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A R T I C U L O

Glass: a small part of the Climate Change problem, a large part of the solution

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The challenging EU targets for reducing greenhouse gas emissions and generating electricity from renewable sources were established as – 20% and 20% by 2020. As part of the strategy, EU confirmed in 2007 the need to save around 300 million tonnes of CO_2 per year from EU buildings by 2020. Housing itself accounts for some 40% of emissions, mostly associated with heating. Industry will be expected to source and use appropriate materials and process technologies to improve their own energy consumption and at the same time deliver products that permit to reach those targets. This article examines the relationship between the emissions from relevant sectors of the glass industry and compares them with the carbon savings that can be achieved with the products the industry makes. Four main areas are discussed: glass fibre insulation, advanced glazing (low emissivity glass and advanced solar glass), continuous filament glass fibre and special glass applications. It is suggested that as well as considering the use of free allowances or border carbon adjustment, member states need to take account of the benefit of these products when formulating emission constraint policies; a carbon credit feedback loop should be also explored to encourage cheaper production and installation and avoid carbon leakage.

Key words: glass, climate change, energy, CO_2 balance, solar glass, glass fibre insulation, advanced glazing, emission trade

El vidrio: una pequeña parte del problema del cambio climático, una gran parte de la solución.

La UE ha establecido los objetivos de reducción de emisiones de CO_2 en -20% y de generación de electricidad a partir de energías renovables en el 20% para el año 2020. Como parte de esta estrategia la UE confirmó en 2007 la necesidad de reducir en 300 millones de toneladas por año las emisiones provenientes de los edificios en el mismo año 2020. El parque de viviendas aporta alrededor del 40% de las emisiones, básicamente relacionadas con sistemas de calefacción. Se espera de la industria que utilice procesos apropiados para mejorar su propio consumo energético y al mismo tiempo desarrolle y produzca materiales que ayuden a cumplir estos objetivos. Este articulo examina la relación entre las emisiones de sectores relevantes de la industria vidriera y las compara con los ahorros de CO_2 que pueden alcanzarse con los productos fabricados. Estos balances energéticos y de emisiones de CO_2 se analizan en cuatro áreas: fibra de aislamiento, acristalamientos avanzados (bajo emisivos y vidrios con control solar), filamento continuo y aplicaciones especiales del vidrio. Se propone a los gobiernos de la UE que tomen en consideración estos productos a la hora de formular políticas restrictivas de emisiones; por otro lado se sugiere la posibilidad de explorar los retornos del ciclo del carbón para promover una producción e instalaciones más económicas y evitar pérdidas.

Palabras clave: vidrio, cambio climático, energía, balances de CO_2, vidrio solar, fibra de vidrio para aislamiento, acristalamientos avanzados, comercio de emisiones.

1. INTRODUCTION

Challenging EU targets have been set for reducing greenhouse gas emissions and generating electricity from renewable sources – 20% and 20% by 2020. These targets get even tighter if an International Agreement is ratified with the EU reduction target moving to 30%. As part of the strategy, in 2007 the EU heads of state and government confirmed the need to save annually around 300 million tonnes of CO_2 from EU buildings by 2020. Housing itself accounts for some 40% of emissions; mostly associated with heating. Industry will be expected to source and use appropriate materials and process technologies to improve their own energy consumption and at the same time deliver products that will help governments meet those targets. Meanwhile the cost of manufacture will become more expensive as energy prices rise and carbon prices rise as allowances become scarcer. Where will these savings and products come from? This article examines the relationship between the emissions from relevant sectors of the glass industry and compares them with the carbon savings that can be achieved with the products the industry makes. Four main areas are discussed: glass fibre insulation, advanced glazing (low emissivity glass and advanced solar glass), continuous filament glass fibre and special glass applications. It is suggested that as well as considering the use of free allowances or border carbon adjustment, member states need to take account of the benefit of these products when formulating emission constraint policies and that a carbon credit feedback loop should be explored with a view to encouraging cheaper production and installation and avoiding carbon leakage.

2. GLASS PRODUCTS CONTRIBUTE ENORMOUSLY TO CARBON REDUCTION

The glass industry is doing its homework and has identified savings that will contribute significantly to Europe meeting its Climate Change targets. Indeed the use of appropriate glass products can drastically reduce energy demand and thus CO_2 emissions right around the world. These products fall into 4 main categories: a) passive insulation b) advanced glazing products reducing heat loss out of buildings where the outside temperature is too cold or reducing heat gain into buildings where the outside temperature is too hot c) products incorporating glass components that utilize the sun's energy to capture heat directly or convert it into power d) products incorporating glass in energy efficient products e.g. lighting. Arguably there are other categories, for instance research seems regularly to indicate applications where glass components could reduce overall energy demand such as in communication (e.g. fibre optics) or by material substitution. Everyday glass products such as glass containers also have an indirect role in saving energy for instance through the efficient use of recycled glass and by providing long-term, safe and inert packaging thereby reducing food wastage.

