



Nanotech: Cleantech
Quantifying The Effect Of
Nanotechnologies On CO₂
Emissions

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Summary

Energy is one of the world's largest markets, but the demand is forecast to far exceed the available supply from current resources. In addition, the use of energy from non-renewable sources is the major contribution to the emission of greenhouse gases leading to increasing concern over climate change.

As a result there is increasing pressure on both industry and governments to find new energy solutions, which will both address this growing supply gap and from industry's point of view, turn a profit. Renewable energy resources are needed to maintain the world's energy supply to slow the depletion of fossil reserves and reduce global carbon emissions.

Sustainable energy has long been a dream and nanotechnologies have long been seen as a technology with the potential to reduce greenhouse emissions, but to date this has not been quantified. Many of the initial ideas were based around replacing current manufacturing techniques with bottom up technologies, whether assembling items atom by atom as proposed by Eric Drexler, or by attempting to understand how nature assembles useful devices from the bottom up and mimic or control these techniques.

While bottom up engineering remains a topic of much research, many of these applications of nanotechnologies are still at an early stage, and there is general agreement that breakthroughs are still ten to fifteen years in the future. These breakthroughs will not only help improve current energy technologies but also open up many possibilities for new energy technologies to power the future world.

This white paper is based on the report "Nanotechnologies for Sustainable Energy: Reducing Carbon Emissions Through Clean Technologies and Renewable Energy Sources" available at www.cientifica.com which examines how nanotechnologies are contributing to sustainable energy, provides detailed market information on the use and impact of nanotechnologies and quantifies the near term impact in terms of carbon dioxide emissions.

Cientifica Nanotechnology Model

Cientifica Ltd provides a nanotechnology model based on primary research quantifying the impact and diffusion of nanotechnologies by industry sector over time. The model takes into account global R&D spending on nanotechnologies and assumes a median seven year time lag between the start of a funding program and a commercially useful output, industry R&D growth rates, global GDP growth predictions and the rate of penetration of nanotechnologies based on primary research to develop the rate of diffusion by industry sector.

Major Assumptions

Technology diffusion is not linear and the Cientifica model takes into account varying rates of adoption as nanotechnologies rapidly become mature in some industries, while others are late adopters. The key reasons for this are cost and sector. In non-cost sensitive areas such as defence, adoption of new technologies tends to be rapid in performance gains can be realised. The opposite is true in industries the major part of industries such as food and clothing where low margins restrict the adoption of new technologies until they costs become low enough. Adoption also varies with sector. The chemical industry has been working with nanomaterials for the past ten years and growth and penetration rates will therefore be slower than in late adopters.

The model assumes a 50% step function in the rate adoption of nanotechnologies in 2012-2013 as a result of there being a sufficient number of well characterised components (materials, dispersions, products) available through mature and reliable supply chains to allow the production of systems based on nanotechnologies. This shift from cottage industry to major industry is analogous to the shift from discrete electronic components to integrated circuits.

The model makes no allowance for sudden scientific breakthroughs. However, whether these are the invention of the transistor or the discovery of DNA the adoption of technologies by the market can take twenty to thirty years. It should be noted that fullerenes were discovered in 1985 and carbon nanotubes in 1991, twenty-two and sixteen years ago respectively.

Finally the model assumes that there will be no major adverse public or ethical reaction to the application of nanotechnologies, nor that there will be any significant acceleration of research for political reasons.

Quantifying The Effect of Nanotechnologies on Global Emissions

Our quantification of the impact of nanotechnologies on carbon dioxide emissions is limited to technologies that are either already on the market, or those that have a clear timeline to commercial introduction. Many of these technologies are based on our improved understanding of and control over materials, and represent incremental improvements in existing technologies rather than truly disruptive breakthroughs.

The future and timelines of other major applications of nanomaterials such as the enabling of batteries and supercapacitors for hybrid electric vehicles and fuel cells for zero emissions vehicles are still unclear and are not included in these calculations.

