Power Plant Modelling
Virtual Plant Demonstration Model

OBJECTIVES

- Review UK and worldwide capability in power plant modelling needed to meet requirements
- Identify where existing plant models can be applied with benefit to current needs
- Identify the benefits and future requirements for a Virtual Plant Demonstration Model (VPDM) for PF and GT/IGCC plant, taking note of potential long term power plant developments
- Identify developments needed to produce a VPDM for present and future clean coal technologies and propose a way forward

SUMMARY

The world-wide industry is facing growing pressures, particularly from ever-tightening environmental constraints, the drive for sustainability and increasing competition. This is providing new challenges and applications for power plant modelling in: new plant development; design and manufacture; plant demonstration and authorisation; engineering support. This has led to a proposal for a new power plant modelling initiative: the development of a Virtual Plant Demonstration Model (VPDM).

It is envisaged that a future VPDM will provide an integrated software framework which will allow the full potential for whole-plant software modelling to be realised, such that UK industry can provide competitive power plant solutions with significantly reduced development costs, significantly reduced risk and at a competitive price.

The project was set up as a potential first step towards a VPDM. It would review the current capability of power plant modelling; it would also look at the future needs and applications, consider how well current models can meet these needs and in particular what further developments are needed. Finally, it would consider the proposed VPDM initiative and consider whether it is the best framework for providing these further developments and if so, what is the best strategy that will enable the UK to produce this VPDM.

The conclusion from the review of existing capabilities is that the UK currently has a strong simulation capability in power generation. Difficulties begin to arise when the range of plant considered in a given study increases, when an equipment change is proposed within an existing study, where operators wish to simulate off-design performance within their own plant or where whole system studies such as economic analyses and cycle optimisation are required.

A common factor, highlighted by all organisations who have contributed, is that the benefits obtained from power plant modelling are key to their businesses but there is a clear requirement for further developments to increase those benefits and to enhance their business opportunities.

It is clear from this project that a major collaborative initiative similar to that proposed for a VPDM, is required for the fossil power plant industry. This project has identified the development needs that the collaborative project must meet and it has also detailed a particular integrated software framework that should achieve these needs. Most of the leading organisations in the UK involved in power plant modelling development or use, have indicated that they would like to participate in preparing such a collaborative project.

This collaboration is regarded as strategic, with a significant element of risk and it is likely to involve companies that compete in the market place. For these reasons, it is regarded as essential that it is carried out under the umbrella of a government supported research and development programme.

Furthermore, collaboration with the USA's Vision 21 programme and with the European process industries CAPE initiative should be investigated.

POTENTIAL USERS OF THE STUDY

Researchers, developers, manufacturers and operators of power plant who are involved in the design and development of fossil power plant.

COST

The total cost of the project is £49 200 with a contribution of £22 990 from the DTI

DURATION

8 months – January 2002 to August 2002

CONTRACTORS

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In collaboration with

Innogy plc
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SUBCONTRACTOR

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DECEMBER 2002

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Department of Trade and Industry

CLEANER COAL TECHNOLOGY PROGRAMME

Project Summary 336

BACKGROUND

All power plant organisations recognise the importance and benefits of computer modelling and typically use a collection of in-house and commercial software to solve technical, commercial or economic problems. However, the challenges for modelling are now increasing.

The world-wide industry is facing growing pressures, particularly from ever-tightening environmental constraints, the drive for sustainability and increasing competition. These pressures will drive the development of more sophisticated power plant and they will pose increasingly complex problems. These same pressures are threatening to make existing coal plant uneconomic or obsolete.

The UK has a track record of power plant development and operation that is second to none. However, the UK has, at times, fallen down on getting these developments into the market place. The risks associated with introducing new advanced technologies can be reduced by the use of major demonstration programmes but these are extremely costly for large plant and difficult to fund.

Another major stumbling block for new plant, particularly coal plant, is getting authorisation and public acceptance to build it – whatever the technology. This is true for large demonstration plant, for commercial plant and for major upgrades to existing coal plant.

All of these needs and applications provide new challenges and opportunities for power plant modelling. The Advanced Power Generation Technology Forum (APGTF) has recognised this and has proposed a new power plant modelling initiative: the development of a Virtual Plant Demonstration Model (VPDM). The Forum sees this as one way of helping to meet these new challenges and in particular, of helping to ensure that new technologies are successful in getting into the market place in the future. It is envisaged that a future VPDM will provide an integrated software framework which will allow the full potential for whole-plant software modelling to be realised, such that UK industry can provide competitive power plant solutions with significantly reduced development costs, significantly reduced risk and at a competitive price.

