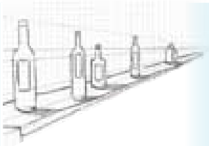
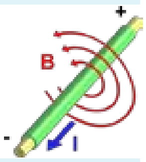
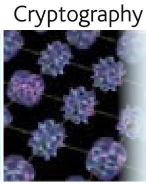
Innovation timeline

400,000 BC	Domestication of fire	
35,000	Counting	
8000	Stone tools	
3500	Wheels	
3000	Astronomy	
1000	Greek alphabet	
320	Botany	
300	Euclidean geometry	
50 AD	Medicine	
100	Steam power	
876	Zero and decimals	
1202	Algebra	
1435	Perspective (in art)	
1439	Printing press	
1543	Anatomy	
1600	Magnetism	
1673	Microscope	
1774	Combustion	
1796	Vaccines	
1799	Electric battery	
1808	Atomic theory	
1820	Electromagnetism	
1822	Difference engine	
1828	Synthetic matter	
1859	Evolution theory	
1860	Carbon-filament light bulb	

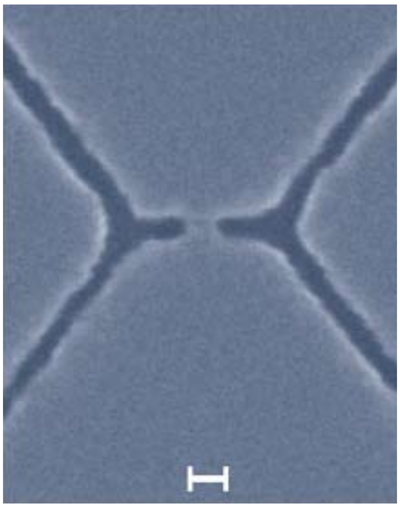
1867	Dynamite	
1869	Periodic table	
1876	Telephone	
1885	Fuel-powered car	
1895	X-ray	
1896	Radioactivity	
1902	Biplane glider	
1903	Chaos theory	
1905	Special relativity	
1910	Antibiotics	
1915	General relativity	
1928	Penicillin	
1942	Nuclear fission	
1943	Artificial Intelligence	
1946	Computer	
1947	Nuclear energy	
1947	Transistor	
1953	DNA-structure	
1959	Nanotechnology	
1969	Apollo mission	
1973	Genetic engineering	
1977	Cryptography	
1984	String theory	
1990	World Wide Web	
1996	Mammal cloning	
2000	Human genome	
2001	iPod	
2005	YouTube	

Atom-thick transistor

Researchers at the University of Manchester in England have made a single-electron transistor using grapheme, a sheet of graphite only one atom thick. Andre Geim, the professor of physics who led the work, says the transistor consists of electrical contacts (blue areas at left and right, below) that supply and collect current through three-nanometer-wide areas (centre) containing a central island of graphene, called a quantum dot. When current is applied, an electron jumps from one contact to the quantum dot and then to the other contact. A problem with previous single-electron transistors, says Geim, is that quantum dots of other materials, when shrunk this much, act "like a droplet of liquid on a hot plate" at room temperature. Graphene quantum dots, however, are stable. The Manchester research could yield a practical technology if fabrication techniques advance enough to produce such small features.

http://www.zdnet.co.za

→ *Short and narrow constrictions in graphene can act as high-quality transistors. (Indicated distance is 100 nm)*

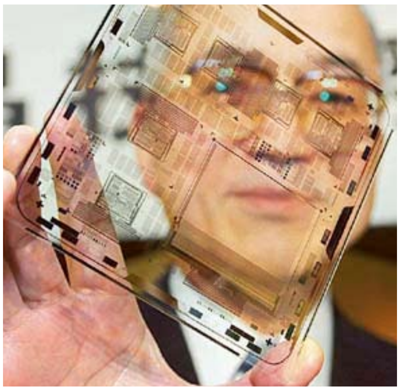


New turbine coating

Using a mixture of exotic metals, Dr Werner Stamm of Siemens Power Generation in Mülheim an der Ruhr has substantially improved gas turbine blades. Using a ceramic coating, he improved the component's maximum temperature, efficiency and service life. Turbines fitted with these blades use fuel more efficiently and thus help to reduce carbon dioxide emissions. In gas turbines, the hot combustion gas strikes the blades in an environment whose temperatures are in excess of 1,000 degrees Celsius. In order to protect these blades, Stamm developed a protective coating that is much more stable than those previously used. He used various metals, including rhenium, which is relatively unknown. The optimal mixture of the materials produces a coating that not only provides protection against oxidation but also serves as an adhesive for layers of thermal insulation. Rhenium, with its extremely high melting point of approximately 3,200 degrees Celsius, improves various properties, particularly the heat resistance. Stamm has been working for Siemens for 15 years and has submitted 52 inventions. The thing he likes most about his work is that he can see the entire life cycle on his products – in this case from the basic material to the coatings and the blade itself – all at a glance.

