Engineering Institute of Technology.

Practical Engineering for the Future Using Renewables and Automation as the Key Drivers

Presented by Dr. Steve Mackay, EIT's Dean of Engineering

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Common Questions/FAQs

Engineering Institute of Technology.

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About EIT

Engineering Institute of Technology.

We are dedicated to ensuring that you receive a world-class education and gain skills that you can immediately implement in the workforce.

Engineering Specialists

EIT is one of the only institutes in the world specializing in Engineering. We deliver professional certificates, diplomas, advanced diplomas, undergraduate and graduate certificates, bachelor's and master's degrees, and a Doctor of Engineering.

Industry Oriented Programs

Our programs are designed by industry experts, ensuring you graduate with cutting-edge skills that are valued by employers. Our program content remains current with rapidly changing technology and industry developments.

World-Class Australia Accredited Education

Our vocational programs and higher education degrees are registered and accredited by the Australian Government. We have programs that are also recognized under three international engineering accords.

Industry Experienced Lecturers

Our lecturers are highly experienced engineers and subject specialists with applied knowledge. The technologies employed by EIT, both online and on-campus, enable us to source our lecturers from a large, global pool of expertise.

Unique Delivery Model

We deliver our programs via a unique methodology that makes use of live and interactive webinars, an international pool of expert lecturers, dedicated learning support officers, and state-of-the-art technologies such as hands-on workshops, remote laboratories, and simulation software.

Presented by Dr. Steve Mackay – Dean

Engineering Institute of Technology.

- ~40 years engineering experience across continents - in electrical, mechanical, chemical and industrial automation. And in a range of industries: mining, oil and gas, building, power plants and industrial software.
- FIE(Aust) CPEng GCC BSc(ElecEng), BSc(Hons), MBA, MMR, PhD
- Chartered professional electrical, mechanical and chemical engineer.
- Driven by curiosity and a love for learning in engineering and science.

An Overview: 1991 – 2022

IDC Technologies and the Engineering Institute of Technology

1. We are a dual sector education and training provider with a global reach.
2. We have clearly articulated qualifications - from diplomas through to a doctorate degree.
3. Our sole focus is engineering, with 300+ lecturers who have strong industry experience
4. EIT's qualifications reflect the needs of the industry
5. We have face-to-face, blended and online platforms of learning. (Our live, interactive online methodology was launched in 2008.)
6. We run engineering conferences in Australia, NZ, South Africa, the UK and Canada…. And now virtually too.
7. We have global partnerships and accreditation - from IEEE to ISA.

Our Online Approach

Engineering Institute of Technology.

Online Learning
Synchronous, online learning results in good, globally composite class sizes and suppresses attrition rates.

Student Support
Lecturers, online students, and those based on campus have dedicated Learning Support Officers (LSOs).

Research
Research and on-going monitoring helps EIT to continuously improve.

Lecturers/Instructors
Selected from around the world for their sound industry experience

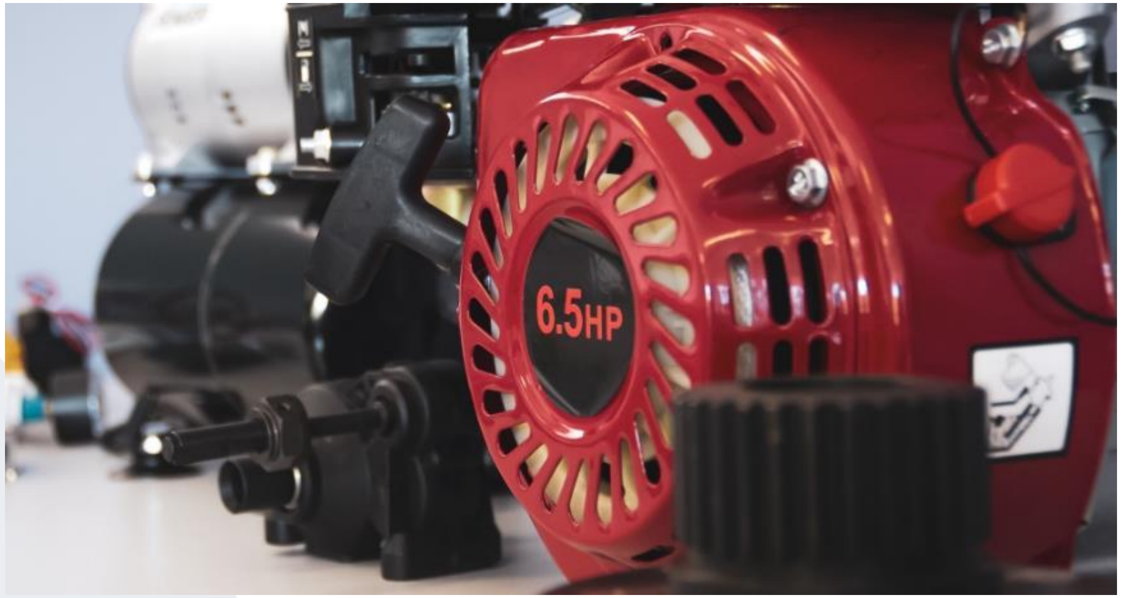
Industry Input
EIT qualifications are driven by industry to prepare students for the workplace.

Libraries
EIT students have access to substantial online libraries.

Labs
EIT students access high quality and realistic virtual and remote labs for their applied learning.

Value for Money
Students get value for money with competitive fees and careful international pricing.

Physical, Remote and Virtual Labs



- **Stimulating experiments –** Virtual labs.
- **Remotely operated plants –** Remote labs.
- **Engineering education 4.0** – Traditional lab with an innovative twist.
- Accurate representation of **current industry hands-on**

- **High availability and asynchronous** – anytime.
- Access to **specialized equipment in a safe and near-limitless testing environment**.
- **No geographical barriers** with diverse and global teams.

Student Experience Survey Results

Engineering Institute of Technology.

#1 Provider in Australia for Quality of Entire Educational Experience for Undergraduate Engineering Programs*

#2 Provider in Australia for Student Support for Undergraduate Engineering Programs*

#2 Provider in Australia for Teaching Quality for Postgraduate Engineering Programs*

Ranked in the **Top 6** Providers in Australia for Skills Development for Postgraduate Engineering Programs*

**2019/2020 aggregated data from the Student Experience Survey - qilt.edu.au*

CRICOS Provider Number: 03567C | Higher Education Provider Number: 14008 | RTO Provider Number: 51971

QILT
Quality Indicators for Learning and Teaching

Agenda

1	The Story – the thesis and the threads
2	Review of climate change
3	Renewables
4	Specific engineering design approaches › Electrical › Water and waste water › Building construction
5	Case studies
7	Wrap-up

1. The Story – The Thesis and the Threads

"The roots of education are bitter,
but the fruit is sweet"

- Aristotle

Today's Objective

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How to apply sustainability and automation to your engineering projects – in the areas of electrical, mechanical, civil and industrial automation engineering - as applied to such diverse areas as mining, infrastructure, construction, defence, energy, water, transport, medical, manufacturing and consultancy.

The stuff of today

Firstly - the premise upon which this session is based:

There is significant growth in climate change engineering, which includes the drive for sustainability, cost efficiencies and automation. This will impact on your work.

With this in mind:

I will call on you (and your fellow attendees) to share your perspective on the future of engineering in South Africa.

Finally:

In small groups - you will be tasked with outlining your team's approach to a practical engineering project given to you.

In a little more detail

Review of Climate Change

A little about renewables

Specific engineering design approaches

- Electrical Generation – T&D - Demand
- Water and Wastewater
- Building Construction

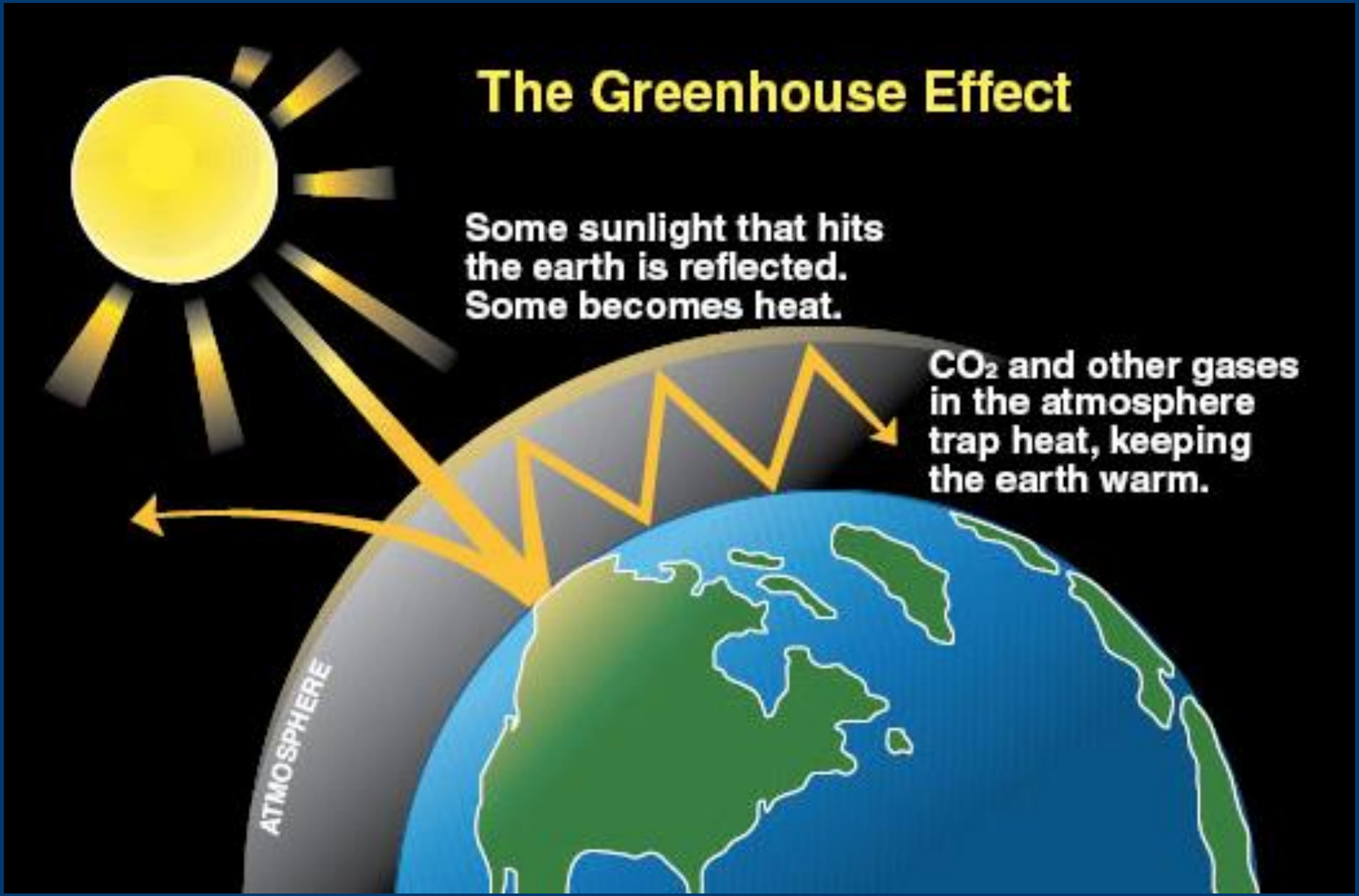
Case Studies

Wrap-up

2. Review of Climate Change

"We are continually faced by great opportunities brilliantly disguised as insoluble problems"

