EEP11 – REPORT ON RENEWABLE ENERGY SOURCES AND FUEL CELLS

The enclosed articles show ongoing industry developments in batteries, photovoltaic solar energy and fuel cells that will filter into AtoN applications in due course.

An interesting article on an application of Artificial Muscle to power a buoy may also be of specific interest if it proves cost effective.

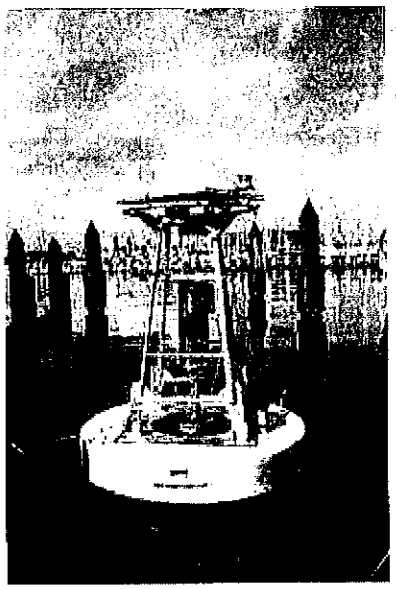
Moray Waddell
10 March 2008

The Energy Blog

The Energy Revolution has begun and will change your lifestyle

August 08, 2007

Artifical Muscle Produces Ocean Power



SRI International has announced the deployment of a prototype buoy-mounted, ocean wave-powered generator off the coast of Florida in the Tampa Bay. The electroactive polymer artificial muscle (EPAM™) technology is used to produce electricity as they bob up and down attached to buoys. The deployment is part of a program sponsored by HYPER DRIVE Corporation, Ltd., a Japanese company focused on development and deployment of wave-powered generators around the world.

The wave-powered generators can be deployed on existing ocean buoys that use batteries as their energy source. The new generator utilizes patented electroactive polymer artificial muscle (EPAM™) technology, and offers a renewable method to continually power ocean buoys. The bouys will be equipped with instrumentation that allows remote monitoring of the generator's output energy as well as wave height and buoy motion. SRI is working with Artificial Muscle, Inc., an SRI spin-off company and the exclusive licensee of EPAM, in the development of the EPAM components for the wave-powered generators.

The generator, initially deployed on a navigation buoy for ports and harbors, is capable of generating 20 joules of energy per stroke, which corresponds to an average output power of more than 5 watts under typical ocean wave conditions. The current development program aims at developing generators that can produce 25 watts of average output power. This is sufficient to supply all the power required by navigational buoys. Future efforts will address the design, development, and deployment of wave-powered generators capable of generating power in the kilowatts range for large-scale clean energy production.

According to the company website:

> EPAM gets significant displacement from this electrostatic pressure as compared to other technologies. The overall displacement is a function of the area of EPAM, and the force exerted is a function of the number of layers of EPAM. These layers can be constructed in multiple planar configurations. Furthermore, the electrode layer of the EPAM can be patterned to achieve specific envelopes of motion.
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> To date, AMI's work in EPAM™ generators has focused on small amounts of power. Typical power generation has ranged from 1 to 50 W. There are many potential generator applications for dielectric elastomers at these smaller power levels.
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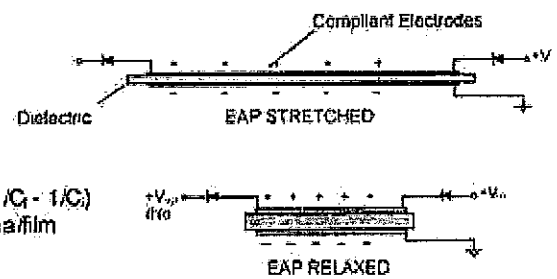
> 
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On June 5, 2007 Artificial Muscle, Inc., (AMI), a privately held company in Menlo Park, CA, announced a $20 million Series B round of financing. AMI will use the funds for ramping up its high volume manufacturing and operations, new product development, and marketing and sales resources to support the plan for initial

product launches.

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August 08, 2007 at 12:14 AM in Ocean Power | Permalink

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Comments

There are a number of different companies out there working on ways to get energy from the ocean. One that I like is this one:

http://www.oceanpd.com/default.html

where they are trying to generate commercial quantities of electrical power from wave motion. There are several others.

