WORLD ENERGY COUNCIL
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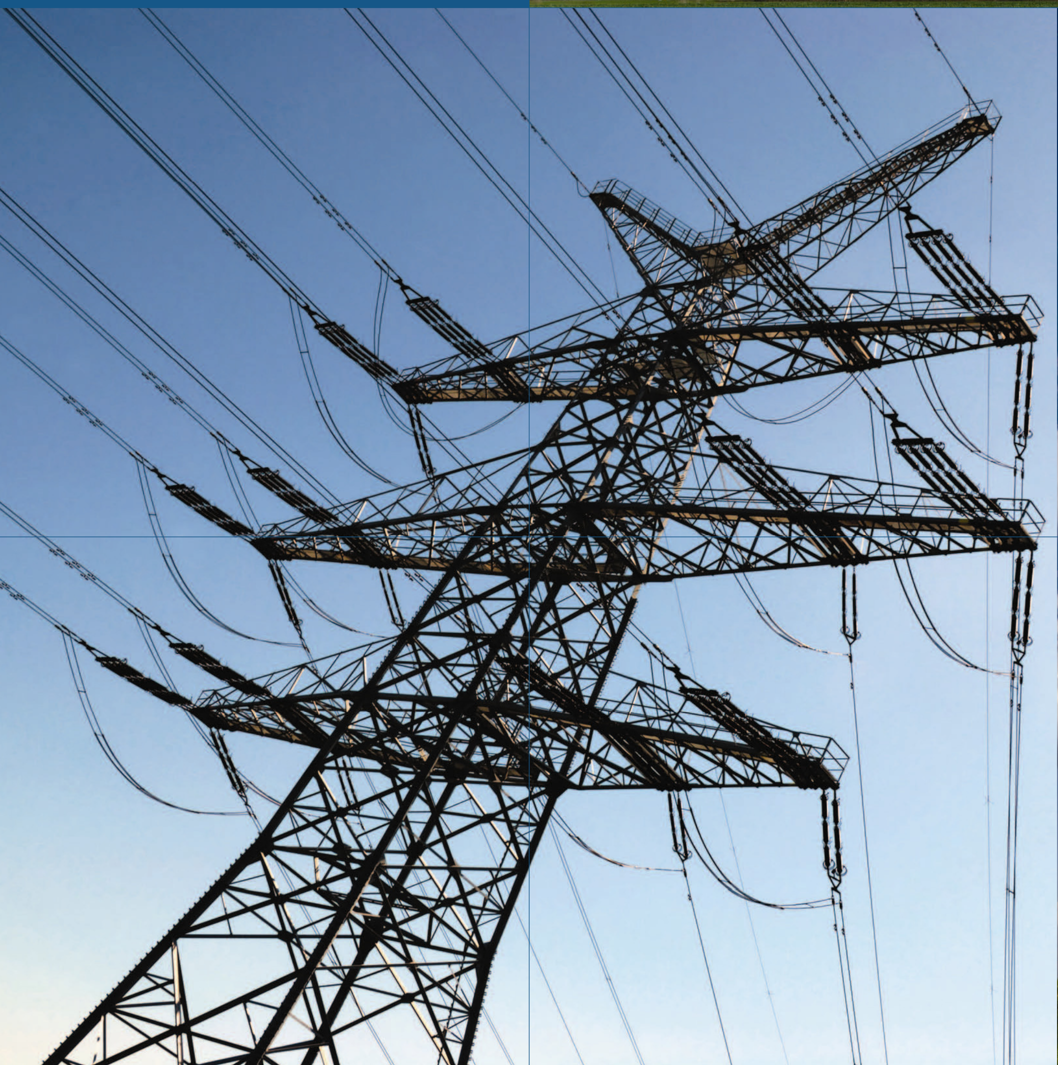
Performance of Generating Plant: Managing the Changes

World Energy Council 2008

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



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World Energy Council 2008

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Thermal Generating Plant Unavailability Factors and Availability Statistics

Contents

Work Group 2

Section 1

Thermal Generating, Combined Cycle/Co-Generation, Combustion Turbine, Hydro and Pumped Storage Plant Unavailability Factors and Availability Statistics.

