONMENT, EQUIPMENT, EMERGENCIES, COMMUNICATIONS, COSHH, PPE, OTHER PROCEDURES.

HAZARD	DETAILS OF CONTROL MEASURES
Working / Falls from Height	Where possible use access tower for areas of working at height Ensure permit to work are in place prior to start of task Where there is restricted access steps may be used. Steps must have up to date inspection in place Ensure that steps are placed on a level and stable ground. Do not overstretch to reach equipment Cables to be kept on drums during installation to avoid trip hazards.
Electricity	Ensure that control panel is isolated when working on live power terminations Permits to work are to be issued for any live testing/commissioning works Ensure permit to work are in place prior to start of task
Occupational Health	Ensure permit to work are in place prior to start of task Operatives to use ear protection during builders works. Ensure gloves are worn during any period where hand held plants are being used Operatives to wear face mask protection during builders works
Environmental Issues Traffic Control	Banks-man to be used during cable installation. Work around ADR to be conned off with barrier tape to avoid public access to work area.

THE ABOVE CONTROLS HAVE BEEN SELECTED TO PROTECT THE HEALTH & SAFETY OF OPERATIVES & OTHERS WHO MAY BE AFFECTED BY THE WORK. THE CONTROLS HAVE BEEN DESIGNED TO PROTECT AGAINST THE HAZARDS IDENTIFIED ON THE RISK ASSESSMENT SUMMARY FORM PART 1. THESE CONTROL MEASURES MUST NOW BE REVIEWED WITH THE OPERATIVES UNDERTAKING THE WORK UTILISING THE RISK ASSESSMENT REVIEW PROFORMA.

BES Ltd.	**Manual Handling / PPE Requirements** **Risk Assessment**
Ref No.: **Site:** **Location(s):**	**Bracknell Forest DC** **9122** **LGF, Plant Rooms & Car Park**
Assessment For: **Personnel Involved:**	**All BES Operatives**
Preliminary Assessment	**Do the operations involve significant risk of injury?** YES / **NO** **Can the operation be avoided/assisted with the use of lifting aids? (Delete As Appropriate)** YES / **NO**
Overall Assessment	**What is your overall assessment of the risk to health & safety?** **Insignificant** Low Medium High **If not significant, please fill in further details below, if insignificant, the assessment need go no further.**

Questions To Consider (if 'Yes', then state level of risk)	**Level Of Risk**					**Possible Remedial Action**
	Yes	**No**	**Low**	**Med**	**High**	
The Tasks – Do they involve:						
Holding loads away from trunk		X				a) Adopt the correct posture before lifting items b) For larger loads – to be carried by two or more persons c) PPE - Wear boots and hat at all times. Gloves and glasses where required in risk assessment. d) Individuals to be aware of their own personal capabilities
Twisting		X				
Stooping	X		X			
Reaching upwards	X		X			
Large vertical movements		X				
Long carrying distances		X				
Strenuous pushing or pulling		X				
Unpredictable movements		X				
Repetitive Handling		X				
Insufficient rest & recovery		X				
The Loads – Are they:						
Heavy		X				
Bulky		X				
Difficult to hold/grasp		X				
Unstable		X				
Harmful (hot/sharp edges)		X				
The Working Environment Are There:						
Constraints on posture		X				
Poor lighting conditions		X				
Poor walking surfaces		X				
Variations in level		X				
Hot/Cold/Humid conditions		X				
Strong air movements		X				
Individual Capability Does The Job:						
Require unusual capability		X				
Hazard those with a health problem		X				
Require special training		X				
Other						
Is movement/posture restricted by PPE		X				

BES Ltd.	Method Statement Register
Site:	**NBP**

I the below detailed person confirm that I have read, understood and agree to abide by the requirements of Burnham Electrical Services Method Statement and associated Risk & Manual Handling Assessments.

NAME	METHOD STATEMENT REF.	SIGNED	DATE
A Weaver (Project Manager)	9122		
L Canavan (Site Foreman)	9122		
C Russell	9122		

Appendix III

Example ADR Agreement

Scottish and Southern Energy
Power Distribution

Honeywell

Appendix 1 – Example ADR Agreement

AGREEMENT FOR THE INSTALLATION ELEMENT OF AUTO DEMAND RESPONSE WORKS

THIS AGREEMENT is made the ___ day of January, 2012, BETWEEN:

COMAPNY, with a registered address of ADRESS ("the Customer") on the one hand, and

HONEYWELL CONTROL SYSTEMS LIMITED, with a registered address of Honeywell House, Arlington Business Park, Bracknell, RG12 1EB, United Kingdom ("the Supplier") on the other

WHEREAS

- Customer has agreed to participate in the Auto Demand Response Pilot ("the Project") with Scottish Southern Energy ("SSE") and has entered into a separate agreement with SSE to that affect;
- In order to fulfil the requirements of the Project, the Customer requires the Supplier to carry out certain installation works ("the Works") at the Customer's ADDRESS (" the Site") as outlined in the Schedule 1 ("Scope of Works");
- Following the completion of the Works, the Customer may be granted access to the Auto-Demand Response System ("the System") by SSE under the agreement between SSE and the Customer;
- In consideration of the payment of one pound (£1) paid by the Customer to the Supplier (receipt of which is hereby acknowledged by the Supplier), the Parties agree to enter into the obligations set out in this Agreement:

IT IS AGREED AS FOLLOWS:

1. The Customer shall allow the Supplier to access the Site as required in order to carry out the Works.

2. The Supplier shall carry out the Works in accordance with the Scope of Works and the Conditions of Contract as included in Schedule 2.

3. In the event that the Project is terminated or cancelled by SSE then the Supplier shall be entitled to terminate its obligations under this Agreement with no prior notice and with no liability whatsoever to the Customer.

4. The terms of this Agreement are those contained within Schedule 2. In the event that there is any conflict between the terms contained within this Agreement or the terms contained within Schedule 2 the terms of this Agreement shall prevail.

5. The Customer gives a further undertakings to the Supplier with regard to access and use of the System;

6. The Supplier will retain the title in the property to be installed at the Site under this Agreement until it has received payment for the goods from SSE. In the event that payment is not received by the Supplier within 30 days of it being due under the agreement between SSE and the Supplier, then the Supplier will be entitled to enter the Site after giving reasonable written notice to the Customer and take possession of the property. Risk in the property will pass to the Customer upon incorporation in the building fabric.

IN WITNESS whereof the parties have executed this Agreement to take effect from the day and year above written.

