

The Practical Journal of Sustainable Living

Clean Slate

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Decarbonising 'stuff'

**Adaptation: from coping
to transformation**

**Heat pumps:
their role in
our zero
carbon
future**



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Contact Penny Rowland at CAT for more information 01654 705988.



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Cover image: Freights filled with imported goods – who should count the carbon? (apiguide/Shutterstock)

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Now is the moment

At the beginning of February, I was invited to join the official launch event marking the start of the UK's presidency of the COP26 UN climate talks, which will be hosted in Glasgow later this year.

As headlines surrounding the event suggested chaos at the heart of government planning, Prime Minister Boris Johnson told gathered policymakers, environmentalists and journalists that he wanted to make 2020 “the moment when we come together with the courage and the technological ambition to solve man-made climate change and to choose a cleaner and greener future for all our children and grandchildren.”

The protestors gathered outside were quick to point out that we have the solutions, what we need is urgent action from governments and policymakers – deeds, not words, from Mr Johnson.

So what do we need now?

For one, COP26 must elicit tougher action plans from all countries. Plans that actually add up to what's needed to close the gap between where we are now and where we need to be to have a fighting chance of staying within 1.5°C of warming.

Every one of us can play a part in keeping up the pressure on the world's governments, by joining protests, writing letters to our elected representatives and local papers, sharing stories on social media and signing petitions. This year, these actions feel more important than ever before.

Meanwhile, at a local and county level, we need to keep building on the momentum of the past year, which has seen the total number

of climate emergency declarations by local authorities rise to over 400.

CAT's new Zero Carbon Britain Hub and Innovation Lab is here to help. As local authorities and communities come together to explore what they can do to tackle emissions in their area, we'll be providing training, resources and advice to help them develop effective, achievable zero carbon action plans.

But make no mistake – these plans will need the support of national government, through funding, policy frameworks, planning rules, large scale infrastructure projects, and more. That's why the Hub and Innovation Lab will also be working with national policymakers, advising on what's needed to get to zero carbon, and pushing for greater ambition. Thank you to everyone who has made a donation to help make this happen following our recent fundraising appeal.

In the words of Sir David Attenborough, speaking at the COP26 launch event:

“The longer we leave it, not doing things but going on talking about the problems, the worse it's going to get. And in the end, unless we do something, it becomes insoluble. So now is the moment.”

Now is the moment – thank you for your support at this crucial time.

Peter Tyldesley
Chief Executive Officer

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Jeremy Corbyn visits CAT to talk climate solutions



CAT's unofficial historian and graphic designer John Urry shows Jeremy Corbyn and Christina Rees around the visitor centre.

In late summer last year, we welcomed Labour Party leader Jeremy Corbyn MP to CAT, along with Christina Rees MP, Eluned Morgan AM and Joyce Watson AM, to discuss practical, proven solutions to climate change.

The visit, which took place before the General Election was called, was a chance to share CAT's Zero Carbon Britain research and discuss the policies that could help address the climate and biodiversity emergency. We also shared updates on the Zero Carbon Britain Hub and Innovation Lab, discussing how CAT can help in the creation of Local Authority Zero Carbon Action Plans.

A site tour gave our visitors the chance to see some of the solutions in action, get a taste of building with earth and share growing tips with our gardening team.

CAT Chair of Trustees Michael Taylor said: "Climate action requires ambitious targets and a clear plan for how to get to net zero as quickly as possible. We welcome the chance to discuss our research and education work with politicians from all the main parties, and we were delighted to have the chance to brief Mr Corbyn in person."

A minor media frenzy surrounding the visit saw it covered by Channel 4

News, ITV News and BBC Wales.

As an educational charity, CAT is politically neutral and works across the political spectrum. As we go to press we're getting ready to welcome Green Party MP Caroline Lucas to CAT – you can read about this visit in the next issue or take a look at our website for updates. www.cat.org.uk



Paul Allen presents Zero Carbon Britain.



Greening your garden

Starting in the spring, a new series of weekend gardening courses at CAT aims to teach people how to boost biodiversity and start growing food in any size garden, for any climate.

The four courses will teach a mixture of theory and practical skills, enabling students to build a tiny garden, a wildlife garden, an edible garden and a dry garden. CAT have teamed up with the National Botanic Garden of Wales to run the courses as part of their Growing the Future project.

Course tutor Ben Wilde said:

“We’re in the sixth mass extinction and we need everyone to do what they can with what they have to help replenish biodiversity and keep our wildlife alive. These courses are a great way to gain knowledge and skills on boosting biodiversity and growing your own food, which will be easily transferable to your home or community.”

For more information and to book a place visit www.cat.org.uk/events/build-a-tiny-garden/



New Hub to offer training and advice on zero carbon planning

CAT's new Zero Carbon Britain Hub and Innovation Lab is beginning to take shape, with a new team about to start as we go to press.

The new Hub will provide essential training, advice and resources to help with the creation of Zero Carbon Action Plans by local authorities, policymakers and industry. Linked to this, the Innovation Lab will respond to key issues, priorities and tasks identified by the Hub, developing ideas that impact on these areas and testing and prototyping solutions.

We'll be showcasing the work of the Hub and Innovation Lab and introducing the team in the next issue of *Clean Slate*. In the meantime, do keep an eye on our website and sign up to our newsletter to stay up to date as things develop. And if you are working on a Zero Carbon Action Plan with your community and would like to work with us, please email zerocarbonbritain@cat.org.uk

Our thanks to the Moondance Foundation for the generosity that has enabled the creation of the Zero Carbon Britain Hub and Innovation Lab.

Growing the Zero Carbon Hub – with your help

Thank you so much to all of you who have donated towards the creation of CAT's new policy team and specialised trainers. They will be part of CAT's new Zero Carbon Britain Hub and Innovation Lab.

So many of you have believed in CAT and supported us when it seemed no one was listening or taking the climate change warnings seriously. It means a lot to us that we have your support to carry out this work.

We are still raising the funds to do this work, from Trusts and Foundations and our individual supporters. If you would like to contribute to make this happen, please visit our website to make a gift today. Thank you.

We'll be using the funds raised to create:

- A policy team. A team of specific researchers and advisors on the economic, built environment, land use and energy policies required for a just transition to a Zero Carbon Britain.
- A consortium of environmental organisations, businesses and institutions from across the UK to collaborate on implementing a Zero Carbon Britain.
- Training the trainers. A team of workshop leaders to advise on and support the creation of climate action plans across the UK.

Your support makes all this possible and creates hope for a future world that is safe, equitable and just. CAT can offer solid, evidence-based answers to the complex problem of climate change mitigation and adaptation. We can do this together.

Thank you,
Tanya Hawkes
Major Gifts and Legacies Fundraiser

To make a donation, please visit www.cat.org.uk/donate or call us on 01654 705988.

Congratulations to CAT graduates



Much deserved celebrations at the CAT graduation.

In November last year CAT welcomed back over 40 students from our Graduate School, along with their friends and families, for a much deserved graduation celebration.

The ceremony saw graduates collecting awards from a range of CAT's postgraduate programmes, including MSc Sustainability and Adaptation, MSc Sustainability in Energy Provision and Demand Management, and MArch Sustainable Architecture. We also celebrated the first graduates from our MSc Sustainable Food and Natural Resources course, which was launched in 2017.

Through their studies at CAT our graduates have developed the skills and knowledge to bring about change and to research and communicate positive solutions, which they are now putting into practice.

This year's attendees join over 1,800 graduates from CAT, many of whom are now experts in their field and are working on creating the changes needed to address the huge challenges of the 21st century.

You can meet some of our graduates, and discover more about the work they're doing to help build solutions, on page 12. Find out more about the work of the CAT Graduate School of the Environment and how you can get involved at www.cat.org.uk/gse or call us on 01654 705950.



Dr Jane Fisher presents awards to the first graduates of our new Sustainable Food and Natural Resources MSc.



The Long Road to Glasgow 2020

Paul Allen reports on the Madrid climate talks and preparations for COP26.



Paul presents Zero Carbon Britain at an official side event at COP25.

I was honoured to be invited to the 2019 COP25 UN climate change talks in Madrid by the International Network for Sustainable Energy (INFORSE). My role was to share CAT's new Zero Carbon Britain research with delegates at an official side event, at the INFORSE stall, and with country pavilions to help show that humanity has all the technologies we need to raise ambition.

One of the key required outcomes for the COP25 negotiations was to settle the remaining details of the 'Paris Accord', so everyone can focus on the vital process of raising ambition at COP26 in Glasgow later this year. Basically, there needed to be clarity and resolution to 'Article 6' of the Paris rulebook, to ensure there is no double counting of emissions reduction, and to build in global equity. Sadly, despite exceeding their schedule by a record 44 hours, COP25 failed to reach a deal on this.

From my observations at the event – and from the analysis by my colleagues from INFORSE – Brazil, Australia and a few other countries wanted weaker rules, for example to allow use of old allowances generated via the Kyoto Protocol.

However, led by Costa Rica, a growing coalition of countries offered the Chilean COP Presidency a set of 11 benchmarks which represent the “minimum” standard to ensure integrity of the global carbon trading system. Known as the 'Unconventional Group', these countries have been working since the pre-COP25 meeting in San José, Costa Rica, to increase the level of ambition in talks dealing with carbon markets. As of 6th January 2020, this group includes: Costa Rica, Switzerland, Belize, Colombia, Paraguay, Perú, Marshall Islands, Vanuatu, Luxembourg, Cook Islands, Germany, Sweden, Denmark, Austria, Grenada, Estonia, New Zealand, Spain, Ireland, Latvia,

The Netherlands, Norway, Slovenia, Belgium, Fiji, Portugal, France, UK, Italy, Finland, Trinidad and Tobago, and Tuvalu.

We all hoped the rules that govern Article 6 would be settled during COP25, but sadly this was not fully the case. Quite reasonably, many call COP25 a failure, as large countries including USA, Brazil and Australia were reluctant to sign up to more ambitious rules – in many ways a reflection of the current political situation, but better to have a late decision than a bad decision. Often the real results are delivered between the COPs. Other countries are being encouraged to join the coalition, as discussions will now resume at the intercessional meeting in May 2020 in Bonn, Germany

COP25 did achieve some positive outcomes, including the adoption of a five-year Gender Action Plan and the inclusion of programmes for land and oceans.

I was moved by the incredibly uplifting swell of enthusiastic ambition from youth, from scientists, from delegates. COP25 gave space to many amazing voices, showing real commitment to delivering the ambition needed. It also allowed me to share CAT's new Zero Carbon Britain work across borders, and to discover lots of innovative new work from countries around the world.

But the reality is that we have an awful lot of work to do. Delivering a stable future climate for everyone on earth now depends on what happens in the run up to and during COP26 in Glasgow, as many Paris commitments must begin in 2021.

To keep up to date with our Zero Carbon Britain research and CAT's presence at COP26 in Glasgow, sign up to our newsletter via www.cat.org.uk/sign-up or follow us on facebook, twitter and instagram.

