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Cleantech

The Impact on Key Sectors in Europe

In association with:

Oxford Analytica

series
CMS Lawyers for Business

Foreword by Cornelius Brandi – Chairman of the CMS Executive Committee

With "Cleantech", we continue our series of reports in conjunction with Oxford Analytica on topics of significant interest to all commercial enterprises operating in the European market. The report provides a commentary from the CMS team involved in the initiative, as well as the independent Oxford Analytica study in full.

CMS has chosen Oxford Analytica as its partner for the proven quality of its research and analysis. We are confident that in doing so this and similar reports have the scope and rigour necessary to stimulate a healthy and productive debate within your own organisations and possibly more widely. In some areas which are still evolving there will as yet be no right or wrong answers. In relation to those, we would not be so presumptuous as to claim that the views we express or the conclusions we reach are likely to be any more accurate than your own. However, by creating the framework and forum for the debate we hope to be able to educate and perhaps encourage others to find the right solutions.

In our commentary, we have intentionally referred to "the Cleantech revolution" because the drivers behind it are transformational in nature and cut across all continents and all industries. The global magnitude of its impact is underscored by the estimate that by 2015, the Cleantech industry will be worth many trillion Euros.

As lawyers, we will naturally be looking at the issues concerned from a legal perspective. Further, our intention is also to examine and, we hope, throw some light on the broader commercial, regulatory, fiscal and political aspects of this important topic.

Clearly the issues related to Cleantech extend well beyond Europe and have global implications. At CMS, however, we think of ourselves very much as citizens of Europe since, of our 2,400 plus lawyers operating from 48 cities around the world, the substantial majority is based in and is offering practical legal advice from within Europe. Our main aim, therefore, is to consider the issues with a European focus and to assess their likely impact on the future development of Europe, particularly as they affect the commercial and corporate environment in which all of our clients have to manage their own businesses with a view to profitability.

This is an economically challenging time worldwide. But Europe is well positioned to seize the enormous growth opportunities afforded by Cleantech, perhaps even more in the midst of profound economic uncertainty. CMS and Oxford Analytica hope that this report will offer valuable insights into how businesses in all industries can prepare for the impact of Cleantech by minimising the potential risks and maximising the unprecedented opportunities it affords.

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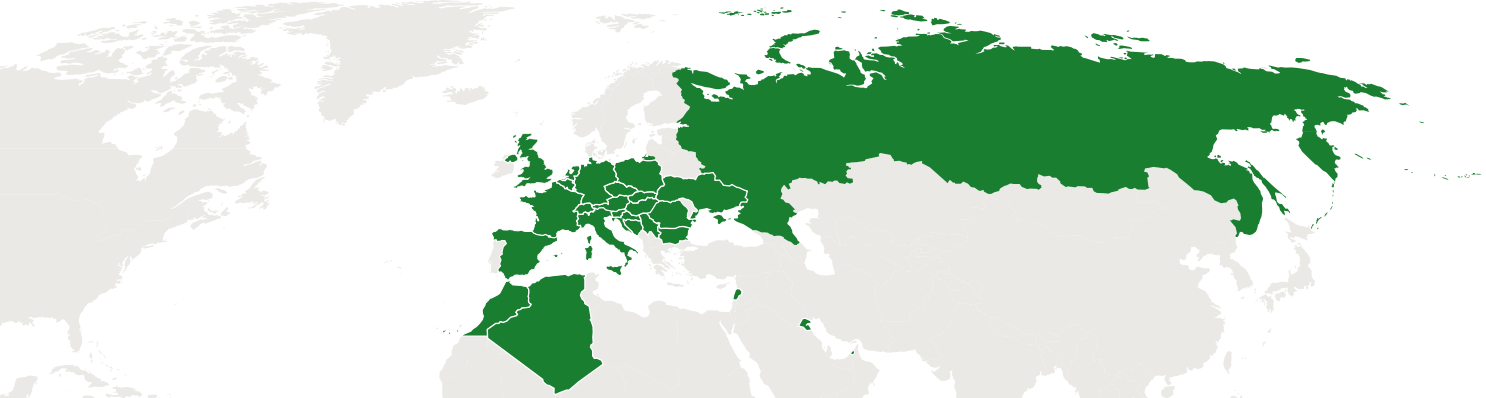

Our Opinion
Clean technology: The revolution has begun

Cleantech is at the heart of a huge global revolution, driven by many factors. Individually each of these factors is significant but cumulatively they are immensely powerful. These factors include (1) protection of the environment (especially environment degradation, resource efficiency and consumption and climate change), (2) energy security, (3) security of commodities (for instance water, food, scarce metals, oil, etc.), (4) financial movement towards internalisation of the external costs of environment degradation, and (5) a global population increasing at a tremendous pace coupled with increasing human longevity.

Defined as technology which is specifically designed to address environment issues (such as remediation of harmful emissions) or is designed to lessen the impact on the planet of current products or services (for instance renewal energy or efficient motors and other products), Cleantech is becoming central to many businesses today: waste management, water management, road transport and consumer goods, to name just a few (the appendix sets out examples of current clean technologies). CMS believes that over the coming years, Cleantech will pervade virtually all commercial sectors. This innovative and fast growing industry could be worth many trillion Euros globally by 2015.

Independent report

CMS commissioned Oxford Analytica, an international and independent consulting firm, to produce a forward-looking report on Cleantech and its impact on key commercial sectors in Europe. We believe that this report can help to frame the current discussion about the enormous market opportunities Cleantech provides, the potential risks and structural barriers that it faces and the potential impacts that it will have on other commercial sectors.

Much of the growth in Cleantech is being driven by government policy and legal regulations. The European Union (EU) and its Member States have set clear targets for instance in clean energy generation, waste management and road transport. The EU is currently, in our opinion, the global thought leader in this area and will continue to be so in the near future but the US, Japan and China are catching up fast.

Despite the recent economic crisis, Cleantech and more stringent environment regulations have remained high on the political agenda. We believe that the ongoing economic crisis will not dampen the take up of Cleantech any more than it is dampening other commercial sectors. In fact we suspect that the economic crisis will stimulate the uptake of Cleantech, not only because the policy makers in almost all the major economies view this sector as a sector of potentially huge growth but also because business managers will seek innovative Cleantech as a means to help increase efficiency and control costs.

Europe at the forefront of Cleantech

As Europe is at the forefront of Cleantech innovation, it is fitting that CMS takes a closer look at this sector and its impact on other sectors. We are the pre-eminent provider of legal services in Europe, with approximately 4,600 employees in 54 offices across Europe, within 28 different jurisdictions.

The past two years and the next five or so years will witness significant change in environment and other (especially energy, product design, water and waste) law, policy and technologies. These are what might be called "bedrock" changes. They will take some time to implement fully but, importantly, they are setting the platform for further more pervasive and detailed changes. The European Union remains at the forefront of such law and policy, and many companies in many sectors will be impacted by tighter EU regulations.

We believe that if in 20 years' time we look back at today, we will say that the end of the first decade of the 21st century was the start of a very steeply rising curve of legal and policy change; a change of such transformational economic importance that it was akin to at least the IT revolution, if not the industrial revolution.

The general message that we take away from the Oxford Analytica report supports this view: massive change in Cleantech and brought about by Cleantech, is on the way. Policymakers, corporations and other stakeholders are best advised to accept and understand this as inevitable. Only then will they be able to turn this development to their advantage.

Shaping an opportunity out of the crisis

Some commentators have said that investment in Cleantech could be endangered because of the current economic crisis. Clearly, tighter budgets and restricted access to capital could delay spending on Research and Development (R&D). Private equity could also slow investment in the Cleantech sector over the next several years.

While it cannot be denied that the prevailing negative business environment causes considerable difficulties, we think that Cleantech should be viewed from a different, longer-term perspective. Indeed, we believe that Cleantech is potentially a significant element of necessary solutions to some of the most difficult problems facing the global economy today.

Furthermore, the economic crisis could be a catalyst for forcing countries and companies to quickly adopt technological innovations which would have otherwise languished. Notably Oxford Analytica sees historical parallels to the Great Depression when new technologies – those that had already been created but had been marginalised – were commercialised and then helped the recovery to gain momentum.

Both the breadth and depth of the current economic crisis will be, we believe, a formative experience for an entire generation of business managers. Much like the Great Depression, this crisis will not be soon forgotten but will likely remain present as a fundamental reference point for many managers. The pressure on companies to reduce costs, increase margins, diminish waste and become more efficient will become a permanent feature of the decision-making process. Cleantech will be a tool in this regard.

Implications for new business

CMS believes that these trends will create a huge market opportunity for many businesses – both start-up and existing players – right across a wide range of commercial sectors. There are already a variety of nascent clean technologies which all hold promise for future development. Other technologies which have been in commercial use for some time are now entering third and fourth generations. It is often said that the use of nanotechnology within Cleantech will further boost the applicability and efficiency of some clean technologies. The Oxford Analytica report takes a look at the impact on several sectors, which we would now like to reflect on.

Clean energy (renewables): importantly, we did not ask Oxford Analytica to report upon the clean energy (i.e. renewables) sector for the simple reason that this sector is already well established and much has been written about this sector. Instead we asked Oxford Analytica to concentrate on sectors which currently are not attracting as much attention.

Personal and freight transport: whether considering new emissions taxes, congestion charges, higher fuel efficiency or alternative fuels, the future of the automotive sector is dependent to a large extent on the development of clean technologies. For the personal and freight transport sectors, Cleantech is both a massive opportunity but also a potential risk. Cleantech is high on the political agenda in Europe and is (and will most certainly continue) to lead to more stringent environment regulations relevant to efficiency and emissions of CO_2 and particulates.

Agrichemicals and water management: regulations are becoming tighter with respect to greenhouse gas emissions, agrichemicals, soil protection and water management. We believe, as does Oxford Analytica, that there is a huge potential for improved efficiency in water management within the agricultural production process. At the same time, future growth areas will likely be agricultural waste management, biocomposites, methane mitigation, use of genetically modified organisms (GMOs), including genetically modified enzyme waste decomposition, and carbon sequestration.

