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What works?

How to cut emissions at the lowest cost

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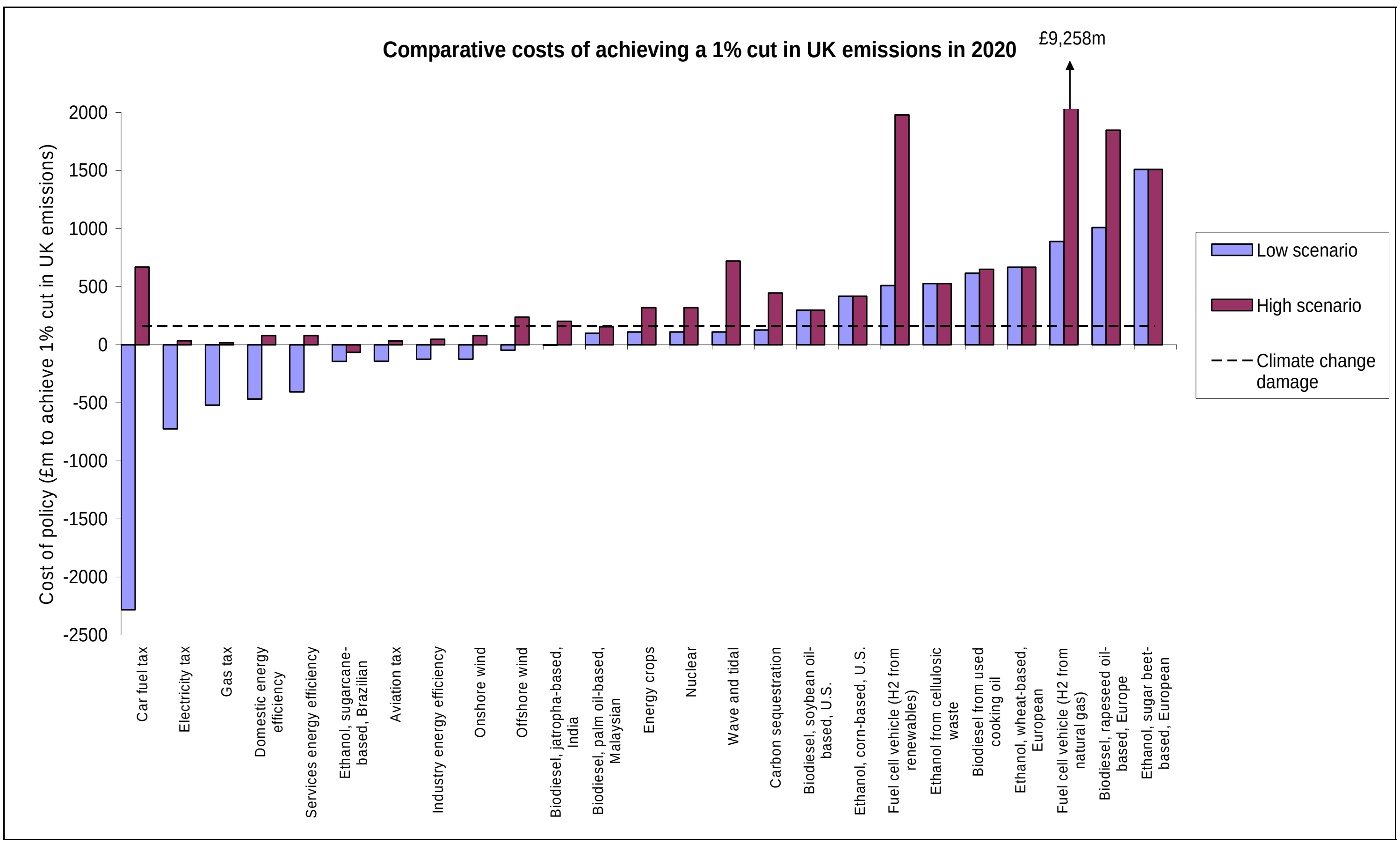
Executive summary

- In March 2007, EU leaders signed up to ambitious targets for reductions in carbon dioxide emissions – a 20% cut by 2020. Not only did they agree on this legally binding target for absolute emissions reductions, but also on the means by which it should be achieved. The agreement mandated a 10% minimum use of biofuels in transport fuels and that 20% of overall energy consumption should be sourced from renewables.

- Europe Economics, an economic consultancy commissioned by Open Europe, have estimated the likely costs of carbon mitigation in 2020. Their figures suggest that the EU is wrong to mandate binding targets for renewable energy and biofuel use, as there are far more cost effective solutions available in terms of curbing carbon emissions. It should be emphasised that climate change has to be tackled using a finite set of economic resources – if these are spent on wasteful policies as opposed to delivering cuts in emissions at the lowest possible cost, an economic problem becomes a environmental problem. Europe Economics' cost estimates are set out in the graph below.



Biofuel targets are expensive, harmful and unpredictable – the EU must scrap them

- The EU's 10% target for biofuel use in transport will be of huge significance both in environmental and social terms. This paper argues that imposing mandates for minimum biofuel use is effectively a form of state support for an environmentally and economically harmful activity, in this case designed to consolidate existing price support mechanisms for vested interest groups, most notably agri-businesses.[1] In setting binding targets for biofuel use, both the US and the EU have adopted flawed and irresponsible policy on the unsubstantiated assumption of future technology improvements.

- **Biofuels, especially those grown in Europe, are by far the most expensive way of reducing carbon emissions amongst those policies modelled.** In terms of fighting climate change, Europe is one of the worst places in the world for producing biofuels. The EU Commission was fully aware that Europe would be an inefficient producer of biofuels, but nonetheless pushed ahead with the plans for binding targets. The Commission's 2006 strategy paper acknowledged that "Most available studies indicate that the abatement costs of EU-produced biofuels are quite high compared with the current 'carbon price'. This means that EU-manufactured biofuels are currently not the most cost-effective way to reduce greenhouse gas emissions."[2] Europe Economics' figures (see graph above) clearly show that biofuels – especially those grown in Europe – are the most cost-ineffective way of reducing carbon emissions amongst the policy options modelled. They are also far more costly than the official social cost of carbon.

- The EU already heavily subsidises its domestic biofuel industry through a combination of protectionist trade instruments, tax breaks and direct subsidies from the Common Agricultural Policy (CAP). According to the Global Subsidies Initiative (GSI), these transfers were already as high as €3.7bn in 2006 – an amount they admit may be a "gross underestimate"[3], and will be only a fraction of the cost of achieving the far higher levels of biofuel use demanded by the 2020 targets. Using estimates from the GSI and Europe Economics, Open Europe have calculated that the 10% EU target would lead to total annual transfers to the wider biofuels industry of €11-23bn by 2020. Considering that the CAP currently accounts for around €40bn of annual EU spending, this is an enormous level of subsidy. Other recent estimates include unofficial figures from the EU's Joint Research Centre (JRC), suggesting that biofuel targets would cost taxpayers €33-€65bn between now and 2020 – a huge sum in itself.[4] However, bearing in mind the GSI estimates for current annual biofuel subsidy levels (which relate to around a fifth of the level of biofuel incorporation that will be required by the targets), and Europe Economics' estimates for the carbon abatement costs of biofuels, the JRC figures may well be an underestimate. Despite remaining uncertainties over the costs of biofuels (itself an argument against setting binding minimum targets), it is clear that a European biofuel industry cannot be viable without political support by means of tariffs and very high levels of subsidy, and consequently the cost of these flawed policies will be borne respectively by consumers and taxpayers.

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1 For more details see: Corporate Europe Observatory, *The EU's agrofuel folly: policy capture by corporate interests* Briefing paper, (June 2007)
2 EU Commission, An EU Strategy for Biofuels Impact Assessment (2006)
3 Global Subsidies Initiative, Biofuels – at what cost? Government support for ethanol and biodiesel in the European Union (October 2007)
4 Unpublished study by the Joint Research Centre, cited in the *FT* (18.01.08)

- **Biofuel targets will spur rainforest destruction.** More cost-efficiency could be gained by sourcing biofuels from the tropics. However, this brings its own problems – most seriously rainforest destruction and land-use change. This is already happening as a result of current biofuels production (and indeed in anticipation of rising demand from the EU), and will inevitably get far worse as a result of EU targets. Deforestation already accounts for 25% of greenhouse gas emissions, more than transport, which contributes around 15%. By trying to prescribe a small and costly reduction in carbon emissions from transport use, the EU will aggravate an even more serious issue, with potentially catastrophic consequences in terms of climate change and broader ecological damage.

- The sheer scale of the EU's targets for biofuel use will drive deforestation – resulting in a net negative result in terms of carbon release. Renton Righelato and Dominic Spracklen have calculated that the 10% target would mean turning over 38% of current agricultural land in Europe, and that "As even this low substitution level cannot be met from existing arable land, forests and grasslands would need to be cleared to enable production of the energy crops. Clearance results in the rapid oxidation of carbon stores in the vegetation and soil, creating a large up-front emissions cost that would, in all cases examined here, outweigh the avoided emissions." They believe that instead of forcing the pace of biofuels production, the EU would be better off preserving existing forests or planting new ones. Their research finds that "forestation of an equivalent area of land would sequester two to nine times more carbon over a 30-year period than the emissions avoided by the use of the biofuel."[5] The Commission's impact assessment claims that Europe can meet the 10% target by using 18% of its current agricultural land. This is a very large shift in land use in itself, but relies on the assumption that 20% of EU biofuel needs will be sourced from imports, and 30% will be from second generation biofuels. These assumptions are questionable given that second generation biofuels do not yet exist, whilst the import estimate brings us back to the concern over land-use change and deforestation.

- **EU Commission ignored the warnings on biofuels – and internal reports maintain that this is bad policy**. The EU Commission was fully aware of the harmful social and environmental effects of large-scale biofuel use – but pressed on with promotion of biofuels regardless. Its 2006 impact assessment noted "increased use of biofuels in the EU will be accompanied by an increased external demand for biofuels and their feedstocks, which is likely to have various effects on developing countries… In addition, there are substantial CO2 losses if grassland is ploughed up or forest cleared. These losses can be expected to outweigh CO2 gains from biofuels for many years." The report admits that "there will be increasing pressures on eco-sensitive areas, notably rainforests, where several millions of hectares could be transformed into plantations."[6] More recently, the Commission's own scientists have said that "The costs [of the target] will almost certainly outweigh the benefits", and suggest that the plan for targets for transport fuel use should be ditched. "The uncertainty is too great to say whether the EU 10 per cent biofuel target will save greenhouse gas or not," it notes.[7] That the Commission was aware, and continues to be aware, of the uncertainty and potentially serious consequences of such huge biofuel targets suggests a major failure in EU policy-making, and an irresponsible approach to global environmental and social welfare.

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[5] Righelato, R. & Spracklen, D. "Carbon Mitigation by Biofuels or by Saving and Restoring Forests?" *Science* (17.08.07)
[6] *An EU Strategy for Biofuels*, Impact Assessment {COM(2006) 34 final}, Commission Staff Working Document, Annex to the Communication from the Commission, Commission of the European Communities, Brussels, SEC(2006) 142.
[7] Unpublished study by the Joint Research Centre, cited in the *FT* (18.01.08)

- **Biofuels targets will lead to starvation for millions.** Production of biofuels diverts large amounts of agricultural production from food to fuel, restricting food supply. Filling a 95-litre fuel tank with pure ethanol requires about 200 kg of corn, which has enough calories to feed a person for a year. It is certain that this shift to biofuels will contribute to higher world food prices – this is already happening as a result of US demand, with 2007 seeing dramatic rises in food bills. Between 2006 and 2007 the price of food aid increased 20%, Indian food prices increased 11%, tortilla prices in Mexico quadrupled, Chinese pork prices rose 42%, the price of pasta in Italy rose 20%, the average Italian household faced an extra £700 on shopping bills and UK food prices rose by a similar amount.

- The EU's targets are equally ambitious to those of the US, and will further exacerbate this trend. The OECD and FAO predict global food price rises of between 20 and 50% for different food products over the next decade. Their report notes that increasing biofuel use is "one of the main drivers". The IFPRI estimate increases of up to 26% for various staples created by biofuel demand alone. Runge and Senauer estimate that for every percentage increase in real prices of staple foods, 16 million extra people will be drawn into food insecurity.[8] Given the scale of increases predicted by the IFPRI, this would mean 240 million people being pushed into food insecurity, of which the EU would be responsible for 60 million.

- **Food price rises will also hit the developed world.** Open Europe calculates that by 2020 the average family of four in the UK can expect, in today's prices, a rise in annual food expenditure of between £200 (€260) and £260 (€340) as a result of worldwide biofuel demand. Of this, the EU would be responsible for £50 – 65 (€65 – 85).[9]

- **Biofuels will lead to food price volatility.** Higher food prices are only half the problem when discussing the social effects of biofuels. Price volatility is also a major concern for those living in poverty or marginal economic situations. Biofuel prices are linked to oil prices. When oil prices increase, fuel crop prices can also increase while remaining competitive, because ethanol producers can pay more for the feedstock. Oil prices are notoriously volatile. This volatility will be transmitted to food markets. Those living on less than $2 per day spend from 50-80% of their budgets on food, meaning they will not only bear a disproportionate impact in terms of the absolute price increases, but will also be more vulnerable to rapid changes in price.

- **Target-driven biofuel cultivation will add to land hunger.** Incidences of biofuel-driven land seizure are already occurring. In Colombia and Indonesia, peasants are reportedly being driven off their land to make way for palm oil plantations.

- **EU biofuel policy based on non-existent technologies.** The Commission's 2007 impact assessment assumes that one third of EU biofuel production will come from so-called 'second generation' biofuel sources by 2020. But there is no scientific consensus on how soon (if at all) industrial supply of second generation fuels will be viable. The EU has gambled global social and environmental wellbeing on non-existent future technologies, the development of which is highly uncertain.

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[8] Runge, C & Senauer, B. "How Biofuels Could Starve the Poor" *Foreign Affairs* (May/ June 2007)
[9] Figures derived from DEFRA, OECD/ FAO, IFPRI, IEA and IMF

- **Even under reasonably optimistic scenarios, biofuels can only have a very marginal effect on climate change.** The OECD have worked on what they admit is an "overambitious" assumption of improved biofuel performance over the coming decades, and a 20% use in transport fuel. They estimate that this would reduce global energy-related CO2 emissions in 2050 by roughly 3.6% or 2.1 Gt of CO2. In order to limit global warming by 2-3°C, CO2-equivalent emissions need to be reduced by roughly 39 Gt of CO2 in 2050.[10] Open Europe estimate that the 2020 target of 10% biofuel use in Europe's transport would deliver only around 0.9 - 1.1% reduction in overall EU greenhouse gas emissions. This also assumes that biofuels do not contribute to deforestation or land-use change – which is practically impossible given the sheer size of the targets. It is entirely possible that biofuel targets will lead to a net increase in atmospheric carbon.

- **Increased biofuel production causes environmental degradation beyond climate change.** Water shortages and pollution are set to be a major problem associated with large-scale biofuel cultivation, both in environmental and social terms. As cultivation is expanded to meet demand for biofuels, increased strain will be placed on already scarce water resources. According to David Pimenel and Tad Patzek, each gallon of ethanol requires 1700 gallons of water (mostly to grow the corn) and produces 6 to 12 gallons of noxious organic effluent (which pollutes clean water sources).[11] Loss of biodiversity is another major concern.

- **This is a serious misallocation of resources.** If the huge expense of achieving the miniscule reduction in greenhouse gases through biofuels were to be redirected towards reforestation projects, almost 28% of the EU's total emissions would be saved. Even if it were to be redirected towards (relatively cost-inefficient) renewables (at current costs), these funds would deliver a 2 – 5% reduction.

- **Focus on sustainable sources misses the central point – what really matters is the target.** Recently, the Commission has been more open in admitting the potentially colossal risks of large-scale biofuel use. Environment Commissioner Stavros Dimas has said "There was a lot of enthusiasm here a year and a half ago - now this enthusiasm is going down because we have seen the environmental problems caused by biofuels, and also the social problems".[12] However, EU policy now seems to be swinging behind the idea of introducing a system of certification of sustainability.

- The OECD are sceptical over whether this would be workable in practice, noting that "biofuel mandates are still targeting ambitious market shares without an in-depth understanding of a sustainable production level and from where this biofuels could be supplied. There is a serious risk that biofuel quotas for demand are higher than potential sustainable supply".[13] Furthermore, without a well enforced (potentially costly) multilateral system, certification could just result in further market segmentation, without reducing unsustainable practices, another concern voiced by the OECD. There would be a very real risk that the practice of certification would merely encourage further protectionism in biofuels markets. The US and the EU have already created

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[10] Doornbosch, R & Steenblik R. "Biofuels: is the cure worse than the disease?" Organisation for Economic Co-operation and Development, Round Table on Sustainable Development, Paris (11-12 September 2007)
[11] Pimentel, D & PATZEK, T. "Green Plants, Fossil Fuels, and Now Biofuels", in *BioScience* 875 (November 2006 / Vol. 56 No. 11)
[12] Interview, BBC Today programme (14.01,08)
[13] Doornbosch, R & Steenblik R. "Biofuels: is the cure worse than the disease?" Organisation for Economic Co-operation and Development, Round Table on Sustainable Development, Paris (11-12 September 2007)

powerful vested interest groups through their respective biofuel policies: this means they would be likely to use strict certification standards to shut out competition, rather than out of genuine regard for sustainability.

- The draft directive on biofuel use – at least as currently drafted – has been rightly criticised for its very lax standards on sustainable biofuel production (for instance, biofuels produced on land converted from savannah and recently cleared rainforest would be permitted). But in one sense this criticism misses the more essential point: even if it could somehow be guaranteed that all biofuel used in Europe did come from 'sustainable' sources, this would still be a totally inadequate solution to the core problem of land pressure created by such massively increased demand. Even if biofuels themselves are cultivated in a socially and environmentally responsible way on existing agricultural land, there is no way of guaranteeing that the food production displaced by this biofuel cultivation will also be sustainable. To give one example, it is practically impossible for biodiesel from palm oil to be genuinely sustainable, given that the product is also hugely important as a food crop. EU biofuel targets will contribute further to the massive jump in overall demand for the commodity, leading to price rises, and thereby increasing the already ambitious pace of rainforest clearance (both illegal and legal) created just by demand for this one crop.

- **Ditching targets rather than tinkering round the edges is the only solution.** Given the huge social and environmental risks associated with such ambitious biofuels targets, and the meagre, uncertain rewards, the priority for the EU should be to immediately ditch these targets. As the OECD conclude: "Current biofuel support policies place a significant bet on a single technology despite the existence of a wide variety of different fuels and power trains that have been posited as options for the future. National governments should cease to create new mandates for biofuels and investigate ways to phase them out, preferably by replacing them with technology-neutral policies such as a carbon tax. Such policies will more effectively stimulate regulatory and market incentives for efficient technologies."[14] Bob Watson, chief scientist at Defra, recently stated that "We should not use biofuels if indeed it leads to other environmental and social problems".[15]

- The EU should also scrap tariffs and subsidies for biofuels. Biofuels may have a part to play in carbon abatement, but that part is likely to be far smaller than envisaged by either the US and the EU. As things currently stand, tariffs imposed on more efficient biofuel production elsewhere in the world promote inefficient – and therefore more environmentally harmful – domestic production. By removing these distortions, biofuels can be sourced from where they are most efficiently produced. Efficiency is linked with environmental effectiveness. However, tariff reductions and an end to subsidies must also be accompanied by abolition of biofuels targets – this is essential in order to offset the risk of tropical deforestation in response to the artificial state-mandated demand that minimum targets create.

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[14] Doornbosch, R & Steenblik R. "Biofuels: is the cure worse than the disease?" Organisation for Economic Co-operation and Development, Round Table on Sustainable Development, Paris (11-12 September 2007)
[15] BBC Radio 4 Today programme (14.01.08)

Renewables targets are badly thought-out and could divert investment from cheaper abatement options

- The effects of renewable targets are unlikely to be as dramatic as those specifically for biofuels – nonetheless, we believe that mandatory targets for their use are misguided, and the EU would be better off abandoning these in favour of simple targets for absolute emissions cuts only.

- **Renewables are likely to remain very expensive options for reducing emissions.** Europe Economics have found that whilst some renewable technologies may become cost effective by 2020, the overall picture is that "renewables generation technologies are typically a very costly way to reduce carbon emissions. In many cases, this is true even once the potential for costs to fall through time has been taken into account". The UK has been assigned a target of 15% overall energy consumption to be sourced from renewables (a seven fold increase on today's levels) - implying costs of up to £11bn.[16] It is clear that large-scale subsidy will be required to bring EU members in line with the Union's 20% target. The Commission has estimated that a 20% renewable target would mean additional average costs compared to conventional supply options ranging from €10.6bn to €18bn per year.[17] This is a huge amount, but could well be an underestimate given the size of the UK-only estimate and the current costs of subsidising renewables.[18]

- **Significant uncertainty remains over how much renewables will cost in 2020.** Renewables may well have a role to play in combating climate change, but the 20% target is an ill-founded, premature and arbitrary judgement on the level of contribution they should make. As Europe Economics' report argues, "The key message from our cost estimates…is the huge uncertainty that exists about the precise cost of many carbon reduction measures. This illustrates the danger of the government 'picking winners' by supporting a particular solution to the problem of reducing emissions, and reinforces the case for using a carbon price to allow the market to identify the best approach." There is a very real risk that by prescribing one particular emissions abatement method, EU renewable targets will direct investment away from more cost-effective options.

