Warm Homes, Healthy Workplaces: Technical Companion

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A References and sources of information

[1] Department for Business, Energy and Industrial Strategy (BEIS) Annex: 2019 UK Greenhouse Gas Emissions, final figures by end user and fuel type and 2019 UK Greenhouse Gas Emissions, Final Figures table 5.1

[2] For further information see this article https://www.greenregister.org.uk/blog/reducing-hot-water-demand-passivhaus-dwellings

[3] BEIS: Estimate based on BEIS: Energy Consumption in the UK (ECUK) 1970 - 2019 Data tables – Table C9

[4] The “energy assessor” role may be similar to the "retrofit assessor" defined in PAS 2035 – see https://www.retrofitacademy.org/what-is-pas-2035/ but we use the term “energy” to highlight the focus and make it clear we are talking about National Climate Service employees

[5] Key figures are from English Housing Survey, Ministry of Housing, Communities and Local Government (MHCLG), 2018-2019 plus appendices

Number of homes with loft	21.1 million (England only)
Number with less than 150mm* insulation	8.1 million (England only)

**new homes should have at least 300mm*

To get estimate of UK, add together:

Total number of homes in	England (2018)	24.25 million
Total number of homes in	Scotland	2.62 million
	Wales	1.48 million
	N. Ireland	0.78 million
TOTAL		**28.7 million**

Then divide overall total by England total = 28.7 / 24.25 = 1.18 multiplier

This would give 9.5 million inadequate lofts but installation rates in Scotland (eg) are likely to be higher so we have taken the lower figure.

[6] Energy Research Partnership 2016 Heating Building: reducing energy demand and greenhouse gas emissions, page 11

Worth noting some breakdown figures for heating (modelled ie based on what we know about the buildings not bills etc)

1900 homes average 230kwh/m2/year just for heating

1995 Building Regs - 110 kwh/m2/year

2014 Building Regs for newbuild - effectively current - 50+ kwh/m2/year

[7] Architect Sarah Lewis speaking at the 2020 Passivhaus conference on projects she had completed said a typical team of 4 skilled workers would take an average of 6 months to finish one full whole-house retrofit. This estimate has been backed up by experienced builders we surveyed.

[8] This information is fiendishly hard to collect as only public sector buildings are required to publish any energy data.

According to Department for Business, Energy and Industrial Strategy (BEIS): Annex: 2019 UK Greenhouse Gas Emissions, final figures by end user and fuel type, the public sector was responsible for 3% of UK greenhouse gas end user emissions, and the business sector was responsible for 25% of UK greenhouse gas end user emissions in 2019 (the last year for which we have “typical” energy use).

It could be argued that the Business & Public sectors are equivalent to non-domestic buildings (as their figures exclude transport and most industrial processes) so 28% is one benchmark figure. However, the figures for the business sector do include items such as industrial machinery and off-road vehicles (but not manufacturing processes, eg for steel, concrete etc), so the emissions attributable to buildings may be considerably less.

LETI’s Climate Emergency Design Guide (2019) gives GHG emission contribution figures of 27% for "business”. Their figures are a synthesis from the CCC, ONS and one other research body. But they roughly tally with the first estimates.

[9] CIBSE (the UK body representing services engineers) gives 33% for lighting in 2010. A study from Loughborough (de Menezes, Buswell et al, 2011) gives 24%. Other studies from 2010 - 2014 give around 25%, with an outlier suggesting less. A "world" study (Ürge-Vorsatz et al, 2015) gives 16% based on 2010 data. The most recent relevant study gives 14% (EU study 2014)

But we could not find anything more up to date relevant to the UK.

On servers and appliances the picture is also mixed. Computers generally use less power than they did but server and storage use locally was keeping the figures high. Now cloud storage is becoming more popular, this reduces cooling and energy demand in our offices but exports much of that demand to server/info stores abroad. Figures go from 15% (CIBSE 2010 again) up to 29% (US/Chinese study 2012)

[10] German case study of Däschler office in Erlangen, refurbished in 2006, from "Retrofit for Purpose" by Greg Penoyre & Sunand Prasad, RIBA 2014

[11] A UKGBC report from 2014 and Retrofit for Purpose above both show how this can be done. The UKGBC report notes that bringing in compulsory Declared Energy Certificates for non-domestic buildings is an urgent first step, which we agree. LETI's Climate Emergency Design Guide has declared 55kwh/m2/yr a realistic target for new offices. Also see this office refurb project by UKGBC

[12] Eg Sara Morris headteacher of Oak Meadow Primary School "The children are more alert in the afternoon and are more attentive because the air is so fresh and comfortable. .." See also other studies, including this example of a Passivhaus primary school

[13] Schools - additional information:

ENERGY BILLS: https://www.gov.uk/government/news/price-comparison-site-launched-to-help-schools-cut-energy-bills(On news page where minister urges them to "shop around" as an answer)

RETROFIT SCHOOLS CAMPAIGN: coordinated by climate action charity Ashden, summarised in an article here: https://environmentjournal.online/articles/school-building-programme-must-focus-on-retrofitting-existing-buildings/

The campaign page is here:

https://www.teachthefuture.uk/greenrecovery

ENERGY USE IN SCHOOLS: 190kwh/m2/year typical, see sector report in Building Energy Efficiency Survey (BEES) 2016

https://www.gov.uk/government/publications/building-energy-efficiency-survey-bees

SCHOOLS BY AGE OF BUILDINGS : from:

https://www.gov.uk/government/publications/property-data-survey-programme

GERMAN SCHOOLS STUDY article by Johan Reiss (Frauenhofer Institute of Building Physics) https://www.sciencedirect.com/science/article/pii/S1876610214004329

ST SOPHIA'S SCHOOL RETROFIT, SCOTLAND:

https://www.hamsonbarronsmith.com/news/st-sophia-uks-first-passivhaus-enerphit-school

CASE STUDY HOME FARM SCHOOL, ESSEX: https://ashden.org/winners/home-farm-primary-school/

[14] Southampton geothermal energy scheme, Wikipedia.

[15] See NHF/Crisis/Heriot-Watt report 2018, quoted in parliamentary report : https://commonslibrary.parliament.uk/research-briefings/cbp-7671/ and NHF 2018 press-release "England short of 4 million homes" quoted in Shelter briefing "Building more affordable homes," 2018
With 1.2 million households on local authority and housing association waiting lists as of 2019, and eviction risk growing, even these levels of new home building would take at least 5 years to tackle the most urgent need.

