# 101 Ways To Kick The Carbon Habit

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# 1. Introduction – The Trouble With Carbon

Carbon itself is not a problem – after all, we are carbon based, as are trees and all other living organisms. Like trees, we are part of the carbon cycle: During our lives we collect and retain carbon and after our death we release it again. If we are buried the carbon is sequestrated while if we are cremated the carbon is released into the atmosphere. In this respect we are also little different from a tree that may fall into a swamp after it dies or may become victim of a forest fire.

Man's problem with carbon has its roots in our ability to accelerate the carbon cycle. We do this by digging up the carbon based deposits that nature has sequestrated and using them as fuel. When we burn these fuels, carbon is released into the atmosphere. The rate at which we are burning these deposits far outstrips the rate at which nature created them in the first instance or would, in normal circumstances, recycle them. This has implications for both the environment and the economic systems of the industrial world.

The environment cannot cope with the volume of carbon we are adding to the carbon cycle. A surplus of deposits is finding its way into the upper atmosphere where particles lock in heat energy and contribute to global warming.

Nature created carbon deposits in geological time. If we used them at the same rate – or even in biological time – there would be little immediate impact on the world's economy. Unfortunately, in recent decades we have been extracting and burning carbon based deposits in 'Internet time'. If time were compressed so that the rate at which nature sequestrated carbon was of the same order of magnitude as the rate at which we are consuming carbon based fossil fuels, then the burning of all of the earth's oil and coal would sound like the bang of a firework with a very short fuse. As supplies of these natural resources dwindle, so prices rise and security of supply starts to impact on Western industrial economies which are now totally dependent on oil, gas and coal.

We are rapidly approaching two potential points of no return. The first is environmental: the point at which global warming starts feeding on itself and no matter how much emissions are reduced the world will continue to get warmer. The second is economic: the point at which the remaining fossil fuels become to scarce and expensive that they cannot be used to build the infrastructure required to power an economy using renewable sources of energy.

There is no single answer to this problem; the solution lies in a number of individual and, in some cases, seemingly unrelated technologies, services or programmes. In this CarbonFree report we list 101 initiatives that could potentially play a role in a renewable energy based world and could also provide key components in a new and rapidly growing industry.

## 2. The Trouble With Oil

Recently it was suggested that the industrial world has become addicted to oil. Oil as a drug is a good analogy, as every barrel of oil consumed contributes to the creation of services and products that in turn stimulate the demand for oil. The oil crisis of the 1970s demonstrated that developed countries could, if pressed, moderate their consumption of oil. However, to date, it has not been possible to break the link between economic growth and oil consumption. In the brief period we have been consuming oil, we have become totally dependent on a rapidly diminishing resource to power our cars, provide the basic components for medicines and clothing and supply the energy that brings food to our tables. As oil is now such a strategic resource, security supply causes tensions between producer and consumer nations.

The world's remaining stocks of oil, which according to some estimates may only last another 30 years, are either located outside the borders of consuming countries or, in the case of oil shale, have a particularly high sulphur content.

## 3. Welcome To The Nuclear Age?

When it was first introduced to the public in the middle of the last century, nuclear power was promoted as the ideal replacement for fossil fuels. It was clean and, as it could be produced close to the point of consumption, it did not carry the geopolitical baggage associated with oil. Nuclear energy could be used to generate electricity or to synthesise fuels, such as hydrogen. When the first nuclear power station was opened, it was even suggested that, in time, the technology would advance to the point where homes or even individual devices could be fitted with miniature reactors. To date, this miniaturisation has only extended to nuclear powered submarines.

The are a number of reasons why deployment of nuclear power has slowed and, in some countries, come to a full stop. A number of high profile accidents such as Three Mile Island and Chernobyl undermined public confidence in nuclear technology. As a result, it is now difficult, within democratic countries, to find suitable locations for nuclear power stations. While within non-democratic companies it is possible to ignore public hostility to the deployment of nuclear power, these countries are often denied access to nuclear technology due to fears that it will find its way into weapons development projects.

There is, however, a third problem associated with nuclear power that has become steadily more pressing during the five decades we have used it to generate electricity. To date, it has not been possible to find a cheap and simple way to dispose of spent fuel. As spent fuel is highly radioactive, it is difficult to find suitable sites for its long-term storage. In addition, shipment of spent fuel represents a potential security risk.

The risks, and potential liabilities, associated with the nuclear power industry have deterred private investors, leaving the sector in the hands of government controlled organisations. The absence of small private operators has helped create an overarching problem that stifles growth within the nuclear power industry: a lack of innovation. The industry requires the step change in technology that can only be provided by a new process, such as hot fusion which would eliminate the cost of disposing of spent fuel, or even cold fusion which would go a long way to changing the public's perception of nuclear power.

## 4. Innovation Within The Energy Industry

As markets mature, the bar to entry into those markets is raised. There is usually only a small window of opportunity within which an individual such as John D Rockefeller or Bill Gates can translate a simple idea into a major enterprise. While, in the case of the IT industry, this window has remained open long enough for companies such as Google to make a mark, there are signs that the barriers to entry are already rising. Within the oil industry, which is over 150 years old, the barriers are now set so high that only the world's largest companies can play – and there are even signs that the oil majors are ceding market share to large state owned operators. It is obvious that, within the oil and gas sector, there is little room left for entrepreneurs or the venture capitalists that fund them.

In its infancy the nuclear industry seemed to be about to provide the platform for change that the energy market needed. However, the barrier to entry into the market rose rapidly when the technical limitations and safety and security issues associated with nuclear energy became apparent.

For the entrepreneur and venture capitalist, the simplest and perhaps the only route into the energy sector is via the renewable energy market. If there were a nuclear reactor on the market that was safe and could be taken home from a DIY store in a car, then concepts such as distributed power and microgeneration would be based on nuclear power. Many of the Next Generation (NextGen) energy advocates are wedded to renewable energy not through any desire to protect the environment but because wind turbines, solar panels and geothermal heat pumps are the only tools at their disposal.

Some of the NextGen energy providers are second-generation entrepreneurs who have learned their craft in the high technology market. They see a parallel between the Internet and distributive energy generation: both are potentially disruptive models that encourage innovation on a massive scale. It is little use explaining to these entrepreneurs that nuclear power will be the only option post peak oil and that renewables will be incapable of filling the gap in the energy market. These entrepreneurs heard similar stories from mainframe computer vendors who claimed that no company would trust their business processes to something as primitive and unreliable as the Internet.

The timing of the current surge in oil prices has been fortuitous for the NextGen energy provider, as it has increased interest in the only energy source they have at their disposal. At some point, new forms of energy will become pervasive enough, and achieve sufficient scale, to displace the incumbent fuels and energy providers. Until that point, however, many renewable energy providers will only be able to compete in a market where oil and gas prices are both high and rising.

## 5. Competing With Oil At $30 Per Barrel

It has been suggested that renewable energy initiatives should be protected by putting a floor under the price of oil. This is impractical, and rather than put a floor under oil prices it would be a better idea to set a ceiling on renewable energy prices, or at least set a target price for engineers and scientists to aim at. If, or rather when, oil prices start to slide, environmentally friendly energy products and technologies, even those based on photovoltaic solar cells, will need to produce energy that is competitively priced in a market where oil costs as little as $30 per barrel. At this price, renewable energy produced on either a large or small scale should still gain traction and may eventually displace fossil fuels as a primary energy source.

During the last two years the market for renewable energy technology has been driven by two key factors: concerns that the burning of fossil fuels contributes to global warming, and rising domestic fuel bills. Fears over spiralling energy costs have caused a substantial investment overshoot. Based on long-term projections of rapidly rising energy prices, householders thought that the day would come when they could not afford to heat their homes. For them especially it made sense to splash out on a small-scale renewable energy system.

As oil prices ease, the incentive to invest in renewable energy technology will fall away. The over-excitement that inflated the market for renewable energy will disappear and people will go back to believing oil is cheap and plentiful. Eventually this sentiment will impact on the renewable energy sector.

Householders are not alone in investing in the renewable energy market. Also heavily exposed, as oil prices slip, are hedge funds that have been using the renewable energy sector to offset risks in markets that become distressed when oil prices climb. While these markets may benefit from a lower oil price, this may not compensate for a heavily funded renewable energy sector that comes to a dead stop, as the dot com sector did in 2002. Even more vulnerable are investors who have taken long-term positions in the silicon supply market in the anticipation that both semiconductor and photovoltaic solar manufacturers will compete for the same limited supplies.

Currently, most photovoltaic solar systems are only economic if heavily supported by grants paid to householders, building developers and power generators. These grants are not sustainable in the long term, and would not be required at all if thin film and nanotechonology based photovoltaics made it to the market. Photovoltaic solar is now where the oil industry was when John D Rockefeller first started throwing his weight around. Back then, the economics of oil – then a niche market seen mainly as a replacement for diminishing supplies of whale oil – was a mess. Sometimes a barrel of oil would fetch less than the price of the wooden barrel it was sold in. Even in those early days the market was erratic and the price would vary from an eye-watering $12 a barrel one month down to 10 cents a few months later. Even as it reaches the end of its useful life, the price of oil is still prone to wild gyrations. Photovoltaic based solar power and, for that matter, any other source of alternative energy has to live with these price variations. However, unlike oil, alternative energy is starting out with an established customer base for energy and an existing infrastructure through which to deliver it.

One form of renewable energy has already benefited from the recent rise in energy prices. Investment in wind technology has enabled the industry, within which not much had happened for quite a while, to innovate. But just as important as having good ideas is marketing those ideas to lots of people and, in so doing, getting unit costs down. The small-scale wind technology industry in particular has come tantalisingly close to reaching critical mass, in part due to the significant media coverage the technology has received of late. Again, the price of the technology is a critical factor, as currently the payback period for equipment still exceeds the time a typical householder resides in a particular property. Even so, a number of retail outlets see a potential market for wind power based microgeneration and have been trying to source low cost rooftop turbines to sell in their stores. This is one renewable energy technology that is probably already well placed to survive a downturn in the price of fossil fuels.

Over the next two decades, beyond the next dip in the road up to peak oil, China, India and a host of other countries will enter the energy market. In the longer term there will not be enough oil to go around, and alternative energy will become a money winner again. To ensure the renewable energy industry does not crash, as it did two decades ago, it will be necessary to engineer the technology to produce energy at a price that the consumer can afford anytime – not just when they are desperate.

