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D2.3: Methodology note on addressing the gap between calculated and actual Energy Performance

ALDREN ALliance for Deep RENovation in buildings

Implementing the European Common Voluntary Certification Scheme, as back-bone along the whole deep renovation process

Disclaimer:

Attention: The present versions are still working documents

*The aim of these **draft** ALDREN Methodology notes is to provide information on how to apply the different ALDREN protocols during the pilot phase, to test, consolidate and validate the work done on the different tasks, to collect feedback from stakeholders on their utility and applicability.*

Therefore, they are made public.

These drafts will be finalized and updated for roll-out before the end of the ALDREN project.

Project resume:

Start: 1 November 2017 End: 30 Avril 2020

The ALDREN objectives are to achieve higher renovation rates and better renovation quality by overcoming market barriers and preparing the ground for investment.

The excellence of the ALDREN solutions offered are:

1. a harmonized Energy performance rating based on the European Voluntary Certification Scheme (EVCS) verified by measurements to increase comparability, confidence and market uptake by standardized solutions (CEN / ISO);
2. associating low energy renovation with high quality indoor environments to trigger renovation and to promote health and comfort;
3. aligning market recognition of high quality with enhanced building value by financial tools and capacity building. Establishing business case for deep renovation to motivate private investment.

These solutions will be integrated in a consistent, common way in a building passport to ensure the results and effective financing also in case of step by step renovation.

The ALDREN coordinate and support actions bring together in ALDREN Alliance the main stakeholders involved in building renovation to specify the needs of the non-residential building sector and to organize the pilot use of the ALDREN procedure.

The ALDREN actions are sound and credible. They answer a market request for common reliable tools by using the EVCS policy instrument (EPBD Art. 11(9)) and by completing it to reach the needed holistic approach for deep renovation.

The implementation and dissemination of the ALDREN procedure will use existing channels of environmental scheme operators for the pilot phase, but also for further dissemination.

The ALDREN overarching outcome will be the infrastructure to enable market transformation by deep renovation driven by the business case and able to directly support the EU policies (EED, EPBD).

Coordinator:

CENTRE SCIENTIFIQUE ET TECHNIQUE DU BATIMENT France

Participants:

- ENBEE SRO Slovakia
- INSTITUTO VALENCIANO DE LA EDIFICACION Spain
- CERTIVEA France
- REHVA Netherlands
- VERCO ADVISORY SERVICES LIMITED United Kingdom
- DANMARKS TEKNISKE UNIVERSITET Denmark
- POLITECNICO DI MILANO Italy

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Revision History

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24 April 2019		CSTB / Olivier Greslou, Rofaïda Lahrech, Simon Ligier	Review
29 April 2019	Version 1.1	Verco / Greg Waring, Robert Cohen, Saadia Ansari	Amendment in response to CSTB review
30 April 2019	Version 1.2	Verco / Greg Waring, Robert Cohen, Saadia Ansari	Revisions to report format only

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Executive summary

1. Executive Summary

The ALDREN Project[1] aims to establish the business case for deep renovation. The 30 month programme which started in November 2017 intends to encourage investment and accelerate the movement towards a nearly zero energy non-residential building stock across the EU, as targeted by 2050 to meet Paris Agreement commitments. The back-bone of ALDREN is the European common Voluntary Certificate (2) (EVC) which will be used will be used to rate the energy performance of the building before renovation based on a harmonized EU calculation framework and to define deep renovation objectives. This document presents the processes and tools proposed to help close the gap between calculated and measured energy performance (EP) for the building before renovation and along the deep renovation process . There are three key components:

1. A framework allowing measured (operational) performance to be compared with predicted (design) performance across all the countries in the ALDREN consortium using a harmonised approach and common language fed by a glossary of terms.

2. A “design for measurability” protocol that sets out and tracks the actions required during the deep renovation process, to ensure that performance predictions are as realistic as possible, that the construction and commissioning process is true to the design intent, and allowing the predicted performance to be verified through measurements.

3. A performance verification tool, which allows the predicted performance in the EVC and actual (measured) performance to be compared at different levels of granularity.

The ALDREN methodology and tools presented in this document set out how nearly zero energy performance targets can become measured outcomes, where driven by client leadership and wider team buy-in, and using the power of advanced simulation of HVAC systems, or other advanced design and verification tools, to optimise design and ensure operation is aligned with the design intent.

[1] ALDREN (ALliance for Deep RENovation in buildings) https://aldren.eu/

Recall of Grant Agreement: how this has been fulfilled

2. Recall of Grant Agreement: how this has been fulfilled

2.1. Recall of Grant Agreement

The contents of the Grant Agreement are presented below. Verco's response to how each task has been delivered to date, and any remaining tasks to complete by the close of the project, have been set out sections 2.2, 2.3 and 2.4 of this document.

Task 2.3.1 Establish harmonised multi-national framework

Description of work

This subtask will consolidate a common language (for each country in the ALDREN consortium) for the joining up of calculated performance with measured performance. This will include definition of all energy end-use categories in offices and hotels which are subject to the EVC asset rating calculation and the other parameters which determine a verified rating e.g. useful floor area, hours of use, intensity of use, annual weather conditions. The objective is to ensure a harmonised approach in different countries for the definition of input and output parameters for predictions and measurements.

• The core tool will be proposed by Verco in English, as an adaptation of a previous development;

• Each partner will provide translation of all terms into their local language.

Task 2.3.2 Develop a design for testability protocol

Description of work

This task will create a protocol to be applied during the four critical stages of a deep renovation (specifically for offices and hotels) to ensure predicted performance can be verified by measurements:

• Design: ensure coherence between simulation model, control strategy, sub-meter plan, predicted energy budgets for sub-systems and each sub-meter and the EVC EP level

• Construction: ensure coherence with design intent; revise energy budgets and EVC EP level

• Commissioning and early occupation: confirm sub-meters and controls are installed and implemented as intended

• Operation: monitor measured energy use against energy budgets for each sub-meter.

Role of participants

• The protocol will be developed and written by Verco, supported by POLIMI;

• Other partners will review

Task 2.3.3 Develop Performance Verification tool

Description of work

This task will develop a Performance Verification Excel tool with four key stages:

• Tool will record outputs from simulation model predicting absolute energy performance for sub-systems and each sub-meter under standard conditions

• After occupation, tool will record differences between actual and standard operating conditions (intensity of use, hours of use, weather) and outputs from 'calibrated' simulation model predicting absolute energy performance for subsystems and each sub-meter under actual conditions

• Tool will track actual metered energy use against budget for sub-systems and each sub-meter on a monthly basis, noting significant deviations

• Tool will use mix of measured and predicted monthly data for past and future performance respectively to track anual EP level and compare predicted and measured EP level each month.

Role of participants

• The core tool will be developed and adapted by Verco; partners involved in at least 3 pilot studies (depending on the stage of building renovation).

• IVE has broad experience in this field, due to participation in projects such as EPISCOPE

• (Task 3.1) will use the tool to track their progress at least on 3 pilot cases (depending on the stage of building renovation).

2.2. Task 2.3.1

There are two key elements of this task.

The first is to define the terms required in order to understand and present the parameters associated with the designed and measured performance of buildings.

The second is to undertake translation of these terms through the ALDREN partners. This allows translation of the Performance Verification Tool (PVT, produced in Task 2.3.3) in each partner language.

In order to avoid excessive re-working of the PVT tool's structure if changes are made during the pilot phase of the Project, the ALDREN partners agreed that the translation phase of the Project should be undertaken close to the end of the Project, once the PVT tool has been tested by the partners in English.

Verco's response to the two key elements of the deliverables is presented in the table below.

Key GA task	Work completed	Comments
Development of Core tool in English	The Performance Verification Tool (PVT), appended as Annex 1 contains the terms required for describing the actual and measured performance of buildings.	The PVT will be tested in English during the pilot phase. Following any necessary amendments, all terms in the tool will be extracted into a single document for translation.
Tranlsation by partners	The translation step of this task will be completed towards the end of the pilot phase of the ALDREN Project and included in the final release of this deliverable at Project close.	This timescale was agreed in the Project roadmap, finalised in January 2018 at the start of the project.

Table 1. Task 2.3.1 response to GA requirements

2.3. Task 2.3.2

This task requires the development and documentation of a protocol, setting out the actions a project team should take in order to validate the performance of the renovated building and ensure this performance is in keeping with the design intent. This protocol is appended to this document as an annex, and accompanied by a tracker tool, produced in Microsoft Excel fornmat, to aid project teams in tracking their progress against each action.

The protocol stages are set out in detail in Annex 1 of this document. How they address the requirements of the GA is summarised below.

Key GA task	Work completed	Comments
This task will create a protocol to be applied during the four critical stages of a deep renovation (specifically for offices and hotels) to ensure predicted performance can be verified by measurements	The ALDREN team developed a revised set of five Project stages, with reference to the 7 stage RIBA plan of work, and each protocol task is assigned to one of these stages.	This work is complete and included as an annex to this document. Some revisions may be made in response to feedback during the pilot phase of the Project.
• Design: ensure coherence between simulation model, control strategy, sub-meter plan, predicted energy budgets for sub-systems and each sub-meter and the EVC EP level	The tasks 0 to 9 in the protocol set out the actions required in order to deliver this element of the protocol.	Complete
• Construction: ensure coherence with design intent; revise energy budgets and EVC EP level	Tasks 10 to 12 in the protocol set out the tasks required across these two stages. The ALDREN stage name spanning these Project stages is “Works” Tasks 11 and 12 ensure coherence of constructed building with design intent. Task 10 requires the update of the Description of Operation to ensure the design intent is clearly stated at this stage,	Complete
• Commissioning and early occupation: confirm sub-meters and controls are installed and implemented as intended		
• Operation: monitor measured energy use against energy budgets for each sub-meter	Tasks 14 to 17 in the protocol set out the tasks required at this stage (denoted “In-use” in the ALDREN Project stages Task 14 & 17 collect & compare measured energy use at sub-system level against energy budgets Task 16 amends the energy budget to reflect the actual conditions of use for the building.	Complete

Table 2. Task 2.3.2 response to GA requirements

2.4. Task 2.3.3

Verco's response to the two key elements of the deliverable is presented in the table below.

Key GA task	Work completed	Comments/deviations from GA
• Tool will record outputs from simulation model predicting absolute energy performance for sub-systems and each sub-meter under standard conditions	Data entry fields are provided in the PVT tool at each ALDREN stage, for simulation model outputs for each sub-system in the EVC calculation. Fields are also provided to record predicted energy use for sub-systems not in the EVC calculation. This is done in case the user of the tool wishes to produce a comparison of the predicted and measured total energy use of the building.	The PVT tool collects sub-meter data aggregated to sub-system level rather than the data for individual sub-meters where a sub-system has more than one sub-meter, for the following reasons • The ALDREN protocol requires that EVC energy end uses are directly metered; offline aggregation of multiple sub-meters for any specific energy end use to a total for the end use should therefore be straighforward • Modern large commercial office and hotel buildings often have hundreds of sub-meters, so aggregating the data to totals per end use 'offline' is a more practical approach for a data collection analysis framework NB Only advanced simulation tools are equipped with sub-meter level data output. Therefore, projects taking the QUANTUM route to compliance would utilise sub-system level outputs from the software only.
• After occupation, tool will record differences between actual and standard operating conditions (intensity of use, hours of use, weather) and outputs from 'calibrated' simulation model predicting absolute energy performance for subsystems and each sub-meter under actual conditions	Tables are provided at Decision and In-use stage for entry of occupancy and weather data into the PVT tool. The simulation outputs from the EVC and advanced simulation under actual conditions are presented in the results sheets of the PVT.	Complete (see above for explanation for tracking at end-use level)

Key GA task	Work completed	Comments/deviations from GA
• Tool will track actual metered energy use against budget for sub-systems and each sub-meter on a monthly basis, noting significant deviations	The simulation outputs under standard and actual conditions are presented in the results sheets of the PVT tool, at 3 resolutions: 1. total (annual) consumption 2. end use level consumption (annual) 3. end use level consumption (monthly) Items 1 and 2 present deviations between the EVC simulation and measured data , showing absolute variance as a % value, and an indicator of the fit between measured data and the simulated data at a monthly resolution.and measured data Item 3 is presented in detail based on advanced simulation data, as sophisticated modelling is required in order to justify analysis at this resolution.	Complete (see above for explanation for tracking at end-use level)
• Tool will use mix of measured and predicted monthly data for past and future performance respectively to track anual EP level and compare predicted and measured EP level each month.	Use of predicted monthly data is described in the protocol, and this data can be input at the Works stage in the In-use sheet and overwritten month-on-month by the tool user.	Complete

Table 3. Task 2.3.3 response to GA requirements

Aims & objectives of Task 2.3

3. Aims & Objectives of Task 2.3

The content in this section of this methodology note is repeated in the appended protocol document, as it forms necessary background for future users of the ALDREN protocol.

3.1. Background to ALDREN's objectives

Around two thirds of existing buildings in the EU are expected to be still in use in 2050[2] (only 30 years from today). Many commentators assess that the EU's contribution towards the goals of the Paris Agreement can only be achieved if the energy demand from most of these buildings is drastically reduced by deep renovations.

The latest assessments of the IPCC[3] indicate that global emissions arising from the combustión of fossil fuels need to be net zero by 2050. The implication is the EU should be planning for a position in 2050 when overall net annual energy demands will be in balance with the total annual zero carbon energy supplies available[4]. With it being likely that there will be limits to the maximum amount of zero carbon energy available across the EU in 2050, it becomes necessary today to allocate the expected capacity of these supplies across the EU economy and set whole building net operational energy intensity targets (kWh/m^2/year) for different building types, according to their need. This can then indicate the net operational energy reduction trajectory every building must aim for if the zero carbon ambition is to be achieved.

Recital 16 of the Energy Efficiency Directive (EED 2012/27/EU) defines 'deep renovations' in a very broad way, as "renovations which lead to a refurbishment that reduces both the delivered and the final energy consumption of a building by a significant percentage compared with the pre-renovation levels leading to a very high [efficient] energy performance". EuroACE believes that only around 15% of current building renovations incorporate any energy efficiency improvements, let alone a deep renovation[5].

The aim of ALDREN is to establish the business case for deep renovation in non-residential buildings with a focus on offices and hotels. The 30 month programme which started in November 2017 intends to encourage investment and accelerate the movement towards a 'nearly zero energy' non-residential building stock across the EU, consistent with the EED, the Paris Agreement commitments and the IPCC's recommended net zero carbon target by 2050.

A key attribute of the approach to be adopted by ALDREN is the idea of energy performance verification. This means that the energy performance intended (i.e. claimed and predicted) at the design stage of a deep renovation will be verified by measurements during the first year of full occupancy. This protocol identifies the necessary actions across the five critical stages of a deep renovation (decision, design, construction, commissioning and early operation) to ensure that performance outcomes do achieve the design intent.

3.2. Recognising the gap between calculated and actual energy performance

ALDREN addresses the operational energy performance of commercial office buildings and hotels subject to deep renovation. It focuses on the energy used for whole building heating, ventilation and air-conditioning (HVAC) but also hot water and lighting (all these collectively known as "regulated loads" and part of the EVC calculation). When a building undergoes a deep renovation, the operational energy performance for regulated loads can largely be secured by the developer with support from supply side stakeholders (designers and contractors and building and facilities managers). Because the operational performance of regulated loads represents the intrinsic energy efficiency of the property asset, it is also a metric of interest to investors targeting lower carbon office and hotel buildings for their portfolios and, notably, to potential tenants seeking to occupy or operate an efficient building.

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[2] European Parliament Energy efficiency of buildings A nearly zero energy future? May 2016
[3] https://www.ipcc.ch/sr15/
[4] As proposed by the Dutch GBC in NL: https://parisproof.nl/wat-is-je-energieverbruik.
[5] Adrian Joyce, Secretary General, EuroACE, presentation to ALDREN partners meeting, Brussels, 10 April 2018

Evidence from the Australian commercial office market shows a focus on performance outcomes, supported by a scheme to measure, rate and disclose the operational energy efficiency of the regulated loads (NABERS[6]), has been transformational in improving the energy performance of existing commercial real estate assets in the market. Over the ten year period from 2006 to 2016, the average NABERS rating (on a consumer-friendly 1 to 6 star scale[7]) has improved from 2.7 to 4.2 stars, representing a 41% reduction in energy intensity for the whole of the rated stock, which climbed to 16 million m^2 of commercial office floor space, around 75% of the overall market for tenancies over 2,000 m^2 (see Figure 1).

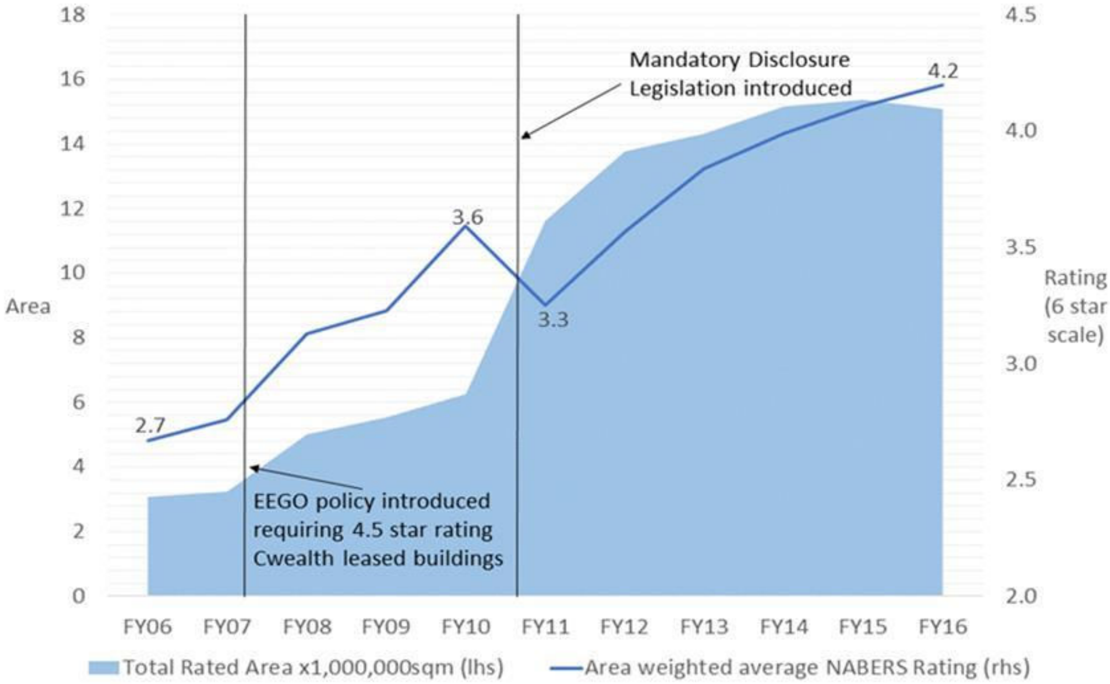


Figure 1: Rated commercial office floor area and improvement in stock average base building energy rating from 2006 to 2016 [Source: NABERS, OEH]

The NABERS base building energy rating has become a KPI influencing investment decisions for existing and new buildings, sales and purchases, largely because it is perceived as a surrogate marker of building quality: a building with a better rating is a building that is demonstrably better designed, better constructed, better commissioned and better operated and maintained. Buildings with better ratings on average enjoy lower vacancy rates, increased rents and enhanced asset values[8].

Given these financial impacts of energy performance on their core business, developers for deep renovations of commercial office buildings in Australia signed up to ‘Commitment Agreements’, a process which involves a target energy performance outcome being specified from the very beginning of the renovation process, a relentless focus on energy performance throughout the design, construction and early operation phases and a commitment to verify the base building operational energy performance after a year of full occupation. Commitment

[6] National Australian Built Environment Rating System

[7] The scale has eleven points, with half stars between the whole stars, and official ratings are rounded down to the nearest half star. The scale was calibrated in 1999 to place average performance then at 2.5 stars on what was a 5 star scale. In 2011, a 6 stars level was added, defined as half-way from 5 stars to net zero. The market is informed that the plain English meaning of each Star level is: 1=Poor, 2=Below average, 3=Average, 4=Good, 5=Excellent, 6=Market leading.

[8] http://cbd.gov.au/sites/prod.cbd/files/NABERS-energy-office-market-analysis-june-2013.pdf

Agreements were conceived to ensure new and renovated offices could operate at their target energy performance levels, compete with rated existing buildings using the same metric and empower occupiers to sign up to pre-lets for space with the in-use energy performance and cost of occupancy they want.

The current approach in the EU to securing the energy efficiency of offices and hotels subject to deep renovation contrasts starkly with Australia's: buildings are required to meet only theoretical energy performance targets. As a result, designers' energy conservation endeavours focus on design and technology that improve predicted building performance, rather than directly measureable improvements in actual performance: a 'design for compliance' culture prevails.

A direct consequence is the existence of a well-documented and large 'Performance Gap'[9] [10]. The empirical evidence shown in Figure 2 illustrates the extent to which there is no correlation between a building's energy intensity (as measured by the utility meters) and its Energy Performance Certificate (EPC) grade. This has resulted in the market distrusting the EPC as an indicator of energy efficiency.

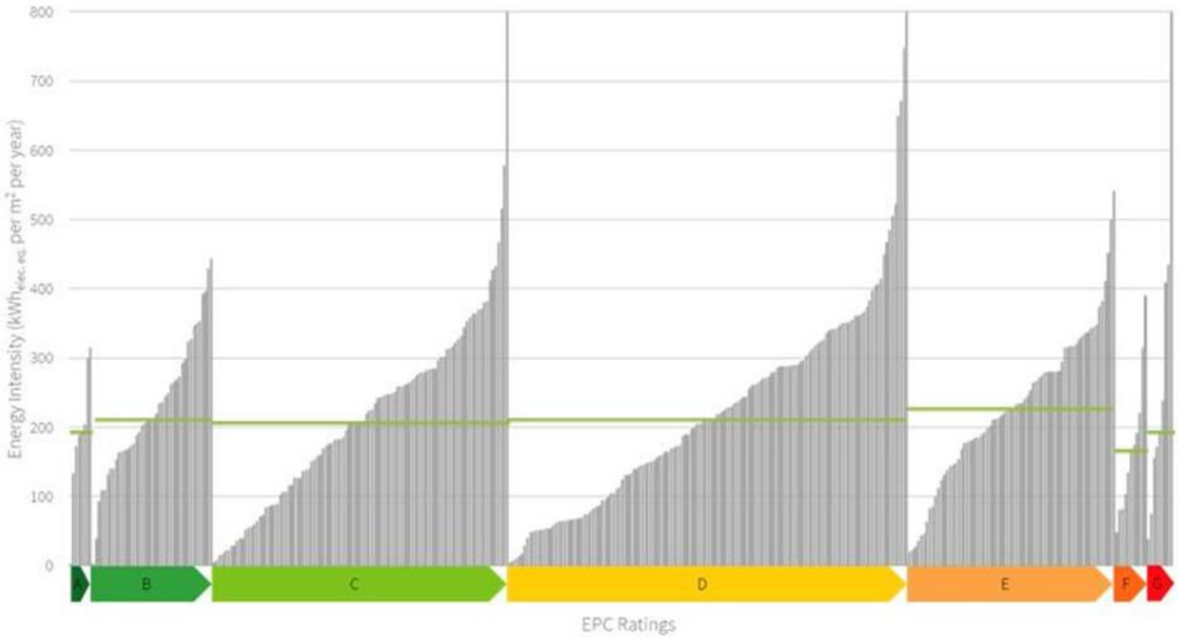


Figure 2: Measured whole building energy intensity does not correlate with EPC grade

3.3. Overview of the ALDREN protocol for addressing the energy performance gap

Design Stage:

- Set and contractually formalise a measurable performance outcome: this increases the level of scrutiny given to building services design throughout the entire delivery of the project and by the whole supply chain. Focus the target on the energy used for the regulated loads to ensure accountability for energy performance.
- Where possible, start with a detailed simulation model of the existing building and calibrate its predictions of energy performance by comparison with measured data
- Agree list of building improvements (fabric, plant, controls) and assess them using the calibrated model
- Ensure coherence between the simulation model, control strategy, sub-meter plan, predicted energy budgets for sub-systems and each sub-meter and the EVC target EP level

9 http://www.greenconstructionboard.org/index.php/performancegap
10 https://www.ukgbc.org/wp-content/uploads/2017/09/UK-GBC-Task-Group-Report-Delivering-Building-Performance.pdf

Construction (works):

- Ensure coherence of the as-built renovation with design intent and simulation model
- Ensure target EVC EP level is not undermined by any changes to design

Commissioning and early occupation:

- Align the description of operations with the as-constructed building and its HVAC systems and their controls.
- Confirm sub-meters are installed, implemented and operate according to the verification plan
- Fine tune the BMS controls to align with the description of operations. If using advanced simulation, the description of operations should also align with the control strategy built into the model (digital twin). If following the QUANTUM approach, deploy the QUANTUM performance test bench to verify alignment of HVAC controls with design intent (articulated in the description of operations).

Operation:

- Monitor monthly measured energy use against energy budgets for each sub-meter, as predicted by the advanced simulation. If following the QUANTUM approach, set sub-system budgets using the EVC calculation under actual conditions. Identify explanations for deviations from design intent and take remedial actions where appropriate.

3.4. Integration of ALDREN protocol activities in the design & construction process

In order to achieve the aims of the ALDREN Verified Energy Perfomance Protocol, it is essential that all stakeholders are aware of, and commit to, their contributions to each task throughout the design, construction and operation of the building.

Embedding the ALDREN tasks in the design process from the concept stage, and obtaining commitment from stakeholders at the outset of the project is the first step towards this goal. Table below sets out the relationship between the stages of the ALDREN protocol and the RIBA (Royal Institute of British Architects) Plan of Work.

RIBA stage #	RIBA Plan of Work stage	ALDREN master stage
0	Strategic Definition	Decision (set requirements)
1	Preparation and Brief	
2	Concept Design	Develop Design
3	Developed Design	
4	Technical Design	Detailed design
5	Construction	Works
6	Handover and Close Out	
7	In Use	In use

Table 4: Alignment between ALDREN and RIBA stages

The ALDREN Verified Energy Perfomance Protocol seeks to integrate existing industry best practices in building design, commissioning and performance verification. Throughout this document, references to existing published materials are provided where these provide additional insight and detail that may assist design teams when implementing the protocol stages.

In recognition of the cost restrictions that apply to any construction project, the ALDREN Verified Energy Perfomance protocol offers stakeholders options to customise the process to their needs. These are:

A. A choice between two methodological approaches:

1. The first adopts advanced building simulation techniques commonly used in Australia to predict the performance of the building accurately and support verification in operation. This approach is especially suited to larger prime office buildings, and is being introduced in the UK through the Design for Performance initiative[11].
2. The second route adopts the process developed in the European Commission funded project QUANTUM[12]. This project has developed a structured approach to specifying a building's description of operations during the design stage, and embedding robust checks in the commissioning process to ensure that this has been delivered.

B. Mandatory and optional elements.

a. Mandatory elements of the procedure must be completed in order to meet the requirements of the ALDREN Verified energy performance protocol

b. Optional elements are highly reccomended activities which will help to reduce the variation between the building's predicted and actual performance.

When considering the route to ALDREN compliance a project should take, it should be noted that while the costs of the Advanced Simulation route can be significant, the model that is produced is a very powerful design tool.

The cost of Advanced Sumulation is variable depending on building size, usage and building complexity. The investment should be considered against the difference between a "typical" new building and one that meets a good standard through implementation of the process. In the UK, for a new build office, that difference would equate to approximately 60kWh/m^2 per year of electricity use. For a building of 10,000m^2 floor area the expected annual cost saving would be £60,000[13], every year. Thus the annual reductions in energy use justify the cost of the process (which could be £20,000-£100,000 in the UK cost depending on the building size and complexity). A 1 year return on investment during the in-use stage of the building would be a reasonable expectation. In many cases the outputs of the advanced simulation also permits plant sizing to be reduced which results in a further capital cost saving for the building during the construction phase.

3.5. Performance Verification Protocol

The Performance Verification protocol is provided as a stand-alone annex to this document. This allows the protocol to be used directly in the application of the ALDREN procedure.

3.6. Protocol tracking tool (PTT)

As an accompaniment to this document, a protocol tracking tool (PTT) is provided in Microsoft Excel ® format. The PTT workbook sets out a summary of the tasks included in each stage of the protocol and enables Project managers to document how they have undertaken and completed each task, thereby providing a check list and audit trail.

3.7. Performance Verification Tool (PVT)

Certain stages of the protocol generate data (e.g. floor area, energy consumption) which should be entered into the ALDREN Performance Verification Tool (referred to hereafter as the PVT).

[11] http://www.betterbuildingspartnership.co.uk/pioneering-developers-adopt-radical-approach-energy-performance
[12] https://www.quantum-project.eu/about-us/
[13] Based on an electricity price of 10 pence per kWh, typical in 2018.

This Microsoft Excel ® tool collects predicted and measured energy performance data and collates it at different levels of granularity for the building Passport across the various retrofit stages and allows the user to track the building’s energy performance after the retrofit against the performance targets set at inception. Outputs from the tool may also help the design team to identify and rectify problems with the buidling’s operation in the early stages of occupation.

