BELLONA

A FREE MAGAZINE PUBLISHED BY THE BELLONA FOUNDATION

101 SOLUTIONS TO CLIMATE CHANGE

- FROM DESERT TO OASIS
- LIMITLESS CLEAN POWER
- CCS: WHAT A CATCH!

POWERED BY Statkraft

All Avinor-owned airports in Norway are engaged in a systematic, long-term effort to reduce their greenhouse gas emissions. Avinor is among the first airport operators worldwide to compensate for emissions from its operations. "We accept responsibility for our own emissions and are taking appropriate steps" says Sverre Quale, Avinor Group CEO.

Oslo Airport Gardermoen (OSL) is Norway's largest and newest airport. From its very inception, there has been a will to invest in environmentally sound solutions at OSL. These include a district-heating network powered by woodchips and an extensive system of heat exchangers that allow heat energy to be extracted from the ground water in winter. In summer, the ground water is used for cooling. Finding good environmental solutions remains an important goal in the continued development of Avinor's airports. New buildings are designed with an eye to reducing energy requirements while letting in plenty of light. A seawater heat-exchange system has been established for the new terminal building at Alta Airport and a similar one will be installed at Kristiansand Airport Kjevik. A new heating plant fuelled by local wood chippings is planned for Stavanger Airport Sola.

Carbon inventory

Every year, Avinor draws up a carbon inventory for its operations. The inventory, published in the Avinor Group's environmental report, is based on methods that have been verified by Det Norske Veritas and are in accordance with the internationally acknowledged standards The Greenhouse Gas Protocol and ISO 14064.

Reducing emissions

Avinor is taking a number of concrete steps to reduce its own greenhouse gas emissions. These include a greater use of electric vehicles and biofuel, and a continuous renewal of its vehicle fleet. In order to reduce fuel consumption by its vehicles, Avinor has focused on ecodriving campaigns promoting fuel economy-maximizing behaviours. More than sixty percent of all airline passengers use public transport when catching a flight from OSL, a higher figure than for any other airport in Europe.

Compensating for emissions

Since 2008, Avinor has compensated for its unavoidable emissions by investing in UN-approved projects aimed at achieving corresponding reductions in global emissions. In addition to reducing emissions, the projects are designed to promote social and economic development. As a result, Avinor is one of the first airport operators worldwide to compensate for its own greenhouse gas emissions. OSL adopted this practice in 2006.

Reducing emissions from aircraft

For the Norwegian aviation sector as a whole, 96 % of greenhouse gas emissions are released from aircraft. Renewal of aircraft fleets is therefore critical for achieving sustainable aviation.

Measures that help reduce emissions from aircraft already in use include engine washing, fuselage improvements, winglets, lightweight seats, increased seating capacity and fuel-economizing technology. However, the greatest climate gains are achieved by replacing old aircraft with newer models.

When travelling from A to B by air, there are a number of factors that can affect fuel consumption. At departure, while still on the ground, an aircraft may have to wait its turn for access to the runway, or perhaps for de-icing. At climb-out, the climb angle may not be optimal for fuel efficiency. When cruising, the available route may not be the shortest possible one, and when approaching the destination, simultaneous arrivals may require an aircraft to spend time flying in a holding pattern while waiting for its turn to land.

Avinor and the airlines collaborate in a number of projects aimed at optimizing in-flight fuel consumption that will result in significant reductions in greenhouse gas emissions from aviation. Regulatory changes and technological developments will both be important for emission reductions in the years ahead.

Social and economic benefits

Due to the great distances within the country and to most destinations in Europe, aviation is of critical importance to Norway.

Two main considerations have motivated the current airport coverage in Norway: the management of the country's resources and the political goals of preventing rural depopulation and maintaining significant settlements in peripheral regions of the country. It is estimated that in Norway, more than 60 000 jobs are directly or indirectly generated by the aviation sector. The aviation sector is estimated to account for 4 % of the country's GDP.

Each year, 400 000 patients are carried by scheduled flights in Norway. Air travel is of particular importance for the health sector in Northern Norway. Aviation also allows nationwide participation in cultural events and sports events.

Aviation is crucial for Norwegian businesses and for maintaining a decentralized population. In most cases, there are few alternatives to air travel; it is estimated that only 6-8% of passenger transport by air can be substituted by other means of transport.

FACTS ABOUT THE CLIMATE IMPACT OF AVIATION

- Globally, aviation is responsible for just over 2% of greenhouse gas emissions.
- Domestic civil aviation is responsible for less than 2% of Norway's greenhouse gas emissions (about 0.9 of 55 million tonnes in 2007). It is only this part of air traffic that is regulated by the Kyoto Protocol.
- Greenhouse gas emissions from all jet fuel (bunker fuel) sold in Norway in 2007 amount to about 2 million tonnes. This includes fuel for domestic flights and for flights to the first foreign destination. Similar reporting from all countries provides the basis for calculating global emissions.
- The Norwegian Institute of Transport Economics has estimated that air travel by Norwegians in 2007 was responsible for a total of 3.4 million tonnes of greenhouse gas emissions.
- The Kyoto Protocol does not address the effects of emission of all types of greenhouse gases. To take into account the high-altitude effects of aircraft emissions, a 'multiplier' in the range of 1.2 and 1.8 has been suggested by CICERO, the Center for International Climate and Environmental Research – Oslo.
- Read more in the report Aviation in Norway. Sustainability and Social Benefit at www.avinor.no

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Dette magasinet er trykket etter strenge miljøkrav og produsert CO_2-nøytralt.

1
LIMITLESS CLEAN POWER

Sun, wind and water: Renewable energy sources are inexhaustible and non-polluting. These sustainable energy sources are the pillars of a zero-emission society.

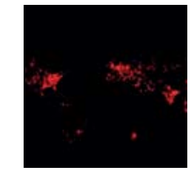
2
FROM DESERT TO OASIS

Bellona and three partners have pooled their resources on "The Sahara Forest Project", a concept that enables seawater to be transformed into fresh water and desert landscape to be covered by new vegetation.

3
ON THE ROAD TO CLEAN TRANSPORT

The transport sector is responsible for 13 percent of global greenhouse gas emissions. Fortunately, solutions exist which cut both CO2 and other pollutants.

4
CCS: WHAT A CATCH!



Cutting-edge technology will soon make it possible to capture CO2 from power stations and factories and store it deep below the earth's surface. Read how.

5
THE INDUSTRIAL REVOLUTION - PART 2

Without industry the world grinds to a halt, yet 40 percent of the world's CO2 emissions and 30 percent of its energy consumption is connected to industrial activities. The Industrial Revolution - Part 2 is knocking at the door.

6
BUILD FOR THE FUTURE

Buildings are responsible for 40 percent of the world's energy consumption. Proven green strategies in the property sector can easily achieve large reductions.

7
GOLD IN GREEN FORESTS

More than two million square kilometers of the world's tropical forests have disappeared since 1990. See how improved forest and agriculture management can contribute to stop the climate crisis.

8
WE ARE THE WORLD

The next four years will determine whether the world successfully tackles the climate crisis. Global warming cannot be stopped without strong political leadership.

101 solutions

BELLONA

Bellona is one of Europe's leading environmental organisations. We were established on June 16, 1986 and are an independent, non-profit foundation whose purpose is to work for greater ecological understanding and protection of nature, environment and health.

Bellona's most important objective is to protect the environment by proposing policy measures and by promoting new environmentally sound technologies. We focus on working in a farsighted and solution-oriented manner and we are constantly in dialogue with other organisations, companies, media, researchers and politicians from all parties. Bellona has always believed that it is necessary to work with many stakeholders, especially within the business community, in order to find good environmental solutions and ensure their implementation. In many cases it is industry and business that are most capable of putting the best climate measures into practice.

Bellona is engaged in the most important national and international environmental issues in the world today. Our organisation has offices in Oslo, Brussels, Washington D.C., Murmansk and St. Petersburg.

There are those who have given up and who think that a climate catastrophe is unavoidable. And then there are those who would gladly do something, but are overwhelmed because the challenges seem so enormous. Bellona believes that we already possess the instruments needed to fight climate change – we just need to get started now.

The climate crisis is a big, but not insurmountable problem. The greatest challenge is that we have very little time. The leaders of the world are all waiting for someone else to take the first step, and in the meantime we continue to race forward in the wrong direction.

What we need are people who are not only concerned about their own future, but everyone's. People who are concerned about what they leave for the next generation. People who think about the world our children and grandchildren will inherit from us. What kind of a world do we want it to be?

Some good things have already happened. Large investments in renewable energy are taking place and industry has begun to take steps to cut its greenhouse gas emissions. Now we have to go a step further. To stop global warming at a maximum of two degrees Celsius, emissions must be cut by up to 85 percent by 2050. This is a fact we cannot deny. It means that we must invest heavily in renewable energy and energy efficiency, and cease using fossil fuels without CO2 capture and storage. Politicians must take action to make this possible. And we, as human beings, voters and consumers, must support this.

For millions of people climate change is not a scary scenario in the future: it's happening now. Pacific islands are about to disappear under the sea. The population of the Maldives has collectively sought asylum in Australia. Global warming is a serious challenge to our way of life and we are already late in taking action if we want to avoid a temperature rise unlike any we have seen before.

At the same time it is necessary to fight poverty, and two-thirds of the world's population has a legitimate need for more energy and increased prosperity. The rich countries have a great responsibility, both to finance climate mitigation measures and to cut their own emissions. To reach these goals, we need globally binding agreements which force emission reductions in all countries and in all sectors. We must bear this burden together. An ideal agreement will not come quickly. It is absolutely vital that the wealthiest countries immediately begin to transition from fossil fuels to renewable energy and finance the deployment of clean technology in developing countries.

In Bellona we are focused on solutions. Therefore, we have proposed 101 of them in this magazine. Some of the solutions, like solar energy and wind energy, are well known, while others are technologies whose potential is still undetermined. The Bellona Foundation has gathered 101 solutions in order to show that it is possible to combat global warming, but it requires a global effort.

In many respects the tasks facing us remind us of elementary school when we were asked to draw how the world would look when we grew up.

But, this time it is reality that we are drawing. How do you want the world to look?

FREDERIC HAUGE
President, the Bellona Foundation

LIMITLESS CLEAN POWER

#1

Almost two-thirds of global greenhouse gas emissions come from the use of fossil fuels such as coal, oil and gas, and as much as 80 percent of the world's energy use is currently based on fossil fuels. Even in Norway, where hydroelectric power is a plentiful source of energy , over half of the energy used is fossil-based. Fossil fuels are used for transportation, industry, buildings (oil heating) and not least for the off-shore petroleum industry.

Renewable energy sources are sustainable, inexhaustible energy sources that do not cause polluting emissions that contribute to global warming. As long as there is sunshine, wind and water we will be able to exploit solar energy, wind power and water power. Renewable energy is therefore the foundation of a zero-emission society.

In contrast to rich countries, large portions of the world's population need secure supplies of energy in order to achieve a basic standard of living. The challenge is to ensure that this development takes place through the use of renewable energy sources.

We must replace existing fossil-based energy production and ensure that economic growth in developing countries is based on renewable energy. We can achieve this by developing new technologies and establishing incentives that make it more profitable to invest in renewable energy than in fossil-based energy – in rich and poor countries alike.

Photo: Istockphoto

1

EMISSION-FREE AND RENEWABLE

CLEAN ENERGY CARRIERS. Using clean energy carriers in buildings, transportation and industry will lay the foundations for a zero-emission society. **A clean energy carrier transports energy from one place to another and causes no pollution when used.** Electricity, hydrogen and heat (warm water, warm air and steam) are clean energy carriers. Because we are unable to capture and store small emissions of greenhouse gases, such as emissions from cars or from oil-fired furnaces, the energy systems of the future will have to be based on clean energy carriers. Until all power generation is renewable, clean energy carriers will have to be produced from a mixture of renewable energy and energy from coal and gas-fired power stations with carbon capture and storage.

2

MODERNISE OLD HYDRO STATIONS

GREAT POTENTIAL. Hydropower generates a sixth of the world's electricity. If we modernise old hydroelectric power plants, they can generate even more electricity.

In Norway, 99 percent of all electricity production is hydroelectric, a renewable, reliable and flexible system which produces energy for generation after generation. The potential for new hydroelectric schemes is the greatest in those parts of the world where energy demand is rising quickly, such as in South America, Asia and Africa. In countries where hydroelectric power is already well established, a great deal can be gained by increasing the efficiency and output of the existing power stations. **As an example, Norwegian electricity production could be increased by 10 percent by upgrading and expanding existing stations.**

In the Philippines, Norwegian hydroelectric expertise combines with local expertise. The power stations in Ambuklao and Binga were built in 1956 and 1960 respectively, and when the Philippines abolished its power monopoly in 2001, the plants were largely out-of-date. In 2007 they were bought by the Norwegian company SN Power, owned by Statkraft and Norfund. New intakes and new water entry tunnels are now being built. Turbines, generators and control systems are also to be replaced. Since SN Power took over, new operating practices have resulted in far fewer outages and the power plant can now produce electricity 90 percent of the time, as compared with 40 percent earlier. In addition, the modernisation of the plant means that capacity will increase by about 30 percent.

3

STOP POWER LOSS

ELECTRICITY IS DISAPPEARING. Before electricity and heat reach your house, a great deal of energy has been used in storing and transporting it. Every year, electricity equating to the production of as many as 500 coal-powered power stations "disappears" in this way.

There is a great deal of electricity to save by making our energy systems more efficient. This is also the case for transportation of district heating. Every year up to 19 000 terawatt hours (TWh) of electricity are generated globally, but only 15 660 TWh ends up being used. In other words, there is a great potential for increased efficiency in the energy system. In technical terms, this can be resolved in several ways, including raising the voltage of the grid, which will reduce loss. Another solution is to upgrade the old substations. This requires political commitment and cash. Transmission companies need to be regulated in such a way that it will be profitable to implement initiatives that increase system efficiency.

4

LET A THOUSAND WINDMILLS TURN

WIND POWER. Wind is free, and by using windmills we can convert the wind's energy into clean electricity. After hydro electric power, wind power is the cheapest and most technologically mature form of renewable energy.

From being a small and insignificant form of energy only a few decades ago, wind power now provides energy to more than 25 million households throughout the world. The Global Wind Energy Council estimates that wind power can be responsible for 16.5 percent of the world's electricity needs in 2020, and that this proportion can increase to as much as 34 percent in 2050.

With its enormous land areas and long coastline, C**hina has exceptional wind resources. China has doubled its wind-power capacity each year for the last five years and is now in the process of passing the US as the world's biggest market for new installations.** Experts suggest that China has only begun to exploit this potential. According to meteorological and economic estimates, there is enough wind to meet China's energy needs until 2030. Spain, Germany and Denmark are other big wind-power countries. The wind conditions are among the best in Europe and the interaction with hydroelectric plants is also a considerable advantage.

5

EVERY LITTLE DROP

SMALL POWER PLANTS. Small power plants have become big business in Norway after the prime minister declared that the era of large scale hydro-electric development is over. Small power plants are defined as power plants generating an output that will service around 2,500 households.

While the larger hydro-electric plants are generally publicly owned, many small power plants are owned by local landowners and farmers. On a global basis, small power plants could be deployed both in developing countries and in areas where large scale hydro-electric potential has already been developed. Smaller hydro-electric developments require less investment and project development is simpler. Small hydro-electric plants have the potential to create income and provide renewable energy in some of the world's poorest and most inaccessible areas.

6

EUROPE'S GREEN BATTERY

HYDRO POWER AS AN ENERGY STORAGE MECHANISM. Hydroelectric stations with reservoirs have an important function in increasing power production from other renewable energy sources such as wind and s olar energy. In contrast to these technologies, hydro power can easily be turned on and off depending on when we need it. In this way, hydroelectric power can be switched on when there is no wind, or little sun.

Norway possesses unique energy resources. About half of Europe's hydro storage capacity is found in Norway. Most of the renewable energy that is being developed in Europe at the moment is intermittent, which means that the flexibility provided by Norway's hydro power is particularly important. Both the power industry and the Norwegian authorities believe Norway could become a major exporter of green power to Europe.

7

THE ANSWER IS BLOWING IN THE WIND

OFFSHORE WIND POWER. The advantages of exploiting off-shore wind power are that the wind over the ocean is stronger and more stable than on land and the areas available for generation are greater. 70 percent of the earth's surface is covered by sea. There are challenges however. These primarily consist of greater costs due to immature technology. At Sheringham Shoal, off the British coast, 88 windmills planted in the sea bed will begin to turn in 2011 and provide electricity for 220 000 households in the Norfolk area. The Norwegian firms Statkraft and Statoil are jointly responsible for this offshore wind park. But this will be a modest plant compared with the plans that British authorities have for the rest of their coastal areas. Zones are being allocated for what it is hoped will yield 25 000 MW of wind power. This is 1,000 times more than Statkraft's first onshore wind park in Britain, which opened this year in Wales.

It now looks as though the greatest concentration of wind power in the North Sea will be built on the British and German sides. These countries are investing heavily by offering subsidies for offshore wind power. The development of bottom-mounted windmills is focused initially on the shallow parts of the North Sea basin, where the turbine towers can be built directly on the sea bed. The deeper sea areas along the Norwegian coast require floating platforms and far more robust technology, which will not be fully developed and competitive for another 10-20 years.

At the end of September 2009, the turbine blades of Hywind, the world's first floating windmill, began to turn and a transmission cable delivered the first kilowatt hours ever produced by a floating wind generator to the shore. The Hywind turbine will be tested for a two-year period and provide some answers about how floating windmills can be built on a larger scale.

The development of renewable energy in Europe will increase dramatically towards the year 2020, and it is anticipated that wind power will be responsible for 50 percent of the growth. Together with Scotland, Norway is the country in Europe with the greatest potential for offshore wind power. A study from Enova shows that the potential for energy derived from the Norwegian seas is 14 000 TWh. This is almost as great as the world's total electricity production! Not all of this will be environmentally responsible or profitable to develop, but the potential is nevertheless enormous.

> VI BØR SATSE STORT PÅ TILTAK VI VET NYTTER. DEN LØSNINGEN JEG VIL PEKE PÅ, ER VINDKRAFT. VI ER OMGITT AV VIND SOM BARE VENTER PÅ Å BLI UTNYTTET TIL ENERGIFORMÅL.
>
> Ingeborg Gjærum, leder av Natur og Ungdom

8

THE SOLAR-CELL REVOLUTION

CONVENTIONAL SOLAR CELLS. A technology that can truly help to solve the climate change crisis has been in small-scale use for decades: wafer-based solar cells – or solar panels. The main reason for the rapid growth of the solar cell industry is that solar cells are becoming dramatically cheaper and better.

