UNLOCKING THE **JOB POTENTIAL** OF ZERO CARBON

Report on the case studies United Kingdom, Hungary and the Republic of Ireland

Anne Chapman, Jonathan Essex and Peter Sims

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Jonathan Essex is a chartered engineer and environmentalist. He has worked for engineering consultants and contractors in the UK, Bangladesh and Vietnam. This work has included developing strategies and business plans for reuse and recycling, and for decarbonising the UK construction and housing industries. His current work focuses on improving the sustainability and resilience of livelihoods and infrastructure investments worldwide. He also serves as a councillor in Surrey.

Peter Sims is an Electronic Engineer who specialises in systems engineering. He particularly focuses on the overlap and interfaces between human and non-human systems. For example, the relationship between energy or transport systems and human behaviour in the context of climate change. This work has included a multi-disciplinary design project to propose a two-degree climate compatible energy system for Europe. He has carried out the modelling of job creation from the transition to a zero-carbon economy described in this report.

Acknowledgements

Whilst many peoples' work has informed this study, and precursor reports on Sheffield and the Isle of Wight (UK) we would like to particularly thank Ray Cunningham (Green House), Tommy Simpson and Hayley Farrell (Green Foundation Ireland) and Josef Gal (Ökopolisz Alaptivány).

The **Green European Foundation (GEF)** is a European-level political foundation whose mission is to contribute to a lively European sphere of debate and to foster greater involvement by citizens in European politics. GEF strives to mainstream discussions on European policies and politics both within and beyond the Green political family. The foundation acts as a laboratory for new ideas, offers cross-border political education and a platform for cooperation and exchange at the European level.

Green House is a think tank, founded in 2011. It aims to lead the development of green thinking in the UK.

CONTENTS

ABBREVIATIONS

EV	electric vehicle
FTE	full time equivalent
GW	gigawatt (one thousand million watts)
ICE	internal combustion engine
kW	kilowatt (one thousand watts)
MW	megawatts (one million watts)
NUTS	Nomenclature of Territorial Units for Statistics
ONS	Office for National Statistics https://www.ons.gov.uk/
PV	photovoltaic
W	Watt, a unit of power
Wh	Watt hour, one watt for one hour, a unit of energy

SUMMARY

Meeting the challenge of climate change requires structural changes to the economy so that it is no longer dependent on fossil fuels: we need to reduce overall energy use and ensure that all the energy that we do use is from renewable sources. This will require the creation of a large number of new jobs.

The Green European Foundation, with the support of Green House Think Tank, has developed a model to estimate the number of jobs that would be created in key sectors of the economy, and to not only demonstrate that a transition is achievable but to also show where those jobs will be. To this end, we have applied the model to the United Kingdom as well as to Ireland (with the support of Green Foundation Ireland) and Hungary (with the support of Ökopolisz Alaptivány).

In too many countries the economy is out of balance. Large cities, linked into a global economy, are thriving, whereas many smaller places and rural areas are in decline. Existing patterns of infrastructure spending, which promote long distance transport links between thriving cities, will only make things worse. But a different path is possible: our research shows that increasing ambition on climate targets and transitioning the economy towards zero-carbon would result in a net increase in jobs all over the three countries looked at, helping to rebalance the economy.

Our model includes: the installation and maintenance of renewable energy systems; sustainable transport; buildings (energy efficiency and installation of renewables); reuse and recycling of waste; and sustainable agriculture. We considered jobs created during a transition phase (to 2030) and in the longer term, by geographic area. The model combines published data about an area with available information on hours of work and hence numbers of jobs involved in, for example, installing wind turbines, driving buses, insulating homes or separating waste for recycling. Where information is available, we have then subtracted the jobs that will be lost in current fossil fuel-dependent activities, such as coal power stations and car maintenance. Many people will need training or support of some kind to take up the new jobs, so we have included an estimate for such 'support jobs'.

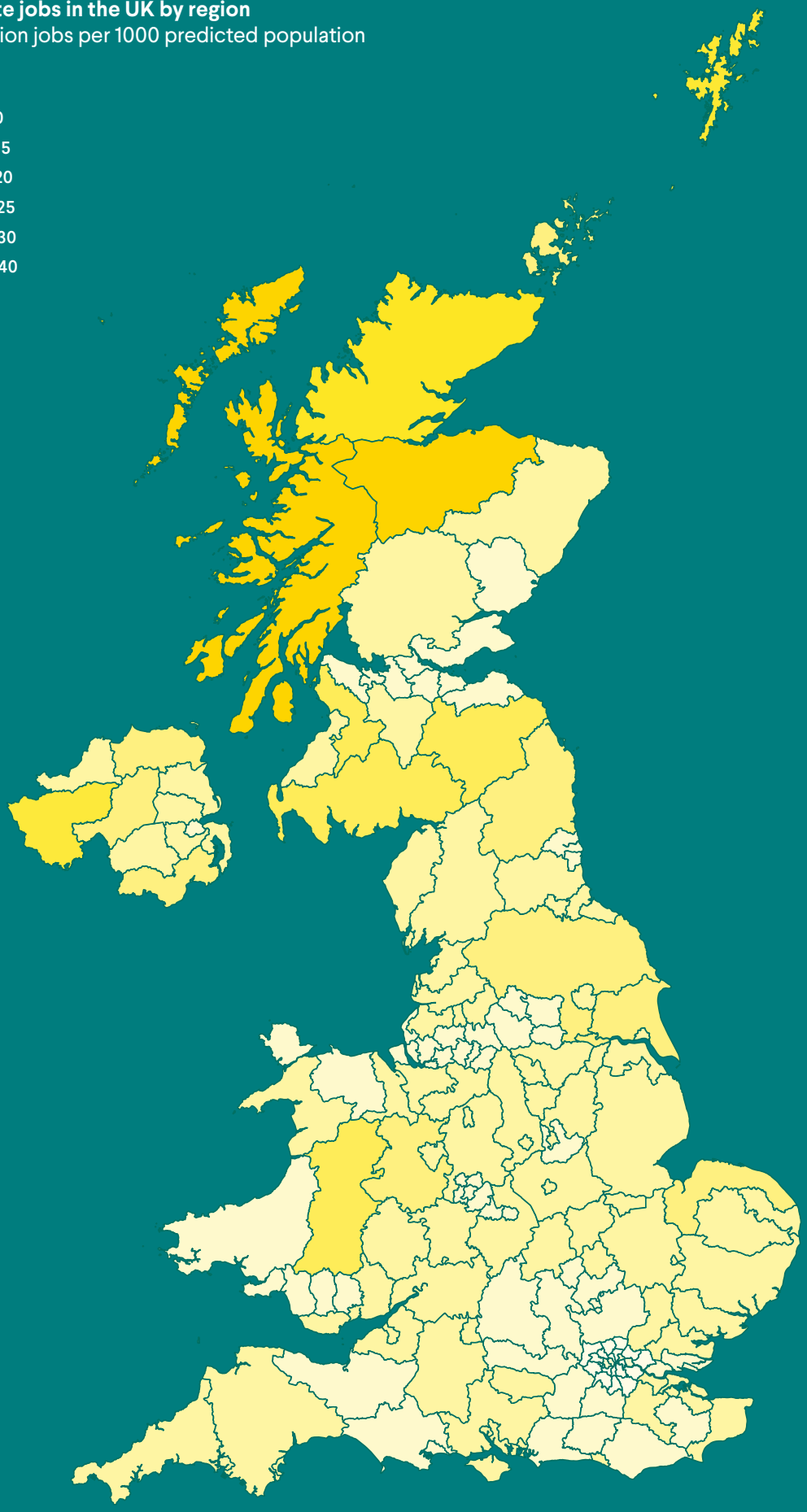
We first developed the model in 2016 in a study of the potential for creating climate jobs on the Isle of Wight, in the UK. This was followed by estimates for the Sheffield City Region in 2017. In 2018, we developed a model for the whole of the UK and estimated the jobs that could be created in Ireland and Hungary (excluding the agricultural sector).

Some of the new jobs are proportional to the population whilst others depend on land availability: producing food and generating renewable energy both require land, which is mostly found in rural areas.

Our job estimates are conservative. Firstly, data on numbers of jobs was not available for some aspects of the transition, so these aspects were not included in the estimates. Secondly, we have not estimated the jobs created in the wider economy by the spending of those in the new jobs. Finally, we have not included jobs in the supply chain, such as making wind turbine blades and generators. These are likely to replace existing manufacturing jobs. This research shows that jobs-intensive investment at the local level can help achieve more ambitious climate targets and shift job creation away from the major cities, reducing regional inequality.

Climate jobs in the UK by region
Transition jobs per 1000 predicted population

- 0-5
- 5-10
- 10-15
- 15-20
- 20-25
- 25-30
- 35-40
- ›45



CLIMATE JOBS IN THE **UNITED KINGDOM**

- 980,000 transition jobs
- 710,000 long term jobs

	Transition	Long-term	
Energy	347,600	103,900	Scale up renewables, especially wind and solar: installing and maintaining 274 GW of new capacity.
Transport	181,800	363,500	Rapidly shift to a sustainable mix of public and active transport.
Buildings	306,900	64,100	Massive street-by-street energy efficiency and renewables retrofit to 20 million homes.
Reuse and recycling	41,800	83,600	Double reuse and recycling from 45% to 90%.
Agriculture	19,800	39,500	Shift to locally sustainable, organic agriculture.
Training and support	80,800	58,900	Upskill, retrain and support people to take up new jobs.

Current Situation: The UK economy is dominated by London. Some large cities and university towns in other parts of the country attract jobs and investment while in many coastal communities and post-industrial towns and villages there are few job opportunities. Growth of aviation and road transport have slowed reductions in carbon emissions.

Climate Opportunity: A transition economy would divert investment from long-distance transport, fracking for shale gas and speculative housing developments into local rail, bus and active transport to localise the economy, alongside massive planned renewables and energy efficient investment, and a new vision for farming and land-use to revitalise rural areas.

