A Young Person's Guide to

Active Buildings

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specific®

Introduction

The UK Government has set targets for the UK to be net zero carbon (NZC) by 2050.[1] To do this, they have decided that, from 2035, no new natural gas boilers will be installed in buildings for heating; and, after 2030, new vehicles will no longer use petrol or diesel to power them. This means that electricity will be used to heat buildings and power vehicles, putting a lot of strain on the National Grid. Further pressures on the National Grid come from the increase in renewable energy being supplied into the grid, which is uncontrollable.

To stabilise the grid, i.e. to maintain the reliability and consistency in power or electricity production and transmission, we need Active Buildings, which are able to control when renewable energy is fed into the grid, and when energy is taken out of the grid. They do this by using energy storage to act as a buffer between a building's energy generation and energy use, and the National Grid. In other words, when the sun is shining or the wind is blowing, not all the energy being generated by solar panels and wind turbines needs to go directly into the National Grid, but can be stored for when the grid needs it. Conversely, when there is a high demand for electricity, this can be taken from energy stores, which have either been charged from renewable energy, or from the grid when there was less demand for electricity.

When electrical currents travel on a network, some energy is dissipated in the form of heat, and is "lost" due to the electrical resistance in the network. This energy is known as network losses. Active Buildings generate energy where it is used, avoiding these losses and maximising the benefits of renewable energy, as the electricity doesn't have far to travel.

Active Buildings have a big role to play in the transition to a net zero carbon world.

What is an Active Building ?

There are 6 principles to an Active Building:

- 1.0 Building Fabric and Passive Design
- 2.0 Energy Efficient Systems and Data Monitoring
- 3.0 On-site Renewable Energy Generation
- 4.0 Energy Storage
- 5.0 Electric Vehicle Integration
- 6.0 Integration with the National Grid

Topic: Climate Change and Net Zero Carbon buildings

Learning Objective 1: Build my knowledge on the impact our energy use in buildings has on climate change and learn how to tackle climate change through reducing our energy consumption and carbon emissions, and using our energy differently.

Learning Objective 2: Evaluate information on low carbon building design, construction and technologies and identify solutions to reduce energy consumption and carbon emissions.

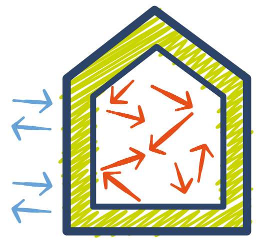
Learning Objective 3: Reflect on the knowledge I have learnt and identify how to apply this knowledge in my everyday life and throughout my career.

1 Climate Change Act 2008 (2050 Target Amendment) Order 2019, https://www.legislation.gov.uk/ukdsi/2019/9780111187654

1.0 Building Fabric and Passive Design

Buildings use a lot of energy and emit a lot of carbon into our atmosphere, which is bad for our planet and is contributing to climate change. Active Buildings have well-insulated and airtight walls, floors and roofs, to ensure warmth is retained within the building in winter months and the risk of overheating in summer months reduced, creating a comfortable and stable indoor environment for us all year round. Very little energy is needed for heating or cooling, and energy bills are low.

Building fabric



An Active Building acts like a thermos flask, preventing heat transfer from inside to outside, and vice versa.

Although in the UK, we are mostly concerned with keeping our buildings warm, many buildings, even in the UK, suffer from overheating, and this can affect us all – too uncomfortable to sleep at home, not able to concentrate in school, longer to recover in hospitals, and less able to work effectively in offices. Overheating is less likely in a well-insulated and well-ventilated building.

Zaha Hadid was one of the world's most inventive architects. Her buildings were beautiful, combining concrete, steel and glass in often organic forms, like this net zero emissions building in the Al Sajaa Desert, United Arab Emirates, which was designed to mimic the dunes.

https://www.zaha-hadid.com/architecture/beeah-headquarters-sharjah-uae/

Materials

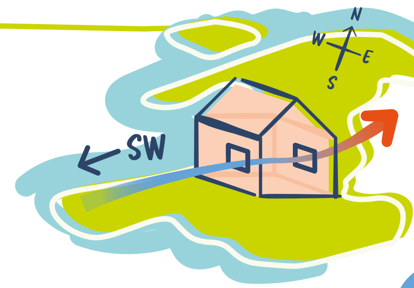
- **Embodied carbon** refers to the greenhouse gas emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of building materials.
- **Natural materials,** like straw or wood, have lower embodied carbon than more heavily processed materials like concrete or steel. However, other factors, such as lifetime and robustness, may affect material choice.

Challenge: Can you find examples of offsite construction in your local area? What materials do they use? What are the benefits?

It is now possible to make buildings in factories and transport them to their final location. This is known as off-site construction, and can lead to lower embodied carbon buildings, due to factors such as the need to spend less time on a construction site and the generation of less waste. They can also be better quality buildings, due to the way they are put together.

Constructing buildings in a factory is also safer and means less time spent on a cold, wet building site.

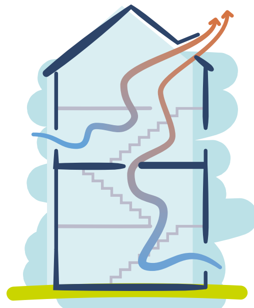
Ventilation and Lighting



Good ventilation is essential to ensure a healthy indoor environment in buildings. There are two types of natural ventilation:

- **Stack effect ventilation**

This is sometimes called the chimney effect. Airflows are created using natural forces that come from changes in air pressure, temperature and air density, between low level openings, such as windows or vents, and high level openings, such as rooflights or chimneys. Fresh air is drawn into the building at low level and warm stale air is drawn out of the building through the chimney or rooflight. The greater the height of the building, the more effective this is, making it ideal for tall office buildings.



- **Cross ventilation**

This occurs where there are pressure differences between one side of a building and the other. Typically, this is a wind-driven effect in which air is drawn into the building on the high pressure windward side and is drawn out of the building on the low pressure leeward side.

