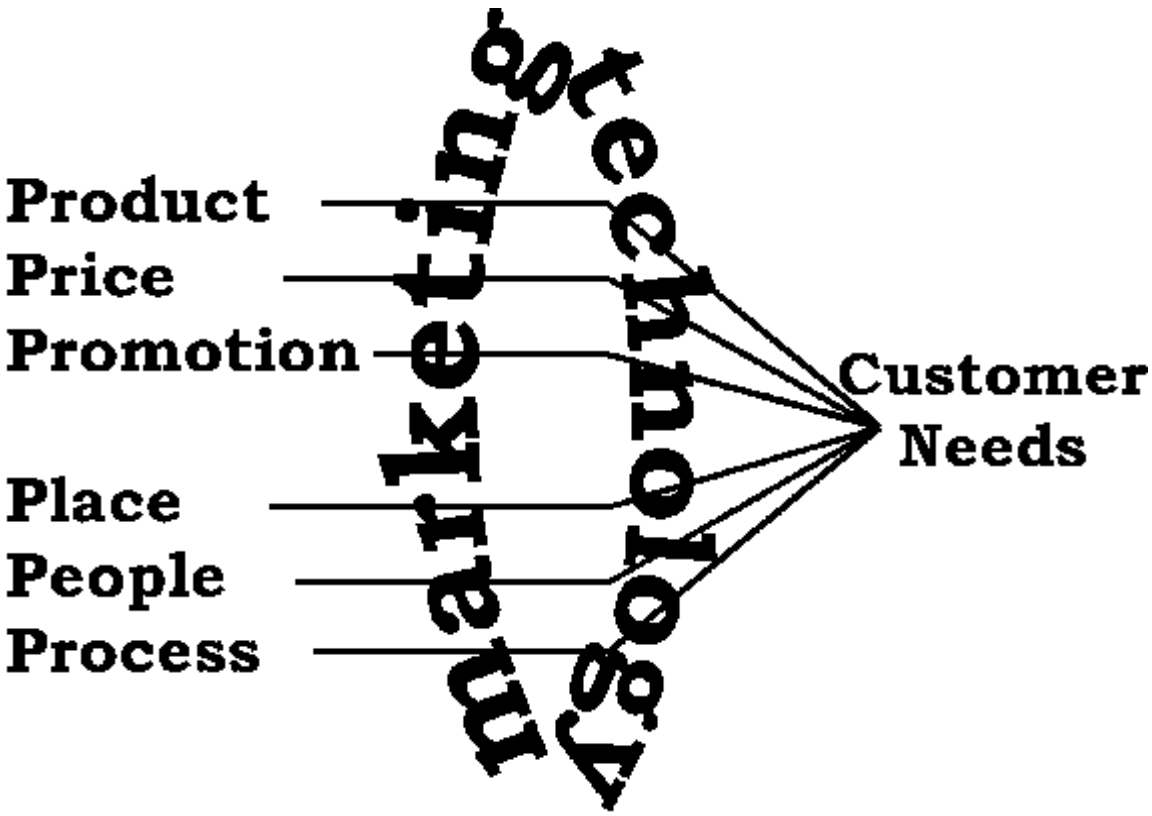
DTI Strategy Work shops for solid state lighting and Photovoltaics

A report by Customer Refocus



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Introduction

The DTI is conducting a strategic review of the Photonics Industry. One mechanism being used is to conduct strategy workshops in which a particular industry segment is discussed.

This is a report on the strategy workshop at which Solid State Lighting and Photovoltaics were discussed.

Principal DTI Objectives

The government along with relevant stakeholders within the photonics sector wishes to identify the opportunities and challenges for the UK over the next 5 to10 years, and develop an action plan for Government and industry to exploit the sector. The strategy workshops are intended to engage with leading companies at a senior level within the supply chain and wider stakeholders as part of the strategic review in order to:

- Develop a comprehensive picture of the industry's strengths, weaknesses, opportunities and threats;
- Analyse and identify the key issues affecting the future growth of the industry (such as technology, skills and finance);
- Develop a vision for the future of the photonics industry in the UK and identify action points and recommendations that enable government and industry to address the challenges posed.