Posted by: eric | August 08, 2007 at 05:10 PM
This is interesting but one has to realize that the amount of power here is only enough to light a candle sized lamp. This is not relevant to power generation to most of those who follow this Blog.

Posted by: JohnBo | August 08, 2007 at 10:41 PM
Not much power just to light a buoy, but at least it saves the effort of having to go replace the batteries periodically. I was wondering if this technology had a potential for scaling up, or if it really is just for lighting buoys.

Posted by: Clee | August 09, 2007 at 03:43 AM
couldn't they put a wind turbine on there as well?

Posted by: Golden Boy | August 09, 2007 at 09:37 AM
I doubt this technology can be scaled up and be competitive. Its big advantage is no moving parts... well almost. It does stress and relax the element but that is very simple. This is just a novelty from what I can see. A wind generator would work but probably has more maintenance. PV solar with a battery is likely the most common low power source for isolated locations.

Posted by: JohnBo | August 11, 2007 at 02:03 AM

www.newelectronics.co.uk
22 Jan 2008

Photovoltaic focus

Researchers get £6.3m for solar cell development.

***Graham Pitcher** reports.*

A team led by Durham University is embarking on one of the UK's largest ever research projects into photovoltaic solar energy. The £6.3million PV-21 programme will focus on making thin film light absorbing cells for solar panels from sustainable and affordable materials. Funding is being provided by the Engineering and Physical Sciences Research Council.

Eight universities and nine industrial partners will pursue the 'medium to long term goal' of making solar energy more competitive and sustainable. At present solar cells are made from key components such as indium, which costs £320/kg.

Principal investigator Professor Ken Durose, from Durham's Department of Physics, said: "Some of the materials currently used may not be sustainable in 20 years time, which is why we have to conduct research into alternative materials that are cheaper and more sustainable. We are also leading the way in making ultra thin solar cells that need less material."

To cut production costs, the team will work to reduce the thickness of the cells. According to the researchers, making a solar semiconductor thinner by 1µm in solar cells generating 1GW could save 50 tonnes of material. Researchers will also experiment with sustainable low cost materials, nanotechnology and dyes on ultra thin silicon to capture more energy.

'Emerald' Green Power at Seawork

Sailing yachts may not have been as commonplace as tugs and pilot boats on the Seawork floating pontoon last month but the *Beneteau 411 Emerald* had lots to show with regard to the likely future of marine on board power.

It is the first installation of a 1kW fuel cell onto a yacht and provides Voller Energy, specialists at providing clean fuel for the marine industry, with an initial public platform to showcase their product ahead of its official launch at the Marine Equipment Trade Show (METS) in Amsterdam later this year.

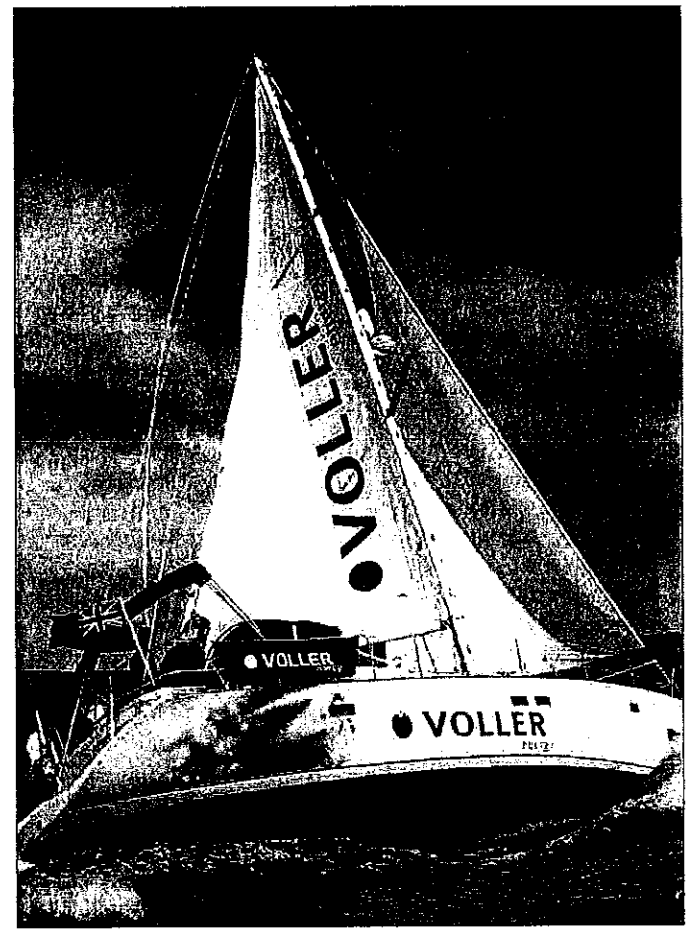
Using a Beneteau Oceanis 411, a popular design of family sailing yacht, allowed Voller to demonstrate the benefits and practicalities of their fuel cell generator under typical usage, whilst also highlighting its retrofit market potential to **Seawork** visitors.