http://www.powergeneration.siemens.com/news-events/technical-papers/gas-turbines-power-plants/

→ *A 300-µm ceramic coating developed by Dr Werner Stamm of Siemens Power Generation (left) increases the service lifetime of turbine blades (right).*



The world's top patent holder

Shunpei Yamazaki
Total USA patents: 1,811
Age: 65
Field: L.C.D.'s, memory chips
Location: Tokyo

Background: His grades in high school were mediocre, so he could only get into a lesser-known university in Japan. While there, he met his mentor, Yogoro Kato, and spent summer vacations working under him with a handful of other students. "He taught us the spirit behind invention – like the training of the heart, how to live."

First Filed Patent: A solar cell, when he was 22. He does not recall celebrating it.

Claim to Fame: Invented what is now a fundamental element of flash memory, used in iPods, cellphones, and countless other products.

What's Next: "I endeavour to do what was done for me and educate young people. I'm trying to do more supervision than invention."

http://www.portfolio.com

New buildings

Architecture, unlike most other art forms, doesn't recede with the passage of time – it's here to stay, whether good, bad or just plain ugly. Fortunately, some great new buildings recently went up – and the best tend to look a little quieter and more elegant than the wild-looking architecture of recent years. Even Frank Gehry's first building in New York City is mellow – a milky glass mélange of pleats rather than an all-out symphony of metal edges and curves. And more than ever, designers are showing a keen interest in making buildings green.

The Nelson-Atkins Museum by Steven Holl

For an addition to the cherished Kansas City institution, architect Holl came up with an ingenious way to expand the museum without overpowering – or even touching – the original neoclassical building. Most of his beautifully scaled new gallery spaces are subterranean, with natural light coming in through a series of translucent "boxes" that cascade down a hillside next to the old museum and connect to it below ground. A big bonus: at night those boxes glow like beacons in a fog.

The IAC Building by Frank Gehry

This office building for Barry Diller's world headquarters, on the edge of Manhattan's Chelsea neighbourhood, took the classic corporate material – glass – and turned it into a confection of muted tones of white (to cut glare), formed into big vertical pleats (why? Because it's unexpected). Inside, the offices and common areas are wonderfully flooded with daylight, and on the higher floors there are views of the Hudson river. The building looks especially great at night, if you're speeding by on the West Side Highway, as if those softly lit pleats are bending in the wind.

The New Museum by SANAA

The Tokyo-based architects of the museum for cutting-edge art in lower Manhattan used a clever strategy for its tight urban site: their seven-story high-rise looks like an uneven stack of boxes, which allows slots of daylight to filter into the galleries from above. Known for quietly ethereal buildings, SANAA has designed a structure that's both tough and tender in its beautiful simplicity and its refined use of industrial materials such as concrete and silvery aluminium mesh.

→ *The IAC Building, Frank Gehry's first in New York City*

→ *The Nelson-Atkins Museum*

→ *The Grand Rapids Art Museum*

The Grand Rapids Art Museum by Kulapat Yantrasast

This calm and cool modernist building in Grand Rapids, Michigan, is the first newly constructed "green" museum in the USA, designed to be LEED certified. The elegant exterior is glass, aluminium and concrete; on the inside 70% of the illumination comes from natural light.

The San Francisco Federal Building by Thom Mayne

A boldly inventive structure with a glass and perforated-metal skin, it is the latest star in the General Service Administration's Design Excellence Program. It's also an award-winning green building with natural ventilation – unheard of in a California public building since the advent of air-conditioning.

On top of all that: **Burj Dubai by Adrian Smith of Skidmore, Owings & Merrill**

Already the world's highest tower, it's still under construction. It won't be open until 2009, and its developers in the booming desert city aren't saying just how tall it will be when completed.

