

This is no ordinary white paper.

This is E.ON's plan of action to help solve the air pollution crisis.

It is printed on paper infused with titanium dioxide: a pure white compound with known 'pollution-eating' properties.

So the first thing our plan will do is help clear the air you're breathing now.

We hope you find it an absorbing read.

Contents

One.

Foreword

Two.

It's time to clear the air

Three.

Solutions for our transport network to help clear the air

Four.

Solutions for our homes to help clear the air

Five.

Solutions for our workplaces to help clear the air

Six.

Delivering at scale across cities and communities

Seven.

Sources

One.

Foreword



Climate change and air pollution are two of the biggest challenges facing the world today. Fundamentally they are similar issues: our behaviour as humans is poisoning the planet upon which we live and depend.

Addressing the challenges of climate change has rightly been a major focus in recent years. There is an increasing awareness of the impact that a changing climate will have on the way we live our lives, not just in the UK but around the world. Like climate change, the deteriorating quality of our air is an issue we often can't see, smell or taste, but is something to which we all contribute.

These are global issues but ones where individuals and organisations can make a real difference – and I believe it is

for our industry to make it possible for them to do so. Because energy is at the heart of solving both problems. We need to change how we power our homes, businesses, communities and transport systems.

Industry and governments can help people and organisations to play their part, and we at E.ON are focused on what we can do to enable this, by finding and applying the energy solutions for customers that will help make the air cleaner.

Urgent action is needed. The World Health Organization has declared that air pollution poses the greatest environmental threat to global health in 2019¹, a view supported by Public Health England, whose March 2019 review² cited air pollution as the biggest environmental threat to health in the UK.

The clean air crisis is a much bigger public health risk than smoking or drinking, which does not discriminate in terms of age or lifestyle. Towns and cities across the UK are exposed to levels of air pollution which breach the legal limit.³ There is also a clear correlation between income and access to clean air where our most deprived communities are often those that are most impacted by air pollution.⁴ The link between income and access to clean air means social justice is a core element of the policy solution.

The issues of combating climate change and promoting cleaner air are linked, as our reliance on fossil fuels to power our homes, our workplaces and our transport systems is one of the major drivers of air pollution.⁵

In our towns and cities road transport is a major contributing factor and, within that, diesel vehicles. Nearly 40% of all NOx emissions within London come from diesel vehicles.⁶ Without a fundamental shift in how we move people and goods it will be impossible to make our air cleaner and to reduce air pollution levels down to legal and healthier levels.

We welcome the UK Government's Clean Air Strategy, just as we do Parliament's historic decision earlier in the Summer to enshrine a 2050 net zero target into law. But this is only the starting point and much more action will need to be taken if we are to have a future where everyone has the right to unpolluted air.

Transforming the status quo means people changing how they live, work and move. In order to achieve significant change and make a real impact to cleaning the air, industries and governments need to come together on a way forward.

There will be tough choices and trade-offs. For example, there is little point switching to electric vehicles or heating systems if the extra power demand is met by fossil fuel sources. We must therefore finish decarbonising the electricity system to unlock the opportunity this can provide for improving local air quality. In addition, we must look to ensure we develop policies to support this transition which avoid

imposing unacceptable price rises for consumers and businesses.

Air pollution – whether it's caused by road transport, housing or manufacturing – does not respect political or institutional boundaries. This means solutions need to be delivered by policy and

action at a national or even European scale. However, we can all make a difference through action at a city level, at a business level and even at an individual level.

E.ON is already taking steps to make it easier for domestic and business customers to make that difference – at home we support them with installing solar panels, batteries, heat pumps and electric vehicle charging facilities as well as helping them to improve their own energy efficiency, so they use less power. At a city level we are the UK leader in district heating schemes which provide a lower emission, more efficient supply of heating and hot water, often to entire communities.

And we're working with our industry partners to make buildings smarter and more intuitive, to allow businesses to take control of their energy – producing it themselves and even taking an active part in helping to run the energy system more efficiently – as well as making charging an electric vehicle possible for everyone.

On the supply side we have committed to providing our customers' homes with electricity backed 100% by renewable sources,⁷ helping to drive further investment in cleaner generation for the UK's energy system.

However, there is much more that needs to be done to make the air cleaner. This will require a comprehensive approach across local, regional and national governments. At its heart must be a fair and just programme so everyone can take action. This will require additional public spending alongside regulations that help to address the worst polluting areas and to send clear signals to the market over the need for new innovative products.

Michael Lewis,
E.ON UK Chief Executive



Two.

It's time to clear the air



Clean air is a matter of life and death. Citizens across the globe are currently exposed to dangerous levels of pollution.

The State of Global Air⁸ report this year suggests one death in ten worldwide is caused by air pollution-related disease, making it a bigger killer than malaria and road accidents.⁹ In Asia, children can expect to have their lives shortened by 20 months because of pollution.¹⁰

Air pollution has a significant effect on public health, and poor air quality is the largest environmental risk to public health in the UK, associated with asthma, heart disease, even elevated levels of psychosis and ranking only after cancer, heart disease and obesity.¹¹ We know from studies that long-term exposure to air pollution reduces life expectancy, mainly due to cardiovascular and respiratory diseases and lung cancer.¹²

However, Public Health England also highlights that even short-term exposure to elevated levels of air pollution can cause a range of health impacts including effects on lung function, exacerbation of asthma, increases in respiratory and cardiovascular hospital admissions and mortality.¹³

Air pollutants are emitted from a range of both man-made and natural sources. A range of sectors, including transport, industrial processes, energy generation and domestic heating, can all have a detrimental effect on air quality.¹⁴

Tackling this can deliver significant positive health benefits for society. The UK Health Forum and Imperial College London, in collaboration with Public Health England, developed a model that estimates a 1 µg/m³ reduction in fine particulate air pollution in England could prevent around 50,900 cases of coronary heart disease, 16,500 strokes, 9,300 cases of asthma and 4,200 cases of lung cancer over an 18-year period.¹⁵

The scale of the problem¹⁶

It is estimated that **long-term exposure to man-made air pollution in the UK** has an annual effect equivalent to:

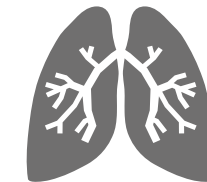


28,000-36,000 deaths

Over the following 18 years a **1µg/m³ reduction in fine particulate air pollution in England** could prevent around:



50,900 cases of coronary heart disease
16,500 strokes



9,300 cases of asthma
4,200 cases of lung cancer

Particulate matter (PM) and nitrogen dioxide (NO₂) are both major components of urban air pollution.¹⁷ PM is a generic term used to describe a complex mixture of solid and liquid particles, some of which are emitted directly whilst others are formed in the atmosphere through complex chemical reactions. The composition of PM varies greatly and depends on many factors, such as geographical location, emission sources and weather. The main sources of man-made PM are the combustion of fuels (by vehicles, industry and domestic properties) and other physical processes such as tyre and brake wear.

Pollutants can travel long distances and combine with each other to create different pollutants. Emissions from distant and local sources can build up into high local concentrations of pollution.

NO₂ is a gas that is produced along with nitric oxide (NO) by combustion processes. Together they are often referred to as oxides of nitrogen (NO_x). Defra estimates that 80% of NO_x emissions in areas where the UK is exceeding NO₂ limits are due to transport,¹⁸ with the largest

source being emissions from diesel light-duty vehicles (cars and vans).¹⁹ Other sources include power generation, industrial processes and domestic heating.