_____
signed on behalf of the Customer by

Date: _____

_____
signed on behalf of the Supplier by

Date: _____

SCHEDULE 1 – SCOPE OF WORKS

1. Honeywell Engineer will conduct a facility audit of the Church Road building with the Customer's representative, at a time that is convenient to the Customer, and identify viable electricity using areas within the building that can be included in the Load Shed strategy

2. Honeywell Engineer will develop an appropriate, tailored Load Shed strategy for the Church Road building

3. Honeywell Engineer will describe and agree the Load Shed strategy with the Customer

4. Honeywell Engineer will supply & install a Honeywell AutoDR Controller in the Church Road building

5. Honeywell Engineer will develop Honeywell AutoDR Controller Programme & hand shake protocol

6. Honeywell Engineer will arrange interface between AutoDR Controller and Building Management System (BMS) in the Church Road building and install the Load Shed strategy

7. Honeywell Engineer will test & commission the System and the Load Shed strategy at the Church Road building with the Customer

8. Honeywell Engineer will undertake training of the Customer's representative(s)

Following installation of the System

9. At times that has been agreed with the Customer, SSE (with Honeywell) will run AutoDR Pilot load shedding events at the Church Road building, monitor performance & produce data

10. The duration of the Pilot phase, SSE (with Honeywell) will conduct load shedding events over a period not exceeding 3 months from the final date of commissioning of the System

SCHEDULE 2 – TERMS AND CONDITIONS

All goods and services sold and supplied by Honeywell Control Systems Limited are sold and supplied subject to these Terms and Conditions of Sale with the exception of goods and services supplied under a maintenance contract.

1 DEFINITIONS

1.1 In these Conditions, unless the context otherwise requires the following expressions shall have the following meanings:

"Conditions" the standard conditions of sale set out in this document;

"Contract" the contract between the Customer and the Supplier for the sale and purchase of the Goods and Services;

"Customer" the person who accepts the Supplier's written Quotation for the sale of the Goods and/or Services, or whose written order for the Goods and/or Services is accepted by the Supplier;

"Goods" the goods including any installment of the goods or any parts for them which the Supplier is to supply in accordance with these Conditions;

"Hazardous Substances" means the following or any by product thereof whether naturally occurring or manufactured which has or is alleged to have an adverse effect on human health, habitability of a site, or the environment, including but not limited to: (a) any dangerous, hazardous or toxic pollutant, contaminant, chemical, material or substance defined as hazardous or toxic or pollutant or contaminant by any statute or statutory instrument of the United Kingdom (or part thereof) or by directive of the European Union; (b) any petroleum product, nuclear fuel or material, carcinogen, asbestos, urea formaldehyde, foamed-in-place insulation, polychlorinated biphenyl (PCBs), and (c) any other chemical or biological material or organism alleged to have an adverse effect on human health, habitability of a site or the environment;

"Incoterms" the international rules for the interpretation of trade terms of the International Chamber of Commerce as in force at the date when the Contract is made;

"Mould" any type or form of fungus or biological material or agent including mould, mildew, yeast and mushrooms, and any my toxins, spores, scents, or by-products produced or released by any of the forgoing;

"Offer" an offer made by the Supplier to the Customer to supply the Goods and Services in accordance with the Conditions;

"Premises" the premises of the Customer at which the Services are to be provided

"Quotation" the quotation or proposal document issued by the Supplier to the Customer in connection with supply of Goods and Services;

"Services" the provisions of services to cover and include but is not limited to the installation of the Goods, commissioning, fault call outs, design and project management to be supplied on a time and materials basis, unless specified otherwise in the Quotation or as agreed between the parties. For the avoidance of doubt the time charged will include time spent traveling to the Premises and the actual time spent by the Supplier at the Premises.

"Supplier" Honeywell Control Systems Limited (registered in England under number 217803) whose registered office is situated at Honeywell House, Arlington Business Park, Bracknell, RG12 1EB.

1.2 A reference in these Conditions to a provision of a statute shall be construed as a reference to that provision as amended, re-enacted or extended at the relevant time.

1.3 The headings in these Conditions are for convenience only and shall not affect their interpretation.

1.4 In these Conditions references to the masculine include the feminine and the singular include the plural and vise versa..

2. BASIS OF THE SALE

2.1 The Customer's acceptance of the Offer and the Services or delivery of the Goods includes the acceptance of these Conditions which can only be varied expressly and by mutual agreement in writing, signed by an authorised representative of the Supplier whose authority must be confirmed by the Supplier.

2.2 These Conditions will apply to the exclusion of all other terms and conditions including any terms or conditions which the Customer purports to apply under any purchase order, confirmation of order, specification, email and all previous representations, understandings and agreements between the parties, whether oral or written.

2.3 The Supplier's employees or agents are not authorised to make any representations concerning the Goods or the Services unless confirmed by the Supplier in writing. In accepting the Offer the Customer acknowledges that it does not rely on any such representations which are not so confirmed, but nothing in these Conditions affects the liability of either party for fraudulent misrepresentation.

2.4 Any advice or recommendation given by the Supplier or its employees or agents as to the storage, application or use of the Goods which is not confirmed in writing by the Supplier, is followed or acted on entirely at the Customer's own risk and accordingly the Supplier shall not be liable for any such advice or recommendation which is not so confirmed.

2.5 Any typographical, clerical or other error or omission in any sales literature, Quotation, price list, acceptance of offer, invoice or other document or information issued by the Supplier shall be subject to correction without any liability on the part of the Supplier.

3. ORDERS AND SPECIFICATIONS

3.1 Unless previously withdrawn or otherwise agreed in writing any Quotation shall be open for acceptance for a period of 30 days or, if different, for the period stated in the Quotation.

3.2 No Order placed by the Customer shall be deemed to be accepted by the Supplier until a written acceptance of order is issued by the Supplier or (if earlier) the Supplier delivers the Goods or provides the Services to the Customer.

3.3 The quantity and description of the Goods and Services and any specification for them shall be as set out in the Supplier's Quotation.

3.4 Except when incorporated in the Offer by specific reference all specifications, drawings, particulars of weights, shapes, descriptions, illustrations, price lists and other advertising material accompanying the Offer are issued or published for the sole purpose of giving an approximate idea of the Goods and/or the Services described in them and will not form part of the Contract.

3.5 The Supplier reserves the right to make any changes in the specification and type of materials in the Goods which do not materially affect the quality or performance, provided that the differences do not make the Goods unsuitable for any purpose which the Customer has expressly made known to the Supplier.

3.6 The Supplier reserves the right to impose additional charges if the Customer requires any alteration or modifications in the specifications, drawings or designs, or any development of the Goods or the Services.

3.7 No order which has been accepted by the Supplier may be cancelled by the Customer except with the agreement in writing of the Supplier and on terms that the Customer shall indemnify the Supplier in full against all loss (including loss of profits) costs (including the cost of labour and materials used) damages, charges and expenses incurred by the Supplier as a result of the cancellation.

4 **PRICE OF THE GOODS AND SERVICES**

4.1 The price of the Goods and/or the Services shall be the Supplier's quoted price stated on the Quotation or acceptance of order or, where no price has been quoted (or a quoted price is no longer valid), the price listed in the Supplier's current published price list on the date of delivery of the Goods or provision of the Services.

4.2 The Supplier reserves the right, by giving written notice to the Customer at any time before delivery, to increase the price of the Goods and Services to reflect any increase in the cost to the Supplier which is due to any factor beyond the control of the Supplier (such as, without limitation, any foreign exchange fluctuation, currency regulation, alteration of duties, significant increase in the cost of labour, materials or other costs of manufacture), any change in delivery dates, quantities or specifications for the Goods and Services which are requested by the Customer, or any delay or disruption caused by any instructions of the Customer or failure of the Customer to give the Supplier adequate access, information or instructions.