As such, the numbers contained in this report should be taken as a minimum expected contribution to emissions reduction, and the actual figure may be far higher.

Furthermore they are based on a global aggregate, and individual nations and regions may move far faster, or slower than the global average.

The Impact Of Nanotechnologies on CO₂ Emissions

From an analysis of the impact of nanotechnologies on CO₂ emissions, it is clear that nanotechnologies provide a piece of the solution, but not the entire one. Currently available technologies have the potential to directly reduce carbon emissions by almost 200,000 tons by 2010, chiefly through weight savings and improved combustion in transport applications and through improvements in building insulation.

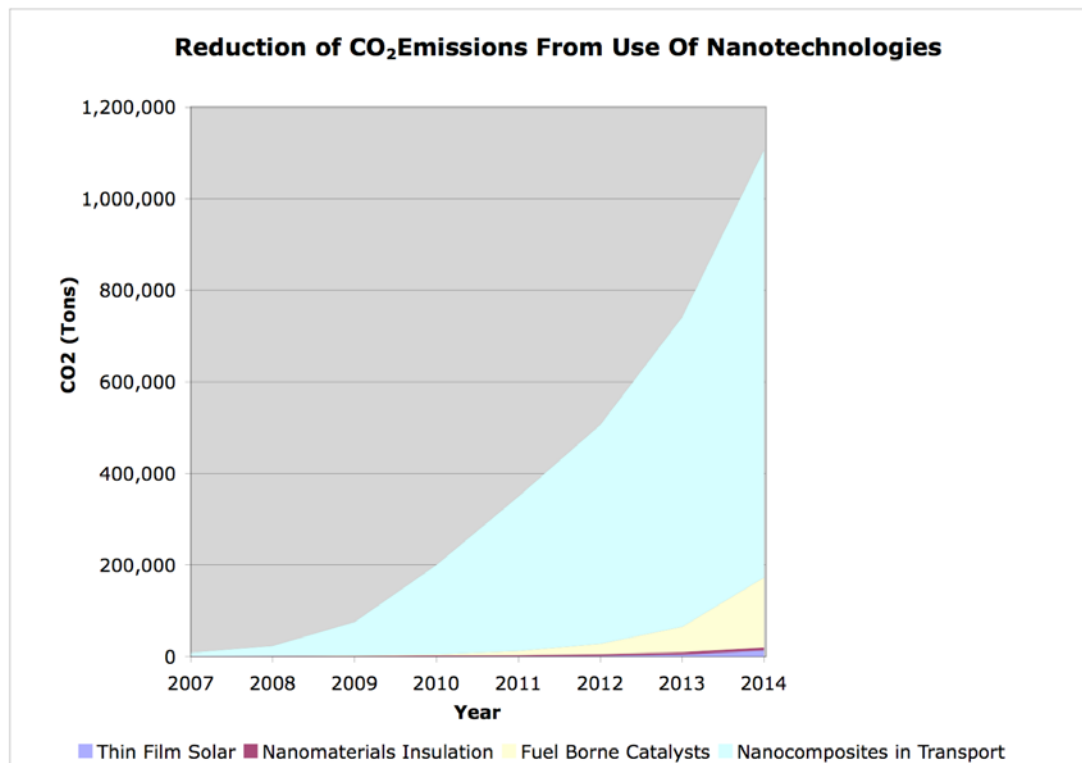


Figure 1 Reduction Of Emissions Due To Use Of Nanotechnologies Source: Cientifica

Taken as a whole, the use of nanotechnologies can contribute to the reduction of global CO₂ emissions in 2010 by 0.00027%, but the underlying picture is far more complex. Our calculations do not take into account the many materials-based advances enabled by nanotechnologies that are currently under development in the academic world, whose applications are as yet unclear. Many of these may possibly enable far more radical reductions in emissions by changing industrial manufacturing processes or allowing breakthroughs in the understanding and harnessing of natural processes such as photosynthesis which allow energy to be stored in a chemical form.