Primary particulate matter (PM_{2.5}) are tiny particles from smoke, soot and dust that can get into the lungs and bloodstream, transported around the body and embedded in organs. Those more likely to be affected are people already suffering from lung and heart conditions, elderly people, the very young and pregnant women and their unborn babies.

Eight out of ten people in the UK now live in cities,²⁰ with around 13%²¹ of the UK population living in the capital. Urban populations are likely to continue to grow, meaning the challenge facing governments at national and local levels is ensuring these cities are sustainable and, equally, liveable.

In this report we have chosen to focus on two of the main pollutants, primarily driven by home and business energy use and road transport: nitrogen oxides (NO_x) and fine particulate matter (PM_{2.5}).

On the positive side, we have seen reductions in both of these areas since 1970. Nitrogen oxides are down in the UK by more than 70%, whilst fine particulate matter is down by almost 80%.²²

While this is good news, there is still much more progress that needs to be made over the coming years, and we all have a role to play.

Energy producers can lead the way by replacing fossil fuels²³ with renewables and low carbon clean power. Solar and wind capacity has grown considerably in the UK over the last decade, and in 2018 the energy capacity of renewables in the UK overtook fossil fuels for the first time.

Homeowners and landlords can play a role in decarbonisation – through greater electrification – for millions of homes in the UK, particularly those which currently use liquified petroleum gas, coal or oil as their primary heating source. They can save money and help the environment with ever greater standards of energy efficiency, better heating controls that save on fuel bills and give greater comfort, more cost and carbon efficient heating systems, as well as domestic solar and battery storage.

Lastly, the business community can also be at the forefront of solutions. The built environment sector is responsible for approximately 40%²⁴ of the UK's carbon emissions each year meaning there are potentially significant reductions which can be achieved for example by embracing smart controls, waste heat recycling, on-site generation and flexibility, and efficient design.

Three.

**Solutions for our
transport network to
help clear the air**



The transport sector is a major contributor to poor air quality. More than half of NOx emissions in the UK come from transport,²⁵ mainly road traffic exhausts, and around a fifth of Fine particulate matter (PM_{2.5}) is transport derived.²⁶

The Committee on the Medical Effects of Air Pollutants estimates 29,000 'equivalent' deaths each year are related to exposure to PM_{2.5} in the UK – a figure this increases to 40,000 when considering the related effects of NO₂ (RCP 2016).²⁷

In the past three decades, there has been progress in reducing transport related air pollutants, but more work needs to be done.

Fundamentally addressing the challenge of transport pollutants will require a range of solutions.

First, we need to do more to enable people to avoid the need to travel in the first place but, where it is unavoidable, inform people on how they can avoid key areas during peak periods. Fewer vehicles on the road will produce lower emissions, partly as a result of easing congestion levels, which will help reduce the direct emissions from a vehicle.

“
Between 1990 and 2016, emissions fell continuously across the European Economic Area
”

Source: European Environment Agency²⁸

Secondly, a shift will be required towards more sustainable modes of transport – moving people out of cars where feasible with much more focus on walking, cycling and public transport.

The third area is to improve the environmental performance of the vehicles on the road, so they emit much lower levels of pollutants into the atmosphere.

Transport pollutants are down*

Source: EEA²⁸

| | |
|------------------------|------------|
| NOx down | 41% |
| SOx down | 63% |
| CO down | 86% |
| NMVOCs down | 87% |
| PM _{2.5} down | 40% |

* Nitrogen Oxides, Sulphur Oxides, Carbon Monoxide, Non-methane volatile organic compounds, Particulate matter 2.5

1. Scandinavian cycle lanes



The cleanest form of travel is walking or pedal power. Although great progress has been made with the cycle super highway in London, the UK has traditionally lagged behind its European neighbours in promoting cycle travel and there is scope for considerable improvements to be made. In Copenhagen, for example, urban roads are commonly designed with three lanes: for motor vehicles, pedestrians, and a raised or demarcated cycle lane. It is possible to travel from the scenic Nyhavn port to Hellerup in the north of the city entirely on cycle lanes. Copenhagen's wider transport network supports bikes too: commuter trains operate special cycle-friendly carriages.

Taking a bike on the Copenhagen underground is encouraged during normal hours, and is inexpensive. Similar approaches are taken across Scandinavia, creating a bicycle-first culture for families and commuters, even in inclement winter months.

JOURNEYS BY BICYCLE

Source: CIVITAS 2016²⁹

| | | | |
|-------------|------------|---------|-----------|
| Copenhagen: | 30% | Paris: | 3% |
| Odense: | 27% | London: | 2% |
| Amsterdam: | 22% | Warsaw: | 1% |
| Berlin: | 13% | Madrid: | 0% |

2. Electrify the trains



According to the Institution of Mechanical Engineers, the UK's share of electrified railways is 42%.³⁰ The rest of the fleet predominantly runs on diesel. The UK government has a goal of removing diesel trains by 2040 and yet in 2017 cancelled a number of electrification programmes.³¹

The cost of converting to electric trains is low by transport standards. The electrification of the 2,250 single track East Coast Main Line cost £671m (adjusted for 2018 values) over seven years. The result was a faster, cleaner, and more popular service: passenger revenues rose by 30%.³²

A recent report by the Railway Industry Association suggests electrification can be done for 33-55% lower cost compared to previous upgrades.³³ There is also the potential to replace diesel with hydrogen in certain rural routes, according to the Institution of Mechanical Engineers.³⁴

To promote cleaner air, and improve the rail service for all users, a commitment to re-engage with electrification is the only logical move, allowing passengers to reach their destination far more quickly.

3. Promote electric vehicles



Promoting a switch to low-emission vehicles will reduce both carbon and air pollutant emissions from the transport sector. We anticipate there will be exponential growth in battery electric vehicles and hybrids over the next few years, provided that the Government continues to nurture this emerging technology until the capital cost of these vehicles is comparable with their petrol or diesel equivalent and that a viable second-hand market grows to support demand for used electric vehicles.

This is expected to be realised by the middle of the next decade.³⁵ However, consumer adoption of this new technology is sensitive to the incentives available today, given the current price premium. For example, the sales of new hybrid vehicles halved in June 2019 compared to June of the year before,³⁶ which has been attributed to the premature withdrawal of a £2,500 subsidy. Ongoing state support for EVs will provide greater reassurance to purchasers.

Furthermore, there should be provisions to ensure all new homes are built with smart charging units as standard, with no exemptions. Interoperability between 'rival' charging networks is essential to make the transition simple for customers and a public campaign to educate the public about the return on investment with an EV would pay dividends.

Norway has shown how a supportive fiscal regime can help significantly drive demand for electric vehicles. Almost half of new cars sold in the first six months of 2019 were fully electric, up from a quarter in the same period the year before. Norway will prohibit the sale of all petrol and diesel vehicles by 2025 and is successfully using tax incentives to promote the switch.³⁷

Closer to home, regional leaders including mayors and city leaders³⁸ have backed calls to phase out the sale of new diesel and petrol cars and vans by 2030, rather than the current national target of 2040. Bringing forward the date to 2030 is perfectly feasible from an energy systems perspective, given how the system is becoming smarter and more flexible.³⁹

Faster charging installations will need to be supported by on-site generation and large-scale battery storage so the demand from customers can be reliably met without impacting the efficient operation of the energy system. The approach will also involve increasing the availability of charge points so the public has confidence they will be able to access them. This is a confidence factor that exists despite the relatively short distance of most journeys.

There will be a role for strategic national charging infrastructure but this does not mean all installations have to be ultra-fast charging. A mixed approach will be required, including the

ability to charge at work during the day and at key destination points such as car parks and shopping centres. Meeting the growing demand will therefore require the engagement of various stakeholders including local authorities, universities, NHS Trusts and, from a business perspective, property owners,

landlords, fleet managers and developers.