4.3 The price for the Goods and Services shall be exclusive of any applicable value added tax and all costs or charges in relation to loading, unloading, carriage and insurance which amounts the Customer will be responsible for when it is due to pay for the Goods and/or Services.

4.4 Any price quoted is for stipulated quantities only and will not apply to an order for any lesser quantities nor subsequent orders for the same goods.

5 **TERMS OF PAYMENT**

5.1 Subject to any special terms agreed in writing between the Customer and the Supplier, where the duration of the Services is less than thirty days the Supplier may invoice the Customer for the price of the Goods and Services at any time after delivery of the Goods or provision of the Services. In the event that the Services will be longer than thirty days then the Supplier shall be entitled to make monthly applications for the value of work carried out to date under the order less the value of work previously paid. Such application shall state the amount due and the basis on which that sum was calculated The date of the application shall be the due date for payment. For the avoidance of doubt the application may be in the form of a Supplier's VAT invoice.

5.2 Should the Customer dispute the amount to be paid it must issue a notice of the payer's intention to pay less not later than fifteen days prior to the final date for payment. The notice must state the sum the Customer considers to be due on the date the notice is served and the basis on which that sum is calculated. In the event that no notice to pay less is provided then the amount outlined in the Supplier's application is the amount that is payable.

5.3 Time for payment shall be of the essence.

5.4 No payment shall be deemed to have been received until the Supplier has received clear funds.

5.5 The Customer shall make payment to the Supplier on or before the final date for payment which shall be thirty days after the due date for payment, and the Supplier shall be entitled to recover the price for the works duly performed.

5.6 If the Customer fails to make any payment by the final date for payment, then, without limiting any other right or remedy available to the Supplier, the Supplier may charge the Customer interest (both before and after any judgment) on the amount unpaid, at 8% over the Bank of England base rate, until payment in full is made (a part of a month being treated as a full month for the purpose of calculating interest).

5.6 Accept in the instance of Adjudication in which case the provisions of clause 31 will apply, for the avoidance of doubt, the Customer shall pay to the Supplier on a full indemnity basis, all costs, expenses, losses and liabilities incurred by the Supplier in connection with any third party costs and legal expenses incurred by the Supplier in obtaining judgment against the Customer.

5.7 Subject to seven days notice being given in writing, the Supplier reserves the right to suspend performance of the Contract works (in whole or in part) should the Customer fail to make payment by the final date for payment. The Customer shall pay, as a debt, the Supplier's reasonably incurred costs as a result of this suspension The Supplier shall be entitled to an extension of time which shall be no less than the period of suspension plus time taken to demobilise and remobilise.

6 **DELIVERY**

6.1 Delivery of the Goods shall be made to the Customer's place of business or to such other place of delivery as is agreed by the Customer in writing prior to delivery of the Goods or at any time after the Supplier has notified the Customer that the Goods are ready for collection.

6.2 The date for delivery shall be specified in the written acceptance of order. Any dates specified by the Supplier for delivery of the Goods are intended to be an estimate only. The Goods may be delivered by the Supplier in advance of the quoted delivery date on giving notice to the Customer.

6.3 When Goods are delivered for export or where non-standard packing is requested by the Customer an additional charge shall be made by the Supplier to the Customer at the rate stipulated in the current price list.

6.4 Subject to the other provisions of these Conditions, the Supplier shall not be liable for any loss (including loss of profit) costs, damages, charges or expenses caused directly or indirectly by any delay in the delivery of the Goods (even if caused by the Supplier's negligence), nor will any delay entitle the Customer to terminate or rescind the Contract.

6.5 Where the Goods are to be delivered in installments, each delivery shall constitute a separate contract and failure by the Supplier to deliver any one or more of the installments in accordance with these Conditions or any claim by the Customer in respect of any one or more installments shall not entitle the Customer to treat the Contract as a whole as repudiated.

6.6 If the Customer fails to give the Supplier adequate delivery instructions at the time stated for delivery (otherwise than by reason of any cause beyond the Customer's reasonable control or by reason of the Supplier's fault) then, without limiting any other right or remedy available to the Supplier, the Supplier may store the Goods until actual delivery and charge the Customer for the reasonable costs (including insurance) of storage.

7 PROVISION OF THE SERVICES

7.1 Performance of the Services shall be made at such time or times as specified in the Quotation or acceptance of any order. Any time stated for performance of the Services are estimates only. If, for any reason, the Supplier is unable to perform the Services within the time specified the Supplier shall not be liable for any loss or damage suffered by the Customer.

7.2 The Supplier confirms that the Services will be provided using reasonable care and skill and, as far as reasonably possible, in accordance with any specification and the reasonable instructions of the Customer from time to time.

7.3 The Customer shall furnish the Supplier without charge and within a reasonable time with all documents, drawings, plans, maps, charts, images, records or other materials and any data or information ("Backround Information") available to it relating to the Services and/or the Premises and shall give such assistance as shall reasonably be required by the Supplier for the carrying out of its duties under the Contract and to enable the Supplier to provide the Services. The Customer shall ensure the accuracy of all Background Information

7.4 The Customer shall make available to the Supplier and its representatives, free of charge and in a timely manner, the necessary equipment and facilities to provide the Services, unless otherwise stated within the Supplier's Quotation.

7.5 The hire, supply or use of specialist equipment by the Supplier to enable access to heights in excess of 3 metres shall not be included in any Quotation or acceptance of order given by the Supplier and the Supplier reserves the right to charge the Customer additional sums to cover the cost of such equipment unless otherwise stated within the Supplier's Quotation.

7.6 In providing the Services to the Customer the Supplier is acting as a contractor only as defined by the Construction (Design and Management) Regulations 2007 ("CDM Regulations") and shall not be responsible for any additional costs incurred in connection with compliance with the CDM Regulations including but not limited to any safety planning needs or special design requirements of the Customer which were not notified to the Supplier in writing prior to conclusion of the Contract. The Customer shall ensure that the Supplier has safe and reasonable access to the Premises to provide the Services.

8 ACCESS TO THE PREMISES

8.1 Where the Supplier or its authorised agents or sub-contractors are to provide the Services upon the Premises or other premises at the direction of the Customer, the Customer shall ensure that such Premises and any equipment and machinery involved and all other arrangements affecting the provision of the Services are ready by the time scheduled for the Supplier to enter upon such Premises and obtain access to such parts of such Premises as may be necessary to commence provision of the Services.

9. RISK AND PROPERTY

9.1 Risk of damage to or loss of the Goods shall pass to the Customer at the time of delivery to site.

9.2 Notwithstanding delivery and passing of risk in the Goods, or any other provision of these Conditions, property in the Goods shall not pass to the Customer until the Supplier has received payment in full of the price of (i) the Goods and (ii) all other goods sold by the Supplier to the Customer for which payment is due.

