

THE THEATRE GREEN BOOK

2 : Sustainable Buildings
(Beta version for trialling)



The Theatre Green Book is built on years of thinking, research and advocacy by pioneering organisations, theatres, theatre companies and individuals. You'll find their names in the acknowledgements and bibliography, and their ideas throughout.

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BURO HAPPOLD

Foreword

The Theatre Green Book is an initiative by theatre-makers – guided by sustainability experts Buro Happold – to move theatre towards sustainability.

Early in the initiative, we divided that challenge into three parts: making productions sustainably, making our theatre buildings sustainable, and reviewing theatres' other operations, from catering to offices, waste to travel. Those three challenges have become the three volumes of the Theatre Green Book.

This volume, Sustainable Buildings, shows how to make our theatres more sustainable, even though many of them are ageing and starved of investment. It's designed for executive directors and facilities managers, for boards, funders, local authorities and designers – for anyone who faces the challenge of taking a theatre building and making it fit for purpose in the context of the climate emergency.

Those theatres include some of our most valued, most loved and most prominent public buildings. If we want theatre to point society towards a sustainable future, then we urgently need to regenerate our theatres to suit a world of life-threatening temperature rise, over-exploited resources, and declining biodiversity.

That journey will never be easy – theatre owners know how hard it is to raise funds for investment. But it is essential. Sustainable Buildings gives theatre clear standards for assessing the challenge, selecting priorities – and setting out on the journey.

Paddy Dillon, Green Book Co-ordinator

Contents

The Theatre Green Book has brought together theatre-makers and sustainability experts to create a common standard for making theatre sustainably.

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THE GUIDANCE

The Sustainable Buildings 'Home Survey Kit' can be found online at

<https://theatregreenbook.com/homesurveytool/>

Complete the Home Survey Kit to generate an initial Sustainability Plan, then turn to Section 9 for guidance on how to finalise it.

TOOLKIT

A toolkit of resources for sustainable theatre buildings can be found online at

<https://theatregreenbook.com/sustainablebuildings-toolkit/>

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sustainable buildings

AT A GLANCE

"We have a once-in-a-generation opportunity to build a resilient recovery plan that is fair and tackles the climate and ecological crisis with urgency. We cannot let this opportunity pass us by." Julie's Bicycle, 2020

To become more sustainable a theatre building must:

- BE LEAN (improve walls, roofs etc so as to lose less energy)
- BE CLEAN (improve services systems to use less energy)
 - BE GREEN (draw energy from renewable sources)
 - Support biodiversity and reduce waste

To make that happen, theatre owners and managers must:

- Survey their building to identify what needs to be done
 - Make a Sustainability Plan
 - Start with the easy wins
- Focus maintenance works on sustainability
 - Start planning for capital projects

Be Lean (waste less energy)

Roofs

1

Roofs are a major source of heat loss, particularly above auditoriums

Walls

2

Walls can be insulated to keep energy in.

Floors

3

Uninsulated overhangs and balconies let energy escape.

Entrances

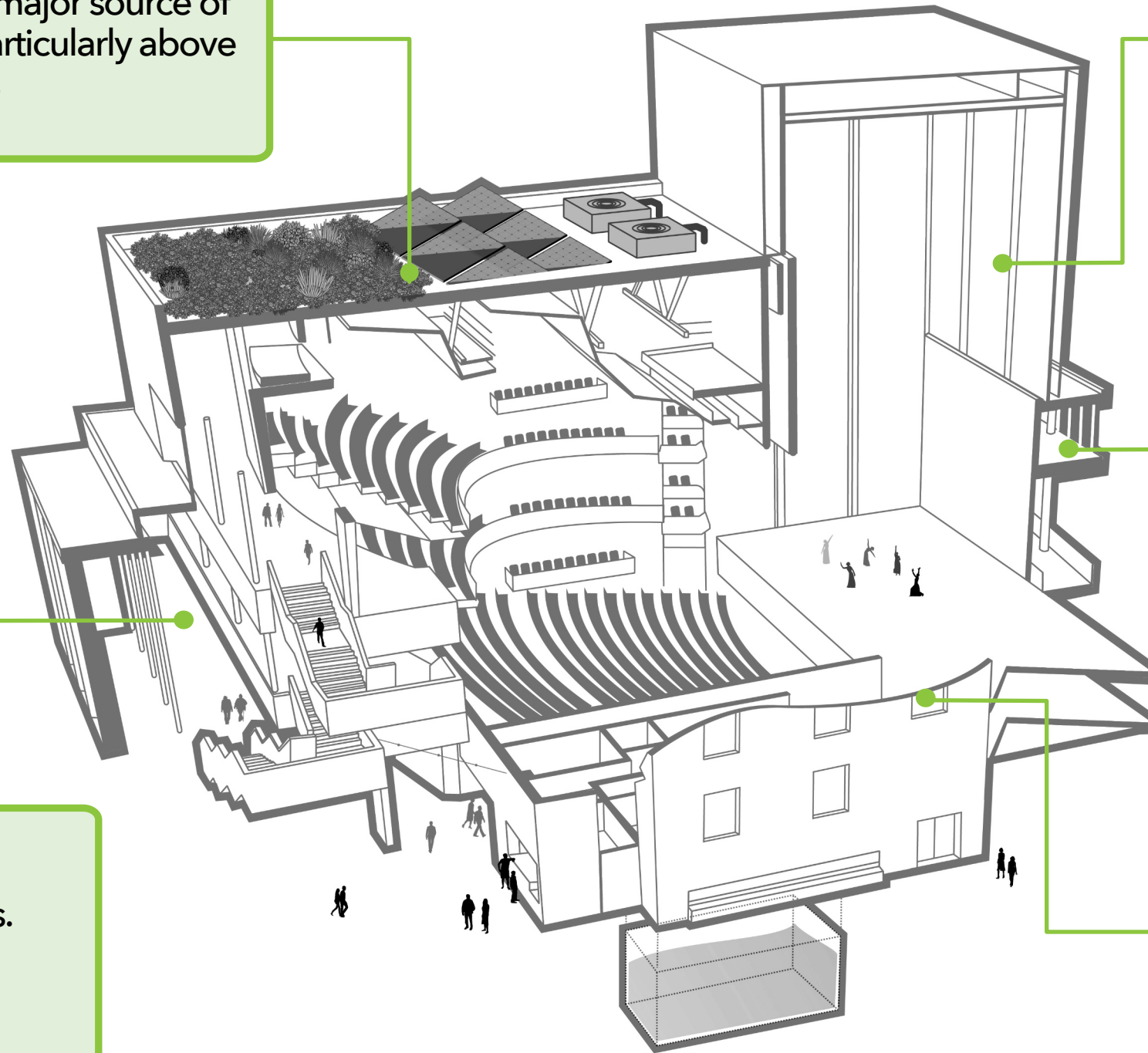
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Entrances need lobbies. Thin, leaky doors waste heat.

Doors and windows

5

Double or secondary glazing stops heat going out of the windows.



Be Clean (improve services systems)

Heating and cooling

1

Replace fossil fuels with low-carbon energy sources.

Ventilation

4

Efficient fans and pumps prevent energy waste.

Lighting

2

Switch to LED. Timers and movement sensors keep lights off unless they're needed.

Hot water

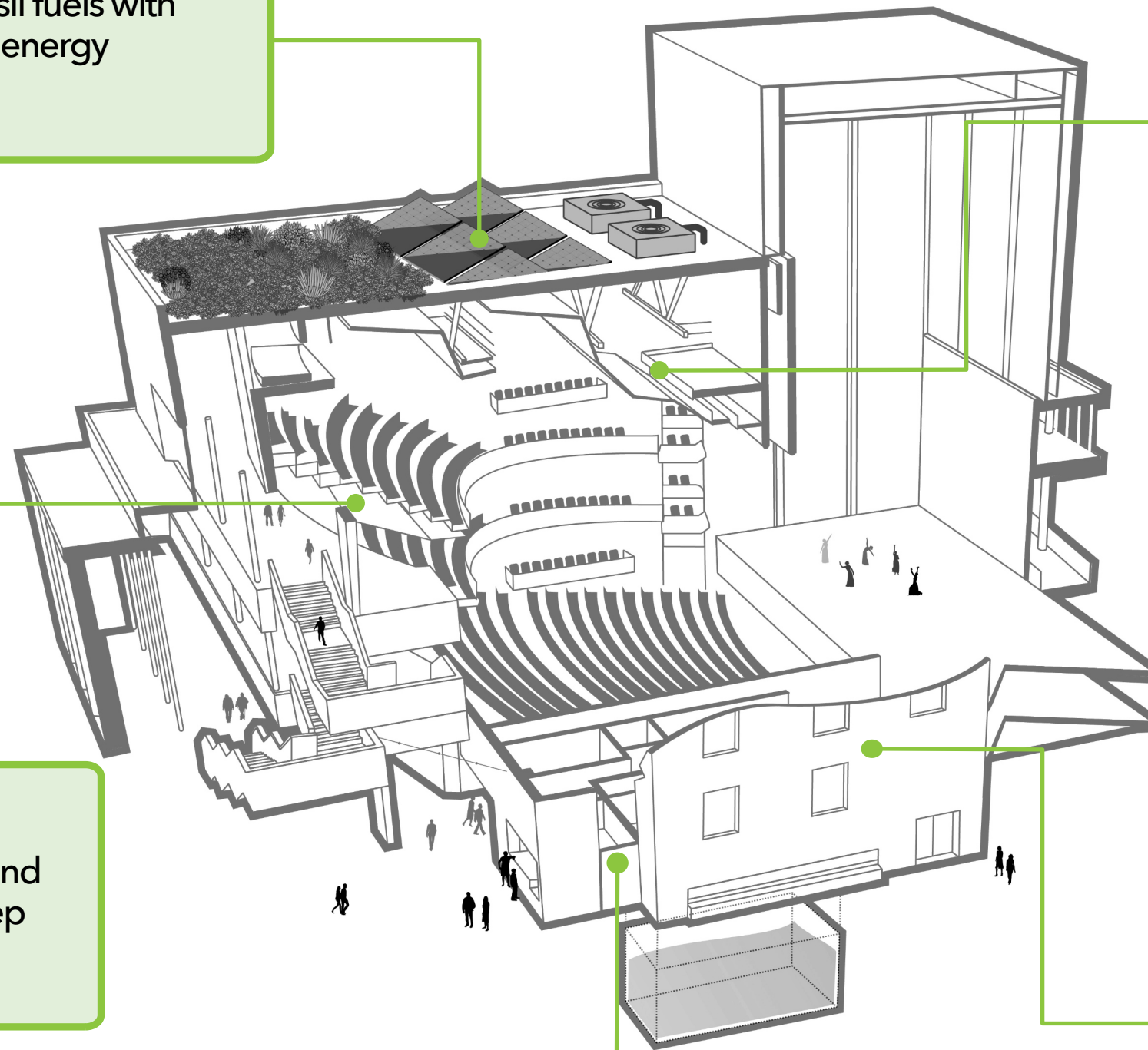
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Hot water supply for taps and showers must be heated sustainably.

Other Systems

5

Lifts, servers, security systems and catering are all big energy users.



Be Green (use renewable energy)

Solar panels

1

'PVs' and thermal panels work well on auditorium or back of house roofs

Turbines

4

Wind power rarely works in towns and cities, but may help rural theatres.

Air source heat pumps

2

Easier to install than GSHPs, these can work well for some theatres.