Waste management: whether it is in terms of reducing volumes of waste delivered to landfills, restricting emissions by incineration facilities or replacing hazardous substances in products, there is huge potential in Europe for Cleantech in the area of waste management. Cleantech in waste management covers the full spectrum; from complex scientific processes to the simple choice of which material to use in the design phase of a product.

Real estate: in the EU this sector is estimated to be responsible for approximately 40% of emissions of greenhouse gases. If it is 40% of the problem then, likewise, this sector could be 40% of the solution. This has been recognised by the EU and its Member States which are implementing various laws and policies to address the efficiency of this sector. Progress is likely to be faster with respect to new build than existing building stock, but in either case tremendous potential opportunity exists for Cleantech in this sector.

Asset valuation models

In our opinion, a need is arising for businesses (and their advisers) to review how they go about valuing assets and investments, including investments in Cleantech. We see significant risks in continuing with simple return-on-investment or "payback models". Law and policy, coupled with procurement strategies in certain areas, is moving towards greater use of concepts such as internalisation of the externalities, cost optimal levels, life cycle costing, etc. Perhaps more importantly, a bigger risk that we see is that a failure to consider the use of Cleantech in a wider transactional context and with a longer term view, could result in negative impacts upon asset values. We perceive that in future transactional due diligence scrutiny will be placed upon performance and efficiency, rather than simply on current legal compliance. This will particularly be the case for assets with a long life span such as infrastructure, buildings and some product lines. Some of these impacts could be latent for a period of time, only to become apparent, say, in a later transaction or at a point when the relevant market changes to embrace higher standards and Cleantech. In these cases assets built to lesser standards and worse performance may suddenly be devalued.

Firmly on the agenda

We are heartened to see that despite the economic crisis, Cleantech has remained firmly on the political agenda. There even appears to be growing momentum to address economic and environment issues together, aiming to reap the "double dividend" of economic development being decoupled from environment degradation (through for instance greater economic efficiency combined with less waste and fewer negative externalities) and the creation of potentially large numbers of jobs, with a related higher skills base, in a sunrise sector. We welcome this initiative.

Appendix: clean technologies

Cleantech encompasses:

Alternative waste management technologies including:
- anaerobic digestion
- biofuel
- carbon capture and storage
- energy from waste
- in-vessel composting
- landfill gas and gasification processes
- leachate treatment
- MBT
- plasma processes
- recovery processes
- recycling processes

Water and waste water treatment technologies including:
- desalination
- grey water
- metering
- water harvesting
- sub-surface irrigation

Alternative energy technologies such as:
- batteries
- biofuel
- carbon capture and storage
- CHP (combined heat and power)
- CCHP (combined cooling heat and power)
- exchangers
- geothermal
- heat pumps
- nuclear
- photovoltaics
- solar
- tidal
- wave
- wind

Transport technologies such as:
- emissions controls
- hybrids
- intelligent traffic systems
- plug-ins
- software controls
- telematics

Infrastructure transmission technologies

Building efficiency technologies especially in relation to:
- building materials
- building management systems
- heating and cooling
- lighting
- water

Consumer product technologies especially those relating to:
- batteries
- energy efficiency
- recoverability and recycling
- resources consumption
- standby
- substances

Technologies to monitor or verify:
- consumption
- emissions
- emissions abatement
- smart metering

Flood adaptation, alleviation and prevention technologies

Agriculture technologies (including GMOs)

Imprint

Paper

We have used a mix of papers including:

- FSC paper (wood-free, uncoated and chlorine/ acid free)
- PlanoArt paper (50% certified pulp and raw materials from monitored origin) DIN ISO 14001 certified
- RecyStar (wood-free, 100% recycled paper with no optical bleaching) 'Blue Angel' and 'Nordic Swan' certified

Production

- No matt film-lamination
- Re-usable cleaning cloths for the maintenance of the printing machines

Colors

- Water-soluble
- Environmental-friendly, ecological colours according to EU guidelines

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Oxford Analytica

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The Impact on Key Sectors in Europe

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Executive Summary

Overview

This report analyses the impact that Cleantech will have in Europe over the next five to ten years, with the aim of preparing companies for potentially far-reaching changes in their sectors. The four sectors covered in this report are:

- personal and freight transport;
- real estate and construction;
- agrichemicals and water management; and
- waste management.

The intersections of these sectors are also addressed.

The focus is on Cleantech: technology that is specifically designed to address environmental issues or to lessen the impact of current products or services on the environment. Cleantech is distinct from the adjacent field of clean energy, although in some of the sectors covered – notably personal and freight transport – the boundary between Cleantech and clean energy blurs.

The development of Cleantech in each of the four sectors is being driven partly by a set of over-arching factors or 'megadrivers', affecting all of the sectors, often in similar ways. The megadrivers are: the economic downturn; policy and regulation; commodity prices; and stakeholder attitudes. One of these megadrivers – the economic downturn – might have been expected to derail the Cleantech agenda. However, instead, the view has gained momentum that addressing environmental concerns is a key part of the long-term solution to the current economic crisis. This view is particularly supportive for Cleantech, given evidence from the Great Depression that suggests that technological change may be particularly rapid during and just after major economic crises.

In addition, each sector is affected by its own set of drivers. Sections 1–4 analyse sector-specific elements of the megadrivers and the sector-specific drivers, and assess the resulting changes each sector is likely to experience over the next five to ten years.

Personal and freight transport

KEY SECTORAL DRIVERS

- 'The 'Greening Transport' package aims to move the costs of congestion, transport-related noise pollution and emissions to the user rather than the taxpayer. The EU is also planning to allocate about EUR 5 billion to public-private partnerships (PPPs) to research into Cleantech.
- The economic downturn will heighten Member States' concerns that mandatory targets may harm key industries. Also, a sustained period of low oil prices could undermine the urgency to reduce oil consumption.
- An EU directive likely to be passed in 2009 will require all public procurement of road vehicles to consider lifetime emissions and fuel consumption costs. With public authorities across the EU procuring over 250,000 vehicles each year, this will drive the development of cleaner and more efficient vehicles.

KEY IMPACTS

- Car manufacturers will focus heavily on improving the fuel efficiency of internal combustion engines and creating more aerodynamic designs with lighter construction materials.
- IT systems focusing on information delivery and intelligent traffic systems will show strong growth.
- Transportation based on natural gas, biofuels, hydrogen, hybrid or electric systems will grow but there is unlikely to be a decisive breakthrough over the time period.
- Battery technology will improve, offering increased power and longer running times. The incentive for innovation will increase as the car industry focuses more on battery technology.

Real estate and construction

KEY SECTORAL DRIVERS

- The EU is attempting to provide a unified regulatory approach across Member States, building on the relative success of voluntary codes, such as the United Kingdom's Building Research Establishment's Environmental Assessment Method (BREEAM) programme. As 'green' certifications gain wider acceptance they are likely to enable owners to charge a rent premium.
- The political agenda is largely focused on providing incentives for the development of new green buildings, but less progress is being made in terms of promoting refurbishment of existing ones. A central driver in this regard is the growing establishment of green public procurement schemes, which are driving Cleantech initiatives in the construction industry.

KEY IMPACTS

- Many new buildings will be conceived from design and construction to be environmentally sustainable, with low emissions.
- There will be short-term improvements in insulation and ventilation, heat recapture, lighting and low-carbon cement.
- Other developments with significant potential include carbon-negative concrete, more efficient drywall products and the use of energy-efficient white paint.
- Globally, there is a growing trend towards developing new 'green cities.'
- A report by business research firm Frost and Sullivan indicates that the green buildings market in Europe could experience annual growth averaging 30% over the next ten years.

Agrichemicals and water management

KEY SECTORAL DRIVERS

- There is a tightening regulatory framework in the areas of greenhouse gas emissions, agrichemicals, soil protection, and water management.
- Dependence on commodity inputs for fertilisers, crop protection chemicals, agricultural machinery and transport will begin to decline.
- Public opinion has the potential to either drive or restrain the use of Cleantech in agrichemicals and water management, but at present is important as a driver.

KEY IMPACTS

- There is huge scope for improved efficiency in water management in the food production process. Key areas will include shifting away from flood irrigation systems, combating salinisation, and wastewater reclamation technologies.
- Management of food production waste, biocomposites, methane mitigation, GM-enzyme waste decomposition and carbon sequestration are all future growth areas.
- There will be significant improvements in methods for targeting agrichemicals.

Executive Summary

Waste management

KEY SECTORAL DRIVERS

- The EU has set demanding targets to divert biodegradable municipal waste from landfill, placed strict limits on emissions from incineration facilities, and stipulated that certain hazardous substances in products should be replaced by non-hazardous ones.
- In innovative waste management, the private sector can operate on a smaller scale and faces fewer procurement obstacles than the public sector. However, economic and environmental incentives are not yet fully aligned.
- Countries that have opted to develop energy from waste plants are reluctant to consider alternative technologies as they are committed to maintaining a waste stream to their facilities in order to provide electricity and heating.

KEY IMPACTS

- Waste materials have not yet been seriously tapped as a source of sustainable energy, but rapid progress is taking place in the fields of gasification, pyrolysis, and anaerobic digestion.
- A crucial factor in the viability of effectively managing waste is the homogeneity of the waste stream: industrial waste is typically more homogeneous than municipal waste. Improvements in waste sorting, particularly at the municipal level, can raise the energy and re-use potential of waste.
- Companies are employing a range of clean technologies to restore to potable quality water that has been captured directly from industrial or municipal wastewater.
- Improvements in tracking and collecting data on waste movement via the internet could significantly improve efficiency.
- The concept of producer responsibility continues to gain prominence. Legislative and consumer pressures enforcing this responsibility may lead more manufacturers to conceptualise effective waste management in the product design stage in order to maximise recyclability.
- E-waste is one of the fastest growing waste sources. Clean technologies targeting the design and disposal of electrical and electronic manufactures will be crucial to stemming the volume and negative impact of e-waste.

