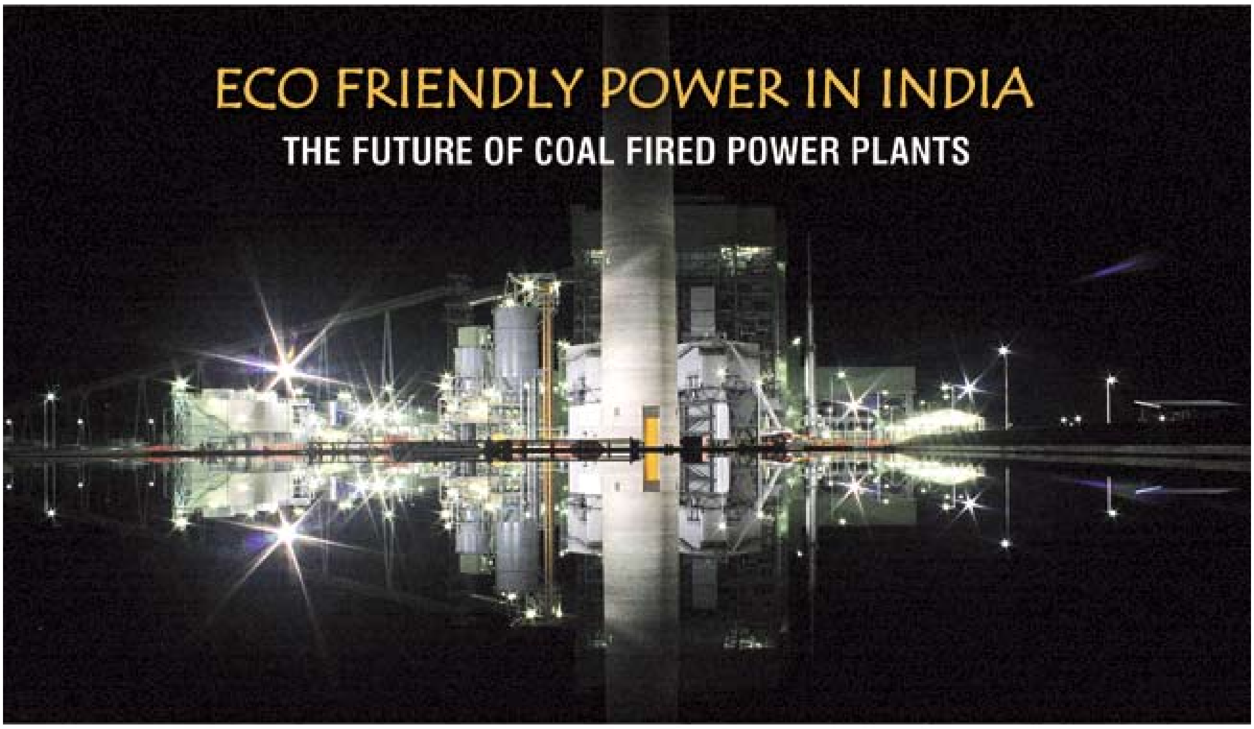

Assuring a reliable power supply for the future poses many challenges. Energy efficiency is one of the key points of the Prime Minister's action plan on climate change. India and other developing countries face a triple challenge of increasing income growth, building energy infrastructure and confronting climate change. The energy needs of developing countries cannot be underestimated. About 1.6 billion people live without electricity and 2.5 billion lack access to modern energy sources. In India, rapid economic growth is putting pressure on an energy infrastructure suffering from decades of under-investment. Planning Commission estimates that by 2031-32 (end of the 15th plan), India will need total installed capacity of 800-1000GW, up from around 160GW today.

Three megatrends influence the production of electric power. First, there is the demographic trend. The ever-increasing number of people living on our planet and economic growth especially in the newly industrializing nations are going to continue driving demand for electric power upward for some time to come. Even the ongoing uncertainties in the financial markets will have only a short-term mitigating impact on this growth at the global level. A second megatrend to be observed stems from the complex topic of the availability of resources. The unequal distribution of resources and the realization that they are finite give every reason to expect that the cost of the available resources will remain highly volatile. Besides, more and more importance is being attached to diversification with a view to reducing reliance on individual suppliers. The third point is conservation of the environment. Climate change is a fact, and power generation, transmission and distribution can make a significant contribution toward slowing it down.

The scale of investment envisioned has critical implications for greenhouse gas emissions and, as a result, climate change. Non-OECD countries will account for almost the entire increase in energy-related CO_2 emissions from now until 2030. According to the International Energy Agency's reference scenario, three-quarters of the projected increase would come from China, India and Middle East. So, what can be done to produce maximum energy with minimum climate effect.

The energy mix of the future will be based on three columns. The first column is the renewable energy sources with privileged feed-in into the power grid. Then we have the base-load power plants. On the fossil side, these are mainly coal-fired steam power plants and, looking to the future, IGCC plants with CO_2 capture and storage. Because of their CO_2 capture systems, these power plants, like most other base-load plants, will provide little flexibility in terms of load following and grid control. For this reason there will be a third column between these two: versatile, high-efficiency combined cycle plants that back up the contribution made by the renewable energy sources. Thanks to their highly versatile response to output control requirements and their very efficient utilization of the input fuel, these are ideally suited to maintaining the stability of the power grid while keeping CO_2 emissions low.