Quick and easy to install, the fuel cell system can be fitted to the existing wiring in a boat. The system operates from Calor Gas, liquefied petroleum gas (LPG) or propane and does not need proprietary fuels such as hydrogen or methanol. The system will fit comfortably in an aft locker normally used for a conventional generator.

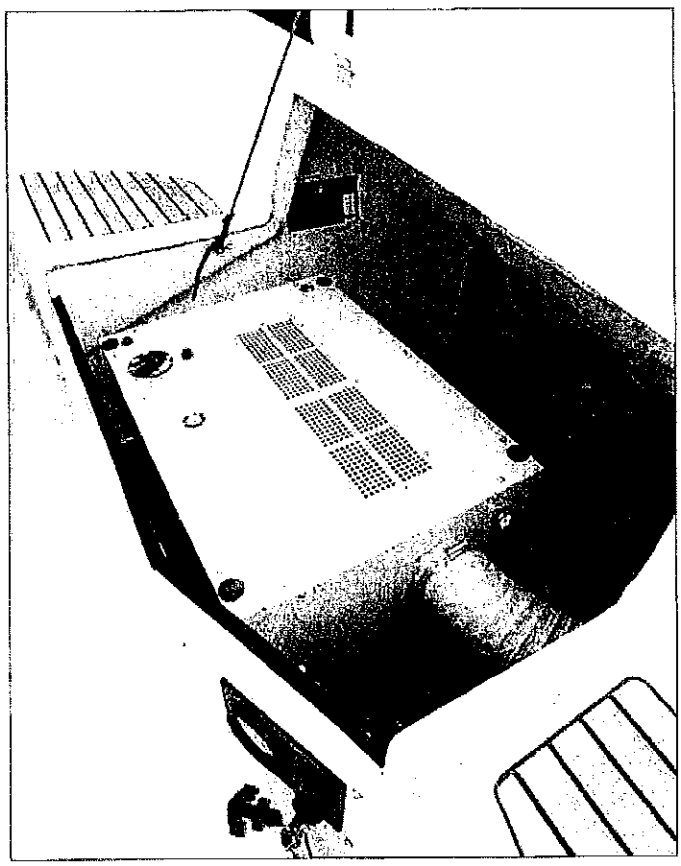
Voller's fuel cell generator is safe and economical. It works by automatically monitoring battery voltage. When the voltage falls, it automatically switches itself on and recharges the batteries. Once the batteries are fully charged, the fuel cell switches itself off to conserve fuel. The generator also provides hot water and heats the cabin.