Additional Project Objectives

Primary objectives are as follows:

- To assemble a group of key stakeholders from the UK photonics sector by providing a workshop in order to engage them in the strategic review process.
- To obtain a strategic picture of the future trends within the UK photonics sector theme addressed by the workshop.
- To evolve key elements of an action plan that will incorporate a series of recommendations.

Secondary objectives include:

- Publicize the ongoing DTI vision and delivery process for UK photonics.
- Provide networking opportunities and strengthen relationships with workshop attendees and wider stakeholders.
- To encourage participation of the Regional Development Agencies within the workshop and photonics strategy.

Methodology

Date

The workshop was held on Wednesday, 17 January 2006. The date was between the Consumer Electronics Show in Las Vegas and Photonics West in San Jose. Due to the process of commissioning the workshop, attendees had little notice. Most attended with about a week and a half's warning. This resulted in a strong bias

towards industrial rather than academic participants. Venture Capitalists were another group notable for their absence, although 12 were invited.

Location

As the Welsh Optoelectronics Forum was associated with the bid to hold the workshop, although not the final organiser, the location was in Wales. There is a potential cluster for Solid State Lighting in South Wales with Enfis, IQE, STS, Global Laser and Trikon all being potential participants. PV is also represented in the area with Intersolar in Bridgend.

Because of this potential and excellent rail and motorway links to the rest of the UK Newport, Gwent was chosen. The location was the King's Hotel, immediately opposite Newport station. The hotel location was excellent, the space was available to hold a much larger event, the food was satisfactory but the level of décor and housekeeping was only just adequate.

Attendance

The final attendance was 47. This was split between 28 interested in Solid State Lighting, 12 interested in Photovoltaics and 7 organisers from Customer Refocus, WOF and the DTI. The attendees were overwhelmingly industrial. Only 3 academics were present. A list of attendees is attached.

Meeting Format

The meeting followed the established DTI format although the SSL session included some discussion of key vertical markets.

Solid State Lighting

Solid-state lighting is not a mature industry and it is still being addressed as a series of vertical markets. The potential list of vertical markets proposed to the workshop included:

- Transport lighting (including Aerospace)
- Transport information systems
- Display backlights
- Horticultural production
- Medical light sources
- Architectural lighting/Low energy buildings
- Stand alone lighting systems
- Micro-generation
- Transmission line support
- Electrical load management & stability
- Emergency Lighting
- Security illumination (CCTV Night Vision – UK already dominates)

The solid-state lighting session started with a discussion of vertical markets. The vertical markets discussed were:

- Horticulture
- Aerospace
- Medical

Architectural lighting was also well covered in the general debate and is presented as a vertical market discussion.

Some general points emerged during the discussion of vertical markets.

- None of the respondents felt they had an overview of the total marketplace for solid-state lighting. There was a demand from all parts of the floor for a road map showing the development of solid-state lighting in terms of technology and applications.
- There was also a demand for market studies by the DTI to show the size of specific vertical markets.
- In all the markets discussed it was felt that the solid-state lighting was being held back because the high initial cost was more important to users than the low running costs. It was felt that this could be dealt with by tax incentives, improved regulation and grants from the Carbon Trust.

Horticulture

Lighting is used in horticulture for stimulating plant growth, for managing storage life, disease control and for point-of-sale applications.

There are three light-sensitive molecules in plants, chlorophyll A, chlorophyll B and phytochrome. Chlorophyll converts red light, the precise wavelength is not well understood, into chemical energy. Phytochrome which is sensitive to the ratio of red and infrared light regulates plant growth. The sophisticated use of light can regulate growth, quality, throughput and disease control of a horticultural establishment. However precise light sources are not widely available and most growers use high-pressure sodium lamps which have the major benefit of having the lowest total cost of

ownership available. Wavelength is not regulated by the growers. However they vary light levels over time by use of such techniques as night breaks. Solid-state lighting has the potential to offer precisely tuned wavelengths which might be varied by time of day or the particular time in the growing season, to say nothing of variation by crop.