Regions of Hungary

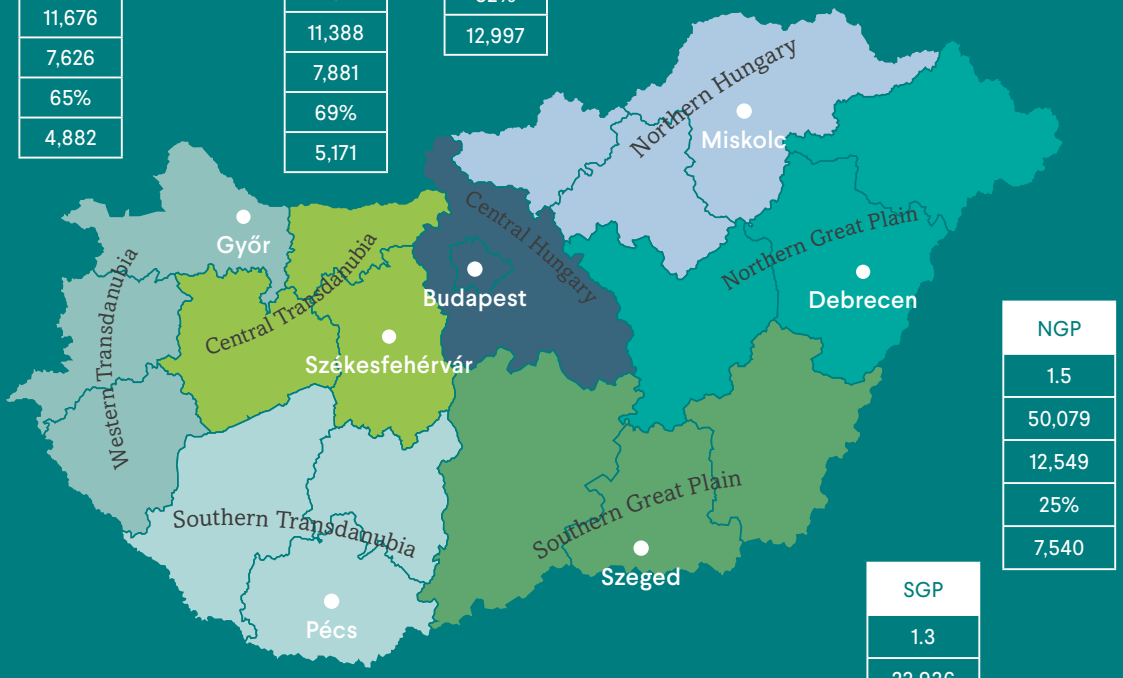
Population (millions)
Unemployed (in 2017)
Transition jobs
As % of unemployed
Long term jobs

WT
1.0
11,676
7,626
65%
4,882

CT
1.1
11,388
7,881
69%
5,171

CH
3.0
40,235
12,997
32%
12,997

NH
1.2
29,389
9,564
33%
5,828



NGP
1.5
50,079
12,549
25%
7,540

SGP
1.3
23,936
11,797
49%
6,686

ST
0.9
25,004
8,262
33%
4,751

From https://upload.wikimedia.org/wikipedia/commons/1/16/RegionsHungary.png

CLIMATE JOBS IN **HUNGARY**

▸ 70,000 transition jobs ▸ 47,000 long term jobs

	Transition	Long-term	
Energy	20,300	5,000	Restart wind (15 GW) and scale up solar photovoltaic (10 GW) and other renewables.
Transport	11,900	23,800	Rapid transition to sustainable transport for all.
Buildings	28,200	5,900	Retrofit of energy efficiency and/ or renewable energy systems to around 2 million homes.
Reuse and recycling	4,400	8,900	Nearly triple reuse and recycling levels to 90%.
Training and support	6,000	4,000	Upskill, retrain and support people to take up new jobs.

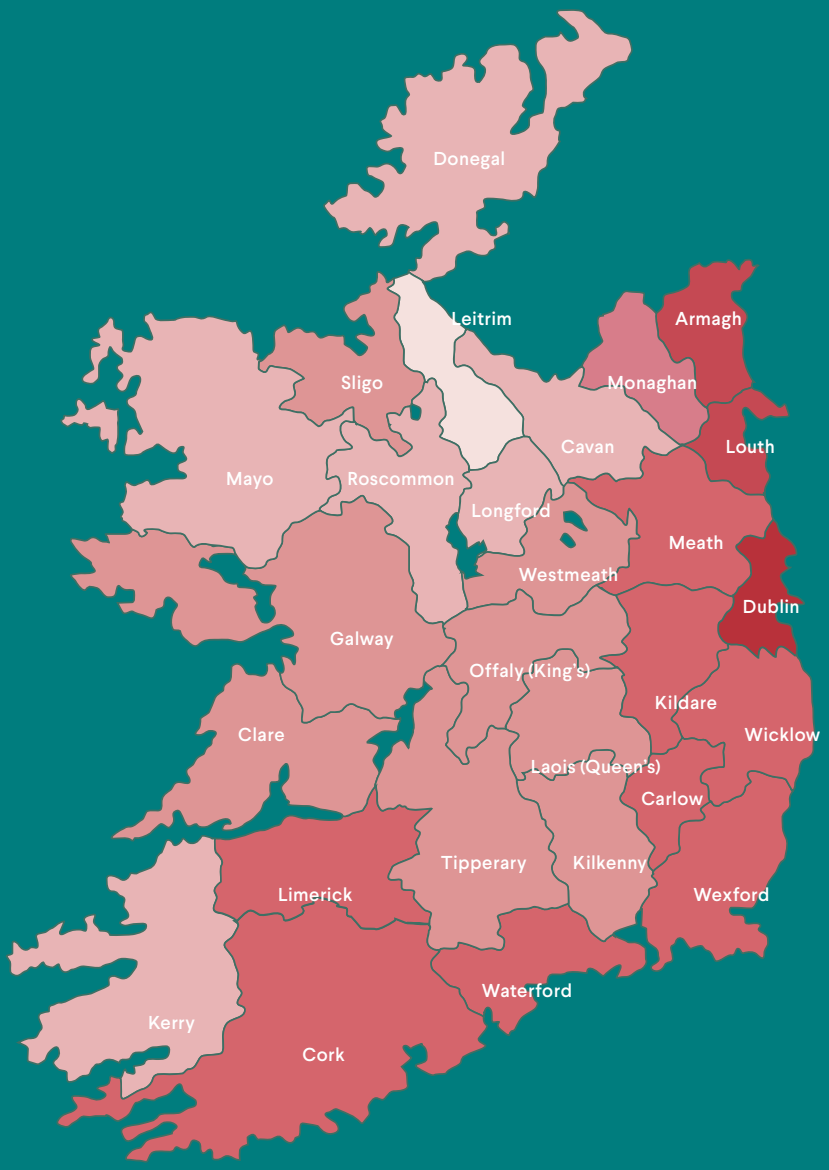
Current Situation: Hungary has a low population density with half the land used for arable agriculture (typically large-scale and industrialised) and a quarter forested. 30% of the population of just under 10 million live in the Central Hungary Region. The economy is increasingly centralised, dominated by the capital, Budapest. No wind turbines have been installed since 2010.

Climate Opportunity: The shift to a sustainable energy economy requires massive investment in renewables and rethinking of transport. The jobs created by a transition to a zero-carbon economy would help rebalance the economy across Hungary and could provide employment for between a quarter and two thirds of those currently unemployed, depending on the region.

Population density of Ireland map
Based upon Republic of Ireland - 2002 Census results

People per km²

- 0-10
- 10-19
- 20-29
- 30-39
- 40-49
- 50-99
- 100-1000
- 1000+



From https://en.wikipedia.org/wiki/File:Population_density_of_Ireland_map.png

CLIMATE JOBS IN **IRELAND**

▸ 53,000 transition jobs ▸ 38,000 long term jobs

	Transition	Long-term	
Energy	17,700	7,200	Strategic investment to install and sustain 18 GW of wind, solar and other renewables.
Transport	8,750	17,500	Shift to electric-powered, sustainable transport.
Buildings	22,100	4,600	Retrofit of energy efficiency and/ or renewable energy systems to around 1.2 million homes.
Reuse and recycling	2,900	5,700	More than double reuse and recycling to 90%.
Training and support	1,500	3,100	Upskilling and support so all can access these jobs.

Current Situation: Ireland has a population of just over 4.8 million, of which 1.8 million live in the Dublin area. 120,000 people were unemployed in June 2018. A particular challenge to the transition in Ireland is the extraction and burning of peat in the Midlands to produce electricity, carried out by the semi-state company, Bord na Móna. Since its creation in 1946, this company has provided good jobs and relative prosperity to a previously impoverished region.

Climate Opportunity: The transition could create far more employment than that lost as peat extraction for power generation is phased out. This provides an opportunity for wider rethinking of what sustainable communities might look like across the country, including a chance to rethink the way Ireland uses its fertile countryside to produce cattle, beef and dairy products for export.

INTRODUCTION

Since 2016, the Green European Foundation with the support of Green House has been carrying out work on estimating the number of jobs that would be created by a transition to a zero-carbon economy; an economy where we take climate change seriously and reduce emissions of greenhouse gases in line with the aspiration to limit global warming to 1.5 degrees [1]. We first focused on the Isle of Wight, an island off the South coast of England, for which we developed a model to estimate the number of jobs that would be created by the transition of key sectors of the economy. The model made use of published data about the number of jobs associated with activities such as insulating homes, or installing renewable energy systems, and data on the Isle of Wight. The report, *A Green Transition for the Isle of Wight,* by Jonathan Essex and Peter Sims, was published March 2017. This was followed by a similar study for a very different area of the UK, the Sheffield City Region. The results were published in May 2018, in the report, *Job Creation from a Sustainable Transition for Sheffield City Region: How delivering a climate change compatible sub-regional economy will create new enterprises and employment* [2]. The research for the Isle of Wight and Sheffield reports was part of the Green European Foundation project on Ecological Production in a Post-Growth Society.

In 2018, Green House has led a project for the Green European Foundation entitled Strengthening Climate Targets, Creating Local Climate Jobs, working with Green Foundation Ireland and Ecopolis in Hungary.

This project has estimated the number of jobs that could be created by more ambitious emissions reduction targets and a local jobs-rich green investment strategy, in local authority areas in the UK, in each region of Hungary and in Ireland. This report describes the methodology used in that work and presents its results

METHODOLOGY

2.1 Overview

Our model combines:

- A zero carbon vision for the economy and how this would impact on each sector in practical terms;
- Published data about the geographic area of interest, such as land area, population, waste generation, etc.; and
- 'Job metrics' – hours of work and hence numbers of jobs per activity, derived from published sources.

These are combined in a spreadsheet to give an estimate for the number of jobs in each sector during a transition period (to 2030) and in the longer term. We have taken 2030 as the date when emissions need to be reduced to net zero because the UK Committee on Climate Change, in its consideration of what would be required to limit global warming to 1.5°C [3], concluded that emissions of carbon dioxide and other long-lived greenhouse gases need to be reduced to net zero in the 2030s, or a decade later if technologies to remove CO_2 from the atmosphere become viable at scale. A precautionary approach is therefore to achieve net zero by 2030.