The Norwegian solar-energy company Renewable Energy Corporation (REC) is amongst the world's biggest suppliers of wafers and solar panels. REC's development work has contributed to huge cost reductions. REC's calculations show that in several markets, such as Japan, Australia and California, solar-cell energy will be economically competitive with few or no subsidies by 2012, and in some markets even earlier.

"Over the past ten years costs have fallen by almost ten percent a year because the technology has developed and the volume has increased", says REC's Director of Technology, Erik Sauar. Solar cells are also relatively uncontroversial to install. "This is a silent and emission-free technology, without moving, dangerous parts", Sauar points out.

In warm parts of industrialised countries, such as Spain, Japan and the US, residents use most electricity when the sun is shining because they want to keep rooms cool by means of air conditioning. This is an ideal starting point for deploying wafer-based solar-cell technology on a large scale.

9

SUPER-THIN SOLAR CELLS

FLEXIBLE SUPER-THIN SOLAR FILM. Imagine that the sun is baking hot and you let down the blinds to get some shade. At the same moment, you begin to produce electricity from solar cells on the outside of the blinds. This is not science fiction. **This product may be available assoon as 2010.**

The conventional wafer-based solar panels are now in competition with super-thin flexible solar cells, in which a film of copper, indium, selenium and gallium is applied onto a foil, so that the solar cells can be bent, rolled up and applied to uneven surfaces. This is a very promising form of solar-cell technology which can help reduce costs dramatically – and thereby increase the competitiveness of solar energy. Hydro Building Systems is among the companies developing this technology through its ownership in Ascent Solar. Even though the window blinds are the first product to emerge from this collaboration, it is thin film integrated into more solid parts of buildings that will have the greatest potential. The vision of the future is solar cells so thin and flexible that they can be applied with a paintbrush.

10

GETTING PAID

INPUT TARIFF. Arnold Schwarzenegger, the Governor of California, is now following Germany's example and introducing feed-in tariffs for small-scale solar power producers. In Germany both companies that build windmills and households with solar panels on the roof know exactly what they are going to be paid for the electricity they generate. The German government has ordered that electricity companies are obligated to both accept and to pay a set price for environmentally-friendly electricity. This makes it simpler to finance renewable projects.

The income for power producers is dependent on what kind of energy source that produced the electricity. In Germany, for instance, solar power has been supported for many years by setting prices several times higher than the market price. **Germany has been one of few countries that have invested in support for solar energy, and is now responsible for almost half of the world's solar-powered energy production.** This has also given rise to a thriving solar energy industry and employment opportunities in the fields of research, building and installation of solar energy equipment.

By means of input tariffs (feed-in), governments can exercise a great deal of influence on the choice of technologies. With a feed-in system, the power-producer's income is secure, while the volume is dependent on how attractive this income is for the parties involved. In some countries, feed-in systems have yielded a far greater output (and therefore expense) than authorities planned, while the output has been smaller than expected in other countries because the subsidy has been too low.

11

MAKE GREEN GOOD BUSINESS

GREEN CERTIFICATES. The objective of green certificates is to increase the production of renewable energy. The system works as follows. Electricity producers are allocated green certificates for the amount of electricity they generate from new renewable power plants. The authorities then mandate electricity suppliers to buy a certain number of certificates. The certificate requirement defines how much renewable energy the scheme will lead to. Income from the green certificates goes to covering the difference between the market price of electricity and the costs involved in investing in new, renewable production.

Sweden has had a market in green certificates since 2003. After four years, the system has led to the development of over 13 TWh of renewable electricity produced from bio-energy, hydro-electric and wind power. **There are now plans for a joint Norwegian-Swedish certificate market from 2012.** This joint certificate market will provide 25TWh of new renewable electricity by 2020. Where and how this new renewable energy generation will be built is determined by the market. Thus politicians only get to decide how much energy is to be developed, while the market determines the technology and the certificate price. The producer receives certificates for a set number of years. In Sweden this is 15 years.

12

THE SUN TOWER IN SEVILLE

Photo Georg Gerster/Panos/Felix Features

CONCENTRATED SOLAR POWER. Solar power is not only harvested by means of solar cells or solar thermal energy, but also through so-called concentrated solar power technology – which many people regard as the most promising means of converting the sun's powerful rays into useable energy.

On the plains outside Seville,Spain, a 115-metre high concrete tower was built in 2006. From the ground, 624 moveable mirrors reflect the sun towards a point at the top of the tower, as shown in the picture. The solar energy boils water and the steam drives turbines which generate electricity. The steam can be stored and can continue to produce electricity after sunset, thus resolving one of the main problems of solar power generation – that power can only be produced when the sun is shining. By 2013 solar towers will produce enough electricity for all of Seville's 180 000 households. **This means an annual reduction in emissions of 600 000 tonnes of CO_2.**

Sun dishes, resembling TV satellite dishes, are another promising concentrated solar-power technology. Solar energy is guided towards the centre-point of the dish and channelled onwards into a material that can absorb the heat. Many dishes can be used simultaneously to form a larger sun park. Spain plays a central position in the development of concentrated solar energy, but the technology is global. Researchers are looking especially at desert areas. Solar radiation bombards the deserts with more power in the course of six hours than the entire population of the world uses in a year.

Sending solar-generated electricity from the deserts to the rest of the world is not just a wild science-fiction idea. This summer, 12 German companies signed an agreement to build several concentrated solar power stations in the Sahara. The goal is that these power plants will supply 15 percent of Europe's electricity requirement through undersea cables. Critics say that the project will consume large amounts of water in an arid area with water shortages. The Sahara Forest Project (described later in this magazine), combines concentrated solar power with salt-water greenhouses. The synergy between these technologies makes it possible to construct a power plant in the desert that does not consume local resources of fresh water.

13

ELECTRICITY FROM WOOD

BIO-POWER PLANT. It is well known that it is environmentally beneficial to generate electricity from water in hydroelectric power stations. But did you know that we can also generate environmentally-friendly electricity and heat from wood?

Tranås Energi is one of many examples of Swedish excellence in terms of exploiting bio-energy. This small energy company's bio-power plant generates environmentally-friendly electricity from bark, shavings and other wood. The wood is burned, heating water. The steam drives turbines which generate electricity. This process also produces a certain amount of extra heat which can be used in a district heating plant attached to the bio-power plant. This plant heats buildings that otherwise would have been heated by electricity. Altogether, the bio-power plant in Tranås generates enough electricity to meet the needs of 500 average Norwegian households.

Not all of the wood from trees should be used for this purpose. A tree is a valuable resource that consists of many different parts. The most valuable part is the tree trunk itself. This can be used to manufacture products that otherwise would have been made from oil, something you can read about further in this magazine.

14

ELECTRICITY FROM SALT WATER

OSMOTIC POWER: In an old factory by the shore at Tofte in Hurum, just outside Oslo, Statkraft has built the world's first osmotic power plant or salient gradient power generation station. **According to Statkraft, this environmentally-friendly method of producing electricity has a global potential of 1600-1700 TWh a year, the equivalent of half of the EU's current energy production.** Osmotic power could supplement renewable energy sources such as water and wind power.

Osmotic power is a renewable and zero-emission energy source which Statkraft has been conducting research on for ten years. Electricity is generated by exploiting the energy that is released when fresh water and salt water combine. By separating the water types with a membrane, osmosis is used to increase the pressure on the seawater side. The pressure that builds up is equivalent to the energy produced from a 120-metre waterfall.

"Osmotic power stations produce electricity around the clock. They do not depend on the sun shining, the wind blowing or the rain falling", says osmotic power officer Stein Erik Skilhagen in Statkraft.

In principle, osmotic power plants can be built at any site where fresh water runs out into the sea. It is a zero emissions technology that can be integrated into existing industrial areas.

An osmotic power plant will probably be the size of a football stadium and deliver enough power for 30 000 European households. The prototype that opened recently at Tofte in Hurum has limited production capacity and is primarily used for testing and development. Statkraft hopes that the first demonstration plants can be built as early as 2015.

15

CATCH THE WAVE

WAVE POWER. Anyone who has swum in big waves has felt their power. Through wave power we can exploit these forces in the sea to produce electricity. Because waves are continuous and because no pollution is caused when they are converted into electricity, wave power is a renewable and environmentally-friendly source of energy.

Just under the surface, the average wave energy is five times more concentrated than the wind energy 20 metres above the water, and up to 30 times more concentrated than the intensity of the sun's radiation. The natural conditions are therefore good for commercial exploitation of wave power, which can become a significant addition to many coastal nations' energy production.

However, the development of wave power is still at an early stage, and is barely in commercial operation anywhere in the world. **Nevertheless, visionary engineers see a great potential and more and more investors are considering investments in wave technologies.** Of some 20 European companies, the Pelamis Wave Farm has come the furthest. The Pelamis Project, the world's first commercial wave-power generating plant, was launched off the Portuguese coast two years ago. The plant consists of three 140-metre long and 3.5-metre thick sausage-like pipes, each supported by four flotation chambers. When the pipes rise and fall in the waves, a kinetic energy occurs which is transferred via a pump to a turbine, which in turn generates electricity. Wave power has an enormous global potential equivalent to nearly the entire world's electricity consumption, according to The World Offshore Renewable Energy Report 2002-2007.

16

HEAT FROM THE EARTH

GEOTHERMAL ENERGY: In the core of the earth the temperature is around 4200 degrees. By drilling down into the earth's crust, it is possible to tap into the heath and use it for energy purposes. **This is geothermal energy, a renewable energy source which has been exploited since the time of the Romans for heating and baths.** It is now a form of energy that is produced in about 25 countries, and is particularly advanced in the US, El Salvador, Costa Rica, Kenya, the Philippines and Iceland.

In Unterhaching in Southern Germany, a geothermal power station was recently opened which will reduce the city's CO_2-emissions by two-thirds. Germany already has several such power stations in operation, but this one uses a new technology, called the Kalina system, which can also be used in the rest of the world to make the energy extraction from geothermal power stations more efficient.

Geothermal energy is relatively inexpensive, reliable and environmentally-friendly, but so far has been restricted to areas where tectonic plates meet. Newer technology has widened the scope considerably and in particular has enabled heat extraction for domestic heating. One of the advantages of geothermal energy is that it is constantly available, as opposed to solar and wind power. Geothermal wells release some greenhouse gases from within the earth, but these emissions are lower per unit of energy than from conventional fossil fuels.

17

RAW MUSCLE POWER

Photo Nikkie Theuns

MECHANICAL ENERGY CAPTURE. Why depend on plugs and transmitted electricity when you can charge up your mobile phone or mp3 player yourself, just by moving? Or how about a dance floor that lights up when you dance on it?

Both Rotterdam and London can boast about their own "sustainable dance clubs", in which the guests literally light up the floor. The floor functions as a big generator, and transforms the vibrations from the dancers into electricity that lights up the floor.

The body generates a great deal of power in the course of a day, and new solutions are constantly being developed to transmit this energy to electronic gadgets. Mobile phone chargers are especially widespread. Some models are fastened to the body so that the energy generated by your body while walking, running or dancing is transmitted to a charger. Another kind of charger receives power from the wheels in a specially-designed trolley case. Currently, chargers are not very efficient – you have to be on the move for between one and six hours in order to obtain from 15 minutes to a full charge of your phone. That's a lot of exercise! Nevertheless it's a good way to keep in shape and at the same time re-charge your batteries.

18

POWER IN THE EBB AND FLOW

Photo istockphoto

TIDAL POWER. Although tidal power is a source of energy that is not well developed, several plants have recently been built to take advantage of the natural gravitational pull of the sun and moon on the oceans. **Tidal power is a form of power generation in which the tide produces energy by driving a generator.**

Tidal energy can be exploited in two ways. One is based on the height difference between high and low tide. Water is trapped at high tide and runs through a conventional hydroelectric power plant at low tide. This method is limited to locations in which there is a large tidal range, or vertical difference between tides. The other method is to exploit the speed and mass of tidal currents, in other words the kinetic energy of tidal water. At present, tidal energy projects and ocean current projects are still at a developmental stage. The Norwegian electricity company Hammerfest Strøm installed a prototype of a tidal power station at Kvalsundet in Hammerfest in 2003. The area between Scotland and the Orkney Islands is suitable for construction of around 40 tidal water turbines, and the plan is for Hammerfest Strøm to supply 40 000 British households with power from 2011.

19

STEALING HEAT FROM THE COLD

Photo istockphoto

HEAT PUMPS. It is cold in the Nordic countries, which means a high consumption of energy for heating. Probably over half of all energy used by buildings goes to heating and hot water.

Heat pumps can help reduce this consumption. **The amount of energy used to heat water or rooms can be reduced by 75percent or more by using a heat pump.** Heat pumps make it possible to transport heat from a lower to a higher temperature level. Even if it is cold outside, there is heat energy that can be used. Some heat pumps work right down to -30 degrees Celsius. In principle, heat pumps use the same technology as refrigerators, but in the opposite manner. Whereas a refrigerator pulls warm air out of the cabinet, the heat pump pulls warm air into the house. Even though the heat pump uses electricity it can provide up to three times as much energy as it uses.

It is possible to extract this heat from a range of sources. Energy is found in the form of heat in air, earth, sea, groundwater and bedrock. It is customary to divide heat pumps into three categories: air-air, air-water and water-water. An air-air heat pump extracts heat from the air outside and delivers warmer air indoors. A water-water heat pump, however, extracts heat from seawater or groundwater and supplies heat to water in radiators or floor heating systems.

20

IN THE WARMTH OF THE SUN

Photo ENOVA

SOLAR THERMAL COLLECTORS. Can you imagine showering in water heated by the sun? This is possible even in cold areas such as in the Nordic countries. All you need is a solar thermal collector installed on top of your house. Like solar panels, solar thermal collectors exploit the rays of the sun. **The difference is that while solar panels generate electricity, solar thermal collectors are used to heat up water. This warm water can be used in the shower or for heating the house.**

When the sun's rays hit the solar thermal collector, water is heated and a regulatory system ensures that the water continues to circulate as long as the sunlight is strong enough to increase the water temperature. The solar thermal collectors exploit the energy from solar radiation and are not dependent on the temperature. This means that they can also produce heat in the winter, as long as there is sunshine. Since the sun often shines on solar thermal collectors in periods when there is little need for heating, the hot water is led out into an insulated tank – a heat-storage facility – so that the energy is available in periods without sunshine.

21

DINNER IN THE SUNSHINE

Photo Chris de Bode/ Panos/ Felix Features

SOLAR COOKERS: Over 100 000 refugees from Bhutan have been living in the southern part of Nepal since 1990. In the last few years, more and more of them have gained access to solar cookers for food preparation. This simple but effective solar-cell technology prevents the local forest from being raided in the hunt for firewood and has dramatically reduced the use of paraffin for cooking.

In many countries, food preparation is the biggest user of energy in daily life. 2.6 billion people in developing countries cook with charcoal, organic waste or firewood, according to a report by the International Energy Agency (IEA). A number of countries use fossil fuels such as propane and paraffin. Increased use of solar cookers yields a significant environmental benefit per household.

The health benefit is also great. Every year as many as 1.3 million people, primarily women and children, die prematurely due to indoor pollution caused by burning biomass. In the Nepalese refugee camp, solar cookers provided by the UN have replaced the paraffin burners. The air in the refugee camp has become better and the inhabitants have fewer respiratory illnesses.

There are two types of solar cookers. One type is a parabolic dish that reflects the sun's rays directly to a centrally-placed pot which quickly reaches a high temperature. The other type which is more common, however, is the simpler "box cooker" in which the pot is placed in an insulated box with a glass or plastic lid and often reflective sides. The sun's heat is absorbed by the pot. The Norwegian Jon Bøhmer recently won the Financial Times Climate Change Challenge with his Kyoto Box – a cardboard solar cooker. The illustration shows a woman preparing food for her family with her new parabolic solar cooker in the refugee camp at Nepal. The solar cooker has to be turned every ten minutes. It takes about 55 minutes to cook an average family meal.

Photo Istockphoto

22

COMPLETE RUBBISH

COLLECTING METHANE GAS: Sao Paolo is the largest city in Brazil and aims to reduce their greenhouse-gas emissions with 30 percent by the year 2012. By collecting methane gas from the city's waste sites, emissions have already been reduced by 20 percent.

Methane is a greenhouse gas, which is 22 times more powerful than CO_2, but has a shorter atmospheric decomposition rate. Methane is formed by the decomposition of certain types of organic material. 60 percent of all methane found in the environment has been created through human activity, especially agriculture. Methane gas from landfills is responsible for two percent of the world's overall emissions of climate gases and the waste that ends up in landfills continues to produce methane for a minimum of 30 years. Sao Paolo takes the problem seriously. The city's landfill sites are covered with earth and plastic so that the methane can no longer escape into the atmosphere. Methane is trapped and burned, producing electricity for many of the city's 19 million inhabitants.

Methane from landfill sites can be recycled and used as heat, electricity, fertilizer or fuel. 85 percent of the energy and heat consumed at the University of New Hampshire in the US, currently comes from the Turnkey landfill site nearby. In Iceland, methane gas from the Alfsnes waste plant enables two buses, thirteen waste trucks, two other trucks and 110 private cars to get around the island without the use of fossil fuels. In Norway and the EU, it is now forbidden to throw decomposable rubbish onto landfill sites. In many developing countries, landfills are a problem which is expected to increase with rising standards of living. For this reason, more and more landfill sites are gaining UN-approved climate quotas for the collection of methane gas. The quotas are sold on the international quota market and make collecting methane a profitable business.

23

LOCAL PRODUCTION, LOCAL USE

SMALL ENERGY SYSTEMS. In Ethiopia, only one percent of the population has access to electricity. Access to energy is a significant factor in lifting people out of poverty. But in Ethiopia, 80 percent of the population lives in villages, far from the country's power grid. The solution for many rural, developing countries is small production units serving local demand, rather than large, centralized plants and grids.

This has been done in the village of Rema 240 kilometres north of Ethiopia's capital Addis Ababa. The country's largest solar energy project is situated in this village. Since 2007 all the houses in the village have been equipped with solar panels by an international organisation. "Now our children can do their homework in the evenings, because we have lights. They are very happy", says Elfenesh Tefera . Rema also has its own school, the International Solar Energy School (ISES), that trains solar-panel engineers.