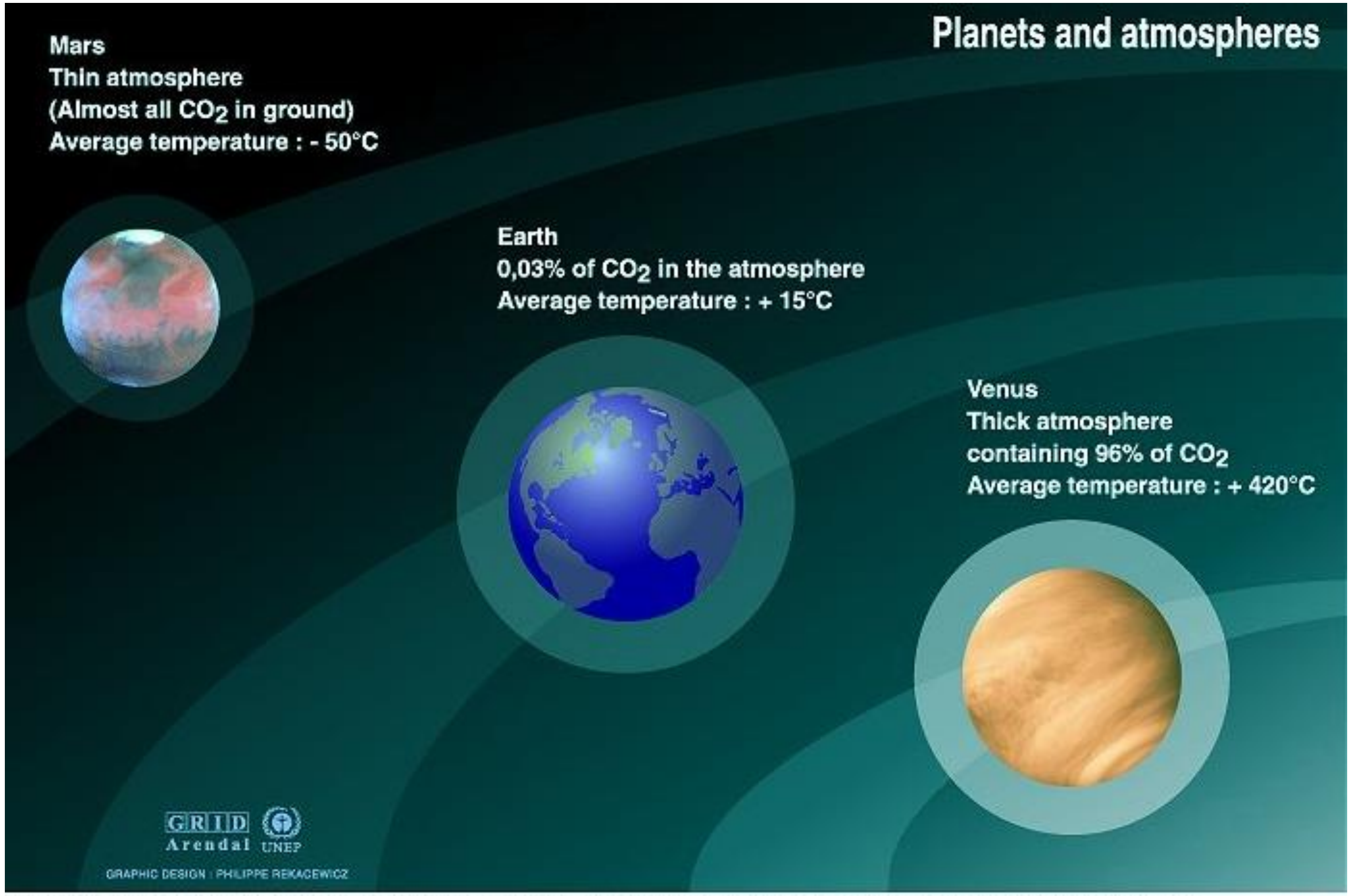
- Lee Lacocco



Source: Climate Commission http://www.climatecouncil.org.au/

The thickness of the atmosphere and the concentration of its gases influence the surface temperature on any planet.

Source: Climate Generation, Elizabeth Andre



Sources: Calvin J. Hamilton, Views of the solar system, www.planetscapes.com; Bill Arnett, The nine planets, a multimedia tour of the solar system, www.seds.org/billa/tnp/nineplanets.html

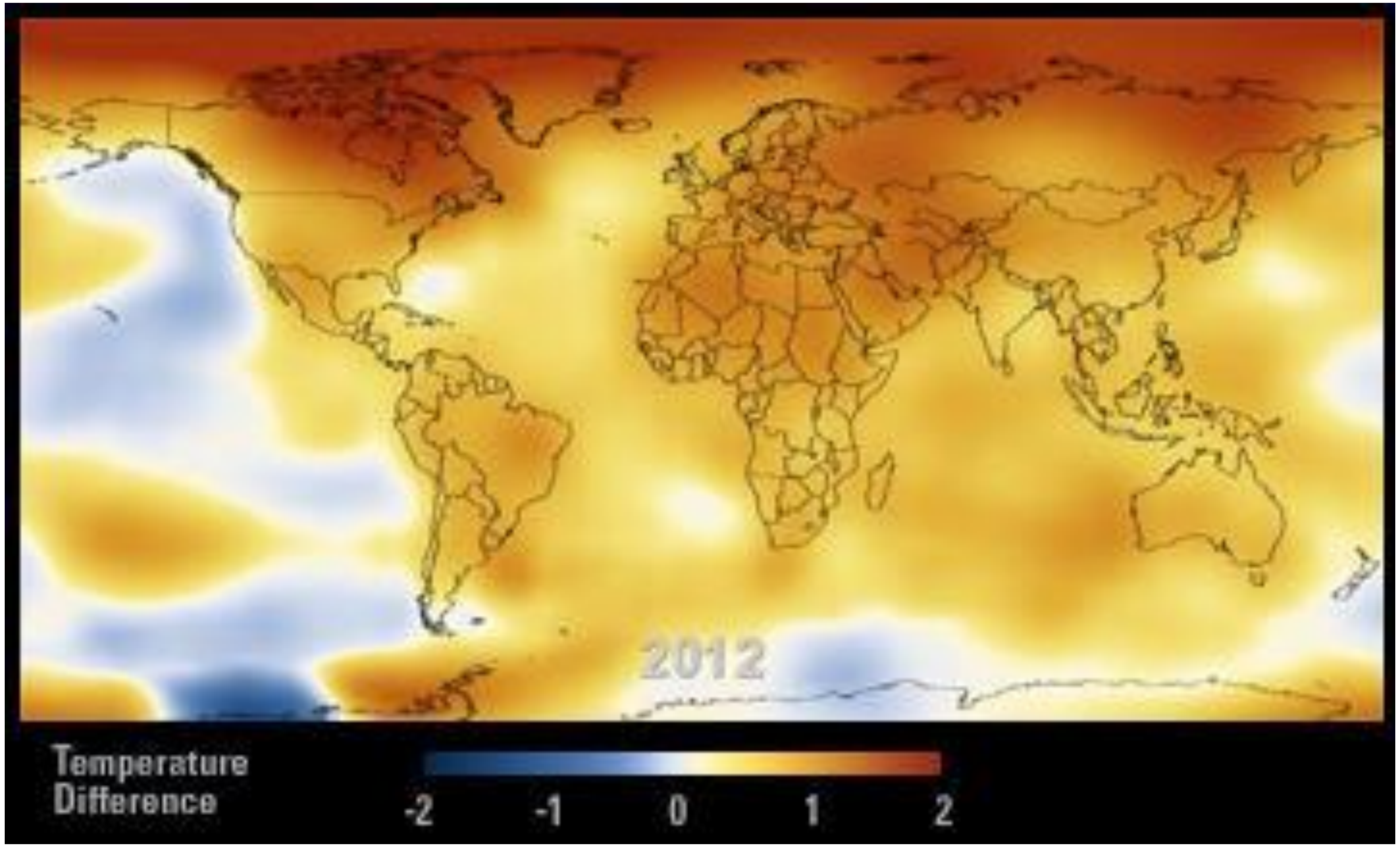
What’s the difference?

Global Warming

Is the increase of the Earth’s average surface temperature due to a build-up of greenhouse gases in the atmosphere.