Where data should be entered into the tool, this is identified in the relevant protocol stages detailed in the next sections.

Summary of protocol steps

4. Summary of protocol steps

The table below lists the tasks included in the ALDREN protocol, split according to the ALDREN master stage. Full details of each task are presented in the protocol annex.

Master stage	Task #	Mandatory / Optional?	ALDREN Protocol task
Decision (Set Requirements)	0	Mandatory	Obtain commitment from stakeholders to participate in ALDRENprocess
	1	Mandatory	Building simulation: asset rating and predicted energy use under actual conditions (LENS A, B)
	2	Optional	Energy audit of existing building (LENS C)
Develop Design	3	Mandatory	Calibration of model for existing building to match measured performance
	4	Mandatory	Agree list of building improvements (fabric, plant, controls)
	5	Mandatory	Calculation at Design Stage of asset rating for renovated building under standard conditions (LENS D)
	6a	Choose either/ both 6a or 6b	Dynamic modelling to simulate design of building and HVAC system (LENS D)
	6b	Choose either/ both 6a or 6b	Agree data points to be tested by QUANTUM performance test bench and ensure measurability (creation of DesOps)
	7	Mandatory	Set base building operational performance target for building and include in contractual documentation
	8	Mandatory	Independent design review to confirm design and modelling are robust (or review efficiency of QUANTUM proposals)
Detailed Design	9a	Choose either / both 9a or 9b	Final design including validation plan (meter layout and targets) and preliminary DesOps
	9b	Choose either / both 9a or 9b	Design application of QUANTUM testbench
Works	10	Mandatory	Revision of DesOps during construction phase
	11	Mandatory	Defend rating against value engineering
	12a	Choose either / both 12a or 12b	Handover, commissioning and early operation intensive fine tuning – DesOps finalised
	12b	Choose either / both 12a or 12b	Handover, commissioning and application of QUANTUM testbench – DesOps finalised
	13	Mandatory	Calculation after completion of asset rating for renovated building under standard conditions (LENS E)
In use	14	Mandatory	Track metered performance against predicted performance under actual conditions
	15	Mandatory	Diagnose and implement improvements (LENS G)
	16a	Choose either / both 12a or 12b	Advanced simulation of predicted performance after year of operation under actual conditions (LENS F)
	16b	Choose either / both 12a or 12b	Prediction of energy performance after year of operation under actual conditions (QUANTUM route)
	17	Mandatory	Compare measured energy against calculations at various resolutions((LENS F vs LENS G)

Table 5: ALDREN Protocol task summary

Anticipated changes before Project close

5. Anticipated changes to this methodology before Project close

5.1. Task 2.3.1

In order to deliver the scope of works set out in the GA for task 2.3.1 the following actions will be taken during months 19-28 of the project:

- Simplification of the headings & text in the Performance Verification Tool into a list of the necessary words/terms and definitions of terms for translation by partners
- Translation by partners

5.2. Task 2.3.2

While no material changes are expected to the fundamental tasks or activities required in the protocol presented here, some amendments to the guidance and supporting information are expected in response to feedback from the pilot process of the ALDREN project.

5.3. Task 2.3.3

While no material changes are expected to the fundamental functionalities of the performance Verification Tool, feedback from the pilot process will be taken into account in the final version.

Furthermore, the necessary architecture for the translation function of the tool to operate (using the translations from task 2.3.1) will be introduced to the PVT during the later stages of the pilot phase, once initial feedback on the English version has been taken into consideration. This avoids excessive rework and minimises the burden on ALDREN partners by ensuring that only a single translation process is required.

Outcomes of Task 2.3

6. Outcomes of Task 2.3

6.1. Overall outcome

The ALDREN methodology and tools presented in this document set out how nearly zero energy performance targets can become measured outcomes, where driven by client leadership and wider team buy-in, and using the power of advanced simulation of HVAC systems, or other advanced design and verification tools, to optimise design and ensure operation is aligned with the design intent.

6.2. Benefits of the ALDREN approach

The ALDREN methodology offers extensive benefits and additional insights at all stages of the design, construction and operation of a building. It has been specifically designed to address the known shortcomings of the predominant approach to the design and delivery of deep renovation building projects in the EU.

1. Setting a target for operational performance at early design stage, and incorporating this into contractual documents, ensures that all stakeholders bear the responsibility for the building's performance in-use. This also sets out a clear view of what needs to be metered discretely in order to verify the actual energy performance of the renovated building.
2. By shifting the focus of the design process away from compliance calculations and onto measured performance, the performance gap is made clear to the design team. Any deviations from design intent are quantified and will be investigated, generating valuable insights for future projects.
3. Embedding the advanced simulation approach into the ALDREN methodology drives development of these skills within the EU, unlocking the potential for accurate predictions of in-use performance of buildings, and allowing design teams to realise the full potential of simulation as a design tool.
4. The additional focus on the description of operations throughout the design, construction, commissioning and early operation stages tackles one of the most common failure points in the delivery of building projects – the failure to ensure that the design intent is defined in sufficient detail and understood by the commissioning engineers and the building users.
5. By including the measured performance of the building in the EVC+ the real world perfomance of the building is visible to the owners, operators and occupants of the building and allows a direct comparison of the true environmental impact of one building against another.

By following the tasks set out in this methodology, the end result will be a better quality building, with proven energy performance and an evidence pack demonstrating how best practice design principles have been applied to deliver a building that delivers a comfortable, productive environment as efficiently as possible.

Annexes to this Document

7. List of Annexes

The three annexes appended to this document are detailed in the table below:

Annnex no.	Annex	File name and type	Description
1	ALDREN Performance Verification Protocol	ALDREN Performance Verification Protocol v1.5.pdf PDF document	This document details the performance verification protocol and introduces the two annexes provided as tools in Microsoft Excel format
2	ALDREN Protocol Tracking Tool	ALDREN Verification Protocol Tracking Tool v1.5.xlsx Microsoft Excel workbook	This tool allows the tracking and recording of actions taken at each stage of the ALDREN performance verification protocol.
3	ALDREN Performance Verification Tool	ALDREN Performance Verification Tool v3.0.xlsx Microsoft Excel workbook	This tool is used to record and analyse performance data from each stage of the ALDREN protocol.

Table 6: Details of Annexes

ALDREN Performance Verification Protocol – addressing the gap between calculated and actual energy performance

ALDREN ALliance for Deep RENovation in buildings

Implementing the European Common Voluntary Certification Scheme, as back-bone along the whole deep renovation process

Contents

Table Index

Figure Index

1. Introduction

1.1. Background to ALDREN's objectives

Around two thirds of existing buildings in the EU are expected to be still in use in 2050[1] (only 30 years from today). Many commentators assess that the EU's contribution towards the goals of the Paris Agreement can only be achieved if the energy demand from most of these buildings is drastically reduced by deep renovations.

The latest assessments of the IPCC[2] indicate that global emissions arising from the combustión of fossil fuels need to be net zero by 2050. The implication is the EU should be planning for a position in 2050 when overall net annual energy demands will be in balance with the total annual zero carbon energy supplies available[3]. With it being likely that there will be limits to the maximum amount of zero carbon energy available across the EU in 2050, it becomes necessary today to allocate the expected capacity of these supplies across the EU economy and set whole building net operational energy intensity targets (kWh/m^2/year) for different building types, according to their need. This can then indicate the net operational energy reduction trajectory every building must aim for if the zero carbon ambition is to be achieved.

Recital 16 of the Energy Efficiency Directive (EED 2012/27/EU) defines 'deep renovations' in a very broad way, as "renovations which lead to a refurbishment that reduces both the delivered and the final energy consumption of a building by a significant percentage compared with the pre-renovation levels leading to a very high [efficient] energy performance". EuroACE believes that only around 15% of current building renovations incorporate any energy efficiency improvements, let alone a deep renovation[4].

The aim of ALDREN is to establish the business case for deep renovation in non-residential buildings with a focus on offices and hotels. The 30 month programme which started in November 2017 intends to encourage investment and accelerate the movement towards a 'nearly zero energy' non-residential building stock across the EU, consistent with the EED, the Paris Agreement commitments and the IPCC's recommended net zero carbon target by 2050.

A key attribute of the approach to be adopted by ALDREN is the idea of energy performance verification. This means that the energy performance intended (i.e. claimed and predicted) at the design stage of a deep renovation will be verified by measurements during the first year of full occupancy. This protocol identifies the necessary actions across the five critical stages of a deep renovation (decision, design, construction, commissioning and early operation) to ensure that performance outcomes do achieve the design intent.

1.2. Recognising the gap between calculated and actual energy performance

ALDREN addresses the operational energy performance of commercial office buildings and hotels subject to deep renovation. It focuses on the energy used for whole building heating, ventilation and air-conditioning (HVAC) but also hot water and lighting (all these collectively known as "regulated loads" and part of the EVC calculation). When a building undergoes a deep renovation, the operational energy performance for regulated loads can largely be secured by the developer with support from supply side stakeholders (designers and contractors and building and facilities managers). Because the operational performance of regulated loads represents the intrinsic energy efficiency of the property asset, it is also a metric of interest to investors targeting lower carbon office and hotel buildings for their portfolios and, notably, to potential tenants seeking to occupy or operate an efficient building.

[1] European Parliament Energy efficiency of buildings A nearly zero energy future? May 2016
[2] https://www.ipcc.ch/sr15/
[3] As proposed by the Dutch GBC in NL: https://parisproof.nl/wat-is-je-energieverbruik.
[4] Adrian Joyce, Secretary General, EuroACE, presentation to ALDREN partners meeting, Brussels, 10 April 2018

Evidence from the Australian commercial office market shows a focus on performance outcomes, supported by a scheme to measure, rate and disclose the operational energy efficiency of the regulated loads (NABERS[5]), has been transformational in improving the energy performance of existing commercial real estate assets in the market. Over the ten year period from 2006 to 2016, the average NABERS rating (on a consumer-friendly 1 to 6 star scale[6]) has improved from 2.7 to 4.2 stars, representing a 41% reduction in energy intensity for the whole of the rated stock, which climbed to 16 million m^2 of commercial office floor space, around 75% of the overall market for tenancies over 2,000 m^2 (see Figure 1).

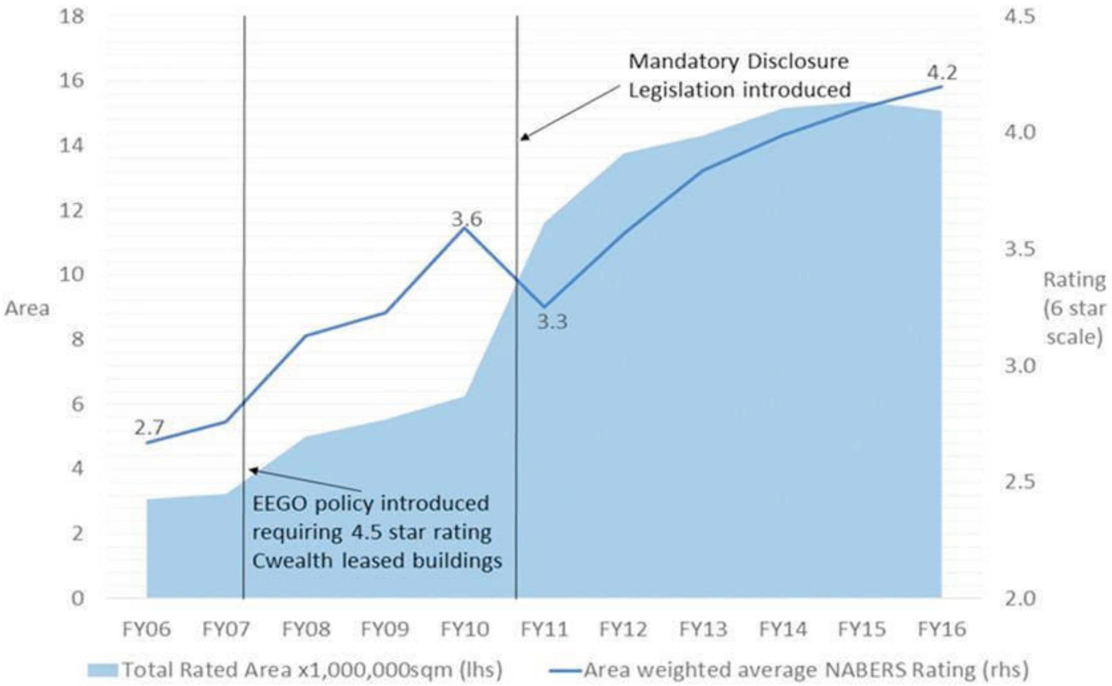


Figure 1: Rated commercial office floor area and improvement in stock average base building energy rating from 2006 to 2016 [Source: NABERS, OEH]

The NABERS base building energy rating has become a KPI influencing investment decisions for existing and new buildings, sales and purchases, largely because it is perceived as a surrogate marker of building quality: a building with a better rating is a building that is demonstrably better designed, better constructed, better commissioned and better operated and maintained. Buildings with better ratings on average enjoy lower vacancy rates, increased rents and enhanced asset values[7].

Given these financial impacts of energy performance on their core business, developers for deep renovations of commercial office buildings in Australia signed up to 'Commitment Agreements', a process which involves a target energy performance outcome being specified from the very beginning of the renovation process, a relentless focus on energy performance throughout the design, construction and early operation phases and a commitment to verify the base building operational energy performance after a year of full occupation. Commitment Agreements were conceived to ensure new and renovated offices could operate at their target

[5] National Australian Built Environment Rating System

[6] The scale has eleven points, with half stars between the whole stars, and official ratings are rounded down to the nearest half star. The scale was calibrated in 1999 to place average performance then at 2.5 stars on what was a 5 star scale. In 2011, a 6 stars level was added, defined as half-way from 5 stars to net zero. The market is informed that the plain English meaning of each Star level is: 1=Poor, 2=Below average, 3=Average, 4=Good, 5=Excellent, 6=Market leading.

[7] http://cbd.gov.au/sites/prod.cbd/files/NABERS-energy-office-market-analysis-june-2013.pdf

energy performance levels, compete with rated existing buildings using the same metric and empower occupiers to sign up to pre-lets for space with the in-use energy performance and cost of occupancy they want.

The current approach in the EU to securing the energy efficiency of offices and hotels subject to deep renovation contrasts starkly with Australia's: buildings are required to meet only theoretical energy performance targets. As a result, designers' energy conservation endeavours focus on design and technology that improve predicted building performance, rather than directly measureable improvements in actual performance: a 'design for compliance' culture prevails.

A direct consequence is the existence of a well-documented and large 'Performance Gap'[8] [9]. The empirical evidence shown in Figure 2 illustrates the extent to which there is no correlation between a building's energy intensity (as measured by the utility meters) and its Energy Performance Certificate (EPC) grade. This has resulted in the market distrusting the EPC as an indicator of energy efficiency.

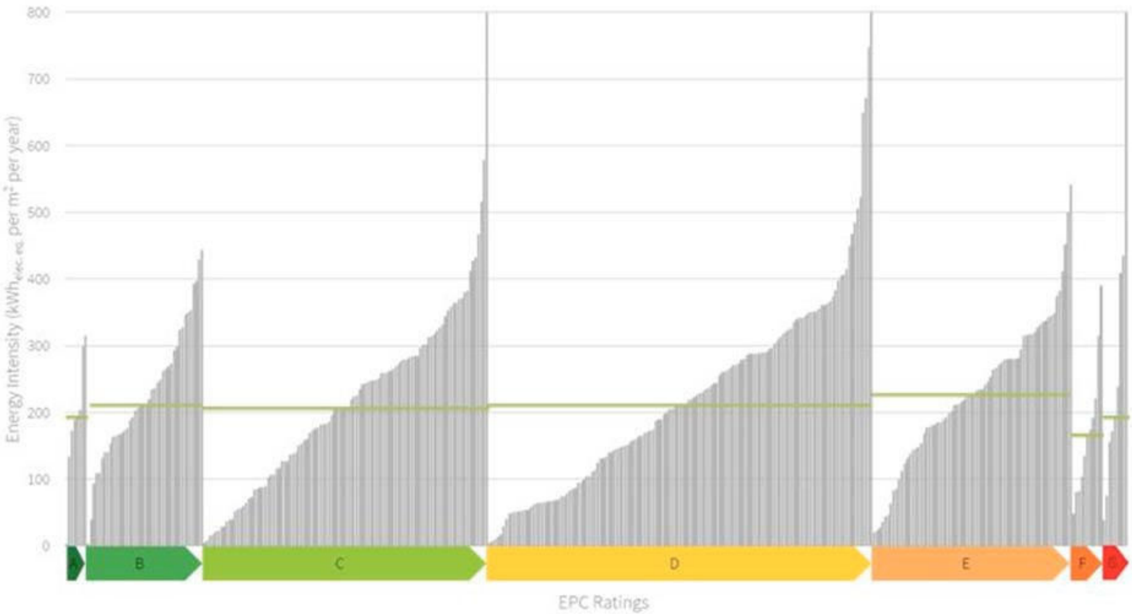


Figure 2: Measured whole building energy intensity does not correlate with EPC grade

1.3. Overview of the ALDREN protocol for addressing the energy performance gap

Design Stage:

- Set and contractually formalise a measurable performance outcome: this increases the level of scrutiny given to building services design throughout the entire delivery of the project and by the whole supply chain. Focus the target on the energy used for the regulated loads to ensure accountability for energy performance.
- Where possible, start with a good quality simulation model of the existing building and calibrate its predictions of energy performance by comparison with measured data
- Agree list of building improvements (fabric, plant, controls) and assess them using the calibrated model
- Ensure coherence between the simulation model, control strategy, sub-meter plan, predicted energy budgets for sub-systems and each sub-meter and the EVC target EP level

[8] http://www.greenconstructionboard.org/index.php/performancegap
[9] https://www.ukgbc.org/wp-content/uploads/2017/09/UK-GBC-Task-Group-Report-Delivering-Building-Performance.pdf

Construction (works):

- Ensure coherence of the as-built renovation with design intent and simulation model
- Ensure target EVC EP level is not undermined by any changes to design

Commissioning and early occupation:

- Align the description of operations with the as-constructed building and its HVAC systems and their controls.
- Confirm sub-meters are installed, implemented and operate according to the verification plan
- Fine tune the BMS controls to align with the description of operations. If using advanced simulation, the description of operations should also align with the control strategy built into the model (digital twin). If following the QUANTUM approach, deploy the QUANTUM performance test bench to verify alignment of HVAC controls with design intent (articulated in the description of operations).

Operation:

- Monitor monthly measured energy use against energy budgets for each sub-meter, as predicted by the advanced simulation. If following the QUANTUM approach, set sub-system budgets using the EVC calculation under actual conditions. Identify explanations for deviations from design intent and take remedial actions where appropriate.

1.4. Integration of ALDREN protocol activities in the design & construction process

In order to achieve the aims of the ALDREN Verified Energy Perfomance Protocol, it is essential that all stakeholders are aware of, and commit to, their contributions to each task throughout the design, construction and operation of the building.

Embedding the ALDREN tasks in the design process from the concept stage, and obtaining commitment from stakeholders at the outset of the project is the first step towards this goal. Table 1: Alignment between ALDREN and RIBA stages

below sets out the relationship between the stages of the ALDREN protocol and the RIBA (Royal Institute of British Architects) Plan of Work.

RIBA stage #	RIBA Plan of Work stage	ALDREN master stage
0	Strategic Definition	Decision (set requirements)
1	Preparation and Brief	
2	Concept Design	Develop Design
3	Developed Design	
4	Technical Design	Detailed design
5	Construction	Works
6	Handover and Close Out	
7	In Use	In use

Table 1: Alignment between ALDREN and RIBA stages

The ALDREN Verified Energy Perfomance Protocol seeks to integrate existing industry best practices in building design, commissioning and performance verification. Throughout this document, references to existing published materials are provided where these provide additional insight and detail that may assist design teams when implementing the protocol stages.

In recognition of the cost restrictions that apply to any construction project, the ALDREN Verified Energy Perfomance protocol offers stakeholders options to customise the process to their needs. These are:

A. A choice between two methodological approaches:

1. **Advanced Simulation route**[10]: this route adopts advanced building simulation techniques commonly used in Australia to predict the performance of the building accurately and support verification in operation. This approach is especially suited to larger prime office buildings, and is being introduced in the UK through the Design for Performance initiative[11].
2. **QUANTUM route**: adopts the process developed in the European Commission funded project QUANTUM[12]. This project has developed a structured approach to specifying a building's description of operations during the design stage, and embedding robust checks in the commissioning process to ensure that this has been delivered. This route does not require advanced simulation to be undertaken and may be more suitable for smaller buildings.

B. Mandatory and optional elements.

a. Mandatory elements of the procedure must be completed in order to meet the requirements of the ALDREN Verified energy performance protocol
b. Optional elements are highly reccomended activities which will help to reduce the variation between the building's predicted and actual performance.

When considering the route to ALDREN compliance a project should take, it should be noted that while the costs of the Advanced Simulation route can be significant, the model that is produced is a very powerful design tool.

The cost of Advanced Sumulation is variable depending on building size, usage and building complexity. The investment should be considered against the difference between a "typical" new building and one that meets a good standard through implementation of the process. In the UK, for a new build office, that difference would equate to c. 60kWh/m^2 per year of electricity use. For a 10,000m2 building the expected annual cost saving would be £60,000[13], every year. This the annual reductions in energy use justify the cost of the process (which could be £20,000-£100,000 in the UK cost depending on the building size and complexity). A 1 year return on investment during the in-use stage of the building would be a reasonable expectation. In many cases the outputs of the advanced simulation also permits plant sizing to be reduced which results in a capital cost saving for the building during the construction phase.

1.1. Protocol tracking tool (PTT)

As an accompaniment to this document, a protocol tracking tool (PTT) is provided in Microsoft Excel ® format. The PTT workbook sets out a summary of the tasks included in each stage of the protocol and enables Project managers to document how they have undertaken and completed each task, thereby providing a check list and audit trail.

[10] Refer to Appendix B for more detail on different simulation approaches utilised in the ALDREN procedure
[11] http://www.betterbuildingspartnership.co.uk/pioneering-developers-adopt-radical-approach-energy-performance
[12] https://www.quantum-project.eu/about-us/
[13] Based on an electricity price of 10 pence per kWh, typical in 2018.

1.2. Performance Verification Tool (PVT)

Certain stages of the protocol generate data (e.g. floor area, energy consumption) which should be entered into the ALDREN Performance Verification Tool (referred to hereafter as the PVT).

This Microsoft Excel ® tool collects predicted and measured energy performance data and collates it at different levels of granularity for the building Passport across the various retrofit stages and allows the user to track the building's energy performance after the retrofit against the performance targets set at inception. Outputs from the tool may also help the design team to identify and rectify problems with the buidling's operation in the early stages of occupation.

Where data should be entered into the tool, this is identified in the relevant protocol stages detailed in the next sections.

Using the protocol tracking tool

2. Using the protocol tracking tool

2.1. Basic principles

The protocol tracking tool is intended as guidance to ensure that the energy performance of the building is properly considered at each stage of the building's renovation. It is a reference tool to ensure that key processes are followed, the correct stakeholers are involved in each step, and that progress is tracked during each ALDREN stage. As mentioned in section •, some sections are mandatory and others are optional. The tool should be used to track progress using the completion notes section for each task.

The tasks within each ALDREN stage (e.g. Decision, Develop design) are not presented in a sequential order and in practice are likely to be undertaken in parallel with each other (e.g. the simulation modelling described in Task 1 is not required to be undertaken before the energy audit in Task 2 – indeed data from the audit would inform the modelling work).

The tool can be navigated using the navigation bar at the top of each page. The "ALDREN intervention points" worksheet can also be used for navigation and shows how the tool maps onto the so-called lens diagram[14], a higher level description of the key stages during a renovation where processes need to be followed in order to understand and minimise the gap between the designed and in use energy performance. Each box of the lens diagram is hyperlinked to the precise tasks in the protocol that are relevant to that particular lens.

Additionally, the tool can be navigated using the hyperlinks in the "Task Index" worksheet that provides a more granular level of navigation to a description of each individual task.

More detail and supporting guidance can be found in Section 3.

[14] The renovation project is looked at through various "lenses" depending on which stage of the project the building has reached.

Protocol description by stage

3. Protocol description by stage

3.1. Introduction

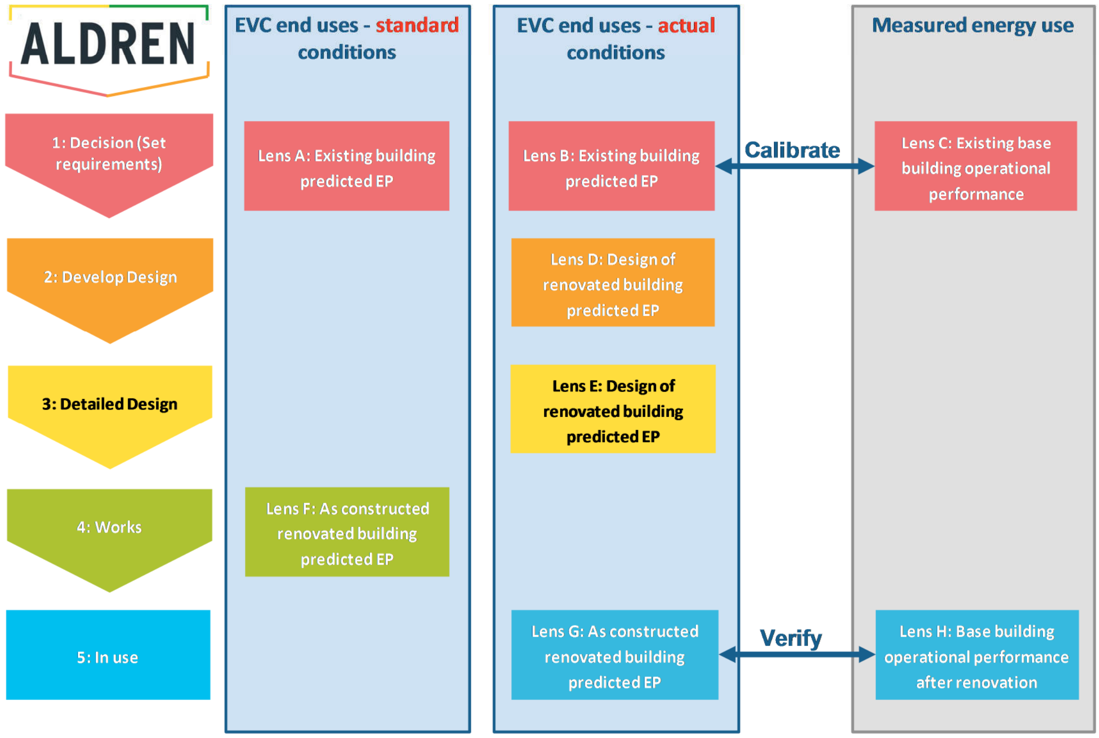


Figure 3: Overview of simulations undertaken at different ALDREN stages in order to validate the EVC calculation.

This section provides additional detail describing each of the tasks outlined in the Protocol Tracking Tool (PTT). It also identifies what data should be input into the Performance Verification Tool (PVT) at different stages of the protocol.

It is of note that where wider methodologies are referenced in the text e.g. QUANTUM, these are not explained in detail here, and that it is the responsibility of the user to investigate the workings of these individual methodologies further by referring to the published material detailing these methodologies.

The PTT Excel tool is intended to be controlled and populated by the building renovation project manager or someone delegated by them, and regularly consulted at each of the ALDREN stages.

3.2. Decision (set requirements)

Stage overview

Early engagement with stakeholders at project inception is critical in order to develop meaningful, achievable renovation targets which can be embedded as success criteria for the project.

At inception & briefing stage, the primary aim of the protocol activities is to obtain commitment to achieving a targeted energy performance from stakeholders participating in the project, then to develop a detailed understanding of the existing building's energy performance prior to the retrofit, using simulation modelling but also collecting measured (metered) data.

3.2.1. **Task 0: Obtain commitment**

Key stakeholders should be made aware of the ALDREN process including the benefits offered by the approach, as well as the time commitment required to carry out the protocol stages. Ideally a face to face meeting would be arranged for this discussion, in order that any queries and concerns can be raised and answered at the outset. The importance of setting (and validating) a target for the building's **measured** energy performance should be stressed at this stage, as this is likely to be an unfamiliar process for some stakeholders.

Wherever possible, written commitment should be obtained at project outset. If stakeholders are not yet appointed at project start, they should be briefed on the ALDREN process and commitment confirmed when they join the project.

Reference information:

- *E.g. ALDREN overview presentation pack or similar*

3.2.2. **Task 1: Building simulation: asset rating and predicted energy use under actual conditions**

EU CEN calculation tools:

- Must calculate at an hourly (or smaller) timestep
- Must enable discrete calculation of each of the CEN end uses
- Packages such as CYPETHERM COMETH, EDSL TAS and IES are compliant tools.

In this task, two key pre-retrofit simulations are undertaken. These calculations are also required for the production of the EVC under the "Energy Rating and Targets" section of the ALDREN approach.