For an airtight building, some mechanical ventilation will be needed to ensure there is always clean, fresh air inside and to manage moisture levels.

In Wales, the wind usually blows from a south westerly direction – this is known as the prevailing wind. If we want to use natural, cross ventilation, it is best to have windows on the side of the prevailing wind and on the opposite side of the building (the leeward side) – this allows the positive pressure from the wind to be pulled through the building, due to the negative pressure on the sheltered side.

- **Natural lighting** (daylighting) reduces the need for artificial lighting, thereby saving energy. It also creates healthy and comfortable indoor environments. However, direct sunlight in a building can cause overheating and glare problems.
  Use of natural light differs for different building types, e.g. direct sunlight for solar heat gains in winter can reduce heating loads in houses; whereas office buildings require light rather than heat gains to avoid glare issues and overheating.

Shading devices, such as shutters or canopies on buildings help to reduce glare and keep buildings cool in summer, reducing the need for mechanical cooling, such as fans or air conditioning.

Architects have lots to think about when they start designing building forms. **Simple building forms are more energy efficient than complex shapes,** as they have fewer walls and fewer junctions, making it easier to ensure they are well-sealed and well-insulated. They also have less surface area in contact with the outside environment.

Passive Design

Existing site features can be used to reduce the amount of energy a building uses, e.g.

- Deciduous trees in front of a south elevation will shade a building in summer, but allow low winter sun into the building.
- Water or vegetation/plants outside a building can help keep a building cool in summer. Lots of hard surfaces such as roads and pavements, for example, absorb the sun's heat and re-emit it into the air, making areas around buildings hotter, whereas greenery or water don't absorb so much heat.
- Planting around a building can also provide shelter from wind.

Challenge: But, how do we make simple building forms look interesting? Can you find examples of interesting buildings with simple forms? What makes them interesting?

2.0 Energy Efficient Systems and Data Monitoring

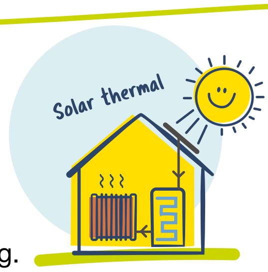
I worry about the amount of energy we use in our homes and schools, and whether we know exactly where the energy is being used. If we monitor our energy usage, we will know where we use the most energy and can work out how to reduce the amount we use. Energy efficient systems with smart control strategies can help minimise energy used for heating, ventilation, cooling and lighting.

Low Carbon heating solutions

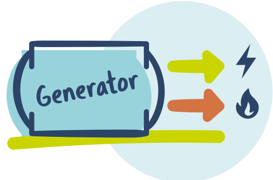
The biggest use of energy in our homes in the UK is for space heating and hot water. While gas used to be the main way to heat buildings, we now need to find low carbon solutions that use less fossil fuels. However, as we learnt in the last section, if we insulate our buildings well and make sure they are airtight, we shouldn't need as much heating as we used to in less well-insulated buildings.

There are several low carbon heating solutions for buildings:

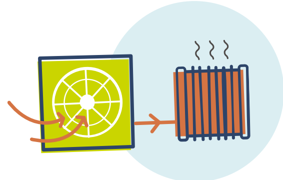
As well as reducing our embodied carbon, we also need to reduce the **operational carbon** of buildings. This is the carbon emissions that occur from a building in use – from heating, cooling, lighting and powering a building. To reduce operational carbon, we need low carbon ways to use our buildings.



- Solar thermal for water heating.

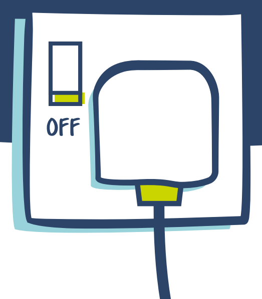


- A combined heat and power plant (CHP) – heat is recovered from a generator making electricity, so less energy is used in total and no energy is wasted – provides free heat for the building.
- Air source heat pumps – transfer heat from the outside air to water, or air, which heats your rooms via radiators or underfloor heating. It can also heat water stored in a hot water cylinder for your hot taps, showers and baths.



- Ground source heat pumps – transfer heat from the ground to water, providing heat for your rooms via radiators or underfloor heating. They can also heat water stored in a hot water cylinder for your hot taps, showers and baths. The thermal mass below the ground means that it remains at a relatively stable temperature all year round, which can lead to better efficiencies than air source heat pumps.

You can save lots of energy by switching things off standby. The standby function can account for **6%** of all energy usage in the home.



Lighting

To reduce energy used for lighting, we can use energy efficient lightbulbs, daylight sensors and occupancy sensors. We should also turn lights off when we leave a room.

Cooling

As with heating, a well-insulated building shouldn't need much cooling. However, if cooling is needed, there are some low carbon solutions:

- Using groundwater, extracted from the ground, from 5m to as deep as 50m below ground.
- Using surface water from lakes, rivers, or docks.
- By opening vents at night to remove the warm air that has built up during the day.

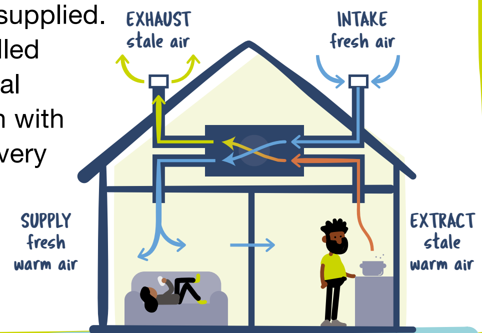
Air conditioning should only be considered for cooling as a last resort.

The USA use more electricity for air conditioning than the whole of Africa uses for everything.

A smart meter home display can help identify how much energy is being used during the day and remind you to switch things off when not in use.

Ventilation

In an airtight building, it is often necessary to use mechanical ventilation as well as, or instead of, natural ventilation. This is usually in the form of an electrically powered fan, or fans, and can be designed to combine heat from the spaces in a building to warm the fresh air being supplied. This is called mechanical ventilation with heat recovery (MVHR).