A. Megadrivers

Policy and regulation

Global momentum, at an intergovernmental level, towards addressing climate change remains strong:

- The Kyoto Protocol adopted in 1997 requires the EU to reduce its greenhouse gas (GHG) emissions to 8% below 1990 levels by 2008–2012. The first and second European Climate Change Programmes (ECCPs) were launched in 2000 and 2005, respectively, and detail the strategy for meeting the Kyoto target. The EU Emissions Trading Scheme is part of these programmes.
- Many EU Member States have committed themselves to ambitious CO_2 reduction targets. For example, the United Kingdom has committed to at least a 26% reduction by 2020 and an 80% reduction by 2050, compared to 1990 levels, as laid out in the Climate Change Act of 2008.

More generally, the EU's Sustainable Development Strategy (SDS) and Sixth Environmental Action Programme "defines the priorities and objectives of European environment policy up to 2010 and beyond."

The economic downturn

The economic downturn has the potential to either slow down or encourage the development of Cleantech:

- Tighter budgets and restricted access to credit, in particular in the area of R&D, may delay the development, testing and broader implementation of new technologies. Access to private sector funding is likely to remain a challenge for the Cleantech sector for at least the next one to two years.
- However, the experience of the Great Depression shows that technological innovation persists, and can even increase, during and immediately after severe economic downturns. In the 1930s, industry research and development (R&D) expenditures more than doubled, and new product innovations emerged, notably petrochemicals, e.g. Lucite and Teflon[1]. It has been argued that technological progress during the Depression 'replenished and expanded the larder of unexploited or only partially exploited techniques', thereby laying the foundation for future prosperity[2]. Several economists, including Robert Solow, have suggested that evidence points to technical change having accelerated after 1929. The same could occur as the global economy emerges from the current downturn. Furthermore, pressure on margins and costs creates incentives for firms to diminish waste and to invest in waste- and cost-reducing innovations.
- The growing reliance of industry on governments for funding offers an opportunity for the public sector to push forward sustainable technologies. However, if such government funding is inadequate or not forthcoming during the economic downturn then research and development efforts will be slowed.

It is notable that Cleantech has not dropped off the political agenda so far, despite the current economic crisis. Instead, there appears to be growing momentum for addressing the economy and environmental issues together, aiming to reap a 'double dividend' of greater economic efficiency combined with less waste and fewer negative externalities. Support for double dividend technologies is central to US President Barack Obama's short- and long-term policy agenda: The first legislative milestone of the Obama presidency – the American Recovery and Reinvestment Act of 2009 – was laden with provisions that seek to provide economic stimulus via 'green jobs'. This could help sustain momentum for Cleantech in Europe.

[1, 2] *Field, Alexander J. 'The Most Technologically Progressive Decade of the Century.' The American Economic Review, Vol. 93, No. 4 (Nov., 2003), pp. 1399–1413.*

A. Megadrivers

Commodity prices

University of Chicago Economics Professor George Tolley has stated that the price of oil "is a more powerful influence on clean technology adoption than any (US) policy". The last year has been characterised by extreme price volatility of many soft and hard commodities. Production capacity reductions in the current lower price environment are likely to contribute to renewed upward momentum in the prices of many commodities in the medium term, thereby providing renewed incentives to turn to Cleantech.

Stakeholder attitudes

There is growing awareness among the public in Europe of the link between carbon emissions and climate change. Public opinion has in recent years swung in favour of companies and products that are perceived as 'environmentally friendly.' For example, a survey conducted in 2008 by Nokia found that 76% of mobile phone customers prefer companies that they perceive to be environmentally responsible. Nonetheless, in 2009, with the effects of the economic downturn at their worst, the emphasis in public opinion is likely to swing back temporarily to the primacy of jobs over the environment.

As a long-term trend, the impetus for Cleantech and greener practices is also mounting among European corporations (partly in response to regulation, and partly in response to consumer demand). Many have begun to include environmental sustainability as a core strategic area both for financial and reputational reasons.

B. Main Report

1. Personal and freight transport

1.1. Introduction

Personal and freight transport is a key area of focus in the effort to reduce carbon emissions. The European transport sector is a leading emitter of greenhouse gases and a major consumer of non-renewable energy. Transport is responsible for about 25% of European CO_2 emissions and accounts for 71% of the oil consumed in the EU.

Cleantech has the potential to play a major role in reducing carbon emissions and in improving European energy security. However, this will require a high degree of political support and an effective regulatory regime, led by the EU. The fundamental changes that are needed in the transport sector, notably reducing reliance on the internal combustion engine, will require a long implementation period: it generally takes up to 12 years to develop a new car model, and even longer for a rail locomotive or aeroplane.

1.2. Drivers

Several interrelated factors are helping to build interest in the adoption of Cleantech in transport. The sector has become a focus for environmental concerns because of its heavy use of fossil fuels and the resulting emissions.

Fulfilling a green agenda, meeting or exceeding expected regulations and reducing operating costs can all offer firms a competitive advantage. However, this requires investment by manufacturers and operators. A key factor in the further take-up of Cleantech in transport will be the ability of major manufacturers and operators to afford such outlays. While financing may prove difficult in the short term given the current economic climate, the incentive for firms to gain competitive advantage remains even during an economic downturn, and may become particularly strong as economies emerge from recession and competition in potential growth markets intensifies.

The three main drivers of Cleantech in the personal and freight transport sector are:

- European policy;
- political limitations; and
- the oil price.

1.2.1. EUROPEAN POLICY

Greening Transport

The European Commission (EC) in July 2008 published a new package of initiatives under the title "Greening Transport." A major aspect of the package involves increasing the prices for both passenger and freight transportation so that these better reflect environmental costs and the inefficiencies of congestion. The intention is to move the costs of congestion, transport-related noise pollution and emissions to the user rather than the taxpayer, in order to encourage greater use of clean technologies and approaches.

The initial emphasis is on the freight sector, where the EC is seeking an overhaul of road toll systems to encourage the acquisition and use of greener and more efficient lorries. Revenue collected through the toll system is scheduled to be used to fund research and employment in the area of making vehicles cleaner and more energy efficient.

European Green Car Initiative

The EC is proposing new regulations to limit CO_2 emissions from January 2015, to 120 grams/kilometre (g/km) on every car sold in the EU. This would represent a reduction of 18% compared to present levels.

Under the European Green Car Initiative, which is a response to the impact of the current economic downturn on car manufacturers, the EU is proposing to drive the Cleantech

improvements needed to meet these regulatory targets. About EUR 5 billion are being allocated to public-private partnerships (PPPs) designed to conduct research into Cleantech. Car manufacturers will receive loans, and registration and circulation taxes on low emissions vehicles will be cut.

Public Procurement

An EU directive likely to be passed in 2009 on public procurement of vehicles will have a significant impact on vehicle development. The legislation requires all public authorities to consider lifetime emissions and fuel consumption costs of any road vehicle purchased after 2012. The main area of impact will be on largely diesel consuming public transportation fleets, notably buses, and utility vehicles such as rubbish collection trucks and delivery vans.

With public authorities in the EU purchasing over 250,000 vehicles each year, vehicle manufacturers will be driven to develop cleaner and more efficient vehicles in order to win public contracts, which will have a knock on impact on vehicle sales in the private sector. Not only will diesel engines undergo further developments, but alternative fuel sources such as biofuels or electric batteries are also likely to benefit. In particular, the lifetime cost calculation could help outweigh the higher upfront cost of greener vehicles, driving mass production and reducing their costs overall.

Other initiatives

The EU has driven a number of other initiatives that will continue to have an impact on the use of Cleantech in the transport sector:

- In 2007 the EC committed to raising the share of biofuels in transport from 2% to 10% by 2020, with a view to reducing oil consumption and cutting emissions. However, in light of the impact that this objective was having on agricultural prices, it is being revised.
- A tightening of the Fuel Quality Directive: this will improve the monitoring and reporting of emissions.
- Given the steep rise in demand for air travel in the EU in the last 15 years, the sector has been included in the EU's cap-and-trade system for CO_2 emissions. Further, efforts are underway to institute a 'Single European Sky', which would unify air traffic controls across the EU and lead to more efficient use of airspace.
- In 2003-4, the EC committed to a 'Quick Start' initiative that allocates EUR 2.8 billion over ten years to public and private sector funds for developing the use of fuel cells in transport infrastructure. In 2007, the EC designated hydrogen as one of six Joint Technology Initiatives for public-private research partnerships and committed EUR 470 million over the subsequent six years.

1.2.2. POLITICAL LIMITATIONS

Despite growing environmental concerns among the public in Europe, Member States are often unwilling to support policies that will negatively impact key industries in the short term. For example, in a move to support luxury car manufacturers that have higher levels of emissions, the UK and German governments have pushed for a delay in the implementation of emissions reductions for new cars.

Within the EC, the momentum for green policies is generating tensions between the Directorate-General (DG) for Environment and the DG for Enterprise and Industry, with the latter worried about the impact on growth. The tension was most evident when the EC was working on emissions standards for cars, which the DG for Environment thought should be mandatory and the DG for Enterprise and Industry argued should be voluntary.

1.2.3. THE OIL PRICE

The success of Cleantech in the transport sector is likely to be particularly heavily linked to the evolution of oil prices. During times of high or volatile oil prices, consumers and companies become more aware of fuel efficiency levels in the personal travel and freight transport choices that they make. However, a sustained period of low oil prices could undermine the urgency to reduce oil consumption.

1.3. Cleantech developments over the next 5–10 years

The Cleantech innovation that would entirely change the transport sector would be the development of a viable alternative to the internal combustion engine. This is unlikely within the next five to ten years, but a variety of measures could result in the use of Cleantech to improve fuel efficiency and reduce carbon emissions in the sector.

1.3.1. IMPROVED FUEL EFFICIENCY

Car manufacturers (including makers of freight vehicles) are likely to address a number of technological factors:

- improving the fuel consumption of engines through re-engineering, or adapting them to run on biofuels or natural gas;
- using more aerodynamic designs, lighter construction materials (such as aluminium or composite materials), fuel-efficient tyres and more efficient air conditioning; and
- though currently banned in many EU countries, building larger lorries that carry greater loads but are made of lighter materials.