The first is the calculation of the existing building's EVC asset rating (lens A), using a dynamic simulation software package consistent with the EU CEN method (see inset). Existing software and calculations used to produce EPC certificates may meet these criteria in many EU countries. This calculation is used elsewhere within the ALDREN process and feeds into the building's renovation Passport. This simulation model uses standard assumptions for the model's boundary conditions (weather, occupancy, hours of use etc) in line with the calculation methodology of the EVC.. The results of this calculation are not used directly for verification of the EVC, but it is expected that this model will be used as the basis for the next calculation. End use level energy consumption for space heating, space cooling, fans (ventilation), pumps, controls and lighting can be taken from this calculation and entered in the PVT in Table 4 for reference. Whole building consumption can be entered in Table 2.

The second calculation is the simulation of existing building's EVC energy consumption under the actual boundary conditions for a 1 year time period. The time period used should align with the available data from the Energy Audit (task 2). This simulation produces a more realistic prediction of the building's energy consumption, by applying the observed boundary conditions to the simulation (e.g. a local weather file, the hours of use of the spaces, etc – see Appendix B for further detail on simulation approach). The results of this calculation are likely to differ significantly from the asset rating calculation if the actual conditions of use are different to the standard assumptions used in the asset rating, and would be expected to give a result closer to the measured performance of the building. This calculation provides a starting point for the model calibration processes described in Stage 2, Task 3 which improves the quality of the model to permit confident design decisions.

The data produced in the simulation under actual conditions is entered into the PVT in Table 3 and 5 of the PVT (mandatory). The results of this calculation feed the analysis presented in Tables 8 and 9 of the PVT's Decision stage results.

Reference information:

- *Simulation guidelines (Appendix B)*
- *CEN calculation method within ALDREN – Reference to be added*

3.2.3. Task 2: Energy audit of existing building

This task collects data describing the measured energy performance of the building. Energy data from the existing building covering a period of at least 1 year should be collected (where possible). Data should be based on actual meter readings (not energy supplier estimates).

Where available, data from both utility meters and sub-meters should be collected for all energy carriers used by the building (electricity, fossil fuels, district heating and cooling, etc.). High resolution data e.g. half hourly or better is highly desirable as this will benefit the calibration activities described in task 3. If high resolution data is not available, useful insights can be obtained by taking multiple daily readings from key meters & sub-meters over a short period (e.g. a week or a fortnight) to determine energy use at different times of day.

Energy consumption data should be entered into the PVT in Tables 4 and 7. The arrangement of the sub-meters in the building may allow energy consumption of certain energy end uses to be measured directly, or may allow this to be determined through calculations using multiple sub-meters.

3.3. Develop Design

Stage Overview

This stage of the protocol aims to outline and agree upon the design criteria that will enable the renovation targets outlined in the Decision Stage to be achieved. Critically, this stage also includes an Independent Design Review to ensure that the design has been rigourously assessed in its ability to achieve the set targets.

3.3.1. Task 3: Calibration of model for existing building to match measured performance

In order to propose meaningful and measureable improvements to the building's energy performance, calibration of the simulation model to be reflective of the existing building's measured energy performance is essential.

In order to do this the following calibration steps will need to be carried out:

- Obtain reliable existing building energy use data (from the energy audit, Task 2)
- Obtain weather files for the building's location for the time period that reliable building energy consumption data is available. If this is not available then weather data for a typical meteorlogical year for that location can be used.
- Identify HVAC scheduling and set points for the same time period as the weather files and measured energy use[15]. (from the energy audit, Task 2)
- Start with the EVC model under actual conditions developed in Task 1 at decision stage
- Identify the uncertain parameters of the model through uncertainty or sensitivity analysis
- Iteratively simulate the building, altering parameter inputs until the simulated consumption is within 20% of the measured consumption (a 10% margin is desirable).
- Reconcile model outputs with measured data

[15] actual occupancy hours and lighting use can be observed to test alignment with BMS schedules

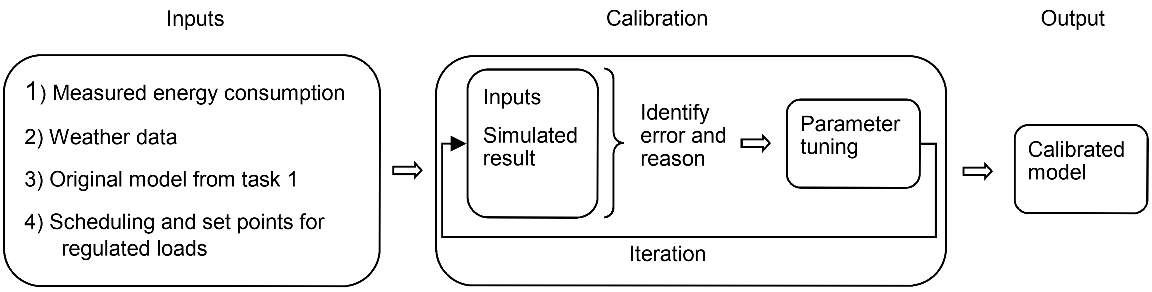


Figure 4: The calibration process showing inputs to the model and iterative parameter tuning with identification of error between measured and modelled building energy use

Identifying the cause of discrepancy between the model and measured consumption enables the correct adjustments to the model, allowing for more effective decisions around improvements to the building design through the planned renovation.

From Figure 4 in terms of identifying error and explanations, it is possible to differentiate between universal or seasonal bias in the error between measured and simulated data. Universal bias is the constant difference between the measured and modelled energy consumption, and could indicate errors in assumed occupancy hours and associated building services scheduling. As an example of seasonal bias, continuously high differences for gas in Winter could indicate that the heating scheduling may not be aligned to the true situation, or that the set point temperatures are not accurate. It could also indicate that the exfiltrations rate (air change rate) has not been accurately measured or is incorrectly assumed.

3.3.2. Task 4: Agree list of building improvements

This stage impresses the need for a formal agreement between all parties involved in the renovation on the scope of the renovation, using the calibrated simulation model to assess the potential renovation measures.

The calibrated model is a useful tool for investigating the effects of how the building will be used by the intended occupiers on the posible renovation outcomes, as well as the implementation of the financial cost benefit analysis. Dialogue with all parties, including the building users is imperative in order to identify and agree upon a list of improvements that are both energy saving and practical in their implementation and adoption.

The results of the simulations for the improved building can be entered into the PVT in tables 11 and 12.

3.3.3. Task 5: Calculation at design stage of asset rating for renovated building under standard conditions

This calculation is undertaken during the assessment of renovation recommendations in the EVC. It is not mandatory for the purposes of performance verification.

3.3.4. Task 6

Task 6 has two options: one involves advanced simulation whilst the alternative requires a methodical focus on satisfying design for testability criteria

Task 6a) Dynamic modelling to simulate renovated building and HVAC system

The first option involves creating a digital twin for the proposed renovation: an ‘advanced’ dynamic thermal simulation to predict the in-use energy consumption from the regulated loads of the renovated building. This model may make use of the three dimensional geometry of the EVC model, but it is a separate model with more sophisticated capabilities. This modelling is more advanced than the CEN method because it includes detailed modelling of the proposed HVAC system and how it is intended to be controlled, rather than treating the HVAC system as a black box with energy use attributed from empirical performance data derived independently from whatever control strategies have been proposed in the specific case (as can be found with most modelling software used for compliance with national building regulations across the EU). Because advanced simulation pays attention to the actual design of the building, alongside the use of local weather files and actual occupancy schedules in each different functional space[16], the model will be able to predict the closest estimate of in-use energy consumption.

There are several key objectives for the modelling:

- to confirm that the proposed design is capable of meeting the energy performance target; typically the building should simulate to at least 10% better than the energy performance target set for the renovation in task 7, to engender confidence that the actual operation will achieve the target
- to inform the development of a verification plan which identifies necessary sub-metering[17]
- to produce monthly targets for each regulated loads sub-system (heating, hot water, cooling, fans, pumps, controls, lighting) and, ideally, each physical sub-meter
- to inform the optimisation of HVAC control, including testing the sensitivity of performance to common control and operational failure modes
- to understand how the HVAC system would operate for each hour of the year and thereby confirm plant capacity requirements more robustly, and enable the designers to identify how much time would be spent in more or less efficient operating modes
- to undertake 'off-axis scenarios' to check the resilience of the design to all plausible future scenarios for occupancy hours, intensity of use and weather. For example, it is to be expected that different tenants in a commercial office may have longer or shorter hours of use than a base case standard condition, including late working, two-shift working and weekend working; also, some spaces may end up being unoccupied for significant periods. A better energy performance will be achieved if the HVAC is designed so that different zones can be serviced independently and only occupied zones are serviced. A developer should expect the target performance to be achieved under all reasonable future scenarios.

In summary, advanced building simulation is a process which involves creating at the design stage a virtual building model to reflect accurately the energy usage of the renovated building, under expected and plausible conditions of use over a year. The virtual model should inform all stages of the building's development from design, through construction and commissioning, and into the early operation tune up and monitoring phases.

Results of this calculation can be entered in Table 13 of the PVT (optional). Further guidance on the Advanced simulation approach can be found in Appendix B.

Task 6b: Agree data points to be tested by the QUANTUM performance test bench

This task involves the QUANTUM route to ensuring that the building can be operated as designed. The QUANTUM route ensures that a Description of Operations is specified at the design stage so that the intended control of the building is well understood, and the resultant controls strategy implemented for the building services can be demonstrated by the contractor to be in alignment with this Description of Operations – failure for the controls to work as intended would be treated as a contractual defect.

[16] through dialogue with the intended building users / client, the building must be divided into functional spaces to cover separately all spaces expected to have significantly different activities or hours of use
[17] For guidance on appropriate and effective sub-metering see section 8, Metering Systems, of NABERS Energy & Water for Offices Rules v3.2 October 2018, https://www.nabers.gov.au/file/2021

3.3.5. Task 7: Set operational energy performance target for building and include in contractual documentation

This is a mandatory task of the protocol tool and is critical to ensuring that the renovated building's operational targets are agreed upon by all participants. By agreeing on a common vision and including this in a contractual agreement, there is a responsibility for each participant to strive to achieve it.

The operational energy target of the building will relate to the regulated energy loads (as defined by CEN Standards and presented in the EVC) and ideally be informed by the advanced simulation (see task 6a). Where the QUANTUM pathway is being followed, the target will be set according to the EVC modelling approach (see task 5).

While the ALDREN PVT tool is used to validate the performance of the building against the EVC, advanced simulation offers a greater insight and confidence that the performance target can be met.

At this stage it is a valuable exercise to review the list of end uses included in the EVC calculation as set out in the PVT tool in order to ensure the proposed metering plan provides sufficient resolution to populate the energy end uses in the PVT tool at the In-Use stage.

3.3.6. Task 8: Independent design review to confirm design and modelling are robust

The building design and the advanced modelling or QUANTUM specification must be subjected to an independent design review (IDR) undertaken by an independent expert who is an experienced energy efficiency professional with high levels of expertise in relation to:

- deep renovation building projects and the design of HVAC services and their controls
- commissioning/tuning of buildings
- energy auditing and energy efficiency improvement of buildings
- simulation of building performance or QUANTUM test bench method.

The IDR should scrutinise the design, metering strategy and commissioning plan and the simulation outputs with the overarching objectives of identifying risks and opportunities in relation to the achievement of the proposed operational energy target. Changes arising from the IDR should be consolidated into the final design package.

The IDR peer review is, importantly, not a pass/fail or compliance exercise; it is instead designed to assist the design and construction team to understand the choices they have and risks they face in delivering the target.

3.4. Detailed Design

Stage Overview

During the detailed design stage, critical actions are required in order to ensure that the energy performance of the building's regulated loads will be measurable accurately so that the performance can be monitored and verified against design predictions. Furthermore, finalising a robust and detailed description of operations lays the necessary foundations for the effective implementation of an efficient controls strategy.

This stage has alternative pathways depending whether the advanced simulation or QUANTUM approaches is being deployed.

3.4.1. Task 9a: Preliminary Description of Operations and Validation plan

This task relates to the advanced simulation pathway. The aim of this task is to ensure that the final design incorporates specifications for controls and metering in sufficient detail to ensure that the buildng will be operated efficiently and the energy performance of regulated loads can be measured in practice.This involves two key elements.

The first task is to confirm the Description of Operations (DesOps), particularly the controls strategy for the HVAC services under plausible occupancy scenarios. This document should set out in detail how the building is indended to be operated, using logical statements such as “the central heating plant should be enabled once a minimum of 20% of the terminal units in the building are calling for heating”.

The second task is to ensure the metering layout allows the energy end uses included in the performance target to be measured directly without complex calculations or adjustments. While summation of meters measuring the same end use is likely to be necessary in most buildings, situations where estimation is required to split the energy from one sub-meter across different end uses should be avoided.

Results from simulations undertaken at this stage can be entered into Tables 14 and 17 of the PVT (optional).

3.4.2. Task 9b: Application of QUANTUM testbench

This task relates to the QUANTUM test bench pathway. It requires tests to be specified that will demonstrate that the implemented controls strategy is consistent with the Description of Operations set out by the design team. The objective is to ensure the contractor can show that the completed building can be operated correctly. For a large office building this would typically include a requirement to test around 150 statements relating to the operation of the building management system.

Results from any simulations undertaken at this stage can be entered into 13 and 16 of the PVT (optional).

3.5. Works

Stage Overview

During the works stage, pressures from construction timescales and the contractor’s approach to implementing the design specification often lead to compromises being made on the final specification of the building. In particular, effective implementation and testing of the controls strategy is often compromised due to time pressure prior to building handover.

This protocol identifies a series of key tasks which mitigate against these risks and ensure the building meets the original design intent.

3.5.1. Task 10: Revision of DesOps during construction phase

Changes to the building’s design and specification will occur during the construction phase. As and when these changes occur, the Description of Operations should be updated, at all times with due consideration that any changes made should maintain or improve the expected energy performance of the building (see also Task 11 relating to value engineering).

The draft Description of Operations should be made available to tenderers for the controls engineering and used as an input into the design of the control system. The objective should be for the implemented control strategy to mirror the control system assumed by the simulation model. If the actual controls replicate how the building operates in the model, the actual HVAC system performance should be close to the simulated performance, giving confidence the target rating will be achieved. Any refinements introduced to the DesOps should be reflected in a revised version of the DesOps document that emerges on completion and handover.

3.5.2. Task 11: Defend rating against value engineering

Decisions made during the construction phase should be evaluated against the agreed building energy performance target in order to ensure value engineering practices do not impact on the overall performance of the building.

Where changes are significant, their impact on energy performance should be studied using the dynamic simlulation model developed in Task 6a, or Task 5 if the QUANTUM test bench approach is being used in place of advanced simulation.

Presenting the impact of the value engineering proposals in terms of the energy cost increase over the life of the equipment ítem, or the building as a whole, may help to gain the support of the client for an energy efficient approach.

3.5.3. Task 12: Handover, commissioning and fine tuning

Commissioning and tuning the building services systems are critical to a building achieving its potential energy performance. It is important to allow sufficient time for this process and not to allow it to be compressed by the pressures of completion and handover.

A smoother accomplishment of the ALDREN process and target rating will be secured when the need for these early operation activities is recognised from the beginning of a project, specifically by being facilitated by the design of the BMS and metering systems, clear, consistent and accurate documentation (e.g. across asset registers, meter schedules and layouts, BMS, EMS, etc.) and by a practical validation plan. The need for these activities must be built into the remit of all those involved, including the design engineers, control engineers, managing agents and facilities managers.

Commissioning checks must be made of metering and sub-metering systems to ensure that these are installed, labelled and calibrated correctly, and that data outputs are functional and easily accessed.

Successful delivery of target performance also requires effective communication of the design intent of the building to all stakeholders in the building's operation (building managers, tenants, maintenance staff, etc.).

The energy performance for regulated loads can be undermined by tenant fit-outs which modify or compromise the original design. Therefore, the developer's building services engineers should have effective oversight of tenant fit-outs, including the option to veto proposals which would prevent the target performance being achieved.

Performance based maintenance contracts for managing agents and facilities managers, linked to achievement of the target base building rating, are likely to produce the best chance of achieving the target. Meters should be treated as maintainable assets and the task of meter data collection and processing should be included in the requirements of the maintenance contract.

It is noted that where responsibility for whole building HVAC control and maintenance is divided between landlord and tenants, early operation fine tuning activities may become more complex.

Task 12a Advanced simulation pathway

The specific activities required include a commissioning process which ensures the controls in the completed building are consistent with its digital twin reflected by the detailed dynamic simulation model of the final design.

A comprehensive programme of fine-tuning of the BMS should be initiated to ensure that the system's response is optimised for different occupancy patterns and seasons, as anticipated by the simulation studies. The final 'Description of Operations' for the actual building, the actual control set up and the control strategy implemented in the simulation model should all be consistent with each other. At least 4 tuning exercises, timed to test seasonal weather variations, each including a detailed review of BMS operation should be planned.

Task 12b: Application of QUANTUM testbench

Taking the QUANTUM testbench route to ALDREN compliance ensures that a structured approach is taken to specifying and validating the correct commissioning of HVAC equipment and controls.

3.5.4. Task 13: Calculation of asset rating for renovated building (LENS E)

The asset rating of the retrofitted building is calculated using a dymamic simulation software package consistent with the EU CEN method (see inset). Existing software and calculations used to produce EPC certificates may meet these criteria in many EU countries. This calculation is also used elsewhere within the ALDREN process and feeds into the building's renovation Passport. End use level energy consumption for heating, cooling, ventilation, and lighting should be taken from this calculation and entered in the PVT in Tables 19 and 20.

EU CEN calculation tools:

- Must calculate at an hourly (or smaller) timestep
- Packages such as CYPETHERM COMETH, EDSL TAS and IES are examples

3.6. In use

3.6.1. Stage overview

During the in-use stage of the ALDREN protocol, the simulation model is refined to account for the actual boundary conditions encountered during the early occupation of the building. Measured energy data is collected and the performance of the building is assessed against the target set during the design phase. Ongoing aftercare and controls interventions by the design team and contractors may be required in order to realise the performance target.

3.6.2. Task 14: Track metered performance against predicted performance under actual conditions

During the first year of occupation, measured energy consumption should be obtained from all meters and sub-meters present in the renovated building on a monthly basis. This data will require processing in order to determine the energy consumption for each fuel supplied to the building, and each energy end-use as specified in the ALDREN Performance Verification Tool. A carefully considered metering layout (task 9a/12a), combined with an appropriately programmed report from automatically read meters is recommended to maximise the efficiency of this process when using the advanced simulation pathway.

Enter the meter data into the Performance Verification Tool in Tables 24 and 26. Compare the measured energy consumption against the calculated performance target (Task 7). Where advanced simulation has been used, this should be tracked at a monthly resolution for each end use within the scope of the CEN calculation as a minimum. If the actual use of the building or the weather conditions differ significantly from those assumed in the predictions at the design stage, the simulation model should be re-run to account for these variations.

If a forecast of the annual performance is desired, the modelled data under forecast conditions (from table 20 for QUANTUM route or table 17 for Advanced Simulation route) can be copied into the metered data table (Table 26) and overwritten each month as the metered data becomes available.

RAG rating performance for each end use and/or meter allows specific areas of under and over-performance to be identified and investigated. This is presented in Tables 28-30 of the Performance Verification Tool. Data showing in red or dark blue cells indicates energy consumption greater than and less than predicted respectively, and where this variance is greate than 25%, the end use should be examined in more detail (task 15)

3.6.3. Task 15: Diagnose and implement improvements (LENS G.1)

Significant variances in energy consumption identified in task 14 should be investigated in order to determine the cause of the deviation between simulated and actual building performance. The cause of the variance may be due to one or more of the following

- Boundary conditions applied to the simulation model do not accurately describe the occupancy, operation and/or weather conditions over the data period.
- Incorrect installation or commissioning of equipment or controls

- Limitations of the simulation software to fully account for the building's description of operation. This can be mitigated or eliminated by employing the full functionality of a software package approved for advanced simulation.

3.6.4. Task 16a: Advanced simulation of predicted performance after year of operation under actual conditions (LENS F)

This is the final simulation stage required in the ALDREN process. At this point in time the detailed simulation model should be refined to account for the true specification of the building and the boundary conditions experienced over the first year of the building's operation:

- As built equipment specifications, fabric details, air permeability and HVAC control strategies
- Actual occupancy – hours of use for each functional space
- Actual weather conditions – the preferred approach is to create a weather data file for the detailed simulation software, using data from a suitable local weather station
- Where the simulation approach allows the prediction of energy consumption for the actual sub-meters installed in the building, the plant and equipent assigned to each sub-meter should be refined in the simulation model to reflect the as-built situation.

The simulation should be re-run, and the results of this simulation transferred into the Performance Verification Tool (Tables 23 and 26).

3.6.5. Task 16b: Prediction of energy performance after year of operation under actual conditions (QUANTUM route)

Where the QUANTUM testbench has been applied to the building rather than advanced simulation, a less sophisticated dynamic simulation using a CEN compliant software tool is deemed appropriate for prediction of energy consumption. The model should still be refined to reflect the boundary conditions for the as-built building as follows:

- As built equipment specifications, fabric details, air permeability
- Actual occupancy – hours of use for each functional space
- Actual weather conditions – the preferred approach is to create a weather data file for the detailed simulation software, using data from a suitable local weather station. Manually adjusting the heating and cooling outputs of the EPC simulation model based on heating and cooling degree days is a poor substitute for calculating the simulation using a suitable weather file and should be used only as a last resort.

The simulation should be re-run, and the results of this simulation transferred into the Performance Verification Tool (Tables 22 and 25).

3.6.6. Task 17: Compare measured energy consumption with the energy consumption predicted in the EVC (LENS F vs LENS G)

There are two aims to this task.

- The first is to validate the EVC calculation against the actual measured energy consumption of the building. This requires the EVC calculation to be calibrated to actual conditions.
- The second element is only used for the Advanced simulation route to compliance. In this case the PVT is used to compare monthly predicted energy budgets for each end use (calculated using the advanced simulation under actual conditions) against the measured consumption on a monthly basis. This represents the completion of task 14 for a full year of operation.

In this step of the ALDREN process, the measured energy consumption of the building is used to validate the performance prediction of the EVC. This is undertaken by comparing the energy consumption of the EVC calculation under actual boundary conditions for the first year of occupation with the measured performance of the building. This task is undertaken using the PVT. In order to achieve useful insights from this process, the process should be undertaken by an engineer with expertise in energy performance, controls and simulation modelling.

Energy consumption for each fuel, and energy end use, are compared in the Performance Verification Tool in Tables 28, 29 and 30. Table 28 presents the performance of the building as a whole.

Table 29 presents the annual consumption of the building and compares this with the simulations for the EVC under Actual conditions, and the Advanced Simulation under Actual conditions (if undertaken). The variance data presented here is used to validate the EVC and highlights areas where further investigation may be required. This data also gives insight into the significance of the advanced simulation as a means of predicting the building's energy performance..

Table 30 presents the variance in monthly consumption between the Advanced Simulation under Actual conditions, and the measured consumption.. An indication of how closely themonthly performance trend matches between the two datasets is also provided. This table is intended for use with the Advanced Simulation route to compliance, to highlight early in the occupation stage any variations between expected and measured performance for further investigation – the higher level of detail offered by advanced simulation tools is well suited to reviewing the data at this resolution.

4. Task summary

4.1. Task summary

The table below lists the tasks included in the ALDREN protocol, split according to the ALDREN master stage.

Master stage	Task #	Mandatory / Optional?	ALDREN Protocol task
Decision (Set Requirements)	0	Mandatory	Obtain commitment from stakeholders to participate in ALDREN process
	1	Mandatory (Asset rating optional)	Building simulation: asset rating and predicted energy use under actual conditions (LENS A, B)
	2	Optional	Energy audit of existing building (LENS C)
Develop Design	3	Mandatory	Calibration of model for existing building to match measured performance
	4	Mandatory	Agree list of building improvements (fabric, plant, controls)
	5	Optional	Calculation at Design Stage of asset rating for renovated building under standard conditions
	6a	Choose either/ both 6a or 6b	Dynamic modelling to simulate design of building and HVAC system
	6b	Choose either/ both 6a or 6b	Agree data points to be tested by QUANTUM performance test bench and ensure measurability (creation of DesOps)
	7	Mandatory	Set base building operational performance target for building and include in contractual documentation
	8	Mandatory	Independent design review to confirm design and modelling are robust (or review efficiency of QUANTUM proposals)
Detailed Design	9a	Choose either / both 9a or 9b	Final design including validation plan (meter layout and targets) and preliminary DesOps
	9b	Choose either / both 9a or 9b	Design application of QUANTUM testbench
Works	10	Mandatory	Revision of DesOps during construction phase
	11	Mandatory	Defend rating against value engineering
	12a	Choose either / both 12a or 12b	Handover, commissioning and early operation intensive fine tuning – DesOps finalised
	12b	Choose either / both 12a or 12b	Handover, commissioning and application of QUANTUM testbench – DesOps finalised
	13	Mandatory	Calculation after completion of asset rating for renovated building under standard conditions (LENS F)
In use	14	Mandatory	Track metered performance against predicted performance under actual conditions
	15	Mandatory	Diagnose and implement improvements (LENS H)
	16a	Choose either / both 12a or 12b	Advanced simulation of predicted performance after year of operation under actual conditions (LENS G)
	16b	Choose either / both 12a or 12b	Prediction of energy performance after year of operation under actual conditions (QUANTUM route)
	17	Mandatory	Compare measured energy against calculations at various resolutions((LENS G vs LENS H)

Table 2: ALDREN Protocol task summary

5. Appendix B – technical guidance

5.1. Advanced simulation & application of "Actual" conditions to simulation models

The "Design for Performance" approach developed and refined in Australia (and currently being introduced by pioneer organisations in the UK) is the global state of the art in understanding and closing the performance gap between design intent and actual building performance.

A critical element of the Design for Performance approach is the use of detailed dynamic simulation of building HVAC loads under forecast and actual boundary conditions in order to generate as plausible a prediction of energy consumption as possible.

The distinction between Forecast and Actual conditions of use is necessary to distinguish the modelling approach at different renovation stages:

- "Actual" boundary conditions can only be applied retrospectively (e.g. for modelling the pre-retrofit building at Decision stage or the post retrofit building at In-Use stage). These values can be determined by measurement or observation (e.g. number of occupants).
- "Forecast" boundary conditions are used at all stages of design and construction. These are the best available prediction of how the building will be used based on design parameters and the expected occupation patterns, and cannot be measured directly.

In the UK, 4 levels of modelling are currently employed for non-residential buildings. Each level is progressively more detailed, more reliable/accurate and more effort than its predecessor:

1. Simple, static energy consumption model eg SBEM; standard conditions of use; monthly timestep, This level of simulation is not compliant with CEN Standards but is used for EPCs for simple non-residential buildings in UK
2. A dynamic simulation model eg IES, TAS; using standard conditions of use; hourly or less time step; this level of simulation is mandated for EPCs for larger or more complex buildings in UK; rigour is equivalent to the CEN method although existing software packages may not be 100% compliant
3. As Level 2 but the simulation model is calibrated to reflect the actual conditions of use (at design stage these are predicted values, at in-use stage, real data from the building's use in early occupation should be used)
4. As Level 3 but also incorporates detailed simulation of HVAC systems and controls (eg Apache HVAC in IES). Predominantly used in Australia but under trial in DfP pilots in the UK.

A level 3 calculation is required as a minimum in order to carry out a meaningful assessment of the performance gap within the ALDREN approach, but level 4 calculations are encouraged wherever possible. Experience in Australia shows that the use of a level 4 calculation approach creates considerable opportunities for optimisation of the controls strategy during the design process as well as increasing the confidence level for the calculation of predicted energy consumption. In Australia, actual energy consumption can now routinely be predicted to a high degree of accuracy (within 10%) at design stage using advanced simulation.

In the vast majority of cases, a level 2 or "compliance" model will have been produced in order to generate an EPC. The table on the following page summarises the refinements that would be typically made to such a model in order to carry out a detailed simulation at level 3 or level 4.

