Economic generation of electric energy with modular reference power plants

New power plant projects not only take many months to plan but also tie up much of the plant vendor's and customer's workforce for the duration of the planning. In addition, construction of the plant has to wait until pre-planning has ended. ABB Kraftwerke AG of Mannheim, Germany, has developed a modular reference steam power plant which can shorten the construction time, irrespective of the size of the plant and the site conditions, by at least 20 percent while also considerably reducing costs. The heart of the modular system is a three-dimensional CAD model, integrated in an Engineering Data Management system. Reference plants in four output classes have been pre-engineered in detail using this model. Alternative self-contained concepts are also available for clients requiring customized solutions. The total plant concept is ready almost immediately after signing of the contract, so that construction can start at once and contracts can be placed with local companies at the earliest possible dates. Power plants already under construction as well as several other projects confirm the benefits of the concept.

A close look at the world's power plant markets, and especially at the concepts employed for coal-fired steam power plants, shows that the situation in the highly industrialized countries differs greatly from that in the developing countries.

In the industrialized countries plants operating with high-temperature processes, integrated coal gasification or coal-fired combined cycle power plants, in which steam turbines are supplied with heat from the exhaust gases of gas turbines, compete for the highest efficiencies, best fuel utilization and lowest pollutant emissions. At the other end of the scale, electricity is produced for the emerging economies by steam power plants based on proven technology for the simple conversion of energy. These 'workhorses' are mainly required to exhibit good availability, be rugged, have a long service life, tolerate poor-quality fuels and sometimes less than professional operation, and make only minimal demands on maintenance and repair.

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Power station vendors offering new plants in these markets must address two main issues:

- They must work together with the customer in developing financing models that can be applied to the project.
- Plant design and project managment details have to be worked out that allow the energy demand to be met as quickly as possible.

In many emerging markets in Asia, Central and South America, an increase in power plant capacity is long overdue. As a rule the utilities in these countries also expect the supplier to assist in the financing of projects.

Modular designs lower costs and save time

ABB has the technology capability necessary to successfully participate in the race for ever-higher efficiencies as well as compete internationally for orders in developing countries. With the latter markets in mind, ABB developed the modular 'reference power plant' (RPP), a range of power station designs combining proven technology with the fastest possible construction, low costs and high availability. What was required was a fossil-fired power station, preferably for fuelling with the widely available sub-bituminous coal. Designs for other types of coal and liquid fuels were developed in parallel and are also a part of the modular RPP platform [1, 2].

All physical elements of the power plant, eg systems, subsystems, components, rooms, structures, etc, are pre-engineered as modules and optimized as part of the overall system. Distinct interfaces are defined for the 'key buildings',

ately after signing of the contract, represent the largest saving in time in the execution of a project. Another advantage is the possibility of contracting the detailed engineering out to companies familiar with the local conditions; this is possible since, by working together with the future operator, it is possible to adapt the computer model to the particular project conditions already during the initial negotiations.

Providing the customer's infrastructure meets certain requirements and the site parameters are appropriate, work on the construction site can begin just six weeks after signing of the contract.

Detailed drawings, for example for subcontractors manufacturing component parts, can be prepared very quickly. The exact planning documents serve in such cases as a reliable starting point for production and make it easier to check that quality specifications are complied with. ABB views it as a special advantage to be able to increase the local scope of supply in order to boost the value added by the home country and at the same time reduce the financing needed for the power plant project.

