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Performance of Generating Plant: Managing the Changes

Executive Summary

World Energy Council 2007

Promoting the sustainable supply and use of energy for the greatest benefit of all

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The challenge is both to improve the performance of the existing generating plant stock and to build enough – but not too much - new generation and transmission capacity to meet growth in demand.

Introduction

The global power sector is facing a number of issues, but the most fundamental challenge is meeting the rapidly growing demand for energy services in a sustainable way, at an affordable cost and in the environmentally acceptable manner. This challenge is further compounded by the fact that the major part of the increase in demand for power and hence in the emissions in the future, will come from developing countries, who strive to achieve a rapid economic development.

> Energy projects are among the most capital-intensive infrastructure investments. Decisions made today will form our lives for decades, and it is important that these decisions are based on facts and a proper economic assessment of available options.

The WEC Committee on the Performance of Generating Plant (PGP) has been collecting and analysing power plant performance statistics worldwide for more than 30 years. It has also produced regular reports, which include examples of advanced techniques and methods for improving power plant performance through benchmarking. This information has been widely disseminated at conferences, workshops and face-to-face meetings held by the Committee in different countries.

> The challenges vary from region to region. While rapidly growing economies in the developing world are hungry for practically any power to support economic growth and provide basic modern energy services to their people, industrialised countries are focusing on ensuring secure electricity supplies at competitive prices in an environmentally acceptable way.

The increasing competition in the electricity sector has had significant implications for plant operation, it requires thinking in strategic and economic rather than purely technical terms. This is not always easy for the global community of power plant operators, which is heavily dominated by engineers with a “technical mindset”. The need for efficient allocation and use of available energy resources and power generation assets; effective scheduling of plant activities, such as outages and maintenance; greater use of analytical tools to conduct cost/benefit evaluation of proposed activities are changing the industry mindset.

International Availability Data Exchange for the Thermal Power Plant

One of the key goals of the PGP Committee is to identify processes, tools, and/or techniques for measuring plant performance to enable generators to benchmark the performance of their units to that of others and to identify “top of the class” performance standards for their peer groups. Traditional measures for plant reliability/availability such as UCF (Unit Capability Factor), UCLF (Unplanned Capability Loss Factor) only tell part of the story. The reality is that mixed regulatory, ownership and market perspectives result in mixed goals, objectives, and priorities for power generating utilities. Varying business models, varying risk profiles, and different "obligations to serve" all further complicate the issue.

What are the key metrics? Technical? Commercial? Environmental? Or even sustainability? The Committee's work suggests that all play a major role in measuring and improving plant performance. As the global power markets continue to "evolve" worldwide, plant performance is becoming increasingly important. However, areas of concern and means for measuring or reporting performance are far from clear or consistent, and the situation is quite fragmented:

- The fact that power markets and regulated frameworks co-exist essentially results in a lack of standards or practices for measuring performance. There are large variations in structure and focus within the different markets globally.
- The definition or scope of performance also varies widely and can cover a range of issues including reliability/availability, capacity, efficiency, cost-effectiveness, environmental performance, and market performance (e.g. commercial availability, value/risk profile, etc.).
- Collection and analysis of performance data is becoming a real challenge due to competitive pressures, variations in markets, technologies and costs structures.
- New drivers geared toward profitability, cost control, environmental stewardship and market economics are shifting the focus away from traditional measures of technical excellence such as availability, reliability, forced outage rate, and heat rate.

In the future, shifts in generation mix will further impact plant reliability and performance as different technologies are introduced for environmental control and power generation. This will likely lead to a situation where generation mix will simultaneously be impacted by further environmental controls applied to aging plant at the same time as different clean technologies (e.g. renewables, IGCC, Carbon Capture) are initially deployed.

The continued assessment of the industry and its trends suggests that while "commercial" metrics are currently the best means for addressing performance, specialised processes and tools are needed to support comparison of performance across facilities. Such capabilities are necessary to be able to relate commercial to technical performance objectives.

- For a generator within an evolving market, a means to consider what optimal performance objectives should be, given commercial realities, role of the plant in the market, etc.
- For comparison of performance of "similar" units across markets, which allows to consider differences in value

- associated with specific performance metrics.
- To provide means to investigate whether it is possible to employ such analytics to "normalise" plant performance across markets to promote benchmarking and identify "top of the class" performance.
- Means to extend this framework to consider other forms of metrics or indices. For example, significant new work is being undertaken for measuring environmental performance and/or sustainability metrics.

To address this, the PGP Committee has developed a new computer-based tool to evaluate and compare plant performance metrics. A series of case studies have been conducted to illustrate how to better apply and leverage both peer group data as well as the broader set of indicators. The model also fully documents and provides a basis of calculations for all major current performance indicators.