Water

Water can be collected from baths or showers for use in toilet-flushing, or for watering plants.

Rainwater can be collected and used for toilet flushing, washing machines and watering plants. However, rainwater harvesting can increase a building's carbon emissions, depending on the design of the system.

Waste heat energy can be collected from showers for other hot water use.

Water saving devices like water saving shower heads, low flush toilets, sensor operated taps and toilet flushing. You can also save water by switching taps off between uses, such as when brushing your teeth.

Water-saving shower heads work by either mixing water with air, or by restricting water flow by squeezing it through very small holes. Both can save lots of water, without ruining your shower experience.

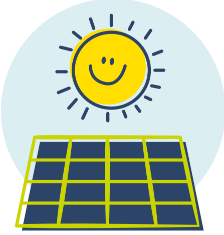
Challenge: Investigate how much energy is used in your school each year. Do you know where it is used? Can you identify any ways to save energy at school? Look here for energy usage in different schools: www.energysparks.uk/schools

Building Services or MEP (Mechanical, Electrical and Plumbing) Engineers design the low carbon heating, cooling, ventilation and water systems for a building.

3.0 On-Site Renewable Energy Generation

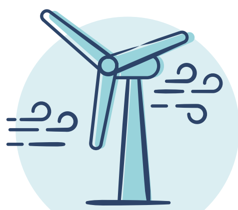
Renewable energy is energy from natural sources that can be replaced at a faster rate than it is used. Renewable energy can be used to provide low carbon heat and power to our buildings, reducing our reliance on fossil fuels (gas, oil, coal). This will help to reduce our carbon emissions and our impact on climate change. There are many different types of renewable energy…

Types of Renewable energy

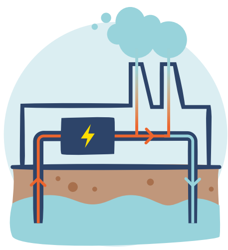


- Solar photovoltaics (electricity)

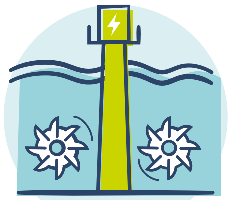
- Solar thermal (heat)



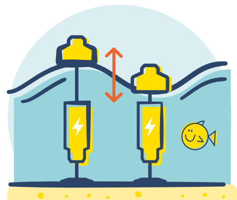
- Wind



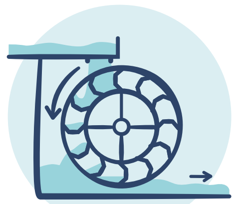
- Geothermal



- Hydroelectric and tidal turbines



- Wave motion



- Hydroelectric wheel

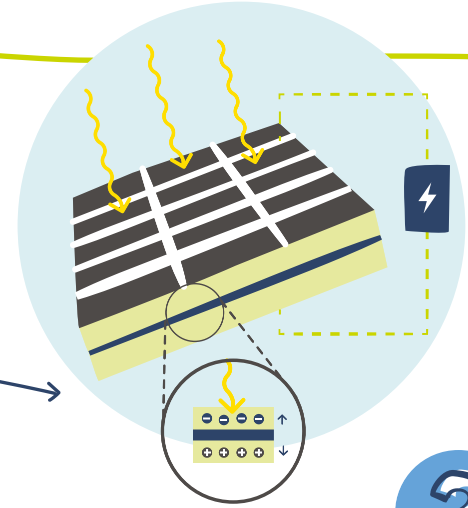
Did you know that if it is too windy wind turbines have to be switched off. Otherwise they will spin too fast and break. This happens in strong winds over 55 miles per hour (mph).

Choice of renewable energy to use will depend on the location, e.g. you could only use hydroelectric if there was a river nearby; if a building will be shaded by lots of trees or other buildings, solar may not be suitable.

Solar

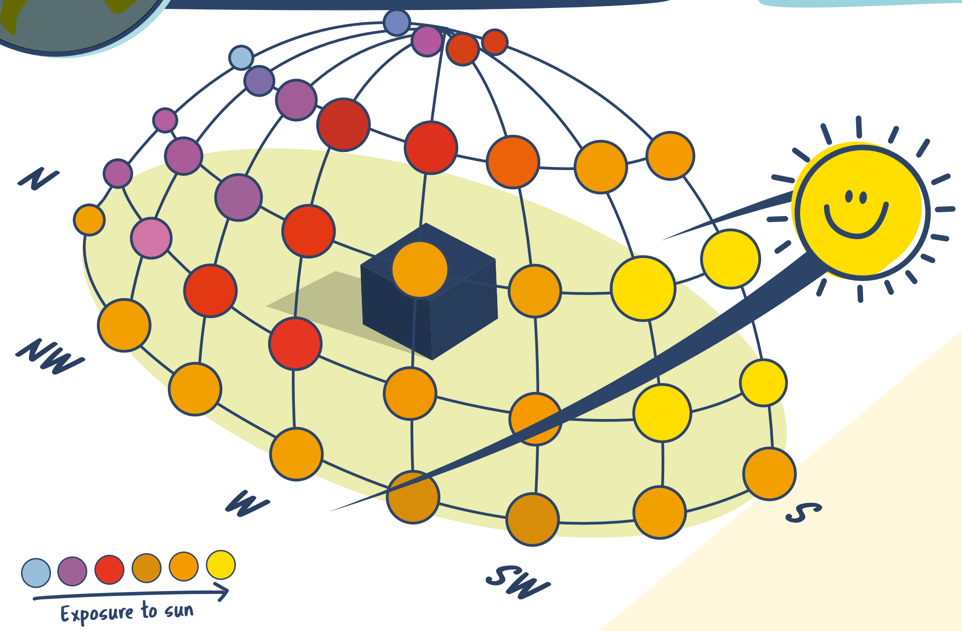
The most common form of renewable energy used in buildings is Solar.