## 6. Microgeneration

In the developed world, domestic energy consumption per household runs in excess of 2,000 kg of oil equivalent. Some of this consumption can be offset, with a consequent reduction in energy bills, by the use of renewable energy. Geothermal and solar energy can be used for space heating and heating water, while solar photovoltaic systems and micro-wind turbines can be used to generate electricity. Some environmentally aware householders are switching to providers

who supply energy derived from renewable sources such as hydro, tidal, wave, and large-scale wind turbine installations, while others are resorting to microgeneration.

In 2004, only 0.5% of energy used in homes was from renewable sources, which includes energy from waste. Clearly, there is significant scope for increasing the use of this largely untapped resource. The high cost of installing renewable energy systems and the long payback times remain a barrier to the widespread adoption of microgeneration technology. However, as more householders install systems, the renewable energy sector will achieve scale, and the cost of equipment will eventually fall to the point where microgenerated energy is competitive with that produced by burning fossil fuel.

There are a number of practical issues regarding the installation of wind, solar and geothermal technologies in housing. The distributed energy generation model will impact on the business model of the energy provider and grid operator, while the use of renewable energy within the consumer market will impact the fossil fuel market.

The idea that householders could become energy providers is relatively new and has been picked up on by vendors of equipment and systems that extract energy from renewable sources. Microgeneration fits well with the concept of local energy generation and community based energy products – itself being driven by people and companies who see themselves and NextGen energy producers as being locked in battle with the monopolistic incumbent grid operators and power generators. However, care must be taken that householders are not misled as to what is achievable using current technology and do not expect to earn a significant return on their investment by selling surplus energy back to grid operators.

## 7. Energy Storage

The key advantage of renewable energy sources, especially wind and solar, is their abundance and relatively widespread availability. The fundamental problem, if they are to be used for electricity supply, is their variability and intermittent nature. The power generated varies over a 24-hour period and is seasonal. In its raw form, renewable energy cannot be relied upon to provide continuous base-load (the minimum amount of electricity that needs to be delivered at all times) or peak power when needed. In practice, renewable energy can only provide about 10–20% of the capacity of an electricity grid and cannot be considered an economic substitute for fossil fuels. In order to improve the business case for installing renewable energy power plants, energy suppliers must have multiple sources to provide almost 100% back-up of renewable energy generation to meet demand, or have some means of storing renewable energy on a large scale. This results in very high generating costs by today’s standards.

In addition, today's grid systems require electricity demand to exactly match supply. Failure to achieve this causes frequency fluctuations, leading to instability of the grid. The intermittent nature of renewable energy means that feeding it directly onto the grid without adequate load management creates instability.

At first sight, it would seem that renewable energy is not cost effective, nor of acceptable quality to be considered as a primary energy source. However, these technologies will be increasingly required to contribute to the world's energy supplies in order to cope with increasing energy demands and to counter the threat of climate change.

Ensuring reliability and quality of supply requires significant load management, energy storage and back-up energy source. It would be possible to deploy back-up power plants running with relatively cheap fuel such as gas. However, a stored energy source is preferable to an auxiliary gas power plant, as it results in cost savings in fuel and in the building of generating facilities and transmission lines to cover peak loads. It is therefore important to find solutions to the efficient storage of large amounts of renewable energy.

Energy storage devices are also required in applications other than electricity supply. They are needed to provide heat and hot water to buildings and industry in weather conditions that are unsatisfactory for generating renewable energy, and to power vehicles and consumer portable electronic devices such as personal computers, mobile phones, personal digital assistants, and audio equipment.

There are also cases where the short-term storing of kinetic energy or the long-term storage of heat energy are of value and can smooth out peaks and troughs in both demand and supply.

## 8. Urban Heat Islands – A Problem And An Opportunity

The temperature within a large city can be as much as ten degrees higher than in the surrounding countryside. The reason for this becomes obvious when considering the energy flows in a city such as London. London consumes as much energy as a country the size of Greece. Each of its 7.5 million residents uses approximately 20 MWh of gas or electrical energy per annum. In addition, people entering the city each day, and the vehicles transporting goods and materials, consume energy. There is even a contribution to the energy flow from the conversion of food, eaten by the population, into heat. Most of this energy, in excess of 150 TWh per annum, ends up as heat that raises the temperature of London's infrastructure and atmosphere.

As well as the energy produced by human activity, London's 1,579 km² receives a total of 1,400 TWh of solar radiation per annum (three times the amount of energy that flows through the UK's electricity grid). In the surrounding countryside, solar energy is absorbed into the ground where, if it is not extracted using ground based geothermal technology, it is returned slowly into the

atmosphere. However, in London a significant proportion of the 1,400 TWh of energy that the sun provides is trapped in man made infrastructure such as roads and buildings.

This energy, though, is highly dispersed and locked for only a short time in the fabric of buildings and the surface of roads. Capturing and redistributing heat energy would, in most cases, only be cost effective if the technology to do it was built into the infrastructure during the construction phase rather than retrofitted at a later date.

An organisation seeking to trade urban heat energy would base its business on a model that combined elements of renewable energy capture and conservation. There are a range of funding and trading arrangements these businesses could enter into with organisations and city authorities.

As the world's population continues to migrate from the countryside into cities, there will be increased interest in the impact of urban heat islands on the local and global environment. Solar heat retention and concentrated energy use will become key issues, and addressing these issues with novel heat extraction and storage solutions will become important niche markets within both the energy and construction sectors.

## 9. Energy Production – New Model Urgently Required

At some point in history, we began taking wood from forests faster than nature could replace it, abandoning an agriculturally based model of energy production. Today we are heavily dependent on an industrial model of energy production that is focused on extraction. During the intervening period we have moved from one natural resource to another: from wood to coal, coal to oil and oil to natural gas. Each fuel has been replaced by, or supplemented with, another that is cheaper, more widely available or more suitable for the needs of the consumer in any particular period. Coal underpinned the industrial revolution, and oil and natural gas enabled us to automate industrial processes during the consumer age. Many people feel we need a new fuel for the Internet age and some believe that hydrogen, produced from renewable sources, is that fuel.

Renewable sources of energy, such as the sun and wind, are thinly distributed over wide geographical areas. While fossil fuels are also the product of the sun's energy, time and natural processes have done the work of collecting this energy and concentrating it in a small area. If we wish to power our economies using the energy of the sun and wind, we must find a way of gathering that energy. Industrial production – in factories, chemical plants, coalmines or on oilrigs – tends to be concentrated in a small, capital intensive, area. However, agricultural processes are carried out over a wide geographic area, and most are to some degree based on the collection of the sun's energy, in the form of either foodstuffs or biomass. When looking for a model for the generation of energy from renewable sources, it may be better to look to agriculture rather than

industry. The adoption of such a model will have significant implications for new entrants and incumbent players within the energy market.

Today technologies used to capture renewable energy, particularly solar energy, are prohibitively expensive. However, advances in nanotechnology are leading the way to a new generation of collectors that, while less efficient than conventional silicon crystal devices, are cheaper to produce. Already electricity can be produced using wind turbines for less than the cost of generating it by burning oil or coal. Farmed energy will radically alter the structure and dynamics of the global energy market, representing a threat to established players and an opportunity to new entrants. It will also alter political relationships within, and geopolitical relationships between, supplier and consumer nations.

## 10. Carbon Emissions And The Consumer

Two issues will dominate the energy market during the 21st century: climate change and diminishing oil supplies. Any debate over what changes must be made to meet these challenges usually concludes that the consumer must change their behaviour. However, it has to be kept in mind that the 'consumer' is a relatively modern construct and that the consumer society did not exist before the second half of the last century. A consumer is merely a worker who has been assigned a secondary role within our economic system. As a worker they can, via unions and trade associations, influence changes within their workplace. However, at the end of the day they are still a worker. Now, via consumer pressure groups, they can exert some influence over markets. Even so, the nature of consumerism has changed little over the last 50 years, and at the end of the day a consumer is still a consumer.

Consumerism spread slowly across the globe until the 1990s. Since then, with the opening up of the Chinese and Russian markets and the emergence of India as a global economic power, the number of consumers has grown exponentially.

The aims of some consumer groups overlap with those of environmental pressure groups. Other consumer groups have agendas that are diametrically opposed to those of environmentalists. Nowhere is this truer than in the automobile market. For almost a century, automobile manufacturers have promoted the car as not only a means of transport but also a symbol of independence and a visible and mobile display of the owner's wealth and status. Over the years, automobile use and ownership have become highly emotive issues. A government attempt to discourage automobile use by increasing the tax on gasoline can lead to consumer groups blocking highways and demonstrating outside government offices.

The automobile is not the largest contributor to carbon emissions, although it is speeding us on our journey towards peak oil. However, it has become a battleground between consumer groups and the environmental lobby. The conflict

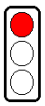
is reminiscent of the factional fighting between various trade unions, which was almost always detrimental to the interests of the worker.

Its role as a status symbol means the automobile will not disappear overnight even though for most people, especially those in urban areas, congestion has made it an expensive and impractical means of personal transport. The automobile industry has started to market the concept of low emission transport. Major manufacturers have done so with an eye to the tough emission limits and congestion charges being introduced in California and parts of Europe. Smaller companies see an opportunity to move into a market that for the last five decades has been dominated by a handful of global manufacturers. It is unlikely the electric car or the hydrogen powered 'Hummer' is the final word in low-emission, renewable energy powered transport. However, they represent the first stage of the migration of consumers into a new and uncharted territory.

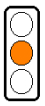
Similar mechanisms are at work in other markets, and while governments may be able to put in place a framework that reduces the impact of consumerism on the carbon cycle, it will be innovators, entrepreneurs and investors who create the products and services that actually reduce emissions. Of these products and services, only a few will endure in their original form. However, even those that fall by the wayside are important first steps in a market that is dominated by consumers who are risk averse and aggressively resist change. The challenge for those active in the renewable energy sector is to identify which products or services work and fit best into an emerging carbon free energy ecosystem, then modify their products or investment strategies to suit.

# 11. 101 Opportunities In The Carbon Reduction Market

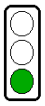
We use a traffic light notation to indicate the feasibility and market readiness of each application:-



Speculative or in the early stages of research.



Technology proved but long-term viability unclear.

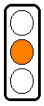


Market-ready or already commercially deployed.

| 1 | Nuclear Power |
|---|---|

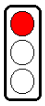
Nuclear power is a mature technology and therefore should have a green indicator. However, in recent years deployment of nuclear technology for power generation has slowed and in some countries no new nuclear power stations are planned or have been built for over a decade. Concerns over proliferation have limited developing countries' access to nuclear technology. In developed countries fears over the safety of nuclear power amongst the general public have made it difficult to obtain planning approval for new plants.