9.3 Until such time as the property in the Goods passes to the Customer, the Customer shall:

9.3.1 hold the Goods on a fiduciary basis as the Supplier's bailee;

9.3.2 store the Goods, (at no cost to the Supplier) separate from those of the Customer or any third party and properly protect, insure and identify the same as the Supplier's property;

9.3.3 not destroy, deface or obscure any identifying mark or packaging on or relating to the Goods;

9.3.4 maintain the Goods in satisfactory condition insured on the Supplier's behalf for their full price against all risks to the reasonable satisfaction of the Supplier.

9.4 Until such time as the property in the Goods passes to the Customer the Supplier may at any time require the Customer to deliver up the Goods to the Supplier and, if the Customer fails to do so forthwith, enter on any premises of the Customer or any third party where the Goods are stored and repossess the Goods.

9.5 The Customer shall not be entitled to pledge or in any way charge by way of security for any indebtedness any of the Goods which remain the property of the Supplier, but if the Customer does so all monies owing by the Customer to the Supplier shall (without limiting any other right or remedy of the Supplier) forthwith become due and payable.

10. END USER CONTRACTS

10.1 The Supplier acknowledges that the Customer may in the course of its business sell on the Goods to its own customer ("End User").

10.2 If the Customer sells on the Goods it shall immediately notify such End Users that title to the Goods remains with the Supplier until payment for such Goods has been made in full to the Supplier.

10.3 The Customer hereby grants to the Supplier the irrevocable right to require an assignment of the benefit of the Customer's contract with the End User (including the rights to all monies payable or to become payable) and any Goods sold thereunder to the Supplier.

10.4 For the avoidance of doubt, the rights granted under clause 10.3 shall only be exercisable prior to the occurrence of an Event.

10.5 For the purposes of this clause 10 an Event shall be as defined in clause 17.1.

11. EXHIBITIONS

11.1 The Customer may not exhibit any Goods or accessories supplied by the Supplier, without first obtaining the Supplier's prior written consent.

12. RETURN OF GOODS

12.1 The Supplier will accept return of the Goods in the following circumstances:

12.1.1 The Customer may return any unused Goods within 30 days provided the Goods are the same quality and condition as at delivery by the Supplier. The Supplier will charge a handling fee equivalent to 30 per cent of the price of the Goods

12.1.2 The Customer may return any defective Goods within the Warranty Period (as defined in Clause 14.1) and subject as in clause 14.5 provided the Supplier will refund to the Customer the price of such Goods.

12.1.3 If any Goods returned pursuant to clause 12.1.2 are not defective the Supplier will refund the price of the Goods less a handling fee equivalent to 30 per cent of the price of the Goods

12.2 The Customer must notify the Supplier by telephone when returning the Goods and must ensure a debit note is returned with the Goods detailing the following: Product code of the Goods; Product name of the Goods; Quantity of the Goods; The purchase price of the Goods; Original invoice for the Goods; Supplier account number; and reasons for return of the Goods.

13 DESIGN LIABILITY

13.1 Unless expressly described in the Quotation, any design liability the Supplier may have is expressly limited to application engineering of the equipment supplied to a design provided by others.

14. WARRANTIES

14.1 Subject to the following provisions the Supplier warrants that the Goods and/or Services will correspond with their specification at the time of delivery and will be free from defects in material and workmanship for a period of 12 months from delivery ("the Warranty Period").

14.2 The above warranty is given by the Supplier subject to the following conditions:

14.2.1 the Supplier shall be under no liability in respect of any defect in the Goods and/or Services arising from any drawing, design or specification supplied by the Customer;

14.2.2 the Supplier shall be under no liability in respect of any defect arising from fair wear and tear, wilful damage, negligence, abnormal working conditions, failure to follow the Supplier's instructions (whether oral or in writing) misuse or alteration or repair of the Goods and/or Services without the Supplier's approval;

14.2.3 the Supplier shall be under no liability in respect of any damage to the Goods caused during transit;

14.2.4 the Supplier shall be under no liability under the above warranty (or any other warranty, condition or guarantee) if the total price for the Goods and/or Services has not been paid by the due date for payment;

14.2.5 the above warranty does not extend to parts, materials or equipment not manufactured by the Supplier, in respect of which the Customer shall only be entitled to the benefit of such warranty or guarantee as is given by the manufacturer to the Supplier.

14.3 Subject as expressly provided in these Conditions, all warranties conditions or other terms implied by statute or common law are excluded to the fullest extent permitted by law.

14.4 A claim by the Customer which is based on any defect in the quality or condition of the Goods and/or Services shall (whether or not delivery is refused by the Customer) be notified to the Supplier within 5 days from the date of delivery or (where the defect or failure was not apparent on reasonable inspection) within a reasonable time after discovery of the defect or failure. If delivery is not refused, and the Customer does not notify the Supplier accordingly, the Customer shall not be entitled to reject the Goods and/or Services and the Supplier shall have no liability for such defect or failure, and the Customer shall be bound to pay the price for the Goods and/or Services as if the Goods and/or Services had been delivered in accordance with the Contract.

14.5 Where a valid claim in respect of any of the Goods and/or Services which is based on a defect in the quality or condition of the Goods and/or Services or their failure to meet any specification is notified to the Supplier in accordance with these Conditions, the Supplier may replace the Goods and/or Services (or the part in question) free of charge or, at the Supplier's sole discretion, refund to the Customer the price of the Goods and/or Services (or a proportionate part of the price), in which case the Supplier shall have no further liability to the Customer.

15. LIMITATION OF LIABILITY

15.1 The Supplier will have no liability for defective Goods and/or Services supplied or performed by its sub contractors where such sub-contractors have been specified or nominated (whether alone or with others) by the Customer.

15.2 Except in respect of death or personal injury caused by the Supplier's negligence, or liability for defective products under the Consumer Protection Act 1987, the Supplier shall not be liable to the Customer by reason of any representation (unless fraudulent), or any implied warranty, condition or other term, or any duty at common law, or under the express terms of the Contract or in tort, for loss of profit, loss of revenue, loss of use, loss of contracts or for any indirect, economic, special or consequential loss or damage, costs, expenses or other claims for compensation whatsoever which arise out of or in connection with the supply of the Goods (including any delay in supplying or any failure to supply the Goods in accordance with the Contract or at all) or the provision of Services or the use or resale of the Goods by the Customer, and the entire liability of the Supplier under or in connection with the Contract shall not in aggregate exceed the price of the Goods and/or Services.

15.3 The Supplier shall only accept liability for damage to the Customer's property caused by the negligence of itself, its employees, subcontractors and agents if the same is notified to the Supplier within 3 days of such damage occurring. Where the Supplier accepts responsibility under this clause 15.3, it may, at its sole option, repair or replace, as the case may be, such property which is proved to the Supplier's satisfaction to have been damaged by its negligence or that of its employees, agents or sub-contractors.

15.4 The Supplier accepts no responsibility or liability where the Services cannot be provided as a result of any act or omission of the Customer or third parties outwith the Supplier's control including but not limited to not making available adequate access to the Premises in accordance with clause 8 hereof and the Customer shall still be liable to pay the Supplier for the Services as if the same had been duly performed.

