OUR JOBS, OUR PLANET

Transport Workers and Climate Change

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A report originally written for the
European Transport Workers Federation

THANKS

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INTRODUCTION

This is a report for the European Transport Workers Federation (ETF) on the implications of climate change for transport workers and their unions. This report tries to do four things:

Start the debate on climate change.

Prepare unions to act on climate change, not only react to the agendas of employers and governments.

Offer realistic transport solutions that meet the needs of transport workers and all humanity.

Propose ideas for what transport unions can do next.

This report is part of a process that began with a report by the ETF on *Trade Union Vision and Sustainable Transport.*[1] In 2011, this was followed by a report for the International Transport Federation.[2]

Unions write many reports to explain our case to governments and the media. This report is not like that. This one is for union members and leaders. Climate change is new, and union activists need to understand it ourselves. So this report tries to explain complex scientific, technical and political matters in clear language.

[1] ETF, n.d.
[2] International Transport Federation Climate Change Working Group and Global Labor Institute, 2010.

Key Points

The science of climate change says we need 75% to 80% cuts in CO_2 emissions within 20 years.

This means we need more radical measures than policy makes are now proposing.

This requires 7 million new transport jobs and 5 million new renewable energy jobs in Europe.

These new jobs would get the European economy moving again.

These jobs must be in the public sector. That way governments can guarantee proper retraining and a new job to anyone who loses theirs because of climate policy changes.

Unions and our allies can start campaigning now for emission cuts and 12 million new jobs.

What's in it for us?

We can protect ourselves. Change is coming. If we do not stop the worst effects of climate change, employers and governments will force change on us. Their changes will destroy jobs. If unions play a central part in fighting for policies to stop climate change, we can fight to defend jobs and services.

We can make our unions stronger. Climate change is the largest challenge facing humanity in this century. Unions that campaign for the needs of the whole society recruit members, make members more confident, and turn members into union activists.

We can defend humanity. It is reasonable to ask what is in it for us as transport workers and transport unions. But we are not only transport workers. We are also human beings. And climate change threatens all humanity.

It Will Not Be Easy

This report lays out ambitious plans. They may seem naïve, for they move beyond business as usual. But the challenges of climate change are great, because we have to change how we use energy, and energy reaches into every part of economy and society.

It is entirely possible that we will not succeed, and will then face the consequences. But there are more than 40 million people out of work in Europe now.[3] The planet needs help. They need work. If we succeed, we can solve both problems at once.

Our Methodology

This report suggests four kinds of changes: REDUCE, SHIFT, IMPROVE, and ELECTRIFY. Here we follow the 2010 report by the International Transport Workers Federation. Examples will explain what we mean:[4]

> REDUCE. We change our lives so we use less energy. For example, cities with dense populations, nearby jobs and local shops create less emissions than suburbs and hypermarkets.

> SHIFT. We use a different kind of transport. For example, getting passengers out of cars and into buses cuts carbon dioxide emissions in half.

> IMPROVE. We make transport more efficient. For example, better designed trucks moving at slower speeds will cut carbon dioxide emissions in half.

> ELECTRIFY. We stop making electricity by burning coal and gas. Instead we use renewables like wind and solar power. This can cut carbon dioxide emissions to almost nothing.

Renewable energy and sustainable transport are only part of the answer. We also need other jobs and policies, in refurbishing buildings, in education and training, in agriculture, and in many

[3]Eurostat, 'Unemployment Statistics', gives 23 million unemployed for the EU 27 in Feb 2011. International Labour Office, *Global Employment Trends 2011*, Geneva, table P2, p.71, gives 17 million for 2010 for non EU Eastern Europe and CIS. That makes a total of 40 million. This does not include Norway and Switzerland. These numbers are approximate – reporting conventions vary from country to country, no national records are precise, there are strong tendencies to under report, and there will have been some change in the numbers by the time this is published. But there will now be at least 40 million unemployed.

[4]The framework for reduce, shift and improve comes from IFT, 2010. The importance of using renewable electricity for transport comes from Mackay, 2009; Kemp and Wexler, 2010; and Neale, 2010a.

other fields. There is a brief discussion of these sectors in Section Four. And there is a detailed discussion of renewable energy, because we cannot have sustainable transport without renewable electricity replacing oil as a fuel.

This report deals only with reducing carbon dioxide emissions. CO2 is the main greenhouse gas and causes more than 70% of global warming. And almost all the greenhouse gas emissions from transport are CO2.

The Numbers

This report is full of numbers. There are estimates of possible cuts in emissions and the number of jobs needed in each sector.

Our estimates are not exact. This is unavoidable. We are talking about the future, and the underlying statistics we rely on are not exact. It might appear more scientific, for instance, if we said that 6,721,000 new jobs would produce cuts of 81.3% in transport CO2 emissions. But that precision would not be honest.

So we talk in round numbers – approximately 7 million new transport jobs will cut transport emissions by about 80%. Estimates of this sort are more scientific, because they reflect more accurately what we know and do not know. For the scientific basis for these numbers, see Appendix One.

SECTION ONE

THE SIZE OF THE PROBLEM

We will not explain the science of climate change in detail here. Good books in many languages already do that.[5] But there is one part of the science we do need to explain. This is why we need big cuts in carbon dioxide emissions quickly.

This part of the science determines the policy we fight for. If we needed small cuts over forty years, we could change transport and the economy a little over forty years. But we need deep cuts quickly, so we need big changes to our economy and our transport. The science means we have to be radical.

Here is the science. Let's start from the basics.[6] The main cause of global warming is carbon dioxide. Since 1800, but especially since 1950, humanity has been putting more and more carbon dioxide (CO2) into the air.

Plants, trees and the ocean absorb about half of this CO2 every year. The other half stays in the air for 100 years or more. So the amount of CO2 in the air is now increasing each year.

CO2 traps heat that is rising from the earth and going into space. The more CO2 in the air, the more the earth warms up.

The great majority of human made CO2 comes from burning oil, coal and gas. Humans put other greenhouse gases into the air. But CO2 is responsible for 70% of the total effect. And in transport almost all the greenhouse gas is CO2 from burning oil. So we will concentrate on CO2 in this report.

For hundreds of thousands of years, CO2 and temperatures have gone up and down together. Now humanity is forcing the pace. The difference between now and the nineteenth century is more than the difference between the nineteenth century and the ice ages. During the ice ages, the level of CO2 in the air was about 180 parts per million (ppm). (That is 0.018%). During the warm periods between the ice ages, CO2 was 280 parts per million. That was the

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[5]In English, Flannery, 2005; Neale, 2008; Peace, 2006; and Hansen, 2010.

[6]For simple explanations of the basics, see Flannery, 2005; and Al Gore's film *An Inconvenient Truth*. See also Neale, 2008; Peace, 2006; Hansen, 2010; and Alley, 2011. Volk, 2008, is a good simple explanation of the carbon cycle. For the more detailed science, see Intergovernmental Panel on Climate Change, 2007; and Richardson et al, 2009.The first half of McKibben, 2010, is a good explanation of the effects climate change is already having.

level in 1800. Now it is 390 ppm.

The Effects of Climate Change

We have already begun to see the effects of climate change, in storms, floods, droughts, and fires in many parts of the world. These extreme climate events are going to get much worse.

Warming will do three important things. First, it will change rainfall patterns. In many areas this means drought. This is already happening in the Sahel, Australia, Central Asia, Greece, and the South-western US.

Climate change will also mean rain that comes at the wrong time of year and rains so hard that the earth cannot absorb the water and the rivers flood. This is already happening in Brazil, the Sahel, Australia, Pakistan, the United States, Canada, Central Europe and Russia.

Second, warming will melt ice and snow. This is already beginning in Greenland, the Arctic and the Antarctic. The result will be rising sea levels around the world.

Third, warming creates much worse hurricanes, or cyclones. The warmer the ocean waters in summer, the stronger these storms.[7]

The problem will be the combination of rising sea levels and bigger storms. The sea will rise gradually. Then one day that will combine with a big storm with a 'surge' – a wall of water that can be 10 meters high, or higher. This has happened in New Orleans, in Bangladesh, Burma and Sri Lanka.[8]

A smaller problem will be heat waves, like the one that killed 30,000 in Europe in 2006. Or fires, like the ones in Greece and Australia.[9]

At the moment most of these disasters are unusual. That is, they are partly caused by warming, but are not entirely new in history. We are just beginning to see unprecedented events.

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[7]For hurricanes see Mooney, 2007; Kerry, 2005; and Curry, 2008.

[8]Heerden and Bryan, 2006, have a good explanation of how hurricane surges work.

[9]Kleinenberg, 2002, is a brilliant analysis of who died and why in a Chicago heat wave. In both Australia and Greece there was widespread feeling that the fires were the result of a wave of arsonists. These explanations had a touch of urban legend. More important, in both countries many hot days in succession followed a long drought. That was in part a result of climate change, and even if the fires were arson, they would not have spread as they did without the heat and drought.

Runaway Change

The big danger, though, is that these effects will combine with what scientists call abrupt climate change, or runaway change.[10]

Scientists are now worried about this because of what happened in the past. For hundreds of thousands of years, the earth has gone back and forth between cold ice ages and warm periods. When the earth cooled into an ice age, temperatures and CO2 levels went down slowly and gradually.

When the earth warmed, it started gradually. Then suddenly there was a swift increase in both CO2 and temperatures. The pace moved from thousands of years to tens of years, and sometimes less.

Scientists know this from drilling down through the ice in Greenland, Antarctica, and glaciers around the world, from drilling into the the mud on the continental shelf in several oceans, and from analysing rock formations in caves in Brazil, France and Israel.

As soon as scientists found these fast explosions in temperature, they knew the reason had to be some kind of feedback effect. But they are not yet agreed what feedback effect will be crucial.

Here are two examples of global warming feedbacks:

One starts because snow and ice are dazzling white. That means they absorb heat. But as the temperature rises, the snow and ice in the Arctic begins to melt. That exposes dark tundra and dark sea, which reflect heat back up into the air. That raises the temperature, which melts more summer snow and ice, and so on. This feedback has already begun.

A second feedback starts because rising temperatures melt the frozen peat bogs of Siberia. As they melt, they release trapped methane, a much more powerful warming gas than CO2. That raises the temperature, which unfreezes more methane, and so on. This feedback has already begun.[11]

Other feedbacks are already happening. For instance, frozen methane gas under the sea has begun to melt off Northern Siberia. There is evidence that the Amazon rainforest has begun to dry out.[12]

The scientists are not yet agreed which feedback or feedbacks will be crucial. It looks likely that feedbacks will work together, reinforcing each other. Because scientists don't know which feedback effects will be critical, they don't know how long we have

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[10] For abrupt change see Alley, 2000; Cox, 2004; Pearce, 2006; and Hansen, 2010.
[11] Pearce, 2006, pp. 105-117.
[12] See Shakhova et al, 2010.

before abrupt climate change. A very rough guess is twenty years. But it could be fifty, or even a hundred years. It could be five years or less.

There is that worrying statistic – we have changed the CO_2 in the air more than the difference between the ice age and the nineteenth century.

Famine, Refugees and War

In any case, there is now a lot of evidence that the pace of climate change events is increasing.

These climate events will not be happening in some neutral, kindly social space. They will be happening in the actual social and economic system we live in. That system will have three main effects.

First, droughts and rainfall changes will lead to crop failures. In many places, that will create famine. Second, storms, floods, famines, droughts and fires will create hundreds of millions of refugees.

Third, there will be war. Climate change will alter the balance of geographic and economic power. It will change where the water is, and bankrupt some countries. This will create strong pressures towards war. Darfur and Chad are early warnings. The rains failed there in 1969 and have never returned. The reason is climate change. The consequences have been forty years of hunger, intermittent famine, local wars for control of disappearing pasture and water, and millions of refugees.[13]

Such things will happen without abrupt climate change. But abrupt change will mean that all these disasters happen very quickly, one upon another. A few minutes of thought will tell you how well our governments will cope with that.[14]

The Scale of Changes We Need

A reasonable guess – it is only a guess – is that we have twenty years to stabilise the levels of greenhouse gases in the air. We may have

[13]See Neale, 2008, pp. 233-245; De Waal, 2005; UNEP, 2007; Gianni, Sanavan and Chung, 2003; Zeng, 2003; Cullen, 2010, pp. 63-88; De Waal, 2007; and Tubiana, 2007. For climate change and war more generally, see Parenti, 2011.

[14] You can also read Kleinenberg, 2002, on a Chicago heat wave; Klein, 2007, on disaster capitalism in general; and Prunier, 2007, on the failure to respond to the Darfur famine of 1984-5. The best documented example, in one of the richest countries on earth, is Hurricane Katrina in New Orleans: see Neale, 2008, pp. 223-233; Brinkley, 2006; and Horne, 2006.

more time, and we may have less. To avoid abrupt climate change, we need to at least stabilise the amount of CO_2 and other greenhouse gases in the atmosphere. We don't have to cut emissions completely. The ocean and plants and trees currently absorb about half of the CO_2 we put in the air. But we do have to cut emissions by half, or a little more.[15]

European emissions are now about double the global average. That means we will have to cut our emissions more, by 75% to 80%. The EU now has a target of 80% cuts by 2050. The problem is that is only a target. And we need the cuts in twenty years, not forty.

That seems like a lot to do. The good news is we can do it. We already have all the technology we need. In the next section, we will show how we can do that. The problem is that the market cannot deliver the scale of cuts in emissions we need. So governments will have to intervene with regulations and millions of new jobs.[16]

These big changes may seem unrealistic, because governments will not agree to them. However, nature does not negotiate.

Most trade union representatives spend most of their time negotiating. That is good. It is why workers want unions. So, for instance, we demand 6% wage rises and we might settle for 3%. Climate is different. If we only do part of what is needed, we face disaster. So only radical action is realistic.

Moreover, right now there is a particularly big gap between government policies and what the science is telling us. In 2008 and 2009 many people hoped the European Union and Obama's USA would lead the world toward determined action on climate change. Then came the UN talks on climate in Copenhagen in December 2009. There is much controversy about the reasons for the failure of those talks. There is a lot of agreement that they did fail.

After that failure, most of the world's governments moved away from serious action. Climate activists of all sorts were demoralised. Environmental NGOS who wanted to lobby governments decided

[15]Strictly speaking, the land and sea absorb about 55% of our current emissions. But as our emissions have increased, the proportion absorbed has also slightly increased. Therefore, as our emissions decrease, the land and sea 'sinks' may only absorb half, or a little less, of emissions. And cuts of 60% globally would make it possible to offset some of the long term warming that is already stored up in the warming of the ocean, but has not yet had an effect.

[16]International Transport Workers Federation and Global Change Institute, 2010, pp 16-18, makes a forceful argument that the problem is not 'political will', as is so often said. Rather, it is that the politicians are doing the will of the 'market', and climate action would interfere with profits.

they had to be 'realistic'.

This is not a permanent shift away from action on climate. There is a powerful force pushing the other way. That force is reality. The reports from the scientists keep coming in. They are increasingly serious. Climate disasters keep appearing on our televisions screens: fires, floods and storms. And the price of food is rising, in part because of climate change.

In a period like this, we need to think seriously about 'unrealistic' solutions. They will appear realistic soon enough.

SECTION TWO
THE JOBS WE NEED

To achieve cuts in emissions of 75% or 80%, we need jobs. Climate change is the result of the work of the hands of men and women. It will need more work by men and women to halt the process.

Many human activities make very little CO2. On a global level:

Three things produce most of CO2 emissions from burning fuels:

Heating for homes and buildings.

Electricity for buildings and industry.

Transport.

European transport emissions are:

25% of all European CO2 emissions.

6% of total CO2 emissions on Earth.[17]

To reduce emissions in European transport and electricity, we need:

7 million new jobs in transport.

5 million new jobs in renewable energy.

8 million indirect jobs.[18]

When we say 'Europe', we do not mean the European Union. We mean the continent.

The new jobs in transport will be of many kinds, including:

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[17]Based on International Energy Authority, 2010, pp. 44-46 and 59-70. Europe here includes EU and non-EU, Turkey and all former Soviet Union countries. These are the percentages of CO2 from burning coal, oil and gas, so do not include emissions from land use change and cutting down forests.

[18]The calculations for the number of jobs in each sector are in Appendix One.

Bus drivers

Bus mechanics

Other bus workers

Train drivers

Train conductors

Railway station staff

Signalling workers

High speed and international rail staff

Tram and metro workers

Constructing new rail lines, stations and depots

Drivers for electric light trucks

Workers to build cycle lanes

Inland waterways workers

Seafarers

Engineers

Trainers

Electricians

Research workers in new technologies

Accounts and office staff Managers

We also need jobs in renewable energy to cut emissions from electricity generation and to provide sustainable power for transport and heating buildings. These will be jobs in manufacturing, installing and maintaining wind power, solar power, wind power, wave power, and in building new electrical grids.

Most of these jobs will be permanent. Transport workers will be needed indefinitely. Building up renewable energy will take twenty years, and by the end of that time we will still need 6 million workers to maintain wind and solar power and to install the next generation of renewable energy.[19]

Some of the jobs in construction of new rail will come to an end

[19]See Neale, 2010b, for calculations of the long term need for workers in wind power. Some of the jobs in construction of new rail will come to an end after ten years or so. However, if the jobs in public transport and renewable energy are public sector jobs, it will be possible for governments as employers to guarantee those construction workers alternative jobs. See the explanation in Appendix One.

after ten years or so. However, if the jobs in public transport and renewable energy are public sector jobs, it will be possible for governments as employers to guarantee those construction workers alternative jobs.

Many new jobs in renewable energy will also be transport jobs. In particular:

TRUCK DRIVERS

Many truck drivers will be needed to transport wind turbine parts, solar cells, parts for concentrated solar power plants, and extensive new electrical grids. Many of these will be large and awkward objects, and much driving will be on small and difficult country roads. Skilled and experienced drivers will be needed.

SEAFARERS

Renewable energy will include large amounts of offshore wind power. That will mean many jobs for seafarers in installation and maintenance.

These are 'direct jobs'. In addition, there will be at least another 5 million 'indirect jobs' in the supply chain for transport, and 3 million in the supply chain for renewable energy. These will be jobs like making buses, railway engines, rolling stock, steel, ships for installing offshore wind, and so on.[20]

We need the jobs now. Many people talk about changes by 2030 or 2050. But the science is telling us we need the changes within twenty years. And to get that work done, we have to start now.

There is another reason for starting now. Forty million unemployed people in Europe want work.[21]

[20] For the calculations for the number of jobs in each sector see Appendix One.
[21]See note 3.

NEW JOBS

Direct Jobs:	Transport	7 million
	Renewables	5 million
Indirect Jobs:	Transport	5 million
	Renewables	3 million
TOTAL	20 million new jobs	

It Will Not Cost Much

How do we pay for it? There are two different answers to this question. One is that it won't cost nearly as much as you think. The other is that spending the money will get the European economy moving again.