In recent years the disposal of nuclear waste has added a technical dimension to the problems faced by the nuclear power industry.

| Vendor | User | |
|---|---|---|
| www.world-nuclear.org | Grid operators worldwide |  |

| 2 | Nuclear Fusion |
|---|---|

Nuclear fusion is the process that powers stars, and to date the only way man has recreated this process on earth is within a hydrogen bomb. Cold fusion, as opposed to the hot fusion within a hydrogen bomb, is a process that could be carried out at room temperature. Research into cold fusion became mired in controversy in the 1980s after it was alleged results of experiments were fabricated. However, a number of research organisations are persisting with research into both cold and hot fusion, and should a breakthrough be achieved the impact on the energy market would be considerable. The prospect, however remote, of cold fusion or a similar technology emerging should be factored into any long-term investment in renewable energy technologies.

| Vendor | Potential user | |
|---|---|---|
| www.jet.efda.org | Nuclear power industry |  |

| 3 | Clean Coal |
|---|---|

The emissions from existing coal fired power stations can be reduced by inserting filters in chimneys. Research is being carried out using bacteria that can both withstand the heat of exhaust gases and absorb carbon dioxide.

The Elsam power station in Denmark is currently being used as a pilot for EU research into the capture of carbon released during the burning of coal.

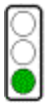
It has also been suggested that in some cases, coal, instead of being mined and brought to the surface, could be burnt underground.

| Vendors | User | |
|---|---|---|
| www.greenshift.com<br>www.iea-coal.org.uk<br>www.lentjes.de | Coal fired power stations |  |

| 4 | Large-scale Combined Heat And Power (CHP) |
|---|---|

As well as providing electricity, a power station, if it is suitably located, can be used to provide heating for nearby buildings. In some cases the domestic heating needs of communities adjacent to the power station can be met using the waste heat from the electricity generating process. The net effect is a reduction of emissions and heat sent into the atmosphere.

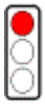
Large-scale CHP is also well suited to power generations systems based on the combustion of biomass or gas from landfill sites.

| Vendor | User | |
|---|---|---|
| www.fw.com | Tornion Voima Oy. Finland |  |

| 5 | Carbon Sequestration |
|---|---|

If carbon released by the combustion of gas, coal or oil can be captured on an industrial scale, some way will have to be found of storing it. In theory it could be returned to disused coalmines. However, it is more likely that special purpose underground stores will need to be constructed to store carbon.

Although less costly and complicated than storing nuclear waste, carbon sequestration will require the construction of a significant amount of infrastructure and will add substantially to the cost of fossil fuel based energy. It is also unlikely that sequestration of emissions from fossil fuel based domestic heating systems will become practicable.

| Vendor | User | |
|---|---|---|
| Various feasibility studies | Fossil fuel industry |  |

| 6 | Carbon Offset For Corporates |
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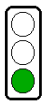
Organisations that carry out a process that creates carbon emissions can 'offset' these emissions by undertaking another process that removes the equivalent amount of carbon from the carbon cycle or produces energy without creating carbon emissions. The offsetting can be relatively informal. For example, a company holding an event could calculate the amount of emissions visitors will be responsible for creating as they travel to the venue. A donation would then be made to an organisation that plants a sufficient number of trees to lock the emissions into the carbon cycle.

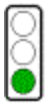
Offsetting may also be undertaken on a more formal basis with organisations trading emissions within a market.

| Vendor | User | |
|---|---|---|
| www.cleanerandgreener.com | Various event organisers |  |

| 7 | Legislation |
|---|---|

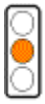
Government agencies can create a framework that will encourage the development of low carbon technologies by setting limits on emission levels. There are a number of reasons why an agency may wish to set limits – aside from a desire to combat the impact of climate change. These may include the avoidance of increased healthcare costs caused by poor air quality in urban areas, or as a means of supporting locally based renewable energy technology vendors.

In some cases, government agencies take legal action against companies or organisations whose emission levels have exceeded stated limits or whose emissions are deemed to have caused environmental damage.

| Vendor | Beneficiary | |
|---|---|---|
| ag.ca.gov | Renewable energy technology sector |  |

| 8 | Taxing Emissions |
|---|---|

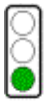
An alternative to regulation is the levying of taxes on activities that produce carbon emissions. Examples include increasing tax on aviation fuel and airline tickets and increasing taxes associated with private motoring and the transport of goods by road. Regulations tend to impact on companies and only indirectly affect the consumer. However, when taxes are levied on goods and services, the consumer sees the prices of those goods and services rise – in some cases to the point where they can no longer afford them. These consumers may feel particularly aggrieved if such taxes are unique to one country or state. When the UK government levied an escalating annual tax on fuel for road transport, private motorists and truck drivers formed a protest group which took direct action, including a blockade of fuel depots and motorways.

| Vendor | User | |
|---|---|---|
| www.sternreview.org.uk | UK Treasury |  |

| 9 | Naming And Shaming |
|---|---|

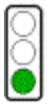
Large organisations are aware of the impact their public profile can have on their financial performance. Consumers' fears over the impact of GM crops on health and the environment have caused financial damage to a number of agro-chemical businesses. As the public become increasingly concerned over the impact of climate change, any company that seems to be doing too little to reduce emissions is vulnerable to wide criticism from pressure groups.

Pressure groups themselves often raise their own public profile by criticising large organisations and companies that supply well-known branded products.

| Vendor | User | |
|---|---|---|
| www.polutionwatch.org | Canadian environmental groups |  |

| 10 | Incentives |
|---|---|

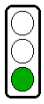
Companies may also wish to increase their profile by publicising their efforts to reduce carbon emissions. Emissions are just one part of the broader issue of sustainability – which impacts not just on the public image of an enterprise but also on its perceived ability to meet the challenges of the coming decades. Increasingly, as climate change will impact on businesses, investors will put a higher value on companies that are able to work within the fiscal and regulatory frameworks designed to reduce carbon emissions.

| Vendor | User | |
|---|---|---|
| www.sustainablebusiness.com | Ethical investors |  |

| 11 | Funding |
|---|---|

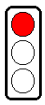
The Carbon Trust has been set up by the UK government to invest in companies that are designing technology and services that will reduce carbon emissions. The Trust operates as a specialist venture capitalist and works alongside established technology incubators – for example, Imperial College has a Carbon Trust Incubator that supported Ceres Power during its start-up phase.

Incumbent energy companies are also using investment in carbon reduction technology as a means of improving their public image. Shell Oil operates the Spring Board scheme, which offers grants of up to $70,000 to small companies who bring carbon reduction technology to the market.

| Vendor | User | |
|---|---|---|
| www.carbontrust.co.uk<br>www.shellspringboard.org | Small to medium size start-up companies |  |

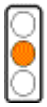
| 12 | Energy As A Service |
|---|---|

Two significant sources of carbon emissions are power stations, who supply businesses and householders with electricity; and gas or oil boilers, used to heat homes, offices and factories. The companies that run power stations or supply gas, like any other commodity suppliers, seek to maximise the number of units they supply to customers. Unfortunately, little account is taken of the amount of units that are wasted by the consumer. It has been suggested that energy, instead of being marketed as a commodity, should be sold as a service – that is to say, the energy company is paid to keep a building powered regardless of how they do it. In some respects the move by electricity companies to provide heat insulation is a step in this direction. However, there is some way to go before the 'Energy As A Service' concept is realised.

| Vendor | Potential user | |
|---|---|---|
| www.eon.uk.com | Householders and businesses |  |

| 13 | Low Power Data Centres |
|---|---|

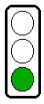
Modern data centres consume large amounts of energy. This energy is turned into heat by the processors within banks of servers – as a result, the rooms in which the equipment is located must be cooled. This means that demand for electricity in commercial areas of cities is often higher in the summer than it is during the winter. IT manufacturers have already started to produce equipment that uses less power, seeing this as a way of gaining an advantage in a highly competitive market where it is difficult to differentiate commodity products. However, to date, little has been done to convert or recycle the heat energy that is produced by data centres.

| Vendor | User | |
|---|---|---|
| www.powerpulse.net | The IT industry |  |

| 14 | Building Energy Management |
|---|---|

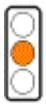
Spiralling energy costs have pushed energy efficiency up the business agenda, with business aiming to reduce property energy consumption by 12% over the next five years. It is believed that, on average, business is willing to pay 10% more in rent for efficiently designed and constructed buildings.

It is less common, today, to find buildings running both their heating and air-conditioning systems at the same time. More attention is being paid to building energy management and companies that are skilled in this area are finding a growing market for their services.

| Vendor | User | |
|---|---|---|
| www.gensler.com/faultytowers | Architects and commercial landlords |  |

| 15 | Industrial Relocation |
|---|---|

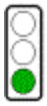
While industrial use of renewable energy is still in its infancy, as more companies look to use power derived from renewable sources it is possible that we will see a relocation of certain industries. If a company wanted to build a factory that would make use of wind turbines, it might decide to move closer to the Midwest of the US. Or, if it was in Europe it might decide to exploit the windy conditions along the continent's north coast. Wider use of solar energy would see companies relocate to areas nearer the equator. While, to date, examples of such relocations are rare, the aluminium producer Alcoa is examining the feasibility of locating one of its smelters in a part of Iceland where geothermal energy can be used as a power source.

| Vendor | User | |
|---|---|---|
| www.alcoa.com | Alcoa Iceland |  |

| 16 | Large-scale Geothermal Systems |
|---|---|

In a number of places around the world, there exist significant sources of naturally occurring geothermal energy. Beyond Iceland, which is well known for its use of geothermal energy, there are a number of other locations where companies are prospecting for subterranean heat energy.

In the US the first phase of the Raft River project is expected to yield 13 MW of power annually, while in Canada the Pumpernickel geothermal reservoir is thought to be capable of sustaining a 20–30 MW plant capable of supplying electrical power for up to 30,000 homes. In Europe the feasibility of using geothermal waters in Germany's Rheinland-Pfalz region is being examined.

| Vendors | User | |
|---|---|---|
| www.usgeothermal.com<br>www.protec-industries.com | Power generators and grid operators |  |

| 17 | Photovoltaic Devices |
|---|---|

One of the technologies closely associated with renewable energy is the photovoltaic solar cell, which converts sunlight into electrical energy. The recent rise in fossil fuel prices encouraged investment in both existing and start-up photovoltaic technology companies. This investment has resulted in an increase in the efficiency of polysilicon devices but has still not brought the reduction in manufacturing costs required if generation of electricity using solar energy is to become cost effective.