For some sectors the transition and long-term jobs are estimated separately as they are for essentially different activities (*e.g.* installing and then maintaining renewable energy systems). In calculating the number of transition jobs we have assumed that the activities required to bring about the transition, such as creating new infrastruc-

1 The 2030 target is consistent with the target to dramatically change our carbon emissions in the next 12 years set out by the IPCC. See IPCC (2018) Special Report: Global Warming of 1.5°C. https://www.ipcc.ch/sr15/

2 Both reports are available to download from https://www.greenhousethinktank.org/climate-jobs.html.

3 https://www.theccc.org.uk/wp-content/uploads/2016/10/UK-climate-action-following-the-Paris-Agreement-Committee-on-Climate-Change-October-2016.pdf

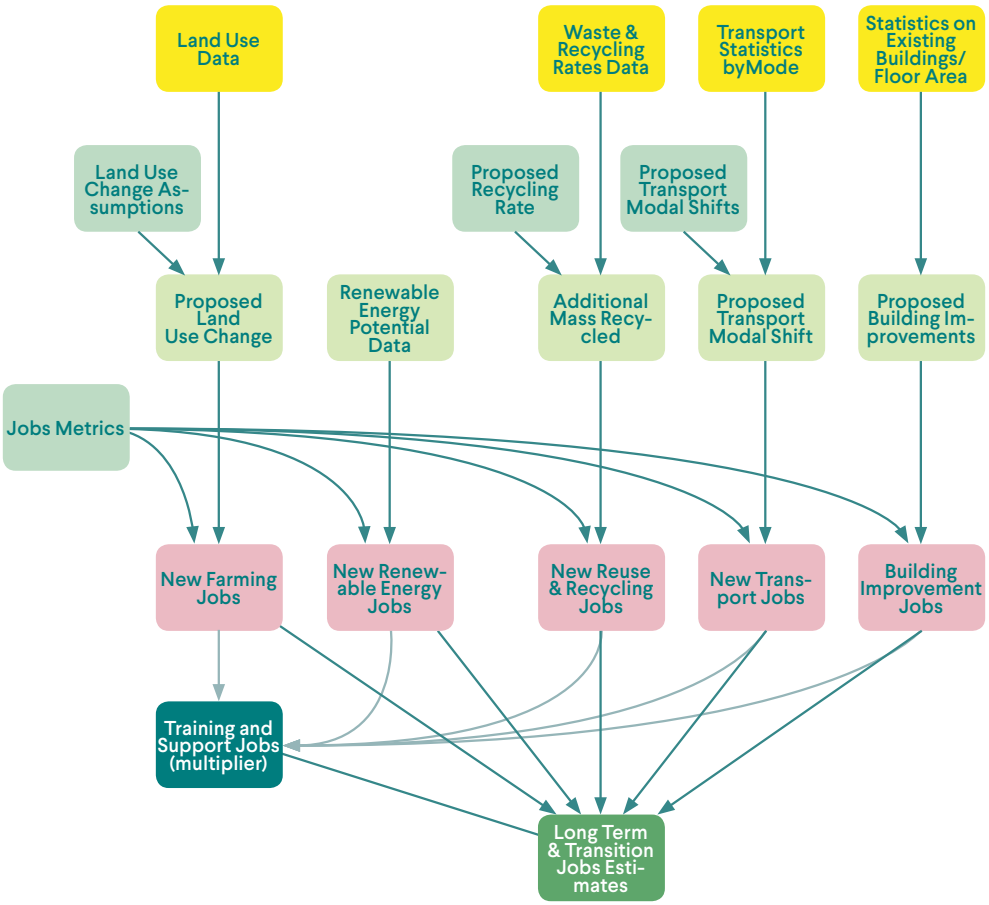
ture, are spread equally throughout the transition period. The transition jobs also include 50% of the long-term jobs, on the assumption that half of the transition will have happened half way through the transition period.

The sectors we have looked at are:

- Energy;
- Transport;
- Buildings (retrofit of renewable energy and energy efficiency measures);
- Reuse and recycling of waste; and
- Sustainable agriculture and forestry (in the UK only).

Once we have calculated the total number of new, full-time equivalent (FTE) jobs in a sector we have then, where information is available, subtracted the jobs that will be lost in current fossil fuel-dependent activities, such as in running coal fired power stations and in the maintenance of internal combustion engine vehicles. Many people will need training or support of some kind to take up the new jobs so we have included an estimate for such 'support jobs', calculated from the total number of jobs. An overview of our method is given in Figure 1.

Figure 2 Overview of methodology



For the UK we looked at each NUTS (Nomenclature of Territorial Units for Statistics) level 3 area, used by Eurostat [4] and the UK Office of National Statistics (ONS).[5] These are similar to the UK areas of local government: they are generally smaller than UK Counties but larger than districts or single Unitary Authorities. For Hungary we modelled jobs in each of the seven NUTS 2 regions and for Ireland the job estimates were modelled for the Republic of Ireland as a whole. This methodology section sets out how we estimated the climate jobs in the UK. Sections 4 and 5 discuss how that method differed for the estimates made for Hungary and Ireland respectively.

4 ec.europa.eu/eurostat

5 ons.gov.uk

2.2 Energy

Vision:
An energy system powered by renewable energy, where electricity is used for transport and heating as well as its current uses.

Onshore wind and river run hydro
The amount to be installed has been taken from national estimates,[6] then scaled to the NUTS3 areas depending on the available land area in each which is not urban, forestry or urban green space.

Offshore wind and tidal
Estimates have only been made at the national level and not allocated to NUTS3 areas.

Solar Photovoltaics (PV)
The jobs estimated under this sector include those associated with ground-mounted solar farms and solar photovoltaic systems installed on the roofs of commercial and public buildings. Those involved in installing and subsequent maintenance of solar PV on domestic properties are included under Buildings. The amount of solar PV installed in each NUTS3 area is based on the available area of former landfill and mining sites, and of the relevant roof areas using the following assumptions:

% of landfill & mining area used for ground-mounted solar PV	40%
% of urban land area assumed to be public/community roof space	2%
% of industrial/commercial land area which can be used for solar PV	10%
Assumed MW PV per Ha ground-mounted solar PV7	0.52 MW
Assumed MW PV per Ha roof-mounted solar PV8	0.83 MW

Finally, the existing jobs in fossil-fuel power stations were subtracted from the total new jobs. Jobs associated with fossil fuels used in the industrial sector have not been included.
A flow chart showing how we have modelled jobs in the Energy sector is shown in Figure 2. The jobs metrics used, and their sources are shown in Table 1.

6 Estimates of renewable potential are primarily based on figure 5.1 of http://fes.nationalgrid.com/media/1363/fes-interactive-version-final.pdf and Allen et al, 2013.

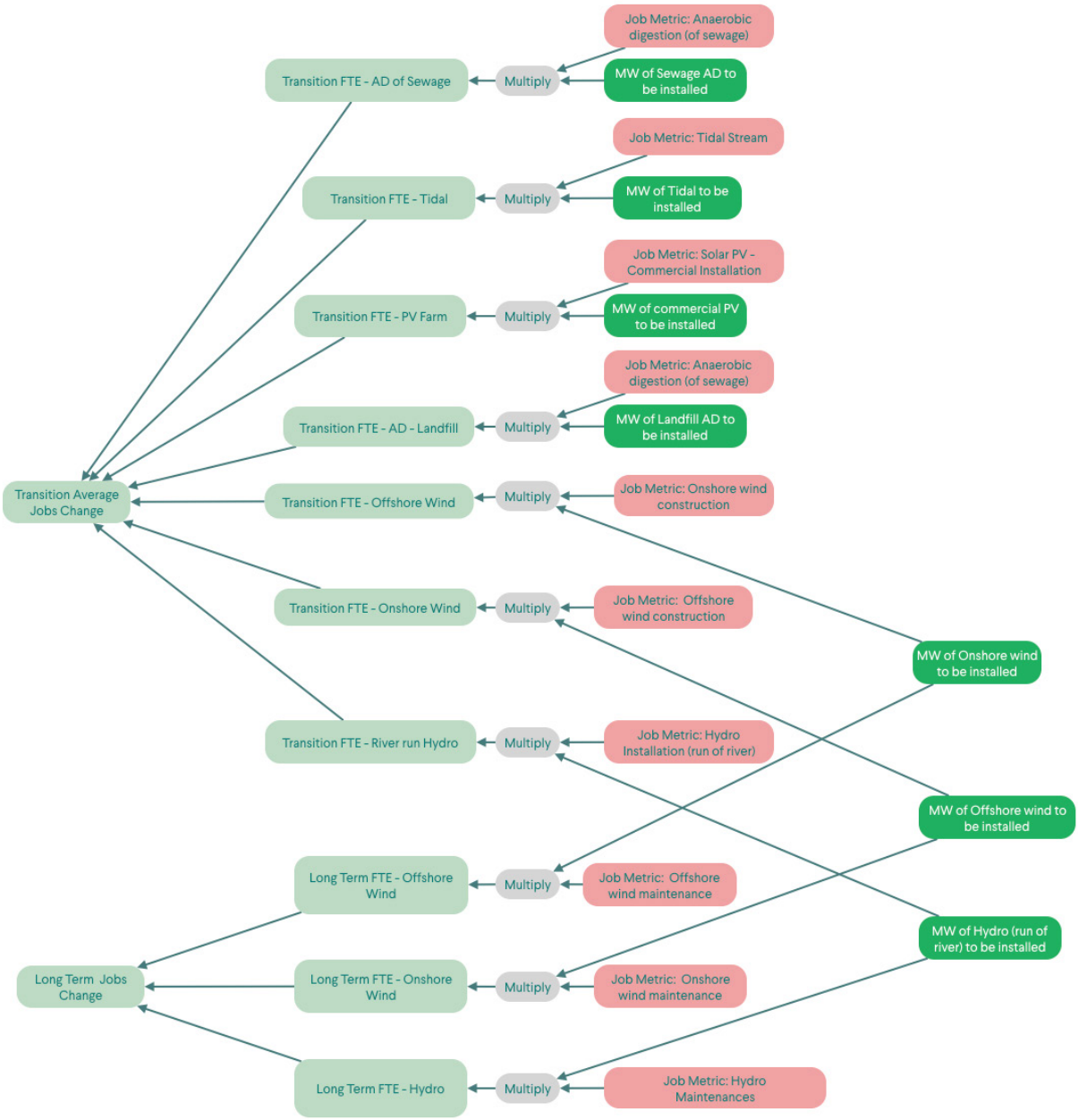
7 Average for Isle of Wight Solar Farms – from Essex and Sims, 2017

8 From Solar PV - Buyers Guide produced by the Energy Managers Association. http://www.theema.org.uk/wp-content/uploads/2015/12/Solar-PV-EMA-Buyers-guide.pdf

Table 1 Job Metrics for the energy sector

Job Type	Scaling metric	Notes	Source
Onshore wind construction	9 job years per MW installed		https://www.campaigncc.org/sites/data/files/Docs/online_companion_nov_2014.pdf
Onshore wind maintenance	0.3 jobs per MW		https://www.campaigncc.org/sites/data/files/Docs/online_companion_nov_2014.pdf
Offshore wind construction	18 job years per MW installed	Assumed to be twice as labour-intensive as on-shore wind	https://www.campaigncc.org/sites/data/files/Docs/online_companion_nov_2014.pdf
Offshore wind maintenance	0.7 jobs per MW	Assumed to be twice as labour-intensive as on-shore wind	https://www.campaigncc.org/sites/data/files/Docs/online_companion_nov_2014.pdf
Tidal Stream	2.1 jobs per MW	From the figures for Dorset in The Resilience Centre, 2015. 64 jobs from 30 MW installed capacity	http://mollymep.org.uk/wp-content/uploads/The-power-to-transform-the-South-West_FINAL1.pdf
Solar PV - Commercial Installation	2 Job years per MW installed	From the figures for Dorset in The Resilience Centre, 2015. 1287 jobs from 650 MW installed	http://mollymep.org.uk/wp-content/uploads/The-power-to-transform-the-South-West_FINAL1.pdf
Hydro Installation (low head: run of river schemes)	48.5 job years per MW installed	From data for <100KW projects in Forrest and Wallace, 2009.	https://www.nls.uk/scotgov/2010/9780755992270.pdf
Hydro Maintenance (low head: run of river schemes)	1.3 jobs per MW	From data for <100KW projects in Forrest and Wallace, 2009.	https://www.nls.uk/scotgov/2010/9780755992270.pdf

Figure 2 Energy jobs modelling flow chart



2.3 Transport

Vision:
Many existing private car journeys will be replaced by walking, cycling or public transport. Internal combustion engine (ICE) vehicles will be replaced by electric vehicles (EVs) or, where this is not feasible, with vehicles that use hydrogen or biodiesel. The railways are almost completely electrified.