Overview of the PGP Technical & Commercial Performance Model

The model provides means to analyse many facilities, even for technologies that the user does not fully understand. It provides a medium for analysing and presenting a thorough availability and economic comparison for various facilities, technologies, markets, and obligations. It serves as an educational tool to facilitate the quick comparison of plants that are difficult to compare side-by-side.

How to leverage plant performance data? The PGP Committee has developed a Technical & Commercial Power Plant Performance Evaluation Model to help the evaluation process.

The model allows comparing various performance metrics across the plants including:

- Commercial Availability
- Traditional Availability
- Capacity
- Capability
- Revenue
- Costs
- Profitability (or Operating Margin)

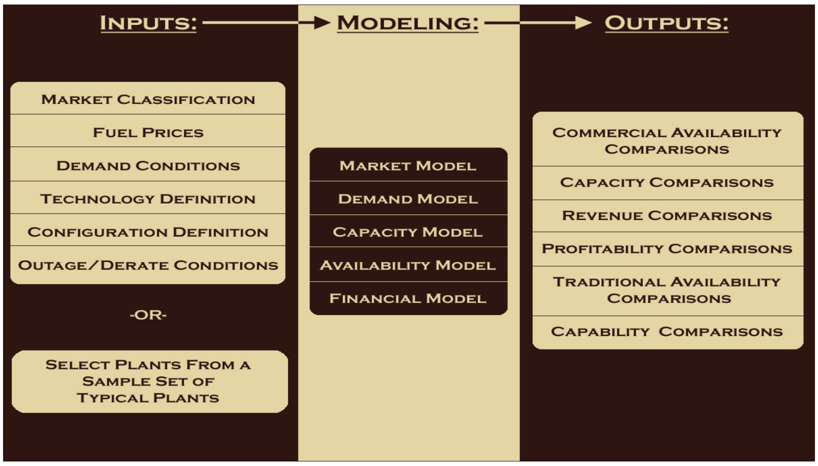
In order to attain these comparisons, there must be a simulation engine to model the systems that generates these comparison metrics. With this in mind, the following models for each plant have been integrated into the PGP model:

- Market Model
- Demand Model
- Capacity Model
- Availability Model
- Financial Model

If a comparison against a certain plant technology is desired, but knowledge of this type of plant is limited, then the model facilitates the comparison by providing a library of typical plants from which to choose and populate the

Figure 1 Calculator modelling data flow

Source: WEC



inputs. This makes it easier to quickly load plant data for comparison and is particularly useful when comparing against an unknown technology, or to speed up the input process, by easily pre-populating the model with inputs from a similar technology, before refining data to the exact scenario desired.

Figure 1 outlines the flow of information through the modelling tool. The first column contains the inputs necessary to feed the models. The second column contains the models that simulate the plants and their markets. The third column contains all comparisons that are generated to easily contrast the plants side-by-side.

Generating Plant Unavailability Factors and Availability Statistics

The evaluation of power plant performance is one of the most important tasks at any power station. Without its availability records, the plant staff can not determine ways to improve performance of the equipment and make the plant a profit-centre for the company. The causes of unavailability must be thoroughly analysed to identify the areas for performance improvement.

The Scope

For many years, the WEC PGP Committee collected power plant availability statistics from the various countries as average indices for several groups of units. The resulting tables provided summary data for each groups but did not allow analysts to examine where exactly their generating plants fit in the distributions of the unit population.

Starting in 1994, PGP opened the data collecting process to include unit-by unit information. In 2007 the new WEC PGP database has been expanded to include individual unit design and performance indices. The design section of the database provides a number of characteristics for filtering the collected data into various groups based on the user's concepts of what constitutes a peer unit.

In the old, historical database, there were data for over 5,000 unit/years. Not all countries have yet been able to enter their data into the new database format. As the contents of the data base grow further, the new unit-by-unit database will become a valid reference for an availability factor expectation, particularly useful for countries in the early stages of deploying gas turbine and combined cycle plant as part of their power systems.

Historical data surveys focused on base-load units, since availability and unavailability factors were not suitable for peaking plants. For example, a fossil-fuel plant operating at peak load for a limited number of hours during the year, and spending the rest of time in reserve, excluding planned annual maintenance shutdowns, would show an availability level in the order of 100%, which would not reflect the real situation. Therefore, it was agreed, whenever possible, to exclude these types of installation from the statistics, along with the units whose utilisation factor is less than 40%.

The new unit-by-unit database allows all operating units to report to it. The design and operation filtering characteristics allow the users to choose the operating parameters of units most similar to their own. The new performance indices expand the options to peaking, cycling or base-loaded units. This new flexibility will allow a broader use of the database for comparing individual unit performance to peer units.

Table 1 Design features in the database

Type of units	No of Design Features
Fossil Steam Turbine	16
Combined cycle/ Co-generation	10
Combustion Turbines	5
Hydro and Pumped Storage	6

What the Future Holds In Store

The benefits of the international cross-comparison system henceforth depend - in addition to the current practices described in this report - on the commitment of power plant operators to enhance them. The underlying goal is to foster international support and participation.