For the sake of everyone's future it is important that developing countries go directly from no electricity to clean electricity. Our wealth is based on the coal of the industrial revolution and the fossil fuels of today. The need for clean energy should come at the expense of growth in developing countries. It is therefore important that financial mechanisms are established through which wealthy countries subsidize the associated costs.

24

SELF-SUFFICIENT SAMSØ

JOINT FINANCING. Thanks to the irrepressible determination of enthusiasts and the belief in joint investments, the small island of Samsø in Denmark is self-sufficient using renewable energy.

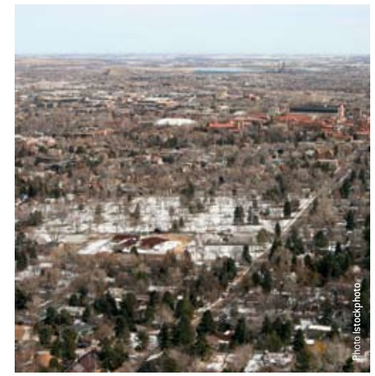
Twelve years have passed since this energy project was established in Samsø, and today 10 offshore windmills, 11 onshore windmills and four district heating plants provide all of the island's heating and electricity consumption. **In fact, they produce more electricity than is needed and are able to export as much as 80 million kilowatt hours a year to the mainland.** This is the equivalent of the total energy requirement of about 4,000 households.

Søren Hermansen, the Managing Director of Samsø Energiakademi, has been involved since the project started up in 1997. He explains:" My task has been to make the project meaningful for people. We have managed to show the inhabitants that it will be profitable to invest in renewable energy. In all, we have invested 420 million Danish kroner over 10 years, divided among 4200 residents. There are now plans to replace fossil-fuelled cars and tractors with biogas, rapeseed oil and electric-car technology."

The Samsø Municipality has acted as borrower on the investment loans and provided a guaranty for the loan for the island's four centralised heating plants. The residents themselves have invested 36 million kroner in windmills. Four of the eleven onshore windmills are jointly-owned by 450 private individuals on Samsø; the fact that they have gone together to own these has contributed to making the project viable. In addition to the wind power and centralised heating, solar energy is also used on Samsø. In November, Søren Hermansen received the "Nobel-prize" of the environmental movement, the 2009 Gothenburg Prize, for his work on the Samsø project. He will use the prize money to write a book about the project and to create new ideas for the next decade.

25

INTELLIGENT ELECTRICITY



SMART GRID. An intelligent electricity grid which will help you to cut consumption, pollute less and give you lower electricity bills: Science fiction or soon-to-be truth?

A smart grid is a collection of different solutions, but essentially it is a matter of transporting and using the electricity in a more intelligent way. An example of this is the automatic measurement and management of electricity consumption, so that the user receives a genuine oversight over the amount of electricity being used, when it is used and how much it costs. The idea is that you can adjust your electricity consumption by means of automatic functions ordered from the electricity supplier. **These enable you to use the electricity when it is cheapest, choose electricity from renewable sources and generally make your consumption more efficient.**

Some pioneers are already on the way, such as in Boulder, Colorado. In May 2008 the city was launched as the US's first "Smart-grid city" and a pilot study was initiated. 50 000 of the city's inhabitants are now connected to a smart grid. Many have installed solar panels on their roofs, some drive electric cars – and some of them can control the lighting and heating in their houses via the internet. Everyone should be in a position to keep an eye on their own consumption, and in due course on their own carbon footprints, thanks to the smart grid. What we see in Colorado foreshadows how the US's energy supply could be changed into an intelligent network. Eventually, the individual house owner can in fact become an electricity supplier, not just a consumer.

26

STORE ENERGY

ENERGY STORAGE. We are constantly hearing that we must reduce our energy consumption, but have you considered how important it is to be able to store energy?

Renewable solar and wind power have an obvious disadvantage: energy is created only when the sun shines or the wind blows. It is therefore important to be able to store this energy so that it can be used when the overall energy consumption is high and thus reduce the need for polluting gas or coal-fired power. The challenge, however, is to find good ways of storing energy – a nut for researchers to crack. For the moment, batteries are the most widely used form of energy storage, but they have their limitations in terms of life expectancy and capacity. Further development of battery technology is therefore an important field to focus on. If, for instance, the Dutch firm Ogron manages to realise its new lithium battery with all the qualities that they are applying to patent, this will mean a minor revolution in the field. The firm claims that it can create a battery with up to a 30 year life expectancy, an extremely short charge time, large storage capacity and relatively low weight. Time will tell whether this is possible. Other potentially good energy storage systems that are being researched include hydrogen, ground water, geological heat, air pressure, water storage and flywheels.

27

THE GOOD EXAMPLE

CITY PLANNING. Some people are lucky enough to be able to start with a clean sheet. In a number of pilot planning projects around the world, the environment is factored in right from day one. In some places, for instance, not a single building is built without an environmental impact assessment.

Malmö in Sweden has a borough that is the topic of discussion throughout the world. Västra Hamnen is a former industrial area, containing the Kockums shipyard. It all began with the decision to locate the European housing exhibition Bo01 in this area in 2001. The theme was ecological and human sustainability and the Swedish government allocated approximately 250 million Swedish kroner to various environmental initiatives.

Västra Hamnen has focussed strongly on social, ecological and economic durability. The new borough is supplied with energy solely from renewable sources: essentially sun, wind and water together with biogas from waste. A large part of the heating for the area is derived from the sea and from a natural subterranean reservoir. Solar thermal energy is also used. Electricity comes primarily from wind power.

Another example is Masdar City, located 30 kilometres outside Abu Dhabi, with an ambition to attract international attention. Masdar means "source" in Arabic, and the goal is to become a global engine in the development of renewable energy. Masdar City will cover six square kilometres of desert. If everything goes according to plan, 50 000 people and 1 500 companies will be located here from 2015. Masdar will demonstrate that it is possible to live in a sustainable manner while increasing the quality of life of the city's inhabitants. The principles laid down for the project include: zero emissions, total recycling of waste, sustainable transportation, extensive use of local materials, locally-produced food and sustainable use of water and energy, the latter of which will be obtained from the sun, wind and waste.

FROM DESERT TO OASIS

#2

We live on a blue planet. The earth's surface consists of two-thirds sea and one-third land. We have an abundance of salt water; however the lack of fresh water is one of our greatest global challenges.

The land can again be divided into three parts. One is dominated by human activity, another by forest – which is steadily shrinking day by day, and the third is desert – which is increasing in size. In other words, we have plenty of seawater and deserts.

Four partners have joined forces to use salt water in the creation of fresh water in The "Sahara Forest Project", with the aim to make dry areas green again. The project consists of a unique combination of technologies which imitate natural processes, and make it possible to make fresh water from salt water, at the same time as producing food, energy and covering the desert landscape with vegetation.

Photo Knut Bry

28

GREENHOUSES AGAINST THE GREENHOUSE EFFECT

BIO-MIMICRY. A couple of thousand years ago, large parts of the Sahara were covered with vegetation. By using nature's own methods, the desert landscape can again be covered with vegetation. Why not mimic nature when we are creating future solutions for energy supplies? Bio-mimicry is the name given to the method on which the Sahara Forest Project (SFP) is based.

The main pillars on which the project rests are salt-water greenhouses, concentrated solar energy, and the cultivation of traditional crops along with energy crops such as algae. The goal is that this combination of tested technologies will ensure that dry areas will become fertile by turning saltwater into fresh water through an economically viable environmental project.

Concentrated solar energy provides the power for driving pumps and fans. By means of the greenhouses, seawater evaporates into fresh water. The damp, cool air provides good growing conditions inside the greenhouses. The fresh water is used for crops and re-vegetation in the surrounding dry areas, and in the concentrated-solar-energy plant, which requires large amounts of water.

"The beauty of the Sahara Forest Project is that you can employ principles from nature, to reverse damage inflicted by unsustainable human usage and turn barren land into biologically productive land", says Michael Pawlyn.

Michael Pawlyn is one of the world's leading bio-architects, founder of Exploration Architecture, and one of the partners of the Sahara Forest Project. He previously designed the famous Eden Project in Cornwall, England, in which the various parts of the building contain their own eco-systems. In the Sahara Forest Project he has formed a partnership with the prize-winning designer of the Seawater Greenhouse, Charlie Paton, Director Bill Watts from Max Fordham Consulting Engineers and the Bellona Foundation.

Nature manages an infinite number of tasks – without creating waste. It is such a system that the four partners wish to create. The technologies are well tested. Concentrated solar energy is already used in the world's largest solar-power plant. Salt-water greenhouses have been tried out in various test centres, including in Tenerife and Oman.

"Through the Sahara Forest Project, poor countries in the south can produce, and in time perhaps export, their own clean energy rather than importing dirty fossil-fuel energy", says the president of the Bellona foundation Frederic Hauge.

In the course of 6 hours the world's deserts receive more solar energy than the world's population uses in a year. A number of initiatives are aiming to begin reaping this CO_2-free source of energy through concentrated solar power. The technology will in many cases consume large amounts of water and much of the energy is lost as heat. The Sahara Forest Project will enable a large-scale development of concentrated solar power in which the surplus heat is used to convert sea water into fresh water. The system thereby creates a large surplus of fresh water that can be used to irrigate barren areas.

29

CULTIVATION WITHOUT FRESH WATER

SEAWATER GREENHOUSES. The solution is simple, tried and tested, inexpensive and makes it possible to cultivate crops all-year-round in some of the world's hottest places. Seawater greenhouses enable the cultivation of crops without adding fresh water. Sea water is evaporated on so-called evaporation mats, or wet cardboard walls, thus removing the salt at the same time as the air becomes damp, and as much as 15 degrees cooler than in the hot desert sun. The cool, damp conditions in the greenhouse mean that the crops manage with very little water. The surplus condensed fresh water can be used for watering crops, or for other purposes. This simple process, carried out in the seawater greenhouses, mimics nature's own water cycle in which seawater is heated up by the sun, evaporates, and forms clouds before returning to the earth in the form of rain.

30

ALGAE

CULTIVATION OF ALGAE. Biological material for energy purposes can be an important contribution to the low-emission society of the future. However, the production must not come into conflict with food production, or use-up dwindling resources of fresh water. Algae and new energy crops can be amongst the solutions to these challenges.

Much of our fossil reserves consists of billion-year-old algae that have sunk to the sea bed and been turned into oil. The algae of the past have given us oil, and environmental problems. More and more people believe that cultivation of algae can be among the future energy and environmental solutions. In 2009 several airlines carried out test flights with algae-based fuels in the tank. Both in Britain and the in U.S. large amounts of public money are being spent to stimulate research and development work, with the goal of attaining large-scale commercial production of algae.

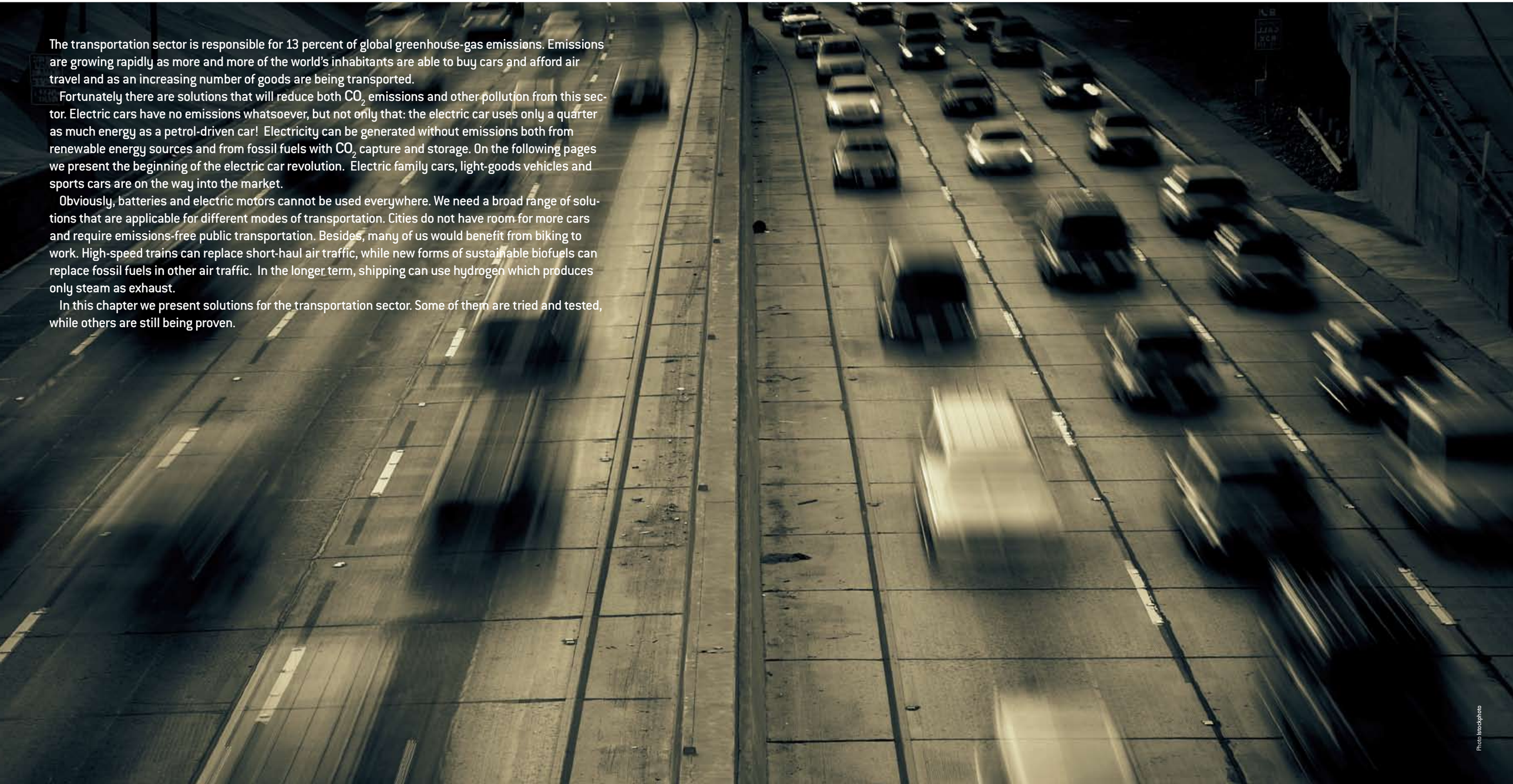
Algae are amongst the fastest-growing organisms known to man and are not particularly fussy about the conditions under which they grow. They can grow in fresh water, salt water or waste water. They grow well in areas that are unsuitable for growing food, and therefore do not come into conflict with food production, or with conservation areas. Algae cultivation can be a relatively inexpensive and simple way of producing environmentally-friendly energy in poor countries. Rather than buying expensive and dirty oil, poor countries can produce their own fuel and other forms of energy. Algae can be used for fodder (animal feed), fuel and fertiliser.

"Algae" is a common term used to describe tens of thousands of different species. Most of these have been little researched. Seaweed is macro-algae, but most species of algae cannot be seen with the naked eye, and are therefore termed micro-algae. The cultivation of micro-algae can occur in open systems such as small pools or ponds, or in so-called photo-bioreactors. In the Sahara Forest Project, both solutions to the problem will be tested. All algae utilize sunlight through photosynthesis. As well as water, they need CO_2 and nutrients such as nitrogen and phosphorus in order to grow. Algae cultivation in areas rich in nitrogen and phosphorus could therefore solve local pollution, as well as constitute a future source of environmentally friendly energy.

> SAHARA FOREST PROJECT SYNES Å VÆRE ET VELDIG INTERESSANT EKSEMPEL PÅ EN MER INTEGRERT OG HELHETLIG FILOSOFI VI KOMMER TIL Å TRENGE MYE MER AV I FREMTIDEN, OM VI SKAL KLARE Å GJØRE ENERGIEN, VANNET OG INDUSTRISYSTEMENE VÅRE MER BÆREKRAFTIGE.
>
> Andris Pielbags, EUs energikommisær

ON THE ROAD TO CLEAN TRANSPORTATION

#3



The transportation sector is responsible for 13 percent of global greenhouse-gas emissions. Emissions are growing rapidly as more and more of the world's inhabitants are able to buy cars and afford air travel and as an increasing number of goods are being transported.

Fortunately there are solutions that will reduce both CO_2 emissions and other pollution from this sector. Electric cars have no emissions whatsoever, but not only that: the electric car uses only a quarter as much energy as a petrol-driven car! Electricity can be generated without emissions both from renewable energy sources and from fossil fuels with CO_2 capture and storage. On the following pages we present the beginning of the electric car revolution. Electric family cars, light-goods vehicles and sports cars are on the way into the market.

Obviously, batteries and electric motors cannot be used everywhere. We need a broad range of solutions that are applicable for different modes of transportation. Cities do not have room for more cars and require emissions-free public transportation. Besides, many of us would benefit from biking to work. High-speed trains can replace short-haul air traffic, while new forms of sustainable biofuels can replace fossil fuels in other air traffic. In the longer term, shipping can use hydrogen which produces only steam as exhaust.

In this chapter we present solutions for the transportation sector. Some of them are tried and tested, while others are still being proven.

Photo istockphoto

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BE PRACTICAL - DRIVE ELECTRIC

Photo Knut Brg

ELECTRIC CAR. 0-100 in 6 seconds, room for five adults and two children and good storage room as well. State-of-the-art, sporty and quiet. What are we talking about? An electric car, of course.

The electric car is perhaps the first thing that comes to mind when someone says "climate-friendly transportation". But for many people it is hard to shake off the image of a clunky little plastic car with barely room for an infant and a shopping bag. However, this is far from the entire truth: the latest generation of electric cars has made dramatic improvements. The car we have described above is not a dream, but is the next model of the electric-car manufacturer Tesla, a company that already produces an electric sports car with a top speed of 130 mph and a range of 220 miles. Frederic Hauge, President of Bellona, owns the tenth car from the factory, which he describes as "a pioneer in the electric-car market".

The roadster pictured here has high performance and a good range, can recharge quickly and boasts an appearance that would delight any sports-car enthusiast. And now, Tesla has designed a larger vehicle that will compete in the higher classes. Development on this model is well advanced and the first cars will be on the road in 2011.

Since Bellona bought Norway's first electric car in 1989 there have been tremendous developments in terms of technology, regulations and popularity. More and more people choose electric cars because they are practical, economic, fun – and environmentally-friendly. Many countries offer powerful incentives for users of electric cars, including driving in bus lanes, free parking, and lower taxes.