Applying light to plant storage is essentially the same scientifically as applying it to stimulating plant growth except in this case the object is to inhibit development.

Diseases and pests respond to light and the right lighting conditions can suppress disease.

The use of correct lighting for plant display in retail environments can enhance the appearance of vegetables and increase sales.

Other potential vertical markets in biotech emerged from the discussion. Red light is used to manipulate the growth of chickens and calves; manipulating light can regulate the growth of fishes and the colour and intensity of light is known as a regulator in human well-being. Solid State Lighting can reduce costs and enable new applications at specific wavelengths.

The general demand for a road map showing technology and applications and a market study that gave statistics about the potential market size applied to horticulture which was an unconsidered opportunity for most attendees.

It was also felt there was not enough research at British universities into the impact of light on plants. The Horticultural Research Institute has been cut back in size significantly and the University of Leicester, once a world leading centre of study into phytochrome has lost its position.

Relabelling horticulture as Biotechnology might make it more attractive.

Aerospace and Transport

In transportation systems, weight, fuel efficiency and cabling specifications are particularly important. Aerospace is an extreme example. Solid-state lighting has the potential to improve all three specifications. Aircraft design cycles are shortening rapidly and in civilian markets may now only be five to 10 years. Aerospace therefore has the potential to be an early adopter of solid-state lighting systems. Lighting is found in the passenger cabin for general lighting purposes, for spotlighting for each passenger and for emergency lighting. There are special lighting requirements in the pilot cabin. Externally there are requirements for navigation and hazard lights. At the airport there are requirements for guidance lights.

In contrast to horticulture it was thought that Aerospace was well supported academically. However an issue general to transportation systems emerged during discussion. The colour of light emitting diodes varies slightly from bin to bin and is not well controlled by the manufactuers who are largely based in the Far East.

British users of light emitting diodes are typically small to medium-sized companies that are unable to cope with the costs of buying enough bins and sorting and into the very specific wavelengths generally demanded for transportation applications. For example the shade of red used in signals on railway lines is specified to within two nanometres. Light emitting diode production is not this accurate. The railways are therefore carrying much higher maintenance costs on signalling equipment than if the regulations were loosened. The availability of a variety of colours from light emitting

diodes calls for a re-examination of the human factors issues lying behind the regulations.

There was the usual demand for a road map showing technology and applications and a market study showing statistics of market size in aerospace and transport in general.

Medical

The discussion about medicine as a vertical market was cut short by lunch. It was a strong sentiment that the NHS should in principle be a significant opportunity unique to the UK. The £15 billion a year spent by the NHS on supplies was mentioned. The 64,000 GP surgeries were also discussed as a scaling factor. As the simple use of light of a particular colour can sometimes be an aid to diagnosis there are large opportunities. Ignoring such sophisticated techniques as Optical Coherence Tomography, there are simple illumination applications for SSL ranging from heat free operating theatre lamps to illuminators for endoscopes. The usual requests for road maps and statistics were made.

Architectural Lighting

Two slightly contradictory positions were stated during the discussion on architectural lighting. On the one hand there was support for the proposition that knowledge about the built environment at Unversities and major Architectural practices in the UK is world class. On the other hand there was support from SME's engaged in selling SSL for the position that most architects are change resistant and not aware of new technologies. There is clearly a requirement to link the world class know how with the practicing architect.

A key problem in introducing solid-state lighting to architecture is that the developer of the building is not the usually the organisation that bears the costs of running the building. Building developers are therefore aiming to keep the initial cost of the building low, whereas tenants are more interested in low running costs.