Key factors influencing plant performance should be identified and analysed to allow a cost/benefit analysis of any activity/programme before its implementation.

To analyse plant availability performance, the energy losses/outages should be scrutinised to identify the causes of unplanned or forced energy losses and to reduce the planned energy losses. Reducing planned outages increases the number of operating hours, decreases the planned energy losses and therefore, increases the energy availability factor. Reducing unplanned outages leads to a safe and reliable operation, and also reduces energy losses and increases energy availability factor.

The access to worldwide generating plant statistics will help power plant operators with the availability records of their plants to benchmark them in the context of global experience. New software for data collection and new, powerful software for analysing the results is now available to bring the world electricity producers closer together in a cooperative manner.

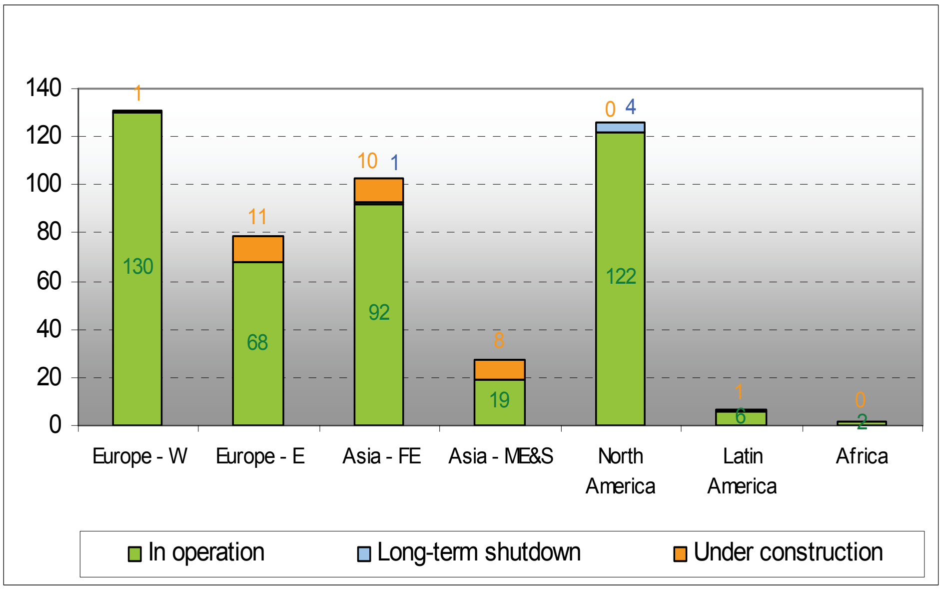
The result will be beneficial exchange of information to improve the performance of power generating assets around the world and improve the quality of life for many people.

Nuclear

Nuclear reactors have generated electricity since 1954, and today nuclear energy is an

Figure 2 Reactor units by region

Source: IAEA-PRISM



important part of the global energy mix. In 2006 nuclear power supplied about 15.2% of the world's electricity. For over 50 years nuclear power plants have accumulated 12,500 reactor-years of operating experience. The statistics presented in this report are based on data collected by the International Atomic Energy Agency (IAEA) for its Power Reactor Information System (PRIS). The database system covers two kinds of data: general and design information on power reactors, and performance data consisting of energy production, energy unavailability and outages.

General and design information relates to all reactors that are in operation, under construction, or shutdown in the world.

The PRIS can be used to assess nuclear power performance as it provides information on plant utilisation and planned and unplanned unavailability due to internal and external causes. Using detailed classification of energy losses and a comprehensive outage coding system, a set of internationally accepted performance indicators is calculated using the PRIS performance data. The indicators can be used for benchmarking, international comparison or analysis of nuclear power availability and reliability from reactor specific, national or worldwide perspectives. This analysis can be utilised in evaluation of nuclear power competitiveness compared with other power sources.

In October 2007, there were 439 operating nuclear power plants (NPPs) around the world totalling 371.7 GWe of installed capacity. In addition there were also 5 operational units in long-term shutdown with a total net capacity 2.8 GWe. There also were 31 reactor units with a total capacity 23.4 GWe under construction.

The ten countries with the highest reliance on nuclear power in 2006 were: France, 78.1%; Lithuania, 72.3%, Slovakia, 57.2%, Belgium, 54.4%; Sweden, 48.0%, Ukraine, 47.5%; Bulgaria, 43.6%, Armenia, 42.0%, Slovenia 40.3% and Republic of Korea 38.6%.

In North America, where 121 reactors supply 19% of electricity in the United States and 16% in Canada, the number of operating reactors has increased in the last three years due to re-connection of two long-term shutdown reactor units in Canada (Bruce-3 in 2004 and Pickering-1 in 2005) and one in USA (Browns Ferry-1 in 2007).