We have assumed a modal shift as set out in *Zero Carbon Britain, Rethinking the Future*, by the Centre for Alternative Technology.[9] Our assumptions about modal shift and changes in vehicle occupancy are shown in Table 2.

Table 2 Assumed changes in modes of transport and vehicle occupancy

	Occupancy		Change in distance travelled	Total change in distance travelled by people	Total change in distance travelled by vehicles
	Current	Proposed	km/person	million km/year	million km/year
Car- EV			55%	350,539	201,538
Car – ICE			-94%	-603,706	-347,093
person km/vehicle km	1.6	1.74			
person km/vehicle	12,480	18,595			
Bus			150%	62,850	6,983
London	19.8	19.8			
urban (outside London)	10.4	14			
rural	9	10			
Train			57%	37,813	291
passenger km/vehicle km	127	130			

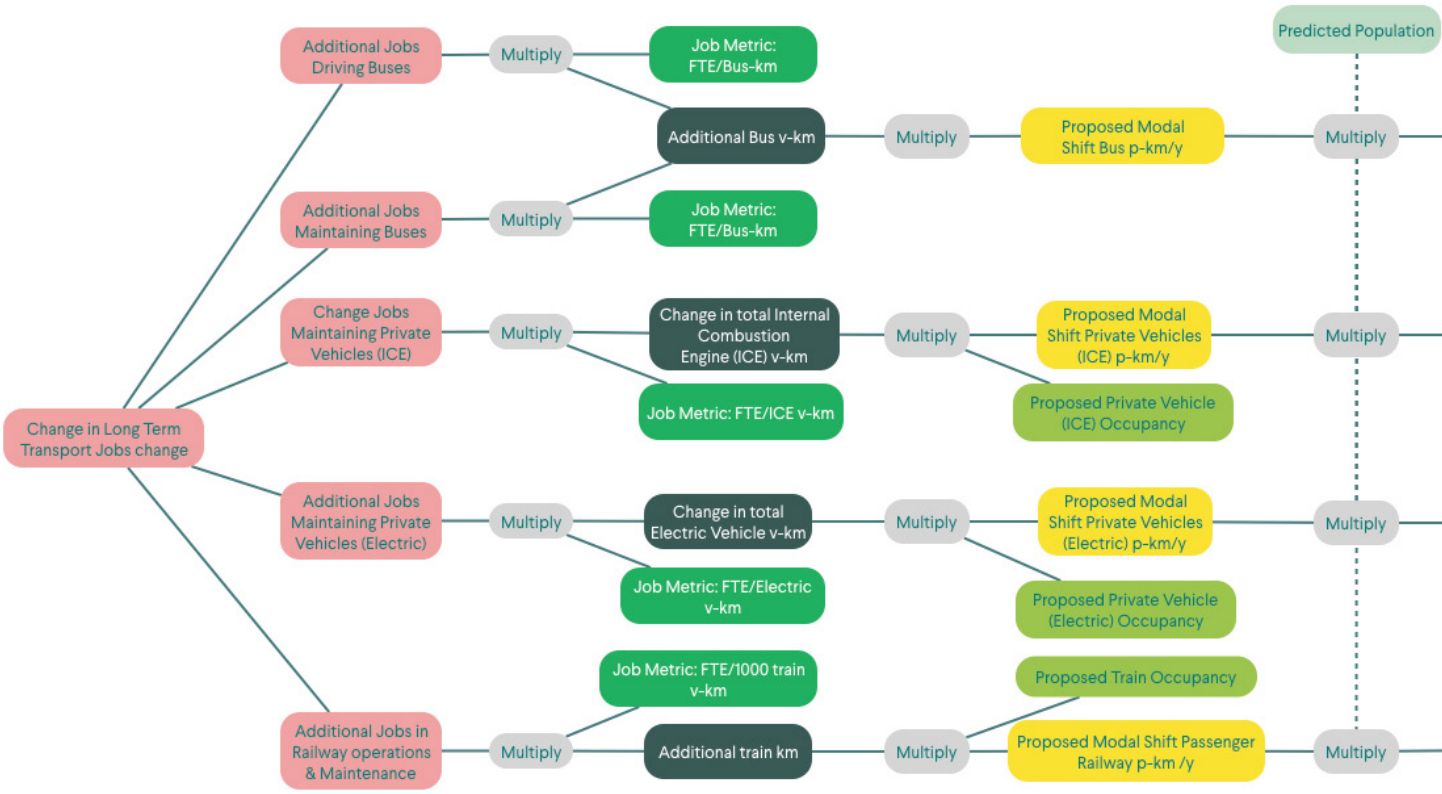
In addition to the modal shift (which is the focus of our job creation calculation) the *transition* to this new transport system will require a massive programme of installation of electric vehicle charging points, substantial completion of the electrification of the current railway system and, potentially, the construction of new tram systems and railway lines. However, insufficient data was available to predict the number of jobs in these areas, so our modelling is of the *long-term jobs only* - in driving and maintaining buses, operating and maintaining the railways and maintaining private electric vehicles. From these new jobs we have subtracted the jobs that will be lost in the maintenance of private internal combustion engine vehicles.

The required modal shift in freight, and the challenge to bring international transport (aviation and shipping) within global climate limits will also result in a significant transformation. This process will be supported by the re-localisation of the economy reflected in the changes across all of the other sectors modelled.

A flow chart showing how we have modelled jobs in the transport sector is shown in Figure 3. The jobs metrics used, and their sources are shown in Table 3. Job estimates have been done for NUTS2 areas then scaled to NUTS3 areas according to population.

9 See p.51 of Allen *et al, 2013.*

Figure 3 Transport jobs modelling flow chart



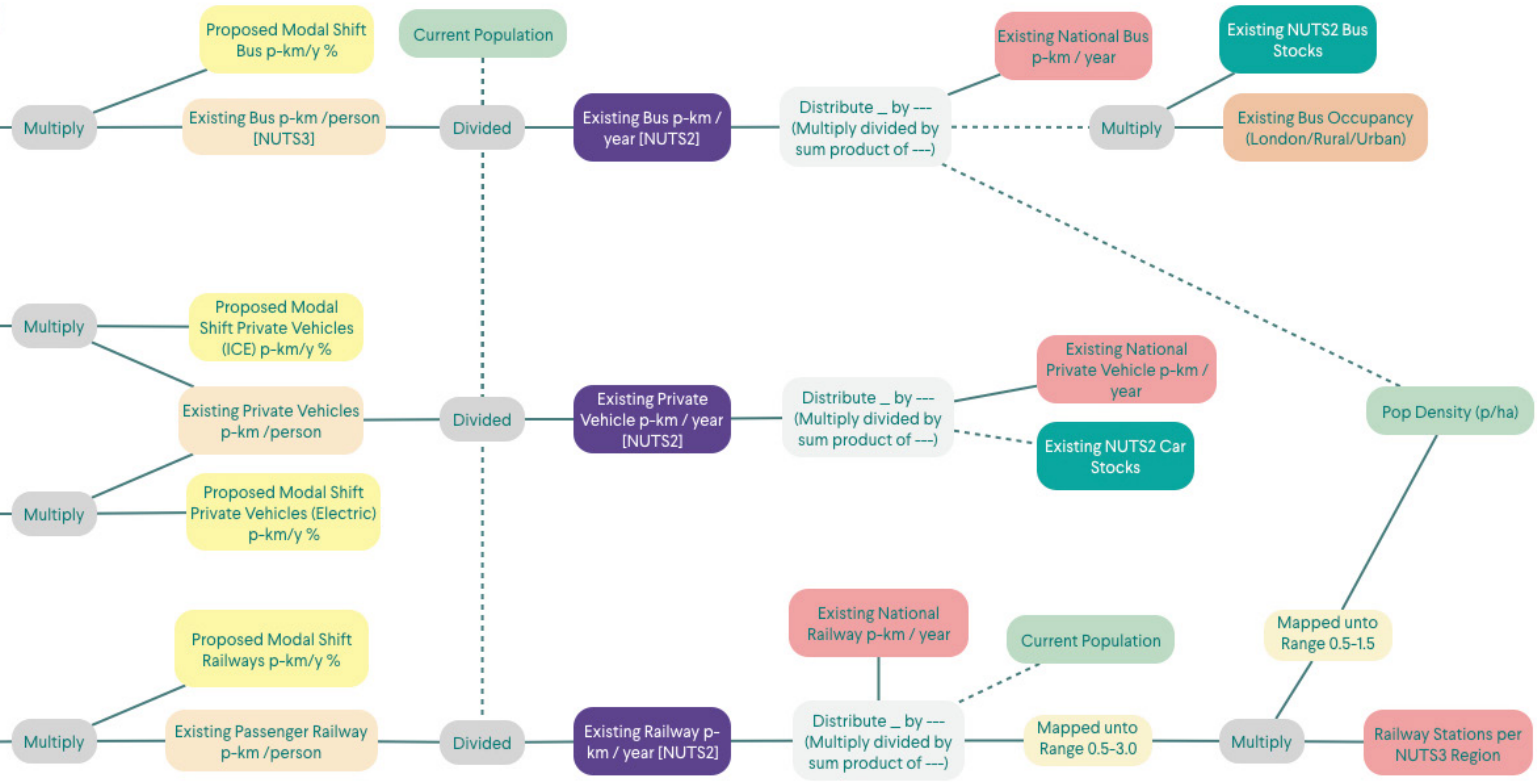

Proposed Modal Shift Bus p-km/y %
Current Population
Existing National Bus p-km / year
Existing NUTS2 Bus Stocks
Multiply
Existing Bus p-km /person [NUTS3]
Divided
Existing Bus p-km / year [NUTS2]
Distribute _ by --- (Multiply divided by sum product of ---)
Multiply
Existing Bus Occupancy (London/Rural/Urban)
Multiply
Proposed Modal Shift Private Vehicles (ICE) p-km/y %
Existing Private Vehicles p-km /person
Divided
Existing Private Vehicle p-km / year [NUTS2]
Distribute _ by --- (Multiply divided by sum product of ---)
Existing National Private Vehicle p-km / year
Existing NUTS2 Car Stocks
Pop Density (p/ha)
Multiply
Proposed Modal Shift Private Vehicles (Electric) p-km/y %
Proposed Modal Shift Railways p-km/y %
Existing National Railway p-km / year
Current Population
Mapped unto Range 0.5-1.5
Multiply
Existing Passenger Railway p-km /person
Divided
Existing Railway p-km / year [NUTS2]
Distribute _ by --- (Multiply divided by sum product of ---)
Mapped unto Range 0.5-3.0
Multiply
Railway Stations per NUTS3 Region