Ground source heat pumps

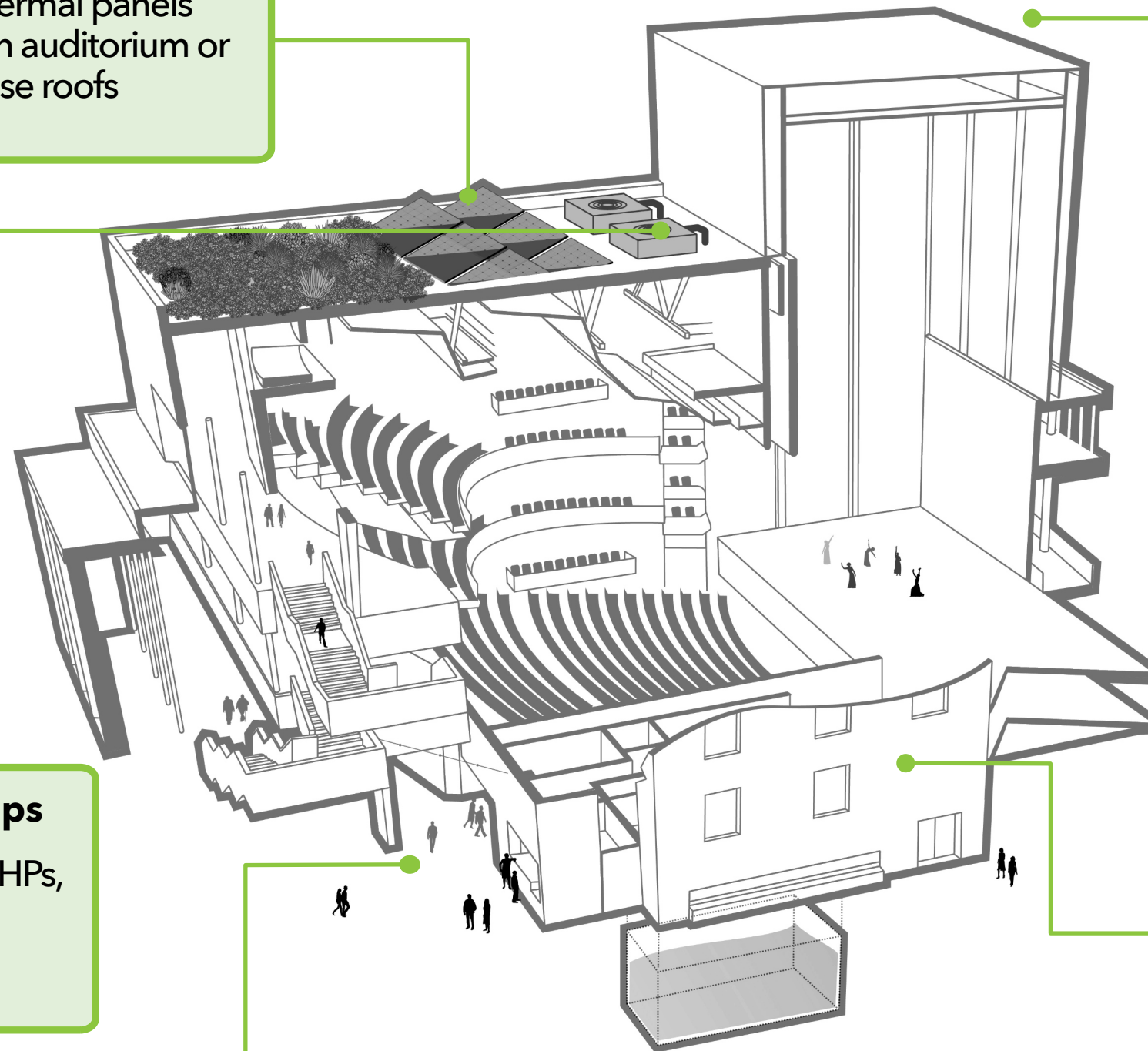
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Warmth in the ground is an energy source, but 'GSHPs' often require major works.

The National Grid

5

Greener every year, the Grid can offer renewable electricity straightaway.



Support biodiversity and use less water

Green roofs

1

Planted roofs can support wellbeing as well as biodiversity.

Rainwater

3

Rainwater can be captured to irrigate plants, but needs storage space.

Landscape planting

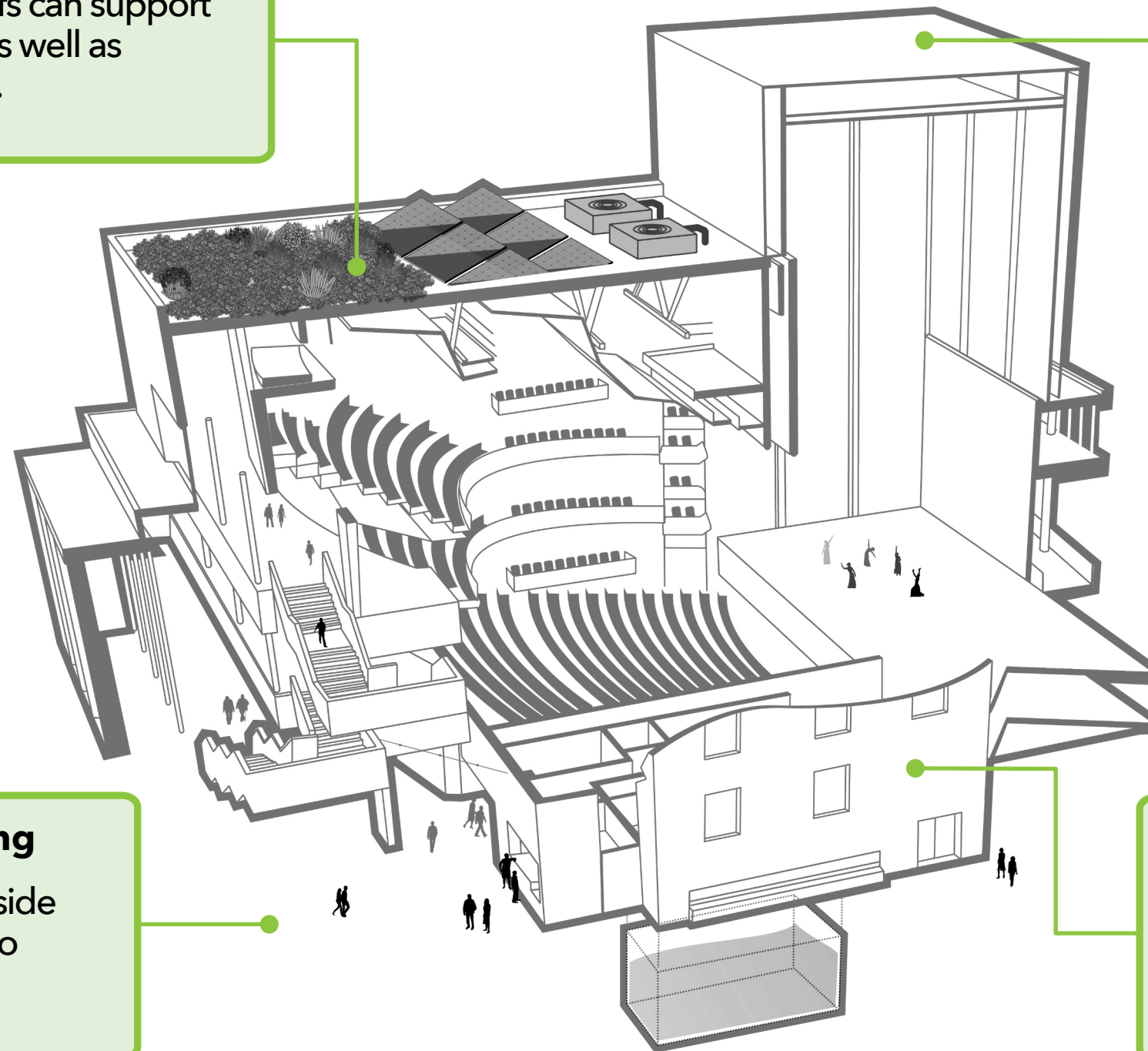
2

Any theatre with outside space has a chance to support biodiversity.

Grey water

4

Water from showers can be reused in toilets, but needs extra pipework and storage.



Making a Plan

Carry out a Green Book 'Home Survey'

See Guidance Section: the Theatre Green Book's Home Survey tool asks you questions about every aspect of your building



Develop a Sustainable Building Plan

The tool automatically categorises actions and puts them in order of priority



Put in hand the 'Easy Wins'

Actions which are low cost and easy to do



Plan your maintenance strategy

Including green upgrades wherever possible



Plan your capital projects

For larger interventions that will need fund-raising, closures or permissions



Set a timetable

To achieve carbon zero

sustainable buildings

THE PRINCIPLES

“Without the cultural sector playing its part in helping current and future society to move towards a more sustainable way of life, this essential shift will not happen.” Creative Carbon Scotland, 2020

1 Introduction

1 Why the Green Book?

The climate crisis is an immediate threat to our safety, equity and prosperity. We urgently need to limit carbon emissions, reduce biodiversity damage, and, in doing so, achieve a just transition where people, places and communities are supported and vulnerable groups protected.

Theatre cannot solve the climate crisis alone, but it can play an urgent role in addressing it. Theatre can question and challenge, provoke, entertain and surprise. It can reflect the preoccupations of generations facing a time of dizzying, frightening change.

But to do that, theatre itself needs to work sustainably.

2 A Clear Path to Sustainability

The Theatre Green Book gives theatre a path towards sustainability. It builds on years of work by theatre-makers and sustainability pioneers like Julie's Bicycle, Creative Carbon Scotland, SiPA, Ecostage and others. It maps the journey towards an industry that is low carbon and low waste, values people, and contributes to a more sustainable society.

3 Scope of the Green Book

The Green Book will have three parts. Together, they will give theatre clear, practical and detailed guidance towards sustainability:

- 1 Sustainable Productions
- 2 Sustainable Buildings (this volume)
- 3 Sustainable Operations

4 Sustainable Buildings

Theatres are among our most high-profile public buildings. About 34 million theatre tickets are sold each year. Theatres are often the most prominent buildings in a town centre. They are flagships for the arts and culture.

It is all the more important, therefore, that theatre and performance buildings are fit for purpose in the context of the climate emergency.

The challenge is all the harder because theatres have often been starved of investment to upgrade fabric and services. Few achieve anything like the environmental performance that we expect of new buildings in the climate crisis. Roofs are often uninsulated; most services systems are old, inefficient, poorly-controlled – and powered by fossil fuels. It is an urgent task to make theatres fit for purpose. The Theatre Green Book aims to provide a blueprint for this journey.

Fortunately, many theatres have pioneered solutions as part of their recent capital projects, and considerable expertise has built up in the sector, and across the design and construction industry. Sustainable Buildings has been developed by bringing together sustainability and building environments experts Buro Happold, design professionals, and – most importantly – professionals who own and manage theatres, so as to develop holistic guidance in the challenge of making theatre buildings sustainable.

5 Scale

Theatres vary enormously in type and scale, but the principles of sustainability are the same. This guidance is designed for performance buildings of all kinds. Whether you are managing a large opera house, or trying to improve a small venue, the process of assessing priorities, developing a Sustainability Plan and delivering improvements is the same, and the guidance will also work for workshop and rehearsal facilities.

Later in the Green Book you will find guidance on theatres of different types (see section 3). Later chapters cover all the different ways of tackling sustainability challenges, from easy wins, through maintenance to large-scale capital projects.

6 The Legislative Background

Legislation helps. The UK Building Regulations enforce rising standards for energy conservation. Part L2b applies to non-residential existing building works, and seeks to enforce minimum energy and carbon guidance. Local Authority Planning Policies may include energy and carbon requirements for extensions and refurbishments. Planning conditions often include sustainability targets, for example a requirement to meet a 'BREEAM' standard.

That legislative background will rightly become more demanding over time. Theatres need to plan now for a world in which sustainability is expected by audiences – and by the law.