In Western Europe, with 130 reactors, overall capacity has declined by 1966 GWe because of shutdown of 11 ageing reactor units. In Eastern

Europe the same number of shutdowns and new grid connections (4) resulted in unchanged number of operating units (68). In Asia, with a total of 111 reactors at present, the number of operating reactors has increased by 10 since the beginning of 2004.

Nuclear electricity production has been growing continuously since the nuclear industry's inception.

From 1975 through 2006 global nuclear electricity production increased from 326 to 2,661TWh. Installed nuclear capacity rose from 72 to 369.7GW(e) due to both new construction and uprates at existing facilities.

In 2006 the worldwide EAF (Energy Availability Factor) was 83% on average. Half of nuclear reactors operated with EAF above 86% (world-wide median value). The top quarter of reactors reached EAF above 91%. For comparison the global energy availability factor for NPPs was 72% in 1990.

The continuous increase in the EAF averaged around 1% per year in the period 1990-2002 but since 2002 this positive trend has stagnated at about 83%.

The average planned unavailability factor has been decreasing continuously from about of 20% at the beginning of the 1990s to 12% in recent years. PHWR, BWR and PWR units have achieved the best results.

The improvement in the Unplanned Unavailability Factor (UUF) was also significant. It decreased from about 8% to 4% during the last 15 years. In 2006 the median of UUF was 1.32%, but more than 45% of reactors were operated with UUF lower than 1%.

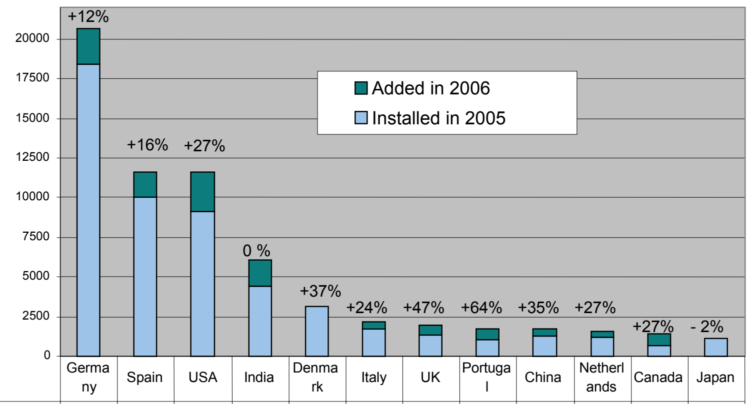
Nuclear plant operators are achieving high availability through integrated operation and maintenance programmes. These achievements show the efforts made by the nuclear industry for a reliable and safe operation of nuclear power plants. They also reflect the impact of de-regulation and privatisation of the electricity market, which have affected all electricity producers.

The main factors contributing to improvements in reactor availability are:

- The elimination of unplanned energy losses through effective failure prevention (root cause analysis), on-line preventive maintenance, timely indications of equipment degradation, and the implementation of concurrent design improvements.
- The reduction of planned energy outages through fuel cycle extensions, effective management of refuelling and maintenance outages, and risk oriented maintenance.
- The continuing exchange and dissemination of operating experiences.

Figure 3 Wind power installed in 2006 (MW) – Top 12 countries

Source: Systémes Solaires – Observ'ER



	Germany	Spain	USA	India	Denmark	Italy	UK	Portugal	China	Netherlands	Canada	Japan
Added in 2006 (MW)	2,233	1,587	2,454	1,619	11	417	631	673	439	336	767	-22
Installed in 2005 (MW)	18,415	10,028	9,149	4,434	3,129	1,718	1,332	1,047	1,260	1,224	684	1,150

- Consolidation in the nuclear industry, which also means that more plants are operated by those who do it best.

Technical, Commercial and Sociological Indicators for Renewable Energies

Wind energy: a dynamic sector

Since the early 1990s, wind power has undergone a considerable level of development. In 1995, the total global installed wind power capacity was 5,000MW. Ten years later, in 2005, the installed capacity reached 59,200MW, including 11,700 MW added during the year (i.e. a growth rate of 25%). In 2006, the first statistics show a total capacity of 72,600MW (13,400MW installed during the year, i.e. 23% growth rate).

Germany is the leader with more than 20,600MW installed in 2006 i.e. nearly one third of the world-wide wind power capacity, followed by Spain with 11,615MW, the United States with 11,600MW, India with 6,050MW and Denmark with 3,140MW. These five countries accounted for nearly 75% of the global capacity in 2006.

Over the past two decades, the power output and the size of wind turbines have been increasing significantly. This growth is now slower for onshore turbines. Typical modern grid-connected wind turbines have diameters of 40 to 90 metres, towers of 50 to 100 metres high and are rated between 500kW and 3MW (average: 1.85MW in Germany in 2006).