15.5 Where the Customer deals as a consumer, these conditions shall not affect the Customer's statutory rights.

15.6 The Supplier shall not be liable to the Customer or be deemed to be in breach of the Contract by reason of any delay in performing, or any failure to perform, the Services or any of the Supplier's obligations in relation to the Goods, if the delay or failure was due to any cause beyond the Supplier's reasonable control. Without prejudice to the generality of the foregoing, the following shall be regarded as causes beyond the Supplier's reasonable control: Act of God, explosion, flood, tempest, fire or accident; war or threat of war, sabotage, insurrection, civil disturbance or requisition; acts, restrictions, regulations, bye-laws, prohibitions or measures of any kind on the part of any governmental, parliamentary or local authority; import or export regulations or embargoes; strikes, lock-outs or other industrial actions or trade disputes (whether involving employees of the Supplier or of a third party); difficulties in obtaining raw materials, labour, fuel, parts or machinery; power failure or breakdown in machinery.

16. HAZARDOUS SUBSTANCES AND MOULD

16.1 The Supplier shall have the right to suspend performance of the Services if the Supplier discovers or otherwise becomes aware of Hazardous Substances or Mould, or conditions the Supplier reasonably believes may cause Hazardous Substances or Mould to be released, accumulated, concentrated or dispersed at the Premises, under circumstances that the Supplier reasonably believes may be hazardous, violate applicable laws, or give rise to claims of any kind against the Customer or the Supplier ("Adverse Circumstances"). If the Supplier suspends performance under this Clause 16.1, the Supplier shall not be obliged to continue the Services until the Customer provides evidence that Hazardous Substances or Mould do not exist at the Premises under the Adverse Circumstances. The Supplier shall have the right to terminate this Contract with respect to any Premises immediately upon determination that Hazardous Substances or Mould are present at the Premises under Adverse Circumstances that the Customer cannot or will not remove or otherwise remedy within sixty (60) days after discovery. The right to suspend or

terminate performance under this Clause 16.1 is solely for the benefit of the Supplier. Nothing in this Clause 16.1 shall be construed to require the Supplier to discover or report Hazardous Substances, Mould or Adverse Circumstances. Failure of Supplier to discover, report, or suspend or terminate upon discovery of Hazardous Substances, Mould or Adverse Circumstances, shall not relieve the Customer of its indemnification obligations under Clause 16.7 of this Contract.

16.2 The Customer represents and warrants that at the Premises where the Supplier will undertake work or provide the Services, there are no Hazardous Substances, except those generated, labelled, stored, used, and disposed in strict accordance with applicable law.

16.3 The Customer warrants and represents to the Supplier that the Customer has not observed or received notice from any source (including without limitation formal or informal complaints of employees or visitors) of: (a) Hazardous Substances or Mould, either airborne or on or within the walls, floors, ceilings, heating, ventilation and air conditioning systems, plumbing systems, structure, and other components of the Premises, or within furniture, fixtures, equipment, containers or pipelines on the Premises; or (b) Conditions that, to the Customer's knowledge, might cause or promote accumulation, concentration, growth or dispersion of Hazardous Substances or Mould on or within such locations.

16.4 The Customer warrants and represents to the Supplier that in areas in which the Supplier will be performing the Services, there are no conditions or circumstances subject to special precautions or equipment required by any statute or statutory instrument or local health or safety regulations or unsafe working conditions. The Customer shall notify the Supplier of any changes in conditions or regulations that occur during the course of this Contract that affect the foregoing representations and warranties, including without limitation discovery of Hazardous Substances or Mould at a Site.

16.5 The Customer acknowledges that the Customer has not retained the Supplier to discover, inspect, investigate, identify, prevent or remedy Hazardous Substances or Mould, conditions caused by Hazardous Substances or Mould, or conditions that might cause or promote accumulation, concentration, growth or dispersal of Hazardous Substances or Mould. The Customer agrees that the Supplier shall not be responsible for any such discovery, inspection, investigation, identification, prevention or remedy, or for any damages arising from or related to the existence of Hazardous Substances or Mould at the Premises.

16.6 The Customer acknowledges that the operation of the Goods may control or affect temperature, humidity, and ventilation at the Premises, which may adversely affect accumulation, concentration, growth or dispersion of Hazardous Substances or Mould, whether or not there are defects in the Goods or the Services. The Customer agrees that the Supplier is responsible for maintaining the Goods in a good working order in accordance with manufacturer's specifications and recommendations, but the Supplier is not responsible for determining whether the Goods or the temperature, humidity and ventilation settings used by the Customer, are appropriate for the Customer and the Premises except as specifically provided in the Schedules. The Supplier shall not be responsible for any adverse affects of temperature, humidity and ventilation conditions created by the Goods.

16.7 To the fullest extent allowed by law, the Customer shall indemnify and hold Supplier harmless from and against any and all claims and costs of whatever nature, including but not limited to, consultants' and legal costs fees, damages for personal injury and property damage, fines, penalties, remedial costs and costs associated with delay or work stoppage, that in any way result from or arise directly or indirectly from the breach inaccuracy or non-fulfilment of the representations and warranties in this Clause 16 or the existence of Hazardous Substances or Mould at the Premises, or the occurrence or existence of the situations or conditions described in this Clause 16, whether or not the Customer provides the Supplier advance notice of the existence or occurrence and regardless of when the hazardous substance or occurrence is discovered or occurs. This indemnification shall survive termination of this Contract for whatever reason. Nothing in this Clause 16 shall be construed to require that the Customer indemnify and hold harmless the Supplier from claims and costs resulting from the negligent use by the Supplier of any hazardous substance brought to the Premises by the Supplier (and the Customer acknowledges that Supplier may bring to the site lubricants or other materials that are routinely used in performing the Service and that may be classified as hazardous).

17. INSOLVENCY OF CUSTOMER

17.1 This clause 17 applies if:

17.1.1 any meeting of the Customer's creditors being held or if any scheme of arrangement composition or trust deed is made or proposed by the Customer or on the Customer's behalf with or for the benefit of the Customer's creditors;

17.1.2 if a petition is presented for the making of an administration winding up bankruptcy or sequestration order in respect of the Customer or a resolution is passed for the presentation of any such petition;

17.1.3 if a receiver, administrator or administrative receiver is appointed over or takes possession of all or any part of the assets of the Customer;

17.1.4 if the Customer is deemed unable to pay its debts within the meaning of section 123 of the Insolvency Act 1986; or the Customer appears unable to pay its debts within the meaning of Section 268 of the said Act

17.1.5 the Supplier reasonably apprehends that any of the events mentioned above is about to occur in relation to the Customer and notifies the Customer accordingly.

17.2 If this clause applies then, without limiting any other right or remedy available to the Supplier, the Supplier may cancel the Contract or suspend any further deliveries under the Contract without any liability to the Customer, and if the Goods have been delivered, but not paid for the price shall become immediately due and payable notwithstanding any previous agreement or arrangement to the contrary.

18. EXTRA CHARGES/VARIATIONS

18.1 If for any reason the Customer requests the Supplier to provide labour or services outside normal working hours any overtime or additional expenses occasioned thereby shall be paid by the Customer unless otherwise provided in the Quotation.