- Solar panels convert solar energy into electrical energy. This is called a **photovoltaic effect** and is the reason they are called photovoltaic (PV) panels.



Did you know that every day more energy from sunlight falls on the earth's surface than can be used by the entire world population in 27 years!

Challenge: What materials are used in photovoltaic panels? What are the advantages and disadvantages of different PV panels?



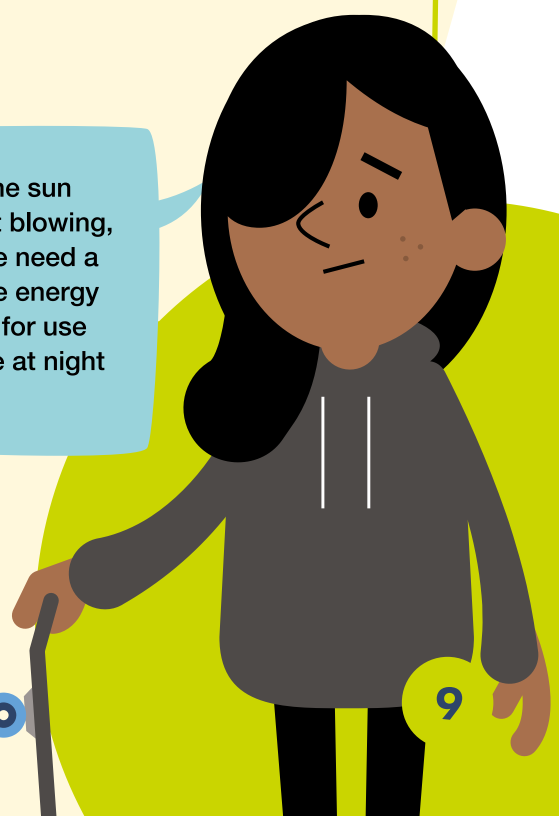
- For solar energy, a south orientation generates the most energy in the UK, as the sun moves from east to west.

The photovoltaic effect was first observed by Edmond Becquerel in 1839.The first solar panel was made by the American inventor Charles Fritts in 1883.

Most solar panels use rare or highly processed materials and are made using expensive and energy intensive manufacturing processes. Did you know that **Materials Scientists at SPECIFIC are developing printable PV panels**, using low cost and earth abundant materials, and are cheap to produce. They can be screen printed using the same machine used to print t-shirts.

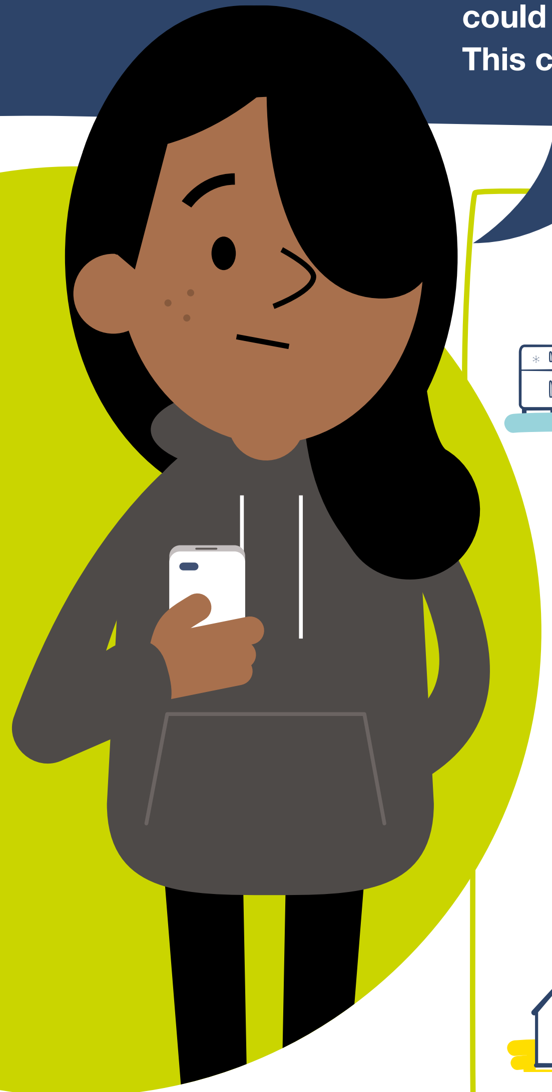
But what happens when the sun isn't shining, the wind isn't blowing, the water isn't flowing? We need a way to store the renewable energy when it is being produced for use at a later time, for example at night when it is dark.

You can find out more about different types of solar panels here: www.greenmatch.co.uk/blog/2015/09/types-of-solar-panels



4.0 Energy Storage

Both thermal and electrical storage should be considered in an Active Building, to maximise our use of renewable energy, reduce peak demand on the grid, and enable greater control of energy use. Energy storage acts as a buffer between the energy generated and used by a building, and the grid. For example, we could store energy we generate today for use tomorrow, or we could charge our stores overnight when energy demand is low. This control helps to stabilise the grid.



The most common form of storage for electricity is the battery. Most batteries used in buildings are lithium ion. For a house, these are about the same size as a fridge/freezer and can be located inside or outside the house.

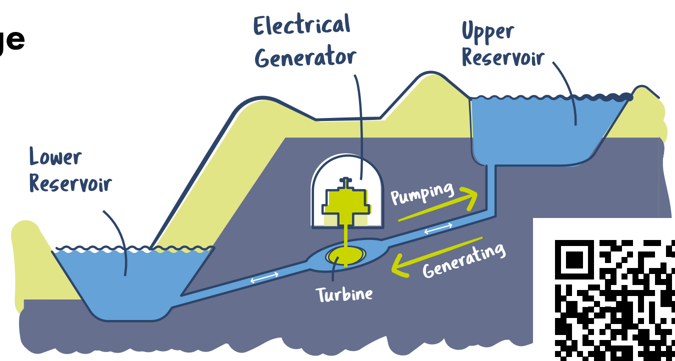
There are different types of thermal storage:

- **Sensible**, such as water, can store energy for a few days.
- **Latent**, such as phase change materials, can store energy for a few weeks.
- **Thermochemical** can store energy for a long time. **Scientists at SPECIFIC are developing thermochemical storage materials** that could capture energy generated from the sun in summer months for use in the winter; or could capture waste heat from industrial processes and use this to heat homes. Thermochemical stores have a much higher density than water, so will take up less space.