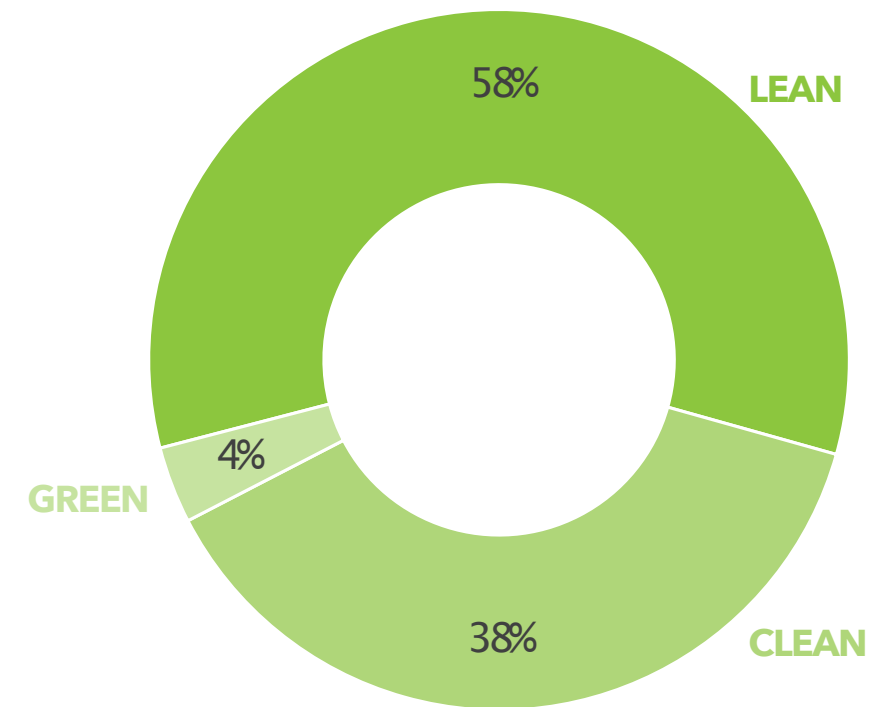
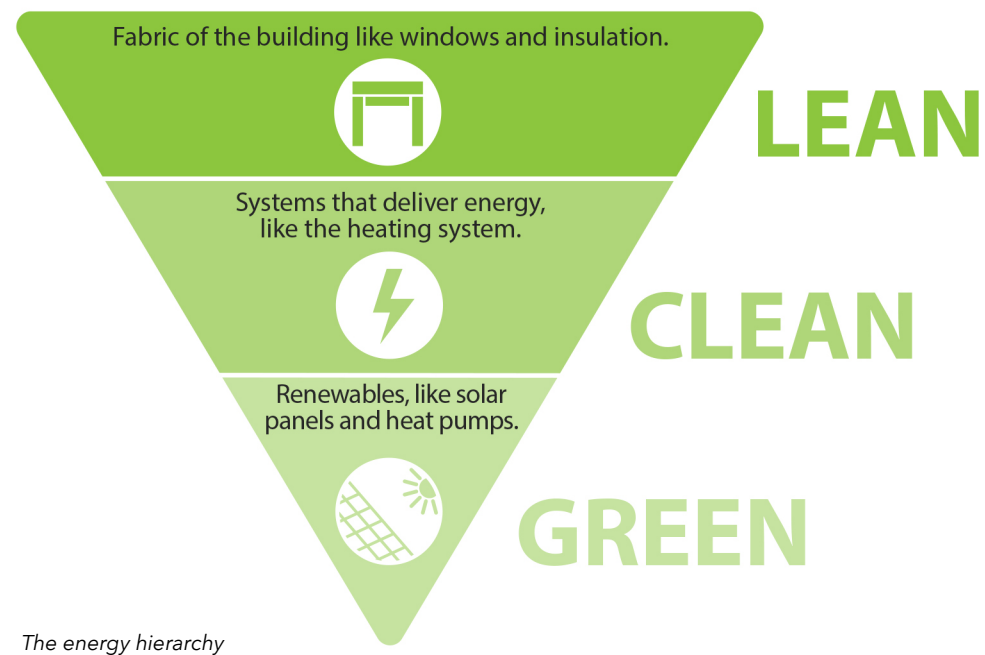
Net Zero Carbon

Ideally, all buildings would be 'zero carbon', causing no carbon emissions in the course of an average year. The aim of Sustainable Buildings is to help building owners map the journey to zero carbon.

Most will still cause some carbon emissions, but might balance that, for example, by generating surplus energy from renewable sources. They'll be 'net zero'.

For many existing buildings, achieving net zero on site will be very difficult. In that case, 'net zero' can only be achieved by 'offsetting' carbon use through schemes that (for example) generate green electricity or plant trees elsewhere.

2 Key Principles



The typical proportion of energy savings resulting from 'Lean', 'Clean' and 'Green' measures. 'Lean' measures have much the highest impact.

1 Lean - Clean - Green

Planning to make a theatre sustainable should be based on the 'energy hierarchy' above.

- 1) First, make your building '**Lean**' by improving its building fabric so it wastes less energy. That means insulating roofs and walls and improving windows and doors.
- 2) Second, make it '**Clean**' by replacing inefficient services systems, so as to minimise the energy they use and deliver the energy demand in the most efficient way possible.
- 3) Thirdly, go '**Green**' by switching that energy to renewable sources by generating energy on site wherever possible, with photovoltaic cells, heat pumps etc.

Typically, the greatest carbon impact is achieved at the beginning of the energy hierarchy. Lean energy savings account for 58% on average (66 kWh/m²/annum), Clean for 38% (43 kWh/m²/annum), and Green for 4% (5 kWh/m²/annum).

For an average theatre size of 3,300m², these savings could amount to approximately 80 tonnes of CO₂ – and save £30,000 per annum.

At the heart of Sustainable Buildings is an online 'Home Survey' tool, which will generate a Sustainability Plan for your building. It will automatically prioritise green measures according to the energy hierarchy.

2 Small Steps

There is no silver bullet for sustainability. No one intervention, from roof insulation to installing a wind turbine, will make a theatre 'green' overnight.

Achieving a sustainable building is a matter of aggregating marginal gains. Bit by bit, each improvement will take the building further down the road towards zero carbon.

Training and Learning

Theatre's shift towards sustainable working needs everyone to understand the principles on which green guidance is based.

More widespread Climate Literacy training can help the whole sector move forwards. Meanwhile theatre's own networks can help share theatre-owners' experiences and lessons learnt in working sustainably.

Go to the Toolkit for information on Climate Literacy training.

3 Go Electric

Gradually, the UK has been shifting towards generating its electricity from renewable sources like offshore wind farms. That process is still continuing. It means that one of the main things a theatre can do to become more sustainable, is to switch as much of its energy use as possible from fossil fuels (like oil and gas) to electricity.

By choosing your electricity supplier carefully, you can make sure the Grid uses renewable energy first. There's guidance in the Toolkit.

By including renewable generation in your Sustainability Plan, you can generate electricity at your theatre – and sell it back to the Grid.

What do We Mean by Green?

The Green Book uses 'sustainability' and 'greener practices' as catch-alls to cover decarbonising theatre buildings, reducing waste and eliminating environmentally harmful practices. That keeps it simple and readable, regardless of anyone's prior knowledge.

For a more precise vocabulary for green theatre, the Future Materials Banks keeps an excellent lexicon of terms at www.futurematerialsbank.com/lexicon.

3 Building Types

1 Different Theatres

Theatres are all different, but they fall into distinct groups, each of which has its own challenges for sustainability.

Historic Theatres




Historic theatres were mostly built in the Victorian and Edwardian theatre boom of the late nineteenth and early twentieth century. They were built quickly and designed to maximise audiences. Typically, they have small foyers, large auditoriums, fly-towers above the stage house, and cramped backstage areas. Roofs are usually pitched and slated, with lofts above the auditorium. Ornate facades surround entrances, while elevations elsewhere are plain brick. Internally, public spaces are decorated with elaborate plaster and timber mouldings, while others are plain.

There may have been original natural ventilation ducts in the auditorium. Other areas will be naturally ventilated through windows. Most mechanical and electrical services will have been added later. Typically, they occupy inadequate plant spaces and voids, and will have been much altered (often with redundant services left in place), with limited records of how they work. Heating is usually through radiators driven by an ageing oil or gas boiler. Mechanical ventilation and air conditioning may have been fitted later onto plant spaces on the roofs.

Mid-Century Theatres

Numerous theatres and arts centres were built in Britain in the post-war boom of the 1960s and 1970s, as modernism first arrived. These theatres vary greatly in size, some doubling as community or arts centres. Most will have more generous public areas and some are equipped with offices, workshops and other ancillary spaces.

Typically, these are much simpler buildings with plain walls and often flat roofs. Many are built of concrete. Like the historic theatres, they are often uninsulated, or barely insulated. Foyers may have large areas of single glazing.

	 Historic	 Mid-century	 Recent
Description	Likely to be Victorian or Edwardian. Likely to be listed under Historic England's register.	Theatres built in the post-war boom of the 1960's and 1970's, as modernism first arrived.	Theatres built during or after the 1990's.
Likely Fabric	Likely to have limited/no insulation, single glazing, draughty. Limited glazing. Limited scope for improvement given the visual aesthetic.	Limited insulation. Large amounts of single glazing.	Modest levels of insulation. Double glazed.
Likely Systems	Extensive "layering" of systems and patchwork fixes. No documentation.	A degree of layering and patchwork.	Relatively modern but coming to end of life. Likely to have some documentation.
Likely potential for improvement	Medium given the likely systems conditions and historic constraints.	High given the fabric potential and state of systems.	Medium given the recent standards of design.
Most likely green interventions	<ul style="list-style-type: none">• Glazing improvements• Roof insulation• Systems upgrades	<ul style="list-style-type: none">• Facade upgrades• Lighting improvements• Renewable energy opportunities	<ul style="list-style-type: none">• Lighting improvements• Ventilation enhancements• Renewable energy opportunities

Services systems will often be a combination of original systems at the very end of their lives, with a patchwork of subsequent upgrades and replacements. Air-conditioning (particularly to the auditorium) may have been upgraded, with new plant on the roof.

More Recent Theatres

The National Lottery initiated a boom in theatre-building beginning in the early 1990s.

These theatres, particularly those built in the last fifteen years, will have been designed and built to more modern standards, including much higher standards for insulation. Services systems will be newer. Some theatres will have been built as exemplars of sustainability, while others would not reach today's standards.

The earliest of these buildings will now be needing to replace services systems, creating opportunities to improve sustainability. For others the challenge will be different. Typically, new buildings fail to perform as well as their designers intend. The challenge is to make quite complex systems work as efficiently as possible, augmenting and upgrading them as necessary.

2 Using the Theatre Green Book

Every theatre is different, but most will fall into one of the above categories, even if it has been subsequently altered or extended.

Many, perhaps most theatres will have carried out upgrades of some kind – whether by insulating roofs, or replacing old boilers – often as part of a capital project. Their Sustainability Plans will take account of what's already been done in identifying next steps and the path to sustainable operation.

Whilst theatres are different in many ways, the principles of sustainability are the same: to reduce energy consumption and carbon emissions through more efficient building fabric (be lean), better services systems (be clean) and – where possible – renewable energy sources (be green), while reducing water use and maximising biodiversity.

4 Be Lean : Building Fabric

1 Introduction

Design professionals talk about the ‘building envelope’, meaning everything – roof, walls, windows and doors – that separates the inside of a building from the rain, cold, heat and snow outside. In older buildings that ‘envelope’ does little to keep energy in. Roofs are often uninsulated (or poorly insulated), made of bare slate on rafters, or asphalt on concrete. Walls might be single skins of brickwork. Windows are single-glazed. Energy pumped into the building to heat or cool it is quickly lost as heat bleeds out into the atmosphere.

The most important task in making any building more sustainable is to improve its ‘envelope’, so as to minimise how much energy is wasted.

2 Insulation

Insulation keeps heat in in winter, and keeps rooms cool in summer. Ideally, it is fitted on the outside of a building, protected only by a final layer of render or roof membrane. This often isn’t possible for existing buildings, since it changes the building’s appearance (flat roofs are an exception), so it can be fitted as a lining on the inside face of roofs and walls. Or, if the wall is made of two “skins” of brickwork, the cavity between them can be filled with insulation.

Roofs

Flat roofs can usually be insulated on the outside when you replace roof coverings. It’s sometimes possible to insulate pitched roofs on the outside (immediately under the slates or tiles), but only if you’re carrying out a major re-roofing – and even then it can be challenging to modify eaves, ridges and gutters to accommodate the extra thickness. More often, pitched roofs will be insulated internally, by fixing insulation to the underside of rafters and covering it with plasterboard or timber linings. Where pitched roofs cover lofts, it’s easiest of all to fit loft insulation directly to the loft floor.

There are some challenges to watch out for. You will need to check that old roof structures can take the weight of extra insulation. And in historic theatres, the auditorium ceiling mustn’t be sealed with loft insulation if you need to inspect a fibrous plaster ceiling below.