[16] See for example https://www.bdonline.co.uk/news/building-regs-changes-not-fit-to-meet-net-zero-target/5103877.article

B Targets, scale of work and job numbers

OVERVIEW - AND FOCUS ON HOMES EXPLAINED

To plan this work we need to use the best information we have about the current state of buildings, the available resources and the most effective way to deploy them to achieve the maximum reduction in emissions and energy use.

For the sake of simplicity and because of the greater availability of data we are focusing here on homes.

CURRENT OVERALL ENERGY USE PER M^2 IN HOMES

Median energy use (gas + electric) per household for all homes in England Wales & Scotland - old and new - in 2018 was just over 15,000kwh [NEED June 2020]. Adjusting to include Northern Ireland and to allow for other fuels gives a figure of approximately 17,000kwh per home per year

Average size of home in UK is approximately 90m2 [ONS Oct 2017]
On this basis energy consumption is approximately 190kwh/m2/yr , however the size data is based on homes sold in 2016.

EPC data, drawing on the data for certificates issued between 2009 and 2019, gives a figure of 290kwh/m2/year. This data is however extremely unreliable with both size of dwelling and energy use being estimates made by trade certifiers.

The Energy Research Partnership "Heating Buildings..." report 2016 gives a figure for *space heating* of 140kwh/m2/yr, and suggests that space heating is 65% of total energy use which would give a total energy use figure of 215kwh/m2/year

An older figure but based on final actually used energy data [Heat Use In the UK 2013] gives overall energy use of 18,190 kwh per home per year which translates to 200kwh/m2/year using the 90m2 average dwelling size.

Taking the average of the above figures gives us an estimated energy use per m2 of **225kwh/m2/year** for existing homes.

CURRENT ENERGY USE PER M^2 IN HOMES *FOR SPACE HEATING*

This figure is also known as the *specific heat demand.*

For all UK housing:

The ERP report cited above gives 140kwh/m2/year.

The 2013 report cited above gives 130kwh/m2/year

Odyssee Indicators energy database for 2010 gives 133kwh/m2/year

Older homes have much higher figures and we will be focusing on those built before 2000 for retrofit so we have taken a figure of **150kwh/m2/year** as our average for this study

CURRENT ENERGY USE PER M^2 IN HOMES *FOR HOT WATER*

This comes out at 27% of the space heating demand *[Committee on Climate Change 2019 UK housing: Fit for the future?]* with similar figures in other publications so we are taking this as

40kwh/m2/year

TARGETS FOR RETROFIT AND CALCULATION OF JOB NUMBERS

As space heating is the biggest area of energy loss, and has the greatest scope for improvements, we use this as a way of defining what can be achieved in different homes.

For whole-house retrofit, to achieve the maximum energy use reduction an older building is capable of, there are already known standards for the maximum heat demand per m2 per year:

Passivhaus "EnerPHit" standard	25kwh/ m2/ yr
Passivhaus "Low Energy" standard	30kwh/ m2/ yr
Energiesprong target standard	30kwh/m2/ yr
AECB Building Standard	40kwh/ m2/ yr
Energiesprong "pilot" standard	40kwh/m2/yr

The EnerPHit standard can achieve (has been measured in use) between 75% and 95% CO_2 emission reductions, the AECB estimates 70% reductions possible with their Building Standard.

However, to carry out a whole-house retrofit takes a lot of skilled work and time [*see note 7 in part A of this Companion*] and if we took these kind of targets for every home we would not be able to achieve the reductions we need in time.

So we are proposing a twin-track strategy - to scale up whole-house retrofits as we train more workers, while also tackling simpler measures on a larger number of homes. These "elemental" jobs - like loft insulation, draught stripping, window replacement - would not be the end of the story, but they would be chosen to make the maximum impact on energy use, bills and comfort, and crucially, they would not "block the future" - the next steps for each home would be set out in a plan, to be installed when resources become available.

The New Economics Foundation report A Green Stimulus For Housing (July 2020) suggests a set of priority retrofit measures with the aim of getting 8.7 million homes up to EPC band C within 4 years, and the remaining homes to the same level over the following 10 years. The report is valuable because it addresses the scale of the problem, recognises the need to prioritise while being holistic, and the crucial issue of ramping up the trained workforce.

Taking that report as a starting point we note however that:

1. the packages of works are skewed towards heat pumps at the expense of fixing the basics like insulation, draughtproofing etc
2. EPC certificates are a very imperfect tool and need to be improved (see section D below).
3. the projected ramping up of the workforce takes no account of the lack of existing retrofit expertise right now. Where the ramping up of numbers is based on previous growth spurts in construction, it ignores the fact that EU workers have until recently formed the majority of the expanded workforce. Recent post-Brexit immigration controls, as well as increasingly draconian controls on immigration from outside the EU area, harm the chances to build a trained workforce.

   Our position is that all workers in the UK – regardless of origin – need to be able to retrain and find decent well-paid work in helping to reduce CO_2 emissions and tackle the climate emergency. And that means allowing for proper training of people with different starting skills.

Based on an enhanced "fabric first" EPC "C+" target, and on where we are now in terms of skills, we have set out a possible programme for rolling out the retrofit of the UK's homes, allowing for gradually increasing the number of skilled workers needed (see also Section C below on training). Of course this is a model, not a fixed blueprint, but we think it is a realistic basis for calculating what can be achieved and how many jobs created over a ten year timescale and beyond.

The chart below shows:

- a realistic training and recruitment scenario (including new job numbers)
- based on using half the available workforce on AECB building standard target level "deep" retrofit
- with the other half implementing selected measures on a larger number of homes (based loosely on the "shopping basket" of measures in the NEF report) to reach min EPC (C) level
- both modelled to complete in a 10 year implementation programme.

The deep retrofit scenario alone could only do 3.8 million homes in that period.

The NEF-based scenario could treat all 29m homes in the UK by late 2028.

A hybrid scenario, where half the newly trained workforce works on the basket of EPC C works and the other half does deep retrofit, would be perfect, and give us over 2 million new site jobs on homes alone by 2030, which could continue till 2050.