3. SAND TO GLASS – IS IT WORTH IT?

Most glass is made from sand. It is no secret that mineralogical transformation, whether converting ores to metals or carbonates to oxides takes a known, finite and relatively significant amount of energy. There are limits to how efficient the best operator can be and until we have abundant carbon-free electricity or someone can by-pass the laws of physics (a concept which industry sometimes has difficulty getting across to policy makers) we have to adapt to the consequences: that is, if we want to continue use the products. However it is important in any situation to weigh up the pros and cons. What are the carbon returns of investing in these glass products: are they of marginal benefit or do the gains far outweigh the cost? In other words is the benefit so great that we should simply get on with it; putting in place the right political and economic climate in order to achieve our environmental objectives?

4. THE GREEN HOUSE GAS EMISSIONS TRADING SCHEME AND CARBON LEAKAGE

Arguably, whether in the EU or elsewhere, one of the most talked about fiscal instruments is the emissions trading scheme. Ultimately putting a high carbon cost onto energy intensive industries, which in efficiency terms are approaching the limits of the laws of physics and cannot cost effectively abate or capture CO_2, will make local production more expensive. If there is no environmentally superior substitutable product (and we must be sure to extend our horizons to life cycle impacts not just manufacture) and these extra costs cannot be passed onto the customer then there is a real risk of "carbon leakage". This can occur where the customer chooses and is able without added cost to source his products from outside the carbon constrained region. As a consequence eventually relocation of production takes place and without carbon constraint there is no carbon reduction and potentially even an overall increase as, at a very minimum, transport impacts increase.

5. WHAT GLASS CAN DO FOR YOU?

5.1 Glass and mineral wool in buildings

We like to be neither too hot nor too cold – at home and at work. In the EU Second Strategic Energy Review - Securing our Energy Future (Nov. 2008), Europe has agreed a forward-looking political agenda to achieve its core energy objectives of sustainability, competitiveness and security of supply. Amongst other things the Commission intends to reinforce the key energy efficiency legislation on buildings and energy-using products and develop low energy and positive power buildings. Glass and mineral wool products will play an essential role in this.

There is a wealth of information available from the mineral and glass wool trade association (in Brussels - Eurima - http://www.eurima.org) for details on how their products contribute to the saving. Recent calculations by producers indicated that carbon payback period for insulation can be as little as 4-5 weeks and similar work in the States indicated that 60 million houses are under-insulated [Sustainability at Owens Corning: 2007]. Estimates of energy savings available through improving the EU building stock indicate a potential and staggering 460 Mt CO_2 [Ecofys V report: 2005]. A large percentage of this will be through the use of glass and mineral wool products.

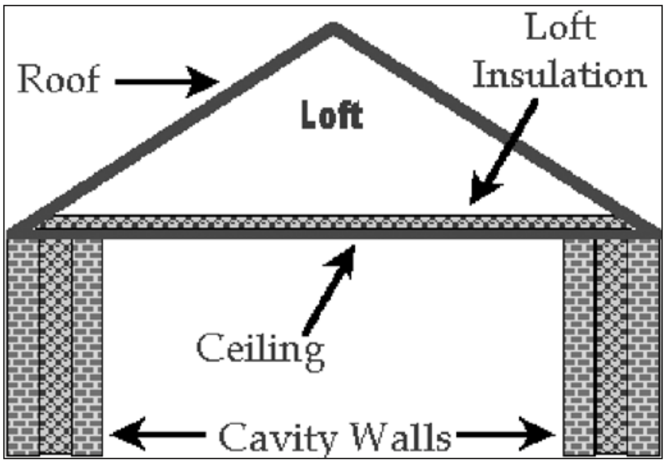

Figure 1: Insulation plays a major part in conserving energy (gcsescience.com)

5.2 Advanced glazing

Whereas traditional building insulation products act by preventing heat flow in all directions, effective modern glazing can be designed to take into account the amount of insolation received and be suited to local conditions depending upon where you live. The simplest glazing upgrade is to convert single glazing to double glazing and it is evident that there is still a lot to do in Europe and elsewhere.