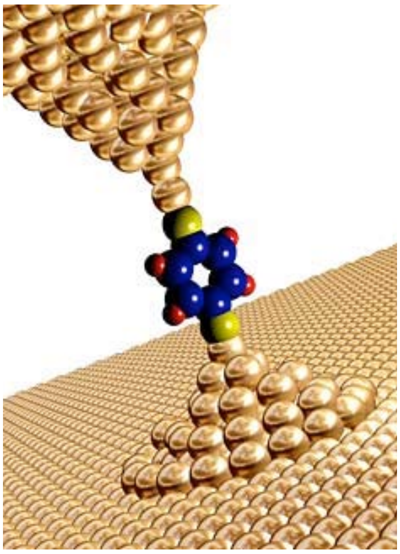
Acknowledgement: Newsweek

http://www.newsweek.com/

Electricity from heat

Materials that convert heat directly into electricity have been useful for some niche applications, like powering deep-space probes. But they've been too expensive and inefficient for the potential killer application: harvesting immense amounts of energy from the waste heat generated by power plants and cars. Now researchers at the University of California, Berkeley, have shown that a cheap organic material can make electricity from heat, potentially opening the way to affordable "thermoelectrics". The researchers trapped a few organic molecules (represented by the multicoloured spheres, above) between a sheet of gold (bottom) and the ultrasharp gold tip of a scanning tunneling microscope.

They heated the gold surface and used the microscope tip to measure the voltage created by the junction of molecule and metal. A large-scale heat-conversion system will require a process for arranging multiple layers of such junctions between two sheets of metal, one for applying heat and the other for harvesting electricity.



→ Graphic of a benzenedithiol molecule trapped between two gold surfaces. When one side is heated, a current is created. (http://berkeley.edu/news/media/releases/2007/02/15_heatelectricity.shtml)

Energy alternatives

Nuclear, solar, wind – they're either antidotes to our petroleum addiction or naive pipe dreams. Here's why each source is destined to succeed – or doomed to fail.

	Why It'll Work	Why It Won't
Cellulosic ethanol	By converting the sugars found in plant cell walls into fuel, the USA could reduce petroleum consumption by 30%.	The enzyme required to convert cellulose biomass into sugar is still too expensive, and current pre-treatment processes waste too much sugar.
Corn-based ethanol	Corn-based ethanol is cheaper to produce than petrol, and new technologies are reducing the amount of fossil fuel required to make it.	Converting the entire USA corn crop would provide just 12% of that nation's vehicle-fuel needs and emit only 13% less greenhouse gases.
Geothermal	An MIT report found that the USA could produce 100 gigawatts of electricity by 2050 by tapping the heat found in subsurface rock.	It's hard to access that rock without inadvertently causing seismic activity. Solving the problem could cost US$1 billion.
Liquefied coal	At the current production rate, USA coal reserves will last for 200 years – and that's not counting potential reserves that can't yet be tapped.	Turning that coal into liquid fuel requires vast amounts of water, an increasingly precious resource.
Nuclear	Zero-carbon-emitting next-generation reactors promise 7 to 17% higher efficiency than traditional plants, and they're much less likely to melt down, like the PBMR.	Nukes are a political third rail; nobody wants a reactor in their backyard. And there's no fully safe place to put spent fuel.
Solar	A coming silicon glut will drive down the price of photovoltaic cells. New, thin-film technology could make the method even cheaper.	Highly refined silicon panels may never be as inexpensive or productive as fossil fuels. Without continued government subsidies, solar could die.
Tidal	Underwater generators can harness the power of tidal motion, potentially costing less than traditional dams and causing less ecological harm.	Only 40 sites on earth offer tidal ranges greater than 7 metres, the minimum to make electricity. And those will work for only 10 hours a day.
Wind	Longer, lighter blades have helped to double turbine efficiency. Wind at next-generation offshore installations is 90% more powerful than on land.	Where wind is, people aren't. No one has come up with economical transmission and storage solutions for this far-flung, intermittent power supply.

How to produce and distribute energy efficiently

Electricity production: Every percentage-point increase in the efficiency of an average coal-fired power plant (800 MW) reduces annual CO_2 emissions by approximately 100,000 tons. The average efficiency of coal-fired plants in South Africa at the moment is around 30%. However, technology already available today can raise efficiency to 46% for hard coal plants and 43% for brown coal facilities, and additional percentage points could be achieved in the future. The best combined cycle plants that use natural gas achieve an electrical efficiency of 58.5% – but Siemens and E.ON are now building one with 60% efficiency. It will also emit around 40,000t less CO_2 per year than plants with 58.5% efficiency, which corresponds to the emissions of 12,000 passenger cars, each traveling 20,000 km per year and emitting the European average of 163 g CO_2/km. Compared to an average coal-fired plant with the same output, the new combined-cycle plant will reduce annual CO_2 emissions by 2.8 million tons.