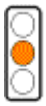
It is often claimed that the photovoltaic devices industry will, like the semiconductor industry, benefit from economies and increases in efficiency. Unfortunately 'Moore's Law' is not applicable to photovoltaic devices due to limits on efficiency and the amount of silicon needed for each device.

| Vendor | User | |
|---|---|---|
| www.sharp.com | Solar panel manufacturers |  |

| 18 | Thin Film And Plastic Solar Devices |
|---|---|

Significant research has been carried out into a range of photovoltaic technologies that either use less silicon or have plastic substrates. If the efficiency of such devices can be increased the cost of powering a home or business using solar energy will be reduced dramatically and large-scale solar installations could become commercially viable.

Progress has also been made with devices that can be overlaid onto windows, reducing the infrastructure needed to support a device.

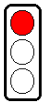
| Vendors | User | |
|---|---|---|
| www.xsunx.com<br>www.konarka.com | Solar energy equipment developers |  |

| 19 | Nano Solar Technology |
|---|---|

Research is being carried out into ultra-thin-absorber cells that are based on semiconductor depositions up to 100 times thinner than conventional thin-film solar cells, which in turn are already 100 times thinner than crystalline silicon cells.

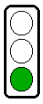
If this research is successful and leads to a product, it will be possible to use relatively low-cost 'printing' technology to produce solar cells.

It has also been suggested that it may be possible to use nanotechnology to produces a device that uses solar energy to extract hydrogen from water.

| Vendors | User | |
|---|---|---|
| www.nanosolar.com<br>www.hydrogensolar.com | Energy research community |  |

| 20 | Solar Hot Water Systems |
|---|---|

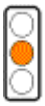
Solar hot water systems are based on simple technology and, for domestic applications, are one of the most cost effective solar-based renewable energy systems. They have evolved from the DIY solar energy systems built by enthusiasts during the 1970s energy crisis. As a significant proportion of the value of a system is added during the installation stage, a large number of plumbing companies have found that hot water solar is both an ideal diversification and an easy entry point into the alternative energy market. The local support that plumbing companies are able to offer to householders, and the relatively low cost of systems compared to photovoltaic based systems, has also made solar hot water a popular choice for householders.

| Vendor | User | |
|---|---|---|
| www.solartwin.com | Domestic users of renewable energy |  |

| 21 | Large-scale Solar Energy Installations |
|---|---|

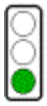
At one time the Bavarian Solar Park project was the largest solar energy installation in the world, consisting of 57,600 photovoltaic panels and made up of three separate systems that provided 10 MW of power. The system used tracking technology to maximise energy production and was connected to the local electricity grid. Other large-scale solar installations are located in Spain and California (Solar One).

To become an economically viable proposition, large-scale solar projects will need access to low-cost collector technology with higher efficiency than is currently available. As the ideal location for large-scale solar installations is within the solar belt, a way of transporting the energy they produce to industrial countries within the northern hemisphere would need to be developed.

| Vendors | User | |
|---|---|---|
| www.powerlight.com<br>www.trec-uk.org.uk | Grid operators |  |

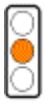
| 22 | Concentrated Solar Power |
|---|---|

Within the solar belt it has been found that solar concentrators can be an effective and relatively low cost way or capturing the sun's energy. A parabolic mirror, which tracks the sun, is used to focus energy onto either a photovoltaic array or a pipe containing water. The system uses less silicon or pipe work than flat collectors and can therefore deliver electricity or water for heating at a lower cost.

| Vendor | User | |
|---|---|---|
| www.heliodynamics.com | Grid operators and housing projects |  |

| 23 | Solar Cones |
|---|---|

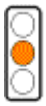
Cones made from aluminised Mylar, Nylon or other film are used to concentrate the sun's energy onto a heat collector. The cones do not have to be as robust as a parabolic dish, and as they are relatively lightweight they do not need to be mounted on expensive supporting frames. At present, the cones are fitted with Tefzel, which has a transparency of 96% but is also expensive. It is envisaged that in some cases a lower-cost material could be used.

| Vendor | User | |
|---|---|---|
| www.barnabusenergy.com | Solar energy system developers |  |

| 24 | Solar Furnaces |
|---|---|

A solar furnace is located in Odeillo in the Pyrénées Orientales (France). It consists of a large mirrored parabolic structure that can be used to concentrate the sun's energy onto a collector that powers a furnace. This furnace operates at 800–2,500 °C and provides 1 MW of thermal power.

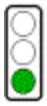
The disadvantage of this type of furnace is the cost of such a large dedicated structure and its remoteness from potential energy users. However, furnaces located within the solar belt would not be so large and could be built close to industrial energy users. It is conceivable that the parabolic structure could form part of an office block or a factory.

| Vendor | User | |
|---|---|---|
| www.imp.crns.fr | Energy researchers |  |

| 25 | Building Integrated Solar Power |
|---|---|

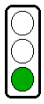
The high cost of solar energy systems can be offset by using them as part of the building they are providing with power. At the simplest level, transparent, thin film, solar collectors can be added to the windows of a residential or office development and used to provide electricity. Solar cells can also be used as decorative cladding.

Architects are increasingly designing roofs structures that are based around either photovoltaic or hot water solar technology.

| Vendor | User | |
|---|---|---|
| www.solarcentury.com | Building developers |  |

| 26 | Large-scale Wind Energy |
|---|---|

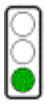
One of the easiest ways a member of the public can gain access to renewable energy is to purchase electricity from a large-scale wind energy operator. These operators have developed wind farms and retail 'green' or carbon free electricity to both domestic and commercial users. Wind energy operators supply electricity using the existing grid system, and prices are usually linked to the tariffs set by incumbent generators. There is therefore no financial benefit for a domestic user of wind generated electricity. However, commercial users may be able to offset carbon emissions generated by their operations against those saved by the wind energy operator.

| Vendor | User | |
|---|---|---|
| www.ecotricity.com | Domestic and commercial energy users |  |

| 27 | Medium-scale Wind Energy |
|---|---|

Increasingly common on industrial estates and close to some large houses are medium size wind turbines. Theses turbines are rated at 15 KW and, given an average wind speed of 5 metres per second, can provide up to 29 MW of power a year. This is enough to provide most of the electricity needs (excluding heating) of a small company or up to seven three-bedroom houses.

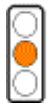
With no way of storing electricity over the long term, users usually retain their connection to the grid system and, in some cases, sell surplus energy to grid operators. While medium size turbines are more cost effective than micro turbines, payback periods are still long. As manufacturers increase production and achieve scale, it is expected prices will fall to the point where payback periods are realistic.

| Vendor | User | |
|---|---|---|
| www.provenenergy.co.uk | Small companies and communities |  |

| 28 | Urban Wind Turbines |
|---|---|

One of the barriers preventing the wide-scale use of wind energy in urban areas is the objections of residents to turbines, which are felt to have a negative visual impact and create noise pollution. Extensive research is being carried out into ways wind turbines can be incorporated into the urban landscape. One suggested solution is to move away from the conventional turbine in favour of an axial design. In some cases the turbines are custom designed to take advantage of wind currents caused by the building on which the turbine is located.

Currently these turbines are either still at prototype phase or, if they are in production, are relatively expensive.

| Vendor | User |  |
|---|---|---|
| www.quietrevolution.co.uk | Urban wind energy users | |

| 29 | Public Transport |
|---|---|

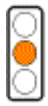
Like the nuclear industry, public transport has suffered as the focus for innovation has shifted to another sector. In the case of public transport, this 'other sector' is private motoring. The automobile has become such a key component in the economy and people's lives that, since the middle of the last century, most developed countries have modified their infrastructure to make it compatible with road transport.

Even though road transport is not the major contributor to carbon emissions, there are, in the developed world, a number of initiatives to slow the growth of private transport and put in place measures that would encourage innovation in public transport.

| Vendor | User |  |
|---|---|---|
| www.transport2000.org.uk | Transport planners | |

| 30 | Rail Transport |
|---|---|

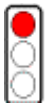
Freight and passengers have migrated from railways onto highways. Innovation within the rail industry has slowed and the infrastructure of most developed countries has been developed around road rather than rail transport. One example is the lack of spurs or railheads capable of delivering rail freight to out-of-town shopping centres or retail distribution depots. Also absent is the innovation within the rail industry required to build an efficient logistics system capable of transferring fresh produce between distribution depots and stores – or for distributing containers that arrive at ports. Capacity is also an issue as most rail systems are incapable of handling both slow moving freight trains and high-speed commuter services. Trains are, however, one of the key alternatives to short haul domestic flights, and the rail operator Eurostar has pointed out in its marketing that a flight from London to Paris creates ten times more carbon emissions than a train journey between the two cities.

| Vendor | User |  |
|---|---|---|
| www.saveourrailways.com<br>www.eurostar.com | Rail passengers and freight companies | |

| 31 | Air Travel |
|---|---|

The recent increase in air travel, driven by deregulation and low cost operators, is one of the major contributors to carbon emissions. Aircraft also release carbon at a high altitude where particulates have made an immediate contribution to global warming.

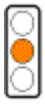
Suggested initiatives announced by airline carriers, such as towing aircraft out to runways and carrying fewer bottled beverages, are merely tinkering at the edge of a large problem. The world's two major aircraft manufacturers are locked in a fierce competitive battle and are expending most of their energy on bringing new planes to the market. Unless they initiate research into technology that will radically cut emissions from aircraft, it is likely that governments around the world will act to limit, through taxation, the number of passengers who use short haul domestic services.

| Vendors | User | |
|---|---|---|
| www.virgin.com<br>www.boeing.com | Business and leisure travellers |  |

| 32 | Hybrid Automobiles |
|---|---|

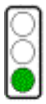
Hybrids are a halfway house between conventionally fuelled and hydrogen or fuel cell powered automobiles. Currently they are regarded as specialist vehicles used by motorists who wish to demonstrate their 'green' credentials. Predominant in the market is the Toyota Prius, although most other motor manufacturers have models in various stages of development. The German manufacturer BMW has a hybrid that is fuelled by liquid hydrogen and is seen as the first step towards an exclusively hydrogen powered car that is refuelled at the roadside.

Many hybrid vehicles also capture energy expended during braking in an attempt to increase overall efficiency.

| Vendors | User | |
|---|---|---|
| www.toyota.com<br>www.bmw.com | www.qtww.com |  |

| 33 | Electric Commercial Vehicles |
|---|---|

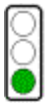
Within urban areas goods are usually delivered by petrol or diesel powered vehicles. An alternative is the electric powered goods vehicle, which typically has a top speed of 40 mph and a range of up to 50 miles. In some cities businesses are being encouraged to use electric vehicles via a range of incentives – for example, the waiving of congestion and parking charges.

| Vendor | User | |
|---|---|---|
| www.nicecarcompany.com | Small companies in urban areas |  |

| 34 | Electric Vehicles |
|---|---|

ZAP, which says it stands for Zero Air Pollution, is introducing the new XEBRA XERO as one of the first electric vehicles for sale that can truly be Zero Air Pollution by recharging from the sun. While electric cars are 90% less polluting than standard gasoline cars, the XERO allows the user who has a very short commute to own a vehicle that can refuel on a cheap and renewable resource – sunlight. It can recharge while parking in any open space exposed to direct sunlight.