18.2 The Customer shall have the right to request changes within the scope of the work; however all such changes are subject to acceptance by the Supplier. If any change/variation causes an increase or decrease in the price of this Contract or in the time required for performance, the Supplier shall notify the Customer of such increase or decrease and this Contract shall be adjusted in writing accordingly. The Supplier shall not be obliged to proceed with any change nor shall such change be effective until a written contract amendment has been accepted by the Supplier. The Supplier's right to payment for such change shall not be affected, in the event the Supplier agrees to proceed

prior to the acceptance of such contract amendment. Unless otherwise agreed to in writing, the Supplier shall have the right to invoice immediately for the total value of the change/variation.

18.3 The Supplier may make a written request to the Customer to modify this contract based on the receipt or discovery of information that the Supplier believes will cause a change to the scope, price, schedule, level of performance, or other facet of the contract. The Supplier will submit its request to the Customer within a reasonable time after receipt or discovery of such information. This request shall be submitted by the Supplier before proceeding to execute the work, except in an emergency endangering life or property, in which case the Supplier shall have the authority to act, in its discretion, to prevent threatened damage, injury or loss. The Supplier's request will where time permits include information necessary to substantiate the effect of the change and any impacts to the work, including any change in schedule or contract price. If the Supplier's request is acceptable to the Customer, the Customer will issue a change/variation order consistent therewith.

19. TERMINATION

19.1 The Customer may terminate this contract for cause if the Supplier defaults in the performance of any material term of this contract, or fails or neglects to carry forward the work in accordance with this contract, if, after the Customer has given the Supplier seven (7) days' written notice specifying such default, the Supplier fails to cure or perform its obligations.

19.2 The Supplier may terminate this contract for cause (including, but not limited to, the Customer's failure to make any payment as agreed herein) if, within seven (7) days following receipt of notice specifying such default, the Customer fails to rectify its default. Without prejudice to such termination the Supplier may subsequently recover from the Customer payment for work performed and for losses sustained for materials, tools, construction equipment and machinery, including reasonable overheads and profit, together with interest calculated (both before and after any judgement or arbitral award) in accordance with clause 5.

19.3 Termination of this contract as above shall be without prejudice of the parties to enforce any right or any obligation for payment which had arisen prior to termination including any right to recover interest on sums outstanding.

20. SALE OF GOODS AND SERVICES ACT

20.1 All Goods and Services supplied or performed by the Supplier are supplied with the benefit of the terms implied by section 12 of the Sale of Goods Act 1979 and section 2 of the Supply of Goods and Services Act 1982. Subject thereto, and whether or not the Contract is a contract of sale, all other conditions warranties and other terms express or implied statutory or otherwise are expressly excluded, save insofar as contained herein or as otherwise expressly agreed by the Supplier in writing provided that if and insofar as any legislation or any order made thereunder shall make or have made it unlawful to exclude or propose to exclude from the Contract any term or shall have made unenforceable any attempt to exclude any such term, the foregoing provisions of this paragraph will not apply to any such term.

21. ASSIGNMENT

21.1 The Customer shall not be entitled to assign the Contract or any part of it without the prior written consent of the Supplier

21.2 The Supplier may assign the Contract or any part of it to any person, firm or Company.

22. PATENTS/INTELLECTUAL PROPERTY

22.1 The Supplier will indemnify the Customer against any claim for alleged infringement of any patents of the United Kingdom or the Republic of Ireland by the normal use or possession of any part of the equipment or goods, provided that the Supplier is given immediate and complete control of any such claim, that the Customer does not prejudice in any manner the Supplier's conduct of such claim and that the alleged infringement does not arise from the Supplier following any instruction given by or on behalf of the Customer, and is not based upon the use of the equipment or goods in combination with any equipment or devices not made by the Supplier. If a final injunction is obtained in any such claim, the Supplier shall, at its option procure for the Customer the right to continue to use the equipment or modify the equipment so that it becomes non-infringing.

22.2 Technical information and the intellectual property rights therein (including software) supplied by one party to the other in connection with this Contract shall remain the property of the furnishing party, and shall be kept confidential and shall not be copied, modified, disclosed or used by the receiving party otherwise than in connection with the Goods and/or Services at the Premises.

23 . SOFTWARE LICENCE

23.1 All software provided by the Supplier to the Customer or (at the request of the Customer) to a third party (the 'Software End User') in connection with this contract shall be licensed and not sold. The Customer or the Software End User of the software will be required to sign a license agreement with provisions limiting the use of the software to the equipment provided under these specification, limiting copying, preserving confidentiality, and prohibiting transfer to a third party. The Customer shall grant the Supplier access to the Software End User for the purposes of obtaining the necessary software license so as not to delay the progress of the works.

24. WAIVER

24.1 Failure by either party to enforce any of the provisions of this Contract or to require compliance with any of its terms at any time during this Contract shall in no way affect the validity of this Contract, or any part hereof, and shall not be deemed a waiver of the right of such party thereafter to enforce any and each such provision.

25. GOVERNING LAW

25.1 The Contract shall be governed by the laws of England and Wales and the Customer agrees to submit to the non exclusive jurisdiction of the English Courts.

25.2 To the extent that the provisions of the Housing, Grants, Construction and Regeneration Act 1996 ("the Act") and any amendments thereof do not conflict with the Conditions, they shall be deemed to be incorporated into the Contract. For the avoidance of doubt, if any provisions of the Act do conflict, these Conditions shall prevail.

26. NOTICES

26.1 Any notice required or permitted to be given by either party to the other under these Conditions shall be in writing addressed to that other party at its registered office or principal place of business or such other address as may at the relevant time have been notified pursuant to this provision to the party giving the notice. Provided that where necessary the despatch of such notice or document has been properly pre-paid a notice or document so given or served shall conclusively be deemed to have been received at the time set out alongside the respective manner of service namely:

26.1.1 by hand on the recipient or an authorised officer thereof – at the time of such service;

26.1.2 by first class post – at the commencement of the first business day next commencing more than 24 hours after despatch;

26.1.3 by facsimile transmission at the commencement of the first business day next commencing more than 48 hours after despatch;

26.1.4 abroad by first class airmail – at the commencement of the first business day next commencing more than 72 hours after despatch.

27. SEVERABILIITY

27.1 In the event that any or any part of the terms, conditions or provisions contained herein shall be determined by any competent authority to be invalid, unlawful, or unenforceable to any extent, such term, condition or provision shall to that extent be severed from the remaining terms and conditions which shall continue to be valid and enforceable to the fullest extent permitted by law.

28. RIGHTS OF THIRD PARTIES

28.1 A party who is not a party to the Contract has no right under the Contracts (Right of Third Parties) Act 1999 to enforce any term of the Contract.

29. RELATIONSHIP OF PARTIES

29.1 Nothing contained in the Contract, and no action taken by the parties pursuant to the Contract will be deemed to constitute a relationship between the parties of partnership, joint venture, principal and agent or employer and employee. Subject to clause 10 neither party has, nor may it represent that it has, any authority to act or make any commitments on behalf of the other party.