Simulation input	Resolution	Level 2 simulation = EVC under Standard conditions	Level 3 simulation = EVC under Forecast conditions (Design stages) EVC under Actual conditions (Decision and In-Use stage)	Level 4 simulation = Advanced Simulation under Forecast conditions (Design stages) Advanced Simulation under Actual conditions (Decision and In-Use stages)
Building geometry	n/a	As design/As Constructed	As Constructed	As Constructed
Fabric details	n/a	As design/ As Constructed	As Constructed	As Constructed
Weather file	Hourly or better	20 year average for location	Actual year for location using data from a local weather station (20 year average for Forecast simulation)	Actual year for location using data from a local weather station
Occupancy (persons/m2)	By functional space	Standard assumption	Actual/forecast occupant density by functional space.	Actual occupant density by functional space
Occupancy hours	By functional space	Standard assumption	Actual/forecast hours occupied for each functional space	Actual hours occupied for each functional space
Air supply rate	By space type	Standard assumption l/person	Design air flow rate. Validate against commissioning data Decision/In-Use stage	Design air flow rate. Check against commissioning data for post occupancy
Temperature settings	By space type	Standard assumption for space type	Design/forecast planned temperature settings & dead bands	Design planned temperature settings & dead bands
Internal heat gains	By space type	Standard assumption for space type	Calculated outside of the simulation model & entered as heat gain value only. Based on Design equipment schedules Revise for post occupancy if Actual equipment schedules markedly different	Calculated outside of the simulation model & entered as heat gain value only. Based on Design equipment schedules Revise for post occupancy if Actual equipment schedules markedly different
Lighting controls	By space type	Rule of thumb calculations based on standard assumptions of hours of use	Rule of thumb calculations based on forecast or actual hours of use	Daylight dimming calculated using simulation of daylight levels in each functional space across actual hours of use
Controls strategy for HVAC	By HVAC system	Inherent in model assumptions used for compliance	As standard method	Actual control strategy defined for each plant item/system using advanced simulation e.g. using Apache HVAC in IES
Major plant characteristics (boilers, chillers)	Plant item	Based on simple efficiency of actual plant item	Based on simple efficiency of actual plant item	Use of actual performance curves for plant items selected from library (if available)

Table 3: Summary of simulation inputs used in different levels of the ALDREN modelling approaches

Table 4, below, identifies the stages at which calculations are expected to be carried out during the ALDREN process. Further simulations may be carried out at any stage in order to investigate the energy performance impact of potential changes to the building's specification.

	ALDREN stage				
Simulation level	**Decision**	**Develop Design**	**Detailed design**	**Works**	**In Use**
Level 2	Task 1 (existing building)	Task 5 (renovated building)		Task 13 (renovated building)	
Level 3	Task 1(existing building)	Task 3 (existing building) Task 4 (renovated building)			Task 16b (renovated building)
Level 4		Task 6a (renovated building)		Task 11 & 12(if re-simulation required)	Task 16a (renovated building)

Table 4: Calculations undertaken at each simulation level for each ALDREN stage

ALDREN PROTOCOL TRACKING TOOL

Introduction:

This document is a tracking tool for ALDREN participants to record their actions taken in response to Task 2.3: addressing the gap between calculated and actual building performance.
The tasks are arranged according to the 5 ALDREN stages spanning the full deep renovation process. The relationship between ALDREN stages and the RIBA plan of work is set out below.

Navigating this document:

This document contains eight worksheets. The purpose of each worksheet is set out below.

Worksheet	Description
Landing page	Introduction to tool & navigation
Process schematic	Overview of ALDREN process within task 2.3
Index of tasks	Task list for all ALDREN tasks, with hyperlinks
1 Decision(set requirements)	Commitment from key stakeholders to engage with ALDREN and initial analysis of the pre-renovation building
2 Develop design	Calibration of the exisiting model and delvelopment of the design to agree on energy performance targets and building improvements. Includes an independent design review
3 Detailed design	Final design of the renovated building
4 Works	Defense of the design against value engineering, handover and commissioning and calculation of the asset rating
5 In use	Measurement of the in-use energy performance of the building, verification of EVC performance ambition and continued improvements

The document can be navigated using the navigation bar at the top of the page (clicking on a link will take you to the relevant worksheet), or using the links to specific tasks in the "Index" section of the workbook.

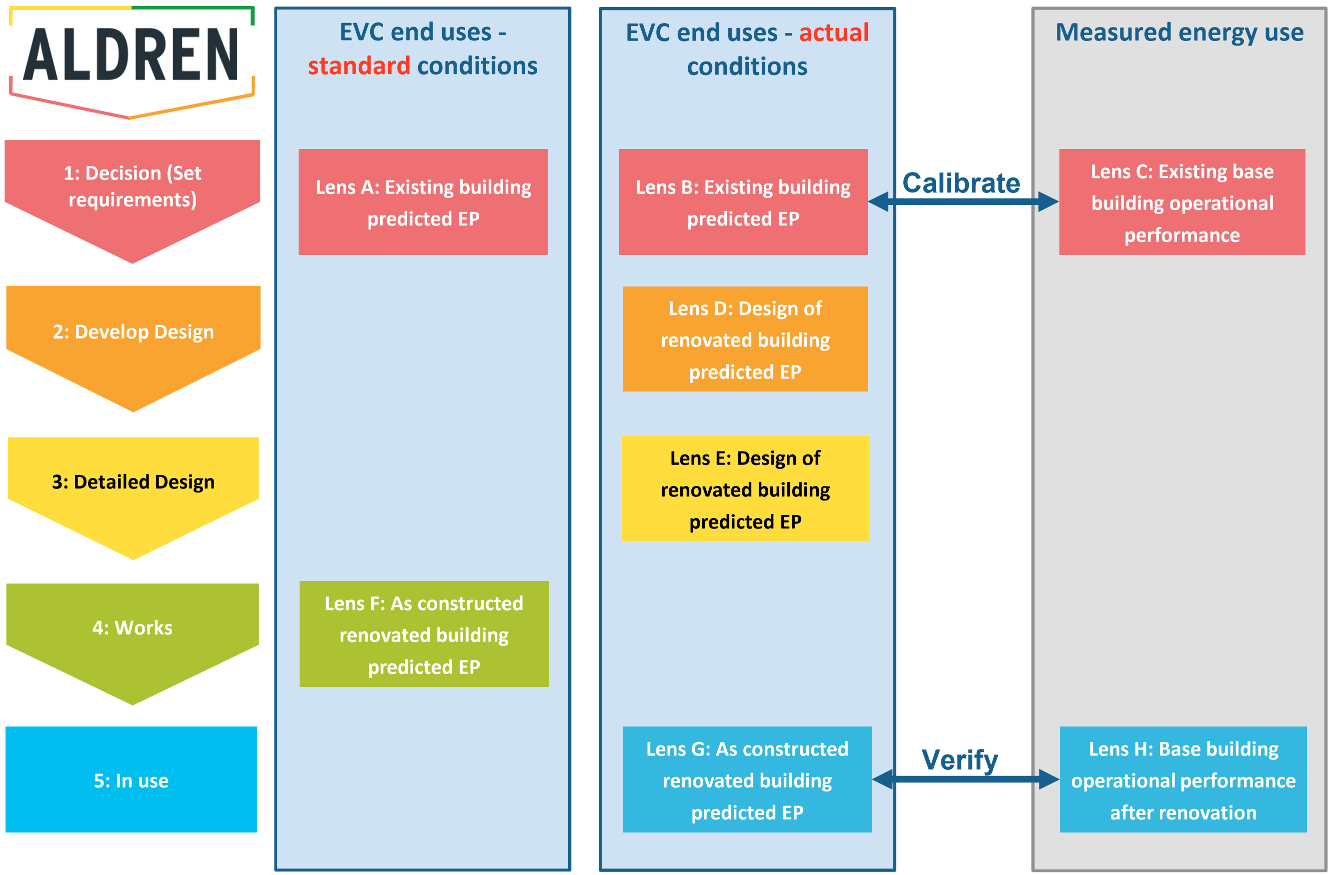
Key to cell colour coding:

Input cell

Relation of ALDREN stages to RIBA stages

RIBA stage #	RIBA stage	ALDREN master stage
0	Strategic Definition	Decision (set requirements)
1	Preparation and Brief	
2	Concept Design	Develop Design
3	Developed Design	
4	Technical Design	Detailed design
5	Construction	Works
6	Handover and Close Out	
7	In Use	In use

ALDREN INTERVENTION POINTS



ALDREN PROTOCOL TRACKING TOOL

Use the llinks below to navigate through the document

Master stage	Task #	ALDREN Protocol task
Decision (Set Requirements)	0	Obtain commitment from stakeholders to participate in ALDREN process
	1	Building simulation: asset rating and predicted energy use under actual conditions (LENS A, B)
	2	Energy audit of existing building (LENS C)
Develop Design	3	Calibration of model for existing building to match measured performance (LENS B)
	4	Agree list of building improvements (fabric, plant, controls). (LENS D)
	5	Calculation at Design Stage of asset rating for upgraded building under standard conditions
	6a	Dynamic modelling to simulate design of building and HVAC system
	6b	Agree data points to be tested by QUANTUM performance test bench and ensure measurability (creation of DesOps)
	7	Set base building operational performance target for building and include in contractual documentation
	8	Independent design review to confirm design and modelling are robust (or review effectiveness of QUANTUM proposals)
Detailed Design	9a	Final design including validation plan (meter layout and targets) and preliminary DesOps
	9b	Design application of QUANTUM testbench
Works	10	Revision of DesOps during construction phase
	11	Defend rating against value engineering
	12a	Handover, commissioning and early operation intensive fine tuning – DesOps finalised
	12b	Handover, commissioning and application of QUANTUM testbench – DesOps finalised
	13	Calculation after completion of asset rating for upgraded building under standard conditions (LENS F)
In use	14	Track metered performance against predicted performance under actual conditions
	15	Diagnose and implement improvements (LENS H)
	16a	Advanced simulation of predicted performance after year of operation under actual conditions (LENS G)
	16b	Prediction of energy performance after year of operation under actual conditions (QUANTUM route)
	17	Compare measured energy against calculations at various resolutions (LENS G vs LENS H)

ALDREN Stage 1: DECISION (SET REQUIREMENTS)

Task #	Task	Mandatory / Desirable?	Description	Purpose	Initiator	Participants (* - if known at this stage)	Completion notes (e.g. activities undertaken & dates, documentation produced, lessons learnt)
0	Obtain commitment from stakeholders to participate in ALDREN process	Mandatory	Key stakeholders should be made aware of the ALDREN process including the benefits offered by the approach, as well as the time commitment required to carry out the protocol stages. Wherever possible written commitment should be obtained at project outset. If stakeholders are not yet appointed at project start, they should be briefed and commitment confirmed when they join the project.	Commitment of stakeholders is essential in order to achieve ALDREN outcomes	Client	Client Architect* Design team* Main contractor* Occupiers (of renovated building)*	
1	Building simulation: asset rating and predicted energy use under actual conditions (LENS A, B)	Mandatory (Asset rating for EVC only)	Calculate asset rating for existing building using a dynamic simulation modelling tool consistent with the EU CEN method. Simulation time step should be 1 hour or less. Update model parameters to reflect actual boundary conditions for weather, occupancy, hours of use etc. and rerun simulation. This simulation will be calibrated in step 3 of the protocol.	Determine initial asset rating as start point of actual conditions model Early insight into how actual boundary conditions affect energy use Creation of simulation outputs for comparison with measured data	Design team	Client Design team	
2	Energy audit of existing building (LENS C)	Optional (highly desirable, where data is available)	Collect energy data from the existing building over a period of at least 1 year (where possible). Where available, data from both utility meters and sub-meters should be collected. High resolution data e.g. half hourly or better is desirable.	Determine pre retrofit operational performance Provide a reference point for calibration of simulation model	Design team	Client Occupiers (of existing building) Design team	

ALDREN Stage 2: DEVELOP DESIGN

Task #	Task	Mandatory / Desirable?	Description	Purpose	Initiator	Participants (* - if known at this stage)	Completion notes (e.g. activities undertaken & dates, documentation produced, lessons learnt)
3	Calibration of model for existing building to match measured performance (LENS B)	Mandatory	Calibrate the EVC model for the actual conditions. The model should be calibrated to reflect the real boundary conditions for the building over a time period for which reliable measured energy consumption is available. Calibrate the model to within a 10% error to enable identification of appropriate energy saving opportunities in terms of the building's fabric, plant design, and controls. Refer to Appendix B of the written protocol guidance for calibration guidance	To understand the current impact of building fabric and design, and building services controls and management on energy performance	Design Team	Client Occupants* Design team	
4	Agree list of building improvements (fabric, plant, controls). (LENS D)	Mandatory	Identify appropriate building improvements for a 'deep renovation' through findings from calibrated simulation, cost benefit analysis and dialogue with the client and building users	Formal agreement of building improvements taking into account the future use of the building	Design Team	Client Architect* Design team Main contractor* Occupant(s)*	
5	Calculation at Design Stage of asset rating for upgraded building under standard conditions	Mandatory (for EVC)	Calculate the asset rating of the proposed renovated building design using a model compliant with the CEN method	Determine asset rating of the renovated design Insight into how the building improvements could affect the overall energy performance rating of the building	Design Team	Design Team	
6a	Dynamic modelling to simulate design of building and HVAC system	Optional - choose either or both of 6a or 6b	Dynamic thermal simulation of the building beyond the EU CEN method, incorporating dynamic modelling of the proposed HVAC system to be used in the building, climate data for the location of the building and design occupancy schedules based on dialogue with the client	Estimate the in-use energy consumption and energy performance of the building post renovation	Design Team	Design Team Client	
6b	Agree data points to be tested by QUANTUM performance test bench and ensure measurability (creation of DesOps)	Optional - choose either or both of 6a or 6b	Specify the Description of Operations including intended occupancy schedules and resultant controls strategy Identify and agree on specific aspects of system control e.g. to achieve demand controlled ventilation rates, to be tested by the QUANTUM performance test bench	Identify the settings and target set points for the control of the building services and their measurability Ensure that the controls strategy is tailored to the design intent	Design Team	Client Architect* Design team All contractors*	
7	Set base building operational performance target for building and include in contractual documentation	Mandatory	Identify an achieveable building operational performance target and ensure that this is factored into both agreements between the designer and client and also tender documents for contractors. Where advanced simulation is being used the outputs of task 6a will inform this target. If the QUANTUM test bench approach (6b) is being used, then the calibrated simulation model from Task 4 (based on the expected use of the renovated building) should be used to inform the setting of a performance target for the energy end uses within the CEN scope.	Identify a common vision for the building renovation with all parties agreeing on the scope of improvements and energy performance targets	Design Team	Client Architect Design team All contractors*	
8	Independent design review to confirm design and modelling are robust (or review effectiveness of QUANTUM proposals)	Mandatory	The design review should be undertaken by an experienced energy efficiency professional who has been assessed for high levels of expertise in relation to: - Deep renovation building projects - The design of energy efficienct HVAC services and their controls - Energy auditing and energy efficiency improvement of buildings - Simulation of building performance Confirm that the design has been reviewed to identify opportunities to improve energy performance and that the building design is appropriate to meet the target base building rating Where the QUANTUM test bench is being used the review will assess the ability for an independent party to verify the proposed HVAC and controls strategy have been implemented correctly.	Objective review of design and modelling, to verify potential improvements in performance and whether the design is capable of meeting the performance target, and whether a commissioning process can verify the design has been implemented correctly.	Client	Client Independent consultant Design team	

ALDREN Stage 3: DETAILED DESIGN

Task #	Task	Mandatory / Desirable?	Description	Purpose	Initiator	Participants (* - if known at this stage)	Completion notes (e.g. activities undertaken & dates, documentation produced, lessons learnt)
9a	Final design including validation plan (meter layout and targets) and preliminary DesOps	Optional - choose either/both 9a or 9b	Specify the metering layout in light of the energy performance targets. Ensure that the proposed metering plan allows the end uses covered by the performance target to be measured directly without complex calculations or adjustments. Confirm Description of Operations, including intended occupancy schedules and resultant controls strategy	Ensure that all contractors are informed of the metering heirarchy design Ensure the client is aware of energy targets and confirm assumptions in the Description of Operations that inform this	Design Team	Client Architect Design team All contractors	
9b	Design application of QUANTUM testbench	Optional - choose either/both 9a or 9b	Confirm that the QUANTUM performance test bench can be applied to the final design to assess the design and intended control strategies of the building services	Ensure that correct implemention of the intended building services design and control strategies can be verified through tests by an independent party	Design Team	Design team	

ALDREN Stage 4: WORKS

Task #	Task	Mandatory / Desirable?	Description	Purpose	Initiator	Participants (* - if known at this stage)	Completion notes (e.g. activities undertaken & dates, documentation produced, lessons learnt)
10	Revision of DesOps during construction phase	Mandatory	Review and adapt the Description of Operations during the construction phase Update any documentation supporting the intended operation and use of the building if affected by alterations during the construction phase	Revision is essential to ensure that the Description of Operations is up to date with any alterations to the design or intended use of the building / areas of the building	Design Team	Client Architect Design team	
11	Defend rating against value engineering	Mandatory	Decisions made during the construction phase should be evaluated against the agreed building energy performance target in order to ensure value engineering practices do not impact on the overall performance target of the building Ensure that the implemented building controls mirror the design control system	Minimise the impact that value engineering has on the quality of the introduced building fabric components and services which contribute to the deep renovation, and hence sustain the intended bulding energy performance target	Design Team	Client Architect Design team All contractors	
12a	Handover, commissioning and early operation intensive fine tuning – DesOps finalised	Optional - choose either/both 12a or 12b	Ensure that the design intent of the building is communicated effectively to the building users Work with the designers, contractors and building managers to finalise the Description of Operations Fine tune the building operation and building services management, including HVAC set points and scheduling to optimise the energy performance. Four detailed reviews of BMS operation are recommended, timed to verify HVAC system performance and control under different seasonal weather patterns Review building log books to ensure that controls strategies are clearly stipulated. Pay extra attention to commissioning checks to ensure that main and sub-meters are installed & calibrated correctly and are functional. Update the advanced simulation model to reflect any material changes to building HVAC or usage profiles that have occurred during the construciton phase.	Ensure that the building is commissioned, operated and managed as designed		Client Design team All contractors	
12b	Handover, commissioning and application of QUANTUM testbench – DesOps finalised	Optional - choose either/both 12a or 12b	Fine tune the building operation and building services management, including HVAC set points and scheduling to optimise the energy performance. Verify the controls strategy has been implemented correctly using the QUANTUM test bench procedure. Pay extra attention to commissioning checks to ensure that main and sub-meters are installed & calibrated correctly and are functional.	Ensure that building controls are functioning as set out in the design intent		Client Design team All contractors	
13	Calculation after completion of asset rating for upgraded building under standard conditions (LENS F)	Mandatory	Calculate the asset rating of the building as it has been constructed under standard conditions e.g. standard occupancy profiles	The constructed building will differ from the design in some way e.g. where materials have been substituted, or installed building services need to be operated in a different way. Re-calculation of the asset rating at this stage is required for the EVCS certificate		Design team	

ALDREN Stage 5: IN USE

Task #	Task	Mandatory / Desirable?	Description	Purpose	Initiator	Participants (* - if known at this stage)	Completion notes (e.g. activities undertaken & dates, documentation produced, lessons learnt)
14	Track metered performance against predicted performance under actual conditions	Mandatory	Collect measured energy data from building utility meters and sub-meters at a monthly resolution from practical completion onwards. Compare the measured energy consumption against the EVC simulation under forecast conditions (QUANTUM route) or the advanced simulation under forecast conditions (Advanced simulation route). Where advanced simulation has been used, this should be tracked at a monthly resolution for each end use within the scope of the CEN calculation as a minimum. If the actual use of the building, or the weather conditions, differ significantly from the predictions at design stage, the simulation model should be re-run to account for these variations. RAG rating performance for each end use allows specific areas of under and over-performance to be identified and investigated.	Tracking the measured performance at this stage enables the design team to address if the renovation will meet the performance target, and carry out improvements to the building if necessary	Design team	Design team	
15	Diagnose and implement improvements (LENS H)	Mandatory	Making use of the findings of task 12a/12b and task 14, opportunities for further improvements to building performance may be identified and implemented	Optimise final performance of renovated building	Building Manager	Design team All contractors	
16a	Advanced simulation of predicted performance after year of operation under actual conditions (LENS G)	Optional - choose either/both 16a or 16b	Carry out a final dynamic thermal simulation to calculate the operational energy performance of the building based on the actual HVAC installed in the building, the actual weather and the actual occupancy schedules of the bulding	Calculating the performance of the building under the actual conditions of use enables the predicted performance to be verified by measurements	Design team	Design team Building Manager Client	
16b	Prediction of energy performance after year of operation under actual conditions (QUANTUM route)	Optional - choose either/both 16a or 16b	If the QUANTUM testbench approach has been used, the EVC simulation under forecast conditions should be adjusted to reflect the actual conditions during the first year of occupation. This simulation can then be used to assess performance in task 17	Apply relevant adjustments to the performance target to allow like-for-like comparison with measured data	Design team	Design team Building Manager Client	
17	Compare measured energy against calculations at various resolutions (LENS G vs LENS H)	Mandatory	Measure base building operational performance after renovation and after fine tuning (Lens G) Compare the measured performance with the EVC simulation under actual conditions in order to validate the EVC certificate. For the advanced simulation route, compare detailed monthly breakdown of end use energy consumption between the advanced simulation under actual conditions with the measured data.	Assess if base building energy consumption is in line with predictions.	Design team	Design team Building Manager Client	

ALDREN PERFORMANCE VERIFICATION TOOL

Introduction:

This document is the ALDREN Performance Verification Tool (PVT). This tool is used for data entry and analysis relating to the addressing the gap between calculated and actual building performance.
The tasks are arranged according to the 5 ALDREN stages spanning the full deep renovation process.

Navigating this document:

The document can be navigated using the navigation bar at the top of the page (clicking on a link will take you to the relevant worksheet), or using the links to specific tasks in the "Index" section of the workbook.
This document contains eight worksheets. The purpose of each worksheet is set out below.

Worksheet	Description
Landing page	Introduction to tool, navigation and key definitions
Process schematic	Overview of ALDREN process within task 2.3
1 Decision (Set Requirements)	Pre-renovaton data from the EVC calculation and measured from the existing building for each end use and utility
1. Decision Stage Results	Calculated energy performance gap at the decision stage
2 Develop design	Output from simulation under standard conditions
3 Detailed design	Output from simulation under standard conditions
4 Works	Output from simulation under standard and actual conditions
5 In use	Metered consumption and actual weather data and functional use data of the renovated building
In Use Stage results	Calculated energy performance gap at the in-use stage

Key to cell colour coding:

Input - dropdown	Input cell	Output cell

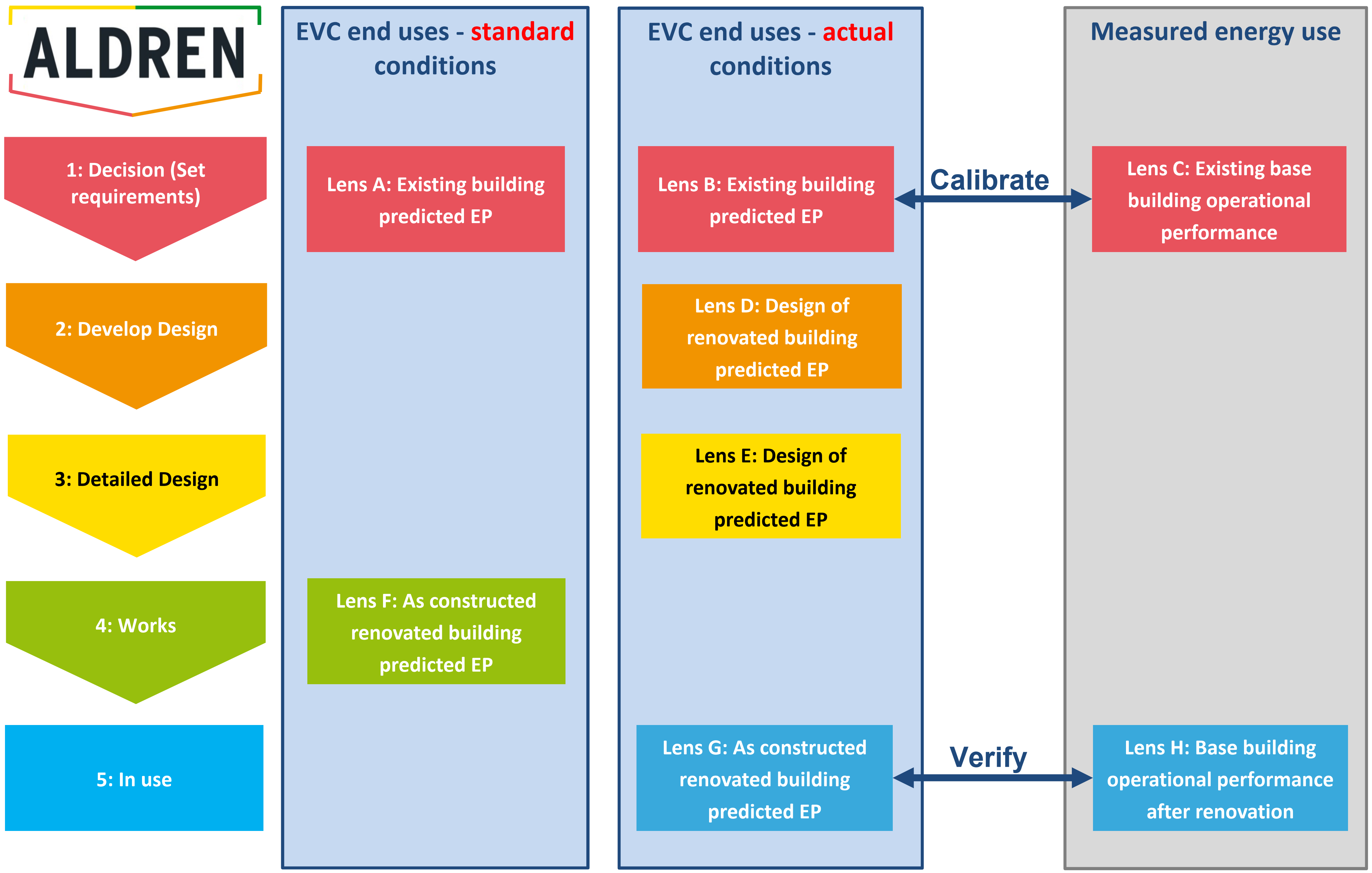
The table below contains a list of key definitions that are useful when using this tool

Term	Definition
Standard conditions	Standard conditions include notional hours of use and averrage annual weather files for a region
Actual conditions	Actual conditions include observed hours of use and real weather files for a particular location that corresponds to measured energy use. Actual conditions also includes the real set points used to manage building services.
Forecast conditions	Forecast conditions include intended hours of use and real weather files for a particular location. Forecast conditions also includes the anticipated set points used to manage building services.
Basic modelling	This type of modelling does not enable all end uses of the building to be modelled. Modelling of some end uses such as HVAC is limited and may not be representative of the HVAC in the actual building.
Advanced modelling	Advanced modelling allows for full dynamic thermal simulations of the building with accurate representation of all end uses including HVAC. This type of modelling also enables actual weather conditions to be imported into the model. Output from this type of modelling can either be
Measured consumption	End use consumption that has been either metered directly or estimated based on power rating and hours of use
Metered consumption	Consumption from individual meters in the real world building
GIA	Gross Internal Floor Area is the area of a building measured to the internal face of the perimeter walls at each floor level
NLA	The Net Lettable Area is the area of a building that may be leased or rented to tenants, it is the area upon which the lease or rental payments are computed. It usually excludes common areas, elevator shafts, stairways, and space devoted to cooling, heating, or other equipment.
Hosting functions	Hosting functions include the core zones of each hotel business, such as guestrooms, halls, offices, reception, service rooms
Non-hosting functions	Non-hosting functions include the additional services offered to guests, highly variable from one hotel to another. These may include spa, swimming pools, gyms and laundry areas.

The relationship between ALDREN stages and the RIBA plan of work is set out below.

RIBA stage #	RIBA stage	ALDREN master stage
0	Strategic Definition	Decision (set requirements)
1	Preparation and Brief	
2	Concept Design	Develop Design
3	Developed Design	
4	Technical Design	Detailed design
5	Construction	Works
6	Handover and Close Out	
7	In Use	In use

KEY ALDREN PROCESSES



ALDREN → ALDREN INTERVENTION → DECISION (SET REQUIREMENTS) → DECISION STAGE RESULTS → DEVELOP DESIGN → DETAILED DESIGN → WORKS → IN USE → IN USE STAGE RESULTS

ALDREN Stage 1: Decision (Set Requirements)

At the Decision stage, calibration of the data model is key to understanding the energy performance of the existing building. In order to do this it is important to consider the consumption of energy end uses from the EVC calculation under both standard and actual conditions. For the means of calibration and understanding of the performance of the pre-renovation buildng, measured energy consumption from the existing building is recorded here. Functional spaces and weather data is also recorded here to provide vital context to the energy consumption data.