Using the NEF assumptions as they stand that would allow by 2030:

1.9m deep retrofits

28.8m EPC works ie more than needed

and then the entire workforce can move on to upgrading the EPC (C) stock to the higher level, over the following years (1.2m deep retrofits a year from 2031 would achieve 26m total properties at EnerPHit or close levels by 2050 ie 90% of existing homes)

15/01/21

CLIMATE RETROFIT JOBS – SCALING UP THE NUMBERS

A CALENDAR YEAR	B PROG YEAR	C NUMBER OF TRAINERS	D NUMBER OF TRAINED WORKERS	E NUMBER OF WORKERS AVAILABLE OVERALL	H NUMBER OF HOMES GIVEN ENERPHIT OR AECB LEVEL RETROFIT	I NUMBER OF HOMES GIVEN WORKS TO GET EPC [C+] WITH UPGRADE LATER	J NUMBER OF NEW JOBS IN CONSTRUCTION ON SITE (each yr)	K NUMBER OF NEW JOBS IN SUPPLY CHAIN (0.8)	L
2021	0								
2022	1	1000	500	2000	500	7000	1500	1200	
2023	2	1200	24000	96000	24000	336000	94000	75200	
2024	3	1440	52800	211200	52800	739200	115200	92160	
2025	4	1730	87400	349600	87400	1223600	138400	110720	
2026	5	2080	129000	516000	129000	1806000	166400	133120	
2027	6	2500	179000	716000	179000	2506000	200000	160000	
2028	7	3000	239000	956000	239000	3346000	240000	192000	
2029	8	3600	311000	1244000	311000	4354000	288000	230400	
2030	9	4320	397400	1589600	397400	5563600	345600	276480	
2031	10	5200	501400	2005600	501400	7019600	416000	332800	
2032	11								
2033	12								
2034	13								
2035	14								
TOTALS		**5200**	**501400**	**2005600**	**1921500**	**26901000**	**2005100**	**1604080**	
TOTAL JOBS									**3609180**
									(360000 average a year)

Please see separate notes on assumptions & methodology for each column WK/CCC 210115

NOTES ON CLIMATE JOBS SPREADSHEET

Columns A & B take into account the time it will take to win backing for this policy, and to plan the rollout. Work can begin soon, but only at a level matching the skills and our ability to plan. That means that year 1 of our 10-year programme might be 2022, or later.

This is not to ignore the fact that some retrofit work is already taking place, albeit on a limited scale, on some local authority and housing association stock; and there is some high quality work and training happening in the small business and cooperative sectors, albeit accessible mainly to better-off homeowners and committed self-builders. We can assume that innovative and exemplary work will continue in these sectors, alongside a National Climate Service programme, whilst these skilled practitioners will also need to be supported with funding to provide initial training opportunities for the new workforce and those needing to be upskilled.

It is possible, therefore, that the initial stages of a NCS programme could proceed more quickly than we have allowed for, but given the likely difficulties in establishing a workable framework to integrate training, direct labour and those working and training in other sectors, it seems wise to base our calculations on the core model set out here. In addition, we can anticipate in practice more than one training pathway, and an initial focus on expanding suitable training courses in the FE sector could mean a slow start with a rapid acceleration once the first cohorts have been trained.

Column C takes into account the approximate number of people in the UK who have all-round retrofit knowledge and skills at present. This is based on membership of organisations such as the Association of Energy Conscious Builders (AECB), the Passivhaus Trust (PHT), the Green Register (TGR) and the London Energy Transformation Initiative (LETI), together with the approximate number of building workers trained to date by the Retrofit Academy and Futureproof.

There are currently approximately only:

1000 members of the AECB

1000 members of LETI

390 members of the Green Register

250 Passivhaus contractors

- and many of these are the same people

The Retrofit Academy is currently training "hundreds" of Retrofit Coordinators" who will play an important role but won't substitute for skilled site labour.

We have therefore taken the figure of 1000 fully expert full-time trainers to start the process. This allows both for the overlap and the fact that most of the above experts are also practitioners. We have then made the assumption that this number can grow by around 20% each year, and these will come from the wider workforce and are not deducted from the site worker numbers.

Column D is based on full training taking 6 months and on 1 trainer being able to take on a class of 10 for that period. So 1 trainer can train 20 workers a year. The first figure of 500 is an estimate of the number of actual building workers who have currently been trained - again hopefully an underestimate as time goes by

Column E is based on each fully trained worker being able to lead/supervise an additional 3 untrained workers. Where these come from the building industry this will be a question of sharpening up and getting the science as well as the practice right. Where these workers come from other industries, having become redundant or transitioned from carbon-intensive industries, or are new entrants to the workforce, they will need additional training which is allowed for "on the job" but will in reality include some general vocational training and inductions before they begin work on site.

Column H is based on the "max" full retrofit that can be achieved, to get homes as close to the EnerPHit standard of energy use as possible, and so it's based on teams of 4 taking 6 months on average for each house or flat [see note 13] It gives a total figure of 1.9 million such completions over the 10 year initial period of this program.

Column I shows the number of homes receiving a carefully limited retrofit, based primarily on carbon cost effectiveness, with a view to maximising short term impact, without blocking future improvements to a higher standard. Again it takes half the available workforce, and is based on the NEF overall assumptions ie: 9 million homes done in 4 years by average of 295,000 workers = 7.5 homes per worker per year, but rounded down to 7 homes per worker per year to allow for a greater proportion of fabric intervention compared with heat pumps and solar pv.

Column J shows the number of new jobs on site each year, which rises to a total of just over 2 million workers trained and employed on this work by the end of the 10 year program. This workforce can then be redeployed, primarily to upgrading the "C+" homes and other buildings, but also to other climate emergency jobs.

Column K shows an estimate of jobs created in the "supply chain" for this work, for example in product or material manufacture. (We discuss this further in Section E). We have taken the lower multiplier of 0.77 from the NEF report, rounded up.

Column L - so, a total of 3.6 million new jobs by the end of 10 years, for homes retrofit alone

FROM 2030 ON

The entire workforce could be redeployed to upgrade all the EPC level homes to deep retrofit standards, using their plans of work as a starting point. Because of this preliminary assessment, and the fact that by this point the supply chain and efficiency of build teams will have improved, we think the number of deep retrofits could now be increased by say 20%, that is 1.2m a year, or 24 million in the remaining period till end of 2050 – ie practically all the existing homes in the UK.

That means nearly every home will be warm comfortable and using, on average, around a third of the energy used today, with energy used for heating reduced by at least 80%.