Call for a climate emergency action plan

As 2020 begins, day after day on the news we see tragic images showing more and more extreme weather events from countries we know and love across the globe.

These are resulting from an escalating climate emergency.

If we delve a little deeper, we find that there are devastating climate impacts in many other less well known places that don't reach the mainstream news.

It's now time to take emergency action. It's clear that unless we do, humanity faces the gravest threat in its history. CAT's new report *Zero Carbon Britain: Rising to the Climate Emergency* makes a clear case that the technologies we need to do this are ready, waiting and getting cheaper by the day – so what are we waiting for?

Please join the 135,000 (and counting!) people who have signed up to my petition calling for a UK-wide Climate Emergency Action Plan, and please urge your family, friends and colleagues to add their names too.

To add your name visit change.org and search 'climate emergency action plan'.



Many thanks,
Paul Allen



Get started with solar thermal and other renewables with our new short courses.

Getting to grips with household renewables

From April, CAT is offering a new suite of courses helping people understand the basics of renewable energy for homes, gardens and community centres.

Focusing on readily available technologies, the series begins with a weekend introductory course followed by five one-day courses providing in-depth information on specific areas: biomass, wind turbines, heat pumps, solar hot water and solar electric panels.

John Challen, CAT's Head of Eco Centre says of the courses:

"Understanding where our energy comes from, how we use it and knowing we have the power to change the way we do both is a big step in effective action on climate change. Renewables are easier and more accessible than people think, and we're excited to be running this new suite of courses to show people just that."

Bookings are available for the whole series or for individual courses. For more information and to book your place visit www.cat.org.uk/events/introduction-to-household-renewables/

A Work that Reconnects Retreat

The annual Sanghaseva work retreat returns to CAT this summer, giving you the opportunity to help out in our gardens and woodlands as you explore meditation and nature connection.

Building on the last six years of retreats at CAT, the week offers the chance to become part of a small temporary community, staying in our Eco Cabins and sharing in daily meditation practice whilst volunteering with physical work in the gardens and woodlands and taking part in workshops drawn from Joanna Macy's 'Work that Reconnects'.

This retreat takes place from 10 to 15 May. It is organised by Sanghaseva and facilitated by Gareth Fysh-Foskett and Dr Julia Wallond. There are a limited number of bursaries available.

Find out more and book your place at <https://www.sanghaseva.org/>

New outdoor learning activities

From early summer, a new outdoor learning area will allow us to offer a greater range of ecology, woodland exploration and nature connection activities for schools, groups and families.

A small contained area of woodland near the main CAT site, known as Charlie's Orchard, is being made ready for new activities, with our creative woodland volunteers helping to draw up plans for a

sensory rope trail and barefoot trail to help both children and adults to reconnect with and appreciate the natural world. The area is also being managed for biodiversity, giving an opportunity for wildlife observation and the study of recovering woodland.

Keep an eye on our website for details of these and other new workshops and activities being developed this year.

New gardens and woodlands trails

This spring will see the opening of two new areas to help visitors to CAT get closer to nature and get to grips with home composting.

A new woodland area will provide a miniature version of our beautiful Quarry Trail, showcasing the site's woodland species and giving a glimpse of its industrial past, but without the steep paths that can make the main trail difficult for some people to access.

This will also give school and family groups the chance to explore the importance of protecting and restoring the UK's woodlands to help address the climate and biodiversity emergencies.

Meanwhile, plans are underway for a new display all about composting. Find out how we compost all our waste at CAT and why it's important for soil care, plant growth and biodiversity. The display will take a

look at the wider issues of greenhouse gas emissions from landfill and artificial fertiliser use and production, as well as demonstrating exactly how to get the most out of your garden and kitchen waste at home. This work is partly funded by the Growing the Future Project of the National Botanic Garden of Wales.

Keep up to date with what's new at CAT on our blog at www.cat.org.uk/news-blog

Showing the love with the Climate Coalition

Throughout February we joined our partners in the Climate Coalition to 'Show the Love' for our amazing planet.

People across the country made and shared green hearts to symbolise their love of nature and their determination to work together on solutions to climate breakdown.

During February half term, special activities allowed visitors to CAT to be part of the campaign, whilst a Nature Tracker Trail helped families to learn about the ways that climate change and other pressures are impacting on UK wildlife, and what they can do to help.

We have a great range of activities planned for 2020, with tours, talks, hands-on learning and family activities running throughout the year. Keep an eye on our website and follow us on social media for details. www.cat.org.uk/whats-on



Sharing knowledge to help build a Zero Carbon Britain



Over 140 people came together at CAT to share climate solutions.

A record number of delegates joined our latest Zero Carbon Britain course at the beginning of December to share climate solutions and build a movement for change. Over 140 people from all over the UK came together, representing government, local authorities, academic institutions, community groups, charities and individuals of all ages.

A diverse programme included CAT's Paul Allen as keynote speaker presenting our latest research, with workshops and lectures including Nicola Peel on 'Creating Bio-Regional Alliances', Trystan Lee on 'Local Energy Modelling', Philip James on 'Energy Modelling in the Zero Carbon Britain Report', and CAT's Amanda Smith on 'Young People and Climate Change'. Representatives of the Machynlleth Climate Emergency Action Team led a session on the local council's declaration and what has happened since.

Site tours allowed delegates to see some of the solutions in action, with the opportunity to follow the Zero Carbon Britain trail around the visitor centre to explore how these technologies could help cut UK greenhouse gas emissions. The global context to why these solutions are so desperately needed was provided by our new Living Wales exhibition, with information on real time and historic changes to climate and habitats around the world.

A key part of the programme was presentations from delegates on work they are already doing, building a picture of what is happening, and facilitating networking to take this work forward.

A wide range of topics included work with schools, research projects, green building, energy, climate declarations and transition towns. It was incredibly inspiring to hear so many stories of communities coming together to take action on the climate emergency, and some of their stories were captured by BBC Wales who came along to film part of the session.

In the words of one delegate, the course is a "great way to share important knowledge on a very vast and complex challenge." Other delegates commented that the course had made them feel both a greater sense of urgency and the determination to rise to the challenges.

In response to increased demand and as part of the work of CAT's new Zero Carbon Britain Hub and Innovation Lab, we have added three Zero Carbon Britain courses for 2020 (29-30 April, 21-22 July and 1-2 December) – book your place via the CAT website at www.cat.org.uk.

More events are planned throughout the year – sign up to our newsletter via our website and follow us on social media to stay up to date with plans as they develop. [CS](#)

Our thanks to The Marmot Charitable Trust, The HT and LB Cadbury Charitable Trust, The 1970 Trust, The Polden Puckham Charitable Foundation, Jam Today and Work Wild Ltd, in addition to a number of generous anonymous donors for their ongoing support for our Zero Carbon Britain research and communications work.

A gardener's privilege

As the barrenness of winter slowly gives way to the sounds and sights of spring, **Petra Weinmann** begins to make plans for the CAT gardens.



A new path winding through the heart of CAT offers the chance to spot nature emerging from its winter sleep.

As I write this, January is waning and a new season is beginning to seem possible. Every winter, despite clear evidence to the contrary, there is a point (usually when returning to the CAT quarry after the Christmas break) when the abundance of summer feels like an improbable dream. The garden at CAT, on its slate tip, can be a gloomy and rocky place, far removed from the verdant haven I know is only a few months away.

In between the storms that have flapped our polytunnels and encrusted the hardy winter volunteers in mud, there have been serene moments. Picture the low sun breaking through and illuminating the thriving mosses, pale birch bark and millions of raindrop crystals on bare twigs. Or hear a robin's song, suspended in the watery air. The world holds its breath in these moments and finds a still point, before tipping into the rush of spring with ever greater momentum.

Looking at the bare garden today the imminent transformation seems profound, and it is a gardener's privilege to pay attention to this unfolding.

Already there are some signs of changes afoot. As I walk the new woodland path through the heart of the garden,

hazel catkins catch my eye. Were they this yellow yesterday? Overhead a pair of nuthatches are picking their way along birch branches as a team. And here comes the persistent call of the Great Tit that always seems to punctuate this journey out of the dark months.

Roger McLennan, our head gardener, is mobilising too. He has been assembling the 'hotbeds' we use to kick-start our plant-raising season. Metal cages are filled with scraps from the café kitchen. These generate enough heat as they decompose to keep the cold night air off our germinating vegetables and avoid using electricity or paraffin. Of course, rotting vegetable matter gives the polytunnel a very distinctive aroma – a sure sign that the growing season has begun!





It's hard to believe that in just a few months the polytunnels will be filled with the colours and scents of summer.



The 'hotbeds' provide frost protection, allowing us to start sowing earlier in the year.

There is still a trickle of crops going to the café. Some leeks, kale, oriental salad leaves, beetroot, garlic, herbs and the last of the (by now wrinkly) apples. Roger and I have been talking to the café manager, Lauren, to discuss what will be available in the months to come. By keeping the communication channels open we can help avoid food waste, and get our home grown produce onto the menu as much as possible. Lauren has made a special request that we grow more Kabocha squashes, so look out for these plump green Japanese varieties in the garden and café if you visit next summer.

As we plot and plan our squashes, spinach, beans and berries, our imaginations begin to fill with the rich colours, sweet tastes and joyful abundance of summer, and gradually the Quarry feels filled with new promise and possibility. [CS](#)

About the author

Petra has been managing the garden displays and helping the biodiversity flourish in the CAT gardens since 2015. When she's not pruning the apple trees and experimenting with chickpea and lentil crops, Petra can be found improving and planning new interpretation for the gardens, and leading university and school groups on garden tours and volunteering days.

New garden courses at CAT

This year we are launching a new series of gardening courses in collaboration with the National Botanic Garden of Wales. If you'd like to learn how to garden in small spaces, create a wildlife haven, get started with edibles or explore gardening in dry climates, take a look at our website for more information, or give us a call on 01654 704966. www.cat.org.uk/short-courses



Meet CAT graduates

CAT now has over 1,800 graduates – people who have immersed themselves in studying sustainable solutions for 18 months or more, gaining the skills, knowledge, networks and qualifications to make a real difference in the world. **Alis Rees** caught up with a few of them to find out about life after CAT.

A new career researching Ash dieback

Ffion Thomas graduated in 2019 as one of the first students on our MSc in Sustainable Food and Natural Resources. Before studying at CAT Ffion had previously worked in German banks and then as Head of Risk Management and Compliance at Mitsubishi UFJ Trust.

Looking for a change of direction, Ffion was able to transfer the research, practical and analytical skills she'd gained through her career to her studies at CAT.

During her studies, Ffion was part of a team looking at the changes to pesticide regulations in the lead up to Brexit. The important work Ffion and the team were doing reached the national press and Ffion was quoted in the Guardian. Her analysis highlighted that the changes could weaken the rigour of the process by which pesticides are approved and monitored in the UK.

Following on from this and the work Ffion undertook in her dissertation, she is now working towards her PhD focusing on agroecological approaches to managing Ash dieback at the Centre for Agroecology, Water and Resilience at Coventry University. "Studying at CAT was life-changing, and has enabled me to take on a new career in an area I love, but which I never thought would be feasible, given I didn't have a scientific background."