Walls

It may be possible to insulate walls from the outside, with systems that apply insulation to the wall and finish it with a coat of render. That’s a major operation, though, and isn’t possible if the facade has historic mouldings and cornices. This approach may be appropriate in back of house areas, or on plainer, Modern buildings. Even then, windows, doors and eaves will need modifying to suit the extra thickness.

Internal cornices, dados and skirtings in historic theatres can also make it challenging to line walls internally. Mouldings will need to be removed and replaced once the walls have been thickened by a layer of insulation and plaster. That can be awkward in geometry. It will disturb historic fabric. It will certainly be expensive.

With plainer walls – either in more modern buildings, or in backstage areas – wall lining is much more realistic, and can be achieved by linings of insulation bonded to plasterboard. Even so, windows and doors will need to be changed, and skirtings replaced. With corridors, you will need to check the insulation doesn’t reduce the width of escape routes or limit access for wheelchairs.

3 Windows and Doors

Windows and doors are weak points in the building envelope. They are often thin and uninsulated. Many have gaps in the junction between window / door and wall.

Where does your building leak?

A local engineer may be able to provide thermographic images of your façade. By highlighting warm areas in red and cold spots in blue, they can identify where heat is leaking out. That can help target priorities for sustainability works.

Windows are typically the key area for focus, followed by walls, then doors.

Go to the Toolkit for more information.

Windows

Draughty, single-glazed windows can be replaced with modern windows that are double or triple-glazed. That’s expensive and disruptive, but will improve comfort as well as reducing energy loss. For historic windows, where double-glazed replacement isn’t possible, an alternative is secondary glazing, where an inner window (usually with a thin aluminium frame) is added. Secondary glazing also avoids the embodied carbon of new replacement windows.

Large areas of glazing in the foyers of more modern buildings present a particular challenge, which can usually only be tackled by full replacement in a major building project.

Doors

Doors are also a weak spot. Main entrance doors constantly open as audiences gather, allowing heat to leak out and causing energy loss and thermal discomfort internally.

Draught lobbies are much the best way to prevent heat loss. Revolving doors are next best, although they won't be appropriate everywhere, and alternative options will be needed for wheelchair-users. Air curtains are slightly more efficient as they simply blast room temperature air down to try and minimise incoming draughts or small gusts of wind. As a cheap and cheerful solution, a wintertime draught lobby can be created simply by hanging a heavy curtain inside the door, French café-style.

4 Some Challenges

Airtightness

Old buildings tend to be leaky. That means they have constant natural ventilation through ill-fitting sashes and draughty doors. It wastes energy but does mean – for all the wrong reasons – a source of plentiful fresh air to replenish oxygen and prevent mould and condensation.

To reduce energy loss you have to make a building airtight. But that can create a problem: insufficient ventilation. That isn't a problem in areas with mechanical ventilation. Elsewhere you'll need to allow for controlled ventilation through 'trickle vents' (openable ventilation slots in new windows) or by 'hit- and miss' vents in walls. Seek professional advice if need be.

Condensation

To prevent energy loss you need a building envelope that separates inside from outside to keep energy in. But in that case there's a risk that the warm, moist air inside the building will condense into water when it meets a cold surface. If that happens within the building fabric, it can cause rot and decay over time. Building professionals refer to this as 'interstitial condensation', and the point at which moisture in the air condenses into water as the 'dew point'.

To avoid problems, make sure you get professional help in designing new insulation and linings. Architects and surveyors can help; so can many contractors. A combination of good ventilation and 'vapour control layers' (to prevent moisture reaching the cold surfaces) can prevent insulation from causing problems.

In historic buildings it's important to use 'breathable' materials to prevent condensation within the structure (in the same way that 'breathable' waterproof clothes stop you sweating). Seek professional advice to make sure the works are appropriately designed.

Cold Bridging

A third challenge is 'cold bridging'. Effective insulation needs a continuous layer of insulating material. Fixings and brackets which pierce it, or structural beams which run through its, act as 'cold bridges' to allow energy out and cold in.

Careful detailing is needed to eliminate or minimise cold bridging and make sure insulation works as effectively as possible.

5 Hazardous Materials

All works to older buildings may involve you in dealing with asbestos and other hazardous materials. Some asbestos was still being incorporated in UK buildings as late as 2001.

Guidance can be found from the Health and Safety Executive (HSE) <https://www.hse.gov.uk/asbestos/>

6 Climate Resilience

Climate change doesn't only require us to make our buildings more efficient. It also places new strains on them. Temperatures are changing, along with rainfall patterns. Extreme weather events are more frequent. Modifying our buildings for climate change means leaner fabric, cleaner services and green energy generation. It also needs us to look at how buildings perform in a changing climate.

We expect over-heating and increased rainfall (and hence flooding) to be far more commonplace, and buildings need to be adapted with this in mind. That may mean larger rainwater pipes and gutters. We've seen public drainage overwhelmed by intense rainfall, so buildings may need to absorb and hold more rainwater on site. Meanwhile, current cooling systems may be overwhelmed by extreme heatwaves.

It is vital that those responsible for the future maintenance and adaptation of existing theatre buildings take proper account of what the future is likely to hold.

5 Be Clean : Building Services

1 Introduction

A theatre's energy consumption will fall into one of the following categories: heating and cooling systems, general plug-loads, show loads, lighting, ventilation, hot water, server rooms, and lifts.

Knowing there is a finite number of categories makes it easier to spot where energy's used and decide how best to target sustainability improvements.

2 Knowing Where You Are

Some theatres can afford professional Facilities teams with a high degree of expertise, and good records of services systems, maintenance, and replacement.

Others necessarily work with tighter budgets, and may know far less about their buildings systems, how old they are and how they work.

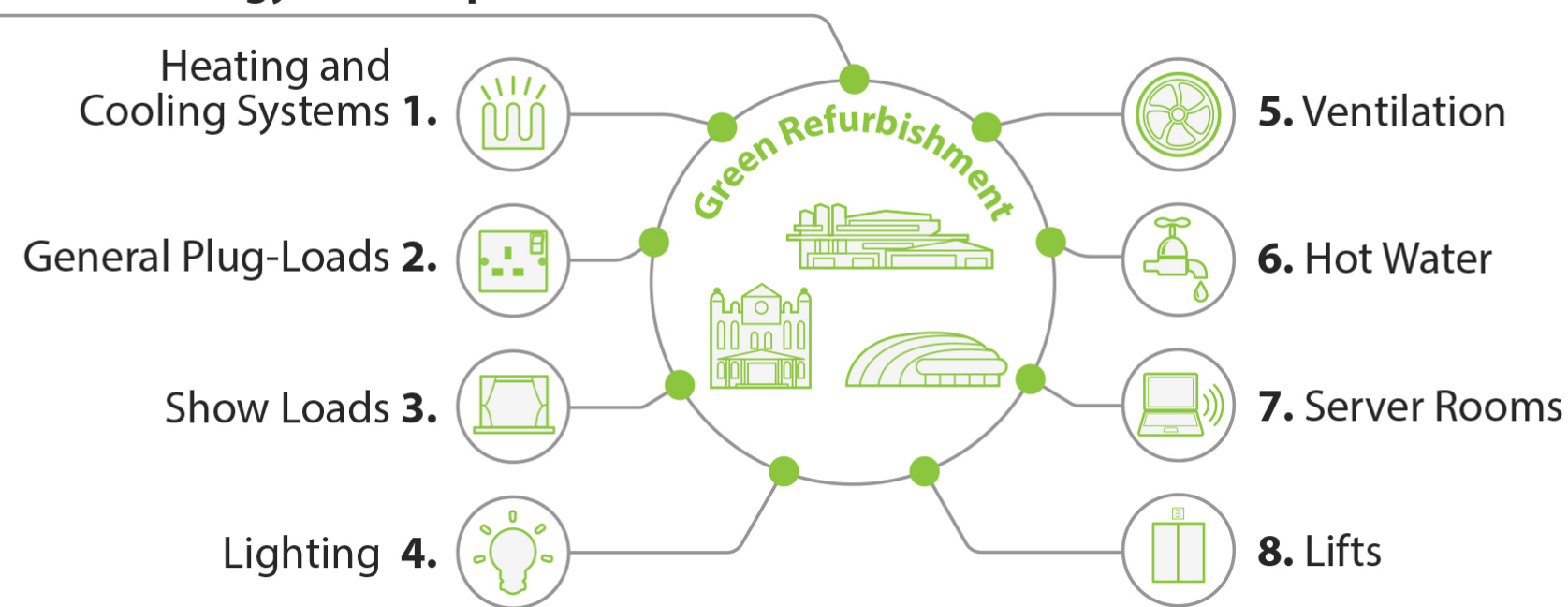
If there are gaps in knowledge, you may be able to fill them by talking with the companies that inspect and maintain systems. You may be able to commission condition surveys from them, or ask them to provide a basic explanation. Utilities bills can tell you how much carbon you're using. If you sub-meter different areas, you'll learn more about how your carbon use is distributed.

Section 8 gives more detail on gathering information.

2 Heating and cooling systems

Heating systems distribute heat from boilers either through radiators filled with hot water, or by blowing warm air around the theatre. Most auditoriums have air systems, while dressing rooms and offices often use radiators.

A Theatre's Energy Consumption End-Uses



Systems are more sustainable when they can work at lower temperatures. That suggests a shift to underfloor heating, larger radiators and fan-coil units in the ceiling (which draw in air from the room, heat or cool it, and blow it out again). Lower temperature systems waste less energy in distribution, and make it easier to work with electric heat sources.

Theatres can reduce energy use by re-thinking the temperatures they aim to maintain. It may be audiences will become more tolerant of occasional hotter or cooler days, as we all accept the realities of the climate emergency.

Heating

Boilers, fired either by oil or gas, are the usual heat source for both heating and hot water systems.

Old boilers should be replaced. Modern 'condensing' boilers are more efficient and use less fuel. It isn't worth changing them until they reach the end of their lives. Once it's time to replace them, the most common green alternative is a heat pump (see section 6), though biomass boilers may work in rural areas. A switch to heat pumps does have consequences, though, and they won't be right for all buildings.

Sometimes, the only option is like-for-like replacement with a fossil fuel boiler. In that case, find a highly efficient model with a long warranty and good service and maintenance support.

Cooling

Mechanical cooling, commonly referred to as “air conditioning”, is often provided in auditoriums and foyers to keep temperatures down in the summer. As with heating, the first step is to reduce the need for mechanical cooling by improving insulation, and shading windows.

Air conditioning should be a last resort. When it really is needed, temperature sensors, timers and occupancy detection can be installed to minimise the use of energy.

To reduce energy, much can be achieved with natural cooling methods such as circulating cool night-time air to bring auditorium temperatures down before a show.

3 Hot Water systems

Hot water systems are typically fed from the main boiler plant, but can also have their own local (“point of use”) electric source – which is usually a more sustainable option. “Point of use” heaters remove peak demand from the main boiler, reduce reliance on fossil fuels, and all but eliminate the energy wasted as hot water is pumped around the building. They can be installed either ad hoc during maintenance, or as part of larger refurbishment projects.

They may not be right for larger theatres which need more hot water, and might not have electrical capacity for multiple electric heaters. If you have to stick with a centralised hot water system, an easy win is to make sure all distribution pipes are lagged.

4 Ventilation

Mechanical ventilation is needed in windowless rooms (like many toilets and basements) to give people enough air to breathe. It’s needed in most auditoriums, and the law requires it in toilets and kitchens to remove smells. In newer buildings it’s likely that most spaces, including foyers and offices, will be mechanically ventilated.

Mechanical ventilation always needs two components: fresh air is pumped into the space, and exhaust air is pumped out of it. In older

buildings, exhaust systems are often inadequate as the heat carried by exhaust air is not ‘reclaimed’.

Mechanical ventilation is often used to spread coolth and warmth as part of the heating and air conditioning systems, by heating or chilling the air before it’s pumped into each room. To avoid energy loss when the used air is pumped out, heat can be ‘reclaimed’ from the exhaust air and reused to warm up the fresh input air. CO₂ sensors can also be installed to ensure a minimal amount of fresh air is pumped in for the current occupancy levels.

