Green consultant's report on building design and water reduction for the development of the University's Sustainable Design Guide.

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Contents list:

1. Introduction.

This report shall define research conducted by our team, to support our clients production of the University of Exeter's sustainable design guide. This research has focussed on two significant aspects, namely water reduction technologies and sustainable building practises throughout each phase of usage and construction respectively. This report, as requested by our client, shall be presented in the form of a performance standard report, displaying the information gathered by our team in a concise and condensed manner, including links or signposting to further studies as appropriate. This project's client brief including information such as aims, scope and deliverables is contained in appendix A of this report, this brief was agreed with project stakeholders but has been subject to change, following ongoing discussions and project presentation feedback.

2. **Building principles and exemplar industry practises.**

- Local, A rated materials/products from BRE green guide

Planning, design and construction strategy for green buildings in BC, Canada, subsection 7.6 in particular, extends beyond BREEAM scheme so may provide insight for further work and development (https://www.greenbiz.com/sites/default/files/document/O16F22028.pdf).

Look to reuse recycled or salvaged goods as well as minimally processed items such as natural stone, slate shingles, wood and plant products to avoid transport and chemical emissions. Durable and low maintenance materials such as fibreglass windows and vitrified clay waste pipe should also be considered in design and refurbishment projects.

Potential of reclaimed steel for skeleton structure of new buildings, case study in the UK shows less environmental impact than new steel (https://thebowzedproject.weebly.com/case-study.html).

- Building bulletin 101 requirements applied to all buildings

Eden project uses ethylene tetrafluoroethylene copolymer (ETFE), or 'cling film with attitude' for their biomes 'window type' structures. Use and inflate 3 layers to produce an incredibly strong, light weight (1% weight of glass) and self cleaning material.

BREEAM case study on 'One Angel Square' building in Manchester, highlighted atrium design as key in facilitating lower heating, energy and cooling costs. One Angel Square case study: https://www.breeam.com/case-studies/offices/one-angel-square-co-operative-group-hq-manchester/.

'Green labs' LEAF (Laboratory Efficiency Assessment Framework) principle introduced by UCL, used to certify laboratory institutions to different levels for efficiency. Link to LEAF 'Green labs' framework tool: Take part in LEAF | Sustainable UCL - UCL – University College London.

- Whole life costing

ISO 15686-5: 2017 - ‘Service life planning’ international standard applicable.

Cardiff University published their desire to be carbon neutral for scope 1 and 2 emissions by 2023. Objectives include refurbishment projects over £25,000 must show a net reduction of 30% in carbon emissions from baseline Microsoft Word - Environmental sustainability enabling strategy action plan 2018_2.docx (cardiff.ac.uk). If Exeter University wants to be a leading part of the sustainability movement, it must at minimum align itself with equally ambitious aims; however, it is noted carbon offsetting is included in Cardiff University’s plan for carbon neutrality.

- Construction waste management plan

New South Wales Glasgow hospitals currently have a comprehensive scheme for planning out waste during design phases and may be used to support future construction projects (New South Glasgow Hospital.pdf (zerowastescotland.org.uk)).

Southampton University (Russell Group) are accredited to (ISO14001: 2015) through their Environmental Management Scheme, part of certification is proving sustainability in life cycle, supply chain and disposition of projects, therefore this should be a certification the University of Exeter aims to achieve.

ISO 20887:2020, relates to ‘sustainability in buildings and civil engineering works — Design for disassembly and adaptability — Principles, requirements and guidance’. This further addresses the consideration of the deconstruction process during building phases.

Sustainable construction using 100% recycled timber should be considered when renovating outside areas across campuses. Used by University of Liverpool in Botanical Garden building construction and design, link to Timber sustainable design and construction: Environmentally Friendly Construction - Ness Botanic Gardens - University of Liverpool.

