17th World Conference on Nondestructive Testing, 25-28 Oct 2008, Shanghai, China

Energy in the future – new challenges for NDT

J Mike FARLEY
Doosan Babcock Energy Limited, Renfrew, U.K.
Phone: +44 141 885 3942, Fax. +44 141 885 3378, e-mail: mfarley@doosanbabcock.com

Abstract

Around the world significant questions are being asked about the future of energy supplies. These questions arise because of concerns about global warming and climate change due to emissions from use of fossil fuels, concerns about the balance between the availability of energy resources and rapidly growing demand for energy (particularly in the developing economies) for power, heat and transport, and concerns about the rising price of fuels, particularly oil and gas. In parallel, the energy industries are increasingly "globalised" with projects in one part of the world dependent on equipment and resources from all around the globe.

This paper will describe the impact of these trends for Non-Destructive Testing and highlight the opportunities and challenges which are arising for the science and practice of NDT worldwide.

Keywords: Global trends in energy, energy, trends for non-destructive testing.

1. Growth of Energy Demand

According to the IEA World Energy Outlook 2007 (WEO 2007)[1], Reference Scenario, global primary energy demand is projected to increase by 55.1% between 2005 and 2030, to a total of 17,721 million tonnes of oil equivalent (mtoe) (Figure 1). In preparing WEO 2007, the IEA also developed an Alternative Policy Scenario that projects global energy market evolution if developed countries were to adopt all of the energy security and climate-change policies they are currently considering and if developing countries followed a less energy-intensive development path. Under this scenario, global primary energy demand over the period 2005 to 2030 increases by 38.1% to 15 783 mtoe, some 1,938 mtoe below the Reference Scenario (IEA, 2007). In the Reference Scenario, fossils fuels account for 82.0% of global energy demand in 2030, compared to 80.9% in 2005. Under the Alternative Policy Scenario, fossil fuels still account for 76.4% of global primary energy demand. The reduction of fossil fuel's share is primarily the result of an overall energy demand reduction with a greater role for nuclear and renewables; in the Alternative Policy Scenario, hydro, biomass, waste and other renewables are 308 mtoe higher in 2030 than in the Reference Scenario and nuclear is 226 mtoe higher. It is precisely because of the growing energy needs of the developing world that most forecasts predict a continuing key role for coal in the future energy mix, regardless of climate change policy.

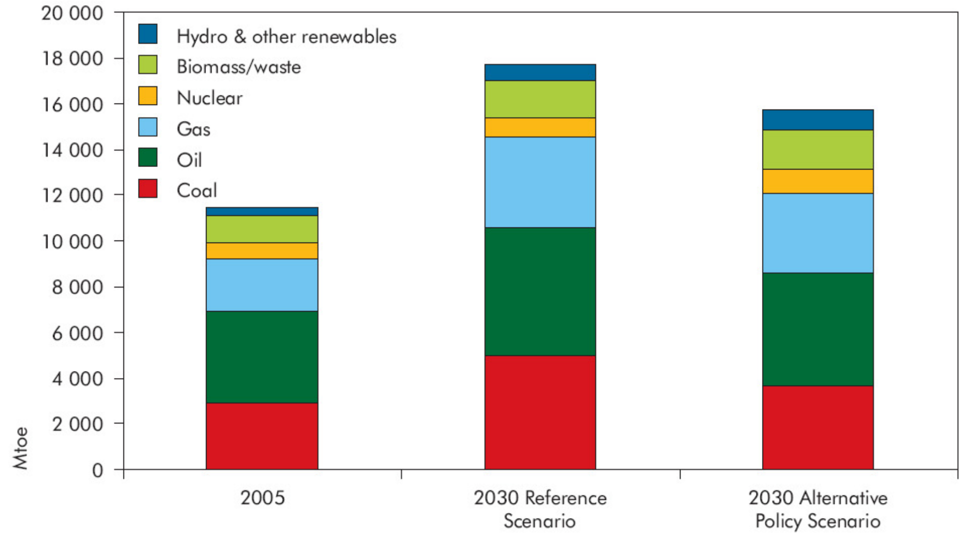

Figure 1 – Energy demand changes under two scenarios for 2030

2. Climate change and the need to reduce CO_2 emissions

All of the energy growth forecasts have major CO_2 emission consequences. The WEO 2007 Reference Scenario sees CO_2 emissions increase from 26.6 gigatonnes CO_2 ($GtCO_2$) in 2005 to 34.1 $GtCO_2$ in 2015 and 41.9 $GtCO_2$ in 2030. In the WEO 2007 Alternative Policy Scenario, emissions rise to 31.9 $GtCO_2$ in 2015 and 33.9 $GtCO_2$ in 2030. In fact, global CO_2 emissions have increased much more rapidly in the past half decade than during the 1990s (Figure 2). Global CO_2 emissions rose from 23.5 $GtCO_2$ in 2000 to 27.1 $GtCO_2$ in 2005 (IEA, 2007). Some forecasts for 2006 project emissions to already exceed 30 $GtCO_2$, reflecting a rise in energy consumption that is well above any of the long-term trends described in the forecasts cited here.