This contradiction is already a material factor that is being addressed by regulation. Energy efficiency regulations already require lighting in a new commercial building to have a minimum efficiency of 45 lumens per Watt. A policy of increasing the minimum efficiency over time would give increasing advantage to solid-state lighting. The government can do this in some buildings without necessarily creating regulations for the whole market. Low-energy buildings can be used to link solid-state lighting to photovoltaics in an architectural context.

Most lighting is bought on initial purchase cost. Even in the over-the-counter market which services users, 60% of purchases by value were of filament bulbs. Even though in many domestic applications long life bulbs actually offer lower total cost of ownership.

Opportunities are however emerging. For example, the MR16, a dichoric halogen 12 Volt spot lamp bulb often used in bathrooms is available in 20 and 50 W versions. LED replacement versions are almost cost effective replacements if a large enough production run could be obtained. Investment in the driving circuit is a key volume dependent cost factor.

Horizontal Market Issues in Solid State Lighting

This information was captured in slide form. The bullet point orientation has been kept.

SWOT

The list of individual SWOT items was very large so rather than presenting a SWOT table each element of the SWOT has been presented as a distinct section.

SSL Strengths in the UK

- Capital equipment for inorganic photonic semiconductor processing, is a major UK strength, including a significant Welsh concentration.
- The UK has a very strong position in producing the basic materials for inorganic photonic semiconductors.
- Infrastructure for volume production of organic photonic semiconductors through printing processes is in place
  - Marketing and device development is not yet there.
  - Driver circuitry for organic devices is not complex, UK can still compete.
  - UK has prospects in display plastic circuitry using ink jet techniques.
  - Johnson Mathey has an important ink jet substrate
- Optics drivers, packaging, thermal management
- Presence of OEM lighting companies
  - Some large
  - Many small
- IEE regulations for under 50 V are flexible enough to accomodate SSL
- Some key verticals are strong in the UK
  - Emergency lighting - emergency lighting systems could be redesigned away from NiCad battery supply.
  - Traffic management control.
  - Infrared illumination for civilian CCTV security
  - Many key early adopter market segments exist but the potential is unexplored

SSL Weakness in the UK

- General knowledge about the potential and availability of SSL is weak.
- There is no practically available source listing the benefits of SSL.
- Ideas good, practical rendition is limited by the small size of many players?
- Where are the venture capitalists?
  - US & Middle & Far East investors more receptive – the see a 50% replacement of other forms of lighting by 2020.
- iLED technology not advanced.
- Most industry participants are addressing small (Niche) markets but these are also the early adopter segments.
- Plastic electronics vulnerable environmentally for outdoor use. Favours early adoption in drier climates.
- No cohesion of the industry around standards.
- Graduate skills are becoming weaker in both lab and theory. Graduates have a lower level of enquiry and confidence in defending ideas compared to the past.
  - The research skill set is better.

Opportunities for the DTI to support the UK industry

- The volume opportunity is plastic, a UK strength but the market is immature.
  - Organic electronics is a source of national synergy.
  - Displays
  - iLED - £ materials, oled, pled (UK University)
- pLED uv free, clean for health care environments.
- Funding for demonstrators is required
- Systems integration with drivers, luminaires etc. is a potential strength if it can be developed.
- LED's are temperature sensitive. Standards for installation can drive UK early adopters.
- The UK has significant expertise in phosphors. This should be encouraged through funding and co-operative programs. Specific opportunities include.
  - Power variation in colour phosphors
  - Removal of the blue halo on displays
  - Use of nano phosphors
- Consumers, creative designers, ordinary architects, installers & venture capitalists lack education about the specific advantages of solid state lighting. Awareness programmes to reach these communities should be created.
- WEEE should be used to advantage.
  - The UK is the world leader in Indium and Gallium recycling both temporarily in short supply.
  - The disposal costs of non SSL lighting forms should be made transparent compared to SSL.
- The potential UK lead in SSL measurement technology can be turned into commercial success by companies providing measurement services and instrumentation products in for example:
    - Light output
    - Efficiency
    - Eye safety