G. Michael Curley, WG2 Chair

- North American Electric Reliability Corporation

Section 2

Nuclear Power Generating Units

Jiri Mandula

- International Atomic Energy Agency

Section 1

Introduction

The evaluation of power plant performance is one of the most important works 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 are thoroughly analysed to identify the areas for performance improvement. The WEC Committee on the Performance of Generating Plant (PGP) for many years has been collecting statistical data on power plant availability using WEC's global network of Member Committees.

There is no simple way to measure overall plant performance, nor is there a single indicator which could be used for this purpose. Operating conditions vary widely between the countries and regions, and in addition to high reliability, power plants must at the same time achieve a number of other objectives: economic, environmental, societal, etc. These objectives are different for different power plants, and each plant has its own particular aspects to take into account.

The increasing competition in the electricity sector has had significant implications for plant operation, and 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 resources; effective scheduling of plant activities, such as outages and on-line maintenance, greater use of analytical tools to conduct cost/benefit evaluation of proposed activities are changing the industry mindset.

These new needs, reinforced by dynamics of the ongoing change, are creating an atmosphere of uncertainty in the market. The uncertainty of meeting demand for electric power and the shareholders' profit expectations place additional pressures on power plant operators. 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. Old plant will need replacing with environmentally friendly generating units to provide the worldwide need for more and efficient electricity sources.

1 Historical vs. News WEC PGP Databases

Scope, Definitions and Terminology

Scope

For many years, 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 didn't allow analysts to examine where their generating plants fit in the distributions of the unit population. WEC PGP still accepts the average tables and a number of them are within this report. We thank any and all WEC members who support the PGP database with data in the historical format.

Table 1
Number of New Design Characteristics

Type of Units	Number of Design Characteristics
Fossil Steam Turbines	16
Combined Cycle/Co-Generation	10
Combustion Turbines	5
Hydro and Pumped Storage	6

Source: GraphicSource Style

However, PGP Committee members felt that there was a need to expand and improve the database for more thorough evaluations.

Starting in 1994, PGP opened the data collecting process to include unit-by unit information. In this latest version of the PGP database, the WEC PGP database is expanded to include individual unit design and performance indices. This brings the new PGP database into a brand new dimension. The design section of the database provides a number of characteristics for filtering the collected data into various groups based on the requester's concepts of what constitutes a peer unit. Initially, we are not asking for many design characteristics for each unit type. However, what we do request will be good starting point for future expansions of the new unit-by-unit database. Figure 2-1 below summaries the number of design characteristics collected for each type of unit. Exhibits 2-1 to 2-4 present the actual characteristics collected.

In the old, historical database, there were data for over 5,000 unit/years in the database. Not all countries, which participated in previous surveys, 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 expected to become a valid reference for an availability factor expectation, particularly useful for countries in the early stages of employing gas turbine plant and combined cycle plant as part of their power systems.

Historical WEC data surveys focus on base-load units, since historical availability and unavailability factors are 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 this type of installations from the statistics, along with the units whose utilisation factor is less than 40%.

The new unit-by-unit database will allow all operating units to report to it. The design and operation filtering characteristics will allow the data requester 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 too. This new flexibility will allow more and more use of the database for comparing individual unit performance to peer units.