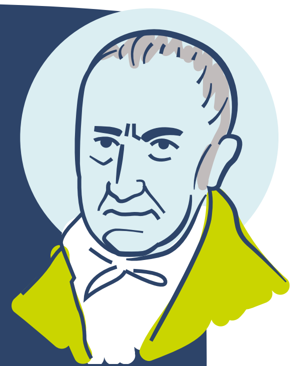
Pumped Hydroelectric Energy Storage

At a larger scale, pumped storage is used to help stabilise our national energy grid. They work by pushing water from a lower reservoir, using cheap electricity at night; then regenerating electricity when it is valuable or needed, using turbines.

The Dinorwig storage system in North Wales can switch on from 0 to 1.3 gigawatt (GW) of power in just 12 seconds!



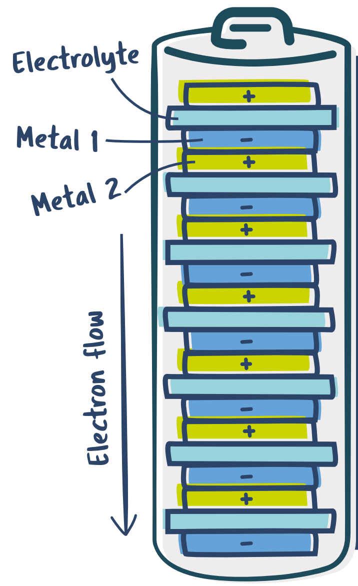
Watch the video here



Did you know that the first battery was invented in 1799 by the Italian physicist **Alessandro Volta**? The word voltage comes from Volta's name - the volt is the unit of measure for electrical potential difference used to drive current around an electrical circuit.

More information on volts here: https://www.studysmarter.co.uk/explanations/physics/electricity/basics-of-electricity/

Challenge: Investigate different battery types. Where do the materials in the batteries come from? What are the advantages and disadvantages of each?



What makes up a battery? Each battery cell is made up of two different metals, with different properties (called electrodes), separated by an electrolyte (a liquid or paste that can conduct electricity). A battery consists of lots of cells stacked up.

Lithium ion batteries (used in buildings and mobile phones) are expensive and have a big carbon footprint, as they use rare, expensive, toxic, difficult to mine, and difficult to recycle materials, such as lithium and cobalt. Therefore, we need new batteries and technologies without these drawbacks. Sodium is an example of a safe and sustainable substance for use in batteries, and could potentially be extracted from sea water. **Materials Scientists at SPECIFIC are investigating different forms of more sustainable batteries.**

Challenge: Watch the video and follow instructions to make your own penny battery.

5.0

Electric Vehicle Integration

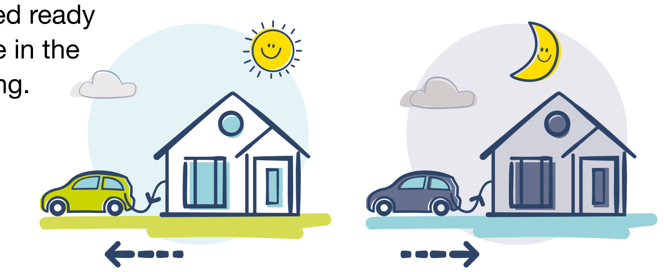
All cars and vans we use in the future will use either a battery or hydrogen to power them, instead of petrol or diesel. Hydrogen cars are not yet readily available, but there are lots of different types of electric vehicles (EVs) already on our roads.

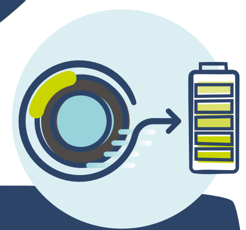
It takes longer to charge batteries used in EVs than it does to fill up with petrol or diesel. This means we will need plenty of EV charging points. Active Buildings can integrate smart EV charge points, which enable energy to be shared with vehicles in a controlled way.

- Different types of EVs include cars, vans, motorcycles, scooters, bicycles and even buses.
- EV charge points can be attached to a building, attached to a lamppost, or free standing.

- Pedelecs (Pedal Electric Cycles) are bicycles which only generate power when the cyclist is pedalling. They can be used to assist cycling in hilly areas.
- Most e-bikes get around 2,000 miles per gallon electric (MPGe), which is approximately 20 times more efficient in terms of electricity than a medium-sized electric car.

- **In the future, the battery in an EV could be used as an extra battery for the home**, for use at times of peak electricity demand, when electricity from the grid may be in shorter supply or more expensive. It can be charged up from renewable energy when more energy is being generated than is needed within the building. For example, if your parent or carer comes home from work and still has lots of charge left in their EV battery, they could connect it to the house and use the energy from the battery to power the heating, cooking, TV, lights, etc, in the evening. At night, when everyone is asleep and there is less demand for electricity, the EV battery can be charged ready for use in the morning.



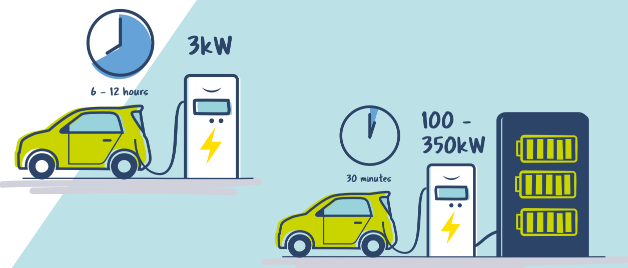


EVs can generate their own electricity to self-charge their batteries as they are driven. This is called ‘energy recovery’.

