UK ADVANCED POWER GENERATION TECHNOLOGY FORUM

Response to 'Energy Policy, Key Issues for Consultation May 2002'

INTRODUCTORY STATEMENT

The Advanced Power Generation Technology Forum (APGTF) welcomes this opportunity to respond to the Government's consultation document 'Energy Policy – Key Issues for Consultation' which has been issued following the publication of the Energy Review. The Technology Forum, a Foresight Associate Programme provides the focus for the UK Power Generation Sector on power generation technologies for fossil fuels, biomass and associated technologies.

A broad range of interests is represented on the APGTF, mainly through the key Trade Associations involving the power generators and users, equipment manufacturers and fuel suppliers (namely Electricity Association, Association Electricity Producers, Combined Heat and Power Association, BEAMA/Power Generation Contractors Association and COALPRO) together with representatives from the Research Community, Government (DTI, DTI-OST and DTI-SEPU) and the Funding Agencies (EPSRC).

The APGTF has given careful consideration to the technological issues surrounding power generation, especially from fossil fuels and biomass, including carbon sequestration. This has included extensive consultation amongst those in the UK with an interest in power generation, not only within the industry but also academic experts. The APGTF has also held a workshop on10/Sept/02 that was attended by over 90 UK experts in the power generation field. The workshop gave broad endorsement to this document and comments of the delegates have been fully considered. The APGTF's comments on the main themes for consultation as presented in the Consultation Document are set out below and follow the same order, namely :-

- Security of Supply
- Climate Change
- International
- Energy Efficiency and Combined Heat and Power
- Renewables
- Transmission, Distribution and Trading

- Nuclear
- Gas and Oil
- Coal
- Innovation
- Transport
- Institutional

Before doing this, it is important to note the following in the context of the PIU Energy Review and the proposed Energy White Paper. It was with some general regret by the APGTF that the PIU report (1) gave virtually no consideration to the prospective impact of future energy policy upon the service and equipment supply industry and employment. Such economic impacts need to be considered openly alongside environmental, social and other issues. It is the strong recommendation that this now be done in the final development of a National Energy Policy. In addition, it is important that decisions on, and the announcement of, future energy policy be made as soon as possible to give a firm, consistent and continuing framework against which all concerned, especially industry, can plan and take decisions.

Since late 1997, the UK power plant market has been subject to considerable uncertainty arising successively from the review of energy sources for power stations; the Stricter Consents Policy; the changes to electricity trading arrangements, and the on-going overall review of energy policy. Against this background, the domestic market has collapsed leading to an absence of orders for new plants and equipment with consequent long-term industrial capacity and employment losses; this is also putting UK manufacturing companies at a disadvantage in the global market where most of its competitors have a domestic market to underpin their business. It is, therefore, highly desirable that a basic policy framework is now rapidly put in place which will give reasonable certainty of a predictable and relatively consistent demand pattern.

At the moment, the market drives towards cheapest electricity; this provides a disincentive towards energy efficiency, new plant investment and fuel diversity. A different set of market conditions or signals needs to be provided in order to create a stable situation.

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- ***The market provides a disincentive towards energy efficiency, new plant investment and fuel diversity. A different set of market conditions or signals needs to be provided in order to create a stable situation.***

SECURITY OF SUPPLY

Current forecasts suggest the UK will become increasingly dependent on natural gas for power generation over the next 20 years. It is generally recognised that the gas to be used for generation will increasingly come from imports. If current trends in policy continue, this will leave the UK exposed to a high level of dependency on a small number of external suppliers and to the cost of gas – unacceptably so, given the primacy of power supplies to the nation's economic activity.

There is, therefore, a strong argument for indigenous fuel sources always being required to dominate the fuel mix to mitigate the above risk. However it is necessary to ensure an appropriate balanced mix of fuels (including gas) and this will require the continued development of clean technologies using these fuels. A balanced mix of fuels will also ensure that future power quality requirements can be met and it will help underpin industry in the global market place.

The requirement for a balanced mix of fuels suggests:

- continuing utilisation of coal (and gas), recognising also that any balance of the UK coal needs can be met from a wide range of politically stable countries, and
- continued development of renewable energy sources such as wind, hydro, biomass and energy from waste.

In relation to the former, technology exists to provide cost-effective coal-fired plant that offers increased efficiency and low emission levels (as indicated in the previous section).

The planned growth of renewables will also place more emphasis on fast response, flexible plant (as well as storage) to ensure secure, uninterrupted supplies. In the short to medium term, this flexible plant is likely to be fuelled by fossil or biomass fuels. In the UK, this kind of plant has traditionally been located centrally but the market for smaller distributed systems, even down to domestic size, is growing. Currently these plants do not have a high efficiency for power generation, so there is an R&D need to produce suitable, high efficiency, flexible plant that can produce uninterruptible power at a competitive price.