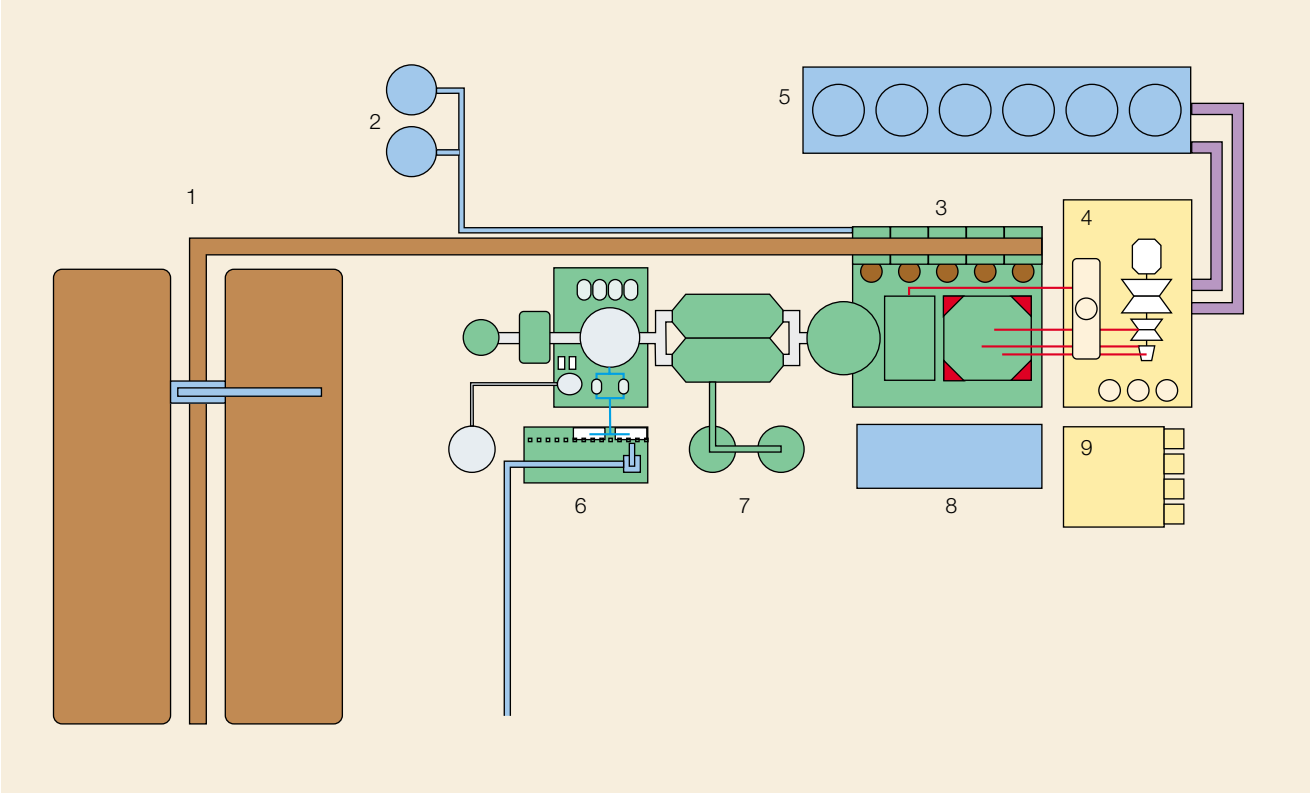
Pre-engineered flexibility

Every electric utility has its own strategy or in-house practices, eg for the feedwater supply, heat-exchangers or layout of the power plant buildings. The ABB modular RPP concept has great flexibility in this respect. The only buildings to have their positions fixed in relation to each other are the boiler, turbine and switchgear buildings **3**. Their interfaces are clearly defined and planned in such a way that construction can begin both simultaneously and independently. Since these 'key buildings' are critical to the scheduling, this independence plays an important role; in conventional power plant construction delays in the progress of one building often lead to overrunning of the schedules for the others. All the RPP ancillaries, such as the fuel supply system, administration building, water treatment plant, etc, can be freely arranged and adapted to suit the circumstances.