One reason it won't cost that much is that governments save money every time they employ someone. When people are out of work the government pays them benefits. When they get a job, the government saves that money. And the new workers start paying taxes, which gives the government more money.

The mix of benefits and taxes is different in every European country. So the return to government would save more by creating jobs in Sweden and Germany, and less in Poland and Greece. But in all cases the savings would be substantial.

The government savings don't end there. Governments would not be throwing this money away. They would be investing and getting money back. Buses, trains and boats would charge for freight and passenger tickets. Renewable energy would cost money to build, but public companies will charge for electricity.

Let us assume that the government gets back 40 Euros in tickets, freight charges and electricity bills for every 100 Euros they invest.[22]

Now combine that with the money governments would save in taxes and benefits.[23] Put all of these factors together, and for every 100

[22]This is a conservative assumption of 40% returns, because we are assuming that renewable energy will be expensive, that passenger transport will be cheap, and that government subsidies will make up the difference. The UK study (Neale, 2010a) assumed 25% returns, because they were including government spending on refurbishing buildings and other forms of energy efficiency for which they did not assume that the government would make any return.

[23]For these calculations, we are assuming one job lost for every three new jobs created. Most of these workers will not be transport workers, but they will still need new jobs in renewable energy or transport. See Appendix Two for the likely

Euros invested the governments will get back:

For spending of 100 Euros	
Sweden gets	104 Euros
Switzerland gets	104 Euros
Germany gets	99 Euros
France gets	90 Euros
EU average gets	83 Euros
UK gets	80 Euros
Spain gets	76 Euros
Poland gets	71 Euros
Greece gets	70 Euros[24]

The Swedish, Swiss and German governments would back everything they spend. The Greek and Polish governments have worse benefits and/or lower taxes, so they would get less back. But they would still get 70%.

It would cost less than you think.

Austerity Europe or Growth?

It would also get the economy moving again. Of course, this investment in new jobs will increase public spending. That seems to fly in the face of current economic orthodoxy. However, in economics there are two main schools of thought on government spending.

One school of economics is called Keynesian.[25] It is named after the British economist John Maynard Keynes. During the depression of the 1930s, Keynes argued that someone had to start spending to get the economy out of a recession. Individuals spend less in bad economic times because they are losing jobs. Companies and banks are reluctant to spend because people won't buy what they make.

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number of jobs losses, and Section Four for how we can protect them.

[24]Calculated from the table on p. 35 of Dolls, Fuestand and Pechl, 2009.

[25]The leading Keynesian economist in the world now is Paul Krugman of Princeton University in the US. He holds a Nobel prize for economics. He also writes a regular column in the New York Times and the International Herald Tribune. His column is written for the general reader, not hard to understand, and applies Keynesian economics to the issues of the moment in the US, Europe and globally.

So, Keynes said, the governments has to make jobs and spend money. That will give people money to spend and businesses a market. That way the economy will start growing.

Keynes used a famous example. He said that even if the government employed people to dig holes one day and fill them in the next day, it would start the economy moving.

The government, Keynes said, had to borrow money now to invest in the future. When good times returned, the government would get more in taxes and could pay back the money.

This is what happened in the 1940s. Because of the Second World War, governments in Europe spent massively on the military and created millions of jobs. That got the economy moving and ended the Great Depression of the 1930s.

After the Second World War governments kept spending. They had much higher national debts than they do now. And the economy was stronger, and unemployment much lower, in the 1940s, 50s and 60s. Keynesian economics became the leading school of economics.

In the 1980s a new school of economics became dominant: neoliberalism. Neoliberalism is now so dominant in the world that most people think it is an iron law that governments must cut spending in bad times. But cutting spending does not work. We have seen this many times.

In the 1980s the International Monetary Fund and the World Bank forced governments in much of Africa to cut spending in hard times. Most of Africa has still not recovered. In the 1990s the IMF and the World Bank did the same in much of Latin America. There they call it 'the lost decade'.[26]

In Europe now we have seen cuts in government spending across the continent. In some countries there is now some economic 'growth'. This means that sales and profits are rising a bit. But that growth has not reached working people. There is still mass unemployment across Europe. Even conservative economists agree that it will take many years, perhaps until 2020, to get us back to where we were in 2008.[27]

[26]See Mosley, Subasat, and Weeks, 2995, on Africa, and Weeks, 2000, on Latin America.

[27]Unemployment stays high for a long time after growth in GDP resumes. One important reason is that productivity improvements are generally cutting the number of jobs needed by about 2% annually. So a 3% increase in 'growth' only creates a 1% increase in jobs. That would take six years to move from 10% unemployment to 4%. European and North American governments are also pursuing austerity policies which reduce the number of jobs available further.

There is also the example of those European countries that have cut spending most. Greece and Ireland were both instructed to cut spending to pay the losses of the banks. The result has been that the economy is worse in both countries, the government is getting even less in taxes, and they have to borrow even more money.

Neoliberalism – Austerity Europe – is the dominant economics now. But it does not work, and there are alternatives. It is not certain that Keynesian government spending would solve our problems. The economic crisis we face runs deep. But it is certain that neoliberalism will make things worse. And thirteen million new jobs would take thirteen million people and their families out of misery.

Public Sector Work

Most of these jobs should be in the public sector. This means government owned and run corporations in energy and transport.

There are several reasons why this is necessary:

The government can employ millions of people immediately, and then transfer them to new work as it comes up. The private sector would take years to get fully up and running, and people would have much less job security.

It is cheaper if we do not have to pay for private profits.

Enormous public contracts given to private companies will generate a great deal of corruption.

But most important, if these are public companies then the government can deliver on a promise to provide retraining and a decent job to anyone who loses their job because of the changes.

This would mean public electricity companies, energy companies, rail, bus and air companies. Many younger people in Europe have trouble imagining how this would work. They point out that the employers would not agree to it, and that it would take a great deal of time. But up until 1975, in most of Western Europe governments controlled large parts of the energy and transport sectors. Governments owned some, or all, of bus travel, railways, road freight, post, airlines, airports, oil companies, gas, water, electricity generation, and coal mines. This was Western Europe, not Eastern Europe.

These sectors of the economy had been “nationalised” by the government. Nationalisation meant the government bought the companies, at a price set by the government. The employers sometimes agreed, if they were going broke. Mostly they did not agree. But the decision to nationalise was made by the government, with the support of the people who elected them, and the employers had to go along. Nationalisation did not take a long time – usually less than a year.

Since 1975, public companies all over Europe have been privatised. Some still survive. But this epidemic of privatisation has made it hard for many younger workers to imagine reversing the policy. However, once decided, nationalisation would not be hard to do.

SECTION THREE
THE DETAILS, SECTOR BY SECTOR

Now for the details of the changes we need, sector by sector. CO2 emissions in European transport are divided roughly as follows:

TRANSPORT CO2 IN EUROPE

Cars	48%
Trucks	21%
Planes	13%
Ships	12%
Buses	2%
Inland navigation	2%
Rail	1%
Other	1%[28]

Cars are half the problem. Trucks are almost a quarter of the problem. Planes and ships together are a quarter. These are the areas where we need to find ways to Reduce, Shift, Improve and Electrify.

[28]Based on European Environment Agency, 2010, pp, 45-46. The numbers there are for the EEA 32, that is the 27 EU countries plus Iceland, Lichtenstein, Norway, Switzerland and Turkey. These totals slightly overestimate the importance of cars and aviation, and underestimate the importance of rail, because they do not include the former Soviet Union countries, which use proportionally less road transport.

Cars, Buses and Trains

We will start with cars, the biggest problem. There are three solutions here:

Get people out of cars and into buses and trains (SHIFT)

Change cities so we have to travel less (REDUCE)

Run buses and trains on electricity from renewables (ELECTRIFY)

Let's start with buses. At the moment buses have about half the CO2 emissions of cars per passenger kilometre.

That's an average. It varies with the design of the bus. But it varies a lot more with the average number of passengers on the bus. Here are some examples:

AVERAGE PASSENGERS PER BUS

Sweden	9
United Kingdom	9
France	18
Germany	18
Austria	25
Netherlands	25
Spain	27
Belgium	27[29]

If buses in the United Kingdom were as full as buses in Spain, they would have one third of the CO2 emissions per passenger. If passengers switch to buses, and the buses have twice as many seats filled as now, we can cut CO2 by three quarters (75%).

The best way to get higher numbers of passengers into each bus is

[29]These figures are for 1999. While the current figures are probably different, the range will still be as great. See European Environment Agency, *Indicator Fact Sheet: TERM 2002 29 EU – Occupancy Rates of Passenger Vehicles*, p. 4.

to have more passengers altogether. For many years Europeans have been leaving buses and buying cars. With this, the number of people in each bus has been falling. If we reverse this, the rates of 'bums on seats' will go up, and the emissions per passenger will go down.

The switch to buses can be quick and easy. The roads are already there. All you need to do is buy the buses, train the drivers, and put them on the roads. You can do that in one year.

Each time you do this you also free up space on the road. Put 40 passengers on a bus, and you take 25 to 30 cars off the road. Then the buses move more quickly. And you make more jobs.

However, we also have to make buses more appealing than cars. This means clean buses, warm in the winter, cold in the summer, that come often, that come on time, that run all night, and that go all places. The more buses we have, though, the easier this is to do.

To appeal, buses also need to be quick and cheap. They will be much quicker if they have their own bus lanes. Bus only streets will make an even bigger difference. The ideal would be much faster trips than we have now, so buses would save people time and grief.

Improving public transport on its own, however, is not enough. We also have to make cars less attractive. At the moment in Europe, traffic control sometimes tries to help buses, but almost never tries to make driving a car more difficult. So when passengers switch to buses, that makes driving a car easier, and tempts many passengers back to cars. Reserved streets, and express buses in cities, would change this.

Cheaper fares would also make a big difference. In the long term the ideal is 'free' public transport. Of course it is not really free. Someone has to pay for it. This would be done in the same way we pay for schools. Everyone pays taxes for schools, including rich people who send their children to private schools. In the same way, car drivers would help pay for bus journeys.

The Belgian city of Hasselt tried 'zero fares' in 1996.Bus use increased tenfold, from 331,000 passengers a year to 3,200,000 a year.[30] But even without free transport now, we can have free passes for the elderly, children and the disabled. And if ticket prices are lowered for everyone, more people will use the buses, and the number of passengers per bus will rise.

Improvements in bus design, driver training, and hybrid buses will

[30] Goeverden et al, 2006, pp. 10-11.

also make a difference.[31] But the decisive changes are a switch to buses, more bums on seats, bus only lanes, and cheap fares.

Passenger Trains

Buses are half the answer. Trains are the other half.

On the face of it, trains produce even lower emissions than buses. The main energy use in a vehicle is moving the air in front out of the way. Then the rest of the vehicle follows in the slipstream, like riders in the pack in the Tour de France. Trains are long. Also, they move with less friction and less energy because the rails and the wheels are made of the same thing – steel.

However, it needs more energy to build the rail cars and the tracks. The roads are already there, and the more buses expand, the more roads come free. So in practice trains work out about the same as buses – about half the emissions of passenger cars.[32]

Again, however, there is variation in passenger numbers. Here are the numbers per train:

AVERAGE PASSENGERS PER TRAIN	
United Kingdom	95
Spain	142
Italy	164
France	183 [33]

In other words, French trains have about half the emissions per passenger of British trains.[34] As with buses, the key to more passengers is more services, longer trains, longer platforms, and reliable services. And above all, lower fares and free transport for some or all.

Trains have three great advantages. They are faster. They are easier

[31]Harvey, 2010a, p. 313.
[32]Harvey, 2010a, pp. 251-4; Chester and Horvath, 2009; and Lenzen,1999.
[33]As with the bus occupancy rates, these figures are for 1999, and although the current figures are probably different, the range will still be as great. See European Environment Agency, *Indicator Fact Sheet: TERM 2002 29 EU – Occupancy Rates of Passenger Vehicles*, p. 4.
[34] French trains are also likely to have more seats than British trains. The length and weight of the train do make some difference to the total emissions, but not much.

to electrify. (The next section explains why this is so important.) And studies show that passengers prefer trains to buses when they have a choice, and so are more likely to use them. This preference for rail is called Schienenbonus in German. [35]

But buses can go more places, and new bus lines can be opened instantly. Train lines will take longer to build. However, there are many closed train lines in Europe that could be reopened quickly.

New Jobs in Public Transport

A switch to bus and rail will create many new jobs. At the moment cars do 83% of passenger travel in the EU, and buses and trains do 17%. In many countries in Eastern Europe, the split is closer to 50-50. Let's assume that we switch so that 25% of passenger travel is by car, and 75% is by bus and train. That would require at least seven million new jobs in bus, rail and water transport.[36]

Buses and Trains Together

It is not, however, simply a matter of running separate bus and train lines. 'Integrated' services will bring more people onto public transport. That means easy, quick changes between one bus and another, or between a bus and a train. Research shows that people will change easily if services are frequent, so waits are short.

This means that rural and suburban bus and train lines make a large carbon difference even if they do not have many passengers. It is often argued that if low capacity services are cut, then the remaining services are more energy efficient. This ignores the fact that these less used lines are feeding the more used lines.

The best example of an integrated system in Europe is Switzerland. At big stations the trains and buses all arrive just before the hour, and leave just after the hour. This makes interchange easy. You know that your bus or train will leave four or five minutes later.

[35] Passenger preference for rail is an intensely discussed topic in transportation planning. Even though it often is part of the explanation for the success of many newly renovated rail systems, it lacked a deeper conceptualisation in research. In order to measure the preference for rail in comparison with other important attributes of a public transport service, market research with inhabitants of a regional railway line (Mücheln to Merseburg) in Saxony-Anhalt has been done. The data show a clear and significant willingness to pay for rail service. This amount is substantially higher than for a bus service. This will result in a higher demand forecast for rail than for bus in case of equal fares for both modes. See Schulz and Meinhold, 2003, pp. 26-29. According to the literature, the passenger preference for rail makes a difference of about 30 %.

[36]See Appendix One for the calculations.

The Swiss have worked for twenty years to get this right.[37]

An integrated transport system will also encourage more walking and cycling. Cycling transforms health. But even short walks to and from the bus stop every day reduce body fat and extend life. There is a global epidemic of obesity, most marked in the United States, but spreading across Europe and China. The most important cause – even more important than changes in the food industry – is the fall in exercise as people switch to cars. [38]

Cycling and walking will not simply happen, however. They require space for bikes on trains and buses, and building safe dedicated lanes for cycling and for walking. A study by the CCOO union found that in Spain in 2008 there were already 11,478 workers in public cycling services and the making, repair, and distribution of bicycles. They expected 20,562 jobs in 2020. And they estimated that with government support for cycling, that could rise to 78,000 by 2020.[39] On a European scale, that would be 2 million new jobs in bicycles. This needs further investigation, and seems a very large number. But there could certainly be a substantial number of jobs in bicycles.

[37] See 'Grâce aux moyens de transport publics, soyez parfaitement mobiles en Suisse', at www.sbb.ch

[38] Roberts and Edwards, 2010, pp. 10-47 is brilliant and surprising. See also Woodcock et al, 2009.

[39] According to a stuvy on “Movilidae y Empleo” by the Instituto Sindical de Trabajo, Ambiente y Saúde.

Electricity

The first steps are to get people into buses and trains. The second step is to run the buses and trains on electricity from renewable sources. 80% of European train lines are already electrified.[40]

Electricity from renewables is not just part of the solution for transport. It is central to low carbon solutions for the whole European economy. However, this involves thinking big. Most proposals for renewable energy in Europe talk of 20% or 40% of electricity. This will give us small cuts in emissions. But very large cuts are possible.

So let's step back for a minute and look at the whole picture. About 25% of European CO2 comes from making electricity used in homes, buildings, and industry. Another 25% comes from oil burned in transport. And 40% comes from coal, oil and gas burned to heat homes and buildings. In other words, electricity currently provides less than a third of all European energy. But we need enough renewable electricity to supply all the current uses. Then we need to go on and make lots more electricity so we can run transport and heat buildings with renewable energy.

We have the technology now. The main solutions are wind power and sun power. They are called 'renewables' because the wind and the sun last forever.

Wind power comes from wind turbines – modern wind mills. They produce the most energy when they are built big, high in the air, in windy places on land or sea.

Solar power comes in two forms. One is Photovoltaic Cells, the arrays of shining glass and silicon you see on roofs. We need to cover the south facing roofs of homes and public buildings all over Southern Europe.[41]

The other kind of solar power is even more productive in sunny places. Concentrated Solar Power uses mirrors to concentrate the energy of the sun to heat mercury or salt to very high temperatures, and then produce electricity.

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[40]UIC and CER, 2008, p. 12.

[41]In northern European climates, wind power currently delivers more energy for the same investment compared to solar power. This is why we have highlighted the use of solar power in southern Europe. This may change as the price of PV solar comes down with mass production and technological innovation. There is also a case for some PV cells in Northern countries to help national industries develop and mature. The reason for south facing roofs is that they get a lot more sun.

We usually think of renewable energy as local and small-scale. But big wind farms and solar farms in the windiest and sunniest places produce big amounts of electricity. With wind turbines, for instance, the amount of electricity produced is 'the cube of the wind speed'. That means that if you double the wind speed, you have eight times as much electricity. If you triple the wind speed, you have 27 times as much electricity. The amount of electricity is also 'the square of the length of the blade'. So if you have a blade three times as long, you have nine times as much electricity. If the wind is three times as strong and the blade is three times as long, you have 243 times as much electricity. This is why wind turbines are big, and why they are put in windy places. It is also why they are tall, to reach the stronger winds.[42]

New kinds of long distance electric cables can now move electricity over thousands of kilometres. These long cables solve a key problem with wind and sun energy. The wind does not always blow, and the sun does not shine at night. But if you mix wind and sun over great distances, and add some tidal power, wave power and geothermal power, you have a steady supply.

Moreover, there are enormous energy resources in North Sea wind, Siberian wind, Kazakh wind and sun, Turkish wind and sun, and North African wind and sun.[43]

Even with these resources, though, we will need to make our energy use more efficient at the same time. If we use half the energy, and make twice the electricity, we can supply almost all

[42]There is a large controversy about the environmental impact of wind farms. This controversy confuses two meanings of the word 'environment'.

MEANING ONE is that things look nice. MEANING TWO is about the effects on the complex web of living things.

Climate change has nothing to do with Meaning One. You can't see carbon dioxide. People who talk about the environment and wind farms are talking about Meaning One. Many people think that wind farms are beautiful, because they are evidence that we are caring for each other. Others dislike them because they look industrial.

In the end, it comes down to a choice. What matters more – how things look, or what happens to life.

There is also objection because wind turbines kill birds who fly into them. This is true. But tall buildings kill many more birds. So do cars. The big killer is cats. No one is campaigning against tall buildings, cars or cats for this reason. And, of course, if serious climate change arrives we will lose more not tens of thousands of birds, but a quarter or more of the species of birds.