When the overall ambient temperature is for a considerable part of the year lower than that which the occupier might consider comfortable the objective is to take advantage of the sun's rays coming through the window and minimise the heat loss outwards both from that insolation and of course from any domestic heating appliances in order not to waste energy. In regions where the ambient temperature is often uncomfortably hot, the increasing tendency, as people aspire to a better lifestyle or have more disposable income, is to install air conditioning and that of course brings with it an energy and carbon burden. In that case the primary objective is to keep heat out. The principle works just as well in vehicles; reducing fuel consumption.

5.2.1 DO THE CARBON SAVINGS OUTWEIGH THE CARBON OUTLAY?

The carbon involved in making these glazing products can be readily calculated; industry has a fine control on its fuel costs. Calculating the carbon saved is more complicated but as the objective here is to get the "big picture", a few reasonable assumptions are all that is necessary. Parameters should include regional ambient conditions, population, types of building, heating or cooling requirements and local fuel or electricity supply characteristics. Furthermore assumptions need to be made about the growth rate of air conditioning in buildings both in the work place and at home and we can take for example the United States as a model of what might be expected.

The European flat glass industry has done its homework. Glass For Europe (the European Flat Glass Association in Brussels; previously GEPVP) contracted TNO (Organization for Applied Scientific Research, a not-for-profit organization in the Netherlands that focuses on applied science) to independently carry out two projects to quantify the CO_2 emitted during manufacture and the savings accrued from the use of energy efficient glazing. The first report (published in 2005 and currently being updated) dealt with "The Energy and Environmental Benefits from Advanced Double Glazing in EU Buildings" and the second, which was published in 2008, dealt with "Solar Control Glass for Greater Energy Efficiency". See http://www.glassforeurope.com/

Essentially the first report identified savings of some 140MtCO_2p.a. across Europe (25) whilst the second identified savings of between 18 and 85MtCO_2p.a. (27) depending upon how fast the use of air conditioning continued to grow in the EU. In the former report these figures were compared with the considerably smaller amount of CO_2 p.a. identified as being emitted by architectural flat glass production in the EU. Production turned out to emit 4.6Mt CO_2 p.a.

Given that in 2007 the EU heads of state and government confirmed the need to save annually around 300 million tonnes of CO_2 from buildings by 2020 you would imagine that by encouraging the manufacture of cheaper low emissivity glazing and pre-empting the increase of air conditioning by insisting on solar control glass would be an imperative. Fortunately regulation has in may places improved the requirements of new build and replacement but going the extra kilometer is essential and probably not at all expensive when compared to the billions of Euros that have recently been found to prop up a flawed financial system.

Low-E double glazing

- Across the EU, buildings account for some **765** Mt CO_2 p.a.
- The EU Heads of State target is to save **300** Mt (40%) of this by 2020.
- The use of low-E double glazing gives potential saving of **140** Mt CO_2 p.a.
- Low-E glazing provides nearly **50%** of the EU buildings' target.
- The manufacturing of one square metre of low-E double glazing leads to the emission of **25** kg of CO_2.
- The CO_2 saving by replacing one square metre of single glazing by low-E double glazing represents **91** kg CO_2 per year.
- Carbon pay back time is **3.5** months if replacing single glazing and 10.5 months if replacing basic double glazing.

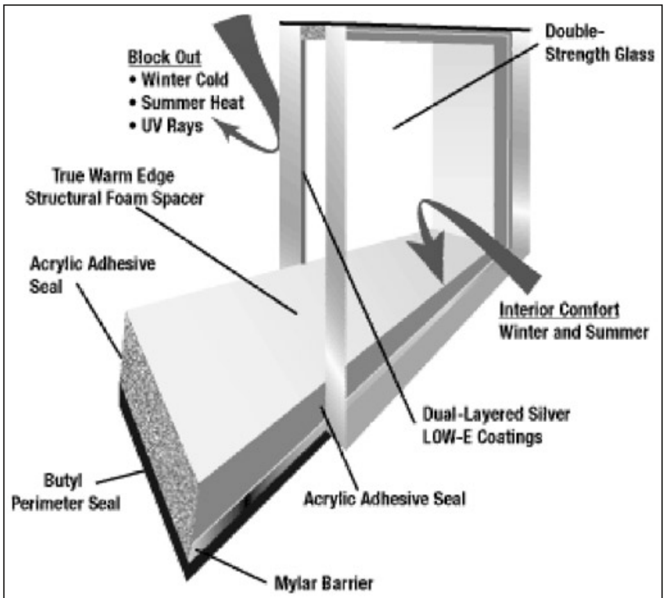

Figure 2: In cooler climates low emissivity glass keeps heat in (Glass For Europe)