- Passivhaus Design

The passivhaus concept has been put forward as one of the most promising ways to meet the World Green Building Council’s aim of achieving full carbon neutrality in home buildings by 2050. It has also featured on ‘World Economic Forum’ social media in 2021. There are currently

11 UK certified Passivhaus schools. However, The University of Leicester's Centre for Medicine is currently the largest commercial Passivhaus in the UK. The centre has a total floor area of over 12,000 square metres, housing 2000 students and staff making it one of the largest Passivhaus buildings in Europe at a cost of £42 million. The project manager said that attention to detail is critical throughout the design and construction process but if this is followed correctly, then there are few issues achieving certification. One of the main issues experienced however was obtaining a large enough air handling unit certified to be used in a Passivhaus building. More detail available at:
https://www.cibsejournal.com/case-studies/the-uks-largest-passivhaus-university-of-leiesters-centre-for-medicine/

Other projects include one of New York's first Passivhaus certified residential projects:
https://www.weforum.org/agenda/2021/01/passive-housing-sustainable-emissions-reduction/

- Heat Pumps

Heat pumps have the potential to deliver immediate carbon emission savings of 60-70% compared to conventional electric heating and 55-65% when compared to an efficient gas boiler. (air quality news) As the grid decarbonises further in coming decades, these carbon emission savings are expected to increase to 90-100% by 2050. If this is used in conjunction with passivhaus thermal insulation then there will be even greater carbon emission savings. Use of a thermostat would also avoid unnecessary heat expenditure for unoccupied rooms. Overall, heat pumps have an average payback period of around 6 years whilst also receiving a government grant for renewable heat premium payment. They are highly efficient and, although they become less efficient in colder temperatures, they are still capable of operating in temperatures as low as -15C.

An example of their use is in Plot A3 New Bailey in New Bailey Street, Salford. A 113,000 square feet commercial office due for completion in 2022 which was featured on UKGBC and achieved a 50% reduction over Good Practice REEB benchmark for performance. Air source Heat pumps on the roof meet all heating requirements and building fabric performance was reduced to near Passivhaus standards with all curtain walling elements designed out. Additionally, there are optimised glazing areas on 45% of the facades which help further with insulation. In order to go above and beyond regarding sustainability, upon completion, any

upfront embodied carbon will be verified, offset and disclosed. Then, every subsequent year the operational carbon and in use embodied carbon will undergo the same process. More information on this project is available here:
https://www.ukgbc.org/ukgbc-work/plot-a3-new-bailey/

- District Heating

District Heating uses heat from refuse incineration plants and combined heat and power plants to heat connected buildings. For instance, Copenhagen's district heating system is one of the world's largest, oldest and most successful, supplying 97% of the city with clean, reliable and affordable heating. The system cuts household bills by 1400 euros annually as well as saving the equivalent of 665,000 tons of co2 annually.
On a smaller scale, the Exeter Energy Network project redistributes the energy centre at RD&E Hospital Wonford and delivers a heat network to deliver heat to the city centre. It is a low carbon CHP generating 16GWH electricity, 37GWH thermal across a 6.5km district heating pipe network with an initial cost of the core scheme estimated to be around £17.5 million. More information available at:
https://www.exetercityfutures.com/programme/partners/city-district-heating-project/

- Photovoltaics

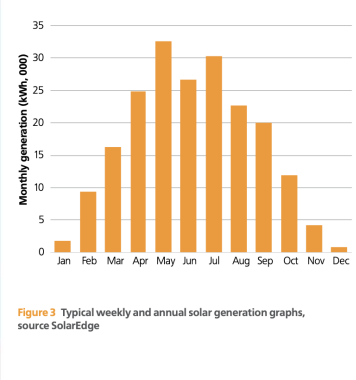

Figure 3 Typical weekly and annual solar generation graphs, source SolarEdge

90% of PV installations on commercial rooftops use either mono or polycrystalline cells. Monocrystalline PV cells are made from high-purity silicon, giving an even colouring and uniform look to the panels. They are slightly more expensive to manufacture than polycrystalline cells, but have higher efficiencies (15-20%).

Regarding the area of solar panels needed to generate significant electricity, a general rule of thumb is that around 6000-8000m2 of sloping roof space is required per megawatt of capacity installed.

Oxford Brookes University has achieved a 33% reduction in carbon emissions since 2005 and having obtained interest free funding through Salix Finance, invested in solar power. They discovered Joju Solar through the Fusion 21 public sector procurement framework and installed panels that added just under 300kWp per square meter of roof space and doubled their solar

PV capacity. Overall the project is generating 224,912kWh per year, with a 57 tonnes CO2 saving with an 8 year payback.