This project was set up as a potential first step towards a VPDM; it would review the current capability of power plant modelling and it would consider the type of applications that modelling has been used for and the benefits achieved. It would also look at the future needs and applications and consider how well current models can meet these needs and in particular what further developments are needed. Finally, it would consider the proposed VPDM initiative and consider whether it is the best framework for providing these further developments and if so, what is the best strategy that will enable the UK to produce this VPDM. A UK workshop would also be run to discuss and provide guidance on these issues.

These issues have been addressed from the perspective of plant manufacturers, plant purchasers and plant operators, with the focus being on clean coal technologies.

CONCLUSIONS FROM REVIEWS

The main conclusion is that the UK currently has a strong simulation capability in power generation, both in the industry and in universities. The same range of in-house and proprietary code is available and used as in the UK's major competing countries. However, further development and improved integration of the various packages is often hindered in complex applications with a key problem being the lack of an acceptable, common data exchange interface.

The US has a major power plant development initiative, Vision 21, in which power plant modelling and its development is a key activity. This interface deficiency has been recognised in the US initiative and is being tackled as a priority. So far, however, in the majority of projects the emphasis has been on producing software within a single computing environment, rather than establishing a framework within which existing software and specialist applications developed and running in different software environments can be seamlessly integrated.

The European chemical process industry has recognised the same deficiencies in their present modelling systems but it is following a slightly different approach to the US to tackle it. The industry has initiated data exchange projects: CAPE-OPEN and Global CAPE-OPEN which are aimed at standardising the exchange of engineering data. These projects will provide a framework within which compliant software can be developed, validated and certificated.

DEVELOPMENT NEEDS

Each power company has its own specific development needs that depend on the precise nature of its business. However, there are also several common themes that are seen as major development requirements throughout the power industry. These themes are summarised below:

- When looking at whole plant systems, companies are often faced with the problem of replicating manufacturers component models.
- If the components of a whole system are made by different manufacturers, then each manufacturer will introduce his own margins for his component. These become additive, with the result that the whole system is often not optimised.
- New plant and plant upgrades are becoming more and more integrated, so it will often be necessary to fully integrate, detailed component models with the whole plant model.
- During the development, design, manufacture, commissioning and operation processes, several different software packages will be used. Stronger links and interfaces are required for the main software and databases used in each activity.
- Engineering accuracy is the priority and particular technical areas need increased capability. It is vital that process, commercial and economic models can be integrated when required.
- Finally, if sufficiently accurate plant models are developed, then industry will be able to use these models as part of a 'plant acceptance test' and ultimately they will be able to play a key role in reducing the requirements for plant demonstration.

THE WAY FORWARD

It is clear from consultations and from the workshop that a major initiative, similar to that proposed by the APGTF for a VPDM, is required for the fossil power plant industry.

In order to meet the Development Needs, the following functional requirements are proposed for a new VPDM:

- The VPDM should be based around full plant process models, which need to be able to fully integrate detailed, accurate component models when required.
- An integrated software framework is needed to achieve this. This must have the ability to integrate a wide range of plant component models for different plant systems, see figure 1.

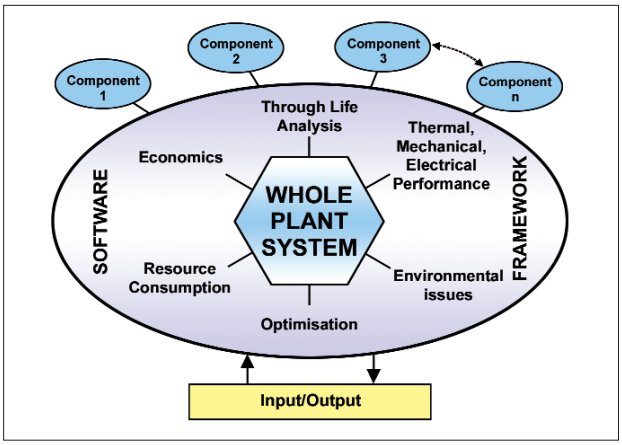

Figure 1 Integrated Framework

- A software interface structure is needed that has the ability to seamlessly transfer data between models and control their operation and interaction.
- The software environment must facilitate the use of existing software, where appropriate.
- Static and dynamic modelling capabilities are necessary. Analysis of design and off-design conditions is required.
- A capability for modelling engineering, commercial, economic and environmental performance for the whole power plant system is required.
- The modelling capability should include: load variations including part load and overload; shut down; cold or hot start; trips; cycling.