General building data

Building general type	Hotel
Gross Internal Area m^2	1000
Hosting functional area (m2)	800
Start month for 1 year tool data period	Jan-17

Pre-retrofit EVC

EVC rating score (calculated using simulation) (kWh/m^2)	35
EVC grade (calculated using simulation)	B

General building information (does not impact the output of the PVT)

Building specific type	Luxury
Level of servicing	Heating
Building ownership	Owner Occupied

Weather data	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17
Actual Heating degree days (HDD)												
Actual Cooling degree days (CDD)												
Actual Global solar radiation												
Standard Heating degree days (HDD)												
Standard Cooling degree days (CDD)												
Standard Global solar radiation												

Table 1: Functional spaces data input

No.	Name	Activity	ıber of occup	Area (m^2)	Source data	Operational Hours of Use hrs./week	Extra hours of service hrs./annum	Voids Weeks/year
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

Table 2: Predicted building level utilities (EVC under STANDARD conditions) (kWh)

Energy	Scope	Quantity	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total

Electricity	Whole building	Electricity imported from grid	56	75	83	82	37	3	96	57	66	53	48	75	731
Electricity	Whole building	Electricity exported to grid	28	26	38	23	18	90	41	48	83	6	16	27	444
Natural gas	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	59	62	15	65	6	15	40	2	85	47	3	35	436
LPG	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	1	25	32	83	98	21	38	14	78	2	63	66	522
Diesel	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	4	12	64	60	32	68	72	78	79	16	90	48	623
Heat	Whole building	District heat import (net)	30	23	74	80	82	60	21	8	94	25	53	29	579
Coolth	Whole building	District coolth import (net)	53	10	84	45	82	99	19	77	4	68	13	63	619
Electricity	Whole building	On site renewables electricity generated	19	15	95	17	60	62	56	1	99	28	68	80	599
Heat	Whole building	On site renewables heat produced	38	29	39	44	82	30	31	39	87	50	61	63	591
Fossil fuel	Whole building	Imported fossil fuel used in CHP	40	14	67	50	21	63	58	76	30	6	44	6	475
Electricity	Whole building	Electricity generated by CHP	84	10	2	80	77	80	58	39	56	65	14	24	590
Heat	Whole building	Useful heat produced by CHP	29	73	49	54	56	7	99	43	42	97	90	32	671

Table 3: Predicted building level utilities under (EVC under ACTUAL conditions) (kWh)

Energy	Scope	Quantity	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Whole building	Electricity imported from grid	79	80	57	97	51	18	67	33	41	13	1	83	620
Electricity	Whole building	Electricity exported to grid	48	100	45	56	3	78	52	25	47	78	69	70	670
Natural gas	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	34	95	6	54	57	78	1	20	75	39	68	28	554
LPG	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	17	63	65	93	58	13	80	55	69	85	16	3	617
Diesel	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	12	75	39	55	21	96	48	97	74	80	90	51	737
Heat	Whole building	District heat import (net)	52	22	33	82	9	64	51	54	75	6	17	19	485
Coolth	Whole building	District coolth import (net)	34	97	57	65	57	89	51	45	10	69	37	72	684
Electricity	Whole building	On site renewables electricity generated	53	98	38	94	17	99	49	63	35	32	79	61	717
Heat	Whole building	On site renewables heat produced	38	50	82	78	96	93	58	100	8	36	79	46	764
Fossil fuel	Whole building	Imported fossil fuel used in CHP	83	82	6	11	2	79	61	49	7	48	65	3	497
Electricity	Whole building	Electricity generated by CHP	85	79	72	12	19	5	50	28	69	23	6	15	464
Heat	Whole building	Useful heat produced by CHP	2	51	66	18	56	22	20	37	19	81	62	24	458

Table 4: Measured building level utilities (kWh)

Energy	Scope	Quantity	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Whole building	Electricity imported from grid	39	14	93	85	84	13	99	57	43	15	30	23	594
Electricity	Whole building	Electricity exported to grid	87	15	51	13	35	22	35	54	8	63	63	81	526
Natural gas	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	57	52	38	5	89	59	25	94	28	34	84	39	604
LPG	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	73	13	2	15	9	34	42	4	75	42	71	69	448
Diesel	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	42	100	48	48	47	88	57	19	49	15	80	94	688
Heat	Whole building	District heat import (net)	36	70	97	62	70	54	87	65	25	50	47	48	712
Coolth	Whole building	District coolth import (net)	21	69	5	16	46	67	91	5	80	40	82	47	569
Electricity	Whole building	On site renewables electricity generated	55	48	98	15	20	29	44	49	57	3	94	81	592
Heat	Whole building	On site renewables heat produced	86	59	80	76	92	26	60	28	85	53	87	45	777
Fossil fuel	Whole building	Imported fossil fuel used in CHP	71	65	43	100	85	57	28	93	31	82	54	55	765
Electricity	Whole building	Electricity generated by CHP	13	43	6	89	36	2	65	31	19	29	63	14	410
Heat	Whole building	Useful heat produced by CHP	97	34	36	65	28	10	53	28	76	38	34	85	584

Table 5: Predicted energy consumption by end use (EVC under STANDARD conditions) (kWh)

Energy	Scope	End use	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Hosting functions	Space Heating	27	38	65	13	61	49	30	8	25	19	3	34	370
Electricity	Hosting functions	Hot water	2	41	96	64	9	81	12	16	10	39	48	43	462
Electricity	Hosting functions	Refrigeration	88	33	50	93	37	35	88	55	97	64	20	78	738
Electricity	Hosting functions	Fans	50	48	87	83	20	86	35	43	29	3	43	49	577
Electricity	Hosting functions	Pumps	57	71	97	61	39	65	14	17	37	83	71	42	653
Electricity	Hosting functions	Controls	57	22	74	62	29	65	85	61	100	19	33	69	674
Electricity	Hosting functions	Humidification	10	11	90	90	79	60	95	70	54	88	74	5	726
Electricity	Hosting functions	Lighting (internal)	29	60	81	98	53	56	69	77	56	6	97	86	769
Electricity	Hosting functions	Plug loads	11	57	51	47	33	80	14	1	98	3	20	80	493
Electricity	Hosting functions	Other	10	41	77	80	61	54	61	70	51	78	4	17	604
Electricity	Whole building	Vertical Transport (lifts & escalators)	19	12	39	44	6	93	70	65	60	63	65	6	543
Electricity	Whole building	Car park ventilation and lighting	23	52	84	10	8	39	95	42	75	17	72	92	608

Electricity	Whole building	Lighting (External)	89	27	91	79	39	39	23	88	69	80	55	88	768
Electricity	Non-hosting	Spa	15	35	91	23	7	44	94	8	33	78	87	57	573
Electricity	N/A	Not in use for Hotels	31	68	60	88	5	38	38	69	75	90	61	44	667
Electricity	Non-hosting	Swimming pool	79	90	3	10	66	84	65	91	47	33	76	88	732
Electricity	Non-hosting	Sauna	4	19	3	81	52	81	22	44	29	30	84	84	535
Electricity	Non-hosting	Gym	91	91	47	99	100	99	12	78	38	53	51	15	773
Electricity	Non-hosting	Kitchen	59	39	46	1	19	21	47	92	22	36	18	61	462
Electricity	Non-hosting	Laundry	80	9	21	27	36	93	42	92	14	94	18	8	533
Electricity	Non-hosting	Other	27	84	40	31	79	97	37	2	82	12	75	97	664
Fossil fuel	Hosting functions	Space Heating	76	34	55	15	29	49	24	56	20	80	81	12	532
Fossil fuel	Hosting functions	Hot water	17	38	17	95	80	69	69	66	84	62	16	27	640
Heat	Hosting functions	Space Heating	74	12	76	49	58	38	3	61	17	63	46	27	524
Coolth	Hosting functions	Space Cooling	90	91	56	94	67	0	3	92	15	91	47	68	714
Heat	Hosting functions	Hot water	83	60	86	6	95	85	95	45	90	23	50	17	735
Fossil fuel	Hosting functions	Other	34	68	70	59	80	6	39	100	93	37	10	42	637
Fossil fuel	Non-hosting	Spa	39	79	57	86	65	36	22	27	67	67	57	86	687
Fossil fuel	Non-hosting	Swimming pool	4	67	70	89	30	74	1	99	54	59	25	61	632
Fossil fuel	Non-hosting	Sauna	18	39	72	8	37	80	26	82	91	55	6	35	550
Fossil fuel	Non-hosting	Gym	6	56	55	50	28	78	7	39	59	2	18	37	434
Fossil fuel	Non-hosting	Kitchen	31	26	36	86	97	51	23	52	91	96	79	25	693
Fossil fuel	Non-hosting	Other	69	44	90	58	8	77	70	76	32	95	90	44	756
Heat	Hosting functions	Other	81	55	9	23	31	26	92	27	52	75	71	5	547
Heat	Hosting functions	Other	41	85	87	81	87	12	27	34	74	73	84	66	752
Heat	Non-hosting	Spa	95	65	62	69	46	75	81	90	77	35	86	62	844
Heat	Non-hosting	Swimming pool	75	92	95	13	31	36	46	89	81	33	44	65	702
Heat	Non-hosting	Sauna	48	32	56	4	8	24	92	6	86	79	51	88	575
Heat	Non-hosting	Gym	3	14	71	62	72	99	94	90	30	93	41	100	767
Heat	Non-hosting	Kitchen	24	10	70	86	52	12	12	50	36	55	57	23	487
Heat	Non-hosting	Laundry	38	22	56	8	38	90	29	58	27	64	83	18	532
Heat	Non-hosting	Other	0	50	48	83	76	60	93	70	23	26	43	53	626
Coolth	Non-hosting	Other	62	56	71	54	62	43	69	43	54	76	81	3	674

Table 6: Predicted energy consumption by end use (EVC under ACTUAL conditions) (kWh)

Energy	Scope	End use	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Hosting functions	Space Heating	66	54	9	28	96	60	66	63	64	10	92	99	706
Electricity	Hosting functions	Hot water	94	48	72	13	23	63	54	30	74	27	55	95	647
Electricity	Hosting functions	Refrigeration	56	11	54	45	23	61	46	74	14	64	0	29	478
Electricity	Hosting functions	Fans	18	99	68	98	38	42	69	47	58	46	36	3	623
Electricity	Hosting functions	Pumps	13	59	65	51	37	30	6	73	16	18	69	42	479
Electricity	Hosting functions	Controls	31	35	32	26	45	83	27	23	49	96	66	41	553
Electricity	Hosting functions	Humidification	23	98	91	3	36	71	16	51	77	58	23	85	632
Electricity	Hosting functions	Lighting (internal)	58	26	77	6	40	11	81	66	26	56	46	41	534
Electricity	Hosting functions	Plug loads	76	90	51	30	24	25	39	41	88	42	34	23	561
Electricity	Hosting functions	Other	72	77	52	12	74	70	7	51	68	69	39	51	643
Electricity	Whole building	Vertical Transport (lifts & escalators)	68	32	63	17	27	65	55	49	87	45	1	91	600
Electricity	Whole building	Car park ventilation and lighting	53	48	39	7	16	41	15	94	100	80	32	33	558
Electricity	Whole building	Lighting (External)	77	18	68	63	36	9	68	85	8	50	44	8	534
Electricity	Non-hosting	Spa	0	35	46	36	77	26	51	3	24	89	98	64	549
Electricity	N/A	Not in use for Hotels	19	36	93	36	11	8	78	100	7	10	97	30	525
Electricity	Non-hosting	Swimming pool	92	97	28	34	39	55	60	27	54	9	13	24	531
Electricity	Non-hosting	Sauna	52	99	20	59	10	27	50	53	93	28	64	89	643
Electricity	Non-hosting	Gym	2	14	86	18	76	11	91	14	88	5	86	93	584
Electricity	Non-hosting	Kitchen	34	65	32	55	73	82	20	35	3	94	65	56	611
Electricity	Non-hosting	Laundry	4	73	20	67	65	27	36	60	99	40	80	92	662
Electricity	Non-hosting	Other	35	80	53	77	25	82	57	59	30	93	21	64	674
Fossil fuel	Hosting functions	Space Heating	46	58	39	22	47	83	38	45	1	65	99	72	613
Fossil fuel	Hosting functions	Hot water	78	99	56	71	53	85	30	70	11	14	61	33	663
Heat	Hosting functions	Space Heating	72	74	6	67	94	70	89	7	86	28	85	79	756
Coolth	Hosting functions	Space Cooling	41	26	40	53	0	21	67	68	75	51	52	52	546
Heat	Hosting functions	Hot water	97	81	61	66	7	69	26	62	84	75	97	31	756
Fossil fuel	Hosting functions	Other	64	42	85	15	92	2	54	13	43	58	95	43	605
Fossil fuel	Non-hosting	Spa	69	63	2	67	60	21	66	62	39	87	75	55	666
Fossil fuel	Non-hosting	Swimming pool	54	27	3	99	45	60	52	88	44	59	63	46	638
Fossil fuel	Non-hosting	Sauna	12	27	94	0	30	75	93	7	66	66	48	46	564
Fossil fuel	Non-hosting	Gym	82	56	73	33	52	66	75	8	59	2	13	99	618

Fossil fuel	Non-hosting	Kitchen	50	48	55	61	56	63	48	85	38	44	41	59	648
Fossil fuel	Non-hosting	Laundry	87	54	70	34	1	60	71	23	44	45	4	66	557
Fossil fuel	Non-hosting	Other	95	9	68	36	30	62	94	62	1	95	79	45	678
Heat	Hosting functions	Other	31	42	59	77	5	24	97	0	98	31	30	61	557
Heat	Non-hosting	Spa	89	98	47	86	2	82	25	16	67	87	83	23	704
Heat	Non-hosting	Swimming pool	28	19	15	46	64	34	98	21	35	40	45	10	455
Heat	Non-hosting	Sauna	15	57	70	73	14	19	100	89	69	51	35	29	621
Heat	Non-hosting	Gym	62	2	53	58	79	13	9	18	4	4	97	22	421
Heat	Non-hosting	Kitchen	90	86	37	88	7	73	79	53	0	76	13	46	648
Heat	Non-hosting	Laundry	15	13	89	7	2	62	54	4	68	21	4	3	342
Heat	Non-hosting	Other	78	86	57	86	3	48	90	7	72	45	75	29	677
Coolth	Non-hosting	Other	31	11	8	89	1	86	1	31	37	72	95	64	527

Table 7: Measured energy consumption by end use (kWh)

Energy	Scope	End use	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Hosting functions	Space Heating	29	82	82	86	36	71	75	22	70	31	42	22	648
Electricity	Hosting functions	Hot water	100	24	92	33	87	20	15	1	62	98	80	75	687
Electricity	Hosting functions	Refrigeration	23	37	85	4	50	94	62	26	95	43	29	32	581
Electricity	Hosting functions	Fans	50	27	51	82	30	21	26	44	73	87	33	58	581
Electricity	Hosting functions	Pumps	57	20	8	96	2	37	69	16	5	96	65	27	498
Electricity	Hosting functions	Controls	59	83	79	34	45	27	31	83	21	29	19	95	604
Electricity	Hosting functions	Humidification	87	90	34	46	17	84	20	8	50	0	9	95	539
Electricity	Hosting functions	Lighting (internal)	55	18	69	28	10	53	42	68	71	84	82	22	604
Electricity	Hosting functions	Plug loads	34	23	7	6	17	92	96	41	91	95	24	33	559
Electricity	Hosting functions	Other	75	14	95	17	83	99	97	78	62	35	45	27	728
Electricity	Whole building	Vertical Transport (lifts & escalators)	29	86	73	43	71	81	63	61	32	16	83	56	695
Electricity	Whole building	Car park ventilation and lighting	33	0	9	14	64	61	30	8	31	32	77	54	413
Electricity	Whole building	Lighting (External)	51	45	26	83	8	78	75	92	71	49	73	18	669
Electricity	Non-hosting	Spa	7	37	58	57	80	62	29	87	25	71	51	19	581
Electricity	N/A	Not in use for Hotels	22	10	67	12	18	36	68	71	79	81	70	62	595
Electricity	Non-hosting	Swimming pool	55	2	81	29	13	28	63	20	84	90	73	87	625
Electricity	Non-hosting	Sauna	60	97	36	37	68	76	3	7	76	93	47	13	612
Electricity	Non-hosting	Gym	15	8	74	22	5	1	34	39	25	10	78	19	331
Electricity	Non-hosting	Kitchen	64	82	44	83	85	27	56	90	4	53	62	11	661
Electricity	Non-hosting	Laundry	96	84	73	1	75	22	48	91	16	89	26	78	699
Electricity	Non-hosting	Other	50	96	98	37	48	13	23	26	45	57	62	63	619
Fossil fuel	Hosting functions	Space Heating	50	31	29	47	41	91	89	4	63	58	80	99	682
Fossil fuel	Hosting functions	Hot water	54	34	54	11	25	18	10	98	18	47	39	99	507
Heat	Hosting functions	Space Heating	37	46	84	98	42	17	65	68	72	5	31	82	648
Coolth	Hosting functions	Space Cooling	55	39	42	16	71	57	83	38	2	40	88	20	552
Heat	Hosting functions	Hot water	65	21	65	48	85	75	38	38	36	19	81	1	571
Fossil fuel	Hosting functions	Other	42	60	76	72	75	16	84	62	2	86	64	44	683
Fossil fuel	Non-hosting	Spa	55	5	37	20	26	11	76	33	88	54	85	85	575
Fossil fuel	Non-hosting	Swimming pool	82	19	80	2	57	9	22	15	77	2	9	72	447
Fossil fuel	Non-hosting	Sauna	6	43	87	85	48	3	69	63	100	48	6	0	558
Fossil fuel	Non-hosting	Gym	8	0	46	41	33	94	75	27	20	82	5	50	480
Fossil fuel	Non-hosting	Kitchen	64	13	14	96	47	13	67	0	88	48	8	10	468
Fossil fuel	Non-hosting	Laundry	22	58	59	44	46	22	39	76	5	99	97	25	592
Fossil fuel	Non-hosting	Other	93	64	27	51	73	99	77	79	7	90	52	50	762
Heat	Hosting functions	Other	64	29	37	32	63	11	100	14	78	77	83	14	601
Heat	Non-hosting	Spa	66	93	30	0	79	29	16	69	9	79	32	54	557
Heat	Non-hosting	Swimming pool	25	44	91	66	79	65	6	1	34	29	64	87	592
Heat	Non-hosting	Sauna	6	49	22	51	50	94	60	64	4	83	23	59	565
Heat	Non-hosting	Gym	40	18	73	73	17	54	63	11	38	39	3	4	433
Heat	Non-hosting	Kitchen	6	54	41	96	12	91	81	11	89	63	37	13	594
Heat	Non-hosting	Laundry	63	47	67	78	79	72	81	55	50	73	55	39	759
Heat	Non-hosting	Other	79	12	29	23	8	81	52	51	82	70	20	35	542
Coolth	Non-hosting	Other	50	43	14	63	68	10	77	52	20	22	6	12	436

ALDREN Decision stage results

The decision stage results includes a comparison of the decision measured consumption in the renovated building against the final design consumption under actual conditions.
These can be viewed at utility level or at end-use level on an annual or monthly basis.

Table 8: Annual total building level consumption (Predicted and Measured)

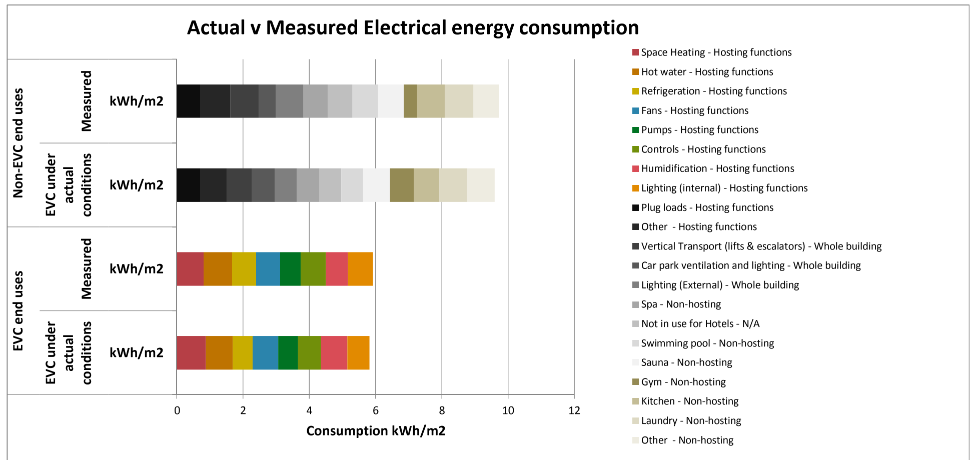
			EVC under standard conditions	EVC under actual conditions	Measured	EVC under standard conditions	EVC under actual conditions	Measured	Variance EVC under actual vs. measured	Variance EVC under actual vs. measured
Energy	**Scope**	**Quantitiy**	**kWh**	**kWh**	**kWh**	**kWh/m^2**	**kWh/m^2**	**kWh/m^2**	**kWh/m^2**	**%**
Electricity	Whole building	Electricity imported from grid	620	620	594	0.8	0.8	0.7	0.0	-4%
Electricity	Whole building	Electricity exported to grid	670	670	526	0.8	0.8	0.7	-0.2	-27%
Natural gas	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	554	554	604	0.7	0.7	0.8	0.1	8%
LPG	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	617	617	448	0.8	0.8	0.6	-0.2	-38%
Diesel	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	737	737	688	0.9	0.9	0.9	-0.1	-7%
Heat	Whole building	District heat import (net)	485	485	712	0.6	0.6	0.9	0.3	32%
Coolth	Whole building	District coolth import (net)	684	684	569	0.9	0.9	0.7	-0.1	-20%
Electricity	Whole building	On site renewables electricity generated	717	717	592	0.9	0.9	0.7	-0.2	-21%
Heat	Whole building	On site renewables heat produced	764	764	777	1.0	1.0	1.0	0.0	2%
Fossil fuel	Whole building	Imported fossil fuel used in CHP	497	497	765	0.6	0.6	1.0	0.3	35%
Electricity	Whole building	Electricity generated by CHP	464	464	410	0.6	0.6	0.5	-0.1	-13%
Heat	Whole building	Useful heat produced by CHP	458	458	584	0.6	0.6	0.7	0.2	22%

Variance to calculated energy performance

Above 100%
+50% to 100%
+25% to 50%
+10% to 25%
+/- 10%
-10% to -25%
-25% to -50%
-50% to -100
Below -100%

Table 9: Annual total end-use consumption (Predicted and Measured)

			EVC under standard conditions	EVC under actual conditions	Measured	EVC under standard conditions	EVC under actual conditions	Measured	Variance EVC under actual vs. measured	Variance EVC under actual vs. measured
Energy	**Scope**	**End use**	**kWh**	**kWh**	**kWh**	**kWh/m^2**	**kWh/m^2**	**kWh/m^2**	**kWh/m^2**	**%**
Electricity	Hosting functions	Space Heating	706	706	648	0.9	0.9	0.8	-0.1	-9%
Electricity	Hosting functions	Hot water	647	647	687	0.8	0.8	0.9	0.1	6%
Electricity	Hosting functions	Refrigeration	478	478	581	0.6	0.6	0.7	0.1	18%
Electricity	Hosting functions	Fans	623	623	581	0.8	0.8	0.7	-0.1	-7%
Electricity	Hosting functions	Pumps	479	479	498	0.6	0.6	0.6	0.0	4%
Electricity	Hosting functions	Controls	553	553	604	0.7	0.7	0.8	0.1	9%
Electricity	Hosting functions	Humidification	632	632	539	0.8	0.8	0.7	-0.1	-17%
Electricity	Hosting functions	Lighting (internal)	534	534	604	0.7	0.7	0.8	0.1	12%
Electricity	Hosting functions	Plug loads	561	561	559	0.7	0.7	0.7	0.0	0%
Electricity	Hosting functions	Other	643	643	728	0.8	0.8	0.9	0.1	12%
Electricity	Whole building	Vertical Transport (lifts & escalators)	600	600	695	0.8	0.8	0.9	0.1	14%
Electricity	Whole building	Car park ventilation and lighting	558	558	413	0.7	0.7	0.5	-0.2	-35%
Electricity	Whole building	Lighting (External)	534	534	669	0.7	0.7	0.8	0.2	20%
Electricity	Non-hosting	Spa	549	549	581	0.7	0.7	0.7	0.0	6%
Electricity	N/A	Not in use for Hotels	525	525	595	0.7	0.7	0.7	0.1	12%
Electricity	Non-hosting	Swimming pool	531	531	625	0.7	0.7	0.8	0.1	15%
Electricity	Non-hosting	Sauna	643	643	612	0.8	0.8	0.8	0.0	-5%
Electricity	Non-hosting	Gym	584	584	331	0.7	0.7	0.4	-0.3	-77%
Electricity	Non-hosting	Kitchen	611	611	661	0.8	0.8	0.8	0.1	8%
Electricity	Non-hosting	Laundry	662	662	699	0.8	0.8	0.9	0.0	5%
Electricity	Non-hosting	Other	674	674	619	0.8	0.8	0.8	-0.1	-9%
Fossil fuel	Hosting functions	Space Heating	613	613	682	0.8	0.8	0.9	0.1	10%
Fossil fuel	Hosting functions	Hot water	663	663	507	0.8	0.8	0.6	-0.2	-31%
Heat	Hosting functions	Space Heating	756	756	648	0.9	0.9	0.8	-0.1	-17%
Coolth	Hosting functions	Space Cooling	546	546	552	0.7	0.7	0.7	0.0	1%
Heat	Hosting functions	Hot water	756	756	571	0.9	0.9	0.7	-0.2	-32%
Fossil fuel	Hosting functions	Other	605	605	683	0.8	0.8	0.9	0.1	11%
Fossil fuel	Non-hosting	Spa	666	666	575	0.8	0.8	0.7	-0.1	-16%
Fossil fuel	Non-hosting	Swimming pool	638	638	447	0.8	0.8	0.6	-0.2	-43%
Fossil fuel	Non-hosting	Sauna	564	564	558	0.7	0.7	0.7	0.0	-1%
Fossil fuel	Non-hosting	Gym	618	618	480	0.8	0.8	0.6	-0.2	-29%
Fossil fuel	Non-hosting	Kitchen	648	648	468	0.8	0.8	0.6	-0.2	-38%
Fossil fuel	Non-hosting	Laundry	557	557	592	0.7	0.7	0.7	0.0	6%
Fossil fuel	Non-hosting	Other	678	678	762	0.8	0.8	1.0	0.1	11%
Heat	Hosting functions	Other	557	557	601	0.7	0.7	0.8	0.1	7%
Heat	Non-hosting	Spa	704	704	557	0.9	0.9	0.7	-0.2	-27%
Heat	Non-hosting	Swimming pool	455	455	592	0.6	0.6	0.7	0.2	23%
Heat	Non-hosting	Sauna	621	621	565	0.8	0.8	0.7	-0.1	-10%
Heat	Non-hosting	Gym	421	421	433	0.5	0.5	0.5	0.0	3%
Heat	Non-hosting	Kitchen	648	648	594	0.8	0.8	0.7	-0.1	-9%
Heat	Non-hosting	Laundry	342	342	759	0.4	0.4	0.9	0.5	55%
Heat	Non-hosting	Other	677	677	542	0.8	0.8	0.7	-0.2	-25%
Coolth	Non-hosting	Other	527	527	436	0.7	0.7	0.5	-0.1	-21%



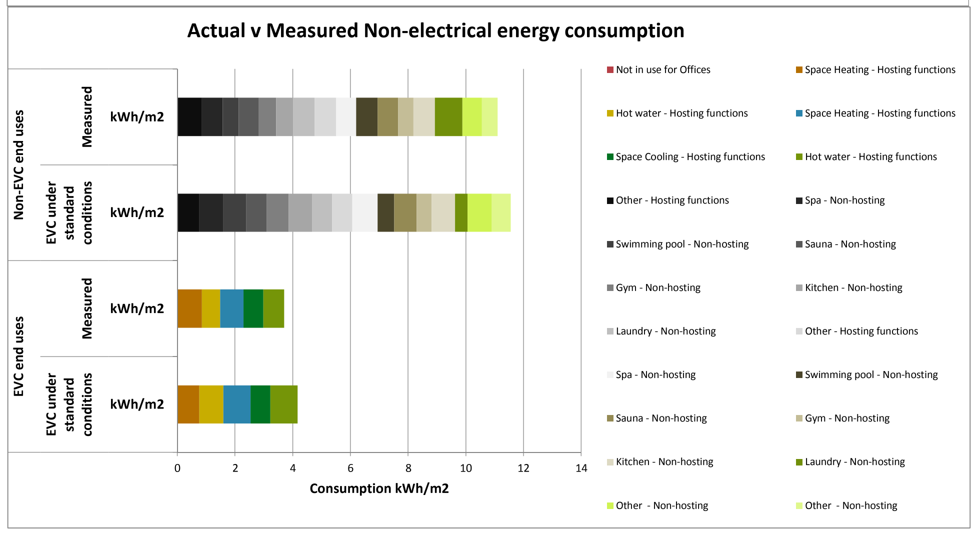


Table 10: Monthly variance between predicted energy consumption using EVC under ACTUAL conditions and measured consumption

Energy	Scope	End use	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Co-efficient of variance	Comments on deviation between Actual conditions simulation and measured performance
Electricity	Hosting functions	Space Heating	128%	-34%	-90%	-68%	164%	-16%	-12%	194%	-8%	-69%	121%	341%	#REF!	
Electricity	Hosting functions	Hot water	-5%	100%	-22%	-60%	-74%	221%	256%	2120%	19%	-73%	-31%	25%	#REF!	
Electricity	Hosting functions	Refrigeration	144%	-71%	-37%	1064%	-54%	-35%	-25%	186%	-86%	50%	-99%	-10%	#REF!	
Electricity	Hosting functions	Fans	-64%	268%	33%	20%	25%	106%	169%	8%	-21%	-47%	11%	-96%	#REF!	
Electricity	Hosting functions	Pumps	-78%	189%	735%	-47%	1964%	-19%	-91%	352%	244%	-81%	6%	58%	#REF!	
Electricity	Hosting functions	Controls	-48%	-58%	-60%	-24%	0%	211%	-12%	-72%	136%	232%	242%	-57%	#REF!	
Electricity	Hosting functions	Humidification	-74%	10%	168%	-94%	113%	-16%	-19%	509%	55%	50195%	162%	-11%	#REF!	
Electricity	Hosting functions	Lighting (internal)	6%	45%	12%	-79%	281%	-80%	94%	-3%	-64%	-33%	-44%	86%	#REF!	
Electricity	Hosting functions	Plug loads	123%	298%	627%	398%	37%	-73%	-60%	2%	-4%	-56%	41%	-31%	#REF!	
Electricity	Hosting functions	Other	-4%	459%	-45%	-32%	-11%	-29%	-93%	-35%	10%	97%	-12%	89%	#REF!	
Electricity	Whole building	Vertical Transport (lifts & escalators)	133%	-63%	-14%	-61%	-62%	-19%	-13%	-20%	170%	188%	-99%	62%	#REF!	
Electricity	Whole building	Car park ventilation and lighting	64%	33323%	354%	-54%	-75%	-32%	-50%	1069%	224%	148%	-59%	-38%	#REF!	
Electricity	Whole building	Lighting (External)	51%	-60%	167%	-23%	335%	-88%	-9%	-8%	-89%	3%	-39%	-57%	#REF!	