Ffion (left) receives her award from Dr Jane Fisher at last year's graduation

Social Entrepreneur of the Year

Sustainable Architecture graduate **Kirsty Cassels** won the Social Entrepreneur of the Year award category at The Scottish Women's Awards 2019. After graduating from our Part 2 Architecture course in 2016, Kirsty set up 'Building Together CIC' with fellow CAT graduate Robert Thompson. It



is a design and build Community Interest Company (CIC) that designs that designs buildings or structures for communities or organisations, using the members of that community to help with the build. As a Community Interest Company, they are bound by their constitution and their profits are capped and poured back into the community. Kirsty says that her studies at CAT played a huge part in getting her to this point.

"It is difficult to suitably express the impact my studies and time at CAT have had on my life. It is a huge part of who I am today, and who I will become.

"My studies at CAT give me a huge advantage in the conventional architectural and construction industries. I have a much higher degree of influence and respect in my environmental opinions and strategies, and my clients and colleagues know, with the backing of the [CAT degree], that I am an expert in environmentally nurturing buildings."

Helping Bath go carbon neutral

Sarah Warren (below right) heard about CAT's MSc in Sustainability and Adaptation Planning from a former student, and



promptly signed up for one of our Open Days. As a parent, the flexibility CAT's courses offered was attractive to her, and the part time and distance learning options were key parts of why she applied. Like Ffion, she graduated last year, and describes her time at CAT as 'life-changing', from the immersive experience to studying alongside like-minded people.

The impact the course had on Sarah prompted her to run for a council election in May 2019, and she was then elected as a Cabinet Member for Climate Emergency and Neighbourhood Services at Bath & North East Somerset Council, helping provide leadership to ensure the district achieves carbon neutrality by 2030.

"The wide-ranging nature of the course has been invaluable. It means I have at least some idea of the right direction of travel, and the right questions to ask, in discussions ranging from building design and insulation, transport, and waste to communications and engagement, food, biodiversity, and land use."

About the author

Alis is CAT's Graduate School Marketing Officer, and is the person to speak to if you have any questions about our Masters degrees, or if you're a CAT graduate who would like to share your story. You can email Alis at gsmo@cat.org.uk or call her on 01654 705953.

Get in touch We'd love to hear from you. Email members@cat.org.uk, and if you would like your letter to be considered for inclusion in Clean Slate, please use the subject 'For publication'.

Understanding impact

Dear CAT,
I sympathised with Neil Kermode's letter in the Autumn issue (CS113), asking how we can understand the carbon impact of what we buy, so I've developed a spreadsheet tool based largely on Mike Berners-Lee's book, *How Bad are Bananas?* It aims to make it easy for committed people like Neil (and doubtless a few other readers!) to estimate their carbon footprint, and see how best to reduce it. Readers are very welcome to get in touch if they would like to try it.

Richard Cocks

If you would like a copy of Richard's spreadsheet, please email members@cat.org.uk with the subject 'Carbon spreadsheet'.

See also article by Judith Thornton on page 23.

Smart streetlights could cut energy use

Dear CAT,
If, worldwide, street lighting was turned off or dramatically reduced during the periods when few people are around (e.g. midnight to 5am), enormous amounts of energy would be saved. The introduction of streetlights controlled by infra-red sensors would provide sufficient lighting for passing vehicles and pedestrian traffic.

Dr G D Pirie

There is the potential to greatly reduce energy use for street lighting. One key part of this is to upgrade lights to much more efficient LEDs, and this is happening around the UK. And having better controls and sensors will save more energy, as you suggest.

A trial conducted across 12 of the world's largest cities found that LEDs can generate energy savings of 50%, and that these savings rose to over 80% with the addition of smart controls.

An example of a system that works in the way you describe is in the city of Eindhoven in the Netherlands, where LED streetlights are dimmed to 20% power when no one is around, switching to full power when a sensor detects movement; other lights in the person's path are then automatically brightened as well.

Joel Rawson, Information Officer

Zero Carbon Britain and disabilities

Dear CAT,
As a decades-long member of CAT and other environmental organisations, I fully accept the need for wide-ranging changes in many areas of life to minimise the ongoing climate emergency. However, in reading recent issues

of *Clean Slate*, and particularly the discussion of a points system for rationing fuel use, I wonder whether you've taken into account the widely varying needs of different sectors of the population – e.g. our varying needs for heat and car use – and the health, social and financial repercussions for some people if new rules on such matters were implemented inflexibly. There are, for instance, many reasons why some of us may be at home for much of the time, rather than out at work or 'play', whether due to age, infirmity, disability, having young children, or working from home. Those who are ill or with other reasons for limited mobility, may not be able to exercise more to keep warm or speed their metabolisms, yet their health may be at risk if cold over longer periods.

If a points system were implemented such that anyone using over x amount of fuel had to pay for additional fuel at a higher rate, this could hit hardest those with the greatest need and least financial resources to meet it (especially given the welfare cuts over the past decade), leaving those who are young, healthy and active relatively 'untouched'.

Similar issues would seem to arise in other sectors, such as transport, where those with mobility issues may again find themselves further disadvantaged and limited in their options if the encouragement to walk, cycle, use public transport and create more car-free areas isn't implemented with their needs in mind also.

Rose Swales

As we push for the changes needed to get to net zero, it is vital that issues of social justice are central to policymaking, particularly as many already vulnerable groups, including those with underlying health issues or restricted mobility, are more at risk from climate change impacts like extreme temperatures and flooding. Some of the measures to cut emissions will help address issues such as fuel poverty, which disproportionately affects disabled and older people. For example, a national programme of retrofitting houses with insulation will reduce fuel bills.

Outside of this, policy mechanisms such as a Personal Carbon Allowance or other form of carbon rationing should take into account health or other specific needs by allocating more credits where needed. As these types of solutions are explored further, it will be important to keep equity at the heart of the conversations.

These issues were highlighted within our 2017 'Zero Carbon Britain: Making it Happen' report, and we will return to the topics in future editions of Clean Slate.

Catrina Toms, Editor

Home heating options

Dear CAT,

I am one of CAT's older members (in both senses of the word!) and am wondering whether you can help me with an important issue? My three-bedroom, 1930s semi, on the sunny south coast has a typical gas central heating system. I would like to change this (if possible/affordable) to a more energy efficient, 'planet-sustainable' system. Ideally, to save cost, I would like to leave the radiators where they are and simply not use them. Have you any suggestions?

Beryl Wright

If your radiators don't need high flow temperatures, due to a mild local climate and/or good insulation levels, then it might be possible to use a small heat pump to supply existing radiators, but set flow temperatures to be lower than from a gas boiler. Heat pumps work best when they deliver low flow temperatures – perhaps 45°C to large radiators. You'd need to discuss the options with some installers – and do come back to us with any more questions. We wouldn't promote direct electric heaters, as at present this leads to higher carbon emissions than a gas boiler (plus much higher running costs). Using one unit of mains electricity will, on average, lead to about one-and-a-half times as much carbon dioxide as one unit of heat from a modern gas boiler.

In direct electric heating, 1 unit of electricity delivers no more than 1 unit of heat at best. Whereas a well-specified heat pump can use one unit of electricity to deliver 3 (or even 4) units of heat. This brings carbon emissions and running costs down below those of a gas boiler. As part of 'Zero Carbon Britain' we see a move to using heat pumps for central heating in most homes, generating the electricity needed from sources such as offshore wind, wave and tidal power. You can read more about this in my article on heat pumps on page 30.

Joel Rawson, Information Officer

Opinions expressed are not necessarily those held by CAT. We reserve the right to edit letters where necessary.





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18	Earth Oven Building
18 - 19	Introduction to Renewables for Households NEW
20 - 24	Ecosystem Services: land use, water and waste management
24 - 26	Bird ID: an introduction
27 - 1	Timber Frame Self Build
29 - 30	Zero Carbon Britain

May 2020

5 - 9	Build a Natural House (Sold out on this date)
9 - 10	Building with Rammed Earth
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11 - 15	Hydroelectric and Marine Energy Generation
18 - 22	Sustainable Building Materials
22 - 24	Ecology 1: an introduction
23 - 25	Build a Wildlife Garden NEW
23	Build a Lapsteel Guitar
23	Renewables for Households: solar PV NEW
29 - 1 June	Build a Tiny House (Sold out on this date)

June 2020

12 - 14	Entomology: The Larger Insects of Wales
13	Earth Oven Building
13	Compost Toilets
13 - 14	Build an Edible Garden
13 - 14	Fixing Your Damp House
14	Reedbeds and Waste Water Management
20	Shrink Pot Carving
22 - 25	Build a Tiny House (Sold out on this date)
26 - 28	Identifying Flowering Plants
27	Build a Lapsteel Guitar
27	Renewables for Households: Wind Turbines NEW
29 - 3 July	Build a Shed: for absolute beginners

Turning point 2020

As we enter a critical decade for climate action, a selection of *Clean Slate* contributors look back on the environmental highs and lows of the past ten years and explore what needs to happen now.



Jaise Kuriakose

Lecturer in Energy and Climate Change
at the Tyndall Centre, and CAT guest lecturer

What were your environmental highs and lows of the last ten years?

The last ten years have seen significant improvement in the understanding of climate science and the impact of climate change on human, natural as well as built and engineered environments. The awareness of climate change and its impact led to one of the greatest diplomatic successes, the Paris Agreement signed by nearly all countries in the world. We have also witnessed the rise of Greta Thunberg and Extinction Rebellion, which led to declaration of climate emergencies across the UK at local level.

Meanwhile, significant energy innovation happened in all sectors including storage, electricity generation, heat pumps, and so on, leading to substantial reductions in costs. The costs for wind and solar have reduced at a level faster than most governments or industrial bodies forecast. In the UK, the cost of offshore windfarms built in 2025 will be as low as £39.65/MWh and will be the cheapest form of energy generation. Wind is already forecast to be cheaper than existing gas power stations as early as 2023. Despite all this progress, along with a considerable public momentum for climate action, there has been less action on the

ground or in terms of policy from national governments across the world. Since 2012, my research has been largely focused on energy decarbonisation and developing carbon budgets at local and national level in the UK. As part of my research an online tool has been developed to help local authorities to calculate their carbon budget and cut their emissions in line with latest climate science and the UN Paris Agreement. 27 local authorities, including Manchester, Sheffield and Leeds, have already adopted our work to set Paris-aligned climate goals and are now actively developing implementation plans to achieve the adopted targets.

What needs to change in the coming decade?

A fundamental shift in the way we live and organise in our society is essential for a radical reduction in emissions aligned with Paris goals. In the UK, 77% of all emissions are just CO₂ which arises from the relatively easy to abate sectors using fossil energy. Some sectors do take more time to decarbonise such as industrial processes or aviation and shipping. Electricity, heating and road transport need to be zero carbon as soon as possible, and are within the direct influence of local policies. Hence, enabling local authorities in using a CO₂-focused approach by prioritising these sectors, picking the 'low hanging fruit', can actually lead to rapid deep decarbonisation.