- **Such large renewables targets are a leap in the dark.** Linked to the issue of cost is uncertainty over whether such huge renewables targets will be at all practical or achievable. Across Europe, renewables use will need to jump from around 6% today to 20% in 2020, or for the electricity sector from just over 15% to around 34%. Much of the existing renewables capacity in Europe is long established, based on large-scale hydro-power in mountainous regions. However, there is limited scope for expansion in these (often protected) areas. Since large-hydro power is by far the cheapest form of renewable energy available, expanding renewable capacity further will have to come from other, more expensive technologies. This is not just a question of a huge increase being required in the EU's absolute renewable capacity, which (significantly) has actually remained fairly static over the past decade, despite high levels of subsidy. The far more daunting fact is that this increase must be achieved through new and more expensive technologies that currently account for a small proportion of renewable capacity – and currently just under 5% of overall capacity.

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[16] Reported in FT (15.01.08); cost estimates from internal DTI paper obtained by the Guardian (13.08.07)

[17] European Commission, *Renewable Energy Roadmap* (10.01.2007)

[18] The EC figures suggest carbon reductions through renewables achieved at a cost of £8 - £20 per tonne of CO_2 in 2020. However, OFGEM note the current system of support for renewables in the UK costs around £65-140 per tonne of CO_2 avoided. Ofgem, *Response to BERR consultation on reform of the Renewables Obligation* (13.09.07).

- **Renewables' costs rise as capacity comes under pressure.** According to Europe Economics, wind power may become economically viable without subsidies by 2020 (although this remains highly uncertain). However, purely on the basis of limits on available sites, (and increasing costs once the prime locations have been used), wind power alone cannot account for the EU's target. It is also an intermittent source of power generation – which is not a serious issue when wind is used in small amounts, but becomes a problem after around a 10% penetration of wind energy on the grid. The sheer magnitude of the EU targets would inevitably mean that investment would have to be forced towards far more expensive renewables options – irrespective of whether this extra expenditure could be better spent on achieving greater emissions reductions through other means. Fundamentally, it is misguided to set a minimum binding capacity for a given policy in advance because the marginal costs per tonne of achieving carbon reductions through that particular policy will increase as the opportunities to realise cheaper options within these boundaries become progressively diminished.

- **Renewable energy targets contradict other key EU environment policies.** The EU often claims its primary tool in combating climate change is the EU Emissions Trading Scheme (ETS), which relies on restricting quantities of carbon that can be emitted. Scarcity in carbon should therefore lead to a price for carbon. But notwithstanding the serious problems that affect the EU ETS specifically, renewables targets are not compatible with the scheme. In order to meet renewables targets, it is almost certain that large amounts of subsidy will continue to be required to spur investment in this form of generation. However, since this would reduce scarcity of carbon within the sectors subject to emissions trading, the price of carbon would also decrease – meaning less incentive to cut carbon. Put simply, the EU ETS and renewables targets are mutually contradictory, and risk creating a 'waterbed' effect – reducing emissions in some areas, but leading to increases in other areas. UK officials, in leaked papers, have already expressed their concerns on this issue: "If the EU has a 20% GHG [greenhouse gas] target for 2020, the GHG emissions savings achieved through the renewables risk making the EU ETS redundant, and prices to collapse."

- Another source of tension with the ETS will arise as a result of free allocations of carbon permits to participants in the scheme. It is widely acknowledged that free allocation is a form of covert industrial subsidy, meaning that high carbon alternatives to renewables (especially brown coal in Germany) are effectively being promoted under current EU policies.[19] If the EU is serious about encouraging more renewables investment, the most obvious place to start would be removing favourable treatment to fossil fuel power sources. But the EU will not even consider this until after 2013. The adoption of renewables targets in spite of these problems is indicative of the ill-conceived and contradictory nature of much of the EU's climate change policy.

Tax cuts on energy efficient goods and green taxes are likely to be far more cost effective solutions

- According to Europe Economics, greater energy efficiency measures are likely to lead to direct financial savings, as well as reduced carbon emissions. However the EU currently actively hinders energy efficiency improvements through import tariffs and VAT on a

[19] Carbon Trust, *EU ETS Phase II allocation: implications and lessons* (May 2007)

variety of energy-saving goods. For example, a single energy efficient light bulb equivalent to 60 watts can cost as much as £4. Open Europe have estimated that without the antidumping duty and the VAT, the price would be 66p - a price drop of more than 80%.

- Europe Economics' research has also found that placing a firm price on carbon, and using the revenues to lower taxes elsewhere in the economy would bring net economic benefits by reducing the deadweight loss of taxation – as well as encouraging investment in lowering emissions. They recommend an 'upstream' tax on the consumption of all primary fuels (e.g. coal, gas, oil) in proportion to their carbon content, thus allowing a carbon price to be extended across the entire economy. Levying taxes on a negative externality such as CO2 emissions should not solely be regarded as a means of restraining pollution. It could also prove an opportunity to cut taxes in other areas of the economy, effectively relieving the burden of taxation on productive wealth creating endeavors, shifting it towards a harmful activity that does incur a long term cost that would not otherwise be internalised by business if the market were left to its own devices. Imposing a price on carbon would to some extent abrogate the need for subsidising particular policies, such as renewables. Investment in renewables would naturally follow as a result of taxation on carbon emitting means of energy production once more cost effective options for carbon abatement are realised.

The EU should focus on targets for absolute emissions reductions – not try to micro-manage national energy policy

- There is a rationale for internationally binding targets for absolute carbon emissions, but setting targets as to the means by which different countries should achieve this end is a step too far. What fundamentally matters is getting as much carbon out of the atmosphere as possible at least cost. By this logic, EU member states should be able to pursue the goal of lower emissions in the way that suits them best. However, prescriptive rules and policy-specific targets as to how to achieve that emissions reduction will inevitably reduce flexibility and distort investment choices, in this case in favour of technologies that are either not cost effective, or whose costs are highly uncertain.

- Simple targets for carbon reductions would not stop member states from pursuing ambitious renewable policies if they choose to do so, but would at least allow them to judge first whether this is the most effective way of cutting carbon emissions. Renewables investment could well be stimulated as a result of other policy instruments, most obviously a carbon tax described above – but this would only happen after more cost effective options for carbon abatement are tackled first.

- There are finite resources available in the fight against climate change, which must be used to their optimal potential rather than unnecessarily squandered on costly abatement methods. Targets for biofuels and renewables, however, channel limited resources towards higher costs and huge uncertainties, and could even result in higher greenhouse gas emissions. Politicians often talk in terms of 'declaring war on climate change'. But one characteristic of all successful war planning is the effective mobilization of economic resources – in this respect, current EU policy is a wholesale failure, and an approach that can only lead to defeat.

Summary of report conclusions		
Directly harmful	**Ineffective/ waste of resources**	**Effective**
Biofuels targets Import duties on green products Biofuel subsidies and tariffs Free allocations to fossil fuel generators in the EU ETS	Renewables targets Emissions trading	Internationally agreed absolute emissions reduction targets Upstream green taxes Energy efficiency/ tax breaks for energy saving products

1 – Renewable energy

1.1 - EU targets are a leap in the dark

- In March 2007, EU leaders made a commitment to generate 20% of the Union's energy from renewable sources by 2020. The politically charged issue of how the 'effort' required to meet these targets should be distributed between member states remained unresolved at the time of writing.

- It seems probable that in 2020, as today, increasing renewable generation capacity on the scale envisaged will require subsidy. Most renewable technologies are not yet competitive enough in their own right to displace cheaper fossil fuel generation without government support. In order to meet the EU's targets of 20% renewable use, subsidy would be required on a massive scale. A leaked internal DTI paper obtained by the Guardian gives preliminary estimates of the per annum costs to the UK of meeting different levels of obligation under the EU renewables target, set out in the table below.

Cost of renewables investment in the UK (internal DTI papers 2007)	
% of primary energy demand supplied by renewables	Costs pa in 2020 £bn
10%	3.6 – 4.4
9%	0.9 – 1.6
14%	8.7 – 10.8
15%	4.8 – 6.3
20%	17.8 – 22.4

- These are clearly huge sums. The grey figures in the table indicate scenarios with higher reliance on renewables in transport and heat, but the DTI paper concedes that there is "considerable uncertainty" regarding the costs, viability and capacity for renewables expansion in these fields. The UK will be assigned a target of 15% - implying costs of up to £11bn.[20]

- It is clear that large-scale subsidy will be required to bring EU members in line with the Union's 20% target. The Commission has estimated that a 20% renewable target would mean additional average costs compared to conventional supply options ranging from €10.6bn to €18bn per year.[21]

- This is a huge amount of required investment, and yet (especially bearing in mind the DTI's UK-only figures cited above) is likely to be an underestimate. The Commission believes that the additional renewable energy deployment needed to achieve the 20% target would reduce annual CO2 emissions between 600 and 900 Mt in 2020. Given their cost estimates, this would imply that emissions reductions can be achieved through renewables for between £8 and £20 per tonne of CO2.[22] This seems overly optimistic, as it is still improbable that technology will improve renewables quickly enough to bring prices down to such an extent, especially given the issue of limitations in capacity for cheaper renewable options (such as wind), and that of declining returns, whereby the optimal sites for cheap renewable generation are exploited first, leaving progressively more expensive options. To give some perspective as to how far things would have to improve, OFGEM has noted that the current system of support for renewables in the UK

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[20] Reported in FT (15.01.08)
[21] European Commission, *Renewable Energy Roadmap* (10.01.2007)
[22] €10.6bn/900m tonnes = €11.70/tonne; €18bn/600m = €30/tonne. Converted to pounds @ 0.7138 = £8.30 – £21.40.

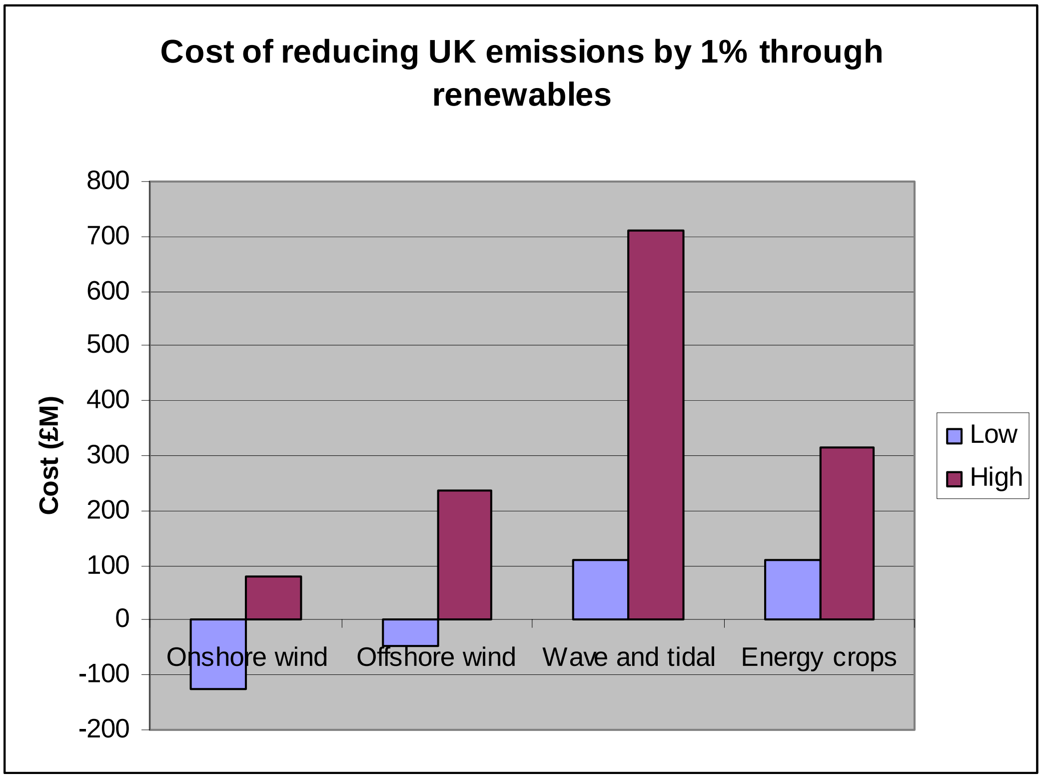
costs around £65-140 per tonne of carbon dioxide avoided, depending on the type of fossil fuel assumed to have been displaced[23]. The UK's system of renewables subsidy is admittedly unusually expensive – hampered by poor subsidy design, together with planning and grid constraints – but even with a far better support system (such as that of Germany) in place, the level of subsidy would still be very high – at around £43 to £92 per tonne.[24] In any case, the example of the UK shows that the actual price being paid in terms of subsidies for renewables may be substantially higher in practice than it should be, even under the uncertain scenario of rapid technological advances.

- When set alongside other means of carbon abatement, the economics of renewables subsidies as a means of fighting climate change seem at best uncertain and at worst adverse. Simply shifting fossil fuel generation from coal to gas costs around £15-20 per tonne of CO2 avoided. As a further point of reference, reforestation and programmes which prevent deforestation would come in at £2.50-£7.50 and £2.50 per tonne of CO2 avoided respectively[25] (although as section 2 argues, the hugely expensive EU biofuels targets will in fact drive even more deforestation and harmful land-use change).

- If the UK and other countries that have similar support systems must continue subsidising renewables, they could do so far more cheaply by adopting a German-style system (see section 1.3). But given that the UK is proposing a system of subsidy that merely adapts the current one, and yet will probably be even more expensive,[26] it seems likely that Britain and a number of other EU states will continue to pay over the odds for supporting renewable investment – meaning the EU renewables targets would in practice be realised at a far higher cost than the already huge cost that would be necessary as a minimum.

- Europe Economics' estimates for 2020 renewables costs are shown in the graph below. They argue that "renewables generation technologies are typically a very costly way to reduce carbon emissions. In many cases, this is true even once the potential for costs to fall through time has been taken into account". They indicate that even after more than a decade of technological improvements and cost reductions, new renewable technologies such as wave energy, tidal generation and energy crops are likely to remain expensive solutions for reducing carbon emissions. Wind power may become economically viable, but the actual costs still remain highly uncertain. In any case, even if we assume that on-shore wind power does become cost-effective, given the sheer size of the EU target (20% total energy use in the UK would equate to 40% of electricity production in the UK), there is no way that wind power alone can provide anything like the capacity needed to cover such a commitment. Current available figures show large disparities between the future costs of renewables, reflecting significant uncertainties on the issue. The large degree of uncertainty is the salient feature of Europe Economics' conclusions, and should alone be reason for scepticism over the wisdom of binding targets.

[23] Ofgem, *Response to BERR consultation on reform of the Renewables Obligation* (13.09.07)
[24] Based on OPTRES, Assessment and optimisation of renewable energy support systems in the European electricity market (2007), Chapter 5. This shows German subsidies for windpower are around a third less per MWH than those in the UK.
[25] Stern, N. *The Economics of Climate Change*, Ch 9 (2006)
[26] See Ofgem, *Response to BERR consultation on reform of the Renewables Obligation* (13.09.07)



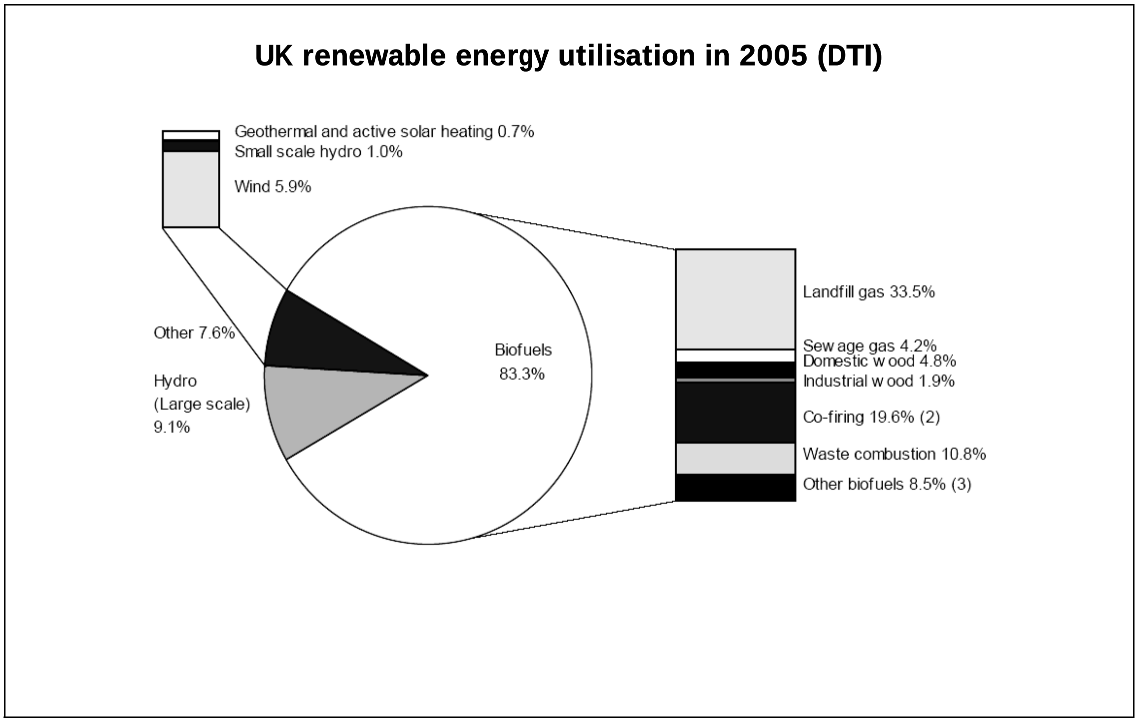
- EU leaders have made a hugely significant commitment without any realistic consideration of the potential cost effectiveness or feasibility of renewables. As argued elsewhere in this paper, this is far more than a simple question of taxpayers' money. Climate change has to be tackled using a finite set of economic resources – if these are spent on wasteful policies as opposed to delivering cuts in emissions at the lowest possible cost, an economic problem becomes a environmental problem.

- Renewable energy no doubt has a role to play in combating climate change, but right now it is certainly not the most cost-efficient means of reducing greenhouse gas emissions, and considerable uncertainty remains over how far technological advances will pare down the cost of renewables over the coming years. Such uncertainty in itself suggests that mandated minimum targets for renewables are premature and irrational.

1.2 - Does Europe even have the capacity to hit 20%?

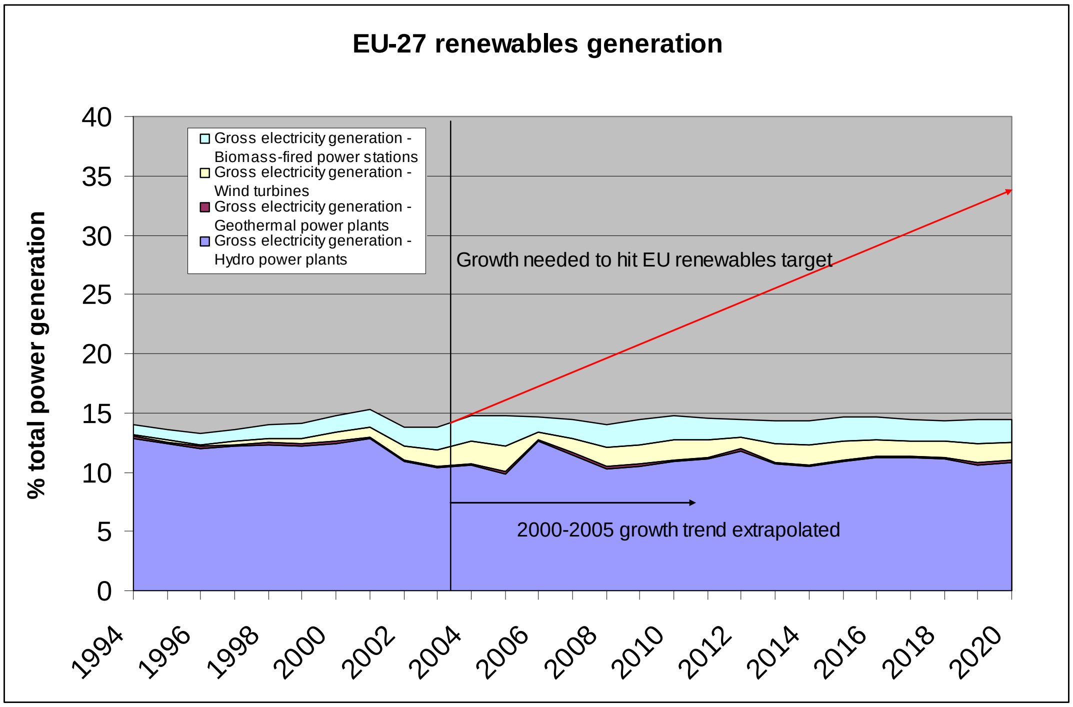
- At present, the UK is heavily dependent on renewable energy capacity sourced from large-scale hydro and energy derived from waste-products, such as landfill gas. This capacity is fairly fixed and not easily scaled up by the kind of ratio that would be necessary to hit renewables targets. The internal DTI paper suggests that the UK would need to generate around 33% of its electricity from renewables in order to hit the likely 2020 renewables target.[27] This is a 7-fold increase on 5% today. That means the burden of increase would be borne by energy produced by other technologies that currently form a negligible proportion of the UK's energy mix.

[27] In the scenario of the UK sourcing 15% of overall energy use from renewables.