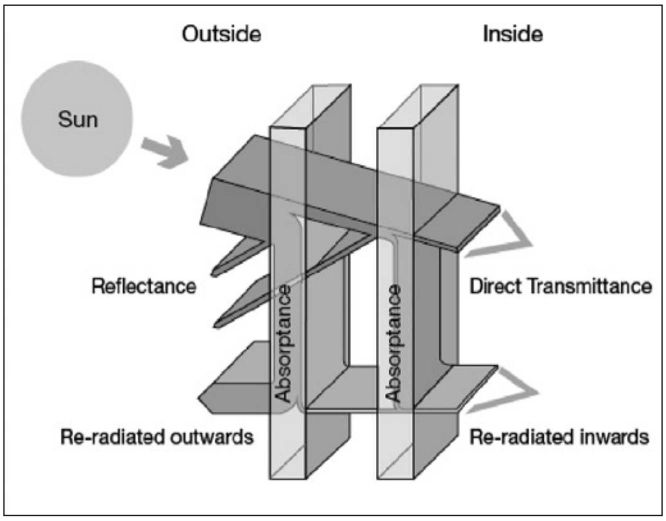

Figure 3: In hot sunny climates Solar Control Glass keeps heat out (Glass For Europe)

Solar Control Glass

- Energy supply for air conditioning is a growing concern.
- In the EU 27 some 5% of new residential buildings and 27% of new non-residential buildings are now air conditioned.
- Air conditioning is higher in the south (83%) compared to the north (15%)
- It is likely that these numbers will continue to climb.
- In the US, average figures are 80% and 65% respectively.

5.3 Continuous Filament Glass Fibre

One of the strangest glass processes to watch is that where glass strands of only 5 to 25 microns are drawn from white hot platinum bushings. The main end-use of these fibres which may be in the form of roving, chopped strand, yarn, mat, fabric or tissue is the reinforcement of thermosetting and thermoplastic resins and these composites are used in a wide variety of applications; not least in the construction of wind turbines. They are also widely used in printed circuit boards. It proved difficult to compare embedded carbon with the carbon saved by wind generation but the big picture indicates that this form of reinforcement is considerably cheaper and less carbon intensive than, for instance, carbon fibre. Furthermore the robust glass fibre characteristics are essential to enable the blades to withstand the enormous stresses that are generated by the flexing and great wing tip speeds: some blades being up to 61m long!

The report from the BTM Consult 13th annual update on the International Wind Power showed that 2007 had the highest number if wind turbine installations to date (19,791 MW); resulting in world-wide 94,000 MW or 1% of global electricity production. With the fastest growing markets in France, China and the USA, it forecasts an annual growth rate of 20.7 % per year reaching 50,000MW p.a. in 2012 at 287,000 MW. Assuming it was logistically possible only 5% of that would be needed to meet the melting requirements of all the world's float furnaces (~260). Cumulative value over the next 5 years is estimated at $300 billion with the top ten suppliers in the world covering around 95 % of the total supply. Two Chinese manufacturers and one from India now represent 18 % of the global supply but could the EU be doing more to encourage production and consumption at home?

5.4 Special glass products

Glass components are essential parts of the solar panels and photo voltaics and efficient lighting. These are becoming more and more common and such applications are identified in the European and national climate change strategies. It would be good to be able to report on the carbon footprint of these products or individual components and compare them with the energy generated and carbon saved, but if the information was out there it was not readily available before going to print. Whilst their production and use looks like a "win-win" situation, just like insulation products and advanced glazing, EU Climate Change legislation is making it more expensive to actually make these products in Europe.

6. APPROPRIATE POLICY

Is there a policy contradiction that we need to address and what solutions are on the table? At the moment all the energy and CO_2 savings accrue to the end consumer who may initially pay increasing costs for the very products that governments want installed. Given the EU Commission's reluctance to allocate sufficient carbon dioxide allowances for production (or impose what it is sometimes referred to as border carbon adjustments) is there a case for returning the value of carbon savings back up the stakeholder chain? Could a form of hypothecation be used to offset the carbon costs of manufacture, keep customer costs down and help maintain EU competitiveness in a global market? There are of course associated implications to explore.