There is still a long way to go before the electric car really takes off, but interest in them is picking up. Bellona's goal is for 10 percent of cars in Norway to be electric cars or plug-in-hybrids by the year 2020. This will require powerful incentives. We want to encourage the use of electric cars, or other emission-free alternatives. Governments should tilt the playing field in favour of electric cars, for example, by ensuring that state-owned businesses use them. It is also important to develop the necessary infrastructure, with a good coverage of charging stations that offer rapid charging. Just as important as government incentives, is the role of the car industry which needs to have the vision to move away from fossil fuels. We must think fresh.

32

RE-CHARGE YOUR BATTERIES

Photo RWE

BATTERY CHARGING. Stop along the road and exchange your empty car battery with a full one? Take a 45 minute break to charge the car in the middle of a long journey? Advancements in electric batteries present interesting possibilities when you "fill your tank" in the future. **Rapid charging depends on access to a high-capacity electricity supply – and demands thick cables.** It is a matter of getting as much power as possible into the battery as quickly as possible. Rapid charge makes it possible to substantially increase the electric car's radius – Tesla claims that its new electric car can be charged in 45 minutes. A well-developed network of rapid-charge bases will require an upgrading of the electricity grid in many areas, not least in the vicinity of shops and restaurants. It is likely that car owners will pay part of the bill for updating the electricity grid through pay-as-you-go arrangements at the charging stations.

The car battery as an electricity supplier is another exciting concept. When the electricity grid is updated to a so-called smart grid – the grid of the future – all units coupled to the network will be able both to collect and deliver electricity. In other words, when you plug in your car at night, the battery system will receive information about supply and demand; it can sell electricity when there is high demand and high prices, such as in the morning, and buy when it is cheap, such as in the middle of the night.

Battery exchange is also amongst the suggestions to ensure continuous power. It takes a little time to charge up a car, so one solution could be to stop at an automatic exchange station where the low battery is simply taken out and replaced with a loaded one. Better Place has gone the furthest with this idea, and the company is demonstrating the technology in Denmark and Israel. Battery exchange will require that all cars using this technology will need to have compatible batteries. This can easily be achieved by setting industry-wide standards.

33
GASOLINE-ELECTRIC VEHICLES

Photo GM Corp.

PLUG-IN HYBRIDS. With the appearance and characteristics of a normal family car, low running costs, as well as low emissions, most buyers of new cars ought to take a good look at a plug-in hybrid. This is an electric car that is loaded up from the electricity grid, but which also has an engine that can charge the batteries, or drive the car. This can be a normal combustion engine or a fuel cell. This type of hybrid is gearing up to be the favourite solution in the car industry and all the major manufacturers are developing their own models. The first commercial plug-in hybrid to come on the market was the Chevrolet Volt, along with its European sister model, the Opel Ampera. **These cars can drive for 60 km before the combustion engine kicks in. These are also relatively large cars, with plenty of room for passengers and luggage.**

Plug-in hybrids have two great advantages: they offer a greater range than the electric cars of today and they are far cheaper to operate than the high-pollution cars of today. Calculations made by the manufacturers of the Volt and Ampera show that electricity costs can be as low as a sixth of the petrol costs for an equivalent car (depending on the prices of electricity and gasoline). Even though these cars partly use fossil fuel, they represent a great leap forward in terms of environmentally-friendly technology. As batteries become more efficient and cheaper, electric-powered driving will be a better experience, with improved environmental performance. In the future, cars running on hydrogen and biofuels will largely be hybrids. We believe that this technology will be of lasting value and open the way for the development of even more environmentally-friendly vehicles.

34
CHARGER ON THE CORNER

CHARGING STATIONS IN NEW BUILDINGS. This initiative may not seem revolutionary, or highly innovative. But it is nevertheless a very effective way to make life simpler for those who drive electric cars, and not least to encourage more people to make the change from their old combustion engine. A straightforward regulation that requires the installation of electric-car charging stations in all new buildings of a certain size will not only encourage more people to use electric cars, but also send an important signal that regulation is a fundamental necessity for the transition to a new energy economy. In the same manner that there are requirements relating to sewerage, ventilation and insulation, there should be a fundamental understanding that as the electric car is going to be ever-present, we may as well be prepared for it. For the construction industry this will involve little extra work but limited costs.

35
THINK BIG

Photo Modec

MASS PURCHASE OF ELECTRIC CARS. This is essential for increasing the production volume of climate-friendly vehicles. But there is a Catch 22 situation because fleet customers will not buy electric cars until there is a high performance electric car available to them at a reasonable cost. So what can we do?

We know that regulation is essential for increasing the proportion of electric cars on the roads. Effective incentives include cutting duties on electric cars, free parking with facilities for battery charging and permission to drive in bus lanes. At the same time, it is evident that the public sector can do even more, especially in relation to vehicle fleet purchasing. **A solid investment in electric cars for public services would not only reap immediate rewards but would also ensure a price reduction for electric cars, due to economies of scale in the production process, and a greater investment in technological development on the part of the industry.**

Several countries have already established requirements that electric cars should be the preferred choice for public purchase. The British Government, for example, has taken a clear stance on this issue by requiring that the public sector uses climate-friendly vehicles. The Post Office is to be equipped with low emission vehicles, the police are using hybrid cars and clear limits have been laid down on emissions from all public vehicles. Funds have also been set aside to build charging points for electric cars. The British Government has implemented these measures in order to reduce the emissions of greenhouse gases, but low-emission vehicles also use less fuel – so the initiative has a clear economic effect in the long term.

Photo Istockphoto

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DRIVING WITH DAISIES

BIOFUEL. By far the majority of the fuel that is used in cars today comes from dirty, old oil. The cars of the future must be powered by electricity as much as possible, while heavy-goods transportation, shipping and aviation must use biofuels or hydrogen.

Bioethanol can be made from forest timber, or from plants such as corn or sugar. In Brazil about half of all petrol-driven transport runs on bioethanol, mostly manufactured from sugar. In Oslo, 21 buses run on bioethanol produced from wood at Borregaard. **Biodiesel is manufactured from oil-rich plants such as soya or rapeseed. Second-generation technologies allow you to produce biofuels from wood.**

Biofuels emit CO_2 on combustion, but since the plants have absorbed an equal amount of CO_2 through photosynthesis, the fuel is essentially regarded as climate-neutral. Nevertheless, because the manufacturing process itself causes emissions, the environmental effect from bio-fuels is normally between 40 and 80 percent of that for fossil fuels. Work is being carried out to develop technology which will allow biofuels to be manufactured from a variety of biological material such as algae. Biogas in the form of methane is also a possibility for driving vehicles. In the Swedish city of Linköping, the city bus company runs several gas-driven buses which use methane produced by the city sewerage system. According to the authorities the project is profitable and is to be expanded.

37

EMISSION LIMITS

Photo Istockphoto

VEHICLE EMISSION STANDARDS. This is an established method of limiting greenhouse gas emissions from vehicles and of increasing vehicle efficiency. **Authorities set standards which regulate how much CO_2 a car can emit per mile, and in some countries how much fuel a car can use per mile.** The system sets strong guidelines for the vehicle industry. In a world in which emission requirements are constantly being tightened, and a phase-out of fossil fuels for private cars is only decades away, these standards are forcing car manufacturers to think anew and to develop new technology.

It will be years before a global emissions system is in place. The EU has introduced standards that the US will not attain for at least seven years, despite tighter, new American emission regulations. But the system is gradually gaining a foothold and will be very important in preventing the growth of CO_2 emissions as car ownership increases. China has introduced very strong emissions regulations and India is going to introduce emission standards in 2011.

38

SKY AND SEA!

Photo Istockphoto

ALGAE FUELS. Industrially-produced biological material that can get a plane in the air, with a carbon footprint far less than that of today – how cool is that? No wonder airlines are interested.

Most of today's biofuels are made from plants cultivated on land that could have been used for food production. At the same time, the need to produce more food will increase dramatically as the global population increases, and there will be clear limitations on how much biofuel can be produced sustainably without the use of entirely new techniques and resources. Therefore, industrial production of biomaterial, especially algae, is particularly interesting. Micro-algae breed astonishingly quickly and can contain a high oil yield. Compared with traditional crops, algae can produce 30 times more energy per unit area. Algae can also be cultivated on land that is unsuitable for traditional farming. Growing algae is well-suited to hot, sunny, dry climates like deserts.

Large commercial producers have already begun to develop technology to produce biodiesel and aviation fuel from algae. Several test flights have been carried out this year. The US Department of Defence has begun a significant research and development programme directed towards the production of aviation fuel from algae. Martin Porsgaard in SAS is among those industry leaders with great expectations for biofuels. He says that SAS's goal is to operate on 50 percent biofuel which will substantially reduce greenhouse gas emissions from aviation. This is an element in SAS's plans to halve the carbon footprint of their passengers by 2020.

Like SAS, Boeing's management also believes that algae-based fuels have huge potential as a source of aviation fuel. Boeing and SAS, together with several other airlines, belong to a group promoting the development and commercialisation of sustainable biofuels for aviation.

39

GET LOCO-MOTIVATED

Photo Istockphoto

HIGH-SPEED TRAIN. If you get on board the train in London just after breakfast you hardly have time for a snack before you've arrived in Paris. With a journey time of barely two hours between the two capitals, the train is not only more environmentally friendly but also saves time in comparison with flying. **High-speed trains are the best solution for transportation over moderate distances.** They are energy efficient, can easily use renewable energy sources and compete with both cars and aeroplanes. The development of high-speed rail lines also leads to the rerouting of a lot of goods traffic from road to train. A number of countries have understood the advantages of the train and Japan, South Korea, Spain and France for example are continuously developing high-speed rail links. This is not only done for environmental reasons, but also because it has been shown that operating them is profitable. Investment costs are high, however, so it requires political will.

40

SMART TRAFFIC

EFFICIENT TRANSPORTATION. Fuel prices are increasing, there is more traffic on the roads and transportation is facing new emissions restrictions. It is therefore necessary to make all transportation, of goods and of people, as efficient as possible. The term intelligent transportation systems (ITS) covers various systems that use information and communication technology to make transportation more efficient.

ITS can contribute to a better use of resources, support the choice of environmentally-friendly forms of transportation and help with the choice of routes that involve the smallest environmental impact. Such systems can also significantly improve traffic safety. **With a well-functioning ITS one always knows where vehicles and cargo can be found and how the traffic picture is developing.** Information is available for those who send and receive goods and can improve the efficiency not only of the transportation itself but of the whole logistical system.

There is an increasing interest in the introduction of ITS and a large number of different technologies are being developed. The increased use of intelligent transportation systems will be a central element of work to make future transportation cleaner, safer and simpler.

41

A PRICE ON THE ROAD

Photo: JohnM

ROAD CHARGES. Put simply, this means drivers pay for their road usage and the related environmental damage. This can be done through road tolls, rush-hour charges or perhaps a congestion charge. **An important point about road charges is to influence the time at which cars drive on the busiest roads,** in order to limit queuing which leads to greater CO_2 emissions. Road charges are used in many places. For example, a rush-hour charge that varies from 0 to 20 kroner has proved effective in Stockholm where it has reduced the number of vehicles passing each day by 22 percent. In London, a congestion charge has encouraged more people to use public transportation, improved traffic flow, and reduced vehicle emissions.

It is important that a good public-transportation system is in place before road charges are introduced. Without a good alternative it is difficult to gain an environmental benefit from the system. But research and experience shows that a good public-transportation system on its own is not enough to lead to a significant reduction in car use. To gain a real environmental effect requires a significant upgrading of public transportation combined with a financial mechanism, i.e. a tax to discourage use of the private car.

42

FEET NOT STREET

Photo: Istockphoto

LEAVE THE CAR AT HOME. The figures are clear: private cars are responsible for 12 percent of the CO_2 emissions in the EU. While emissions are going down in other sectors, vehicle emissions continue to increase. There is no doubt that the environment would benefit from a reduction in the use of cars. At the same time we know that society without cars is unrealistic. But their use can be limited.

Vauban is a new suburb of Freiburg in Germany. The suburb was created to be a sustainable model for other city areas. Its houses are built to be as energy efficient as possible. Vehicular traffic is limited to the main street, along which the tram to the centre of Freiburg runs. There are parking lots, but they are expensive and are located on the outskirts of the city. People use bikes, walk or take the tram. **In fact, the car-free life has captured so many hearts that 70 percent of the households now manage without a car at all.**

You don't need to go as far as the residents of Vauban to live in a slightly more environmentally-friendly fashion. But a change of attitude is necessary, and perhaps an understanding of what we are actually doing when we turn the ignition key. To quote from the British newspaper The Guardian: "One-quarter of all car journeys is less than two miles. By walking 3 km you use up about half the energy in a small bar of chocolate. The same distance by car expends 10 times as much energy but from the wrong source."

There is an increasing desire to live in an environmentally-friendly manner. Therefore initiatives that make it more tempting for people to reduce their own CO_2 emissions are extremely important, for instance, the expansion of the public transportation network, better bicycle paths, or travel remuneration for cycling to work.

43

SMART DRIVING

Photo: Istockphoto

ECO-DRIVING. Many of us love cars and for many the car is the symbol of freedom. But this freedom leaves a bad taste in the mouth when it is fossil fuel that makes the car move. Bellona is working to make the transportation sector emissions-free, but until the fossils have been parked there is still something you can do to help the environment, even with the car that you now have. **By making small adjustments in the way you drive you can reduce the car's CO_2 emissions by between 10 and 20 percent**. Eco-driving is financially beneficial and reduces environmental effects. The potential is also great for air traffic, ships, buses and trucks. SAS has just launched a new technique for landing their planes which saves fuel and cuts CO_2 emissions. For those of us who are not airline pilots, here are some useful tips:

- Use the highest possible gear and skip over some gears when shifting up.
- Use the accelerator thoughtfully, and release it when going down hill.
- Avoid leaving the car idling.
- Plan your driving route and schedule.
- Avoid unnecessary use of roof racks and ski boxes.
- Ensure correct tire pressures and car servicing.
- Use an engine-block warmer with a timer switch in temperatures under 5 degrees Celsius.
- Consider the environment when buying a car and selecting fuel.

44

BUS DE LUXE

Photo: ITDP

HIGH-QUALITY BUS SERVICES. Imagine a normal morning; you walk to the bus stop, which resembles a tram platform, and sit down in an unusually large bus with extra-large doors. It drives quickly away from the platform and down the road, which is empty of car traffic. You can watch endless queues of cars on the adjacent motorway or under the bus track, while you get to work in record time along the dedicated bus lane. This is not an image of the future – it is a reality for thousands of commuters all over the world.

High-standard bus routes are inexpensive alternatives to tram and train lines. They do not require the same infrastructure development and the vehicles cost less than trains. For this reason, many countries with poor economies have adopted such systems for public transportation. One example is the Columbian capital Bogotá, which built a high-standard bus route in the year 2000, with four dedicated bus lanes. Several other countries in Latin America, Africa and Asia have established or are establishing similar systems.

High-standard bus routes are a natural choice in most city areas. A well-developed public-transportation network persuades more people to choose a more environmentally-friendly transportation alternative than cars. At the same time, we know that most buses run on diesel. There must therefore be a strong focus on developing more climate-friendly technologies for buses.

Electric buses are largely identical to so-called trolley buses which, like trams, receive electricity from an overhead cable. The trolley bus has obvious limitations, so various types of battery-powered buses are under development. I addition to electric buses we need to develop other low-emission or zero-emission technologies such as hydrogen or environmentally-friendly bio-fuels.

> I DAG ER DET INGEN AV VERDENS VIKTIGSTE LEDERE SOM TREKKER KLIMAENDRINGENE I TVIL. DET ER ETTER MIN MENING DET ALLER VIKTIGSTE I KAMPEN FOR Å BEGRENSE DE FARLIGE KLIMAENDRINGENE.
>
> Erik Solheim, Miljø- og utviklingsminister

45
MEET ONLINE

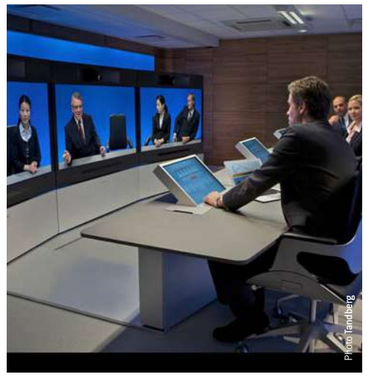
Photo Tandberg

VIDEO CONFERENCES. With our busy schedules it is a great relief not to have to spend hours travelling, just for a short meeting with a colleague. Very many work-related journeys can be replaced by a video meeting. The principle is simple. The various delegates to the meeting couple themselves up in their respective places and can see each other with the help of a screen. Meetings may be held one-to-one, via private PC screens, or as large conferences in meeting rooms with many delegates in different places. From an environmental perspective, less travel is a great advantage. **An EU report shows that video conferences are the most important IT tool for reducing CO_2 emissions.** In addition, it makes financial sense for the company because journeys cost both time and money.

Bellona uses video conferences as often as possible and we note with pleasure that many other companies are doing so. Our experience is that extensive use of video meetings makes it easier to organise meetings across national and continental boundaries. They are also more efficient. For us video conference is a win-win solution.

46
BACK TO THE AGE OF SAIL

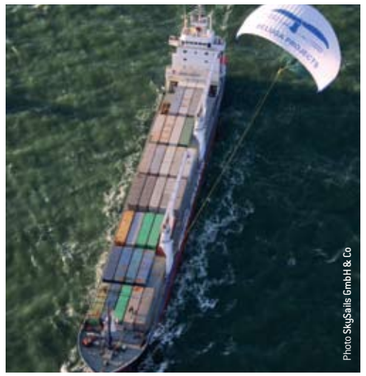
Photo SkySails GmbH & Co

FULL SAIL: Imagine a container ship on its way over the Atlantic. Then, imagine a kite-surfer on a Mediterranean beach. Can you imagine a combination of these two? We can.

Sometimes one has to look back in order to look forward, and one of the truly exciting ways of creating a more environmentally-friendly shipping industry has to be a vintage solution: wind power – sails.

This is not a matter of turning to old-fashioned schooners to transport containers over the Atlantic, but of using modern, kite-like sails on ordinary cargo ships. The company SkySails manufactures such sails and promises a savings in fuel consumption of between 10 and 35 percent, and a halving when wind conditions are perfect. **At a time when fuel for shipping is becoming steadily more expensive this solution is a real gift for shipping lines – and for the environment.**

At the moment the technology is still under development, and only test ships have been equipped with a SkySail. Despite teething troubles, the ship Beluga SkySails, for instance, has reduced its fuel consumption by 5 to 10 percent. As more manufacturers become involved, the sails will become bigger and better. As more shipping lines deploy modern sails, the effect will be noticeable in global terms.