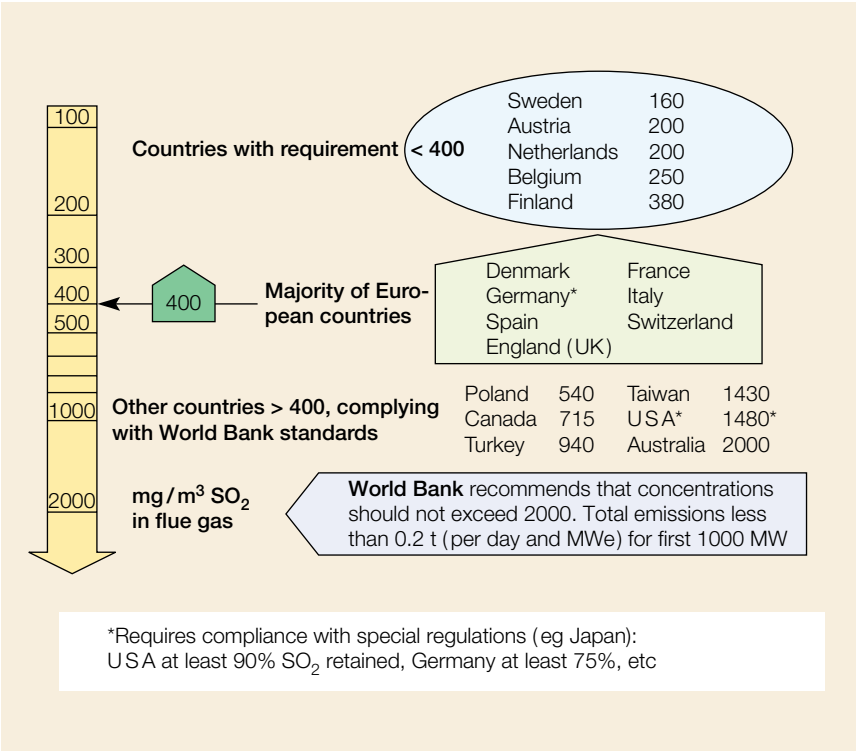
The client can also choose the feedwater pump drives (steam turbine or electric motor drives), plus the required redundancy. Alternative modules are included in the RPP concept so that the user can run through the different possibilities open to him on the screen. To replace two motor-driven pumps rated at 50 % each by a turbine-driven pump with

Reference steam power plant: layout with the main buildings **3**

1 *Coal handling system*
2 *Start-up fuel*
3 *Steam generator*
4 *Turbine building*
5 *Cooling tower*
6 *Flue gas desulfurization system*
7 *Electrostatic precipitator*
8 *Auxiliary building*
9 *Switchgear building*



100 % rating or three 50 % feedwater pumps with electric motor drives, for example, all the user has to do is press some buttons. The same versatility applies to the heat-exchangers: the user can choose between plate- or tube-type heat-exchangers, complete with all the required pipe connections, foundations and support structures. Condensers are available in single-flow or double-flow design, and the high-pressure feedheaters can be positioned upright or horizontally.



Outline of permissible SO_2 emission limits in various countries, neglecting further requirements which are decisive for the plant design, such as half-hour values, annual averages, etc **4**

Broad range of steam generators for project-specific steam data

The wide choice of components is also the basis for deciding whether the operation of the power plant should be subcritical or supercritical. A supercritical process is also possible with the 300-MW units offered by the RPP platform. The superiority of this technology is proven in the Western world and in parts of Asia. What is now necessary is to make this more efficient process, which also has less impact on the environment, familiar and acceptable to the emerging economies. This will not be without problems, since the capital investment for a supercritical power plant is slightly higher than for a conventional plant and is amortized only in the medium term, depending on fuel costs and other assessment criteria. In the industrial countries, at least, the supercritical plants are increasing their market share considerably. It remains to be seen which strategy the potential operators of plants in the emerging markets will follow.

A broad spectrum of boilers can be used with the modular RPP: ABB Combustion Engineering in the USA builds natural draft boilers for turbosets with low steam data, boilers with controlled circulation for higher but still subcritical steam pressures, and a series of forced-flow boilers for supercritical steam parameters.

The boilers with controlled circulation were developed in order to:

- Secure reliable heat transfer in the subcritical range under all operating conditions.
- Be capable of responding to fast load changes as dictated by the electrical grid.