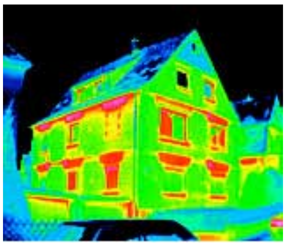
Power transmission: Techniques for minimising transmission losses include gas-insulated lines for metropolitan areas and high-voltage direct current transmission (HVDC) systems for transmitting electricity over long distances or via submarine cables. Siemens is now building an HVDC line in India that will transmit 2,500 MW of electricity over a distance of 800 km to the capital, New Delhi. This HVDC transmission system exhibits much lower line resistance than a conventional alternating current transmission line, thereby reducing CO_2 emissions by around 690,000 tons a year.

Renewable/alternative sources: One-third of hydroelectric power worldwide is generated using technology from Voith Siemens Hydro. That's 930 TWh per year, which saves some 540 million tons of CO_2 emissions compared to fossil sources. A further 10 million tons is saved by 6,300 Siemens wind turbines around the world, with a total peak output of 5.5 GW. Europe's biggest biomass power plant (in Vienna) provides 50,000 households with electricity and 12,000 with heat. A new Siemens geothermal facility near Munich also produces environmentally friendly energy.

Additional measures: Every major nuclear power plant (1,600 MW) saves some 9 million tons of CO_2 compared to plants that use fossil fuels. Combined heat and power – the simultaneous generation of electricity and process steam or district heating – increases fuel utilisation in combined cycle plants to as much as 90%. In the future, power plants using fuel cells linked with gas turbines will achieve electrical efficiencies of up to 70%, while in integrated gas combined cycle (IGCC) power plants CO_2 can be separated and then sequestered below ground. Pilot IGCC facilities are now being planned.

How to save and use energy more efficiently

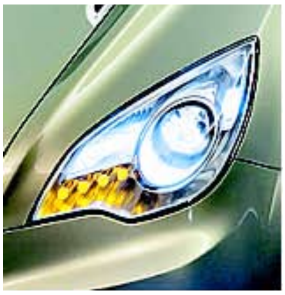
Heating and air-conditioning systems consume most of the delivered energy we use in first world countries, which is why a lot of energy can be saved by heat insulation, more efficient air conditioners and automation systems for buildings. Siemens offers energy saving performance contracts for public buildings, whereby the investment in new systems is financed by the energy savings achieved. Typical savings in energy consumption are from 10% to 40%. Siemens has carried out some 1,900 such projects in 6,500 buildings since 1995, with guaranteed savings of Rand 20 billion and 2.4 million tons of CO_2.



The electric motor is probably the most underestimated energy-saving lever. Such motors account for 65% – 70% of total industrial electricity consumption; about 20 million of them are currently in operation around the world (in drives, pumps, compressors etc.). By utilising energy-saving motors and frequency converters and optimising overall systems, electricity consumption could be reduced by 10% – 50% per unit, depending on the application. Such investments pay for themselves in less than two years and offer worldwide potential CO_2 savings of some 600 million tons per year. Eskom recently launched energy performance contracting programs for the South African industry.

Electrical household appliances: Today's appliances use much less electricity than in 1990, the reference year for the Kyoto Protocol. Refrigerators from Bosch und Siemens Hausgeräte GmbH, for example, use 75% less electricity than in 1990, washing machines and dishwashers 35% – 40% less and electric stoves 30% less. As these devices account for more than half of total private household electricity consumption, replacing them can save a lot of energy. Further potential results from reducing standby operation of appliances and optimising information and communication networks.

Lighting: Energy-saving lamps and light-emitting diodes (LEDs) use around 80% less electricity and last 15 – 50 times longer than incandescent light bulbs. Applications today include headlights for various types of vehicles, displays and general lighting systems. Some 2,700 TWh of electricity are utilised for lighting around the world, which corresponds to 19% of total consumption, or the combined power output of all hydroelectric plants. Switching to energy-saving lamps and LEDs could reduce annual CO_2 emissions by about 450 million tons worldwide.