Finally, there is the prospect of electric vehicles acting as a balancing element for the energy system.

Smart charging points will identify when to charge the batteries, and when to draw power from them, to smooth out demand.

During times of peak power demand, electric vehicles will have the capability of feeding energy back into the grid. E.ON is working with Nissan⁴⁰ on a strategic project involving up to 1,000 EVs using bi-directional charging technology, installed at businesses across the UK.

4. The role of data analytics



The city of Boston, Massachusetts, wanted to encourage commuters to switch from cars to trains. In theory, the rail lines are conveniently located for a huge number of commuters – yet Bostonians seemed reluctant to embrace rail and free up the roads.⁴¹

A team set out to discover the reason using big data analytics, through a journey planning app installed on smartphones to collect anonymised data on the journey of each commuter. The data pointed to a clear problem between where commuters lived and their journeys to the rail station: a lack of viable transport options from home to station meant many potential rail commuters simply stuck to their cars. The Boston authorities could thus address the issue by commissioning more buses to the train station through the commuter belt.

Beyond Boston, big data analytics can be used to improve the attractiveness of public transport and improve the efficiency of the road fleet. Traffic control systems that are linked to air quality monitoring and forecasting could also be used to give priority to low-emission vehicles, vary speed limits and direct traffic away from congested and polluted areas. These could then be directly linked to smart apps to inform and help passengers take proactive action.

The associated reduction in braking, acceleration and stop-start driving will improve the emissions performance of those vehicles.

Suggested transport policies to help clear the air

Immediate focus on tackling roadside emissions

- Provide clean and affordable public transport so there is genuine choice which can help reduce the volume of traffic on roads.
- Use air quality monitoring data to create Clean Air Zones across the UK.
- Exemptions from Clean Air Zone charges should be limited to battery electric vehicles.
- Vehicle scrappage scheme should be targeted at the worst polluting vehicles with greater levels of financial support provided for battery electric vehicles.
- Incentivise 'final mile' delivery companies to use low emission vehicles.

Bring forward the ban on petrol and diesel vehicles to 2030

- Tighten emissions standards on manufacturers during the 2020s to significantly ramp up sales of battery electric vehicles.
- Consider placing volume obligations on vehicle manufacturers to support this ambition.
- All new homes should have smart charging units as standard with no exemptions.
- Deliver on interoperability so that customers can charge their vehicles at every public charging point on a pay-as-you-go basis.

Promote electric vehicle uptake

- Grant support to reduce the upfront cost of battery electric vehicles and home chargers should not be reduced any further until the forecourt costs of electric vehicles are comparable to petrol and diesel vehicles.
- To help enable low income households to buy low emissions vehicles, additional funding may be required to overcome those barriers.
- Fuel Excise Duty should be replaced with a tax regime that encourages fewer miles to be driven and the adoption of vehicles that have less of an impact on local air quality.

Increase the availability of second-hand electric vehicles

- Maintain the current levels of incentives to increase deployment of electric vehicles on company car fleets over the next five years, including favourable benefit in kind tax benefits for zero emission vehicles. This will help increase the future supply of the second-hand market.
- Clearly signal, through regulation, the requirement for businesses to provide workplace charging: this would allow the current tax incentives to be gradually phased out.

Innovation

- Set up an innovation fund to encourage new designs that reduce or eliminate the particulate matter which is created by brake dust and tyre wear.
- Accelerate the electrification of trains and investigate the potential role of hydrogen to replace diesel, as advocated by the Institution of Mechanical Engineers.

Four.

**Solutions for
our homes to help
clear the air**



Homes account for 28% of all UK energy demand,⁴² putting them on the front line in the push for lower emissions.

The connection between air pollution and the energy we use at home or work isn't always obvious. Nevertheless, the way in which we heat our homes can ultimately impact local air quality. One of the principal forms of indoor air

pollution is particulate matter (PM) which is produced by many forms of home heating. The increasing popularity of burning solid fuels in our homes is having an impact on our air quality and is now the single largest contributor to PM emissions.

However, the dominant form of heating in the UK is gas boilers, fitted in the vast majority of the UK's 28 million homes.⁴⁴

NOx emissions are produced from gas boilers and from September 2018 the Energy-related Products (ErP)⁴⁵ Directive set a maximum NOx emissions level for natural gas and LPG boilers of 56mg/kWh, with a higher limit of 120mg/kWh applied to new oil-fired boilers; however, older heating systems will typically emit much higher levels of NOx.

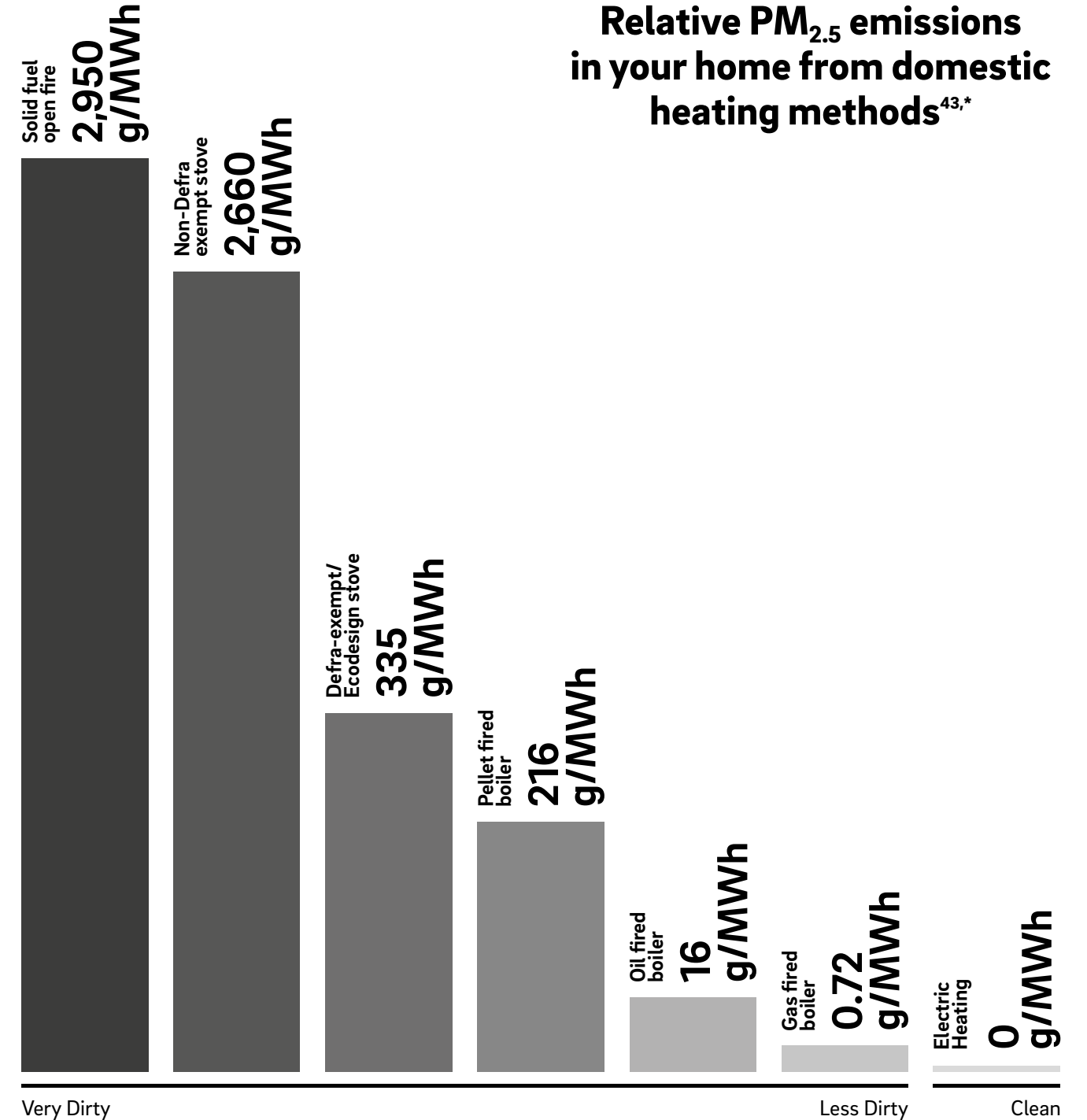
Around half of the UK's electricity demand is still met by fossil fuels,⁴⁶ so turning on a light or using a hairdryer adds incrementally to the UK's need to generate. And almost every time anyone takes a shower the water is heated by a gas boiler, which emits NOx gases.