6.1 Energy Intensive Industries dilemma

The Energy Intensive Industries (EII), those whose energy costs make up ~20-30% of the production costs some even much higher, include essential sectors from the construction industry: e.g. cement, lime, glass, ceramics, steel, aluminium, etc. They are particularly hard hit by climate change legislative and economic instruments geared to forcing them to internalise the environmental cost of carbon dioxide from fossil fuel combustion and mineralogical transformation. But where do they really sit in the sustainability picture?

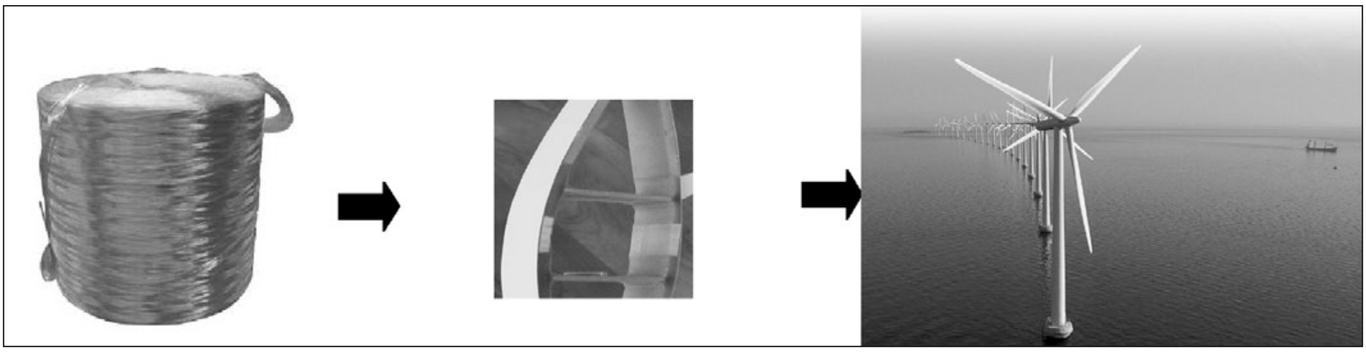

Figure 4: Glass Fibre made into wind turbine blades (PPG)

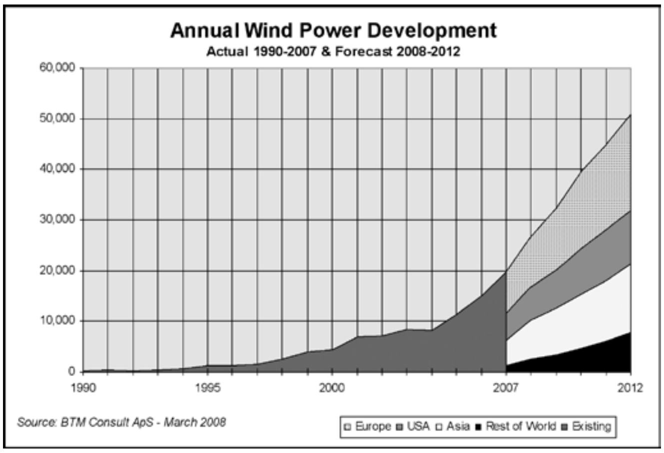

Figure 5: Predicted growth in wind turbines (BTM Consult ApS +PPG)

We can see from the above that some products are essential to an effective climate change strategy and provide vastly more benefit than manufacturing impact. If we can't find low carbon alternatives can we, as nations, provide enough energy from low or zero carbon sources for their continued manufacture in the EU? And if we think radical changes in manufacturing and construction practices are possible; by what mechanisms and in what transition period can they be made?

Most EU EIIs argue that within a few years all profitability will be removed because there will be little or no ability to pass through costs, free allocation will be reduced, allowance availability will decrease and energy prices will rise. In contrast, extra EU operators will benefit as customers will turn to comparatively cheaper imports from countries which perhaps have less aspirational environmental objectives than those in the EU? The EU member states are grappling with the dilemma and can find no simple answer.

6.2 Carbon leakage

There are serious issues here; if it is no longer cost effective to make these construction materials e.g. steel or glass, in the EU and businesses can't compete with imports the manufacturers may eventually shut up shop or decide to relocate to somewhere cheaper. If the UK still consumes the product then nationally we have what is called "carbon leakage" i.e. someone, somewhere else emits the carbon while the member state consumer benefits from the cheaper import. Putting aside any moral issues, CO_2 is not site specific so the effects are not "out of sight, out of mind" - they continue to be felt world wide.