Conventional electric cars are recharged from a grid supply and typically have a range of up to 50 miles, making them suitable for short commutes within urban areas.

| Vendor | User | |
|---|---|---|
| www.zapworld.com | Motorists in urban areas |  |

| 35 | Electric Scooters |
|---|---|

For a commuter who lives beyond walking or cycling distance of the workplace or rail station there is the option of an electric scooter. This has a top speed (60 mph) and range (50 miles) high enough to make it practical in both rural and urban areas.

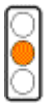
The scooter is charged from a grid supply and is currently sold for the same price a small automobile.

| Vendor | User | |
|---|---|---|
| www.vectrix.co.uk | Commuters in urban and rural areas |  |

| 36 | The Internet |
|---|---|

The Internet, which supports tele-working and video conferencing, should have reduced the need for people to travel. However, just as the paperless office has proved elusive because the PC gives us more things to print, so tele-presence fails because the Internet provides us with more friends and business associates we would like to meet in the flesh. Business-to-business networking and online shopping has opened up global markets and driven down the cost of goods. While consumers save money and no longer need to travel to physical stores, they have responded by buying more goods from ever more remote locations – increasing rather than decreasing carbon emissions.

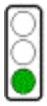
On the positive side the Internet has increased the pace of innovation in the renewable energy sector.

| Vendor | User | |
|---|---|---|
| www.cisco.com | Business users and online shoppers |  |

| 37 | Automobile Sharing |
|---|---|

Part of the attraction of the automobile is that it provides drivers with their own personal space to travel in. Some regard growing automobile use as contributing to increased social division, alienation and a range of other social ills. However, here the Internet may offer a solution through its encouragement of social networking. There are a number of online services that enable drivers, mostly those based in large cities, to share either journeys or automobile ownership.

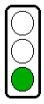
Seeing automobile clubs as an extension of online social networking, a number of private investors have funded schemes hoping their trajectory will be similar to that of eBay.

| Vendors | User | |
|---|---|---|
| www.liftshare.org<br>www.citycarclub.co.uk | Private motorists |  |

| 38 | Congestion Charging |
|---|---|

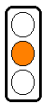
The automobile is a reliable, comfortable and convenient means of door-to-door conveyance. As well, private motoring is relatively cheap, as the cost of the infrastructure needed to support automobile use and to repair the damage it causes to the environment and public health is met from general taxation.

Congestion charging is seen as a means of imposing a realistic cost structure onto automobile use and is most successful when used in areas, mostly urban, where alternative low cost means of transport are readily available. Technology exists to support 'highway use' charging, which can be applied in both urban and rural areas. One of the likely impacts of such schemes will be to encourage automobile and journey sharing services.

| Vendor | User | |
|---|---|---|
| www.iess.co.uk | Transport for London |  |

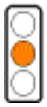
| 39 | Parking Charges And Restrictions |
|---|---|

Some local authorities and planners are attempting to control private automobile use by restricting the number of parking places that can be included in new developments. The impact of such restrictions is spread over a number of years as infrastructure is replaced. There is also a limit on what can be achieved at a local level, as planners will take into account the interests of local businesses from which councils receive revenue. However, some councils have been progressive enough to attempt to set parking charges that are above average for vehicles that produce higher $CO_2$ emissions and less for the least polluting cars

| Vendor | User | |
|---|---|---|
| www.richmond.gov.uk | Residents in urban areas |  |

| 40 | Cycling |
|---|---|

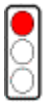
As car use increased, highways became less pedestrian and cyclist friendly, which in turn encouraged more people to use an automobile rather than cycle or walk to school or work. Making cities more cyclist and pedestrian friendly often involves building infrastructure to separate the cyclist or pedestrian from the automobile and truck driver. Some cities have effectively closed off parts of their highway infrastructure to motor vehicles, providing areas where people can cycle and walk safely. However, to have a significant impact on carbon emissions, routes between residential areas and schools and workplaces need to be designed so that they can be navigated easily using combinations of frequent public transport services, bicycles and on foot.

| Vendors | User | |
|---|---|---|
| www.ecf.com<br>www.bikeleague.org | Cyclists |  |

| 41 | The Hydrogen Economy |
|---|---|

The hydrogen economy is a broad overarching concept that is to the renewable energy lobby what cold fusion is to the nuclear industry. However, the hydrogen economy encompasses many disciplines within which innovation is moving at a pace and entrepreneurs and investors are particularly active.

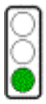
Hydrogen itself is not a fuel but merely an energy carrier. There are significant challenges that must be met before hydrogen can be transported and used as a replacement for fossil fuels. However, at some point, a number of separate initiatives will combine into substantial developments in areas such as transport and distributed power generation.

| Vendor | User | |
|---|---|---|
| www.hydrogenassociation.org | Pending |  |

| 42 | Hydrogen Production |
|---|---|

Currently most hydrogen is produced using no renewable energy, and as a consequence many hydrogen powered devices are responsible for at least as many carbon emissions per watt of power as fossil fuel powered devices. Hydrogen can be extracted from gas that has previously flared off from oil fields or refineries. It can also be extracted from oil. The advantages here are that any carbon emissions are produced in one place and are therefore easier to capture. The disadvantage is that this does not offer a solution to the problem of 'peak oil'.

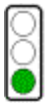
Hydrogen can also be extracted from water, using electrolysis. The energy for this could come from a nuclear reactor. However, the ideal solution would be to produce hydrogen using renewable energy.

| Vendor | User | |
|---|---|---|
| hy9.com | Oil and gas companies |  |

| 43 | Hydrogen From Wind |
|---|---|

Basin Electric Power Cooperative have installed an electrolyser-based hydrogen refuelling station. In addition to the core electrolyser module, Hydrogenics supplied compression, storage and dispenser equipment as part of the contract.

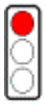
The station was one of the first United States based hydrogen fuelling stations to use electricity from a wind power resource to produce hydrogen from water, in this particular case using electricity generated by wind resources either owned or contracted by Basin Electric.

| Vendor | User | |
|---|---|---|
| www.hydrogenics.com | Hydrogen powered vehicle owners |  |

| 44 | Hydrogen From Solar Energy |
|---|---|

Researchers believe that highly ordered titanium nanotube arrays could extract hydrogen from water with a photoconversion efficiency of 13.1%. If this research could be turned into a product it might lead to a commercially practical means of generating hydrogen using solar energy.

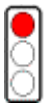
The research is supported in part by the US National Science Foundation and by a Seed Grant provided by the Penn State Hydrogen Centre.

| Vendor | User | |
|---|---|---|
| www.mri.psu.edu | Pending |  |

| 45 | Hydrogen From Corn |
|---|---|

Researchers are attempting use a microbial fuel cell to convert organic material into electricity. Previous work has shown that these fuel cells can generate electricity from glucose and from municipal waste water and that these cells can also directly generate hydrogen gas.

The microbial fuel cells contain two electrodes and anaerobic bacteria – bacteria that do not need oxygen – that consume the sugars and other organic material and release electrons. These electrons travel to the anode and flow in a wire to the cathode, producing electrical current. The water in the fuel cell donates positive hydrogen atoms that combine with the electrons and oxygen to form water.

| Vendor | User | |
|---|---|---|
| www.psu.edu/ur/2006/cornstover.html | Pending |  |

| 46 | Hydrogen Injection |
|---|---|

The Hy-Drive system generates and injects hydrogen gas into a regular internal combustion engine, enhancing the combustion process by allowing fuel to burn more efficiently and completely. In previous extensive customer trials and tests, the Hy-Drive system has demonstrated significant performance enhancements, including reduced emissions, increased torque/horsepower, fuel savings and extended engine life.

| Vendor | User | |
|---|---|---|
| www.hy-drive.com | Hydrogen power vehicle manufacturers |  |

| 47 | Hydrogen Delivery |
|---|---|

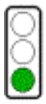
One approach to hydrogen delivery is to generate it near the point of delivery to the motorist. The Air Products system uses natural gas to generate the hydrogen, which is then fed into cars. The hydrogen not used for fuelling vehicles can be directed to a 50 kW PEM fuel cell that generates electric power. The electrical output from the fuel cell is then supplied to the electrical grid system for general consumer use. This electricity provides enough power on a daily basis for up to 30 homes.

| Vendor | User | |
|---|---|---|
| www.airproducts.com | Users of hydrogen power vehicles |  |

| 48 | Hydrogen Powered 4x4s |
|---|---|

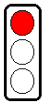
It is unlikely that the 4x4 or SUV will play a large role in the transport system of the future. But a company called Intergalactic Hydrogen have been trying to ease motorists into the hydrogen fuel market by converting some of the most fuel hungry vehicles to run on hydrogen.

As a promotion the company has been driving a Hummer, converted to run on hydrogen, around the US and is trying to convince the Governor of California to convert his.

| Vendor | User | |
|---|---|---|
| www.intergalactichydrogen.com | Private motorists |  |

| 49 | Hydrogen Storage |
|---|---|

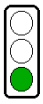
Storage is a key problem that must be overcome if hydrogen is to be used as an energy carrier. Hydrogen takes significantly more space than the energy equivalent of fossil fuel and it also leaks through metal pipes. Proposed methods of transporting hydrogen include converting it to a compound and then extracting the gas at the point of use. This process would itself use energy, reducing the efficiency of hydrogen as a carrier. It has also been suggested that lithium buckyballs might absorb hydrogen with 12 lithium atoms and can store 60 hydrogen molecules. Research is ongoing in this area as part of the US Hydrogen Fuel Initiative.

| Vendor | User | |
|---|---|---|
| www.vcu.edu | Pending |  |

| 50 | Hydrogen Fuel Cells |
|---|---|

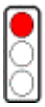
Hydrogen fuel cells are being used as a replacement for conventional combustion power plants, and generators.