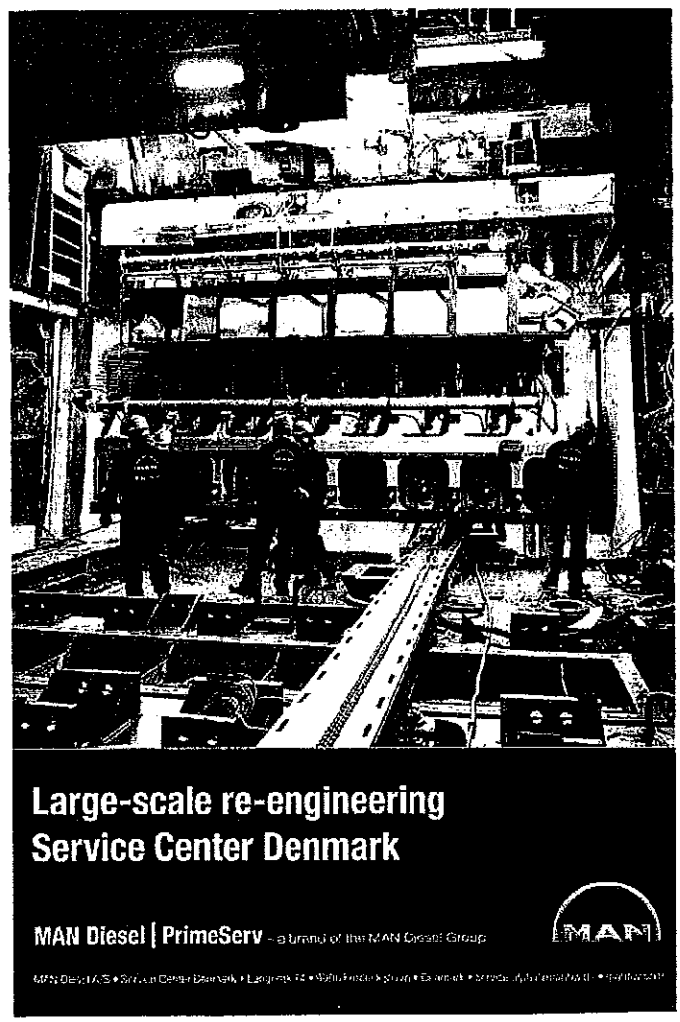
Voller's chief executive Stephen Voller said, 'Our fuel cell generator will completely change the way that people sail. Most skippers are used to turning everything off to conserve power. With Voller that will no longer be necessary. They can use an electric kettle, enjoy an ice cold beer on board, and no longer have to worry about switching lights on. In short, with the power burden removed, sailing will become even more pleasurable.'

MJ Information No: 23208



The fuel cell is neatly installed on Voller Energy's yacht 'Emerald'. Photo of fuel cell by Patrick Eden.





Engineering & Technology
9 Feb 2008
www.theiet.org/engtechnmag

'The Ultrabattery has a lifecycle that is at least four times longer and produces 50 per cent more power than conventional battery systems.'

AUTOMOTIVE

Battery breakthrough boosts HEV prospects

By Lorna Sharpe

EFFORTS TO develop a cheaper battery for hybrid electric vehicles (HEVs) passed a major milestone in January, when a test vehicle clocked up 100,000 miles on the odometer.

The Ultrabattery test programme is the result of an international collaboration. The battery system was developed by CSIRO in Australia, built by the Furukawa Battery Company of Japan and tested in the UK by product-engineering firm Provector. Funding was arranged by the Advanced Lead-Acid Battery Consortium (ALABC), which represents battery manufacturers and their suppliers.

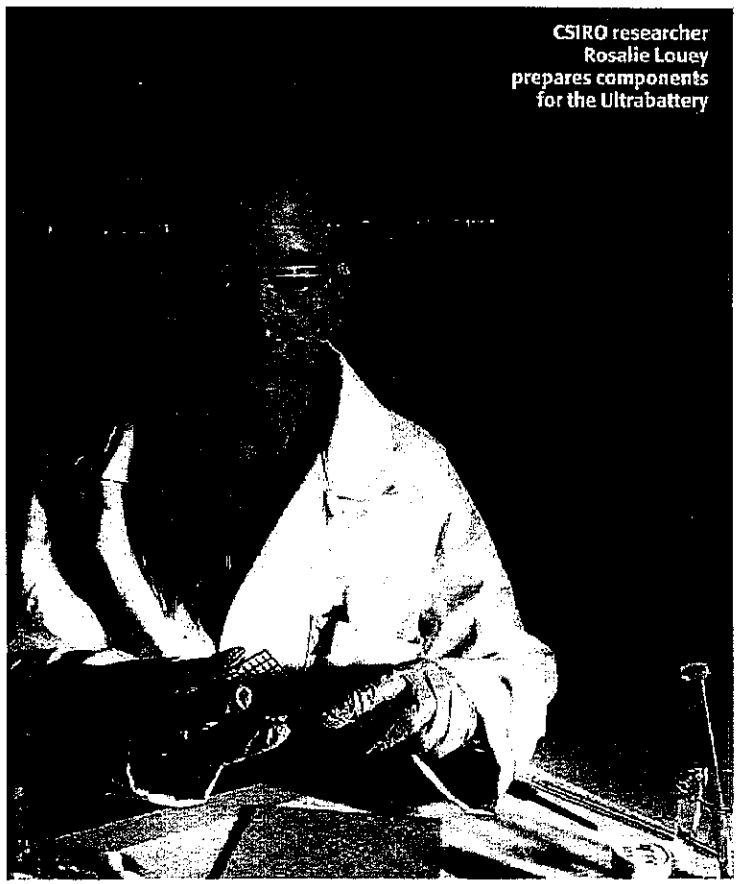
Over the last year, a team of drivers put the battery to the test in a Honda Insight at the Millbrook Proving Ground near Bedford, UK. Completion of 100,000 miles is significant because it demonstrates that the Ultrabattery can last as long as nickel metal hydride (Ni-MH) batteries installed in many hybrid electric vehicles. It also produced more power than Ni-MH batteries and costs considerably less.