Improving the energy efficiency of millions of houses, and transforming how we live in them, will translate to a direct lowering of NOx, CO₂ and other pollutants.

Put simply, our homes are often the problem. The Committee on Climate Change's latest progress report to Parliament stated that "all of the key buildings policy gaps identified in our 2018 progress report remain unaddressed or only partially met".⁴⁷

However, there are available solutions to the challenges presented by our current housing stock. Here are the main obstacles to lowering the impact on air quality caused by Britain's houses, and how they can be overcome.

Relative PM_{2.5} emissions in your home from domestic heating methods^{43,*}



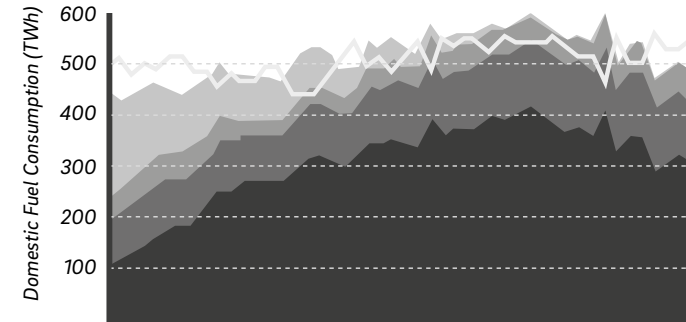
Challenge

1. Waste less heat

There are more than 28 million homes in Great Britain, of which about 20 million have cavity walls, 8.5m solid walls and 24 million have a loft.⁴⁸ The uptake of energy efficiency measures over the last couple of decades has made a significant contribution to the fall in gas demand since the early 2000s, with 70% of properties with a cavity wall and the large majority of lofts having insulation. Thicker loft insulation can cut heating consumption by 2%, whilst cavity wall insulation can deliver a further 7% saving and solid wall insulation can reduce consumption by around 12%.

However, there is limited funding available to help some groups of customers install insulation measures. E.ON, for example, offers free-of-charge installation of cavity and loft insulation to eligible customers, as part of the Affordable Warmth Scheme.⁵²

It is clear that further action is needed to ensure that the existing housing stock is fit for the 21st century with modern levels of comfort. Taking action to improve the fabric efficiency of buildings will directly reduce air pollutants arising from the existing heating systems of those buildings as a result of reducing heating demand whilst still meeting the desired level of comfort.



Final domestic energy consumption by fuel.

Source: Energy Consumption in the UK, BEIS 2018⁴⁹

- Natural Gas
- Electricity
- Other
- Solid Fuels
- Mean Temperature

However, there remain considerable opportunities to improve the fabric efficiency of the existing building stock. At the end of 2018, only 70% of properties with a cavity wall were insulated, leaving around 5 million cavity

walls remaining to be insulated and, whilst most households have some degree of loft insulation, only 66% of homes have insulation of 125mm or more.⁵⁰ Very little progress has been made in installing solid wall insulation with less than 10% of the housing stock completed.

Over the last year, progress has stalled. In its 2019 progress report to Parliament, the CCC highlighted only 43,000 loft insulation measures had been installed against a target indicator of 545,000 measures. This picture is repeated for new cavity wall insulations (82,000 actual vs 200,000 target indicator) and solid wall insulation (18,000 actual vs 90,000 target indicator).⁵¹

Challenge

2.

Promote low-emission sources of heating

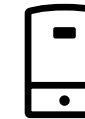
Heating our homes is the main cause of pollution associated with housing

Switching to more efficient and alternative sources of heating can make a big impact on air quality but the issue here is one of scale. By far the majority of homes in Britain have a gas boiler and either improving the efficiency of individual units or replacing them with something altogether more efficient will take significant effort and time.

Improving the energy efficiency of individual homes and heating systems can play a part in tackling issues around large scale emissions, local air quality and also fuel poverty. More efficient modern heating emits less and costs less to run.

The UK needs to do more to speed the growth of district heating networks at scale, both in new build developments, and where appropriate, retrofitted into existing communities. The 'no regrets' approach of district heating means a network is installed once, with just the single generation source evolving over time to make best use of newer, more efficient lower emitting technologies.

Inefficient boilers

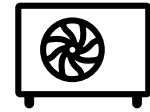


At an individual level, gas boilers will have little impact on air quality across a whole community – even though the worst G-rated boilers may be as inefficient as 30%. Nevertheless, this changes at a community level. The London Environment Strategy recognises that, whilst road traffic in Greater London contributed slightly more than half of London's NOx emissions in 2013, by 2020 nearly 50% of central London's NOx emissions will be from domestic and commercial gas.⁵³ Therefore, targeted measures to reduce the contributions from these sources will be important in continuing to improve air quality in London. The challenge in the short term is to accelerate the move from lower rated boilers to at least an A+ model. This isn't easy: the upfront cost of a replacement boiler can deter people – especially those in low-income households or rental landlords – who would otherwise stand to benefit in the long run.

Legislation is a proven way to improve standards in boilers. The Boiler Plus⁵⁴ legislation mandated all gas boilers manufactured and installed in the UK to have an efficiency rating higher than 92%.⁵⁵ Alongside this, the Energy-related Products (ErP) Directive required new boilers to comply with tighter NOx emission limits.

E.ON is offering discounted energy efficient A+ replacement boilers for anyone eligible under the Affordable Warmth Scheme. An estimated six million people could potentially benefit.⁵⁶

Heat pumps



Electrification of heating provides additional air quality benefits for householders. Heat pumps act like a fridge in reverse, these thermal heat exchanges draw energy from the surrounding environment – air, ground or even water – and often provide around three times more heat for each unit of energy used to power it.⁵⁷ They are growing in popularity: in Europe sales rose 13% in 2018, with 27,000 sold in the UK.⁵⁸ Furthermore, they are being increasingly incorporated into the designs of new district heating networks.

The Committee on Climate Change has recognised in its recent net zero report to the Government that there is an important role for heat pumps and hybrid heat pumps.⁵⁹ Innovation and large-scale deployment has the potential to reduce their cost, making them a realistic alternative for households and businesses.