It can be seen from the figure above that the major contribution to emissions reduction will come from weight savings in the transportation sector rather than from any new energy sources. As a result, nanocomposite materials will have the greatest impact in the near term.

The impact of nanotechnologies in emission reductions will be in three main areas,

- a) The reduction of emissions from transportation through weight reduction and improved drive train efficiency
- b) The use of improved insulation in residential and commercial buildings
- c) The generation of renewable photovoltaic energy

Each of these areas offer spectacular growth opportunities, although some, such as weight reduction using nanocomposite materials are

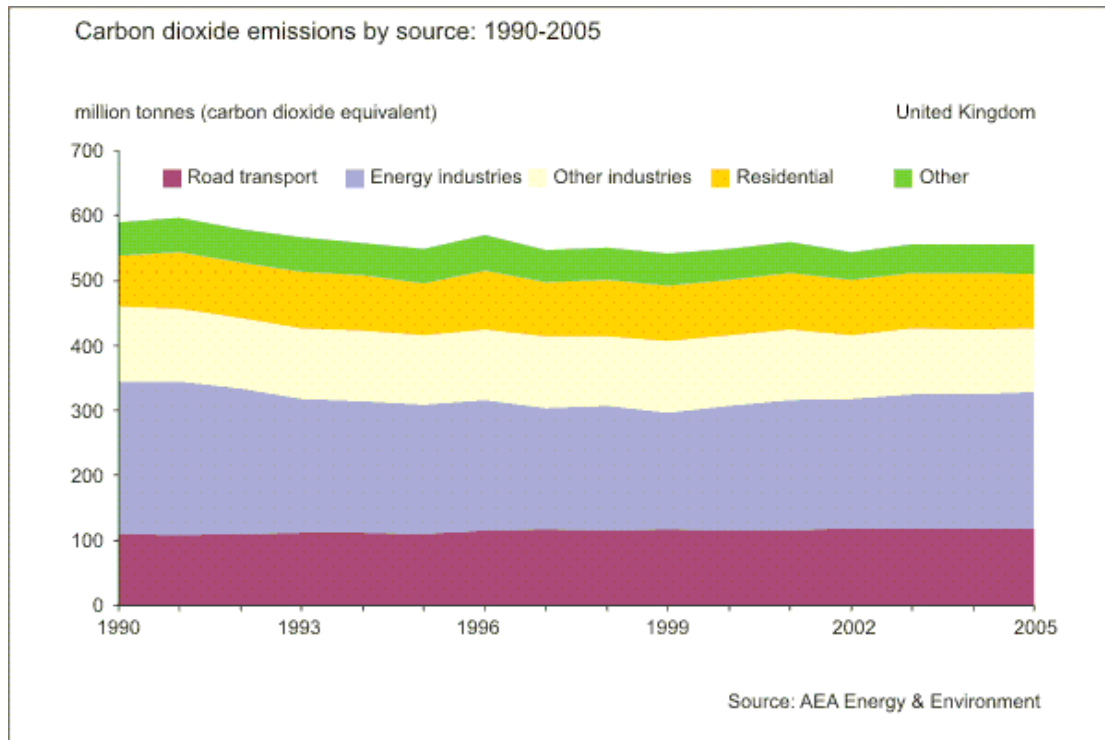


Figure 2 Sources of UK CO₂ Emissions

1. Reduction of Transport Emissions

The traditional automotive industry rule of thumb is that a 10% reduction in weight gives a 5% increase in fuel efficiency, but the adoption of composites across the vehicle, from engine parts to body panels has increased this saving. According to the US Transportation Research Board, the relationship between fuel consumption and vehicle weight is now linear. Thus, if we assume that a manufacturer reduces the weight of a vehicle by 10%, a corresponding fuel consumption reduction of 10% will occur.