47
CAPTURED BY THE SEA

Photo Istockphoto

CARBON CAPTURE AND STORAGE IN SEAWATER. One of the biggest challenges in connection with carbon capture is the storage of CO_2. A solution now seems to be on the way. The company Ecospec believes it is able to imprison CO_2 in sea water, without any danger of the carbon leaking out later. The technology is alluring in itself: ships are equipped with machinery that can treat sea water. The equipment increases the pH value in the water and leads the exhaust through it. **The CO_2 is thus bound up as calcium carbonate in the water, which can be released into the sea, reducing the ship's emissions by about 50 percent, or perhaps more.**

There are still substantial issues with this technology. Above all, we must be sure that the carbonate is in fact stable under various conditions, such as in the case of reduced pH and increased temperatures – both of which are anticipated effects of global warming. The solution will be unusable if it turns out that the carbonate disintegrates again, releasing CO_2. Ecospec claims that it is stable and the technology is now to be tested. If this is the case, then this can be a fundamental tool in making the maritime industry more environmentally friendly. The technology is very exciting and a good example of current research on solutions that were not even discussed just a few years ago.

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BRING SHIPPING INTO THE FOLD

Photo Istockphoto

EMISSION TRADING FOR SHIPPING. Ship transport continues to grow. In 2009 shipping is likely to be responsible for 2.7 percent of the world's total CO_2 emissions. In 2020 the proportion may increase to 6 percent and in 2050 to as much as 18 percent. Nevertheless, international shipping is exempt from fuel duties, and ships can operate using cheap, polluting heavy oils. This is essentially subsidizing pollution.

There are many reasons for this. Shipping is global and therefore must be regulated globally. The UN's shipping organisation, the International Maritime Organization (IMO) currently develops most shipping regulations. But when very different countries with very different interests are to arrive at common solutions in IMO, the road is often long and complex. An additional, challenge is that shipping is represented in IMO by the countries in which ships are registered. These are typically small countries with significant revenues from shipping, which often act on behalf of ship owners rather than protecting the environment. The largest flag states, so-called flags of convenience, resist and block many suggestions for improvements. This is an important reason why IMO has not managed to reduce or limit emissions from shipping and why Bellona and many others would like a more democratic body to set environmental objectives for the shipping industry.

When it is essentially free to pollute, it is difficult to provide incentives for environmental improvements. Many of the good solutions that are available today are therefore not implemented. For this reason, the ships must be put into a global emissions trading system or pay fuel taxes. To get an IMO-based solution to work, all ships must be treated equally, regardless of the country in which they are registered. If duties vary according to where ships are registered they will simply change flags. Many people are actively proposing that ships registered in poor countries should be exempt from emissions reductions. It is essential to establish regulations that treat all ships equally whilse at the same time protecting the interests of poor countries. Among other solutions, incomes from emission trading and environmental taxes could go to poor countries and traffic between developing countries could be given a transitional exemption from the regulations.

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FUEL CELLS FOR SHIPPING

Photo Eidesvik

NEW MARITIME TECHNOLOGY. The first commercial ship to be powered by fuel cells was the Viking Lady launched in September 2009, at Eidesvik in Norway. This occurred as part of the FellowSHIP collaborative project, which aims to develop fuel cells for shipping and off-shore energy supply.

A fuel cell transforms chemical energy to electrical energy, for instance, when hydrogen and oxygen reacts to produce water and electricity. A fuel cell is far more efficient than a traditional combustion engine. Therefore, operating fuel cells is more environmentally friendly than conventional motors and emissions are less. If the fuel is carbon-based, such as natural gas, the fuel cells will release CO_2, but to a lesser extent than a normal combustion engine. If the fuel is carbon-free, such as hydrogen, the "exhaust" will only be water and heat. Shipping is a growing source of greenhouse gas emissions and there is a great need for new, climate-friendly technology. Collaborative projects such as FellowSHIP can be an important contribution to solving the environmental challenges of the maritime industry. The FellowSHIP project is a collaboration between Eidesvik Offshore, Det Norske Veritas, Vik-Sandvik and WärtsiläShip Power Automation. Eidesvik has collaborated with Bellona since 2001 in developing environmentally-friendly maritime fuel systems.

CCS: WHAT A CATCH!

#4

Today 1.6 billion people live without electricity. Energy is the key to an increased standard of living and it will take a long time before renewable energy will be available in the amount that is needed. Coal, by contrast, is both cheap and widely available. This is why coal-fired power stations spring up like mushrooms. The problem is that all the red spots on this map are responsible for filling the atmosphere with CO_2.

The seas and forests of the world do not have the capacity to soak up all the CO_2 that is pouring out from factories and from coal and gas-fired power stations. Therefore, our future energy supplies must be renewable. Even the most optimistic, however, doubt that renewable energy can be responsible for more than half of the world's total energy needs by the year 2050. This is 50 percent too little. Fortunately, by means of new and ground-breaking technology we can capture CO_2 from power stations and factories, and store it deep under the earth's crust. The world can no longer afford to sit back and contemplate CO_2 capture and storage (CCS). It is time to get building – on a large scale!

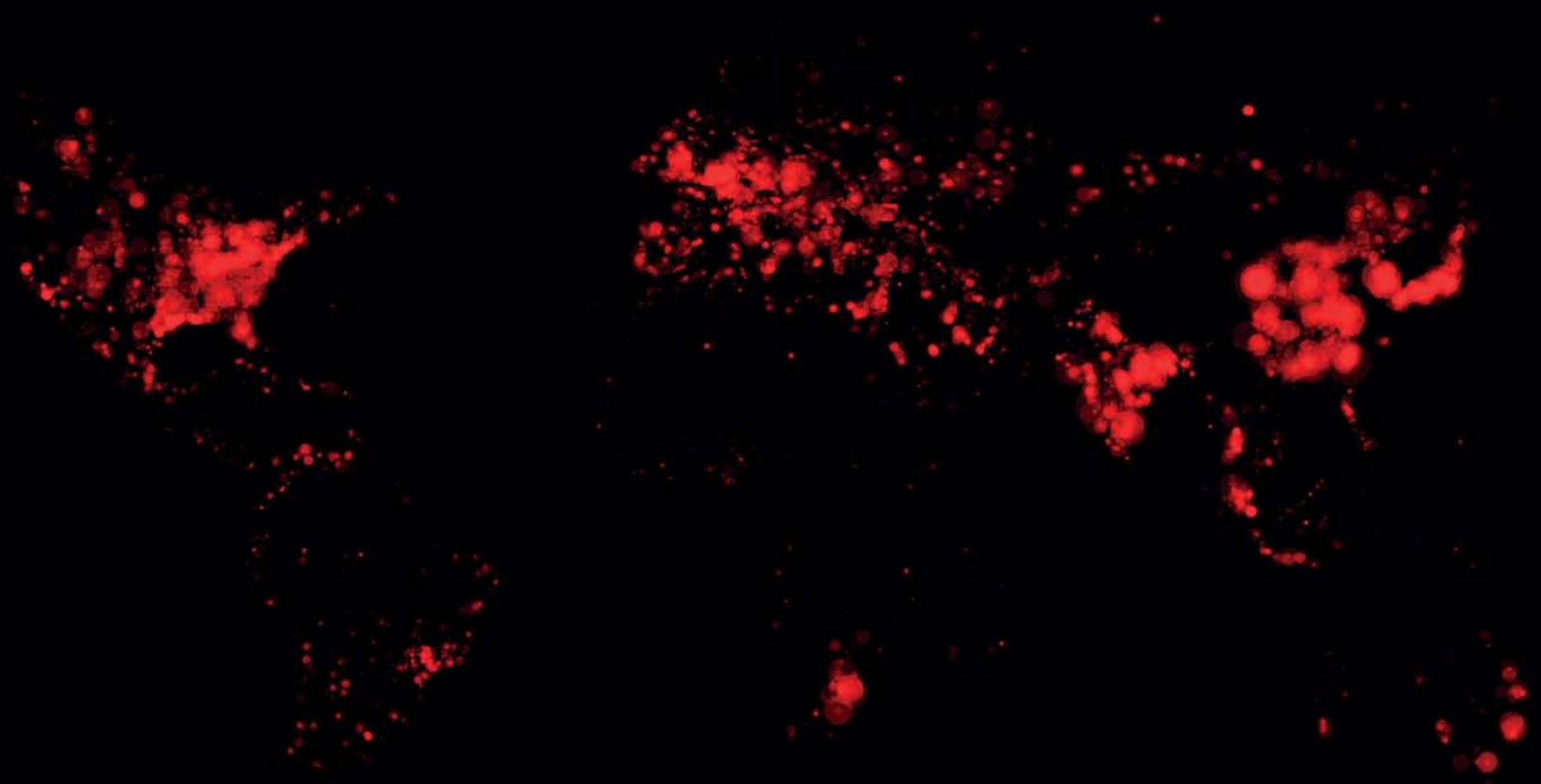

Illustration Gerilja & Bellona

50
PUT THE FOSSILS BACK

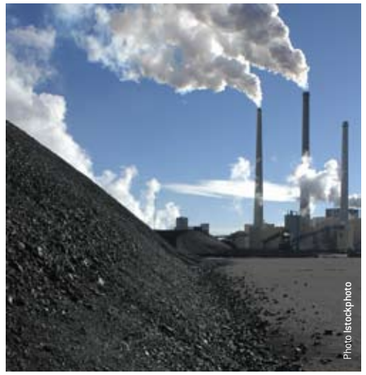
Photo Istockphoto

CO_2 STORAGE. Over the coming years, millions of tonnes of CO_2 will be captured from major factories and power stations. But what shall we do with it? Let's put it back where it came from!

During the 1990s, the Norwegian oil company Statoil had a problem. The natural gas they were producing at the Sleipner field contained far too much CO_2 for European gas buyers. They had to get rid of the CO_2. This occurs in many gas fields around the world – CO_2 is extracted and released into the atmosphere. **However, the Sleipner development was a special case due to the fact that Norway as the first country in the world introduced a tax on CO_2.** This gave Statoil an incentive to think creatively.

Skilled engineers discovered that by injecting CO_2 down into the 400 kilometre-long Utsira Formation they could both get rid of the CO_2 and extract the water they needed to inject into the oil field to maintain the pressure, while at the same time avoiding having to pay the CO_2 charge. Three birds with one stone! Since 1996, a million tonnes of CO_2 a year have been stored in the Utsira Formation, and scientists have confirmed that the formation is intact. The stored CO_2 has behaved as expected and remained in the reservoir. The Utsira Formation in the North Sea consists of a long layer of sandstone and has the capacity to store many billions of tonnes of CO_2. In other words, it provides safe storage space for centuries.

51
CAPTURE THE PROBLEM

Photo Martha Steenstr

CO_2 CAPTURE FROM GAS AND COAL POWER. From 2010, Norway will capture 100 000 tonnes of CO_2 a year from a gas-fired power station and an oil refinery at the Mongstad Technology Centre. It is expensive, slow, and the CO_2 that is captured will initially be released again. Is it worth it? Definitely.

The Mongstad Technology Centre is one of dozens of demonstration projects now being planned or built. Despite delays it looks like Mongstad will be among the first. Every year, 100 000 tonnes of CO_2 will be removed with Aker Clean Carbon's amine technology and Alstom's carbonate technology (based on chilled ammonia). There is great international anticipation for the Mongstad project. Not without reason. Coal and gas-fired power stations currently represent half of the world's power supply and a quarter of the world's total greenhouse gas emissions. In China alone, the government is planning to increase coal production by as much as 30 percent by the year 2015.

Coal is cheap and abundant. Like it or not, fossil fuels form a part of our immediate energy future. But there is a glimmer of hope. As much as a third of the world's total CO_2 emissions can be removed by means of CO_2 capture and storage (CCS). In Europe the potential is even greater – half of emissions can be removed with CCS. But developing new technology is expensive. This is why it is important that Norway and other countries are moving ahead with demonstrating CO_2 capture technologies. In order to make the technology more efficient and less expensive, it is important to demonstrate it on a large scale. There are over 8000 major sources of emissions in the world suitable for CO_2 capture. The International Energy Agency (IEA) has stated a goal of making CCS commercially available from 2020, and has called for the construction of a 100 CCS projects globally by 2020.

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SWEEPING THE CHIMNEYS

Photo Istockphoto

CO_2-CAPTURE FROM INDUSTRIAL PLANTS. It is not only coal and gas-fired power stations that emit large quantities of CO_2. Factory chimneys are one of the main sources of increased CO_2 emissions.

Worldwide there are nearly 3000 industrial sources large enough to warrant CO_2 capture. Capturing CO_2 from these industrial sources can make up a third of the necessary emissions cuts from industry in 2050. The concentration of CO_2 from oil refineries, gas terminals and fertilizer, cement, steel and paper factories is often higher than from gas-fired power stations, which makes the CO_2 capture less expensive. But this does not mean that it is cheap. Therefore, it is important that industrial plants are included in emission trading schemes, such as the EU ETS, so that a price will be attached to emitting CO_2. As the technology becomes less expensive and emitting CO_2 becomes more expensive, it will become cheaper to capture CO_2 rather than to emit it. This is why companies such as Norsk Hydro, Yara and Statoil are examining the possibilities of locating new factories in places well-suited for capture, transport and storage of CO_2.

53
MEMBRANE TECHNOLOGY FROM BIOLOGY LESSONS

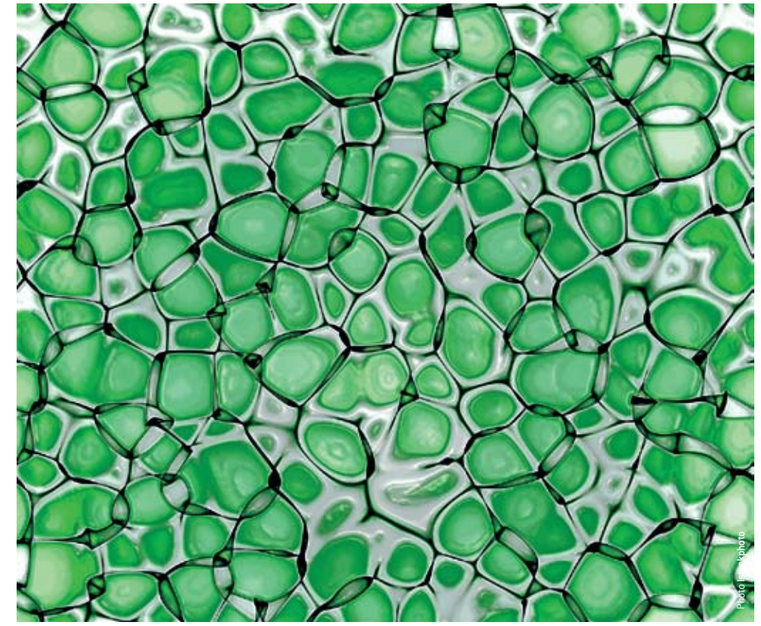
Photo Istockphoto

THE TECHNOLOGY OF THE FUTURE. Researchers are now working to make a membrane that only allows the passage of CO_2. If they succeed they will be able to remove CO_2 from power stations and factories – and use less energy and less money.

We learned about membranes in biology; the thin film used by cells in all plants and animals for separating nutrients from waste matter. **Now researchers at the Norwegian University of Science and Technology in Trondheim are working to produce a super-membrane that separates CO_2 from other gases.** Put simply, the membrane acts as a gatekeeper which only allows CO_2 to pass through. This new membrane is shaped as millimetre-thin plastic tubes and the secret is that it also contains amine molecules with which the CO_2 reacts. This enables the CO_2 molecules to jump from amine molecule to amine molecule through the membrane, like Tarzan swinging from vine to vine through the jungle. In this way CO_2 can be captured for storage. So simple – and so difficult, but if the researchers succeed in transferring the good laboratory results to an industrial scale the new super-membrane will be able to cut the costs of CO_2 capture dramatically.

> DET MEST AVGJØRENDE ER EN HØY INTERNASJONAL PRIS PÅ UTSLIPP AV KARBON. JO DYRERE DET BLIR Å SLIPPE UT CO_2 OG ANDRE KLIMAGASSER, DESTO MER LØNNSOMT BLIR DET Å REDUSERE UTSLIPPENE. I TILLEGG MÅ VI SATSE PÅ UTVIKLING AV NYE TEKNOLOGIER, SOM FOR EKSEMPEL KARBONFANGST OG -LAGRING.
>
> Jens Stoltenberg, Statsminister i Norge

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FIGHTING CO_2 WITH CO_2

PUTTING OUT FIRES. Coal mine fires are estimated to be responsible for as much as one percent of the world's total CO_2 emissions. CO_2 capture and storage (CCS) can be key to the difficult challenge of extinguishing many of the world's ravaging coal mine fires.

Coal is still one of the world's most important energy sources, not least because it burns well. One of the disadvantages is that coal can begin to burn while it is still in the mine. This leads not only to major local damage: coal mine fires also result in enormous CO_2 emissions – perhaps as much as one percent of the world's total CO_2 emissions. Coal mine fires are astonishingly difficult to extinguish and can burn for many decades.

Perhaps the most famous coal mine fire started in 1962 at Centralia in Pennsylvania, USA, and is still burning over 48 years later. Today, Centralia is a ghost town. At Svalbard in Norway a fire in the Svea coal mine lasted for five months before it was extinguished. The Svalbard fire was extinguished by a large amount of chilled CO_2, amongst other things, which suffocated the oxygen supply to the flames. In the world's biggest coal-producing country, China, there are over a hundred coal mine fires at any one time (picture). Enormous resources are disappearing for nothing. Even worse is the local pollution this creates, as well as the large CO_2 emissions. With the commercialization of CCS, it is possible that more coal mine fires can be extinguished using chilled CO_2 from the chimneys of factories and power plants.

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LET THE CAR REMOVE CO_2 FROM THE ATMOSPHERE

Photo: Knut Bøy

CARBON NEGATIVE. Soon we will be able to drive cars with a broad smile on our faces, in the knowledge that for each passing mile, we are removing a little CO_2 from the atmosphere. The energy of the future is not just carbon neutral, it is carbon negative.

"This is not science fiction", stresses an enthusiastic Frederic Hauge, President of Bellona.

The prerequisite is that you're driving an electric car and that it is charged with power from a power station fuelled by biomass, rather than by gas or coal, and the power station is equipped with CO_2 capture and storage (CCS).