Table 3 Job metrics used in estimation of Transport Sector jobs

Job Type	Scaling Metric	Notes	Sources
Driving buses	0.4 FTE jobs per 10,000 bus miles/year	Bus drivers employed in the UK per bus miles in the UK.	ONS data: *Annual Bus Statistics 2011/12* and Table EMP04 All in Employment by Occupation, Apr-June 2016.
Maintaining buses	0.1 FTE jobs per 10,000 bus miles/year	Employment in bus maintenance in the UK per bus miles in the UK. Existing maintenance intensity assumed to apply to Trolley/EV/hydrogen buses.	ONS data: *Annual Bus statistics 2011/12* BUS 0208 and Table EMP04 *All in Employment by Occupation*, Apr-June 2016
Railways - Operation and maintenance	4.1 FTE jobs per 10,000 train miles/ year	Total UK rail industry staff divided by total train-km (Includes supply chain),	Rail Delivery Group *Annual Report 2016* and Office for Rail and Road, 2016 /17 statistics.
Maintaining private internal combustion engine vehicles (ICE)	0.5 FTE jobs per 1,000,000 private vehicle miles/year	Based on 233,000 FTE jobs supporting 316.7 billion vehicle miles.	ONS, Table TRA8901 and Table EMP04, *All in Employment by Occupation*, Apr-June 2016.
Maintaining private electric vehicles (EVs)	0.3 FTE jobs per 1,000,000 private vehicle miles/year	Based on EVs requiring approximately 2/3 of the maintenance of ICE vehicles.	Van den Bulk, 2009.

2.4 Buildings

Vision:
Energy efficient buildings that require little heating or cooling and generate much of the energy they use.

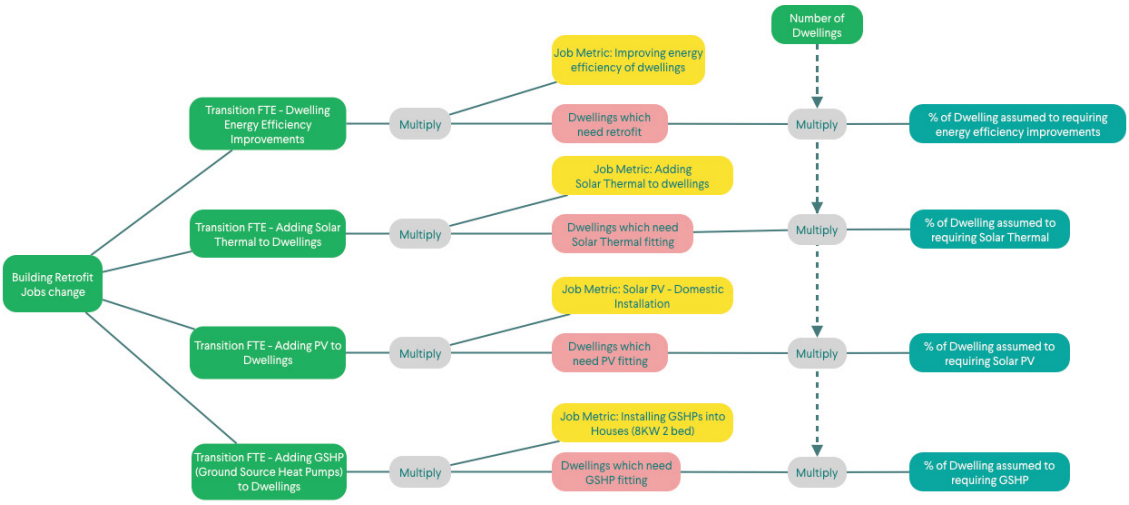
Whilst there is clearly a need to make all buildings energy efficient and to retrofit them with renewable energy technologies, we have not been able to find data on the number, size and location of commercial, public and community buildings. Our job estimates are therefore just based on retrofit of domestic dwellings. To estimate the numbers of jobs created we have assumed that 75% of dwellings require improvements to their energy efficiency, 75% will be fitted with solar thermal, 20% with solar PV and 13% with ground source heat pumps. The numbers of buildings containing dwellings in each NUTS area have been obtained from Eurostat (2011 census data). In some cases the number of dwellings was not available at the NUTS3 area level, in which case we have scaled down from the NUTS2 level by population.

A flow chart showing how we have modelled jobs in the buildings sector is shown in Figure 4. The jobs metrics used, and their sources are shown in Table 4.

Table 4 Job metrics used in estimation of Buildings Sector jobs

Job Type	Scaling Metric	Notes	Source
Improving energy efficiency of dwellings	81.5 jobs for 1000 dwellings per year	Direct labour only. 134 hrs on site per house + 3hrs survey (see source)	Birmingham City Council, 2009
Adding Solar Thermal to dwellings	34.5 jobs for 1000 dwellings per year	Source has 1 FTE (direct and indirect) per 100m2 installed. Assume out of 2900 FTE jobs 400 are direct. Also assumed 4m2 per house as most installations are 2x2m2 panels.	Batisti, *et al*, 2007
Solar PV - Domestic Installation	26.6 jobs for 1000 dwellings per year	Assume it takes 30.75hrs to install 1 kW of PV, and 2 kWp installed per dwelling.	Birmingham City Council, 2009
Installing Ground Source Heat Pumps in houses	208 jobs for 1000 dwellings per year	Assume 8 kW heat pumps in 2 bed houses. From capital costs in source, assuming 40% of cost is labour and a wage of £26,000 per year.	www.gshp.org.uk and https://www.kensaheat-pumps.com/wp-content/uploads/2015/06/Retrofit-blueprint-document-120916.pdf
Dwelling Maintenance	3.1 jobs per 1000 dwellings	Additional maintenance as a result of retrofit & to maintain energy efficiency standards.	Birmingham City Council, 2009

Figure 4 Buildings Sector jobs modelling flow chart



2.5 Reuse and recycling of waste

Vision:
A society where products are repaired and reused much more than they are today, reducing the amount of waste we produce. Most of what does end up as waste is recycled.

The estimate of job creation is based on the shift to higher value recycling. This will facilitate a dramatic shift to increasing amounts of repair, remanufacturing and reuse. The job estimates in this area reflect the amount of extra employment in sorting, storing and making these materials and products available for reuse, repair and recycling. As limited breakdown of the waste sector is available in either the construction and demolition, or commercial and industrial sectors we have used data on the jobs involved in recycling of municipal solid waste alone. We have assumed that recycling rates will increase to 90% from their current levels.

We have looked at three types of waste:

- Municipal solid waste (MSW);
- Commercial and industrial waste (C&I); and
- Construction and demolition waste (C&D)

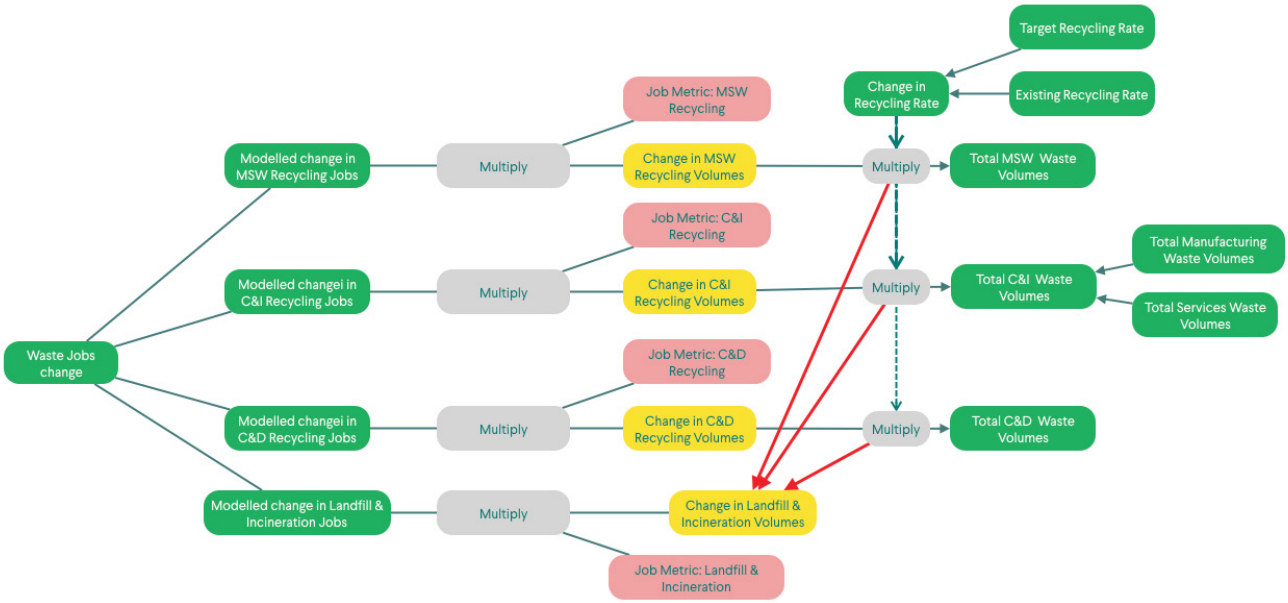
The tonnes of MSW by local authority area are available from ONS and we used this information to work out the amount in each NUTS3 area. The tonnes of C&I and C&D waste in each NUTS3 area was then scaled from national totals (obtained from Eurostat) on the basis of the percentage of the total MSW in each area. Existing recycling rates for MSW were obtained from Eurostat and the rate for recycling of C&I and C&D waste assumed to be the same as for MSW. In practice the current recycling rates may be higher in the latter, but this tends to be low value *downcycling* of materials rather higher value (and higher employment intensity) upcycling of products. A flow chart showing how we have modelled jobs in the waste sector is shown in Figure 5 and the job metrics used in Table 5.