A second element of security of supply relates to the ability to transmit power to the ultimate customer. Reliance on large central generation plant requires a strong transmission and distribution system. However, the encouragement of distributed generation, providing the power and heat needs of local regions through co-generation and small-scale power generation plant, would help ensure security of supply in those areas. This approach will need positive action by Government if it is to be practical and there will be a need for technology development and implementation addressing energy system management issues.

- ***There is a strong argument for indigenous fuel sources being required where possible to dominate the fuel mix to mitigate security of supply risks. However, it is also necessary to ensure an appropriate balanced mix of fuels (including coal, gas and biomass) and this will require the continued development of clean technologies using these fuels.***

- ***A balanced mix of fuels will also ensure that future power quality requirements can be met and it will help underpin industry in the global market place***

CLIMATE CHANGE

It should be noted that the main scenario presented in the PIU Energy Review [(1)] shows 70-80% of the power generation in the UK coming from fossil fuels; this scenario is also regarded as the most likely across the globe for 2020. Renewables are expected to gradually increase their contribution but fossil is still expected to be dominant for many years to come. It is therefore essential that Research, Development, Demonstration and Deployment is strongly supported for fossil power generation, as this is where the biggest reductions in carbon emissions can be achieved, as part of an overall energy research strategy.

In the short to medium term incremental improvements in plant efficiency offer the most cost effective way of reducing carbon emissions from fossil plant. Higher efficiencies can be achieved through already available technologies and a preliminary study of the options for coal has been carried out in the DTI's 'Review of the Case for Government Support for Cleaner Coal Technology Demonstration Plant'[(2)]. This review highlighted the potential of supercritical or ultra-supercritical boiler technologies and gasification technologies. Some of these technologies can be retrofitted to existing UK plant giving carbon savings of 15-20%, compared with conventional pulverised coal plant, relatively quickly and cheaply with resulting costs of generation being 2.0-2.8p/kWh. These technologies can also be used for new plant build giving even higher carbon savings but at higher capital costs with generation costs of 2.6-3.7p/kWh – these generation costs being very competitive with the cheapest renewables.

Similarly, retrofit options exist for the UK's existing fleet of Combined Cycle Gas Turbines (CCGTs) that has the potential to increase the efficiencies of the older CCGTs up to that of the latest designs, resulting in significant, cost-effective carbon savings.

The DTI's review [(2)] concludes that there is no economic case for building new cleaner fossil power generation plant at present electricity prices. However, it also points out that there is some evidence to suggest that a relatively modest contribution to the development of key supercritical steam plant technologies might help reduce the 'first taker' risk involved and encourage the retrofit of such technologies to existing UK plant. This would also help promote the take-up of similar technologies in developing markets, which would have an even greater impact on carbon dioxide (CO_2) emissions overseas. The APGTF supports this approach and sees it as a cost-effective way of achieving significant CO_2 reductions both in the UK and globally.

Looking towards the short to medium term, the Foresight report 'The Transition to Zero Carbon Emissions'[(3)], has proposed that a R&D programme be carried out with technology aim points corresponding to a further increase of electrical efficiency of 10-15% above that of currently, best-available technologies with resulting plant and generation costs being commercially competitive. This would result in carbon savings of up to 50% compared with current fossil plant in the UK. To develop these technologies, the Foresight report proposes support for a 10-15 year strategic research and development programme and it sets out how this can be funded.

In the medium to long term, it will be necessary in the UK to apply Carbon Management Technologies (CMTs) to fossil plant, both coal and gas, for the capture and storage of CO_2. The capture of CO_2 is relatively well understood and proven as a technology although there is a need to demonstrate the technologies at the large scale required by a fossil-fuelled plant. Also there is a strong requirement for research to reduce the costs and to improve the removal efficiencies. Also both environmental impact and the degree of reliability of storage need to be addressed. According to the Foresight report[(3)], CO_2

capture in large gas turbines (GTs) increases the costs of generation by about 0.7p/kWh and for large coal plant by approximately 1.7p/kWh. These costs compare very favourably with the costs of other options for avoiding CO_2 emissions in power generation, such as renewables or nuclear.

It is also clear that the oil companies operating in the North Sea have a potential interest in taking large quantities of relatively pure CO_2 to use for enhanced oil recovery (EOR). Here the UK has a specific asset to exploit. The capacity of the North Sea fields is more than sufficient to capture and store any likely UK CO_2 production; there would also be scope to sell storage capacity to other North Sea countries to help them with their CO_2 reduction programmes. There is a need for urgent action in this area because of the limited lifetime of the North Sea fields and the supporting infrastructure. However, a preliminary study reported in the DTI's 'Review of the Case for Government Support for Cleaner Coal Technology Demonstration Plant' [(2)] has indicated that there are a number of uncertainties surrounding CO_2 storage and its use in EOR.