5 Lighting

Lighting is often a high proportion of a theatre’s energy consumption. A move to LED lighting throughout is a relatively simple switch. Improving lighting controls is just as important. Automatic switches with sensors for movement and daylight levels deliver significant energy savings, particularly in little-used areas.

6 General “plug loads”

Anything that gets plugged in draws energy and contributes to theatre’s carbon footprint. That means computers, white goods, bar fridges, fan blowers and heaters, communication devices (radio and mobile phones), workshop tools, vending machines – and much else. All those products publish energy data, so when purchasing new, make sure you’re buying as efficiently as possible. And replacing old white goods (for example) can contribute significant savings – but that’s only worth doing if they’re reaching the end of their lives.

7 Show loads

Show loads will include things like lighting rigs, audio-visual systems, special effects, communications. Managing them sustainably is covered in the Theatre Green Book, volume 1 : Sustainable Productions, chapter 8.

8 Controls

No matter how efficient the kit you install, it will waste energy if it’s on unnecessarily – for example, if lighting burns all night or radiators heat up empty rooms. Controls are key to any system within the theatre and ensuring they are operating only when needed and to the degree required is vital.

Installing the right controls for heating, cooling and lighting is essential, and can generate significant savings without much cost or disruption.

Once they’re installed, it’s important to keep managing them. You’ll find more information on building management in the Theatre Green Book : volume 3, Sustainable Operations.

Building Management Systems

Building Management Systems (BMS) come in many shapes and sizes and usually depend on the complexity of the building and the number of systems that need controlling. A good system should be simple to use with well documented user guides so that knowledge is not lost when people leave. Well-designed, and operated by well-trained managers, a good BMS can make sure a theatre runs as efficiently as its infrastructure allows.

By their nature, however, BMSs can be complicated, and require technical knowledge to run them efficiently. Training staff and simplifying controls can be an early step towards running your building sustainably.

6 Be Green : Renewables

1 Introduction

Theatres can generate their own electricity on site from renewable sources. Solar Photovoltaics (PVs) create electricity from light. Turbines generate it from wind. Generating renewable electricity reduces the need to pull energy from the fossil fuel sources that still power much of the National Grid. At slack times, theatres can put spare power back into the grid.

Theatres can also use the energy around them more directly. Heat pumps draw energy from the air or ground to power heating or cooling systems directly. They use some electricity in the pumps, but don't rely for heating or cooling either on fossil fuels (e.g. in gas boilers), or on pulling electricity off the grid.

This section describes the main ways theatres can turn to sources of renewable energy.

2 Solar PV Panels

Solar photovoltaic ('PV') panels are usually installed on roofs, and generate electricity which can both power systems within the theatre, and, at slack times, be fed back into the National Grid. PVs are installed in arrays either on pitched roofs, or on flat roofs, with frames to angle them towards the sun. They don't need direct sunlight, but operate most efficiently when facing as close to south as possible at an angle of about 30 to 40 degrees.

Like anything installed on a roof, they will make it hard to maintain or replace the roof afterwards, so make sure the roof is repaired or replaced before installing them (and that it's strong enough to carry the weight). However, they are the most common and viable form of renewable energy.

3 Solar Thermal Panels

Solar thermal panels use the sun's heat directly to heat up water either for showers and taps, or to pre-heat water for radiators.

They come in a couple of varieties: tubular or flat plated, with the latter looking similar to Solar PV panels. They typically work less well for theatres than PVs – particularly if the theatre is quite small, and doesn't have a constant need for hot water.

4 Wind Turbines

Wind turbines use the wind's power to generate electricity. They're mostly viable at large scale in open areas – so they don't often apply to theatres. Some rural theatres may be an exception: for example, a large turbine powers Glyndebourne Opera House.

5 Heat Pumps

Heat pumps come in a few different guises: water-source, air-source or ground-source, depending on where they draw energy from. Air-source heat pumps are most likely to be the viable option for theatres. But changing a gas boiler for a heat-pump isn't a straightforward like-for-like replacement, so professional advice is needed.

Air-source Heat Pumps

These are usually standalone, external units with fans that extract heat from the air and use it to warm up water that's pumped into the building. They are now quite commonly specified for new buildings and theatres, but work best at low flow temperatures so they need the building fabric to be insulated and not too leaky; otherwise they become very large and can't work efficiently. Air-source heat pumps are a great alternative to fossil fuels, but may require significant alterations to the building.

Ground-source Heat Pumps

These are typically a fridge-size unit that sits within the building. Pipework extends outside the building, either snaking around a large area of ground, not far below the surface, or diving vertically into the ground as part of a building's structural piles. They're common in new buildings but less so in existing theatres.

Water-source Heat Pumps

Water-source Heat Pumps require a local source of water to provide the heat. This might be a nearby river or canal, or an aquifer below ground. Liaison with the Environment Agency is required to ensure environmental harm is prevented or mitigated. These are the least common version of heat pump.

Biomass boilers

Biomass boilers are similar in size to gas or oil fired boilers, and are considered to be renewable if the timber they burn (often in pellets) comes from a sustainable source. However, they need a lot of fuel storage, with large vehicle access for deliveries, and can cause air quality issues in built-up urban areas, from particulate matter in the fumes. They're not often found in theatres.

6 Storing energy

Energy demand isn't constant. Theatres need a lot of power before and during shows. Hot water is needed for dressing rooms at specific times of the day. By contrast, most renewable energy systems generate energy continually (or during daylight in the case of solar panels). Storage systems can capture that energy for use during peak hours.

These typically take the form of batteries for electricity or water tanks for heat. They aren't commonly used – unless you have a very large array of PVs, you're more likely to use the electricity yourself (or send it back to the grid). And batteries raise issues such as fire compartmentation, which need professional advice.

7 'Pay-back'

Renewable energy sources save you buying energy from the National Grid. That means that over time, the savings you'll make from PVs, for example, will pay back the cost of installing them in the first place. Grants can significantly help reduce payback periods. The Energy Saving Trust provides a source of information on the latest available grants. (See Toolkit)

8 Challenges for renewables

Renewables are a high profile way of showing a theatre's commitment to sustainability, and will likely be needed to reach zero carbon. In terms of actual impact, though, they come behind measures to make the building itself more efficient (be lean), and measures to improve services (be clean). Indeed renewable energy will only have its full impact if it's operating on a building that's been upgraded to conserve heat efficiently.

When the time comes to move on to renewables, there will be a number of hurdles to face. These include:

- Planning and listed building permissions for solar panels, external plant and other changes.
- Finding plant space either internally or on roofs.
- Upgrading roofs before you place PVs or other plant on them.
- Upgrading services systems to suit the new energy source.

7 Biodiversity and Water

1 Introduction

Society is increasingly aware of the challenge we face. Humanity is in a climate and biodiversity state of emergency.

Sustainable buildings have an important part to play in biodiversity and efficient water use. What's more, supporting biodiversity can also create far more humane places to work and visit, raising staff wellbeing and creating a sense of place.

2 Water

Water is a valuable resource. Sustainable water use in the theatre and its surroundings focuses on reducing, recycling and reusing.

Water systems such as toilets and showers can minimise wastage. Not all the water theatres use needs to be potable (drinking water). Rain and stormwater, treated on site without chemicals, works just as well for irrigating plants or green roofs, and serving water features.

Reducing water use

Non-potable water is defined as water that does not meet drinking water standards for human consumption, but is suitable for other low risk uses, such as toilet flushing, irrigation or laundry.

Potable water is defined as water that is fit for human consumption and typically meets drinking water standards. Cutting down the use of drinking water can be achieved by:

- Low-flow and waterless fixtures.
- Leak prevention systems that flag unexpected water use.
- Reducing water demand for irrigation by careful selection of plants along with intelligent sub-soil irrigation systems that draw on harvested and treated rainwater.
- Using non-potable water for irrigation or toilet flushing.

Greywater

Greywater is water discharged from fixtures such as sinks, showers, laundry, or drinking fountains (it doesn't include water discharged from toilets and urinals). It can be reused for purposes like flushing toilets.

However, the retrofit to include a greywater system can be costly and disruptive. Dual pipework is needed, as well as storage tanks and filtration. The first step is a feasibility study to check how much greywater you might save, how much you could use, and whether you have space for greywater storage. For many theatres it won't be viable.

Rainwater

Rainwater harvesting means collecting run-off from roofs and terraces to store for future use. Filtered rainwater harvesting can be used for toilet flushing, laundry, and cooling systems, or for irrigation of planting.

Rainwater harvesting can be applied to many buildings, although it does require a storage tank (which will be heavy) and associated filtration, particularly in cities.

3 Biodiversity

Buildings can promote biodiversity. Planted landscapes, green roofs and living walls are all ways in which a theatre can provide a habitat for life.

It's important to recognise where you're starting from in improving the biodiversity of a theatre. Is it in the city-centre (like most theatres) or out in the country? Have the surroundings been previously polluted? Are there existing habitats for biodiversity, which need to be protected? What are the species most likely to colonise new planting? Professional advice from an ecologist may be needed to answer some of these questions.

A theatre's sustainability plan must include measures to deliver a positive impact on biodiversity for all of the buildings and land under its control. If your sustainability needs a capital project, the Local Authority may well require biodiversity improvement among their planning conditions.

Green Roofs

Green roofs can clean the air and provide niche urban wildlife habitats. They connect internal and external spaces through roof terraces and planting. Planting can provide a calming environment and contrasting seasonal displays.

It's important to select plants that will support insects, require little irrigation, and survive the dryer, warmer climate that global warming is already producing.

Green roofs can also help by absorbing rain, preventing it from overwhelming drainage systems. Good water management means balancing irrigation needs and water demand as efficiently as possible.

4 Other opportunities

It's worth thinking laterally about how a theatre can improve biodiversity and use water efficiently.

- Landscape, terraces and green roofs can create 'green corridors', linking between buildings and sites.
- Partnership with neighbours and local communities can connect sites and align strategies.
- Car parks offer opportunities for planting, rainwater capture, and below-ground storage and treatment.

Sedum Roofs

These are living roofs, where vegetation is used as the top layer of the roof build-up. A sedum roof should be self-sufficient and will develop over time. These types of roofs absorb carbon dioxide, attenuate rain fall and rainwater build-up, increase a building's biodiversity and create a point of interest. *Go to the Toolkit for more information.*

8 Gathering Information

1 Introduction

The Theatre Green Book : Sustainable Buildings is built around a Home Survey tool which asks you a series of questions about your theatre. They'll build up a picture of your theatre's current level of sustainability, and what's needed to move it forward. They'll cover:

- Its building fabric (roofs, walls, windows and doors)
- Its services systems (their condition, operation and the fuel they use)
- Any renewables you're already using – or opportunities for installing them

Your answers will allow the tool to develop a Sustainability Plan that identifies actions to move your theatre towards sustainability. That process is covered in the next section.

Meanwhile, it's important to know how your theatre is performing now. That gives you a baseline. As improvements are made, you'll be able to re-measure, tracking your progress towards zero carbon.

Measuring how your theatre operates allows you to:

- Compare yours with similar theatres
- Identify areas to focus on (helping you refine your Sustainability Plan)
- Set targets

2 Measuring Energy Use

Electric and gas (or heat) meter readings are invaluable in the quest to reducing energy consumption. The famous business quote, "what you can't measure, you can't improve" also applies to energy.

You should aim to improve your energy metering as a top priority and commit to record and regularly check the data. It is worth reviewing the consumption at least once per year – but ideally every month. A reading before and after a show will help you understand the significance of your show loads. Each time you instal new equipment

or complete a green project, you can measure energy to assess its impact. The more you commit to metering and checking, the more you will understand how your building functions and what consumes the most energy.

The important information to look for is energy consumption in kilowatt-hours (kWh) rather than the power in kilowatts (kW).

If you currently have only limited sub-metering, you could instal sub-meters to monitor specific circuits at specific times of the day. Clamp-on electrical meters are a cheap alternative – but have a 20% margin of error.

Air temperature and quality can also be measured, to help you focus heating and ventilation on the spaces and times which need it most. Monitors such as AirThings Wave are relatively inexpensive (circa £250).