Heat pumps can be particularly apt for larger, older buildings. In fact, Historic England advises: “Heat pumps are generally well-suited to historic buildings as they work efficiently when run on a constant low temperature, a method suited to buildings with thick masonry walls that are able to retain heat and release it slowly. This is referred to as having thermal mass.”⁶⁰

They provide a viable alternative to traditional heating systems, especially for homes relying on oil, coal and LPG heating, and operate most effectively in well insulated buildings. Heat pumps can also play a key role in the design of new housing estates as well as operating in a hybrid mode with gas as a transition to a lower carbon energy system. The 2019 Spring Statement set out the Government’s intention to introduce a 2025 Future Homes Standard which would prevent new homes being connected to the gas grid. Heat pumps will play a key role in helping housing developers comply with this standard.⁶¹ Increasingly heat pumps are being incorporated into the designs of district heating networks.

District heating



A way to avoid the inefficiencies of in-house boiler heating is to switch to district heating.

In this model, heat is produced in localised hubs or energy centres and sent via super-insulated pipes to single apartment blocks, a network of local buildings, or even an entire community. Production at scale is more efficient and, in some circumstances, heat can be captured from industrial and commercial processes, avoiding waste and the need for first-use generation.

Once the networks are built, the generation source within the energy centre can change as new technologies develop – and change more easily than retrofitting significant numbers of individual technologies in residential properties. For example, there are existing schemes which have moved from coal or oil to gas, biomass, biogas or even large-scale electrical heat pumps, further reducing emissions.

One of the ways London is looking to reduce its emissions is through new low or even zero-carbon developments like Elephant Park, just south of the River Thames in Elephant and Castle.

Its innovative combined heat and power energy centre – installed and operated by E.ON – is designed to run partially on biogas and aims to use 100% renewable gas by 2023. Solar panels on the roofs will eventually generate 3% of Elephant Park’s total electricity.

With 3,000 sustainably designed homes as well as shops and space for offices, it will also feature plenty of outdoor spaces and the city’s largest new park in 70 years, increasing the area’s beauty and offsetting carbon emissions.

Heating empty houses



The Energy Saving Trust is vocal about ending the habit of keeping heating on when no one is home.⁶² The problem tends to be basic human nature and a love of routine: households set heating schedules via a timer or to hit a fixed temperature, so the heat comes on whether it is needed or not. Individual radiator valves offer the chance to turn off the heating in unused rooms, but, again, these require active attention from householders.

Smartphone energy control apps bring intelligent micro-management to heating, for example connecting the homeowner's smartphone to a Wi-Fi-enabled thermostat to allow remote control of heat settings. Apps can use geolocation to identify if anyone is home – with the heating turning on automatically when the first person heads back home. Furthermore, smart radiator thermostatic valves make it possible to control the heat in each room of the house remotely.

Wood stoves cause dirty air



In the opening chapter of Bleak House, Charles Dickens wrote of London in the age of coal and wood fires: "Smoke lowering down from chimney pots, making a soft black drizzle, with flakes of soot in it as big as full-grown snowflakes gone into mourning, one might imagine, for the death of the sun... fog everywhere."

Domestic wood or coal burning stoves and open fires remain popular, present in one in ten UK households. It is estimated that these home fires cause 40% of the damaging particulate matter in the UK,⁶³ three times more than road transport.

Open fires are often an aesthetic choice as much as a heating one. Fires and wood stoves make a house feel like a home. However, education around the air pollution caused by such stoves could encourage homeowners to reduce the frequency of their fires, to lower the impact.

Education around fuel types is also needed; wet wood and coal pollute far more than seasoned, dry wood.⁶⁴ The Woodsure approved scheme guarantees logs have a moisture content lower than 20% – consumers may benefit from learning more about this scheme. The EU Ecodesign standards⁶⁵ for stoves, which come into force in 2022, raise standards, but there is an opportunity to impose even higher efficiency standards on stoves.

Challenge

3.

Switch to zero-emissions electricity

As we move to an energy system which is more electricity driven than in the past, it is important to ensure the way we produce electricity does not harm the environment from either a greenhouse gas or air quality perspective. The use of fossil fuels for generating electricity produces NOx emissions, which when combined with refineries makes up around 22% of the total NOx emissions.⁶⁶

Increasing the deployment of renewable generation capacity, both at an industrial scale and also on rooftops all across the UK, will help to reduce the residual demand for fossil fuel based generation, directly contributing to further reductions in NOx emissions over the longer term and across the wider geographical area.

Phasing out coal fired power stations by 2025 and continuing the path of decarbonisation of the electricity system to 2030 will help to play an important role in reducing the emissions of air pollutants. It is important for public policy to encourage the deployment of the most cost-effective renewable technologies such as solar, so that the significant uptake of solar we have seen from households since 2010 can continue into the next decade, allowing more customers to have an important stake in our future energy system.⁶⁷ Technology development is also allowing for more of the electricity produced by solar to be utilised within the home, as battery costs have fallen considerably over time.⁶⁸ Optimisation of solar panels will unlock further opportunities to reduce some of the key air pollutants.

The solution: with solar PV, houses are able to generate up to 30% more power than they typically use.⁶⁹ Domestic batteries from 2.4 kWh upwards can store power for use within the property at times more convenient to owners, increasing the potential and financial attractiveness of solar. In the absence of a Feed-in Tariff support system, some energy companies are offering householders the chance to sell excess energy to the utility provider for a profit. Meanwhile, Government proposals for a Smart Export Guarantee will re-introduce a financial support system for customers installing solar panels so that they receive a price for exporting any surplus electricity back to the grid. Additionally to that, new build housing developers should be encouraged to fit solar PV to ensure all new developments are future proofed, as is the case with the regulations in Scotland.⁷⁰

The solutions are here. Let's implement them.

Homes in Britain are improving, but more can be done to help them become more efficient, while contributing to cleaner air. Domestic energy consumption⁷¹ has fallen 17% from 2002 to 2017. The National Infrastructure Commission says 21,000 energy efficient measures should be installed a week.⁷² Progress under current Government energy efficiency targets is only 9,000.⁷³

“
Energy efficiency is vital to cutting the costs of energy for homes and businesses and is a cost-effective method of reducing our carbon emissions. In spite of this, and the inclusion of energy efficiency targets in the Clean Growth Strategy, the current rate of improvements to buildings is far too slow.

”
Rachel Reeves MP, BEIS Committee Chair⁷⁴

**Better boilers,
insulation, and
efficient design
can cut energy
demand by
14% by 2030.**

43% reduction in UK greenhouse gas emissions since 1990

Source: Committee on Climate Change, Reducing UK Emissions Parliamentary report 2018⁷⁵

Source: Committee on Climate Change, Reducing UK Emissions Parliamentary report 2018⁷⁶

Suggested housing policies to help clear the air

✓ Make energy efficiency a national infrastructure priority

- Increase the Energy Company Obligation (ECO) funding pot from £640m.
- We believe this can be funded by targeting Winter Fuel Payments at the most vulnerable members of society, meaning around £1bn is freed up to fund additional household energy efficiency programmes for the 'fuel poor'.
- Additionally, ring-fence part of the health and social care budget to proactively invest in making homes warmer, better insulated and with more efficient heating systems.

✓ Give people the opportunity to improve their homes

- To support the deployment of solid wall insulation and heat pumps, incentives should be made available to households to help reduce their upfront cost, such as via a fossil fuel heating scrappage scheme and stamp duty or council tax rebates.
- Energy investments supported through Green Mortgages, a 'Help to Improve' scheme to sit alongside 'Help to Buy', or a Government-backed investment ISA.

✓ Use standards to reduce fossil fuel heating demand

- Tighten private rented sector standards to better insulate homes and remove heating systems which cause the greatest impact on local air quality.
- Existing standards on new fossil fuel heating systems should be tightened during the 2020s to support the transition to alternative fuels which can deliver additional air quality benefits.

✓ Innovation

- An innovation fund will also be required to reduce the cost of external wall insulation and heat pumps.