See MacKay, 2010; Harvey, 2010b, p. 210; Gipe, 2004, pp.298-301; and Sustainable Development Commission, 2005, pp. 65-71 and 153-166.

[43] See Elliott, 2010; and Czich, 2006. References to Czich's recent work can be found at www.transnational-renewables.org. See also DLR, 2005; and DLR, 2006.

our energy needs with no CO_2 emissions.

We could start doing this tomorrow, with the political will. And it would mean at least 6 million new jobs[44] - mostly factory jobs making wind turbines and solar power.

Electricity for Buses and Trains

However, we cannot simply say 'change all the buses to electricity'. There is a problem.[45] The most efficient uses for electricity are the ways it is used now, in lighting, machines and industry. This is not an accident. Electricity is currently used in the places where it works best.

Using electricity for transport is less efficient. That is why we use oil. In a diesel engine, the fuel is burned right there in the engine, on site. With electricity, the fuel is burned in a power plant, and then turned into electricity, and then moved long distances, and then turned back into motion. A lot of energy is wasted.

The same is even truer of heating a home. If you burn gas in the house, the house heats directly. If you burn gas in a power station, the heat is turned into electricity, the electricity runs through many wires to the house, and there the electricity is turned into heat. Energy is lost each step of the way. So:

> First we build enough renewable electricity to supply the lighting, machines and industry that electricity goes to now.
>
> Then we build enough renewable electricity to transform transport.
>
> Finally, we build even more electricity to heat homes.

However, this will require enormous amounts of wind, solar and other renewable power. So much that renewable electricity alone will not be the answer. This is why electric cars on their own are not the answer. We simply will not have enough electricity. So we need to switch to buses and trains, and fill more of the seats, and electrify them. The challenge is so large that just doing one of these is not enough.

We are going to have wait some time – ten years at the fastest – for enough electricity to make a big difference to transport. And even then, there will not be enough to cover Europe in electric cars. We

44 See Appendix One.

45 See Nicol and Gupta, 2010 for housing; and Harvey, 2010a.

will have to switch to buses and trains, and redesign trucks, as well.

Changing Cities

The third thing we need to do about transport emissions is REDUCE our actual travel. This is not mainly a matter of giving up trips we would otherwise do. It is a matter of changing how we live in cities.

Globally, the differences between cities are enormous. The CO_2 emissions from transport each year are:

TRANSPORT CO2 PER PERSON	
Hong Kong	378 kg
Berlin	774 kg
Paris	950 kg
Brussels	1290 kg
Munich	1390 kg
Houston	5,590 kg [46]

Houston, Texas has fifteen times the transport CO_2 emissions of Hong Kong. These are extremes. 95% of journeys in Houston are by car. 84% in Hong Kong are by public transport, walking or cycling. Houston is suburban sprawl, Hong Kong is urban dense. But even in Europe, Munich has twice the emissions per person of Berlin. And Hong Kong is evidence that Berlin could be much lower.

So we can cut emissions by at least half by gradually changing the shape of cities.[47] There are several ways this can be done.[48]

First, simply increasing the density of the population. This does not mean high rise buildings of ten or twenty stories. They consume large amounts of energy for heating, cooling and lifts.[49] It means cities with buildings five to eight stories tall – that look like Paris inside the ring road. The denser the population, the less distance

[46] Union Internationale des Transports Publics, 'Media Backgrounder: Public Transport and CO2 Emissions'. The data are for 2001, and are of course partly out of date. But the spread between low and high emissions is likely to be much the same now.
[47] Why at least half? Because Berlin is half of Munich, and Hong Kong is half of Berlin.
[48] Harvey, 2001a, pp. 254-8; Cervero, 1998; Newman and Kenworthy, 1999; and Newman, Beatley and Boyer, 2008. Owen, 2009, is a good popular summary of the argument.
[49] A recurring theme in Roaf, Chricton and Nicol, 2005.

people have to travel. There are also more passengers on any one bus or metro. And it is easier for people to walk or cycle, because the distances are shorter.

The other key is mixing homes, businesses and shops together. Again, this is already done in many older European cities. If jobs are close, and daily shops are close, people travel less far and walk more. Cities also look better, and feel better, because there are always people on the street at all times of day and night, and local business owners want the streets to stay calm.[50]

This is a matter of planning. Local authorities need to insist on building up, not sprawl. This means bans on shopping malls and mega stores in the outskirts.[51] It means less parking spaces in the city. This does not mean more population density overall. Instead, it means city dwellers can be much closer to real countryside and open space, instead of to suburbs.

None of this can happen quickly, because people already have homes and jobs. But planning can be biased to reinforce density and locality. At the moment planning is biased in the other direction, toward cars.

There is one further step that would make an enormous difference – removing cars from the cities. This has been done in the historic centre of many cities. Once done, people don't want to go back.

But we are talking about something larger – no cars in most of the city. The benefits would be enormous. Some roads would be reserved to buses. Motor wheelchairs and small vehicles for the disabled would be allowed on all streets. But most streets could be closed to cars and parking. A street two cars wide, with parking each side, and then a pavement, would become open space six cars wide. Children could play football, or hide, and older people could sit in the sun or walk about and talk to the neighbours. The system of allotments and community gardens found in many European cities could extend into allotments right in front of houses. The air would be cleaner and quieter. Trees would grow. And on the streets that remained the traffic would flow more quickly and easily.

This is an ambitious idea. It is not something to force on people. But if the people of just one city voted to do it, everyone would see it on their televisions, visit, and go home and do likewise.

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[50] For this understanding everyone in the field owes a debt to Jacobs,1992, originally published fifty years ago.

[51] See Beauvais, 2008.

Freight: Road, Rail, and Inland Navigation

Cars are the most important problem: about half of European transport emissions. We turn now to trucks, about a quarter of emissions. In Europe, freight travels:

60% by road.

27% by rail.

13% by water.[52]

These are averages. In Western Europe, the percentage of rail freight is smaller, and in Eastern Europe it is larger.

There are four main ways to cut CO2 emissions from freight:

IMPROVE the efficiency of trucks.

SHIFT freight from trucks to rail and inland navigation.

ELECTRIFY rail freight with renewable energy.

REDUCE the amount of freight moved.

We will start with improving trucks. This can cut emissions by a third over the short term and more than half over the long term.

CHANGES SO TRUCKS USE FUEL

Improved Aerodynamics

Wide Based Tyres

Weight Reduction

Low Friction Lubricants

Speed Reduction

Ecodriver Training

Full Loads

Strict Government Fuel Standards

Hybrid Diesel/Electric Trucks[53]

[52] Harvey, 2010a, p. 320.

[53] Harvey, 2010a, pp. 321-4; Ang-Olsen and Shroeer, 2002; and Vyas et al 2002.

The three changes that will make the most difference are speed reduction, full loads and strict government fuel standards. All these changes can be made quickly.

Speed limits can be changed immediately. They make a difference because much of the energy in moving a truck goes in pushing the air at the front out of the way. A truck at 110 kph uses twice as much energy to do that as a truck at 80 kph. The overall reduction in fuel use is less, but still substantial. A 20 km cut in speed, from 115 kph to 95 kph, means a 17% cut in fuel to cover the same distance.[54] And trucks that go slower can also be built lighter, with smaller engines.

Reducing speed limits means more jobs. Transport is not a large part of the cost of most goods. So the companies will still send the goods. But it will take longer for trucks to get there, and mean more jobs for drivers.

It would also mean that we would need more trucks. This would have a carbon cost in the factories. But that would also make jobs in the factories. And governments could insist on state of the art, low carbon new trucks. That would reduce the average emissions of all trucks quickly.

Speed limits for cars would also make a considerable difference. The government of Spain, as a temporary measure in the face of rising oil prices, reduced the speed limit from 120 to 110 km an hour during the months of March to June 2011. They found that cut spending on petrol by 450 million Euros over three months.

Running trucks with full loads requires careful control of inventory, shipping and planning, but it can make an enormous difference. A truck with full load on the flat uses 30% of its fuel to move the load, and 70% to move the truck. Thus, a truck that is one-quarter full uses two and a half times more fuel per tonne of freight as a truck that is three-quarters full.[55]

Stricter EU and government regulations for energy efficiency will also make considerable difference. The key is regulations that insist that within three to five years all trucks are as efficient as the most efficient truck now. Once that is achieved, then the standards are tightened again. These regulations could also insist that new trucks are hybrid trucks that use both diesel and electric, like hybrid cars. These hybrids convert the energy from braking resistance into electric power.

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[54]Extrapolating from figures in Ang-Olsen and Shroeer, 2002, p. 9, which give savings of 13.6% on a cut from 70 mph to 60 mph. Their study is a model of careful and scrupulous use of statistics in emissions studies.

[55]Harvey, 2001a, p.324.

Taken together, these changes can reduce emissions by at least 50%. Very strict speed limits and careful loading could reduce them by even more.[56]

Smaller Trucks

Then there is a long term solution – smaller trucks. The difficulty with the heavy trucks we have now is they cannot be converted to electrical power run from renewable energy. Heavy trucks are simply too big, and demand too much energy. But smaller trucks, a quarter the size of the ones we use now, can run on renewable electricity.

There is a problem, however. Proper regulation of working hours and health and safety currently apply to large trucks. They do not apply to small trucks. A shift to small electric trucks without regulation would be dangerous for workers, for car drivers, and for pedestrians. So we need proper regulation extended to smaller trucks. But once that happens, electrification would create an enormous increase in jobs for truck drivers. Trucks a quarter the size would require four times as many drivers. But it would cut emissions to almost nothing.

It would also concentrate the minds of trucking companies. At the moment there is no way to run full size trucks on renewable energy. But if companies faced the outlawing of big trucks, they would invest a great deal of money into solving this technical problem. It is entirely possible we would not have to move to smaller trucks.

This is not an immediate solution, because it only makes sense after large amounts of renewable energy have been built. (See the section on electricity above for the reasons why.)

Because there would be more jobs, the cost of shipping would rise. So this cannot happen without government regulation.

Switch to Trains

A second long term solution is a switch from trucks to rail freight and inland navigation. This could threaten the jobs of existing truck

[56]Harvey, 2010a, pp. 322-3; Ang-Olsen and Shroeer, 2002; and Vyas, Saricks and Stoldosky, 2002. The figures in these studies are all now ten years out of date. They are also for the United States. For both reasons, possible emissions reductions in Europe may now be less. For inspiration about what is possible in Europe, see the remarkable efforts of the Colruyt group of stores in Belgium, in Colruyt Group,n.d. Colruyt try everything: careful loading, computer control of trips, ecodriver training for staff with company cars, well designed trucks, asking each employee what would help them give up a car, and much more.

drivers. Section Four explains what we plan to do about this. Some readers may want to skip to that section now, and then return to this section.

A diesel railway engine uses about half the fuel per tonne of freight of a diesel truck. One reason is that a train is much longer, and has the same advantage as the Tour de France. Another is that freight trains move more slowly.

Inland navigation on rivers and canals uses less than half the fuel of a diesel truck, partly because it moves slowly.[57]

Of course railway lines, rivers and canals don't go everywhere. Trains and boats have to take the freight to depots. There it can be unloaded into light vans and trucks to deliver it the last few kilometres. Crucially, however, vans that cover short distances can run on electricity.

The market, left to itself, will not deliver rail. For the last fifty years we have seen a steady shift from rail to road. This is not just driven by profits. It has been encouraged by governments – partly by railway closures, but mainly by building roads. On a global level, the World Bank worked steadily to encourage road building and car buying all over the world.[58]

What we need is a conscious reversal of these government policies. That would require government regulations to direct freight to rail, and government financial support for new rail networks.

We are not proposing that all road freight switch to rail. Even at the end of 15 or 20 years, there would still be a mixture of diesel road freight, electric road freight, rail freight, and inland navigation.

Inland Navigation

With climate change, inland navigation is caught between a rock and a hard place – often literally.

On the one hand, inland navigation has about half the emissions of CO2 per tonne of rail freight, and a quarter of the emissions of road freight. A large expansion of inland navigation makes sense.

On the other hand, climate change is making the major rivers less navigable. Both low water and flooding block boat traffic. Large investments in infrastructure are needed, in dredging, in opening up blocked old waterways, and in new canals to link waterways. The owner operators and small businesses which dominate the

[57]Unpublished paper by Inland Waterways section of the ETF.
[58]World Bank, 2008; Roberts and Edwards, 2010, pp. 66-88.

industry have invested heavily in new technology. But there are tight limits to the money they can raise.

Government help is needed in building and buying new boats, which will use much less fuel. Major public works are also needed. With another recession looming, none of this will happen without a change in government policy.

In addition, workers in inland navigation need the political support of environmentalists. At the moment, environmentalists often organise to block dredging and new canals, because of the impact on wildlife and plants. But inland navigation is very low carbon, and climate change means it will not work without improved infrastructure.

Moreover, both rail and inland navigation suffer from the problem of fixed routes. This requires more sophisticated computerised systems for moving freight, and a large fleet of electric trucks to carry the cargo the last few kilometres.

Switch to Electricity

80% of the rail network in Europe is already electric. Where it is not, simply adding electric cables is not that difficult. But as with passenger rail, the really big saving comes when most of the electricity on the grid comes from renewable sources. Then it is possible to reduce emissions from rail to almost nothing. This is the big reason for switching from road freight in trucks to rail freight – the possibility of renewable electricity.

Reduce Freight

Finally, the fourth way to reduce emissions from freight is to move less freight – to reduce. The solutions here involve difficult political and moral choices.

It is possible to say, for instance, that 'food miles' should be drastically reduced. It makes no sense for the UK to export hundreds of thousands of tonnes of pork every year, and to import hundreds of thousands of tonnes as well.

But any moves to reduce global trade will also be moves to reduce exports, and therefore jobs, in the poorest countries in the world. They will also destroy the economies of several exporting European countries, of which Germany is the biggest.

So reduction is trade is not a simple matter. But there is one thing transport workers can campaign for. Economists say that 'cheap transport' has been essential to the growth of global trade. That is true. But that transport is cheap because many port workers, seafarers and truckers have seen their unions undermined, their conditions worsen, and their real wages fall. If unions can win back those losses, transport will become more expensive. Then the growth in global trade can be restrained.

Timing

It makes sense to take these changes in a certain order. The first changes are almost immediate. Speed limits can be reduced in a week.

Driver training and strict emissions standards for new trucks could follow within a couple of years.

Switching large amounts of freight to rail requires a few years to build the new lines. In many cases, though, new lines could be built for faster passenger trains. Then much of the old network could be turned over to slower freight trains.

Finally, a switch to renewable electricity on all lines would follow.

Regulations requiring smaller electric trucks could come in at the same time as the switch to rail.

Aviation

The ultimate key to road and rail transport of people and freight is renewable electricity. That provides the possibility, over the next ten to twenty years, of very low carbon mobility.

Aviation and shipping are a smaller problem right now – only an eighth of emissions each.[59] But planes and ships cannot run on electricity. In the long run, that creates problems. And many aviation emissions are released into the upper atmosphere, where they have at least double the impact of aviation emissions on the ground.[60]

The first solution is improving energy efficiency in existing aviation. There are several ways of doing this. One is improving the design of planes. Planes are already quite efficient aerodynamically. But it is possible to cut fuel use by building planes with lighter materials. Flight plans can be changed to go more directly, and use less fuel.

Better systems for managing air traffic control could dramatically reduce time and fuel wasted in circling airports. The key here is reducing airport congestion. If we reduce the number of flights (see below), we will reduce congestion.

Planes could also fly at slower speeds. There would be problems with limiting speeds, because it would cost airlines more in wages. But that would also mean more jobs for pilots and cabin crew, and save airlines money in fuel costs. As the price of oil rises, that will become increasingly important.

One problem is that planes are built to last. The new generation of aircraft are use much less fuel per journey. But it will take twenty years or more to replace the old planes. The solution here is government and European regulations to insist that older aircraft are retired, and new planes introduced. This would also create many jobs in aircraft manufacture.

Biofuels – gas made from trees and plants – are also a possible alternative to conventional aviation fuel. Unfortunately, there are serious problems with biofuels. (We discuss these in Section Five.) But if there is a case for biofuels anywhere, it is in aviation.

All of these measures taken together could reduce emissions from flights by at least a quarter, and possibly by more.[61]

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[59]See note 28.
[60]See Penner et al, 1999; but also Bows et al, 2006.
[61]Bows, et al, 2006; and Harvey, 2010a, pp. 314-319.

Another way to cut emissions is for people to switch to high speed trains for shorter journeys. Short haul flights are particularly important because much of the energy used in the average flight comes at take-off and landing. It takes more energy to get going than to keep going. This means that short haul flights have more emissions per kilometre than longer flights.

On a flight of 250 km, take off and landing use about 50% of the fuel. On a flight of 3,700 km, take off and landing use 7%. The very short flight uses about 40% of the fuel per kilometre of the long flight.[62]

Two thirds of all flights from Vienna airport, for instance, are for 900 km or less.[63] High speed trains provide an attractive alternative for some of these flights. A train going only 250 kph will take you from Moscow to London in ten hours, and from Istanbul to Paris in nine hours.[64] There is also the possibility of night travel with sleeper bunks on ordinary train lines. These could be done overnight, slowly, and deliver people rested and ready for a morning coffee.

We have the technology. Many kinds of high speed trains have now proved themselves in Japan, France, and Germany. In Spain the new trains from Madrid to Barcelona have largely replaced planes. We would need major projects to build high speed railways across Europe.

Here is how it could work. Assume that 25% of all passenger kilometres switch to rail. Because short flights use more fuel per passenger, this would give CO2 cuts of about 40%. Further savings from design, new planes, slower speeds and different work routines would bring the total cut in emissions up to 55%.

Section Four explains how we can do that and still protect the jobs of existing workers. Some readers may want to turn to that now, and then return here.

[62]Jardine, 2005. Also, a lot of energy is used up in making the planes themselves, and all the tools, plant, machines, runways, etc. that service them. The technical word for this is 'embodied energy'. Much of this embodied energy is the same for a short haul flight as a long haul flight. This also means that short haul flights have more emissions per kilometre.

[63] Unpublished research by Heinz Högelsberger.

[64]There are problems with very high speed trains. Fuel use begins to rise a lot above 300 kph. Also, very high speed trains encourage many people to make trips they would not have made otherwise, and thus increase emissions.

Shipping

About an eighth of European transport emissions come from shipping.[65] The good news is that shipping has the smallest CO2 emissions of any freight transport. Shipping has about one third the emissions of rail freight per tonne of cargo, and rail has about half the emissions of road freight.[66] This is why there is no sensible way to SHIFT freight away from shipping.

But there are two problems. Ships at sea can't run on renewable electricity. And shipping is the fastest growing form of transport.