Their excellent technical availability is between 95 and 99%. However, their capacity factor (ratio of the total actual energy production over the potential energy production) is impaired by wind intermittence, as wind availability varies between 20 and 30% for onshore; and up to 40% for offshore farms.

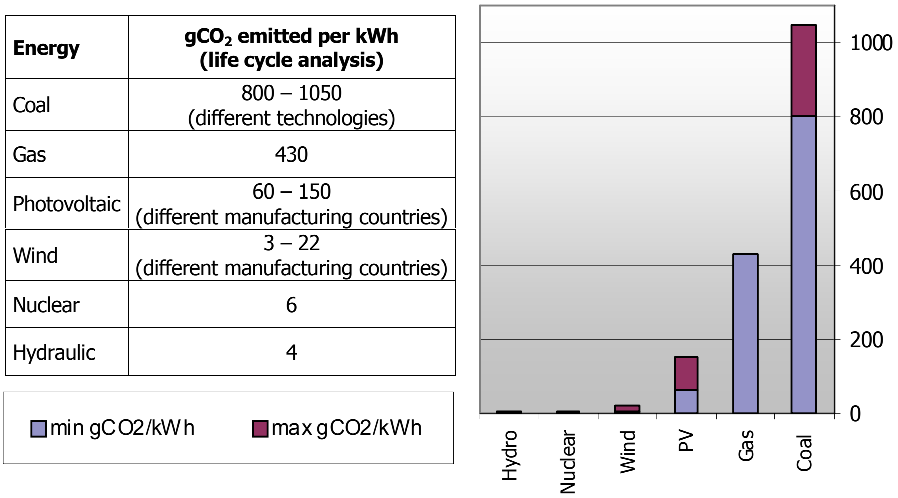
Currently the most powerful turbine is rated at 6MW with a rotor diameter of 115 metres and a tower of 125 metres. The 3-6 MW wind turbines are in fact mainly intended for offshore installations.

Wind turbines are designed to work for some 120,000 hours of operation throughout a lifetime of about 20 years. It is now technically feasible to build wind turbines at water depths over 30 metres and far offshore.

Nevertheless such installations are expensive, and most offshore wind farms are located in shallower waters within 18km from shore. In 2005, a new offshore wind capacity of 900MW was installed in the world.

Figure 4 gCO_2 emitted per kWh (life cycle analysis)
Source: Jancovici

Energy	**gCO_2 emitted per kWh (life cycle analysis)**
Coal	800 – 1050 (different technologies)
Gas	430
Photovoltaic	60 – 150 (different manufacturing countries)
Wind	3 – 22 (different manufacturing countries)
Nuclear	6
Hydraulic	4



Despite its positive image, wind energy has several drawbacks:

- Intermittence
- Grid integration difficulties
- Poor forecasts wind conditions
- Visual impacts
- Noise impacts
- Other environmental impacts

Offshore wind energy production is currently much more expensive than onshore. Initial investment is 50 to 100% higher depending on site (depth, distance from shore, type of substratum). O&M costs are also 50 to 100% higher depending on the site.

The kWh cost for onshore production is estimated between 0.05 and 0.12€/kWh depending on the turbine size and site, whereas offshore production cost is estimated to lie between 0.08 and 0.20€/kWh.

Thus onshore wind energy production can compete with coal, gas and nuclear electricity and other energies which cost between 0.03 and 0.06€/kWh, when external costs (impact on human health, ecosystems and global warming) are not considered.

Long-term wind electricity production potential is estimated at 4,500TWh per year, in other words 27% of worldwide electricity production in 2003 (16,570TWh). This is lower than for biomass (11,000TWh) and hydro (7,500TWh), and approximately identical to solar energy (4,000 to 4,400TWh).

Photovoltaic Energy

Over the past fifteen years, photovoltaic (PV) solar energy has demonstrated an exponential growth. Once a leading-edge technology only used for satellites, PV cells are becoming more accessible day by day. In 1992, a capacity of 110MWp was installed in the world. By the end of 2005, a cumulative installed capacity of 4,640MWp was achieved with 1,460MWp added during last year, in other words an outstanding growth rate of 34%. Solar PV is the fastest growing power generation technology.

However, counting and evaluating PV systems is more difficult than counting and evaluating alternatives, since they are smaller, numerous, often directly installed on scattered private roofs and rarely assembled in an industrial plant. Historically, Japan was one of the first countries to massively support PV energy, and this is reflected in its cumulative capacity of 1,430MWp in 2005, representing 31% of the worldwide PV energy installations.