- The rest of Europe has more far installed renewable capacity than the UK, but essentially faces the same problem. Across Europe, renewables use will need to jump from around 6% today to 20% in 2020, or for the electricity sector from just over 15% to around 34%. As in Britain, much of the existing renewables capacity is long established, based on large-scale hydro-power in mountainous regions. However, there is limited scope for expansion in these (often protected) areas. The Commission envisages a very limited growth in hydro use"the relative exhaustion of the potential expansion capacity, very close to the saturation level (a very mature technology)". Since large-hydro power is by far the cheapest form of renewable energy available[28], expanding renewable capacity further will have to come from newer, more expensive technologies. As the graph below illustrates, this is not just a question of a major increase being required in the EU's absolute renewable capacity, which (highly significantly) has actually stayed fairly static over the past decade, despite huge levels of subsidy. The far more daunting fact is that this increase must be achieved through means that currently account for a very small proportion of renewable capacity – and currently just under 5% of overall capacity.

[28] See OPTRES, pg. 10



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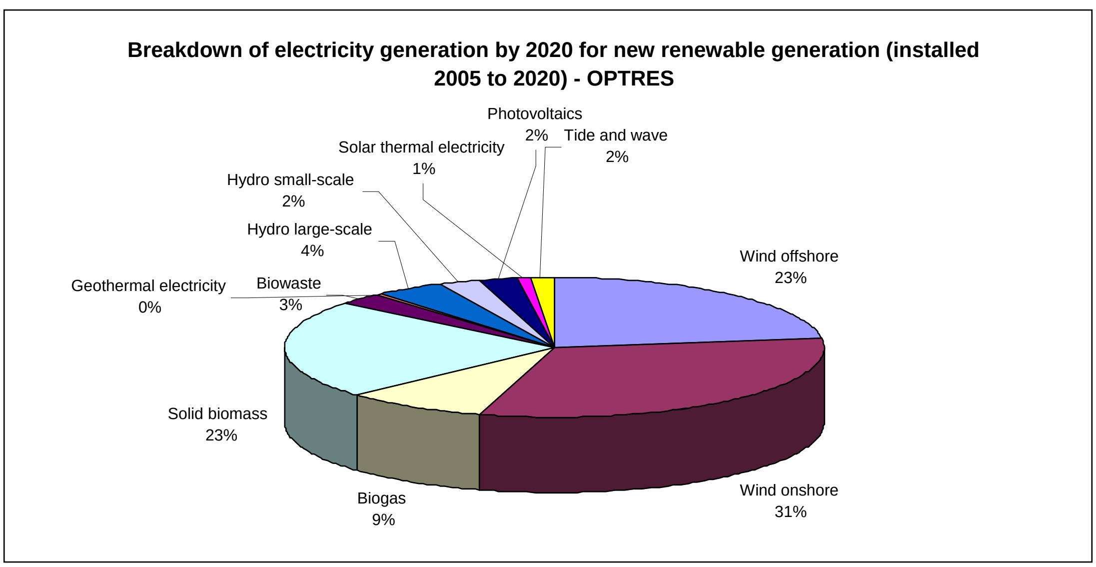
- A study for the Commission estimates the level of contribution different forms of newly installed renewables will need to make in order to reach the 2020 targets. The findings are set out in the pie-chart below:



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- The study seems to rely heavily on two assumptions. First, that "improved national policies" for subsidizing renewables are implemented, with a view to harmonization by

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[29] Data from Eurostat. Projections on electricity supply from EU Commission, Renewable Energy Roadmap (2007): "Electricity production from renewables could increase from the current 15% to approximately 34% of overall electricity consumption in 2020."

[30] OPTRES, pg. 69

2015. Second, that there will be a marked increase in the potential for solid biomass, and that this will play a big part in meeting the 2020 target. "Improved national policies" and subsequent harmonisation are bold, and important, assumptions to make, given the report claims that these will deliver around 40% more capacity growth than a continuation of existing policies. As discussed in 1.3, there are a wide range of subsidy systems in operation across the EU, some much more effective than others. It is not clear that we will see improved performance of subsidy systems (the UK's latest proposals for reform of its subsidy mechanism could be a step back), and harmonisation seems undesirable (see 1.3), particularly as subsidies to renewables may be problematic in themselves (as argued in 1.3, 1.4 and 1.5). The notion that there will be a huge leap in biomass capacity in the run-up to 2020 is also dubious, given that the same study indicates that current biomass capacity is at its full potential.[31] Europe Economics' estimates for energy crop use (as a power station fuel) show lower costs per tonne of carbon saved than liquid biofuels (for use in transport), but the costs are still both too high and too uncertain to be of any encouragement. Even if we assume that it is feasible to tap new biomass potential through increased agricultural and forest yields, this would be extremely concerning in itself. As section 2 argues, shifting to biofuels brings with it a host of serious environmental and social problems.

- The EU needs to shift around 730 Twh of generation capacity to renewables to meet the 2020 target. On top of around 50Twh of estimated additional large-scale hydro capacity, it is thought that there is around 220 Twh potential for further on-shore wind generation capacity[32], which may be cost effective by 2020 (in terms of undercutting the official social cost of carbon), but still far more expensive than other alternative carbon abatement options. Around 260 Twh of offshore wind power may be available – but as Europe Economics' figures show, it is still very uncertain how much this would cost, and whether this will be below the social cost of carbon. Even if the potentials for wind and hydro were to be fully realised, and the challenges of intermittent power supply from wind (discussed below) could be overcome, the EU would still be 200 Twh short of meeting its target. After this point, far less cost-effective technologies would become the only option.

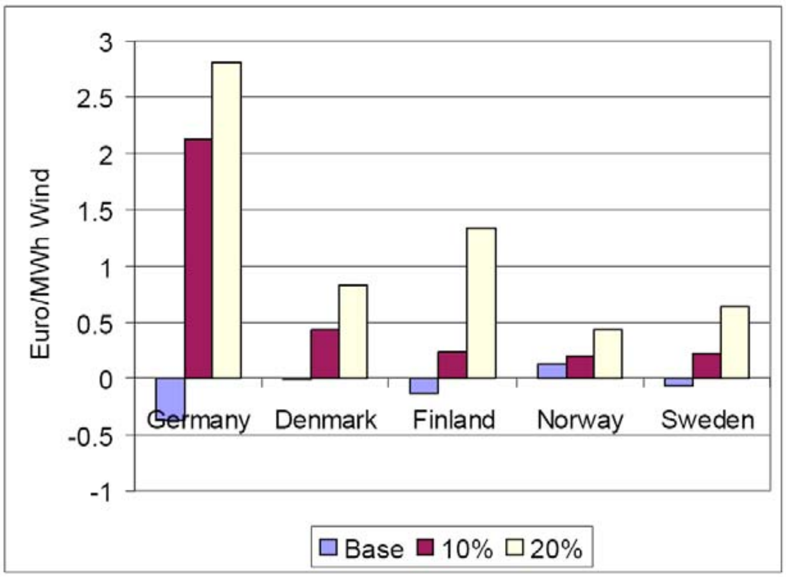
- Fundamentally, it is misguided to set a minimum binding capacity for a given policy in advance because the marginal costs per tonne of achieving carbon reductions through that particular policy will increase as the opportunities to realise cheaper options within these boundaries become progressively diminished, notwithstanding technological developments. The Commission acknowledges this problem: "The additional production costs are highest in the year 2020 due to the costs rising over time as more renewables are developed."[33] As on-shore wind generation potential becomes increasingly scarce, and more costly, investment will be forced towards more expensive options such as off-shore wind farms, irrespective of whether this extra expenditure could be better spent on achieving greater emissions reductions through other means.

- If wind generation is to account for the majority of expansion in renewable capacity, this could also raise serious issues surrounding reliability of supply. Wind farms are an intermittent generation method – they will not work at full production capacity all of the time, for obvious reasons. This is not much of a problem if wind is only a small

[31] OPTRES, pg. 69
[32] OPTRES pg. 69
[33] EC Renewable Energy Roadmap Impact Assessment (10.01.07) pg. 16

proportion of overall energy mix. But the more overall generation capacity becomes dependant on wind, the greater the risks posed by its intermittent nature. Beyond around 10% penetration of wind power into an electricity network, intermittence becomes a problem.[34] The Commission predicts that under the 2020 targets, 18% of EU electricity generation would come from intermittent sources, mostly wind.[35] Higher penetration of wind generation will mean higher system operating costs, reflecting the increased cost of balancing supply and demand that comes with dealing with less predictable supply sources. Studies have demonstrated dramatic increases in operating costs with increased proportions of wind power in the national energy mix, as the graph below shows:

Cost of integrating different penetrations of wind power[36]



- Because of intermittence, wind has to be backed up by conventional fossil fuel generation which will take up the burden of generation when there are dips in wind strength. This of course means higher costs. Costs for backup power supplies depend on the amount of notice that needs to be given before the alternative source 'kicks in', the most expensive method being 'spinning reserve', which can be brought online at very short notice – within just a few minutes or even seconds. 'Spinning reserve' refers to the practice whereby fossil fuel power station machinery is still effectively in motion (burning fuel, and producing emissions) but without actually generating electricity. When demand increases, the generation function is switched on, and combustion ramped up. Since wind is relatively unpredictable, spinning reserve must play an

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[34] *Design and Operation of Power Systems with Large Amounts of Wind Power, first results of IEA collaboration*, Global Wind Power Conference September 18-21, 2006, Adelaide, Australia
[35] EU Commission, *Renewable Energy Roadmap* (10.01.07)
[36] Source, EU project Greennet EU-27, cited in "Design and Operation of Power Systems with Large Amounts of Wind Power": "The integration costs of wind is calculated as the difference between the system operation costs in a model run with stochastic wind power forecasts and the system operation costs in a model run where the wind power production is converted into an equivalent predictable, constant wind power production during the week. If the realised wind power production in one week has a positive correlation with the load variations, it can happen that in fact in this week the integration costs are negative. This is most likely to happen for low amounts of wind power, and did in fact occur in the Base case."

important part in balancing power supplies if wind penetration is high. As Graham Sinden of Oxford's Environmental Change Institute notes, "The UK electricity system has never operated without fossil fuel backup, and never will. The relevant question is: how much additional backup is required because of wind? At current levels, none at all, at 10 per cent it starts to be noticeable, and at 20 per cent or more the costs are significant."[37]

- Sinden believes that the problems of intermittency can be mitigated through 1) diversification of geographic locations of wind turbines and 2) diversification in types of intermittent renewable sources – for example, more photovoltaic energy.[38] There is no reason to doubt that this could help to alleviate intermittency risks and costs of backup, but on the other hand these strategies would still lead to higher costs through the need for more transmission infrastructure (required to deliver power from more remote areas to power consuming areas) and required investment in more expensive technology – photovoltaic in particular being extremely costly.

1.3 - Some subsidy systems are better than others - but none are perfect

- There are a variety of different subsidy systems for renewables across Europe, but two dominate: quota-based systems, and those based on feed-in tariffs.

- The UK is among a minority of European countries that use a quota-based system. Introduced in 2002, this is known as the Renewable Obligation (RO). Electricity suppliers are obliged to source a progressively increasing proportion of their electricity from renewable sources (in 2006/07, this was 6.7%). The system works on the basis of Renewable Obligation Certificates (ROCs) being awarded to renewable electricity generators. One ROC is awarded per MWH of electricity produced. These are then sold on to the electricity suppliers, and count towards their compliance with the RO target. If the supplier is unable or unwilling to meet the RO target through purchase of ROCs, they have the option of meeting that obligation through a 'buy out' – which currently stands at £33.24 per MWH. The money from these buy outs are then 'recycled', paid back to suppliers in proportion to the amount of ROCs they have presented.

- One major problem with ROCs and other 'green certificate' type schemes implemented in other European countries is the relatively high risk factor attached to them. Risk carries a premium, and therefore adds to the cost of a given subsidy scheme. A quota system such as that of the UK is inherently driven by the size of the quota, and the closer renewable use comes towards meeting the quota target, the higher the risk that renewable use will 'overshoot' the target. If this were to happen, investors in renewable projects would be unable to sell their ROCs, as demand would have dried up. Consequently, the more renewable generation capacity is built, the lower prices will be. In this sense, quota-based systems create an incentive to build less renewable capacity rather than more. [39] Neuhoff and Butler argue that in the UK, the risk results in a premium on the capital costs, or rate of return, that is required and thus increases the costs per wind turbine by 30%.[40]

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[37] *Oxford Today*, Volume 17 Number 2, Hilary 2005

[39] Mitchell, C, Bauknecht, D & Connor, PM. "Effectiveness through Risk Reduction: A Comparison of the Renewable Obligation in England and Wales and the Feed-In System in Germany"
[40] Butler, L, Neuhoff, K (2004): *Comparison of feed-in tariff, quota and auction mechanisms to support wind power development*. Working Paper, University of Cambridge

- Due to higher capital costs in Britain only a few highly capitalised, integrated energy companies are generally able to undertake the risk of investment. Large generation companies can often simply sell their ROCs to their own in-house suppliers, making the market less liquid and competitive.[41]

- Feed-in tariffs work on the basis of statutory requirements on utilities to pay privately owned power generators a premium for electricity generated from renewable sources. These have been extremely successful at fostering renewable investment in countries such as Germany. The success of this policy is owing largely to the long-term certainty that a fixed-price tariff can provide for renewables investors. Feed-in systems do not have volume or price risk because generators know that all their output has to be purchased at a set price.[42]

- Feed-in tariffs have the disadvantage, however, in that the state must necessarily choose the "right" price for subsidy. If this is set too low, there will be limited incentives for investment in renewables. If it is set too high, unnecessary costs would be passed on to consumers, and resources will be wasted. OFGEM argues that because the price of tariffs is fixed, they reduce incentives towards price minimisation.[43]

- No subsidy mechanism is perfect, and must inevitably involve the state picking winners. The UK's method of subsidy for renewables is particularly deficient, and if the government does choose to continue with the policy of subsidising renewables, it would do well to look at a feed-in system along the lines of that implemented in Spain and Denmark. Its latest proposal for a 'banded' system of ROCs is likely to make renewables subsidies even more costly – the last thing Britain needs given the EU renewables target. Banded ROCs, because they favour certain technologies, would also mean that the trend of picking winners would become even more conspicuous and risky.

- The fundamental flaw faced with any subsidy system is the inherent difficulty of ensuring that the level of support reflects accurately the real additional costs of generation. Since these alter in response to fossil fuel prices, geographical location and technological change, it is very difficult to create a system of subsidy that provides both long-term price certainty (which the contrast between the UK and Germany shows is crucial) and the responsiveness to reflect the actual cost of developing renewables technologies. For this reason, as section 4.2 argues, a simple carbon tax may be a preferable option to the complex system of direct subsidies for renewables that prevails in Europe.

- The EU Commission's draft proposals contain measures that will allow so-called guarantees of origin – a certificate allowing producers to trade their renewable energy within the 27-nation bloc. This could hypothetically mean a Maltese solar farm could produce electricity for use in France, if the receiving country does not have enough potential to meet its individual target or if it finds it too costly to produce such energy within its own borders. However, such a scheme could risk creating major distortions, as renewable producers in a given member state could choose to sell their electricity and

[41] C. Mitchell, D. Bauknecht and P.M. Connor, "Effectiveness through Risk Reduction: A Comparison of the Renewable Obligation in England and Wales and the Feed-In System in Germany"
[42] C. Mitchell, D. Bauknecht and P.M. Connor, "Effectiveness through Risk Reduction: A Comparison of the Renewable Obligation in England and Wales and the Feed-In System in Germany"
[43] Ofgem, *Response to BERR consultation on reform of the Renewables Obligation* (13.09.07)

export resultant green certificates into other countries with higher feed-in tariffs. This fear has already been voiced by the German Government.[44]

- Such a situation would undoubtedly create impetus for pan-EU harmonisation of subsidy systems and prices. The idea of a common EU feed-in tariff is of concern because it would reduce the ability to determine national energy priorities and to adapt to changing circumstances. Europe-wide feed-in tariffs would give the EU substantial new powers to influence electricity prices, and would be difficult to change should the need arise. If the EU sets a tariff that is too low or too high, the nature of EU policy-making would ensure that the mistake would be more difficult to resolve than it would be at national level.

1.4 Renewables targets are not compatible with emissions trading

- The EU Emissions Trading Scheme is supposed to be the EU's primary tool in fighting climate change. Our critique of the ETS (and emissions trading more generally) is set out in section 4.1 below. This section focuses on the ways in which the ETS interacts in a negative way with renewables targets – and vice-versa.

- A much-criticised aspect of the ETS is the manner in which it has been moulded as a means of covert industrial subsidy to some of Europe's worst polluters. As Karsten Neuhoff at the Carbon Trust has noted, free permit allocations are nothing less than a subsidy to fossil fuel generation, and are actively hindering moves to renewable generation. It seems clear that in order for subsidies for renewables to be in any way effective, the EU needs to stop giving allowances away free under the ETS.[45]

- Another concern that has previously been raised over binding renewables targets is that they contradict and undermine a quantity control mechanism like the Emissions Trading Scheme, because, by displacing electricity supply on the grid, the availability of carbon permits under the ETS will increase. [46] This would mean lower carbon prices, and hence more pollution from participants in the scheme.

- On account of this (and concerns over the cost of meeting the target) the UK government has suggested, in leaked documents, that Britain should seek to negotiate its way out of meeting a 20% renewables target for 2020. The documents offer a telling insight into official concerns over the contradictions in an EU climate change policy which simultaneously seeks to promote trading mechanisms as well as renewables targets:

  "*If the EU has a 20% GHG [greenhouse gas] target for 2020, the GHG emissions savings achieved through the renewables risk making the EU ETS redundant, and prices to collapse. Given that the EU ETS is the EU's main existing vehicle for delivering least cost reductions in GHG, and the basis on which the EU seeks to build a global carbon market to incentivise international action, this is a major risk.*

  Remedies to overcome this risk will be difficult to agree or ineffective. Expanding the scope of the EU ETS to include aviation emissions would not by itself create

[44] EUobserver (21.12.07)
[45] Carbon Trust, EU ETS Phase II allocation: implications and lessons (May 2007)
[46] See Open Europe, *Europe's Dirty Secret* (August 2007)

enough demand to overcome price collapse. Tightening EU ETS caps to reflect the renewables target imply taking EU wide emission reductions beyond the 20% GHG target which would be difficult to agree in the EU. Relying on later agreement to a 30% GHG target to rescue damage to the EU ETS is risky if 30% is not realised, and if not, clarity in 2009 or so this, would be very late for redesigning the ETS or renewables target in response."

- The paper goes on to say that UK officials have been actively lobbying the Commission to consider the "tensions" between the EU ETS and binding renewables targets.

- There is clearly little expectation that the ETS on its own will provide sufficient incentives for the massive investment in renewables necessary to reach the targets. However, if renewable use is to be enforced by other means, whether through subsidy or regulation, the overall scarcity of carbon credits tradable in the ETS will decline, along with the price of carbon and any resulting incentive to reduce emissions through the ETS.

- The interaction between renewables targets and the ETS suggests that EU climate change policy has not been considered in a coherent or rational way. Member States have essentially agreed to a series of mutually contradictory policies which will ultimately undermine the end objective of reducing emissions.

1.5 – EU renewable targets pick winners, directing investment away from more cost-effective options

- **Renewables undoubtedly have a role to play in combating climate change, but the 20% target is an ill-founded, premature and arbitrary judgement on the level of contribution they should make.** The interlinked EU targets for renewable energy and biofuels risk making artificial technology choices for the direction of investment in climate change mitigation.

- **What matters ultimately is the level of absolute reduction in greenhouse gas emissions.** Since global warming is a trans-national issue, it is entirely appropriate that legally binding targets for emissions are set at an international level – whether through the EU, the UN or by other means. But there is no logical reason why targets for national energy mix choices should be made at EU level, especially when these targets appear to artificially tilt resources for fighting climate change away from more cost effective options, such as those discussed in sections 3 and 4 of this report.

- Simple targets for carbon reductions would not preclude the possibility of pursuing ambitious renewable energy investment at national level, which indeed may up to a certain point be cost effective in some member states, such as with wind-power in Denmark. This would allow different member states to judge what policy works best in terms of the real objective of cutting carbon emissions, and is most cost effective in their particular national circumstances. Renewables investment could well be stimulated as a result of other policy instruments, such as a carbon tax – but this would at least allow the market to investigate whether more cost effective options for carbon abatement are available first, rather than being railroaded into making economically and environmentally unsound choices – as seems probable with the EU targets.

- It would be foolish to deny that in the future it is possible that renewables could become more cost efficient, perhaps to the point that they can be economically justified as a key tool in the fight against climate change. But this has not been achieved yet, and can only happen through substantial technological improvements. There is no justification for the EU prescribing national energy policy as is proposed through its target for minimum renewables use. Attempting to achieve the target is likely to be a hugely costly and perhaps impossible undertaking – it will be a misallocation of valuable resources in the fight against climate change.

2 - Biofuels

2.1 Renewable energy targets drive biofuels use – expensive, harmful, unpredictable

> "*Corn grain is as much a carbon-based fuel as petroleum, wood or coal are… To accelerate the contemporary plant growth, a significant subsidy from ancient plants is used*."
>
> Tad Patzek, Professor in Civil and Environmental Engineering, University of Berkeley

- Biofuels are a central part of the EU's climate change strategy. The EU Spring Council, meeting 8 - 9 March 2007, proposed, as part of a broader energy package, mandatory targets for 10% use of biofuels in all road transport fuel by 2020 – this commitment to biofuel use is 'integrated' within the EU's 20% overall renewable energy target. This almost doubles the current (non-binding) target of 5.75% by 2010. This proposal was presented as a major step to combat climate change.