The APGTF strongly supports a conclusion of the DTI's report [(2)] that 'there is a strong case for assessing in a systematic way the legal, scientific, engineering and economic aspects both of EOR and of geological capture and storage'. This needs to be done with some urgency.

- ***Renewables are expected to gradually increase but fossil is still expected to be dominant for many years to come. It is therefore essential that R,D&D and Deployment are strongly supported for fossil power generation, as this is where the biggest reductions in carbon emissions can be achieved, as part of an overall energy research strategy.***

- ***In the short to medium term, as an important transition step to fully sustainable energy systems, incremental improvements in plant efficiency offer the most cost effective way of reducing carbon emissions from fossil plant. At the same time they will provide substantial opportunities world-wide, provided the UK has a strong home base including demonstration of such technologies as part of a CO_2 reduction programme.***

  Towards the longer term there is a strong case for assessing in a systematic way the use of captured CO_2 for Enhanced Oil Recovery in the North Sea and of geological capture and storage. This needs to be done with some urgency. With continuing Government support, Britain and British companies could be well placed to benefit from longer-term world markets as they arise.

INTERNATIONAL

The UK's power engineering industry involved with the production of fossil fuel plant currently has a 10% share of the world market. The UK has manufacturing strengths in areas such as gas turbines, boilers, steam turbines, clean coal technology, flue gas clean-up, materials, combustion science, catalysts and power systems engineering. It is also an acknowledged leader in systems design, environmental assessment and in the overall technical and financial management of power plant construction and operation. In order to retain this position and to ultimately grow it, there needs to be a strong programme for research, development and demonstration backed up by policies and measures appropriately targeted to encourage deployment of the technologies. Such a programme needs to have

a strong international element especially for those parts that address the long term issues associated with climate change.

Significant benefits can be gained from pre-competitive collaboration in the R&D for long-term power generation technologies. There is a range of opportunities open to the UK for such collaborations and these include: EU programmes; IEA programmes; one to one collaboration with other national programmes, such as the ongoing interaction with the USA on clean coal technologies. Once past the development stage, new near to zero emission power plant will need to be demonstrated at full scale, both to gain operational experience and to reduce the investment risks attaching to new untried designs.

The Foresight report on 'Power without Pollution' [(4)] recognises the importance of international collaboration and it presents an analysis of total UK funding on research and development compared to its main competitors. The APGTF agrees with the conclusion of the report that UK funding, which has been reducing for several years, is small compared to countries like USA, Japan and Germany. As an example in 2000 the R&D funding on coal technology is given as: £83m in USA; £61m in Japan; £12m in Germany; £2m in UK – more recently, President Bush has pledged to invest $2 billion over the next 10 years in new efforts to demonstrate advanced clean coal technologies. The Foresight report concludes that to maintain its international competitiveness, UK funding for Energy R&D must increase significantly in order that the UK can be an equal partner in, and thereby benefit fully from, international collaborations.

Finally, the APGTF would welcome Government support for international collaborations (particularly those within the EU or North America) and through organisations such as the International Energy Agency and with bi-lateral agreements with other national programmes (eg the UK-USA MOU on Energy Research and Development).

- ***For the UK's power engineering industry to retain global market share and to ultimately grow it, its programme for R,D&D needs to have a strong international element, particularly in the EU and North American context. Furthermore, to maintain its international competitiveness, UK funding for Energy RD&D must increase significantly in order that the UK can be an equal partner in, and thereby benefit fully from, international collaborations.***

ENERGY EFFICIENCY AND COMBINED HEAT AND POWER (CHP)

According to the Energy Review [(1)] , 'energy efficiency has the closest match with all the major sustainable development initiatives'. The Energy Review in discussing efficiency gains and targets, focuses on end use. The APGTF supports this view. However it feels that there are also substantial gains to be achieved by further development of power generation technologies (a further 10-15% efficiency above that of currently available technologies given an appropriate programme of research, development and demonstration as stated earlier).

To achieve these efficiency increases requires a combination of incremental improvements of existing power generation technologies such as supercritical pulverised coal, GTs and Integrated Gasification Combined Cycle plant (IGCC) together with the development of step-change technologies such as ultra supercritical plant (which requires new materials) and fuel cells.

It will be important to recognise the increasing importance that cross-cutting technologies will play in developing higher efficiency plant. This is highlighted in the Foresight report on 'Power without Pollution' which gives examples of: integration of different plant types, such as fuel cells with gasification or GTs; common plant which is used in many generation technologies, such as boilers, gas turbines etc; enabling technologies such as materials, control systems, advanced computer systems etc which support development across a wide range of technologies. Future R and D programmes need to ensure that maximum benefit is obtained across all power generation technologies from cross-cutting themes.