Five.

**Solutions for our
workplaces to help
clear the air**



Solutions for our work places to help clear the air

Every week around 32 million⁷⁷ Britons go to work. The workplaces in which we operate have a key role to play in determining the quality of air that we breathe.

To improve the air we breathe it is vital that businesses as well as consumers follow some simple guidance that can be easily referred to as being lean, being clean, and being green.

Being lean



Businesses can contribute to lower emissions by using less energy. Clearly, there should be no action that compromises operational effectiveness or productivity within the business, but the first step should be to ensure operational efficiency to eliminate waste and unnecessary emissions.

This is particularly important for manufacturers, retailers, and other large-scale users of power.

A Building Management System (BMS) offers a unified software interface for controlling an office block. A BMS makes it easy to control all mechanical equipment, including lighting, power systems, ventilation, air conditioning, and heating. An analytics package will track potential savings, and then help deliver and monitor those improvements over time. Some buildings use sensors to identify locations where staff are working, so under-used zones can be shut down. An effective BMS can manage up to 95% of a building's energy consumption without the need for major equipment installation.⁷⁸ Marks & Spencer, with 600 sites nationwide, achieved a 34% energy reduction by implementing a lean philosophy based around a BMS, implemented in partnership with E.ON.

LED lights are a great way to reduce the dependency on fossil fuel-based generation. They typically consume 85% less energy than traditional incandescent lights.⁷⁹ However, the return on investment is a little more complex: LED bulbs are more expensive, but also last longer, typically between 10,000 to 15,000 hours. A longer operational life means lower maintenance costs – significant for enterprises with awkward fixtures, such as retail or warehouse space needing a cherry picker and team to replace bulbs.

Being clean



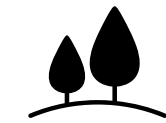
Being clean means switching to more environmentally friendly energy sources.

Not all are futuristic. Some, such as heat pumps, are relatively mature technologies, simply under-deployed by businesses. A heat pump can reduce heating and cooling costs, leading to direct savings, while it can also contribute to lower emissions of air pollutants.

As with domestic properties, district heating offers a step change for businesses able to access an existing network. Heat is created centrally and then distributed as hot water via super-insulated pipes. The economies of scale from centralised production make district heating an efficient, lower carbon solution that contributes to better air quality.

For large energy consumers in the 5 to 200 MWe energy range, such as manufacturers, paper mills, and chemicals plants, a combined heat and power (CHP) plant offers high efficiency and on-demand energy. CHPs burn fuel to generate power, and then recycles the heat waste for secondary purposes. Whilst not renewable in itself, a CHP plant can cut energy costs and could result in lower fossil fuel use, thereby contributing to an improvement in air quality.

Being green



The ultimate solution for air quality is to decarbonise entirely. Delivering net zero by 2050 will require fossil fuels to be practically eliminated.

Business can help, by switching to zero carbon technologies. Solar PV is practical for businesses with large areas such as roofs. The performance of solar PV is enhanced when it is integrated with a battery.

Electric vehicles are another important part of being green. For many companies, such as couriers, short journey and light-delivery missions are particularly suited. Businesses can help their employees switch to plug-in vehicles by taking advantage of the current tax breaks available. Benefit in kind, vehicle excise duty, capital allowances, and salary sacrifice regimes all incentivise electric vehicles. Calculations by a coalition of car manufacturers show that company car drivers can pay between £2,940 and £4,880 less tax over four years, depending on their tax bracket.⁸⁰ There are grants for installing charging points at commercial premises. The Workplace Charging Scheme grant, a voucher-based scheme, is up to £500 for each charging socket, up to a limit of 20.⁸¹

2 steps to get started

1. Appoint an internal energy champion

Appointing an 'energy champion' to take control of improving energy usage, ideally a senior manager or board member, can promote better behaviours in staff such as cycling to work or taking public transport. They can initiate investigations into leaner working practices and energy efficient control systems, and work with an energy partner to explore new avenues, such as electric vehicle charging points for staff, solar PV, heat-pumps, and the availability of heat networks.



2. Commission an energy audit

An energy audit for a company will provide a full run-down of energy operations, and the potential for efficiency upgrades. Experts, usually from an energy partner or consultancy, will review how the company functions, how it uses energy and monitors usage, and examine opportunities to install new technologies. An audit can unite disparate parts of the energy equation into a single, unified, whole. For example, advocating solar PV in tandem with a battery storage solution. Or studying the feasibility of installing electric vehicle chargers.



An audit will also take into account the individual circumstances of each business. When done right, an energy audit can result in lower bills, improved efficiency, and help for companies to embrace better technologies. Empowered by these factors, businesses can also help in the fight for cleaner air.

Suggested policies for businesses to help clear the air



• *Maintain current incentives on businesses to electrify their vehicle fleets.*



• *Use business rates to incentivise businesses to invest in energy efficiency and other solutions which enable them to take action and reduce emissions from their buildings.*

Six.

**Delivering at scale across
cities and communities**



Solutions for cities and communities to help clear the air

A collaborative approach to addressing air pollution is required.

All levels of government need to play their part and make cleaning the air a joint priority, given its serious, negative effects on public health and education, transport infrastructure, housing and business. Only a fully integrated approach which brings together planning, environment, transport and health policies along with citizens, communities and commercial priorities will be able to address the issue effectively.

To tackle this issue efficiently, it must be done at scale.

District heating schemes, for example, need planning consent, the co-operation of developers and energy partners, so-called 'anchor' customers from business or government and a policy framework designed to encourage the necessary commitment and investment from all.

Local authorities can influence planning requirements for new buildings to ensure that new buildings do not exacerbate, and potentially help to improve local air quality – for example, by mandating green infrastructure and encouraging more sustainable and active travel, car-free transport specifications or parking restrictions along with distribution hubs for delivery companies.

Measures to address air pollution can have many positive effects on other serious challenges. Studies⁸² show the positive effects of improved living conditions not only on chronic health problems, such as asthma, but also in educational attainment among children.

Inspiration for cities and communities tackling air quality can be found across the world

Cycle lanes in Copenhagen, Denmark

Copenhagen aims to become the world's best cycling city,⁸³ and policies have been introduced to reduce the need for private car usage and promote the use of bikes.



Commercial buildings are required to have 0.5 bicycle spaces per employee,⁸⁴ and residential developments 2.5 bike parking spaces per 100 square metres. The city currently has over 469 kilometres of cycle paths while new 'cycle superhighways' are being built to reach the suburbs. Focus is also placed on broader lanes, improved design of intersections and behavioural campaigns to help make Copenhagen a safer cycling city.

Through these kinds of initiatives, Copenhagen wishes to achieve a rise in the proportion of inhabitants feeling safe while biking from 67% in 2010 to 80% in 2015 and further to 90% in 2025.⁸⁵

Concurrently, Copenhagen has also discouraged private car use through a tax increase of up to 150% on new car sales (albeit with reduced amounts for smaller, less polluting vehicles).⁸⁶

As a result, cycling is on the up: 62% of commutes by Copenhagen residents are done by bike, as are 41% of trips into the city by workers and who live outside.⁸⁷

The world's largest air purifier in Xian, China

Like much of China, Xian can experience heavily-polluted air – particularly in the winter, with much of the city's heating relying on coal. Developed to find an effective, low-cost method to artificially remove pollutants from the atmosphere, the Xian Tower was built, with construction completed in 2018.⁸⁸



The tower is over 100m high, but it's at the base where the air-cleaning process begins. Polluted air is sucked into a network of greenhouses, and is then heated via solar energy. The hot air rises through the tower and passes through multiple layers of cleaning filters before emerging from the top.