Improve through Design

The International Maritime Organization has produced two impressive reports in the last ten years on the environmental impact of shipping.[67] Their main solutions are:

Changes to the design of the engine

Changes to the design of the propeller

Changes to the design of the ship as a whole

Sophisticated systems for monitoring and adjusting fuel use

All these measures, taken together, could probably cut fuel use by 25% to 50%.[68]

Also, it is usually true that the larger the ship, the less the fuel use per tonne. Unfortunately, almost no ports in Europe that could accommodate a new generation of 'super-ships'.

These are design changes for new ships. At the moment the average life of a ship is 28 years, so it would take some time for new design to have an effect.

There has been extensive and passionate discussion in the IMO of a

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[65] See Note 28.

[66] I am simplifying the estimates in Buhaug, et al, 2009, pp. 172-182. The discussion there is quite careful and complicated, and reveals large differences in emissions between different kinds of rail in difference countries, and between different kinds of ships.

[67] IMO; Buhaug at al, 2009.

[68] Crist, 2009, is a useful summary, and for more detail, Buhaug et al, 2009, pp. 60-80 and 221-243.

detailed new standard for energy efficiency. There is as yet no way of enforcing this standard. But even if it was only enforced across Europe, that would affect most ships. The nature of the industry means that many ships have to be ready to go anywhere in their working lives.

Speed reduction can cut fuel use by large amounts.[69] Cut speed in half, and you cut total emissions for the voyage by three quarters. But notice, it takes twice as long to get there. That means that ships have to spend twice as long at sea. That means that if you cut the speed for all the ships in a fleet, you need twice as many ships. And twice as many seafaring jobs.

That would mean about 1.4 million new seafaring jobs globally.[70] This could not be done immediately. An enormous number of new ships would be needed. To build them over ten years would require three times as many shipyard workers. So ten years would be difficult, but possible.

The energy to build these new ships would be more than offset by getting better designed ships into service quickly.

Also, it would take time to train the new workers. These are skilled jobs, and about half of them are ships officers, who require extensive training. That too would take some time.[71]

But over ten years it would be possible to gradually reduce speeds. Here is a table of the effect of different speed limits:

Speed	Hours	Fuel used	Speed cut	CO2 cut	Ships
25	24	230	0%	0%	100
15	40	83	40%	64%	167
12.5	48	58	50%	75%	200
10	60	38	60%	84%	250[72]

[69]We need a bit of arithmetic to explain why. The amount of fuel a ship uses increases with the cube of the speed. So if you double the speed from 10 knots to 20 knots, the amount of fuel used increases 8 times (2x2x2=8). But if you cut the speed by half, you cut the distance travelled by half. So to cover the same distance, you need twice the time.

Time cut	Speed	Distance	Total Fuel	Speed cut	CO2 cut
One day	25	600	230 tonnes	0%	0%
Two days	125	600	58 tonnes	50%	75%

See Crist, 2009, p. 34.

[70]See Bimco and ISF, 2010.

[71]See Bimco and ISF, 2010.

[72]Adapted from Crist, 2009, p. 34.

During 2008-09 Maersk, a leading global shipping firm, ran their whole fleet at much reduced speeds to see if they saved fuel and money. They did. It worked.[73]

Of course, there would be problems enforcing speed limits. There are an enormous number of shipping lines, leasing companies, and subcontractors. But tachographs in trucks have regulated a diverse industry. Telephone service providers now keep records of the GPS of every user every time they call someone. Technically, it would be easy to monitor ship movements.

Also, ships differ and each one needs a different speed limit. But formulas could easily be developed to take this into account, in the same way the IMO has done in developing environmental standards for new ships.[74]

The problem we face, though, is the power of the market. Some serious commentators, from environmental organisations and the industry, have argued that slowing speeds is a win-win. It costs the shipping company less, and it saves the planet.[75]

This is true, but within limits. The companies who ship the goods lose market share if they are slow. And they have to wait for the money to come back from sales. So shippers will move freight to the fastest ships. This is why containers and car ferries have much higher emissions than other ships. They are forced to go faster to compete.

Moreover, with large reductions in speed, the shipping company will face increasing costs for extra ships and more workers.

So it is difficult to cut speeds a lot if only one shipping line does it. The shipping lines need regulation that forces all the ships using ports in a region to observe the same speed limits. Then none of them lose out.

The Political Problem

By combining design changes, sophisticated operating systems, and speed limits, we can cut shipping emissions by at least 85%. However, shipping is a global industry. The system of flags of convenience already makes it difficult to control safety, wages, working conditions, and pollution.

Unions campaign for 'port state' regulation – the national government that controls the port sets standards that all ships have

[73]Vidal, 2010.
[74]The key factor is that speed is a function of the square root of the waterline length.
[75]For example, Iverson and Leape, 2010.

to observe. This is clearly the way to control CO_2 emissions.

Within the limits of the present system, this seems very hard to achieve. However, voluntary measures for design changes will not be enough to solve the problem.

Unions are put in a difficult position. We have to campaign for real solutions, steadily, wherever we can. If we do not, then the discussion will be dominated by pretend solutions.

But at the same time, the climate problems of shipping cannot be solved by shipping unions alone. If governments set policies to cut all transport and other emissions, then they will be willing to enforce port state regulation as well. So shipping unions will solve this problem by putting united pressure along with other transport unions, other unions, and the rest of civil society.

Reduce

Very deep cuts in emissions are possible. But we still face a long term rise in emissions as global trade increases. We have already commented on this problem in the section on road freight. The central point we made there was that global trade has grown quickly on the back of 'cheap transport'. That transport is cheap because transport workers are cheap. In the long term, the solution is better pay and conditions for transport workers.

Ports

Ports are different from other transport sectors. In the other sectors, the key is reducing CO_2 emissions. With ports, that still matters. But the wider climate campaigning of port unions is more important.

We start with what can be done to improve ports. These are the changes that are important with any workplace:

Using electric vehicles in the port

Refurbishing buildings for efficient heating and cooling

More efficient lighting

More energy efficient IT

Efficient machines

More efficient motors

The World Ports Climate Initiative and the European Sea Ports Organization have begun research on ways of doing this.[76] Unfortunately, their current policy is that such measures should be voluntary for any port.

Another possibility is the use of electricity by ships in port. Traditionally, ships use their own engines to generate electricity in port. Shore side electricity from the city's power supply is now in use in many European ports. It is important in reducing sulphur dioxide in the air, and some other pollutants. This makes for cleaner ports and cleaner cities.

But shore side electricity will not cut CO_2 emissions substantially until most electricity comes from renewable energy. And shore side electrify from coal power stations has higher emissions than using the ship's fuel.[77]

The emissions from port operations, however, are small compared to the emissions from trucks and ships that use the ports. Port unions can play an important role here. But they have to press for

[76] See www.espo.be and www.wpci.org

[77] Fridell, 2009. It is true that shore side electricity in the port of Götenberg was able to reduce emissions by 6,000 tonnes of CO_2 a year. This was because most electricity in Sweden already comes from renewable energy. This is unusual in Europe.

programs that protect workers.

For example, in the California cities of Los Angeles, Long Beach and Oakland, the Teamsters union has been part of a wider Coalition for Clean and Safe Ports.[78] The teamsters represent truckers. They argued for strict environmental regulation of trucks using these ports, in the interests of both truckers and the environment. They won strict regulation. But then the trucking employers forced the drivers to pay the costs of buying new trucks, leading to extensive overtime and lower incomes.[79]

This example shows two things. First, unions can play an important part in campaigning for low carbon trucks. Such campaigns will make a difference far more widely than one port. This is because trucks in any one region will all have to use that port at some time.

Second, workers may lose out. To avoid that, unions have to be central to campaigns and central to developing policy. They also have to be prepared, if necessary, to act in defence of their members.

At the moment, it appears more difficult for unions to influence the environmental standards of ships than of trucks. But there will be ways unions can object to particular environmental abuses.

Port unions will also be important in combating climate change for two reasons. One reason is that port unions in many countries are well organised. The other is that port workers have a long and honourable tradition of supporting other unions and wider social causes.

But that support is far more likely if unions in each port are also pushing smaller improvements in the port operations through collective bargaining, joint committees with management, and alliances with environmental organisations and policy makers outside the port.

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[78] Www.cleanandsafeports.org

[79] See particularly Coalition for Clean and Safe Ports, 2010; and Smith, Bensman and Marvy, 2010. Also see Boston Consulting Group, 2008; Consumer Federation of California, 2008; and Haveman and Monaco, 2009.

Buildings, Industry and Other Sectors

This report is about transport and climate change. It is also about renewable energy, because transport emissions cannot be cut enough without using renewable electricity.

Changes to transport and renewable energy will effect more than half of European CO2 emissions. However, these measures will not be enough on their own. We will also need changes to five other important areas:

Refurbishing houses and buildings so they use less energy

Redesigning industry to use less energy

Training and education in skills for the new industries

Research in low carbon technologies

Changes to land use and agriculture

There is not space here to deal with these areas in detail. But they would probably require at least 4 million new direct jobs, and possibly more.

Summary

We have now looked to changes in each area of transport. The changes we propose would cut transport emissions by at least 80%. In the process, we would create at least 13 million jobs across Europe, almost all permanent jobs. With these new jobs, and with the changes we have suggested, we will be able to cut CO2 emissions from transport roughly as follows:

	CO2 Emissions as %	
	Now	In 20 years
Cars	48	6
Trucks	21	5
Planes	13	5
Ships	12	2
Bus and Trains	3	0
Inland Navigation	2	2
TOTALS	100	20

[The numbers for now in fact add up to 99, because of fractional differences in the original percentages.][80]

So 7 million transport jobs would bring about 80% cuts in transport emissions in twenty years.

And 5 million renewable energy jobs would bring more than 90% cuts in electricity generation emissions in twenty years.

These cuts could be larger, in time, as the design of cities changes, or if more people walk or cycle to work.

[80] For the calculations see Appendix One.

SECTION FOUR
HOW TO PROTECT EXISTING JOBS

Any policies for cutting CO2 emissions mean some jobs will disappear. We cannot hide this. We have to be honest. We also have to make sure that when jobs disappear, workers still have a livelihood.

This is moral, but not simply morality. If some workers gain jobs from climate policies, and some lose, workers and unions will be in bitter competition with each other.

This section sets out what we can do. The key is that anyone who loses a high carbon job is guaranteed proper, lengthy retraining and a new job at the same wages or better. This will only happen if the new transport and renewable energy jobs are in the public sector. If the work is done by private train companies or wind corporations, they will pick and choose the workers they want. But if governments run the new energy and transport corporations, they can make redundant workers a promise and keep it.

That's the bedrock guarantee that people need. It's the reason why the new climate jobs will have to be in the public sector.

But most people will not actually need to take up the guarantee. Let's take aviation and road freight.

With the switch we have proposed from short flights to high speed rail, 25% of aviation jobs would disappear over 20 years. To put it another way, one job in 80 will disappear each year. Turnover and retirement in the industry is far higher than that.

At the end of 20 years, we would still have 75% of the aviation jobs we have now. That provides a place for the many younger aviation workers who love their work.

For road freight, the problems would be smaller, for several reasons. One is the possibility of smaller, electric trucks, and in the long term the possibility of larger electric trucks. But let's take the 'worst case' – a switch of one half of road freight to rail over 20 years. That would mean one job in 40 will disappear each year. Again, retirement and turnover rates are already much higher than that.

Moreover, there will be a much larger number of new jobs for drivers on the buses. For truckers, there will be a large demand for delivery drivers to drive electric light trucks the last few kilometres. There will be an endless demand for bus drivers. There will be a large demand for skilled and experienced drivers who can train a new generation of bus drivers. And many jobs in renewable energy will be transport jobs driving and maintaining trucks.

Mechanics, repair workers, engineers, electricians, sales staff, accounts staff and office staff can take their skills directly from trucking firms or airports into railways and bus services.

Of course, the transition will not be smooth. Some employers will be sacking workers while others are hiring new entrants to the industry. The solution here is a register for aviation workers, and a register for road freight workers. These would be like the registers that have been negotiated for dockers in many ports. Anyone in aviation or road freight in a country would go on a national register, and they would have first chance at vacancies in the industry.

A register will only work if it is negotiated at national level and backed by the government.

These are ambitious proposals. A national register is not something employers or governments grant lightly. Governments and policy makers are not currently thinking of new public sector jobs in transport and energy. Such policies run counter to neoliberal orthodoxy.

But all the proposals we are making in this report are ambitious. We need deep changes to avoid climate catastrophe. The changes to employment policies also have to be radical.

If unions stick to policies that support growth in all sectors, we will not be able to deliver that growth. Climate change is coming. If we do not take radical action, we will face radical circumstances. When climate catastrophe arrives, governments will cut aviation, trucking and much else swiftly and savagely. Then there will be no protection for the workers affected.

So unions will need to do two things at once. We need to campaign for serious cuts to emissions. But we need to insist at the same time that those cuts can only come if workers are properly protected. We need to be control of the process, not have it done to us. This is not just a matter for workers in aviation and road freight. It will only happen if workers in other sectors, and other unions, insist that all workers are protected.

Finally, most of the workers who lose their jobs will not be in transport, but in other jobs in manufacturing, mining and auto sales. They deserve, and must have, the same protection and guaranteed new jobs. There will be many more new jobs than jobs lost. (See Appendix Two for the calculations.)

SECTION FIVE

CONVENTIONAL SOLUTIONS

That is what we need to do. If we do not, we are headed for climate catastrophe. These are ambitious plans. They are not the sort of plans we hear from our governments and the European Union at the moment. Instead, they are proposing a variety of solutions.

These solutions tend to work through the market. They do not disturb established corporations. They do not create many jobs. We will pay for them. And they won't deliver the radical action we need to halt climate change. But we need to understand how these solutions work, why they appeal to many people, and how we can react to them.

Biofuels

We will start with biofuels.[81] Biofuels are fuels made out of plants. Some can be used in cars and trucks, and some for heating and power. The most common biofuels are ethanol from Brazilian sugar cane, ethanol from maize in the USA, and palm oil from Indonesia.

At first biofuels looked really attractive. They are natural. In theory, they are part of a natural cycle. The carbon in the sugar cane is burned as fuel. It goes into the air as CO2. You then grow another crop of maize. That crop takes the CO2 out of the air through photosynthesis. Then that carbon is burned again, and so on. The carbon is endlessly fixed.

Many environmentalists liked this idea very much. The EU now has a target for biofuels to be 10% of transport fuels by 2020. It turns out this was a mistake, for several reasons.

First, and most important, there is not enough land for biofuel on a big scale. If you plant biofuels on land, you have to cut down a forest somewhere else. And the forests do far more to fix the carbon, particularly tropical rainforests, with enormous biomass and even larger stores of carbon in the soil.

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[81]For biofuels start with Smith, 2010. George Monbiot has been an influential critic of biofuels for several years: see Monbiot, 2008, 'The Last Straw' and the other articles on his website, www.monbiot.com. There are also useful resources at at www.biofuelwatch.org.uk. See also Crutzen et al, 2007; Fargione et al, 2008; Searchinger, et al, 2008; and Hoojier, et al, 2006.

So biofuels in Brazil and Indonesia mean cutting into the two great rainforests left on the planet.

Second, biofuels create hunger. If the market faces a choice between feeding a car in California and a child in Calcutta, it will feed the car. Jean Ziegler, the United Nations Special Rapporteur on the Right to Food, says 'to fill a 50-litre tank with bioethics, 232 kilograms of corn have to be burned. A child in Zambia or Mexico can live for a whole year on that amount.'[82]

In both 2008 and 2010-11 have seen steep rises in the prices of grain world-wide. These are driven by a combination of lost crops replaced by biofuels, the rising cost of oil for making fertiliser, speculation by hedge funds and banks, and harvest failures to due climate change.[83]

Third, it often takes more energy and emissions from fossil fuels to make biofuels than it would if petrol was used instead. This is the case with making ethanol from maize in the US, and with making palm oil in Indonesia and transporting it to the US.

For all these reasons, most environmentalists have now reluctantly turned away from biofuels. However, biofuels are a very attractive option for long haul aviation. In the long run, there is no other way to imagine powering them. 'Second generation' and 'third generation' biofuels are now being developed. It is claimed they will not have the same problems. Maybe this is true. But right now, in practice, the argument in the EU is about the biofuels we have. Arguing that some biofuels will be all right is likely to confuse this argument.

Carbon Capture and Storage

Carbon capture and storage is also called 'clean coal' and 'carbon sequestration'.[84] It works like this. Coal is burned in a power station. As the exhaust air leaves the power station, 'scrubbers' take the CO2 out of the air. That CO2 is then sent down a pipeline and stored in an undersea cavern, an old coal mine, or an old well.

This is an appealing idea to many transport workers for three reasons. It allows us to keep using coal, a cheap and reliable fuel. Many railway jobs depend on transporting coal. And in many

[82] *Liberation*, 22 October, 2007.
[83] There is controversy about how much each of these four factors contributes to the price rise. Numbers vary widely, and often seem like guesses reflecting the political agenda of the author. It is not a good idea to believe anyone who gives precise percentages.
[84] For carbon capture and storage, start with Harvey, 2010b, pp. 389-426; and Rochon, 2008.

European countries the traditions of the miners unions are respected and valued.

These are all good reasons. But there are problems with carbon capture and storage. First, the scrubbers approximately double the cost of a power station.[85] This is why power companies have not used them in working power stations. The answer here is government regulation – no new coal power stations without 100% capture and storage.

The second problem is the most difficult. It takes enormous energy to transport the CO2 over long distances to the storage places.[86] And most power stations are nowhere near those places.

Third, no one yet knows if the CO2 will leak from storage caverns.

Fourth, there is general agreement among the engineers developing carbon capture and storage that it will take twenty years before the technology is developed enough. We need to move more quickly.

These are the reasons why there is not yet a full size working power station anywhere in the world using carbon capture and storage. So a sensible attitude from unions is that we want substantial investment from governments and the EU to encourage research on clean coal. In the meantime, we do not want new coal fired power stations without full carbon capture and storage.

Nuclear Power

There is long running controversy about using nuclear power to make electricity. There are several arguments in favour.[87] The first is that nuclear power facilities make electricity without emitting carbon dioxide.

The second is that nuclear power can supply a steady source of electricity. The supply from renewables fluctuates. This makes nuclear power a valuable backup for renewable energy.

The third is that governments are prepared to build nuclear power plants, and do not appear to be prepared to build renewables on the same scale. We have to save the planet, so we should take what we can get.

There are several arguments against. The first main argument is that no one has discovered a way of safely disposing of the

[85]Rochon, 2008, p. 27.
[86]Rochon, 2008, p. 21.
[87]For the arguments over nuclear power, see MacKay, 2010; Caldicott, 2006; and Harvey, 2010b, 325-388.

radioactive waste. Some of it lasts for thousands of years, and disposing of it is expensive.