One important approach to obtaining a step change in efficiency is the wider implementation of CHP. It is recognised that CHP is able to make a significant contribution to reducing carbon emissions over the next 10-15 years, up to 6MtC per annum by 2010 [(5)] , but only if it is properly incentivised. Both developers and equipment suppliers made considerable efforts to be in a position to meet an expanding UK CHP market following the positive Government statements made several years ago, and the setting of a 10GW installed capacity target by 2010. Unfortunately, exactly the opposite occurred in the market as a result of other Government policies which impacted adversely on CHP development, especially the imposition of the Climate Change Levy on exports of electricity from CHP plants into the grid, and the highly negative effects of NETA upon smaller, intermittent generators. Although this is partly being addressed by the CHP QA scheme, the general industry view is that the certainty of a CHP obligation will be necessary if the 10GW target is to be achieved by 2010. It is vital that full confidence is restored to the CHP market.

There are large-scale technologies already commercially available that can achieve overall energy efficiencies of 70-80%. CHP technology has traditionally focused on large industrial or large commercial installations; new technologies now being developed are offering the potential of small-scale applications of CHP, down to the domestic level, which are targeting energy efficiency levels of up to 80%. These mini and micro technologies are another area that merits further research and development, with micro-GTs and fuel cells as being examples of near-term and medium term technologies.

This section refers to the technology developments that have the potential to produce step-changes. However, there are other issues and barriers that need to be addressed before these step-changes can be realised; these are discussed further below in the section on Institutional.

- ***Energy efficiency and the improved use of energy remains an important issue. This requires continued technology development and deployment, allied to policy measures that will encourage its take-up in an increasingly risk adverse market. It is vital that confidence is restored in the CHP market.***

RENEWABLES

The remit of the APGTF covers biomass and waste but does not include directly other forms of renewable power generation. However, there are some important general technological issues that refer to fossil and renewable power generation that will be commented on here.

The contribution which renewables can make to meet the UK's energy requirements will depend upon active, continuing Government support. The PIU proposed target of 20% by 2020 will be difficult to achieve, even given the potential for wind energy (both on and offshore), biomass and energy from waste. It will require, as a minimum, the following aspects to be addressed.

- consents
- economics
- public acceptance
- storage or back-up
- limits imposed on biomass cofiring by 2006 qualifying date

Also, such technologies will continue to need support in lieu of the environmental benefits which they offer having a monetary value directly reflected in electricity pricing policy. In addition, new and emerging technologies will require support for commercial-scale demonstration plant to promote market acceptance and help overcome insurance and financial risks that would otherwise render such projects non-viable. It is apparent that, especially in the UK's liberalised electricity market, new technologies will fail to achieve commercialisation as the risks of a 'first of kind' plant are now too high to be taken.

Power production from biomass approaches CO_2 neutrality, however, large amounts of biomass are needed to meet power generation requirements. According to the Foresight report 'The Transition to Zero Carbon Emissions' [(3)] , using current plant technology and current biomass stock, to produce 10MW requires approximately 4000ha of biomass planting, corresponding to an efficiency of 35%. This report proposes a R&D programme that would increase power generation efficiencies for solid fuels to 60% in the medium term which would result in a reduction of this acreage by 40%; or from the same acreage it would produce 70% more power. The technology development requirements for biomass power generation plant are similar to those for fossil fuel, at plant sizes of c10MW, with future technologies likely to be based on gasification or pyrolysis.

Estimates suggest that the biomass power generation market could be worth in excess of £100 billion over the next 20 years. By having operational demonstration plant, UK companies would gain a competitive advantage in the world market – relevant also to project developers, consulting engineers, engineering contractors, operation and maintenance service companies, banks and insurers. However, the recent problems with the UK biomass project ARBRE highlight the problems outlined above associated with getting new technology projects going.

The cofiring of biomass in existing coal-fired power stations can quickly produce benefits for CO_2 emissions; it will also help set up a market for biomass production which will assist the whole of the biomass sector. However the limits imposed by government that after 2006, at least 75% of the biomass must consist of energy crops planted since 1990, is placing the commercial viability of cofiring in doubt.

The potential for energy from waste is relatively modest but important as it helps to address the increasing waste issue; technology developments are aimed at doing this cleanly and with high efficiency. These developments parallel those for fossil and biomass fuels and this should be noted in any future R&D programme. This would provide an opportunity for linking waste and energy policies through a small number of large-scale gasification plants.