Although the project is in early stages, improvements in air quality have been observed over an area of 10 square kilometres (3.86 square miles) in the city and the tower has produced more than 10 million cubic meters⁸⁹ (353 million cubic feet) of clean air a day since it opened.

Preliminary results show an average reduction in PM_{2.5} levels of 15% during periods of heavy pollution. And anecdotally, a number of locals say they have noticed a difference in the air quality,⁹⁰ even during the winter when the city is especially prone to pollution.

Hållbarheten in Malmö, Sweden

Hållbarheten (which translates into English as 'the sustainability') is one of the world's most ambitious pilot projects for future energy homes. The project was conducted during 2012-2016 and showcased how sustainable development can be at the heart of urban development, offering a future where clean air is available to all.



E.ON invested in an eight-family apartment building to test a variety of energy solutions. The heat for the building came from three sources: a high-efficiency electricity-driven heat pump, an innovative gas-driven heat pump and district heating. These solutions were all integrated with local generation through solar collectors that also provide the heat for the pool and ground heating. A wind turbine and individual solar panels provided each apartment with its own locally produced renewable electricity.

Transport was also factored into the design. Electric vehicles and e-bikes were made accessible. Smart home devices made it possible for homeowners to control appliances remotely and schedule activity, to reduce energy usage. Each apartment was equipped with over 100 metering points that provided detailed feedback on individual consumption of heating, electricity and tap water – along with the means to actively improve energy efficiency.

The project validated the model of sustainable urban development and led to the commercialisation of products and services that are on the market today.

The neighbourhood solution: ectogrid

When neighbouring businesses work together to balance their energy consumption, remarkable things can happen. E.ON's ectogrid connects energy users in the same neighbourhood, sharing their heating and cooling. For example, a bakery that would otherwise waste the heat from ovens can input that energy into the ectogrid for use elsewhere where the heat is needed. Buildings can make energy 'deposits' or 'withdrawals' from the grid, balancing the energy demands across buildings and eliminating the need for separate businesses to generate their own, sometimes competing, heating or cooling needs. The unusual factor is the temperature – the ectogrid operates at between 6°C-30°C, compared to 75°C-80°C in standard heat networks – meaning there are low, to practically no, distribution losses.



Distributing thermal energy flows between neighbours means energy is only added to the system when needed, effectively using and reusing all available thermal energy and making it possible to decrease both pollution and the energy consumption in a city.

The European Space Agency tackling emissions

E.ON is working with the European Space Agency (ESA) and Earth observation specialist Astrosat, capturing satellite imaging data to accurately identify areas across the UK where energy efficiency measures are most needed.



The project uses near real-time and archived data gathered from orbiting satellites – including optical sources, thermal-infrared for heat mapping and air quality and pollution tracking – combined with Astrosat's ThermCERT software to help tackle issues such as housing condition and insulation, air quality, and even traffic management.

When cross-matched with existing housing or data on vulnerable customers, the unique platform provides local authorities and even entire cities with a street-level view of where improvements are most needed. This means they can better target their approaches to upgrading housing stock, optimising energy efficiency installations, improving air quality or easing congestion across communities.

Fraser Hamilton, Chief Operating Officer at Astrosat, said: "We've applied our technical knowledge to E.ON's wealth of experience with local authorities and ESA's space acumen to create something truly unique that will add real value to the UK energy market - a space-age solution to Earth's energy challenges by leveraging the power of space technology to deliver real-world benefits."

“

Our work with the European Space Agency and Astrostat is a truly innovative and exciting project is about harnessing the power of space, alongside our experience working with local authorities and delivering real change in terms of fuel poverty and carbon emissions, to help reduce heat loss and unnecessary energy expenditure in regional areas across the UK.

”

Michael Lewis, Chief Executive of E.ON UK

Suggested policies to help communities clean the air



Widespread monitoring of air quality

- *Open data should be used to analyse local air quality.*
- *Data can also be used to support public awareness campaigns to increase awareness of air quality concerns, so people can take steps to avoid hotspot areas.*
- *There should be a particular focus for air quality monitoring around areas such as around schools.*
- *Central Government funding for tackling air quality should be supplemented at a local level from revenues raised from Clean Air Zone charges.*



Invest in alternatives

- *Encourage more cycle and pedestrianisation routes to support a reduction in traffic congestion.*
- *Promote low-carbon heat networks such as ectogrids which use fuel sources that have a limited impact on local air quality. This should include consideration of both financial incentives and the role of regulations and standards within housing standards to drive deployment.*

Seven.

Sources



Sources

1. <https://www.who.int/emergencies/ten-threats-to-global-health-in-2019>
2. <https://www.gov.uk/government/news/public-health-england-publishes-air-pollution-evidence-review>
3. <https://www.blf.org.uk/sites/default/files/Joint%20parliamentary%20briefing%20on%20the%20Environment%20Bill%20and%20air%20pollution%20standards%20-%20June%202019.pdf>
4. <https://www.imperial.ac.uk/news/163408/ethnic-minorities-deprived-communities-hardest-pollution/>
5. <https://www.who.int/airpollution/ambient/about/en/>
6. <https://www.london.gov.uk/sites/default/files/Driving%20Away%20from%20Diesel%20final%20report.pdf>
7. <https://www.eonenergy.com/renewable.html>
8. <https://www.stateofglobalair.org/>
9. https://www.stateofglobalair.org/sites/default/files/soga_2019_report.pdf
10. <https://www.theguardian.com/environment/2019/apr/03/toxic-air-will-shorten-childrens-lives-by-20-months-study-reveals>
11. <https://www.gov.uk/government/publications/health-matters-air-pollution/health-matters-air-pollution>
12. <https://www.who.int/airpollution/ambient/en/>
13. <https://www.gov.uk/government/publications/health-matters-air-pollution/health-matters-air-pollution>
14. <https://www.eea.europa.eu/themes/air/air-pollution-sources>
15. <https://www.gov.uk/government/publications/health-matters-air-pollution/health-matters-air-pollution>
16. <https://www.gov.uk/government/publications/health-matters-air-pollution/health-matters-air-pollution>
17. <https://www.who.int/airpollution/ambient/pollutants/en/>
18. https://consult.defra.gov.uk/airquality/air-quality-plan-for-tackling-nitrogen-dioxide/supporting_documents/Draft%20Revised%20AQ%20Plan.pdf
19. https://consult.defra.gov.uk/airquality/air-quality-plan-for-tackling-nitrogen-dioxide/supporting_documents/Draft%20Revised%20AQ%20Plan.pdf
20. <https://www.gov.uk/government/publications/rural-population-and-migration/rural-population-201415>
21. <https://www.trustforlondon.org.uk/data/topics/population-geography/>
22. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/778483/Emissions_of_air_pollutants_1990_2017.pdf
23. <https://www.theguardian.com/environment/2018/nov/06/uk-renewable-energy-capacity-surpasses-fossil-fuels-for-first-time>
24. <https://www.ukgbc.org/wp-content/uploads/2017/12/UK-GBC-Leading-the-way-FINAL-WEB.pdf>
25. https://naei.beis.gov.uk/overview/pollutants?pollutant_id=6
26. <https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-air-pollutants-8/transport-emissions-of-air-pollutants-6>
27. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/734799/COMEAP_NO2_Report.pdf
28. <https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-air-pollutants-8/transport-emissions-of-air-pollutants-6>
29. https://ec.europa.eu/transport/sites/transport/files/cycling-guidance/smart_choices_for_the_city_cycling_in_the_city_0.pdf
30. <https://www.imeche.org/docs/default-source/1-oscar/reports-policy-statements-and-documents/imeche-air-quality-report.pdf?sfvrsn=>
31. <https://www.railway-technology.com/news/uk-railway-electrification-costs-could-be-slashed-by-half/>
32. <https://www.railengineer.co.uk/2018/12/11/the-past-present-and-future-a-look-at-electrification-of-the-uks-railways/>
33. https://www.riagb.org.uk/RIA/Newsroom/Stories/Electrification_Cost_Challenge_Report.aspx
34. <https://www.imeche.org/policy-and-press/reports/detail/the-future-for-hydrogen-trains-in-the-uk>
35. <https://publications.parliament.uk/pa/cm201719/cmselect/cmbeis/383/383.pdf>
36. <https://www.smmr.co.uk/2019/07/bump-in-the-road-to-zero-as-low-emission-car-demand-reverses-in-june/>
37. <https://uk.reuters.com/article/us-autos-electric-norway/electric-cars-grab-almost-half-of-sales-in-oil-producing-norway-idUKKCN1TW2WO>
38. <https://www.transport-network.co.uk/City-leaders-want-2030-petrol-and-diesel-ban/15113>
39. <https://theenergyst.com/millions-electric-vehicles-sooner-predicted-no-sweat-says-national-grid/>
40. <https://www.eon.com/en/about-us/media/press-release/2018/emobility-eon-and-nissan-enter-into-strategic-partnership.html>
41. <https://www.raconteur.net/sponsored/an-end-to-the-rush-hour-crush-how-data-is-liberating-road-and-rail>
42. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/820843/Energy_Consumption_in_the_UK__ECUK__MASTER_COPY.pdf
43. <https://consult.defra.gov.uk/airquality/domestic-solid-fuel-regulations/>
44. <http://fes.nationalgrid.com/media/1409/fes-2019.pdf>
45. <https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:239:0136:0161:EN:PDF>
46. <https://www.nationalgrid.com/group/news/britains-clean-energy-system-achieves-historic-milestone-2019>
47. <https://www.theccc.org.uk/wp-content/uploads/2019/07/CCC-2019-Progress-in-reducing-UK-emissions.pdf>
48. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/694022/Detailed_Release_-_HEE_stats_27_Mar_2018_FINAL.pdf
49. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/820843/Energy_Consumption_in_the_UK__ECUK__MASTER_COPY.pdf
50. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/795929/Detailed_Release_-_HEE_stats_18_Apr_2019.pdf
51. <https://www.theccc.org.uk/wp-content/uploads/2019/07/CCC-2019-Progress-in-reducing-UK-emissions.pdf>
52. <https://www.eonenergy.com/cavity-wall-insulation.html>
53. https://www.london.gov.uk/sites/default/files/les_appendix_2_-_evidence_base_0_0.pdf
54. <http://boilerplus.org/faq/>