What can we as individuals do to make a real difference?

Individuals have a major role in this transition, both by influencing local policy and by making lifestyle changes to help deliver the Paris goals. Ultimately radical changes at a local level and changing to a low carbon lifestyle through consumption patterns will force the national policymakers also to change.



Tanya Hawkes
Major Gift and
Legacy Fundraiser

What were your environmental highs and lows of the last ten years?

The low point: Entering the decade having watched the failure at the Copenhagen Conference of the Parties, as the

international process was sabotaged from all sides, especially by the high emitting countries and their lobby groups. We discovered what we were up against. The high point: People! Meeting environmentalists from Nigeria, Algeria, Alberta and Russia; the global school strikes; studying at CAT and working 'virtually' with people around the world to find climate solutions. On a very personal note, because I was raised in a big Irish Catholic community, reading Pope Francis' Encyclical 'Laudato Si' and witnessing the rise of a global Catholic climate movement. Life is full of surprises!

What needs to change in the coming decade?

Politically and economically: Expand and strengthen public sector institutions, internationally, regionally and locally, with democratic accountability. Neoliberal economic policies in the last 40 years have shrunk the parts of the state that were designed to help people. We'll need less GDP measurements, less defence spending and more adaptation finance, disaster relief, strong climate action in local authorities and devolved areas, combined with international peacebuilding. We'll need to develop evolving systems to deal with climatic uncertainty and build new economic systems

of human activity that are helpful, useful, connected and that fairly and justly share the products we create. In essence: let's organise the work that needs doing, to be able live lives that are enriching for all living things.

What can we as individuals do to make a real difference?

Get to know our neighbours: our human neighbours, near and far, and our neighbours that make up the natural world and are an extension of us. Climate change and biodiversity are borderless, and so are the solutions. The false borders that divide us from each other, and from nature, prevent us from moving forward. We'll need to think in borderless, international ways if we are to adapt to the climate change that we can't prevent; whether to assist displaced people to migrate, to share knowledge of new technologies, to protect disabled and other vulnerable groups, or to mediate transboundary agreements over food trade and shared areas of nature. We'll need to support each other in times of hardship and joy, and that process starts with a conversation with the neighbour you've never spoken to, and extends to a global empathy with all life on earth. Our bonds will be our strength.



Paul Allen
Zero Carbon Britain
Project Coordinator

What were your environmental highs and lows of the last ten years?

The increasing evidence of the highly serious nature of the climate emergency was

an ongoing low for the past decade. This was revealed in highly detailed research reports such as the IPCC 1.5°C report, and in the record number of extreme weather events experienced across the globe during the decade. Another low was the increasing inability of countries such as the US, Brazil and Australia to join those ready to act, culminating in the lack of ambition in the outcomes from COP25 in Madrid.

My first high of the last decade was the successful opening of CAT's new WISE building in 2010 – making this happen was really quite an achievement. The next high was the successful launch and traction gained by our 2013 *Zero Carbon Britain: Rethinking the Future* report. This was the first time we had assembled the really detailed hourly model, integrating food and land-use. Knowing that we really do have all the technologies we need was seriously uplifting. The work of the high ambition coalition to get the 1.5°C target recognised in the 2015 Paris Agreement was another high.

Perhaps the best high point was the run-away feedback amongst councils across the UK and beyond which kicked off during 2019, making climate emergency

declarations and working on action plans – this is the new leadership we have been waiting for!

What needs to change in the coming decade?

At a systemic level, we need a new consensus to act across all political parties and across continents. We need to stop thinking in terms of individuals facing environmental challenges and recognise we humans are both the challenge and the solution. Humans need to see ourselves collectively as part of nature – we know what we need to do, we have all the tools we need, and we work most effectively as a hive.

What can we as individuals do to make a real difference?

We must come together and be the change we want to see in the world, to build that future that we know is possible. But we do need to recognise that it is not all just down to individual actions, once we come together we will find we can make systemic change happen too.



Peter Tyldesley
Chief Executive Officer

What were your environmental highs and lows of the last ten years?

The substantial decarbonisation of the UK electricity generation sector has been a real positive over the past 10 years, with coal almost disappearing from the mix. Government policy on renewables has been disappointing with the effective ban on onshore wind farm developments in 2015 and the end of the Feed in Tariff scheme in 2019 both hitting the sector and slowing progress.

The demonstrable increase in public support for action on climate change over the past 18 months has been a real high. Recognition of climate change as an issue has increased dramatically but there is an ongoing failure to recognise it as *the* issue and therefore to prioritise action on this above all other priorities.

The ongoing decline in UK wildlife as evidenced by the State of Nature Reports in 2016 and 2019 continues to be a real concern.

On a personal level, my own environmental “high” was being appointed CEO of CAT in September 2019.

What needs to change in the coming decade?

There needs to be a dramatic increase in the scale and pace of change and recognition that, one way or another, significant public investment is going to be required.

What can we as individuals do to make a real difference?

Individuals have two great sources of power: as consumers and as citizens and voters.

The dramatic rise in the availability of vegan food shows that companies will respond to consumer demand. The choices that we make as consumers to buy or not to buy can make a real difference.

As citizens, we can make our voices heard in a number of ways – signing or starting petitions, writing to our MP, Assembly Member or local councillor, joining activist groups and supporting organisations such as CAT with our time and/or money. There is a real danger that, as people become aware of the scale of the challenge, they move from blissful ignorance to panic or despair, neither of which is conducive to positive action, so it can be helpful to remember these two sources of personal power.



Jane Fisher
Ecologist and Programme
Leader, CAT Graduate School

change since ‘An Inconvenient Truth’. Following the broadcast there has been regular news coverage about climate change and ecological collapse in a way that was unheard of just a few years ago. I think, like a lot of environmentalists, I felt as if all the work we’d all been doing for so many years was finally being recognised as important, and that this might be the start, the first crucial steps necessary to achieve actual change.

The low was also last year, when the Amazon burnt, and still burns. The Amazon rainforest is an ecosystem which powers climate cycles, stores huge amounts of carbon and biodiversity and is home to indigenous people. To see it literally going up in smoke, much of it under the eyes of a president who doesn’t recognise its importance, is a huge concern. My 7-year-old son cried when he saw the pictures on the news.

What needs to change in the coming decade?

There needs to be strong environmental legislation which protects natural and semi-natural ecosystems, and which works globally. For too long natural systems have been considered as ‘nice to have’,

including by many in the sustainability movement. The role these systems have in balancing global climate and oceanic cycles, cycling nutrients and basically making life on earth possible for all living things has been greatly undervalued. We need to find a way of valuing these aspects, ensuring their protection and working across international borders to do so.

What can we as individuals do to make a real difference?

As consumers, we have power to patronise companies that provide goods and services with minimal environmental impacts. Use labels like MSC and FSC, avoid processed foods that have palm oil or other land-hungry crops, and buy more local whole foods. Eat in a way which spares land: more plant based. These choices have national and international impacts. At a more local level, protect your local nature, be it through fighting new planning applications on green field sites, school fields, odd corners of greenery and farmland, or protecting old street trees and planting new ones, and encouraging wildlife into our towns and cities.

What were your environmental highs and lows of the last ten years?

The high for me came last year when the BBC showed the David Attenborough documentary, ‘Climate Change: The Facts’. It was the first serious, prime-time, main channel programme about climate

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Adaptation: from coping to transformation

Wildfires, drought, hurricanes, flooding – the impacts of our emissions are impossible to ignore.

Tanya Hawkes looks at how plans can be made for an uncertain future.

The climate is changing. The 2018 'Special Report on 1.5°C' from the Intergovernmental Panel on Climate Change (IPCC) shows that we are being forced to adapt to a certain level of climate breakdown. We can limit greenhouse gas emissions but we cannot mitigate their effects entirely. Over the coming decades, we will increasingly be forced to adapt to levels of climate change which will be uneven, regionally unique and non-linear. National and regional adaptation plans will need to deal with a high degree of uncertainty and strengthen long-term scenario planning skills and international cooperation.

What is adaptation?

Whilst climate change *mitigation* aims to reduce CO₂ emissions, *adaptation* is how we cope with and adapt to climate impacts.

Different types of adaptation can be categorised as: *coping* (responding to events as they happen); *incremental* (responding to events, but also learning from them and changing approach); or *transformational* (making long-term changes in advance of events).

For example, have you bought a fan in the last three years because of increasingly hot summers? That's *coping*. Installing an air conditioning system to keep cool, would be more *incremental*, as a learned response to change, but might also contribute to greater emissions. *Transformation* is when we create a new pathway to change. For example, when we see that business as usual methods are not working (e.g. installing a cooling system that actually adds to climate change), so long term solutions, like retrofitting homes with better insulation and passive cooling and heating systems, transforms and helps us adapt.

Towards net zero

Adaptation planning can help create a net zero carbon future with climate resilient systems. It is a way of planning for the likelihood and severity of disasters, such as flooding, heatwaves, storm surges, and identifying what and who are most vulnerable, then putting in place response measures to help recover from the impacts

of climatic events.

We can build adaptive capacity into some of our methods of cutting greenhouse gas emissions, so that some adaptation measures can have the co-benefit of helping us reach net zero. For instance, reforestation in rural areas and tree planting in urban areas can help to mitigate flooding from rivers or control higher temperatures in urban areas. At the same time, it acts as carbon sequestration, contributing to getting to net zero. More localised food production results in shorter supply chains, which are more resilient to climate change impacts, whilst clocking up fewer food miles and thereby contributing towards our carbon reduction target.

A just transition

Climate justice requires a multi-level approach to adaptation.

The expectation from the United Nations Framework Convention on Climate Change is that states will develop their own adaptation plans based around their

unique vulnerabilities to climate change. The Flexible Workplan of the Adaptation Committee 2019-2021 is the framework for helping countries to develop their own solutions, using data systems for planning and implementing action.

Adaptation research often discusses the importance of 'regional determinants' and gathering the unique knowledge of a certain area to create appropriate plans. For example, an area prone to flash floods might focus on green infrastructure (see box), or an area prone to drought might invest time in transboundary treaties with neighbouring states to share resources. Many areas will need a mixture of such strategies.

Whilst it makes sense that there is an emphasis on regions to develop adaptation plans at community and municipal levels in response to their own unique circumstances, regulatory and financial frameworks from higher levels of government are essential to reduce the risk to vulnerable areas and people. Shared

Green and blue infrastructure vs grey – an example of a multi-solving adaptation tool

'Green' infrastructure is plant-based, like trees and grass roofs. 'Blue' infrastructure is water-based, like ponds and swales. Some might be both, like reed beds.

Traditional 'grey' infrastructure, such as the drains and pipes that we are used to in urban areas, tend to draw water (such as rainfall) to rivers as quickly as possible. This has two effects: sudden rainfall overwhelms sewers (and sometimes streets) creating either flash floods or overspill from rivers and sewers, which kills fish and wildlife. Also, paving and tarmac are reducing our porous surfaces and reducing plant growth, both of which contribute to heating, even in rural areas.