Is industry crying wolf on this? Is EU industry actually at risk? The UK glass industry has seen competitive leakage with the closure of over 50% of the installations (although not flat glass to date) that were in the original UK climate change agreements in 2000. High production costs and competition have driven out of the UK all melting and manufacture of glass cookware, scientific glassware, vacuum flasks, lighting, specialist product manufacturing and domestic ware such as drinking glasses (What, no British made pint pots in my local pub? Sadly no!) With these industries go not just the jobs but the skills base, the R&D and the links to the academic institutes who rely on the presence and activity of these industries for part of their continued financing and reputation. Regulators also lose control of any environmental impacts.

EII industries are central to the dilemma of competitiveness and carbon leakage and saving energy. The current EU options to mitigate competitiveness effects include proportional allocations to take account of competition, an international agreement with multinational/multisector sign up or a form of border (tax) carbon adjustment. CO_2 benchmarking of manufacture may play a role in all three. International agreements present perhaps insurmountable political problems and many economists dislike border tax mechanisms as they interfere with free trade. So where do we go from here? Currently the most likely option is special treatment with a continued but reducing proportion of free allocation based on evidence of vulnerability to extra-EU competition.

Is there another or complimentary way of looking at the problem? In terms of sustainability we have already seen the vast CO_2 savings that glass products bring to the equation and to a greater or lesser degree most industries have positive and negative sides. Whilst building regulations have improved "new build" in member states and should continue to do

Figure 6: Solar tower with glass mirrors. (National Workshop on "Solar Thermal Power Generation" at IIT Bombay April 28, 2008)

Figure 7: Glass in Photovoltaics (Schott)

so, the retro fitting of energy saving measures in existing buildings is still very difficult and expensive to implement. How can we incentivise retrofit? How can we ensure that the very products we need are available at affordable prices, locally and sustainably produced?

6.3 Taking stock

Thus we have 3 major issues:

- The negative impact of CO_2 emitted by the glass manufacturers
- The increasing costs and competitive aspects of the manufacturing glass in the EU and
- The requirement to supply more energy positive products and actually encourage their use.

How does one issue compare with another?

Firstly what jumps straight out of the figures above is that, should it be so minded, society can take much greater advantage of the environmental benefits of glass manufacture than it is doing to date. Given that the return on investment in terms of carbon dioxide is so high, it seems incredible that a greater effort has not been made to really encourage the manufacture and use of these glass products. Has energy been too cheap to date - at least for the consumer? Have the people responsible for planning, designing and constructing buildings been disconnected from the people who eventually pay the fuel and electricity bills – leaving the latter to pick up the tab from poor construction? Are changes in building standards across the world too slow in addressing climate change and energy security? If changes came more quickly what could be done to help industry retool in order to keep up with those demands?

Secondly having once decided to use these energy saving products, how do we make their purchase and installation cheaper, their market penetration greater and the customers' payback period shorter?

Thirdly how do we keep production close to the customers?

6.4 Encouraging good works

Incentives for "good works" exist at many levels. For instance UK government grants have been available for installation of energy efficient boilers with the benefits to some extent running back up the stakeholder chain. "Joint Implementation" could even be interpreted as a form of incentive for "good works" where under Article 6 of the Kyoto Protocol, an Annex I country can invest in emission reduction projects (in any other Annex I country) and in this way lower the costs of complying with their own Kyoto targets by using those greenhouse gas reductions for their own commitments. The principle could be extended whereby EIIs invest in and manufacture products that reduce energy consumption downstream. Couldn't they benefit at least temporarily from those reductions? Might not upstream stakeholders receive CO_2 allowances proportional to the benefit that their products bring – at least for a given period? This would encourage or kick-start local production and use of low carbon energy saving and generating products (insulation, photovoltaics, thermally efficient glazing etc.).

Governments tend to shy away from hypothecation – the use of monies from one source being returned to that same source to provide a positive feedback loop. Governments are wary of it because, as was stated November UK government response to its consultation on Phase 3 EUETS: "it is an inefficient means of determining public expenditure priorities which should generally be looked at in the round rather than by creating artificial links between particular spending programmes and specific revenue streams". In other words monies that are not "earmarked" can be used for any eventuality: health, transport, defence etc. It is also feared it may lead to market distortion.

However, given that EU and UK industry is struggling with rising production costs in a global market, could not at least a percentage of the CO_2 savings be recycled back to the EUETS manufacturers to bring down the cost of production in the EU and make it cheaper to implement those climate change adaptations that policy says we require? The UK and Europe have extremely challenging climate change objectives; what better way to rise to that challenge than with environmentally sound products made locally.

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