For more information please see:
https://www.jojusolar.co.uk/portfolio_page/a-hub-of-high-efficiency-at-oxford-brookes-university/

For an in depth guide to photovoltaics please visit:
https://www.bre.co.uk/filelibrary/nsc/Documents%20Library/NSC%20Publications/123160-NSC-Solar-Roofs-Good-Practice-Guide-WEB.pdf

- WELL V2 Building Standard 2019

Based on our research, it is evident that although WELL is a prestigious accreditation in building design, environmental sustainability is not its main focus and there are many other factors involved such as employee welfare. Therefore, it is not the most suitable for the aims of this project. However, please find a case study of ASID headquarters that achieved WELL platinum:
https://www.asid.org/news/asid-headquarters-in-washington-d-c-is-first-space-in-the-world-to-earn-both-leed-and-well-platinum-certification-under-well-building-standard-v1

3. Water efficiency

3.a. Short and medium term aims

- Wash hand basins

Example: Aberdeen University - Sensor spray mixer taps used (included in a scheme which reduced water consumption by over 100,000 cubic metres per year)

Example: Newcastle University - Push head taps installed after any refurbishment which is carried out

- Urinals

Example: Oxford University - ‘Cistermetre’ type divide in the washrooms. Ensures that they are only flushed during times that the washroom is in use.

Problems associated: Devices would still have to be fitted with fully adjustable fittings, allowing the flushing rates to be increased if any problems arise (eg. blockages). This is an added cost to the project.

- W/Cs

Many universities have installed dual flush toilets. (4.5 litres and 2.2 litres). This is a larger volume than is suggested in the Exeter minimum standards (2 litres)

Example: Aberdeen University - Following refurbishment, 13 litre cisterns sn will be replaced with a 6 litre

- Dishwashers

Standard dishwasher. Uses a maximum of 4 gallons of water per wash. For example the KitchenAid KDTM354DSS dishwasher

3.b. Scope 1 & 2 Carbon Reduction Targets

- Rainwater harvesting

This involves collecting and storing rainwater instead of allowing it into drains. Collected from the roof and then re-used within the home or in the garden.

Example: Plymouth University - Rainwater harvesting technology used in a number of university buildings. Collected from the roof and stored in tanks. It is then used for flushing toilets

Problems associated: Dependent on the site's potential rainwater yield (regional rainfall, size of catchment area). This requires a large area of installation, high level of building work required. Storage area required.

- Greywater harvesting

Greywater systems collect used water from sinks, dishwashers, showers and baths ('grey water'), clean it and then pump it back into the system where it can be used for toilets, washing machines and outside taps

Example: Reading University Investigation (2016) - Predicted it could save £1347-£4000/year on their campus. Payback within 5-6 years. Investigation carried out in two halls of residence

Problems associated: Large scale building work required. Area needed for water storage and treatment. However, it is a better alternative than rainwater harvesting in lower rainfall areas.

3.c. Formalised suggestions

- Leak detection systems

University of Surrey: installation of strategic meters, pattern analysis, increasing reporting and heat-vision cameras. Identified approximately 8,400,000 lites/year of year

Smartpipes have been developed by the University of Birmingham. Sensors attached to outside of pipes, making them easier to fit and reduce changs of pipes being damaged during installation

- Showers

Many universities have included shower specifications in their guides. Oxford Brookes University have installed aerators to maximise the effectiveness of taps. Automatic/sensor shut off nozzles also installed.

- Monitoring systems

Through monitoring on a smaller scale (eg. departments/buildings) it could allow for department led incentives

Newcastle University: fully automatic metre readings rolled out across the University

Oxford University: Half-hourly metered data. Prevents the reliance on regular metre readings being carried out in person. Allows changes of use over the course of the day to be seen. Highlights any irregularities in water usage.

- Water usage in labs

Laboratory Efficiency Assessment Framework (LEAF) developed by UCL. This allows Universities to join a scheme, which allows them to gain bronze/silver/gold awards depending on what action you take. This also gives advice on the most efficient equipment for example.