Green and blue infrastructure is a multi-solving tool with co-benefits. It is a key adaptation tool, to address flooding and heatwaves. It helps preserve and create new biodiversity, promotes nature connection for people, acts as carbon sequestration, muffles noise and reduces localised air pollution. Some of the key benefits are outlined below.

Green infrastructure adaptation	Reduce flooding and the need for super sewers	Co-benefit: biodiversity	Urban cooling	Connect to nature/homes for nature
Rain gardens	Main reason	x	x	x
Trees	x	x	x	x
Green roofs	x	x	x	x
Porous paving	x			

Global perspective: who is already adapting?

Across the world, many areas are already developing the tools to adapt to climate change, some with informal settlement change and some with more formal strategies.

Multi-Criteria Analysis: Dhaka

In Dhaka, capital of Bangladesh, Multi-Criteria Analysis (MCA) is promoted as a method to prioritise vulnerable areas from flooding. The framework of MCA is designed to involve more stakeholders to try to strengthen the existing government adaptation plans. This more integrated assessment may help counter problems such as water ponds and other flood management tools being shelved to make way for greater urban development. The short term socioeconomic issues are often prioritised over tackling longer term climate change risks, and the MCA method hopes to reverse this situation.

Tarea Vida: Cuba

Tarea Vida ('Project Life') is part of a 100-year adaptation plan adopted in 2018 by Cuba's Council of Ministers. No new build on low-level coastal areas, planned relocation of populations from affected areas, a rethink of the country's current agricultural practices, and restoration of damaged habitats are some of the key goals. Cuba has a unique governmental system that prioritises health and education and state intervention, which might be a key component in their ability to plan adaptation.

Local democracy and participation: Kenya and Nicaragua

Urban Participatory Climate Change Adaptation Appraisals (UPCCAA) in Mombasa, Kenya and Estelí, Nicaragua are using the stories and evidence of local people to analyse how and where climate effects are worsening.

Involving groups that are usually marginalised from local and national decision-making is part of this participative process. For instance, Climate Defence Programmes that prioritise feedback from women who are responsible for the day-to-day management of water and food provide access to valuable local ecological knowledge and identification of potential risks through the gathering of these experiences.

Visioning and futuring: British Columbia and the Philippines

In British Columbia, Canada, a process called the Local Climate Change Visioning Project enables local stakeholders to visualise different future high to low carbon scenarios, plus the associated risks and benefits, as the beginning of local climate change mitigation and adaptation plans.

Participatory video making in the Philippines is bridging a gap between the traditionally voiceless youth and decision makers, in an experimental method. Youth as a previously marginalised group are helping to build resilience to climate change in their local areas.

support from national and international communities will be essential so poorer areas don't shoulder the burden of climate breakdown effects that they aren't responsible for.

Citizen participation

Until recently much climate change adaptation research was top-down. Now many areas are developing participatory methods alongside centralised planning to incorporate the knowledge and experience of local citizens and stakeholders.

Inclusive governance structures and the strengthened role of civil society are

helping to produce effective adaptation plans based on local knowledge, with NGOs in the global south providing and developing expertise that could be applicable elsewhere. Sharing knowledge may be key to resilience.

Communities already vulnerable to the effects of climate change, such as the Caribbean Small Island States, the megacity of Dhaka and other places that are already predisposed to periodic drought, flooding and crop failure, are finding ways to gather data and plan adaptation to extreme weather events that suit their local areas and maximise democracy.

In Bangladesh, mother-of-four Nila Boti grows vegetables in a ring-garden to protect her produce from floodwater.



This democratic, participative and inclusive approach could be part of the solution to addressing some of the inequalities created or exacerbated by the impacts of climate change.

Risks, opportunities, and management: adaptation in the UK

The UK's Department of Environment, Food and Rural Affairs (DEFRA), under the overall framework of the Climate Change Act 2007 and their National Adaptation Programme, produces the current guide to 'making the country resilient to a changing climate'.

Some of the particular vulnerabilities and risks facing the UK include: a long coastline, some of which is at risk, even now, to rising sea levels; an agricultural industry that will require significant changes in terms of its land use; and a historical reliance on high emissions for our economic growth, including large amounts of investment in fossil fuels from the City of London. We can expect greater coastal erosion, warmer winters, more frequent and severe summer heatwaves, and more severe and unexpected flooding.

The significant challenges that climate change represents to our future economy arguably receive too little attention from the UK government. [GS](#)

About the author

Tanya researches climate adaptation solutions within a social justice framework. She has a postgraduate diploma in Environmental Policy and studies MSc Sustainability and Adaptation at CAT. She is a contributor to 'Low Carbon Living 2050', Palgrave Macmillan, and 'Zero Carbon Britain: Rising to the Climate Emergency'. References available on request.



Green roofs, such as this example in Fukuoka in Japan, can help reduce flooding, enhance biodiversity and connect people to their environment.

yyama / Shutterstock.com

Sector	Risks	Management and opportunities
Natural environment	<ul style="list-style-type: none"> • Change to ecosystems causing shifts in distribution and abundance of freshwater/marine life, habitat loss, diseases and invasive non-native species of plant and animal. Loss of resilience of ecosystems due to inability to adjust and adapt to the speed of change. • Peatland restoration put under pressure by temperature increase. • Rivers over-extracted for water, reduction in biodiversity and bank stability, vicious cycle. 	<ul style="list-style-type: none"> • Large-scale tree planting, forest management, rewilding to help capture carbon. • Creation of wildlife corridors. • Restoration of peatlands.
Infrastructure and the built environment	<ul style="list-style-type: none"> • Flooding, particularly in coastal areas, but also inland risks from flash floods. • Intensity of urban heat in cities and built up areas. • Transport issues from heat, flooding and unpredictable weather. 	<ul style="list-style-type: none"> • Increase sea defences where possible. Managed relocation for affected communities in coastal areas when sea defences won't work. • Green and blue infrastructure, which is a way of slowing down water flow in flood prone areas. • Knowledge of the regional variants based on gathering local learning will help. • Trees, green roofs, green walls, ponds, and urban gardens to help with heat management.
Land use and agriculture	<ul style="list-style-type: none"> • Risks of flooding, water shortages and unpredictable weather. • Disruption to food supplies. • Unintended consequences of land use change, such as bioenergy causing displacement of food crops, or import of crops that displace forests. 	<ul style="list-style-type: none"> • Reforestation. Changes to farming and land use to reduce waste, build resilience, increase local food production and build further international co-operation to help with food supply fluctuations. • Accounting for unintended consequences of land use change through international carbon balance sheets.
Health and wellbeing	<ul style="list-style-type: none"> • Heat related deaths could double by 2050. • Risk to human life and wildlife. • Possible compounding factors of air particulates and ozone. • Disruptions to health and social care services. 	<ul style="list-style-type: none"> • Car reduction in cities, more cycling-friendly infrastructure. • Green and blue infrastructure in cities to reduce localised pollution and increase nature connection. • Changes to land use can influence diet in positive ways, with overall reduction in meat and dairy consumption.

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The carbon footprint of production, and how much it matters

In the first of two articles, **Judith Thornton** discusses the carbon footprint of the 'stuff' that we buy.

Earlier in the year I did some carbon footprint calculations with CAT members and students, and decided to make a basic carbon calculator that people could fill out on paper.

It's relatively simple to get emission factors for domestic fuel use (electricity, gas, wood, oil etc), and for various modes of transport. Dietary emissions are tricky to do accurately, but at a simple level we can make assumptions about vegans compared to meat eaters. For most people, domestic energy, transport and diet are the categories that have the largest impacts, and they are certainly the categories which we can exert most influence over.

If you do one thing today to combat climate change, have a go at the carbon footprint calculation in the box, and act on the findings.

At a UK wide scale, Zero Carbon Britain does a detailed job of working out emissions across the major sectors and how to reduce them. But obviously these categories don't represent our total impact; we have things like consumer goods, business impacts and public services to account for.

Typically we use a fixed value for these regardless of individual circumstances, and, for the carbon calculator above, I made a simplistic estimate of values to use. But when I did my own carbon footprint, this element was a large chunk of my overall footprint. If this is also the case for you, the obvious thing to do is to focus on doing something else that contributes to combating climate change – such as political lobbying in order to change government policies and advocacy with friends and family to encourage them to make personal changes.

However, it did get me thinking about the carbon footprint of these fixed elements, in particular the carbon footprint of physical goods, i.e. our 'stuff'.

Calculating the carbon emissions of production

Life Cycle Assessment (LCA) is the most commonly used method for working out total carbon emissions from individual goods and services. We start by defining the object or service, and then we draw a flow diagram of everything that we are going to include, expanding it outwards. But

whenever we do a bottom up calculation, we are going to miss out impacts, so the answer is usually lower than it should be.

There are several reasons for this. Firstly, it's difficult to do a complete 'cradle to

grave' assessment of products, particularly if the lifespan is uncertain, or its disposal is going to be a long time in the future.

Accounting for proportions of capital inputs are also difficult (e.g. how much of the total

Carbon footprint calculator

A Contributor	B Your Data	C Units	D Multiplication Factor	E Total (kgCO ₂ e)
Home energy use				
Electricity		kWh	0.352	
Gas		kWh	0.185	
Wood		tonnes	190	
Oil		litres	2.53	

Travel

car, petrol <1.41		miles	0.25	
car, petrol >1.41		miles	0.457	
car, diesel <1.71		miles	0.234	
car, diesel >1.71		miles	0.346	
Bus		miles	0.197	
Train		miles	0.075	
Air		miles	0.255	

