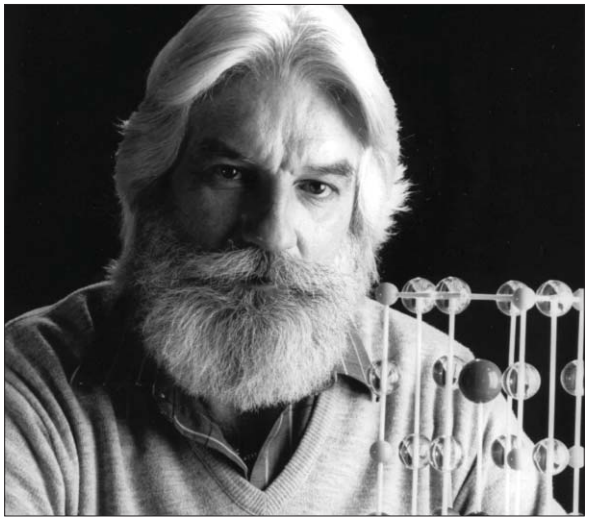
Profile

Champion of the SuperGrid

Superconductor pioneer **Paul Grant** has a solution to the world's energy problems. He tells Daniel Clery that we should unite superconductivity with nuclear power and the hydrogen economy



Energy visionary Paul Grant.

For most of his career, Paul Grant has focused on the minuscule – principally the structure of magnetic materials and the composition of high-temperature superconductors. It was in studying the latter that he made his name – discovering, in the 1980s, a number of ceramic-based materials with high superconducting transition temperatures, and thereby contributing to the then widespread belief that superconducting cables and levitating trains would be just round the corner. He even appeared on TV when scientists demonstrated the exciting new materials to US President Ronald Reagan in 1987.

But now, at the age of 72, Grant is well into the second decade of what is, essentially, a new career, and he is starting to think very, very big. Superconductors still have a role in his new thinking, but they are part of a much broader canvass – the solution to the world's energy crisis. He is not proposing a new type of nuclear reactor, a clean way of burning coal, or a super-efficient solar cell. Instead, he is interested in linking up advanced energy technologies so that their combined effect is very much more than the sum of their parts.

His big idea is the SuperGrid, a continent-sized electricity transmission grid that uses high-temperature superconductors instead of copper cable. Buried underground, the cable would be cooled by liquid hydrogen produced in a new generation of nuclear plants that would supply much of the power to the grid. The hydrogen would also act as an energy store that could be called apon when demand peaks, and as a fuel that could be sold to power cars.

He acknowledges that not only would the SuperGrid be hugely expensive – probably in the trillions of dollars, although he does not imagine it would be built all at once – it would also be very controversial since it relies heavily on nuclear power. But he has no doubt that the world needs the nuclear option. "You cannot beat nuclear for its environmental footprint and power density," he says. "[The SuperGrid] is the sort of energy society we should be looking at 50 years from now. How it will actually take shape, no-one knows."

The SuperGrid is the sort of energy society we should be looking at 50 years from now

In person

Born: Poughkeepsie, New York, 1935
Education: Clarkson University (BS), Harvard University (PhD)
Career: IBM (1953–1993), Electric Power Research Institute (1993–2004), currently an independent consultant
Outside interests: skiing and mountaineering
Family: seven children from two marriages

Company man

Grant grew up in Poughkeepsie, New York State, and joined IBM when he was 17. Four years later the company, which he describes as "an ideal paradigm for a paternalistic socialist society" sent him to college, first to Clarkson University to study electrical engineering and then to Harvard to do a PhD in applied physics. He returned to IBM in 1965, moving to its labs in San Jose, California.

Grant worked on a number of projects throughout the 1960s and 1970s, including research on organic superconductors. Then, in 1986, following the discovery of high-temperature superconductors by Georg Bednorz and Alex Müller at IBM's Rüschlikon research lab in Zurich, Grant's group became one of many around the world to develop superconductors with ever higher transition temperatures. Indeed one of his materials, known as thallium-2223, held the record for the highest transition temperature (125 K) from February 1988 until 1993.

But by the end of the decade, IBM's interest in high-temperature superconductors was starting to wane as there were no clear applications in information processing. In 1989 Grant went on sabbatical from the firm to the National University of Mexico in Mexico City, where his wife had previously worked as a chemistry professor. When he returned he decided that, after 40 years at IBM, it was time for a change.

In 1993, after passing up two university offers, Grant joined the Electric Power Research Institute (EPRI) in Palo Alto, California, which, he says, made him "an offer he could not refuse" to continue his work on superconductivity. Grant found himself working in an office next door to Chauncey Starr, one of the pioneers of nuclear power in the US and founder of EPRI, who died in April this year. "I found a new mentor and my whole view on energy policy and technology changed," Grant says. At IBM, he says, if you could make something faster, smaller, cooler or cheaper, your idea would succeed. In the energy business, technology is only 50% of the equation, "the rest is policy and societal acceptance", he says.

Nuclear advocate

Apart from teaching him to love politics, Starr also engendered in Grant an enthusiasm for nuclear power. Grant is convinced that this is a "sound and safe" way to generate electricity and that many proposed alternative energy solutions, such as wind farms, solar farms and biomass crops, all eat up too much land.