- One of the most frequently cited justifications for biofuel targets is the ability of this energy source to cut carbon emissions, and consequently fight global warming. Biofuels are sometimes described as being carbon neutral, as those emissions that do take place as a result of their combustion are already part of the current 'carbon cycle'. In other words, the carbon dioxide produced is recycled between existing biomass, as opposed to fossil fuel combustion which releases into the atmosphere ancient carbon reserves buried beneath the earth's surface for hundreds of millions of years.

- However, in reality, biofuel production is not carbon neutral – and in some cases could be even worse than fossil fuel combustion. First of all, the production of refined biofuels (whether ethanol or biodiesel) requires considerable energy inputs. There is still an active debate as to the extent to which biofuels save carbon, and indeed whether certain biofuels contribute to any net carbon saving *at all*. In an impact assessment published the year before biofuel targets were agreed, the Commission acknowledged that "**With ranges of uncertainty for all three fuel chains averaging 30-40 percentage points, nothing definitive can be said about the average amount of greenhouse gas savings".**[47] The table below (contained in the Commission report) contains a range of estimates on carbon savings from biofuels:

[47] European Commission, An EU Strategy for Biofuels Impact Assessment (2006)

Reduction of greenhouse gas (GHG) emissions for biofuels from different European feedstocks as compared with fossil fuel emissions (EU Commission)			
source	**bioethanol from sugar crops**	**bioethanol from grain**	**biodiesel from rape**
VIEWLS – today[48]	20–73%	minus 21% to plus 32%	18–64%
VIEWLS – for 2010[49]	35–72%	16–64%	7–74%
Sheffield Hallam[50]	47–54%	62–67%	51–55%
Imperial College[51]	minus 11% to plus 63%	5–68%	48–80%
Concawe/Eucar/JRC[52]	37–44%	minus 6% to plus 43%	16–62%
PWC[53]	40–60%	40–70%	50–70%
IEA[54]	34–55%	18–46%	43–63%
ADEME[55]	75%	75%	74%

- The merits of corn-based ethanol (currently the most favoured biofuel in the US) are particularly questionable. As Tad Patzek, Professor in Civil and Environmental Engineering at Berkeley notes, "Corn grain is as much a carbon-based fuel as petroleum, wood or coal are… To accelerate the contemporary plant growth, a significant subsidy from ancient plants is used." Patzek argues that production of corn ethanol is 3 to 4 times less efficient relative to gasoline or pulverised coal, due to the lack of concentration and transformation of chemical energy achieved in current biomass – "given 10^8 years, crude oil or coal became almost pure automotive or power station fuels, whilst corn grain created in 100 days is far from being pure ethanol".[56] His studies show that "excluding corn grain/ ethanol transportation energy, it takes 5 times more fossil energy to produce corn ethanol in the best biorefinery than gasoline or diesel fuel from crude oil in an average refinery."[57]

- Patzek and Pimentel argue in a 2006 paper that "Our up-to-date analysis of the 14 energy inputs that typically go into corn production and the 9 invested in fermentation and distillation operations confirms that 29 percent more energy (derived from fossil

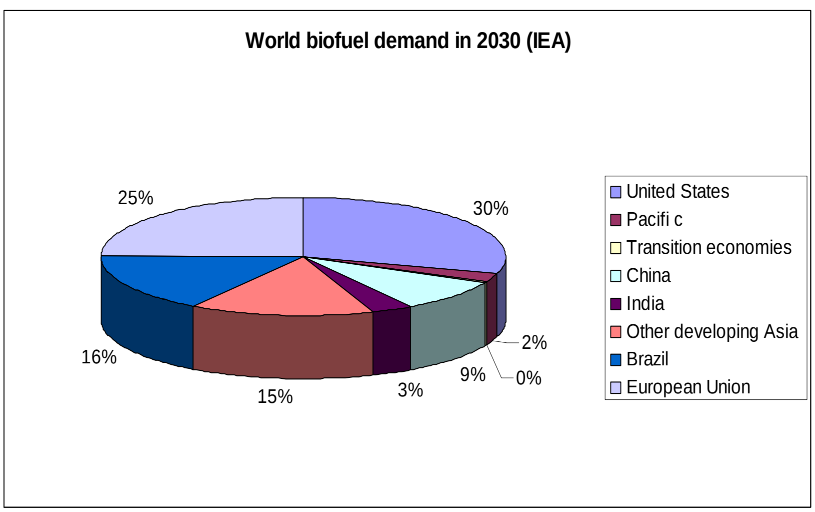
[48] VIEWLS (2005): Environmental and Economic Performance of Biofuels.
[49] VIEWLS (2005): Environmental and Economic Performance of Biofuels
[50] Sheffield Hallam University (aggregation of various work by Nigel Mortimer).
[51] Imperial College, London (aggregation of various work by Ausilio Bauen/David Hart).
[52] Concawe, Eucar, JRC Ispra: Well-to-Wheel analysis of future automotive fuels and power trains in the European context. 2005. http://ies.jrc.cec.eu.int/WTW.
[53] Price Waterhouse Cooper (2005): Biofuels and other renewable fuels for transport. A study commissioned by the Federal Public Service of Public Health Food Chain Safety and Environment, Brussels, Belgium.
[54] IEA (2004): Biofuels for Transport. An International Perspective.
[55] ADEME/PWC/DIREME (2002): Bilans énergétiques et gaz de serre des filières de production de biocarburants. Rapport technique, version definitive, Novembre 2002.
[56] Patzek, T. "The real biofuel cycles" *Online supporting material for Science letter*, Vol. 312, p. 1747 (26.06.06)
[57] Patzek, T. "The real biofuel cycles" *Online supporting material for Science letter*, Vol. 312, p. 1747 (26.06.06)

fuels) is required to produce a gallon of corn ethanol than is contained in the ethanol". Patzek explains that "The energy cost of producing and refining carbon fuels in real time, for example, corn and ethanol, is high relative to that of fossil fuels deposited and concentrated over geological time. Proper mass and energy balances of corn fields and ethanol refineries that account for the photosynthetic energy, part of the environment restoration work, and the coproduct energy have been formulated. These balances show that energetically production of ethanol from corn is 2-4 times less favorable than production of gasoline from petroleum. From thermodynamics it also follows that ecological damage wrought by industrial biofuel production must be severe… Equivalent CO_2 emissions from corn ethanol are some 50% higher than those from gasoline, and become 100% higher if methane emissions from cows fed with DDGS [Dried Distillers Grains] are accounted for."[58]

- Patzek places great emphasis on what he calls the fossil fuel "subsidy" that is intrinsic to modern, mechanised intensive agricultural methods: "If one compares a corn field with a prairie, one concludes that the prairie runs on sunlight, whilst the corn field runs on fossil fuels." [59] This analogy becomes particularly striking when considering the industrialised and carbon intensive manufacture of agrofuels.

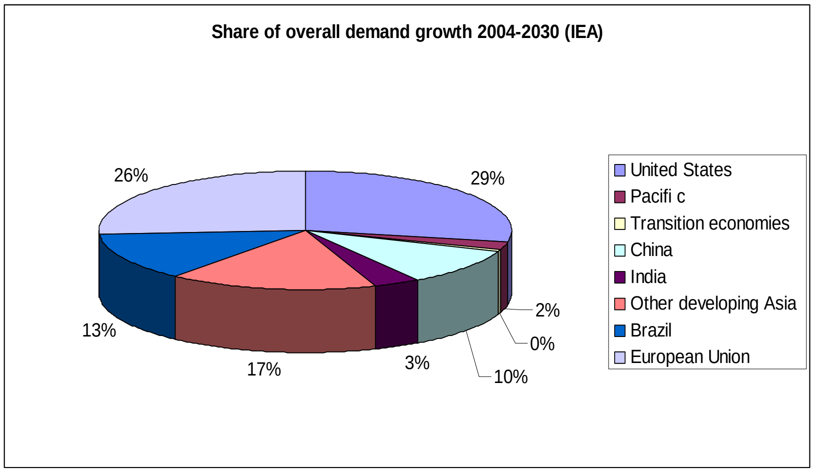
2.2 - How big a share will the EU have in this?

- Up until now, the US has been the dominant force behind soaring biofuel demand. As a result of the new targets however, the EU is set to catch up rapidly. According to the International Energy Agency (IEA), the EU will account for 25% of world biofuel demand by 2030, only slightly below the 30% expected from the US. In terms of demand growth, the EU will account for 26% against the US's 29%. The US and EU are by far the most significant drivers of biofuel demand, and on current trends will account for the majority of both absolute demand and demand growth over the coming decades.



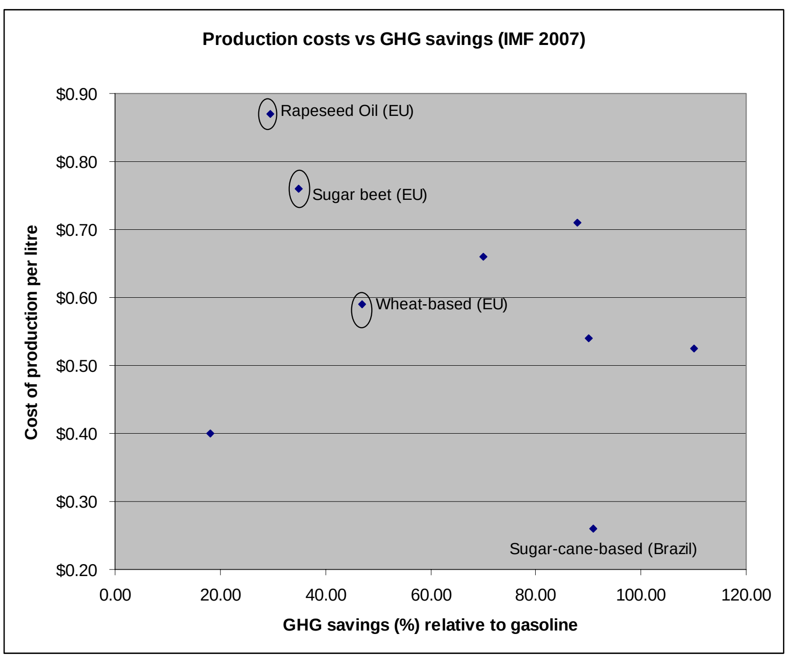
[58] Patzek, T. "A First-Law Thermodynamic Analysis of the Corn-Ethanol Cycle" *Natural Resources Research*, Volume 15, Number 4, December 2006 , pp. 255-270(16) and

[59] Patzek, T. "The real biofuel cycles" *Online supporting material for Science letter*, Vol. 312, p. 1747 (26.06.06)

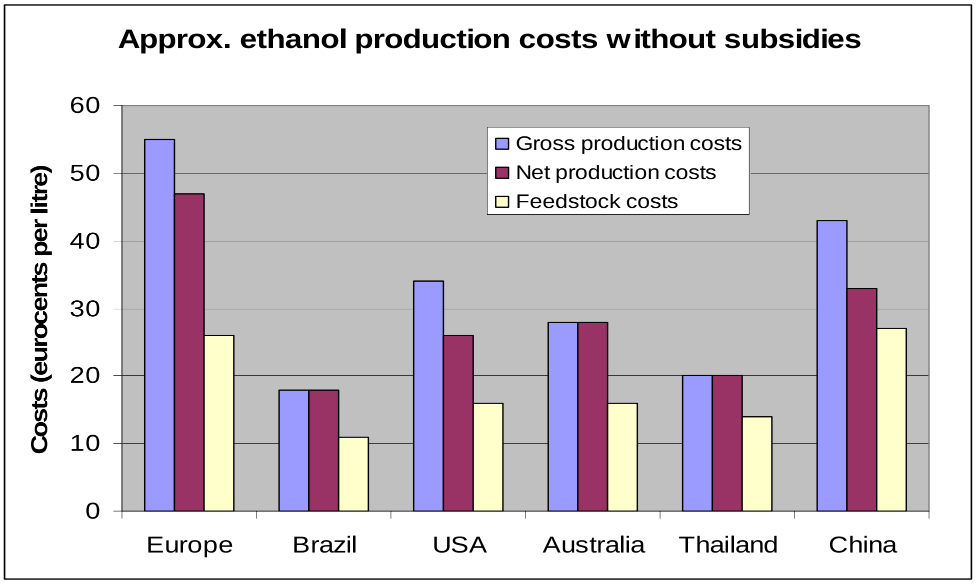


2.3 - The EU is one of the worst places in the world to produce biofuels – an environmental and economic negative

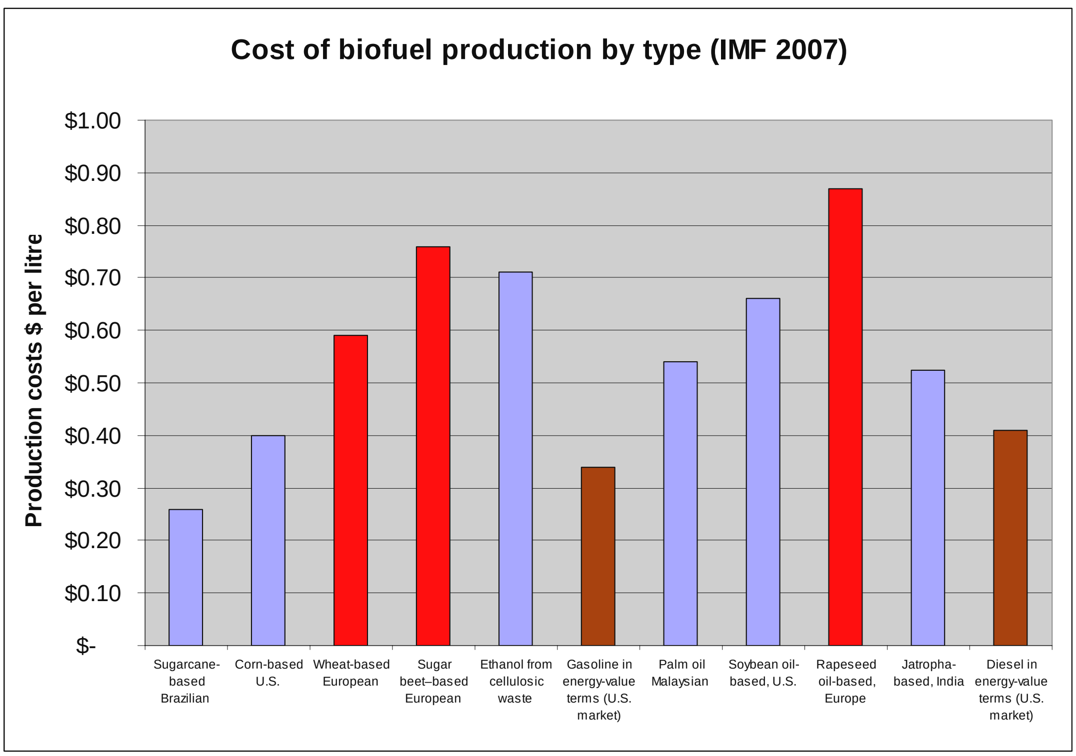
- The economics of biofuel production is intrinsically linked with the efficacy of biofuels in bringing about carbon mitigation. Where a process is inefficient, this means that the energy input costs of that process will in turn be high – implying higher levels of necessary fossil fuel input. If we compare the cost of biofuel production against the potential greenhouse gas savings (using IMF figures), there is a clear correlation between the two. European production is shown to be far inferior to that of Brazil by this measure.



- Because tropical climates are far more efficient at producing fuel crops, it follows that the level of fossil fuel 'subsidy' required to release the energy of tropical crops must be lower than that required for the equivalent process in temperate climates. Consequently, in terms of fighting climate change, Europe is one of the worst places in the world for producing biofuels. Economists Oliver Henniges and Jurgen Zeddies argue that "Reducing emissions of greenhouse gases is only a secondary goal because the net energy efficiency of the biofuel crops grown in Europe is low. Thus the biofuel industry has much higher carbon abatement costs than do some other fields of energy use." [60]



[61]



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[60] Henniges, O & Zeddies J. "Economics of bioethanol in the Asia-Pacific: Australia – Thailand – China" in *FO Licht's World Ethanol and Biofuels Report*, Vol 3. No.11 (2005) Figure shows a standardized comparison of the gross and net production costs of ethanol for a 200-million-liter plant. The gross costs include investment costs, variable costs like feedstock and processing, and a risk factor growing and processing technologies and its relatively low taxation of the fossil fuels used in biofuel production.
[61] *Ibid*.

- The EU Commission was fully aware that Europe would be an inefficient producer of biofuels, but nonetheless pushed ahead with the plans for binding targets. The Commission's 2006 strategy paper acknowledged that "Most available studies indicate that the abatement costs of EU-produced biofuels are quite high compared with the current 'carbon price'. This means that EU-manufactured biofuels are currently not the most cost-effective way to reduce greenhouse gas emissions."[62]

- To make matters worse, growing biofuels in high cost locations will inevitably mean a squandering of economic resources, which could be spent more productively in fighting climate change. Europe is an extremely bad place to grow biofuels – even the poorly performing US is more efficient. That means a European biofuel industry cannot be viable without political support by means of tariffs and subsidies, and consequently the cost of these flawed policies will be borne respectively by consumers and taxpayers.

2.4 - Biofuels in Europe – huge costs, and a new form of farm subsidy

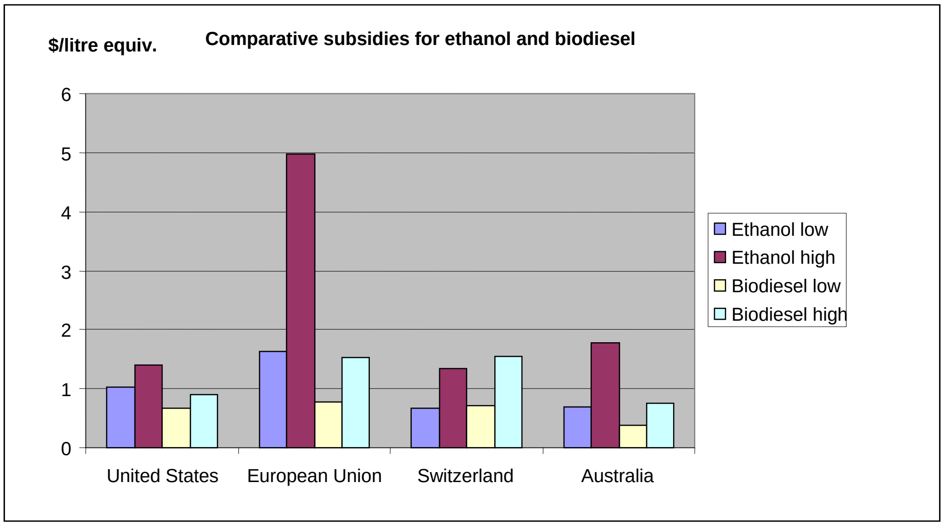
> "*The EU maintains significant import protection on some types of biofuels, notably ethanol which has a tariff protection level of around 45% ad valorem*."[63]
>
> EU Commission

- The EU already has the protectionist trade defence instruments in place necessary to give effective subsidies to its biofuel industry. There is a comprehensive system of subsidies in place for biofuel production in Europe, as an extensive study by the Global Subsidies Initiative notes:

  - Excise tax exemptions amounted to € 3 billion in 2006. This is a cost that represents foregone state revenues on fuel taxes. It is permitted by Directive EC 2003/96 on Energy Taxation, which allowed Member States to exempt or reduce excise duties so as to compensate for the higher costs of producing biofuels. In this way, the EU is using a tax break loophole as a major subsidy mechanism for biofuel production.
  - The 2003 reform of the CAP introduced a specific area payment (€ 45 per hectare) for farmers who choose to cultivate energy crops. The EU spent €25.6 million on such payments in 2006.
  - Another new feature of the CAP reforms allows farmers to grow non-food crops (i.e., feedstock for biofuels) on set-aside land not being used for food production, whilst still receiving the area payment for the set-aside land. Farmers can earn an additional € 100–500 per hectare—depending on location—compared with retaining that land in fallow.[64]

[62] EU Commission, An EU Strategy for Biofuels Impact Assessment (2006)
[63] EC Renewable Energy Roadmap (10.01.07)
[64] Global Subsidies Initiative, *Biofuels – at what cost? Government support for ethanol and biodiesel in the European Union* (October 2007)

- A separate study from the GSI shows that the EU subsidises biofuels more than any other major producer:



[65]

- The GSI calculate that transfers to biodiesel in the EU equate to around 65% of the market value of the product, whereas for ethanol they are between 70 and 110%. They calculate that the cost of subsidizing one tonne of CO_2 equivalent emissions through biofuels is between €575 and €800 for ethanol made from sugarbeet, around €215 for biodiesel made from used cooking oil, and over €600 for biodiesel made from rapeseed.[66] As discussed above, inefficient biofuel processes mean more energy intensive production processes, and consequently less carbon abatement. Import tariffs levied on biofuels have a distortative effect on trade, in effect promoting inefficiency. Through biofuel protectionism the EU is giving a subsidy to increased carbon emissions.