Climate Change

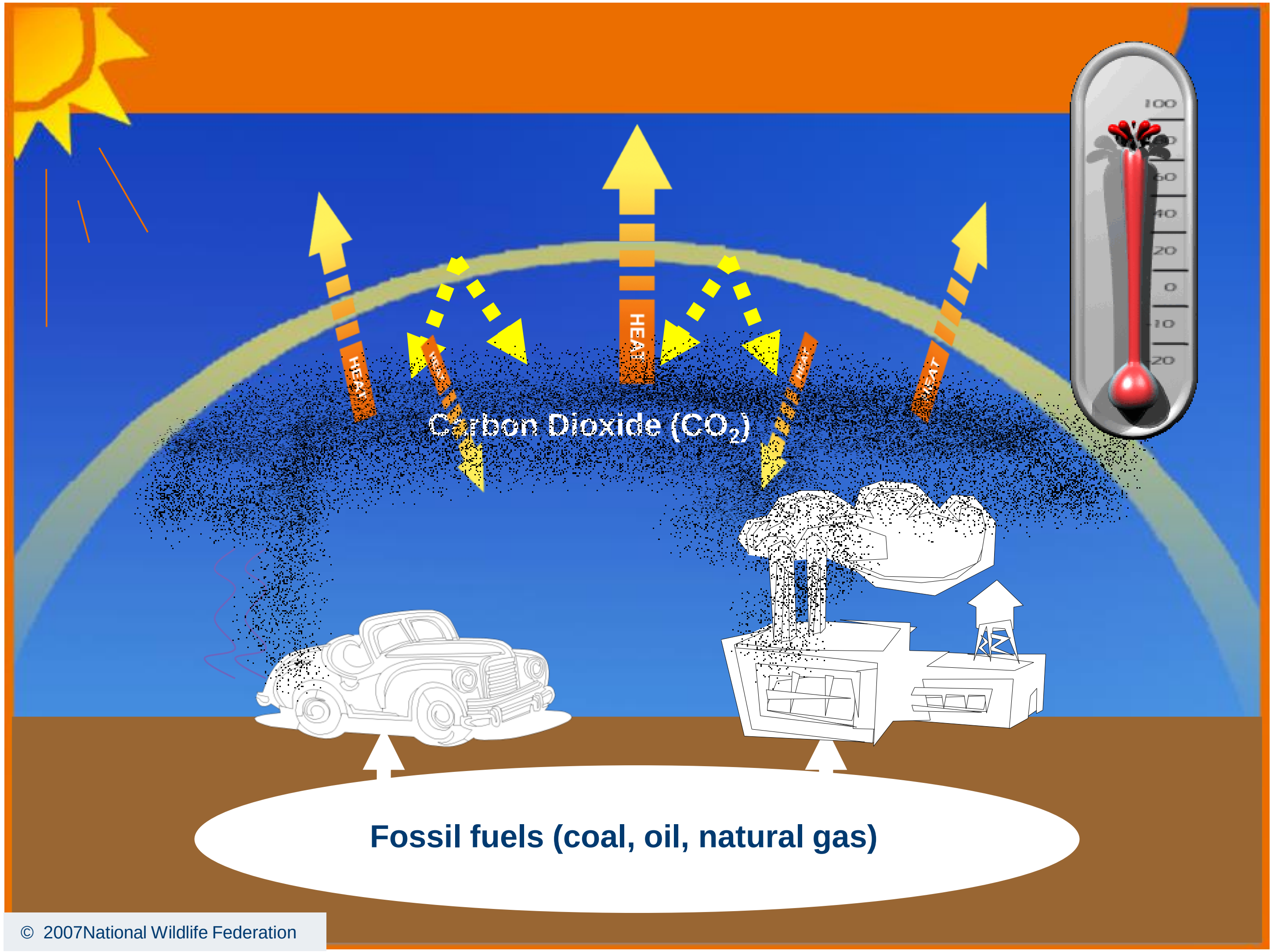
Is the long-term changes in climate, including average temperature and precipitation. It recognizes that, although the average surface temperature may increase, the regional or local temperature may decrease or remain constant.



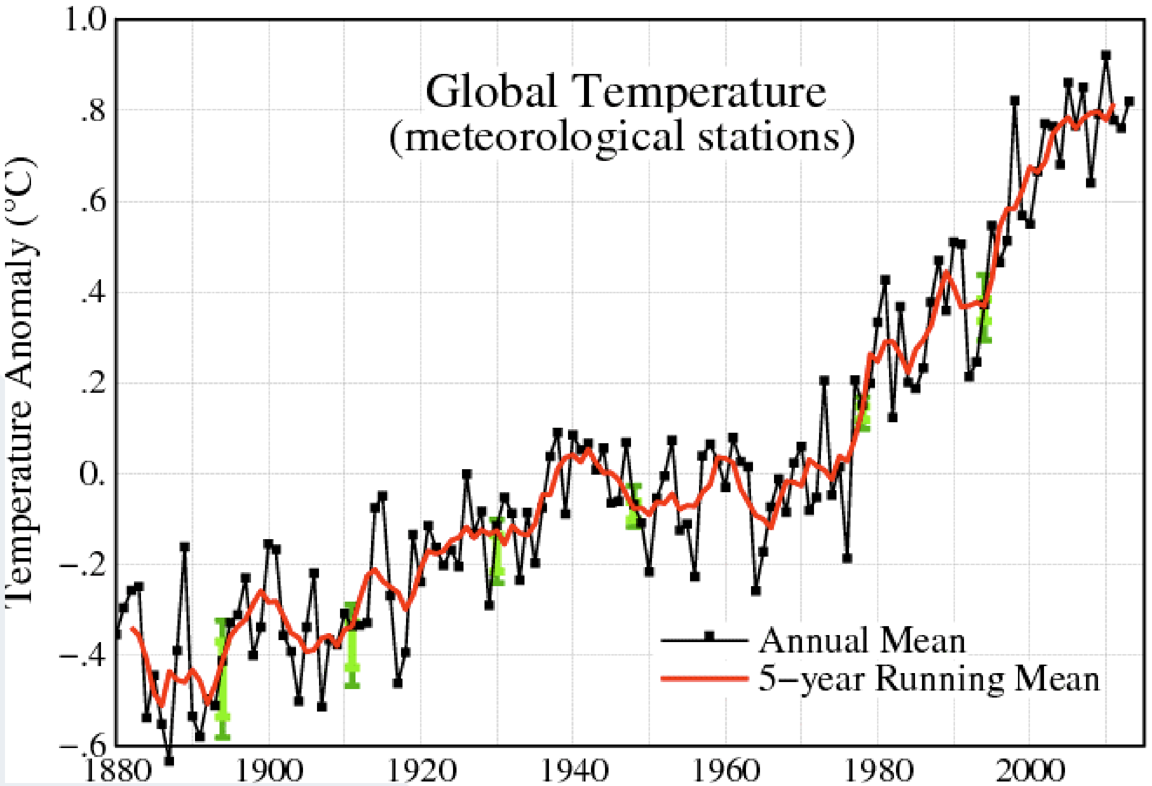
Source: NASA Climate http://climate.nasa.gov/key_indicators#globalTemp

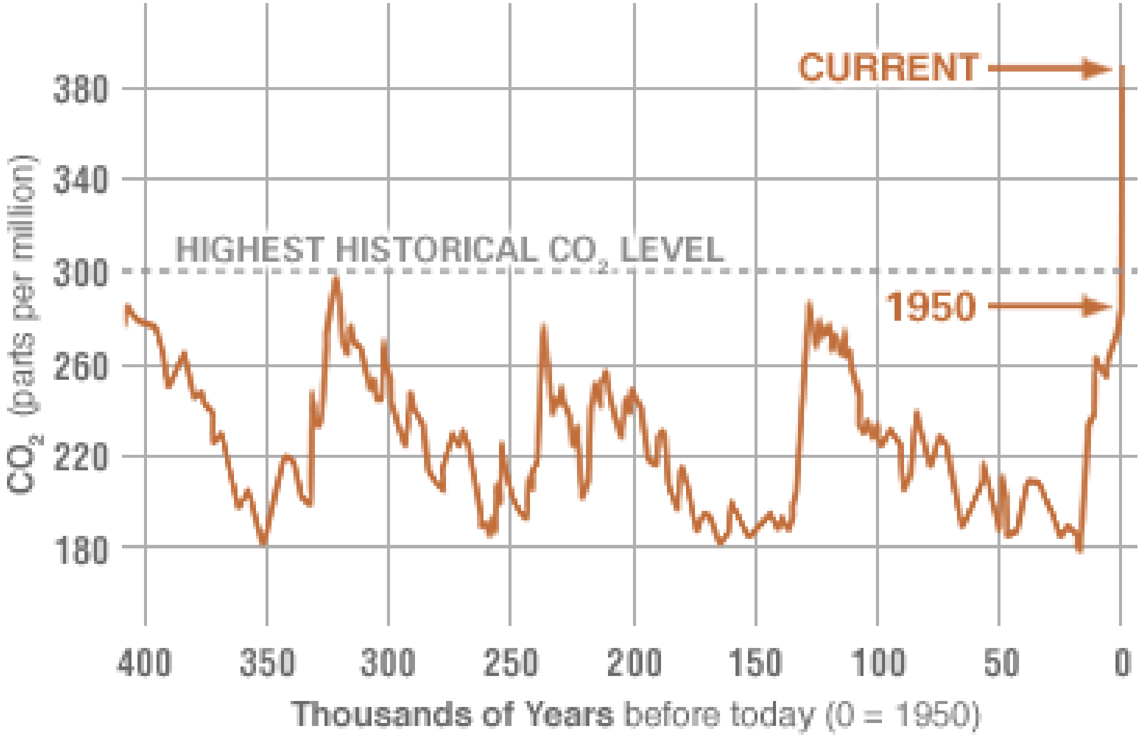
This map shows the five-year average variation of global surface temperatures from 1884 to 2012. Dark blue indicates areas cooler than average. Dark red indicates areas warmer than average.