Threats against the UK industry that the DTI should address

- US & other countries already support SSL installation in new buildings for energy savings.
- High quality consistent wavelength bin output is confined to Japan.
  - UK needs a medium sized company that can manage the bin variation issue.
- Regulation passing to EU
  - UK needs to lead the regulatory processes
  - EU regulations will lag the technology more than national capabilities for regulation
  - Regulations (typically transport signals) that demand colour to be precise within ±2 nm are not achievable by LED-SSL
  - LED lighting in Europe could fall under laser legislation thus inhibiting applications
- A safety incident involving an LED and an untutored public could give LED's an undeserved bad name. Prior education could reduce this.

Drivers of Future Growth - Technology

Short term

- MR16 replacement (as above)

Longer term

- The opportunity to become a major producer of organic LEDs is still open. The UK has strengths in Ink jet, reel to reel and flexible electronics, including chip level integration that are very appropriate for the production of organic LEDs.
- European recycling industry strength.
  - Capability to take technology through a vertical chain. Organic is still open.

Drivers of Future Growth - Skills

- Good metrology especially at UV is required.
- Graduate skills are inadequate. More Ph. D's are required.
- There is a poor marketing perspective in the industry
- The printing industry has excellent technology transfer skills. e.g. food, pharmaceuticals, colour graphics.
- Most installers are trained monkeys. Installation requirements have to be robust.
- Lighting specifiers & installers need to know how to specifiy and source SSL devices and how to handle safety issues.

Drivers of Future Growth -Finance

- Re-educate the sources of finance post bubble re technology.
  - UK VC's
- Different forms of tax relief to encourage pull from applications rather than push from academic development.
- The high initial cost versus the low total cost of ownership problem.
- The Carbon Trust should fund high installation costs.

Drivers of Future Growth - Market Information

- Technology and application road map
- Market statistics for key early adopter segments
- Technically aware political leadership
- An improved understanding of how light and biology interact is required of lighting designers.
    - Human performance
    - Animal behaviour
    - Plant growth
    - Medical and vetinary applications

A Vision for 10 years out

- UK will dominate the supply of capital equipment for inorganic LED's. Manufacture of inorganic LED's will be left to others
    - The UK academic base in inorganic LEDs still supports the capital equipment and materials suppliers.
- The UK will dominate in printing technologies for organic SSL

- UK maintains world lead in pLED's and now dominates
- The UK is the world leader in measurement
    - This leadership will transfer into world leading instrument building and process control abilities.

Principal DTI Actions to Drive the Vision

- Network customers with suppliers
- Build a database of the UK industry and installation capability
- Provide technology and application road map
- Provide market statistics for key early adopter segments
- Develop success stories about early adopters
- Educate significant populations about SSL NOW!
- Careful tracking of EU regulation especially laser legislation reform?
- Develop an SSL safety code before other countries
    - Relaxation on tax (energy), regulations
- Increased support from Carbon Trust to deal with high installation cost issues
- Develop support programmes that allow SME's to provide application consultancy to potential users (A successful example was the West Wales/Eastern Ireland Intereg programme on laser applications where a new application for high brightnes LED's was enabled – inspecting slaughtered chickens for blood)
- Keep a high level of linkage between global academic research into inorganic LED's and the UK capital equipment and materials industry through active support of cooperation programmes with the EU (eg. Eureka), Russia (eg TACIS), Japan and the USA.

Photovoltaics

Contributed by Ian Maxwell of the WDA.

Background

The PV market is growing steadily with an annual increase of 30-40%. This is led by Germany which has overtaken the US and Japan as the largest adopter in 2004. Germany, in 2004, accounted for 39% of the world market with the rest of Europe accounting for a mere 8%. Japan still has the largest installed capacity with over 50% of the world total. Both, grid connected and stand alone systems are gaining in popularity with stand alone systems providing a real competitive alternative in rural areas.