Still not sure? Let's take one step back. Biomass, such as plants, trees and algae, grow by absorbing the sun's energy and CO_2 from the atmosphere through photosynthesis. Apart from the ocean, trees are the most important contributors to absorbing CO_2 from the atmosphere. Biomass is a suitable substitute for fossil fuels in power stations. For this reason, more and more power stations have entirely or partially replaced fossil fuels with biomass. CCS on biopower stations works in the same way as for coal and gas-fired power stations. The difference is that the CO_2 that is captured and stored comes from the atmosphere.

"If we use biomass in large power stations in combination with CO_2 capture and storage, we will actually be removing CO_2 from the atmosphere and producing carbon-negative electricity and heat", says Hauge. For hundreds of millions of people, carbon-negative solutions can end up being the difference between existence and non-existence. If climate scientists like NASA's James Hansen are right, today's concentration of CO_2 in the atmosphere must be reduced to prevent dangerous disruptions to the world's climate.

"We must dare to open our eyes for the possibilities that carbon-negative solutions provide. And we need politicians who dare to think outside the box and invest where it really counts. The alternative is that whole countries will vanish into the sea, that the water supply for millions of people will dry up as glaciers diminish and disappear, and that natural disasters will force the world's poorest people to leave the lands on which they have lived for generations", says Hauge.

THE INDUSTRIAL REVOLUTION - PA RT 2

#5

Like it or not, industry drives the global economy. Without materials such as steel, cement, fertiliser, chemicals, aluminium and silicon we cannot build roads, railways, bridges, houses, windmills, solar panels, cars, computers, electricity networks and all the other things on which we have become so dependent. The need for industrial products is expected to increase substantially in the coming decades, as the world's steadily-increasing population gains a higher standard of living.

But at the same time, industry represents a major environmental challenge. Industrial activity causes 40 percent of the world's CO_2 emissions and 30 percent of its energy use. Even though many companies have made great progress during the past decades in making their energy use more efficient and cutting emissions, the total production volume has increased more rapidly. The result is that industry's total greenhouse gas emissions and energy use have increased. The key to solving the industrial climate challenge is a strong focus on developing more efficient manufacturing processes for cleaner and better products.

Photo istockphoto

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ENERGY MANAGEMENT

ENERGY EFFICIENCY. Industry uses enormous amounts of energy. Half of the world's electricity generation is used to run factories. In addition, vast amounts of coal, gas, oil and biomass are burned to produce heat. This leads to enormous CO_2 emissions from the factories themselves, but also from the power stations if they are not based on renewable energy sources. So it's important for the environment that we make smarter use of energy, for example by using more efficient pumps, compressors, fans, and cooling systems.

Smarter use of energy benefits not only the environment but industry too, since less energy used means less money spent. **But even if the technology already exists and is profitable it will not automatically be used.** Companies are not always aware of the opportunities offered by smarter energy use, and management is not always good at recognising the benefit of energy-efficiency measures.

To improve this, industry can focus more on systematic analysis and improvement of its energy use (energy management) and search for ways in which to save energy. Several companies, for instance, have employed their own "energy hunters" who actively seek out opportunities for saving electricity. Governments can also contribute by requiring companies to use the best available technology so that new and more efficient technology is developed and demonstrated on a large scale.

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THE ALUMINIUM OF THE FUTURE

Photo: Istockphoto

EFFICIENT PRODUCTION. Aluminium is amongst the world's most important materials. Production has doubled in the last 20 years and it is expected that the world will use three times more aluminium in 2050 as today. In one sense, aluminium is good for the environment. Since it is relatively light and strong, it is possible to make lighter and more energy efficient cars, trains and aircraft. The drawback? **Aluminium plants require huge amounts of electricity, which in most countries is supplied by polluting coal and gas-fired power stations.** The metallurgical production process also produces CO_2 and another strong greenhouse gas, sulphur hexafluoride. Fortunately, good solutions are plentiful. The most efficient aluminium factories use only a third as much electricity as older plants and new technology is being developed and demonstrated. Another important solution is to ensure that as much aluminium as possible is recycled. At the moment nearly 20 percent is lost. Production based on scrap aluminium uses only a twentieth of the energy used by production from its raw material, bauxite. Also, it will soon be possible to do CO_2 capture and storage on aluminium factories, a solution you can read about elsewhere in this magazine.

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CLEANER STEEL

Photo Istockphoto

NEW TECHNOLOGY IN STEEL PRODUCTION. Steel is one of the world's most important materials and is necessary, for example, for building bridges such as Brooklyn Bridge (illustration), roads, railways, buildings, factories and power systems. Also the development of wind power and solar-cell parks demands large amounts of steel. Therefore the International Energy Agency expects that in 2050, nearly two-and-a-half times as much iron and steel will be needed compared to today. If we do not adopt more environmentally-friendly manufacturing techniques, the greenhouses gas emissions from the steel industry will increase accordingly. **Even today, iron and steel plants are responsible for nearly five percent of the world's total greenhouse gas emissions.**

So it is vital that iron and steel should be manufactured in a less polluting process. All the major European steel manufacturers are members of the organisation ULCOS (Ultra Low Carbon Dioxide Steelmaking) which is working to reduce CO_2 emissions in steel production. Steel is 100 percent recyclable, but the actual production produces high emissions. Since 2003, ULCOS has studied 80 different technologies for producing steel with lower emissions and has now zeroed in on four breakthrough technologies. These will be demonstrated in pilot plants in Germany and France.

Photo istockphoto

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THE WORLD'S BUILDING BLOCKS

NEW MATERIALS. The Colosseum in Rome has been standing for nearly 2000 years. One of the reasons is the natural substance that binds the building blocks together – pozzolan. **By learning from nature we can both build better and emit less CO_2.**

Almost everything we build and use comes from materials that are industrially produced. Cement, metals, chemicals and composites are the building blocks of today's infrastructure. The problem is that their production leads to considerable emissions of greenhouse gases. For instance, as much as four percent of the world's total CO_2 emissions come from cement factories. In searching for other materials that can reduce industry's CO_2 footprint we have a lot to learn from nature. Instead of cement we can, for example, use the natural pozzolan aplite to make concrete. This way, concrete is produced simply by crushing aplite, grinding it and mixing it with water, a process which produces a fraction of the emissions from normal cement.

The strongest material so far made by man is kevlar. This is made by boiling oil and sulphuric acid at 750 degrees under pressure, which leads to large greenhouse-gas emissions. By comparison, spiders make entirely natural fibres that are stronger than kevlar and at the same time naturally bio-degradable. Just think if we could learn the secret of the spiders!

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BLACK CARBON

Photo istockphoto

REDUCE SOOT EMISSIONS. CO_2 is the biggest man-made climate sinner, but did you know that soot emissions are amongst the most important contributors to global warming?

Small particles of soot, often called black carbon, are formed naturally by forest fires. But it is human activity that leads to the largest soot emissions through burning coal, oil and biomass. It is especially shipping, trucks, coal-fired power plants, factories and traditional cooking with coal, char coal or firewood that emits soot into the atmosphere. This has become an extremely serious problem that is attracting the attention of researchers all over the world.

Soot contributes to global warming in two ways. The black particles absorb heat from the sun's rays and heat the atmosphere, which in turn heat up the earth. When soot settles on glaciers, the sun's rays are absorbed by the soot rather than the glacier reflecting the rays back into the atmosphere again. **Thus the soot contributes to both ice melting and to atmospheric warming.**

In contrast to CO_2 which remains in the atmosphere and contributes to global warming for several decades, soot is washed out of the atmosphere by rain after just a few days or weeks. In other words, by cutting soot emissions global warming can be reduced far more quickly than by reducing CO_2 emissions. After a few weeks the heating effect of the soot will decrease.

Technically, it is not difficult to reduce soot emissions. Modern trucks, coal-fired power stations and factories have minimal or no soot emissions and direct burning of coal or wood in traditional cooking can be replaced by cleaner alternatives. The challenge is that modern technology is often not available in developing countries where soot emissions are greatest. It is therefore important that rich countries give developing countries economic and technological support for measures that can reduce soot emissions. Reduction of soot emissions is one of the low hanging fruit in the battle for the climate and soot emissions can be reduced by 50 percent by 2030.

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LAUGHING GAS IS NOT SO FUNNY

CLEANER FERTILISER PRODUCTION. Laughing gas is not so funny. In fact, N20, as it is scientifically called, is 310 times more aggressive on the climate than CO_2. Last year, Norway's overall greenhouse gas emissions went down a little, almost entirely because emissions of laughing gas were reduced by as much as 90 percent. The mineral fertiliser manufacturer Yara can take much of the credit for this. The company has developed an almost magical little pellet. Yara's pellet functions as a catalyst which helps separating nitrogen from oxygen. **Thus the emission of laughing gas from the production of artificial fertiliser is reduced by as much as 90 percent.** The technology can be added to existing factories and Yara has already begun to use it in their factories in China. If all mineral fertiliser companies followed Yara's leadership, worldwide emissions of greenhouse gases would be reduced by the equivalent of nearly 100 million tonnes of CO_2. This is twice as much as Norway's total emissions.

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USE SURPLUS HEAT

WASTE HEAT BECOMES ELECTRICITY. Have you noticed that when you charge your mobile phone, it is not only the battery that is charged – the charger itself also becomes hot? This is because the charger is not 100 percent efficient. The same goes for large factories, which due to the nature of the manufacturing processes often waste huge amounts of energy. In fact, it is estimated that the total amount of energy wasted from Norway's factories is between 30 and 35 TWh – about one third of the total energy used. Instead of wasting this energy, we make use of it, for example, for district heating or generating electricity.

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LEARN FROM NATURE'S SYMBIOSIS

INDUSTRIAL SYMBIOSIS. In nature there is no waste. All waste products from one organism are used others. This interaction benefits everyone: it creates symbiosis. Industrial symbiosis imitates nature's collaborative solutions.

Factories need energy, materials and infrastructure to produce useful products, but also waste products. These are often viewed as rubbish that it is both expensive and environmentally damaging to dispose of. The most famous example of symbiosis is the Clownfish who finds shelter amid the sea anemone tentacles (image). **And if we follow nature's example, we find that what for one company is waste can be a useful resource for another.** If several factories are built close to each other, they can share infrastructure and take advantage of each other's waste energy and materials. For instance, a bio-ethanol factory can be located next to a gas-fired power station and use the latter's surplus heat for its production process, a mineral fertiliser factory can use the sulphur from an oil refinery, and so on. Together this means a more effective use of materials and energy.

In Kalundborg in Denmark, seven major companies have got together and established an industrial cluster, reducing their CO_2 emissions by 240 000 tonnes a year. In addition, more than 500 000 tonnes of waste products a year are recycled and three million cubic metres of water re-used every year. As a result of all this, the companies have cut their production costs substantially.

If industrial symbiosis is so good, why does it not happen more often? One reason is that it requires several large companies to coordinate major, commercially sensitive decisions. In addition, it is not always easy to spot opportunities beyond one's own factory gates. But with increased communication on the part of industry and some enabling and coordinating on the part of the authorities, there are good opportunities for more companies to develop more symbiotic relationships – to the benefit of the environment, the climate, and themselves.

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SAME SHIT, NEW WRAPPING

RECYCLING. Only five percent of the energy required to manufacture a new can is used when the same can is recycled. Therefore, an aluminium should never end up as waste on a rubbish tip.

The story of recycling is the story of everything we don't need to do again. Many materials are so good that they can be used over and over. A good example is aluminium, which we use for everything from aeroplanes and cars to pop and beer cans. The environmental benefit from recycling aluminium arises primarily from the amount of energy saved. Re-casting aluminium uses only five percent of the energy taken to manufacture virgin aluminium. In all, about 70 percent of all aluminium is recycled. By maximising recycling of various materials, Norway could reduce its greenhouse-gas emissions by about 10 percent.

> MITT HÅP ER AT HASTIGHETEN PÅ DE ENDRINGENE VI HAR SETT I HOLDNINGER, OPPFATNINGER, FOLKELIG OG POLITISK ENGASJEMENT, OG I NÆRINGSLIVETS DELTAKELSE, VIL FORTSETTE DE NÆRMESTE ÅRENE. DA VIL VI GANSKE SNART FÅ DEN AVTALEN VERDENS BEFOLKNING VIL TRENGE.
>
> Pål Presterud, direktør CICERO

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STOP THE WORST EMITTERS

Photo: Istockphoto

EMISSIONS LIMITS. Solving the climate crisis requires us to use both the stick and the carrot. One kind of stick is to set an Emission Performance Standard (EPS), a method of banning reckless manufacturing processes. Thanks to this type of regulation, the emission of sulphur dioxide in EU countries, which primarily came from large coal-fired power stations and caused acid rain, has been reduced by more than 70 percent in the course of 20 years. In the EU and the USA there is now talk of introducing a similar emissions limit in respect of CO_2 from power stations. In Norway, 99 percent of electricity comes from hydro-electric schemes, but large parts of Europe depend on burning coal and gas to generate electricity. Power stations are responsible for almost a third of the EU's greenhouse-gas emissions. In the EU, Bellona is striving to introduce an emission limit of 150 grams CO_2 per kilowatt hour of electricity produced. In practice, this would mandate CO_2 capture and storage in coal and gas power stations. The limit could initially be set a little higher and apply only to new power stations. But over the next 20 years, all fossil-fuel-fired power generation without CO_2 capture and storage must be phased out in Europe.

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USE THE MONTREAL PROTOCOL

REGULATION OF CFCS. Do you remember the hole in the ozone layer? That we don't hear so much about this anymore is due, in part, to Dr. Mario Molina who received the Nobel Prize in chemistry for his ground-breaking work on how CFC gases affect the ozone layer. Emissions were subsequently regulated by means of the Montreal protocol which, unlike the Kyoto protocol, is a text-book example of how the world community can get together to save the environment. **The ozone layer can probably be declared fully healthy during the course of this century.**

A group of researchers, with Molina in the lead, is now suggesting that we use the same Montreal protocol to regulate the emissions of HFC gases, or Hydro Fluor Carbons. In addition to the more familiar CO_2, methane and laughing gas, there are several other gases emitted by human activity that are disrupting the global climate. One group of them is HFC gases, which were developed to replace ozone gases, especially in air-conditioners. The replacement benefited the ozone layer, but it was later realised that HFCs are very aggressive greenhouse gases. Since air-conditioners have become more and more common, both in industrialised and developing countries, the use of HFCs is expected to rise considerably over the coming years. If nothing is done to avoid it, emissions could increase to as much as 135 giga-tonnnes of CO_2-equivalents by 2050. This is three times as much as today's total emissions of greenhouse gases! If HFC gases are phased out through the Montreal protocol, other, already existing climate-friendly technologies can take over.

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BUMS ON ECO-DESIGN

Photo: Per Øyvind Haugen/Pål Laukli

ENVIRONMENTALLY-AWARE DESIGN. Check the chair you are sitting on. Is it made to be taken apart when it is no longer used? Eco-design ensures that products are made to be recycled.

Raw-material production, be it plastic, steel or food, is energy intensive and therefore the most polluting stage in the product's life cycle. Some raw materials are so valuable that they create fighting and conflict as well as the environmental damage caused by their extraction and production. There are therefore more and more manufacturers who design and manufacture their products on the basis of a different perspective – that the product after its first life should be able to continue to be useful as something else.

"All our chairs are recyclable and are made purely from recycled or renewable materials", explains environmental director Carl Petter Aaser in Håg AS.

Environmentally-friendly product design means that attention is paid to the environment already at the product-development stage. "Five principles govern how we design and manufacture our chairs. They should have low weight, fewer parts, be made of recycled or renewable materials, they should have a long life-span and we think from cradle to cradle throughout the entire production process. It is hard to get hold of enough recycled materials, but the parts from the chairs can be re-used", says Aaser.

The plastic in Håg's chairs originated as bottle tops, some are also from Volvo bumper bars and from shampoo and soap bottles. In Norway, the recycling proportion is over 60 percent but with better incentives, more information and last but not least, better-designed products, it will be possible to achieve a recycling rate of 95 percent.

BUILD FOR THE FUTURE

#6

Buildings are responsible for approximately 40 percent of the world's energy use, and some of the easiest and most substantial cuts can be found in this sector. Energy efficiency produces quick and significant reductions in greenhouse gas emissions, and it nearly always pays for itself. Energy efficiency is the low hanging fruit! This great opportunity is nevertheless generally not pursued.

US President Barack Obama is among those who have realised this. Through "The American Recovery and Reinvestment Act of 2009" he has introduced a 30 percent tax deduction on investments relating to a number of energy-efficiency measures and has increased the grant limit from $500 to $1,500. In addition, there is no upper limit to the tax deduction for those measures that require large investments. Replacing windows and doors, insulation, roofing, various heat pumps, hot-water tanks, bio energy heating, various heating and ventilation systems, solar panels, sun traps and mini wind turbines are included in the measures covered by the scheme. Commercial buildings receive a grant per square metre if they reduce energy consumption.

Photo: Istockphoto

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ENERGY-PLUS HOUSES

Photo Thomas Ott

ENERGY PLUS HOUSES. Many houses are built with little thought to their life cycle energy costs. When a property developer is looking to earn as much as possible from the sale of houses, it does not pay to make extra investments in energy-sparing and efficiency measures. It is not the developer who pays the fuel bills, after all.

There are alternatives to today's energy-consuming houses, including houses built not only to save power but to produce it as well. There is long-standing interest in energy efficient houses in Europe, but now there is increasing interest in so-called energy plus houses, which generate more energy than they consume. Such houses are being built in a number of countries, including the much discussed Freiburg project in Germany, where the terraced houses are roofed with solar panels. The buildings are far better insulated than the norm and have a whole house heat recovery ventilation system. Most energy plus houses in Europe are based on solar panels, thanks to good grant programs for solar energy. In Britain, a number of public buildings and housing complexes in recent years have been equipped with their own energy yielding wind turbines either mounted on the roof, or erected on the grounds.

Saving electricity is both sensible and necessary for reducing CO_2 emissions. The European Parliament and the Council reached an agreement on energy performance of buildings November 18 2009 that fixes 2020 as deadline for all new buildings to be nearly zero energy buildings.

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LIVE GREEN – PAY LESS

Photo Smakrat(49)

TAX DEDUCTIONS, SUBSIDIES AND CERTIFICATES. In Germany for energy-saving projects, loans are available at a 1.6 percent interest rate, and in France for no interest. The loans run for 15 years and are for amounts up to 20,000 and 30,000. This money can be used to install a heat pump and additional insulation – and typically halves the energy consumption. Rather than paying for electricity, one repays the loan. Money and energy are saved.