How Global Warming Works



Temperature & CO_2 Data

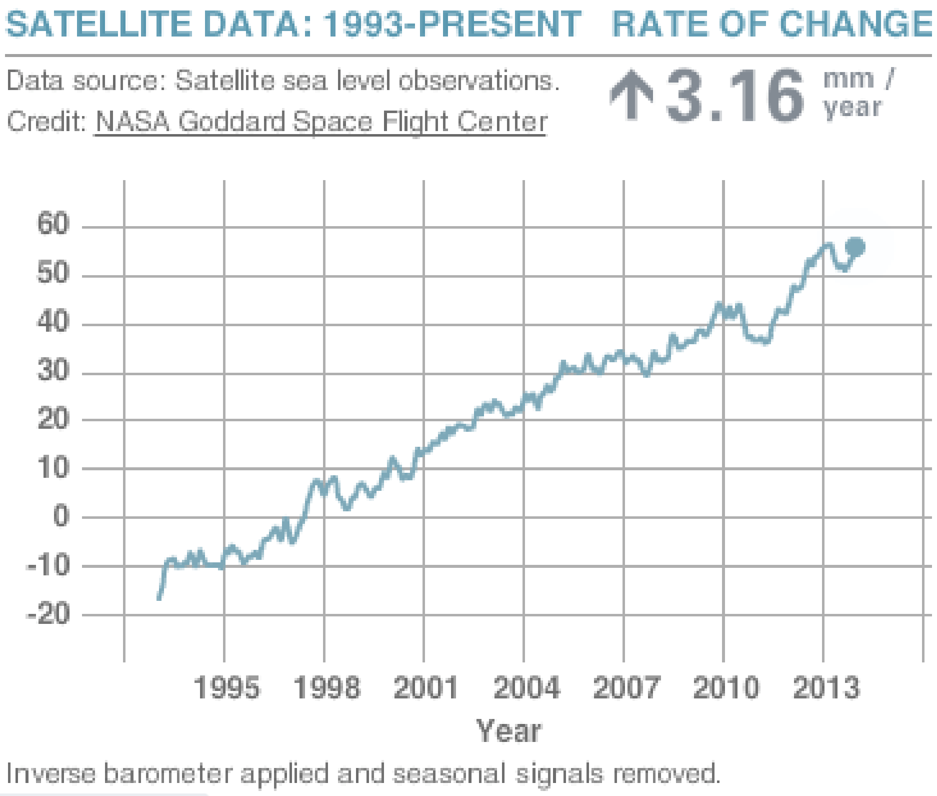


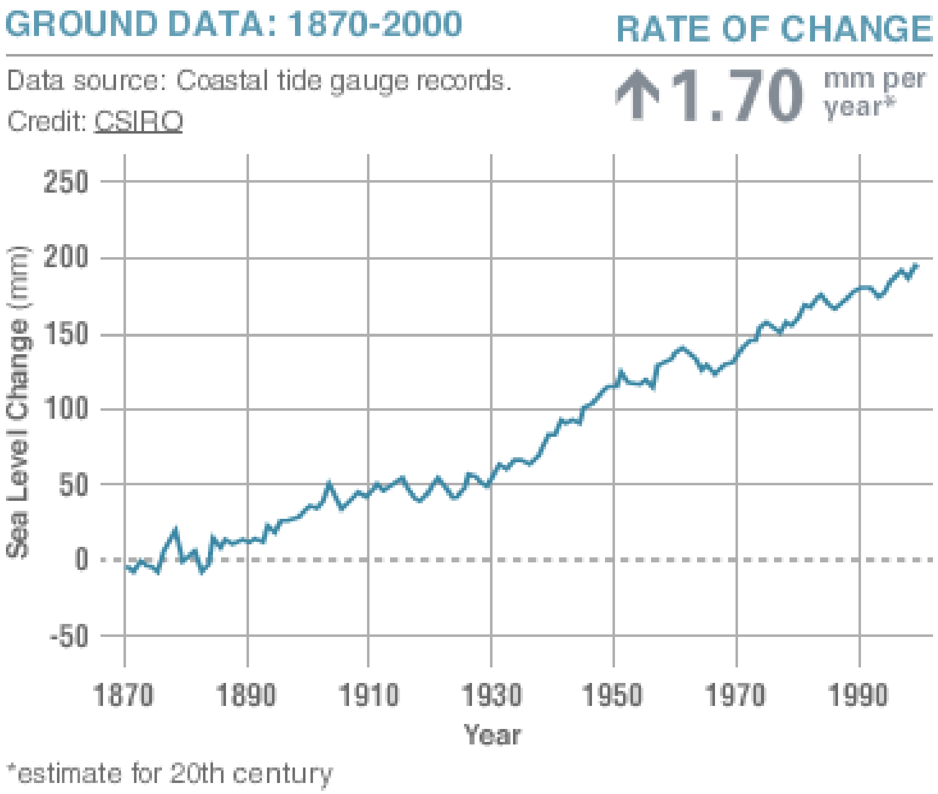


Source: NASA Goddard Space Flight Center
http://data.giss.nasa.gov/gistemp/graphs_v3/

Source: NASA Climate, Data from NOA
http://climate.nasa.gov/key_indicators#co2

Global Sea Level Rise

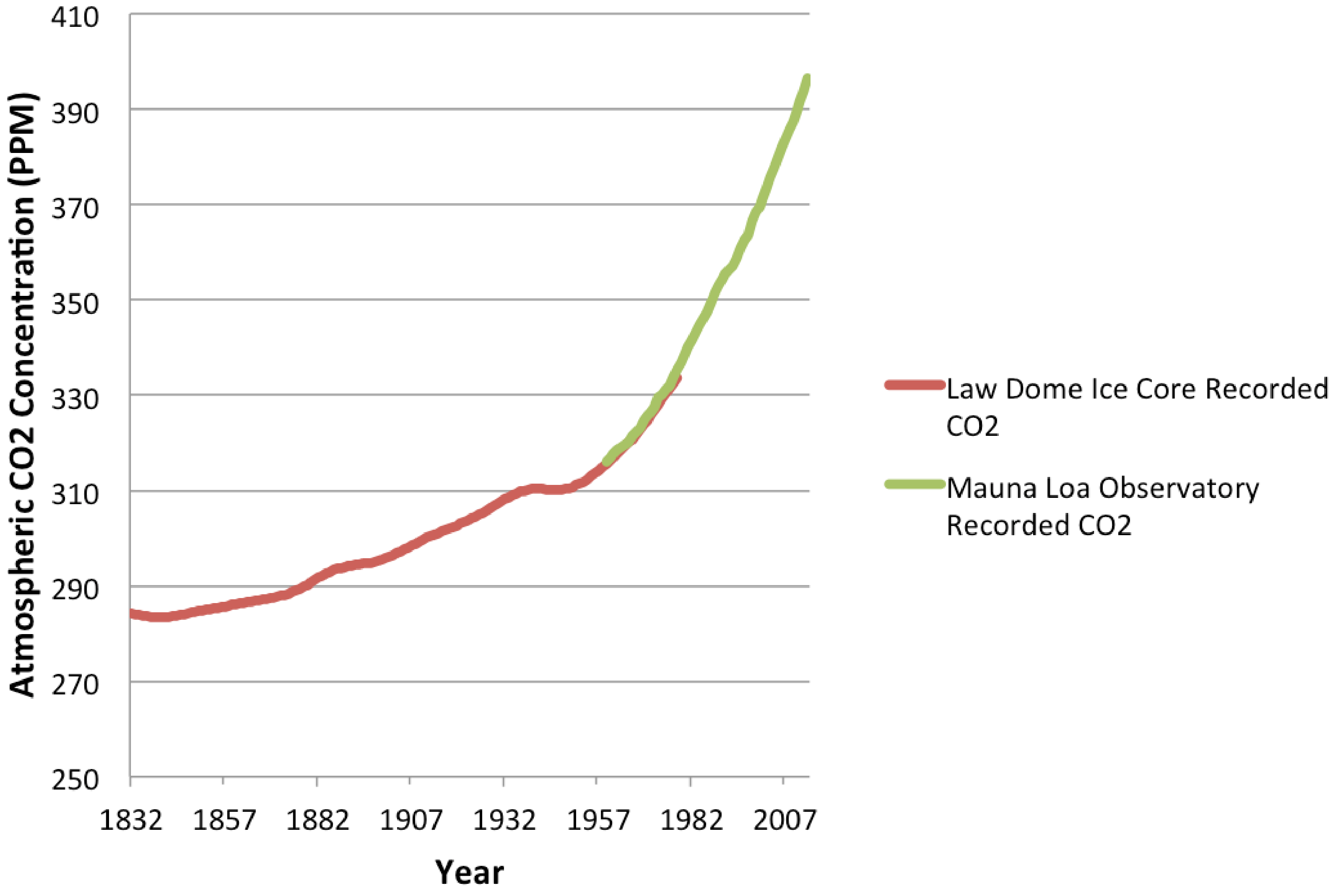




Visit: http://climate.nasa.gov/key_indicators for interactive charts on sea level and other key climate change indicators.

Source: NASA Climate
http://climate.nasa.gov/key_indicators#seaLevel

Historic Atmospheric CO_2 Concentrations



Sources:

- Mauna Loa Observatory, NOAA: ftp://aftp.cmdl.noaa.gov/products/trends/co2/co2_annmean_mlo.txt
- Law Dome Ice Core, Carbon Dioxide Information Analysis Center: http://cdiac.ornl.gov/ftp/trends/co2/lawdome.combined.dat

“Warming of the climate system is unequivocal,
human influence on the climate system is clear…”

- The Intergovernmental Panel on Climate Change, January, 2014, Press Release

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Fossil Fuels…

Take-Home Messages from Climate Change Science

- Global Warming is serious
- A global mean temperature increase of 4 to 5 degrees results in an Arctic increase of around 20 degrees.
- Solar Management is a form of climate repair that increases albedo of earth
- Can create problems with flooding/drought/hurricanes
- Reflecting sunlight back into space may be the ultimate solution
- Reduction of reliance on fossil-fuels as soon as possible is needed.
- There is no one-all miraculous solution.

(Thanks for this succinct summary from: New Tools for Climate Repair: an Introduction for Engineers. Professor Jim Haywood Sep 19, 2019

Institution of Mechanical Engineers – IMechE)

3. Renewables

“Don’t let what you cannot do interfere with what you can do.”

- John R. Wooden

Energy Resources (Renewables)