Fuel cell powered cars are at the prototype phase of development, while fuel cell powered buses have been in operation on a trial basis in several cities, including Vancouver, Chicago and Palm Springs. In 2003, ten European cities including London started a two-year trial of 30 Mercedes EvoBus fuel cell powered buses. Three of these went into service in the UK in January 2005.

| Vendors | User | |
|---|---|---|
| www.ballard.com<br>www.plugpower.com | Bus and automobile manufacturers |  |

| 51 | The Distributed Power Model |
|---|---|

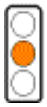
The structure of power distribution systems has changed little during the last 100 years. Electricity is generated in large power stations, then distributed via a nationwide grid. NextGen energy providers regard centralised power generation as inefficient and outdated and regard the power generator's control of the grid as a barrier to entry into the energy market. The NextGen providers would prefer an Internet of energy that would allow them to supply energy generated using small-scale installations – a wind farm for example – to local customers, then pool surplus energy with other NextGen providers. The battle between NextGen energy providers and the incumbent generators is reminiscent of the competition for the IT market during the 1990s which resulted in networks of PCs displacing mainframes and small Internet service providers gaining control of the last mile of telecoms networks.

| Vendor | User | |
|---|---|---|
| www.distributed-energy.com | Pending |  |

| 52 | Intelligent Grids |
|---|---|

An online energy management portal provides customers with an insight into their energy usage and also allows them to automatically and intelligently manage energy used in their home or business. For instance, users can choose when to run high energy consuming appliances or adjust thermostats to offset peak energy costs. The result is an understanding of how energy costs relate to usage as well as the ability to increase energy efficiency and reduce the consumer's carbon footprint.

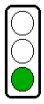
The Gridpoint system is supported by a range of 'plug-and-play' appliances and renewable energy systems.

| Vendor | Potential user | |
|---|---|---|
| www.gridpoint.com | Energy consumers and grid operators |  |

| 53 | Smart Metering |
|---|---|

In Ontario, all homes and businesses will be equipped with smart meters by the end of the decade.
By the end of 2007, Ontarians will begin to use smart meters in their homes – first in major urban centres, with rural areas to follow. The Ontario Energy Board has established a set of rates for smart meter users that allows them to shift their electricity use to take advantage of lower prices during off-peak hours – something those with conventional meters cannot do.

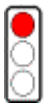
There are a number of market drivers which could potentially accelerate the uptake of smart metering. These include the need for intelligent technology to measure the amount of energy being generated using a domestic microgeneration system where the householder is selling surplus energy.

| Vendor | User | |
|---|---|---|
| www.ieso.ca | The Ontario Energy Board |  |

| 54 | Renewable Energy Grids |
|---|---|

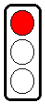
North Africa and southern Europe is the best location for solar energy installations, while the coastline of northern Europe has the high winds required to power wind turbines. Moving the energy created at the edge of Europe into the central industrial areas is a challenge that, according to researchers at the German Aerospace Centre, could be met with a high voltage DC trans-Mediterranean renewable energy network. The researchers claim that energy losses across the network would be approximately 3% per 1,000 km.

It is interesting to speculate as to the impact of removing oil and gas from the geopolitics of North Africa and Europe.

| Vendor | User | |
|---|---|---|
| www.dlr.de/tt/trans-csp | Energy researchers |  |

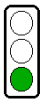
| 55 | Urban Power |
|---|---|

Currently most energy related initiatives within urban areas focus on conservation rather than on generation. However, a city the size of London's 1,579 km² receives a total of 1400 TWh of solar radiation per annum – three times the amount of energy that flows through the UK's electricity grid.
In addition, each of its 7.5 million residents uses approximately 20 MWh of gas or electrical energy per annum – which ends up as heat. If these sources of energy could be tapped they would provide a valuable source of power for households and businesses and would also help reduce the ambient temperature of the city, which during summer months can be up to ten degrees higher than in the surrounding countryside.

| Vendor | User | |
|---|---|---|
| www.carbonfree.co.uk/cf/city_power.htm | Pending |  |

| 56 | Sustainable Cities |
|---|---|

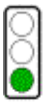
Builders and developers are increasingly marketing new developments on their 'sustainability'. In developing countries whole towns are being designed to be energy neutral. Arup, the Shanghai Industrial Investment Corporation and the University of East Anglia's carbon reduction team are collaborating on the supply of renewable energy to Dongtan, the world's first sustainable city.

| Vendor | User | |
|---|---|---|
| www.arap.com | Shanghai Industrial Investment Corporation |  |

| 57 | Road Energy |
|---|---|

Driving home through a rural area one winter's evening, a Dutch engineer noticed a large number of sheep sleeping on the road. The sheep were taking advantage of the fact that the tarmac surface of the road was releasing the solar energy it had collected throughout the day. The engineer set about designing a collector that could be built into the road and transferred the heat energy to an aquifer from where it could be recovered at a later date with a heat pump.

The road energy system has been installed in a number of major road systems in the Netherlands.

| Vendor | User | |
|---|---|---|
| www.ooms.nl | City planners and engineers |  |

| 58 | Street Lighting |
|---|---|

Streetlights remain on even when streets are empty and highways are almost devoid of traffic. Some feel that the light itself, as well as carbon emissions created by powering municipal lighting, is a form of pollution.

By integrating streetlight systems with control technology, the resulting 'intelligent' system can be remotely monitored and controlled, which can significantly reduce maintenance costs and down time for failed lamps while creating a positive impact on citizens' security. Simply dimming the streetlights to a lower light level in the middle of the night, when there is less traffic, substantially reduces the amount of energy used, and lowers energy costs.

| Vendor | User |  |
|---|---|---|
| www.streetlight-vision.com | Municipal planners and highway engineers | |

| 59 | Building Design |
|---|---|

Four demonstration homes in Borrego Springs, California, which are available for sale, have been designed with a goal of 90% energy reduction and built with the latest zero energy technologies, including state-of-the-art wall, cooling and solar electric systems. The homes will be tested for energy efficiency continuously over the next 12 months and the information will be shared with other builders, manufacturers and municipalities throughout the US.

| Vendor | User |  |
|---|---|---|
| www.clarumzeroenergy.com | The Building Industry Research Alliance | |

| 60 | Community Wind Energy |
|---|---|

Wind farm operators encounter significant resistance from local communities when siting turbines. However, where communities benefit directly from an installation, there are fewer objections, and in some cases it is residents who initiate the project. This issue lies at the heart of the distributed power model and its role in reducing carbon emissions.

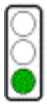
With significant wind projects installed in 30 states, interest in community wind is growing among farmers and communities across the country. Locally owned and community based wind projects can generate both revenue and electricity while keeping energy dollars local and not polluting the air and water.

| Vendor | Users |  |
|---|---|---|
| www.windindustry.org | Local communities | |

| 61 | Community Energy Projects |
|---|---|

Community energy projects raise awareness of energy related issues at a local level. They provide a counterweight to the prevailing approach to energy use within the consumer society. Groups address issues such as conservation and small-scale energy generation and manage recycling schemes.

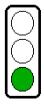
Small local based projects are instrumental in raising awareness of energy related issues and motivating residents, and the companies that market products and services to them, to adopt strategies that limit carbon emissions.

| Vendor | User | |
|---|---|---|
| www.ohiovalleycreativenergy.org | Small energy using communities |  |

| 62 | Gas From Landfill |
|---|---|

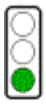
Methane vented into the atmosphere from decomposing waste that has been buried in landfill sites contributes to global warming. The gas can be burned and the energy used for heating local businesses or households, replacing energy that would have been generated by burning fossil fuels.

Methane can also be used as a fuel for combined heat and power installations.

| Vendor | User | |
|---|---|---|
| www.cogeneration.net | Municipal waste processors |  |

| 63 | Personal Carbon Footprint |
|---|---|

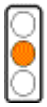
Making them aware of the amount of the amount of carbon emissions that result from their activities is the first step towards getting the consumer to modify their lifestyle. In some cases, a small change can have a significant impact on a person's carbon footprint. The Carbon Footprint service includes a calculator that enables the user to estimate the amount of carbon emissions they are personally responsible for.

| Vendor | User | |
|---|---|---|
| www.carbonfootprint.com | Consumers |  |

| 64 | Personal Carbon Offset |
|---|---|

The UK government suggested a scheme that would involve the use of bank cards that stored both pounds and carbon points. When the consumer bought electricity, gas and fuel, they would use their carbon points, as well as pounds. To help reduce carbon emissions, the government would set limits on the amount of carbon that could be used. People would be able to trade emissions: if they decided not to buy an SUV but purchased a smaller car instead, they could trade their carbon points with someone opting to buy a larger car.

While personal carbon trading is merely a speculative idea, consumers already have the opportunity via the Carbon Footprint service to offset their carbon emissions.

| Vendors | User | |
|---|---|---|
| www.targetneutral.com<br>www.carbonfootprint.com | Consumers |  |

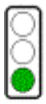
| 65 | Microgeneration |
|---|---|

Microgeneration is a broad concept encompassing a range of renewable and non-renewable energy technologies. It offers the householder or small company the opportunity to become their own energy providers and in some cases supply energy to third parties. Currently access to power grids is limited and most microgenerators, who generate surplus power, can only resell energy that is excess to the requirements of the grid operator. For this reason, the long-term viability of the microgeneration market is dependent on the adoption of the distributed power model.

| Vendor | User | |
|---|---|---|
| www.microgeneration.com | Householders and small businesses |  |

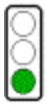
| 66 | Small-scale Geothermal Energy |
|---|---|

Geothermal energy systems are proving to be increasingly popular with householders. They are also popular with electricity suppliers who regard ground and air based geothermal systems as a way of winning business from heating oil suppliers. Although energy is extracted from the ground or air, electricity is needed to do so. Typically the heat energy output is four times the electrical energy input, and some systems have achieved an electrical energy to heat energy ratio as high as seven. Being a relatively low technology solution, it is likely the cost of equipment will fall as more vendors are drawn into the market, and the investment the sector has recently received translates into innovative new heat pumps and collectors.

| Vendor | User | |
|---|---|---|
| www.earthenergy.co.uk | Householders |  |

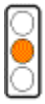
| 67 | Small-scale Wind Energy |
|---|---|

Depending on its location and size, a typical home would require a 2.5–6 kW peak output system to meet its total power requirements. Systems providing up to 1 kW cost approximately $5,000 while those providing 1.5–6 kW cost between $7,000 and $30,000. It is unlikely a small turbine would generate enough surplus energy to justify the additional equipment required to resell electricity to the grid operator. A medium size turbine would generate surplus power that would reduce equipment payback periods if the householder could sell this energy at retail prices to neighbours. Despite concerns about the performance of small turbines, their high profile in media coverage of renewable energy and carbon emissions has encouraged a number or retailers to enter the wind energy market.

| Vendor | User | |
|---|---|---|
| www.windsave.com | Householders |  |

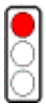
| 68 | Small-scale Solar Energy |
|---|---|