Diet (standard) 2200kg. Diet (vegan, minimally processed, low waste) 1100

Stuff	N/A		1100
-------	-----	--	------

	Your total kg CO ₂ e per year	
--	--	--

Instructions

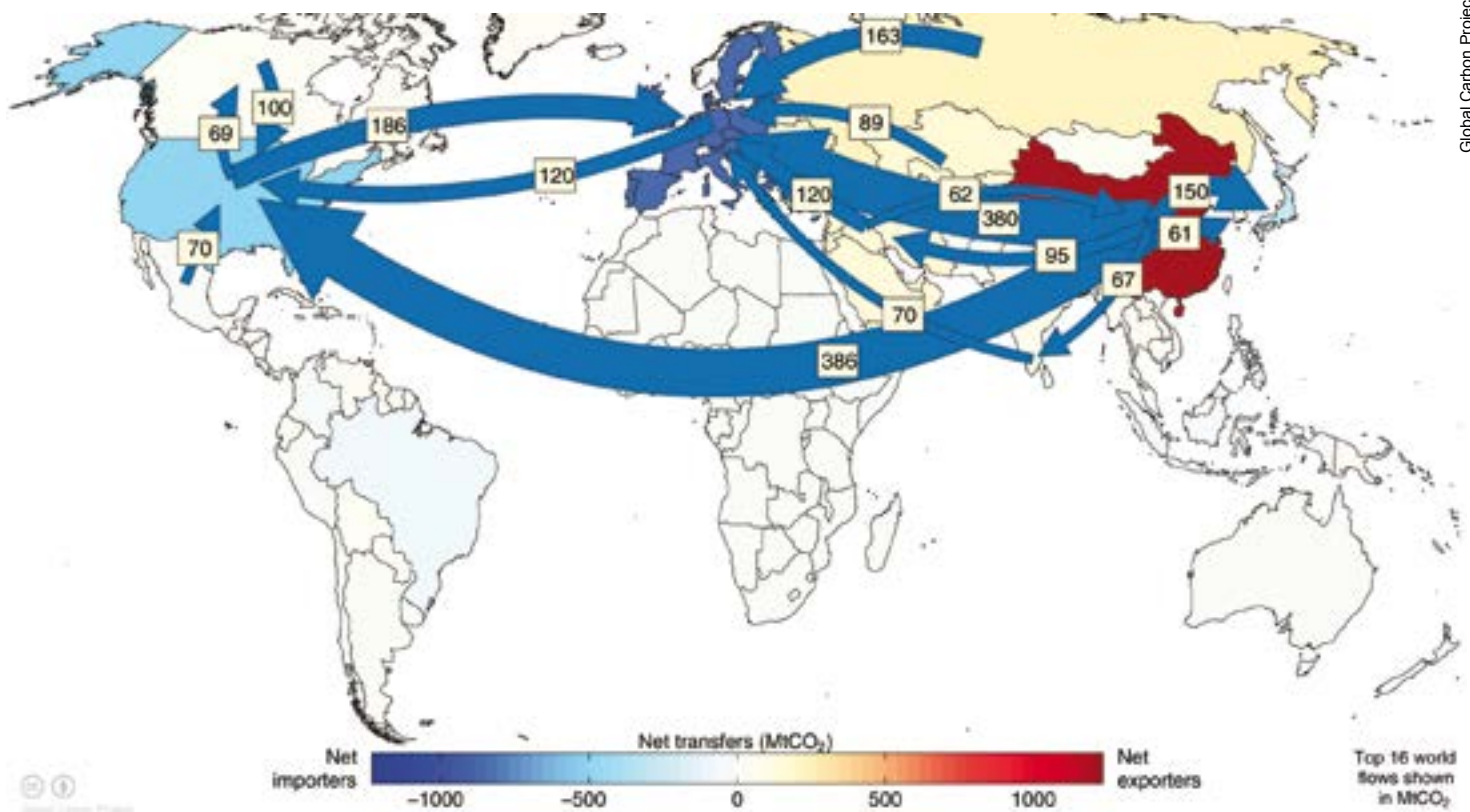
Put your data into column B

Multiply column B with column D

Write total in column E

Add up all the numbers in column E to get your carbon footprint

You can get kWh data for your gas and electricity from your bills. Oil and wood are in litres and tonnes respectively. You can either calculate the emissions for your whole household, or divide your home energy use by the number of occupants. The background assumptions about how diet impacts on carbon emissions could be an article by themselves, as could the factors relating to modes of transport. However a rough calculation is probably better than none at all, and for most of us the largest source of error probably relates to working out distances travelled by various means. A full set of emissions factors is available at the link below if you'd like to adapt the calculation. <https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2018>



carbon impact of a vehicle comes from the impact of building the factory in which the vehicle was assembled?). How widely we cast the net also makes a difference; when we undertake LCA we draw a system boundary, and ignore environmental impacts of parts of the process that are outside that boundary. It's also unrealistic to undertake LCA for systems that involve a lot of individual items; for example we wouldn't want to have to list every physical item purchased by the NHS if we were analysing its impacts.

The alternative approach is to undertake a 'top down' calculation. We can take the total impact of a country, for example, and divide it by the number of citizens. This gets us round some of the problems described above for bottom up calculations, but other problems arise.

The principal issue is that it's not possible to do calculations for specific objects, just general sectors or geographic regions. This is a feature of the methodology; the usual technique is to use 'environmentally extended input-output analysis'. In this, tables are constructed of the financial inputs and outputs from each sector of the economy into and out of every other

sector. Carbon emissions from each of these sectors can then be incorporated into the table, and by use of matrix algebra we can calculate the total impacts of goods and services in an economy, and how changes in one sector impact on others.

These analyses get done at different scales. Global approaches allow us to take the emissions of the entire planet and to see how the flows of goods and services between countries are tied to environmental damage. Within regions and sectors, these analyses allow us to determine the total impact of economic sectors. Whilst most commonly done for carbon emissions, it is also possible to analyse different environmental metrics in the same way.

Production of stuff – whose emissions are they?

Lots of our goods are produced in other countries. Are we responsible for these emissions, or are they the responsibility of the country in which they are produced? Hopefully, we would agree that they are our emissions; if I choose to buy a mobile phone, then just because it has been produced in another country, the emissions associated with production are my responsibility.

However, this isn't the way carbon footprints are generally reported, either at individual or country scale. Because of the likelihood of double counting and the complexity of supply chains, the IPCC requires governments to measure and report on territorial emissions; the emissions occurring within our own country.

Since the UK is less of a manufacturing nation, our carbon footprints are actually rather larger than simply our share of territorial emissions. We can use the technique of environmentally extended input-output analysis (described above) to calculate our total 'consumption emissions'; these are our territorial emissions *plus* emissions from imported goods, *minus* emissions from exported goods.

When we look at consumption emissions at a global scale, we get a geographical perspective of the carbon impact of stuff. The map above shows the 16 largest flows (in Million tonnes of CO₂) across the globe. For the purposes of this analysis, the EU is taken as a whole. The two largest flows across the globe are the consumption emissions of goods produced in China and exported to the US (386 Mt CO₂)

Clean Slate 25

Carbon omissions: accounting for 'stuff'

A woman with short dark hair, wearing a red shirt, is working on a large array of green circuit boards. She is holding one board up, and many others are visible in the background, creating a sense of depth. The boards are densely packed with electronic components.

How should we account for imported goods as we work towards zero carbon? In this edited extract from CAT's *Zero Carbon Britain: Rising to the Climate Emergency* report, we look at how we can measure and reduce the impacts of goods and materials produced outside our borders.

It is widely assumed that decarbonisation is basically an energy problem. From a world perspective it is true that greenhouse gas emissions (GHG) arise principally from burning fossil fuels but, from a national point of view, direct energy emissions might account for little more than half the total depending on what we define as 'our emissions' – meaning those we are responsible for.

Whose emissions?

The table shows the effects on the total GHG emissions of the UK in 2016 by adopting various 'frames' of responsibility. There are good and bad reasons for choosing any of these frames but, broadly speaking, decarbonisation gets harder, and more expensive, as you move down the list. That is one reason why governments and most research institutions try to stick to the 'easy end' and assume that the rest will somehow be dealt with elsewhere. But these emissions do occur, and the responsibility has to be picked up somewhere. They are in fact 'carbon omissions' that need to be accounted for if we are to take the mitigation process seriously.

In CAT's Zero Carbon Britain scenario we have adopted a compromise frame, incorporating traditional 'production accounts' and international aviation and shipping, but not imports of goods and materials, or land use change abroad that would be attributed to our food consumption.

Land use change abroad

In some accounts, land use change abroad that is attributable to food consumption in the UK amounts to as much as 100 MtCO₂e per year, though our knowledge about the extent of this issue is incomplete.

It is a very complex issue, but it is estimated that the problem arises largely from consumption of livestock products within a globalised market – for example, clearing forests to rear cattle that we import and eat or to grow feed for UK livestock.

For this reason, the dietary changes and food importing rules in our Zero Carbon

2016 UK emissions (MtCO ₂ e)	Frame
383	Emissions from direct UK energy use.
473	All GHG emissions arising from UK territory, less carbon captured by soils and plants. Often called a 'production account' it is the basis of current international agreements on climate change (the UNFCCC's Kyoto Protocol) and official emissions targets and carbon budgets.
515	<i>All production GHG emissions, plus those from international aviation and shipping.</i>
784	Emissions associated with all goods and services consumed, including imports, minus exports. Often called a 'consumption account' or our 'carbon footprint'.
(up to) 884	All consumption emissions plus emissions associated with land use change abroad attributable to UK food consumption, sometimes referred to as 'indirect land use change'.

UK GHG emissions associated with various frames, and details of what the frames include. The frame used for our scenario is highlighted in *italics*. Data is taken from BEIS (2019) and Audsley et al. (2009).

Britain scenario – no imports of livestock or feed – can be considered to reduce indirect land use change effects to a negligible level.

The 'stuff' we import

In CAT's scenario, carbon emissions from imported goods are considered only by stating that our scenario must be part of a concerted global effort to reduce greenhouse gas emissions – the UK alone cannot 'solve' climate change. Other nations also have to decarbonise at rates and along trajectories coherent with their fair share of the global carbon budget. This means that GHG emissions associated with the production of goods that we import are accounted for globally.

However, it has been widely argued that allocation of responsibility for GHG emissions should not be on the basis of production, but consumption. In other words, the emissions from all goods and services should be allocated according to who consumes them and not from where they are produced.

This is bad news for wealthy countries like us that import a great deal of goods and commodities, but good news for countries that export large amounts, like China. Of course, whatever the accounting conventions, the total world emissions

remain the same – the national totals would just be allocated differently.

It could be asked then, if production accounts are good enough for current international agreements regarding emissions reduction, like the Kyoto Protocol, why quibble?

The argument, however, is that accounting based on production seems somehow unfair, open to abuse, and leaves a distinct impression of accounting fraud.

For example, on a consumption basis, taking net imports into account, we find that the UK has much higher emissions. Unlike production emissions, which have declined considerably from 818 MtCO₂e in 1990 to 503 MtCO₂e in 2017, consumption emissions have actually increased from 862 MtCO₂e in 1997 to 996 MtCO₂e in 2007 before declining in recent years to 784 MtCO₂e in 2016.

Since fairness is likely to be a key component of any international decarbonisation process, consumption as well as production emissions are important when considering nations' contributions to tackling climate change. Although we have not modelled it in our scenario, we can make some general suggestions about what we could do to decrease these emissions if we were to include our responsibility



Should we be aiming to manufacture more of the essential ingredients of a Zero Carbon Britain, like wind turbines, within our own borders?

for imported goods and still aim for zero carbon. For instance, the emissions associated with the import of food could be reduced from a potential 59 MtCO₂e to less than 1 MtCO₂e (assuming a decarbonised energy and transport system), which shows what can be done through a combination of reduction in demand, altered product choice, and increased domestic production.

Based on this example, a number of additional things could help us decrease the consumption emissions from the 'stuff' we import:

- Reducing how much we buy (or consume), whether it is produced at home or abroad.
- Encouraging long-life products, product-service systems, and much higher levels of reuse and repair. This would also reduce the demand for goods.
- Importing items with lower or zero greenhouse gas emissions, including alternative low or zero carbon materials – for example, bioplastics and composites.
- Increasing imports that would constitute additional 'carbon capture' – for example, the import and use of wood products. According to our rough calculations, current use of imported timber and wood products results in an additional 42 MtCO₂e captured per year. With more use of plant-based products in buildings and infrastructure, this could go part way to

'balancing out' additional emissions from imports.