Researchers overcame technical barriers that have limited the performance of lead-acid batteries by integrating a supercapacitor with the plates inside the battery cell. This meant the discharge of energy could be managed better, preventing the accumulation of sulphur deposits.

CSIRO low-emissions transport specialist David Lamb said: "Previous tests show the Ultrabattery has a life cycle that is at least four times longer and produces 50 per cent more power than conventional battery systems. It's also about 70 per cent cheaper than the batteries currently used in HEVs.

"CSIRO's ongoing research will further improve the technology's capabilities, making it lighter, more efficient and capable of setting new performance standards for HEVs," Lamb added.

ALABC president Dr Patrick Moseley told *E&T* that the test programme aims "to demonstrate to everyone who matters that the right form of lead-acid battery can work for a perfectly good lifetime in a hybrid electric vehicle". If manufacturers take up the technology, he said, the price of HEVs could fall by £2,000-3,000, encouraging more people to buy them, "which would be good for the planet – and would also help to sell lead, which a lot of our members have an interest in".



CSIRO researcher Rosalie Louey prepares components for the Ultrabattery

IMLA

The solar sell

Will solar power make a significant contribution to the world's energy needs? By **Graham Pitcher.**

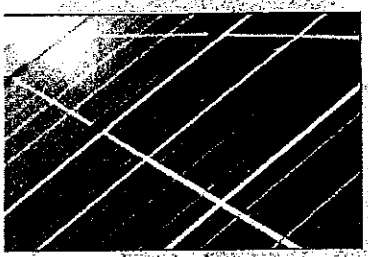
Consensus amongst the scientific community is that the world's climate is changing. Those with what may be seen as a dissenting opinion claim this is part of the natural cycle. However, the majority apportion blame for climate change to our seemingly insatiable appetite for energy.

Whether it's electricity to power the array of devices in our homes or the various forms of energy which power our vehicles, CO_2 generation is contributing to – or even creating – the 'greenhouse effect'. The more CO_2 we generate, the worse things become and a section of the scientific world is raising the spectre of a 'tipping point', beyond which the Earth will be unable to recover.

So it's no surprise to discover that scientists and engineers alike are looking urgently for new ways to provide the power which we all desire. One option being presented is a return to nuclear power. While this might reduce CO_2 emissions – and opponents are not convinced about this – the approach creates another problem: disposing of radioactive waste.

Another strand of research is looking to capitalise on renewable energy resources. Here, developers hope to capture the energy available in the wind, the tides and the Earth itself. But a major theme in renewable energy is to harness the power of the Sun.

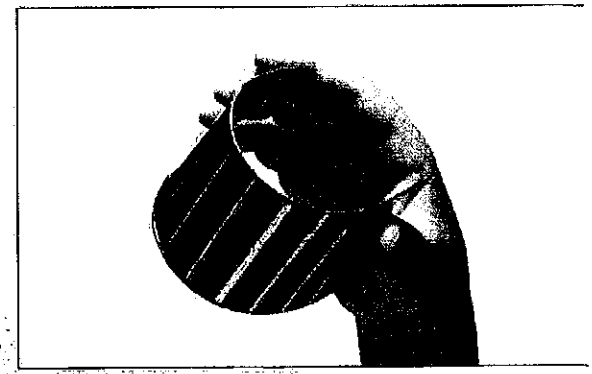
And it will be no surprise to learn that hundreds of research sites around the world are working on solar power – some on developing the fundamental technology required; others are more concerned with the production aspects.