Around one-half of the CO_2 emissions are from power generation, one-quarter from transport and one-quarter from domestic and industrial.

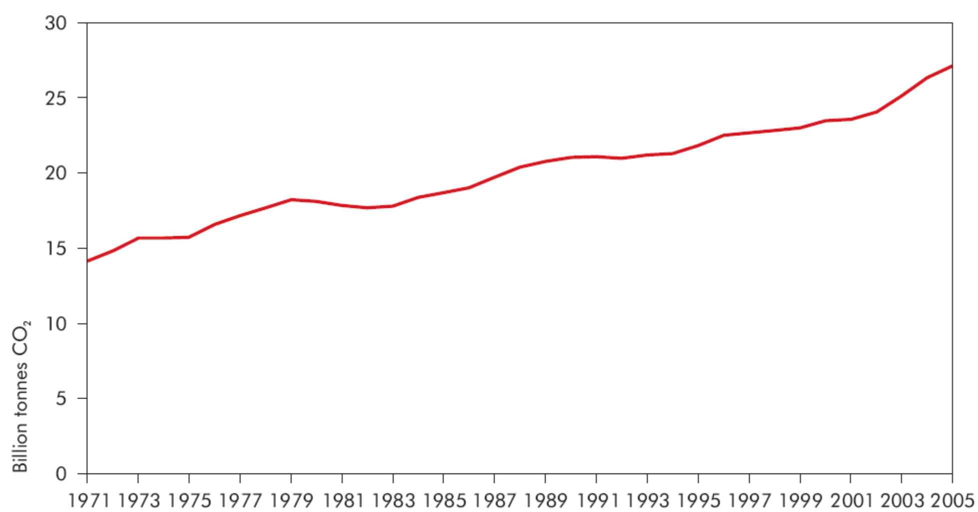

Figure 2 – Global CO_2 emissions from fossil fuel combustion, 1971-2005

3. Responses to energy challenges

The responses to these concerns have varied from country to country, with some countries (e.g. EU, Australia, Canada) more concerned about climate change and some (e.g. USA, China, India) more concerned about security of supplies. Climate Change was a priority topic at the G8 Summit in the UK in July 2005 and Energy a priority topic in Russia in July 2006. The countries which signed up to the Kyoto Protocol agreed to cut Greenhouse Gas Emissions (including CO_2) by 12.5% below 1990 levels by 2012. In Europe, the Kyoto Protocol has been implemented by a burden-sharing agreement and CO_2 allowances are being traded through the Emissions Trading System. At Bali in November 2008, there was agreement to proceed towards worldwide reductions in carbon dioxide emissions to be implemented post 2012.

A number of common threads emerge:

i) Some increased use of gas as a cleaner source of energy and power in the short term, but growing concerns about price and security of supplies.
ii) Rapid development of renewable energy sources.
iii) Renewed interest in nuclear power due to the long-term resource availability and the CO_2-free nature of power generation.
iv) Increased investment in the development of clean coal technologies, including carbon dioxide capture and storage, designed to use the huge global resources of coal more cleanly.

All of these trends bring opportunities and challenges in a globalised industry for NDT and Technical Diagnostics.

4. Increased use of gas for power generation

More pipelines are needed, many through hostile terrain and some through territory where terrorism is common. In normal circumstances, safety of pipelines must be ensured by careful inspection during installation (radiography or automated ultrasonic) and in-service (on-line inspection) to detect corrosion, fatigue cracking or gross damage. Due to the environmental consequences of methane leakage, increased attention must be given to leak detection (primarily at seals, compressors, bolted joints).

There is a huge growth in the transport of LNG (liquefied natural gas) by ship. This requires LNG terminals and large fleets of LNG ships. Both use nickel alloys and stainless steels and require careful NDT and leak detection.

5. Rapid development of renewable energy sources

In addition to hydroelectric projects (the largest by far being the 18 GW Three Gorges Dam project in China), there is rapid development of Wind Turbines generation capacity, mostly for onshore sites. In Europe, wind power has developed most rapidly in Denmark, Germany and Spain. Wind turbines have grown in size – now up to 5 MWe – and in northern Europe there are now projects to instal wind turbines offshore in the shallow waters of the North Sea. The challenges for wind generation are the intermittency of the resource, the cost per unit of electricity and the achievement of satisfactory availability. Large markets have emerged for wind turbines in the USA and China. NDT challenges are testing methods for turbine blades, turbine towers and condition monitoring of gearboxes, rotor hubs and electrical equipment.

Wave and tidal power are at an earlier stage of development with projects in the UK and Portugal. Achievement of satisfactory availability will undoubtedly be an important challenge since repairs in the hostile marine environment will be exceptionally difficult. Condition monitoring and remote diagnosis will be essential.

Photovoltaics have a huge potential to generate power in sunnier countries. NDT on PV materials is carried out on a micro-scale.