- Producing more in the UK – domestic production of which the UK is entirely capable, but has systematically off-shored because production is cheaper elsewhere, could be reclaimed and increased once again. This might mean higher industrial energy demand, and perhaps more non-energy emissions. We might need to install more energy infrastructure and capture more carbon as a result. Fewer imports would, however, decrease fuel demand for aviation, shipping and UK distribution even further.

Having said this, with a somewhat de-industrialised economy deeply dependent on imports for finished goods and raw materials, rapidly increasing domestic production may be problematic for the UK. Furthermore, with higher emissions at the start of the decarbonisation process, we might fail to keep to a carbon budget that would give a reasonable chance of avoiding a 2°C global average temperature rise. The purchase of international credits might be necessary to aid the transition, or a re-assessment of geengineering options to remove CO₂ from the atmosphere may indeed have to be considered. Neither of these options, however, provide an alternative to decarbonisation – they would

simply 'buy us time'.

Using consumption accounting methods would almost certainly make it more challenging to get to net zero, but some of the changes mentioned here might be beneficial to the UK – for example, we might create more jobs by producing more at home.

There are many unanswered questions and, unlike the rest of our scenario, we have not quantified any of these effects or explored the possibilities. How much more energy infrastructure would we need? What are the options for low or zero carbon materials currently? Do we have enough land to capture sufficient carbon? How much might demand for goods reduce? These are areas we would love to look into in more depth, and will form important subjects for further research. [🔗](#)

Zero Carbon Britain: read the full report.

You can read CAT's *Zero Carbon Britain: Rising to the Climate Emergency* report online or buy your copy from our online shop at www.cat.org.uk/zcb. For news about our new Zero Carbon Britain Hub and Innovation Lab, aimed at helping turn climate emergency declarations into Zero Carbon Action plans, see news page 5.

References available on request.

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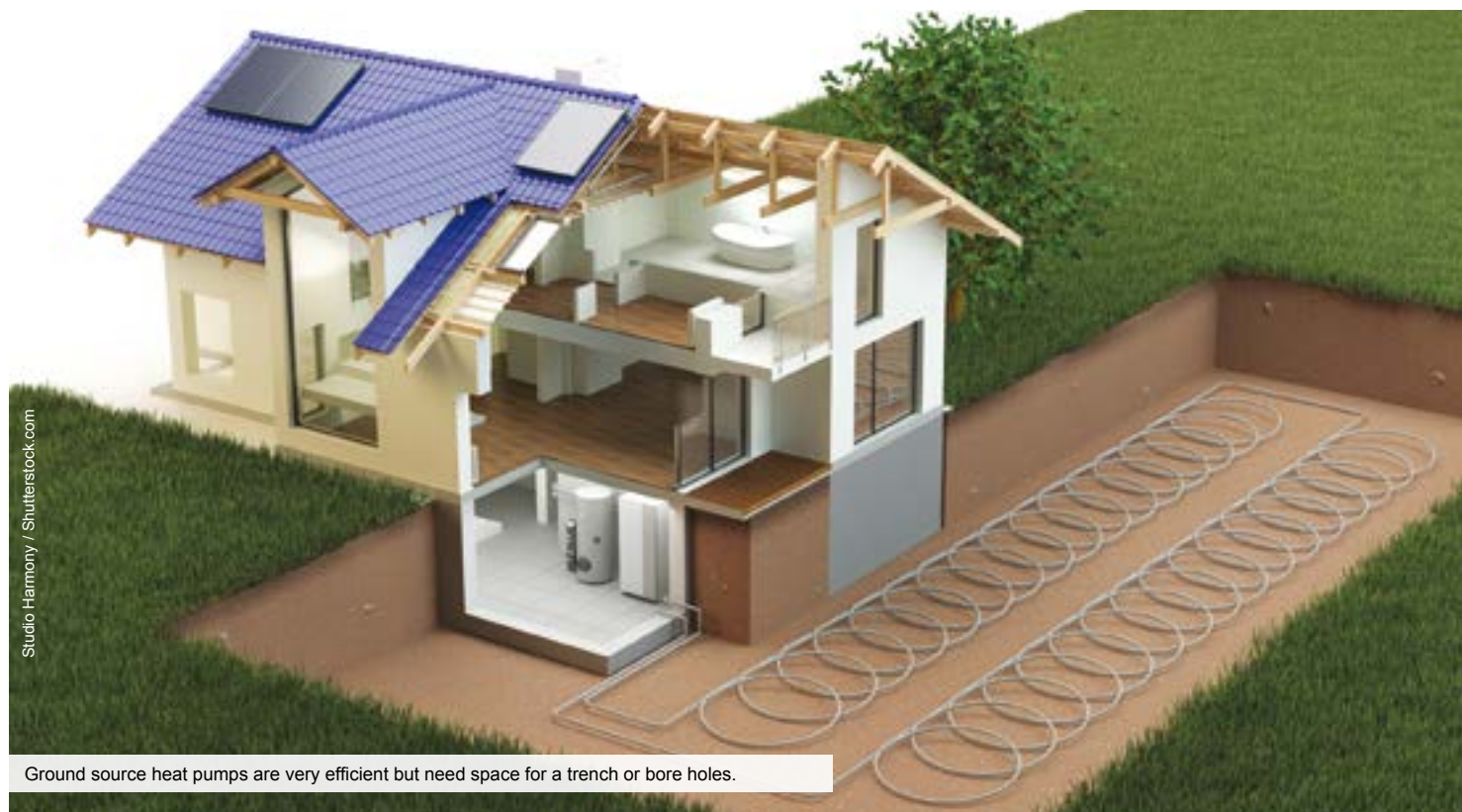
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More than hot air: why heat pumps could be key to a zero carbon future

Both CAT's Zero Carbon Britain scenario and the UK Committee on Climate Change's 'Net Zero' report focus on heat pumps as an important element in cutting greenhouse gas emissions. **Joel Rawson** gives us an overview of the technology and some advice for getting the most out of this low carbon heat source.



As interest in moving to a low carbon future grows, heat pumps are increasingly attracting attention as a low or zero carbon heating solution. They're a key part of CAT's Zero Carbon Britain scenario.

However, heat pumps are a very different technology to the boilers or electric heating we're used to. For them to be effective, it's important to have good information for consumers and training of installers. Here are some of the key issues to consider, and some resources that could be helpful.

What is a heat pump?

Although well established for cooling (e.g. in fridges and freezers), units for heating have also been around a long time. The CAT pioneers tried out early models back in the 1970s, in the Conservation House (now the Whole Home).

The physics is complex, and is based

on the vapour compression cycle, which some of the links below explain in more detail. In very simplified terms, heat pumps use electricity to boost a low source temperature up to the temperature required for central heating. The source temperature extracted from the air or ground may be below 10°C in winter, but in relative terms still contains lots of energy when compared to absolute zero (-273°C).

The most important thing to know is that the efficiency of a heat pump will drop – and electricity use increase – as the gap between source and delivery temperatures widens. So the key is to keep delivery temperatures as low as possible.

Are heat pumps a zero carbon choice?

The electricity to power a heat pump needs to be from zero carbon generation to be completely renewable. In Zero Carbon

Britain we propose heating most homes using heat pumps, via a green grid of wind, solar, and other renewables.

We also use heat pumps to help with energy storage in Zero Carbon Britain. With household hot water cylinders and larger heat stores in district heating systems we could store about 200 GWh (200 million kWh) of heat. This allows for 'demand side management', as we can use smart web-linked controls to charge water stores at times of day when electricity supply exceeds demand.

Even on the current UK grid, heat pumps are already a low carbon choice. Coal power stations are almost all phased out, while wind power has been growing rapidly. This has reduced carbon dioxide (CO₂) emissions to about 300 grams of CO₂ per kilowatt-hour (kWh), compared to over 750 grams of CO₂ per kWh back in 1990.

Using a modern gas boiler causes about

200 grams of CO₂ per kWh. So if grid electricity is used for standard direct electric heating, it would cause about one and a half times the carbon emissions – and be much more expensive.

However, a heat pump can use one unit of electricity to give three (or perhaps more) units of heat. That ratio means overall carbon emissions could be half as much as with a new gas boiler. The benefit is greater against heating oil, as this emits 30% more CO₂ per unit.

Hopefully you're already on a green tariff, but it's still important to minimise electricity use, and keep nationwide demand low. Using heat pumps means we can build far fewer wind farms than if we use direct electric heating.

How do I make my heating system suitable for a heat pump?

To keep the delivery temperature low, the best option is underfloor heating, which runs at about 35°C. When that's not feasible, larger or more radiators can be run at about 45°C – whereas standard radiators at 60°C or more will result in poor efficiency and high running costs. For these flow temperatures to work, you also need good insulation.

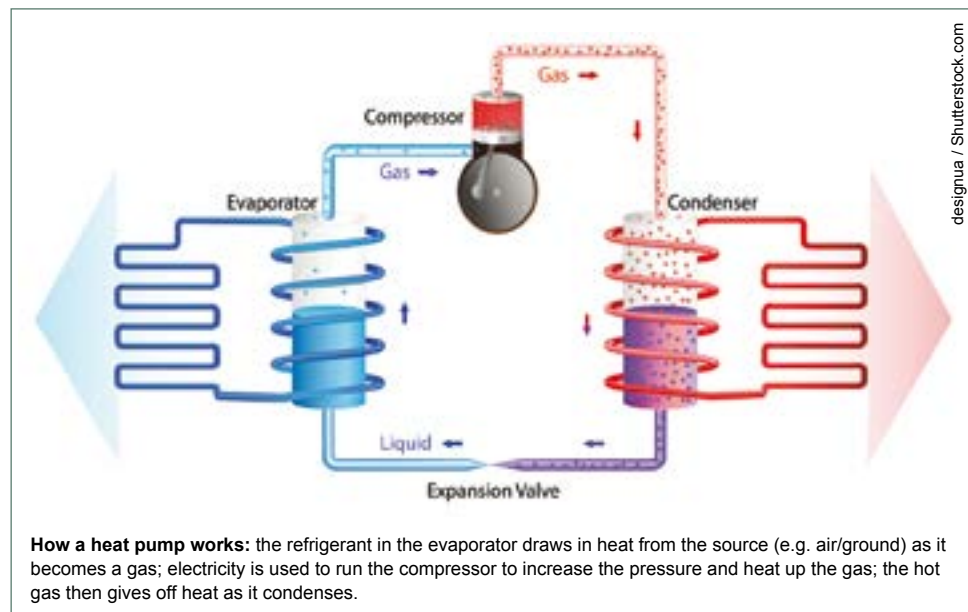
CAT's Zero Carbon Britain report highlights measures to improve insulation, draught-proofing and heating controls in order to reduce annual space heating demand from 10,000 kWh to 4,000 kWh for an average house.