Electricity	Non-hosting	Spa	-96%	-5%	-22%	-37%	-3%	-58%	77%	-96%	-3%	26%	93%	229%	#REF!	
Electricity	N/A	Not in use for Hotels	-13%	276%	40%	204%	-38%	-77%	14%	39%	-91%	-88%	39%	-52%	#REF!	
Electricity	Non-hosting	Swimming pool	66%	4248%	-65%	18%	201%	98%	-4%	34%	-35%	-90%	-82%	-72%	#REF!	
Electricity	Non-hosting	Sauna	-14%	2%	-43%	57%	-86%	-64%	1468%	607%	23%	-70%	37%	593%	#REF!	
Electricity	Non-hosting	Gym	-88%	78%	16%	-19%	1332%	650%	169%	-65%	254%	-46%	10%	384%	#REF!	
Electricity	Non-hosting	Kitchen	-47%	-21%	-27%	-34%	-14%	201%	-65%	-61%	-36%	76%	4%	422%	#REF!	
Electricity	Non-hosting	Laundry	-96%	-14%	-73%	10200%	-13%	27%	-26%	-34%	505%	-55%	213%	18%	#REF!	
Electricity	Non-hosting	Other	-31%	-17%	-46%	108%	-47%	552%	144%	127%	-34%	63%	-67%	1%	#REF!	
Fossil fuel	Hosting functions	Space Heating	-8%	89%	35%	-53%	13%	-9%	-58%	926%	-98%	12%	24%	-27%	#REF!	
Fossil fuel	Hosting functions	Hot water	44%	196%	4%	544%	111%	366%	192%	-28%	-36%	-70%	53%	-66%	#REF!	
Heat	Hosting functions	Space Heating	94%	60%	-93%	-32%	124%	301%	37%	-90%	20%	497%	175%	-4%	#REF!	
Coolth	Hosting functions	Space Cooling	-26%	-32%	-5%	223%	-100%	-63%	-20%	78%	3040%	27%	-42%	154%	#REF!	
Heat	Hosting functions	Hot water	50%	292%	-6%	36%	-92%	-8%	-31%	66%	135%	288%	19%	3015%	#REF!	
Fossil fuel	Hosting functions	Other	53%	-30%	12%	-79%	22%	-87%	-35%	-80%	1788%	-33%	48%	-2%	#REF!	
Fossil fuel	Non-hosting	Spa	26%	1272%	-94%	234%	134%	100%	-14%	91%	-56%	61%	-13%	-35%	#REF!	
Fossil fuel	Non-hosting	Swimming pool	-35%	38%	-96%	4097%	-21%	581%	129%	492%	-44%	3305%	636%	-36%	#REF!	
Fossil fuel	Non-hosting	Sauna	91%	-37%	8%	-100%	-38%	2290%	35%	-89%	-34%	38%	682%	9301%	#REF!	
Fossil fuel	Non-hosting	Gym	934%	32372%	60%	-19%	59%	-30%	0%	-70%	190%	-98%	166%	100%	#REF!	
Fossil fuel	Non-hosting	Kitchen	-23%	283%	302%	-36%	18%	374%	-28%	100403%	-57%	-8%	393%	493%	#REF!	
Fossil fuel	Non-hosting	Laundry	304%	-7%	18%	-23%	-99%	178%	83%	-70%	750%	-55%	-96%	163%	#REF!	
Fossil fuel	Non-hosting	Other	2%	-85%	155%	-29%	-58%	-38%	22%	-21%	-79%	5%	52%	-10%	#REF!	
Heat	Hosting functions	Other	-52%	49%	60%	140%	-91%	109%	-3%	-100%	26%	-60%	-64%	351%	#REF!	
Heat	Non-hosting	Spa	35%	5%	56%	17205%	-98%	183%	57%	-77%	607%	10%	163%	-58%	#REF!	
Heat	Non-hosting	Swimming pool	12%	-56%	-84%	-30%	-19%	-47%	1406%	1342%	3%	39%	-30%	-88%	#REF!	
Heat	Non-hosting	Sauna	137%	17%	211%	43%	-73%	-80%	68%	39%	1674%	-38%	55%	-50%	#REF!	
Heat	Non-hosting	Gym	56%	-88%	-28%	-21%	362%	-76%	-86%	58%	-91%	-89%	3576%	419%	#REF!	
Heat	Non-hosting	Kitchen	1357%	58%	-9%	-9%	-41%	-20%	-3%	398%	-100%	20%	-65%	255%	#REF!	
Heat	Non-hosting	Laundry	-76%	-73%	33%	-92%	-97%	-14%	-34%	-92%	35%	-72%	-93%	-92%	#REF!	
Heat	Non-hosting	Other	-1%	632%	94%	273%	-61%	-41%	73%	-87%	-12%	-36%	279%	-15%	#REF!	
Coolth	Non-hosting	Other	-38%	-73%	-45%	41%	-99%	780%	-99%	-40%	91%	233%	1503%	451%	#REF!	

ALDREN | ALDREN INTERVENTION | DECISION (SET REQUIREMENTS) | DECISION STAGE RESULTS | DEVELOP DESIGN | DETAILED DESIGN | WORKS | IN USE | IN USE STAGE RESULTS

ALDREN Stage 2: Develop Design (data entry optional)

These tables allow the building's consumption under forecast conditions to be entered at an early stage of design, using either the EVC calculation or advanced simulation.

Simulation start month	Jan-17

Table 11: Predicted building level utilities (EVC under FORECAST conditions) (kWh)

Energy	Scope	Quantity	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Whole building	Electricity imported from grid	13	20	86	95	84	10	8	61	40	93	54	12	578
Electricity	Whole building	Electricity exported to grid	72	1	61	2	6	67	1	80	54	95	91	91	621
Natural gas	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	1	46	20	5	99	53	48	30	91	6	26	76	500
LPG	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	75	22	90	98	8	28	86	94	45	68	38	44	696
Diesel	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	17	50	86	64	22	87	43	54	73	64	65	0	625
Heat	Whole building	District heat import (net)	6	6	44	24	65	90	95	84	28	7	94	19	562
Coolth	Whole building	District coolth import (net)	79	61	1	36	15	85	76	62	83	25	41	75	638
Electricity	Whole building	On site renewables electricity generated	82	30	61	26	42	90	36	36	26	80	54	53	617
Heat	Whole building	On site renewables heat produced	69	7	35	41	55	94	97	60	94	74	29	45	700
Fossil fuel	Whole building	Imported fossil fuel used in CHP	29	79	91	62	17	64	4	3	5	4	27	87	471
Electricity	Whole building	Electricity generated by CHP	32	94	83	20	46	28	90	40	42	54	52	36	618
Heat	Whole building	Useful heat produced by CHP	33	23	94	19	14	5	11	8	5	54	92	39	399

Table 12: Predicted energy consumption by end use (EVC under FORECAST conditions) (kWh)

Energy	Scope	End use	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Hosting functions	Space Heating	1,358,721	1,323,968	1,385,914	1,299,831	1,303,321	1,288,266	1,324,182	1,367,500	1,320,499	1,327,109	1,329,465	1,252,435	15,881,212
Electricity	Hosting functions	Hot water	649,615	614,320	649,864	590,440	580,799	582,364	608,848	635,156	583,846	552,713	534,578	497,883	7,080,428
Electricity	Hosting functions	Refrigeration	64,924	69,721	69,951	69,304	69,750	69,841	64,730	62,620	59,135	61,536	63,152	62,069	786,733
Electricity	Hosting functions	Fans	117,403	122,131	130,257	119,927	128,993	141,220	130,593	129,803	126,702	137,778	125,634	126,467	1,536,909
Electricity	Hosting functions	Pumps	1,918	2,082	1,927	1,795	1,834	1,792	1,917	2,006	2,101	2,305	2,157	2,203	24,038
Electricity	Hosting functions	Controls	5,254	5,498	5,907	5,666	5,543	5,545	5,133	4,811	4,570	4,875	4,996	4,838	62,637
Electricity	Hosting functions	Humidification	6,165	6,542	6,831	6,585	6,909	6,545	6,877	6,607	6,206	6,547	7,042	7,487	80,342
Electricity	Hosting functions	Lighting (internal)	1,980	2,156	1,972	2,094	1,967	2,049	2,012	2,051	1,874	2,018	1,826	1,704	23,704
Electricity	Hosting functions	Plug loads	744	801	804	826	887	850	899	835	760	803	882	954	10,043
Electricity	Hosting functions	Other	2,084	2,136	2,138	2,349	2,561	2,449	2,558	2,484	2,366	2,553	2,609	2,441	28,726
Electricity	Whole building	Vertical Transport (lifts & escalators)	282,179	277,920	285,277	284,207	286,859	260,899	279,918	293,209	312,856	334,798	365,011	337,650	3,600,783
Electricity	Whole building	Car park ventilation and lighting	156,544	167,533	171,472	180,363	193,909	197,864	214,841	206,389	214,753	202,556	192,462	209,237	2,307,923
Electricity	Whole building	Lighting (External)	279,740	295,452	298,399	310,841	328,385	298,479	316,129	324,504	315,714	320,443	304,921	334,520	3,727,527
Electricity	Non-hosting	Spa	199,030	188,653	200,372	188,131	178,463	182,193	181,833	164,722	150,051	139,422	131,422	132,669	2,036,961
Electricity	N/A	Not in use for Hotels	92,258	89,786	87,747	86,843	79,109	75,481	79,850	86,758	94,319	89,701	96,292	95,947	1,054,092
Electricity	Non-hosting	Swimming pool	357,030	347,866	323,147	305,769	328,448	306,433	334,808	308,084	291,223	303,595	285,898	263,474	3,755,774
Electricity	Non-hosting	Sauna	24,784	25,520	23,033	22,188	21,011	22,544	22,262	22,575	20,794	22,220	20,900	22,107	269,937
Electricity	Non-hosting	Gym	413,963	399,665	433,964	464,933	448,913	466,204	487,358	483,542	522,750	480,984	455,161	481,960	5,539,396
Electricity	Non-hosting	Kitchen	82,550	79,291	84,997	93,448	87,606	82,529	85,583	80,249	76,795	76,389	73,459	80,646	983,542
Electricity	Non-hosting	Laundry	220,606	213,806	212,974	224,407	246,109	227,038	213,484	207,412	227,510	206,327	212,495	209,323	2,621,493
Electricity	Non-hosting	Other	25,594	25,458	24,625	24,426	22,505	23,927	24,154	25,344	25,063	24,725	26,289	27,120	299,231
Fossil fuel	Hosting functions	Space Heating	64,407	60,514	59,844	64,606	59,298	57,674	62,224	57,108	59,391	63,026	60,861	58,779	727,732
Fossil fuel	Hosting functions	Hot water	465,568	477,131	503,418	522,318	549,736	520,635	520,015	563,657	524,126	546,238	499,474	506,271	6,198,589
Heat	Hosting functions	Space Heating	208,668	217,367	210,888	229,920	232,750	218,903	238,479	247,216	231,327	228,843	248,957	263,384	2,776,703
Coolth	Hosting functions	Space Cooling	219,326	237,367	217,771	205,301	215,404	229,781	215,317	214,607	202,205	198,683	184,795	177,289	2,517,845
Heat	Hosting functions	Hot water	395,715	427,244	448,469	426,129	399,152	383,177	409,432	397,440	434,573	451,550	427,473	442,067	5,042,420
Fossil fuel	Hosting functions	Other	100,732	90,941	91,560	100,239	96,227	99,612	94,500	90,375	86,792	91,343	95,268	86,240	1,123,829
Fossil fuel	Non-hosting	Spa	280,210	270,886	245,169	244,265	244,262	227,203	218,836	227,487	237,498	256,773	270,869	251,289	2,974,748
Fossil fuel	Non-hosting	Swimming pool	444,426	418,768	419,231	435,032	410,464	447,506	461,102	442,344	465,165	436,888	421,474	418,093	5,220,494
Fossil fuel	Non-hosting	Sauna	203,419	221,881	210,159	224,417	228,889	214,933	215,452	225,277	213,995	202,531	203,594	216,808	2,581,355
Fossil fuel	Non-hosting	Gym	85,358	79,724	84,509	88,025	95,908	88,192	86,437	88,947	83,426	79,731	81,451	80,562	1,022,270
Fossil fuel	Non-hosting	Kitchen	159,560	162,043	155,057	161,876	147,854	149,138	147,451	138,446	125,067	123,699	119,939	123,964	1,714,092
Fossil fuel	Non-hosting	Laundry	342,956	375,222	377,256	398,301	377,447	411,498	402,180	377,711	401,268	433,094	472,257	483,992	4,853,183
Fossil fuel	Non-hosting	Other	287,298	270,373	290,775	300,285	325,809	326,319	339,123	369,025	357,721	379,649	414,534	436,996	4,097,905
Heat	Hosting functions	Other	229,873	232,061	214,475	205,345	212,985	214,074	203,468	200,087	216,629	229,178	250,445	236,708	2,645,330
Heat	Non-hosting	Spa	264,897	241,823	217,879	226,788	247,792	267,537	292,824	303,466	275,544	284,452	293,738	298,552	3,215,293
Heat	Non-hosting	Swimming pool	492,873	489,930	507,467	494,930	490,443	480,403	441,291	447,772	422,338	416,318	394,432	425,918	5,504,115
Heat	Non-hosting	Sauna	182,370	182,855	201,081	201,346	200,728	186,826	181,536	177,065	180,604	172,094	188,014	189,890	2,244,410

Heat	Non-hosting	Gym	247,537	242,491	258,807	251,850	256,010	266,866	250,762	249,163	226,979	205,231	217,427	223,425	2,896,548
Heat	Non-hosting	Kitchen	297,607	322,229	314,628	328,602	349,132	354,583	364,043	334,121	350,075	379,432	341,523	365,800	4,101,775
Heat	Non-hosting	Laundry	455,815	458,522	468,937	495,513	501,947	471,211	484,700	521,096	510,978	507,489	524,927	506,226	5,907,359
Heat	Non-hosting	Other	49,005	48,515	49,014	47,011	43,411	45,371	43,721	42,331	38,903	42,016	46,129	47,997	543,425
Coolth	Non-hosting	Other	403,903	423,819	432,125	400,838	400,096	372,130	342,928	351,425	357,922	391,025	362,159	367,740	4,606,108

Table 13: Predicted building level utilities - (Advanced simulation under FORECAST conditions) (kWh)

Energy	Scope	Quantity	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Non-hosting	Sauna	46	9	88	1	51	70	55	32	46	8	46	11	463
Electricity	Non-hosting	Gym	56	0	33	29	25	2	23	56	49	54	89	74	490
Electricity	Non-hosting	Kitchen	32	31	83	75	20	33	31	49	33	2	85	85	558
Electricity	Non-hosting	Laundry	9	1	14	5	47	18	71	69	4	68	3	27	336
Electricity	Non-hosting	Other	31	60	28	93	42	68	72	52	61	86	26	38	657
Fossil fuel	Hosting functions	Space Heating	49	59	20	53	6	79	98	54	22	89	20	12	560
Fossil fuel	Hosting functions	Hot water	13	77	6	59	76	55	1	78	47	85	7	45	549
Fossil fuel	Hosting functions	Other	9	95	32	44	61	10	4	3	38	76	10	77	458
Fossil fuel	Non-hosting	Spa	48	26	97	64	86	41	59	97	43	53	0	8	622
Fossil fuel	Non-hosting	Swimming pool	97	93	14	8	59	94	66	78	74	76	74	87	819
Fossil fuel	Non-hosting	Sauna	68	67	70	80	5	69	37	23	34	53	82	37	625
Fossil fuel	Non-hosting	Gym	80	18	75	66	2	15	19	59	85	78	39	90	626

Table 14: Predicted energy consumption by end use (Advanced simulation under FORECAST conditions)

Energy	Scope	End use	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Hosting functions	Space Heating	2,012,350	1,962,584	1,887,437	2,034,477	1,986,382	1,992,635	1,968,705	1,998,338	2,080,270	2,023,660	1,995,248	2,061,206	24,003,292
Electricity	Hosting functions	Hot water	908,655	834,100	805,290	880,749	816,625	791,264	789,612	845,398	908,039	861,954	849,528	928,211	10,219,425
Electricity	Hosting functions	Refrigeration	98,743	95,118	88,616	81,859	82,842	88,947	91,341	85,365	88,473	80,938	86,479	82,308	1,051,027
Electricity	Hosting functions	Fans	293,770	318,694	296,517	320,125	325,243	318,591	290,010	293,338	280,580	291,689	303,342	280,364	3,612,263
Electricity	Hosting functions	Pumps	8,509	9,328	8,527	8,262	8,475	9,213	8,937	8,595	8,387	8,010	8,084	8,352	102,677
Electricity	Hosting functions	Controls	1,764	1,887	1,910	1,884	2,041	2,112	2,192	2,335	2,132	1,995	2,173	2,113	24,540
Electricity	Hosting functions	Humidification	3,465	3,377	3,692	3,403	3,236	3,137	2,969	2,969	3,196	2,992	3,191	2,879	38,507
Electricity	Hosting functions	Lighting (internal)	6,068	5,559	5,049	4,932	4,973	4,877	5,268	5,290	5,542	5,325	4,808	4,524	62,215
Electricity	Hosting functions	Plug loads	1,330	1,308	1,349	1,244	1,136	1,184	1,289	1,365	1,302	1,298	1,287	1,261	15,354
Electricity	Hosting functions	Other	9,408	9,438	8,496	7,845	8,204	8,433	8,236	8,087	7,326	7,102	7,147	7,605	97,328
Electricity	Whole building	Vertical Transport (lifts & escalators)	107,022	107,833	109,127	119,943	112,220	113,825	106,029	98,618	108,010	106,160	100,419	94,353	1,283,558
Electricity	Whole building	Car park ventilation and lighting	238,223	248,845	244,293	265,150	290,323	318,946	334,706	313,922	320,573	318,919	296,250	305,700	3,495,850
Electricity	Whole building	Lighting (External)	420,924	441,843	475,042	457,840	455,612	466,539	465,878	499,299	522,664	516,653	533,884	510,079	5,766,259
Electricity	Non-hosting	Spa	156,003	146,108	131,536	138,040	132,349	137,801	132,426	124,124	134,062	127,828	122,857	129,304	1,612,438
Electricity	N/A	Not in use for Hotels	155,374	146,770	134,951	122,291	131,679	125,697	131,332	142,347	139,295	125,890	137,265	143,867	1,636,758
Electricity	Non-hosting	Swimming pool	311,560	325,930	341,411	364,562	358,398	370,701	371,195	394,472	397,127	413,235	409,349	418,841	4,476,780
Electricity	Non-hosting	Sauna	330,029	346,843	354,336	320,281	316,828	311,000	293,331	264,649	248,005	247,340	268,277	272,167	3,573,085
Electricity	Non-hosting	Gym	303,053	283,268	296,726	279,938	298,805	322,077	340,505	320,153	321,597	333,566	314,874	301,096	3,715,659
Electricity	Non-hosting	Kitchen	311,195	287,281	305,476	315,629	330,413	318,956	339,842	373,015	351,219	358,756	383,978	390,307	4,066,066
Electricity	Non-hosting	Laundry	146,564	140,980	131,976	142,443	137,679	136,033	124,744	125,406	123,086	123,305	127,034	134,521	1,593,769
Electricity	Non-hosting	Other	305,020	328,091	308,676	290,145	265,276	267,128	283,136	299,017	287,786	284,186	294,291	278,196	3,490,948
Fossil fuel	Hosting functions	Space Heating	455,247	410,698	448,407	454,254	426,370	402,934	398,758	422,393	418,847	394,210	391,980	393,038	5,017,135
Fossil fuel	Hosting functions	Hot water	333,570	334,789	321,559	297,299	325,971	329,187	332,184	346,513	363,108	334,522	303,889	315,329	3,937,921
Heat	Hosting functions	Space Heating	351,033	378,433	376,195	385,508	417,043	413,666	375,472	338,485	365,440	349,998	360,009	325,242	4,436,523
Coolth	Hosting functions	Space Cooling	45,344	46,964	43,978	43,772	42,537	38,567	41,834	41,540	40,565	44,614	47,051	47,159	523,925
Heat	Hosting functions	Hot water	376,162	390,955	422,434	417,335	391,933	412,375	429,149	449,466	474,949	471,196	497,259	489,290	5,222,503
Fossil fuel	Hosting functions	Other	138,941	126,223	119,410	126,630	135,472	133,261	122,021	133,250	120,574	124,800	118,772	119,707	1,519,061
Fossil fuel	Non-hosting	Spa	169,067	176,214	167,438	168,038	166,464	173,542	171,739	187,512	178,806	163,194	154,741	168,224	2,044,980
Fossil fuel	Non-hosting	Swimming pool	373,805	373,967	341,041	344,884	363,896	339,264	317,838	334,400	343,550	312,613	295,477	320,015	4,060,750
Fossil fuel	Non-hosting	Sauna	276,131	285,592	260,075	261,009	270,497	286,152	281,360	268,709	258,899	250,166	253,704	231,719	3,184,012
Fossil fuel	Non-hosting	Gym	287,475	289,004	289,804	317,197	347,629	351,520	359,320	373,643	346,782	345,529	360,816	347,506	4,016,225
Fossil fuel	Non-hosting	Kitchen	123,168	126,430	126,200	131,016	132,454	130,261	122,286	110,349	117,853	127,501	134,623	134,098	1,516,238
Fossil fuel	Non-hosting	Laundry	169,510	156,604	158,521	170,302	174,356	185,607	202,703	191,598	186,081	170,886	162,937	146,665	2,075,768
Fossil fuel	Non-hosting	Other	83,589	81,666	77,151	83,371	79,545	79,387	73,582	73,196	70,623	66,366	70,938	71,311	910,723
Heat	Hosting functions	Other	358,847	375,757	342,895	338,284	327,949	318,938	300,495	311,136	291,621	300,735	320,500	304,711	3,891,868
Heat	Non-hosting	Spa	149,594	151,730	140,020	143,586	137,749	137,899	130,485	130,868	130,283	129,707	128,469	127,657	1,638,046
Heat	Non-hosting	Swimming pool	291,807	270,419	286,180	295,338	298,657	283,357	291,066	305,684	319,084	308,607	313,938	323,235	3,587,372
Heat	Non-hosting	Sauna	40,989	38,216	40,257	36,742	34,829	34,169	31,939	33,370	31,882	29,468	30,661	31,552	414,072
Heat	Non-hosting	Gym	214,786	222,513	212,884	212,322	192,222	179,564	166,963	160,747	165,319	156,721	155,499	150,584	2,190,125
Heat	Non-hosting	Kitchen	479,030	521,100	478,400	448,529	448,997	475,284	509,591	479,939	463,352	452,540	428,919	458,798	5,644,479
Heat	Non-hosting	Laundry	325,076	308,935	329,901	330,726	313,239	344,277	312,266	342,021	332,357	364,579	376,806	393,415	4,073,599
Heat	Non-hosting	Other	100,997	107,021	108,097	104,332	110,096	120,664	128,387	131,157	128,269	132,120	136,824	144,832	1,452,796
Coolth	Non-hosting	Other	298,316	275,481	249,265	246,386	235,477	213,823	233,424	221,468	207,438	228,117	238,783	248,645	2,896,624

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ALDREN Stage 3: Detailed Design (data entry optional)

These tables allow the building's consumption under forecast conditions to be entered at a more developed stage of design, using either the EVC calculation or advanced simulation.