Table 2 Costs of different power plant types

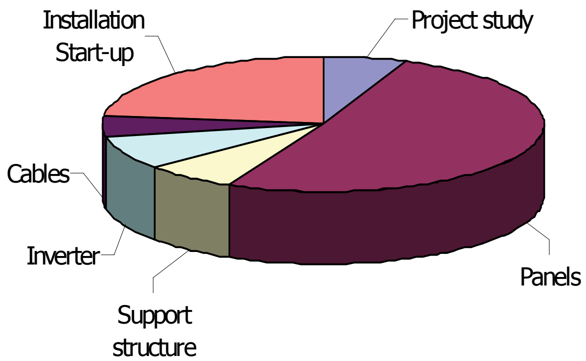
Source: European Commission ExternE 1999, IEA

Type of plant	Investment costs (€ /kW)	Production costs (€ /MWh)	External costs € /MWh)
Nuclear	800-1,600	25 - 30	2.30–18.80
Coal	800-1,200	30 - 35	19.00–99.00
Gas	350-650	35 - 60	7.00–31.00
Large Hydro	~2,000	30 - 65	0.04– 6.03
Geothermal	1,400-1,700	50 - 80	0.20– 0.50
Biomass	1,350-2,200	40 -110	2.00–50.00
Wind (onshore)	900-1,300	50 -120	0.50– 2.60
PV grid-connected	4,000-9,000	250 -650	1.40– 3.30

Figure 5 Investment costs (in %)

Investment Costs (in %)

Element	Cost
Project study	6 %
Panels	51 %
Support structure	7 %
Inverter	8 %
Cables	5 %
Installation/start-up	23 %



Source : IEA

Over the past two years, Germany has become the largest market, representing 58% of the new installations worldwide in 2005 and a cumulative capacity of 1,910MWp in 2005 and 3,063MWp by the end of 2006. The United States is the third largest market with 105MWp installed in 2005 and a cumulative capacity of 465MWp. Far behind Germany, Japan and the United States, come the two Asian Giants: India and China.

PV energy depends on the energy delivered by the sun, and thus on the day and time. At high noon on a cloudless day at the equator, the sun delivers about 1kW/m² to the Earth's surface. Nevertheless, this measure has to be corrected when accounting for clouds, latitudes and sunsets. Solar power is characterised by the solar irradiance, which is the average number of kWh per m² per year (or day). Typical irradiance ranges from 700 kWh/m²/year in northern regions (Northern Europe, Canada) to 2200 kWh/m²/year in the sunniest areas (Africa, Southern Europe).

Moreover, PV cells cannot fully convert sun power: typical solar panels have an average yield of 12%, with the best available panels at about 20%. A production of about 1kWh per m² PV panel on average can be expected every day in a good area after taking into account weather, latitude and yield.

PV energy seems to be an ideal solution for providing alternative electricity supply but has several major drawbacks:

- Intermittence
- Grid integration difficulties

- Weather dependence
- Use of toxic materials for equipment manufacturing

Theoretically solar energy has enormous potential. The total amount of solar energy reaching the Earth's surface is a thousand times greater than the world total energy consumption.

This energy is not totally retrievable using current technologies, but the technical potential for converting solar energy directly into heat or electricity is huge and expected to be more than 440,000TWh/year, i.e. about three or four times the present total energy consumption of the world.

The long-term solar electricity production potential (assuming a reasonable required land area) is estimated at 4,400TWh per year, i.e. more than 26% of the worldwide electricity production in 2003 (16,570TWh).

PV energy certainly has significant potential for future growth throughout the world and is likely to enjoy continuous development in coming decades, in particular, since major technical improvements and cost reductions are still expected to take place. Developed countries and probably China will significantly increase their installed capacity.

Pioneer countries in this field, Japan and Germany, are also the most active in R&D and will preserve this advantage for many years. PV energy could be a really suitable solution for developing countries that have much sunlight, but on its own will not be able to support development in remote areas.

Technical breakthroughs are expected and costs will certainly decrease thanks to important R&D efforts and widened production. Ultimately, PV energy currently needs strong incentive mechanisms to accelerate its development, find new markets and encourage technical improvements.

Biomass

Biomass is a renewable source of energy. It includes various organic materials, such as wood by-products and agricultural wastes, which can be used to produce energy.

Long-neglected in favour of fossil fuels, biomass has made a comeback in recent years. It can substitute for some fossil fuels for the chemical industry and energy (biofuels for transport, heat and electricity). Electricity from biomass called bioelectricity, has enjoyed strong development, in particular due to its use for co-generation. A biomass plant can provide heat and electricity at the same time.

In 1998, 98.8TWh were produced from biomass throughout the world. In 2005, the world electricity production from biomass reached 183.4TWh.

Biomass was the second largest renewable energy sector with 5.6% of the total renewable electricity in 2005, behind hydro power (89.5%) but ahead of wind energy (3.0%). However,

Table 3 Land area required for different renewable power plants
Source: WEC and US DOE

Energy source	Wind	Solar (PV)	Biomass	Geothermal
Land area for a 1 GW plant	100 km² but can be used for agricultural purposes	30 km² but panels can be installed on roofs	5000 km²	200 km²

biomass actually delivered only 1% of the global electricity, far behind fossil fuels (66.4%), large hydro (16.2%), and nuclear (15.2%).