The second is that accidents happen, at Three Mile Island in the United States, at Chernobyl in Ukraine, and at Fukushima in Japan. There is no such thing as a fool proof or absolutely safe technology.

Indeed, no bank or insurance company in the world will write comprehensive insurance for a nuclear power station. And no power company will build one without the protection of a national law limiting their liability in the event of an accident. Every country in the world with a nuclear power station has such a law. The banks, insurance and power companies do not think nuclear is safe.

The third argument is that nuclear power is expensive, and only exists because of large government subsidies. The largest of these subsidies is that governments meet the bill for dealing with the waste. If subsidies on that scale were available to wind and solar power, we could meet our energy needs more cheaply. In practice, governments are reluctant to spend such large amounts of money twice. If nuclear power is chosen, there will not be enough, and there will not be enough investment in renewables.

There is controversy about the long term effects of nuclear accidents. Estimates of the long term death toll from Chernobyl vary from under 500, by the IEA, which is close to the nuclear industry, to 900,000, by scientists from Eastern Europe. There is no consensus. Over the next decade data from Japan may settle this issue.[88]

Until 2011, the balance of power in this controversy was unclear. In the wake of events in Japan, most voters given a choice about building new nuclear power stations will reject them. In this report we have not recommended new nuclear power stations.

Carbon Markets and Carbon Offsets

Many market solutions have been proposed to cut emissions. In different ways, they all try to increase the price of carbon.[89] The best known form is the EU's Emissions Trading Scheme (ETS). This is supposed to work like this:

Each company that is responsible for carbon dioxide emissions joins

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[88] Yablokov, Nesterenko, and Nesterenko, 2009, and Vidal, 2011.

[89] The definitive book on market solutions to climate change is Lohman, 2006. It is elegant, funny, and devastating, and it is significant that no proponents of market solutions have replied to it. Gilbertson and Reyes, 2009, is an updated and simpler version of Lohman, and is available in English, Spanish and German. See also Bohm and Dabhi, 2009; and Neale, 2008, pp. 203-222.

an emissions trading scheme. The company is given, or buys, permits. Each permit allows them to emit one tonne of CO_2. If the company emits that tonne, they have to hand in the permit to the government body running the scheme. If the company does not emit that tonne, they can sell the permit to another company, who have more emissions than they do permits.

Each year the total number of permits available goes down. As that happens, companies will be more and more encouraged to cut their emissions.

This is a market solution, and it appeals to people who think the market is a good way of solving problems. The theory is that it will encourage companies to cut emissions in the cheapest ways possible. The companies who can cut most easily will, and then they will sell their permits to the companies that find it hardest to cut. Overall, that provides the most cuts the cheapest.

Carbon trading almost always goes along with something else, called 'carbon offsets'. These carbon offsets are from countries that are outside the carbon trading scheme. So, for instance, a steel plant in Denmark can pay a company for credits. The company in Brazil can claim that they are planting sustainable trees, and invent an amount of CO_2 saved. The company in Brazil makes money. The steel plant in Denmark still pollutes just as much as they would otherwise.

Another form of carbon offset is to buy credits for carbon savings that would have happened anyway. A Dutch company, for instance, can buy from Ukraine credits that come from the closing of so many factories in Ukraine after 1989. But that does not reduce the total amount of CO_2. Ukraine already cut those emissions. And buying the credits allows the Dutch company to increase its emissions.

Carbon offsets are a way of cheating. But what about carbon trading without offsets? Can't that work? There are three answers to this.

First, in practice carbon trading comes with carbon offsets. This is because the people who set up carbon trading schemes want it that way.

Second, look at actual carbon trading schemes. The only one that is up and running on any scale is the European Union scheme. Governments have handed out so many free permits on that scheme that the price has remained very low and no companies have been under heavy pressure to cut emissions. , For example, aviation fuel will be included in the EU scheme from 2012. On past form, this will add an extra $6 to $9 to the price of a barrel of aviation fuel. [90] This is a small margin compared to the large movements we have seen in the price of a barrel of oil. It will not change the policies of airlines.

Third and most important, regulation always works better than a carbon trading scheme. One reason is that for most industries energy is a small cost of the total expense. So the extra cost of permits has to be very high before they change their behaviour. If it is very high, there is then a political fire storm about rising prices.

But regulation works better for another reason. Market mechanisms encourage people to be good sometimes. Regulation makes them good all the time. For instance, market incentives will encourage airlines to run fewer short haul flights. Regulations forbidding short haul flights will stop all of them.

Again, a higher price for diesel will encourage trucking companies to save fuel. A lower speed limit, enforced by police, will make companies save fuel.

There is one telling example – acid rain. In the 1980s it was understood that sulphur emissions from coal fired power plants were going up into the atmosphere. There they mixed with oxygen to make sulphuric acid. Large quantities of that fell in 'acid rain' that killed trees, destroyed whole forests and polluted rivers.

In Germany, the government passed laws forcing the power plants to take the sulphur out of the emissions. Within 15 years, that worked almost completely. In the United States, the government introduced a sulphur permits trading scheme. Thirty years later, a good proportion of the sulphur is still going into the air.[91]

We could multiply examples. For instance, a tax on petrol will discourage motorists from driving. But strict EU regulations on the performance of new cars will save more fuel. Car free cities would have an even greater effect.

There is always a regulation that works better than market mechanisms.

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[90] The average price of EU carbon credits up until the end of 2009 has varied from 13 to 20 Euros per tonne of CO2 or equivalent. That is about $18 to $28 dollars a tonne. A barrel of oil produces, once refined, an average of about 320 kilos (0.32 tonnes) of CO2. That means the cost of a permit for a barrel of oil will be roughly $6 to $9. As of this writing, a barrel of Brent (crude) is a bit over $100 and a barrel of jet fuel is just under $120.

[91] The US sulphur dioxide scheme, based on trading, began in 1990 and was expected to cut sulphur dioxide emissions by 35% by 2010. The German scheme, which involved regulation and no trading, cut emissions by 90% between 1982 and 1996. Lohman, 2006, pp. 108-9.

Some people argue that we have to accept carbon markets because the old culture of regulation and government intervention has gone. We have to live with a new reality, they say.

They also say that regulation is not going to happen. Carbon trading may happen, they say, and we cannot wait. This argument can sound attractive. But carbon trading will not cut emissions on anything like the scale we need. So far, in Europe, they have not cut emissions at all.

When governments want to protect people, they don't use the market. We do not allow rich people to pay more to drive too fast and not wear seatbelts. We have laws. We do not discourage medicines that kill people by taxing them. We forbid dangerous medicines. We do not discourage child labour by taxing employers. We forbid it.

Carbon trading does not work. Government regulation and investment in new jobs works.

SECTION SIX
WHAT DO WE DO NEXT?

We can see what kind of changes to transport will help to save the planet. But many years of leaving the market to solve the problem have shown that will not work. We need decisive action by governments. Unions have a key role to play in making this happen.

At the moment governments and the United Nations are retreating from serious plans for action. The UN climate talks in Copenhagen in 2009 ended with little prospect for action. Since then global negotiations have limped along, but do not look promising.

Many environmental organisations have become discouraged. They have concentrated on lobbying governments. Now that policy makers are resistant, they do not know where to turn. The underlying problem is that environmentalist organisations have been largely limited to the more affluent in society.

It will not be easy to make governments take serious action, because energy reaches into every part of the economy and society. To move governments to action, we have to mobilise the majority of society. Unions can be central to that process.

There is no country in Europe where unions represent the majority of workers. But unions are the largest organisations in civil society. They reach into every part of that society. In most European countries, everyone knows a union member. And union members can speak to them as friends and equals. If unions mobilise themselves over climate, they can mobilise ordinary people in a way no other organisations can do right now.

Transport workers and our unions can begin by working on several levels: joining national campaigns, educating our members, bargaining with employers, and influencing policy makers. The ETF can also organise European wide action.

We can cooperate with other unions and environmental organisations in national campaigns. Unions have already done this in Austria, Belgium, Britain and the United States. In Austria, for instance, the Vida union is part of a coalition with Friends of the Earth and others to move Beyond Austerity. In Britain, the Transport Salaried Staffs Association is part of a coalition with other unions and climate campaigns fighting for A Million Climate Jobs Now.

Not all unions or environmental groups will join such coalitions at first. But they quickly gather support.

We can educate our own union members about climate change and climate jobs. Many European unions have begun to do this with day schools and conferences. A speaker on climate can also be invited to regular union meetings.

We can make climate, and climate jobs, part of collective bargaining. We can do this at the local level, in workplace bargaining. And we can do it in national negotiations, and in European works councils.

For instance, port workers can negotiate for cold ironing by all ships in port. This will reduce CO2 emissions and other forms of pollution a great deal.

Road transport unions can negotiate for tighter speed limits and more jobs to reduce emissions. They can also negotiate for paid training in environmental driving skills, and standards for new trucks in the fleet.

Air traffic controllers can negotiate for smarter routeing systems, so that they can reduce the amount of fuel wasted as planes circle the airport waiting to land.

This would be a departure from normal union practice. Usually we negotiate for things that will directly benefit union members, and only union members. But here we would be negotiating for broader social and environmental purposes.

If we publicise these negotiations widely, it will increase the pride of members in their union, particularly among young workers. And it will increase respect for unions among the population as a whole.

Some employers will welcome 'climate negotiations'. Many will not. Their first reaction may be that these are matters beyond the proper role of unions. And they may be reluctant to do anything that will cost them money. But unions will have considerable public support in taking on these matters. Employers will know this, and will not want to look bad. In some places, negotiations will be possible. Once there are some good examples in practice, other unions and employers will be encouraged to negotiate.

Globally, unions have only begun to think about how to negotiate on climate matters. We are at an early stage. Part of the process of developing this report will be for transport unions to discuss, and come up with concrete ideas for negotiation.

It will be important to mobilise allies outside the unions to support us in these negotiations. For instance, union workers at a power plant in the Washington state, USA, recently negotiated a deal with management to stop coal burning by 2025. That deal guaranteed them jobs in a low carbon plant. But they could not have done that without the support of the local Sierra Club, the largest environmental organisation in the USA, and the mediation of the governor of the state.

Transport unions in Europe can translate this example into our own reality. For instance, in Section Three we discussed the excellent climate change transport initiatives of the Colostrum Group company in Belgium. Transport unions negotiating with other road transport employers could ask them to consider similar initiatives. And they could ask environmental organisations and government policy makers to join with them in a joint talk with the employers.

We can influence policy makers. Many European unions have close links with particular parties. And many do not. But where we do, we can try to change their policies to support climate action and government spending.

This will not be a simple or easy process. Nor will it happen overnight. But there are many people in political parties who want action on climate. If unions and our allies can show those people that there is substantial public support for taking climate seriously, they will be encouraged to change their organisations. And they can be encouraged if unions show they can mobilise public support.

Unions can also hope to influence more socially minded governments who can promote our ideas at government level and push for these proposals to be discussed at European sectoral social dialogue level.

Unionised transport workers across Europe could all to give a postcard or leaflet about climate change and jobs to every passenger and transport user. The leaflets would be given out in many languages, all on the same day.

In some transport companies, it would be possible to do this by negotiating agreement with management. In others, unions would have to feel strong enough to do it without management approval. In some companies, union members might be afraid to give out the leaflet. Then workers not on shift, or from other unions and environmental groups, could hand out the leaflet at stations.

The leaflet would have to be simple. Our message on climate is complex. But a leaflet can make a few key points, and direct people to union contacts and websites where they can find the broader arguments. Agreeing the wording will not be easy. And we would have to take time to organise properly so that we were able to do it in many countries on the same day.

A simple leaflet could have a very large impact. Tens of millions, perhaps even a hundred million passengers and transport would receive it.[92] It would be news. It would establish in everyone's mind the idea that unions care about climate change, and want action.

The process of organising everyone to leaflet and the discussions that creates among workers would change and educate transport workers themselves.

Transport unions could organise joint climate and jobs demonstrations across Europe. Here we have to be careful. Our experience is that it is easy to call a 'European Day of Action'. It is difficult to make that action happen in any real way. But it is not impossible. This would make more sense to everyone if it was supported by many unions, not just transport unions. And it would have more impact if it was a joint demonstration with environmental campaigns. But to get large numbers, it would have to be for climate jobs. A generic climate demonstration would be much smaller.

However, we have to be careful of calling for demonstrations we cannot deliver. Bad turnouts demoralise people. It will only make sense to do this when we know we can organise good numbers in several countries. And it may make sense to do it as a European day of action, with demonstrations in some countries, and other activity in other countries.

Moreover, Europe wide action will make campaigning in each country easier. But the campaigns at national level will be more important in the long run. Politics moves at different speeds, in different ways, in each country. It is very unlikely that we will win what we need at a European level first. But if one country can break through, the workers in other countries will see that on their televisions and be encouraged to do likewise.

All this is only laying the groundwork. These actions, and others, will change people's minds. They can create a tide of opinion.

Union action and campaigning, in particular, can have several effects. We can change the national conversation about climate so that people know unions think a solution is possible. We can

[92] There would be a financial cost to this, and an environmental cost in paper. But it would be worth it. Unions already produce large amounts of paper, in reports, posters, leaflets and letters, and we do it because we know it matters.

mobilise many environmentalists behind the idea that unions are important allies.

Crucially, we can persuade many people that action over climate change does not mean sacrifice. It does not mean that ordinary people give up their standard of living. Instead, it means more jobs and better lives for most people. If unions can recast the debate about climate change in this way, we will make it possible to mobilise far more people than now.

Unions can also hope to influence more socially minded governments who can promote our ideas at government level and push for these proposals to be discussed at European sectoral social dialogue level.

Actually stopping climate chaos before the horrors arrive will not be easy. Energy reaches down into every part of the economy and society. Powerful corporations and governments are opposed to actions beyond the limits of Austerity Europe. Our task will not be easy. In the end, it will require political and industrial action. But the measures we propose are a start. In the process, we will recruit to unions and build our strength and confidence. That is good. But it is not why we campaign on climate change. We fight for our future, because we are humans, and live on Earth.

Appendix One

CALCULATING JOBS AND EMISSIONS CUTS

This appendix shows the detailed calculations of the number of jobs we will need and the cuts in CO_2 emissions we can expect.

We are using figures for the number of jobs that would be needed now, and for the demand for transport and electricity now. It is true that in future innovation will bring down the amount of labour needed to build alternative energy or power a truck engine. It is not possible to be sure how much.

It is also true that in the future demand for both transport and electricity will increase. Again, it is not possible to say by how much. So we are assuming that the changes from innovation will balance the changes from increased demand.

This is different from the way all other scenarios are calculated. We are not factoring in future demand, and we are not factoring in future innovation. To put it another way, we are assuming that growth will be balanced by technological innovation. In the very long term this is probably not true. Over the next 20 years, it is likely to be true. So we are calculating the number of jobs and scale of emissions reductions if change happens <u>now</u>.

<u>Job Years and Permanent Jobs</u>

We are using a different model for calculating jobs than that usually used in the literature. The normal procedure is to assume that sustainable transport and renewable energy jobs will be provided by private companies. The authors then estimate the number of <u>job years</u> that will be required.

Instead, we talk about <u>permanent jobs</u>. Our model assumes that all new jobs in transport and energy will be public sector jobs employed by governments. We also assume that some workers will be employed for a time in one job, and then transferred to another. For example, some workers will be employed for some years in building new railway lines, and then will transfer to jobs installing wind turbines, manufacturing solar power, or working on the railways.

We are also assuming that the transition to sustainable transport and power will take twenty years. At the end of those twenty years, however, the workers will still have jobs. A public transport network will still require staff. Renewable energy workers will be doing much more maintenance and less manufacture. But large numbers will still be required to build and install a second generation of renewable energy, as wind turbines and solar power reach the end of their working life. [See Neale, 2010b, for detailed calculations of this balance for wind power.]

This allows us to estimate numbers of permanent jobs. In practice, in reality, the mix of public, private and cooperative jobs will be more complex than in our model. However, the model simplifies that reality enough to allow reasonable estimates.

The Reliability of Our Estimates

The numbers we produce are estimates. This is unavoidable, because there are holes in the data we are using. Moreover, the numbers in the data are only approximate. For instance, we use the figure of 881,000 jobs in rail in the EU. But in the UK, for example, the prevalence of subcontracting on railway maintenance means that job numbers cannot be exact. Again, we use figures for the total of passenger kilometres on rail, buses and in cars. These figures are produced by sample surveys, which cannot be precise, and are done in different ways in different countries.

We also make a series of assumptions as we process the data. For instance, we make estimates of how far we need to take economies of scale into account when estimating jobs in an expanded public sector network.

In the literature on green jobs, it is customary simply to say that such and such a number of new jobs will be created in such and such a sector. These estimates are often given with a brief footnote to a data source. It is difficult to rely on such numbers. One simply cannot tell how the calculations were done or what the assumptions were. So one is presented with a precise number that seems scientific but is not.

Here we have taken a different approach, and show how we reached our estimates. This will allow readers to weigh the reliability of the estimates. Showing the uncertainties is part of the scientific method.

However, we do need solid, simple estimates for the numbers of new jobs. It is difficult to campaign for 'millions' of new jobs. Here the model we are using comes to our rescue. We are dealing with two variables – the number of jobs and the number of years those jobs take to deliver a certain level of cuts in emissions. The uncertainty in the estimates can be assigned to either variable. So we can opt for a fixed number for the jobs, or a fixed level of cuts in emissions.

That means we can say with confidence that we want seven million new jobs in renewable energy, for instance, but that it may take fifteen to twenty-five years to reach the level of cuts in emissions we want.

That allows us to campaign honestly for seven million new jobs in public transport and five million in renewable energy.

Now for the numbers:

Total emissions in Europe	7 trillion tonnes of CO2
Transport emissions	1.7 trillion tonnes (24%)
Electricity generation	2.8 trillion tonnes (40%)

[Source – Tables in International Energy Agency, 2010, on pp. 44-47 and 58-67. The data are for 2008, the last year statistics are available for. These are emissions for OECD Europe, plus non-OECD Europe, plus former Soviet Union. I have added the emissions form aviation and marine fuel bunkers, and counted both as transport emissions. This gives somewhat higher totals, and a larger percentage for transport emissions, than the more common method of ignoring aviation and marine fuel.]

Public transport jobs

We calculate the jobs needed in public transport in the following way. We begin with the EU-27. [Source – Eurostat 2010]. The modal split for inland transport passengers in 2008 was:

Modal Split of Passenger Transport in EU	
Passenger cars	83%
Buses and coaches	9.4%
Rail tram and metro	7.3%
(Total public transport	17%)

Assume a shift to:	
Cars	25%
Public transport	75%

That means an increase of 340% in public transport in the EU. We will not need an equivalent increase in public transport workers, because some of the increases will be covered by economies of scale. So let's assume we need an increase of 250% in the number of public transport workers.