Finally, a rational assessment should be carried out of how and where to use renewable technologies in a mixed energy portfolio, such that optimum carbon reductions can be achieved for a given investment. In some cases, the economic optimum could be to link fossil and renewable technologies. Examples where there could be a benefit are: cofiring of biomass with fossil fuels; solar feed-heaters for fossil power plant;

integration of fuel cells into fossil power plant cycles; local integration of intermittent renewables with small-scale fossil generation to produce quality, uninterruptible power. In the longer term, the integration of renewables, hydrogen production and power production by fuel cells needs to be considered.

- ***New technologies will require support for commercial-scale demonstration plant to promote market acceptance and help overcome the risks that would otherwise render such projects non-viable. In the UK's liberalised electricity market, new technologies will fail to achieve commercialisation as the risks of a 'first of kind' plant are now too high to be taken.***

- ***The APGTF believes the proposed target of 20% by 2020 will be difficult to achieve and will require certain key difficulties to be addressed, in particular the site consent process and the issue of public acceptance. Also the limitations imposed by the qualifying date of 2006 for biomass cofiring need urgent review.***

TRANSMISSION, DISTRIBUTION AND TRADING

Considering the development of distributed generation (DG), the APGTF believes that the key drivers that will determine which power plant will enter into the market place in the future are

- Cost (eg capital, through-life, fuel, infrastructure)
- Regulation (eg environmental, government policy, public opinion)
- Resources (eg fuel, fuel flexibility, security of supply)
- Business/Market Dynamics (eg plant ownership, electricity/emissions trading)

Over the next 20 years some of these drivers are expected to lead to the gradual growth of DG, where electricity and possibly heat is produced close to the load centre. This would lead to some displacement of the conventional large power plant. The 'European Union Energy Outlook to 2020' [(6)] predicts that up to 20% of electricity in the EU could come from DG by 2020. The APGTF believes this is optimistic for the UK.

The key technologies for DG out to 2020 are likely to be combustion engines and micro GTs initially with fuel cells potentially entering the market in large numbers from about 2010 provided key market and technology issues are addressed. These technologies will enter the market when they are price competitive with existing forms of energy. However, for these technologies to be successful, it is the view of the APGTF that they will need a supporting R,D&D programme.

Also there is the need for Government Energy Policy to ensure that adequate investment takes place consistently in the transmission and distribution network, both to maintain the timely replacement of ageing assets and the required quality of supply. This must take place alongside more systematic

change in these sectors that will result, for example, through the new demands imposed by the growth in distributed generation.

- ***The APGTF believes that the EU prediction of 20% distributed generation by 2020 is optimistic for the UK. The types of power plant technology that enter the market will be determined by the key drivers of: cost; regulation; resources; business/market dynamics. For the distributed generation technologies to be successful, they will need a supporting R,D&D programme.***

NUCLEAR

Nuclear power is not in the remit of the APGTF, however, the Consultation Document asks the question 'How confident can we be that other low carbon options will be readily available, in sufficient time and sufficient quantity, to ensure that we can continue on our path of reducing our carbon emissions as most existing nuclear stations close over the next 20 years?'

The APGTF has prescribed a programme for the short, medium and long term development of fossil fuelled power generation technologies in the Foresight report [(3)]. Although the cleaner fossil technologies that will be produced could be used to replace a substantial portion of nuclear, the view of the APGTF is that the needs of the UK for power in the future can be best met by a mixed portfolio of fuels and technologies, the emphasis within the mix changing with time. This means that there should be:

- further development and implementation of cleaner fossil fuelled technologies (coal and gas)
- limited new build of nuclear
- gradual but increasing growth of renewable energy (bearing in mind the issues outlined earlier under Renewables)

A combination of ageing plant, growth in power demand and environmental pressures means that a commitment to this mixed portfolio is required within the next 5 years. This period is therefore represents a critical time for the UK as the current regulatory framework is hindering the introduction of new plant and the refurbishment of extant plant. This is particularly true of advanced coal plant where Government support is needed for UK industry to demonstrate commercially, new clean-coal technologies.

- ***The view of the APGTF is that the needs of the UK for power in the future can only be met by a mixed portfolio of fuels and technologies (fossil, nuclear and renewables). A combination of ageing plant, growth in power demand and environmental pressures means that a commitment to this mixed portfolio is required within the next 5 years. This is particularly true of advanced coal plant where Government support is needed for UK industry to demonstrate commercially, new clean-coal technologies.***

GAS AND OIL

While gas will continue, under most foreseeable scenarios, to be a major fuel source for power generation in the UK for many years to come, the need for diversity in inputs arising from security of supply issues was stressed earlier. In this respect it is felt unnecessary to impose restrictions on new gas-fired plant. The issue of diversity should be approached by calculated positive measures in relation to other forms of generation - whether through the existing Renewables Obligation; a prospective CHP obligation; assistance to coal-fired plant to implement efficiency improvements and modern emissions reduction technology; a modest new nuclear programme for the medium-term, etc. Such an approach would give the confidence to ensure the continued development and investment in a broad-based portfolio of technology to meet future needs and the required security of supply.