Europe and North America are the two leaders with almost 75% of the global bioelectricity production ahead of Asia (about 18%) and Africa with only 0.2%.

Wood and other biomass materials can be processed and used to generate electricity. There are three major transformations presently in use: combustion, gasification and pyrolysis of biomass.

Combustion is the most common way of converting solid biomass fuels to energy because of the low cost and high reliability. Gasification and pyrolysis are still under development but are generally expected to become more common in the future.

Biomass is a part of the renewable energy portfolio and it can offer an array of benefits:

- No greenhouse gases during the life cycle and lower overall emissions than fossil-fuel plants
- Forest sustainability
- Energy independence and regional integration
- Proven technologies for combustion and co-firing
- Use of low-cost products

Biomass systems are most often fuelled by waste wood, from logging operations, forest thinning, low-grade wood or sawmill residues, which are far too frequently burnt in the open without pollution control. These systems create a commercial market for wood, while also boosting the forestry economy.

Moreover, biomass cultivation can reduce the risk of wildfires by removing small diameter trees that act as a fuel. It prevents harmful effects of forest fires on the atmosphere, including release of mercury, toxic materials, GHGs and NOx.

Biomass conversion to electricity provides significant benefits, but is also has several major drawbacks:

- Seasonal availability
- Transport and processing
- Emissions
- Land area requirement

The land area that is required for exploitation by a biomass power plant is huge when compared to other energies. Table 3 shows this land area required for exploitation of a 1GW renewable energy plant (average values).

Theoretically biomass energy has enormous potential. The long-term biomass electricity production potential is estimated at 11,000TWh per year, i.e. more than 60% of the worldwide electricity production in 2005 (18,140TWh). This potential is higher than that of other renewable energies: hydro (7,500 TWh), wind energy (around 4,500 TWh), Solar energy (4,400 TWh). However, biomass must be divided amongst all uses (food, heating, electricity, bio-fuels).

Technical advances are expected and should promote a decrease in cost and diversify solutions to adapt power plants to the feedstock and needs. However, biomass needs incentive mechanisms to accelerate its development, find new markets and encourage technical improvements.

Biomass is a relatively clean energy. It will certainly be beneficial and can play a sizeable role in GHG emission reduction. However, due to its different uses – heat, electricity, bio-fuels and especially food – and geographically limited localisation, biomass electricity alone will be unable to supply the entire electricity needs.

Markets & Risk Management Strategies

This new PGP project was conducted by the Work Group on Markets and Risk Management Strategies which was set up to establish means to determine the risks in power markets and the methods implemented to manage such risks. Cognisance is to be taken of the continuing changing market environment while maintaining confidentiality of the project participants.

Objectives:

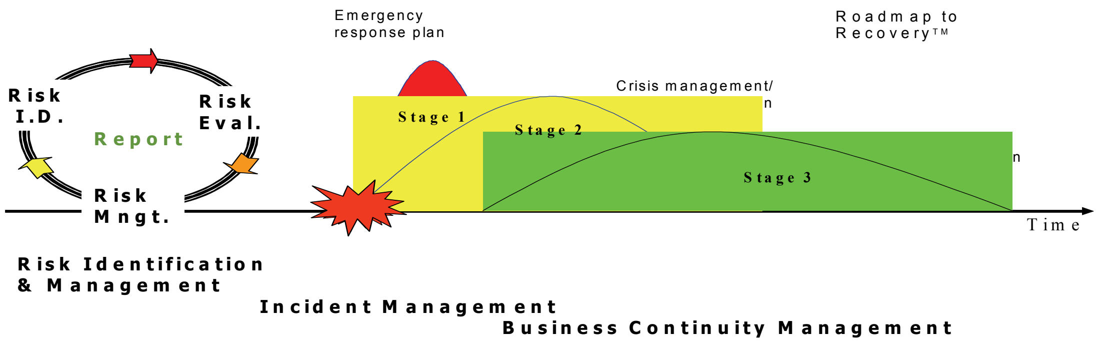
- Establish world wide participation reflected by the Work Group Members
- Identify those risks, uncertain future events, and the relevant markets that could influence the achievement of the power plants objectives.
- Establish a categorisation standard for these risks indicating opportunities for benefit or threats to success
- Establishment of best practices for Risk Management with regard to termination, tolerance or mitigation of each risk and the use of flexibility, forward planning etc
- Establish a glossary of market developments that have created changes in risk to power plants.
- Establish methods for reviewing and reporting on risk tolerance and risk management processes

Enterprise Risk Management (ERM) is an integral part of Good Corporate Governance and management in general. Corporate Governance is essentially about:

- Promoting best business practice
- Enhancing organisational performance and well-being
- Adding shareowner and stakeholder value

It goes beyond pure structure to encompass all business processes. It is therefore important to note that corporate governance is not about indicating compliance to appropriate ‘rules’, but rather towards demonstrating that fundamental good business practice is alive and well in everything the organization undertakes.