OTHER ADVANTAGES OF A MIXED APPROACH – AND CONCLUSION

Doing half deep half urgent/light (and allowing more time for the deep) also means:

- we can learn as we go on both counts and feed that into both spheres
- we can adapt what we do as the climate actually changes
- the proportion of deep/light can be tweaked by review, once we get packages of buildings assessed

This mixed approach allows a comprehensive assault on the state of the nations' building stock, creates a multi-skilled workforce, and remains flexible enough to be adjusted as the situation changes.

APPENDIX 1 - HOW DO YOU CALCULATE JOBS? A COMPARISON

The commonest approach we have seen is "new jobs-for-a-year per £million spent" (or job-years per £million). So for example the Forbes, El-Haram et al 2012 paper *"Forecasting the number of jobs created through construction"* examines a number of studies, including the use of the Labour Forecasting Tool developed for the Construction Industry Training Board. It concludes that while a figure of 13.3 jobs per £million had been used (for example by Scottish Enterprise) based on an industry-wide average, looking at outcomes down the line a figure of 8.5 jobs per £million was more realistic.

The NEF Green Stimulus paper which informs our own argument above, includes figures which would generate about 9 jobs per £million: 9 million homes done in 4 years by average of 295,000 workers = 7.5 homes per worker per year. If the average cost of the energy measures is £15,000 (based on limited measures to achieve EPC level C), then that means each worker "costs" (or installs/creates) 7.5 x £15k = £112.5k each year. In which case £1million gives you just under 9 "job-years" We have chosen to reduce the "productivity" slightly (to

7 homes per worker per year) to reflect the more labour-intensive package of work that we would propose. This gives us 8.5 job-years per £million.

Another approach is based on how long it takes to do a particular job. This is only possible where the nature of the work is broadly consistent and builders and practitioners can use their experience to gauge output. Thus for "deep" retrofit, where a house may be taken apart and put back together, we have consistent figures suggesting the optimum approach is a team of 4 doing an average of one home every 6 months. We have had this approximate figure from Scots retrofit architect Sarah Lewis (speaking at the PassivHaus conference 2020), LETI member and Passivhaus Trust research & policy director, and Malcolm McMahon at the Green Register. That means one worker can complete on average 0.5 retrofit homes per year. The figure reflects both the labour intensity of the task, and the difficulty of "rushing" it.

With these retrofits having typically come in at around £75,000 a property over the last decade, that gives a "cost" of £37,500 a year per job-year, or 27 job years per £million. We have chosen to reduce the average spend to £50,000 per home - we believe this will allow an effective whole-house intervention, once we have the process running efficiently - which gives a cost of £25,000 per job-year if the time taken remains the same (this would of course mean the workers' pay would need to be further subsidised, at least initially). These figures give 40 job years per £million. The figures for deep retrofit illustrate why we have chosen to limit the number of these projects initially. The figures for the lighter package of measures are however consistent with other economic modelling.

APPENDIX 2 - WHERE WILL THE WORKERS COME FROM?

The numbers involved look large. However, after much discussion and circulation for comment, we think they are realistic. In terms of what is needed: we have less time to do more work, and the work is extensive - this is our inherited reality. In terms of workers who will be available, who will need jobs, we can anticipate the following:

EXISTING RETROFIT BUILDERS

There are an estimated 160,000 workers currently working on repair maintenance and improvement of buildings. Our premise is that these workers can become part of the NCS programme but will still need the training, or the "leadership" of trained workers. This not only a truth universally acknowledged in construction, it's also corroborated by the pitiful (6%) take up of the Green Homes Grant, in massive part because of the shortage of certified skilled installers.

EXISTING OTHER BUILDERS

Beyond these are the remaining 2 million plus building workers who are currently employed on projects including large-scale roadbuilding, HS2, speculative offices, intense newbuild housing developments in selective market hotspots, and out-of-town shopping centres. In any serious climate action scenario these sectors will decline, and workers will become available for other work.

OTHER WORKERS LOSING JOBS

But the central premise of the NCS is that it will allow redeployment of workers who will need to be transitioned from industries affected by decarbonisation. It's important that we all recognise the level of change that will be required.

To achieve the huge emissions reductions we need, and then to create a stable and fair world economy which can steadily take carbon out of the atmosphere over the following decades/centuries, will mean more than electrification and retrofit works. It will require a significant shift in the way that we do things: consumer goods will need to be more durable, repairable and shareable; more homes will need to be designed with shared amenities and communal spaces (sometimes termed co-housing); work-related transport will need to be reduced; low/zero carbon leisure will need to become the norm. More people will be involved in growing food and other crops, tending the landscape, repairing things - fewer people will be involved in making short-lived ephemeral products from oil-plastic or high carbon materials, and far fewer people in advertising, promoting, fighting over market share etc.

So not only would we expect sectors like fossil fuel extraction and distribution, aviation and car making to decline, there will be - needs to be - a decline in other areas of high carbon production. Our point here is that we need not fear an absolute shortage of workers for buildings, even though many will need or want to be redeployed to other new sectors like renewable energy, sustainable agriculture, biodiversity management, low/zero carbon manufacture, and very crucially, the health, care and education sectors, as we manage a just transition.

APPENDIX 3 – ESTIMATE OF ENERGY SAVINGS IN 10 YEARS

1. Estimate of energy used for heating homes

A. Using Estimates of Heat Use DECC Statistics Dec 2014

Final annual consumption of energy for domestic space heating in 2013 = 28,728 thousand tonnes of oil equivalent

1 toe = 11,630,000 Wh = 11,630 kWh = 11.63 MWh

1000 toe = 11,630 MWh = 11.63 GWh

29,000 x 1000 toe = 29,000 x 11.63 GWh = 337,000 GWh **= 337 TWh**

B. Using Heating Buildings - Energy Research Partnership report 2016

Average UK EIU for space heating was 140kWh/m2/year

so extrapolating -

Average UK home is 90m2 = 140x90 = 12600kWh/ year = 12.6 MWh/ year

No of UK homes in 2010 was 27 million

Estimated space heating energy use 2010 = 27,000,000 x 12.6 MWh = 340 TWh

and extrapolating to now-

No of UK homes in 2019 is 29 million

Estimated space heating energy use 2019 = 29,000,000 x 12.6 MWh = **365 TWh** (assuming EUI and average area of homes is same)