Photovoltaic based solar energy systems provide the householder with an opportunity to resell electricity to the grid operator. The current generation of solar panels is expensive and has a long payback period. Advances in photovoltaic technology are bringing down the cost per watt of energy produced. As well, some building material manufacturers are experimenting with roof tiles that incorporate solar cells that, if successful, will mean it will be possible to build a 'micro-generation' ready house.

| Vendors | User | |
|---|---|---|
| www.marleyeternit.co.uk<br>www.konarka.com | Householders |  |

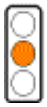
| 69 | Hydrogen Powered Homes |
|---|---|

The Home Energy Station uses natural gas as its base energy source. It is designed to work in a home-based refuelling environment and is able to supply a sufficient amount of hydrogen to power a fuel cell vehicle, such as the Honda FCX, for daily operation while providing electricity for an average-sized household.

| Vendors | User | |
|---|---|---|
| www.honda.com<br>www.plugpower.com | Pending |  |

| 70 | Small-scale Hydro Power |
|---|---|

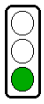
Water wheels and other simple devices can be used to extract power from streams and small rivers. These can be used to generate power in remote locations in the developing world or as part of microgeneration projects in the developed world. They are particularly suited to mountainous areas.

| Vendor | User | |
|---|---|---|
| www.beck-mickle-hydro.co.uk | Trial phase |  |

| 71 | Lighting Equipment |
|---|---|

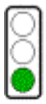
Lighting requires as much electricity as is produced by all gas fired generation and 15% more than produced by either hydro or nuclear power. The annual cost of this service including energy, lighting equipment and labour is US$360 billion, which is roughly 1% of global GDP. Electricity accounts for some two-thirds of this, but the electricity used by lighting is also a major source of $CO_2$ emissions, equivalent to 70% of those from the world's cars.

The International Energy Agency claims that if consumers switched to more efficient lighting systems, electricity demand in 2030 would be unchanged from 2005 levels.

| Vendors | User | |
|---|---|---|
| www.iea.org<br>www.philips.com | Householders and industry |  |

| 72 | Packaging |
|---|---|

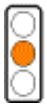
Green Mountain Coffee Roasters and International Paper developed an all-natural paper hot beverage cup available in consumer outlets US-wide. In a conventional cup, the inner surface is lined with a petroleum-based plastic to prevent leaking. The new cup is lined with a bio-plastic made from a renewable resource – corn. After use, and under the proper conditions, it will break down into water, carbon dioxide and organic matter. The carbon dioxide released, rather than being extracted from the ground, is merely that which was extracted from the atmosphere by the corn and it can be buried as part of a composting process. Consumers are becoming increasingly unwilling to buy goods with excessive petrochemical based packaging, especially in areas where there is a limit to the volume of plastic they can dispose of in any given week.

| Vendor | User | |
|---|---|---|
| www.internationalpaper.com | Food and consumer goods industry |  |

| 73 | Transported Goods |
|---|---|

Food miles are a way of attempting to measure how far food has travelled before it reaches the consumer. This is a good way of looking at the environmental impact of foods and their ingredients. It includes getting foods to you, but also getting waste foods away from you, and to landfill sites.

The number of food miles a product accumulates will influence the amount of carbon emissions it – and the consumer who buys it – is responsible for.

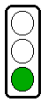
| Vendors | User | |
|---|---|---|
| www.organiclinker.com/food-miles.cfm<br>www.lifecycleproject.ca | Consumers and retailers |  |

| 74 | Recycling |
|---|---|

Using recycled materials helps reduce air pollution typically caused by manufacturing plants that rely solely on unprocessed, virgin raw materials.

Carbon emissions are 40 times lower when recycled beverage containers are used to make new aluminium as compared to the use of virgin ore. Some aluminium beverage cans contain up to 55% recycled content.

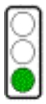
Carbon emissions from making steel, copper, glass and paper from recycled materials are four to five times lower than making these products from virgin materials. In 1996, recycling these materials reduced carbon emissions by 33 million tons.

| Vendor | User | |
|---|---|---|
| www.green-living.com | Consumers, retailers and manufacturers |  |

| 75 | Waste Water Heat Recovery |
|---|---|

Currently, warm waste water from dishwashers, washing machines and showers is disposed of directly into the drain with no attempts being made to recover this wasted energy. The Warmit project developed a compact, low cost stainless steel and plastic heat exchanger to recover this wasted energy in a wide variety of domestic and industrial applications and markets. The Warmit device has achieved a reduction of up to 50% in the energy consumed while taking a shower. It is also able to improve the performance of electrically heated showers by 50%.

A European consortium developed the Warmit Heat recovery device, which will be marketed by a manufacturer of bathroom equipment.

| Vendor | User | |
|---|---|---|
| www.aki.co.uk | Householders |  |

| 76 | Household Energy Saving |
|---|---|

An energy survey or audit of a householder's energy usage and costs can identify specific energy efficiency measures appropriate to reduce energy bills.

The Department of Energy and the Lawrence Berkeley National Lab have developed a Home Energy Saver audit tool that can provide a detailed estimate of household energy use, as well as savings estimates for various energy efficiency options. The service also includes listings of energy-efficient appliances, and other resources.

| Vendor | User | |
|---|---|---|
| www.energyhog.org | Householders |  |

| 77 | Standby Technology |
|---|---|

Throughout the world, in any given year, electrical equipment in sleep mode uses up to 7 TWh of energy which itself is responsible for approximately 800,000 tonnes of carbon during the generation process.

It is thought that 40% of all electricity used to power electronics in the home is consumed while the products are turned off or in 'standby mode'. Across the US this is the equivalent to the annual output of 17 power plants.

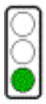
Companies are responding to calls to reduce the energy used by devices and to introduce standards that set a maximum power rating for a device that is in standby mode.

| Vendor | User | |
|---|---|---|
| www.panasonic.com/environmental/energystar.asp | Consumers and IT industry |  |

| 78 | Lawnmowers And E10 |
|---|---|

Studies show that a typical lawnmower emits as much pollution in one hour's work as a car emits during a 100-mile journey. The small engines found in most lawn-care machines make a negative impact on the air we breathe. Filling those tanks with ethanol-enriched fuel can cut the amount of pollutants released into the air. All small engines can efficiently burn E10, a mixture of 10% ethanol and 90% gasoline found at filling stations across the country.

The use of 10% ethanol-enriched fuel reduces greenhouse gas emissions by 12–19% compared with conventional gasoline, according to Argonne National Laboratory.

| Vendor | User | |
|---|---|---|
| www.drivingethanol.org | Householders |  |

| 79 | Solar Energy Makeover |
|---|---|

Sharp Electronics recently contributed a solar energy system to the ABC show 'Extreme Makeover: Home Edition' for a project in Douglas, Kansas. The episode details the reconstruction of a house destroyed by a propane gas leak explosion. The Nutsch family lacked the insurance or income to rebuild their home, so the 'Extreme Makeover: Home Edition' crew constructed a house for them that is powered only by electricity.

The programme is just one of many being produced by television companies around the world that raise awareness of problems caused by carbon emissions and highlight ways householders can make their homes more energy efficient.

| Vendor | User | |
|---|---|---|
| www.ramseyenv.com | Householders |  |

| 80 | Insulation |
|---|---|

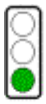
Most industrial countries embarked on large house-building programmes during the last century. As energy prices were relatively cheap before and after the 1970s oil crisis, developers paid little heed to the amount of heat that leaked out of houses. Most householders find that the first step in a microgeneration or small-scale renewable energy project is to reduce the amount of energy required to heat their home. As consequence, the thermal insulation market is expanding, innovating and attracting investment.

| Vendor | User | |
|---|---|---|
| www.secondnatureuk.com | Householders |  |

| 81 | Micro CHP |
|---|---|

CHP (combined heat and power) is a very efficient technology for generating electricity and heat simultaneously, by using conventional generation technologies, fuel cells or Stirling engines within a CHP 'plant'. The heat generated in the process is utilised via heat recovery equipment for a variety of purposes including industrial processes, community heating and space heating. Domestic or micro CHP systems can be installed in place of standard domestic boilers.

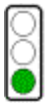
Domestic systems have the potential to be as much as 90% energy efficient, reducing the energy bill for the home and reducing carbon dioxide emissions per household.

| Vendor | User | |
|---|---|---|
| www.microchp.co.uk | Householders and microgeneration projects |  |

| 82 | Pumped Hydro Energy |
|---|---|

There are over 90 pumped hydro system installations throughout the world: in Australia, Bulgaria, Canada, China, the Czech Republic, France, Germany, Ireland, Japan and Norway. They include the 850 MW Rocky Mountain scheme in Georgia, USA; the Dinorwid and Ffestiniog plants in Wales, UK; the Tianhuanping plant in China; and the Raccoon Mountain plant in Tennessee, USA.

In 2003, hydroelectric storage facilities around the world provided about 90 GW of electricity – approximately 3% of global electricity capacity. In the early 1990s, pumped hydro accounted for nearly 3% of the summer electricity capacity in the USA. However, pressure from deregulation caused investment to decline. In Europe and Japan, the proportions of pumped hydro capacity in grids are about 5% and 10% respectively.

| Vendor | User | |
|---|---|---|
| Government energy agencies | Grid operators |  |

| 83 | Wave Power |
|---|---|

A novel offshore wave energy converter called Pelamis, which uses technology developed for the offshore industry, has a similar output to a modern wind turbine. The first fullscale pre-production prototype has been built and is being tested at the European Marine Energy Centre in Orkney, UK.

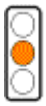
It is anticipated that future 'wave farm' projects would consist of an arrangement of interlinked multi-machines connected to shore by a single subsea cable. A typical 30 MW installation would occupy a square kilometre of ocean and provide sufficient electricity for 20,000 homes.

| Vendor | User | |
|---|---|---|
| www.oceanpd.com | Enersis, Portugal |  |

| 84 | Tidal Energy |
|---|---|

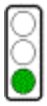
A strategically placed barrier will capture tidal energy as seawater flows into and out of an estuary. The locations where such barriers can be built are limited due to silting of rivers, the use of estuaries for shipping and potential disruption to the local ecosystem.