Figure 6 Spectrum of integrated risk management



The thrust is therefore towards a pro-active approach to sustaining and enhancing business performance, rather than fire fighting and defence in preventing corporate failures. This approach focuses on a positive contribution. Therefore, corporate governance, and as such also enterprise or integrated risk management, includes opportunity management.

Risk management is not an 'add on' activity, but an integral part of business management with the ultimate objective of minimising the variability and unpredictability of expected performance outcomes.

Risk Identification, Evaluation and Management are therefore a process directed at decreasing the likelihood of an unpredictable outcome, and also the relative impact of an unpredictable event, should it occur. Despite our best efforts though, some events can be either beyond our control (floods or earth quakes) or cannot be fully managed (fire).

Such events require some form of pre-determined emergency processes and business recovery strategies, with the ultimate objective of re-establishing business capability within the shortest possible time and with minimum human casualty, financial and sustainability impact on the organisation and the environment. It is therefore advisable to clarify risk management strategy up front to ensure that the risk assessment and management process cover both prevention / reduction of exposure and recovery processes post an event. This is the point at which risk assessment and risk management strategy can be brought together in the risk assessment model.

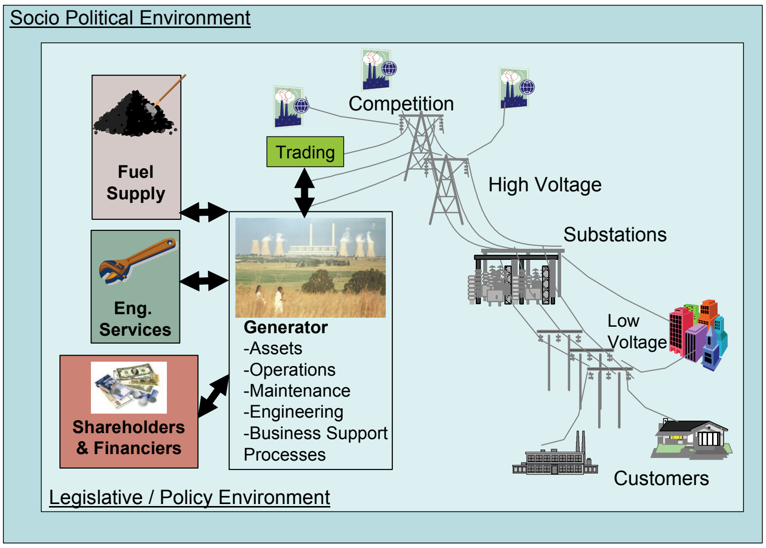
When undertaking risk assessment, it is critical to have a good understanding of the business as well as the environment within which it operates. Some important lessons have been learnt from operational experience:

- Most non-operational risks emanate from that interface and if not timely identified and managed, like during contracting phase, could result in significant exposure at a later stage when changes in the environment occur.
- Operational risks are often seen as easy to manage, thus the amount of time spent on understanding the full systems impact of either the risk or the solution are often too little, resulting in unintended outcomes.
- Risk management is integral to any job. It cannot be done by someone else.

With the above in mind it is useful to identify so called 'flash points' or 'hot spots' (areas of interface in the supply chain) from where it is likely that key risks may arise. Some examples of such flash points are:

- Regulatory Interface
- Suppliers
- Fuel Delivery
- Trading

Figure 7 Operating environment



The Triple Bottom Line – Dilemma or opportunity?

Many a company has battled with the question of balancing Triple Bottom Line performance (i.e. the 3 elements of sustainability, i.e. economic, social and environmental performance). It is not the intention to resolve this predicament here. However, some fundamental underlying truths are necessary to reflect on from an ERM perspective.

The following depiction of the sustainability dilemma may be familiar:

One is even tempted to say: "What is the question?" Is it not obvious that profitability is a function of sustaining the environment that enables the creation of wealth? Therefore, it is not the one or the other, but rather how the one can be used to grow the other.

The move towards triple bottom line reporting standards is driving the focus towards long-term sustainability for both the environment and the company. It is only when one is sidetracked by the pursuit of short-term profitability that it is hard to accept the need for such balance.

Over the last 10 years massive strides have been made in the development of ERM processes.

These developments have been captured in various publications, and have also given rise to the development of well-respected international standards, e.g.:

- Risk Management Standard by Federation for European Risk Management Associations (FERMA)
- Australian / New Zealand Risk Management Standard 4360
- British Standard on Business Continuity Management (PAS 52 and BS 25999)

The work presented in the report is aligned to these standards, as confirmed by various workgroup participants but represents a further customisation specifically directed at application in energy utilities. As with all processes, it will continue to be further developed and refined, based on experience and new developments in the discipline of Enterprise Risk Management.

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