Another incentive is "white certificates", where energy companies are obligated to save a certain amount of energy. Rather than achieving the savings themselves, the company can buy certificates which document energy-reduction measures that have been carried out elsewhere – for instance by a housing cooperative that has installed additional insulation or a control system.

White certificates have been introduced in several countries in Europe, though implemented differently. In France the scheme has cut 56 TWh, which is the equivalent of the electricity produced in 16 gas-fired power stations.

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CONTROL FREAKS!

Photo Istockphoto

CONTROL SYSTEMS FOR ELECTRICITY. Everything can be controlled. By simply pressing a few buttons you can program room temperatures to automatically lower while you are asleep or at work. Lights turn off, electronic devices go on standby and water pipes close. You save electricity and money. **Experience shows that just measuring energy consumption reduces it by 10 – 20 percent.**

According to Enova, a programmable heating control panel is ideal for people living in houses that can be divided into several heat zones, or for people with a lifestyle that makes it possible to reduce the temperature for periods of five hours or more. A programmable heating control panel can reduce consumption by approximately 20 percent. Bellona's new office building in Oslo, which will be completed in Autumn 2010, will have a control system for heating, lighting and ventilation so that heat, light and air will only be used when necessary.

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SAVING ENERGY AND THE INTERNET

Photo Istockphoto

LESS IT WASTE. You may turn off the lights, but are you saving with Internet use? The Internet's steadily increasing demand for electricity is a great challenge. Some people believe that the Internet has become too popular and is in danger of causing its own downfall. A study commissioned by the US Environmental Protection Agency estimates that the USA's data servers used 61 billion kilowatt hours in 2006. This represents 1.5 percent of the USA's total electricity consumption. **Every time you Google something, you create 0.2 grams of CO_2 emissions.** This does not sound like a lot – until you multiply it by over 200 million! That's how many people Google every day.

Some companies are now considering locating their data equipment at sea, so they can exploit wave or tidal energy to meet power needs, and use sea water to cool the systems down. Fortunately, there are many intelligent solutions to reduce energy waste from IT systems. But some of these techniques require planning. A well-designed computer room can use up to 30 percent less energy in comparison with a poorly-designed room. Servers and PCs generate heat and in the average server room over half of the energy is used for cooling purposes. One solution is to use the surplus heat, for instance, to heat the building or other buildings by means of centralised heating.

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GREEN WHITE GOODS

Photo Istockphoto

REPLACE APPLIANCES AND ELECTRONIC ITEMS. In Scandinavia, electrical appliances are responsible for approximately ten percent of electricity consumption in private homes. Old appliances often use twice as much energy and water as their modern counterparts.

According to Elsparefonden in Denmark, the average age of Danish household appliances is now ten years. If you have old white goods at home, you will save money and protect the environment by exchanging them for new ones. **If all households in Europe changed to category A refrigerators and freezers, total energy consumption would be reduced by more than the total electricity consumption of Denmark.**

Energy marking of household appliances has existed for 15 years in the EU and 12 years in Norway. During this time, white goods have become significantly more energy efficient. Today it is hard to find white goods with a lower energy rating than C in Norwegian stores, and within the next few years B and C-rated goods are also likely to disappear. Refrigerators and freezers are now actually sold with energy rating A++. An A++-rated refrigerator uses about 50 percent less electricity than a B-rated one.

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REPLACE WITH LED

ENERGY-EFFICIENT LIGHTING. Lighting is responsible for about ten percent of electricity use in Scandinavia.

A LED light (light-emitting diodes) lasts for 50 000 - 100 000 hours and uses up to 80 percent less energy than an incandescent light bulb. LED lights are expected to form about 90 percent of the market by 2020.

Using LED also eliminates another problem; heat. For example, most stores produce a great deal of excess heat, but it is more desirable for lighting to generate as little heat as possible, particularly in warmer parts of the world. If all Norwegian households changed six of their light bulbs to energy-saving bulbs, Norway would save the same amount of electricity as the total annual electricity consumption of Tromsø.

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THINGS THAT LAST. GET A NEW MODEL!

LIFE CYCLE ANALYSIS. Things we use often have a much longer lifespan than we think. Energy and raw materials are derived from the natural world and used to manufacture materials and goods. These are then transported around the world by ship, train and truck before they arrive in the store. After we have owned them for a while, they end up in the trash, or are recycled.

Life cycle analysis is a matter of studying the use of resources and energy, and its consequences for the climate and environment, throughout the entire life cycle of a product. Such analyses can often give surprising results. Did you know, for instance, that over 80 percent of the energy use in the life cycle of a computer, or mobile phone, occurs before you have even taken it out of its box and plugged it in? For washing machines the opposite is true: By far the greater part of its energy use occurs during the years it is being used.

This information is useful both to governments, companies and to consumers who want to reduce the effect their lifestyle has on the climate and the environment. While it is environmentally effective to retain your mobile phone another year, it will often be better for the environment to switch your washing machine for a new and more efficient one that uses less electricity. Something to keep in mind!

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BRING IN THE BATHWATER

RECOVER THE HEAT FROM USED WATER. Heating water is responsible for half of the energy use in a house. But once you've used it, the water runs away down the drain. The heat could have been used to pre-heat the new cold water that is on its way in. In Canada, grants are available for installing heat recovery systems for showers to capture this heat.

This is how the system works: **Waste water from the shower passes through a copper drain pipe and "clings" to the sides, transferring the heat to the metal.** A thin copper pipe supplying fresh, cold water is coiled around the drainpipe. So the cold water is not in direct contact with the waste water but is still able to absorb its heat. The cold water enters the house at perhaps 10 degrees Celsius, but the absorbed heat from the waste water has raised its temperature by about 10 to 20 degrees Celsius before the water arrives in the hot-water tank.

It is also possible to use a heat pump to recover the heat from waste water. A water-to-water heat pump requires large amounts of water to be profitable, and is therefore mostly used in high volume situations like housing complexes or commercial kitchens. Husby Amfi in Stjørdal in Nord-Trøndelag, Norway consists of 56 low-energy houses which recover heat from waste water. To heat the tap water, planners chose a solution not previously used in Norwegian housing. The water is heated by a heat pump which absorbs the heat from all wastewater other than from toilets. This heat source makes the heat pump extra-effective: one kilowatt-hour of electricity produces five kilowatt-hours of heat

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TURN OFF THE TAP

SAVE WATER. Substantial resources are used to bring water to the world's population and as a result of climate change access to clean water will become even more unevenly distributed.

OECD countries have a consumption per inhabitant of over 100 litres of water a day, in the U.S. it is 330 litres, whereas in developing countries it is only 10 litres. When a toilet in the western world is flushed twice, it uses as much water as a person in a developing country uses in an entire day for food, drink and washing. If you shorten your daily shower by one minute you can save 3 300 litres of water a year and 200 kilowatt hours of energy.

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TURN IT OFF!

USE THE OFF BUTTON. The amount of electricity that is used on standby mode varies between equipment, but the combined consumption is enormous. The British Department of the Environment has calculated that the UK could reduce CO_2 emissions by 3.5 million tonnes by avoiding the use of standby mode. As much as eight percent of the country's electricity consumption goes on standby. In Denmark, the proportion is seven percent and in Sweden research has been carried out showing that the use of standby increases an average family's annual electricity bill by 1500 NOK.

> I KØBENHAVN ER VI STOLTE AV VÅRES FLOTTE RESULTATER MED SYKLER OG FJERNVARME. NÆR 40 PROSENT AV KØBENHAVNERNE SYKLER TIL OG FRA ARBEID ELLER STUDIER HVER DAG, OG NESTEN ALLE FÅR VARME GJENNOM FJERNVARMESYSTEMET. DET MERKES PÅ CO_2-REGNSKAPET.
>
> Ritt Bjerregard, Københavns Overborgermester

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WITH LAW IN HAND

Photo: Solar Decathlon/US Department of Energy

ENERGY LABELLING. The houses that are being built today will still be standing in 50 - 60 years or more. By that time, the global CO_2 emissions should have been reduced by 85 percent. According to the research institute Ecofys, the EU could save 460 million tonnes of CO_2 per year if all buildings being renovated were to be upgraded to current energy efficiency standards. This is as much as the total annual emissions of Italy.

Many initiatives to cut energy consumption in buildings are inexpensive. It is also not necessarily more expensive to build better. An effective way to sharpen the focus on energy use in buildings is to introduce energy labels, or certificates like we have on appliances. Energy certificates for houses are well established in the EU and will be introduced in Norway in 2010. Under the new law, all houses that are sold or rented must have a certificate rating the energy-consumption class on a scale from A to G. The certificates, or grades, will give homeowners a better idea of their energy use, thus leading to energy savings. If you are building a new house, it is worth knowing that energy grade B involves reduction of energy consumption by a quarter without costing appreciably more than a building with a far poorer energy rating. Achieving energy grade A involves a more expensive construction process, but the resulting energy savings will more than pay for the extra cost in the long run.

For new buildings, laws and regulations are the best way to create new standards and provide a long term and predictable framework. If one is to fulfill the full energy efficiency potential of existing buildings, then subsidies and/or other incentives are necessary to encourage initiatives such as additional wall and loft insulation, installation of heat pumps or replacement of windows.

Governments need to lead by example. Building regulations could be stricter for public buildings than for private ones, since many buildings are publicly owned. This would influence the rest of the building trade, encourage new technology and increase the skills of architects, engineers and builders. But the public sector lacks incentives to reduce energy consumption. Investment budgets are separate from operational budgets and lower energy costs reduce operating budgets. In France, 12 percent of the building volume in the entire country is publicly owned, and the French government has decided that it will double the number of old buildings to be renovated every year. This means that 400,000 buildings a year will have their energy loss and CO_2 emissions reduced, saving the tax payers large sums over many years.

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STAY OUT OF THE COLD

Photo Rockwool

BETTER INSULATION. Do you think your electricity bill is too high? Much of what you are paying for probably leaks straight out through walls and windows if your home is not properly insulated.

Many houses, even relatively new ones, are poorly insulated. A good and correctly insulated house maintains its temperature better and does not have problems with draughty floors and uneven room temperatures. At the same time, energy consumption is reduced and both carbon emissions and heating costs go down. **The Climate Map by McKinsey/Vattenfall has documented that globally, proper insulation could save 1,6 gigatonnes of CO_2 each year.** This is the equivalent of Russia's entire CO_2 emissions.

80

GET DRESSED

Photo Istockphoto

SAVE ON HEATING INDOORS. Put on an extra sweater. When New Scientist wrote about ten things we can do to save the world, the first tip was: Dress according to the weather. Don't walk around the house in a T-shirt when the snow is drifting outside! Lowering the room temperature by one degree reduces energy consumption by five percent.

81

TAKE YOUR TIE OFF

Photo Istockphoto

SAVE ON COOLING. In most places people dress according to the conditions, but not everywhere. Japan has a strong tradition that bind businessmen to the same dress code all year round, winter and summer. But five years ago the government launched a cool biz-campaign with the slogan "no jacket, no tie". The campaign was aimed at saving energy on air conditioning as well as reducing greenhouse gas emissions. The Japanese summer is extremely warm and damp, but this does not stop businessmen from turning up in a vest – because of social etiquette. The official cool biz-period lasts for four months, from June to September, and participating public offices and private companies do not push the thermometer under 28 degrees. South Korea's Ministry of Environment and the British Trades Union Congress have had their own cool biz-campaigns since 2006.

In some of the world's biggest economies, such as the USA, China and India, it is expected that consumption from air conditioning will triple by 2030, according to the McKinsey/Vattenfalls Climate Map. American houses are now on average twice as big as European ones, and almost eight out of ten are equipped with air conditioning.

GOLD IN GREEN FORESTS

#7

Every single day, metre upon metre of the world's largest onshore carbon sink – the rainforest – is destroyed. At the same time, increased global food production produces increased greenhouse-gas emissions from an agricultural sector that has to continually grow to feed the nine billion people who will inhabit the earth in 2050.

Biomass represents both the challenge and the solution to the climate problem. We have to let the rainforest remain and strengthen the rights of the local population that guards it. We have to use agricultural waste to create new energy and we also have to reduce the emissions of greenhouse gases currently being created on such a large scale by the world's food producers.

Photo: iStockphoto

Photo Istockphoto

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THE EARTH'S TREASURE CHEST

PRESERVE THE TROPICAL FORESTS. Over two million square kilometres of the world's tropical forests have been lost since 1990, as much as half the land area of the EU. This forest probably stored 20 billion tonnes of carbon which is 12 times as much as the US's annual CO_2 emissions. **For the world, the rainforest is not only an important regulator of weather and precipitation, but also a treasure chest of biodiversity.**

Felling and burning of forests accounts for nearly a fifth of annual global emissions of greenhouse gases. In short, when trees are chopped down and burned, carbonates that were bound up in the tree are released as CO_2. In addition, the former rainforest floor gives off large amounts of CO_2 and methane. The loss of tropical forests therefore represents a double blow for the climate: large amounts of CO_2 are released and at the same time we lose one of the most important stores of CO_2.

Both Norway and the EU have set a goal of limiting global warming to two degrees Celsius in order to avoid the most dangerous and dramatic consequences of climate change. To achieve this goal, global emissions must be reduced substantially and quickly. One measure that can be carried out relatively inexpensively in the short term is to ensure that the tropical forests remain intact and continue to bind the carbonate rather than releasing it into the atmosphere.

Dense, virgin rainforest stores more carbon than other types of forest. The most important rainforest countries – Brazil, Bolivia, the Democratic Republic of Congo, Cameroon, Ghana, Papua New Guinea, Indonesia and Malaya – are responsible for as much as 70 percent of greenhouse gas emissions from deforestation. It is therefore possible to concentrate efforts and achieve large reductions in emissions. Brazil has more rainforest than any other country in the world. Since its peak deforestation in 2005 the country has more than halved its deforestation of rainforest – and stopped over a billion tonnes of CO_2 from being released into the atmosphere, according to the Rainforest Foundation Norway. In 2008, Brazil set a target of reducing deforestation by 80 percent by 2020. The country has established a dedicated fund to finance the control of deforestation and to promote the maintenance and sustainable use of the forest.

According to the well-known British economist Nicholas Stern, reduction in deforestation is the most cost-effective method of cutting greenhouse gas emissions. He estimates that it will cost five billion US dollars a year to halve deforestation and thus reduce global greenhouse gas emissions by about ten percent. Even though many believe that these estimates are too low, there is broad agreement that reducing emissions from deforestation is a relatively inexpensive method of cutting greenhouse gas emissions that will yield great rewards in other environmental respects as well.

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IT COSTS TO SAVE

ALL CHIP IN. If rainforest countries are to allow their forests to remain, rich countries must help pay the bill. It costs money to save the rainforests.

Not long ago, Sumatra was covered by thick rainforest. Most of this species-rich, irreplaceable rainforest is now gone. The Sumatran Tiger is almost extinct, as is a large number of other unique species that depended on the rainforest for their survival. The destruction of the rainforests has made Indonesia one of the world's worst climate-polluting countries. When emissions from deforestation are taken into account, the country is in third place on the worldwide list of emissions, with only the US and China releasing more greenhouse gases each year.

But there is a reason that the rainforest is being cut down. Locally, the financial rewards are great. For this reason, countries with rainforests and the people who live in the forests must be compensated for keeping the forest intact as a global reservoir for carbon and biodiversity. It must be as profitable for the local population to allow the forest to stand as it is for them to cut it down. Rainforest countries are dependent upon rich countries to help them cover the costs of looking after the forest. The Norwegian government's finance initiative, which allocates up to three billion kroner a year to conserving the forest, is an important start towards an international finance programme of this sort. Even if we must accept footing the greater part of the bill, the reward is a relatively inexpensive reduction in greenhouse gas emissions.

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A CLIMATE AGREEMENT FOR THE RAINFOREST

FORESTRY INTO THE AGREEMENT. A future international climate agreement must include forest conservation, but this must occur in addition to pronounced emission cuts in other sectors.

The goal to keep the global temperature increase at two degrees Celsius requires very rapid cuts in emissions. Careful forestry management can make a contribution to this goal. **While it may take a long time before widespread implementation of climate-friendly technology is a reality, the chain saw or bulldozer that is attacking the rainforest can be stopped straight away.**

It is in the tropics that the forests are disappearing rapidly: about 130 000 square kilometres are destroyed every year. Like the Arctic, the rainforests are very vulnerable to climate change. A rise in temperature of between one and three degrees will turn large parts of the Amazon, the largest rainforest in the world, into a savannah. It is estimated that an emissions reduction of seven billion tonnes of CO_2 equivalents is attainable by 2015 through measures to reduce deforestation. Within the existing international climate convention there are no initiatives or mechanisms for reducing deforestation, even though this sector is responsible for nearly a fifth of the world's overall greenhouse gas emissions. The renewed agreement that will run from 2013 must encompass emissions from deforestation. This requires commitments from heavily forested developing countries and financial support from industrial nations.

> NESTEN 18 PROSENT AV DE GLOBALE UTSLIPPENE KOMMER FRA ØDELEGGELSE AV SKOG I UTVIKLINGSLAND. AVSKOGING MÅ DERFOR INKLUDERES I KLIMAAVTALEN DERSOM VI SKAL LYKKES MED Å BEGRENSE DEN GLOBALE OPPVARMINGEN.
>
> Gro Harlem Brundtland, Tidligere statsminister og WHO-direktør

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PLANT A TREE

Photo: Wanjira Mathai/Green Belt Movement

PLANTING FORESTS. The world's forests and seas form the earth's great carbon stores. The Green Belt Movement of Nobel Prize winner Wangari Maathai (illustration) has 4000 local activist groups who plant trees – both to slow down climate change and to enable us to adapt to it as easily as possible. The movement believes that planting and protecting forests is a vital part of the battle against global warming.

Trees and other forest plants consume CO_2 to grow and live. The more forest there is on the earth, the more CO_2 will be bound up. This CO_2 would otherwise exacerbate the greenhouse effect. The potential for forestation is great. The UN climate panel has estimated that in 2030 we could bind up to 50 times Norway's emissions just through forestation.

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STOP DIRTY INVESTMENTS

Photo: Istockphoto

PULL THE OIL FUND OUT OF THE RAINFOREST. Norway is among those pressing for the protection of the rainforests. At the same time, during 2008, Norway invested 8.7 billion kroner in companies that are destroying the rainforest.