Rail systems: The amount of energy consumed by rail systems is already low – in Germany it is lower than the energy required for the operation of refrigerators and freezers. Promoting public transportation is therefore an environmentally friendly measure. There is still potential for conservation here, however – for example, through regenerative braking and the use of lightweight materials like aluminum. A subway line built by Siemens in Oslo, Norway, consumes 30% less energy than a conventional system, for example.

Passenger cars, trucks: Piezo-electric fuel injection technology and hybrid drives that combine electric motors and combustion engines can cut fuel consumption by 20% – 25%. There's also great potential in reducing weight, optimising aerodynamics, and the future integration of brakes and electric drive units into vehicle wheels. Telematics and parking guidance systems also reduce the time wasted in jams or looking for parking spaces – pastimes that often make up 40% of the traffic volume in cities. London's Congestion Charge has reduced traffic volume and jams by more than 20%.

Acknowledgement: Siemens

The sources of greenhouse gases

About one third of the approximately 40 billion tons of CO_2e that are emitted annually around the world as greenhouse gases comes from agriculture, forestry, land clearing measures and waste. “CO_2e” refers to CO_2 equivalents. Other greenhouse gases – including methane, laughing gas, fluorocarbons and industrial gases (e.g. sulphur hexafluoride) – are converted into these equivalents to show their global warming potential compared to carbon dioxide (CO_2). Methane’s global warming potential, for example, is 21 times that of CO_2, with one ton of methane corresponding to 21 tons of CO_2e. More than two-thirds of the greenhouse gas emissions (currently about 27 billion tons of CO_2e) are energy-related, meaning they are caused by people’s energy consumption. The emissions result from electricity generation in power plants, generation of heat, and fuel combustion by transport vehicles. In Germany, about 87% of greenhouse gases result from energy use, while the remaining 13% come from other sources, including agriculture and the chemicals industry.

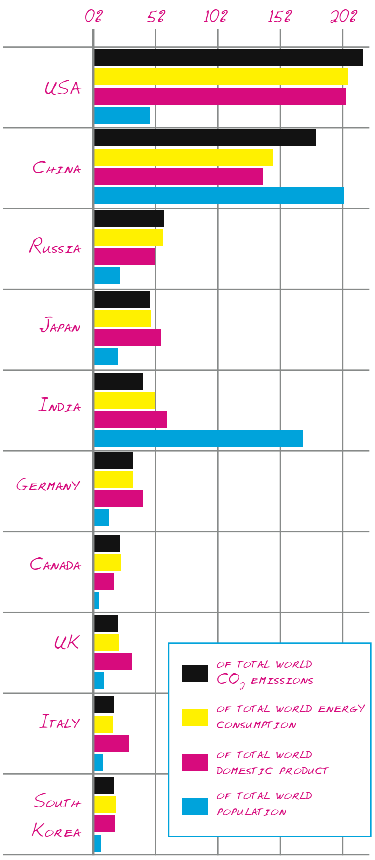
Power plants are the source of nearly 25% of the world’s greenhouse gas emissions. The largest share of CO_2 from these plants results from turning fossil fuels into usable energy such as electricity and district heating; a small share is also generated during the facilities’ construction and by the supply of fuels. The cumulative CO_2 emissions of lignite power plants, for example, are about 1,000 g/kWh of electricity; hard coal plants produce 780 g/kWh.

And the atmosphere even feels the effect of nuclear power plants, which give off small amounts (around 25 g/kWh) of CO_2 from uranium mining and enrichment. Photovoltaic facilities account for about 100 g/kWh of CO_2, due to the production of solar cells, modules and inverters. Wind plants (20 g/kWh) and hydroelectric facilities (4 g/kWh), by contrast, have very low CO_2 emissions.

A look at regional distribution of energy-related emissions shows the biggest shares are from the USA (over 21%) and China (almost 18%), followed by Russia (nearly 6%), Japan (4.5%), India (4%), and Germany (3.2%). According to the International Energy Agency, energy-related emissions will rise by almost 50% to about 40 billion tons of CO_2 by 2030 if countermeasures aren’t taken. As the world’s largest coal consumer, China is expected to surpass the USA as the largest producer of CO_2 by 2010. But China’s emissions are still low, seen on a per capita basis: about four tons of CO_2 per year, compared to roughly ten tons in Germany and 20 tons in the USA.

Acknowledgement: Pictures of the Future, 2007

Top 10 CO_2 Emitters



Regional Growth of Carbon Dioxide Emissions