If you have a Building Management System (BMS), this could be a very helpful tool to understand problem areas with your theatre. Professional consultants use tools to "diagnose" more complex systems and potentially make significant savings. See the toolkit for more information on Building Management Systems.

Preparing an annual Display Energy Certificate (see sidebar) is a formal discipline for measuring your energy use.

For a more holistic record of your current position in sustainability, you can measure your impacts with the Creative Green Tools, developed by Julie's Bicycle (JB) for the arts and culture industries. (Link: <https://juliesbicycle.com/reporting/>) Over 5,000 organisations, in 50 countries worldwide, use JB's free set of carbon and environmental calculators to record, measure and understand the impacts of their venue, office, tour, production, event or festival.

The Creative Green Tools make it easy to measure your energy use, water consumption, waste generation and recycling, travel and production materials. The results can then monitor your environmental strategy and organisational priorities and progress over time.

DECs (Display Energy Certificates)

Commit to undertaking an annual Display Energy Certificates (DEC). This not only gives you a formal reading of your annual consumption, it provides a reasonable benchmark to compare to, it suggests some simple improvements, and it allows other theatres to compare to your theatre, which is a very healthy way to improve energy transparency. Plus, it is a legal requirement for all public buildings anyway.

Having a DEC which you update yearly will allow you to track improvements in your carbon reduction through the improvement in your DEC rating. This will enable you to ensure your interventions and projects are having a positive effect on your theatre's performance and will allow you to communicate these improvements as 'good news stories' to audiences, the general public, funders etc

Note: do not confuse DEC's with an "Energy Performance Certificate" (EPC) as the latter predicts the energy consumption based on pre-assumed building usage (i.e. it is not a measurement).

You can find out more about Display Energy Certificates here: <https://www.gov.uk/government/publications/display-energy-certificates-and-advisory-reports-for-public-buildings>

To get a Display Energy Certificate, you need a qualified assessor. Local assessors can be found online.

Go to the Toolkit for more information.

3 Benchmarking

The most important measure for any theatre is to track your own progress towards zero carbon, measuring current energy use against the moment you prepared your Sustainability Plan.

Should you wish to measure yourself against similar theatres, Display Energy Certificates are available to search on the DEC register. The key piece of information to look for is the "Annual Energy Use" in kWh/m²/year for both heating and cooling.

From their Creative Green data, Julie's Bicycle has developed a set of benchmarks to help organisations compare their environmental performance against the industry average. The benchmarks use 'relative' metrics - use of energy per square metre, per year - to help you measure your own organisation against the benchmark, whatever its size or scale.

The Creative Green Tools will compare your impacts to the Julie's Bicycle benchmarks automatically.

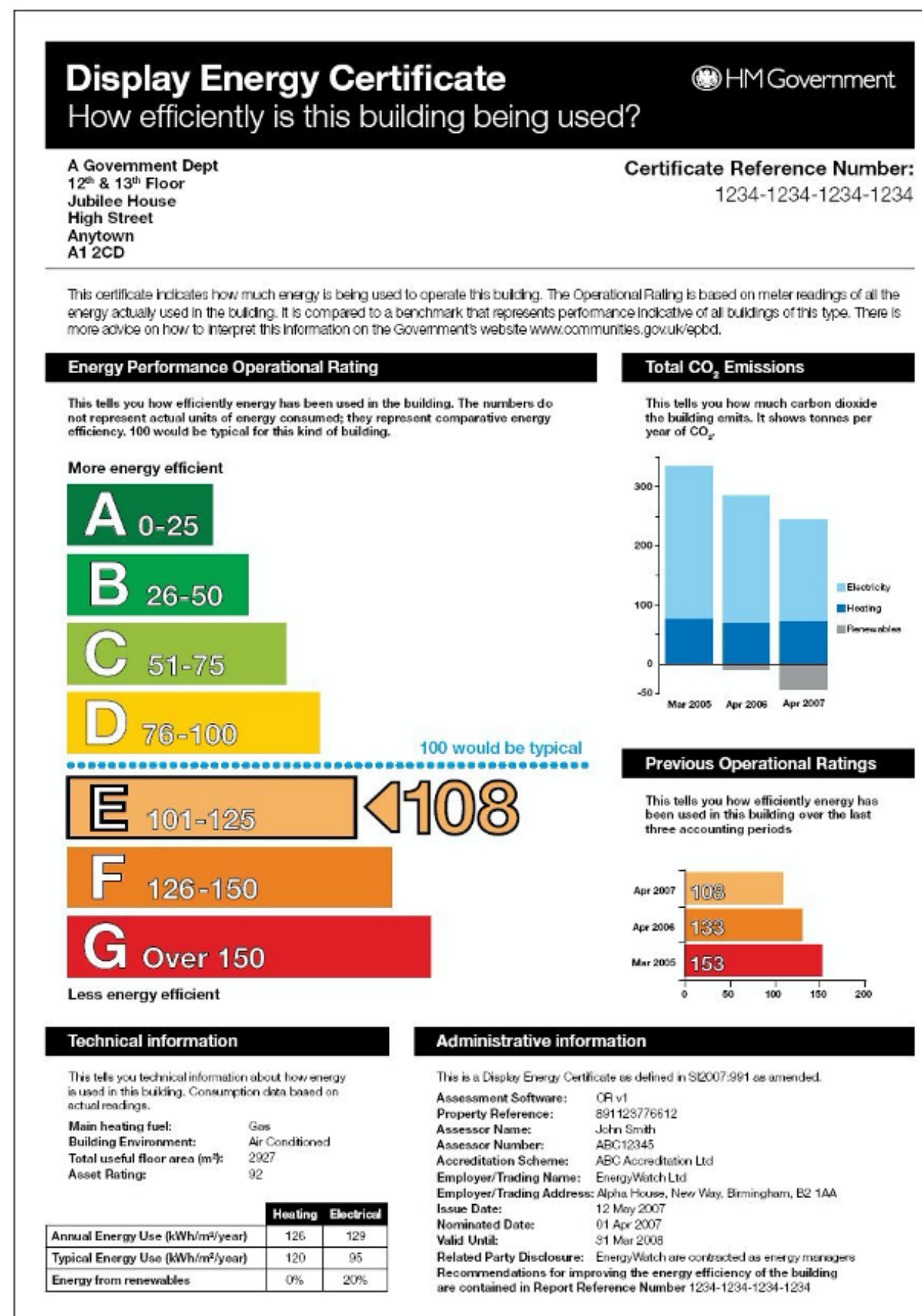
4 Sharing

Theatre's journey towards sustainability depends on sharing knowledge, experience and data.

Once you've commissioned DEC, share it on your webpages and display it in your foyer. Messaging to your audience members can be vitally powerful.

If you're using Julie's Bicycle's Creative Green tools, upload your data onto the Creative Green portal.

Use theatre networks to share experience and contacts, support others and disseminate lessons learnt.



9 Developing a Sustainability Plan

1 Introduction

The Theatre Green Book's Home Survey tool will take you through a series of questions about your theatre. They'll cover everything from roof insulation to entrance doors, from the state of your boilers to the possibility of fitting PVs on the roof.

The tool will output a provisional list of the actions needed to make your building sustainable, whether fitting secondary glazing or replacing lights. It will automatically list them in order of impact, to help you tackle the most beneficial actions first.

And it will automatically divide them into three categories:

- Easy Wins
- Maintenance Projects
- Capital Projects

Every theatre is different, however, and there's only so much that can be done automatically. The final step in making a Sustainability Plan is to go through the list yourself, and re-order it to reflect the specific needs and challenges of your building.

Your Sustainability Plan will answer the two key questions:

- What are the works our theatre needs?
- What order should we tackle them?

The Home Survey tool

You'll find the Home Survey tool [here](#). It's been developed by Buro Happold to allow theatre owners and managers to create a Sustainability Plan for their theatre. This section explains how. You'll still need professional advice, but the Home Survey tool will put you in a position to seek the right advice at the right time (see below).

2 What Are the Works Our Theatre Needs?

The tool is based around a long list of the possible interventions that will make a theatre building sustainable.

As you go through the Home Survey, it will rule out actions you've already taken.

It will also identify works which aren't possible. For example, it may not be possible to fit a draught lobby to the entrance of a historic foyer. In that case, it will suggest alternatives: a revolving door, or failing that, a heat curtain.

This is also the moment to spot realistic compromises. Secondary glazing may be less effective than complete window replacement - but it will still be a lot better than leaving old windows as they are because there's no money to replace them.

Through the Home Survey, the tool will identify the works your theatre needs. It can then help define the order in which you deliver them.

3 What Order Should We Tackle Them?

The right Sustainability Plan needs to balance two different factors:

- What has the most impact?
- What's easiest to achieve?

What has the most impact?

In general, buildings can best move towards sustainability by tackling building fabric first (Be Lean), then services systems (Be Clean), and then adding renewables (Be Green).

That's a good starting-point. The Home Survey tool will automatically prioritise interventions according to this list, and to the impact they're likely to have on your theatre.

But the other driver needs to be taken into account as well.

What's easiest to achieve?

Some high-impact works will involve cost (requiring a lengthy fund-raising process), getting planning or listed building permissions, or closing the theatre for disruptive works. In the meantime, progress can still be made by addressing works that may have less impact, but are easier to get on with.

So your overall list of works needs to be triaged into three categories:

- Easy Wins
- Maintenance Projects
- Capital Projects

The Home Survey tool will do this automatically, though further triage will be required to make the list bespoke to your theatre (see next page).

Easy Wins are those works which can be carried out straightaway, with little or no cost or disruption. An example would be adding timing controls to lights and heating systems, or switching to a green energy provider. It's essential to get on with these while you're planning your capital projects. That way you can be sure you're moving towards sustainability as quickly as possible.

Maintenance Projects are works which don't involve closure or planning permissions, and can be carried out as part of annual maintenance works. An example might be fitting secondary glazing to dressing room windows, or replacing water heaters in toilets.

Capital Projects are those major works which require exceptional spending, disruption or permissions. They might include re-roofing, replacing foyer windows, putting in new services systems, or replacing boilers with heat pumps.

The Green Book will automatically assign each intervention to one of those categories. But every theatre is different. In the next phase of making a Sustainability Plan, theatre-owners and managers must juggle interventions to suit their judgement of what's achievable, and to fit sustainability works in with everything else the theatre does.

4 Finalising the Plan

First, you can shift interventions between the three categories of Easy Win, Maintenance and Capital Project, depending on your own intimate knowledge of the theatre and organisation.

Next, you can re-order them to suit your general maintenance programme. For example, you may have put roof insulation high on the list - but the right time to do it is when your roof coverings need replacement anyway. The table in Section 11 Maintenance identifies some of the typical refurbishment works theatres regularly undertake. When carrying out these works, there are often green opportunities missed, or where it may cost significantly less to integrate a Green Intervention. Use this table to help re-order your list of Green Interventions.

Finally, you may find specific reasons to defer some works or prioritise others. For example, you may have gas boilers which are a long way short of sustainable. But if they're only a few years old, it makes no sense to replace them until they've given a few more years of life. If your boilers are not yet in need of replacement and are relatively efficient, then leaving them as they are is fine. Push boiler replacement down the list and make a plan to remove them later on.

5 Setting a Timeline

The process outlined above will create a Sustainability Plan that:

- Identifies the works your theatre needs to make it sustainable
- Places them in order of priority under three headings: Easy Wins, Maintenance Works and Capital Projects

The next task is to set a timetable for achieving each of those columns.

The final step is to check that your timeline delivers improvements that move you towards sustainability at the speed your organisation needs.

Professional Advice

The Theatre Green Book aims to empower theatre owners and managers to develop Sustainability Plans quickly and without undue expense. But some of the decision-making can be complex, and you won't always be sure that everything in the plan is feasible, or what other complexities it might involve.

Once you have an initial Sustainability Plan, therefore, you'll probably then need to involve professional sustainability consultants, engineers, architects, building surveyors and others to help confirm feasibility, refine costings, and hone the Sustainability Plan into a final working document.

If you don't have the money, then get going with the Easy Wins and Maintenance, and pull together a professional team to revisit the Sustainability Plan in the first phase of your Capital Projects.