- ***It is felt unnecessary to impose restrictions on new gas-fired plant. The issue of diversity should be approached by calculated positive measures in relation to other forms of generation. Such an approach would give the confidence to ensure the continued development and investment in a broad-based portfolio of technology to meet future needs and the required security of supply.***

COAL

Coal is important for the UK to help ensure security of supply and to give a suitably diverse fuel mix.

The APGTF has carried out a review of current clean coal plant and has identified supercritical pf plant and IGCC plant as the main plant types that are currently commercially available for new build and which give a significant reduction in CO_2 compared to the existing fleet of UK coal plant. Current designs of these plant types can achieve efficiencies of up to 45%, which results in a reduction of 15-20% in the CO_2 emission per unit of electricity generated compared to the present UK coal-fired stations.

There are also designs available for retrofitting clean coal technology to existing coal-fired plant. This would be based around replacing the existing systems with supercritical technology and would result in CO_2 reductions of up to 15%. The option of retrofitting an existing CCGT with an IGCC has also been considered by the DTI [(2)] as an option for switching fuel on a CCGT from gas to coal.

The case for the new build options is likely to be determined by the market place. However, the APGTF believes that there is a case for Government support for the validation of emission reduction components and the demonstration of retrofit supercritical technology on an existing sub-critical pulverised coal plant. The risks involved in being the first to carry out such a retrofit are currently such as to deter the generators from committing to such a project.

There is also no doubt that in many parts of the world including China and India, coal will continue to be a major fuel for power generation. If the UK can continue to exhibit a modern, technologically advanced and environmentally benign coal-fired power plant sector (and related equipment and service supply industry), this will ensure UK industry is well placed to participate actively in significant overseas markets. This will not happen if the UK coal-fired power plant sector simply withers without providing the opportunity to demonstrate new cleaner technologies, including retrofit application as

recommended in the DTI Review [2]. Further pressure on existing coal plant will come from the Large Combustion Plant Directive (LCPD) that comes in from 2008; this could severely limit the lifetime of existing plant. There is, therefore, an urgent need for decisions on how the LCPD and future retrofits are to be implemented.

It is important to continue to develop super-critical coal plant to 700 degC steam conditions, often referred to as ultra supercritical, which will have an efficiency of 50-55%. A target of 2010 has been set for the availability of commercial designs. This represents a step-change in technology as new high temperature materials are needed. Continued support for the ongoing research and development programme is needed, both within the EU's Framework 6 Programme and in complementary activities in the UK.

In the medium term, IGCC offers a route to higher efficiencies and the production of hydrogen, possibly with co-utilisation of biomass and waste. The economics will depend on the relative cost of gas versus coal, however further refinement of the designs and demonstration are required to make them more cost competitive and to prove that IGCC can perform in commercial markets.

The development of carbon management techniques, particularly CO_2 capture and storage, will undoubtedly become increasingly important. Capture and storage has, however as noted earlier, some way to go before it is technologically proven at a reduced cost, environmentally acceptable and commercially viable. However, with the existing work being done in the UK and, for example, the possibilities arising from Enhanced Oil Recovery, with continuing Government support for the necessary development work, UK industry could be well placed to benefit from longer-term world markets as they arise.

- ***The APGTF believes that there is a case for Government support for the demonstration of validation of emission reduction components and retrofit supercritical technology on an existing sub-critical pulverised coal plant.***

- ***Further pressure on existing coal plant will come from the Large Combustion Plant Directive (LCPD) that comes in from 2008; this could severely limit the lifetime of existing plant. There is, therefore, an urgent need for decisions on how the LCPD and future retrofits are to be implemented***

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- ***In the medium term, IGCC offers a route to higher efficiencies and the production of hydrogen, possibly with co-utilisation of biomass and waste.***

- ***If the UK can continue to exhibit a modern, technologically advanced and environmentally benign coal-fired power plant sector, this will ensure UK industry is well placed to participate actively in significant overseas markets. The same is true of EOR linked to CO_2 capture and storage, where with continuing support, UK industry could be well placed to benefit from longer-term world markets as they arise.***

INNOVATION

There are significant risks and costs to industry in developing new technologies and in seeking to establish a 'first of kind' scheme at a commercial scale. Government assistance is essential not only to encourage initial research and development, but also to help bring the resultant technologies to the market. It is in this latter area that support has been particularly lacking over recent years in the UK, with many examples of new technologies being far more effectively commercially exploited, as a result, by competitors. As noted earlier demonstration can be expensive, particularly with large power generation power plant and the risks are such that it would be inappropriate for these to be borne by private industry alone – by way of comparison, as mentioned above, President Bush has pledged $2 billion over 10years for demonstrating advanced clean coal technologies.