Similarly, rail and aeroplane manufacturers are seeking ways of improving their fuel consumption:

- new trains are being fitted with fuel-efficient engines and regenerative braking systems; and
- aeroplane manufacturers have already introduced more efficient designs, improved engines and use of lightercomposite materials.

1.3.2 INFORMATION TECHNOLOGY

Cleantech employing information technology has significant growth potential in the transport sector over the next five to ten years.

Driver information

Information systems are being installed in cars, lorries, and rail locomotives. These systems provide the driver with a wide range of data and information that can assist in driving the vehicle more efficiently. Combined with training systems, this could result in drivers becoming more aware of their energy consumption and adapting their driving styles. In the rail sector, this has already resulted in clear fuel efficiency gains.

Passenger information

Passenger information systems are already in use, but if installed in a more coordinated and comprehensive manner would encourage greater use of public transport, by better integrating suburban, urban and long distance passenger travel. These systems help to minimise passenger waiting times, and, if provided on the internet or via mobile phone, enable improved passenger travel planning.

Intelligent traffic systems

Systems that combine monitoring, control and information can be used to improve traffic flow in cities or on motorway networks. Technological development of in-road detection systems or in-car tracking could streamline such systems.

Intelligent traffic systems can also be used to establish cordon zones in areas prone to congestion, tolling drivers upon entry to those areas during times of congestion, and encouraging more evenly distributed traffic patterns. Such technology is currently deployed in London, Madrid and Singapore, with more cities likely to follow suit as traffic congestion increases.

1.3.3. ALTERNATIVE FUELS

The transport industry is already experimenting with a variety of alternative fuel systems, which would either work with an internal combustion engine as a hybrid or as entirely stand-alone systems. A key challenge that all alternative fuel systems will have to address is the ability to replicate the vast network of refuelling stations that exists for petroleum fuels.

B. Main Report

Biofuels

Biofuels can be used in existing petrol or diesel engines, with appropriate modifications. Efforts are also underway for their use in aeroplanes, with Virgin Atlantic undertaking an experiment to operate one of its jets using biofuels.

However, first generation biofuels, which are created from agricultural produce such as corn or sugar, have been criticised for driving up agricultural prices and for not being as environmentally friendly once the energy used in their production is considered. Second generation biofuels offer better prospects. These are based on cellulosic production technology, which can convert any plant-based feedstock into ethanol. This means that cellulosic ethanol can be produced from dedicated 'energy crops', such as switch-grass or hybrid poplars, which can be grown on marginal land and pasture. But production costs are high. An advanced (Fischer Tropsch) plant in the 150 million gallon petroleum fuel equivalent capacity range requires an investment of more than EUR 660 million.

Hydrogen

Hydrogen is the next evolutionary step for road transport after the internal combustion engine. The use of hydrogen as a fuel allows the use of fuel cells, which generate electricity through the chemical reaction of hydrogen and oxygen and produce water as a by-product. However, hydrogen is highly energy intensive in its production, particularly in its liquid form, which is most useful to the transport sector.

EC initiatives aim to make fuel cell passenger vehicles commercially available throughout Europe by 2020.
A number of pilot projects are underway in Scandinavia using buses, while Boeing has flown a small plane using fuel cells.

Hybrid or electric systems

Hybrid systems, which combine an internal combustion engine with an electric motor, are gaining in popularity, with vehicles such as the Toyota Prius benefiting from tax incentives. These systems are technologically advanced and likely to continue to receive government and manufacturer support even in the event of a period of sustained low oil prices.

Electric cars that use power stored in batteries have a relatively short range and in most cases must still rely on traditional engines. These cars could have a strong future in urban areas, where short distances are covered and charging points can be readily installed. But for electric cars to be truly successful, there needs to be a significant improvement in battery technology, in particular in the area of lithium-based batteries (see below).

Electric cars may face competition from hydraulic-hybrid vehicles if the technology proves commercially viable. Particularly relevant for urban vehicles with high start-stop cycles, this technology captures kinetic energy from braking to pressurise a fluid or gas, which can then power a motor. However, with electric cars such as the G-Wiz already in production, electric vehicles have an advantage. They are also being adapted for non-passenger use. The Dutch logistics company TNT is to replace (initially) 100 diesel trucks by electric models by the end of 2009.

Natural gas

An alternative to the use of petroleum fuels in the internal combustion engine, natural gas has lower emission levels and could offer a quick solution to reduce emissions, notably in buses. Cities such as New Delhi have successfully moved entire public transportation networks to compressed natural gas. The EC has set targets for the introduction of natural gas, but it will face distribution challenges, as well as political opposition due to Europe's heavy reliance on Russia for its gas supplies.

1.3.4. BATTERY TECHNOLOGY

As technology develops, batteries will provide increased power and longer running times between recharging and/or replacement. New battery technology may first become more widely used for electronic products, but then could also have an impact on transportation.

Lithium is currently the metal of choice for battery construction, and lithium-ion batteries are currently used to power laptops and mobile phones. They are light, cheap, recyclable, and can deliver high voltages. In January 2009, General Motors announced that its 2011 Chevrolet Volt passenger car would be powered by lithium-ion batteries – these batteries are currently produced in South Korea, but the demand created by General Motors could incentivise innovation in the United States and the EU[3]. However, there are some safety risks associated with their manufacture, and global supplies of lithium are limited – so Lithium is unlikely to be the final solution for battery-operated vehicles.

[3] Claire Cain Miller, The New York Times, "A New Market for Battery Start-Ups?", 12 January 2009.

2. Real Estate and Construction

2.1. Introduction

It is now widely recognised that the real estate and construction sectors are major sources of carbon emissions. Construction, occupation and maintenance of buildings requires energy and natural resources, generates landfill waste, produces potentially harmful airborne particles and leads to the emission of greenhouse gases.

According to the UN's Intergovernmental Panel on Climate Change (IPCC), energy use in building accounts for 33% of man-made greenhouse gas emissions globally. Both residential and commercial buildings are large consumers of energy through heating, cooling, IT and lighting. According to US company Johnson Controls, commercial buildings in the United States consume 60% of the electricity generated in the country. Such levels of energy consumption also mean high levels of carbon emissions. Retrofitting buildings with greater levels of insulation as well as improving lighting and ventilation can reduce those emissions.

While technological innovation and regulatory pressure are improving energy efficiency in new buildings in Europe, the stock of existing buildings, which continues to be a large energy consumer, remains to be addressed. The age of Europe's housing stock means that there is significant potential to improve energy efficiency – in particular in high-rise buildings with many residents, which often suffer from poor maintenance. In a study undertaken by Oxford Brookes University as part of a recent energy audit, it became clear that poor energy performance is often linked to poor building quality, obsolescence, and poor maintenance.

The sector will increasingly look to Cleantech to provide improved energy efficiency and longer life buildings, as owners and residents seek to reduce their carbon footprints and comply with future environmental legislation. The perceived higher cost of Cleantech solutions and the inconsistent nature of still evolving legislation in different EU countries are currently barriers to widespread adoption of lower environmental impact technologies in these sectors. However, there is strong momentum towards more environmentally friendly building in the long term, notably in moves towards the construction of entirely new 'green' towns and cities.

2.2. Drivers

The three main drivers of Cleantech in the real estate and construction sectors are:

- regulation and voluntary codes;
- government assistance; and
- potential commercial and market advantage through more appealing, healthier buildings and lower construction and operating costs.

2.2.1. REGULATION AND VOLUNTARY CODES

European regulation

Though all European governments have their own building standards, these have historically tended to deal with new construction rather than existing buildings or renovations, and have in the past not been very exacting in their requirements for energy use and environmental standards.

The EU is attempting to institute a unified regulatory approach across Member States regarding both the construction of new buildings as well as the refurbishment of existing buildings. This forms part of the EU's Sustainable Development Strategy (SDS) and Sixth Environmental Action Programme. The most important Directive is the Energy Performance of Buildings Directive (EPBD). This was passed in 2002 and is likely to remain a significant driver of Cleantech in buildings, particularly as it covers both residential and non-residential buildings. It requires individual countries to establish their own minimum standards and implement them.

The original deadline for the implementation of the EPBD was 2006, but most Member States extended it to 2009 and it may require further extension. Efforts are underway to revise and expand the Directive – the updated version could be adopted in 2009. An EC proposal presented in November 2008 recommends a number of changes, including that all buildings that undergo major renovations – defined as a renovation that is more than 25% of the building's value – will be required to meet national minimum standards. At present, only buildings with a useful floor area of over 1,000m² are affected[4]. Given that 72% of building stock, according to the EC, is smaller than 1,000m², this would be a major change. The proposal includes a deadline for implementation of the new revised regulations by 31 January 2012[5].

Countries such as Ireland, Denmark, Germany and the Netherlands have made good progress with implementation. But several other member countries have not yet taken serious action. In 2007, France and Latvia lagged so far behind that the EC threatened legal action for their failure to state whether or not they had implemented the measures required by the EPBD. In 2008, the EC launched court proceedings against the United Kingdom and Belgium for similar reasons. The EU has begun to seek greater engagement from Central and Eastern European countries through energy audit and research initiatives (in coordination with the European Bank for Reconstruction and Development).

In the United Kingdom, the first part of the Code for Sustainable Homes was launched in 2008 and by 2016 will require all new homes – in both the private and public sectors – to achieve a high standard of environmental performance. This legislation is intended to form the basis of the forthcoming Code for Sustainable Non-residential Buildings, which will apply to offices, shops and other non-residential properties. The United Kingdom is also set to adopt the use of Energy Performance Certificates (EPCs), recording the energy performance of individual buildings.

Voluntary codes

The growth of voluntary codes has been driving the use of Cleantech in several Northern European countries. One of the most widely recognised is the United Kingdom's Building Research Establishment's Environmental Assessment Method (BREEAM) programme. Similar 'green badge' certification systems are in place across Europe, including the Green Calc+ system in the Netherlands, la haute qualité environnementale des bâtiments (HQE) in France, the Minergie tool in Switzerland and the Deutsches Gütesiegel Nachhaltiges Bauen (DGNB) in Germany.