2. Estimate of reduction possible with NCS programme

Using "Energy Use Intensity" metric for space heating, ie how many kWh/m2/yr and the figure cited in Heating Buildings - Energy Research Partnership report 2016 of 140kWh/m2/yr for the average UK home (in 2016 but will be similar now)

Our NCS programme is to take approx 2m homes down to 25kwh/m2/yr ("deep retrofit")

and another approx 27m going to 80kwh/m2/yr (EPC "C" mid range, rounded down)

So if each home is 90m2 then the figures are:

average heating energy used per home before retrofit =90x140 kWh/yr = 12.6 MWh/ yr

average heating energy used per home after deep retrofit = 90x25 kWh per year = 2.25 MWh/ yr

average heating energy used per home after EPC C upgrade = 90x80 kWh per year = 7.2MWh/ yr

so:

standard	energy used before per yr		energy used after retrofit, per yr	
1.9m deep retrofits	1.9m x 12.6 MWh	23.94 TWh	1.9m x 2.25 MWh	4.28 TWh
26.9 EPC[C] upgrades	26.9m x 12.6 MWh	338.94 TWh	26.9 x 7.2 MWh	193.68 TWh
TOTAL		**362.9 TWh**		**197.96 TWh**

Reduction in energy use to 197.96/362.9 to just less than **55% of current levels**

Or a reduction of 362.9-200.5 = 174.6 / 362.9 = a **reduction of just over 45%.**

RETROFIT PHASING AND JOB NUMBERS FOR NON-DOMESTIC BUILDINGS

Introduction and rationale of the model

Clearly, calculations of job numbers in public and commercial buildings can only give us a ballpark figure; commercial buildings in particular are privately owned (although we might argue for buildings that are no longer required as offices to be requisitioned for conversion to social housing or for other public uses). We may expect that strong legislation for energy efficiency standards will force commercial landlords and tenants to commission their own retrofit works, which will lie outside the scope of a National Climate Service.

Buildings which are part of a local authority estate are of course simpler, though the picture for public buildings is complicated by the fact that many are subject to PFI deals which leave estate management, repairs and maintenance in the hands of private consortia and their outsourcing chains. We support campaigns to revoke these deals, which are a huge and unnecessary drain on public finance and can result in serious safety and standards issues.

For the purposes of our modelling we leave aside precise issues of how the work is to be implemented in these different settings, and concentrate instead on estimating the amount of labour required overall. But we need to recognise that this will be a large underestimate, as a lot of work that would have been carried out anyway will be additional to what is included in our model.

For all types of non-domestic buildings, there will be a role for a NCS in setting standards, employing assessors to determine what works should be done on each building, inspecting the finished work for safety and energy efficiency, and monitoring energy demand in use and identifying performance gaps.

In estimating the number of workers needed to retrofit other buildings, we have considered two possible approaches to calculating the number of jobs needed: first, based on available figures for costs per area, and the jobs these figures translate to; and second, based on the size of project and estimates of labour required extrapolated from the figures we have already calculated for homes.

It is apparent that the number of skilled workers needed to retrofit all eligible buildings would far exceed the numbers which could realistically become available within ten years, when added to the two million needed for homes retrofitting. We address this by prioritising the buildings where the biggest carbon savings can be made, and those with clear additional benefits to communities, ie schools.

As with housing retrofit, we focus here on a ten year roll-out, but the remaining work should of course continue after the first ten years, until all public and commercial buildings are brought to the highest possible level of energy efficiency, along with the vast majority of homes.

THE CALCULATIONS

The main figures in this section are based on "Area and age of Office Stock" (2013), a report by Cundalls (engineers) for EEIG (Energy Efficiency Infrastructure Group), which takes data from a previous 2005 study by Dr Harry Bruhns for the CaRB and UCL.(see here)

<u>A) by cost per area</u>

Assuming average cost of refurb per m2 = 0.6 x cost of newbuild, then:

offices = £1,500/m2 x 87.2 km2 (total floor area) = £131 billion
shops = £1,400/m2 x 93.0 km2 = £130bn
schools/unis = £1,600 x 110.2 km2 = £176bn
factories = £1,350 x 209.2 km2 = £282bn
Total cost = £719 billion per year

The ARCOM (2012) report gives an average of 8.5 site job years per £1m invested. So if we tackle all the above buildings, we get
8.5 x 719,000 = 6,111,000 job years
= **611,100** jobs for 10 years

In reality we will plan to refurbish the worst examples, and take on other less common building types where the savings are good.

So if we did all the education buildings but only the worst 10% of the rest that would generate

8.5 x 176,000 job years = 149,600
+ 8.5 x 54,300 x 0.1 = 46,200
giving a total of **195,800** jobs for 10 years

B) by size of project and workers required

There are a total of 325,000 separate office buildings in the UK
15,000 of these are 100m2 or bigger - these can be our first target for a 10 year programme.
With shops and factories, we can take the biggest 15,000 as with offices.
There are 24,000 schools - we can put all of these in the 10 year programme
There are 106 universities - we can put 1000 uni buildings in the programme, picking out approximately the ten worst from each institution.

That gives us a package of 60,000 buildings over 10 years.

Retrofit measures for shops, offices and factories are less "fiddly" than for homes, but the areas of each building are larger. So working on the same team sizes and estimated completion times as housing (one team of 4 doing one building in 6 months) that would give us a workforce of **120,000** to tackle these priority buildings.
In both cases this (now skilled and experienced) workforce could move onto finishing off improving the remaining buildings after the 10-year urgent programme. We note that, in reality, individual people would come and go, some transferring to other types of work while others are recruited.

CONCLUSION/ COMPOSITE ESTIMATE

If we aim for an NCS workforce of **200,000** in this field then we can commit to tackling all the schools, all the worst university buildings, and the least efficient other non-domestic buildings over the decade: the exact proportion will be easier to determine i) after assessment, and ii) after every year of practice and monitoring.

NEW HOMES AND WORKFORCE

HOUSING NEED

In contrast with demand - which includes already-housed people wanting to move area or improve their housing conditions – new housing need for the purposes of this argument should address:

1. homeless people living in temporary accommodation or on the streets - 300,000 Shelter 2019 *adjusted)*
2. new households being formed - 200,000 a year *(KPMG/Shelter 2014 adjusted)*
3. people in overcrowded homes who need more space - 900,000 English Housing Survey 2018-9 *adjusted)*

Categories 1 and 2 need completely new homes; category 3 needs new homes to be built in the right sizes and numbers to allow people to move to a larger home, while releasing the smaller one for another household. Category 3 also overlaps with category 2.