Sources continued

55. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/795185/Review_of_interventions_to_improve_air_quality.pdf
56. <https://www.eonenergy.com/about-eon/media-centre/eon-offers-replacement-boilers-for-240-to-anyone-on-the-affordable-warmth-scheme/>
57. <https://www.eonenergy.com/air-source-heat-pumps.html>
58. <https://www.ehpa.org/index.php>
59. <https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf>
60. <https://historicengland.org.uk/images-books/publications/eehb-heat-pumps/>
61. <https://www.gov.uk/government/news/spring-statement-2019-what-you-need-to-know>
62. <https://www.energysavingtrust.org.uk/about-us/news/creature-comforts-cost-home-owners-%C2%A378-million>
63. <https://consult.defra.gov.uk/airquality/domestic-burning-of-wood-and-coal/>
64. <https://consult.defra.gov.uk/airquality/domestic-solid-fuel-regulations/>
65. https://ec.europa.eu/growth/industry/sustainability/ecodesign_en
66. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf
67. <https://www.gov.uk/government/statistics/solar-photovoltaics-deployment>
68. <https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/>
69. <https://www.eonenergy.com/solar/battery-storage.html>
70. <https://www2.gov.scot/Resource/0052/00521754.pdf>
71. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/820843/Energy_Consumption_in_the_UK__ECUK__MASTER_COPY.pdf
72. <https://www.nic.org.uk/news/mps-highlight-need-for-swift-action-to-boost-energy-efficiency-of-uk-homes-and-workplaces/>
73. <https://www.parliament.uk/business/committees/committees-a-z/commons-select/business-energy-industrial-strategy/news-parliament-2017/energy-efficiency-inquiry-launch-17-19/>
74. <https://www.parliament.uk/business/committees/committees-a-z/commons-select/business-energy-industrial-strategy/news-parliament-2017/energy-efficiency-inquiry-launch-17-19/>
75. <https://www.theccc.org.uk/wp-content/uploads/2018/06/CCC-2018-Progress-Report-to-Parliament.pdf>
76. <https://www.theccc.org.uk/wp-content/uploads/2018/06/CCC-2018-Progress-Report-to-Parliament.pdf>
77. <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/uklabourmarket/august2019>
78. <https://www.eon.com/en/business-customers/success-stories/marks-spencer.html>
79. <https://www.eonenergy.com/business/building-and-energy-management/lighting-and-controls.html>
80. <https://www.goultralow.com/company-cars-and-fleet-vehicles/tax-benefits/>
81. <https://www.gov.uk/government/publications/workplace-charging-scheme-guidance-for-applicants-installers-and-manufacturers>
82. https://www.energysavingtrust.org.uk/sites/default/files/reports/1-424-15_Payne.pdf
83. <https://www.centreforcities.org/reader/can-uk-cities-clean-air-breathe-2/cities-around-world/#case-study-copenhagen-investing-in-infrastructure-to-make-cycling-easier-faster-and-safer>
84. <https://www.centreforcities.org/reader/can-uk-cities-clean-air-breathe-2/cities-around-world/#case-study-copenhagen-investing-in-infrastructure-to-make-cycling-easier-faster-and-safer>
85. <https://stateofgreen.com/en/partners/city-of-copenhagen/solutions/cycling-the-fast-way-forward/>
86. <https://www.centreforcities.org/reader/can-uk-cities-clean-air-breathe-2/cities-around-world/#case-study-copenhagen-investing-in-infrastructure-to-make-cycling-easier-faster-and-safer>
87. <https://www.centreforcities.org/reader/can-uk-cities-clean-air-breathe-2/cities-around-world/#case-study-copenhagen-investing-in-infrastructure-to-make-cycling-easier-faster-and-safer>
88. <https://www.businessinsider.com/china-builds-worlds-biggest-air-purifier-2018-12?r=US&IR=T>
89. <https://www.ndtv.com/india-news/china-opens-worlds-largest-air-purifier-to-fight-pollution-5-facts-1801126>
90. <https://www.ndtv.com/india-news/china-opens-worlds-largest-air-purifier-to-fight-pollution-5-facts-1801126>

*Smoke plumes are not to scale. Emission factors show emissions in the home - emissions during production of fuel or electricity are not included here. Emission factors taken from EMEP 2016 Guidebook (1A4 - small combustion tables). The following definitions were used: Solid fuel open fire wood burned in an open fire, Non-Defra approved stove, Wood in a conventional stove, Defra-approved / Ecodesign stove, Wood in an advanced / ecolabelled stove, Pellet fired boiler, Wood in pellet stoves and boilers, Oil fired boiler, Fuel oil in a medium (.50KWth<1MWth) boiler, Gas fired boiler, Natural gas in a small (<50kWh) boiler.