- Europe Economics have calculated (based on figures from the IMF – the best available for the full range of biofuels) the likely additional costs of different types of biofuels in 2020, set out in the table below:

Estimated additional costs of biofuels in 2020 (Europe Economics/ IMF)		
Type of biofuel	1% reduction in UK emissions (£m)	£/tonne CO2
Ethanol, sugarcane-based, Brazilian high	-144	-29
Ethanol, sugarcane-based, Brazilian low	-65.6	-13
Ethanol, corn-based, U.S.	417.6	85
Ethanol, wheat-based, European	667.2	136
Ethanol, sugar beet-based, European	1510.4	308

[65] Cited in Doornbosch, R & Steenblik R. "Biofuels: is the cure worse than the disease?" Organisation for Economic Co-operation and Development, Round Table on Sustainable Development, Paris (11-12 September 2007)
[66] Global Subsidies Initiative, Biofuels – at what cost? Government support for ethanol and biodiesel in the European Union (October 2007)

Ethanol from cellulosic waste[67]	527.2	108
Biodiesel[68], palm oil-based, Malaysian high	98.4	20
Biodiesel, palm oil-based, Malaysian low	156	32
Biodiesel, soybean oil-based, U.S.	297.6	61
Biodiesel, rapeseed oil-based, Europe low	1009.6	206
Biodiesel, rapeseed oil-based, Europe high	1848	377
Biodiesel, jatropha-based[69], India high	201.6	41
Biodiesel, jatropha-based, India low	-4	-0.8

- Using Europe Economics' projections for the costs per tonne of carbon reductions using biofuels, and our estimates for the expected carbon savings, we estimate total additional costs of around €15 - 17bn pa in that year. The GSI estimates that total transfers to the biofuels industry in 2006 were already as high as €3.7bn in total, speculating that given a five-fold increase in the level of incorporation, a three-fold increase in total cost will occur – meaning annual subsidy costs €11bn in 2020. However, the GSI emphasises that this figure is almost certainly too low: "These are probably gross underestimates of the total amount of support provided, as many subsidies are underreported. No central database exists on their nature and scale… often key information is lacking, especially on support for capital investment."[70] It might also be added that simply scaling up current annual costs is not the most accurate way of calculating the future level of subsidy, given that the share of ethanol (which receives twice the 'per litre' subsidies of biodiesel) as a percentage of total EU demand is expected to double from around 23% today to 45% in 2020.[71]

Transfers to the EU biofuel industry in 2006 (GSI)			
	Units	**Ethanol**	**Biodiesel**
Total transfers	€ millions	1,290	2,436
Support per litre consumed	€ / litre	0.74	0.5
Support per gigajoule (GJ)	€ / GJ	35	15
Support per litre of petrol or diesel equivalent	€ / litre equivalent	1.1	0.55

- Using the method of multiplying GSI's 'per litre' costs by estimates for the expected total volume of EU production for both ethanol and biodiesel in 2020, together with a 20% cost discount for technology improvements, total subsidies would be around double

[67] This is a projected cost, as this technology has not yet been developed. The IMF believe it is 5 years away. Although there is reason to be sceptical over whether or not cellulose derived biofuels will become viable, we have used the IMF estimate for their hypothetical costs within our end cost estimates.
[68] Estimates for palm oil biodiesel assume best practices in land management and does not account for potential emissions caused by rain forest deforestation suggested by some environmental groups.
[69] As with cellulosic biofuels, jatropha-based biodiesel is still being developed.
[70] Global Subsidies Initiative, Biofuels – at what cost? Government support for ethanol and biodiesel in the European Union (October 2007)
[71] EU Commission, *The impact of a minimum 10% obligation for biofuel use in the EU-27 in 2020 on agricultural markets* (30.04.07)

the GSI's original estimate – at around €23bn. Given that estimates for total cost are still uncertain, we have set out a range in the table below:

	GSI prediction	OE/ Europe Economics low scenario	OE/ Europe Economics medium scenario	OE/ Europe Economics high scenario	OE (using GSI per litre costs)
TOTAL M£	8325	11110	11130	12400	17325
TOTAL M€	11100	14822	14847	16541	23051

- There are also other important subsidy effects associated with EU biofuel policy, which are more difficult to quantify. Government targets, as discussed below, have a hugely distortative effect on farm prices. Artificial targets, like that of the EU, can tilt farm prices in favour of the broader agricultural industry. The EU Commission's Joint Research Centre, in an unpublished paper, has said that "The costs [of the target] will almost certainly outweigh the benefits", saying that taxpayers would face a bill of €33bn-€65bn between now and 2020.[72] In light of both Europe Economics' estimates of the costs of biofuels and the GSI's calculations of existing annual costs, these figures are likely to be underestimates. What it clear is that an enormous level of subsidy will be required for such an ambitious biofuels policy, and that considerable uncertainty remains over just how much taxpayers will need to contribute. As argued elsewhere in this paper, uncertainty over costs and expected carbon savings is in itself a powerful argument against targets for specific technologies.

- Given that the interest groups created by such regimes are already well entrenched, reforming this situation may prove difficult, as the OECD comment:

  "*Trade between the efficient producers and OECD countries is therefore mutually beneficial. Nevertheless, it is also mostly absent as a result of the import tariffs and production subsidies that protect domestic consumers and keep prices artificially high. Liberalising the market will prove extremely difficult given the Gordian knot with agricultural markets that has since long been characterised by agricultural subsidies, high import tariffs, export subsidies and preferential treatment arrangements*."[73]

2.5 - Biofuels can only have a marginal impact on climate change

- Wherever and however they are produced, it is doubtful that biofuels have the potential to either displace a significant amount of conventional fossil fuels, or to make a serious contribution towards combating climate change. The OECD attempt to project the long-term effects of large-scale use of biofuels. They work from what they admit is an "overambitious" assumption that by 2050 (thanks to technology improvements) biofuels

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[72] Internal paper seen by *FT*, (18.01.07)
[73] Doornbosch, R & Steenblik R. "Biofuels: is the cure worse than the disease?" Organisation for Economic Co-operation and Development, Round Table on Sustainable Development, Paris (11-12 September 2007)

will reduce greenhouse gases over their lifecycle by 90% relative to gasoline, and on the basis that they will account for 20% of transport fuels by this date. They estimate that this would reduce global energy-related CO_2 emissions in 2050 by roughly 3.6% or 2.1 Gt of CO_2. In order to limit global warming to 2-3°C, CO_2-equivalent emissions need to be reduced by roughly 39 Gt of CO_2 in 2050.[74]

- If it is assumed that technological improvements deliver greater productivity, and that second generation biofuels do become commercially viable, Open Europe estimates that 10% biofuel use in Europe's transport would deliver only around 0.9 - 1.1% reduction in overall greenhouse gas emissions.[75] This also assumes that biofuels do not contribute to deforestation and land-use change – which is practically impossible given the sheer size of the targets (see 2.6 below). It is entirely possible that biofuel targets will lead to a net increase in atmospheric carbon. **Even under reasonably optimistic scenarios, the contribution of biofuels towards curbing global warming can only be marginal, if not irrelevant.**

- **Using biofuels to achieve such a meagre reduction is a serious misallocation of resources.** To give an indicative example, if our median biofuel cost projection of €15bn were to be spent on achieving a 1.1% reduction in emissions (or 58 million tonnes) were to be redirected towards reforestation projects, this would equate to 1.5bn tonnes of CO_2 being saved, almost 28% of the EU-27's total emissions.[76] Even investment in renewables for electricity production would be far better. Although future costs remain highly uncertain, as argued throughout this paper, even under current prices this level of investment in renewables would result in emissions reductions of 2 – 5%, or 120 – 260 million tonnes.

- In the following sections, we review the non-subsidy cost of biofuel targets. It should be emphasized that we have already seen many of the negative effects of biofuel targets on account of existing US policy. The EU targets are on a similar scale to those in the US, meaning that these existing effects can only be radically amplified, with potentially disastrous consequences for the environment and the world's poorest people.

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[74] Doornbosch, R & Steenblik R. "Biofuels: is the cure worse than the disease?" Organisation for Economic Co-operation and Development, Round Table on Sustainable Development, Paris (11-12 September 2007)

[75] Working on the assumption of 20% import mix; 45% ethanol and 55% diesel use; 30% second generation use (derived from European Commission, *The impact of a minimum 10% obligation for biofuel use in the EU-27 in 2020 on agricultural markets* (30.04.07) in upper estimate, 5% second generation use in lower estimate, and a 20% improvement in performance (as used by Europe Economics), a 10% substitution would imply around a 6.7% reduction in transport emissions, or 1.1% overall, assuming the share of transport in overall EU emissions holds steady at 17%.

[76] Based on Nicolas Stern's upper range estimate of £7.50 per/tonne CO_2 for reforestation.

2.6 - Such high targets for biofuels will mean deforestation – the effects of which outweigh any emissions avoidance of extra biofuel use

> "*If even five percent of biofuels are sourced from wiping out existing ancient forests, you've lost all your carbon gain*."
>
> Doug Parr, chief UK scientist, Greenpeace[77]

- Even if the most efficient biofuel technologies and plant types are used, there can be no escaping from the fact that scale of the targets adopted in both the US and the EU will necessitate substantial expansion in cultivation and deforestation – a process which would tip the environmental balance sheet firmly into the negative.

- The surge in demand for biofuel use in the developed world is already contributing to tropical rainforest deforestation. EU targets can only exacerbate this trend, and indeed some countries are already clearing land in anticipation. Indonesia has begun an ambitious programme for massive increases in palm oil cultivation, and is set to overtake Malaysia in 2007 and become the world's largest producer by 2008. These two countries aim to supply 20% of Europe's biofuels by 2009. In South East Asia, the market for biofuels is causing enormous destruction of rainforests.[78] Environmentalists say an estimated 16.8 million hectares of forest have been cleared for palm oil plantations in Indonesia – with only 6.3 million hectares actually planted with the crop.[79] The clearance of jungle to make way for plantations also often involves massive man-made forest fires. Earth Policy Institute President Lester Brown has warned that increased use of biofuels will lead to "very rapid deforestation, if no one intervenes. It is leading to a lot of land-clearing in the Amazon, Indonesia and Malaysia."[80]

- Forests store enormous amounts of carbon: in total, the world's forests and forest soils store over one trillion tonnes of carbon - about one and a half times that of the atmosphere. Deforestation by humans releases this stored carbon, and is therefore a major contributor to climate change. The Stern Review notes that agriculture and deforestation contribute 14% and 18% respectively of greenhouse gases. However, some believe this may be an underestimate. Forest clearance is particularly difficult to monitor accurately, and the FAO estimate that 25% of greenhouse gas emissions come about as a result.[81]

- One particular area of concern, again centring on South-East Asia, is the destruction of peatlands. These are huge stores of ancient carbon, and many have been earmarked for the coming expansion in palm oil plantations. According to Greenpeace, the tiny Indonesian province of Riau (Sumatra) stores a massive 14.6 billion tonnes of carbon – which is equivalent to one year's global greenhouse gas emissions. Riau's peatlands have already been severely damaged by palm oil plantation expansion.[82]

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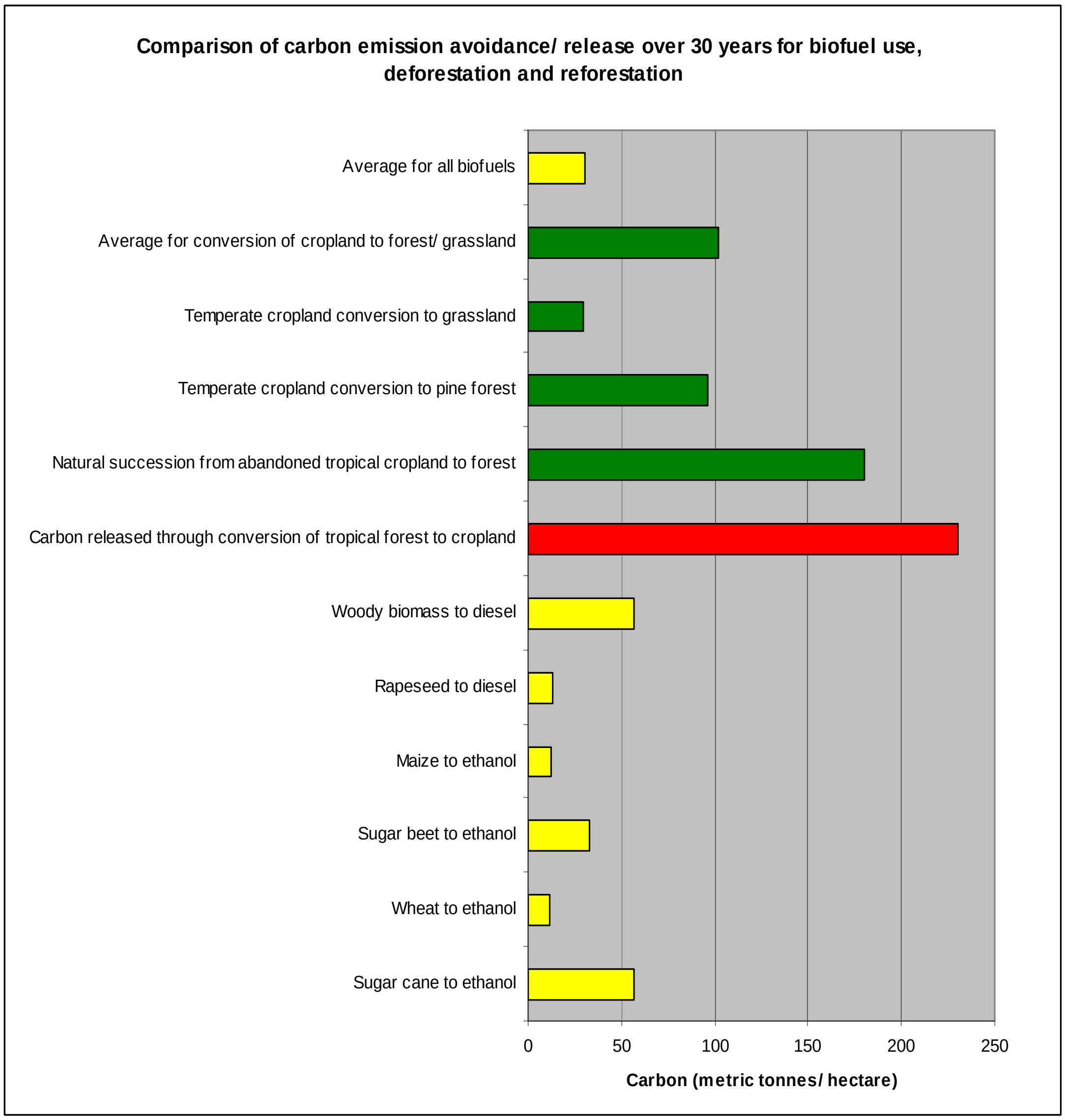
[77] http://petroleum.berkeley.edu/patzek/BiofuelQA/Brazil/food_first_backgrounder.htm
[78] Agence France Presse, 25 July 2007
[79] Agence France Presse, 25 July 2007
[80] Interpress Service, 27 July 2007
[81] Biofuelwatch et al. *Agrofuels - Towards a reality check in nine key areas* (June 2007)
[82] Greenpeace press release (08.11.07)

- Renton Righelato and Dominick V. Spracklen argue that the EU's targets for biofuel use will inevitably drive deforestation – resulting in **a net negative result in terms of carbon dioxide release**. They note that:

  "A 10% substitution of petrol and diesel fuel is estimated to require 43% and 38% of current cropland area in the United States and Europe, respectively. As even this low substitution level cannot be met from existing arable land, forests and grasslands would need to be cleared to enable production of the energy crops. Clearance results in the rapid oxidation of carbon stores in the vegetation and soil, creating a large up-front emissions cost that would, in all cases examined here, outweigh the avoided emissions."

  The graph below summarises their findings:



- Righelato and Spracklen believe that instead of forcing the pace of biofuels production, the EU would be better off preserving existing forests or planting new ones:

    "*forestation of an equivalent area of land would sequester two to nine times more carbon over a 30-year period than the emissions avoided by the use of the biofuel. Taking this opportunity cost into account, the emissions cost of liquid biofuels exceeds that of fossil fuels*."

- They conclude that:

    "*If the prime object of policy on biofuels is mitigation of carbon dioxide–driven global warming, policy-makers may be better advised in the short term (30 years or so) to focus on increasing the efficiency of fossil fuel use, to conserve the existing forests and savannahs, and to restore natural forest and grassland habitats on cropland that is not needed for food*."

- They note that forest preservation and reforestation have a number of clear environmental benefits in other respects – not least in terms of preserving biodiversity, an issue discussed in more depth below (section 2.8).

- A report from the UN backs up Righelato and Spracklen's findings, also stressing that biofuels are not guaranteed to reduce greenhouse gas emissions, and arguing that producing and using biofuels can only result in emissions reductions compared to petroleum fuels if no clearing of forest or peat is involved.[83]

- This was an issue the EU Commission was clearly aware of before the biofuel targets were agreed. The noted that:

    "*The use of bioethanol produced from sugar cane would give greater greenhouse gas savings. Brazilian production based on sugar cane reduces GHG emissions to 440 kgCO2-eq/toe compared with petrol emissions of about 4 400 kgCO2-eq/toe. However, additional production using for example virgin savannah could cancel out the GHG benefits for decades.*"[84]

- The Commission's impact assessment claims that Europe can meet the 10% target by using 18% of its current agricultural land. This is a very high figure in itself, but relies on the assumption that 20% of EU biofuel needs will be sourced from imports, and 30% will be from second generation biofuels. The Commission's land-use figure is questionable given that second generation biofuels do not yet exist, whilst the large import expectation should raise concerns over its implications for land-use change and deforestation.

- The simple carbon release caused by deforestation and agricultural conversion described above is only half the story, however. The process of land conversion in itself is believed to contribute towards complex feedback effects. Deforestation brings about an acceleration in the *rate* of climate change. The NGO Biofuelwatch argue that "There is strong evidence that the results of deforestation and ecosystem degradation can be non-linear, i.e. that both agricultural intensification and expansion could trigger large-scale,

[83] UN Energy, *Sustainable Bioenergy – A Framework for Decision Makers* (April 2007)
[84] EU Commission, An EU Strategy for Biofuels - Impact Assessment (2006)

irreversible ecosystem changes and possible collapse, causing irreversible climate feedbacks."[85] This means that during the interim time lapse before viable second generation biofuels are developed (it is uncertain they ever will be) it is likely biofuel demand would be met through tropical deforestation and agricultural conversion. The potentially large carbon release and effects of large-scale land change during that period risk taking climate change past the tipping point that would trigger such feed-back effects.

2.7 - Blind faith in 'second generation' biofuels that may not materialize

> "*Industry is either betting on miracles or counting on taxpayer bail-outs. Faith in science is not science.*"
>
> Eric Holt-Giménez, Executive Director, Institute for Food and Development Policy[86]

- The EU Commission, in line with scientific consensus, openly acknowledges the problems with 'first generation' biofuels, particularly corn-based ethanol. Nonetheless, the Commission places great emphasis on the development of 'second generation' biofuels, which it is hoped will lead to far greater carbon savings and higher productivity per hectare (which would in turn mean less pressure on food cultivation). But there is no scientific consensus on how soon (if at all) industrial supply of second generation fuels will be viable. The Commission's 2007 impact assessment simply assumes that one third of EU biofuel production will come from second generation sources by 2020, and concludes on this basis that pressure on European food production caused by energy crop cultivation will be moderate.

- This is a heroic assumption given that such technology has not yet been fully developed, and serious barriers still remain in making cellulosic ethanol production viable on an industrial scale. Patzek argues that there are "formidable obstacles" to the development of such a process:

  > "*close to one billion years of plant evolution have made cellulose very stable and resistant to biochemical attacks. Cellulose can be quickly decomposed and hydrolyzed only by mechanical grinding or steam exploding and severe chemical attack by hot concentrated sulfuric acid or sodium hydroxide. Biochemical enzymatic attacks take a long time and have low efficiency*."