Hang on back (HOB) external power filters are designed with a flow restricting valve on the filter's intake tube. By turning the flow control knob, water is restricted from flowing into the filter, reducing the output of the filter. Filter adjustment is different from previous methods. It reduces the gallons per hour flowing through the filter. Water circulation in the aquarium will also be reduced. This is the easiest way to cut back on strong water currents if your filter allows.

4. **Sustainable design guide suggestions.**

University of Birmingham produced a video/animation outlining their ‘sustainable estates framework’ for the future. This is an innovative approach used to accompany the document itself, broadening the potential audience to non-subject matter experts and stakeholders such as students, through a more digestible and engaging format.

University of Bristol is a good example of sustainable design guides, being easy to follow with clear information. But it needs to have a contents list with page numbers so students and interested parties can skip to sections of particular interest. Uni of Bristol policy link: sustainable-construction-strategy-2017.pdf (bristol.ac.uk).

University of Edinburgh current waste strategy is a good example of a clear and digestible guide with SMART objectives to avoid ‘wishy-washy’ language. Edinburgh waste strategy: waste_strategy_implementation_plan_2019-2023.pdf (ed.ac.uk).

Appendix A - Client Brief.

Client Brief

Project Title: Building design and water reduction: Reviewing existing practice and making recommendations for the development of the University's Sustainable Design

Project Activities:

· Mapping audit of existing practice amongst other institutions (HE and other) for:
- Sustainable design guidelines
- Water reduction strategies
· Further research into best practice examples and identifying recommendations for the University

Client Contact: Andy Seaman	
Phone: N/A	Email: a.seaman@exeter.ac.uk
Other: N/A	

Background

The impacts of climate change cannot be avoided anymore. Activists and academics state that the bigger your carbon footprint, the bigger your moral duty to reduce it, consequently arguing how environmental responsibility is vastly important in reducing the potential implications of climate change. One of the most effective ways to change people's behaviour is through education as in order to make significant reductions in global greenhouse gas emissions, every individual needs to play a part; therefore, without informed actors and stakeholders effective environmental action is unlikely.

Efficient building design and construction as well as sustainable use of freshwater sources can make a significant difference on greenhouse gas emissions, as shown within the IPCC's most recent report in 2019. In 2019, the University of Exeter produced an emergency environment and climate emergency 'white' paper, which presented many areas and goals in which the University needed to address to become increasingly sustainable and reduce carbon emissions. The paper sums up the University's desire to reduce its carbon footprint and emissions to become a leading University when relating to sustainability.

One of the areas reported on within the paper was building design and water reduction. With the paper stating that 'the campus water bill is well over £1 million per annum', it is clear that water use is both an economic stress on the University as well as an environmental one. This is why it is essential to look at the University's building design and usage, whilst alongside this assessing potential ways to reduce water use and stop water wastage.

Aim

This project aims to research best practises for;

- Firstly, building design, focusing particularly on renovations as well as new builds.
- Secondly, water saving technology.
- This research should be conducted on a global scale with a view to establishing a minimum standard of sustainability principles beyond BREAM. This new overarching standard

for the University should be both industry leading and enduring with regards to the future innovations.

Scope

Evaluating existing mechanisms, practise and guidelines employed by the University of Exeter relating to building construction and water usage is not part of this exercise.

Potential recommendations of improving relevant performance shall be applicable to all University of Exeter estates.

Best practise initiatives shall be assessed from any area of industry, although higher education institutions shall be a part of the Russell Group program.

This project shall not consider individual equipment usage, devices or tools, rather evaluating higher level, overarching efficiency concepts and novel concepts.

Water reduction and efficiency recommendations may address each phase of usage including capture, recycling during laboratory experiments and minimal acceptable standard guidelines.

Short and long-term gain recommendations are applicable as part of this project.

Resources

- Green Consultant team
- University of Exeter's white paper
- Academic research and journals
- Access to more people in the university may be advised by Joel and Andy following future meetings
- Joel Smith offered to send most up to date annual reports and policy statement links
- Andy Seaman to sign off on the project (a.seaman@exeter.ac.uk).