Domestic hot water could add 2,000 to 3,000 kWh, and as this is at a higher temperature, efficiency is vital. As well as an efficient shower and taps, choose a location for the hot water cylinder that reduces pipe runs to sinks and shower(s). To reduce heat loss, keep pipe diameters as narrow as is possible while meeting the required flow rate.

Meeting a reduced annual heat demand of 7,000 kWh with a gas boiler would cause about 1.5 tonnes of CO₂ emissions. A heat pump on the current mix would emit only half as much carbon, reducing further as the grid decarbonises.

How do I choose an efficient heat pump?

A 'coefficient of performance' (COP) measures efficiency: a COP of 3 means one unit of electricity yields 3 units of heat (the other 2 units sourced from the air or ground). However, a COP excludes electricity for top-up heating (e.g. an



immersion) or other components. And the COP will vary – it may be 3.5 if supplying water at 35°C, but drop to 2.5 when supplying 55°C.

More useful is a seasonal performance factor (SPF) comparing heat output to electricity use across different weather conditions.

Heat pumps should all have a standard energy label (as with boilers and other appliances), giving standardised figures for performance to help you compare models.

For more detail, the Building Research Establishment (BRE) have produced an online tool that compares the seasonal performance of heat pumps, based on data for the UK climate. You can choose different heat pump models and flow temperatures and see an estimated SPF: <https://www.bre.co.uk/heatpumpefficiency>

Ground source or air source?

A ground source heat pump (GSHP) should be more efficient, because about two metres down the ground stays around 10°C all year round. You'll require an area of a few hundred square metres for trenches, or to drill one or two boreholes up to 100m deep. Soil type will be a factor – for example wet sandy soil is much better at holding and conducting heat than a dry soil.

In very low winter temperatures an air source heat pump (ASHP) will be less efficient than a GSHP, but they are much cheaper to install. And if you live somewhere with a mild climate, ASHPs can still perform well.

Some heat pumps supply warm air rather

than water, but warm air heating can be tricky to get right in older homes. Some houses built or renovated to a very high standard of airtightness (such as with a 'Passivhaus') can make use of a mechanical ventilation and heat-recovery (MVHR) system. Even with these, it may be better to have a small heat pump for hot water and some space heating alongside the MVHR, rather than combining the technologies.

How much will a heat pump cost?

Figures from the government's incentive scheme in recent years show an average installed cost of just over £8,000 for air source heat pumps of between 6 and 10 kilowatts (kW). About 70% of domestic ASHP installations in the RHI statistics were between 6 and 15 kW, with the average cost around £1,000 per kW.

For ground source, 70% were again in the 6 to 15 kW range, with an average installed cost of £1500 to £1800 per kW.

The average quoted is the median (middle) value rather than the arithmetic mean. This is to stop it being distorted by a small number of high cost installations.

What support is available?

At the moment a heat pump can't compete on installation cost with a gas or oil boiler, but support is available through the Renewable Heat Incentive (RHI) to get the UK heat pump market going (as happened with the feed-in tariffs for solar PV).

Ofgem's RHI pages have lots of resources and advice about eligibility and how to apply: <https://www.ofgem.gov.uk/domestic-rhi>



An air source heat pump is cheaper to install compared to a ground source one.

RHI payments are usually based on the heat demand from your home's Energy Performance Certificate (EPC), plus the heat pump's assessed efficiency. You must have metering of the heat pump's electricity consumption, but usually just to monitor performance. For a house with separate backup heating, payments will be based on metered use of the heat pump.

Ground or water source heat pumps currently get 20.89 pence per kWh of 'renewable heat', while air source heat pumps get 10.71 pence. These payments continue for seven years, increasing with inflation.

The 'renewable heat' figure is basically the total energy demand met minus electricity use, which means that the more efficient a heat pump is, the more you'll be paid.

The proportion you're paid for is calculated from the SPF, as $(1 - 1/\text{SPF})$. Or alternatively $(\text{SPF} - 1)/\text{SPF}$. For an ASHP with an SPF of 2.8, this gives $(2.8 - 1)/2.8 = 0.64$, or 64%.

Therefore, if the total heat demand is 7,000 kWh, you'd be paid for 64% of that, which is about 4,500 kWh. At 10.71p per kWh, that's just under £500 per year, for seven years.

You can calculate your own figures using the government's RHI calculator: <https://www.gov.uk/renewable-heat-incentive-calculator>

To get the most accurate results you'll need a current EPC for your house, giving figures for annual energy demand for space

and water heating, and a predicted SPF. Or the calculator has the option of estimating figures based on the type of house and insulation levels.

How do I choose installers?

You can find RHI-accredited installers through the Microgeneration Certification Scheme (MCS): <https://mcscertified.com/find-an-installer/>

The best thing to do is to get quotes from a few installers, and perhaps compare other options (like a pellet boiler/stove).

The Renewable Energy Consumer Code is linked to the RHI and MCS, and has some tips on comparing quotes: <https://www.recc.org.uk/consumers>

To help when choosing between quotes, see Ethical Consumer's report on 11 heat pump manufacturers: <https://www.ethicalconsumer.org/energy/shopping-guide/heat-pumps>


Although they generally get poor marks relating to workers in supply chains and the sourcing of 'conflict minerals' (e.g. in central Africa), the same is true for manufacturers of gas boilers and most other appliances. It's rare for any of these large companies to get more than 10 out of 20 on Ethical Consumer's scale. Clearly there's some way to go with moving towards international standards and agreements that will improve things. With Zero Carbon Britain we promote a 'just transition', with an equitable deal for workers, customers and citizens.

Further Advice

CAT renewable energy expert, Dr Alan Owen, is delivering our new one-day course on heat pumps in August - one of several new courses on domestic renewable energy options: <https://www.cat.org.uk/events/renewables-for-households-heat-pumps/>

John Cantor was advising CAT about heat pumps back in 1979, and his website has plenty of useful advice on current options. Although his book 'Heat Pumps for the Home' is currently out of print, it is available as an e-book: <https://heatpumps.co.uk/>

The Microgeneration Certification Scheme site mentioned above also has lots of documents available in the installers section. These may be of interest to those wanting more detailed information: <https://mcscertified.com/standards-tools-library/> (see for example product standard MCS 021, 'Heat emitter guide', for more on how reducing building heat loss and increasing radiator size will allow for lower flow temperatures).

See more on our information service webpages, or by contacting us via the website form or on 01654 705989. <https://www.cat.org.uk/info-resources/free-information-service/> 

About the author

Joel is CAT's Information Officer, providing free and impartial advice on a wide range of topics related to sustainability.



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Gifts our supporters leave in their wills are a vital part of our long term work. As an organisation we often reflect back over the last 45 years of progress and how our supporters have made that possible. However, we are constantly aware of the challenges that face us. Although we can see the impact of our work across the world in the movements that are now tackling climate change, we know that there are decades of work still ahead of us. By remembering us in your will you are helping us plan for this vital work which is yet to come.

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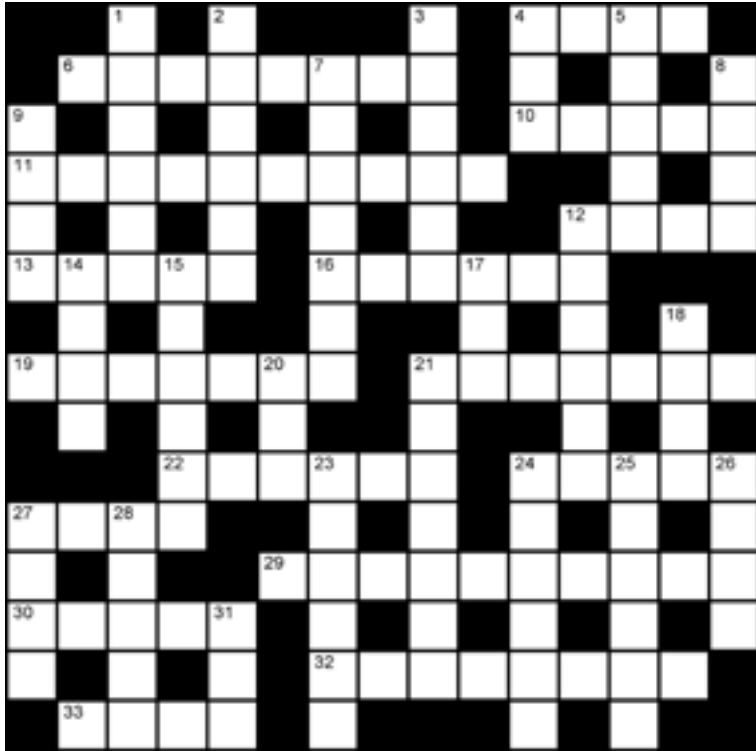
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without burning
fossil fuels

abundance investment > make good money

Cryptic crossword by Brominicks

<http://www.brominicks.wordpress.com>



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Please send your completed crossword entry by 30th March to *Clean Slate* Crossword, Centre for Alternative Technology, Machynlleth, Powys, SY20 9AZ.

Solution will be published in the next issue of *Clean Slate*.

Clean Slate 114 Crossword Winner: David Carter, Stockport

Across

- 4 Album concealed by butterfly expert (4)
6 Reversing long vehicle – arrived outside plant (8)
10 Sing McCartney's last song and Lennon's first (5)
11/2/23/8/18 An LP by chart toppers– blues legends? Not exactly! (3,7,6,6,4,4)
12 European knocking back most of French port (4)
13 Wimp out of final penalty shot, it's all over (5)
16 Outfit that is behind many singles (6)
19 See 30
21 George, he began photographing McCartney before they got together (7)
22 Carry-on in Bangkok reportedly leads to disorder (6)
24 Republican discharged from robust investigation (5)
27 See 4 Down
29 Husband gets out of removing stubble avoiding embarrassment (4-6)
30/19 Dialogue from 'Brief Encounter' used for Fab Four track? (5,7)
32 Flog hip-hop track about knight retrieving dragon's teeth? (4,4)
33/31 Artist finally leaves Tokyo to work with nothing on! (4,3)
- 5 It's used to distribute ballad Lennon penned (5)
7 Perfect kind of theatre production needs direction (7)
8 See 11 Across
9 Yesterday, a hit? Not the live version (1,1,1,1)
12 Group say Pete's not exactly keeping time (6)
14 *abcdefghijklm?* (4)
15 Composed and recited 8 (6)
17 Spring range over 25% off (3)
18 See 11 Across
20 Rise in salary – not what you'd expect to hear from cat (3)
21 Pete's upset with current manager (7)
23 See 11 Across
24 Contract shall not cover McCartney's latest song (6)
25 Paul and Ringo reformed, every other member of group missed John (6)
26 Supply skilled teacher (4)
27 1 of 4 American gents? (4)
28 Did nothing to secure large organ replacement (5)
31 See 33 Across

Clean Slate 114 Solution



Down

- 1 See 3
2 See 11 Across
3/1 He arranged merger to gain ground (6,6)
4/27A Change due after cheesy DJ oddly neglected No.1 (3,4)

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