2018 YEAR OF RESOURCES

The Geological Society
serving science, profession & society



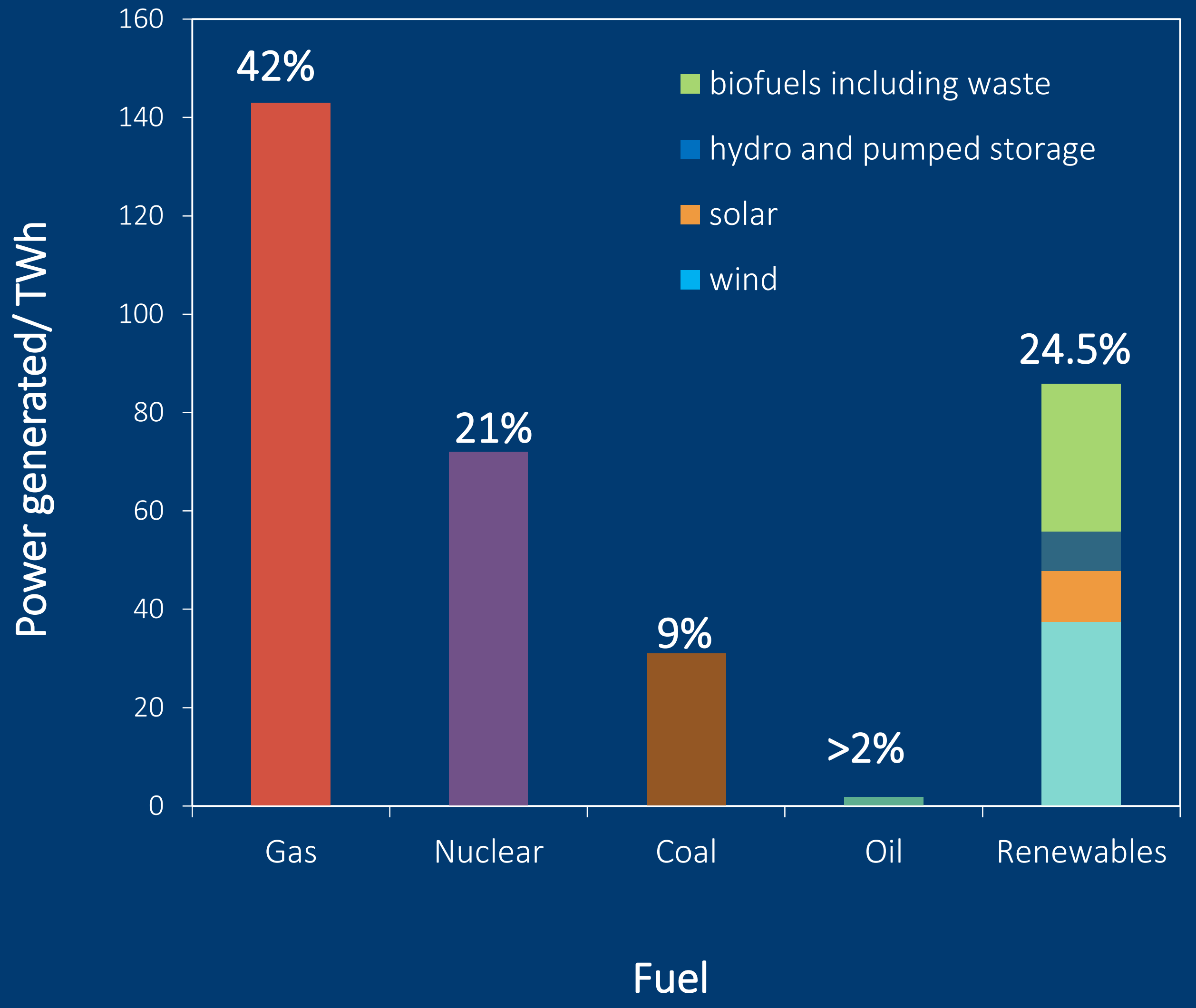


UK Renewables

The UK uses renewable energy resources to generate heat and electricity. Put these renewables in order from largest to smallest contributors to electricity generation.

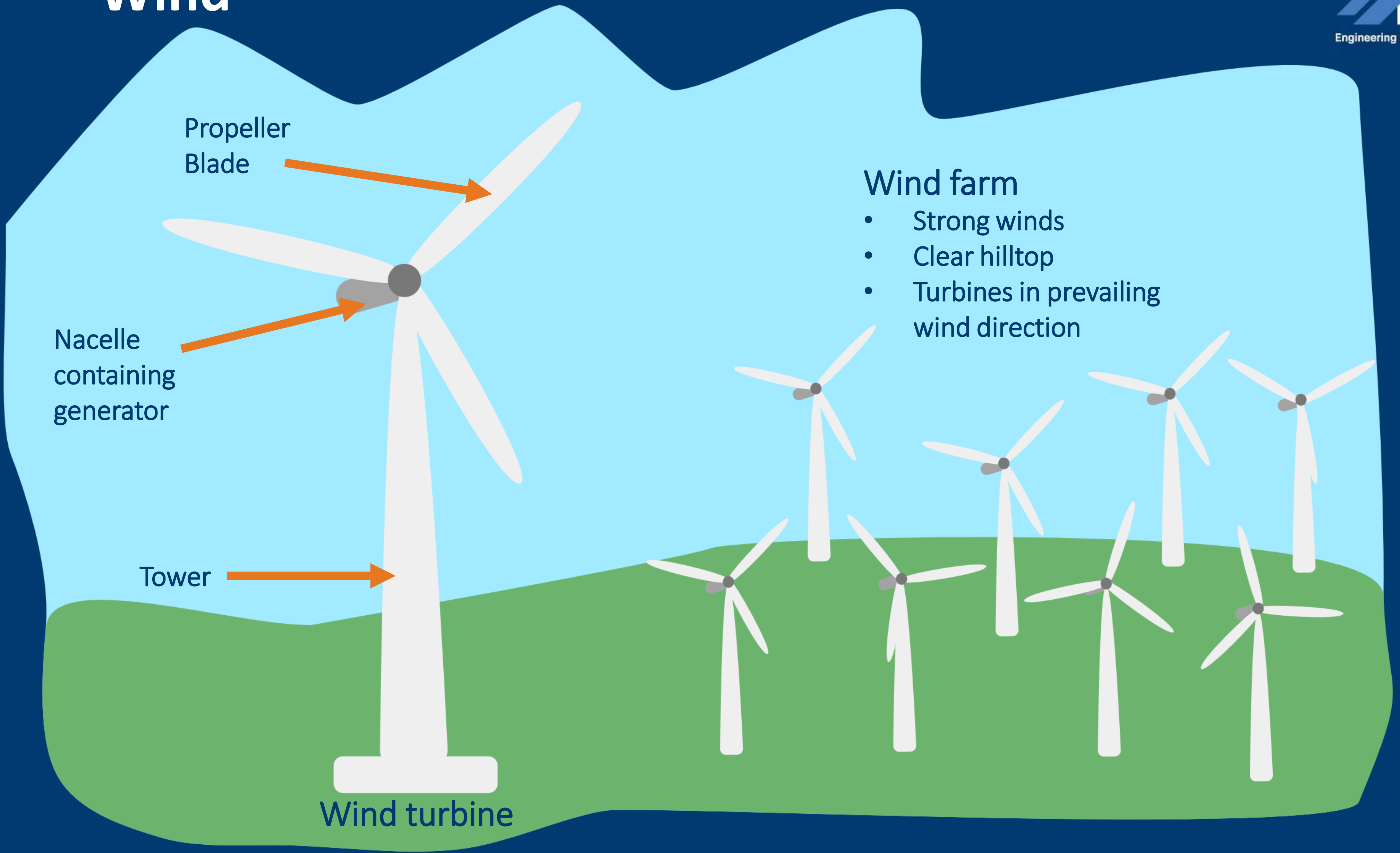
Largest contributor	Onshore Wind	29%
	Other Bioenergy	28%
	Offshore Wind	21%
	Solar PV	12%
	Hydroelectric	6%
Smallest Contributor	Landfill Gas	4%

UK Energy Mix



UK Electricity generated 2016 Department of Business, Energy and Industrial Strategy

Wind


Propeller Blade
Nacelle containing generator
Tower
Wind turbine
Wind farm
• Strong winds
• Clear hilltop
• Turbines in prevailing wind direction

Wind

The amount of power, and therefore electricity, a wind turbine can produce is largely based on wind velocity using this equation:

$$Power = \frac{1}{2} \rho A V^3$$

ρ = air density; ~1 kg m^3
A = swept area (πr^2)
V = velocity (m s^{-1})

Higher wind speed = lots more power

Larger wind turbine = more power

Power is measured in <u>Watts</u>

Wind

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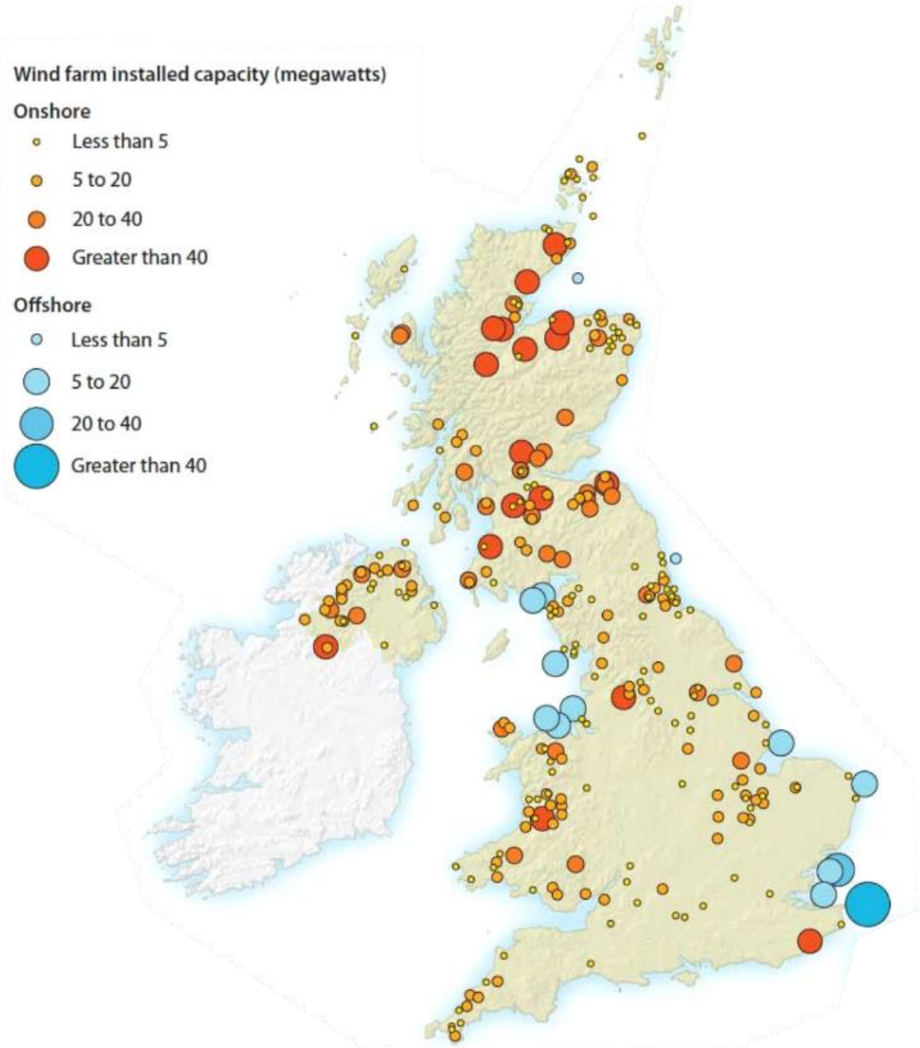
- UK has 9,220 wind turbines (Oct 2018) with a capacity for 20.1 gigawatts – 6th largest producer of wind power in the world

- In 2017 17% of UK electricity was generated from wind power (29% by renewables in total)