Research sites around the world are working on developing solar cell technology, aiming to increase efficiency and reduce manufacturing costs.

One of the latter companies is G24 Innovations (G24i), which is about to go into production at its 18,000ft² plant on the outskirts of Cardiff. G24i's technical director is Martin Bellamy. He is keen to highlight solar power as a solution. "It's not about putting solar panels on buildings," he believed. "It's about providing power for people who don't have energy; there's no point in extending the mobile phone network to the developing world if there's no mains electricity to plug the chargers into."

G24i has licensed dye sensitised thin film solar technology from US company Konarka. It's been working on taking the technology from the lab to the point of production. Although the plant is about to start manufacture, the company is planning what it says is 'significant expansion' in capacity next year.



The fundamental technology is the Graetzel cell, invented 1988 by Dr Michael Graetzel and colleagues at the Ecole Polytechnique Federal de Lausanne.

"It's an organic solar technology," Bellamy observed, "although it's actually two technologies: the organic substrate and the inorganic dye."

G24i sees the technology being special for two reasons. "Firstly, it's a low light technology," said Bellamy, "and very few solar technologies do anything in low light. Secondly, it has the potential to scale."

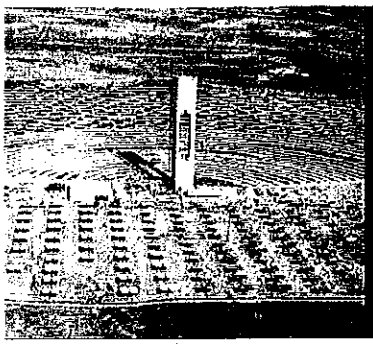
Bringing the price down

The latter observation is crucial. Bellamy believes many solar developers have gone for the performance aspect first, then tried to scale their process. "The challenge," he believes, "is to bring the price down to $1/W and you can only do that with volume." And G24i is using a roll to roll process.

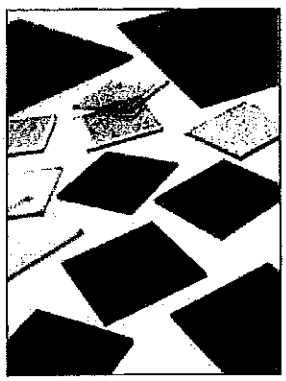
"Traditional modules are units and therefore manufactured in a batch process. Our process allows modules to be 'churned out' just like newspapers."

Jef Poortmans, director of the Solar + programme at Belgian research centre IMEC, says the organisation is using its semiconductor expertise to boost sustainable energy generation. It has two main areas of interest: crystalline silicon solar cells; and organic semiconductor based devices.

And he sees good prospects for photovoltaics (PV). "The PV market is booming," he claimed, pointing to a recent PV event held in Milan. "There were 500 companies exhibiting and 30,000m² of exhibition space," he claimed.



The Almaden solar project in Spain, being built by energy company Solucar, is aiming to generate 20MW of electricity, enough to power 12,000 homes.
The project will use 1255 heliostats with a surface area of 152,000m². These will concentrate solar radiation on to a receiver positioned on top of a 155m tower.



Above: Belgian research centre IMEC is looking at a range of organic semiconductors for use in solar cells.
Below: G24i has built an 18,000ft² plant to manufacture organic solar cells on a 1000m long substrate. The roll to roll process is set to enter volume production next year.

more efficiently. For that reason, projects such as the solar tower in Spain (see panel above) are seen as more attractive – at least for the near future.

Two potential solutions

IMEC is looking at two ways of making organic solar cells. In the first approach, polymers are dissolved in a solvent and the solution applied to a foil substrate. The solvent is evaporated, leaving a semiconductor film. The result, said Heremans, is a bulk heterojunction. However, one electrode would need to be evaporated in a vacuum, which means the process is not yet continuous.

The other approach uses small molecules evaporated on a foil. "These form dense films and are more reliable," Heremans believed. Multiple layers are more easily formed with this approach, but it does not allow the creation of a true bulk heterojunction.

"The best efficiency with this approach is less than 5%," Heremans noted, "but we need to reach 8 to 10% before productisation and we expect major improvements from new materials."