Stakeholders

- University of Exeter
- Green Consultants

Outputs

Published report 31st March informal ‘cheat sheet’, citations if appropriate or link to study/other project

Presentation 16th March

Key dates.

Presentation of your project progress by 18th March 2021.

Final submission of report due 31st March 2021.

Possible constraints.

- Lack of time resources (-35hrs each).
- Limited access to university data.

Appendix B - Draft research findings.

Suggestions on water sustainability:

Toilet	- Adjustable flappers. - Use grey water (Stanford) **Standard - only install 4.8 litres (low flush) toilets to reduce water use.**	
Taps	- Stanford University = uses water misers (plastic parts that can be put on taps) on autoclaves so that water doesn't need to be running 24 hours a day on all of the devices as the misers sense when the water is needed and when it is not, reducing their water usage by 50% within those buildings. - Tap timers so they deliver 1.5litres per operation e.g. for hoses. University of Durham does this.	https://www.waterirrigation.co.uk/water-timers/battery-water-timers.html
Fountains	- Stanford shut down and drained.	
Leak detection technology	- Distributed acoustic sensing. The technology converts fibre optic cables, which are run alongside pipelines, into an ecosystem of highly-sensitive, individual vibrational sensors. **Standard - have distributed acoustic sensing on all pipes, to be able to identify leaks without having to replace whole pipe sets.**	https://www.apsensing.com/technology/distributed-acoustic-sensing-das-dvs
Irrigation	- Smart weather based irrigation controllers - Stanford does this. This automatically adjusts the watering schedule based on local weather conditions. E.g. The controller reduces the amount of watering when the weather cools down, and adds time when it heats up.	

	- Use grey water for turf e.g. athletic fields irrigation. **Standard - add smart weather based irrigation controllers to all irrigation sites.**	
Monthly reports	- Could send to each department to make them aware of their water use **Standard - have a monthly water usage report sent to each building or department - set them targets for next month.**	
Low flow showerheads and shower timers	- By showers being on timers it encourages students / staff to take shorter showers. University of Durham does this. **Standard - have a maximum of 1.25 GPM flow rate on all showerheads.**	https://www.amazon.co.uk/dp/B003UQ17O4?linkCode=gs2&tag=mlbuk-21
Washing machines	- High efficiency washers - Front loading washing machines can use up to 70% less water than the same size top loader, because they're able to wash clothes by picking them up and dropping them into the wash water repeatedly, unlike top loaders which wash clothes by having them float around in water. **Standard - all washing machines have to be A+++ rating, plus be front loading.**	https://www.bosch-home.co.uk/product-list/WAW28750GB?intcid=EasyProductFinder%7CEnergyEfficientWM%7CMay2020%3A%3AWebsite%3AContentTeaser%3A
Dishwashers	**Standard - dishwashers to use the maximum of four gallons of water per wash.**	E.g. KitchenAid KDTM354DSS dishwasher
Water fountains	**Standard - Replace bottle fed water coolers with mains fed versions.**	University of Cambridge has done this.

The university of Exeter- minimum standards for sustainability design guide: **Scope 1 & 2 carbon reduction targets**	Description	Similar relevant example	Problems associated
Rainwater harvesting	Collection and storage of rainwater instead of allowing it into drains. Collected from the roof, then re-used within the home/garden.	<u>Plymouth:</u> Rainwater harvesting technology used in a number of university buildings. Collected from roof and stored in tanks. Used for flushing toilets	Dependent on the site's potential rainwater yield (regional rainfall, size of catchment area). Large area required.
Greywater systems	Greywater systems collect used water from sinks, dishwashers, showers and baths ('grey water'), clean it and then pump it back into the system where it can be used for toilets, washing machines and outside taps	<u>Reading University Investigation (2016):</u> Predicted it could save £1347-£4000/year. Payback within 5-6 years. Investigation carried out in two halls of residents	Large scale investment. Better alternative than rainwater harvesting if lower rainfall

Suggestions to include in the Sustainable Design Guide: WATER

Leak detection Systems:

- <u>Example: University of Surrey:</u>
    - Installation of strategic meters, pattern analysis, increasing reporting and heat-vision cameras.
    - Identified approx.. 8,400,000 litres/year of leaks