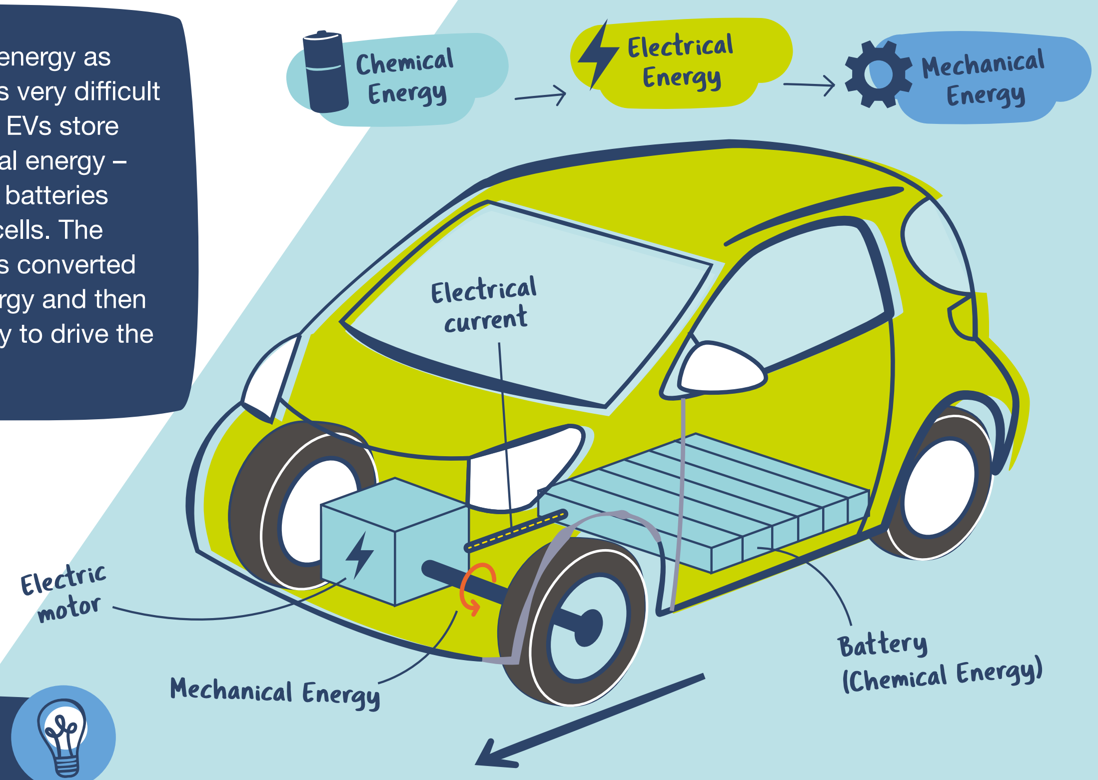
If you brake when driving an EV, mechanical (kinetic) energy is converted to electrical energy, hence recharging the battery. This is called ‘regenerative braking’.

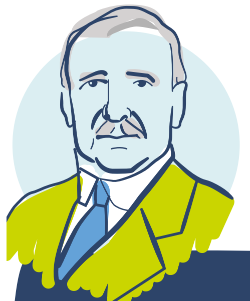
Numeracy Challenge: Find out how many miles an average EV can do per kilowatt hour and then plan a journey, from Swansea to London for e.g., including charging stops.

EVs can be charged quickly, using lots of power over a short time, e.g. 100 - 350kW in 30 minutes; or slowly, using less power over a long time, e.g. 3kW in 6 – 12 hours. Slow chargers are typically used for home charging, where your EV can charge overnight. Rapid chargers are needed at Motorway service stations, to allow fast charging during long journeys.



Storing electrical energy as electrical energy is very difficult and inefficient, so EVs store energy as chemical energy – either in chemical batteries or hydrogen fuel cells. The chemical energy is converted into electrical energy and then mechanical energy to drive the vehicle.



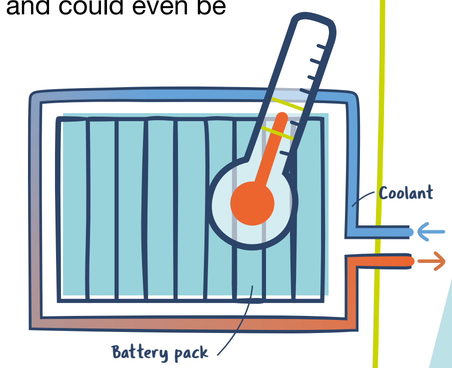


The first production electric car was built by English inventor Thomas Parker in 1884.

According to the Welsh Government, most personal trips in Wales are relatively short distance, averaging 8 miles[1]. The most sustainable ways to travel for short distances are by walking, scooting, or cycling.

An EV battery can store between 2,500 and 10,000 times more energy than your mobile phone.

The high electric current running through the batteries in an EV creates heat, thereby wasting electrical energy, which is inefficient and damaging, and could even be dangerous. Therefore, the batteries are cooled continuously by passing a coolant around the battery pack. The optimal temperature for a battery is between 10 and 30°C.



Did you know that the first hydrogen fuel cell was developed by Welsh scientist, William Grove, in the 1840s? His fuel cell was capable of generating energy by combining hydrogen and oxygen – the technology behind today’s fuel cell electric vehicles. [Incidentally, he also invented one of the first incandescent lights, which was later perfected by Thomas Edison.]