Simulation start month	Jan-17

Table 15: Predicted building level utilities (EVC under FORECAST conditions) (kWh)

Energy	Scope	Quantity	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Whole building	Electricity imported from grid	93	21	52	67	89	95	42	6	25	28	52	1	572
Electricity	Whole building	Electricity exported to grid	3	57	78	99	74	7	29	48	89	6	15	80	584
Natural gas	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	3	97	61	43	72	52	49	42	71	87	45	33	654
LPG	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	26	20	63	44	96	20	96	6	0	9	13	15	410
Diesel	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	5	27	95	74	47	58	66	12	81	87	17	16	586
Heat	Whole building	District heat import (net)	24	45	57	95	71	59	20	100	88	30	36	28	652
Coolth	Whole building	District coolth import (net)	65	35	72	43	25	28	26	40	18	45	85	31	513
Electricity	Whole building	On site renewables electricity generated	54	0	3	57	30	39	70	54	84	15	39	27	470
Heat	Whole building	On site renewables heat produced	71	68	41	61	94	58	95	91	36	20	43	78	755
Fossil fuel	Whole building	Imported fossil fuel used in CHP	34	47	72	8	84	27	69	41	8	13	29	53	484
Electricity	Whole building	Electricity generated by CHP	71	27	86	50	30	19	7	92	27	97	91	57	654
Heat	Whole building	Useful heat produced by CHP	35	28	8	82	21	57	58	33	0	19	79	27	447

Table 16: Predicted energy consumption by end use (EVC under FORECAST conditions) (kWh)

Energy	Scope	End use	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Hosting functions	Space Heating	1,980,004	2,028,121	2,000,808	2,098,363	2,211,157	2,283,582	2,399,440	2,405,164	2,424,991	2,353,488	2,386,918	2,338,463	26,910,501
Electricity	Hosting functions	Hot water	766,295	776,071	776,461	845,178	909,778	989,953	1,065,308	1,098,323	1,184,464	1,173,565	1,218,703	1,219,464	12,023,563
Electricity	Hosting functions	Refrigeration	5,576	5,344	5,204	5,100	5,609	6,029	5,958	5,787	6,323	6,685	6,175	5,713	69,503
Electricity	Hosting functions	Fans	315,577	343,163	320,563	314,763	293,262	278,110	280,384	254,656	229,834	213,707	204,365	194,893	3,243,276
Electricity	Hosting functions	Pumps	978	956	893	877	802	748	780	797	845	868	786	824	10,155
Electricity	Hosting functions	Controls	5,505	4,969	4,523	4,822	4,806	4,650	4,204	3,866	4,084	4,192	3,992	4,196	53,808
Electricity	Hosting functions	Humidification	6,765	7,058	6,478	5,993	6,096	6,636	6,672	6,474	7,106	7,766	7,302	6,600	80,948
Electricity	Hosting functions	Lighting (internal)	5,695	5,613	5,953	5,472	5,639	5,764	5,952	6,142	5,772	5,297	4,952	4,591	66,845
Electricity	Hosting functions	Plug loads	4,404	4,019	4,288	4,671	4,861	5,105	5,148	4,733	4,334	4,218	4,388	4,379	54,549
Electricity	Hosting functions	Other	76,703	80,047	85,325	85,252	91,387	100,125	103,027	100,136	94,705	92,140	84,992	77,810	1,071,649
Electricity	Whole building	Vertical Transport (lifts & escalators)	462,505	462,861	457,652	476,508	520,392	505,866	522,100	523,389	483,357	452,803	453,442	430,248	5,751,123
Electricity	Whole building	Car park ventilation and lighting	446,746	489,741	523,105	569,763	600,239	622,289	679,375	695,121	640,066	623,444	656,242	717,570	7,263,702
Electricity	Whole building	Lighting (External)	371,422	354,303	350,544	326,385	309,463	300,917	299,673	277,396	288,609	297,511	309,647	290,512	3,776,382
Electricity	Non-hosting	Spa	24,840	24,323	23,835	24,666	23,622	21,929	23,738	22,029	22,856	23,022	24,574	23,597	283,031
Electricity	N/A	Not in use for Hotels	46,520	49,030	49,568	49,616	51,469	54,997	60,445	57,608	55,225	50,476	49,898	53,867	628,721
Electricity	Non-hosting	Swimming pool	315,833	311,316	284,257	303,618	308,828	338,536	337,045	315,135	337,297	314,649	283,389	261,712	3,711,614
Electricity	Non-hosting	Sauna	50,986	50,505	51,157	51,440	51,093	51,545	53,783	50,967	55,236	53,401	57,328	56,822	634,263
Electricity	Non-hosting	Gym	291,817	310,637	324,795	325,549	321,339	299,342	289,689	297,572	292,863	296,405	291,420	284,689	3,626,117
Electricity	Non-hosting	Kitchen	386,192	363,959	393,617	377,585	377,232	397,633	432,915	441,604	416,755	421,178	462,958	487,022	4,958,651
Electricity	Non-hosting	Laundry	480,334	441,718	436,335	416,531	416,466	391,884	380,286	370,711	367,135	383,094	385,204	371,213	4,840,912
Electricity	Non-hosting	Other	230,050	209,506	201,814	203,976	217,325	225,644	204,114	201,154	183,482	179,765	190,929	181,215	2,428,974
Fossil fuel	Hosting functions	Space Heating	51,789	49,868	53,225	49,120	50,789	50,510	55,440	58,226	57,084	61,069	66,033	63,394	666,548
Fossil fuel	Hosting functions	Hot water	89,328	96,064	88,965	90,992	90,513	93,414	102,648	98,683	106,038	99,664	107,172	97,298	1,160,779
Heat	Hosting functions	Space Heating	185,791	189,296	198,523	190,373	177,282	159,913	162,618	159,988	160,255	160,275	176,177	188,885	2,109,376
Coolth	Hosting functions	Space Cooling	152,692	143,636	135,637	139,277	127,080	135,374	142,022	139,810	153,127	154,592	166,201	181,107	1,770,554
Heat	Hosting functions	Hot water	444,515	433,054	460,211	470,266	433,411	475,465	434,439	453,115	417,526	394,604	400,437	422,918	5,239,960
Fossil fuel	Hosting functions	Other	97,492	88,660	86,665	84,733	88,883	95,376	90,731	94,744	104,168	104,700	106,497	97,077	1,139,724
Fossil fuel	Non-hosting	Spa	306,285	303,225	309,821	307,719	323,667	350,775	376,188	374,840	367,533	368,874	332,767	326,300	4,047,994
Fossil fuel	Non-hosting	Swimming pool	278,925	259,007	275,487	294,807	282,019	289,679	294,784	317,744	293,738	272,618	270,112	251,673	3,380,593
Fossil fuel	Non-hosting	Sauna	162,564	163,103	158,322	151,156	137,044	138,345	131,452	129,463	132,573	128,569	127,301	137,151	1,697,041
Fossil fuel	Non-hosting	Gym	352,337	339,922	333,517	321,269	309,470	318,937	314,465	337,479	342,093	343,236	311,134	302,107	3,925,967
Fossil fuel	Non-hosting	Kitchen	251,894	251,073	269,922	278,409	274,318	255,664	243,982	256,576	247,168	265,074	262,683	259,305	3,116,067
Fossil fuel	Non-hosting	Laundry	483,641	492,719	471,141	464,733	456,904	496,195	501,727	477,028	447,378	435,270	471,115	453,435	5,651,286
Fossil fuel	Non-hosting	Other	228,608	223,507	235,626	245,712	244,074	262,947	288,930	317,720	297,657	289,143	264,178	288,685	3,186,786
Heat	Hosting functions	Other	195,033	208,243	222,144	236,770	250,761	245,664	225,368	214,101	228,542	235,072	232,803	231,962	2,726,463
Heat	Non-hosting	Spa	335,199	332,092	340,638	355,229	353,811	352,546	346,332	346,901	331,977	304,356	326,128	296,050	4,021,259
Heat	Non-hosting	Swimming pool	202,850	199,950	217,654	210,801	228,864	229,652	225,367	233,030	252,134	257,035	277,873	254,719	2,789,928

Heat	Non-hosting	Sauna	235,798	238,978	222,617	228,710	215,918	218,818	227,691	244,652	261,796	287,312	304,034	298,534	2,984,858
Heat	Non-hosting	Gym	230,544	212,854	200,689	196,597	178,024	183,215	175,936	171,009	172,585	158,898	149,115	147,113	2,176,578
Heat	Non-hosting	Kitchen	390,829	397,888	399,902	385,551	372,665	364,439	383,530	352,770	331,568	318,240	319,361	328,443	4,345,187
Heat	Non-hosting	Laundry	494,241	471,527	502,043	458,932	491,704	512,041	470,397	467,318	473,452	510,672	559,905	554,141	5,966,373
Heat	Non-hosting	Other	18,499	18,887	19,327	20,587	20,366	20,210	21,245	23,367	22,116	23,640	22,211	23,021	253,476
Coolth	Non-hosting	Other	226,178	241,861	249,737	234,695	247,186	261,550	243,151	245,887	230,325	219,989	219,495	241,442	2,861,496

Table 17: Predicted building level utilities - (Advanced simulation under FORECAST conditions) (kWh)

Energy	Scope	Quantity	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Non-hosting	Kitchen	93	59	80	43	4	89	74	98	59	39	100	4	742
Electricity	Non-hosting	Laundry	97	54	33	49	57	61	95	67	21	18	36	19	607
Electricity	Non-hosting	Other	66	29	85	89	57	42	39	58	14	44	22	42	587
Fossil fuel	Hosting functions	Space Heating	78	18	82	71	1	67	28	20	80	13	9	32	497
Fossil fuel	Hosting functions	Hot water	84	10	21	39	54	56	27	19	47	89	85	48	580
Fossil fuel	Hosting functions	Other	12	47	45	77	92	1	10	29	76	72	36	6	504
Fossil fuel	Non-hosting	Spa	27	16	91	51	96	36	19	85	37	66	43	34	601
Fossil fuel	Non-hosting	Swimming pool	58	63	100	48	2	24	88	56	81	46	58	25	647
Fossil fuel	Non-hosting	Sauna	37	100	90	39	63	25	14	67	99	44	47	71	694
Fossil fuel	Non-hosting	Gym	73	31	2	28	4	78	99	29	47	82	63	97	634
Fossil fuel	Non-hosting	Kitchen	14	60	27	70	40	98	53	19	13	29	5	49	477
Fossil fuel	Non-hosting	Laundry	98	46	63	46	90	50	7	7	56	66	77	23	630

Table 18: Predicted energy consumption by end use (Advanced simulation under FORECAST conditions)

Energy	Scope	End use	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Hosting functions	Space Heating	2,079,789	2,115,602	2,108,017	2,039,220	2,078,773	2,091,166	2,117,075	2,108,180	2,066,347	1,971,164	1,959,091	2,051,906	24,786,330
Electricity	Hosting functions	Hot water	854,371	901,390	842,051	763,296	745,212	716,612	762,126	695,141	686,651	666,557	664,007	719,958	9,017,373
Electricity	Hosting functions	Refrigeration	79,158	84,393	91,745	90,780	91,910	88,158	93,421	87,024	84,023	89,267	89,205	96,630	1,065,715
Electricity	Hosting functions	Fans	212,170	199,789	210,233	199,410	194,347	208,834	223,671	240,659	264,658	247,070	260,952	258,843	2,720,633
Electricity	Hosting functions	Pumps	1,880	1,841	1,860	1,689	1,748	1,832	1,922	2,063	2,223	2,230	2,138	2,263	23,690
Electricity	Hosting functions	Controls	547	566	531	555	554	512	508	486	473	464	448	408	6,053
Electricity	Hosting functions	Humidification	8,331	8,216	8,356	8,793	8,742	8,832	8,937	8,805	8,841	9,091	8,759	8,053	103,755
Electricity	Hosting functions	Lighting (internal)	3,463	3,279	3,054	3,295	3,293	3,027	3,277	2,962	2,852	2,639	2,670	2,801	36,613
Electricity	Hosting functions	Plug loads	2,308	2,182	1,984	1,829	1,907	1,885	1,982	1,829	1,803	1,845	1,981	2,175	23,710
Electricity	Hosting functions	Other	83,475	77,688	70,299	74,732	74,919	74,441	76,526	70,813	69,422	69,138	69,177	65,334	875,962
Electricity	Whole building	Vertical Transport (lifts & escalators)	487,454	483,657	526,567	554,970	609,679	638,504	591,859	647,035	601,012	554,337	533,238	553,457	6,781,771
Electricity	Whole building	Car park ventilation and lighting	352,099	325,462	323,849	341,000	315,629	299,487	283,102	275,378	299,452	305,347	310,416	332,045	3,763,265
Electricity	Whole building	Lighting (External)	324,256	336,452	345,829	377,763	352,081	317,076	336,639	345,457	317,200	294,130	269,755	283,166	3,899,804
Electricity	Non-hosting	Spa	255,379	269,097	253,934	261,337	235,897	213,038	220,563	231,128	215,854	226,707	204,097	194,704	2,781,735
Electricity	N/A	Not in use for Hotels	63,033	62,908	65,735	67,157	65,321	61,829	64,201	58,931	57,984	56,677	58,504	63,614	745,896
Electricity	Non-hosting	Swimming pool	182,411	176,121	163,549	149,568	159,178	147,496	152,854	138,128	126,818	120,822	117,858	120,111	1,754,914
Electricity	Non-hosting	Sauna	355,320	380,849	401,733	429,409	443,267	407,299	405,899	422,401	447,892	476,118	520,270	561,409	5,251,867
Electricity	Non-hosting	Gym	56,442	58,154	52,376	56,721	60,101	59,361	64,562	66,775	65,488	70,366	73,923	72,614	756,883
Electricity	Non-hosting	Kitchen	421,395	420,559	391,713	426,032	461,251	481,140	445,387	477,438	442,892	441,491	460,329	466,239	5,335,866
Electricity	Non-hosting	Laundry	275,461	268,353	256,401	232,065	250,422	226,910	210,488	224,944	223,704	217,015	204,452	214,038	2,804,252
Electricity	Non-hosting	Other	158,701	166,481	169,296	152,496	140,962	145,142	141,340	137,125	145,866	152,430	147,450	146,737	1,804,025
Fossil fuel	Hosting functions	Space Heating	30,038	27,291	25,836	28,022	30,670	28,936	29,546	31,391	33,862	37,240	38,729	41,738	383,300
Fossil fuel	Hosting functions	Hot water	323,482	291,838	272,592	252,127	262,058	248,962	234,269	219,217	222,259	213,124	197,943	202,631	2,940,503
Heat	Hosting functions	Space Heating	154,475	158,483	156,080	170,010	182,501	189,466	170,766	174,123	161,755	153,982	147,054	135,380	1,954,075
Coolth	Hosting functions	Space Cooling	210,495	218,751	202,081	203,828	223,293	202,782	222,552	211,633	198,988	216,982	210,965	202,522	2,524,872
Heat	Hosting functions	Hot water	467,511	509,736	548,798	533,529	569,199	601,924	615,286	669,611	605,940	611,128	671,403	669,869	7,073,935
Fossil fuel	Hosting functions	Other	349,457	365,510	355,930	359,600	357,843	352,900	366,891	372,919	345,669	317,686	290,125	270,607	4,105,139
Fossil fuel	Non-hosting	Spa	429,124	449,145	488,399	441,688	465,752	494,934	495,203	517,805	495,184	501,945	548,676	502,337	5,830,194
Fossil fuel	Non-hosting	Swimming pool	436,223	428,685	434,985	414,404	394,466	417,792	422,910	401,803	382,680	419,765	383,659	410,804	4,948,175
Fossil fuel	Non-hosting	Sauna	403,310	363,761	368,240	331,627	351,663	348,997	360,797	330,669	358,377	354,128	385,199	407,339	4,364,106
Fossil fuel	Non-hosting	Gym	402,571	440,490	479,916	444,625	422,088	426,755	407,371	385,034	387,303	422,123	407,864	388,979	5,015,120
Fossil fuel	Non-hosting	Kitchen	496,374	539,389	516,446	505,083	515,432	564,392	575,204	543,259	590,490	622,875	660,958	710,773	6,840,675
Fossil fuel	Non-hosting	Laundry	215,639	224,144	244,577	260,570	262,890	254,425	229,118	237,235	249,476	272,117	264,046	241,434	2,955,671
Fossil fuel	Non-hosting	Other	123,816	122,907	116,945	122,743	124,703	115,899	124,596	119,624	117,253	125,987	119,406	123,697	1,457,578
Heat	Hosting functions	Other	165,110	167,557	181,578	181,336	193,419	198,216	180,297	192,387	186,295	200,669	202,232	219,700	2,268,797
Heat	Non-hosting	Spa	398,923	426,655	439,765	411,271	392,550	403,519	399,378	400,203	407,018	447,631	478,373	500,722	5,106,007
Heat	Non-hosting	Swimming pool	404,178	415,043	420,230	405,493	421,492	379,347	407,685	436,430	400,401	403,062	378,505	402,639	4,874,504
Heat	Non-hosting	Sauna	252,685	266,402	247,405	271,540	271,116	246,458	262,554	283,452	303,272	303,304	330,584	308,746	3,347,517
Heat	Non-hosting	Gym	479,868	511,788	530,835	541,060	572,759	621,890	583,857	636,838	589,550	557,606	600,174	565,965	6,792,191
Heat	Non-hosting	Kitchen	355,212	340,688	367,329	369,166	396,389	372,195	395,729	412,297	376,650	373,860	400,137	403,202	4,562,855
Heat	Non-hosting	Laundry	163,559	179,822	177,354	184,418	182,061	198,700	194,582	192,104	185,913	188,352	184,228	176,158	2,207,252
Heat	Non-hosting	Other	347,883	375,547	356,063	362,350	347,296	338,536	371,660	346,366	334,871	330,262	349,226	315,411	4,175,471
Coolth	Non-hosting	Other	237,289	224,480	230,923	220,841	222,217	225,970	221,399	210,778	191,591	194,164	181,779	197,483	2,558,915

ALDREN | ALDREN INTERVENTION | DECISION (SET REQUIREMENTS) | DECISION STAGE RESULTS | DEVELOP DESIGN | DETAILED DESIGN | WORKS | IN USE | IN USE STAGE RESULTS

ALDREN Stage 4: Works

At the works stage predicted energy consumption under standard conditions is recorded. The EVC score is also calculated for the final design.

General building data

Gross Internal Area m²	1000
Hosting functional area (m2)	800
Start month for 1 year tool data period	Jan-17

Post retrofit EVC

EVC rating score	45
EVC grade	A

General building information (does not impact the output of the PVT)

Building specific type	Public sector (central or local government and services)
Level of servicing	Heating

Simulation start month	Jan-17

Table 19: Predicted building level utilities - (EVC under STANDARD conditions) (kWh)

Energy	Scope	Quantity	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Whole building	Electricity imported from grid	34	33	26	30	12	48	89	45	48	40	40	36	480
Electricity	Whole building	Electricity exported to grid	66	95	39	46	17	25	10	26	71	44	15	15	468
Natural	Whole building	Total Fossil fuel imports	31	2	59	19	91	0	61	16	70	32	38	14	433
LPG	Whole building	Total Fossil fuel imports	18	29	67	78	35	35	64	57	37	0	92	29	542
Diesel	Whole building	Total Fossil fuel imports	78	40	95	42	55	37	78	77	13	55	87	81	741
Heat	Whole building	District heat import (net)	15	39	53	3	75	97	7	31	40	67	49	16	492
Coolth	Whole building	District coolth import (net)	16	13	99	54	68	23	25	40	61	21	45	58	522
Electricity	Whole building	On site renewables electricity generated	87	90	67	41	97	13	69	86	45	13	42	9	661
Heat	Whole building	On site renewables heat produced	58	2	25	25	48	40	40	87	49	65	46	49	535
Fossil fuel	Whole building	Imported fossil fuel used in CHP	38	77	31	78	56	53	77	73	21	55	23	21	604
Electricity	Whole building	Electricity generated by CHP	13	80	40	5	15	83	87	97	81	87	64	84	735
Heat	Whole building	Useful heat produced by CHP	66	93	98	42	77	14	28	85	79	39	28	41	689

Table 20: Predicted energy consumption by end use - (EVC under STANDARD conditions)

Energy	Scope	End use	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Hosting functions	Space Heating	49	29	79	40	64	80	90	12	33	73	88	62	700
Electricity	Hosting functions	Hot water	29	39	44	88	8	6	76	98	62	53	3	87	594
Electricity	Hosting functions	Refrigeration	19	88	42	46	50	37	57	15	13	85	9	4	465
Electricity	Hosting functions	Fans	28	18	35	13	54	38	30	70	30	47	40	66	470
Electricity	Hosting functions	Pumps	35	46	76	91	22	77	10	88	56	32	37	13	583
Electricity	Hosting functions	Controls	86	62	64	93	78	83	5	43	90	61	19	12	696
Electricity	Hosting functions	Humidification	97	36	73	19	1	0	22	97	45	44	58	22	516
Electricity	Hosting functions	Lighting (internal)	99	25	10	92	12	31	50	6	99	39	35	4	502
Electricity	Hosting functions	Plug loads	91	59	42	78	77	5	77	4	37	80	99	2	649
Electricity	Hosting functions	Other	95	9	37	57	5	95	5	25	56	12	55	20	471
Electricity	Whole building	Vertical Transport (lifts & escalators)	39	26	51	27	87	66	2	16	78	12	30	75	509
Electricity	Whole building	Car park ventilation and lighting	3	92	57	65	97	55	20	75	57	2	34	92	650
Electricity	Whole building	Lighting (External)	51	34	13	14	93	34	7	94	96	72	26	43	577
Electricity	Non-hosting	Spa	6	69	45	39	86	46	80	24	4	49	85	16	550
Electricity	N/A	Not in use for Hotels	71	89	64	52	85	8	11	19	63	21	81	7	571
Electricity	Non-hosting	Swimming pool	96	37	22	75	100	49	91	27	15	16	66	24	618
Electricity	Non-hosting	Sauna	6	8	49	69	41	16	94	22	1	88	89	42	527
Electricity	Non-hosting	Gym	64	69	55	2	40	19	68	22	3	29	48	70	489
Electricity	Non-hosting	Kitchen	2	5	34	41	50	25	47	45	30	44	19	2	344
Electricity	Non-hosting	Laundry	70	30	82	56	6	7	34	60	34	94	81	97	651
Electricity	Non-hosting	Other	77	18	21	86	32	69	4	88	6	85	22	72	580
Fossil fuel	Hosting functions	Space Heating	76	27	92	70	42	5	58	47	57	98	94	1	667
Fossil fuel	Hosting functions	Hot water	19	66	26	43	70	51	66	36	16	19	17	83	513
Heat	Hosting functions	Space Heating	46	22	44	30	31	32	93	55	6	20	88	83	548
Coolth	Hosting functions	Space Cooling	15	31	63	77	94	97	41	77	13	71	43	31	652

Heat	Hosting functions	Hot water	71	67	83	69	4	3	83	29	18	93	61	48	628
Fossil fuel	Hosting functions	Other	90	21	97	77	64	88	64	17	73	10	32	29	662
Fossil fuel	Non-hosting	Spa	72	8	36	78	13	100	6	94	11	85	92	48	643
Fossil fuel	Non-hosting	Swimming pool	97	27	72	82	39	56	80	77	80	98	78	53	841
Fossil fuel	Non-hosting	Sauna	1	71	7	7	37	3	52	95	16	6	98	82	474
Fossil fuel	Non-hosting	Gym	89	35	17	82	21	89	10	98	92	79	29	16	656
Fossil fuel	Non-hosting	Kitchen	79	51	68	70	6	55	8	67	41	39	78	57	619
Fossil fuel	Non-hosting	Laundry	50	11	98	93	44	28	32	78	5	40	61	42	582
Fossil fuel	Non-hosting	Other	9	27	73	43	68	95	64	8	23	34	48	94	585
Heat	Hosting functions	Other	19	24	85	44	71	71	1	53	23	67	31	6	494
Heat	Non-hosting	Spa	55	18	21	26	29	92	24	26	66	52	58	36	502
Heat	Non-hosting	Swimming pool	79	58	10	64	12	99	18	10	48	79	55	3	536
Heat	Non-hosting	Sauna	40	55	88	73	16	81	37	23	34	9	56	64	576
Heat	Non-hosting	Gym	74	60	60	7	0	63	24	95	92	38	51	71	635
Heat	Non-hosting	Kitchen	21	33	30	100	45	65	2	5	90	49	61	50	553
Heat	Non-hosting	Laundry	12	41	92	78	33	54	10	70	67	84	26	16	585
Heat	Non-hosting	Other	79	64	17	30	27	67	45	86	59	81	41	66	662
Coolth	Non-hosting	Other	42	20	65	29	51	92	34	15	67	65	34	92	605

ALDREN Stage 5: IN USE

This page contains details of the building in use post completion. As the functional spaces are likely to have changed during the renovation, this data will need to be re-recorded here to provide context to the data. The metered consumption of the existing building can be entered in Table 25. The months of metered data should be matched with the months that the simulation has run for to allow for seasonality to be observed.

Table 21: Functional spaces data input

						Operational Hours of Use	Extra hours of service	Voids
No.	Name	Activity	Number of occupants	Area (m^2)	Source data	hrs./week	hrs./annum	Weeks/year
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

Weather data (Actual)	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17
Actual Heating degree days (HDD)												
Actual Cooling degree days (CDD)												
Actual Global solar radiation												
Standard Heating degree days (HDD)												
Standard Cooling degree days (CDD)												
Standard Global solar radiation												

Table 22: Predicted building level utilities - (EVC under ACTUAL conditions) (kWh)

Energy	Scope	Quantity	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Whole building	Electricity imported from grid	2348	53	4780	9160	4830	422	1048	8610	507	234	7881	9213	49086
Electricity	Whole building	Electricity exported to grid	2674	7741	7441	8576	1590	699	8718	7671	1816	2017	760	7585	57288
Natural gas	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	6797	4213	6018	4552	7659	5375	5720	777	3490	9863	7068	8526	70059
LPG	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	4315	9484	4859	4287	3390	7432	6	3765	8227	856	9014	3942	59576
Diesel	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	3437	1502	5780	3646	621	1077	2817	4861	8900	2470	9026	4254	48390
Heat	Whole building	District heat import (net)	7573	1242	4594	8051	8102	4675	4768	9982	5437	1161	581	8649	64813
Coolth	Whole building	District coolth import (net)	5850	725	4177	2268	5443	1333	6274	7115	1505	7782	4777	7995	55244
Electricity	Whole building	On site renewables electricity generated	7136	5072	5299	3418	9574	2643	5316	2957	3856	8379	4908	1232	59790
Heat	Whole building	On site renewables heat produced	717	9957	1215	3038	8571	387	5647	3931	3500	7810	3315	8967	57054
Fossil fuel	Whole building	Imported fossil fuel used in CHP	2197	6720	7277	304	4420	9035	2911	1354	5113	3835	323	2703	46191
Electricity	Whole building	Electricity generated by CHP	2177	5098	3215	4445	590	7448	7458	1548	1676	7525	4176	3404	48759
Heat	Whole building	Useful heat produced by CHP	6499	1147	3067	9212	2611	961	5736	2650	5184	5255	1879	3646	47847

Table 23: Predicted building level utilities (Advanced simulation under ACTUAL conditions)

Energy	Scope	Quantity	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Whole building	Electricity imported from grid	4926	7508	4350	6142	9838	6089	3355	9001	5581	2712	520	1062	61084
Electricity	Whole building	Electricity exported to grid	3957	1559	5085	5025	2466	6056	6461	832	8699	9226	9804	9718	68889
Natural gas	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	9545	7468	5295	9000	863	8111	5431	394	9860	6376	6287	5725	74357

LPG	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	5039	9926	9607	1471	8452	5410	8772	1768	4095	6721	6864	4801	72926
Diesel	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	7902	5596	7778	2965	327	5373	7365	4038	5983	5369	327	4649	57670
Heat	Whole building	District heat import (net)	7002	3607	1738	5742	7162	9413	1573	6899	3521	8465	5243	8655	69020
Coolth	Whole building	District coolth import (net)	6521	6324	4250	1552	9018	1737	2298	8421	5122	346	6300	6123	58010
Electricity	Whole building	On site renewables electricity generated	284	8775	2565	9593	215	3310	7750	5641	1440	8490	7238	3645	58945
Heat	Whole building	On site renewables heat produced	4742	189	7	7471	5347	6706	4878	8219	2015	1465	3131	5093	49262
Fossil fuel	Whole building	Imported fossil fuel used in CHP	6801	5898	9696	1342	6195	4042	413	7825	2988	5594	7064	6038	63895
Electricity	Whole building	Electricity generated by CHP	9718	6770	4627	9129	392	8317	5979	2428	2632	7749	9011	3853	70605
Heat	Whole building	Useful heat produced by CHP	4058	7552	5787	6311	412	9099	1228	1848	6332	7120	1662	9977	61388

Table 24: Metered energy consumption by building level utility (kWh)

Energy	Scope	Quantity	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Total
Electricity	Whole building	Electricity imported from grid	3986	7931	822	5042	4098	3126	3587	3155	7654	3113	6577	8978	58068
Electricity	Whole building	Electricity exported to grid	8810	5090	7693	4876	9484	9973	3132	5177	7706	7695	3286	6406	79328
Natural gas	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	592	6855	2390	9335	2925	5404	8286	5134	2529	216	564	941	45171
LPG	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	8344	2564	5877	5764	1838	1210	1232	4024	5931	2543	4206	741	44274
Diesel	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	9999	7499	3079	8740	9390	9215	4864	2537	1542	2902	8886	1005	69658
Heat	Whole building	District heat import (net)	3850	1547	7638	86	2713	8370	3193	9830	5768	7719	9606	1950	62270
Coolth	Whole building	District coolth import (net)	5101	5410	550	1269	3164	5986	5785	2098	5506	4649	819	6055	46389
Electricity	Whole building	On site renewables electricity generated	4954	255	215	3120	1471	9178	258	7382	8860	5691	7056	4026	52465
Heat	Whole building	On site renewables heat produced	1180	6646	9188	648	3132	4894	132	3124	6705	1345	7064	7248	51307
Fossil fuel	Whole building	Imported fossil fuel used in CHP	9712	1913	1563	3923	9800	2323	5486	7855	114	887	9917	8272	61767
Electricity	Whole building	Electricity generated by CHP	6640	7782	8010	3815	9414	5944	6316	7597	1384	1773	8737	9855	77270
Heat	Whole building	Useful heat produced by CHP	6025	6594	9337	2487	5740	8061	2596	196	5245	8894	3449	7016	65638

Table 25: Predicted energy consumption by end use - (EVC under ACTUAL conditions) (kWh)

Energy	Scope	End use	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Hosting functions	Space Heating	629	898	298	960	301	520	563	392	666	651	805	141	6826
Electricity	Hosting functions	Hot water	332	867	670	354	627	26	337	769	414	196	638	47	5276
Electricity	Hosting functions	Refrigeration	431	893	796	43	506	721	269	774	577	95	295	608	6009
Electricity	Hosting functions	Fans	310	718	380	37	737	430	815	174	463	444	175	756	5438
Electricity	Hosting functions	Pumps	210	185	966	664	261	356	440	940	137	711	865	788	6523
Electricity	Hosting functions	Controls	724	427	969	607	490	808	782	435	158	121	247	366	6133
Electricity	Hosting functions	Humidification	970	51	75	255	427	898	263	543	873	497	459	659	5970
Electricity	Hosting functions	Lighting (internal)	881	844	280	265	60	641	497	482	747	725	610	555	6586
Electricity	Hosting functions	Plug loads	555	639	6	805	460	493	421	596	637	233	439	591	5876
Electricity	Hosting functions	Other	869	885	816	192	526	264	482	713	754	54	176	707	6437
Electricity	Whole building	Vertical Transport (lifts & escalators)	669	291	63	691	983	664	521	250	863	690	266	418	6368
Electricity	Whole building	Car park ventilation and lighting	309	913	385	453	188	282	622	130	750	643	632	477	5785
Electricity	Whole building	Lighting (External)	983	577	459	395	867	156	128	622	670	392	319	615	6182
Electricity	Non-hosting	Spa	303	589	876	663	107	565	250	360	455	788	664	262	5883
Electricity	N/A	Not in use for Hotels	790	883	282	690	594	111	237	435	859	297	710	190	6078
Electricity	Non-hosting	Swimming pool	23	879	390	257	328	115	976	812	343	522	675	299	5620
Electricity	Non-hosting	Sauna	781	353	71	668	308	750	173	594	123	920	353	6	5100
Electricity	Non-hosting	Gym	588	695	280	226	561	261	249	711	573	473	576	23	5216
Electricity	Non-hosting	Kitchen	664	662	296	68	392	723	317	805	132	311	298	368	5036
Electricity	Non-hosting	Laundry	370	113	949	386	629	76	839	155	746	586	522	342	5713
Electricity	Non-hosting	Other	142	986	179	579	241	245	611	526	786	278	17	319	4907
Fossil fuel	Hosting functions	Space Heating	665	683	916	939	150	260	429	199	163	22	419	591	5436
Fossil fuel	Hosting functions	Hot water	477	954	243	857	124	842	39	716	745	95	74	425	5591
Heat	Hosting functions	Space Heating	724	974	61	652	424	411	269	173	438	591	2	76	4794
Coolth	Hosting functions	Space Cooling	914	790	114	480	840	475	391	841	98	439	469	330	6180
Heat	Hosting functions	Hot water	525	768	466	346	293	429	652	840	568	626	982	433	6928
Fossil fuel	Hosting functions	Other	498	840	652	269	446	634	593	444	686	556	928	448	6994
Fossil fuel	Non-hosting	Spa	151	210	288	837	861	347	627	665	249	184	971	931	6319
Fossil fuel	Non-hosting	Swimming pool	137	215	528	40	119	261	317	849	912	389	720	736	5224
Fossil fuel	Non-hosting	Sauna	769	360	258	532	87	740	428	621	916	332	618	486	6147
Fossil fuel	Non-hosting	Gym	217	514	371	276	412	736	939	57	882	210	693	603	5908
Fossil fuel	Non-hosting	Kitchen	501	129	484	834	507	9	726	173	480	928	984	13	5767
Fossil fuel	Non-hosting	Laundry	239	581	520	391	653	352	302	380	81	513	592	969	5574
Fossil fuel	Non-hosting	Other	594	468	576	149	32	69	943	841	485	435	836	147	5574
Heat	Hosting functions	Other	989	652	581	531	874	642	304	402	435	771	626	980	7787
Heat	Non-hosting	Spa	41	324	55	804	121	822	16	562	564	964	188	279	4741
Heat	Non-hosting	Swimming pool	828	696	645	63	246	205	287	473	557	117	589	694	5400
Heat	Non-hosting	Sauna	380	643	893	773	666	479	511	551	253	321	593	29	6091
Heat	Non-hosting	Gym	626	615	494	565	221	979	965	596	993	155	288	138	6636
Heat	Non-hosting	Kitchen	335	942	204	362	201	228	37	378	554	904	846	509	5501
Heat	Non-hosting	Laundry	570	671	560	353	350	717	293	824	196	392	472	667	6066