  He concludes that "despite claims to the contrary, a real industrial process for lignocellulosic ethanol does not exist, and may never have a sufficiently favorable energy balance."[87] In his earlier paper, produced with David Pimentel, Patzek found that cellulosic biomass produced with current technology is even worse than that for corn-based ethanol, with 50 percent more energy being required to produce a gallon than the product can deliver.[88]

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[85] Biofuelwatch et al. *Agrofuels - Towards a reality check in nine key areas* (June 2007)
[86] http://petroleum.berkeley.edu/patzek/BiofuelQA/Brazil/food_first_backgrounder.htm
[87] Patzek, T. The real biofuel cycles" *Online supporting material for Science letter*, Vol. 312, p. 1747 (26.06.06)
[88] Pimental, D & Patzek, T. "Green Plants, Fossil Fuels, and Now Biofuels", in *BioScience* 875 (November 2006 / Vol. 56 No. 11)

- Eric Holt-Giménez, Executive Director, of the Institute for Food and Development Policy believes that "Major discoveries in plant physiology are required that permit the economically efficient breakdown of cellulose, hemi-cellulose, and lignin. Industry is either betting on miracles or counting on taxpayer bail-outs. Faith in science is not science."[89] The OECD are also sceptical as to whether second generation biofuels can become economically or technologically viable:

  "*As second-generation technologies are still in the demonstration phase, it remains to be seen whether they will become economically viable over the next decade, if ever. Even with positive technological developments there are serious doubts about the feasibility of using residue material* [such as wood from forestry projects] *as biomass feedstock on a large scale. The logistical challenge of transporting biomass material to large production facilities is likely to impose a floor below which production costs cannot be lowered. This leads some to believe that the second-generation biofuels will remain niche players, produced mainly in plants where the residue material is already available in situ, such as bagasse (cellulosic residue from sugarcane pressing) and wood-process residues.*"[90]

- Others disagree, believing that it will be possible to attain industrial scale production of cellulosic ethanol. Henning Jørgensen, Jan Bach Kristensen and Claus Felby admit that "a number of technical and scientific issues within pretreatment and hydrolysis remain to be solved", but that "significant improvements in yield and cost reductions are expected, thus making large-scale fermentation of lignocellulosic substrates possible."[91]

- One view is that cellulosic ethanol production may be viable in theory, but that there is still a long way to go in terms of developing the necessary technology. Cassman and Liska predict that commercially viable, large scale production techniques are at least 7–10 years off. In the meantime, food prices are expected to rise rapidly.[92]

- Clive Bates, at the UN Environment Programme (UNEP) is sceptical of the EU approach, arguing that:

  "*the stand-by excuse of technology-promoting scoundrels everywhere is that we need big subsidies now to prepare for the brave new dawn tomorrow. I agree you need an innovation system - but it's not obvious that you get to cheap second-generation biofuels via lavish subsidies for a very large uptake of expensive dead-end first generation biofuels. For now, the best transport responses are fuel efficiency and changes in driver behaviour. Longer term it's about mobility demand and the physical layout of our lives.*"[93]

- Even if a process can be found to mass produce second generation biofuels, it still remains uncertain whether this is compatible with sound forest management as a means of curbing carbon emissions. Miko U.F. Kirschbaum argues that there are problems associated with maintaining forests simultaneously as carbon stores and effective fuel

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[89] http://petroleum.berkeley.edu/patzek/BiofuelQA/Brazil/food_first_backgrounder.htm
[90] Richard Doornbosch and Ronald Steenblik, "BIOFUELS: IS THE CURE WORSE THAN THE DISEASE?" Organisation for Economic Co-operation and Development, Round Table on Sustainable Development, Paris (11-12 September 2007)
[91] Jørgensen, H, Kristensen, J & Felby, C. "Enzymatic conversion of lignocellulose into fermentable sugars: challenges and opportunities" *Biofuels, Bioprod. Bioref.* (22.05.07)
[92]Cassman, K. & Liska, A. "Food and fuel for all: realistic or foolish?" *Biofuels, Bioprod. Bioref.* 1:18–23 (2007)
[93] Bates, C. Blog (14.11.07)

reservoirs, which is what would be required in the scenario of high usage of lignocellulosic ethanol: "forests store the most carbon when they remain undisturbed and are allowed to grow to maturity, whereas using wood for bioenergy requires wood removal from forests, which reduces on-site carbon storage. Hence, it is difficult to manage a forest simultaneously for maximum carbon storage and supplying fuelwood".[94]

- What is certain is that a great deal has been staked on non-existent future technologies, the development of which is highly uncertain.

2.8 - Increased biofuel production means environmental degradation beyond climate change

- Water shortages are set to be a major problem associated with large-scale biofuel cultivation, both in environmental and social terms. As cultivation is expanded to meet demand for biofuels, increased strain will be placed on already scarce water resources. According to Pimental and Patzek, each gallon of ethanol requires 1700 gallons of water (mostly to grow the corn) and produces 6 to 12 gallons of noxious organic effluent (which pollutes clean water sources).[95]

- This is likely to be a danger in Africa, large parts of which have been earmarked for future biofuel production. As well as the obvious effects of water shortages on food supplies (which could exacerbate the upward pressure of biofuels on food prices described below), water can also fuel conflict. A recent report from the UN argued that the Darfur conflict has been partially driven by disputes over water, and predicts that the potential for conflict in this region and across Africa is likely to increase as competition for water resources increases. According to Achim Steiner, the UN Environment Programme's Executive Director, "It doesn't take a genius to work out that as the desert moves southwards there is a physical limit to what [ecological] systems can sustain, and so you get one group displacing another."[96]

- Pimental and Patzek argue that the broader environmental impacts of biofuels are "enormous". These include severe soil erosion, fertilizer and pesticide use. Unlike crops which are grown for food, there is no consumer demand to reduce chemical interference in crop production – all that matters is maximizing output. [97]

- The OECD offers this summary of the wider environmental effects of biofuels:

  "*The growth of the biofuels industry is also likely to place pressure on the environment and biodiversity. Biomass feedstocks can be most efficiently produced in tropical regions, where suitable and available land is mostly concentrated, and annual yields are highest. However, as long as environmental values are not adequately priced in the market there will be powerful incentives to replace natural ecosystems such as forests, wetlands and pasture land with dedicated bio-energy crops, thus harming the environmental credentials of biofuels… When such*

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[94] Kirschbaum, M. "To sink or burn? A discussion of the potential contributions of forests to greenhouse gas balances through storing carbon or providing biofuels", *Biomass and Bioenergy* 24 (2003) 297 – 310
[95] Pimentel, D & Patzek, T. "Green Plants, Fossil Fuels, and Now Biofuels", in *BioScience* 875 (November 2006 / Vol. 56 No. 11)
[96] Guardian (23.06.07)
[97] Pimentel, D & Patzek, T. "Green Plants, Fossil Fuels, and Now Biofuels", in *BioScience* 875 (November 2006 / Vol. 56 No. 11)

> *impacts as soil acidification, fertilizer use, biodiversity loss and toxicity of agricultural pesticides are taken into account, the overall environmental impacts of ethanol and biodiesel can very easily exceed those of petrol and mineral diesel.*"[98]

- The EU Commission has long been aware of the serious environmental impacts of large-scale biofuel cultivation. They acknowledge that increased production of crops for fuel, rather than food, make the situation much worse:

> "…*soil and water quality and biodiversity are all affected by the use of chemical inputs. The general use of chemicals could go up on the overall crop area if the increased demand for agricultural biomass cannot be met otherwise, in particular in the short to medium term*…Some of these environmental pressures are similar to those exerted by current cropping practices on non-biofuels, but may be exacerbated if biofuel production expands… *growing demand for biofuel feedstocks is likely to seriously increase environmental pressures in some producer countries outside the EU. Specific examples are large scale expansion of sugar cane (Brazilian savannah), palm oil (South East Asian rainforest) and soya (Brazilian rainforest). Increasing demand for palm oil (currently in particular for food production) is already contributing to the clearance of large tracts of rainforest in Malaysia and Indonesia. Although this option assumes monitoring schemes will be put in place, they might be more difficult to implement in non-EU countries than in the EU."*[99]

- The UN's report warns that "where crops are grown for energy purposes the use of large scale cropping could lead to significant biodiversity loss, soil erosion, and nutrient leaching. Even varied crops could have negative impacts if they replace wild forests or grasslands."[100]

- The impact of deforestation on biodiversity is particularly startling. In Indonesia, clearance of forest has led to a decline in the orang-utan population: Hardi Baktiantoro, director of the Centre for Orangutan Protection, said at least 1,500 orangutans had died in 2006. In some cases this is due to habitat destruction, but Baktiantoro also told reporters that plantation workers torture and kill orangutans because the endangered animals eat palm oil seedlings.[101]

- A study by Swiss research institute EMPA [102] uses the UBP indicator to gauge the overall environmental impact of biofuels. It finds that while certain biofuels can lead to savings in carbon emissions relative to petroleum, there are relatively few that deliver an advantage over conventional fossil fuels when the aggregate impact are taken into account. Methane technologies perform well compared to the major liquid alcohol and biodiesel products (such as ethanol from corn, sugar cane etc.) being backed by the US and EU as transport fuels. The results are set out in the graph below:

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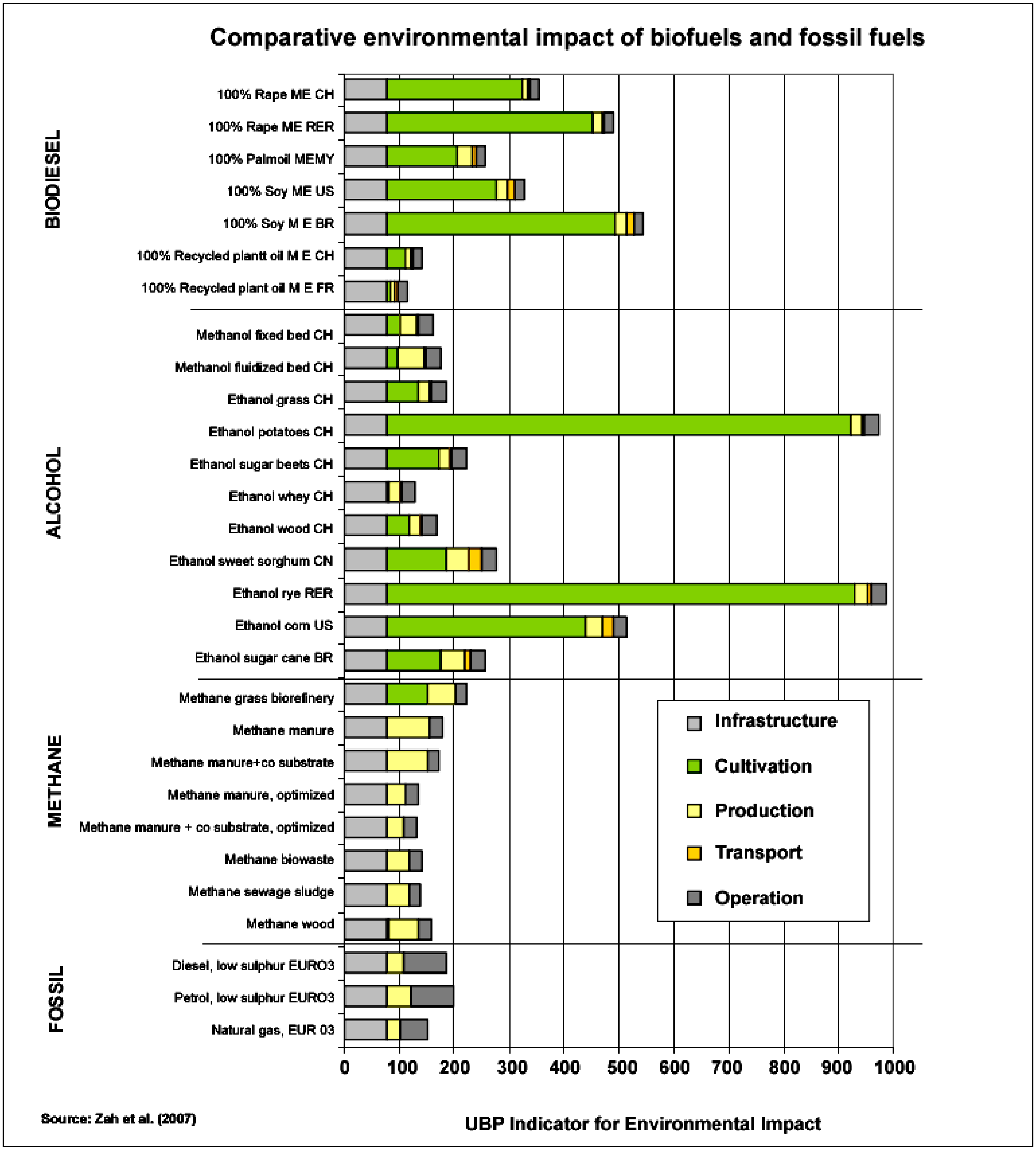
[98] Doornbosch, R & Steenblik R. "Biofuels: is the cure worse than the disease?" Organisation for Economic Co-operation and Development, Round Table on Sustainable Development, Paris (11-12 September 2007)
[99] EU Commission, *An EU Strategy for Biofuels - Impact Assessment* (2006)
[100] UN Energy, *Sustainable Bioenergy – A Framework for Decision Makers* (April 2007)
[101] Agence France Presse, 25 July 2007
[102] Zah, R et al. "A Life Cycle Assessment of Energy Products: Environmental Impact Assessment of Biofuels" Empa, Swiss Federal Institute for Materials Science and Technology, Technology and Society Lab (22.05.07)



2.9 - Higher food prices will starve the world's poorest

- The human effects of biofuels are potentially as bleak as the environmental effects. The two are likely to exacerbate each other however, as the combination of environmental degradation and land/ resource hunger drives poverty, conflict and further environmental damage.

- With a rapidly rising global population, strain on food supplies is as high as ever. Yet huge US biofuel targets are already driving a dramatic trend of global food price inflation. With the EU following suit with equally ambitious targets, the situation can only get far worse. Increased use of crops for biofuels leads to lower food output and thus higher food prices. In 2006/07 alone:

  - the price of food aid has increased 20%;
  - Indian food prices have increased 11%;
  - tortilla prices in Mexico quadrupled;
  - Chinese pork prices rose 42%;
  - Italian pasta manufacturers say the price of pasta will go up by about 20% in 2007. The average household in the country will face an extra £700 this year on their shopping.[103]
  - UK food prices rose by £750 in 2007.[104]

> "*Filling a 95-litre fuel tank with pure ethanol requires about 200 kg of corn, which has enough calories to feed a person for a year*."
>
> Runge and Senauer[105]

- A foretaste of the potential social consequences came in February 2007, when demonstrations erupted in Mexico City in response to the tortilla price increases. The protests compelled the normally free-market-minded President Felipe Calderon to cap prices of tortillas at 78 cents per kilo.[106]

- The OECD and FAO predict global food price rises of between 20 and 50% for different food products over the next decade. Their report notes that increasing biofuel use is "one of the main drivers" [107]

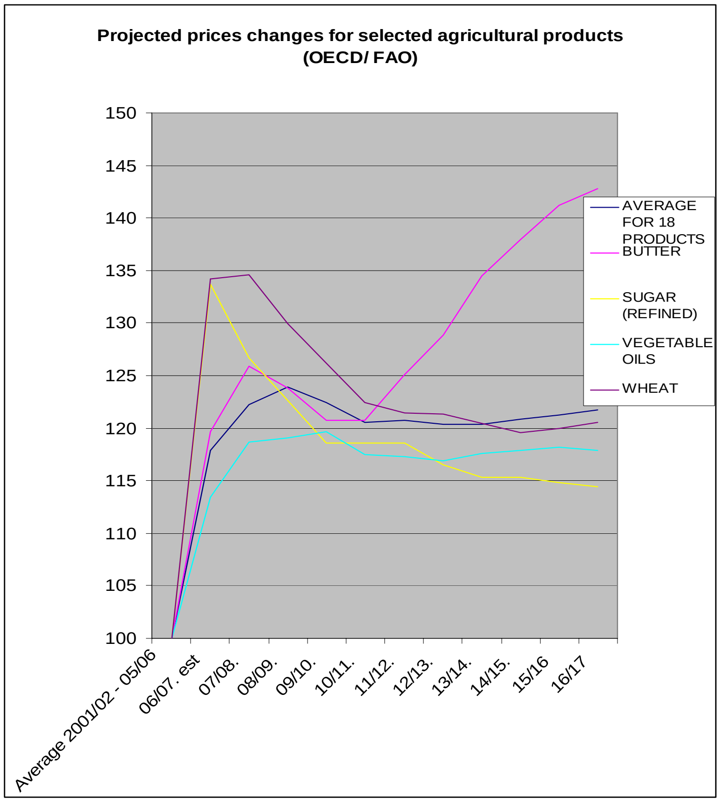
- The International Food Policy Research Institute, in Washington, D.C., has also produced estimates of the potential global impact of the rising demand for biofuels. Their findings are set out in the table below:

Changes in World prices of feedstock under two scenarios compared with baseline levels (%) (IFPRI)

	Scenario 1 (Biofuel expansion under current polices)	**Scenario 2 (Drastic biofuel expansion)**
Cassava	11.2	26.7
Maize	26.3	71.8
Oilseeds	18.1	44.4
Sugar	11.5	26.6
Wheat	8.3	20

[103] Telegraph (02.09.07)
[104] Telegraph (16.01.08)
[105] Runge, C & Senauer, B. "How Biofuels Could Starve the Poor" *Foreign Affairs* (May/ June 2007)
[106] Christian Science Monitor, 27 July 2007
[107] OECD/ FAO, Agricultural outlook 2007-2017 (April 2007)

- It is still uncertain just how much food prices will be affected by the surge in biofuel demand, but it seems highly probable that whatever happens, the price increases will be dramatic. The scale of the increase will be highly dependant on technological improvements, productivity changes, policy, oil prices and population growth. As argued in section 2.7, given the huge uncertainties and unknowns regarding the rate and possibility of development in these areas, and the potentially adverse effects on world food prices, it is all the more concerning that the EU has set such ambitious targets.

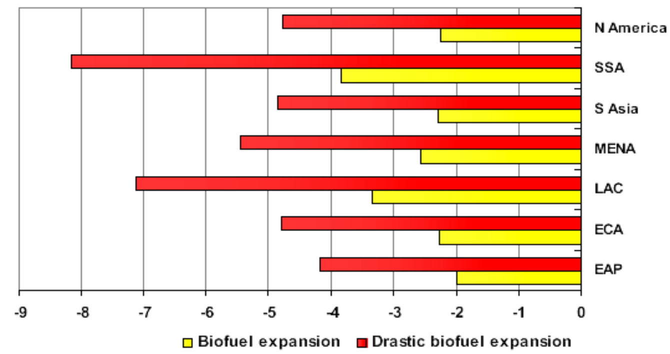


- Increasing food prices are highly significant, most of all for the world's poorest people. This bucks the trend seen over the last half century, in which the real price of major food crop commodities such as maize, wheat, rice, and sugar have steadily decreased due to continuous improvements in agricultural production and trade. But now prices for several key crops are being determined primarily not by their value as human food, but as feedstock for biofuel.[108]

- As data from the IFPRI shows, Sub-Saharan Africa will be hit hardest by reduced food supply as a result of biofuels expansion:

[108] Cassman, K. & Liska, A. "Food and fuel for all: realistic or foolish?" *Biofuels, Bioprod. Bioref.* 1:18–23 (2007)

Calorie availability changes in 2020 compared to baseline (%)



Source: IFPRI IMPACT projections.
Note: N America = North America, SSA = Sub-Saharan Africa, S Asia = South Asia, MENA = Middle East & North Africa, LAC = Latin America & the Caribbean, ECA = Europe & Central Asia, EAP = East Asia & Pacific.

- Several studies by economists at the World Bank and elsewhere suggest that calorific consumption among the world's poor declines by about half of one percent whenever the average prices of all major food staples increase by one percent. When one staple becomes more expensive, people try to replace it with a cheaper one, but if the prices of nearly all staples go up, they are left with no alternative.[109] There are more than 850 million undernourished people in the world with greatest numbers in India (212 million), Sub-Saharan Africa (206m), South and Southeast Asia (152m), and China (150m). According to Cassman and Liska, the regions already most affected by food insecurity (such as sub-Saharan Africa) will be most at risk from a surge in biofuel production.[110]

- The UN notes that high food prices could be "especially harmful" for the poor, "as they could suffer from even greater pressure on already limited financial resources."[111] C Ford Runge and Benjamin Senauer estimate that for every percentage increase in real prices of staple foods, 16 million extra people will be drawn into food insecurity. If these predictions are correct, 240 million people would be drawn into food insecurity under current biofuel policies.[112] Given the size of the EU's contribution to overall future demand for biofuels, this would imply that EU targets alone will push around 60m people into chronic hunger.

- Runge and Senauer conclude that:

> "*The world's poorest people already spend 50 to 80 percent of their total household income on food. For the many among them who are landless laborers or rural*

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[109] Runge, C & Senauer, B. "How Biofuels Could Starve the Poor" *Foreign Affairs* (May/ June 2007)
[110] Cassman, K. & Liska, A. "Food and fuel for all: realistic or foolish?" *Biofuels, Bioprod. Bioref.* 1:18–23 (2007)
[111] UN Energy, *Sustainable Bioenergy – A Framework for Decision Makers* (April 2007)
[112] Runge and Senauer originally calculated that as many as 600m people would be drawn into food insecurity. However, this was based on previous estimates from IFPRI (2006), which have since been revised downwards – we have therefore adjusted their estimate to reflect this change. Runge, C & Senauer, B. "How Biofuels Could Starve the Poor" *Foreign Affairs* (May/ June 2007); Drawing on: Runge, C. Ford, Benjamin Senauer, Philip Pardey and Mark Rosegrant. *Ending Hunger in Our Lifetime: Food Security and Globalization*. John Hopkins University Press. Spring 2003

subsistence farmers, large increases in the prices of staple foods will mean malnutrition and hunger. Some of them will tumble over the edge of subsistence into outright starvation, and many more will die from a multitude of hunger-related diseases." [113]

2.10 - Negative distribution effects in developing world; biofuels already driving land seizure

- Some argue that the surge in biofuel demand in the developed world and increased agricultural prices can provide opportunities for producers in the developing world through promotion of a commodity in which the latter group of countries have a comparative advantage in producing. Whilst higher agricultural prices may benefit producers, they are potentially harmful to consumers – particularly the urban poor.[114]

- Furthermore, for rural workers who do not own their own land, the potential rewards from biofuel production may prove unattainable. As the UN argue:

  "*the benefits to farmers are not assured, and may come with increased costs. [Growing biofuel crops] can be especially harmful to farmers who do not own their own land… at their worst, biofuel programmes can also result in a concentration of ownership that could drive the world's poorest farmers off their land and into deeper poverty*."