In 2005, the last year for which we have statistics, there were the following transport workers in the EU:

Transport Workers in the EU	
Rail	881,000 workers
Buses and others	1,863,000
Air transport	400,000
Road freight	2,753,000

[Sources: Eurostat, 2010, p. 125.]

The category I have called 'Buses and others' is in fact called 'Other scheduled land transport; taxi operation; other land passenger transport' by Eurostat. That means buses, trams, metros, taxis and chauffeurs. The last two are hard to estimate, but will come to a considerable number.

Let's estimate them at 500,000. Then rail, bus, tram and metro workers are 2.2 million workers. These numbers are for direct workers. That is:

2.2 million direct workers on bus and rail in the EU

We need an increase of 250% in the number of public transport workers. That would mean 5.5 million new direct workers in public transport. These would be railway, bus, tram, metro and waterways workers:

5.5 million new public transport workers in the EU

The calculations for Europe outside the EU are more difficult, because we lack key transport statistics. However, we do have statistics for Turkey in 2008:

Modal Split in Turkey

Cars in Turkey	51%
Buses and coaches	47%
Rail, tram and metro	2%

[Eurostat, 2010.]

One reliable source says that the split is also about 50-50 in Eastern Europe. [Harvey, 2010.] This fits with the statistics for car ownership, which are much lower than for the EU. So we will assume that the modal split outside the EU is 50-50.

We do not yet have statistics for the number of public transport workers in Turkey or Eastern Europe. But we do have figures for the number of passenger kilometres in Russia, Turkey and the EU:

Public Transport passenger kilometres (billions)

EU 27	1,086 billion pkm.
Russia	322 billion pkm.
Turkey	100 billion pkm.

[Source: ERF, 2010, p. 49; and Eurostat, 2010, pp. 204-5.]

Russia and Turkey combined have 422 billion pkm. They also have 220 million of the 380 million people outside the EU.

Let's assume that the relationship between passenger kilometres in the rest of Eastern Europe is the same as in Russia and Turkey. That would give us a total of 729 billion pkm in Europe outside the EU.

If the ratio of public transport workers to passenger kilometres is the same as in the EU, then Europe outside the EU currently has about two thirds of the public transport workers in the EU total, or about 1.5 million workers.

The change in modal split in non-EU Europe is:

From	Cars 50% and	Public transport 50%
To	Cars 25% and	Public transport 75%.

That is a 50% increase in public transport kilometres. That would mean an extra 0.75 million new public transport workers. Again, however, we will allow for economies of scale and assume:

500,000 new public transport workers in non-EU Europe.

This figure is less precise than the figure for the EU, but since it is much smaller it makes less difference to the total.

A switch from air travel to high speed rail would also create jobs. 2008 is the last year for which we have figures. Remember, pkm is passenger kilometres:

The top 30 EU and non-EU airlines carried just over 800 billion pkm.

EU rail carried 409 billion pkm.

There were 818,000 rail workers in the EU

[Source, European Commission, Energy and Transport in Figures, 2010, pp. 123 and 128, and Eurostat, 2010, p. 125. The top 30 airlines carried the vast majority of passengers.]

The air pkm for all of Europe are double the pkm for rail in the EU.

Assume that one third of current air pkm switch to rail.

That is equal to two thirds of the total EU rail pkm.

That would require two thirds of the present EU rail workers.

That would be about 550,000 new rail workers.

We will round that down to 500,000 new workers in high speed rail. There are likely to be less economies of scale here, because we are talking about new lines.

TOTAL NEW PUBLIC TRANSPORT WORKERS

EU 27 public transport	5.5 million new workers
Outside EU public transport	0.5 million new workers
High speed rail	0.5 million new workers
TOTAL	6.5 million new workers

In addition, there would be a considerable number of jobs in:

Building cycle paths
Manufacture, distribution and repair of bicycles
Improving inland navigation canals and rivers

So we will round the total up to at least:

7 million new transport workers

In making these calculations, we have not worked out how the new jobs will be split between rail, buses, waterways metros, and trams.

It is likely that the split will be much the same as now, with about 3 bus workers for every 2 rail workers. It is also likely that workers on inland navigation will account for a larger proportion of public transport than they do now.

Indirect Workers

We also need to calculate the number of indirect workers. Here we are on shakier ground, not least because the estimate of what is a direct job and an indirect job will differ from one national statistical service to another. One reasonably reliable report from the UK suggests 2 direct workers for every 1 indirect worker on buses, and 1 direct worker for 1 indirect worker on rail. [Source: Ekosgen, 2010, pp. 14-24.]

That would suggest about 7 indirect workers for every 10 direct workers across public transport as a whole. That would mean:

7 million new direct transport workers

5 million new indirect transport workers

These will be permanent jobs.

We still have not made any allowance for new jobs as a result of a switch from road to rail freight. That is because the figures we have for rail jobs include both passenger and freight jobs. If rail freight expands at roughly the same rate as passenger rail, the increase in freight jobs is already included in our calculations for the increase in passenger transport jobs.

We have also not made any allowance for new jobs for new jobs in railway construction. There will undoubtedly be many such jobs. However, the model we are using assumes that workers will transfer from one job to another. This means that in the early years many workers will be employed on building new railway lines. But once these lines are built, they will be able to transfer to other jobs, in renewable energy or on the new railways. This avoids a calculation which assumes that we are hiring railway workers now to work on trains that are running on tracks that have not yet been built.

We have also not made any calculations for new jobs in international shipping. New jobs in domestic and European water transport are included under the calculations for new passenger public transport jobs.

Renewable Electricity Jobs

To calculate the number of jobs needed in renewable electricity, we start with European electricity consumption. In 2008 this was 5,355 TWh (Terawatt hours). [Source: International Energy Agency statistics database, www.iea.org.]

In the EU, 17% of that electricity came from renewable sources. [Source: Eurostat]. In non-EU Europe the proportion may well be smaller.

In any case, we will need to build sufficient new capacity to produce another 10,000 TWh of renewable energy, about twice our current consumption of electricity. That would not mean tripling total electricity supply, because the great majority of fossil fuel power plants could be retired.

This assumes that there will be savings from energy efficiency in industry, homes and public buildings of 50%. It also assumes that a switch to public transport and improved design and operation of cars, trains and buses will combine to reduce fuel use by 50%.

This electricity will be largely from onshore wind, offshore wind, PV solar power, and concentrated solar power. For the moment, we will make the calculations as if all renewable energy came from wind.

We will assume that wind has a capacity factor of about 30%. This means that over time a wind turbine produces 30% of its full capacity. Some sources assume 35%, but in practice this is a bit optimistic.

So 1 GW of installed wind at theoretical full capacity would produce 8,760 Gigawatt hours a year (24x365=8,760). But at 30% it would produce only 2,628 Gigawatt hours a year.

Let us assume we build enough capacity to produce 10,000 TWh after 20 years. That is enough for 500TWh each year, or an installed wind capacity of 190 GW a year.

How many jobs will this require? The traditional rule of thumb used in the wind energy business is that for every MW installed, 10 job years of direct jobs, 5 job years of indirect jobs in the supply chain, and .33 permanent maintenance jobs.

This has recently been questioned by Wei, Patadia and Kammen (2010), and by Burton (2011), pp. 7-11. Their estimates partly rely on reports for individual projects, and vary greatly. But it would make sense that with improving productivity the numbers of jobs should be falling. And the old rule of thumb comes from numbers in the EU, where half of wind turbines manufactured are in fact exported.

So a more accurate way to go is to use statistics for the actual number of workers and actual capacity installed. The great majority of manufacture and installation is in the EU, the US and China:

In the EU, in 2008, there were 10 GW installed and 108,000 direct workers in the wind industry. About half of turbines manufactured were exported. [European Wind Energy Association]

In the US, in 2008, there were 8.5 GW installed and 85,000 direct workers. [American Wind Energy Association]. About half of the turbines were imported.

The most reliable figures for China come from Pan, Ma and Zhang, 2011. However, these figures are based partly on projections from input/output tables, and not on actual numbers of workers. They do not include installation workers. And they assume about 3.1 jobs in manufacturing per MW (low) and 2.0 jobs on wind farms (very high).

They estimate 74,000-82,000 jobs in 2010 for 16.0 GW installed, of which 50,000 are in manufacturing. They add that they think the number may be higher. This is with 80% local manufacture of turbines, but this 80% may include imported parts.

If we add these numbers for the EU in 2008, the US in 2008, and China in 2010, we get 275,000 workers for 34.5 GW installed.

The World Wind Energy Association estimates 300,000 wind workers for 2010. That year there was 36 GW of new installation, for a cumulative total of 192 GW. Assuming 333 workers per GW on operations and maintenance, that would be 64,000 workers on maintenance and 236,000 workers in manufacturing and installation.

The true numbers are probably somewhere in the region of the WWEA numbers. In that case we will assume:

> For 1 MW of wind energy installed:
>
> direct jobs: 6.66
>
> indirect jobs: 3.33
>
> permanent jobs on operations and maintenance: 0.33
>
> For 190 GW installed a year, that would be:
>
> 1,270,000 direct manufacturing and installation jobs each year,
>
> and 63,000 new permanent maintenance jobs a year.
>
> Over twenty years, that is an average of
>
> 1,270,000 direct manufacturing and installation jobs each year,
>
> And 630,000 maintenance jobs.

Those would be the jobs if all renewable energy was onshore wind. But much of it will be offshore wind, solar PV, Concentrated Solar Power (CSP).

A recent study of solar power in California provides a rough estimate for the number of jobs in PV cells. [Ban-Weiss, Larsen, Li and Wilusz, p. 23]. This would be 20 jobs per MW installed, and a total of 13 job years in maintenance over 25 years, or about 0.5 jobs a year per MW installed.

But PV cells have a capacity factor of only 20%, unlike the 30% of wind. So for the same amount of electricity produced, we would need:

7 direct jobs in wind and .33 indirect jobs

30 direct jobs in solar PV cells and 1.0 indirect jobs

This estimate is in line with the relative costs of wind power and solar power:

	Capital Cost ($/kw)
Onshore wind, low cost	1,300
Offshore wind, low cost	1,800
Solar PV, low cost	6,000
CSP	6,000

[Source: Harvey, 2010b, p. 474.]

We have been unable to find reliable numbers for the jobs required in CSP. Such numbers as there are estimate for the future and involve assumptions about technological innovation. They also include only construction, and not the manufacture of parts, which is a major part of the work involved. We would expect any European public climate work to include the manufacture of many parts as direct employment.

The capital costs are about the same per kw as for Solar PV. But CSP has a much better capacity factor, about 32% instead of 20%. On the other hand, running costs are about six times as high:

	Cost of Electricity (cents/kw)	
	Capital	Operations/Maintenance
Onshore wind, low cost	4.2	1.1
Offshore win, low cost	3.6	2.4
Solar PV, low cost	19.4	4.1
CSP	8.2	26.0

[Source: Harvey, 2010b, p. 474.]

We will assume that the number of jobs in operations and maintenance is also six times as high. This is probably not exact, but good enough for our purposes here. So for the same amount of electricity produced, we would need:

7 direct jobs in wind and .33 permanent maintenance jobs

30 direct jobs in solar PV cells and 1.0 permanent maintenance jobs

20 direct jobs in CSP and 6.0 permanent maintenance jobs

Finally, there is offshore wind. Here the increased capital costs suggest that there will 1.4 capital jobs for every onshore wind jobs, and two maintenance jobs for every one onshore wind jobs. So for the same amount of electricity produced, we would need:

7 direct jobs in wind and .33 permanent maintenance jobs

10 direct jobs in offshore wind and .66 permanent maintenance jobs

30 direct jobs in solar PV cells and 1.0 permanent maintenance jobs

20 direct jobs in CSP and 6.0 permanent maintenance jobs

We cannot know for sure what the mix of energy will be over a twenty year period. But let's take two possible cases:

	CASE ONE	CASE TWO
Onshore Wind	50%	30%
Offshore Wind	30%	30%
Solar PV	10%	20%
CSP	10%	20%

Manufacturing and Installation

In Case One, the number of jobs in manufacture and installation would be 1.5 times the number needed for the same amount of onshore wind power.

In Case Two, the number of jobs in manufacture and installation would be 2.15 times the number needed for the same amount of onshore wind power.

So we will take the average, and assume that the number of jobs in total manufacture and installation will be 1.8 times the number needed for the same amount of wind power generated.

For the equivalent of 190 GW of offshore wind installed per year, that is 2.2 million new jobs in manufacture and installation.

Operations and Maintenance

In Case One, the number of jobs in operations and maintenance would be 3.2 times the number needed for the same amount of onshore wind power.

In Case Two, the number of jobs in operations and maintenance would be 5.1 times the number needed for the same amount of onshore wind power.

So we will take the average, and assume that the number of jobs in operations and maintenance will be manufacture and installation will be 4.0 times the number needed for the same amount of wind power.

For the equivalent of the electricity generated by 190 GW of wind power installed per year, that is 252,000 new jobs in operations and maintenance each year, and an average of 2.5 million jobs over 20 years.

That would be:

2.2 million direct manufacturing and installation jobs each year, and

An average of 2.5 million maintenance jobs each year over 20 years.

We will also need a new 'smart' grid with long distance cables to connect far flung sources of renewable energy. One estimate for the UK was that it would take 50,000 jobs a year for 20 years to build such a grid there [Neale, 2010b]. Scaling this up would suggest about 700,000 jobs a year in building the grid. However, the British figure is a rough estimate, and conditions and distances in other countries will be different.

That would make a total of:

2,200,000 new jobs in manufacture and maintenance

2,500,000 new jobs in operations and maintenance

700,000 new jobs in renewing the grid

TOTAL: 5,400,000 new jobs.

We will round that to:

5 million new permanent jobs in renewable energy.

There will also be indirect jobs in renewable energy. We assume that the ratio between direct and indirect jobs is the same as for onshore wind, 2:1. Then the total number of jobs is:

Jobs in Renewable Energy

5 million direct jobs

3 million indirect jobs

New Jobs in Transport

7 million direct jobs

5 million indirect jobs

12 million direct jobs in renewable energy and transport

8 million new indirect jobs

For a total of 20 MILLION JOBS

CUTS IN EMISSIONS

The supply of renewable electricity on the scale we have suggested would mean that within 20 years there would be very little emissions from electricity generation. Of course at first there would be a considerable carbon cost (embodied carbon) in the manufacture and transport of wind turbines and solar power. But once all of electricity for industry, and most energy for transport, was supplied by renewable energy, emissions would be very small. We would have cuts in emissions in this sector of at least 90%.

For transport the figures are more complex. Let's return to the table of European transport emissions in percentages:

Cars	48%
Trucks	21%
Planes	13%
Ships	12%
Buses	2%
Inland navigation	2%
Rail	1 %

[Source: European Environment Agency, 2010, pp, 45-46.]

The numbers there are for the EEA 32, that is the 27 EU countries plus Iceland, Lichtenstein, Norway, Switzerland and Turkey. These totals slightly overestimate the importance of cars and underestimate the importance of rail, because they do not include the former Soviet Union countries, which use proportionally less road transport. The number for rail emissions is also artificially low, because 80% of European rail is currently electrified, and the emissions are counted as electrical emissions, not transport.

Bearing that in mind, let's take this table not as percentages. Instead, let's think of current European transport emissions as equal to a baseline of 100:

On that baseline of 100,

CARS = 48.

If the modal split in passenger transport goes down to 25% by cars, that would reduce pkm by car from 1815 billion passenger kilometres to 692 billion pkm. That is a reduction of two thirds. We assume that all buses and trains will run on renewable energy, so emissions will also fall by two thirds.

That brings total car emissions down from 48 to 16.

The remaining car transport emissions could be reduced by at least 60% by better design, tighter regulation, and stronger speed limits.

That would reduce total car emissions from 16 to 6.

TRUCKS = 21.

We assume one half of truck traffic would eventually switch to electric trucks or electric rail. We assume that all electricity will come from renewable sources. That reduces emissions from 21.0 to 10.5

The remaining half would be cut in half by better design, tighter regulation, stronger speed limits, and other efficiency measures. That reduces 10.5 to 5.

AVIATION= 13.

With aviation, we assume that high speed rail eventually replaces one quarter of passenger kilometres. Because this will happen on short haul routes, which have more emissions per pkm, it will reduce emissions by at least half.

That reduces aviation emissions from 13 to 6.5.

Better design, other efficiency measures, and speed limits can reduce that by at least 25%. That reduces aviation from 6.5 to 5.

SHIPPING = 12.

With shipping, we assume that efficiency measures and design can reduce emissions by a third, from 12 to 8.

Speed limits can then reduce that by 75%, from 8 to 2.

BUSES AND RAIL = 2.

We assume complete use of electricity from renewables for buses and rail, and reductions in emissions to 0.

INLAND NAVIGATION = 2.

Here we assume renewable electricity cannot be used, and that similar reductions to shipping are possible. However, there is also likely to be a substantial shift from road freight to inland navigation. We therefore assume that on balance emissions will remain the same, at 2.

These possible reductions do not take account of embodied energy in making new railways, planes, ships and so on. This is because in the transition to a new low carbon economy there would be considerable embodied energy in the new vehicles and infrastructure. But once most electricity for industry, and most transport, was supplied by renewable electricity, there would still be embodied energy, but it would be embodied renewable energy.

The totals would be:

	Now	In 20 years
Cars	48	6
Trucks	21	5
Planes	13	5
Ships	12	2
Bus and Trains	3	0
Inland Navigation	2	2
TOTALS	100	20

[The numbers for now in fact add up to 99, because of fractional differences in the original percentages.]

That is a cut of 80% in CO2 emissions from transport.

And 90% of CO2 emissions from electricity generation.

Jobs and Emissions Cuts in Housing and other sectors

It is more difficult to make European wide estimates for sectors other than renewable energy and transport.

The two most important sectors here are energy efficiency in buildings and industry.

For housing, we do have a pretty reliable figure for the UK. This is 3.5 million job years over twenty years, or 175,000 jobs a year. These are not permanent jobs. [Source, Gupta and Nicol, 2010.] This is a careful study done by two scientists with extensive experience in the field, and it is based on robust data provided by a government research department.

However, it is difficult to extrapolate from this study to the rest of Europe. The UK has badly insulated housing, in other countries air conditioning is relatively more important, and reliable estimates would depend on detailed data from several countries.

Extrapolation from the UK figures would give us an estimate of about 2.5 million for Europe. We can say with some confidence that the actual figure would be 2 to 3 million direct construction workers in Europe. The lower figure is probably more likely than the higher.

Also, we have assumed in this report that refurbishment of homes and buildings will be combined with enough renewable electricity to eventually heat many of the homes and buildings with electricity. Our six million jobs in renewable energy include about two million where the end user will be in housing.

However, electricity, transport and buildings between them account for more than 80% of European CO2 emissions. We can estimate that 15 to 16 million direct jobs would cut these emissions by more than 75% overall.