Solar

25.7 MW Lauingen Energy Park in Bavarian Swabia, Germany

Solar

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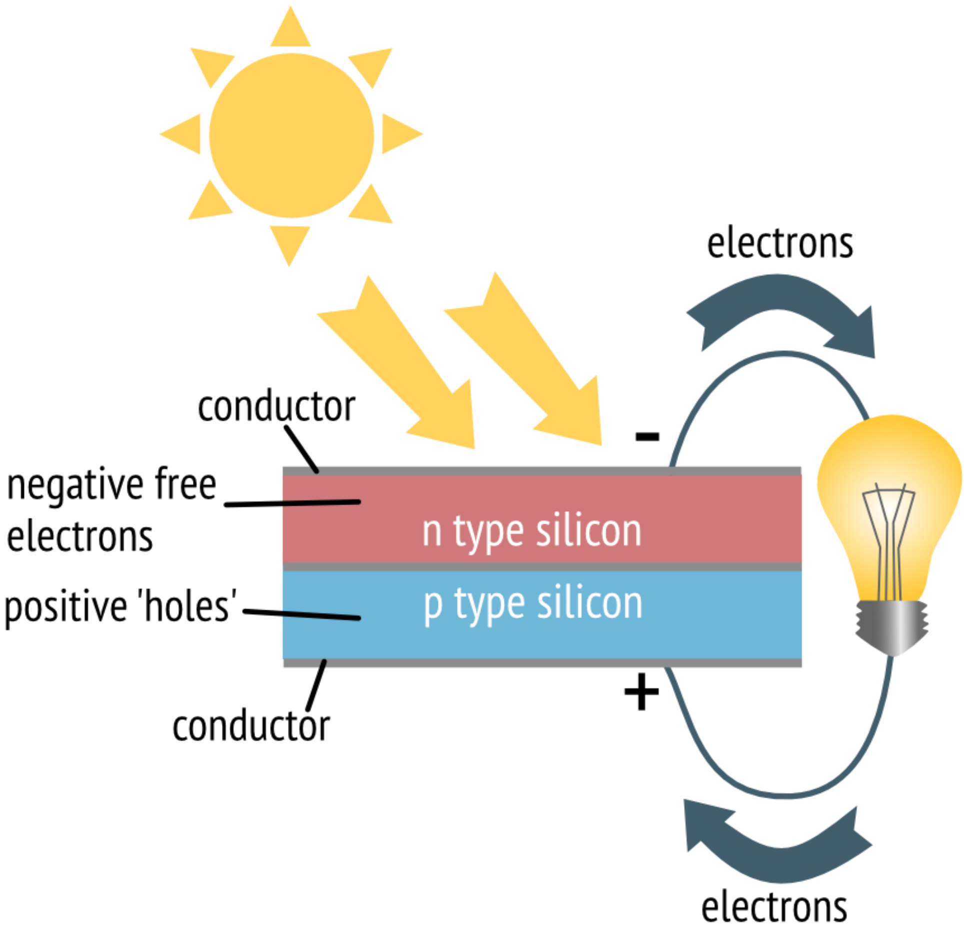
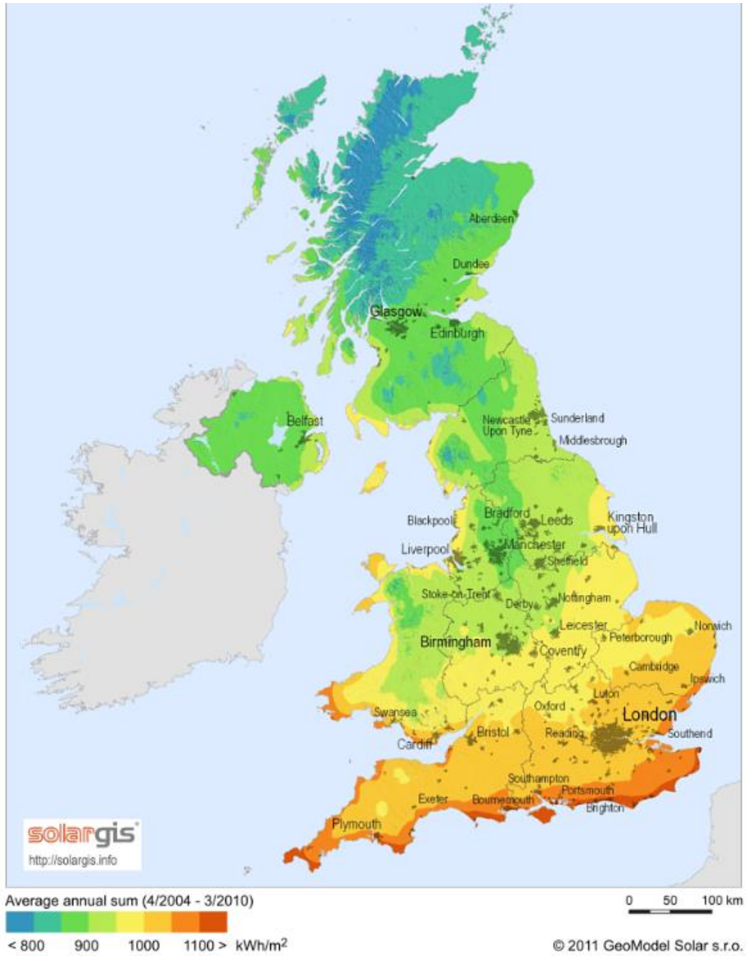
- **Thermal solar panels** are used to generate heat energy,
- **Photovoltaic (PV) cells** made from silicon turn sunlight directly into electricity
- **3.4%** of total electricity was generated by Solar PV in the UK in 2017 (29% by renewables in total)



Solar

- South of UK has ‘solar potential’ equal to Germany which generates 7% of electricity from solar PV.
- Solar panels are expensive. You need a lot of them and they require rare metals such as cadmium and indium.
- An average UK house uses around 3kW of energy each year – you need 12-15 solar panels to generate this much power.



UK solar a potential

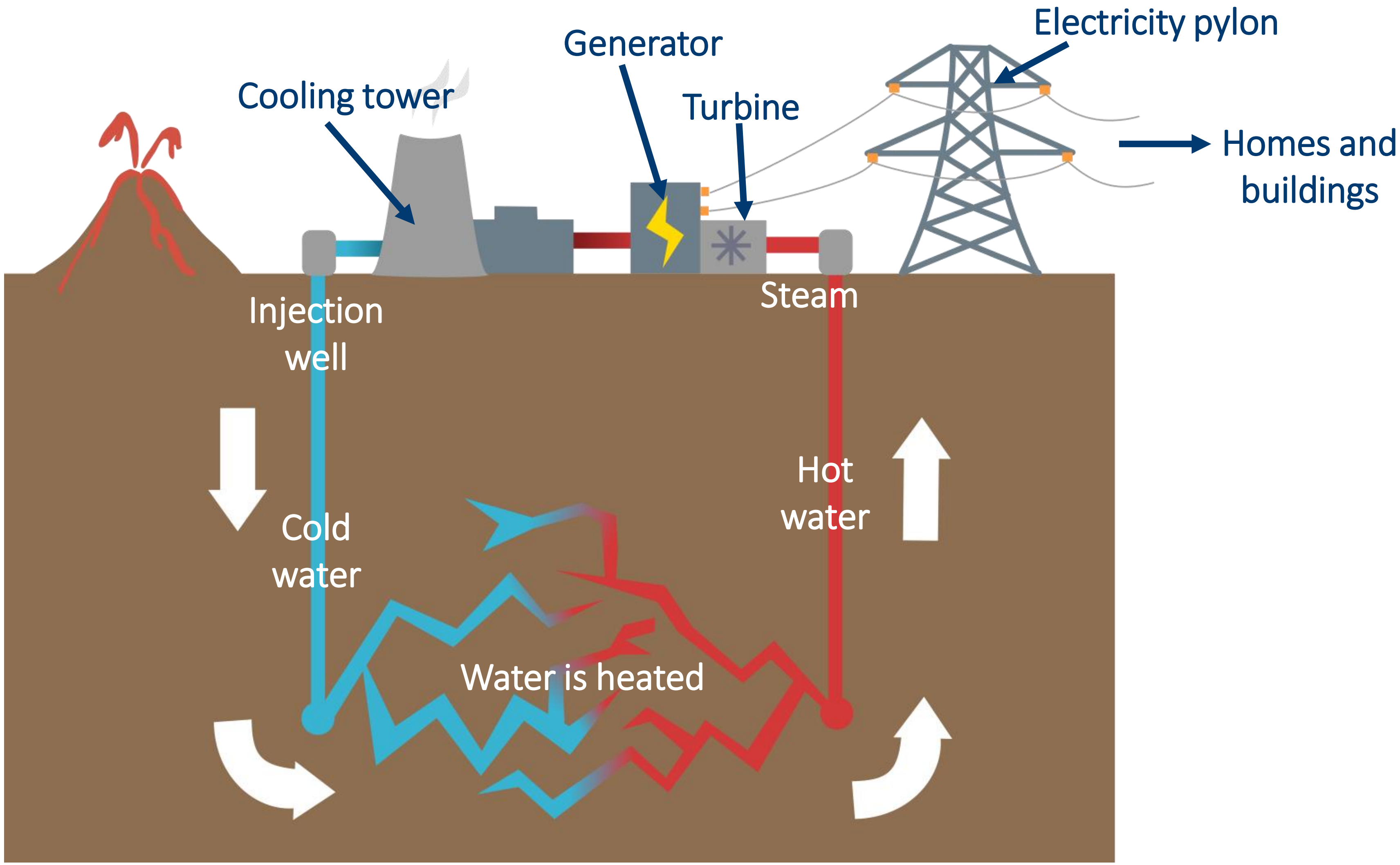
Geothermal

Geothermal

- **Geothermal energy** = heat energy from the Earth
- **Decay of radioactive elements** and **residual heat** from planetary formation 4.5 billion years ago
- Water is pumped down into hot rock where it is heated.
- Steam can then be used to heat buildings directly or to generate electricity by spinning a turbine.