Outside Europe, countries have also developed their own green accreditation systems, including Greenstar in Australia and Leadership in Energy and Environmental Design (LEED) in the United States. LEED status is a designation given by the US Green Building Council and accords different levels of certification (Bronze, Silver, Gold and Platinum). LEED is used as a guideline by many countries, including the United Arab Emirates and China.

There is now an acknowledged need to embed these voluntary standards into much stricter building codes that all new construction is required to follow. Research indicates that the construction industry wants greater levels of regulation to make 'green building' more widespread. A survey in 2007 by the Chartered Institute of Building (CIOB) in the United Kingdom indicated that the UK construction industry sees regulation as the main driver of greener building but that the clear majority of the respondents also felt that current regulations "do not go far enough to create energy efficient buildings.[6]"

[4] European Commission, Proposal for a Directive of the European Parliament and of the Council on the Energy Performance of Buildings (recast), November 2008.

[5] European Commission, Proposal for a Directive of the European Parliament and of the Council on the Energy Performance of Buildings (recast), November 2008.

[6] CIOB, "The Green Perspective: A UK Construction Industry Report on Sustainability", 2007.

2. Real Estate and Construction

Green Public Procurement

The construction sector has been identified as one of nine key areas for European public authorities to implement 'green public procurement' procedures. This would incorporate environmental benefits and life-cycle costing into the procurement process. Further legislative efforts can be expected in the near term as the EU seeks to use publicly funded construction to drive the use of Cleantech in the construction and maintenance of buildings.

2.2.2. GOVERNMENT ASSISTANCE

The long-term potential financial and other benefits of reducing carbon emissions by upgrading buildings to be more energy efficient is insufficient to convince many owners and residents to make the initially necessary investments. Therefore, improving existing buildings and implementing Cleantech solutions is likely to require further government assistance in the form of tax breaks or grants. In one example of the political importance of these issues, the American Recovery and Reinvestment Act of 2009 includes USD 5 billion for the weatherisation of houses.

In Europe, the political agenda has largely focused on providing incentives for the development of new green buildings. For example, the UK government is planning to build three million new homes by 2020, while aiming for all newly constructed houses to be carbon neutral by 2016. Incentives have included removing stamp duty on all new zero-carbon homes. Such moves are proving popular with consumers and voters.

However, less progress is being made in terms of refurbishing existing homes. The fundamental issue remains that, while a market incentive exists for new buildings to be more environmentally friendly, additional financial assistance is needed to drive the refurbishment of existing building stock[7].

This is of particular concern to countries in Central and Eastern Europe, where many inefficient buildings from the communist era remain. To make a significant reduction in carbon emissions would require very extensive national refurbishment programmes. This would be hugely costly as well as a highly sensitive political issue.

One key area of focus will be high-rise residential buildings. With 36 million European households living in often poorly maintained high-rise buildings, the refurbishment of these buildings could result in significant energy efficiency gains[8].

2.2.3. COMMERCIAL ADVANTAGE

For some real estate developers, the benefit of green building is clear: in the US, LEED-certification has been shown to raise tenancy occupancy even at higher prices. For example, the Solaire building in New York City is a LEED Gold residential building and its owners are able to charge a 5% rent premium over nearby comparable buildings due to the health benefits from the building's improved air quality. Across Europe, green buildings have yet to achieve the commercial advantage of the Solaire building, but the market can be expected to develop – particularly as the European construction sector emerges from its current downturn.

The attractiveness of the green building market, combined with the rising regulatory and political focus on environmental standards, has prompted the emergence of a number of green real estate investment funds, though most of these focus on commercial rather than residential property. Venture capital is also beginning to invest in a wide array of energy efficient building designs, management and construction materials.

However, a challenge remains, as often the developer is not the ultimate beneficiary of green buildings, particularly in the case of residential developments. As a result, the developer is often unwilling to bear the higher level of up-front investment. The EU is exploring a public-private partnership system to fund green construction projects and help economic recovery.

[7] *Pedro Guertler and Winton Smith, "Energy Efficiency in the Refurbishment of High-Rise Residential Buildings", Association for the Conservation of Energy, 2006.*

[8] *See www.euroace.org.*

2.3. Cleantech developments over the next 5–10 years

The long life span of European building stock means that only a dramatic change in replacement rates, or significant levels of refurbishment, will have the impact upon CO_2 emissions necessary to meet the declared goals. The Cleantech impact upon the sector will be twofold. The first is a focus upon new buildings that are conceived from design and construction to be environmentally sustainable, with low emissions. The second is the retrofitting and refurbishment of existing building stock using new technology and construction techniques.

A report by business research firm Frost and Sullivan indicates that the green buildings market in Europe could experience annual growth averaging 30% over the next ten years. The use of Cleantech in new buildings, particularly commercial ones, is likely to provide the greatest long-term investment opportunity in the sector in Europe. However, cost effective methods to renovate existing housing stock could also present significant opportunities.

2.3.1. QUICK SOLUTIONS

The major area of focus in the short term will be on improving insulation and ventilation, to reduce energy consumption. Other areas of short-term potential are heat recapture, lighting and low-carbon cement. According to a 2008 Merrill Lynch report, such energy efficient technologies are the 'low-hanging fruit of Cleantech'[9]. Other potential areas include energy-efficient control systems such as sensor-controlled lighting and a reduction in water consumption through the re-use of wastewater or rainwater harvesting systems.

2.3.2. IMPROVED DESIGN

In the longer term, building design will have to integrate new energy systems and also become part of a more sustainable form of lifestyle. For instance, this could result in the use of distributed energy systems through combined heat and power, which would make buildings – particularly large commercial developments – self-sustaining or even net producers of energy. Architecturally, efforts are already underway to improve the use of sunlight and ventilation. In this regard, the integration of solar power systems into new constructions looks set to grow.

2.3.3. NEW CONSTRUCTION MATERIALS

Cleantech will play a major role in the development of more suitable building materials, for example by reducing the high levels of carbon used to manufacture cement. In China, energy-saving bricks are being developed that are not only produced more efficiently but also provide greater levels of heat and sound insulation. Each European country has a different architectural character that influences the type of materials used, such as clay and concrete products in Southern Europe or timber frame and claddings in Scandinavia, but all offer some role for Cleantech.

Other developments with significant potential include:

- The use of carbon-negative concrete, which absorbs CO_2 during production in a way that makes it faster and more energy-efficient to produce.
- Drywall products that improve insulation and are developed from recycled material. More generally, recycling and re-use of waste will gain momentum, as in other sectors.
- A paper prepared in 2008 by the Lawrence Berkeley National Laboratory has indicated that the use of white roofs could play a major role in reducing carbon emissions in warm climates; a 1,000 ft² dark roof painted white to reflect sunlight could cut energy use by 20% through lower cooling costs.

[9] *"The Sixth Revolution: The Coming of Cleantech", Merrill Lynch, November 2008.*

2. Real Estate and Construction

2.3.4. ECO-CITIES

Globally, there is a growing trend towards developing new 'green cities', which are built and maintained on an environmentally sustainable basis. Some are designed to be entirely self-sustaining in energy use and incorporate environmentally friendly planning for associated sectors such as transport and waste management.

A leading example of such a city is Masdar City in Abu Dhabi, which aims to be the world's first zero-carbon, zero-waste, car-free city. Masdar City has received EUR 3 billion worth of direct infrastructure funding, plus EUR 14 billion in corporate investment. The developers intend to power the city entirely with solar energy. The focus on energy efficiency is also growing in China: Dongtan bills itself as the world's first sustainable city, and other cities such as Chongming Island are being considered as future eco-cities.

3. Agrichemicals and Water Management

3.1. Introduction

The food production sector is critical to efforts to address climate change and improve the environment. Worldwide, food production is the biggest user of land and water, and it is a major contributor to greenhouse gases and pollution. At the same time, with projections of further rapid global population growth over the next decades, growing food insecurity in some parts of the world, increased food price volatility and global interest in biofuels, reducing agricultural output is not a realistic option. Therefore, significant opportunities exist for suppliers of clean technologies whose products can reduce the negative effects of food production on the environment while sustaining or increasing yields.

In Europe, these global trends are combining with growing regulation to drive interest in Cleantech in agrichemicals and water management. The economic downturn may also, counter-intuitively, support investment in Cleantech, as some governments are interested in prioritising tools that tackle both economic and environmental problems. Additionally, public opinion in Europe may increasingly help to drive adoption of environmentally sustainable food production.

3.2. Drivers

The two major factors affecting Cleantech in agrichemicals and water management in Europe are:

- European policy and regulation; and
- commodity price volatility.

Two other important factors could help to drive Cleantech but could also restrain it:

- the economic downturn (one of the megadrivers analysed above); and
- public opinion.

3.2.1. EUROPEAN POLICY AND REGULATION

Common Agricultural Policy

The EC published its 'Health Check' of the Common Agricultural Policy (CAP) in May 2008 and the document was approved by EU Agriculture Ministers in November. It lays out new measures designed to streamline agricultural regulations. Under the 'New Challenges and Rural Development Policy' section of the reform, the Commission identified four areas of focus:

- mitigating climate change;
- renewable energies;
- water management; and
- halting the loss of biodiversity.

The specific measures to be implemented under each of these areas are still becoming clear. Although more funding under the CAP is likely to flow into support for Cleantech initiatives than in the past, thereby directly benefiting suppliers of Cleantech in agrichemicals and water management, encouragement of Cleantech is still not central to the CAP.

Greenhouse gas emissions

Food production is an important source of greenhouse gas (GHG) emissions and so reducing GHG emissions from food production must be part of any successful European plan to meet GHG emission targets. GHG emissions from food production include:

- methane emissions from ruminant livestock and manure (43% of all methane emissions in the EU are from food production); and
- nitrous oxide emissions from soils, mainly as a result of nitrogen fertilisers.

Over the next five to ten years, new EU Directives are likely that address aspects of these GHG emissions (see below).