Go to the Toolkit for more information.

10 Easy Wins

1 Introduction

Most theatres have some easy wins that can improve sustainability with little cost or effort. The Home Survey tool should identify them, and there's no reason to hold off putting them in hand straightaway.

Try and get measuring in place beforehand (such as installing clamp-on meters - see below) so you can see the impact of these Easy Wins on your operation.

2 Measuring

One easy win is to improve your knowledge of your building by sub-metering or fitting clamp-on meters to capture where energy is going. They don't save energy in themselves, but they'll help you hone your Sustainability Plan to ensure you're moving towards sustainability as effectively as possible.

3 Go Electric

The National Electricity Grid is increasingly powered by renewable energy sources, so switching power use from gas or oil to electricity is an easy way of accessing zero carbon power (see sidebar).

For example, theatres can switch hot water taps from the gas boiler to an electric point-of-use water heater. (NB this may only apply to smaller theatres with lower hot water demand - see section 5).

4 Common Easy Wins

The following list covers some common easy wins that you may be able to put in hand at your theatre:

Lean

- Draught proofing windows and doors
- Cavity Wall insulation
- Installing a draft lobby or electric "air curtain" to main doors
- Night Cooling (see Theatre Green Book volume 3 Sustainable Operations for more info)
- External features like parasols to minimise summer cooling

Clean

- Check for nearby district heating connections
- Hot water flow restrictors on taps and showers
- Installing smart heating controls
- Improving lighting controls by installing daylight and/or occupancy sensors
- CO2-controlled ventilation to the auditorium
- Replacing old white appliances with A-rated appliances
- Building Management System (BMS) diagnostics
- Cleaning mechanical ventilation filters
- Checking and aligning hot water operating hours to match occupation
- Improving hot water tank insulation
- Installing /upgrading insulation on hot water pipework

5 Sharing

With each piece of work you put in hand, try to record the impact and share it (see Section 8 for more information). It will help others in their decision-making, and make sure the theatre sector is spending its limited resources as wisely as possible in tackling the climate emergency.

The National Grid

The electricity grid is on a trajectory to decarbonise, so by moving to electric consumption, theatres can automatically join a shift towards zero carbon. Currently, there is more opportunity than ever to select low or zero carbon electricity tariffs through green energy suppliers.

Your choice of electricity supplier can ensure that the electricity you buy from the grid is coming from sustainable sources.

Go to the Toolkit for more information about Green energy suppliers.

11 Maintenance

1 Introduction

Many theatres struggle to maintain their buildings. Busy programming make maintenance projects difficult. Scarce resources often need to be focused on operation. Buildings are sometimes left to take care of themselves, with problems postponed until the next capital project.

Unfortunately, capital projects, taking place every twenty years or so, are themselves a heavy burden. The fundraising effort is challenging. Closure loses audiences. Funders prefer new spaces like studios to the unglamorous task of insulating roofs or replacing boilers.

Maintenance is essential to sustainability. Maintenance ensures that:

- Plant works efficiently
- Problems are dealt with quickly, avoiding deterioration of building fabric
- Theatres avoid more major rebuilding and repair, which bring their own carbon footprint in terms of materials

2 Regular Maintenance

Regular maintenance can increase the serviceable life of plant and equipment, reducing ongoing replacement costs. It will also ensure plant and systems operate at their most efficient, reducing energy use and cost. Although maintenance can be a large expense it can often pay for itself long term.

3 Planned Preventive Maintenance

Planned Preventive Maintenance goes beyond reacting to immediate problems by looking longer term and planning out problems before they occur. It's a necessary step towards a sustainable strategy for regular plant upgrade and replacement,. That, in turn, can steer theatres clear of problems and make capital projects less of a shock to the system.

Refurbishment tasks typically undertaken within theatres	Green Intervention worth considering	Green Intervention Reference
Bar refurbishment	A-rated appliances	C33
	Underfloor heating	C23
Auditorium seating	Consider displacement-ventilation opportunities	C41
Toilet upgrades	Increased airtightness around wall/floor junctions	L7
	Install LED lighting	C1
	Improve lighting controls - install daylight and/or occupancy sensors	C2
	Install instantaneous point-of-use water heaters	C10
	Underfloor heating	C23
	Replace extract-only with mechanical ventilation and heat recovery (MVHR)	C27
	Install auto-stop hot taps	
Office (or back of house) upgrades	Increased airtightness around wall/floor junctions	L7
	Install LED lighting	C1
	Improve lighting controls - install daylight and/or occupancy sensors	C2
	CO2 controlled ventilation	C3
	Install instantaneous point-of-use water heaters at tea points	C10
Accessibility improvements	Enhance door air leakage improvements	L8
Stage lighting enhancements	Convert stage lights from Tungsten to LED	C13
Rewiring whole or part of the building, or extending wiring to new facilities	Install sub-meters on areas known or suspected as high usage	C15
	Replace old light fixtures with LED fixtures	C1
	Install movement-sensor and/or daylight sensor lighting controls where relevant	C2
	Increase electrical load capacity to future-proof electric heat	
	Rationalise switching	
Lamp replacement	Replace any remaining tungsten or CFL lamps with LED equivalents	C1
	Replace fluorescent tubes with plug-in LED replacements	C1
Resurfacing roof to cure leaks	Add insulation	L05
	Strengthen to support PV panels	
	Install skylight to enhance daylight	L06
	Paint surface white to reflect solar radiation and minimise the heat island effect	

4 Sustainability Upgrades

Maintenance programmes are also the opportunity to put in hand key sustainability works. These may vary from gradually replacing water heaters, to minor insulation works, replacement of windows or installation of secondary glazing. Carried out progressively, costs can be spread over a number of years. Maintenance allows significant progress to be maintained on sustainability even while theatres gather themselves for the next big capital project.

Replacing rotten windows	Ensure good quality double (or triple glazing if the room often needs heating) and insulated frames (required by Building Regulations anyway)	L02
Redecoration	Replace old light fixtures with LED fixtures	C01
	Install movement-sensor and/or daylight sensor lighting controls where relevant	C02
Replacing gas/oil boiler(s) supplying heat to radiator systems	Check flow and return temperatures that the system runs at. If close to 40° then heat pumps could be considered, but seek professional advice first	G01
	Install heating zone valves	C18
	Install water sub-meters to domestic hot water	C29
	Upgrade insulation to hot water pipework	C08
	Consider upgrading heating emitters (like radiators) to accommodate low-temperature heating.	C23
Replacing gas/oil boiler(s) supplying heat to Air Handling Unit only	Dedicated heat pump or upgrade AHU to include integrated heat pump	C26
Renewing controls	Install or update Building Energy Management System	C16
	Install thermostatic radiator valves (TRVs) on radiators	C17
	Improve timing and zone controls	C18
	Optimised start/stop	C14
Replacing hot water	Weather compensation	C14
	Electric point-of-use heaters - especially if pipe runs are long	C10
Chiller needs replacing	Consider a heat pump with simultaneous heating and cooling functionality	
Replacing /upgrading ventilation plant	Install CO2 sensors to demand-control fresh air rate (post-Covid)	C03
	Install a heat recovery mechanism	
	Install units with integrated heat pumps to reduce the demand on fossil-fuel heating.	C26
	Install high efficiency fans with variable speed drives (and suitable controls)	C25
	Install electric and heat sub-meters	C15
	Simplification or upgrade of BMS controls	C16
Adding/refurbishing showers	Install low-flow water efficient shower heads	C11
	Waste water heat recovery system	C40

5 Killing Two Birds with One Stone

Maintenance is also the opportunity to make sure that the theatre's journey to sustainability is being managed as cost-efficiently as possible.

While some energy, water or other environmental measures are worth considering at any time, many others become practically or financially viable only when some other refurbishment work is underway. The cheapest time to insulate a roof is when you're replacing the roof coverings. While you've paid for scaffolding to repaint high level windows, that's the moment to install secondary glazing.

The table above offers examples of such opportunities.

12 Capital Projects

1 Introduction

Some sustainability improvements are major works. Their cost may need fund-raising. They may require planning or listed building permission. They may be so disruptive as to require closure of the theatre.

In that case they need to be achieved as part of a capital project – or through a series of capital projects.

2 Prioritising Sustainability

Theatres have many conflicting priorities. Most capital projects will have multiple goals, to make the most of closures and fund-raising opportunities. For example, as well as a wish-list of sustainability improvements, theatres may also need to sort out access, re-seat the auditorium, or build a new studio.

In past capital projects, it's sometimes been the case that sustainability has dropped to the bottom of this wish-list, superseded by projects that support artistic growth (a new flying system), engagement (teaching space), or audience development and revenue (replacing the bars). Funding often supports more high profile projects over the mundane business of insulating lofts.

It's therefore essential to make sure that sustainability goals are written into the basic aims of the capital project, and that all stakeholders agree on sustainability as an urgent priority which mustn't be compromised.

It helps if the capital project can be seen as an essential element in a Sustainability Plan with defined goals, targets and dates. In that case it will be clear to all that dropping the sustainability elements prevents the theatre reaching targets which everyone has agreed.

3 Stakeholders

For that reason, it's important to make sure that stakeholders are fully behind the project, and sign up to its sustainability ambition from the outset.

Achieving Board support is vital for most theatres. The Board must establish sustainability as a primary aim, as well as providing continuity and supporting staff.

Internal stakeholders may include department heads who understandably have different priorities and agendas. It's important to create a shared goal of sustainability (climate literacy training can help with this).

At the outset, write a list of the external stakeholders who need to give a sustainability project their support. They may include landlords, statutory authorities, and funders. It's usually worth talking to them early to bring them on board and make this a shared journey.

4 Starting Out

Your capital project needs to start from defined goals that relate directly to the theatre's Sustainability Plan.

If you're starting from a Sustainability Plan developed through the Green Book, then you will have some clear goals and a prioritised list of actions to target.

That document can be the basis of your early conversations with stakeholders.

The next step will be to get some professional advice to:

- Confirm the sustainability thinking
- Confirm feasibility
- Assess costs

5 Building a Team

Theatres are bespoke buildings which require specialist knowledge. The team you need may include architects, sustainability consultants, services and structural engineers, acousticians, fire and access consultants, as well as project managers and cost consultants.

Make sure all of them are experts both in performance buildings, and in sustainability. Be certain they understand the project's sustainability goals. To achieve a successful project, you need the right people around you.

Large expert teams can be costly. The more thinking you do for yourself, or supported by a small team, the better the chance of your running through iterations so as to shape the project in a way that suits your theatre, and your sustainability goals. Start small and add knowledge as you need it.

Capital projects aren't easy. They need:

- Energy and determination to drive them through
- Flexibility to shape them to changing circumstances

Sustainability Frameworks

In the UK, BREEAM is the most recognised framework for ensuring capital projects are sustainably managed. Planning authorities and funders often require projects to achieve BREEAM 'Excellent' standard.

The most appropriate scheme for refurbishments is BREEAM Refurbishment and Fit-Out. You can find more information here: <https://www.breeam.com/discover/technical-standards/refurbishment-and-fit-out/>

Other standards are available, including the living building challenge (<https://living-future.org/lbc/>). Your professional team can advise on the most appropriate framework to use.

Seeking Advice

The Theatres Trust offers advice on planning, funding and managing capital projects.

Check out their web page at <http://www.theatrestrust.org.uk/how-we-help/advice/advice-notes>.

6 Heritage

Many theatres are historic listed buildings. Upgrading them to operate sustainably requires a high degree of sensitivity and expertise. It will involve nuanced decisions between heritage value and the need to improve building fabric or introduce new services systems. Some things simply won't be possible. At the same time, historic buildings have already spread their embodied energy over many years. Keeping an existing building in use is far more sustainable than building a new one – even if it's designed to the best modern standards.

Heritage expertise is essential to achieve the best outcome. Historic England should be seen as a partner in this process, not an opponent. Their guidance is invaluable. The Theatres Trust is the UK's lead body for theatre buildings and may be able to provide advice and support on sustainability improvements to historic building.

Before any works to a historic building, start by commissioning a Conservation Management Plan. It will define the heritage value of the building, guide decision-making about change, and set a framework for stewardship of the building. Engage heritage authorities in the process and make the most of their expertise.