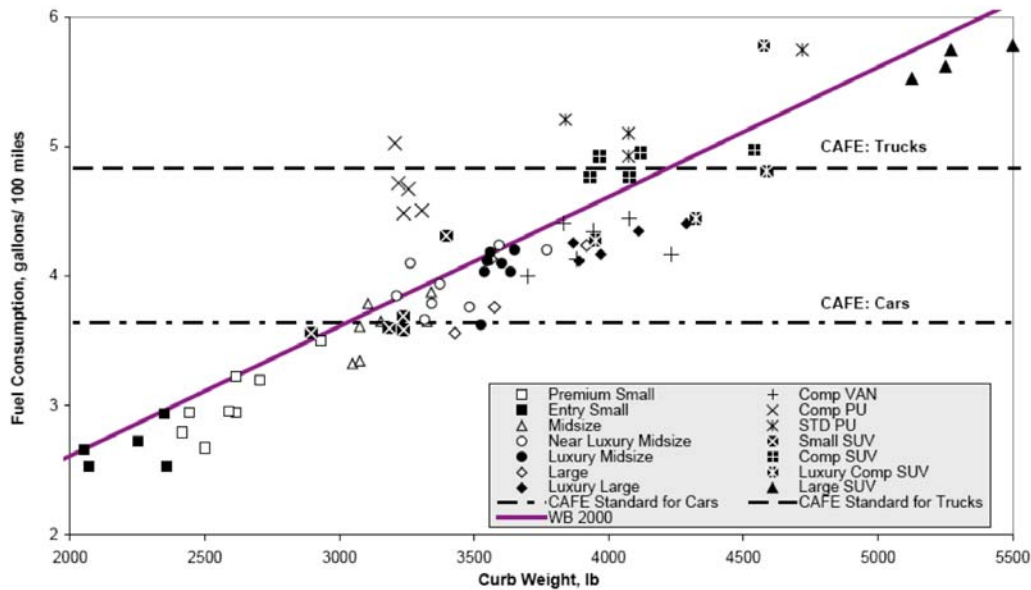


Figure 3 Relationship between vehicle weight and fuel consumption: Source Committee on Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards, Transportation Research Board, USA

Weight reduction is the key driver for the use of nanocomposite materials in the automotive sector, which started as long ago as 2001 when General Motors introduced their nanocomposite thermoplastic olefin (TPO) step-assist for the 2002 Chevrolet Astro and GMC Safari minivans.

The use of nanocomposite materials over traditional polyolefins includes improving the polymers' stiffness, dimensional stability, gas barrier, electrical conductivity, and flame retardancy. Nanoparticles are so small and their aspect ratio so high that the properties of composite materials improve with lower loadings and fewer penalties (such as higher density, brittleness, or loss of clarity) than with conventional reinforcers like talc or glass.

Assuming that vehicles built from 2005 onwards began to make increasing use of nanocomposite materials as prices fell and supply chains were established, rising to a maximum of 20% of weight, and that the use of these materials will take ten years to diffuse through the automotive industry, we estimate that their use will lead to a saving of over seven thousand tons of CO₂ in 2007. The figure will increase to over nine hundred thousand tons by 2015.