Heat	Non-hosting	Other	78	778	990	880	166	718	696	11	152	862	400	223	5954
Coolth	Non-hosting	Other	608	835	493	445	929	782	408	715	857	210	948	845	8076

Table 26: Predicted energy consumption by end use (Advanced simulation under ACTUAL conditions)

Energy	Scope	End use	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Hosting functions	Space Heating	325	66	138	298	672	839	306	894	852	231	996	128	5,744
Electricity	Hosting functions	Hot water	297	214	132	912	92	556	63	169	230	217	226	165	3,273
Electricity	Hosting functions	Refrigeration	336	60	733	1,000	801	832	124	830	181	907	341	485	6,629
Electricity	Hosting functions	Fans	600	503	651	254	342	153	773	393	3	128	128	46	3,972
Electricity	Hosting functions	Pumps	611	257	646	902	146	753	4	897	522	202	353	785	6,080
Electricity	Hosting functions	Controls	736	91	103	863	186	254	141	903	786	682	649	279	5,674
Electricity	Hosting functions	Humidification	791	655	139	780	718	998	408	606	811	780	813	475	7,974
Electricity	Hosting functions	Lighting (internal)	240	478	234	65	12	912	855	772	19	745	944	772	6,048
Electricity	Hosting functions	Plug loads	973	319	812	513	835	429	310	769	505	872	783	111	7,231
Electricity	Hosting functions	Other	912	826	467	945	592	750	774	974	565	496	439	556	8,294
Electricity	Whole building	Vertical Transport (lifts & escalators)	340	466	673	633	285	226	908	835	337	386	198	334	5,619
Electricity	Whole building	Car park ventilation and lighting	930	182	115	104	126	595	777	967	542	286	567	218	5,409
Electricity	Whole building	Lighting (External)	641	316	595	617	477	454	70	559	648	724	15	109	5,224
Electricity	Non-hosting	Spa	831	382	317	977	665	607	773	948	336	882	69	924	7,710
Electricity	N/A	Not in use for Hotels	874	792	348	858	459	187	614	628	893	949	330	997	7,930
Electricity	Non-hosting	Swimming pool	293	49	885	905	37	899	346	455	819	564	53	784	6,089
Electricity	Non-hosting	Sauna	854	280	939	183	899	942	777	323	674	624	77	986	7,555
Electricity	Non-hosting	Gym	515	83	984	469	338	963	513	483	18	582	187	460	5,595
Electricity	Non-hosting	Kitchen	830	987	811	618	182	675	991	655	204	37	338	794	7,121
Electricity	Non-hosting	Laundry	744	211	873	50	608	923	205	141	106	422	817	452	5,552
Electricity	Non-hosting	Other	919	670	430	780	533	908	694	435	597	481	312	825	7,584
Fossil fuel	Hosting functions	Space Heating	942	710	261	608	961	669	435	12	621	908	972	729	7,830
Fossil fuel	Hosting functions	Hot water	760	325	553	611	719	918	534	293	742	445	950	724	7,573
Heat	Hosting functions	Space Heating	400	354	679	867	2	175	319	285	807	512	704	684	5,787
Coolth	Hosting functions	Space Cooling	860	195	78	701	555	394	672	328	660	284	27	39	4,793
Heat	Hosting functions	Hot water	461	466	851	135	562	788	535	80	26	82	673	849	5,506
Fossil fuel	Hosting functions	Other	944	618	746	333	639	890	152	182	549	740	777	371	6,942
Fossil fuel	Non-hosting	Spa	221	450	684	275	108	7	299	753	784	861	439	521	5,401
Fossil fuel	Non-hosting	Swimming pool	857	225	926	880	930	613	678	907	206	642	61	313	7,238
Fossil fuel	Non-hosting	Sauna	304	670	46	832	469	128	317	300	467	202	339	160	4,233
Fossil fuel	Non-hosting	Gym	64	607	235	738	768	894	598	31	173	753	815	27	5,702
Fossil fuel	Non-hosting	Kitchen	396	399	855	179	115	504	665	980	682	118	735	997	6,626
Fossil fuel	Non-hosting	Laundry	863	119	651	738	199	362	767	491	90	863	218	634	5,995
Fossil fuel	Non-hosting	Other	609	476	538	51	510	787	114	662	444	154	874	150	5,368
Heat	Hosting functions	Other	195	291	679	721	393	485	228	313	359	153	991	543	5,352
Heat	Non-hosting	Spa	700	896	560	369	848	161	440	403	207	628	200	633	6,044
Heat	Non-hosting	Swimming pool	924	411	368	270	628	999	323	160	490	739	895	372	6,579
Heat	Non-hosting	Sauna	595	142	138	727	973	543	988	357	561	614	959	877	7,472
Heat	Non-hosting	Gym	460	973	612	772	418	693	729	487	980	734	348	310	7,516
Heat	Non-hosting	Kitchen	690	637	981	553	461	446	542	318	343	731	275	165	6,140
Heat	Non-hosting	Laundry	573	447	626	931	998	709	286	970	737	119	224	639	7,260
Heat	Non-hosting	Other	644	186	396	307	609	928	875	289	132	995	819	843	7,023
Coolth	Non-hosting	Other	472	907	843	826	371	793	399	416	108	364	958	482	6,940

Table 27: Measured energy consumption by end use (kWh)

Energy	Scope	Meter	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Total
Electricity	Hosting functions	Space Heating	937	77	609	921	349	380	817	874	20	910	3	63	5,960
Electricity	Hosting functions	Hot water	997	759	475	520	178	251	146	653	74	90	933	876	5,953
Electricity	Hosting functions	Refrigeration	965	408	709	711	277	504	436	622	535	859	16	385	6,429
Electricity	Hosting functions	Fans	747	966	320	675	309	430	994	453	317	128	302	781	6,421
Electricity	Hosting functions	Pumps	422	332	523	349	773	507	596	830	270	706	426	819	6,553
Electricity	Hosting functions	Controls	447	779	944	4	584	21	543	361	261	288	491	849	5,572
Electricity	Hosting functions	Humidification	911	764	983	205	11	854	148	839	665	520	719	164	6,784
Electricity	Hosting functions	Lighting (internal)	92	157	292	590	552	234	340	342	720	915	896	62	5,191
Electricity	Hosting functions	Plug loads	944	537	324	473	390	37	26	838	4	474	224	419	4,690
Electricity	Hosting functions	Other	889	742	795	849	12	609	593	731	626	750	565	120	7,281
Electricity	Whole building	Vertical Transport (lifts & escalators)	105	526	38	822	467	916	663	694	840	437	28	960	6,496
Electricity	Whole building	Car park ventilation and lighting	890	37	340	367	394	25	52	156	795	167	51	877	4,151
Electricity	Whole building	Lighting (External)	742	355	619	256	893	522	132	798	403	619	190	698	6,227
Electricity	Non-hosting	Spa	843	715	111	164	46	342	840	477	823	533	30	763	5,688
Electricity	N/A	Not in use for Hotels	537	733	925	772	571	386	510	388	220	857	290	919	7,106
Electricity	Non-hosting	Swimming pool	982	691	915	106	988	611	433	581	93	28	862	464	6,755
Electricity	Non-hosting	Sauna	783	893	314	894	722	108	801	294	549	26	186	802	6,371
Electricity	Non-hosting	Gym	918	142	173	869	571	250	281	289	910	821	54	765	6,045
Electricity	Non-hosting	Kitchen	783	798	778	796	21	348	156	36	305	879	583	53	5,536

Electricity	Non-hosting	Laundry	469	999	873	699	8	794	269	346	237	546	443	770	6,454
Electricity	Non-hosting	Other	456	988	236	967	505	458	791	731	790	799	43	340	7,104
Fossil fuel	Hosting functions	Space Heating	792	343	631	951	848	327	119	301	722	632	942	64	6,671
Fossil fuel	Hosting functions	Hot water	617	332	942	556	447	338	645	854	407	879	954	77	7,050
Heat	Hosting functions	Space Heating	111	723	129	709	345	214	638	915	861	484	42	26	5,196
Coolth	Hosting functions	Space Cooling	515	802	686	118	543	664	43	521	589	95	345	973	5,893
Heat	Hosting functions	Hot water	788	800	133	684	579	706	903	522	230	509	541	506	6,900
Fossil fuel	Hosting functions	Other	765	513	403	776	606	187	34	128	908	660	304	617	5,900
Fossil fuel	Non-hosting	Spa	94	296	551	240	961	943	101	302	81	783	939	461	5,753
Fossil fuel	Non-hosting	Swimming pool	521	693	11	555	808	808	733	440	958	978	761	556	7,821
Fossil fuel	Non-hosting	Sauna	528	861	13	22	452	555	743	440	182	918	715	342	5,772
Fossil fuel	Non-hosting	Gym	469	549	940	838	459	492	758	836	9	283	642	121	6,397
Fossil fuel	Non-hosting	Kitchen	846	636	801	682	210	386	146	745	557	399	763	157	6,327
Fossil fuel	Non-hosting	Laundry	434	686	474	24	440	758	56	274	272	405	317	853	4,993
Fossil fuel	Non-hosting	Other	113	759	874	329	192	116	578	807	136	550	625	15	5,095
Heat	Hosting functions	Other	830	824	320	604	93	883	278	314	78	11	288	578	5,101
Heat	Non-hosting	Spa	641	263	614	727	340	578	305	815	81	135	134	533	5,166
Heat	Non-hosting	Swimming pool	981	660	60	798	148	683	307	371	207	289	480	990	5,973
Heat	Non-hosting	Sauna	904	660	120	999	547	106	780	750	125	281	684	93	6,052
Heat	Non-hosting	Gym	808	355	257	596	412	266	269	739	864	847	569	125	6,108
Heat	Non-hosting	Kitchen	297	780	89	364	98	832	368	931	908	201	636	297	5,800
Heat	Non-hosting	Laundry	356	524	741	613	694	85	277	353	349	699	762	512	5,964
Heat	Non-hosting	Other	685	898	321	997	4	371	467	144	64	536	731	447	5,666
Coolth	Non-hosting	Other	286	663	350	161	762	475	477	6	945	597	1,000	19	5,740

ALDREN | ALDREN INTERVENTION POINTS | DECISION (SET REQUIREMENTS) | DECISION STAGE RESULTS | DEVELOP DESIGN | DETAILED DESIGN | WORKS | IN USE | IN USE STAGE RESULTS

ALDREN In-Use stage results

The in-use stage results includes a comparison of the in-use measured consumption in the renovated building against the final design consumption under actual conditions. As with the results at the Decision stage, these can be viewed at utility level or at end-use level on an annual or monthly basis.

Table 28: Annual total building level consumption (Predicted and Measured)

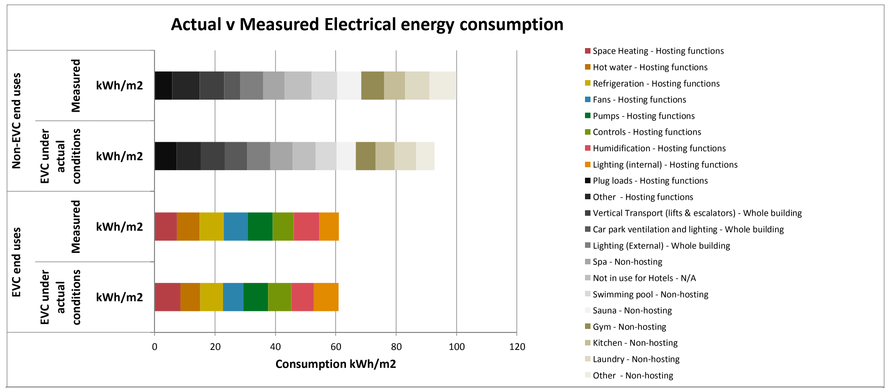
			EVC under actual conditions	Advanced sim under actual conditions	Measured	EVC under actual conditions	Advanced sim under actual conditions	Measured	Variance measured vs. EVC under actual	Variance measured vs. EVC under actual
Energy	Scope	Quantitiy	kWh	kWh	kWh	kWh/m^2	kWh/m^2	kWh/m^2	kWh/m^2	%
Electricity	Whole building	Electricity imported from grid	49086	61084	58068	61.4	76.4	72.6	11.2	15%
Electricity	Whole building	Electricity exported to grid	57288	68889	79328	71.6	86.1	99.2	27.5	28%
Natural gas	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	70059	74357	45171	87.6	92.9	56.5	-31.1	-55%
LPG	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	59576	72926	44274	74.5	91.2	55.3	-19.1	-35%
Diesel	Whole building	Total Fossil fuel imports (incl to generators, CHP, etc.)	48390	57670	69658	60.5	72.1	87.1	26.6	31%
Heat	Whole building	District heat import (net)	64813	69020	62270	81.0	86.3	77.8	-3.2	-4%
Coolth	Whole building	District coolth import (net)	55244	58010	46389	69.1	72.5	58.0	-11.1	-19%
Electricity	Whole building	On site renewables electricity generated	59790	58945	52465	74.7	73.7	65.6	-9.2	-14%
Heat	Whole building	On site renewables heat produced	57054	49262	51307	71.3	61.6	64.1	-7.2	-11%
Fossil fuel	Whole building	Imported fossil fuel used in CHP	46191	63895	61767	57.7	79.9	77.2	19.5	25%
Electricity	Whole building	Electricity generated by CHP	48759	70605	77270	60.9	88.3	96.6	35.6	37%
Heat	Whole building	Useful heat produced by CHP	47847	61388	65638	59.8	76.7	82.0	22.2	27%

Variance to calculated energy performance

- Above 100%
- +50% to 100%
- +25% to 50%
- +10% to 25%
- +/- 10%
- -10% to -25%
- -25% to -50%
- -50% to -100
- Below -100%

Table 29: Annual total end-use consumption (Predicted and Measured)

			EVC under actual conditions	Advanced sim under actual conditions	Measured	EVC under actual conditions	Advanced sim under actual conditions	Measured	Variance measured vs. EVC under actual	Variance measured vs. EVC under actual
Energy	Scope	End use	kWh	kWh	kWh	kWh/m^2	kWh/m^2	kWh/m^2	kWh/m^2	%
Electricity	Hosting functions	Space Heating	6,826	5,744	5,960	8.5	7.2	7.5	-1.1	-15%
Electricity	Hosting functions	Hot water	5,276	3,273	5,953	6.6	4.1	7.4	0.8	11%
Electricity	Hosting functions	Refrigeration	6,009	6,629	6,429	7.5	8.3	8.0	0.5	7%
Electricity	Hosting functions	Fans	5,438	3,972	6,421	6.8	5.0	8.0	1.2	15%
Electricity	Hosting functions	Pumps	6,523	6,080	6,553	8.2	7.6	8.2	0.0	0%
Electricity	Hosting functions	Controls	6,133	5,674	5,572	7.7	7.1	7.0	-0.7	-10%
Electricity	Hosting functions	Humidification	5,970	7,974	6,784	7.5	10.0	8.5	1.0	12%
Electricity	Hosting functions	Lighting (internal)	6,586	6,048	5,191	8.2	7.6	6.5	-1.7	-27%
Electricity	Hosting functions	Plug loads	5,876	7,231	4,690	7.3	9.0	5.9	-1.5	-25%
Electricity	Hosting functions	Other	6,437	8,294	7,281	8.0	10.4	9.1	1.1	12%
Electricity	Whole building	Vertical Transport (lifts & escalators)	6,368	5,619	6,496	8.0	7.0	8.1	0.2	2%
Electricity	Whole building	Car park ventilation and lighting	5,785	5,409	4,151	7.2	6.8	5.2	-2.0	-39%
Electricity	Whole building	Lighting (External)	6,182	5,224	6,227	7.7	6.5	7.8	0.1	1%
Electricity	Non-hosting	Spa	5,883	7,710	5,688	7.4	9.6	7.1	-0.2	-3%
Electricity	N/A	Not in use for Hotels	6,078	7,930	7,106	7.6	9.9	8.9	1.3	14%
Electricity	Non-hosting	Swimming pool	5,620	6,089	6,755	7.0	7.6	8.4	1.4	17%
Electricity	Non-hosting	Sauna	5,100	7,555	6,371	6.4	9.4	8.0	1.6	20%
Electricity	Non-hosting	Gym	5,216	5,595	6,045	6.5	7.0	7.6	1.0	14%
Electricity	Non-hosting	Kitchen	5,036	7,121	5,536	6.3	8.9	6.9	0.6	9%
Electricity	Non-hosting	Laundry	5,713	5,552	6,454	7.1	6.9	8.1	0.9	11%
Electricity	Non-hosting	Other	4,907	7,584	7,104	6.1	9.5	8.9	2.7	31%
Fossil fuel	Hosting functions	Space Heating	5,436	7,830	6,671	6.8	9.8	8.3	1.5	19%
Fossil fuel	Hosting functions	Hot water	5,591	7,573	7,050	7.0	9.5	8.8	1.8	21%
Heat	Hosting functions	Space Heating	4,794	5,787	5,196	6.0	7.2	6.5	0.5	8%
Coolth	Hosting functions	Space Cooling	6,180	4,793	5,893	7.7	6.0	7.4	-0.4	-5%
Heat	Hosting functions	Hot water	6,928	5,506	6,900	8.7	6.9	8.6	0.0	0%
Fossil fuel	Hosting functions	Other	6,994	6,942	5,900	8.7	8.7	7.4	-1.4	-19%
Fossil fuel	Non-hosting	Spa	6,319	5,401	5,753	7.9	6.8	7.2	-0.7	-10%
Fossil fuel	Non-hosting	Swimming pool	5,224	7,238	7,821	6.5	9.0	9.8	3.2	33%
Fossil fuel	Non-hosting	Sauna	6,147	4,233	5,772	7.7	5.3	7.2	-0.5	-7%
Fossil fuel	Non-hosting	Gym	5,908	5,702	6,397	7.4	7.1	8.0	0.6	8%
Fossil fuel	Non-hosting	Kitchen	5,767	6,626	6,327	7.2	8.3	7.9	0.7	9%
Fossil fuel	Non-hosting	Laundry	5,574	5,995	4,993	7.0	7.5	6.2	-0.7	-12%
Fossil fuel	Non-hosting	Other	5,574	5,368	5,095	7.0	6.7	6.4	-0.6	-9%
Heat	Hosting functions	Other	7,787	5,352	5,101	9.7	6.7	6.4	-3.4	-53%
Heat	Non-hosting	Spa	4,741	6,044	5,166	5.9	7.6	6.5	0.5	8%
Heat	Non-hosting	Swimming pool	5,400	6,579	5,973	6.8	8.2	7.5	0.7	10%
Heat	Non-hosting	Sauna	6,091	7,472	6,052	7.6	9.3	7.6	0.0	-1%
Heat	Non-hosting	Gym	6,636	7,516	6,108	8.3	9.4	7.6	-0.7	-9%
Heat	Non-hosting	Kitchen	5,501	6,140	5,800	6.9	7.7	7.2	0.4	5%
Heat	Non-hosting	Laundry	6,066	7,260	5,964	7.6	9.1	7.5	-0.1	-2%
Heat	Non-hosting	Other	5,954	7,023	5,666	7.4	8.8	7.1	-0.4	-5%
Coolth	Non-hosting	Other	8,076	6,940	5,740	10.1	8.7	7.2	-2.9	-41%



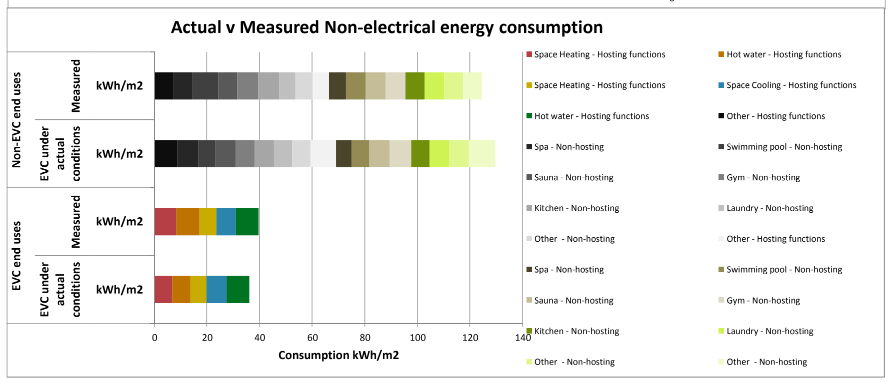


Table 30: Monthly variance between predicted energy consumption using Advanced Simulation under ACTUAL conditions and measured consumption

Energy	Scope	End use	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Co-efficient of variance	Comments on deviation between Actual conditions simulation and measured performance
Electricity	Hosting functions	Space Heating	-65%	-14%	-77%	-68%	93%	121%	-63%	2%	4075%	-75%	32139%	104%	101%	
Electricity	Hosting functions	Hot water	-70%	-72%	-72%	75%	-48%	122%	-57%	-74%	210%	140%	-76%	-81%	80%	
Electricity	Hosting functions	Refrigeration	-65%	-85%	3%	41%	189%	65%	-72%	33%	-66%	6%	2037%	26%	70%	
Electricity	Hosting functions	Fans	-20%	-48%	103%	-62%	11%	-64%	-22%	-13%	-99%	0%	-57%	-94%	54%	
Electricity	Hosting functions	Pumps	45%	-22%	24%	158%	-81%	49%	-99%	8%	93%	-71%	-17%	-4%	68%	
Electricity	Hosting functions	Controls	65%	-88%	-89%	19597%	-68%	1107%	-74%	150%	201%	137%	32%	-67%	123%	
Electricity	Hosting functions	Humidification	-13%	-14%	-86%	280%	6332%	17%	175%	-28%	22%	50%	13%	189%	78%	
Electricity	Hosting functions	Lighting (internal)	162%	204%	-20%	-89%	-98%	290%	152%	126%	-97%	-19%	5%	1141%	112%	
Electricity	Hosting functions	Plug loads	3%	-41%	151%	8%	114%	1053%	1069%	-8%	13314%	84%	250%	-74%	84%	
Electricity	Hosting functions	Other	3%	11%	-41%	11%	4682%	23%	30%	33%	-10%	-34%	-22%	365%	42%	
Electricity	Whole building	Vertical Transport (lifts & escalators)	223%	-11%	1681%	-23%	-39%	-75%	37%	20%	-60%	-12%	611%	-65%	71%	
Electricity	Whole building	Car park ventilation and lighting	4%	396%	-66%	-72%	-68%	2255%	1395%	518%	-32%	71%	1021%	-75%	129%	
Electricity	Whole building	Lighting (External)	-14%	-11%	-4%	141%	-47%	-13%	-47%	-30%	61%	17%	-92%	-84%	43%	
Electricity	Non-hosting	Spa	-1%	-47%	187%	497%	1335%	77%	-8%	98%	-59%	65%	127%	21%	93%	
Electricity	N/A	Not in use for Hotels	63%	8%	-62%	11%	-20%	-52%	20%	62%	306%	11%	14%	8%	57%	
Electricity	Non-hosting	Swimming pool	-70%	-93%	-3%	757%	-96%	47%	-20%	-22%	779%	1884%	-94%	69%	104%	
Electricity	Non-hosting	Sauna	9%	-69%	199%	-80%	25%	772%	-3%	10%	23%	2280%	-59%	23%	89%	
Electricity	Non-hosting	Gym	-44%	-41%	469%	-46%	-41%	286%	82%	67%	-98%	-29%	244%	-40%	103%	
Electricity	Non-hosting	Kitchen	6%	24%	4%	-22%	765%	94%	537%	1730%	-33%	-96%	-42%	1413%	82%	
Electricity	Non-hosting	Laundry	58%	-79%	0%	-93%	7523%	16%	-24%	-59%	-55%	-23%	84%	-41%	77%	
Electricity	Non-hosting	Other	101%	-32%	82%	-19%	6%	98%	-12%	-40%	-24%	-40%	619%	143%	48%	
Fossil fuel	Hosting functions	Space Heating	19%	107%	-59%	-36%	13%	104%	267%	-96%	-14%	44%	3%	1035%	51%	
Fossil fuel	Hosting functions	Hot water	23%	-2%	-41%	10%	61%	171%	-17%	-66%	82%	-49%	0%	846%	57%	
Heat	Hosting functions	Space Heating	260%	-51%	426%	22%	-99%	-18%	-50%	-69%	-6%	6%	1588%	2493%	83%	
Coolth	Hosting functions	Space Cooling	67%	-76%	-89%	493%	2%	-41%	1457%	-37%	12%	199%	-92%	-96%	89%	
Heat	Hosting functions	Hot water	-42%	-42%	540%	-80%	-3%	12%	-41%	-85%	-89%	-84%	24%	68%	69%	
Fossil fuel	Hosting functions	Other	24%	20%	85%	-57%	5%	377%	353%	42%	-40%	12%	156%	-40%	68%	
Fossil fuel	Non-hosting	Spa	135%	52%	24%	14%	-89%	-99%	196%	150%	866%	10%	-53%	13%	108%	
Fossil fuel	Non-hosting	Swimming pool	64%	-68%	8675%	59%	15%	-24%	-8%	106%	-79%	-34%	-92%	-44%	74%	
Fossil fuel	Non-hosting	Sauna	-42%	-22%	252%	3745%	4%	-77%	-57%	-32%	156%	-78%	-53%	-53%	76%	
Fossil fuel	Non-hosting	Gym	-86%	10%	-75%	-12%	67%	82%	-21%	-96%	1766%	166%	27%	-78%	80%	
Fossil fuel	Non-hosting	Kitchen	-53%	-37%	7%	-74%	-45%	31%	357%	32%	22%	-70%	-4%	534%	59%	
Fossil fuel	Non-hosting	Laundry	99%	-83%	37%	3027%	-55%	-52%	1266%	79%	-67%	113%	-31%	-26%	109%	
Fossil fuel	Non-hosting	Other	438%	-37%	-38%	-85%	166%	578%	-80%	-18%	226%	-72%	40%	874%	93%	

Heat	Hosting functions	Other	-76%	-65%	112%	19%	324%	-45%	-18%	0%	360%	1317%	244%	-6%	84%	
Heat	Non-hosting	Spa	9%	240%	-9%	-49%	149%	-72%	44%	-51%	156%	366%	49%	19%	84%	
Heat	Non-hosting	Swimming pool	-6%	-38%	509%	-66%	323%	46%	5%	-57%	137%	155%	87%	-62%	63%	
Heat	Non-hosting	Sauna	-34%	-79%	15%	-27%	78%	413%	27%	-52%	347%	118%	40%	839%	72%	
Heat	Non-hosting	Gym	-43%	174%	138%	30%	1%	160%	171%	-34%	13%	-13%	-39%	148%	70%	
Heat	Non-hosting	Kitchen	133%	-18%	998%	52%	368%	-46%	47%	-66%	-62%	264%	-57%	-45%	98%	
Heat	Non-hosting	Laundry	61%	-15%	-16%	52%	44%	739%	3%	175%	111%	-83%	-71%	25%	73%	
Heat	Non-hosting	Other	-6%	-79%	23%	-69%	16063%	150%	87%	101%	105%	85%	12%	88%	96%	
Coolth	Non-hosting	Other	65%	37%	141%	413%	-51%	67%	-16%	7408%	-89%	-39%	-4%	2426%	96%	