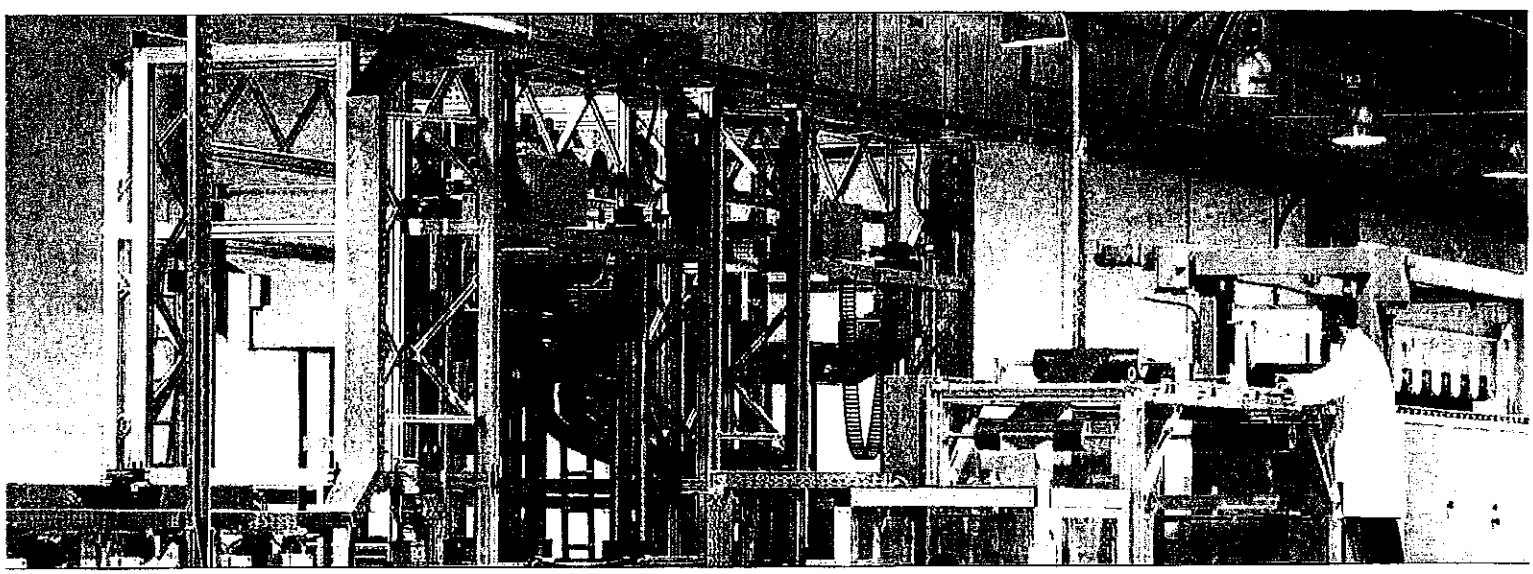
Bellamy is keen to point out that G24i is not interested in developing the basic science; its focus is on manufacturing and production. "And that's where most research falls over," he claimed. "In many cases, the effort is making the solar cells more efficient, rather than making the process commercially viable. Although there are lots of dye sensitive research sites, nobody is doing it with a view to mass production."

Bellamy's observation about pursuing manufacturability rather than performance is underlined by the fact that G24i's modules are only 4% efficient. "But, because they produce energy all day," he contended, "they produce more energy per peak Watt than any other approach."

Although G24i's products will help address climate change, Bellamy says it's more about personalising energy 'just like the mobile phone personalised communications'. "We can provide a solution for those need energy, but you need to step back and look at why we all use energy. In the developing world, it's enabling technology; here, it's plug into the wall and that means burning oil, generating CO_2 and so on."

Bellamy sees solar power as a solution. "The end user isn't concerned with $/W, it's how much energy is produced. Solutions are about providing communications, security and so on. People don't buy solar on its own, just like you don't buy a battery; you buy a battery to put into something. Bringing the end user into the energy equation is essential."

Bellamy believes some 1.5billion people don't have access to a reliable source of power and the solution is organic solar cells, rather than their crystalline silicon based relatives. "It doesn't matter how cheap you make crystalline silicon, you can't make enough of it. There's no point in making, say, 10,000 parts; the market will want millions and we have the potential to make this volume," he concluded.