Table 5 Job metrics used in estimation of Waste Sector jobs

Job Type	Scaling Metric	Notes	Source
Recycling of municipal solid waste (MSW)	2.9 jobs per 1000 tonnes of waste recycled	Excluding indirect & induced jobs.	Friends of the Earth, 2010
Recycling of commercial and industrial waste (C&I)	1.5 jobs per 1000 tonnes of waste recycled	Assuming 50% less jobs intensive than MSW recycling due to larger volumes.	
Recycling of construction and demolition waste (C&D)	1 job per 1000 tonnes of waste recycled	Assuming 66% less jobs intensive than MSW recycling due to larger volumes & inclusion of soils in waste volumes.	
Waste disposal	0.3 jobs per 1000 tonnes of waste	Source states that waste disposal (landfill & incineration) employs roughly a 10th of reuse and recycling.	Waste Watch, 1999, p.6

A flow chart showing how we have modelled jobs in the waste sector is shown in Figure 5.

Figure 5 Waste sector jobs modelling flow chart



2.6 Sustainable agriculture and forestry (in the UK only)

Vision:
A UK agriculture that provides sufficient food to feed the UK population, as well as providing fibre, leather and fuel, through a sustainable approach to farming and land management that combines a permaculture design approach with predominantly organic farming methods, which together also increase biodiversity.

Our modelling of jobs in agriculture started from estimating the amount of food UK agriculture needs to produce to feed the UK population and the amount of land needed to produce that food, as well as land needed for energy crops (for on-farm use) and for fibre crops (hemp and flax). For this we based our modelling on work carried out by Simon Fairlie (see Table 6).

When modelling land-use we have aimed to maximise sufficiency in each area. To achieve this we have prioritised horticulture (fruit and vegetable growing) on arable land before other agriculture land-use (up to the level required to provide sufficient fruit and vegetables for the local population), as the significantly higher labour intensity of horticulture and perishability of the product means it is more important to locate horticulture near centres of population. We have also allocated permanent pasture to dairy cows to maximise local food production before cattle for beef for the same reason. We have assumed that 40% of existing permanent pasture could in theory be used for arable crop rotation so have included this in available arable land. This leads to more mixed farming, rather than large-scale industrial agriculture that locates arable and livestock farming in different parts of the country. The amount of existing arable and permanent pasture land in each NUTS area was obtained from ONS. We also envisage increased management of 50% of existing woodland and better management of hedgerows (we have assumed 10% of field boundaries are laid hedges and that there are 0.01km of field boundary per hectare of arable and pasture land). Finally, we have used data on the numbers of jobs per hectare for different land uses, or per head of livestock, to calculate the number of long-term jobs.

Table 6 Diet and land requirements

					Land Required per person			Livestock	
Consumption		Calories in diet	Production needed per person	Yield *(feed required)*	Arable	Permanent pasture	Other land	Yield per head	livestock
	g/ person/ day	kcal/ person / day	tonnes /year	tons/ha *(tons/ton)*	ha/ person	ha/ person	ha/ person	tonnes / head	head / ha
Cereals for human food	448	1526	0.164	4.30	0.038				
Potatoes	453	300	0.165	25.00	0.007				
Sugar	32	100	0.012	7.50	0.002				
Vegetables and fruit	500	150	0.183		0.002				
Green Manure					0.011				
Milk (incl butter, cheese)	568	330	0.207	3.7 (3.26 net)	0.047	0.029	0.226	4.800	0.727
Beef (grass reared)	33	86	0.012	0.40		0.030		0.227	0.753
Cereals for pigs	(Bacon) 36	180	0.013	3.00	0.003			0.070	
Cereals for poultry eggs/chicken	30	50	0.011	3.40	0.009			0.014	
Sheep	9	24	0.003	0.08			0.039	0.018	0.214
Fish	11	11	0.004						
Energy crops (biofuels)					0.008				
Fibre crops (hemp and flax)	14		0.005	3.00	0.002				
		2757			**0.126**	**0.06**	**0.27**		

Adapted from Table F: Livestock Permaculture, p.98 of Fairlie, 2010
Other land includes moorland, 50% of which is allocated for rough-gazing of sheep.

The metrics used to calculate the numbers of jobs required to produce this food assume organic farming methods and are shown in Table 7. We have subtracted the number of existing jobs in agriculture, assuming that 88% of the farming jobs in Eurostat data are associated with the activities we have modelled (based on modelling of the number of agricultural jobs using job metrics for conventional farming), to calculate the net number of jobs. Transition jobs are assumed to be 50% of the long-term jobs. The transition could also involve jobs in planting new woodland, but we have not been able to find data on the number of jobs involved in this. We have not included jobs in non-farm horticulture in urban areas or jobs from the production of fibre crops as no metrics were available. The flow chart showing how we calculated jobs in the agriculture sector can be found in Appendix 1.

Table 7 Job metrics used in estimation of Agriculture and Forestry Sector jobs

Job Type	Scaling Metric	Notes	Source
Cereal Crops (Organic)	1.3 jobs per 100 ha		Hamer, 2012
Potatoes (Organic)	8.3 jobs per 100 ha		Hamer, 2012
Sugar (Organic)	2.4 jobs per 100 ha		Hamer, 2012
Fruit & veg (Organic)	7.7 jobs per 100 ha		Hamer, 2012
Dairy (Organic)	29.4 jobs per 1000 cows	excluding labour to grow grain for feed	Soil Association, 2006
Beef (Organic)	9.1 jobs per 1000 head of cattle	excluding labour to grow grain for feed	Soil Association, 2006
Pigs (Organic)	2.4 jobs per 1000 pigs	excluding labour to grow grain for feed	Soil Association, 2006
Sheep (Organic)	2.7 jobs per 1000 head of sheep	Not shepherded	Soil Association, 2006
Poultry - eggs (Organic)	2.9 jobs per 10,000 chickens (eggs)	excluding labour to grow grain for feed	Soil Association, 2006
Woodland management	0.3 jobs per 100 ha	Scaled from proposals for Britain in source	Independent Panel on Forestry, 2012
Timber processing (indirect)	0.1 jobs per 100 ha		Public and Corporate Economic Consultants, 2000
Biodiversity improvements	1.7 jobs per 10 km of hedge	Hedge Laying	Table 5 of Hird, 2015

RESULTS OF UK MODELLING

3.1 Overview

Our results indicate that at least 980,000 jobs would be created during the transition phase to 2030 and 710,000 in the longer term through the changes that we have suggested.

These estimates are conservative.

- Firstly, data on hours of work involved was not available for many aspects of the transition, so these aspects were not included in the estimates.
- Secondly, we have not estimated the jobs created in the wider economy by the spending of those in the new jobs.

- Finally, we have not included jobs in the supply chain, such as those involved in making wind turbine blades and generators. These are likely to replace existing manufacturing jobs.

A summary of the results for the UK, showing the transition and long-terms jobs in each sector is shown in Table 8. The transition and long-term jobs in each NUTS area, as well as the population in 2018 and 2030, land area and population density of each area, are shown in Table A2.1 in Appendix 2.

Table 8 Summary of transition and long-term climate jobs in the UK

	Transition	Long-term
Energy	347,599	103,916
Transport	181,732	363,463
Buildings	306,918	64,075
Reuse and recycling	41,777	83,554
Agriculture	19,765	39,530
Training and support	80,800	58,909
Total	**978,592**	**713,448**

3.2 Energy sector results

The additional renewable energy capacity to be installed in the UK, along with total transition and long-terms jobs this would create is shown in Table 9.

Table 9 Energy Sector: Renewable energy to be installed and transition and long-term jobs in the UK

Technology	Capacity to be installed	load factor	Annual generation	Transition Jobs	Long-term jobs
	GW	%	GWh	Average	
Offshore Wind	140	43%	530	277,788	92,400
Wave	9	29%	23		Not estimated
Tidal	21	24%	44	6,965	
Onshore wind	39	29%	99	48,776	12,929
River run hydro	1.2	30%	3	6,503	1,611
PV on domestic roofs	6.3	9%	5		Estimated in Buildings sector
PV ground-mounted and commercial roofs	55.4	9%	43	9,078	
Anaerobic digestion of landfill and sewage gas	1.4				Not estimated
Existing jobs lost				-1,512	-3,024
Total	**274**		**746**	**349,111**	**103,916**

The jobs in each NUTs area are shown in Table A2.2 in Appendix 2. Note that jobs in offshore wind and tidal energy have not been allocated to a particular area.

There are other types of renewable energy, such as wave power and anaerobic digestion for which we have not included job estimates. [10] Also, an all-renewable electricity system will require significant battery storage, upgrading the distribution network and improved demand management (including enabling and encouraging households and industry to switch their use of electricity to times when it is available from renewable sources). There will be jobs involved in all these activities but they have not been included in our estimate because of insufficient data.

3.3 Transport sector results

The total estimated number of long-term jobs in transport is shown in Table 10. Transition jobs have been assumed to be 50% of the long-term jobs. In addition there will be jobs during the transition in building the new infrastructure required: installing electric-vehicle charging points, electrification of railway lines and possibly constructing new tram systems and light railways. However, we have not been able to find the data required to estimate these jobs. Critically, this transition requires a shift in freight travel in the UK and internationally. This has not been included in this modelling work.

Table 10 Transport Sector jobs in the UK

	Total long-term jobs
Maintenance of private electric vehicles	67,392
Maintenance of private internal combustion engine vehicles	-158,664
Bus drivers	264,694
Bus maintenance	69,428
Railways operation and maintenance	120,614
Total	**363,463**

The jobs in each NUTS region are shown in Table A2.3 in Appendix 2.

3.4 Buildings sector results

The estimated transition and long-term jobs in the building sector in the UK, from retrofitting residential buildings with energy efficiency measures and renewable energy technologies are set out in Table 11.

Table 11 Buildings Sector jobs in the UK

	Number of residential buildings retrofitted	Jobs years	Transition jobs	Long-term jobs
			FTE	FTE
Installation of:				
- Energy Efficiency Improvements	20,387,610	1,662,561	138,547	
- Solar Thermal	20,387,610	703,021	58,585	
- Solar PV	5,436,696	199,022	16,585	
- Ground Source Heat Pumps	3,533,852	733,954	61,163	
Additional maintenance			32,038	64,075
Total		**3,298,558**	**306,918**	**64,075**

The jobs in each NUTS area are shown in Table A2.4 of Appendix 2.

10 The generation of wave energy is anticipated to become commercially viable from 2030, which is beyond the time period considered in this study.

In addition there will be jobs retrofitting commercial, community and public buildings but we have not been able to quantify the scale of this challenge in terms of the location, number and size of these buildings, which is a pre-requisite to enable us to estimate these jobs.

3.5 Waste sector results

Table 12 shows the change in mass of waste recycled or sent to landfill or incineration, [11] assuming an increase from the existing recycling rate (which is 45% for the UK as a whole), to 90%. This table also shows the numbers of jobs gained and lost as a result of this change.

Table 12 Change in waste recycled and jobs created in the UK

	Change in mass recycled/ disposed of	Change in Jobs
Type of Waste	Tonnes/year	FTE
Municipal solid waste (MSW)	12,596,299	37,156
Commercial and industrial waste (C&I)	10,553,926	15,566
Construction and demolition waste (C&D)	54,718,966	53,802
Landfill & Incineration	-77,869,191	-22,969
Total Jobs		**83,554**

The average number of jobs over the transition period is assumed to be 50% of the jobs shown in Table 12, which are long-term jobs. The existing recycling rate in each NUTS area, the assumed change in the amount of waste recycled and the resulting jobs in each NUTS area is shown in Table A2.5 in Appendix 2.