Technological developments in steam power plants

Endeavors to boost efficiency have been one of the key factors in making power plants more economical for many years now and will continue to be crucial going forward, particularly with a view to reducing the impact of fossil-fueled power plants on the climate and the environment. Here we have already come a long way. For example, the efficiency of coal-fired power plants has been improved by 5 percentage points since 1992. The current state of the art is supercritical power plants in the 800-MW class, which attain efficiency levels of 46 per cent at steam parameters of 285 bar and 600/610°C. These power plants are design for a service life of at least 30 years and for intermediate- and base-load duty. There is still potential for further improvement, and the sights are now set on efficiencies >50 percent, to be achieved, for example, by a 700°C steam power plant. Major German engineering company is pushing the development of the turbine train for such a power plant configuration.

Increasing efficiency is of decisive importance for fuel savings and thus for climate and environmental compatibility. For example, if we take as a basis the Bergkamen steam power plant, built in 1981 with a capacity of 747 MW and an efficiency of 37.5 percent - still better than the average efficiency of approximately 35 percent attained by today's coal-fired power plants in Europe - there are signs of great potentials for new units: In 2001, the efficiency of the Japanese power plant Isogo, which has a design capacity of 600 MW, was already 42 percent. The reference power plant Nordrhein-Westfalen, which was designed for an efficiency of 47 percent, was developed for an identical capacity. Compared to Bergkamen Isogo produces approximately 12 percent less CO_2, and the reference power plant cuts emissions by as much as 20 percent. In principle, the following applies to such power plants (rating 700 to 800 MW) featuring state-of-the-art technology: Every one percentage point increase in efficiency reduces CO_2 emissions by 2.4 million metric tons per annum and cuts fuel costs by 2.4 percent. Against this backdrop an increasing number of supercritical power plants compared to subcritical plants have recently been ordered, also in countries such as China and India.

In the meantime the companies which has commissioned and executed these projects has accumulated a wealth of experience with these power plants and has numerous references: After the commissioning of Isogo in 2002 (steam parameters 251 bar, 600/610°C), Niederaussem (1.025 MW, 256 bar, 576/600°C) went on line in 2003.. Units 1 and 2 in Waigaoqiao (900 MW each, 250 bar, 538/566°C) were commissioned in 2004. Advanced technology like that installed in Waigaoqiao II enables highest efficiency levels and consequently reduces the impact on the environment. After being put into operation one after another, the two units play a very important role in Shanghai's power grid and even in China-East power grid. Today's supercritical plants like the one in Waigaoqiao II are demonstrating the highest availability equal to subcritical plants with superior operability. Waigaoqiao Phase II has become a benchmark and model for other power plants, not only in China but also in other parts of the world.

Units 1 to 4 of Huaneng Yuhuan Coal-fired Plant were commissioned in 2006 and 2007 respectively. The plant is located in the Zhejiang province, south of Shanghai, consisting of four 1,000-megawatt generating units. The plant boosts an efficiency of

Steam turbine at Waigaoqiao

Steam turbine at Yuhuan coal-fired power plant

above 45 percent, which is very much a winning performance in this field. The Kogan Creek power plant (750 MW, 250 bar, 540/560°C) in Queensland, Australia also came on line in 2008. This plant was built as a turnkey project.

This has been followed by the third unit in Waigaoqiao, which is designed for 1.000 MW, 270 bar and 600/600°C. The above mentioned power plants are the biggest units implemented in this range in the last few years. In the meantime there is a trend toward capacities between approximately 700 and 800 MW.

In India, today, coal already accounts for more than 50 percent of power generation. In the future as well, coal will remain the most important source of energy for the country's power generation industry.

In some of the projects, the turbines operate at a temperature of 565 degree Celsius and a pressure of over 240 bar, thereby increasing the efficiency of the associated coal-fired power plants. Against this background it can be seen that economy of operation and environmental considerations are of decisive importance in the generation of electricity. Increasing efficiency by a single percent point in a coal-fired power plant of this size will save around 2.4 million metric tons of carbon dioxide emissions over a lifetime of 30 years.

CO_2 capture for climate-friendly fossil-fueled power plants

Fossil energy sources - especially coal - will continue to be an important pillar of our energy mix in the mid-term, too. To be able to use this energy form in an environmentally compatible way, the efficiency with which electric power is generated and used must be improved as far as possible, while at the same time ways have to be found to reduce the CO_2 burden associated with coal-based power generation.

The technologies required for this are already available or are currently being developed.

The IGCC (integrated gasification combined cycle) approach is a good solution for new build power plants. In this process, coal is first converted to gas and then the gas is used to fuel a combined cycle process. When this technology is used, the CO_2 can be removed before the fuel is combusted (pre-combustion capture).

An alternative approach for new builds but also for backfitting power plants already in service is post-combustion capture. With this technology, the CO_2 is removed from the flue gases, compressed and transported to a reservoir for storage. Depleted or still active gas and oil deposits and saline aquifers are currently used as reservoirs.

There are a number of solutions for CO_2 capture in coal-fired power plants. Some companies are also developing its own process for post-combustion capture that is ideally suitable for backfitting power plants that are already in service and for new build power plants. The capture ready design for preparing today's new power plants for CO_2 capture has already been designed by some of the engineering majors, whenever they need to in future.

Whether with or without CO_2 capture: Advanced supercritical coal-fired power plants are an important option for the future. Because without coal, it will not be possible to meet the world's energy demand. It is clear that the major source of energy for India, in the short term as well as the long term, will be coal. If we have to live with coal in a carbon-restrained economy, we would need to find a way to treat the CO_2 emissions from coal-based power plants. As India is going to remain coal-dependent for a long time, it is imperative that we assume global leadership in carbon capture and storage technology. The new 800-MW class can make a vital contribution toward this.

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