IMEC's involvement – and that of similar organisations – is seen by Poortmans as obvious. "Semiconductor device expertise and processing equipment expertise is an asset; particularly for crystalline silicon. In fact, many microelectronics companies are building their PV activities."

IMEC is participating in a broader European PV approach. Poortmans explained: "The European PV technology platform was established in 2005 to create a strategic research agenda. The first version of this is now available."

The European PV effort is intended to promote the rapid development of a world class cost competitive industry in Europe for sustainable electricity production. An important part of the work is to create strong links between industry, research and the market.

Cost competitive target

The plan lays out targets for PV technology in terms of €/W. A typical turnkey system is expected to cost €1/W in 2030, compared to at least €5/W today. In the longer term, this is expected to drop to €0.5/W. Solar generated electricity is predicted to cost €0.06/W in 2030 and to be broadly cost competitive with wholesale electricity.

Because of the relatively high cost of electricity in Italy, solar power is already at cost parity. But projections claim that, by 2030, solar power will be as cheap as conventionally generated electricity in most of Europe – even in the north of Norway. However, for solar power to be competitive at northern latitudes, efficiencies must increase substantially.

G24i's technology is relatively simple. The module comprises an negative electrode made from titanium foil and a transparent conductor layer. Titanium dioxide powder is painted onto the Ti foil and this acts as a support system for the ruthenium based dye. When light hits the dye, electrons are generated and collected by the conductor layer.

"The TiO_2 particles are very fine and very porous," said Bellamy, "which maximises the surface area."

G24i produces cells on a 305mm wide flexible substrate which can be up to 1000m long. The 305mm allows 24 of the 12.5mm wide cells to be placed alongside each other. Voltage is produced across the width of the substrate, whilst current is proportional to length.

"We can then configure modules," Bellamy continued. "If you want to charge a lithium battery, you need 5V, so we split the substrate to make two 12 cell wide modules."

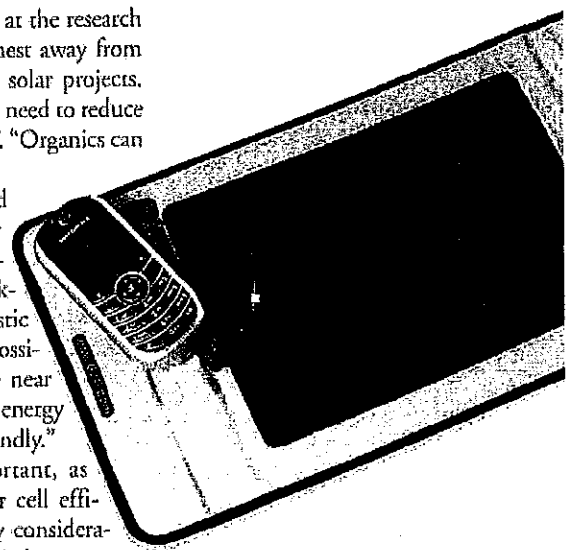
IMEC fellow Paul Heremans is leading organic solar cell development work at the research centre and admits this work is furthest away from industrialisation of IMEC's current solar projects. Amongst the challenges he sees is the need to reduce the cost of solar to $1/W, or €0.5/W. "Organics can meet this goal," he believes.

However, the processes required to make organic solar cells are very different to those used to make 'traditional' semiconductors. "We're looking at using substrates such as plastic foil," he remarked, "and paper is possible. But most processes take place near room temperature, so have a small energy budget and are environmentally friendly."

The latter point is important, as some observers see solar cell efficiency as a secondary consideration, with embodied energy as the primary one.

If you take a 20% efficient solar cell, which needed 400kWh for manufacture, and a 15% efficient cell which needed only 50kWh, observers say the latter is the better bet, because it produces net energy more quickly and thus has a better EROEI figure – energy returned on energy invested. So the solar PV industry is not only being challenged to boost the efficiency of its products, but also to make them

For some years, the concept of using a space based solar array to capture energy, then transmit it back to Earth, has been considered, such as the Sun Tower concept developed some years ago by NASA and pictured here.
A number of schemes have been put forward, with arrays of various sizes. Energy would be transmitted by microwave or laser to a receiving station on the surface and converted there into electricity.



Above: G24i believes solar cell technology will enable solutions, such as the mobile phone charger example shown here.