6. Renewed interest in Nuclear power generation

There is renewed interest in many countries in nuclear power (Generation III reactors) due to the long-term availability of the resource, the CO_2-free nature of the power generation and the relatively low cost of power from this source. In China, thirty additional reactors are to be built by 2020. In the USA, a licencing process is underway for a new generation of reactors (APWR, ABWR, etc.) and in Finland and France the first EPWRs – a new design based on French and German experience – are being built. The British government is encouraging a new generation of nuclear power plants. The challenges to nuclear are public concerns over storage of nuclear waste, the protection of plant against terrorism and the operational safety.

NDT plays an important role in ensuring the safety of nuclear power plant, both through inspection during construction and in-service. It is essential that the lessons learned over about thirty years in inspection of the existing nuclear plant are transferred to the new. These include:

i) importance of design for inspectability;
ii) importance of inspection qualification (performance demonstration).

Generation IV reactors which are now being developed include new sodium-cooled fast reactor designs. This type of reactor which is already being built in India (500 MW^e) poses many challenges for NDT and condition monitoring including under-sodium viewing, ISI of austenitic and transition welds and tubing inspection.

7. Clean coal technology

There is increased investment in development and building of new coal-fired power plants, designed to use the huge global resources of coal more cleanly, including large programmes in China and India. There are two key steps towards cleaner coal:

i) Increased efficiency gives more electricity (MWh) and less CO_2 per tonne of coal burned.

Figure 3 shows the evolution of coal-fired power plant efficiency. The “Best Available Technology” advanced supercritical power plant in 2006 – being built in Europe – is 46/47% efficient and emits about one-third less CO2 than old inefficient plants. CO2 emissions are reduced from >1000 g/kWh to 700 g/kWh.

Fehler! Es ist nicht möglich, durch die Bearbeitung von Feldfunktionen Objekte zu erstellen.

Figure 3 : Progressive improvement in efficiency and reduction of CO_2 emissions for coal-fired power plant

The target in Europe and the USA is plant with efficiency in the range 50-55%. The technology is being developed in Europe through a collaborative project known as AD-700. The steam pressure (350 bar) and temperature (700°C) of such a plant necessitate a step-change in materials from the ferritic, martensitic and austenitic steels used in BAT plants to nickel alloys (including In617 and Alloy 263). Many of these materials are now being tested in a live-steam test loop at the E.ON Scholven Power Plant in Germany. The 700°C plants will require careful inspection of these new materials during manufacture and monitoring in-service to determine how well the basic materials, weldments (including dissimilar metal welds) perform in service. Life assessment techniques will need to be developed.

ii) Carbon dioxide capture and storage (CCS).

To meet global CO_2 reduction targets the technology of CCS is essential. Carbon dioxide must be captured from the flue gas (separated from nitrogen), cooled and compressed and piped away for injection under the ground into storage reservoirs which may be oil-fields, depleted gas-fields or saline acquifers, see Figure 4.

Fehler! Es ist nicht möglich, durch die Bearbeitung von Feldfunktionen Objekte zu erstellen.

Figure 4 : Options for Carbon Dioxide Storage

There are three technologies for carbon dioxide capture. These are post-combustion capture by scrubbing (probably with an amine or ammonia), oxyfuel firing (where the combustion air is separated into nitrogen and oxygen) and pre-combustion capture (where the coal is first gasified, the syn-gas produced is converted to CO_2 and hydrogen and the hydrogen is separated and burned in a special gas turbine).

Each of these technologies will bring their own challenges for NDT. Storage also brings interesting challenges for NDT, including integrity of pipelines which carry CO_2 and the sealing of injection wells in CO_2 reservoirs.

8. Globalisation of energy business and related NDT

In each of the areas of energy technology discussed above, the business of design building and operating plant is “globalised”. Technology developed in one country is used in many other countries. Projects are “global” and the safety, reliability and availability of energy plant depends on the actions of a whole “supply chain” of contractors around the world, each with their own non-destructive testing and technical diagnostics personnel.

Industrial companies procure materials and equipment from wherever they are produced most efficiently and cost effectively - increasingly from developing countries. The applicable codes and standards are usually those specified by the ultimate purchaser, e.g. ASME Code or European Standards. NDT during manufacture will be carried out by the local personnel.

When plant is being erected and commissioned, the responsible workers may be local or the work may be carried out by teams of personnel from third countries. This has been the norm for many years in the Middle East but now is happening in the USA and Europe.

These trends have to be recognised by the NDT industry, customers need to be able to procure highly reliable NDT services anywhere in the world.

9. Conclusions

- The changing Power Generation field will continue to stimulate new and important research, development and applications in NDT and Technical Diagnostics;
- Global co-operation (scientific, technical and business) is essential to meet the Energy Supply, Safety, Environmental and Anti-Terrorist challenges of the 21st Century;
- NDT Societies, Certification Bodies, Standards Bodies and Accreditation Bodies must recognise the global market for NDT in the energy industries.

10. References

[1] IEA World Energy Outlook 2007 (WEO 2007)