Smartpipes:

- University of Birmingham have developed system for detecting leaks – smartpipes
- Low cost, low power sensors to detect water leaks. Sensors attached to outside of pipes, making them easier to fit and reduce chances of pipes being damaged during installation
- https://www.birmingham.ac.uk/research/global-goals/clean-water-and-sanitation/innovation/smart-wireless-sensor-networks-for-water-leak-detection.aspx

Showers:

- Assists in maintaining a constant flow of water by mixing air into the water stream and distributing low flow water as spray.
- Can reduce flow rates to as low as 2 litres per min for taps and 3.7 in showerheads
- Example: Oxford Brooks University
    - Aerators installed to maximise the effectiveness of taps. Automatic/sensor shut off nozzles in

Monitoring usage:

- Meters that show the water usage per building
- Example: Newcastle University:
    - Fully automatic metre readings rolled out across university
- Example" Oxford University:
    - Half-hourly metered data rather than relies on regular meter readings being taken. Allows changes of use over the course of the day to be seen
- This is particularly useful in identifying leaks. Oxford have meters that make out-of-hours water use visible, as well as irregularities in water use

Water usage in labs:

- Upgrade from a lab water bath to a bead bath
    - Need for water is removed entirely, the equipment experiences less wear and uses less energy
    - University of Cambridge Medicine department and Institute for Medical research already converted
- UCL Laboratory Efficiency Assessment Framework (LEAF)
    - Bronze, silver, gold levels depending on what action you take

  Take part in LEAF | Sustainable UCL
  Sustainable Laboratory Equipment Guide

  This gives advice on the most efficient equipment etc which should be used in labs.

  Water tanks (fish):

    - Hang on back (HOB) external power filters are designed with a flow restricting valve on the filter's intake tube. By turning the flow control knob, water is

restricted from flowing into the filter, reducing the output of the filter. Filter adjustment is different from previous methods. It reduces the gallons per hour flowing through the filter. Water circulation in the aquarium will also be reduced. This is the easiest way to cut back on strong water currents if your filter allows.

Building principals, observations and exemplar industry practises

Principle	**Example of use or greater sustainable standard/analogue example**	**Further detail**
Local, A rated materials/products from BRE green guide	1. Planning, design and construction strategy for green buildings in BC, Canada, subsection 7.6 in particular, (https://www.greenbiz.com/sites/default/files/document/O16F22028.pdf), extends beyond BRE scheme. 2. Potential of reclaimed steel for skeleton structure of new buildings (https://thebowzedproject.weebly.com/case-study.html).	1. Should also look to reuse recycled, salvaged goods. Minimally processed goods such as natural stone, slate shingles, wood and plant products to avoid processing and chemical emissions. Durable and low maintenance materials such as fibreglass windows and vitrified clay waste pipe. 2. Case study in the UK shows less environmental impact than new steel.
Building bulletin 101 requirements applied to all buildings	The Eden project uses ethylene tetrafluoroethylene copolymer (ETFE), or 'cling film with attitude' they say for their biomes 'window type' structures. BREEAM case study on 'One Angel Square' building in Manchester, highlighting atrium design as key in facilitating lower heating, energy and cooling costs. 1. 'Green labs' LEAF (Laboratory Efficiency Assessment Framework)	They use and inflate 3 layers which is incredibly strong, but only 1% the weight of glass, can also transmit UV and are self cleaning. One Angel Square case study: https://www.breeam.com/case-studies/offices/one-angel-square-co-operative-group-hq-manchester/. 3. LEAF 'Green labs' framework tool link: Take part in LEAF | Sustainable UCL -

