How can Materials Science help save the planet from environmental disaster?

What is the disaster?

As the third millennium dawns, materials science technology has never been better placed to combat the planet's environmental disasters. From lead rubber bearings used to help protect buildings against earthquakes to identifying the perfect balance of earth materials in avalanche protection dams, materials science is at the heart of today's disaster management techniques. These types of disaster tend to be localised, near tectonic fault lines for example; however there is a category of disaster that threatens our planet as a whole, it's cause – global warming.

The term "global warming" is used to describe noticeable net increases in the earth's temperature; looking generally at the past 100 years. The following graph (Figure 1) of global temperature record illustrates this effect.

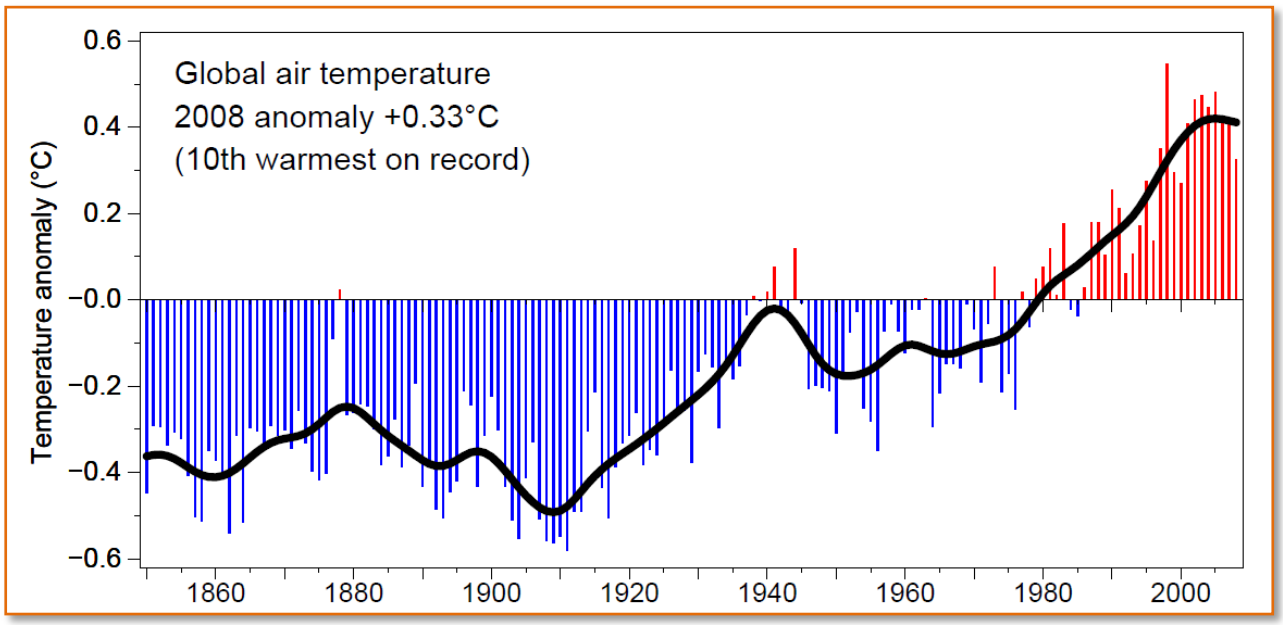

Figure 1: Uncertainty estimates in regional and global observed temperature changes: a new dataset from 1850 - Brohan, P., J.J. Kennedy, I. Harris, S.F.B. Tett and P.D. Jones, 2006

Primary disasters caused by global warming vary in magnitude and severity, and include extreme weather, floods, drought, changes in seasonal weather behaviour and higher sea levels. These in turn can lead to secondary disasters such as damage to eco systems causing major effects on farming, wildlife migration and can give rise to the possible extinction of some species.

There is a significant amount of evidence that points to global warming being a product of more than just natural causes. Human industrial development is inevitable, and as a result so are the emissions of greenhouse gases (GHG's), the primary cause of global warming. "The debate about whether there is a global warming signal now is over, at least for rational people" – Tim Barnett of the Scripps Institution of Oceanography in La Jolla, California.