Our vision is for the amount of waste produced to be greatly reduced through reuse and repair, which is reflected in the higher overall figure for the recycling modelled here. In the longer-term these jobs could transition from waste sector jobs to jobs maintaining products to avoid them becoming waste in the first place. [12]

3.6 Agriculture and forestry sector results

For the UK as a whole we have estimated that there will be a net increase of 33,300 jobs in agriculture and 6,230 jobs in woodland management, hedge laying and timber processing. The numbers of jobs in each NUTS area are shown in Table A2.6 in Appendix 2.

We believe that the statistics for the existing jobs include supply chain jobs and other activities that we have not modelled, which in turn means that our job estimates for agriculture could be significant underestimates (despite only using 88% of the existing jobs figure). This is why for many rural areas the modelled net number of jobs, after subtracting the existing farming jobs, is negative.

11 This is also called energy-from-waste in many reports. The energy and carbon saved in reuse and recycling is far greater than that recovered from burning waste.

12 Such a notion of a circular economy is now widely discussed.

Table 13 Assumed use of land and livestock numbers

Land used for	Ha	No. of animals
Arable		
Cereal Crops (Including animal feed)	3,462,384	
Potatoes	459,877	
Sugar	108,286	
Fruit & Vegetables	131,732	
Hemp & flax	115,888	
Energy Crops	532,106	
Green Manure	985,155	
Pasture on Rotation for beef	3,940,979	
Pasture on Rotation for dairy cows	2,393,010	
Permanent Pasture		
Dairy Cows	3,191,113	4,056,967
Beef Cattle	753,501	1,733,815
Grazed orchards	3,293	
Pigs		12,706,069
Chickens		50,214,923
Rough Grazing / number of sheep	753,501	410,189

HUNGARY JOBS MODELLING AND RESULTS

4.1 Overview

For Hungary we estimated the numbers of jobs for NUTS2 areas (Hungarian Regions) in essentially the same way as for the UK, using Eurostat data on population, area, numbers of dwellings, amount of waste, existing recycling rates, etc. We used similar assumptions and job metrics as for the UK modelling. Key differences in our methods and assumptions are outlined below.

Statistics for the NUTS2 regions of Hungary, with the estimated transition and long-term jobs are shown in Table 14. These jobs include 'support jobs', which are calculated from the total number of jobs in each sector.

Table 14 Hungary regions and jobs estimates

NUTS	Area name	Population		Area (ha)	Pop Density	Total Additional Jobs	
Code		2018	2030	ha	p/ha	Transition	Long-term
HU	**Hungary**	**9,797,561**	**9,665,170**	**9,301,300**	**1.05**	**64,846**	**43,473**
HU10	*Central Hungary* Közép-Magyarország	3,000,076	2,959,537	691,600	4.34	11,925	11,491
HU21	*Central Transdanubia* Közép-Dunántúl	1,056,097	1,041,826	1,108,600	0.95	7,230	4,744
HU22	*Western Transdanubia* Nyugat-Dunántúl	983,251	969,965	1,132,900	0.87	6,997	4,480
HU23	*Southern Transdanubia* Dél-Dunántúl	894,223	882,140	1,419,700	0.63	7,580	4,358
HU31	*Northern Hungary* Észak-Magyarország	1,143,902	1,128,445	1,342,600	0.85	8,774	5,346
HU32	*Northern Great Plains* Észak-Alföld	1,468,088	1,448,250	1,772,300	0.83	11,512	6,918
HU33	*Southern Great Plains* Dél-Alföld	1,251,924	1,235,007	1,833,600	0.68	10,824	6,134

4.2 Energy Sector

Hungary currently has around 8 GW of installed capacity for electricity generation, most of which is oil, gas, coal and nuclear generation, with around 300 MW of wind, 57 MW of hydro and 29 MW of solar, in 2015.[13] In addition, biomass is used, predominantly for industry and space heating.

There is evidence that there is significant renewable potential in Hungary. For example, in 2010 the Hungarian Energy Office received 68 bids to construct 1.1 GW of wind power capacity, nearly three times the 410 MW for which they were going to grant licences.[14] However, the government scrapped this wind tender[15] and instead decided to invest in two new nuclear power stations, with support from Russia.[16] This tender alone suggests that 400 MW/year of new wind capacity could be delivered. Solar power has grown rapidly in recent years and by 2016, according to one source, there was 225 MW of installed capacity.[17]

To generate the electricity currently produced by existing nuclear, coal and oil power stations, and to provide power for an electrified transport system, we estimate that around 15 GW of wind generation and 10 GW of solar PV capacity will be needed[18] plus 1 GW of anaerobic digestion, biomass and geothermal (although we do not have jobs metrics for all of these technologies). We have assumed that wind and solar generation will be distributed across the country by land area. With 23% forest cover in Hungary, there is also potential to expand the use of biomass, such as for space heating.

We have calculated the new jobs associated with installation of wind and solar power (assumed to happen over the transition period) and the long-term maintenance of wind turbines using the metrics we used for the UK estimates. We have not subtracted the jobs in fossil fuel power stations that will be lost, but given that in the UK there were about 100 jobs per 1 GW of fossil fuel generation with just under 6 GW of such generation capacity in Hungary[19] it is likely that around 600 jobs will be lost. We have assumed that jobs in the nuclear industry will be switched to decommissioning of the existing power stations.

13 From Table 12.1, p. 93 of Mavir, 2017.

14 https://www.windpowermonthly.com/article/989494/hungarian-government-overwhelmed-bids-wind-energy-licenses.

15 https://www.windpowermonthly.com/article/1017835/hungary-scraps-wind-tender

16 https://www.reuters.com/article/us-russia-hungary-putin-orban-nuclear/russia-to-start-building-two-nuclear-reactors-in-hungary-soon-putin-idUSKCN1LY204?feedType=RSS&feedName=worldNews&utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+Reuters%2Fworld-News+%28Reuters+World+News%29

17 https://en.wikipedia.org/wiki/Solar_power_in_Hungary#cite_note-2

18 Assuming a 40:60 split between new solar and new wind generation capacity, as modelled in Zero Carbon Britain 2 for the UK (Allen, 2013).

19 See Table 12.1, p.93 of Mavir, 2017

The amount of wind and solar to be installed, the jobs involved in this and the long-term jobs from maintenance of wind turbines are shown in Table 15.

Table 15 Hungary, Energy Sector jobs

	Capacity to be installed		Transition jobs			Long-term jobs
	Wind	Solar PV	Wind	Solar PV	Total*	Wind
	MW	MW	Job years	Job years	Average over 12 year period	FTE
Hungary	**15,000**	**10,000**	**16,200**	**1,638**	**20,319**	**4,950**
Central Hungary Közép-Magyarország	1,115	744	1,205	122	1,510	368
Central Transdanubia Közép-Dunántúl	1,788	1,192	1,931	195	2,421	590
Western Transdanubia Nyugat-Dunántúl	1,827	1,218	1,973	200	2,474	603
Southern Transdanubia Dél-Dunántúl	2,290	1,526	2,473	250	3,101	756
Northern Hungary Észak-Magyarország	2,165	1,443	2,338	237	2,932	715
Northern Great Plains Észak-Alföld	2,858	1,905	3,087	312	3,871	943
Southern Great Plains Dél-Alföld	2,957	1,971	3,194	323	4,004	976

* The total for transition jobs includes 50% of the long-term jobs, as well as the jobs in installation.

4.3 Transport Sector

We have modelled a modal shift from private internal combustion engine (ICE) cars to buses and private electric vehicles (EVs), and estimated the jobs associated with bus driving, bus maintenance and maintenance of private EVs then subtracted the current jobs in maintenance of ICE cars, using the same job metrics used for the UK. We have not estimated a modal shift or associated jobs for train travel. The change in vehicle-miles travelled and the associated long-term jobs are shown in Table 16. The average number of additional jobs during the transition period is assumed to be 50% of the long-term jobs.

Table 16 Hungary, Transport Sector jobs

	Proposed Modal Shift (additional v-km)			Jobs change from Proposed Modal Shift			
Name	Buses	Private EVs	Private ICE Vehicles	Bus Drivers	Bus Maintenance	Maintenance of private EVs	Maintenance of private ICE vehicles
	v-km	v-km	v-km	FTE	FTE	FTE	FTE
Hungary	**750 M**	**22,742 M**	**-43,151 M**	**28,425**	**7,456**	**7,604**	**-19,725**
Central Hungary Közép-Magyarország	230 M	6,964 M	-13,213 M	8,704	2,283	2,329	-6,040
Central Transdanubia Közép-Dunántúl	81 M	2,451 M	-4,651 M	3,064	804	820	-2,126
Western Transdanubia Nyugat-Dunántúl	75 M	2,282 M	-4,330 M	2,853	748	763	-1,980
Southern Transdanubia Dél-Dunántúl	68 M	2,076 M	-3,938 M	2,594	680	694	-1,800
Northern Hungary Észak-Magyarország	88 M	2,655 M	-5,038 M	3,319	870	888	-2,303
Northern Great Plains Észak-Alföld	112 M	3,408 M	-6,466 M	4,259	1,117	1,139	-2,956
Southern Great Plains Dél-Alföld	96 M	2,906 M	-5,514 M	3,632	953	972	-2,520

4.4 Buildings Sector

For the number of buildings to be retrofitted with energy efficiency measures and/or renewable energy systems, we have used the number of residential buildings with one dwelling from Eurostat data. This gives 2.5 million dwellings in Hungary and, as for the UK we have assumed that 75% will require improvements to their energy efficiency, 75% will be fitted with solar thermal, 20% with solar PV and 13% with ground source heat pumps. We have then calculated the jobs that this will create using the same job metrics we have used for the UK. Long-term jobs are those involved in maintenance of the installed measures. Our jobs estimates by region are shown in Table 17.

Table 17 Hungary, Buildings Sector jobs

	Number of residential buildings with one dwelling	Additional Jobs	
		Transition	Long-term
		FTE	FTE
Hungary	2,498,706	28,212	5,890
Central Hungary Közép-Magyarország	479,896	5,418	1,131
Central Transdanubia Közép-Dunántúl	270,117	3,050	637
Western Transdanubia Nyugat-Dunántúl	255,543	2,885	602
Southern Transdanubia Dél-Dunántúl	264,840	2,990	624
Northern Hungary Észak-Magyarország	348,718	3,937	822
Northern Great Plains Észak-Alföld	460,272	5,197	1,085
Southern Great Plains Dél-Alföld	419,320	4,734	988

4.5 Waste Sector

To estimate the number of jobs that could be created in the waste sector we have assumed that recycling rates will increase from 31% to 90%. Data on the amount of waste in each region has been obtained from Eurostat. We have subtracted the jobs lost in landfill and incineration from the new jobs in recycling. We have assumed that on average throughout the transition period, the number of jobs will be 50% of these long-term jobs. The increased amount of waste recycled and the decrease in that sent to landfill or incineration, along with our estimates of the net number of jobs created, are shown in Table 18.