(Note that the ageing population together with an increase in smaller households will make "co-living" more appealing to many, and the mass retrofit projects can facilitate that where appropriate by redesigning groups of homes so people can share facilities)

If we assume we need 200,000 homes a year to "stand still", and that one new home of the right size "solves" 2 overcrowded homes, then building 300,000 new homes of the right kind a year for ten years could:

- eliminate homelessness by year 3 (provided that more people were not forced into homelessness, ie benefits were raised, rents capped and vulnerable tenants properly supported)
- eliminate overcrowding by year 8

But this will only work if the new homes are genuinely affordable, and that means the overwhelming majority need to be council homes, built, owned and managed by local authorities and let at genuine council rents.

HOUSING SUPPLY

New housing completions in 2018 stood at 165,000. But these include an unstated proportion of the 630,000 student rooms completed in the same year, where they are grouped into flats or other types of "clusters".

Based on previous figures over the last decade (2013 saw 110,000 completions for example) we estimate the actual number of new "permanent" homes built as running at approximately 130,000 a year until 2020.

That leaves a shortfall of 170,000 a year to reach the target of **300,000**, and of course the conversion of the 130,000 from unaffordable, undersized and environmentally inadequate, to affordable and sustainable homes in well-planned communities.

JOBS

Based on construction spend (taking the approach used above for non-domestic buildings) the extra 170,000 homes a year would generate approximately **200,000** new jobs, for the whole 10 year period.

Taking the average construction cost of a new home at £140,000 (70m2 average area x £2000 which allows for range of types and 10% uplift to reflect better wages and standards) x 170,000 extra homes = £23.8 billion a year

and if £1m generates 8.5 site jobs for a year then that gives **us 202,300 extra jobs building new homes.**

C Training and retooling

The kind of staged strategy outlined above is in line with the Retrofit Academy's approach. Along with others they have been campaigning for proper training and a holistic approach, and succeeded in getting a standard (PAS 2035) agreed to avoid some of the mistakes of the past, where a failure to understand the energy dynamics of the whole house has resulted in disappointing performance in practice and sometimes to overlooking of potential dangers (such as cold bridges causing condensation on electrical wiring).

There are already many experts working in the UK who understand the techniques and difficulties of successful retrofit. There are hundreds of builders who have learned this expertise. But we need hundreds of thousands more builders as well as designers and assessors, and they all need to be suitably trained.

We will need specific new training for building workers - heating engineers, plumbers & electricians who will be putting in new kinds of services, carpenters who can repair, rehang joists so they don't make cold bridges and create routes for ductwork, dry liners and plasterers who can also install breathable systems, bricklayers and roofers who may be altering as much as replacing the fabric, groundworkers who may be helping to install new natural cooling for office buildings or better water disposal to reduce flooding, and many more.

We will also need training for energy assessors, retrofit designers, site project managers and building inspectors.

One of the stumbling blocks at present is a construction industry dominated by labour only contracts with few opportunities for in-work training, long outsourcing chains with little accountability for profit-driven private contractors or cost-cutting commissioners, and the predominance of businesses too small to accommodate apprentices or pay for additional training to upskill workers.

In addition, both initial and continuing professional development training for construction trades has tended to promote a "silo" approach where trainees in specific trades - eg heating engineers, joiners, electricians etc - are given little grounding in the way the whole house works together, or the way their part of the work fits with the work of other tradespeople. This is a major reason for the “performance gap” – the difference between the energy efficiency of a building as calculated on paper and how energy efficient it is in practice.

This “silo” approach is mirrored in the predominance of businesses selling and installing specific items (eg heating systems) without offering a proper energy assessment of the whole house to determine how well that system can “perform” in practice. And it is mirrored in the government’s funding approach, which encourages one-off purchases of such items, again without reference to an overall energy-efficiency plan for the whole house.

To some extent the performance gap can also be due to residents not being aware of the most energy efficient way to “use” their house and its installed heating systems and appliances (and we should certainly provide accessible information and basic training for non-professionals as well) – but we know from experience how often this is used as an excuse by social and private landlords or building contractors to evade responsibility for common problems such as damp or excessive energy bills which are likely caused by substandard design or structural work.

Organisations like the CITB (Construction Industry Training Board) have a National Open College Network Level 3 course, and the Association for Environment Conscious Building, Futureproof, the Retrofit Academy and the Carbon Coop all run courses which can be taken by specialist builders, as well as courses aimed at assessors and designers.

These organisations can play an important role in pioneering and developing good practice, as well as in equipping householders and community groups with the information they need to choose retrofit measures wisely. So we would advocate that, rather than simply subsume them within the National Climate Service, we should give them more resources and provide public funding to enable interested practitioners to access their courses.

But to build a skilled workforce at the scale needed, and make this high standard of training a universal norm, we will need a systematic overhaul of Further Education construction training and apprenticeships. This should ensure that tens of thousands of places on good low-emissions construction courses are available everywhere, leading to high standards in both theoretical understanding and practical skills. Courses must offer appropriate work experience, and be supported by relevant apprenticeships and the opportunity for subsequent employment in the NCS. In most cases, this will take the form of employment within local authority direct labour organisations, which need to be closely integrated with local colleges and other training providers.

D Standards and inspection

The importance of thorough inspection and monitoring of standards cannot be overstated; no amount of regulation of energy efficiency and safety standards will be effective without the means to ensure they are being achieved in practice. It would be one of the main tasks of a National Climate Service to ensure that this is in place.

For too long, the big "housebuilders" – essentially, investment vehicles run by people who have no real connection with construction or people's real housing needs – have succeeded in persuading governments to hold back or hold down building standards, so that they don't have to change the way they operate. This in turn deprived energy conscious builders of a "level playing field" and disincentivised investment in training for low emissions building and retrofit.

One reason why many homes haven't had even the limited improvements required by the Building Regulations (see here for an update) is our privatised inspection system - turning building inspectors into hired consultants for contractors, encouraging a "flexible" attitude to achieving standards, and depriving local authority building control departments of the resources needed to check on small works such as extensions, conversions and repairs, many of which slip through without approval.