GHG's absorb more infrared radiation from the sun than the rest of the atmosphere; this radiation is not reflected back out at night – hence the name 'greenhouse' gasses.
We need to reduce these GHG's to prevent further global warming and steer our planet away from environmental disaster.

How can materials science help?

Materials science has numerous applications in helping to reduce these GHG's. The major causes of GHG emissions need to be understood in order to identify where materials science can best be applied to reverse the problem. Below (figure 2) gives a comprehensive view of global GHG emissions, showing which industries and activities are causing the most damage. As we look at some of the main contributors in this text, we see that materials science is already being applied significantly in these areas as part of the solution.

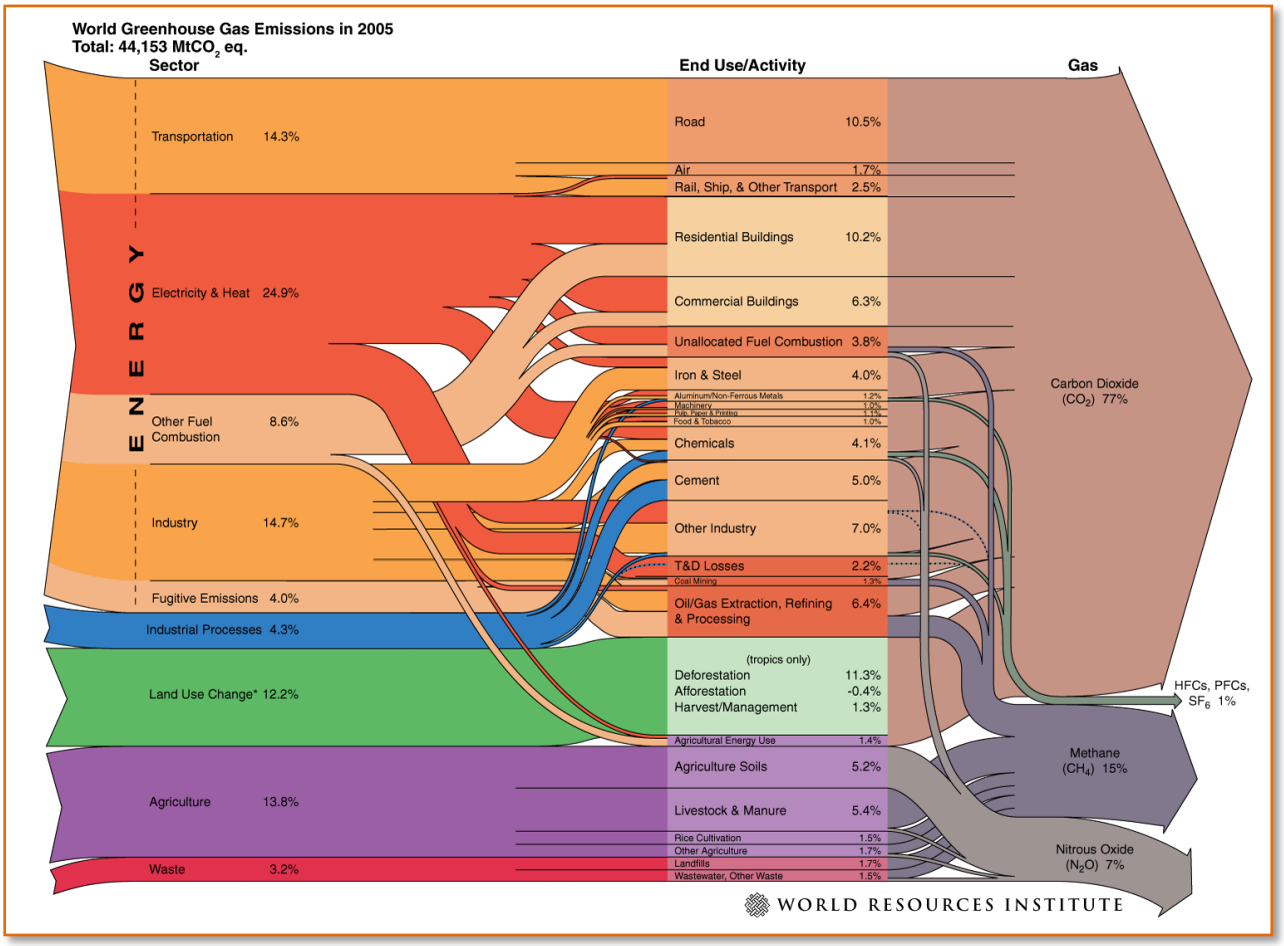

Figure 2: World Greenhouse Gas emissions updated chart for 2005 – www.wri.org

From figure 2 we can see that a large portion of GHG's are produced by burning fuel for transportation. Already we have seen materials science play a part in reducing these emissions. Boeing's 787 uses carbon fibres embedded in resins that have only recently been manufactured tough enough for extensive application in an aeroplane. The fuselage, wings and vertical and horizontal tails are all built from these new advanced composites through a range of different, unique and inventive manufacturing techniques. By replacing aluminium alloys with carbon fibre composites as the primary construction material, the overall weight of a large passenger jet can be cut significantly and hence reduce fuel usage. In the future we expect to see these technologies applied in road vehicles.

New advanced composites that act like batteries, releasing electricity, are currently being developed for use in electric cars. When referring to The Tesla Roadster, a US manufactured electric car weighing 1,200kg (450kg of which is accounted for by the hefty battery), Dr Emile Greenhalgh, an engineer at Imperial College said "with our material, we would ultimately lose that 450 kilos. That car would be faster and travel further."

Materials science is applied heavily in the development of new sustainable insulation materials. We can see from figure 2 that a large portion of emissions come from energy used to heat or cool homes. By building and improving homes with advanced insulating foams that are being developed based on using rapidly renewable materials, energy consumption in this area can be largely reduced.