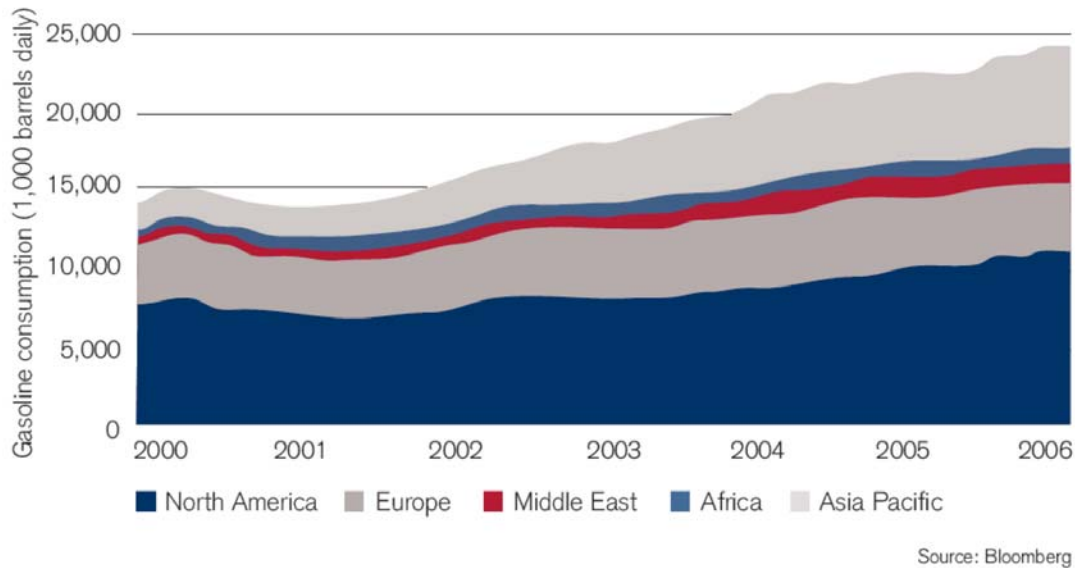


Figure 4 Global Gasoline Consumption

The use of fuel borne catalysts is expected to further increase efficiency, and despite the recent troubles of market leader Oxonica, we have assumed increasing numbers of market entrants giving a mean fuel saving of 7% (manufacturers estimates range from 5-15%). Unlike nanocomposite materials, the use of fuel borne catalysts is not limited to newly built vehicles and the potential market is correspondingly larger. As a result of its use, and using a conservative version of manufacturers estimates of the market size, we estimate a reduction in CO₂emissions of 2,600 tons in 2010 rising to 153,000 tons by 2015.

2. Reduction of Residential and Commercial Energy Use Through Improved Insulation

Heating and cooling account for about 40% of global residential energy use and are expected to decline somewhat as a proportion of total residential energy (IPCC). The EIA estimates residential sector energy consumption at 60 quadrillion BTU in 2006 rising to 65 quadrillion BTU by 2015. A similar figure holds for the commercial sector, although not for the industrial sector with consumption rising from 24 quadrillion BTU to 31 quadrillion BTU by 2015.

Nanomaterials are already being used to reduce the energy required for heating and cooling, and from manufactures estimates these materials are some 30% more efficient than current technologies (without taking into account lighter weight, the ability of materials such as aerogels to trap sunlight etc).

Based on estimates of penetration of the total insulation market by nanomaterials, a total CO₂ reduction of 1250 tons is expected to rise to 6563 by 2015, with 71% of the savings coming from the residential sector in 2007 falling slightly to 68% in 2015 as the number of more energy efficient commercial buildings increases.

3. Thin Film Solar Cells for Renewable Energy

While photovoltaic energy generation is often used to illustrate how renewable energy can replace fossil fuels, most estimates place its highest impact at 1% of global energy generation by 2015. Thin film solar panels using flexible substrates will open up new application areas, but silicon-based solar technologies, previously hampered by a shortage of silicon, a situation forecast to ease in 2008, are now promising far higher conversion efficiencies.

As a result, many of the thin film technologies will remain niche players while global giants such as Sharp and BP Solar will continue to dominate the market. Based on an estimate of thin film technologies accounting for some 2% of the solar energy market by 2015, the potential for emissions reduction by 2015 is a mere 13,000 tons of CO₂ annually.