Nuclear is central to Grant's idea of the SuperGrid, which sprang from

a Department of Energy meeting on superconductivity that he attended in 1999 that asked for a "wild idea" in the area of energy. It occurred to him that if future cars were going to run on hydrogen, why not let the hydrogen have the duel role of fuel and cryogen. Thus was born the SuperCity, Grant's imagined metropolis powered by fourth-generation high-temperature gas-cooled reactors that generate electricity and split water to form hydrogen. The underground superconducting cable that carries power into the city also delivers hydrogen to filling stations and into homes for heating and cooking. Rooftop solar power and burning of municipal waste add to the energy mix and, if demand is high, fuel cells in local substations can use hydrogen to produce extra electricity. Total carbon emissions: virtually zero.

When Grant described the concept to Starr, the latter said Grant was "thinking too small" and should be considering a continental-scale system: this is the SuperGrid. Such a system would not replace the existing transmission networks in the US, but would instead link up scattered grids allowing them to work more effectively. Any sort of power generator can feed into the SuperGrid, and to allow certain areas to cope when demand is high they can take in power from other areas where there is excess capacity. In addition, as superconducting transmission is lossless, the nuclear power stations could be sited anywhere, in the middle of a desert even, far from population centres.

Grant believes that the SuperGrid is feasible, since no new discoveries are needed to realize it. It is just a massive engineering problem, he claims. Two teams of researchers – one including EPRI employees – have been working on proposals to build prototype supercables delivering electricity and liquid hydrogen. The Department of Energy is expected to decide on funding soon and Grant hopes something will be built in the next couple of years.

According to Grant, turning this symbiotic vision of hydrogen, superconductivity and nuclear power into reality would require huge taxes on carbon-based fuels. But he thinks it more likely that politicians and the power industry will wait until they have no choice, when natural gas starts running out in 20 or 30 years' time. Before such a visionary change happens, Grant feels that "we humans will oxidize every atom of carbon on the planet".

Space science

Europe sets its sights on Mars

ESA

Destination Mars
An artist's impression of the ExoMars lander.

European scientists have voiced their preference for Mars as the main target for manned space exploration, in contrast to the US's focus on a lunar base. A workshop led by the European Science Foundation (ESF) in Athens in May agreed on the scientific goals for Europe's planetary exploration over the next 30 years, refining the Aurora roadmap launched by the European Space Agency (ESA) in 2001.

Aurora, which accounts for 15–20% of ESA's €3bn annual budget, was initially conceived as a step-by-step exploration programme culminating in a manned mission to Mars in about 2035. But the outlook changed in 2004 when US President George W Bush announced the US's own Vision for Space Exploration, which contained an ambitious plan for a permanent human base on the Moon, and which has led to international moves to coordinate space exploration.

Budget realities may force space scientists' hands

In part to address these developments, ESA initiated a review of human space exploration as seen from the perspectives of science, policy, industry and the public. Its final report will be presented at the next ESA council meeting at the end of 2008, when funding decisions will be made. A draft report by the ESF on the scientific perspective was discussed in Athens by over 85 scientists. With life in our solar system as the primary scientific theme, the group settled on three main targets for a human exploration programme: Mars, the Moon and nearby asteroids.

In particular, the Athens workshop recommended that Europe concentrate on a post-2020 robotic Mars Sample Return (MSR) mission. Before MSR will come ExoMars, a robotic rover due to launch in 2013, and for which the UK company Astrium was last month awarded a £2.5m contract to develop a prototype. The scientists at the workshop discussed what should come between ExoMars and MSR but acknowledged that budget realities may force their hand. "Exploration is not a science-driven programme," says Jean-Claude Worms, head of space sciences at the ESF. "We are there to accompany the programme, and if it happens to go to the Moon, then there is unique science to be done there."

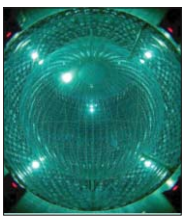
Michael Schirber

Astroparticle physics

Neutrino detector finally starts up

An experiment that was put on hold for several years following a leak has at last been switched on deep underground in the world's largest astroparticle observatory. Borexino, located in the Gran Sasso National Laboratory under the Appenine mountains in central Italy, is designed to measure the properties of the elusive subatomic particles known as neutrinos but was delayed because of environmental concerns that followed the accidental leak in June 2003 of 50 l of the volatile liquid 1,2,4-trimethylbenzene used as its detecting medium. "We lost between three or four years," says Borexino spokesperson, Gianpaolo Bellini of the University of Milan.

Some 300 tonnes of the detecting medium are now contained within a nylon sphere at the heart of Borexino, and surrounded by photomultiplier tubes that sit inside a stainless-steel vessel 13.7 m in diameter filled with 1000 tonnes of a shielding liquid. A few of the of enormous numbers of neutrinos originating from fusion reactions in the Sun or particle interactions inside the Earth will interact by elastic scattering with electrons in the 1,2,4-trimethylbenzene atoms. These "recoil" electrons generate very faint flashes of light that can be detected by the photomultiplier tubes.



New light on neutrinos
Borexino opens after a four-year delay.

This set-up will be used to study how neutrinos "oscillate", in other words how they change from one type, or "flavour", to another as they travel through space or matter. Other experiments have already shown that neutrinos oscillate, which hints at physics beyond the Standard Model, but Borexino is the only detector currently capable of measuring the neutrinos that originate from beryllium-7 reactions. These neutrinos are well suited to studying oscillations because they all have nearly the same energy and therefore have a highly predictable flux. The first results are due in September.

Alexander Hellemans