The Conservation Management Plan should include a section on opportunities and challenges relating to sustainability works. If you already have a Conservation Management Plan, update it to include this section.

Your Sustainability Plan should be written in the light of this document. The guidance at the heart of Sustainable Buildings is designed to flag up issues that particularly relate to historic theatres.

7 Funding

Funding for capital projects is always a challenge. Most theatres will aim for a combination of:

- Arts Council for their country
- Heritage Lottery Fund
- Local Authorities
- Philanthropic Trusts
- Private giving
- Landlords
- A restoration levy on tickets

At present, relatively few funds are targeted at sustainability works. However, this is changing, and increasingly funders are both supporting sustainability – and, indeed, requiring it.

The Theatres Trust offers good advice on fund-raising for capital projects at http://www.theatrestrust.org.uk/assets/000/001/478/Fundraising_for_a_Capital_Project_FINAL_original.pdf?1565081529.

8 Design

Capital projects involve building work – which itself uses resources and has a carbon footprint. The energy that goes into making steel, bricks and concrete is known as 'embodied energy'.

In the context of the climate emergency, it is essential to build in ways that minimise carbon and resource use. The first question is to ask whether new building is necessary at all? There are often alternative ways of achieving a theatre company's goals, by reviewing operation, or repurposing existing spaces.

If building is absolutely necessary, make sure your designers are experienced in sustainable design and use materials and techniques

that avoid adding to the theatre's existing carbon 'debt'. Choose long-lived and robust materials which won't need replacing.

Measure the embodied carbon 'debt' involved in any building works, as well as the reduction they offer in carbon usage.

9 Programming Capital projects

A perennial issue for theatre capital projects is the damaging effect of prolonged closure on audience development, artistic momentum and revenue. Think about programming from the outset. If possible, divide the project into 'chunks' that can be carried out sequentially. And allow contingency on each phase of the works. Building works very often run late.

10 Sustainability in Operation

Theatres often find that sustainability projects which offered benefit on paper are much less effective in real life. The capital project doesn't end when the builders leave. It's essential to retain designers for a period of occupation and review, to ensure everything is working as effectively as possible. See 'Soft Landings'.

Beyond that, guidance on running your building sustainably will be found in Theatre Green Book volume 3 : Sustainable Operations.

Soft Landings

Soft Landings is an initiative to ensure capital projects end smoothly and deliver their intended benefits. It allows for a period for review and monitoring after completion, so as to make sure planned improvements are actually achieved.

You can find more information at: <https://www.thenbs.com/knowledge/what-does-government-soft-landings-mean>

13 Zero Carbon and Beyond

1 Introduction

The ultimate goal is to achieve zero carbon emissions each year.

That may take several years to achieve. For some, it may be impossible – for example, in a historic theatre which can't be fully insulated, or for theatres who can't raise the funds for all their plans.

In that case, theatres can reach 'net zero' by off-setting the amount of carbon they can't get rid of. Off-setting means investing in a scheme (for example, tree-planting) which is calculated to absorb the same amount of carbon as the theatre is emitting. The result is that the building's impact is cancelled out: it's 'net zero'.

Offsetting should be the last resort. The first step is to reduce carbon emissions as far as practically possible.

Scope 1, 2 and 3 Emissions

Scope 1 emissions are caused directly by the theatre, when it burns fossil fuels like oil and gas in a boiler.

Scope 2 emissions come from indirect energy generation – i.e. when a theatre buys electricity which the electricity company makes by burning fossil fuels in power stations.

Scope 1 and 2 are mostly within a theatre's control. They're the focus of this guide.

Scope 3 emissions are indirect. They're far harder for theatres to control. They're caused by the journeys audience make to reach the theatre, the carbon emissions of supply companies, and the transport needed to deliver supplies and take away waste. It's easy to get confused trying to calculate, let alone change them.

Theatre Green Book : volume 3 Sustainable Operations gives further advice on tackling them.

Defining Net Zero Carbon

In 2019, the UK Green Building Council (UKGBC) produced a framework definition for a net zero carbon building in operation. It defines the steps to achieving a net zero carbon building in operation as follows:

1. **Reduce Operational Energy Use:** Reductions in energy demand and consumption should be prioritised over all other measures. In-use energy consumption should be calculated and publicly disclosed on an annual basis.
2. **Increase Renewable Energy Supply:** On-site renewable energy source should be prioritised. Off-site renewables should demonstrate additionality.
3. **Offset Any Remaining Carbon:** Any remaining carbon should be offset using a recognised offsetting framework. The amount of offsets used should be publicly disclosed.

For existing theatre buildings, the energy scope is defined as all areas under operational control or influence where a net zero carbon balance has been achieved on an annual basis.

The energy scope should be disclosed to allow comparability between buildings.

The framework only addresses "Scope 1 and 2" emissions (see sidebar), which account for the direct building carbon emissions (e.g. from boilers) and purchased energy (e.g. electricity).

For an existing theatre, net zero carbon is defined as follows:

"When the amount of carbon emissions associated with the building's operational energy on an annual basis is zero or negative. A net zero carbon building is highly energy efficient and powered from on-site and/or off-site renewable energy sources, with any remaining carbon balance offset."

Note that energy consumption and carbon emissions are intrinsically linked. Carbon reduction is the ultimate aim, but indicatively, reducing your energy consumption will ensure carbon emissions reductions, and energy consumption is often far easier to manage and control.

2 Offsetting

If you decide to off-set residual carbon, it's best to follow UK Green Building Council guidance:

Carbon offsets should either be procured directly or via recognised existing offsetting frameworks. Both of these routes should seek to demonstrate 'additionality' (i.e. they wouldn't be happening anyway), avoid double-counting and provide a clear process for verifying actual carbon savings. Offsetting frameworks worth considering include the Clean Development Mechanism and Gold Standard.

If theatres are on a journey to net zero, then the amount they need to offset will keep reducing. Make sure you regularly balance your need against your offsets – and don't fall behind on the payments.

3 Restorative Action

It will be a challenge for many theatres to reach zero carbon. All the same, it is important to focus on the longer necessity of restoring some of the damage we have already done to the planet.

Ultimately, public buildings should aim to take restorative action by generating electricity, supporting biodiversity, and taking whatever measures they can to address the climate emergency.

The journey need not end at carbon zero.

sustainable buildings

THE GUIDANCE

Click [here](#) to fill in the Sustainable Buildings 'Home Survey Tool'.

The output will be a draft Sustainability Plan which divides the actions you need into three categories - Easy Wins, Maintenance, and Capital Projects, and places them in order of impact (Lean - Clean - Green).

Complete the Home Survey Tool to generate an initial Sustainability Plan, then turn to Section 9 for guidance on how to finalise it.

Acknowledgements and Thanks

How the Green Book has been prepared

The Theatre Green Book is built on a number of core principles:

- The initiative is backed by a broad partnership of organisations that span the full range of theatre.
- The Theatre Green Book absorbs and learns from existing guidance for the sector. It does not set out to reinvent the wheel, but to define common standards and shared guidance that will make the journey easier for everyone.
- The guidance is built on numerous conversations and focus groups with working theatre practitioners of all sorts. It reflects the actual experience of running theatres and making theatre.
- The Theatre Green Book’s guidance is underpinned by the expertise of sustainability consultants Buro Happold.

Sustainable Buildings is based on the input of numerous theatre owners and managers, and others, whose names are acknowledged in the next section.

Future versions of the Green Book

Sustainability advice will change. Future developments of embodied carbon and the circular economy will alter the landscape of sustainability. Emerging technologies like carbon capture may offer new options.

But these things typically change over long periods of time (years and decades). We are in a climate emergency now, and so the best possible thing to do is plan for what you know will be impactful now, and alter the plan as and when required. This guidance will be updated with time to ensure new advances and new technologies are considered.

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We apologise if any names have been missed. Very many others have helped by answering questionnaires, and joining sustainability groups convened by the many theatre organisations, companies and others who are working for sustainability, and whose thinking has contributed to this guide.

We know many more would have liked to help this initiative if time had allowed, and look forward to their thoughts and feedback.

Literature Review

Toolkit	Summary	Year of Publication	Publisher/Author	Link
Julie's Bicycle: Fit for the Future guide	<ul style="list-style-type: none"> A guide on how to incorporate sustainability into building design Contains lots of useful case studies Contains a summary of technologies Has a list of places to get funding 	2015	Julie's Bicycle and Arts Council England	Fit for the Future guide 2015.pdf (juliesbicycle.com)
Julie's Bicycle Renewable and Green Electricity Factsheet	<ul style="list-style-type: none"> Useful reference to find suppliers of renewable energy Contains pros and cons lists of different renewable energy sources 	2017	Julie's Bicycle	Renewable and Green Electricity Factsheet 2017–Julie's Bicycle (juliesbicycle.com)
Julie's Bicycle – Creative Green Tools	<ul style="list-style-type: none"> Online toolkit that is a set of carbon calculators Designed specifically for the creative industry 	Updated in 2019	Julie's Bicycle	Introducing the Creative Green Tools –Julie's Bicycle (juliesbicycle.com)
Green Theatre Guide	<ul style="list-style-type: none"> Contains practical actions and tips on ways theatres can reduce carbon emissions Contains case studies showcasing how these actions have helped cut carbon usage Links to an online carbon calculator Important to note that this was published in 2008 so some of the information regarding fossil fuels is a little out of date 	2008	Greater London Authority	Green Theatre Guide 2008.pdf (juliesbicycle.com)
Benchmarking Energy Use in Performing Arts Buildings	<ul style="list-style-type: none"> Contains a useful benchmark for energy use per floor area and energy use per recommended capacity Is a lot more rigorous than CIBSE TM46 but is a more realistic reflection of how spaces are used 	2012	Julie's Bicycle	CIBSE – Building Services Knowledge
Green Theatre Choices Toolkit	<ul style="list-style-type: none"> Contains a list of common materials used in productions, then ranks them based on environmental effect Also contains a pros and cons list for each material More useful in terms of productions rather than in terms of the sustainability of buildings as a whole 	2010	Mo`olelo Performing Arts Company	Toolkit.pdf (sustainablepractice.org)
White Light Green Guide	<ul style="list-style-type: none"> A guide on choosing more energy efficient lighting Mostly focuses on stage lighting and productions but there is a section on lighting around the building Contains practical and easy to understand tips 			Green-Guide.pdf (sustainablepractice.org)
Historic England: Energy Efficiency and Historic Buildings: How to improve energy efficiency	<ul style="list-style-type: none"> Is a guide to improving energy efficiency in older/heritage buildings Contains a useful checklist of measures that can be taken Discusses the use of a 'whole building approach' 	2012	Historic England	Energy Efficiency and Historic Buildings: How to Improve Energy Efficiency (historicengland.org.uk)
Responsible Retrofit Guidance Wheel	<ul style="list-style-type: none"> Interactive online tool geared towards retrofitting of older buildings Lets the user look at different measures that can be taken and the risks associated with them 		STBA	Guidance Wheel STBA (responsible-retrofit.org)
RIBA sustainable outcomes guide	<ul style="list-style-type: none"> Is a useful guide to initially look at Sets out key performance metrics and targets to meet in order to meet UN sustainability goal 	2019		RIBA sustainable outcomes guide
Becoming a Sustaining Organisation: The Case of Greening the Wharf at Sydney Theatre Company and Its Impacts	<ul style="list-style-type: none"> A useful case study of the Greening the Wharf project – a project that aimed to make Sydney Theatre Company more sustainable 			



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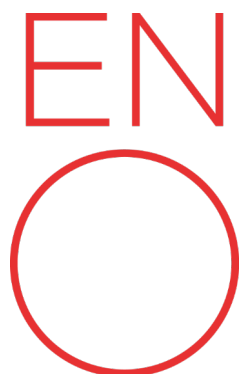


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Buro Happold is an international, integrated consultancy of engineers, consultants and advisers. After leading the construction industry in declaring a climate emergency, we've committed to reduce our own impact by achieving challenging science-based targets. We are collectively working towards an equitable and green future by adapting our business to mitigate climate change and the biodiversity crisis and helping others achieve their sustainability goals.

<https://www.burohappold.com/about/>

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