Conclusion

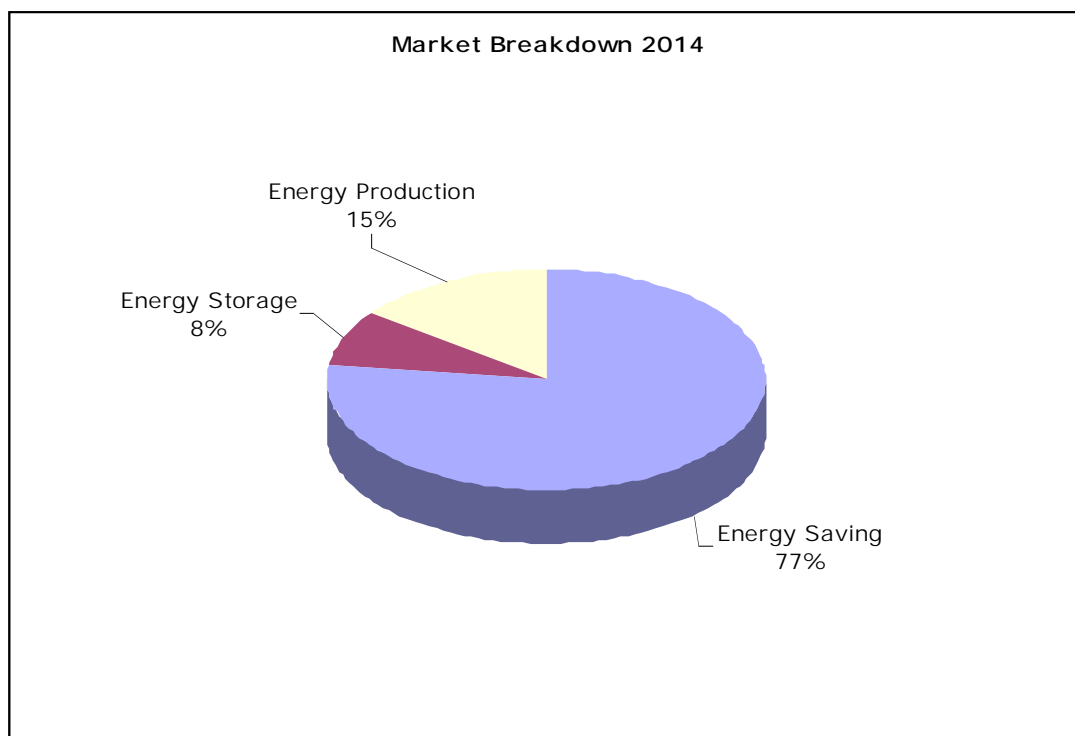


Figure 5 Sustainable Applications of Nanotechnology in 2014

In the short-term (2007-2010), the main impact of nanotechnology on the sustainability will still be the improvement of efficiency in current technologies rather than providing new energy sources. On the longer term (after 2010), however, it is more likely that a stronger influence of nanotechnology will be seen in enabling the use of revolutionary new energy sources such as hydrogen and solar conversions by improving the processes or providing nano-engineered materials for their energy storage and release.

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- * Market analysis & forecasting
- * Strategic technology consulting
- * Competitor benchmarking
- * Customer / supplier awareness
- * Risk assessment
- * Policy and legislative hotspots
- * Investment and acquisition studies
- * Product penetration and market positioning
- * Supplier identification and evaluation

Methodology

Cientifica's consulting engagements always start with you, the client, not with nanotechnology. While nanotechnologies may have a disruptive, incremental or no impact on your business we first understand your business before putting together a project team with a single point of contact.

Team

Combining in-depth understanding of nanoscale science and applications and business, our analysts make Cientifica the leading provider of global nanotechnology business intelligence and consulting services to industry, government and investors worldwide. In addition, our primary research is underpinned by in-house access to the largest nanotechnology network in the world, ensuring you benefit from constant contact with thousands of scientists and business leaders alike.

Clients

Cientifica's clients range from Fortune 500 companies to investment banks and start ups on three continents. While the majority of our clients are mid to large-cap, our network extends to many of the start-ups in nanotechnologies. We understand the value to be gained through joint ventures and alliances.

To find out how we can help answer your specific consulting needs, please contact consulting@cientifica.com