- The report adds that the biofuel industry will draw in large-scale, highly capitalised agri-businesses, harming existing smallholders: "large investments are already signalling the emergence of a new bio-economy, pointing to the possibility that still larger companies will enter the rural economy, putting the squeeze on farmers by controlling the price paid to producers and owning the rest of the value train."[115] George Monbiot argues that "If there is one blindingly obvious fact about biofuel, it's that it is not a smallholder crop. It is an internationally traded commodity that travels well and can be stored indefinitely, with no premium for local or organic produce."[116] Runge and Senauer note that "the history of industrial demand for agricultural crops in these countries suggests that large producers will be the main beneficiaries. The likely result of a boom in cassava-based ethanol production is that an increasing number of poor people will struggle even more to feed themselves."[117]

- Target-driven biofuel cultivation will also add to land hunger. Indeed, incidences of biofuel driven land seizure are already occurring. In Colombia, armed groups are reportedly driving peasants off their land to make way for palm oil plantations. The Guardian reported in June 2007 that thousands of peasants have fled a campaign of killing and intimidation. According to the Colombian President, the country had 172,000 hectares of palm oil four years ago producing no biofuel at all; this year it expects to have nearly 400,000 hectares producing 1.2 million litres per day. But in some areas a government investigation found irregularities in 80% of palm oil land titles. Similar scenarios are being played out in Indonesia, where smallholders are being forced off their land by large-scale agri-businesses.[118]

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[113] Runge, C & Senauer, B. "How Biofuels Could Starve the Poor" *Foreign Affairs* (May/ June 2007)
[114] OECD press release (04/06/07)
[115] UN Energy, *Sustainable Bioenergy – A Framework for Decision Makers* (April 2007)
[116] Guardian (06.11.07)
[117] Runge, C & Senauer, B. "How Biofuels Could Starve the Poor" *Foreign Affairs* (May/ June 2007)
[118] http://www.sawitwatch.or.id/index.php?lang=en

2.11 - Biofuels tie food prices to oil prices – leading to higher price volatility

- Higher food prices are only half the problem when discussing the effects of biofuels. Price volatility is also a major concern for those living in poverty or marginal economic situations.

- Biofuel prices are linked to oil prices. When oil prices increase, fuel crop prices can also increase while remaining competitive, because ethanol producers can pay more for the feedstock. Because biofuel production already comprises such a large (and increasing) share of overall agricultural production, and because oil prices are high, agricultural commodity prices have become tied to oil prices. This upward pressure on oil prices will allow ethanol and biodiesel producers to pay higher premiums for corn and oilseeds. As Cassman and Liska argue, it is ironic that although energy independence has been cited on both sides of the Atlantic as a key justification for biofuel use, the economic viability of biofuels is perversely reliant on high oil prices.[119]

- The tying of agricultural prices to oil prices means that expanded land use and productivity improvements will not necessarily reduce food prices. Whilst the combination of high oil prices and government subsidies ensure that biofuels remain profitable, any extra grain production will be shifted towards biofuel production.[120]

- As Cassman and Liska argue, this means that the "convergence of valuation between petroleum and agricultural commodities such that food prices are likely to rise substantially. While countries with adequate resources to support an expansion of biofuel crop production will benefit from this convergence, developing countries and regions that consistently experience food shortages or rely on food imports will face greater food insecurity."[121]

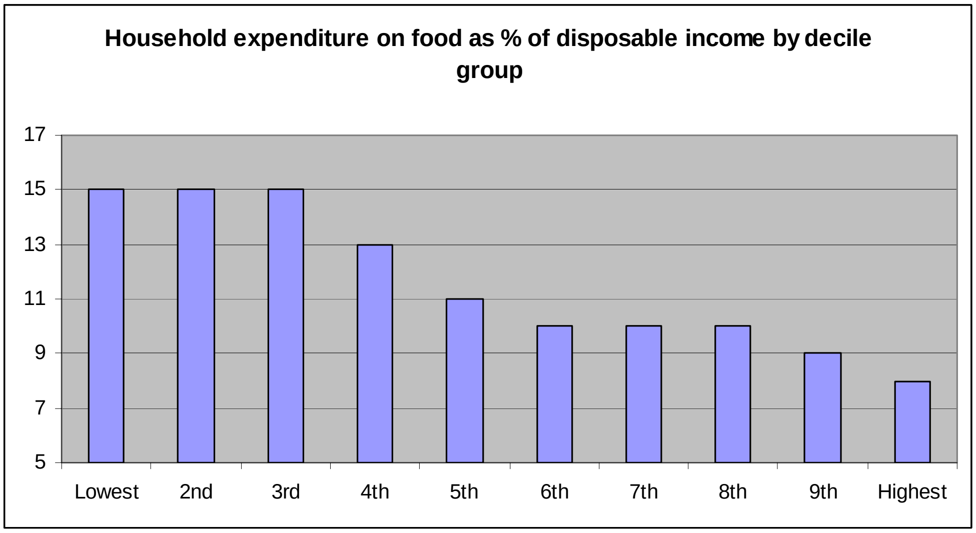
- Oil prices are notoriously volatile. This volatility will be transmitted to food markets. Those living on less than $2 per day spend from 50-80% of their budgets on food, meaning they will not only bear a disproportionate impact in terms of the absolute price increases, but will also be more vulnerable to rapid changes in price.

2.12 – Consumers in Europe will be hit with higher food prices

- It is certain that biofuels will contribute to higher world food prices – this is already happening. There is still, however, considerable uncertainty as to how much more expensive food will be as a result of surging biofuel demand. There are a number of unknown factors at play, including technology changes, oil prices, agricultural productivity changes and policy decisions. Regarding the last variable, it seems certain that if China were to adopt its own biofuels targets, this would create significant upward pressure on food prices. Changes in food demand will also be dependant on factors such as changing dietary habits – the move towards a more meat heavy 'western-style' diet in countries including China is key here. Estimates should therefore be qualified bearing this uncertainty in mind, and need to be expressed as lying within a range of possible price scenarios. Open Europe estimate that by 2020 the average

[119] Runge, C & Senauer, B. "How Biofuels Could Starve the Poor" *Foreign Affairs* (May/ June 2007)
[120] See comments of Jeffrey Currie, Goldman Sachs in "Biofuelled", *Economist* (21.06.07)
[121] Cassman, K. & Liska, A. "Food and fuel for all: realistic or foolish?" *Biofuels, Bioprod. Bioref.* 1:18–23 (2007)

family of four in the UK can expect, in today's prices, a rise in annual food expenditure of between £200 (€260) and £260 (€340) as a result of worldwide biofuel. EU demand is expected to increase family food bills by £50 (€65) to £65 (€85).[122] Similar trends would be expected in the rest of Western Europe. As the graph below illustrates, these price increases punish the poorest in society, as those on lower incomes spend a higher proportion of their income on food.



- The UK government, in a leaked paper, has acknowledged the scale of this problem, noting that achieving the EU target would be "very challenging" and would require a 25-fold increase on 2006 sales levels of biofuels:

  "*This could have significant cost implications to the economy as a whole, as well as bringing risks that the production of the associated feedstocks might have adverse impacts on the wider environment as well as on other sectors (including the food market)*."

- In the developed world, food still represents a relatively small proportion of overall expenditure. However, food prices have a disproportionately high impact on expectations of future inflation. Combined with rising oil prices, rising food prices could exacerbate inflationary pressures, particularly harmful at a time of potential economic slowdown.

2.13 - Biofuels will not improve Europe's energy security

- It is frequently claimed that biofuels are beneficial to Europe's energy security. However, with such high fossil fuel energy input requirements for the production of biofuels, substituting 10% of EU transport fuel use will achieve only a fraction of this in terms of ultimate fossil fuel use. Open Europe estimates that this level of substitution would translate to a 5% drop in EU fossil fuel use in transport.[123] Since transport absorbs

[122] Figures derived from DEFRA, OECD/ FAO, IFPRI, IEA and IMF
[123] Using figures from GSI for fossil fuel displacement: 50–68% for Ethanol from sugar beet, 22–32% for ethanol from grains, 45–63% for biodiesel from canola.

61%[124] of the EU's net imports of crude oil, biofuels overall would make an almost insignificant 3% dent in the EU's import needs.

- Furthermore, it is not clear that biofuels are intrinsically a secure energy supply source. James and Stephen Eaves argue that, unlike with gasoline, weather patterns have an effect both on the supply and the demand of gasoline. For instance, hot weather will increase gasoline demand, but will not affect the supply. But with biofuels, hot weather both increases demand and restricts supply. They argue therefore that the supply response of biofuels is weaker relative to gasoline, effectively meaning higher price spikes in response to weather patterns. Furthermore, they argue that it should not be assumed that crop yields are necessarily more reliable than oil imports, arguing that (in the US context), "based on history, by displacing gasoline with ethanol we exchange geo-political risk with yield risk, and history suggests that yield risk is about twice as high."[125]

2.14 – Focus on sustainable sources misses the central point – what really matters is the target

- Recently, the Commission has been more open in admitting the potentially colossal risks of large-scale biofuel use. Environment Commissioner Stavros Dimas has said "There was a lot of enthusiasm here a year and a half ago - now this enthusiasm is going down because we have seen the environmental problems caused by biofuels, and also the social problems".[126] However, policy now seems to be swinging behind the idea of introducing a system of certification of sustainability. The OECD are sceptical over whether this would be workable in practice, as "biofuel mandates are still targeting ambitious market shares without an in-depth understanding of a sustainable production level and from where this biofuels could be supplied. There is a serious risk that biofuel quotas for demand are higher than potential sustainable supply".[127] Furthermore, without a well enforced (potentially costly) multilateral system, certification could just result in further market segmentation, without reducing unsustainable practices, another concern voiced by the OECD. There would be a very real risk that the practice of certification would merely encourage further protectionism in biofuels markets. The US and the EU have already created powerful vested interest groups through their respective biofuel policies: this means they would be likely to use strict certification standards to shut out competition, rather than out of regard for sustainability.

- The draft directive on biofuel use – at least as currently drafted – has been rightly criticised for its very lax standards on sustainable biofuel production (for instance, biofuels produced on land converted from savannah and recently cleared rainforest would be permitted). But in one sense this criticism misses the more essential point: even if it could somehow be guaranteed that all biofuel used in Europe did come from 'sustainable' sources, this would still be a totally inadequate solution to the core problem of land pressure created by such massively increased demand. Even if biofuels themselves are cultivated in a socially and environmentally responsible way on existing agricultural land, there is no way of guaranteeing that the food production displaced by this biofuel cultivation will also be sustainable. To give one example, it is practically impossible for palm oil (set to play a big part in supplying EU biodiesel) to be genuinely

[124] Eurostat
[125] Eaves, J & S. "Neither renewable not reliable", *Regulation*, Cato (Autumn 2007)
[126] Interview, BBC Today programme (14.01,08)
[127] Doornbosch, R & Steenblik R. "Biofuels: is the cure worse than the disease?" Organisation for Economic Co-operation and Development, Round Table on Sustainable Development, Paris (11-12 September 2007)

sustainable, given that the product is also important as a food crop. EU biofuel targets will contribute further to the massive jump in overall demand for the commodity, leading to price rises, and thereby increasing the already ambitious pace of rainforest clearance (both illegal and legal) created just by this one crop.

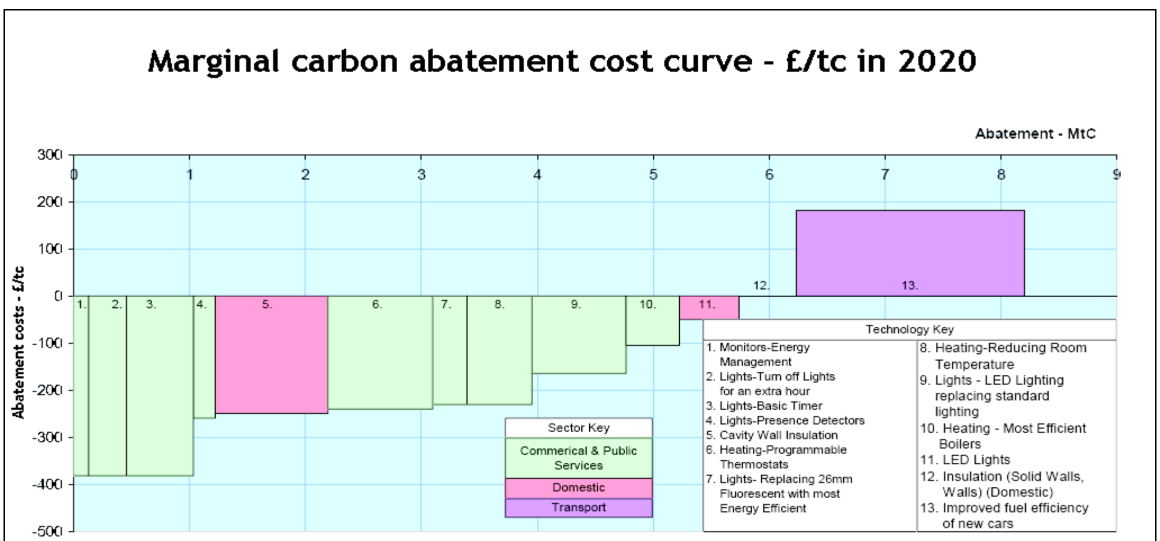
3 - Energy efficiency

3.1 - Energy efficiency - a win-win area

- According to Europe Economics, adopting energy efficiency measures are likely to lead to direct financial savings, as well as reduced carbon emissions. Given that such measures seem to be economically beneficial, it is unclear why the market has not yet adopted them of its own accord. Europe Economics believe that market failure (through information asymmetries) or hidden costs (such as hassle, management time etc.) are to blame.

Estimated cost of reducing UK emissions in 2020 by 1 per cent through energy efficiency measures (£m)		
£m	**Low**	**High**
Domestic energy efficiency	-468	78
Services energy efficiency	-406	78
Industry energy efficiency	-125	47

- Nicolas Stern's separate research also finds that energy efficiency is an extremely cost-effective way to reduce emissions. Interestingly, transport energy efficiency is extremely expensive, suggesting that EU attempts to limit carbon emissions from vehicles (discussed in 3.2) are a poor policy solution.



[128]

[128] Stern, N. *The Economics of Climate Change*, Ch 9 (2006)

- The theoretical savings to be gained through energy efficiency are clear, but there is a separate debate over which policies are best used in practice to implement them. This will prove a contentious subject.

3.2 - Regulation as a way of changing behaviour – a cautionary note

- Enforcing energy efficiency through government action (either at UK or EU level) can be problematic, and evidence as to its effectiveness is at best mixed. For example, Home Information Packs are neither green nor cheap. An EU directive agreed in 2002, "The Energy Performance of Buildings Directive" required that homes and other buildings should have an energy efficiency survey when they are bought, sold or rented. This would then be used to produce the Energy Performance Certificate (EPC), which would give homes an efficiency grade from "A" to "G" (with A as the most efficient). Transposed in the UK to create the requirement for Home Information Packs, this the scheme was designed to encourage people to adopt more energy efficiency measures. However, this would come at a £337 million annual compliance cost.

- **It is not clear that EPCs will lead to changes in behaviour that can justify this cost.** The UK Government had predicted that 31% of people who got Energy Performance Certificates would change their behaviour by enough to save 10% of their total energy bill. However, polling shows that only 18% have said they might act on the energy rating, and in practice far fewer are likely to actually make such changes. The Better Regulation Commission has argued that "We accept that the introduction of EPCs may make some contribution towards reducing the energy consumption in buildings, although we have seen no evidence that this contribution will be sufficient to justify the additional administrative burdens imposed."

- Much of what the survey will cover will be obvious to people already – like whether a property has single glazing, insulation etc. Instead of charging people for information which will not be useful, the Government could use the money to give grants for people to actually carry out energy efficiency enhancing work – like installing loft insulation or a better boiler.

- Spending the £337 million annual cost of EPCs on investments to directly reduce emissions would indeed be more effective. According to the Government's own assessment, even investing the same money in onshore wind power instead could reduce emissions by 12 million tonnes. Putting the money into subsidies for domestic energy efficiency (boilers, insulation, smart meters etc) could save even more.

- Another example of trying to regulate for energy efficiency is the Commission's attempt to place CO_2 caps on cars manufactured in Europe. Imposing strict limits could force production to be pushed outside Europe, to locations with lower environmental standards. Extra tariffs on imports of goods from such locations have been suggested – but these risk becoming a vehicle for protectionism. Even the process of legislating for caps on vehicles within the EU shows member states attempting to use EU regulation to gain a competitive advantage over other member states. The original ceiling of 130g C02/km would have been unattainable for German manufacturers such as Porsche and BMW. However, Rome and Paris are reported to have been lobbying for a strict set of rules in the hope of gaining market share for their industries, with smaller Italian and

French models (such as Fiat and Renault) being far better placed already to achieve the 130g ceiling.[129]

3.3 - EU-level green tax breaks to promote energy efficiency – low hanging fruit

- In terms of realisable, effective policies that can be conducted in the EU context, a good place to start is tax breaks for energy efficient products. This is one area for reform the UK and France have already begun to consider.

- Earlier research by Open Europe suggests that by removing VAT and tariffs on some of the most important green products, their price could be reduced by up to 80%. For instance, despite the forthcoming EU-wide ban on incandescent (conventional) light bulbs, the EU still imposes a 66.1% tariff on low-energy light bulbs from China, Vietnam, Pakistan and the Philippines. This is hardly a coherent policy, and has substantially driven up prices. Moves to reform this clear inconsistency have come against protectionist resistance from manufacturers such as German firm Osram. Conversely, other European firms who have outsourced production to the Far East are keen to see drops in tariffs.

- Today, a single energy efficient light bulb equivalent to 60 watts can cost as much as £4. Open Europe have estimated that without the antidumping duty and the VAT, the price would be 66p - a price drop of more than 80%. While the UK Government is trying to encourage people to cycle to work, bicycles are presently subject to steep tariffs – sometimes as high as 48.5%. We estimate that a standard high quality bicycle for commuters could go from costing £250 today to less than £80 without the anti-dumping tariffs and the VAT. This could encourage far more people to try cycling to work. Buyers of energy efficient cars could save some £5,000-6,000 if the VAT and the EU tariff of 10% were removed. A Toyota Prius which costs £19,000 today could fall in price to just £13,775. Wind turbines and solar panels are other green products that could be made cheaper. Without the tariff and the VAT, a typical wind turbine would go from £6,500 to a little over £5,000. A simple domestic solar panel costing £150 today could be reduced in price by more than £30. Other green products which should be subject to similar tax and tariff incentives include insulation, condensing boilers, water management systems and heat exchangers.

- It is clear that energy efficiency policies can be a major part of climate change strategies at UK and EU level. Top down, restrictive regulatory approaches are not certain to be an effective solution.

- It is far better to aim for the 'low hanging fruit' of tax breaks for energy saving products, particularly those that are currently being protected solely for the benefit of industrial interest groups within Europe.

[129] Telegraph (08.08.07)

4 - Carbon pricing mechanisms - Tax vs trading

- As the name suggests, carbon pricing mechanisms are designed to place a cost on carbon, thereby introducing the 'polluter-pays' principle into business practice and providing incentives to reduce emissions, and thus costs.

- As Europe Economics argue, carbon pricing mechanisms have the advantage over Government subsidies and regulations in that they encourage the market to seek out the most cost-effective way of reducing emissions: "Once a price has been placed on carbon, companies and consumers would have incentives to reduce carbon emissions in the most cost-effective ways (which the government is unlikely to be able to identify in advance)."

- There are two principle methods of carbon pricing – taxes, a direct control on the price of a given amount of carbon, and trading, working on the basis of quantity restriction. There are also hybrid systems which combine aspects of each. The debate on tax vs trading is now well established – and is set to continue.

4.1 Trading

- The EU has taken the lead in establishing its own trading system for carbon – the Emissions Trading Scheme (ETS), and has been keen to emphasize this fact. Nonetheless, criticism of the EU scheme – and emissions trading more generally – is mounting.

- In an earlier paper, Open Europe identified key flaws with the ETS which look set to continue for the foreseeable future. The first phase of the system - running from 2005 to 2007 - has been a failure: more permits to pollute have been printed than there is pollution. The price of carbon has collapsed to almost zero, creating no incentive to reduce pollution. As a result, UK firms covered by the scheme increased their emissions by 3.6% in the first year alone. Across the EU, emissions from installations covered by the ETS rose by just under 1%.

- It was hoped that changes to the system which will apply in the second phase will make it more effective. Scarcity in permits will be created in the system, unlike in the first phase. However, important new problems are emerging. ETS participants will be able to import credits from the Kyoto mechanisms (essentially a giant global system of carbon offsets, generated by projects in developing countries) in such numbers that these are likely to cover most or possibly all of this scarcity. There are in theory caps on the numbers of these that can be imported, but in practice these are far too lax to meaningfully restrict supply of Kyoto credits. This was very much a result of lobby group pressure applied whilst the legislation was being drawn up.

- Offsetting emissions through projects in developing countries is not in itself objectionable, so long as these reflect real emissions reduction. However, as numerous studies have shown, most credits have been generated through accounting scams, whilst the quality of others is highly questionable. For instance, there have been widespread reports of credits being awarded to projects that would have happened anyway – meaning the credits are merely subsidizing higher emissions. The development aspect of the mechanisms has been largely sidelined, with the main beneficiaries comprising highly capitalized large-scale businesses in India and China. Sub-Saharan Africa will see just 4% of the overall investment.