Grenfell Tower saw working-class council tenants become the victim of the drive for cost savings, unscrupulous product suppliers, incompetent or unqualified contractors cutting corners, consultants, and of course the entire system of outsourcing chains, with little oversight or accountability, that infests so much social and private housing development and much of the public estate besides (eg hospital and school buildings). But the enquiry has also revealed that there had been cuts in building inspectors and the inspector given responsibility for the tower had 120 jobs to oversee, with 30 on site at the same time - a massive but not untypical increase in workload compared with before privatisation.

To make sure we get this right we need to give local councils the resources to inspect building jobs properly within the framework determined by the NCS, employing far more inspectors and ending a system which allows a contractor to pay an inspector for approval.

At the same time, the Building Regulations can't provide detailed guidance on how to retrofit homes, which can differ vastly. There are good standards and guidance now available, with a lot of research on what has gone wrong in the past.

Meanwhile the PAS (Publicly Available Specification) 2035 standard covers most aspects of the retrofit procedure, including training & registration for assessors, designers and installers. The NCS will consult on reviewing it with a panel of experts and experienced builders to address any concerns and update it as the retrofit programme progresses.

"General" building inspectors will be able to check whether approved guidance is being followed and ensure that both energy efficiency and safety standards are being met. As we have mentioned, the question of building performance *in use* is an important one, and it is vital that work is followed up with monitoring of energy demand and thorough inspection for any snags or unforeseen problems that will need to be rectified (eg overheating, cold bridges and damp around electrical conduits).

E Technical issues: materials, products, processes

INSULATING MATERIALS

Overview

Many of the materials commonly used in retrofitting buildings come from the oil industry and a lot of CO_2 is emitted in making and importing these materials. This is also true for materials like mineral wool which can be made from natural - but not inexhaustible - materials, fired at extreme temperatures.

The oil industry materials - like polystyrene, polyurethane and "PIR" foam (the kind used on Grenfell Tower) - also cause pollution when they are made, are very flammable, and don't allow vapour or moisture to pass through freely (which can lead to condensation inside the wall). They also deteriorate, are hard or impossible to recycle, and release gases within the building which may be bad for our health.

Mineral wools, though generally considered safer and more durable, may contain formaldehyde and other toxic glues and binders which are bad for health and for the climate. Proponents of mineral wool argue that formaldehyde is becoming obsolete in its manufacture, and that a high percentage of the material used is typically recycled - though recycled materials may be more likely to contain toxic substances. Like many industries, an issue of concern is the cost-driven relocation of manufacture to regions where environmental and health and safety protections are lower (see, for example, https://inthesetimes.com/article/west-virginia-epa-denmark-pollution-environment-factory). As trade unionists, we must be alert to the wellbeing of workers and their local communities as much as that of consumers.

Potential for using natural products

For all these reasons we want to move to really sustainable materials which also usually perform better in the damp and changeable weather we have in the UK.

The priority must therefore be to grow local industries making more and more of the "new" natural and sustainable materials. There are jobs now in production of insulating materials in the UK, as well as the beginning of renewably-produced natural products. A mass retrofit programme will mean expanding these local industries, to avoid carbon costs associated with transportation, and ensure the lowest possible embodied carbon in our buildings.

Sheep wool insulation, for example, could make a valuable contribution, and has many benefits, for example the ability to absorb formaldehyde. Sheep wool is largely classified as Euroclass E which means it is flammable. Anecdotally it is generally harder to burn wool than for instance plastic materials, but obviously caution is required as to how it is used.

Currently, 22,000 to 40,000 tonnes of wool are produced every year in Britain from 40,000 farms. Much of this is exported for quite low prices but could be diverted to insulation manufacture. A small amount of sheep wool insulation is made in the UK already, but it contains up to 40% plastic polyester and toxic flame retardants. Non-toxic plastic free sheep wool insulation is made in Austria and Germany and they are willing to license their production methods to the UK.

Wood fibre and wood quilt insulations can be very effective and are made from wood waste, and yet in the UK one million tonnes of wood waste currently go to landfill every year. Again we could establish factories in the UK to produce these materials instead of importing them from other European countries. Companies producing carcinogenic glued wood composite products could alter some of their production lines to produced non-toxic wood fibre insulation.

Hemp is widely grown on UK farms, making a valuable contribution to rotation systems and producing a wide range of healthy and bio composite products. Hemp and flax fibre can be used to make insulation quilts and batts (again currently only imported from Europe). Left over hemp straw can be mixed with lime to produce Hempcrete, an effective insulation materials for houses, as described in this article on the Carbon Coop website, 2019. A small industry to do this already exists in the UK and could be rapidly expanded with hemp processing factories set up in different regions. Lime binders used with hempcrete are already manufactured in the UK.

Producing natural materials for insulation can have other environmental benefits – for example, hemp sequesters carbon at a faster rate than growing trees, meaning that hemp-based construction materials can actually be carbon-negative, even after allowing for transport emissions if we grow the hemp and produce the materials locally (see this article in the Guardian, 2014). Hemp cultivation can aid sustainable food production as it fits well into a crop rotation and helps improve soil (see here for example).

How we prioritise land use, and how far and how quickly we can scale up production of natural materials, are issues that need to be explored urgently. For example, what are the implications of scaling up sheep farming and how should its uses be prioritized? (We may be eating less meat, but can surely expect that wool will make a comeback for clothing as the popularity of petroleum-based fabrics declines. And we need to consider how we manage landscapes to prevent soil erosion and flooding). Some of these issues will be discussed in the chapter on Agriculture, along with questions of land ownership and how this impacts on land use.

A range of recycled insulation materials are also available though even these are largely imported, made from recycled paper, cloth and denim and much more. Again, these are industries where many more jobs could be created.

The EU Construction Product Regulations are currently being revised to include safe emissions level standards. This means that many current products, including insulation, will no longer be regarded as safe for use in buildings, and will lead to much greater adoption of natural, low embodied energy, non hazardous materials. It will be important to ensure that these regulations are also adopted in the UK.

COMPONENTS

The new insulation materials industry we hope to promote will need workers. But we also need special components like windows and solar energy collectors - and these also need workers. Some of the thousands of skilled engineers being transitioned from jobs in car and aviation companies could choose to retrain, to adapt their skills to making components for retrofitting buildings.

For example, we don't have a large-scale high performance window company in the UK - all our really good insulating windows - "combination windows" - timber framed inside with a separate aluminium outer frame - are imported, adding to overall carbon emissions. The climate jobs retrofit programme would allow us to recruit engineers and designers to start a local high-performance window industry.