The benefits of PV are that it produces no CO_2 and has negligible public resistance to implementation. PV can be installed virtually anywhere, from crowded urban areas to rural dwellings. The aim in the US is to have half of all new electricity generation powered by PV by 2025. To become a reality this will require government commitment. Long term policies in Japan and Germany are developing the market and therefore driving technology. PV is unlikely to impact on the UK's commitment to reduce CO_2 emissions by 2010 but has the potential to make a substantial contribution by 2030.

The UK Government through the DTI has been supportive of this industry in the form of grant support (30M Euros) in a demonstrator programme of field trials, e.g. the 85kW installation on Technium OpTIC building in North Wales. This grant support is due to finish in 2006 with nothing to take its place.

The driving influence is cost, which is falling annually, combined with the increasing price of oil and advances in technology, is making PV more competitive. Additionally, the added value of PV systems is not appreciated by policy makers, regulators or the building and finance sectors. For example, PV modules can replace roofing and cladding materials to offset or eliminate the additional cost. Currently the European PV industry employs 15,000 people.

UK Industry

Regionally, Wales has 2 of the 3 manufacturers of PV products in the UK; Sharp and ICP Solar. The other company is Romag working with BP Solar and Marley Roofing in County Durham. BP Solar no longer manufacture PV modules in the UK because the adoption of PV was slow compared with other European countries. Wales has a supply chain: PV research at the University of Wales, Bangor, two leading manufacturers and two well respected installers. The South facing façade of Technium OpTIC in North Wales is thought to be the largest PV installation of its type (CIS) in the world. However, the material most used by the PV industry now and for the foreseeable future, silicon, is in short supply.

Whilst the UK can invest money in PV research for the next generation of PV it is the establishment of market demand for the current technology over the next few years that will drive this industry to new heights. To develop an indigenous industry and to ensure that global companies that are already located in the UK remain, it is essential that demand is created in the UK.

Various models have been tried but without government intervention and consistent long term support PV will remain a curiosity rather than mainstream and part of an integrated energy policy. The model used in Germany, that of a feed-in-tariff, has proved not only simple and effective but has given rise to a large demand for PV creating and an estimated industry supporting 35,000 jobs in 2007. PV by end of 2003, 5MW had been installed in the UK while 410MW had been installed in Germany.

10 Year View

Over the next 10 years, the UK with political will, could have an industry equivalent to Germany and implementation now could be used to offset the introduction and scale of additional nuclear generation. This argument would not be lost on environmental detractors of increased reliance on nuclear energy.

Assuming that no mechanism such as a feed-in-tariff to stimulate market demand had been implemented, a major part of in implementing PV sources will be legislation on building regulations along the lines of: all new houses to generate c50% of power from PV and commercial and public sector 20%. This would generate an estimated market size of c1GW/annum or £4bn per/annum in the UK. A feed-in tariff is likely to get us to the same point and give rise to large market growth

Thin film PV will be reaching commercialisation in niche applications but it is likely to be later than 10 years to reach acceptance in mass grid connected markets.

Silicon will still be a major material in PV for the foreseeable future and therefore investment by the UK in silicon plant will not be wasted. This will safeguard jobs and create an industry in the UK.

There are likely to be significant niche, non-grid markets – but to address this market global collaboration may be required.

There is some debate as to whether a large 3rd World market exists which could be harnessed by aid from developed countries, e.g. water treatment and desalination plants. Knowledge and expertise can be offered by the UK to developing countries.

The future holds significant opportunities for a combination of technologies, including PV, intelligent systems, hot water, orientation of cells, control and sensors in developing systems responsive to market demands.

Actions for 10 years:

To gain momentum needed to pursue this as a widespread energy source a dedicated PV association and a high profile champion is required for the industry. To date barriers to implementation are:

- Too much change of policy and individuals in key government positions, therefore a feed-in tariff is seen as a simple way of understanding of how a PV energy contribution could work
- The Carbon Trust document on PV is thought to be flawed and therefore not making a strong case for PV. DTI need a strong case for PV NOW! From an authoratative source to offset the reputation of the Carbon Trust e.g. Fraunhofer in Germany or IEA

To protect the industry, investment in silicon plant in the UK (to control and safeguard the industry) over the 10 year timescale is considered desirable.