Table 18 Hungary, Waste Sector jobs

		Change in mass recycled/disposed of			
	Net long-term jobs	Municipal solid waste (MSW)	Commercial and industrial waste (C&I)	Demolition and construction (D&C)	Landfill & Incineration
	FTE	Tonnes/y	Tonnes/y	Tonnes/y	Tonnes/y
Hungary	**8,871**	**1,734,934**	**2,435,725**	**2,022,181**	**-6,192,840**
Central Hungary Közép-Magyarország	2,717	531,248	745,835	619,205	-1,896,287
Central Transdanubia Közép-Dunántúl	956	187,012	262,551	217,975	-667,538
Western Transdanubia Nyugat-Dunántúl	890	174,112	244,441	202,939	-621,493
Southern Transdanubia Dél-Dunántúl	810	158,347	222,309	184,564	-565,220
Northern Hungary Észak-Magyarország	1,036	202,560	284,380	236,097	-723,037
Northern Great Plains Észak-Alföld	1,329	259,966	364,974	303,008	-927,949
Southern Great Plains Dél-Alföld	1,134	221,688	311,235	258,393	-791,316

IRELAND JOBS MODELLING AND RESULTS

5.1 Overview

For the Republic of Ireland we used data from Eurostat and the job metrics we used for the UK estimates, to produce job estimates for the country as a whole. The total transition and long-term jobs are shown in Table 19.

Table 19 Transition and long-term jobs in Ireland

Sector	Transition	Long-term
Energy	17,650	7,200
Transport	8,750	17,500
Buildings	22,100	4,600
Waste reuse and recycling	2,856	5,712
Training and support	1,541	3,147
Total	**52,897**	**38,159**

5.2 Energy Sector

Our estimates of jobs in the energy sector assume that electricity supply needs to about double from the existing 26,740 kWh/year, so as to provide energy for transport and heating (with heat pumps). In August 2017 there was 2.9 GW of renewable generation capacity installed in Ireland. Our assumptions about the renewable energy that needs to be installed, the electricity generated and the jobs created (using the job metrics set out in Table 1) are shown in Table 20. We have subtracted from our estimates the numbers of jobs that will be lost in coal and peat. Peat is currently extracted and burnt to produce electricity in the Midlands of Ireland, by the semi-state company, Bord na Móna. Since its creation in 1946, this company has provided good jobs and relative prosperity to a previously impoverished region and a challenge to the transition will be to replace those jobs with ones of similar quality.

Table 20 Ireland renewable energy needed and job estimates

Technology	Installed capacity	Assumed load factor	Generation	Transition jobs	Long-term jobs
	GW	%	GWh/year		
Offshore wind, wave and tidal	6.0	36%	23652	8300	4200
Onshore wind	10.0	25%	21900	10800	3000
Solar PV	2.5	10%	2190	400	
Anaerobic digestion/biomass [20]	0.5	90%	4383	550	
Peat jobs lost				-2000	
Coal jobs lost				-400	
			52125	**17650**	**7200**

20 Assumes 1.5 jobs per 1000 MWhr, from Table 4.5 of The Resilience Centre 2015.

5.3 Transport Sector

Our modelling of the transport sector in Ireland assumed a modal shift from private internal combustion (ICE) engine cars to buses and private electric vehicles (EVs). We estimated the jobs associated with bus driving, bus maintenance and maintenance of private EVs and subtracted the current jobs in maintenance of ICE cars, using the same job metrics used for the UK. We have not estimated a modal shift or associated jobs for train travel. The average number of additional jobs during the transition period is assumed to be 50% of the long-term jobs.

5.4 Buildings Sector

We have used the number of residential buildings with one dwelling, obtained from Eurostat, to give a figure for the number of dwellings in Ireland of 1.2 million dwellings. As for the UK, we have assumed that 75% will require improvements to their energy efficiency, 75% will be fitted with solar thermal, 20% with solar PV and 13% with ground source heat pumps. We have then calculated the jobs that this will create using the same job metrics we have used for the UK. Long-term jobs are those involved in maintenance of the installed measures. Our jobs estimates by NUTS area are shown in Table 23.

5.5 Waste Sector

We have assumed that the recycling rate of the approximately 9 million tonnes of waste produced a year in Ireland will be increased from 42 to 90%. This should create 5,712 jobs in the long-term. We have assumed that in the transition period there will, on average, be 50% of these jobs, giving 2,856 jobs.

CONCLUSIONS

Measures to protect the environment, reduce pollution and tackle climate change are too often seen as threatening jobs and economic prosperity. Hence President Trump's roll back of environmental legislation in the USA trying to preserve jobs in coal, or in June 2018, Len Mcluskey of the Unite Union, the second largest union in the UK, calling for Labour MPs to vote for construction of a third runway at Heathrow because it would create hundreds of thousands of new unionised jobs. [21]

However, the research described in this report makes it clear that a transition to a zero-carbon economy is possible and it is going to involve a lot of work, which will create millions of jobs across Europe. Many in the union movement do recognise this and acknowledge that there are no jobs on a dead planet. [22] Instead they are calling for a 'just transition' that ensures the new jobs are of similar or better quality in terms of wages and conditions as those that are lost, and that workers in fossil-fuel dependent activities who lose their jobs are able to take up the new ones. [23]

The need for a just transition is one reason why we have included jobs in training and support: those who are currently unemployed, underemployed or working in jobs that are likely to disappear need to be enabled to take up the new jobs.

Another aspect of the transition that we propose is the shift in the location of new jobs. In the power sector, for example, the old model of a few large-scale power stations supplying the country means many jobs being created in a small number of places. Renewable energy, in contrast, is available whether the sun shines, the wind blows, or rivers run. It is easier to do at smaller scale, providing a more dispersed pattern of jobs in installation

21 www.theguardian.com/environment/2018/jun/24/union-boss-urges-labour-mps-to-back-heathrow-expansion

22 See http://oecdobserver.org/news/fullstory.php/aid/5294/There_are_no_jobs_on_a_dead_planet.html

23 See https://www.tuc.org.uk/research-analysis/reports/tuc-climate-change-and-%E2%80%9Cjust-transition%E2%80%9D

and maintenance of these systems. There are choices that need to be made here: the current UK government seems to have turned its back on small scale renewables and is focusing its support on offshore wind. [24] This will not provide the jobs across the country envisaged here. UK policy on renewables has been inconsistent and characterised by booms and busts, making it difficult for companies to provide quality, long-term secure jobs. Similarly, policies of the former Spanish government towards support for renewable energy created uncertainty with regard to future revenues, discouraging investment in the sector and resulting in the loss of 75,000 jobs between 2008 and 2017. What is needed is a clear and stable framework to support the transition and realise the potential for jobs.

Transport is another sector which generates the inequalities we see today, in particular those between thriving large cities linked into an increasingly globalised economy and declining small towns and rural areas [25]. All three countries considered in this report are dominated by their capital cities. Spending on transport infrastructure over the last few decades has mainly gone to promoting long distance links between cities. We need to re-orientate this spending to providing local transport: good quality bus services (which will provide jobs all over the country) and safe walking and cycling routes. We also need to decarbonise transport through electrification and use of alternative fuels such as hydrogen or sustainable biodiesel.

Electrification of the railways and private cars clearly requires planned, co-ordinated action, but will provide jobs all over the country. A co-ordinated approach is particularly needed to ensure, for example, that rural areas are not left behind when it comes to the installation of electric vehicle charging points. as they often have been in the provision of broadband across the EU. [26] Another area where a planned co-ordinated approach is going to be needed is in the retrofit of buildings. Experience in the UK has shown that this is best done through local authority-led street-by-street programmes, supported by public money. [27] In the UK, these have in the past focussed on cavity wall and loft insulation, whereas we now need to do whole-house retrofits that install multiple measures at once. Only such a programme is likely to realise the reductions in carbon emissions that are needed and provide good quality jobs in every community.

Limitations of modelling and further work

The modelling carried out has been limited by the lack of data in many areas. Below we summarise how further research would enable additional job estimates to be included and make the current estimates more accurate.

1. Job metrics that if available would enable additional activities/sectors to be modelled:

- Labour intensity of demolition and deconstruction per tonne of construction and demolition waste produced.
- Labour intensities of fitting heat pumps, solar thermal and direct electric heating to dwellings (e.g. person-hour per typical dwelling) and to commercial, industrial and public buildings (e.g. person-hours per 1000m2 of building).
- Labour intensities of installing solar PV panels, for commercial and domestic scale installations.
- Additional jobs through more labour based approaches to road maintenance, such as early filling of potholes and increased frequency of routine maintenance (e.g. drain clearance) to reduce the frequency of major resurfacing/reconstruction (e.g. jobs or person hours per mile of carriageway).
- Labour intensity of planting new woodland (hours per hectare)
- Labour intensity of building new tramway, railway lines and schemes to increase walking and cycling.
- Jobs per MWh of energy storage – for both installation and subsequent maintenance (e.g. pumped hydro, compressed air, hydrogen production etc.).
- Jobs per MW to maintain current electricity grid and to labour intensity of increasing grid capacity (per additional GWh/year).

2. Data that would enable the modelling to be refined or additional activities modelled:

- Floor area of public sector and commercial sector buildings by NUTS area.
- Existing cycle paths per NUTS area.
- Existing recycling rates for commercial and industrial, and construction and demolition wastes.

24 See Chapman, 2018 for information about the history of UK government support for renewable energy. https://gef.eu/publication/community-energy-in-the-uk/

25 See https://gef.eu/publication/beyond-capital-centered-growth/

26 See for example https://www.agriland.ie/farming-news/eu-broadband-behind-target-particularly-in-rural-areas

27 For example, the Kirklees Warm Zone scheme which won an Ashden award in 2009 - www.ashden.org/winners/kirklees-council.

3. Further modelling work that could be carried out:

- Refining modelling of agriculture and forestry jobs. Currently job estimates are low because all proposed farming jobs are modelled to replace all existing ones and our model does not cover as many activities as have been included in the statistics on existing jobs. This could include calibrating the model against existing statistics on farming jobs. This may require adding multipliers for farm management and on farm processing/distribution/retail jobs and estimates for jobs in urban horticulture (on non-farm land).
- Model tram and railway infrastructure change required to deliver proposed modal shift so that km of new railway and tram way needed can be estimated.
- Model non-residential building retrofit required.
- Model energy demand & supply relationship so storage and distribution network changes can be identified and then jobs modelled.
- Work out locations for offshore renewable energy hubs and therefore jobs so the jobs involved can be allocated to NUTS areas.
- Model sewage, landfill and farm-based anaerobic digestion.

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