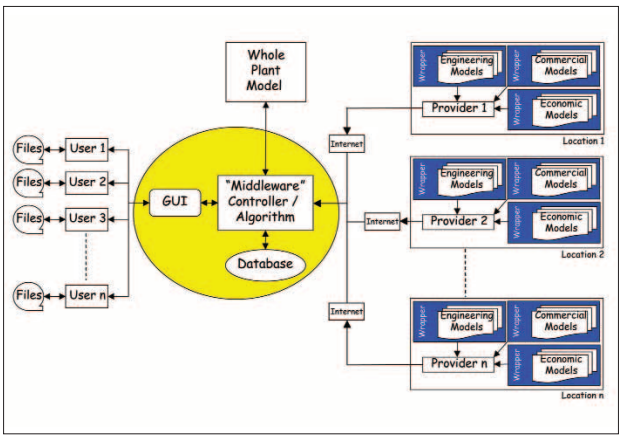

Fig 2 An example of a VPDM Integrated Framework

An example of how an integrated framework could look for a VPDM is shown in figure 2. The middleware would ensure that the component models correctly interface with the whole plant model. It would then control the solution procedure, ensuring that the whole plant model and the component models are numerically integrated in the required manner. The component models could reside on the suppliers' own computers, which would ensure that any valuable intellectual property can be protected, with the required data exchange taking place over the internet using standard secure internet procedures and protocols.

The workshop agreed that a UK collaborative initiative is needed to develop the required VPDM. This collaboration is regarded as strategic, with a significant element of risk and it is likely to involve companies that compete in the market place. If successful, it will provide a key tool in helping the UK industry to develop the low emission technologies that, in the near future, will be required in all world markets. For these reasons, it is regarded as essential that it is carried out under the umbrella of a government supported research and development programme.

Furthermore, the government's Memorandum of Understanding (MOU) with the US Department of Energy should be utilised to ensure that there is mutual benefit to the UK and USA from collaboration between this proposed VPDM project and the plant modelling projects in Vision 21.

Finally, the CAPE-21 initiative of the European process industries should be investigated further to see if there is mutual benefit for the power and process industries from sharing experiences or perhaps collaborating. However, it should be recognised that there are major differences between the two industries, which may limit the extent of the benefit.

CONCLUSIONS AND RECOMMENDATIONS

The conclusion from the review of existing capabilities is that the UK currently has a strong simulation capability in power generation, both in the industry and in universities.

Generally, the current models are accurate and well validated within their limits of applicability. Problems begin to arise when the range of plant considered in a given study increases, when an equipment change is proposed within an existing study, where operators wish to simulate off-design performance within their own plant or where whole system studies such as economic analyses and cycle optimisation are required.

A common factor, highlighted by all organisations, is that the benefits obtained from power plant modelling are key to their businesses but there is a clear requirement for further developments to increase those benefits and to enhance their business opportunities. Other countries and industries are investing heavily in improving their modelling capabilities. Failure to follow suit in the UK power industry will certainly result in the UK industry losing its competitive advantage.

Each power company has its own specific development needs that depend on the precise nature of its business. However, there are also several common themes that are seen as major development requirements throughout the power industry. These are driven by the need to meet tighter economic, environmental and safety constraints; if these requirements can be met, it will result in significant benefits for UK industry.

It is clear from this project and in particular from the workshop that a major collaborative initiative, similar to that proposed by the Advanced Power Generation Task Force for a VPDM, is required for the fossil power plant industry.

This project has identified the development needs that the collaborative project must meet and it has also detailed a particular integrated software framework that should achieve these needs. The next stage is to prepare a detailed project proposal to deliver this new integrated software framework.

This collaboration is regarded as strategic, with a significant element of risk and it is likely to involve companies that compete in the market place. If successful, it will provide a key tool in helping the UK industry to develop the low emission technologies that, in the near future, will be required in all world markets. For these reasons, it is regarded as essential that it is carried out under the umbrella of a government supported research and development programme.

The Vision 21 initiative of the USA and the CAPE-21 initiative of the European process industries should be investigated further to see if there is mutual benefit for the power industry and the process industry in sharing experiences or perhaps collaborating.

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DTI/PUB URN 02/1525