	principle introduced by UCL and certified to different levels for lab efficiency.	UCL – University College London.
Whole life costing	1. ISO15686-5: 2017 applicable as well as BREEAM. 2. Cardiff University (Russell Group) deem to be carbon neutral for scope 1 and 2 by 2023.	2. Objectives include refurbishment projects over £25,000 will show a net reduction of 30% in carbon emissions from baseline (Microsoft Word - Environmental sustainability enabling strategy action plan 2018_2.docx (cardiff.ac.uk)).
Construction waste management plan required	1. New South Wales Glasgow hospitals have a very comprehensive scheme for planning out waste during design phases (New South Glasgow Hospital.pdf (zerowastescotland.org.uk)). 2. Southampton University (Russell Group) are accredited to (ISO14001: 2015) through their Environmental Management Scheme. 3. ISO 20887:2020, relates to 'sustainability in buildings and civil engineering works — Design for disassembly and adaptability — Principles, requirements and guidance'. This further addresses the consideration of the deconstruction process during building phases. 4. Sustainable construction using 100% recycled timber, used by University of Liverpool in Botanical Garden building construction and design.	4. Link to Timber sustainable design and construction: Environmentally Friendly Construction - Ness Botanic Gardens - University of Liverpool

Adopting ISO20400 into procurement practises	1. ISO14001: 2015 also addresses the sustainability of your supply chain, as you must review your suppliers and their environmental standards.	
Examples of good, engaging sustainable design guides or strategy plans	2. University of Birmingham produced a video outlining their 'sustainable estates framework' for the future, this could be a great method to make a more digestible, engaging sustainable design guide message for non-specialist stakeholders. 3. University of Bristol has a good guide, easy to follow and clear information. But it needs to have a contents list with page numbers so students/interested parties can skip to sections they're interested in. 4. University of Edinburgh current waste strategy. Good example of a clear strategy and digestible, SMART objectives, good because it avoids 'wishy-washy' language like most documents and the client aims to avoid.	2. Uni of Bristol policy link: sustainable-construction-strategy-2017.pdf (bristol.ac.uk). 4. Edinburgh waste strategy: waste_strategy_implementation_plan_2019-2023.pdf (ed.ac.uk)

Standard	**Case study**	**Further information**

Passivhaus	Built using passive design in 2015, the International Renewable Energy Agency Headquarters uses 42% less energy than is required by the global energy standards. There are 11 UK certified Passivhaus schools in total The University of Leicester, Centre for Medicine is currently the largest commercial passivhaus in the UK: ● cost £42 million and has a total floor area of over 12,000m2 ● Was one of the largest non-domestic Passivhaus buildings in Europe ● Project manager said there were few problems during the certification process due to the attention to detail that had been followed throughout the design and construction stages ● one of the main issues was procuring a large enough air handling unit certified to be used in a Passivhaus building ● holds 2000 students and staff ● A three year soft landings programme will be conducted to ensure the building is operated correctly and maximum comfort levels are achieved ● The greatest challenge going forward is educating the occupants to operate the building. To ensure the building stays comfortable, users will be taught to operate louvres for shading, whilst reminded to be wary of the unwanted heat gains generated from appliances that would have been welcome in their previous building. ● The £42 million project being built by PHT Patron member Willmott Dixon, who are acting as main contractor, with consultancy from experienced Passivhaus experts WARM: Low Energy Building Practice. ● The project is being funded by £32m from resources and a £10m public appeal which has already raised a fifth of the target. ● Passivhaus consultants: WARM	Passivhaus for Educational Building Aims to: ● Promote & encourage implementation of the standard & increase awareness of Passivhaus in educational buildings & student accommodation. ● Highlight the benefits that Passivhaus can bring to occupant comfort and learning outcomes ● Engage with the Department for Education (DfE) on guidelines & requirements for education buildings Phase II includes short guidance tailored towards passivhaus for educational building clients online webinars, focusing on refurbishment **Passivhaus: the route to zero carbon** This analysis has shown that Zero Carbon targets don't necessarily result in Zero emission buildings and that, when considering how to define a Zero Carbon building, it is essential to take into account the complete picture of how the building will use energy as well as the impact of the seasonality of