The combination of supercritical steam data and modern turbine technology ensures higher efficiencies, a lower specific fuel consumption and therefore more profitable power generation, without compromising high reliability, availability and a maintenance-friendly design. Boilers are available which have been developed for combined sliding and fixed pressure operation, for both base-load and medium-load operation. ABB has experience with vertical and spiral-wound furnace wall tube arrangements.

Flue-gas cleaning for improved environmental compatibility

While in Europe it is standard procedure to pass the cooled exhaust gases leaving the boiler through a flue-gas cleaning system to remove harmful pollutants, this technology still represents new territory for many of the world's countries. In some regions, financing by the World Bank can depend on power plants meeting at least the minimum requirements for environmentally compatible operation, as indicated for example in **4**, which gives SO_2 emission limits for various countries.

It goes without saying that the modular RPP platform includes pre-engineered systems for the removal of particulates, sulfur and NO_x from the flue gases, supplemented by modules for environmentally sound water and waste management. The latter take into account the experience and know-how of

European power plant vendors and may help some potential power plant operators to navigate the obstacles in this field. The modules have been designed such that even completed projects can be upgraded at any time to comply with new, more ambitious national environmental standards **5** [8].

Highly developed ABB turbine technology

Steam turbines for sliding or fixed pressure operation in a subcritical or supercritical process have long represented a valuable share of the ABB reference plants. The possible combination of low-pressure turbine modules with the widest range of condenser designs and arrangements facilitates operating modes aimed at optimum economy even with extreme cooling-water temperatures.

It is important here to mention here that even for the highest RPP ratings ABB can install an impulse wheel in the high-pressure steam turbine to provide the basis for a control stage. Fitting such a wheel allows simple reserves to be provided in less-stable networks without adversely affecting the efficiency.