Manufacturing companies, operators and banks are both unable and unwilling to take the risks associated with 'first of kind' commercial implementation of major new infrastructure projects, leading to financial assistance, in one form or another, being therefore necessary to overcome the possible market failure. In addition, however, it is also essential that there is a stable and supportive operating environment against which technology can be demonstrated on a commercially relevant basis. With its total emphasis on predictable, reliable power, NETA has not so far offered such an environment for new energy technologies, making even the commissioning of new plant involving tried and tested technology a much more risky and potentially costly operation than hitherto.

Much of the UK power generation industry needs to compete in the global market place. Over the next 25 years the global business for new generating plant is expected to be in excess of £2000 billion with the UK's share of that market recently being in the range 11-12.5%. Most of the UK's share comes from its fossil fuel related activities. However, it is becoming increasingly difficult to compete in the area of established technologies, because many of the developing countries now have these technologies and can produce them, or support them, at competitive prices with low cost labour. The only way that UK industry will be able to compete in the future is by bringing new technologies and new ideas to the market place, ideas and technologies that its competitors will not have. For this reason, it is essential that the UK have an active, well supported research and development programme that will produce the new technologies for the future.

The IEA [(7)] looks out to 2020 and predicts that coal will remain the largest single source of electricity production over that period; world gas –fired power generation is predicted to increase by three-and-a-half times and it is expected to be the world's second largest source of power generation. This means that there will be a strong, global demand for low carbon, clean fossil power and this should be an important part of any UK power generation research and development programme.

The sections above, together with the Foresight report [(3)] give detailed recommendations on the R&D priorities needed to develop low carbon fossil fuel power plant. The Foresight report 'Power without Pollution' notes that these priorities can be grouped into eight areas for action, which incidentally are also the groupings for nuclear and renewables research, namely:

- Basic Research
- Device Research
- Virtual Demonstration
- Physical Demonstration
- Condition Monitoring and Reliability Engineering
- Systems Analysis
- Social Research
- International Collaboration

As noted above, R&D needs to be considered within an overall system for development, demonstration and commercialisation of near to zero emissions technologies. In this system the essential elements are: R&D; policies and measures to support a market for the technologies; action to win social acceptance. The development system is not linear, with all three elements needing to be addressed together with feedback and interaction between them.

It will be essential that any UK initiative developed in energy RD&D should not be done in isolation. The next EU/EC RTD Framework Programme (FP6) is under development and it is likely that this will form the basis of future Framework Programmes post 2006. The UK has a significant opportunity to take a leading role in the formation of large critical mass Integrated Projects and Networks of Excellence (two of the proposed `New Instruments` in FP6) in the field of energy. It is important that the UK Government takes an active role in supporting the response of the UK Energy Sector in this respect and in shaping future programmes to the ensure benefit to the UK, especially industry.

Both the report of the Royal Commission on environmental pollution and the report of the Chief Scientific Adviser's Energy Research Review Group highlight the potential of developing hydrogen as an energy carrier to give a long term, step change benefit to the UK's energy system. This has been recognised by the APGTF and reported in the Foresight report [(3)]. Fuel cells and conventional technologies such as gas turbines and internal combustion engines can all utilise hydrogen to produce electricity, although further development work is needed to make this commercially viable.

Hydrogen can be produced from fossil fuels, for example by the gasification of coal and if this is combined with CO_2 sequestration, it provides a clean method of production. Assisting gasification technologies (including waste to energy applications) is hence a first step along the road to a possible "hydrogen economy". The synthetic gases produced contain high levels of hydrogen, enabling the issues surrounding its use as a fuel to be addressed.

As with energy policy more generally, the APGTF supports an approach encouraging diversity of supply. So, too, in the RD&D field, it would seem premature and unjustifiable to try to pick exclusive winning technologies at this stage. Indeed, it is widely recognised that there is no one single, winning technology and it is, therefore, essential to maintain a balanced RD&D strategy. Research funds should be directed toward the cleaner use of fossil fuels and nuclear energy as well as renewables. All types of energy production will be required to meet future needs and emissions levels.