- Another key problem with the ETS is the negligible lack of auctioning, which has been heavily criticized. As Economist Karsten Neuhoff notes:

  > "*Any free allocation represents a subsidy – and where only fossil-fuel generation is subsidized, this distorts investment choices in favour of fossil-fuel generation. Where coal receives a higher allocation than gas, the investment choice is, in addition, distorted towards coal. The level of such subsidies under proposed second-phase NAP is so high that the construction of coal power stations is more profitable under the ETS with such distorting allocation decisions than in the absence of the ETS.*"

- Free permit allocation has in effect become a vehicle for delivering covert industrial subsidies to politically favoured industries on a truly epic scale - across the EU, power generators are estimated to have netted €6-8bn in windfall profits.[130]

- Of course, these are reformable aspects of the ETS. It would undoubtedly improve matters if the system could be shifted to a 100% auctioning regime. Sometimes referred to a 'hybrid' method combining aspects of both taxes and trading, this would capture the revenue raising potential of a carbon tax (see below) and shut off the current subsidy stream to power generators.

- Import limits on Kyoto credits could be substantially tightened, whilst higher standards and more transparent governance rules could be imposed on credit generating projects overseas.[131] However, it is worth considering how quickly these reforms can in practice be made. The ETS has already created a widespread, complex web of vested interests across Europe who are likely to resist reforms just as vehemently as they insisted originally on the inclusion of the harmful aspects of the system (such as lax import caps and minimal auctioning). Given the painfully slow course of reform in other areas of EU policy (for example, agriculture) it may be some time before we see an ETS that has ironed out the current problems.

- This draws us towards the next part of the argument on emissions trading – the more fundamental problems, the unreformable flaws inherent in all trading systems. As indicated above, regulatory capture – where industries successfully lobby to shape policy for their own profit – has been very apparent in the ETS. But this is a risk in all trading systems. The price of carbon within a trading system is primarily driven by state action – because of this, the regulator can always expect lobby-group pressure to be exerted in order to shape allocation decisions.

- Another problem associated with trading systems' reliance on bureaucratic intervention is the difficulty regulators face in getting the allocation 'right'. There are a huge number of variables that have a bearing on the price of carbon – from weather patterns, technology improvements, energy prices, political action in other spheres of climate change policy (see section 1.4), economic growth, not to mention the goings-on in external markets that may be 'linked' to the trading system in question. Only looking at one possible variable, a boom in economic growth could send the price of carbon too

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[130] German Environment Ministry, cited in Smith K. "Pollute and Profit", *Parliamentary Brief Magazine* (May 2007)
[131] For more on this subject, see Open Europe, *Five ways to make trade work for trade work for development*, Ch. 5 (June 2007)

high. On the other hand, a slowdown would mean emissions falling faster than expected, introducing more slack into the carbon market, and consequently lower carbon prices. Bearing in mind the complexity and unpredictability of all these factors, it is extremely difficult for bureaucrats to make the right call when it comes to allocations. A further problem is what Prof. Catrinus Jepma describes as 'information asymmetry' – because bureaucrats cannot fully know the capacity (or lack of it) for participants in the trading system to mitigate emissions, they are not only at risk of making bad choices, but also more liable to come under the influence of pressure from industrial lobbyists who will be all too willing to plug the gap in information.

- But perhaps one of the most important problems with trading systems is lack of price stability and predictability. The objective of any effective climate change policy should be to stimulate permanent investment in low carbon technologies. But such investments inevitably operate in long term time frames – before committing to such capital outlay, the company in question needs to know that the decision will deliver a pay-back ten or fifteen years down the line, and consequently needs to have a reasonably accurate idea of what the future price of carbon will be. It is very difficult to make such financing decisions on the basis of an unstable, unpredictable or volatile carbon price. Emissions trading by its nature cannot deliver this long term price signal. Because of the huge range of variables mentioned above, the price of carbon faces a volatility risk during a given trading period. During phase one of the ETS, the price of carbon varied from €30/tonne to €0.30/tonne.

- Some have argued that volatility within a trading phase can be calmed through measures such as safety valves (if the price hits a certain level, the state intervenes by injecting more permits into the system, lowering prices) or banking (where permits can be saved for future phases if the price sinks too low).[132] This does pose risk of regulatory capture again, as the intervention prices would certainly come under lobby pressure. And although they may help to tame wilder price swings within a trading phase, because emissions trading has to be multi-phase, such mechanisms can only have a limited effect in delivering the necessary price signals for carbon. Confidence in the carbon price needs to be established not just for a given phase, but over the long term, and it is questionable whether these instruments can fully deliver this.

- Indeed, because emissions trading has to be conducted within time delimited trading periods, it is therefore constrained by the allocation decisions made for a given phase. If the wrong decision is made at the beginning of that phase, the system will be stuck with it for the length of that phase. But in order to get a longer term price signal, longer phases are necessary – this means that lengthening the phases carries the risk of fixing in place bad policy for longer should the allocation be misjudged. Shorter phases give more frequent opportunities to correct bad choices, but conversely sacrifice the long term price signal.

- A recent survey showed that 93% of businesses wanted the ETS trading period extended to ten years or more. However, governments are unlikely to agree to this as it means that caps can only be revised down every ten years, and so the path of emissions reductions would have to be very gradual (which is why none of the Government bodies

[132] Parry, I & Pizer, W. "Combatting Global Warming", *Regulation*, Cato (Autumn 2007)

surveyed agreed with this idea). This is an important tension within emissions trading – and one which is likely to prove extremely difficult to resolve.[133]

4.2 - Tax

- Whilst quantity restriction systems like emissions trading do offer greater certainty in terms of the rate of emissions reduction, they do so at an uncertain price, as argued above. Conversely, carbon taxes offer price certainty at the expense of uncertainty in the level of abatement. As with a trading system, the state is very certainly the chief protagonist, as taxation inherently relies upon judgements made by bureaucrats. However, one important advantage of taxes is their flexibility. If a bad decision is made one year, it can be quickly rectified the next year. Yet once the right 'ball park' level of taxation is discovered, business can have a reasonable degree of certainty what the price of carbon will be doing in a decade's time.

- Levying taxes on a negative externality such as CO2 emissions should not solely be regarded as a means of restraining pollution. It could also prove an opportunity to cut taxes in other areas of the economy, effectively relieving the burden of taxation on productive wealth creating endeavors, shifting it towards a harmful activity that does incur a long term cost that would not otherwise be internalised by business if the market were left to its own devices. According to Europe Economics, green taxes are one of the best ways of reducing UK emissions:

  "*we consider that the most cost-effective way of reducing carbon emissions is to introduce an economy-wide carbon price, and that the best way of doing this would be to abandon the EU ETS and to tax the consumption of primary fuels in proportion to their carbon content. This would avoid the administrative costs of monitoring emissions directly, and would raise additional tax revenue which could be used to reduce taxes elsewhere in the economy.*"

- Europe Economics' calculations show that raising revenue from carbon taxation is likely to have lower deadweight costs for the economy than the taxes it would be replacing. So substituting taxation in other areas of the economy for a tax on carbon would mean a net economic welfare gain for society, as shown in the table below:

Costs of achieving a 1% reduction in UK emissions in 2020 (Europe Economics)						
	High			Low		
	Loss of economic welfare in relevant market	Reduced deadweight loss from taxation elsewhere	**Net cost of policy**	Loss of economic welfare in relevant market	Reduced deadweight loss from taxation elsewhere	**Net cost of policy**
Car fuel	1,247	3,531	-2,284	1,177	507	670
Aviation	85	227	-142	51	18	33
Electricity	186	911	-725	152	117	35
Gas	120	641	-522	96	79	17

[133] For more detail, see Open Europe, *Europe's dirty secret: why the EU Emissions Trading Scheme isn't working*, (August 2007)

- As Ian Parry and William Pizer at Resources for the Future argue, as long as green taxes are revenue neutral, and so long as resulting revenues are not simply diverted to dubious subsidies to politically favoured environmental projects, there should be little reason to see them as economically harmful. Writing in the US context, they also suggest that such policy could deliver net economic benefits.

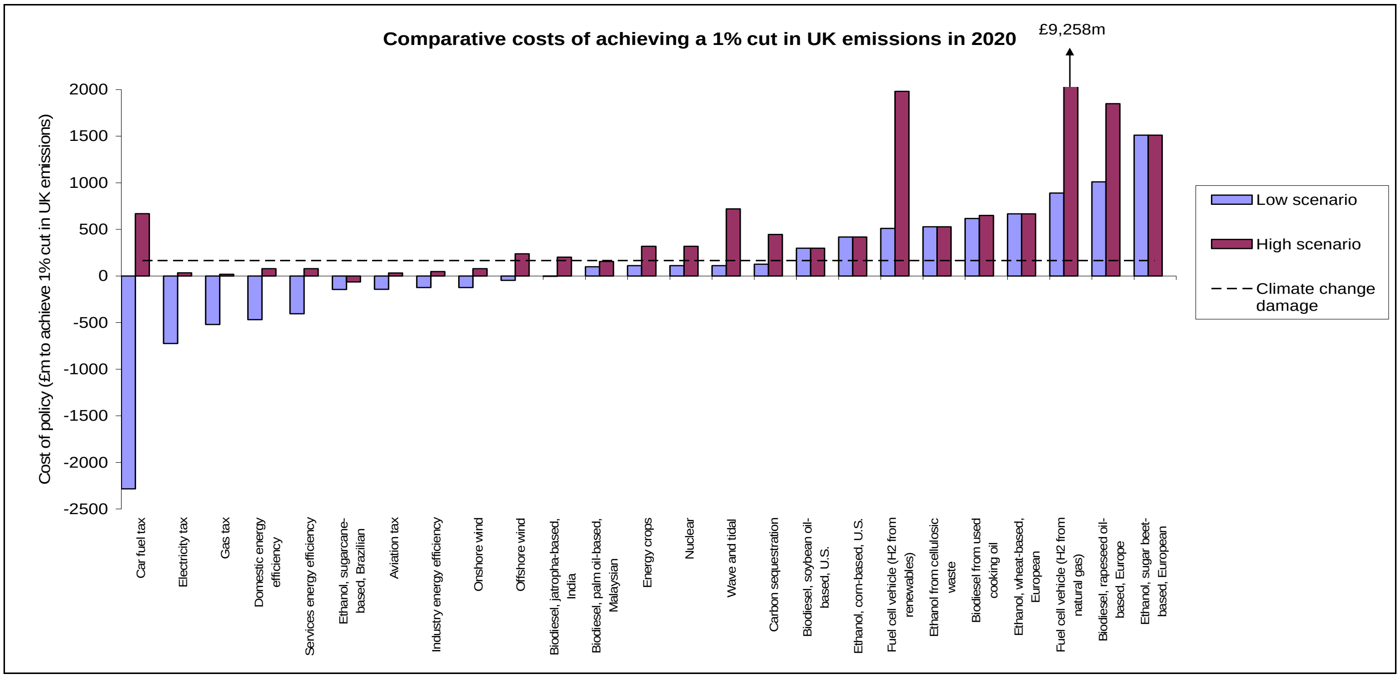
- In line with the conclusions of Europe Economics, Pizer and Parry believe that 'upstream' taxation would be the most efficient form of tax: "To maximize opportunities for cheap emissions reduction, a CO2 tax would be imposed upstream in the fossil fuel supply chain, as this encompasses all possible sources of emissions when fuels are later combusted."[134] They go on to suggest that devices such as tax credits can be used to incorporate incentives for downstream activities that offset emissions, for example carbon capture and storage.

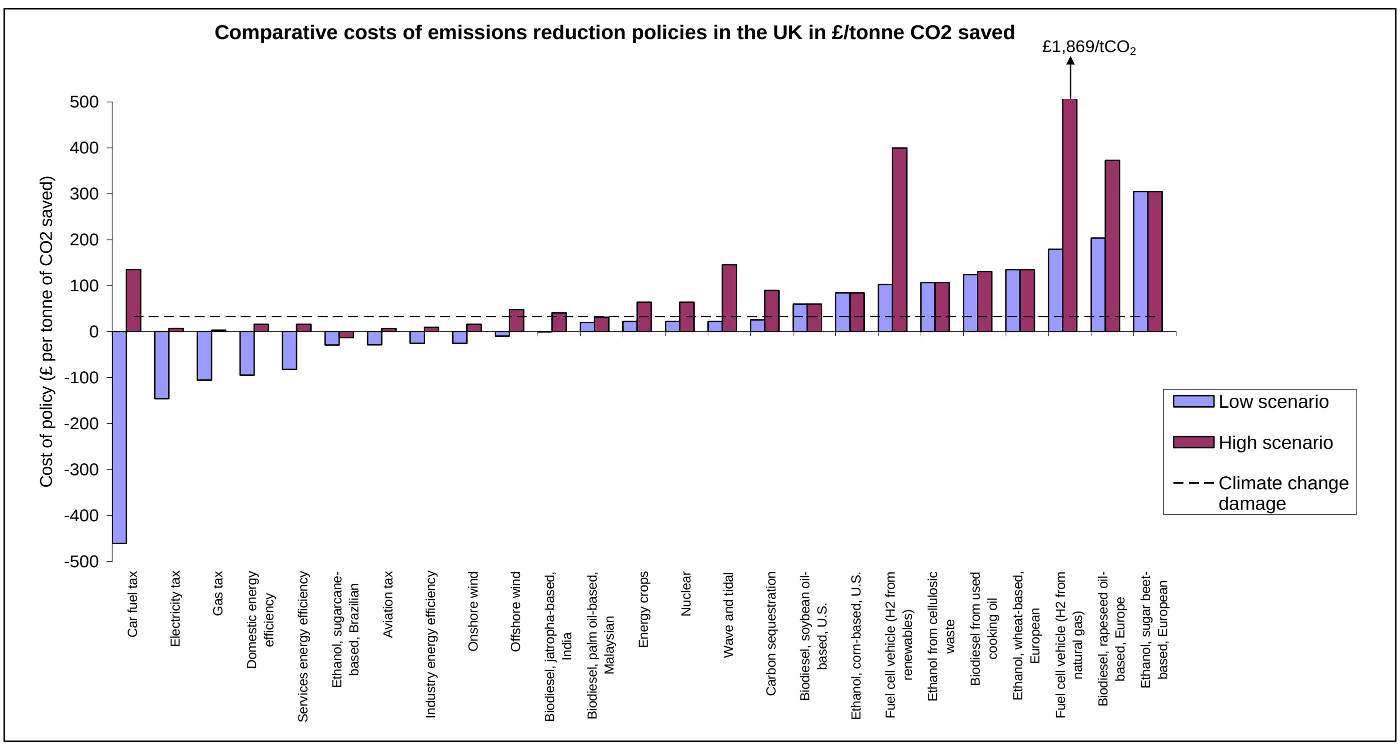
- Imposing a price on carbon would to some extent abrogate the need for subsidising particular policies, such as renewables. Investment in renewables would naturally follow as a result of taxation on carbon emitting means of energy production once more cost effective options for carbon abatement are realised. As taxes on carbon are progressively raised, more expensive renewables technologies would become cost effective. This would ensure that the most cost effective means of carbon abatement are tackled first, and the level of investment in renewables will reflect this need (which can be adjusted by raising or lowering the tax) rather than arbitrary targets. As Europe Economics argue, "once a price has been placed on carbon it is only appropriate to provide additional support for specific technologies where this can be justified on the basis of further market failures (i.e. other than climate change externalities, which are already captured in the carbon price). For instance, additional support for renewables should only be provided to the extent that this can be justified by likely spillover benefits from innovation and cost reductions through time."

[134] Parry, I & Pizer, W. "Combatting Global Warming", *Regulation*, Cato (Autumn 2007)

5 - Final Conclusions

- Europe Economics have quantified the economic impact of various ways of reducing the UK's carbon emissions, set out in the graphs below.





- As Europe Economics' estimates show, biofuels remain an extremely expensive option, especially those produced in Europe. More cost-efficiency can be gained by sourcing biofuels from the tropics. However, this brings its own problems – most seriously rainforest destruction and land-use change. This is *already* happening as a result of biofuels production, and can only get far worse as a result of EU targets. Deforestation already accounts for 25% of greenhouse gas emissions, more than transport, which contributes around 15%. The Commission have admitted that "Biofuels cost more than other forms of renewable energy. But they are currently the only form of renewable energy which can address the energy challenges of the transport sector". This suggests that policy-makers have viewed the issue on a 'departmental' basis, in terms of bureaucrats responsible for the transport sector having to be seen to be 'doing something', irrespective of whether this is the best way to tackle the issue of total carbon emissions.[135]

- By trying to prescribe a small and costly reduction in carbon emissions from transport use, the EU will aggravate a far more serious issue, with potentially catastrophic consequences in terms of climate change and broader ecological damage. Even under a highly optimistic future mass production scenario, biofuels can only ever make a very marginal impact on fuel consumption and overall carbon abatement, whilst the environmental, social and economic risks are vast. Attempting to simply substitute fossil fuel use for biofuels does not address the root of the problem – lack of energy efficiency and over-reliance on personal transport. As Tad Patzek argues, "we should decrease consumption of these fossil fuels, increase the efficiency of our economy, whilst producing some biofuels for local consumption".[136]

- Open Europe believes the EU should:

    1) **Scrap biofuels targets.** In imposing mandates for biofuel use, both the US and the EU have made a leap into the dark on the highly tenuous assumption of future technology improvements. Targets are effectively a form of state support for an environmentally and economically harmful activity designed to consolidate existing price support mechanisms for vested interests groups, most notably farmers.[137] As the OECD conclude: "Current biofuel support policies place a significant bet on a single technology despite the existence of a wide variety of different fuels and power trains that have been posited as options for the future. National governments should cease to create new mandates for biofuels and investigate ways to phase them out, preferably by replacing them with technology-neutral policies such as a carbon tax. Such policies will more effectively stimulate regulatory and market incentives for efficient technologies." Certification of sustainable sourcing is unlikely to be an effective solution to the problems associated with biofuels. Aside from such a system being a potential avenue for protectionism and further harmful market segmentation, it does not address the core problem of pressure on land resources –

[135] Clive Bates at UNEP makes this point strongly on his blog (14.11.07): "I suspect the idea of biofuels targets have come from policy-makers asking the question: 'how do we reduce the emissions from transport?'. They conclude that fuel substitution is one of the best options they have then designed a mechanism to make that work - but by indiscriminately subsidising a change of land-use in Europe and beyond. Perhaps they feel an implicit sectoral burden sharing regime at work… that transport must somehow take its 'fair share' of the reductions compared to power station, chemical plant and homes. Of course, the climate is indifferent to burden sharing… it doesn't care where the reductions come from."
[136] Patzek, T. "The real biofuel cycles" *Online supporting material for Science letter*, Vol. 312, p. 1747 (26.06.06)
[137] Corporate Europe Observatory, *The EU's agrofuel folly: policy capture by corporate interests* Briefing paper, (June 2007)

meaning displaced food cultivation would contribute to land-use change and deforestation even if biofuels are grown on current agricultural land.

2) **Scrap tariffs and subsidies for biofuels.** Biofuels may have a part to play in carbon abatement, but that part is likely to be far smaller than envisaged by either the US and the EU. It is clear that tariffs imposed on more efficient biofuel production elsewhere in the world promote inefficient – and therefore more environmentally harmful – domestic production. By removing these distortions, biofuels can be sourced from where they are most efficiently produced. Efficiency is linked with environmental effectiveness. However, tariff reductions should also be accompanied by abolition of biofuels targets – this would offset the risk of tropical deforestation to make way for increased production.

- Targets for renewables are unlikely to have such dramatic effects as the related targets for biofuels. However, we suggest that these should also be abandoned. As the Europe Economics study argues, the huge uncertainty over the precise cost of many carbon reduction measures "illustrates the danger of the government 'picking winners' by supporting a particular solution to the problem of reducing emissions, and reinforces the case for using a carbon price to allow the market to identify the best approach." Furthermore, it is clear that renewables targets contradict the EU ETS – if the EU tries to maintain both policies, they will simply work against each other. At the very least, the EU must abandon the policy of handing out free allocations to fossil fuel power generators, which effectively acts as a subsidy mechanism protecting these industries against competition from renewables.

- There is a rationale for internationally binding targets for absolute carbon emissions, but setting targets as to the means by which different countries should achieve this end is a step too far. What fundamentally matters is getting carbon out of the atmosphere at least cost. By this logic, EU member states should be able to pursue this goal independently or through mutual cooperation in the way that suits them best. If they fall short of their emissions targets, they should expect to face infringement procedures, as is the case in other areas of EU policy. But there should be no place for prescriptive rules and policy-specific targets as to how to achieve that emissions reduction: these will inevitably reduce flexibility and distort investment choices, in this case in favour of technologies that are not cost effective.

- Simple targets for carbon reductions would not stop member states from pursuing ambitious renewable policies if they chose to do so, but would at least allow them to judge first whether this is the most effective way of cutting carbon emissions. Renewables investment could well be stimulated as a result of other policy instruments, most obviously a carbon tax – but this would only happen after more cost effective options for carbon abatement are tackled first. The most obvious among these is energy efficiency and reduced energy consumption. This could be stimulated by taxes on carbon, but the essential corollary to this should be to cut taxes which are currently levied on energy saving products, most notably VAT and EU import duties.

- As argued throughout this paper, there are finite resources available in the fight against climate change, meaning these must be used to their optimal potential rather than unnecessarily squandered on costly abatement methods. Targets for biofuels and renewables, however, channel limited resources towards higher costs and huge uncertainties. Politicians often talk in terms of 'declaring war on climate change'. But one characteristic of all successful war planning is the effective mobilization of economic resources – in this respect, current EU policy is a wholesale failure, and an approach that can only lead to defeat.

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