Carbon Trust data currently used as a benchmark is thought to be inaccurate and misleading. An industry "bible" on costs needs to be assembled by a high profile credible source, e.g. Fraunhofer Institute in Germany or IEA. These costs of PV to include:

Total life costs: Against other electricity generating technology

Maintenance costs

PV integrated into buildings and substitution for cladding, roofing tiles etc

End of life costs (98% can be recycled)

The Photovoltaic Ecosystem

It was the considered view of the group that for the PV industry to thrive in the UK there must be a feed-in tariff, along the lines of the German model, to stimulate market demand now, using today's technology. This will give a platform for future generations of PV technology to find a market.

Photovoltaics	Significant presence in UK?	Global players in UK?	Declining or growing?	Research base?
End User	Few	No	Stable	N/A
Volume manufacture	Yes*	Yes	Growing	No
Equipment (OEM)	Yes – SMEs	No	Growing	Yes
Sub-assemblies	Yes	No	Growing	Yes
Components	No	No	Stable	N/A
Materials	Yes	Yes	Declining	Yes
Academic programmes	Yes	Yes	Growing	Yes

SWOT Analysis

Strengths

- Academic – New materials, increasing performance

PV SuperGen considered a premier project

Expertise in installation (building integrated systems – but in a small market)

Expertise in manufacturing (knowledge base, in techniques using lasers and vacuum deposition)

- Linkage overseas (to sell skills and expertise in overseas in design and technology – but not mass volume manufacture

Global market leader in the UK (Sharp) but presently only assembly (technology supply chain absent, parts brought in from overseas)

Weaknesses

- No global scale industry in the UK, either in demand or supply chain

Poor PR for the PV proposition

No Market in the UK

- No future planning for large scale manufacture for current or next generation technology

Consistency of Government policy e.g. 10 year PV policy scrapped after 3 years!

- Catch up with other countries both in technology and infrastructure will require funding to catch-up and to accelerate

No strong links between academia and alignment with industry

PV will have no effect on 2010 targets and therefore is not on the radar screen of energy analysts and opinion leaders. If no significant investment now, PV will have no effect by 2020/30. Need an integrated long term energy policy to include PV

Opportunities

- Establish links with Japan and China
- Combination of PV and thermal

Influence an EU directive on building regulations for new build

Feed-in tariff – adopted across the EU

- Generate arguments on basis of total life costing using innovative designs
- Invest heavily in current technologies to ensure tomorrows industry
- Innovative applications, using best products available (poor products giving PV a bad name), e.g. cars, yachts
- Increase PR – drive demand

Manufacture PV grade silicon

Off grid applications – e.g. LED lighting

- Batteries or other methods of storage

Power electronics for control and to mitigate safety issues

Threats

Industry dominated by Japanese industry but increasingly China will be a force

Potential to stimulate market but may open the doors for overseas rather than indigenous companies

Japanese government support for PV diminishing therefore companies expanding globally

Material costs are increasing (e.g. silicon 3x in the last 9 months) companies being tied into long 10 year contracts with suppliers

Number of players reducing and therefore those remaining control the market and therefore the price of PV

Representation and networking:

- Currently PV falls under the umbrella of a renewables trade association (REA). PV in this consortium is too small to compete with other renewables for share of voice and therefore does not get on the political agenda of opinion leaders.
- A route to a much greater awareness is to have its own PV industry group that solely represents the PV industry
- Networking groups would include building regs., energy conservation, architecture and environmental groups

- Develop PR messages – possible start at a regional level and influence local councils, building regs., (out of town shopping parks, condition of planning approval?)
- What level of PR would make a difference?

Government lobbying required to embed PV into the energy mix and overcome barriers in government and individual thinking

Regulation:

- Need a initial pump priming mechanism possibly via an EU recommendation for feed-in tariff
- Potential for adopting the German model, feed-in rate gives breakeven in 5-6 years with feed-in guaranteed for 10 years.