Powerful economic interests within the forestry industry, plantation sector, industrial agriculture and the petroleum sector are some of the forces behind the destruction of the world's rainforests. **One of the solutions to the environmental crisis is to make wealthy capital funds, such as the Norwegian Government Pension Fund – Global (the "Petroleum Fund"), refrain from investing in companies that are damaging rainforests.** The Norwegian Petroleum Fund is amongst the largest in the world. In 2008 the fund invested at least 8.7 billion kroner in some of the world's most aggressive companies in terms of damaging rainforests, according to Rainforest Foundation Norway. These include the logging companies Samling (Malaysia) and Olam (Singapore), the palm oil company Wilmar International (Singapore), as well as the three oil companies Repsol (Spania), Occidental (USA) and Chevron (USA). The Petroleum Fund has increased its investments in these companies form 4.8 billion kroner in 2007 to 8.7 billion kroner in 2008.

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GET THE RAINFOREST OUT OF YOUR HOUSE

DO NOT BUY DESTROYED RAINFORESTS. Even though it looks beautiful, a square meter of mahogany can mean many times its own size in destroyed rainforest.

Harvesting the most valuable types of wood in the forest, such as mahogany, is often the first stage of deforestation. For every tree that is cut down, at least another ten surrounding trees are destroyed. In Norway we steadily import less wood from the rainforests and most of us think that it is not possible to buy trees from the rainforest from Norwegian dealers. Unfortunately, this is not the case. Every year, a significant amount of tropical wood is imported into Norway and other European countries. The wood that is sold includes teak from Burma, the location of Asia's last great natural teak forest. According to the Rainforest Foundation Norway, there are no labelling systems for tropical timber that can guarantee that the goods you are buying have not come from a destroyed rainforest. To be sure that your internal décor does not contribute to deforestation and increased greenhouse gas emissions you should not use tropical timbers. At www.regnskog.no you can find a list of the various types of wood from the rainforest.

Photo: Istockphoto

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WOOD FOR MOST PURPOSES

PLANNED BIOUSE. Is there any substance we can use to make anything from ice cream and chocolate to batteries, clothes and cement? The answer is actually yes – a tree trunk!

Trees and other so-called biomass are a fantastic resource. They can not only be used to generate environmentally-friendly energy. The Borregaard company in Sarpsborg, Norway specialises in getting as much as possible out of tree trunks before the last bits go to produce heat. For example, from a tree trunk they can manufacture environmentally-friendly biofuel which can replace polluting petrol and diesel. **20 of Oslo's local buses already run on ethanol from Borregaard.** The company also makes ingredients for paints, which otherwise would have been produced from oil, as well as heat which can replace dirty oil-based heating. Another product they make is vanilla, a flavouring used in ice cream and chocolate.

Much of this would otherwise have been produced with the aid of oil. All plastic products use carbon as a building block. Today, plastic is made mainly from fossil-based materials such as oil, but in the future it can be made from biomass.

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THE NEW BLACK GOLD

BIOCHAR IS SEEN BY MANY SCIENTISTS and policy makers as a promising solution for climate change mitigation and adaptation. Some even argue that biochar is a so-called fast mitigation measure – one that can achieve deep, early reductions of greenhouse gases. Biochar is a fine grained, charcoal-like product obtained when biomass is heated in a closed container with limited supply of air. The method is called pyrolysis.

The biochar is then applied to soils. This becomes a climate mitigation measure since the carbon will stay in the soil for hundreds to thousands of years. New plants will grow and absorb CO_2 and one can speak of a carbon negative cycle; removing CO_2 from the atmosphere and putting it in the soil.

Adding carbon to soil has several benefits; it retains water and nutrients which leads to increased yields and plant growth. **It also reduces emissions of nitrous oxide - a greenhouse gas that is released from farmland, and some trials show that the use of biochar in agriculture could reduce the need for artificial fertilizer.**

Adding carbon to soil is nothing new, deep in the Amazon there are layers of very fertile, carbon rich soils that were produced by ancient human settlements dating back thousands of years. It seems that these settlements lived off the land by "slashing and charring" biomass out of the forest as opposed to the "slash and burn" method which is not sustainable but damages the forest and climate. Today there are pilot projects in Africa that produce biochar from agricultural waste that would otherwise release greenhouse gases when it decomposes. 16 African and Latin-American countries, as well as Australia, have made submissions to the UN's climate panel to include biochar in a post-2012 climate agreement.

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A POTENT ENVIRONMENTAL COCKTAIL

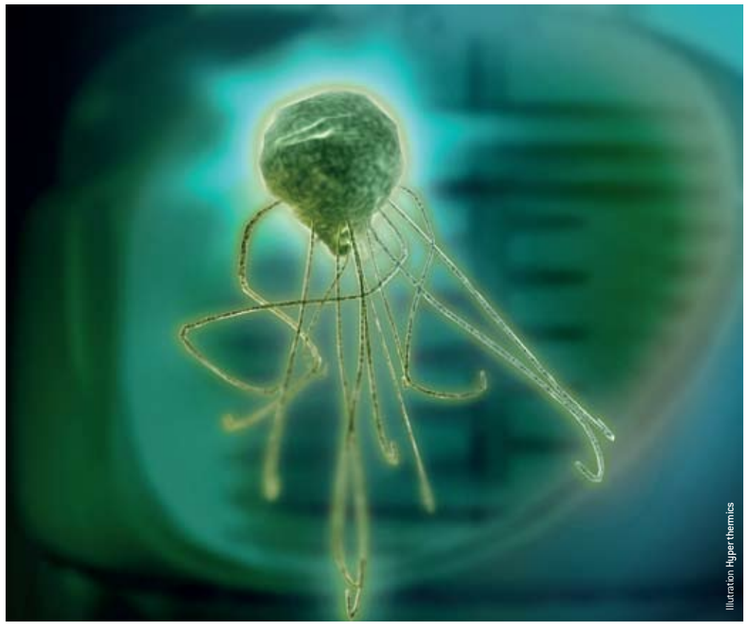
Illustration: Hyperthermics

BIOGAS. Thermophile bacteria don't look pleasant, but there is much evidence that they can be good for the environment by accelerating the production of biogas.

In Sweden, over 15 000 cars run on biogas, and by 2010 all petrol stations must supply bio-gas or bio-ethanol. Biogas from wet organic waste such as animal droppings and food waste is relatively simple to produce. It can be used for heating, or it can be upgraded to fuel – and in addition the by-products are ideal for soil improvement.

Recently, the presence of certain bacteria has also aroused interest in biogas. The Norwegian firm Hyperthermics has discovered that thermophile bacteria, small creatures that are most comfortable in high temperatures, can accelerate the biogas process. By adding thermophile bacteria to the biomass in a biogas reactor and increasing the temperature to between 80 and 90 degrees centigrade, biogas is formed ten times as quickly with less energy use. Such a substantial reduction of time and money used in the production process is being viewed with great interest.

Nevertheless, for many countries the first priority is to put in place an infrastructure and a system for the production and use of biogas. In Norway, the potential is still great. The Bellona Foundation has estimated that if as much as 60 percent of the country's farm animal slurry was collected for biogas production, agricultural emissions could be cut by 12 percent.

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MEAT-FREE MONDAY

Photo: Scanpix

EAT LESS MEAT. Sir Paul McCartney (illustration) has been a vegetarian for many years. Together with his two daughters he is backing the "meat-free Monday" campaign, which encourages people to have one day a week without meat on the menu.

Meat production is generally more damaging for the climate than the production of fruit and vegetables because farm animals emit more methane and nitrous oxide, which are far more powerful greenhouse gases than CO_2. In addition, the animals eat food that people could have eaten directly. **If people cut down on meat consumption, land areas could be freed up for food cultivation.** This is particularly important because we will need more food in future years to feed the growing global population. The UN fears that as many as 370 million people could starve by 2050.

Greenhouse gas emissions from Norwegian agriculture consist of about half methane and half nitrous oxide.

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GAS IS NO LAUGHING MATTER

Photo: Istockphoto

OPTIMISED FERTILIZER USE. Agriculture uses more fertiliser than necessary. This results in unnecessary emissions of the powerful greenhouse gas nitrous oxide.

Nitrous oxide, better known as laughing gas, is 310 times more powerful a greenhouse gas than CO_2. For this reason, a small reduction in emissions can produce a large positive effect on the environmental balance. **Agriculture is responsible for nearly half of all nitrous oxide emissions in Norway, and fertilizer is responsible for over a half of this.** This is because the slurry consists of nitrogen, among other things, which forms nitrous oxide once it comes into contact with the air.

Some fertilising for agriculture cannot be avoided, but at the same time we know that a great deal of it can be cut out without a negative effect on crops. According to the research institute Bioforsk, the wheat grown in Norway is over-fertilised by at least 15 percent.

WE ARE THE WORLD

#8

If global warming is to be halted, the world's economy will have to undergo a major adjustment, and it will have to happen quickly. From the board rooms of global companies to our own kitchen tables, decisions need to be taken that will involve change. This will not happen without strong political leadership. Never has the need for real statesmanship been stronger

According to the leader of the Intergovernmental Panel of Climate Change (IPPC), Rajendra Kumar Pachauri, the next four years will determine whether the world will manage to tackle the climate crisis. If we do not succeed, the consequences will be extremely serious for large parts of the earth's population in generations to come.

It is easy to assume that cuts in emissions are expensive and will threaten the economy, employment and welfare. It will not be cheap, but the alternatives are much more expensive. On behalf of the British government, the well-known economist Lord Nicholas Stern produced the Stern report, the most extensive and most reliable piece of work that has been carried out to establish the costs of global warming. The conclusion is clear. The financial loss caused by not implementing measures would be the equivalent of a 5-20 percent reduction in the gross world product now and for all time. Carrying out work to limit global warming is far cheaper. According to Stern, around two percent of the gross world product must be used annually to ensure that global warming does not exceed 2 – 2.4°C.

Photo istockphoto

Photo: Istockphoto

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ALL PULL TOGETHER

INTERNATIONAL AGREEMENTS. A global problem requires global solutions and depends on international cooperation. It is a significant challenge that international cooperation requires time and patience, tolerance and cultural understanding. For instance, during international negotiations, in relation to trade and resources, it is customary that one party will only assume a responsibility if the other reciprocates. **The "wait and see" tactic can be effective in some situations, but it is unsuited to international climate negotiations when our future is at stake.**

There is no possible compromise in respect of CO_2 levels in the atmosphere: the world has an absolute level that has to be in place. For this reason, climate negotiations are not like other negotiations. Delays in the reduction of emissions and weakness of ambition can be measured directly in terms of thinner ice, higher average temperatures and more extreme weather. Climate change is occurring more quickly than previously assumed. Many people are already feeling the effects of it and are becoming climate refugees.

Fairness is a central issue in negotiations on a new climate agreement. Should a country's present level of emissions be taken as a starting point, or should the right to emit CO_2 be divided equally amongst all the people of the world? In a historical perspective, the rich countries have already used up their "quotas" and have in fact created the climate crisis. The poor countries have, up to the present day, released minimal quantities of greenhouses gases into the atmosphere, and must be given the opportunity to increase their standard of living. Poorer countries need financial support from the rich countries to achieve clean growth.

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LIMIT THE FESTIVITIES

EMISSIONS TRADING. Norway's Prime Minister Jens Stoltenberg compares the CO_2 emission trading system with drinks vouchers at a company party. The simplest way to cut emissions is to set a limit on how much can be emitted. Since last year's party ended up as a drunken orgy, the management have decided that alcohol consumption should be restricted somewhat this year. Therefore they issue fewer drinks vouchers.

The emission trading system works in the same way. The fewer the vouchers, the lower the emissions – even if some of the party-guests trade vouchers between themselves. What counts is the total CO_2 emission. The authorities issue allowances that are lower than the expected emission from companies, which means that the companies must either reduce their emissions or buy allowances from someone that has managed to reduce its emissions. **The system puts a price on pollution and a financial gain is derived from cutting emissions.** In the CO_2 market, competition will help ensure that the cheapest measures are carried out first. Europe has had emission trading for power stations and for some industrial sectors since 2005.

But if the emission trading is really to do its' job, all countries and all sectors must be subject to it, so that commercial advantage will not be gained by establishing plants overseas. The emissions limit must also be credible and long-term. If investors are to buy expensive zero-emission technology they must feel sure that climate policy will maintain a steady course over the next 20-30 years. Even a good "cap-and-trade" system has its limitations. The market chooses the cheapest solutions first – and defers the more expensive ones. This can cost precious time when we really need major cuts in emissions quickly.

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SPREADING YOUR BETS

OTHER MEASURES. A rigid, global "cap-and-trade" system is a good means of attaining a cut in emissions. It is a real challenge for the countries of the world to reach such an agreement, and hence it is very unlikely to be realised in the next few years. Regional CO_2-markets, such as the one in the EU, are a good start, but sadly, have their limitations. The EU has to take into account that high emission costs and energy prices in Europe may lead to jobs and emissions being moved out of the EU countries. There may be other barriers that prevent change. Even today there are many examples of profitable energy-efficiency measures that are not implemented.

In order to get on with necessary changes it is important to implement other measures in addition to emission trading. Subsidies can give a kick-start to the necessary development of renewable energy production. Even now, individual countries, for example, can introduce taxation on fossil fuel energy for heating, and thereby make bio-energy and heat pumps profitable. Strict requirements for energy solutions in new buildings, equipment, machines and vehicles can be made through laws and regulations. With a "carrot and stick" approach, combined with a great deal of creativity, important changes can start today.

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CLEAN DEVELOPMENT MECHANISM

CDM. The clean development mechanism (CDM) is one of three flexible mechanisms under the Kyoto Protocol.

CDM allows industrialized countries with a greenhouse gas reduction commitment to invest in ventures that reduce emissions in developing countries as an alternative to more expensive emission reductions in their own countries. Private companies and organisations can also invest in, and carry out such projects in developing countries. To be approved as a CDM project, certain criteria must be fulfilled, including documentary evidence that the project would not have come to fruition without the CDM mechanism. An independent third party must also check the project plan before it can be approved by the CDM Executive Board in the UN.

The project is monitored and approved by an independent body, which ensures measurable, genuine reductions in emissions in-line with the approved project plan. The CDM Executive Board then issues a certified emission right to the investing party. The number of emission rights corresponds directly to the number of tonnes of greenhouse-gas emissions reduced.

As an example India has a great potential for wind power, but the initial investment costs have been too high. Due to CDM credits the Satara and Supa wind parks in India have recently been realised. Through financial support, it has been possible for the developer to make the project profitable.

97
MIMIC THATCHER

Photo Scanpix

FORBID SUBSIDIES FOR FOSSIL-BASED ENERGY. Margaret Thatcher did it in Britain in the mid-1980s, when she removed subsidies from unprofitable coalmines. Today, the American president, Barack Obama is following in her footsteps in asking the G20 countries to join him in forbidding the subsidy of coal, oil and gas.

The world spends about 300 billion dollars a year on subsidising petrol. Consumption rises because the prices are artificially low, and emissions are therefore greater than necessary. Removing such subsidies by 2020 will reduce global CO_2-emission by ten percent within 2050, according to the International Energy Agency (IEA) and the OECD.

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GREEN REVOLUTION

Photo Istockphoto

SUPPORTING TECHNOLOGY. Without public subsidies, solar cells would still be restricted to cabins and sailboats!

The world needs new technologies to solve the climate problem. In this magazine we present many technological solutions. Some have already been taken in use, and others will become profitable, as soon as restrictions are placed on the use of fossil fuels. But many important technologies face demanding barriers: The need for research, expensive test sites and most importantly the lack of public subsidies. Today many promising technologies might end up in a desk drawer, because of lack of political support. To realize a new clean technological revolution, a helping governmental hand is required.

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WANTED: LEADERS WITH COURAGE

POLITICAL COURAGE. The biggest threat to the climate is lack of commitment. Many might believe that it's all going to be OK, but in fact the challenges we are facing require an extraordinary effort – now. For this reason, the world needs courageous national leaders more than ever to lead the way. Those who dare to go ahead and accept responsibility, and initiate significant cuts in emissions even if others do not do the same. Our earth needs an ambitious climate agreement. But we will not get one without someone taking the first step. This requires swimming against the current. Taking unpopular decisions. And thinking further ahead than the next opinion poll and election.

> KLIMAUTFORDRINGEN KREVER EN NY VERDENSORDNING. STRUKTURENE FRA ANDRE VERDENSKRIG MÅ VIKE PLASS FOR NOE NYTT. DEMOKRATIETS PRINSIPP OM ÉN MANN ÉN STEMME MÅ AVSPEILES.
>
> Göran Person, tidligere statsminister i Sverige

100
SPREAD THE WORD

Photo Istockphoto

CLIMATE EDUCATION. Climate knowledge must be included in all education. Architects and craftsmen must learn what effect their choice of materials and energy use may do to the climate. Life-cycle analysis must be included in the curriculum for all types of courses.

Climate Teachers is a teachers' network established by the Danish ministry of education in advance of the UN's climate conference in Copenhagen. Its mandate is to ensure that children and young people acquire knowledge of the challenges to the climate. The Teachers' Network offers access to the latest and most relevant climate-teaching material. Conferences are also arranged which provide inspiration for climate teachers all over Denmark. To become a Climate Teacher is free of charge, and over 2000 have so far signed up. Such a good initiative should be implemented globally.

101
NOT JUST RUBBISH

Photo Istockphoto

EXTENDED PRODUCER RESPONSIBILITY. Waste is and will remain a valuable resource that can save tons of greenhouse gas emissions.

Every Norwegian throws away 428 kilograms of rubbish a year, and this is only a quarter of the country's total rubbish produced every single year. Rubbish is defined as: everything we ever have bought, or received that has lost its purpose for us as individuals. It does not, however, mean that rubbish is without value. On the contrary, it is a valuable resource if recycled. **One of the solutions to the waste heap, and also to the climate crisis is to extend the responsibility of the manufacturer, so that it applies also to the waste treatment of its products.**

This is called Extended Producer Responsibility (EPR). The logic is simple: if one manufactures something then one is also responsible for the product's environmental damage, after it has ended up as rubbish. This involves the manufacturer taking the economic responsibility for the waste treatment. When the producer responsibility is truly effective, products are designed to last from cradle to cradle, not just from cradle to grave. The climate benefits vary. For glass, several hundred kilos of CO_2 are saved for every tonne we recycle, whilst we can save up to 20 tonnes of CO_2 per tonne of copper. For this reason, politicians need to dare to make tough demands – and follow up on them so that the products we make are for the future, not for the scrap heap.

thanks

1
LIMITLESS CLEAN POWER

Sun, wind and water: Renewable energy sources are inexhaustible and non-polluting. These sustainable energy sources are the pillars of a zero-emission society.

2
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