Power is generated primarily at ebb tides as the barrage creates a significant head of water, much like a hydroelectric dam. This technology is very well established at La Rance, France where a 240 MW plant has operated since 1966.

| Vendor | User | |
|---|---|---|
| www.oceanenergycouncil.com | Power generators and grid operators |  |

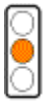
| 85 | Underwater Turbines |
|---|---|

Where a barrier is not practical, freestanding turbines can be located in tidal waterways. Verdant Power intends to deploy tidal turbines in New York's East River. The eventual field of underwater turbines will have a capacity of up to 10 MW. The company's business partner is the New York State Energy Research & Development Authority, which has invested more than $2 million to date in the project. New York University has identified nearly 600 MW of potential kinetic hydropower in the State of New York.

| Vendors | User | |
|---|---|---|
| www.bluenergy.com<br>www.verdantpower.com | Cities located near tidal waterways |  |

| 86 | Farming Renewable Energy |
|---|---|

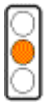
Farmers are already moving into the energy market, producing biofuels and leasing land to wind energy operators. Creating a sustainable energy market requires energy to be harvested, rather than extracted from the earth. Large scale solar and biomass based energy production necessitate the management of large areas of land. As the farmed energy model evolves, farmers may occupy a strategic position within the energy market.

| Vendors | User | |
|---|---|---|
| www.usda.gov<br>www.advancingrenewableenergy.com | www.shelburnefarms.org |  |

| 87 | Farming Wind |
|---|---|

An increasing number of small rural communities in Canada and the US Midwest, which until recently have been struggling to survive in the face of competition from low cost imported agricultural products, are discovering that wind energy provides benefits in the form of investment, job creation, land lease fees and new local tax revenues.

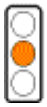
However, at present, rural wind farms are located at some distance from industrial energy users. In time, and if a distributed power model is adopted, industry may begin to relocate to rural areas to take advantage of wind generated energy.

| Vendor | User | |
|---|---|---|
| www.canwea.ca | Farming communities |  |

| 88 | Grass Energy |
|---|---|

The Grass Energy Collaborative is an organisation committed to developing grass energy as a renewable biofuel.

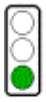
The Grass Energy Collaborative intends to harvest approximately 300 acres of grass on Shelburne Farms and land nearby, press it into 1/2-inch diameter pellets, and store these pellets in silos owned by Meach Cove Trust in Shelburne, Vermont, USA. The grass pellet fuel will be burned in a few commercial heating systems, one of which will be the ChipTec gasifier located in the Farm Barn.

| Vendor | User | |
|---|---|---|
| www.shelburnefarms.org | Farmers |  |

| 89 | Biomethanne |
|---|---|

Pacific Gas and Electric (PG&E) intend to purchase 8,000 mcf of renewable natural gas from production facilities located on large dairy farms in California and feed it into their extensive gas pipeline network. In addition to producing renewable energy, each of these facilities can produce significant greenhouse gas benefits.

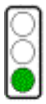
As additional gas-generating facilities are built on farms across the central valley, California consumers will benefit from a new source of renewable, environmentally friendly energy.

| Vendor | User | |
|---|---|---|
| www.environmentalpower.com | PG&E |  |

| 90 | Bio Diesel |
|---|---|

D1 plan to produce 8,000 tonnes of biodiesel per year from a range of vegetable oil feedstocks using a continuous process. The UK based company's technology and processes are proprietary, and so far the company has successfully completed refining tests for a range of vegetable oils, including rapeseed, soy, palm and jatropha. Issues regarding land use may limit the market for biodiesel at some point.

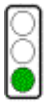
D1's refinery is used as a stand-alone processing plant. It is designed so that modules can be used in conjunction to scale up refining capacity as required. The largest such refinery is the 32,000 tonne refinery operated by D1 in Teesside, UK.

| Vendor | User | |
|---|---|---|
| www.d1plc.com | Automobile and truck drivers |  |

| 91 | Biobutanol |
|---|---|

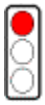
Biobutanol can be blended with conventional grades of petrol and can already be used at up to a 10% blend without any modification required to existing vehicle technology. There is potential to increase this concentration in the future. It has an energy content closer to that of petrol than ethanol and so offers better fuel economy than petrol/ethanol blends.

British Sugar Group, part of Associated British Foods, are collaborating with BP and DuPont to begin production of the next generation of biofuels in the UK. The European sugar market has been disrupted by limits placed on production. Farmers producing sugar beet and sugar refiners are seeking new outlets for their products.

| Vendor | User | |
|---|---|---|
| www.britishsugar.co.uk | Farmers and fuel refiners |  |

| 92 | Ethanol From Wood |
|---|---|

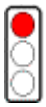
Researchers at Purdue University, Indiana, USA are using genetic tools in an effort to design trees that can readily and inexpensively yield the substances needed to produce alternative transportation fuel. The scientists are focused on a compound in cell walls called lignin that contributes to plants' structural strength, but which hinders extraction of cellulose. Cellulose is the sugar-containing component needed to make the alternative fuel ethanol.

| Vendor | Potential user | |
|---|---|---|
| uns.purdue.edu | Forestry estates and fuel refiners |  |

| 93 | Enzymes And Ethanol |
|---|---|

A fungus is being reprogrammed to produce large volumes of low cost enzymes to convert cellulose, xylan and other hemicelluloses into fermentable sugars that can then be used to produce ethanol.

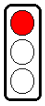
It is hoped to use the fungal expression system to develop better and lower cost enzymes that can be used to convert even greater amounts of cellulosic substrates into fermentable sugars. These sugars can be used to manufacture ethanol and a range of other petroleum substitutes.

| Vendor | Potential user | |
|---|---|---|
| www.dyadic-group.com | Biofuel refiners |  |

| 94 | Fuel From Candy |
|---|---|

In a feasibility study funded by the UK Engineering and Physical Sciences Research Council, bioscientists at the University of Birmingham demonstrated that bacteria give off hydrogen gas as they consume high-sugar waste produced by the confectionery industry.

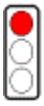
The hydrogen has been used to generate clean electricity via a fuel cell. Looking to the future, it could also be used to power the hydrogen fuelled road vehicles of tomorrow. There is increasing recognition that, over the coming decades, hydrogen could provide a mainstream source of energy that is a safe, environmentally friendly alternative to fossil fuels.

| Vendor | Potential user | |
|---|---|---|
| www.epsrc.ac.uk | Sugar industry and fuel cell manufacturers |  |

| 95 | Ethanol From Waste |
|---|---|

Syntec are developing technology that produces ethanol using a gasification-catalytic synthesis – a thermo-chemical process that converts gas into ethanol. Syntec's catalysts are designed to produce ethanol from waste gas, such as biogas from landfills, sewage, manure and wood waste.

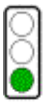
A prototype plant currently under construction will use landfill gas and, if successful, will create fewer carbon emissions than a plant producing ethanol using a fermentation based process.

| Vendor | User | |
|---|---|---|
| www.syntecbiofuel.com | Pending |  |

| 96 | Energy Storage – Redox Batteries |
|---|---|

A flow battery is a special type of fuel cell. The difference is that, in a fuel cell, the electrolyte remains at all times within the reactor and the fuel is flowed into the reactor, whereas, in a flow battery, the electrolyte is sourced externally from the reactor and the fuel is dissolved in the electrolyte. In addition, unlike fuel cells, flow batteries are not based on rare or valuable materials. Fuel cells typically use platinum or other expensive catalysts to speed the oxidation of their energy carrier. The material at the heart of the most commercially available flow battery is vanadium, a plentiful, non-toxic metal.

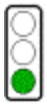
The first vanadium based energy storage system in the US is a 250 kW eight-hour (2 MWh) system that began operating in March 2004 in Castle Valley, Utah. It was developed in partnership between the power company Pacific Corp. and the vanadium based battery developer VRB Power Systems.

| Vendor | User | |
|---|---|---|
| www.vrbpower.com | Pacific Corp |  |

| 97 | Energy Storage – Capacitors |
|---|---|

A supercapacitor, or ultracapacitor, is an electrochemical capacitor with characteristics of both batteries and capacitors. Capacitors consist of two conductive parallel plates separated by a dielectric insulator. The plates hold opposite charges that generate an electric field. Unlike batteries, which store energy in chemical form, capacitors store energy in the field. Supercapacitors are usually made with carbon nanotubes and polymers.

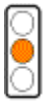
ISE Corporation builds petrol and diesel hybrid-electric drive systems for buses and trucks that use supercapacitors designed by Maxwell Technologies. Honda has developed its own supercapacitor which it uses in its hydrogen powered fuel cell car, the Honda FCX.

| Vendor | User | |
|---|---|---|
| www.maxwell.com | ISE Corporation and Honda |  |

| 98 | Energy Storage – Flywheels |
|---|---|

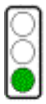
Beacon Power Corporation have a contract from the US Department of Energy to design a 20 MW Smart Energy Matrix frequency regulation power plant. This project directly supports Beacon's plan to develop commercial-scale flywheel based frequency regulation facilities.

At present, flywheel energy storage technology is confined to applications in conventional electrical generation installations. However, flywheels could also be incorporated into wind energy projects to overcome problems associated with short-term intermittence.

| Vendor | User | |
|---|---|---|
| www.beaconpower.com | US Department of Energy |  |

| 99 | Mobile Power Stations |
|---|---|

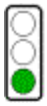
Often, when energy is needed beyond the reach of a grid or during a power failure, little thought is given to the emissions from petrol or diesel powered generators. Even when the generator is used as a permanent source of electrical power, its environmental impact has been deemed less important than the benefits of a 24-hour power supply. Increasingly, however, emissions are being taken into account when energy sources are used in remote locations. Mobile power stations can be constructed using a range of renewable energy technologies, and in some cases are hybrids that use solar panels, wind turbines and fuel cells.

| Vendor | User | |
|---|---|---|
| www.skybuilt.com | Remote communities |  |

| 100 | Stand-alone Solar Power Devices |
|---|---|

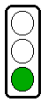
A large number of devices used by consumers are relatively low powered and are supplied with a step down transformer to convert mains power to a 5 or 12 V supply. A simple photovoltaic solar panel will often capture enough energy to power the device or charge batteries so the device can be used at night.

Stand-alone solar devices are particularly relevant in remote communities. Typical examples are compact water purification and solar powered cooking equipment.

| Vendor | User | |
|---|---|---|
| solarcooking.org | Consumers and remote communities |  |

| 101 | Wood Pellets |
|---|---|

Wood pellet fuelled boilers are used as a basis for carbon neutral heating for small and medium sized buildings and as back-up for domestic solar or wind powered heating systems. Unlike log fuelled boilers, the rate at which the fuel is consumed can be controlled. The pellets are manufactured from a mixture of wood industry waste and farmed timber. The industry is relatively immature and there are still some issues regarding emissions from some inferior grade pellets.

| Vendors | User | |
|---|---|---|
| www.fulghumfibres.com<br>www.framfuels.com | Consumers in North America and Europe |  |

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