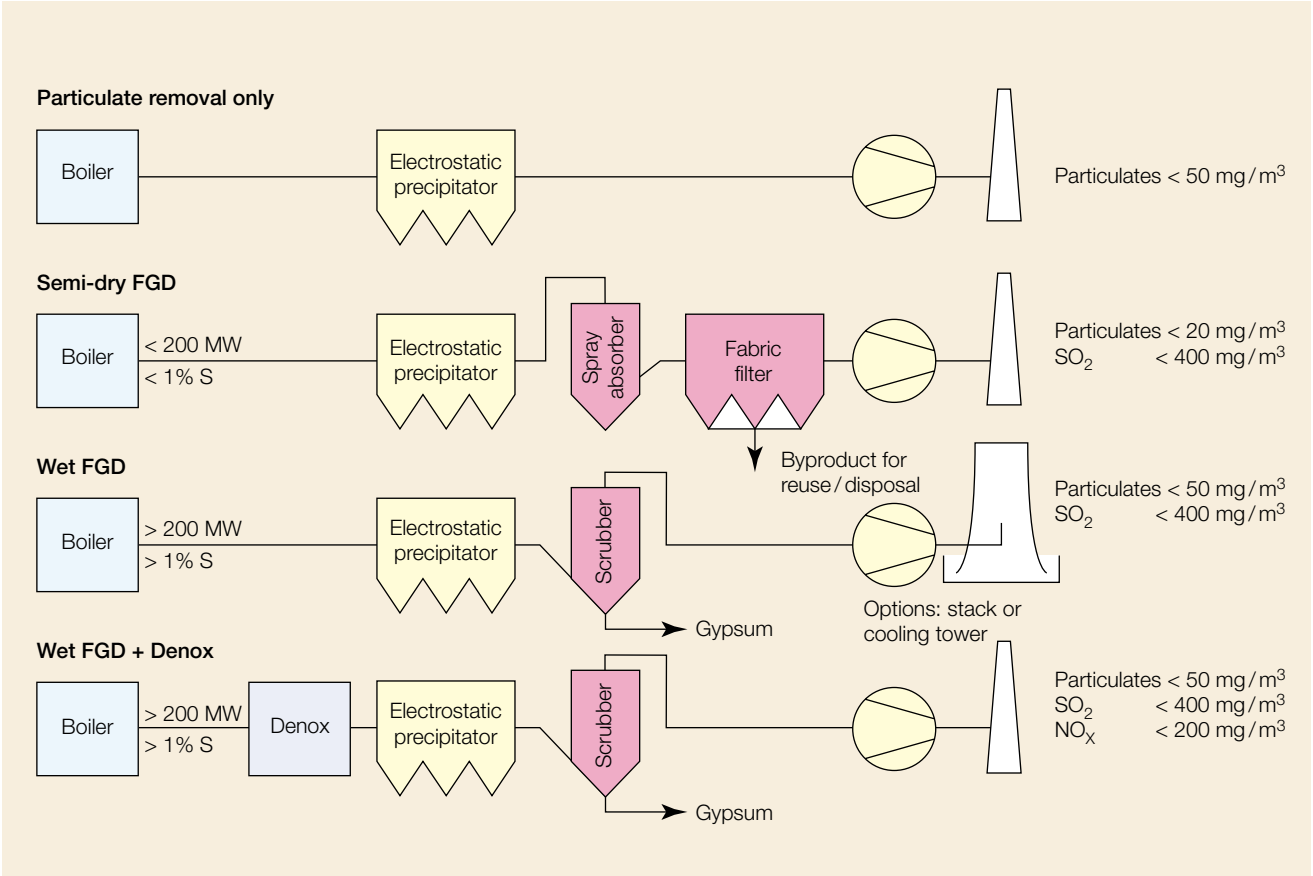
Focus on financing

The importance of financing in the international power plant business today is underscored by a look at the orders for which ABB has been able to arrange financing in recent years: from a volume of approximately US$ 500 million in 1990, financing has risen to about ten times this figure. The market trend is therefore clear: against the background of deregulation and strong competition, the ability to arrange financing for power plant projects is increasingly becoming a decisive factor in winning orders. The same is true of the necessity to purchase power plant components and systems from different countries.

It is here that the advantages of the pre-engineered modular RPP comes to the fore: matching power plant parts can be manufactured at different locations all over the world.

Besides global sourcing, sophisticated multinational models for financing and securing loans, which also increase the value added by the country ordering the power plant, increasingly help to safeguard funding of the project. Here, ABB has the advantage of having companies located all over the globe. These companies are often the key to being able to successfully take advantage of international programmes for securing

Flue-gas cleaning modules for a reference steam power plant **5**



loans. Financial engineering is therefore becoming increasingly important in the realization of planned projects in the emerging markets 6.

ABB has founded two independent companies to handle in a professional way the complex financing and contractural issues involved:

- ABB Project & Trade Finance (PTF) arranges the supplying companies' export credit, funding, bank loans and financing by the World Bank and/or multinational development banks, and also arranges counter-trade deals, leasing and other similar financing models.
- ABB Energy Ventures has worldwide responsibility for the formation and management of Independent Power Producers (IPPs). ABB Energy Ventures has drawn up feasibility studies for 23 power plants of all types with ratings of more than 5,500 MW, led the contract negotiations and arranged the financing. At the present time, ABB has an IPP project on every continent.

As diverse as power plant technology presents itself – ranging from custom-built, 'one-off', top-end facilities for demanding high-tech operators to combinations of modules adapted to specific requirements – as diverse also are the possibilities for their realization. Experience with many different models for financing and operation make it possible for efficient power plants, adapted to suit, to be built quickly and cost-effectively. Once on stream they supply the electricity so urgently needed in the emerging economies, energy without which neither economic, technical nor social development is possible.

between / for **Contracts**	Country / utility	Project developer	Operator	Power plant vendor	Banks	Fuel supplier
Power supply	●	●	◑	◑		
Power plant delivery (EPC)		●	◑	●	◑	
Operation and maintenance		●	●	◑		
Fuel supply	◑	●	◑			●
Loans	◑	●			●	
Land purchase	●	●				

BOO/BOT (Build, Own, Operate/Build, Own, Transfer) – contract structures for power plant projects 6

● *Parties to contract*
◑ *Parties contributing to contract terms*
Spheres of interest

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