1 www.gov.wales/sites/default/files/consultations/2020-11/supporting-information-transport-data-and-trends.pdf

6.0

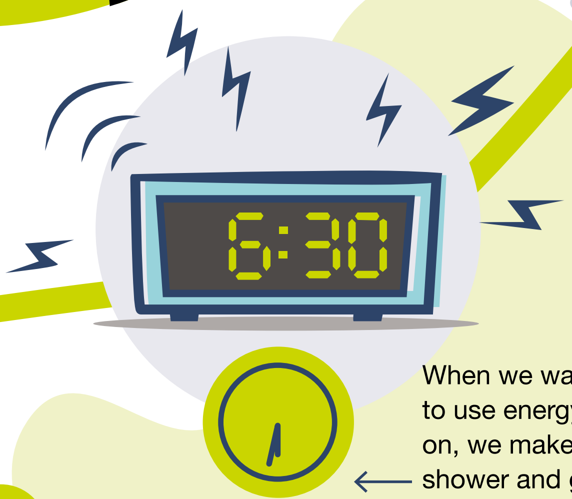
Integration with the National Grid

In addition to controlling energy use within a building, control strategies and energy storage enable Active Buildings to manage their interaction with the National Grid, controlling when energy is imported from and exported to the grid. This helps stabilise and reduce pressure on the grid from otherwise uncontrolled import and export, which is critical in a decarbonised society.

Some energy suppliers pay you to reduce demand during peak times - if you can shift your daily electricity use outside of peak times you can save money.

The data monitoring installed in the building will enable us to display energy use and generation, which will help influence occupant behaviour, whether in homes, schools, offices, or industrial buildings, and reduce our energy use.

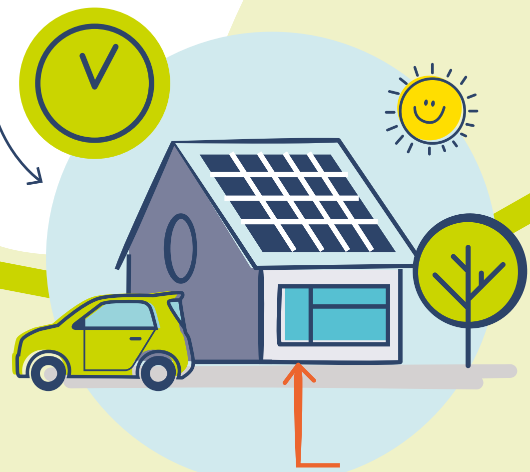
SPECIFIC were involved in a project exploring Domestic Demand Side Response (DSR) as a smarter way to manage our interaction with the National Grid. Find out more here:



When we wake up we start to use energy. We put lights on, we make breakfast, we shower and get ready for school, we watch TV or put the radio on.

This keeps increasing as people head to work and puts an increase in demand on the grid.

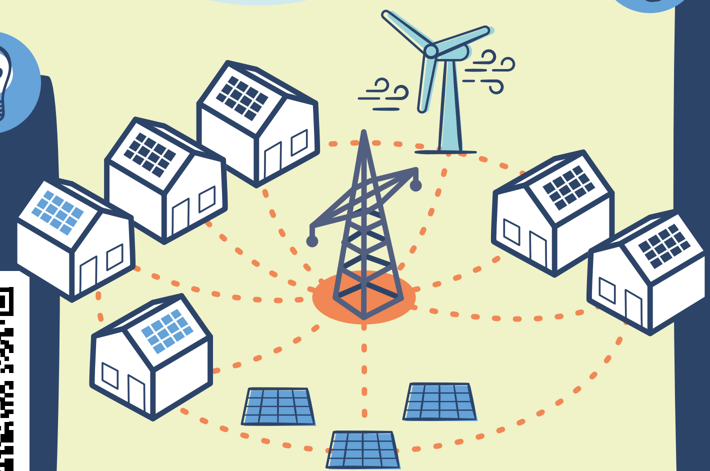
Active Buildings can store energy in the daytime to use when people get home in the evenings.



This means we can use energy that has been stored in the day e.g solar energy and not rely on fossil fuels.

When people go to bed and turn off the lights the demand decreases.

Did you know that it is thanks to Austrian actress and inventor, Hedy Lamarr, who developed frequency-hopping technology in 1941, that we have secure wi-fi, GPS and Bluetooth today?



As different building types use energy in different ways and at different times of the day, or even year, sharing energy makes a lot of sense. For example, schools and offices use energy during the day, but are closed at night when we have all gone home. Schools with solar panels don't need the energy they can generate in the summer during the holidays, so all that energy will just feed into the grid or go to waste, unless the school is connected to other Active Buildings, that can use the energy.

If we had lots of Active Buildings, we would need fewer fossil fuel burning power stations and could save money on the infrastructure needed to get power to and from power stations, i.e. the National Grid.

Solar micro-grids can provide a more reliable and affordable power supply for areas where the National Grid is inconsistent, helping to support the United Nations Sustainable Development Goal 7: access to affordable, reliable, sustainable, and modern energy. The SUNRISE project has helped to build several micro-grids in rural communities in India: www.sunrisenetwork.org/tag/micro-grids/

Challenge: Can you find some examples of microgrids or community energy schemes locally, or globally?

Summary

Now I know how low carbon, Active Buildings are created ...

- First we need to make sure the building is well insulated and uses the natural environment and site features to reduce the amount of energy it will need.
- Then we need to make sure we use the most efficient systems for heating, lighting, powering and ventilating the building.
- We will put in measuring devices to allow us to see how well the building is working and whether we need to change anything.
- We should then look at which renewable energy options are suitable for the building and whether we can generate enough energy to match what we will use in the building.
- Including some energy storage will help us to use all the energy we are generating, meaning we will need less energy generated from fossil fuels.
- Lastly, we need to think about how we can include electric vehicle charging and how we can share our energy with other buildings.

I now know that if there were lots of buildings like ours, we could reduce our use of fossil fuels and reduce our carbon emissions. This will help save the planet from climate change.

I have also learnt about materials and technologies that can be used within a low carbon building now and in the future.

Challenge: Design your own Active Building

Challenge: How could we make our school an Active Building?