3. Agrichemicals and Water Management

Agrichemicals

So far, EU regulations cover areas such as maximum chemical residues in food, the protection of water from agrichemicals, and the protection of soil from nitrate contamination. Significant further Directives are being formulated. For example, as part of its Thematic Strategy on the Sustainable Use of Pesticides (a component of the EC's Sixth Environment Action Programme), the European Parliament in January 2009 voted in favour of banning 22 dangerous chemicals from use in pesticides, on grounds that they may be hazardous to human health. (Some 800 chemicals are used in food production in the EU, as insecticides, herbicides and fungicides.)

The Directive will have a significant impact on the agrichemicals sector, especially suppliers of large-scale farms, and further measures of this type are likely. EU and national measures are also likely to offer support for broadening the use of integrated pest management techniques (see below).

Soil degradation, contamination and erosion have also become serious problems in Europe. The EU's Soil Framework Directive (2006), another part of the Thematic Strategies, focuses on improving soil quality, following narrower, earlier Directives, such as the Nitrates Directive (1991). Further regulation at the EU or national level is likely over the next five to ten years. Technical improvements in both the precision and sensitivity of monitoring instruments will contribute to quickening implementation of this regulation.

Water management

The agriculture sector uses about 33% of water used in Europe, and agriculture accounts for about 70% of water use globally. Current irrigation techniques often are inefficient, leading to water wastage, soil erosion and salinisation. Food production can also be a major contributor to water pollution.

The EU Water Framework Directive (WFD), passed in 2000, is the most important EU initiative in the area of water management.

The WFD is designed to protect good quality waters and improve poor-quality waters across Europe. A 2007 implementation report of the WFD stated that Member States had fulfilled most of their reporting obligations but noted legal actions taken against states for delayed reporting.

In terms of water quantity, the EC adopted a Communication in 2007 on water scarcity and droughts; a follow-up report in 2008 found "some encouraging policy initiatives at both the EU and national levels" but noted that much work remained to significantly raise water quantity, especially in vulnerable areas of Europe.

3.2.2. COMMODITY PRICE VOLATILITY

The European food production sector continues to depend heavily on oil and other commodity inputs for fertilisers, crop protection chemicals and in agricultural machinery and transport. As a result, the recent commodity price volatility has increased pressure in the food production sector to reduce dependence on oil and other commodities. This will lead to broader need for Cleantech to generate efficiencies and long-term cost savings. Demand for clean energy storage equipment is also likely to grow, as this would help reduce the impact of power outages or temporary price spikes, allowing farms to reduce their dependence on utility companies.

3.2.3. PUBLIC OPINION

Public opinion has potential to either drive or restrain Cleantech in agrichemicals and water management, although, on the whole, it appears to be an increasingly important driver. As the public's knowledge and concern about climate change and water issues grows, consumers and voters are increasingly looking to buy food that is environmentally friendly.

The economic downturn is likely to reduce consumers' willingness and ability to pay extra for organic food, but any decrease is likely to be temporary, particularly given that the biggest proponents of organic food tend to be young and therefore are likely long-term buyers. This trend may help drive interest in Cleantech that supports organic food production and more environmentally sustainable agrichemicals and water management techniques.

However, in Europe, while demand for organic products is one driver behind environmentally sustainable food production, public opinion has the potential to slow Cleantech development in the sector due to attitudes towards genetically modified (GM) crops. The European public has traditionally been sceptical about the safety of GM crops. However, opposition to GM crops among European publics appears to be waning, partly due to new information and partly due to concerns about global food shortages. GM crops may begin to become more widely accepted as their advantages become acknowledged. However, there is likely to be stronger growth in acceptance of GM enzymes (such as for processing waste) than of GM crops.

3.3. Cleantech developments over the next 5–10 years

In the EU, Austria stands out as having the highest proportion of organic farms – followed closely by Finland and Denmark. In terms of the separate (yet overlapping) category of innovative Cleantech in agrichemicals and water management, Scandinavia, Germany and the Netherlands are all leading countries within Europe, while the world leader in Cleantech in food production remains Japan.

3.3.1. AGRICHEMICALS

Fertilisers

German chemicals companies are leading the drive towards developing new, more efficient fertilisers. However, the major Cleantech advances over the next five to ten years will not necessarily be in chemical composition but in more precise, technologically advanced delivery methods. Computer-controlled systems – building on Global Positioning System (GPS) and leaf testing technology – and on-board robotics can be used to target nutrients or pesticides more efficiently, reducing wastage and over-application. The equipment exists; although it requires some investment by farmers, momentum is clearly building within this field of precision agrichemicals.

Crop protection

There will be a drive for a reduction in reliance on chemicals for crop protection. Biopesticides (consisting of living micro-organisms) will become more widespread; at present these constitute less than 1% of the global market in pesticides. They degrade rapidly and have little environmental impact. Both chemical crop protection and biopesticides, as well as natural predators and crop rotations, form part of what is coming to be regarded as best practice in crop protection: 'integrated pest management'.

Direct pesticide, herbicide and fungicide risks to humans are also likely to be reduced in coming years by implementing improved handling systems. There is also likely to be a rise in the need for returnable, recyclable and biodegradable containers for pesticides.

Soil protection and decontamination

Using plants that naturally over-accumulate heavy metals may help to reduce the cost of decontaminating soil and to reduce further contamination. However, technology will also play a key role in this area.

3. Agrichemicals and Water Management

GM technology and 'no till' cultivation

The development of herbicide-resistant crops has reduced the need for ploughing to prevent weed growth. This enables a range of soil conservation techniques. One of these is 'no till' cultivation that disturbs soil less, meaning less carbon is released from the soil's upper layers and the soil is left in better health. The technique is already widely applied in Western Australia (on about 92% of the land) and in Brazil – where half the country's crop land is now under no till – but less so in Europe. This could gradually also begin to be applied in Europe over the next five to ten years.

Denitrification

Nitrogen is one of the key nutrients applied in chemical fertilisers or manure. High levels of nitrate (as well as phosphate) contaminate soil and water. Denitrification technologies can alleviate this. Bioreactors, which degrade contaminants using micro-organisms, can be used for denitrification. Bioreactor technology continues to be adapted and made more efficient, and is likely to become more widely used in managing waste from food production.

3.3.2. WATER MANAGEMENT

There is huge potential to improve efficiency in water management in the food production process. Key areas of growth for Cleantech will include:

- shifting from flood irrigation systems to targeting frequent irrigations more closely to crop requirements, such as using trickle irrigation;
- technologies to combat salinisation: biotech advances are being applied in an effort to develop salt tolerance in major crops. Commercialising salt tolerant crops could lead to substantial water savings, as 'flushing through' farmland with large quantities of water to reduce soil salinity will not be needed;
- moreover, exploiting plants that have high salt resistance levels could be developed into 'salt water agriculture'. This is most likely to be implemented for new biomass crops (at least initially) and novel minor vegetables, such as samphire. Commercial rollout over the next five to ten years is possible;
- further biotech innovation is likely ultimately to result in the development of drought-resistant crops; however, this is not as far advanced as development of salt tolerance; and
- wastewater reclamation technologies (see Section 4. Waste Management).

4. Waste Management

4.1. Introduction

The amount of waste produced in the EU represents a major environmental challenge. Every year, about two billion tonnes of waste are produced by EU Member States. In 2006, each EU citizen generated just under 520 kilograms (kg) of municipal waste, though wide disparities exist between the EU-15 and new Member States. Whereas EU-15 citizens produced on average over 570kg/head (800kg/head in Ireland), new Member States produced only 335kg/head (260kg/head in Poland).

Cleantech for waste management covers the spectrum from complex scientific processes to simple material choices in a product's design phase. Cleantech can impact the waste sector by:

- using improved product design and packaging to decrease the amount of waste produced;
- providing financial incentives to companies to recycle by making component reclamation less costly; and
- promoting a near "closed loop" cycle in which waste is turned into clean energy or other usable products such as potable water.

Implementation of Cleantech in the waste management sector can have a positive financial impact on individual firms, which is maintaining the attractiveness of this area from an investment perspective even during the current economic downturn. Structural changes to the sector have the potential to greatly reduce waste output in Europe, thereby reducing the emission of greenhouse gases and curtailing the area devoted to landfills.

Encouraging the shift away from landfills will continue to be a priority in several European countries (e.g. the United Kingdom), mainly due to the shortage of available sites and issues over planning permission. Further, rotting waste emits methane – landfill accounts for about 2% of the EU's total emissions of greenhouse gases.

4.2. Drivers

The primary drivers of innovation and adoption of Cleantech in the waste management sector are:

- European environmental regulation on greenhouse gases and incineration;
- financial incentives;
- the cost of commodities; and
- political will.

4.2.1. EUROPEAN ENVIRONMENTAL REGULATION

EU legislation on waste management is built on Directives dating back over 30 years.

- The Waste Framework Directive (WFD) is the central element of the environmental acquis, and subsequent legislation can be considered as 'daughter' Directives. A key aspect of the WFD is the so-called 'waste hierarchy': reduce, re-use, recycle, recover, and dispose. A 2008 amendment proposed statutory recycling targets for specific materials.
- The Landfill Directive sets demanding targets to divert biodegradable municipal waste from landfill. These targets are:
  - by 2010 to reduce biodegradable municipal waste landfilled to 75% of that produced in 1995;
  - by 2013 to reduce biodegradable municipal waste landfilled to 50% of that produced in 1995; and
  - by 2020 to reduce biodegradable municipal waste to 35% of 1995 levels, which will entail diverting 20 million tonnes a year from landfills.
- The Waste Incineration Directive places strict limits on emissions from incineration facilities.
- The Restriction of Hazardous Substances (RoHS) Directive as of 2006 has stipulated that six hazardous substances (including lead, mercury and cadmium) in products should

4. Waste Management

be replaced by non-hazardous ones. The Directive aims both to reduce pollution and improve occupational safety. It has implications for both the manufacturers themselves and companies that import and export, or purchase and re-sell, electrical and electronic products. Given a number of problems in its first few years of implementation, in December 2008 the EC proposed to reform the RoHS, aiming to clarify scope and definitions, to create a binding list of products and to introduce coherent mechanisms for assessing their conformity. The RoHS reform also identifies four additional substances presenting potential environmental risks that should be kept under close scrutiny and possibly included in the list of banned substances in the future.