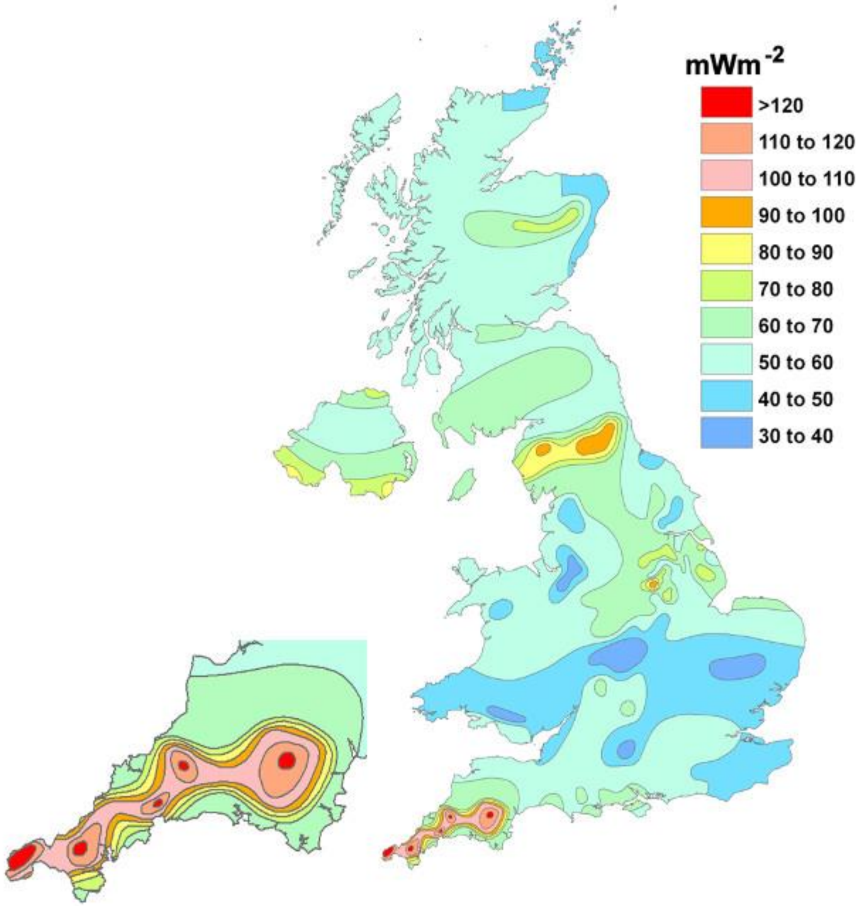
Nesjavellir Geothermal Power Station, Iceland

Geothermal


Electricity pylon
Generator
Cooling tower
Turbine
Homes and buildings
Injection well
Steam
Cold water
Hot water
Water is heated

Geothermal

- ~ 190 ˚C granite 4.5km beneath Cornwall.
- United Downs Geothermal Energy Project has funding to build a pilot geothermal energy plant
- 10MW of electricity and 55MW of heat.

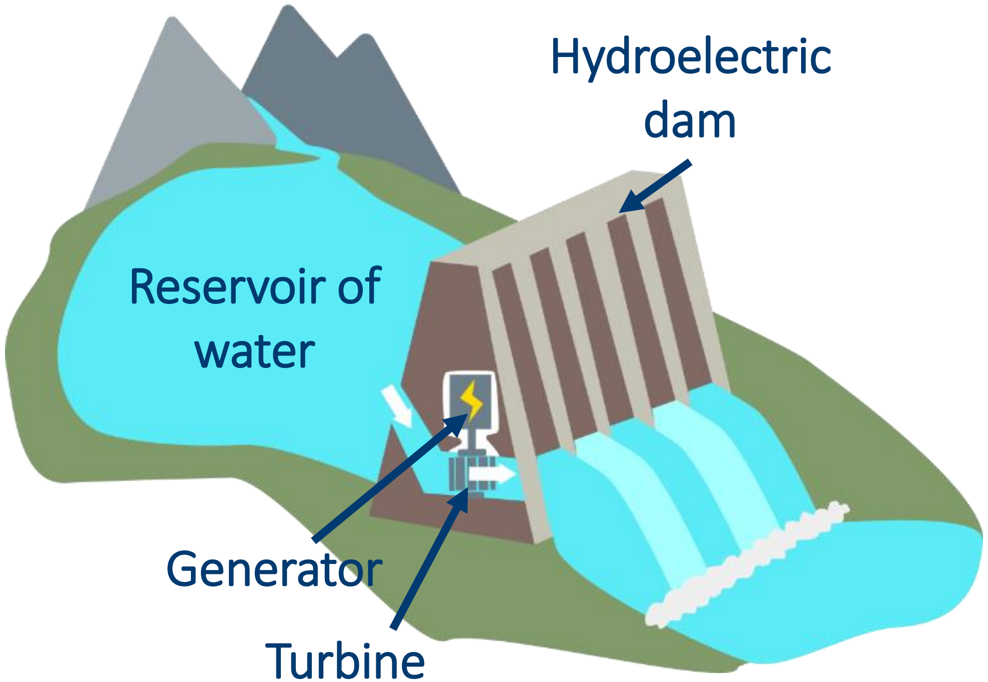


© BGS (NERC)

Hydroelectric

- Hydroelectric power harnesses the kinetic energy of running water.

  Water flows downwards with gravity to spin a turbine.
  More reliable than solar and wind power.
  Hydroelectric dams are very expensive and can harm wildlife.
  1.5% electricity from hydroelectric schemes in the UK (29% total)



Hydroelectric

Cruachan Power Station, Argyll and Bute, Scotland

Biofuels

- Biofuel - either directly from plants or from waste.
- Main UK sources are wheat and cooking oil
- Bioethanol – used as fuel and as a petrol additive to increase octane and lower carbon emissions
- Biodiesel – used as fuel and used to reduce levels of particulates and carbon monoxide in diesel powered vehicles

Biofuels

Biofuel makes up 3% of all UK road and non-road fuel (2016) and 9% of UK electricity generation

In 2016 93,000 ha were used for biofuels, 41,000 ha of this was to grow wheat (DEFRA)

Ethical and environmental issues

4. Specific Engineering Design Approaches

"The whole purpose of education is to turn mirrors into windows"

- Sydney J. Harris

4.1 Electrical Engineering

4.1 Electrical Engineering

Climate Hazard	Key Impacts	Impacted Segment	Adaption Strategies
Increased air temperatures	› Lower generation efficiency › Decreased coal-to-gas conversion efficiency › Decreased combined cycle gas turbine efficiency › Decreased solar PV efficiency	Generation	› Implement air chillers or more efficient chillers › Site new generation in cooler locations
	› Reduced carrying capacity of lines and transformers › Increased losses in lines and transformers	Delivery – Transmission & Distribution	› Underground hardware › Use more heat-resistant materials › Implement more effective cooling for transformers
	› Increased peak demand and total energy demand for cooling	Demand-End Use	› AC energy efficiency › Building thermal efficiency › Peak load shifting

4.1 Electrical Engineering

Climate Hazard	Key Impacts	Impacted Segment	Adaption Strategies
Increase in precipitation	› Reduced combustion efficiency due to increased moisture content of coal	Generation	› Protect coal stockpiles › Switch to fuel that is more moisture-resistant (e.g., natural gas)
	› Damaged power lines from snow and ice › Flooding of underground infrastructure › Damaged towers due to erosion	Delivery – Transmission & Distribution	› Improved flood protection for equipment at ground level › Use covered and/or insulated conductors › Include lightning protection (e.g., earth wires, spark gaps) in the distribution network

4.1 Electrical Engineering

Climate Hazard	Key Impacts	Impacted Segment	Adaption Strategies
Decrease in precipitation	› Decreased availability of freshwater for thermal cooling	Generation	› Switch to recirculating or dry cooling › Switch to more “water-efficient” fuels (e.g., natural gas, wind, solar) › Increase volume of water treatment system › Restore/reforest land

4.1 Electrical Engineering

Climate Hazard	Key Impacts	Impacted Segment	Adaption Strategies
Sea level rise/increased storm surge during hurricanes and tropical storms/increased nuisance flooding during high tides	› Flooding/damage to coastal/low-lying infrastructure	Generation Delivery-Transmission & Distribution Demand-End Use	› Implement flood control (dams, dikes, reservoirs, polders, etc.) › Improve coastal defences (seawalls, bulkheads, etc.) › Build in and/or relocate to less exposed locations › Raise structure levels › Improved drainage systems › Product fuel storage

4.1 Electrical Engineering

Climate Hazard	Key Impacts	Impacted Segment	Adaption Strategies
More frequent/severe extreme events (floods, typhoons, drought, high winds, etc.)	› Damaged infrastructure › Disrupted supply chains and offshore activity › Damage to facilities related to soil erosion	Generation Delivery-Transmission & Distribution	› Same as above › Concrete-sided buildings instead of metal › Implement more rigorous structural standards › Implement porous materials for better wind flow › Increased decentralized energy generation › Cite infrastructure away from heavily wooded areas/rigorously prune trees

4.2 Water and Waste Water Treatment

Atlantic Canada impact on W&WWP

- In winter freezing rain and severe snowstorms
- Power Outages
- Increased spring flooding
- Submerged water and wastewater infrastructure
- Autumnal hurricanes and severe rain events
- Rural communities in particular hard hit
- Mobile generators/pump trucks at Water & WWP
- Rogue waves and flooding with salt water

- In summer droughts and water conservation
- Water treatment/quality concerns
- Bulk municipal water demands
- Septic conditions (odours) due to low flows
- Operational issues at WWTP
- Potential effluent discharge issues for small WWTP
- Blue green algae formation (kills animals)

Climate Resilient Infrastructure

- Planned, designed, built and operated that anticipates, prepares for and adapts to changing climate conditions
- Withstand, respond to, and recover rapidly from disruptions caused by climate
- Previously only looked at historical data – now need to look at historical and climate models

Mitigation and Adaption

Mitigation

- Reducing energy demand by increasing energy efficiency
- Phasing out fossil fuels by switching to low carbon
- Removing CO_2 from atmosphere

Adaptation

- Rainwater storage
- Reducing paved areas
- Air-conditioning
- Raising pumps at WWTP
- Public awareness campaigns
- Climate Change Planning Tools
- Seawalls/managing retreats

Projected Change in Atlantic Canada

Known Changes

- Increase in extreme temperature parameters
- Increase in precipitation intensity
- Melting of permafrost
- Increases in extreme water levels

Likely Changes

- Increase in freezing rain
- Decrease in snow
- Increase in wave energy

Highly Unknown

- Increase in wind/gusts/changes to direction
- Decreases in visibility

4.3 Building Construction

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FIGURE 3 How the environmental impacts of climate change affect buildings and the people and processes within them (Image from: De Wilde & Coley, 2012)[60]