30. BUILDING MANAGEMENT SYSTEMS and HVAC – WORKS DONE BY OTHERS

30.1 Automatic valve bodies and dampers shall be set in place and installed by others. Electric wiring and electric wiring accessories shall be supplied and installed by others unless stated otherwise in the Quotation.

31. ADJUDICATON

31.1 A party to this contract ("the Referring Party") may at any time give notice ("the Notice") in writing to the other party of its intention to refer a dispute arising under the contract to adjudication.

31.2 The parties may agree the identity of the adjudicator. Where an adjudicator is not agreed within 2 days of the Notice being given the Referring Party shall immediately apply to the Chartered Institute of Arbitrators for the nomination of an adjudicator, which nomination shall be communicated to the parties within 5 days of receipt of the application.

31.3 Within 7 days of the Notice the Referring Party shall refer the dispute to the adjudicator. The adjudicator shall reach a decision within 28 days of referral or such longer period as is agreed by the parties after the dispute has been referred. The adjudicator may extend the period of 28 days by up to 14 days, with the consent of the party by whom the dispute was referred. The adjudicator shall have the power to correct his decision in the event of any typographical or clerical error made by accident or omission,

31.4 The adjudicator shall act impartially. The adjudicator may take the initiative in ascertaining the facts and the law. The decision of the adjudicator is binding until the dispute is finally determined by legal proceedings, by arbitration (if the contract provides for arbitration or the parties otherwise agree to arbitration) or by agreement. The adjudicator is not liable for anything done or omitted in the discharge or purported discharge of his functions as adjudicator unless the act or omission is in bad faith and any employee or agent of the adjudicator is similarly protected from liability.

31.5 The provisions of this clause 31 shall only apply where the Contract formed is a “construction contract” as defined by sections 104 to 107 of the Housing Grants, Constructions and Regeneration Act 1996 (as amended, extended or re-enacted from time to time).

31.6 Notwithstanding the foregoing should a dispute under the contract between the Customer and the Supplier be referred to adjudication the adjudicator shall be to allocate his fees and expenses as between the parties

Appendix IV

Imperial College – Additional Modelling

Imperial College ADR Analysis

The amount of demand response potentially available for network management purposes is based on control of the buildings Heat Ventilation and Air Conditioner (HVAC) systems, and will be dependent on the outdoor weather condition and internal building requirements. More generally, the main factors influencing the building thermal demand, the operation of HVAC systems and ultimately the amount of demand response that may be available are

(i) Location, height and orientation of building;
(ii) Insulation level, as thermal energy demand depends on the building thermal inertia and on heat flow exchange characteristics with the external environment through walls, windows, doors and roof related to wall, floor, roof and windows;
(iii) Outdoor temperature profiles, humidity, solar radiation and other weather factors, as heating and cooling energy demands are driven by the difference between the indoor and the outdoor conditions.
(iv) Design of HVAC systems and equipment used;
(v) Activities taking place in the building, which are needed to approximate the internal heat gain patterns from occupants and equipment in the building.
(vi) Demand payback, given that demand reduction periods will be normally followed by load recovery periods, which lead to increase in demand that would need to be accommodated.

In this context, it will be important to understand how the amount of available demand response changes across different weather conditions and seasons, the time over which demand response may be required, amount and duration of the demand payback while monitoring the indoor temperature and air quality relevant for maintaining in-door comfort levels. Given that the scope of this project was limited to the installation and demonstration of basic ADR functionality, it is proposed that a comprehensive set of trials is conducted in further trial to fully understand these key interactions, which will be necessary for the determining the role and value of ADR in providing support to distribution network management.

Modelling for relevant to NTVV T2 Project

Assessing the limits of ADR

Having calibrated the models of the buildings, a number of simulations are carried out to understand the limits of the ADR and examine the key parameters relevant for the application of the ADR to distribution network management.

For this exercise, several ADR strategies were simulated on the hottest day in the period under consideration, which was 24 of May 2012. The Building thermal demand for this day is higher than the demand observed in the actual trials, given increased chillers consumption due to higher outdoor temperature and solar radiation. Consequently, even though the modelled strategies are similar to the original ADR trial strategies, the achieved load reduction is considerably higher and varies from 150 to 200 kW.

Two ADR events are simulated, one starting at 12:00 and the other at 16:00, considering various event durations from one to four hours. Results of these simulations, presented in Figure 1, clearly showing load reduction and load recovery periods (payback). We observe that the level of load recovery (energy payback) following the load reduction is related to the duration of controlled period. However the impact of load recovery on the building demand is influenced by the outdoor temperature at the point of ADR exercise and building activities schedule, as shown in Figure 2.

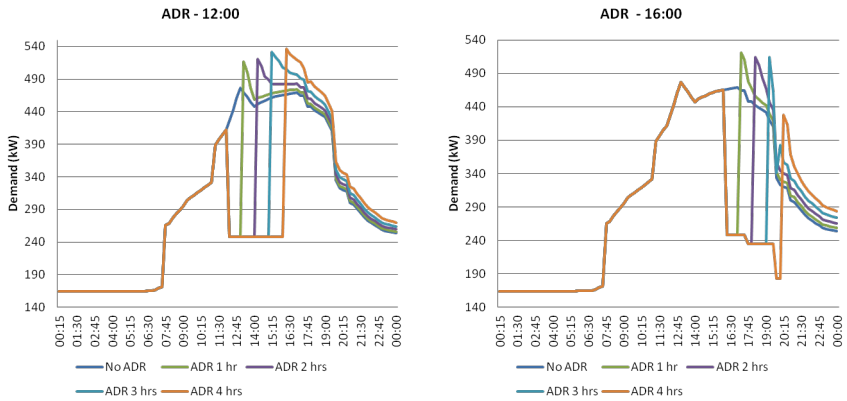


Figure 1: Impact of ADR event duration and time of day on the payback

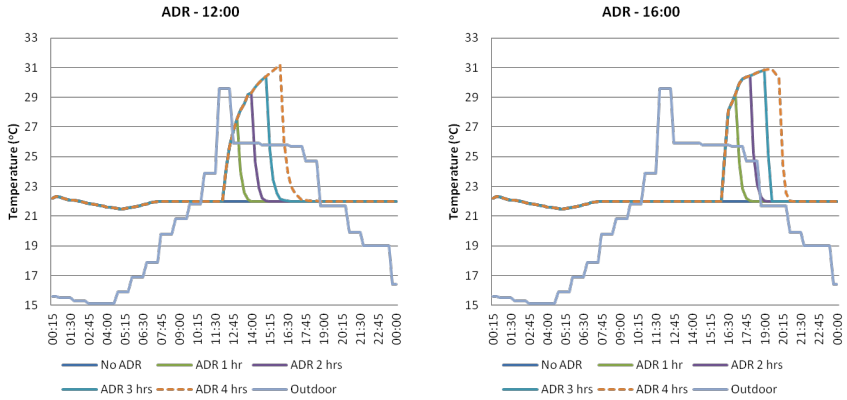


Figure 2: Impact of ADR event duration and time of the day on indoor temperature

Effects on the indoor temperature for each ADR strategy are shown in Figure 2. The temperature increases to 27 and 29 Celsius for one hour duration of ADR event starting at 12:00 and 16:00, respectively. These values are over the temperature limit and affect comfort levels. Clearly, longer ADR intervals will lead to higher temperatures.