There are similar problems with estimates for energy efficiency in industry. Here regulation will be rather more important. More to the point, each factory, workplace and industry is different. The general approaches are the same, but each job is different. And much of the work would be done as part of the work of a much larger workforce at a company. This makes estimates difficult.

Any comprehensive approach to climate change would also involve jobs in waste, in agriculture, in forest, and in education and training, as well as many smaller sectors. We have not made estimates for all these sectors.

The two other main greenhouse gases, methane and nitrous oxide, must also be tackled. However, estimates here are even more difficult. This is partly because we have reliable figures for CO_2 from burning oil, gas and coal, because governments count the usage of these fuels for other purposes. Methane and nitrous oxide are produced in other ways, and there are large variations in the estimates of how much is produced. We have reliable figures for how much is in the atmosphere, but not for the ways it gets there or how much is absorbed by sinks. So here again, we have not attempted estimates.

Appendix Two

CALCULATING JOBS LOST AND TRANSFERS

This appendix gives the detailed calculations for the jobs that will be lost in the new low carbon economy, and where those workers can find jobs.

Everything written in this appendix assumes that governments will guarantee that anyone who loses a job because of the changes to a low carbon economy will be guaranteed employment in renewable energy or public transport.

The plans we suggest will create 12 million direct jobs and 8 million indirect jobs in Europe. Some jobs will also disappear. Most of these will be in:

Automotive manufacture

Automotive sales, servicing, repair and petrol distribution

Coal mining

Oil and gas production

Road freight

Aviation

However, there will be many more new jobs than old jobs. One reason is that more work will be required. Wind and solar power require more workers than coal and gas for the same amount of energy. This is why coal is used now. Coal is cheaper because it requires less human labour.

Buses and trains require more paid jobs than people driving themselves to work. Driving yourself is work, but it's not paid work. So there are more paid jobs in public transport than when people use cars.

The other reason is that time scales are different. Millions of renewable energy workers will be hired immediately. But it will take them 20 years to replace all the jobs of coal miners. Again, the workers building new rail lines will go to work immediately. These new rail lines will eventually carry much of the traffic now going by cars, planes and trucks. But the transition will take 20 years.

Over the course of 20 years, most of the jobs lost can be covered by the normal process of retirement from the industry.

Now we will turn to the detailed calculations.

Road Freight

In this report we have suggested two possible futures for road freight.

One future is that smaller trucks, lower speed limits, and technological breakthroughs in batteries make it possible for trucking to switch to renewable electricity. This would mean few job losses in trucking.

The other future is that one half of road freight switches to rail over 20 years.

There are currently about 2.8 million workers in road freight in the EU. [Source: Eurostat, 2010. *Panorama of Transport*. ec.europa.eu/eurostat]. So:

There are 2,800,000 jobs in road freight

1,400,000 jobs will be lost over 20 years

That is 70,000 jobs lost a year.

Retirement (1 worker in 40) provides 70,000 openings a year.

So individual truck drivers will not lose jobs, though some may want to transfer to the very large number of new jobs driving buses and training bus drivers.

These calculations are for the EU. The calculations for jobs outside the EU would probably be similar.

Aviation

For aviation, we have assumed a reduction of one quarter of flights over 20 years. There are about 400,000 workers in aviation in the EU. [Source: Eurostat, 2010. *Panorama of Transport*. ec.europa.eu/eurostat].

400,000 workers in aviation

100,000 jobs will be lost over 20 years

That is 5,000 jobs lost each year

Retirement (1 in 40) provides 10,000 openings a year.

Again, no one has to leave the industry.

The calculations for jobs outside the EU would probably be similar.

Automotive Production in the EU

Jobs in automotive production will be lost because of the transition from cars to buses and rail.

There are about 2.3 million workers in the automotive manufacturing industry in the EU. [Sources: ACEA statistics at www.acea.org and OECD STAN Database at oecd.org].

This includes manufacture of buses and truck trailers. It also includes the manufacture of some parts, and not others. It would be reasonable to estimate the number of direct workers on automobiles and parts at 3 million.

We have suggested a shift from 83% car journeys to 25% car journeys. However, we estimate that the shift in the number of vehicles will be less, because some people will keep cars for some of their journeys. Our estimate is that half the number of cars will be bought and manufactured. So:

We start with 3,000,000 manufacturing workers.

Half these jobs will be lost – 60% to buses and 40% to trains.

The first stage will be the switch to buses. This will be quick.

So 900,000 jobs will be lost quickly.

In practice, in the first few years some workers will move from car manufacture to bus and minibus manufacture, so the number of jobs lost will be less - perhaps 600,000 jobs lost.

That will leave 2,400,000 workers in manufacturing.

The second stage will be the switch to rail.

600,000 jobs will be lost over 10 years.

That is 60,000 jobs lost a year.

But 60,000 manufacturing workers will retire each year (1 in 40).

Again, retirement will provide as many job opportunities as are lost.

Automotive Sales, Service and Repairs in the EU

There will be more jobs lost here than in manufacturing. There are currently 4.3 million direct jobs in this sector in the EU. [Sources: Eurostat, Structural Business Statistics, table for *employment motor sales*, 2008 data, at ec.europa.ue/eurostat].

This includes jobs in petrol stations, and petrol distribution. It also includes jobs in bus and truck sales and repair. We will estimate 4 million jobs involving cars, perhaps a slightly high number.

We start with 4,000,000 workers.

Half these jobs will be lost – 60% to buses and 40% to trains.

The first stage will be the switch to buses.

This will be quick.

So 1,200,000 jobs will be lost quickly.

Many of these will be workers with mechanical and repair expertise, and most of them with automotive expertise of some kind. It will not be difficult to absorb many of them into the maintenance of buses.

That will leave 2,800,000 workers in the sector.

The second stage will be the switch to rail.

800,000 jobs will be lost over 10 years.

That is 80,000 jobs lost a year.

But 70,000 workers will retire each year (1 in 40).

At least 10,000 other workers will leave the industry.

Coal Miners and Oil Fields

There are between 500,000 and 800,000 workers in the coal industry in the EU, Ukraine and Turkey. The low figure comes from EURACOAL's estimates for direct employment. The higher number is suggested by the OECD's figures, which define employment more widely. We will use the higher figure.

[Sources: EURACOAL at www.euracoal.org; OECD STAN Database at oecd.org; and Eurostat, Structural Business Statistics, table for *employment in mining and quarrying*, 2008 data, ec.europa.ue/eurostat].

Assume 800,000 mineworkers in the EU, Ukraine and Turkey.

It will take 20 years to completely replace coal.

That means a reduction of 40,000 jobs a year.

Normal retirement will cover 20,000 jobs a year.

That leaves 20,000 mineworkers needing a new job each year.

There will be 8.5 million new jobs in renewable energy and transport in the EU, Turkey and Ukraine.

212,500 of them (1 in 40) will retire each year.

That will easily create transfers for 20,000 mineworkers each year.

Mining and Manufacturing Jobs Are Being Lost Already

So far we have been writing as if manufacturing and mining jobs would continue in the same numbers, if it was not for the transition to a low carbon economy. In fact, this is not accurate. Technological innovation moves quickly in these industries. Productivity is increasing, and the number of workers required for the same output is falling.

This means that even without a low carbon economy, mines and car factories will lose jobs. With the plans we propose, all these workers will be guaranteed a new permanent job. Without such plans, many would be unemployed for long periods. So the transition to a low carbon economy can make their lives better, not worse.

However, for the purposes of the calculations we want to make here, we will assume that employment in these industries would be steady.

We have also done the calculations as if Europe was a closed economy. That is to say, we have not taken account of the jobs lost, or created, outside Europe. In practice, if anything like the changes we propose take hold in even a few countries in Europe, working people in the rest of the world will be inspired to do likewise. So Middle Eastern countries, for instance, would lose jobs in oil production, but gain even more jobs in wind and solar power.

Concentrations of Job Losses

However, there is a problem with simply speaking of a transfer of workers to new occupations. This is that jobs are concentrated in some countries. There are now:

800,000 automotive manufacturing jobs in Germany

180,000 coal mining jobs in Poland

270,000 direct coal mining jobs in Ukraine

Sources: OECD STAN database and EURACOAL]

Germany would have to quickly absorb about 240,000 of the manufacturing jobs. And another 240,000 jobs in automotive sales and repairs. That is almost half a million workers who would lose their jobs in the switch to buses.

But there will be over 1,000,000 new jobs in Germany. Indeed, an expansion in renewable energy would provide a large number of factory jobs of similar kinds, and often more satisfying, compared to automotive manufacture.

With 12 million new jobs:

POLAND would have 550,000 new jobs.

180,000 coal jobs would be lost over 20 years.

That is 9,000 coal jobs a year.

Retirement from coal would cover 4,500 jobs a year.

That would leave 4,500 coal workers looking for a new job each year.

Retirement from the new jobs would open up 13,750 jobs a year in renewable energy and transport.

That would provide transfers for all the coal miners needing new jobs.

UKRAINE would have 650,000 new jobs.

270,000 direct mining jobs would be lost over 20 years.

Roughly 130,000 indirect jobs would be lost over 20 years.

A total of 400,000 jobs would be lost over 20 years.

That is 20,000 coal jobs lost a year.

Retirement from coal would provide openings for 10,500 workers a year.

That would leave 9,500 coal workers looking for a new job each year.

Retirement from the new jobs would open up 16,250 jobs a year in renewable energy and transport.

That would provide transfers for all the coal miners looking for jobs.

So in both Poland and Ukraine the jobs could be absorbed. However, coal mine jobs are difficult to replace, in two ways.

First, there is a deep pride in the job, in the skill, and in the solidarity and help miners provide each other in their working lives. However, there are also strong reasons why many mineworkers do not want their children to follow them down the mine.

Second, isolated communities have grown up around the mines. In many countries, when mines have closed those communities have lost population and become unhappy places. There is a solution to this. A large proportion of the jobs in both wind and solar power are factory jobs. Governments can ensure that those factories are built in the mining communities, so they remain thriving villages and towns.

Regions of Vast Potential

In the richest parts of Europe the majority of the new jobs will be in transport. These regions now have extensive car use, so they will need more new transport workers.

In Russia and Turkey, many people already use public transport. So the majority of the new jobs will be in renewable energy. And Europe has four important regions with vast potential for renewable energy. These are:

North Sea offshore wind, between Norway and the UK.

Siberian wind in Russia.

Central Asian wind and sun, especially in Kazakhstan.

Turkish wind and sun.

[Source: Gregor Czisch, 2006. *Low cost but totally renewable electricity supply for a huge supply area: a European/Trans-European example*. IEE-RE, Univeristat Kassel, Germany.]

<u>The North Sea</u>

In the North Sea, there are about 100,000 direct jobs in oil and gas in the UK and Norway. [Source: OECD STAN Database, country profiles for Norway and UK]. On our plan, these jobs would go over 20 years, or at about 5,000 jobs a year. At present the industry is expecting to wind down faster than that. The possibility of North Sea offshore wind, in this context, is a godsend. Many of the jobs would require the same seafaring and technical skills as are used currently, and people could make the transition smoothly.

<u>Automotive Manufacture in Turkey and Russia</u>

Turkey has just under 40,000 directly employed in the automotive industry. Almost half of the vehicles built are trucks, buses and minibuses, so less than half of these workers are making cars. [Sources: Gunduz Findikçioğlu, *Turkish Automotive Industry June 2011* at osd.org.tr; and Hűlya Őzbundum, *The Automobile Industry in Turkey*, 2010, at osd.org.tr].

Moreover, in Turkey currently cars account for only 50% of journeys. A switch to buses would mean a reduction of 25% of car manufacturing jobs, or about 5,000 jobs.

TURKEY has 40,000 automotive manufacturing workers.

About 20,000 are car workers.

5,000 of these jobs would be lost.

3,000 would be lost quickly in the switch to buses.

2,000 more would go over 20 years.

That is 200 jobs a year.

But 1,000 workers a year would retire in automotive manufacturing.

RUSSIA has about 600,000 direct workers in automotive manufacturing. As in Turkey, only about 50% of Russian journeys are by car. If they switch to 25% of journeys by car, we can still expect a smaller fall in car ownership.

So we will assume that car manufacturing falls by 25%.

There are 600,000 workers in automotive manufacturing.

150,000 of them will eventually lose their jobs.

90,000 will lose their jobs swiftly in the switch to buses.

60,000 will lose their jobs over 10 years in the switch to trains.

That is 6,000 a year.

But 11,250 manufacturing workers will retire each year.

That will create openings for the 6,000 looking for work.

Energy Jobs in Russia

Energy jobs are a larger challenge, because there are so many fossil fuel workers in Russia. There are roughly 400,000 jobs in coal mining and about 700,000 jobs in the oil industry. There are probably similar amounts of jobs in gas production. [Sources: Fiona Hill, 2004, *Energy Empire: Oil, gas and Russia's revival*, The Foreign Policy Centre, London; and *Brief History of Coal mining in Russia*, figures for 2001, at www.russaincoal.com].

So at a rough estimate, there are on the order of two million jobs in coal, oil and gas in Russia.

RUSSIA has 2,000,000 oil, gas and coal workers.

Those jobs would be lost over 20 years.

That is 100,000 jobs lost a year.

Retirement in oil, gas, and coal would create 50,000 jobs a year.

That leaves 50,000 workers looking for new jobs each year.

Russia would have 2,000,000 new jobs.

Retirement in these new jobs would create 50,000 openings a year.

This is a tight fit. However, there will also be workers leaving these sectors every year for various personal reasons every year, and that should provide more openings.

Moreover, any Russian government that gave up using Russian oil and gas would be likely to make very large investments in renewable energy. Oil and gas make up a small percentage of the Russian workforce, but a large percentage of government income and trade earnings.

That is a very mixed blessing for the Russian people. It carries all the problems of a resource curse that comes with high income from scarce resources controlled by an elite. Renewable energy would provide many more jobs, and less windfall profits. But it would make sense to replace the riches of Russia's endowment with oil and gas with the riches of Siberian wind.

Central Asia

Finally, there is Azerbaijan and Central Asia. Oil and gas has been crucial to the economy of several countries in the region. The number of workers, however, is proportionately much smaller. The reserves of wind and sun, particularly in Kazakhstan, but more generally in the region, are enormous.

Summary

In sum, where the changes happen over ten or twenty years, the jobs lost can be covered by retirement and turnover in employment in the traditional jobs and in the new jobs in transport and renewable energy.

However, there will be lost jobs quickly with the shift from cars to buses.

The main losses will be:

1,200,000 jobs in automotive sales and repairs in the EU

600,000 jobs in automotive manufacture in the EU

90,000 jobs in automotive manufacture in Russia.

Adding these, and rounding up, we have a total of 2,000,000 jobs lost quickly.

Roughly another 1,000,000 indirect workers will also lose their jobs and need job transfers. That means:

A total of 3,000,000 workers will need job transfers.

So at the beginning of the programme, there would be:

7 million new jobs in transport

5 million new jobs in renewable energy

8 million indirect jobs in the supply chain

For a total of 20 million new jobs

But 3 million worker will need transfers

So there will be 17 million net new jobs in Europe.

Over 20 years, some 5 million direct and indirect workers would have to transfer to the new low carbon economy. Twenty years after the beginning of the transition, there would be 12 million more jobs in Europe than at the start.

Appendix Three

EMBODIED ENERGY AND EMISSIONS

This appendix deals with an important question. We often contrast the emissions from a wind turbine or a solar power tower with the emissions from burning coal. But what about the 'embodied energy'? This is the oil, coal and gas that has to be burned to make the wind turbine, to transport the parts, to make the cement, aluminium and steel, to mine the raw materials, to transport them, and so on.

The oil, coal and gas that are burned produce emissions. So the wind turbine is not simply CO2 free. How much difference does this make?

Likewise, buses and trains do not only use the electricity or oil it takes to run them. There is also the oil, gas and coal burned in getting the fuel from the ground to the tank. There is the fuel burned and emissions produced in making the buses and trains, and all the raw materials. And there is the fuel burned and emissions produced in making and maintaining the roads and rail lines.

At first sight, this would suggest that renewable energy and public transport are not that low carbon. And indeed, embodied energy makes some difference. But not all that much. Here is why:

Embodied Energy in Wind and Solar Power

One reason is that the amount of embodied energy is not large. The relevant literature has been summarised in L. D. Danny Harvey's magnificent two volumes on *Energy and the New Reality* (Earthscan, London, 2010).

Harvey uses the idea of 'payback time'. This is the length of time the wind farm takes to produce an amount of energy equal to all the energy used in making the turbines, transporting them, making and transporting the materials, building the factories, and so on.

For different studies of wind farms, the payback time varies from two to eight **months** [Harvey, 2:161-4]. A wind turbine lasts 20 to 25 **years**. The amount of fossil fuel energy used in making a wind farm is tiny compared to the amount of energy produced.

For solar PV cells, the usual payback time is 2 to 4 years. [Harvey, 2:38-40, using his table on p. 39 but allowing for the point he makes about the limits of process-based calculations on p. 40.]

Estimates for payback times for concentrated solar power vary from 6 months to 2.5 years [Harvey, 1:64-5].

This means that the time needed to produce as much renewable energy as was used in making the solar power is about 10% to 20% of the total lifespan of the solar device. Energy is not the same as emissions. But these numbers would suggest that the emissions reductions from using solar power would be in the region of 80% to 90%, rather than 100%.

Embodied Energy in Transport

Fewer researchers have done the calculations for embodied energy in transport. But Harvey [1:251-4] has a detailed table based on the work on Lenzen in 1999 on energy use in mega-joules per passenger kilometre in Australia. Here are some of his figures:

FUEL ENERGY USE (Mj/pkm)

	Total	fuel energy		embodied energy	
		direct	upstream	vehicle	infrastructure
interurban bus	1.4	0.86	0.18	0.23	0.09
interurban rail	0.94	0.29	0.45	0.33	2.0
urban bus	1.7	0.42	0.51	0.09	2.8
interurban car	2.4	0.57	0.81	0.60	4.4

These numbers show that the amount of embodied energy in transport is about a third to a half of the total energy used.

This is true for buses and trains, but also for cars. Public transport uses less energy for fuel per passenger than cars do. Public transport also uses less energy for upstream fuel production than cars do. And public transport uses less energy for making the vehicle, and less for infrastructure.

Changes in Embodied Emissions Over Time

So embodied energy is not that large when the transition to a low carbon economy begins. But as the transition gathers pace, there are less and less embodied emissions.

At the start of the transition wind turbines are manufactured using electricity from coal. And they are transported using trucks powered by oil. But after 20 years all the electricity at the factory will come from renewable energy. Moreover, renewable electricity will provide most of the energy for the transport as well. Embodied emissions were low to begin with. After 20 years they will be tiny.