	● Main Contractor: Willmott Dixon ● Technical consultants: Couch Perry Wilkes **The Inside story of New York's greenest condo** ● Charlotte of the Upper West side is set to be one of New York's first certified Passive House residential projects. Business of Home called it New York's greenest condo and also featured on the World Economic forum instagram page earlier this year. Luxury apartments costing $76 million. ● Passive House certification means that the building has to be air tight, the energy usage may not exceed 10 watts per square meter of living space, and the internal temperature must adhere to strict seasonal regulations **The Inside story of New York's greenest condo** ● Charlotte of the Upper West side is set to be one of New York's first certified Passive House residential projects. Business of Home called it New York's greenest condo and also featured on the World Economic forum instagram page earlier this year. Luxury apartments costing $76 million. ● Passive House certification means that the building has to be air tight, the energy usage may not exceed 10 watts per square meter of living space, and the internal temperature must adhere to strict seasonal regulations **The International Renewable Energy Agency Headquarters** Built using passive design in 2015, the International Renewable Energy Agency Headquarters uses 42% less energy than is required by the global energy standards.	renewable generation. The results show that a Passivhaus Classic building, with no generation capacity, will generate significantly lower emissions than a notional Zero Carbon building21 - which isn't Zero Carbon anyway as its emissions will 2 be around 18 KgCO2/m .year. The analysis shows that Passivhaus is the only realistic way to achieve Zero Carbon without massive renewable energy expansion coupled with a significant investment in grid capacity. However, even when using Passivhaus as a mechanism to significantly increase efficiency, achieving a Zero Carbon built environment is only really viable if the system boundary is extended beyond individual buildings. the passive house concept has been put forward as a way to meet the World Green Building Council's aim of achieving full carbon neutrality in home buildings by 2050

District heating	• The Exeter Energy Network project refurbishes the energy centre at RD&E Hospital Wonford and delivers a heat network to take heat from there to the city centre. Low carbon CHP generating 16GWh electricity, 37GWH thermal, 6.5km District Heating pipe network. Initial cost of the core scheme is estimated at £17.5m • copenhagen's district heating system is one of the world's largest, oldest and most successful, supplying 97% of the city with clean, reliable and affordable heating. The system cuts household bills by 1400 euros annually as well as saving equivilant of 665,000 tons of co2 annually	• uses waste heat from refuse incineration plants and combined heat and power plants
Heat pumps	• used in Plot A3 New Bailey in New Bailey Street, Salford. A 113,000 commercial office due for completion in 2022. Featured on UKGBC and achieving a 50% reduction over Good Practice REEB benchmark for performance. Air Source Heat pumps on the roof meet ALL heating requirements. Building fabric performance reduced to near Passivhaus standards with all curtain walling elements designed out. optimised glazing areas of 45% of the facades. on completion the upfront embodied carbon will be verified, offset and disclosed. every subsequent year the operational energy and in use embodied carbon will undergo the same process	have the potential to deliver immediate carbon emission savings of 60-70% compared to conventional electric heating and 55-65% when compared to an efficient gas boiler. (air quality news) As the grid decarbonises further in coming decades, these carbon emissions are expected to increase to 90-100% by 2050. If this is used in conjunction with passivhaus thermal insulation then there will be even greater carbon emission savings. Use of a thermastat would also avoid unnecessary heat expenditure for unoccupied rooms

		• government grant for renewable heat premium payment • payback period of roughly 6 years • air source heat pumps become less efficient the cooler it is outside, but they are still capable of operating sufficiently in temperatures of -15c • heat pumps can use the electricity produced from solar panels from sunlight and create up to 4 times as much energy as they consume
Solar PV	**Tilal al Ghaf Sales and Experience Centre** • 405 m2 • curved roof form incorporates photovoltaic panels and is orientated to best protect the interior whilst maximising capturing the sun's rays to generate electricity • 100% of renewable energy used in the project comes from PV panels installed on the roof and excess is fed back to the grid • PV panels installed on the roof and connected car parking shading structure provide more than 200% of total annual energy demand • it is a net energy positive building which has driven the project to target Zero Energy Certification with ILFI	battery storage will be key due to the intermittent sunlight, particularly if not south facing
Waste heat/water recovery		works by extracting hot water and utilising it to heat up the incoming mains water which

		reduces the strain placed on the boiler and the energy required to heat water. devices are shown to be approximately 60% efficient (carbon savings depend on the source of heat)
WELL v2 2019	ASID Headquarters is first space in the world to earn both LEED and WELL platinum certification under WELL building standard V1	• WELL largely for employee welfare as opposed to reducing carbon emissions