Modelling of pre-cooling

If the load reduction can be scheduled in advance, it may be appropriate to apply pre-cooling. This strategy decreased the indoor temperature set point, prior to ADR exercise, to an acceptable level. In this particular case the set point temperature is decreased for two degrees for two hours before the ADR event. The effect of pre-cooling on the demand profile is depicted in Figure 3 where pre-cooling energy is the area between no ADR and ADR demand profiles before the event. However, in this particular case, the benefits from pre-cooling in relation to impact on the comfort are only observed for the first hour.

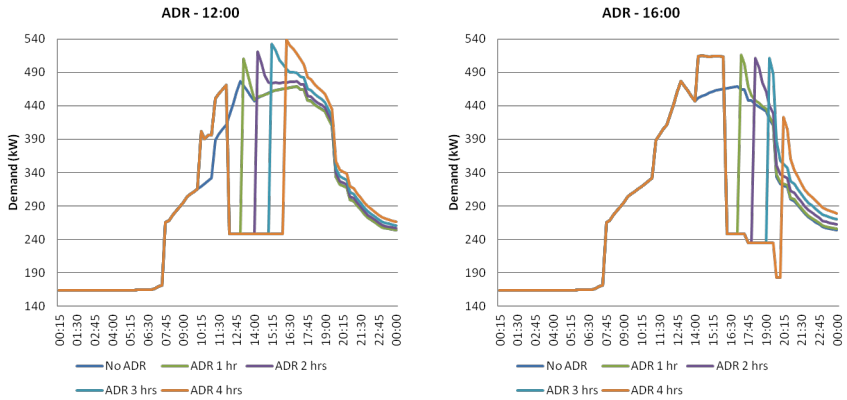


Figure 3: Impact of ADR event duration and time of the day on the payback with pre-cooling

Effects on the indoor temperature for each ADR strategy are shown in Figure 4.

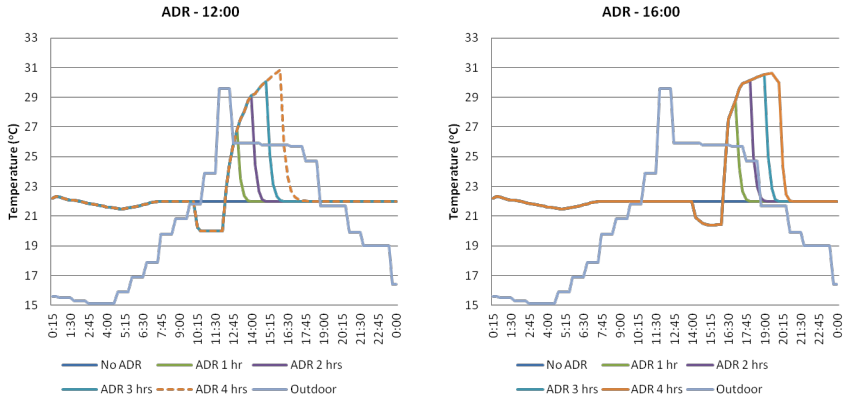


Figure 4: Impact of ADR event duration and time of the day on indoor temperature with pre-cooling

The analysis shows that the effectiveness of pre-cooling may be affected by the outdoor temperatures and operating points of chillers. When the pre-cooling interval starts at 10:00 the outdoor temperature is near to 22 degree Celsius and the demand is below 330 kW, the chillers are operating part-loaded. However at 14:00 the temperature is above 25 degree Celsius and the demand is near to 440 kW, then chillers are operating nearly their full capacity and the indoor temperature cannot reach the pre-cooling temperature set point. This demonstrates that the ability to execute pre-cooling strategy will be dependent of weather conditions and the availability of chillers and this particular result cannot be generalised. It is therefore proposed to examine the pre-cooling strategy in more depth in future trials.

Interaction between level and duration of load reduction

As observed in the simulations presented above, the impact of demand response on the indoor temperature increases significantly with the duration and in general terms the temperature increases obtained are beyond limits that may be considered comfortable. In this section, instead of reducing the load on all three chillers, ADR event involves control of only one chillers unit. This strategy reduces the volume of demand response, but has significantly smaller impact on the indoor temperature inverses. We also observe that the peak of the load recovery (payback) is reduced.

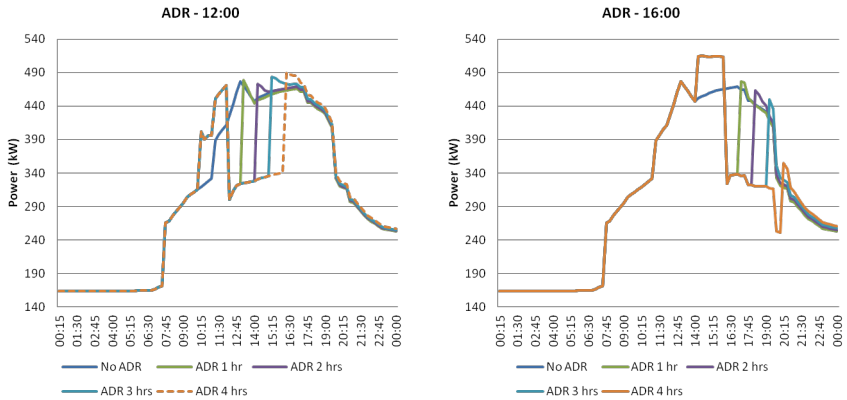


Figure 5: Impact of ADR event duration and time of the day on the payback with reduced level of demand response

Strategy that involves switching off one chiller only, has little impact on the indoor temperature, which rises slightly above 25 degree Celsius and can be considered to be within the comfort limits for all ADR intervals. This shows that carefully choosing flexible strategies can assure customer comfort requirements while providing demand response.

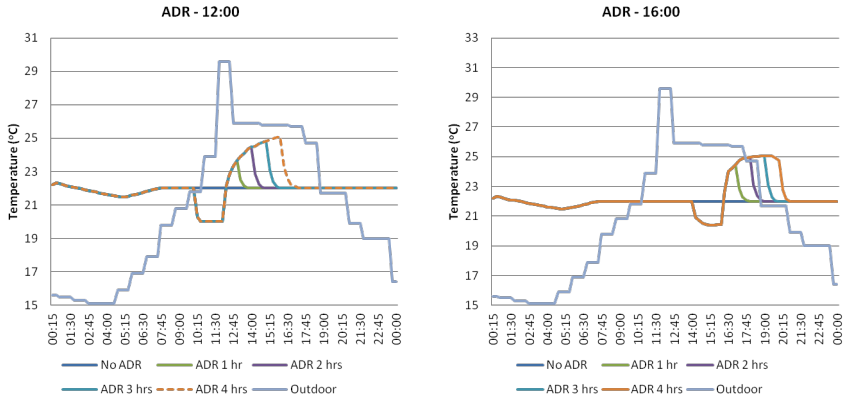


Figure 6: Impact of ADR event duration and time of the day on the indoor temperature with reduced level of demand response