There are limits to this process. Ships for installing and maintaining offshore wind farms will still need to need use oil. And large wind turbines will probably still need large trucks powered by diesel to get them to the wind farms. This is one reason why we suggested in Appendix One that the emissions from renewable energy could be cut by more than 90%, but not completely.

BIBLIOGRAPHY

Richard Alley, 2000. *The Two-Mile Time Machine*. Princeton, Princeton U.P.
Richard Alley, 2011. *Earth: The Operator's Manual*. W. W. Norton, New York.
Jeffrey Anglepoise and Will Shroeer, 2002. Energy efficiency and strategies for freight trucking: potential impact on fuel use and greenhouse gas emissions. *Transportation Research Record*.
Jean Marie Beauvais, 2008. *Setting Up Superstores and Climate Change*. Beauvais Consultants.
BIMCO and ISF, 2010. *Manpower 2010 Update:The Worldwide Demand for and Supply of Seafarers: Highlights*. Dalian Maritime University and Warwick Institure for Employment Research. Www.bimoco.org.
Stefan Bohm and Siddharta Dabhi, eds., 2009. *Upsetting the Offset: The Political Economy of Carbon Markets*. Mayfly, London.
Boston Consulting Group, 2008. *San Pedro Bay Ports Clean Trucks Program*. Www.cleanandsafeports.org
Alice Bows, Sarah Mander, Richard Starkey, Mercedes Bleda, and Kevin Anderson, 2006. *Living within a Carbon Budget*. Tyndall Centre, Manchester.
Alice Bows with Kevin Anderson and Paul Upham, 2008. *Aviation and Climate Change: Lessons for European Policy.* Routledge, London.
Alice Bows and Kevin Anderson, 2009. 'Aviation in a Low Carbon EU', in G Stefan Gössling and Paul Upham, eds. *Climate Change and Aviation*. Earthscan, London.
Douglas Brinkley, 2006. *The Great Deluge*. William Morrow, New York.
Øyvind Buhaug at al, 2009. *Prevention of Air Pollution From Ships: Second IMO GHG Study.* International Maritime Organization.
Jesse Burton, 2011. *One Million Climate Jobs: Renewable Energy Jobs*. Unpublished paper for One Million Climate Jobs project in South Africa.
Helen Caldicott, 2006. *Nuclear Power is Not the Answer.* New Press, New York.
Cambridge Systematics, 2009. *Moving Cooler: An analysis of transportation strategies for reducing greenhouse gas emissions.* Urban Land Institute.
Robert Cervero, 1998. *The Transit Metropolis: A Global Inquiry.* Island Press, Washington, DC.
Mikhail Chester and Arpad Horvath, 2009. Environmental assessment of passenger transportation should include infrastructure and supply chains. *Environmental Research Letters*.
Colruyt Group, n.d. *Mobility: Commuter traffic, logistics and transport of goods within the Colruyt Group*. www.colruytgroup.com

Consumer Federation of California, League of United Latin American Citizens, Los Angeles Alliance for a New Economy, and National Association for the Advancement of Colored People, 2008. *Foreclosure on Wheels: Long Beach Truck Drivers Program Puts Drivers at High Risk for Defaults*.
John D. Cox, 2005. *Climate Crash: Abrupt Climate Change and What it Means for Our Future*. Joseph Henry, Washington DC.
Phillipe Crist, 2009. *Greenhouse Gas Emissions Reduction Potential from International Shipping*. Joint Transport Research Centre, OECD and International Transport Forum, Discussion Paper No. 2009-11.
PJ Crutzen, AR Mosier, KA Smith and W Winiwarter, 2007. N2O release from agro-biofuel production negates global warming reduction by replacing fossil fuels. *Atmospheric Chemistry and Physics Discussions*.
Heidi Cullen, 2010. *Weather of the Future*. Harper, New York.
Judith Curry, 2008. 'Potential Increased Hurricane Activity in a Greenhouse Warmed World', in Michael MacCracken, Frances Moore and John C. Topping, Jr., eds. *Sudden and Disruptive Climate Change*. Earthscan, London.
Gregor Czisch, 2006. *Low cost but totally renewable electricity supply for a huge supply area: a European/Trans-European example*. IEE-RE, Univeristat Kassel, Germany.
Alex de Wall, 2005. *Famine that Kills: Darfur, Sudan*. Second edition. Oxford, Oxford University Press.
Alex de Wall, ed. 2007. *War in Darfur and the Search for Peace*. Global Equity Initiative, Harvard, Cambridge.
DLR (German Aerospace Centre), 2005. *Concentrating Solar Power for the Mediterranean Region*. . Available in both English and German.
DLR (German Aerospace Centre), 2006. *Trans-Mediterranean Interconnection for Concentrating Solar Power for the Mediterranean Region*. www.dlr.de/tt/trans-med. Available in both English and German.
Mattias Dolls, Clement Fuest and Adreas Peichl, 2009. *Automatic Stabilizers and Economic Crisis: US vs. Europe*. Institute for Study of Labor.
Ecosgen, 2010. *Employment in Sustainable Transport*. Campaign for Better Transport and Sustrans, www.bettertransport.org.uk
David Elliott, 2010. Unpublished paper on renewable energy for Campaign against Climate Change report.
Patrik Ericsson and Ismir Faslagic, 2008. *Shore-Side Power Supply*. MSc Thesis, Chalmers University of Technology, Göteberg.
European Environment Agency, 2010, *Towards a resource-efficient transport system: TERM 2009: indicators tracking transport and environment in the European Union*. www.eea.europa.eu
European Environment Agency, *Indicator Fact Sheet: TERM 2002 29 EU – Occupancy Rates of Passenger Vehicles*. www.eea.europa.eu
European Sea Ports Organisation, 2009. *Policy Statement on Reduction of Green House Gas Emissions in Ports*. www.uspo.be
Eurostat, 2010. *Panorama of Transport*. ec.europa.eu/eurostat.
European Union Road Federation (ERF), 2010. *European Road Statistics Handbook 2010*. Www.erf.be.

European Transport Workers Federation (ETF). *Trade Union Vision and Sustainable Transport*. Www.itfglobal.org/etf.
V Eyring, ISA Isaksen, T Bernsten, WJ Collins, JJ Corbett, O Endresend, RG Grainger, J Moldanova, H Schlager, and DS Stevenson, 2009. Transport impacts on atmosphere and climate: Shipping. *Atmopsheric Environment*.
J Fargione, J Hill, D Tilman, S Polasky, and P Hawthorne, 2008. Land Clearing and the Biofuel Carbon Debt. *Science*.
Tim Flannery, 2005. *The Weather Makers*. Allen Lane, London.
Erich Fridell, 2009. Ship emissions in harbour: Shore side electricity. Swedish Environmental Research Insititure, presentation at a conference in Keil. www.wpci.org
Ross Gelbspan, 1998. *The Heat is on*: *Climate Crisis*, *the Cover-up*, *the Prescription*. Perseus, London.
Ross Gelbspan, 2004. *Boiling Point: How Politicians, Big Oil and Coal, Journalists and Activists Have Fueled the Climate Disaster.* Basic, New York.
A. Gianni, R. Sanavan, and P. Chung, 2003. Oceanic Forcing of Sahel Rainfall on Interannual to Interdecadal Timescales. *Science*.
Paul Gilbert, Alice Bows, and Richard Starkey, 2010. *Shipping and Climate Change: Scope for Unilateral Action*. Tyndall Centre, University of Manchester.
Richard Gilbert and Anthony Pearl, 2010. *Transport Revolutions: Moving People and Freight Without Oil*. Second edition. New Society, Gabriola Island, British Columbia.
Tamra Gilbertson and Oscar Reyes, 2009. *Carbon Trading: How it works and why it fails*. Critical Currents Occasional Papers Series, Dag Hammerkjold Foundation, Stockholm. Also available in German and Spanish. www.carbontradewatch.org
Paul Gipe, 2004. Wind Power. Second edition, Chelsea Green, White River Junction.
Cees van Goeverden, Piet Rietveld, Jorine Koelemeijer, and Paul Peeters, 2006. Subsidies in Public Transport. *European Transport*.
Greenpeace, 2010. *Koch Industries: Secretly Funding the Climate Denial Machine*. www.greenpeace.org/usa
Rajat Gupta and Fergus Nicol, 2010. Unpublished paper on emissions from buildings for Campaign against Climate Change report.
James Hansen, 2010. *Storms of My Grandchildren*. Bloomsbury, London.
LD Danny Harvey, 2010. *Energy and the New Reality 1: Energy Efficiency and the Demand for Energy Services*. Earthscan, London.
LD Danny Harvey, 2010. *Energy and the New Reality 2: Carbon-Free Energy Supply.* Earthscan, London.
Jon Haveman and Kristen Monaco, 2009. *Comprehensive Truck Management Program: Economic Impact Analysis*. Beacon Economics for Port of Oakland.
International Energy Agency, 2010. *CO2 Emissions from Fuel Combustion: Highlights*. Www.iea.org.
Ivor van Heerden and Mike Bryan, 2006. *The Storm: What Went Wrong and Why During Hurricane Katrina*. Viking, New York.

James Hoggan and Richard Littlemore, 2009. *Climate Cover-Up: The Crusade to Deny Global Warming*. Greystone, Vancouver.
A. Hoojier, M. Silvius, H Woosten, and S Page, 2006. *PEAT-CO2 , Assessment of CO2 emissions from Drained Peatlands in SE Asia*. Dreft Hydrulics Report, available from www.wetlands.org.
Jed Horne, 2006. *Breach of Faith: Hurricane Katrina and the Near Death of a Great American City*. Random House, New York.
Intergovernmental Panel on Climate Change, 2007. *Climate Change 2007: The Physical Science Basis*. Cambridge UP, Cambridge.
International Energy Agency, 2010. *CO2 Emissions from Fuel Combustion – Highlights*. Www.iea.org.
International Labor Organization, 2011. *Global Employment Trends, 2011*. www.ilo.org.
International Transport Federation Climate Change Working Group and Global Labor Institute, 2010. *Transport Workers and Climate Change: Towards sustainable low-carbon mobility*.
International Maritime Organization, 2000. *Study of Greenhouse Gas Emissions from Ships*.
Arild Iverson and Jim Leape, 2010. 'In shipping, keeping up means slowing down'. WWF, www.wwf.panda.org.
Christine Jardine, 2005. *Calculating the Environmental Impact of Aviation Emissions*. Univeristy of Oxford Environmental Change Institute and Climate Care. Www.jpmorganclimatecare.com.
Jane Jacobs, 1992 (1961). *The Death and Life of Great American Cities*. Vintage, New York.
Peter Jacques, Riley Dunlap and Mark Freeman, 2008. The Organisation of Denial: Conservative think tanks and climate. *Environmental Politics*.
Suzanne Jeffrey, 2011. Why we should be sceptical of climate sceptics. *International Socialism*.
Martin Kemp and Josie Wexler, 2010. *Zero Carbon Britain 2030*. Centre for Alternative Technology.
Emmanuel Kerry, 2005. Increasing Destructiveness of Tropical Cyclones over the last 30 Years. *Nature*.
Naomi Klein, 2007. *The Shock Doctrine: The Rise of Disaster Capitalism*. Allen Lane, London.
Eric Klinenberg, 2002. *Heat Wave: A Social Autopsy of Disaster in Chicago*. Chicago University Press, Chicago.
Manfred Lenzen, 1999. Total Requirements of energy and greenhouse gases for Australian transport. *Transportation Research D*.
Larry Lohman, 2006. *Carbon Trading: A Critical Conversation on Climate Change, Privatisation and Power*. Special issue of *Development Dialogue*, no. 48, Stockholm. www.thecornerhouse.org.uk
David McCollum, Gregory Gould and David Greene, 2009. *Greenhouse Gas Emissions from Aviation and Marine Transportation: Mitigation Potential and Policies*. Pew Center of Global Climate Change.
Rob McCulloch, Ethan Pollack and Jason Walsh, 2010. *Full Speed Ahead: Creating Green Jobs Through Freight Rail Expansion*. Blue Green Alliance and Economic Policy Institute.

John McQuaid and Mark Schleifstein, 2006. *Path of Destruction: The Devastation of New Orleans and the Coming Age of Superstorms*. Little Brown, New York.
David JC MacKay, 2009. *Sustainable Energy – without the hot air.* UIT, Cambridge. www.withouthotair.com
Bill McKibben, 2010. *Eaarth: Making a Life on a Tough New Planet*. St. Martins, New York.
George Monbiot, 2006. *Heat: How to Stop the Planet Burning*. Allen Lane, London.
Chris Mooney, 2007. *Storm World: Hurricanes, Politics, and the Battle over Global Warming*. Harcourt, London.
Paul Mosley, T. Subasat and John Weeks, 1995. Assessing Adjustment in Africa. *World Development*.
David Moxon and Jonathan Neale, 2010. *One Million Climate Jobs Technical Note: Jobs and Emissions in Transport*. Campaign against Climate Change trade union group. www.climate-change-jobs.org
Jonathan Neale, 2008. *Stop Global Warming: Change the World.* Bookmarks, London.
Jonathan Neale, ed., 2010a. *One Million Climate Jobs: Solving the Economic and Environmental Crises*. Campaign against Climate Change trade union group. www.climate-change-jobs.org
Jonathan Neale, 2010b. *One Million Climate Jobs Technical Note: Jobs and Capacity in Renewable Energy.* Campaign against Climate Change trade union group. www.climate-change-jobs.org
Peter Newman and Jeffrey Kenworthy, 1999. *Sustainability and Cities: Overcoming Automobile Dependence*. Island Press, Washington DC.
Peter Newman, Timothy Beatley and Heather Boyer, 2008. *Resilient Cities: Responding to Peak Oil and Climate Change*. Island Press.
Naomi Oreskes and Erik Conway, 2010. *Merchants of Doubt*: *How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*. Bloomsbury, London.
David Owen, 2009. *Green Metropolis: Why Living Smaller, Living Closer, and Driving Less are the Keys to Sustainability.* Riverhead, New York.
Jiahua Pan, Haibing Ma, and Ying Zhang. *Green Economy and Green Jobs in China: Current Status and Potentials for 2020*. Worldwatch Report 185.
Christian Parenti, 2011. *Tropic of Chaos: Climate Change and the New Geography of Violence*. The New Press, New York.
Fred Pearce, 2006. *The Last Generation: How Nature Will Take Her Revenge for Climate Change*. Eden Project, London. Also published, 2007, as *With Speed and Violence*. Beacon, Boston.
J Penner, D Lister, D Griggs, D Dokken, and M Mcfarland, 1999. *Aviation and the Global Atmosphere*. Cambridge UP, Cambridge.
James Lawrence Powell, 2011. *The Inquisition of Climate Science*. Columbia University Press, New York.
Harilaos Psaraftis, Christos Kontovas and Nikolaos Kakalis, 2009. Speed Reduction as and Emissions Reduction Measure for Fast Ships. Paper at 10th International conference on Fast Sea Transportation, Athens.

Katherine Richardson et al, 2009. *Synthesis Report on Climate Change: Global Risks, Challenges and Decisions*. University of Copenhagen. www.climatecongress.ku.dk
Sue Roaf, David Chricton and Fergus Nicol, 2005. *Adapting Buildings and Cities for Climate Change*. Architectural Press, Oxford.
Ian Roberts and Phil Edwards, 2010. *The Energy Glut: Climate Change and the Politics of Fatness*. Zed, London.
Emily Rochon, 2008. *False Hope: Why Carbon Capture and Storage Won't Save the Climate*. Greenpeace International, Amsterdam.
Thomas Sanchez, 1998. The Connection between Public Transport and Employment. Paper at Association of Collegiate Schools of Planning Annual Conference, Pasadena.
Preston Schiller, Eric Bruun, and Jeffrey Kenworthy, 2010. *An Introduction to Sustainable Transportation: Policy, Planning and Implementation*. Easrthscan, London.
Mareike Schulz and Chajim Meinhold, 2003. Quantifizierung des Schienenbonus - Messung des Kundennutzens mittels Choice-Based-Conjoint-Analyse. *Der Naverkehr.*
T Searchinger, R Heimlich, RA Houghton, F Dong, A Elobeid, J Fabiosa, S Tokgoz, D Hayes, and Tun-Hsiang Yu, 2008. Use of U.S. Croplands for Biofuels Increases Greenhouse Gases through Emissions from Land Use Change. *Science*.
N Shakhova, I Semiletov, A Salyuk, V Yusopov, D Kosmach, and Ö Gustafsson, 2010. 'Extensive Methane Venting to the Atmosphere from Sediments of the East Siberian Arctic Shelf'. *Science*.
James Smith, 2010. *Biofuels and the Globalisation of Risk*. Zed, London.
Daniel Sperling and Deborah Gordon, 2009. *Two Billion Cars: Driving Towards Sustainability.* Oxford, Oxford UP.
Sustainable Development Commission, 2005. *Wind Power in the UK*.
Jerome Tubiana, 2007. Darfur: A War for Land, in De Waal, 2007.
John Vidal, 2010. Modern cargo ships slow to the speed of the sailing clippers. *Observer*, 25 July.
Tyler Volk, 2008. *CO2 Rising: The World's Greatest Environmental Challenge*. MIT Press, Cambridge.
A Vyas, C Saricks and F Stoldosky, 2002. *The Potential Effect of Future Energy-Efficiency and Emissions Improving-Technology on Fuel Consumption of Heavy Trucks*. Center for Transportation Research, Argonne National Laboratory.
UIC and CER, 2008. *Rail Transport and Environment Facts and Figures*.
Union Internationale des Transports Publics, 'Media Backgrounder: Public Transport and CO2 Emissions'. www.uitp.org
United Nations Environment Programme, 2007. *Sudan: Post-conflict Environmental Assessment*.
John Vidal, 2011. Nuclear's Green Cheerleaders forget Chernobyl at Our Peril, *Guardian*, April 1.
John Weeks, 2000. Latin America and the “High Performing Asian Economies”: Growth and Debt. *Journal of International Development*.

Max Wei, Shana Patadia, and Daniel Kammen, 2009. Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US? *Energy Policy*.
George Ban-Weiss, David Larsen, Sonny X. Li, and Dano Wilusz. *Job Creation Studies in California for VoteSolar*.
J Woodcock, P Edwards, C Tonne, B Armstrong, O Ashiru, D Banister, S Beevers, Z Chalabi, Z Chowdhury, A Cohen, O Franco, A Haines, R Hickman, G Lindsay, I Mittal, D Mohan, G Tiwari, A Woodward, and I Roberts, 2009. Public health benefits of strategies to reduce greenhouse-gas emissions: urban land transport. *The Lancet*.
World Bank, 2008. *Safe, Clean and Affordable: Transport for Development*.
Alexey Yablokov, Vassily Nesterenko, and Alexey Nesterenko, 2009. *Chernobyl: Consequences of the Catastrophe for People and the Environment*. Annals of the New York Academy of Sciences.
N Zeng, 2003. Drought in the Sahel. *Science*.