Require government pressure on utility companies to guarantee feed-in for c10years

Procurement:

- Influence government to insist that new public sector buildings have PV incorporated into design – the public sector is risk averse and not currently known as an early adopter.

Need to communicate success stories, e.g. OpTIC's PV wall

Innovation:

- Need to develop innovative PR activity
- expert and authoritative voice as a focal point for the press (academic?)
- Target interest groups in the building industry
- Feedback results to building companies
- Recognition that there are 2 markets (grid connected and non-grid connected
- Seize the market now

Difficult to make the case to do it in the UK (no market in the UK)

Access to finance

Not a problem

Taxation

Again a feed-in tariff would overcome this

Accessing Government

- Too much change of policy and individuals in key positions, therefore a feed-in tariff seen as a simple way of understanding of how a PV energy contribution could work

Carbon Trust document on PV is thought to be flawed and therefore not making a strong case for PV. DTI need a strong case for PV NOW! From an authorative source to offset the reputation of the Carbon Trust –e.g. Fraunhofer in Germany or IEA

Skills and training

Lack of knowledge of how solar works and the benefits, particularly by the potential implementers in the building industry. There is a need to broaden the message to a wider audience to gain wider public acceptance. Education of an raising awareness of planning authorities and bodies like the Countryside Alliance, Friends of the Earth.

Drivers for Growth

- Feed in tariff
- Political will **à** electorate push
- Drive 1st generation PV otherwise there will be no market for next generation technology
- Dissemination of correct information (commission highly credible organisation)
- Linkage between market and skills
- CO2 fears
- Fossil fuels prices
- Energy security
- Technology development **à** links with other technologies, e.g. solid stae lighting, flat panel displays, electroluminescence, printable electronics etc

Generate electricity where it is needed

10 Years Time (UK)

Building regs. – All new houses to generate c50% of power from PV and commercial and public sector 20%. This would generate a market size of c1GW/annum or £4bn per/annum in the UK. In Germany the PV industry is set to create and sustain 35,000 jobs by 2007.

- Feed-in tariff is likely to get us to the same point and give rise to large market growth
- Thin film reaching commercialisation in niche applications
- Use of silicon still a major material in PV investment by the UK in silicon plant not wasted!!
- Significant niche, non-grid markets – global collaboration
- 3rd World large market? Knowledge and expertise can be given by developed countries
- Combination of technologies, intelligent systems, hot water, orientation of cells and control and sensors
- Development of market responsive systems

<u>Worst Case at 10 years</u>

Business as usual: Discreet companies

No large scale power

No indigenous market in the UK

Bits and pieces, small scale and ad hoc

Importing energy

Discontinue successful academic projects

No political will

Actions for 10 years:

- Lobby for feed-in tariff
- News feeds - PR
- Investment in silicon plant in the UK (to control and safeguard industry)
- Champion required for the industry
- Accurate industry "bible" on costs
- Funding
- Total life costs: Against other electricity generating technology
  Maintenance costs

PV integrated into buildings and substitution for cladding, roofing tiles etc

End of life costs (98% can be recycled)

2.6 Lighting (LEDs etc)	Significant presence in UK?	Global players in UK?	Declining or growing?	Research base?
End User	Yes	Yes	Stable, but growing as market for Solid-State lighting	Yes Built Environment
Volume manufacture	Yes (many SME's)	Yes Traffic Signals	Stable, as electronic production converting to LED	N/A
Equipment (OEM)	Yes (many SME's with large market shares)	Yes	growing	Moderate
Sub-assemblies	No	Yes (several large groups)	growing	N/A
Components	No (Yes for conventional sources)	Yes	Stable	Yes
Materials	Yes	Yes	Stable	Yes
Academic programmes	Yes (but not many on LEDs)	PLED's	Stable/Declining	Yes Flexible organics