- The Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Directive, in force since 2007, is further pressuring companies to act. The REACH Directive has implications for the re-use/recycling of some materials that contain hazardous elements, e.g. the type of glass found in monitors and televisions. Supply chains will be monitored for "substances of very high concern" (SVHC). Not only will manufacturers and importers be required to gather information on the properties of the chemical substances used in their products in order to manage them safely, but there will also be requirements for this information to be shared with downstream users and distributors.
- Under the Waste Electrical and Electronic Equipment (WEEE) Directive, in force since 2003, firms are required to facilitate re-use and recycling of electrical and electronic manufactures and to minimise the quantity disposed of as unsorted waste. Also, firms need to guarantee that they will take back and manage waste from the manufactures that they produce. In light of technical, legal and administrative difficulties encountered since the introduction of the Directive, the EC is proposing to reform the WEEE. The planned reform focuses on changing collection targets and setting minimum inspection requirements for Member States in order to strengthen enforcement.

Many countries have implemented these Directives through legislation, which in turn drives Cleantech in waste management at the national level. For example, enacted in response to the Landfill Directive, the UK Waste and Emissions Trading Act stimulated the emergence of Cleantech as authorities were compelled to plan their future waste patterns and divert waste from landfill. However, compliance remains a problem – most acutely in Italy, as highlighted by the long-standing waste crisis in the south of the country.

Small- and medium-sized businesses, in particular, are concerned that they will have to bear a relatively high compliance cost to meet any new requirements. This may have an impact on EU competitiveness.

4.2.2. FINANCIAL INCENTIVES

Public sector incentives

In the context of the economic downturn, public-private partnerships (PPPs) will start to gain importance to help kick-start new Cleantech in waste management and build confidence between companies and the authorities.
The UK's Department for Environment, Food and Rural Affairs (Defra) started a EUR 32 million New Technologies Demonstrator Programme (NTDP) for innovative technologies in waste and recycling. The programme aims to demonstrate emerging alternative waste treatments and test their environmental and economic viability. NTDP sites include visitor centres designed to allow stakeholders from the waste management sector to learn about the new technologies[10].

The NTDP fits within an overarching Waste Improvement Programme (WIP) and alongside the Waste Infrastructure Delivery Programme (WIDP). WIDP is the cornerstone of the UK Private Finance Initiative (PFI) market for waste, overseeing some EUR 2.1 billion of funding for about

[10] *www.defra.gov.uk*

20 long-term municipal waste treatment projects, each delivering its own waste treatment infrastructure. Cleantech investors are hoping to access this funding.

Private sector financing and innovation

In innovative waste management, the private sector can operate on a smaller scale and faces fewer procurement obstacles than the public sector. Further, private companies are concerned primarily with homogeneous waste streams, which are usually simpler to treat than the more diverse contents found in municipal waste. Thus, individual companies are driving waste management innovation, even though many – especially small–to medium-sized companies – do not yet see it as a priority, given that economic and environmental incentives are not yet fully aligned.

4.2.3. ECONOMIC DOWNTURN

While some have pointed to the global economic downturn as an obstacle to Cleantech innovation, it is also possible that the crisis will increase the demand for technologies that maximise the usability of materials at each stage of their life cycle. In this sense – regardless of commodity cost fluctuation – it may be that price signals from the wider economy may prove effective in persuading consumers and producers to treat their waste more carefully.

4.2.4. RELATIVE PRICE OF COMMODITIES

Nonetheless, the price of commodities can have an impact on the impetus for recycling and re-use technologies in two primary ways. As the price of commodities rises:

- the incentive to reclaim components of disposed goods, such as copper in electronics, increases; and
- companies choose slightly less costly recycled materials, if they are available, over 'virgin' (non-recycled) materials.

Given recent extreme commodity price volatility, declining prices will not reverse these considerations in the short-to-medium term.

4.2.5. POLITICAL WILL

Effecting change is difficult given the sensitive nature of the politics of handling waste and the longstanding problems with public engagement on this issue. In August 2008, the European waste management and recycling sectors had an annual turnover of EUR 100 billion and employed about 1.5 million people. Any significant policy changes towards Cleantech must take the labour market impact into account.

While some countries have developed effective strategies for waste management, in others the issue has been bedevilled by the reluctance of voters to adapt their behaviour, as well as the attitudes of local authorities. Entrenched interests sometimes resist any significant restructuring of the waste management sector. Countries that have opted to develop energy from waste (EfW) plants are reluctant to consider alternative technologies as they are committed to maintaining a waste stream to their facilities in order to provide electricity and heating. Countries such as the UK and Greece, which have a reliance on landfill, are more open to newer Cleantech.

4.2.6. NGO PRESSURE

Non-governmental organisations (NGOs) can also serve as independent drivers of improved waste management technology, especially in the realm of harmful e-waste.

The Greenpeace Guide to Greener Electronics is an example of the kind of pressure being exerted on manufacturers by the NGO community. The Guide scores electronics companies according to their environmental performance in several areas, including energy efficiency, reduction in hazardous chemicals used and e-waste management. For example, in its 10th edition of December 2008, Nokia is awarded the highest score, based on a good take-back policy, and products being PVC-free (as of 2005) and (as of 2009) free of brominated flame retardants (BFRs – neurotoxins).

4. Waste Management

4.3. Cleantech developments over the next 5–10 years

There could be significant change in the European waste management sector over the next five to ten years. Change will be facilitated by technology transfer from leaders in the EU – such as the Scandinavian countries, Germany and Austria – to laggards in Cleantech implementation in waste management, including Ireland and the United Kingdom.

4.3.1. ENERGY FROM WASTE

Waste materials represent as yet poorly exploited sustainable energy sources. However, the political push for energy security along with the regulatory impetus to divert waste from landfills will increase the already growing body of technologies and processes to recover energy from waste. There are a number of clean technologies currently being implemented, and several others being tested as pilot programmes. Most progress is taking place in the fields of gasification and pyrolysis, and anaerobic digestion.

Gasification and pyrolysis

Gasification and pyrolysis are not new technologies, but test programmes currently underway are implementing them in more progressive ways. Gasification converts carbon-containing solids and liquids into gas. Pyrolysis is chemical decomposition by heating.

Gasification plants in Northern Europe have evolved from a capacity of 10,000 tonnes per annum (tpa) in 1990 to 80,000 tpa in at least three new facilities being planned. Pyrolysis has great potential as it allows waste to be converted into a range of transportable fuels. It also has the potential to refine oil back into crude oil, thereby closing the loop. However, these processes can be of unreliable operational efficiency and highly complex – costly barriers to entry remain. Major examples include the following:

- Plans are underway for a EUR 73 million waste biomass-to-gasification plant in Romania, designed to convert 500 tonnes of municipal waste to 20 megawatts (MW) of power per day.
- Construction of the world's largest biomass plant in South Wales, fuelled by wood chips from forestry plantations, is expected to be completed by 2010, and should generate enough clean electricity to power half of the homes in Wales. This could be a potential growth area, as a recent Defra report claimed that the majority of the 10 million tonnes of waste wood being produced in the UK goes unused[11].
- The US Army is testing Tactical Garbage to Energy Refineries (TGERs) – mobile 'energy from waste' technology small enough to fit inside a standard shipping container. Through a process involving thermal decomposition, TGERs are able to convert a tonne of waste into 60 kilowatts (KW) of power. Should these pass the pilot stage, they could serve as models for mobile, small-scale units to reap energy from waste.

Anaerobic digestion

Great scope for growth exists in the field of anaerobic digestion technology – a process that uses bacteria to break down organic material partly into biogas, which can then be used for heat and electricity. Barriers to this technology being rolled out include the initial capital required to construct plants, and associated odour and visual pollution. Nonetheless:

- Large networks to recover this biogas and use it as fuel are already in their second and third generations in Germany, where thousands of biogas plants are in operation. Methane mitigation is a major issue in several European countries with large livestock populations.

[11] *CleanTech Group, "UK Approves World's Biggest Biomass Plant", November 2007; "UK Waste Wood Going to Waste," April 2008.*

- UK retail company Marks & Spencer announced it would begin diverting its waste food away from landfills and into small-scale anaerobic digestion plants in an effort to become 'carbon neutral' by 2012. The goal is to reap the biogas from the process to power some Marks & Spencer shops.
- Professionals from across the EU, including Greece, Italy, Norway and the Netherlands, have created the European Anaerobic Digestion Network (AD-NETT) in order to disseminate information on developments in the field.

4.3.2. OTHER WASTE TECHNOLOGIES IN FOOD PRODUCTION

Waste decomposition using GM

GM enzymes have been used for a long time in cheese making and industrial processing. A future growth area is likely to be waste (such as manure and compost) decomposition using GM enzymes. A disadvantage of this process is that the beneficial impact of crop residual decomposition for soil is lost.

Biocomposites

Many countries no longer permit the burning of crop residuals. Instead, one niche use for such residuals that is likely to increase significantly over the next five to ten years is as biocomposites: woody material and the fibre of the stems of crops such as hemp, sisal and jute can be processed (combined with a resin) for use in packaging, insulation and other areas. For example, some car manufacturers such as Volkswagen have used hemp fibres in the inside panels of car doors; such fibres, when mixed with artificial glue, are very strong. In another area, the potential for the use of processed plant residues to improve the water-retaining and other qualities of fast-draining soils may become increasingly attractive.

Carbon sequestration

Carbon sequestration already plays a huge part in European Cleantech and clean energy initiatives. However, a comprehensive carbon sequestration system for food production has yet to be established. Financial incentives for farmers to sequester carbon in soil have so far proved too costly and difficult to structure, outside of the forestry industry, but this could begin to change in European food production over the next five to ten years.

Storage efficiency

There is significant potential for improvement in terms of efficiency in storage of produce. Apart from moves towards more environmentally friendly packaging, such improvement includes advances in packaging that help to keep food fresh. In addition, there is likely to be further rollout of building structures and materials that improve chilling and heating components.