In the short term we could encourage existing companies to start producing in the UK, by a combination of demonstrating the new increasing market, and providing sites and infrastructure. Alongside these and new “home-grown” companies we can also (in the case of windows and doors) use smaller-scale joinery workshops taking on NCS apprentices and helping rapidly scale up the skilled NCS workforce.

PV and solar thermal panel production as well as equipment and ducting for MVHR (mechanical ventilation with heat recovery), appropriate radiators (for lower output heating systems, especially in newbuild), heat pumps, shading devices and timber connectors will all need engineers. Other manufacturing opportunities include endoscopes and small fibre optic cameras to check cavities, as well as "point-cloud" technology which allows a 3D survey to be created electronically.

Building up green industries for primary materials such as steel is also vital, and is discussed in the chapter on Industry.

A NEW CONSTRUCTION TIMBER INDUSTRY?

The UK currently imports 90% of its construction timber. Growing softwood and turning it into useable timber products, including engineered timber beams and panels is a chance to provide jobs and skills, and reduce the carbon footprint of building products. But expansion of softwood plantations needs to be done carefully to avoid sterile monocultures which damage or restrict other plants and wildlife. This can be done, both by planting slightly differently - including open spaces - and by mixing in broad-leaved native trees and shrubs. See here for more discussion.

MVHR (MECHANICAL VENTILATION WITH HEAT RECOVERY)

The purpose of MVHR is to provide a healthy level of air exchange in a well-insulated building without wasting the energy that has been used for heating. The extracted (polluted) air is taken through a central heat exchanger where the warmth is transferred to the (fresh) supply air.

Some experts don't think that MVHR is appropriate for most retrofit, even though it can work well for new Passivhaus buildings. But whilst the need for breathable materials and adequate ventilation may make it harder to reduce energy use than we would have liked, making a building nearly airtight whilst allowing vapour to permeate and providing plentiful clean, slightly warmed air intake has to be part of the solution, where it can work.

One objection to MVHR is that it may give an insufficient rate of air exchange to remove toxic particles, eg from petrochemicals in insulating materials and furnishings. It can be argued that MVHR is bad for health as the use of plastic and metal components in pumps and machinery add to the pollution load in buildings. High level ventilation of buildings will improve air quality by removing stale and polluted air, but does not remove the source of the pollutants! A meta study of MVHR gave very mixed results.

Simple extractor fans are likely to be insufficiently effective. However, there are a number of intermediate solutions being developed (eg by Smartvent and Passivvent) that provide demand controlled air extraction and input (with humidistats which automatically turn the fan on and off in accordance with air humidity), and which can operate from solar energy during the day. In practice, the energy assessor will look at each building and draw up a schedule of the best retrofit possible.

HEAT PUMPS

A heat pump works in a similar way to a fridge, using low level warmth from the air or ground outside (or, sometimes, from a water source) to warm a liquid or gas refrigerant coolant, which is then compressed, increasing its temperature significantly. The indoor unit of the heat pump passes air or water over the hot coolant, and then uses it to heat the building. The heat transfer can be reversed to remove excess heat during hot weather. The advantage of such as system is that, when working efficiently, it has a very low energy demand, actually providing more energy in the form of heat than the energy supply needed by the pump (an energy efficiency of up to 300% is possible). For this reason heat pumps have been widely promoted as the system of choice for decarbonising heat, especially if powered by onsite solar energy.

Heat pumps are most efficient when warming a large area of heat-emitting surface, rather than heating a small area to a high temperature to warm a room (and causing draughts). Therefore, extra large radiators or underfloor heating are usually required for the system to save a lot of energy (and money) and warm the space adequately. Needless to say, the building needs to be well insulated and draught free for this to work well. Heat pumps also require more energy input when the air or ground is cold, as the heat "uplift" required is greater. When badly installed, in poorly insulated buildings or in very exposed sites, or with inappropriate heat distribution systems in the house, they may be unable to heat the building adequately in cold weather, and have a high supplied electricity demand (hence being expensive to run).

Air source heat pumps are easier and cheaper to install, but use energy less efficiently, especially in winter because they don't have access to the warmth stored in the ground during cold weather. They need to spend energy (and generate noise) on a fan system to blow air across the hear exchangers. They also need to incorporate a defrost cycle to prevent ice forming on the heat exchangers in cold conditions (when the heat is most needed).

Ground source systems are generally more efficient than air source, especially in winter when the outside air is very cold. They require a sufficient amount of outdoor space to bury the coils, though in some cases this can be achieved efficiently by installing a shared system for a street, block of flats or other compact group of dwellings. However, installing a ground source system properly requires a thorough understanding of the movement of heat in the ground, the local geology and the heating and cooling requirements of the building, all of which means a high upfront cost and out of reach for most households unless installed as part of a public service.

The efficiency of the GSHP can decline over the course of the cold season as the heat is extracted from the area around the ground loop, as heat moves only slowly through the ground to replace it. However, it is possible to create a “thermal bank” – a bank of earth used to store heat between seasons – using solar heat collected during the summer.

Apart from performance in use, there are two major concerns with heat pumps from an environmental perspective. Firstly, heat pumps are currently imported, with associated transport costs. To solev this we need to focus on building up a local industry and creating jobs in heat pump manufacture (as well as ensuring that more people are trained to perform the necessary buildings inspections and carry out the installations to a high standard).

Secondly the commonest refrigerants currently in use are HFCs (hydrofluorocarbons) which have a high global heating potential and can leak or be released when a system is dismantled. The country is currently phasing out hydrofluorocarbons (HFC) used as refrigerants by 2030, and more sustainable refrigerants are available. However, these introduce slightly different engineering requirements for the compressors, if the same level of energy efficiency is to be maintained.

The overall conclusions is that, whilst heat pumps can be an ideal solution for many buildings, especially for newbuild or when installed as part of a complete retrofit, we should be wary of the tendency to regard them as a panacea. As always, the key is a proper assessment of the building, evaluation of what work will achieve the biggest energy efficiencies, and installing any new heating system as part of a whole house plan rather than as a one-off intervention.

Once again, this is best achieved not through the provision of grants to householders to purchase systems as a one-off, but through a systematic and accountable programme delivered by a national climate service focused on achieving the best energy efficiency possible for each building.