What I've learnt about Active Buildings:

1 Building Fabric and Passive Design

I have learnt that:

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2 Energy Efficient Systems and Data Monitoring

I have learnt that:

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3 On-Site Renewable Energy Generation

I have learnt that:

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4 Energy Storage

I have learnt that:

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5 Electric Vehicle Integration

I have learnt that:

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-

6 Integration with the National Grid

I have learnt that:

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-
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Glossary

Building fabric
This refers to any element, such as the ground floor, walls, roof, windows and doors that enclose the interior of a building, separating the internal from the external.

Carbon footprint
The total amount of greenhouse gases (including carbon dioxide and methane) that are generated by our actions. The average carbon footprint for a person in the UK is about 10 tonnes CO2 per year.

Data monitoring
Data monitoring of a building's electrical and mechanical equipment (such as ventilation, lighting, energy, fire systems, security systems, water, and heating systems) is used to provide vital information on how a building is operating and the internal environmental conditions.

Electricity grid/ National Grid
The network of power lines used to distribute electricity over a geographic area. Buildings can import electrical energy from the grid and can export electrical energy to the grid.

Embodied carbon
The greenhouse gas (carbon) emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of building materials.

Energy efficient systems
This describes use of the most energy efficient heating, cooling, lighting and power equipment used in a building, combined with controls to ensure equipment works together efficiently.

Fossil fuels
Fossil fuels are a non-renewable resource made from decomposing plants and animals. They are found in the Earth's crust and contain carbon and hydrogen, which can be burned for energy, e.g. for heating and powering our buildings. Examples include coal, natural gas, and oil. When fossil fuels are burnt, they emit carbon dioxide into the atmosphere, contributing to climate change.

Geothermal
Heat (thermal) derived from the ground (geo), from depths of a few metres to multiple kilometres beneath the Earth's surface.

Greenhouse gas (GHG)
Gases, especially carbon dioxide, that trap heat in the Earth's atmosphere, preventing heat from escaping into space.

Hydroelectric energy (hydroelectric power)
A form of energy that harnesses the power of water (hydro) in motion, such as a flowing waterfall, to generate electricity. Hydropower supplies one sixth of the world's electricity.

Integration with the National Grid
This describes how a building communicates with the National Grid, seamlessly coordinating energy supply and demand. Good communication can lead to energy and cost savings, a more stable grid, and improved use of renewable energy—all of which benefit consumers (building users), the environment, and the nation's energy and economic security.

Net zero carbon
A state in which the amount of greenhouse gases (often referred to as carbon) produced is equal to or less than the amount removed from the atmosphere.

Operational carbon
The greenhouse gas (or carbon) emissions that occur from a building in use – that is from heating, cooling, lighting and powering a building.

Passive design
Passive design is design that works with the local climate to maintain a comfortable temperature in a building. It uses building layout, fabric and form to reduce or remove the need for mechanical cooling, heating, ventilation and lighting.

Phase change materials
Substances that absorb and release heat energy when they change phase, e.g. when a material melts, it changes from a solid phase to a liquid phase.

Photovoltaic (PV) energy
Photovoltaics is the direct conversion of light (photo) into electric power (voltaic), using semiconducting materials, such as silicon.

Renewable energy
Energy derived from natural sources that are replenished at a higher rate than they are consumed.

Thermal mass
The ability of a material to absorb, store and release heat. Materials such as concrete, bricks and tiles absorb and store heat. They are therefore said to have high thermal mass. Materials such as timber and steel do not absorb and store heat, so have low thermal mass.

Thermochemical energy storage
Thermochemical energy storage is the process of storing & releasing heat energy (thermo) through the breaking and reforming of (chemical) bonds that bind water within a hydrated salt. This form of energy storage allows excess thermal energy to be stored and used hours, days, or months later, e.g. storing heat generated by the sun in summer for winter heating.

United Nations Sustainable Development Goals (UNSDGs)
The UNSDGs, established in 2015, are a collection of 17 interlinked objectives designed to serve as a "shared blueprint for peace and prosperity for people and the planet now and into the future". https://sdgs.un.org/goals

Useful Links:

SPECIFIC's Active Classroom: www.specific.eu.com/the-active-classroom/

SPECIFIC's Active Office: www.specific.eu.com/the-active-office

Awel Aman Tawe: www.awelamantawe.org.uk

Energy Sparks: www.energysparks.uk

BBC Bitesize: www.bbc.co.uk/bitesize

Egni Coop: www.egni.coop/category/education/

Swansea Community Energy: www.swanseacommunityenergy.org.uk/

NASA Climate Kids: www.climatekids.nasa.gov/menu/renewable-energy/

This Guide has contributed to my knowledge in several Areas of Learning and Experience within the Curriculum for Wales:

Our natural world is diverse and dynamic, influenced by processes and human actions.

- I have learnt the impact buildings have on climate change.
- I have learnt how we can reduce their impact on climate change.
- I have learnt how to use the natural world to produce energy.
- I have learnt how to control and reduce our carbon emissions from buildings.

[Humanities]

Informed, self-aware citizens engage with the challenges and opportunities that face humanity, and are able to take considered and ethical action.

- I have learnt actions I can take to reduce energy used in buildings and to help Wales meet climate change mitigation targets.
- I have learnt that how we use energy and buildings has an effect on climate change and how we can reduce the effect.
- I have learnt about the global challenge of tackling climate change.

[Humanities]

Design thinking and engineering offer technical and creative ways to meet society needs and wants.

- I have learnt how to design low carbon buildings.
- I have learnt about different low carbon technologies that can be used on buildings.

[Science and Technology]

Matter and the way it behaves defines our universe and shapes our lives.

- I have learnt how solar panels and batteries work.
- I have learnt that materials scientists are needed to develop new low carbon technologies and to improve existing technologies.

[Science and Technology]

Take action now:

- I could encourage my school to get involved with Energy Sparks, or analyse the data from Energy Sparks if the school is already involved.
- I could make changes at home and encourage others to change the way they use energy.

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