4.3.3. IMPROVED SORTING

A crucial factor in the viability of effectively managing waste is the homogeneity of the waste stream: industrial waste is typically more homogeneous than municipal waste. Improvements in waste sorting, particularly at the municipal level, can improve the energy and re-use potential of waste. For instance, plastics and glass are now commonly sorted using optics to recover even very small pieces. Sorting technology in Material Recovery Facilities (MRFs) is consistently improving, and this is likely to continue as demand for purer waste streams increases.

4.3.4. WASTEWATER RECLAMATION

At about EUR 310 billion per year, the global market for water is exceeded only by electricity and oil in size. In industrialised countries, industry uses 60% of the water supply[12]. Companies are employing a range of clean technologies to restore water captured directly from sources such as industrial or municipal wastewater to potable quality.

[12] *'The Clean Tech Revolution' (2008) by Ron Pernick and Clint Wilder.*

4. Waste Management

Innovative solutions to meet rising demand for water are appearing all over the world. For example:

- Singapore has set a target date of 2011 to supply 2.5% of its municipal water from reclaimed wastewater. Its NEWater project involves microfiltration and reverse osmosis.GE Water has committed over EUR 60 million to develop an R&D centre in Singapore[13].
- Another technology under development involves membrane bioreactors, which use advanced ultrafiltration techniques using suspended biomass. Such techniques have potential to extract not only clean water but also nutrients and energy from sewage.

4.3.5. INTERNET-BASED WASTE TRACKING

Information technology is also being used to improve waste management. Waste management is a data-hungry sector, and improvements in tracking and collecting data on waste movement could significantly improve efficiency. For instance, Toyota created an internet-based waste tracking system for its North American operations.

4.3.6. PRODUCER RESPONSIBILITY

Mainly driven by regulation, the concept of producer responsibility continues to gain prominence. Legislative and consumer pressures enforcing this responsibility may lead more manufacturers to conceptualise effective waste management in the product design stage in order to maximise recyclability. US technology firm Hewlett-Packard creates products with their eventual disposal in mind, thereby ensuring a higher level of recyclability at the end of a product's life. Other firms have gone a step further, aiming for 'closed loop production', which eliminates waste from the product cycle altogether. Interface, a leading global flooring manufacturer, provides an example. The company has since 1994 implemented an 'Ecometrics' system to measure inputs of materials and energy, and outputs of products and waste.

Retailers as well as producers are embracing the producer responsibility ideal of waste management. Marks & Spencer collaborated with Wrap (Waste and Resources Action Programme) – a UK government funded non-profit – to promote a closed loop recycling programme. One of their innovations in packaging, a so-called 'integrity seal', which uses heat to close plastic bags, needs less plastic and lengthens products' shelf lives.

4.3.7. E-WASTE

E-waste (i.e. waste from electrical and electronic products) is one of the fastest growing waste sources. About 4% of all EU municipal solid waste is e-waste, which may contain harmful elements such as lead and mercury (both used in screens) and cadmium (used in rechargeable batteries).

Clean technologies targeting the design and disposal of electrical and electronic manufactures will be crucial to stemming the volume and negative impact of e-waste. Disposal of electric and electronic manufactures can take place in landfills and incinerators, in both cases with potentially harmful effects on the environment. In addition, export of e-waste from developed to developing countries is a significant, often illegal, commercial activity. In developing countries, the products may be repaired or recycled, either of which can be hazardous for human health. Using Cleantech to reduce e-waste in Europe may therefore have far-reaching global consequences.

The WEEE Directive is going to drive significant change in the sector over the next five to ten years. EPR is likely to become the norm, whereby manufacturers will become responsible for their products beyond the point of sale, and until the end of their use, appropriately managing them when they become waste. This is likely to lead to products that last longer, are easier to recycle or upgrade, and do not contain hazardous substances.

[13] *'The Clean Tech Revolution' (2008) by Ron Pernick and Clint Wilder.*

More firms will devote greater resources to 'lifecycle' analysis and management, addressing the environmental impact and taking responsibility for products' entire production chains. These include production and acquisition of raw materials; the manufacturing process itself; product distribution; and 'end-of-product-life' management.

Light bulbs

Mercury in light bulbs is perhaps the most important current issue in e-waste. In accordance with new EU regulations, incandescent light bulbs are now in the process of being phased out in the EU. These are being replaced with alternative, low energy bulbs. Though the low energy bulbs generally contain less mercury than the levels expended by incandescent bulbs, they can produce a hazardous waste stream when not properly disposed. Work is currently being undertaken (notably at the Centre for Waste Management at the University of Central Lancashire in the UK) to develop a technology to produce efficient alternative light bulbs to address this issue.

Mobile phones

The mobile phone industry has yet to make significant use of Cleantech in product design, continuing to generate potentially toxic electronics waste. However, some progress has been made, eg by Nokia, in the area of recyclability: about 60% of metal in new Nokia handsets is made from recycled materials. Moreover, under the RoHS Directive, companies have had to eliminate several hazardous substances from their products. Other recent developments have taken place in the field of biodegradability:

- Samsung launched three models with corn-based plastic cases in Europe (and Asia).
- Nokia has developed a handset using recycled cans, plastic bottles and car tires; similarly, Sony Ericsson has developed one based on recycled and plant-based plastics.

Prototypes of cell phones powered by fuel cells are being developed: Toshiba has announced a model to be released in 2009[14].

Microchips

New microchips are permitting energy savings as higher numbers of transistors can be fitted onto each microchip. Changes are also taking place in terms of the raw materials used in microchip production. In particular, there is a drive to reduce reliance on lead for soldering, thereby reducing potentially toxic waste.

[14] *Clean Tech Group, "Fuel cell-powered cell phones materializing", February 2008.*

C. Implications for Business

Cleantech has the potential to have a far-reaching impact on the operations of both European companies and foreign companies operating in Europe. Key areas of impact over the next five to ten years will be:

1. REGULATORY SHIFTS

Companies across a wide range of sectors will be impacted by a tightening of regulation, driven by the EU, aimed at promoting greater environmental sustainability (e.g. on building materials, landfill diversion and manufacturing standards) and reducing toxic emissions. However, implementation is taking place at an uneven pace across Member States, which may create confusion and additional costs for companies. Therefore, investments by companies in regulatory foresight and monitoring will reap benefits in the longer term. Crucially, regulatory change in adjacent sectors will also need to be monitored, given the growing potential for 'regulatory spillover' across sectors. Also, to the extent possible, companies should enhance the adaptability of their operations to potential future regulatory change.

2. REPUTATIONAL RISKS

With public opinion across Europe 'greening', companies face potential reputational risks if they engage in practices that are perceived as being harmful to the environment, or if they do not comply with environmental regulations. Communication will become increasingly critical: Companies may find that failure to indicate environmental awareness could result in a negative reputational impact. As Cleantech is applied more broadly, authorities and consumers will expect a higher level of 'greenness' in their goods and services. Voluntary 'green' certifications may come to play a more important role in consumer and procurement choices.

3. LOBBYING NEED

As tighter regulation is devised, it will become increasingly important for companies and industry associations to ensure that their views are adequately represented at the national and EU level. Some sectors have been very successful in promoting or restraining environmental legislation to their benefit. It would be worthwhile for companies in other sectors to invest in learning from such successful case studies, and also to build mutually beneficial alliances with companies/associations in other sectors and countries. Broad alliances will prove particularly useful in ensuring that the competitiveness risks associated with higher costs of implementing environmental regulation (at least in the short term) are adequately taken into account.

4. PROCUREMENT DECISIONS

Companies will need to become increasingly aware of new developments in Cleantech as they formulate long-term procurement decisions. Failure to incorporate rapidly evolving technologies could have increasingly serious direct financial implications – for example, retaining old technologies could result in less efficient energy and water consumption and higher utility-related bills. Key areas of this changing procurement focus are likely to be manufacturing equipment, logistics, and real estate.

5. LIFE CYCLE RESPONSIBILITY

European regulation is putting a greater onus on companies to be responsible for the entire life cycle of their products and services. This represents an opportunity for companies that are incorporating environmental issues into all aspects of their corporate strategy, but poses a serious risk to companies that are not yet doing so. Driven by e-waste concerns and the WEEE Directive, the concept of producer responsibility may increasingly be transferred to other sectors. Municipalities will expect producers and retailers to assume more of the costs of product disposal, providing producers with incentives to design products with high levels of recyclability and to better understand their supply chains. In the short term, this is likely to raise costs for companies, but those that manage to adapt quickly and most effectively stand to gain competitive advantage over rival companies in Europe.

6. UPGRADING INFORMATION TECHNOLOGY

Information Technology (IT) upgrades will go hand-in-hand with many new Cleantech applications. Short-term gains can be made across most sectors by using IT to better manage company information, resulting in improved energy use and reduced emissions. For example, in food production, IT can help in the more efficient broadcasting of agrichemicals. In some sectors, enhanced IT will be at the core of adapting to Cleantech, with transport companies, for example, coming to depend on fleet management technology that encompasses areas such as driver training and optimising routes; and manufacturers will need to employ sophisticated IT systems to track and manage waste across supply chains.

7. INVESTMENT OPPORTUNITIES

Cleantech provides a number of investment opportunities, with new innovations potentially resulting in high levels of return. However, given the wide range of nascent technologies, and the relatively limited availability of funding at the moment, companies need to select the technologies they choose to invest in with care. In this regard, companies should analyse most closely those technologies that are likely to be positively affected by long-term government incentive structures and/or that may benefit from new PPPs.

8. TECHNOLOGY TRANSFER

Companies should look outside their national borders (and also outside Europe) in order to learn about Cleantech applications in their sector. For example, Japan remains a world leader in the application of Cleantech to food production. Companies that currently are laggards in Cleantech have huge potential to 'catch up' with competitors, or even overtake them, by skilfully and rapidly adopting existing clean technologies. Similarly, it may be that certain particularly successful clean technologies help to transform entire economies, potentially enabling rapid catch up or overtaking by some developing countries. Such a development path could emulate what has been occurring in telecommunications in Africa, as mobile telephony has leapfrogged terrestrial telecommunications. European companies should be attentive to opportunities such development could present, for new export markets, offshoring functions and international expansion.

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