- ***Government assistance is essential not only to encourage initial research and development, but also to help bring the resultant technologies to the market. It is in this latter area that support has been particularly lacking over recent years in the UK, with many examples of new technologies being far more effectively commercially exploited, as a result, by competitors.***

- ***The only way that UK industry will be able to compete in the future is by bringing new technologies and new ideas to the global market place, ideas and technologies that its competitors will not have. For this reason, it is essential that the UK have an active, well supported research and development programme that will produce the new technologies for the future.***

- ***The APGTF supports an approach encouraging diversity of supply. This applies also in the RD&D field, where it would seem premature and unjustifiable to try to pick exclusive winning technologies at this stage. It is, therefore, essential to maintain a balanced RD&D strategy. Research funds should be directed toward the cleaner use of fossil fuels and nuclear energy as well as renewables.***

TRANSPORT

As it is outside the remit of the APGTF, Transport is not specifically addressed. However it is recognised by the APGTF that the issue is a critical one for energy in the UK with strong environmental implications. Longer term there is a clear link between the production of power and that of low carbon fuels towards a possible hydrogen-based economy. These issues are raised in the previous section on Innovation.

INSTITUTIONAL

The development of low carbon and zero carbon emission power plant requires commitment to a long term strategic Research, Development and Demonstration, which should set out a strategy for a minimum of 10 years. The programme should be industry led with strong partnerships between universities and industry and ensure a much needed revitalisation of the nation's skill base, especially in power generation which is becoming increasingly weak. Such a strategic programme will require greater funding than current levels and will need to embrace different types of support schemes (from direct grant to nearer market mechanisms like launch aid).

In addition to supporting a strategic RD&D programme, it is essential that the UK's national research effort in energy is organised and co-ordinated in such a way as to gain maximum benefit from the resources available. This requires significant improvement in the current position. The APGTF believes that these issues can be best addressed through following the recommendations of the Foresight report [(4)]. These recommendations are:

Establish a Government Chief Technologist for the Energy Sector
The UK lacks an authoritative centre for examining the technical options available for tackling policy issues relating to energy. Because of this there is no recognised authority to lead on the objective assessment of alternative options, the level of investment needed to bring them to the market and the role of the UK in such developments. This requirement would be most effectively covered by a Chief Technologist for Energy, who could advise government on energy technology policy and act as the main link between government and industry.

Sustainable Energy Centre
Support for UK Energy Research is fragmented between (for instance) the Research Councils, DTI, DEFRA, the Carbon Trust and industry. There is a need for a single unit to steer and co-ordinate these activities and to advise all organisations of R&D opportunities and priorities. Specific tasks for this centre should be:

- Assessment of technology prospects
- Providing a panorama on international developments
- Advising on priorities and opportunities
- Acting as a broker for setting up collaborative programmes between industry, government and the research community

This view is similar to the Sustainable Energy Policy Unit proposed in the Chief Scientific Adviser's review.

Implementation Group
As a result of these new, recommended initiatives, there is a requirement for an industry led group covering the three zero or near-zero power generation technology areas (fossil, nuclear and renewables – referred to as ZEPG), to monitor the RD&D needs and the requirements for successful market deployment of near-to-zero and zero emission generating plant. This new group would focus on global as well as UK markets. It would need to forge close links with the main funding and policy agencies in the UK and EU and would ensure that any RD&D policies and strategies developed are beneficial to UK industry. It would also help to ensure that advantage is taken of common themes across the three ZEPG technology areas and that appropriate national and international collaborations are formed.

The new group, which the APGTF is referring to as the Clean Power Systems Group, should be broadly based, involving the complete fuel chains and include manufacturers, trade associations, users and research workers from all three ZEPG sectors. This group, which would focus on policy and strategy across all three sectors, must form close links with the appropriate associations and fora that represent the individual sectors. The basis of such a group has been established through the UK Energy Foresight initiative and now needs to be taken forward.

- ***The development of low carbon and zero carbon emission power plant requires commitment to a long term strategic Research, Development and Demonstration, which should set out a strategy for a minimum of 10 years. The programme should be industry led with strong partnerships between universities and industry. Action is needed now.***

- ***Such a strategic programme will require greater funding than current levels and will need to embrace different types of support schemes. It would also need to address the revitalisation of the nations skill base which is becoming increasingly weak for power generation***

- ***There is no recognised authority to lead on the objective assessment of alternative options, the level of investment needed to bring them to the market and the role of the UK in such developments. This requirement would be most effectively covered by a Chief Technologist for Energy.***

- ***Support for UK Energy Research is fragmented. It is essential that a greater level of co-ordination is established. In this respect there is a need for a single unit to steer and co-ordinate these activities and to advise all organisations of R&D opportunities and priorities. Also, there is no recognised authority to lead on the objective assessment of alternative options, the level of investment needed to bring them to the market and the role of the UK in such developments.***

- ***As a result of these new, recommended initiatives there is a requirement for an industry led group covering the three zero or near-zero power generation technology areas (fossil, nuclear and renewables), to monitor the R,D&D needs and the requirements for successful market deployment of near-to-zero and zero emission generating plant. This new group would focus on global as well as UK markets.***

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