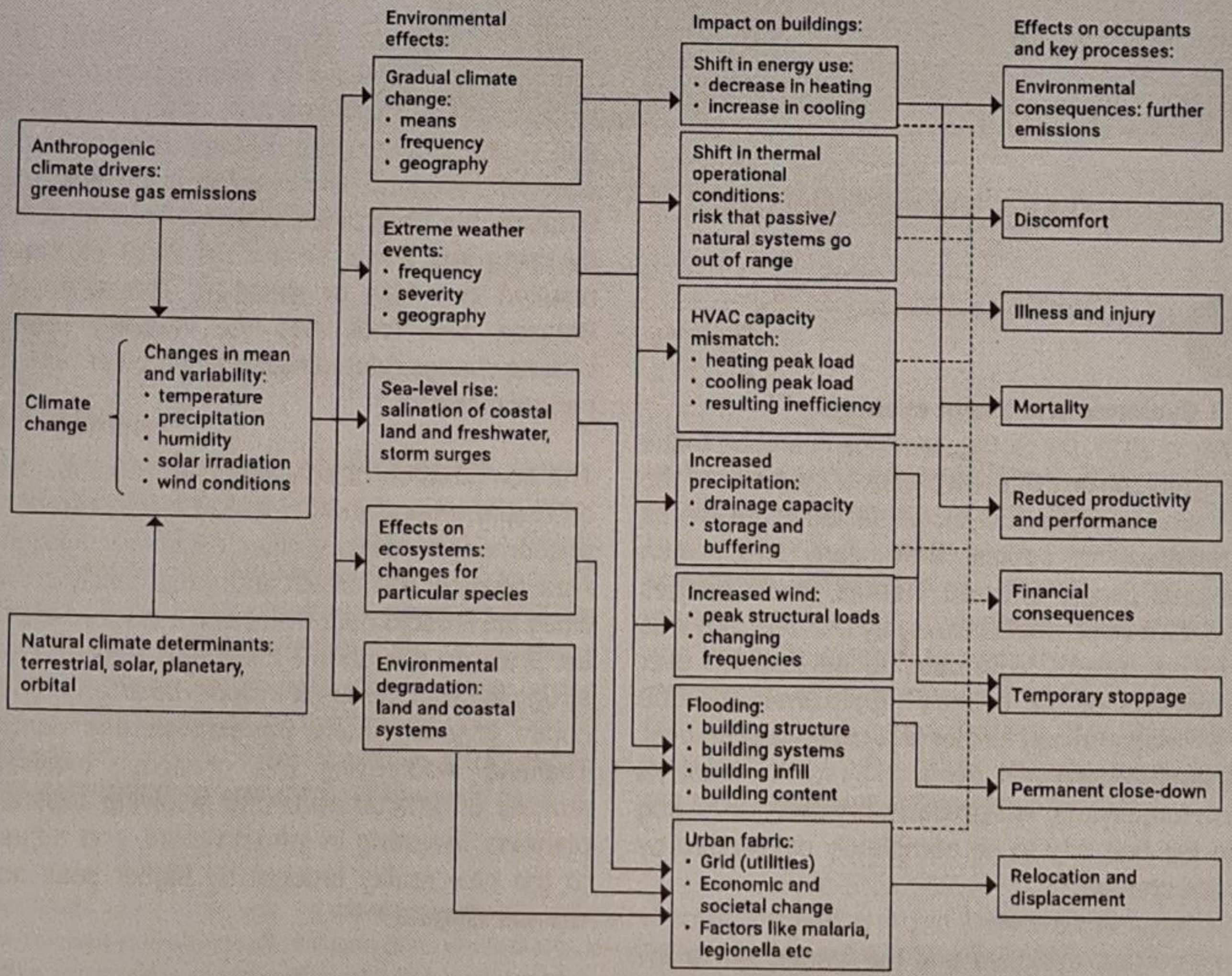

TABLE 7 Summary of adaptive approaches by climate impact and sphere of construction (Adapted from: L. Amitrano et al., 2007; Gupta & Gregg, 2011)[72, 135]

Climate change impact	Building design	Planning/ external factors
Increased temperature averages and extremes (e.g. heatwaves)	**ALL CLIMATES:** - Control solar gain through site or building changes: green roofs, white roofs, ventilated roofs, integrated green cover on walls, internal and external manufactured shading devices. - Provide adequate insulation and ventilation (natural ventilation, ceiling fans, raised structure where appropriate). - Decrease lighting and equipment loads. **HOT CLIMATES:** - Maximize external wall areas (plans with one room depth are ideal) to encourage movement of breezes through the building (cross-ventilation). - Ventilate roof spaces. - Include high ceilings and other design features for natural ventilation. - Arrange multiple buildings to benefit from mutual shading. - Shade whole building summer and winter (consider using a fly roof or other roof shading strategy). Minimize east and west openings. - Consider lightly coloured roof, walls, and surrounding paving (high albedo). - Provide screened, shaded outdoor living areas to provide additional relief from heat. **HOT – HUMID** - Use materials which reduce heat gain, provide fast heat loss, and minimizes humidity. - Limit the number of large, glazed windows. - Fewer windows can be helpful in humid climates. - Openings to buildings should avoid direct sun. **HOT-DRY:** - Use thermal massing with natural ventilation, such as: - Install convective (stack) ventilation, which vents rising hot air while drawing in cooler air. - Use materials which minimize heat gain and capture solar radiation where diurnal temperature ranges are high. - Use wind towers or earth air tunnels - Arrange multiple buildings to benefit from mutual shading. **HOT-DRY** - Use thermal mass, i.e. use lightweight construction where diurnal (day/night) temperature range is low and include thermal mass where diurnal range is significant. - Provide insulation with a proficient vapour barrier. - Use window shading (louvres) to minimize heat-gain. - Consider using Trombe or water walls and solar chimneys. **COLD:** - Manage shading to allow solar gains in winter. - Where heat gain is desirable, locate buildings on southern slopes (northern hemisphere), exposure to cold winds can be minimized by placing buildings on the leeward side. Consider ventilation and solutions to prevent heat-loss at exit points. - Provide insulation with a proficient vapour barrier. - Place windows to facilitate heat gain. - Consider using Trombe or water walls and solar chimneys	**ALL CLIMATES:** - Consider orientation of building (longer walls facing north and south) and placement of surrounding geographic features, trees, and structures to capture and direct wind flow and control solar gain. - Implement efforts to strengthen social connectivity, community capacity, skills and networks. **HOT CLIMATES** - Increase green space for microclimate cooling, including landscape (green infrastructure). - Use garden ponds and water features to provide evaporative cooling (blue infrastructure). - Provide access to external shaded space for overheating relief (also important in cold climates, as buildings designed for the cold climate can be most ill-equipped to cope with high temperature extremes). - Install rainwater collection systems. **COLD CLIMATES:** - Make streets wide enough to prevent shading.

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Climate change impact	Building design	Planning/ external factors
Increased water stress/ wildfire risk	ALL CLIMATES: - Use fire-resistant building materials. - Install building fire suppression systems (sprinklers) in high-risk zones. - Provide for emergency irrigation of surrounding landscaping to reduce fire risk (link with rainwater collection system).	ALL CLIMATES: - Plan drought resistant ground shading plants to retain ground moisture. - Install rainwater collection systems. - Balance the need to plant vegetation for cooling and shading with the need to clear at-risk vegetation. (Potentially problematic for shading and reduction of UHI - Consider alternative building elements to replace lost site shading, e.g. traditional fabric courtyard coverings or a raised PV system that remains open underneath)

Storms, floods and sea-level-rise

Climate change impact	Building design	Planning/ external factors
More intense storms with high speed winds and driving rain, e.g. cyclones	ALL CLIMATES: - Consider frangible architecture options. - Apply a "triage" approach to building design and construction and consider Design for Deconstruction (DfD). - Raise the house above flooding levels. - Use rectangular or square roofs with multiple slopes (hip roof) and sufficient gradient. - Build circular or geodesic-shaped houses, e.g., domes. - Upgrade fasteners in roof structures and in sub-floor. - Ensure weathertightness (sealing corners, holes, unintended entry points for wind or rain) and drainage detailing (routing water away from the building as quickly as possible through sloped drainage pipes). - Limit overhangs on roofs. - Use water-resistant materials.	- Avoid cyclonic areas. - Consider orientation of building and placement of surrounding geographic features, trees and structures to capture and direct wind flow. - Install warning systems. - Promote efforts to strengthen social connectivity, community capacity, skills and networks.
Hail events	ALL CLIMATES: - Use impact-resistant roofing materials. - Design more appropriate window protection. - Install protection of externally fitted services and fixtures, such as PV.	

Climate change impact	Building design	Planning/ external factors
Flooding and increased concentration of rain events	ALL CLIMATES: - Consider frangible architecture options. - Increase repair drainage capacity with or without integrated green infrastructure. Consider flood barriers / raised entry threshold. - Plan for higher placement of electrical, ventilation and heating systems. - Use moisture-resistant materials. - Design for de-/ re-construction. - Elevate building so finished floor is above flood plain. - Implement systems for rainwater collection and use, consider stormwater control through green roofs. - Use sloped roofs instead of flat roofs.	- Avoid flood-prone areas. - Improve land-use and site management. Plant trees to improve soil stabilization. - Improve permeation of water into the ground - reduce hard surfaces and increase provision of pervious and/or semi-pervious surfaces such as vegetation, pebble beds and porous pavements/ reduction of hard surfaces. - Use nature-based solutions (NbS), such as the planting of trees, to improve soil stability. - Consider including flood gates. - Consider including green infrastructure such as sustainable drainage systems. - Develop early warning systems and prepare evacuation plans. - Promote efforts to strengthen social connectivity, community capacity, skills, and networks.
Sea-level rise	ALL CLIMATES: - Design for de-/ re-construction - Construct buildings above ground - Use wet-dry architectural approaches, including selection of water and salt resistant materials	- Avoid coastal areas. - Use nature-based solutions to reduce storm surge, such as mangroves.

5. Case Studies

"Education is what remains after one has forgotten what one has learned in school"

- Albert Einstein

Waste Water Treatment Plants

Picture Copyright Aerofloat Australia

Oil Refineries on the Coast

Picture copyright Bloomberg Inc.

Motor Control Centres

Picture Copyright of TM Process and Controls, Inc.

Housing Estates on the River

Image is copyright of United Country Real Estate

Gold Mines in Western Australia

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Road-making

Image is copyright of Popular Mechanics

Break into groups – Select one case study

Your Mission:

1. What is your greatest climate challenge?
2. List one Mitigating Strategy Point.
3. List one Adaption Strategy Point.
4. Can automation assist your mission?

6. Wrap-up

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EIT
Engineering Institute of Technology.

CLIMATEGENERATION

A WILL STEGER LEGACY

Energy Resources (Renewables)

2018 YEAR OF RESOURCES

The Geological Society

serving science, profession & society

Further References in creating the slides and exercises

1. Chapter of Effects of Climate Change in Electric Power Infrastructures by Daniel Burillo. Accessed 1st March 2022 from: https://www.intechopen.com/chapters/64723

This was used for the Electrical engineering considerations.

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This was used for the Civil Engineering Considerations in the exercises.

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Further References in creating the slides and exercises

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This was used in the Building Construction section.

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