In developing new, sustainable, low emission methods of producing electricity, materials science has an important part to play. Super heat resistant materials that maintain their structural properties under extreme conditions are required for use in geothermal power stations - generating electricity from convection currents deep below the earth's crust. Strong corrosion-resistant materials designed to be submerged in sea water are required for costal barrages, generating electricity from the tides. In fact engineers at the University of Liverpool claim that building estuary barrages in the North West could provide more than 5% of the UK's electricity - ScienceDaily.com (Mar. 27, 2009). Wind farms are an increasingly popular way of producing clean, sustainable electricity. Materials science is at the core in determining the efficiency of these machines, new materials and manufacturing methods are allowing for lighter, stronger and therefore larger blades that yield a greater electrical output.

Materials can also help to reverse the problem. Materials exist that actually absorb CO2. All cement outputs CO2 in its production process then re-absorbs some of this CO2 upon hardening. Regular cement produces more CO2 than it absorbs but Novacem, a well established cement manufacturing company, have recently patented a type of cement that actually absorbs more CO2 than it produces. Whilst the overall carbon footprint of regular cement is 0.5 tonnes of CO2 per tonne used, the new cement actually absorbs around 0.6 tonnes of CO2 per tonne used. This is by no means a solution to the problem of GHG emissions; after some rough calculations, given that the World Resources Institute tells us that in 2005 total GHGs were estimated at 44,153,000,000 tons, we can estimate that if a developing country with the population of the United States were to build all of its residential housing using this new concrete, existing CO2 would only be reduced by 1 percent! What this does mean though is that any future building projects using this concrete could operate more sustainably with greatly reduced impact on the environment

Will we succeed in preventing environmental disaster?

Materials science plays a part in many of the solutions to the problem of GHG emissions, and in many more ways than those summarised in the text above. Though despite the world of materials science and engineering already significantly combating the GHG emissions problem we are still heading for disaster. The bottom line is that no one solution will prevent environmental disaster. It will take multiple solutions implemented by many organisations and individuals alike and almost definitely at substantial monetary cost. As long as we take the problem seriously and continue to invest in sustainable materials science and engineering technologies to combat it, we still have time to win the battle against global warming, one step at a time.