Definitions and Terminology

The calculation methodology and rules introduced for the historical and new database broadly reflect the existing standards and their use should be encouraged within the framework of the WEC survey. The documents uniformly used for definitions and calculations include:

- Eurelectric publication “TherPerf data base: Evaluation of Performance Indicators 1990-2004”
- IEEE Standard 762 “Definitions for Reporting Electric Generating Unit Reliability, Availability and Productivity”
- ISO Standard 3977 “Gas Turbine - Procurement – Part 1; Introduction and definitions." This standard was introduced in 1997 and contains many of the same definitions as IEEE 762.
- International Atomic Energy Agency (IAEA) Power Reactor Information System (PRIS) database.
- World Association of Nuclear Operators (WANO) database

A number of Member countries reported their 2003-2005 data in the historical format and provided self-calculated information for five performance indicators. These five indicators have thus been defined, for international application, for the different areas in which operators must ensure a high degree of vigilance in order to achieve a satisfactory quality of service:

Five Core (Primary) Performance Indicators

- Energy Availability Factor (EAF)
- Unit Capability Factor (UCF)
- Unplanned Capability Loss Factor (UCLF)
- Planned Capacity Loss Factor (PCLF)
- Load Factor (LF)

The new PGP database collects unit-by-unit performance hours/MWh lost so that the PGP database will calculate the performance indices, not be calculated by the countries that supply them. As a result, the new database will allow data requesters to filter data based on the MW size of the unit, hours of operation, unplanned outage hours and many other parameters.

From the “raw data”, a number of new indices as well as the historical indices are now available to data requesters. These new indices are:

Three Additional (Secondary) Performance Indicators

- Unplanned Automatic Grid Separations per 7000 hours of operation (UAGS 7)
- Utilization Factor (UF)
- Unplanned Energy Loss Rate (UELR).

The focus of the new database is to create a higher-quality management tool than the existing database. These new indicators are intended principally for use by operators to monitor their own performance and progress, to set their own challenging goals for improvement, and to gain an additional perspective on performance relative to that of other plants. It provides the tool for more detailed benchmarking of units by operation and design. It provides the flexibility to allow the data requester to examine and compare units based on their own desired criteria and not on the fixed, rigid output of this report.

The web-based retrieval software for pulling unit-by-unit data will be operational and demonstrated starting with the November 2007 WEC Congress in Rome Italy. Thus, the international exchanges will start at this meeting and continue to foster a commitment to emulate the best practices, thereby maintaining the satisfactory level of performance observed.

3 Brief Description of the Core and Additional Performance Indicators Monitored by the WEC PGP Committee

Energy Availability Factor (EAF)

EAF is a percentage and measures of the potential amount of energy that could be produced by the unit after all planned and unplanned losses are removed. Not all the available energy will be created. However, EAF will identify the percentage of power during a period *could* be generated.

Outside Management Control (OMC) problems are not included in EAF.

Energy Availability Factor is equal to IEEE762 OMC Weighted Equivalent Availability Factor (XWEAF) which excludes outside management control outages or derates (also known as OMC PLS events).

Unit Capability Factor (UCF)

Unit capability factor is the percentage of maximum energy generation that a plant is capable of supplying to the electrical grid, limited only by factors within control of plant management. A high unit capability factor indicates effective plant programmes and practices to minimise unplanned energy losses and to optimise planned outages, maximising available electrical generation.

NOTE: Energy Availability Factor (WEC indicator) is defined on the same basis; but EAF is reduced by losses that are not under the control of plant management.

UCF is equal to IEEE762 Weighted Equivalent Availability Factor (WEAF) which includes outside management control outages and derates.

Unplanned Capability Loss Factor (UCLF)

Unplanned capability loss factor is the percentage of maximum energy generation that a plant is not capable of supplying to the electrical grid because of unplanned energy losses (such as unplanned shutdowns, outage extensions or load reductions due to unavailability). Energy losses are considered unplanned if they are not scheduled at least four weeks in advance. A low value for this indicator indicates that important plant equipment is reliably operated and well maintained.

UCLF is equal to IEEE762 Weighted Equivalent Unplanned Outage Factor (WEUOF).

Planned Capability Loss Factor (PCLF)

Planned Capability Loss Factor is the percentage of maximum energy generation that a plant is not capable of supplying to the electrical grid because of planned energy losses (such as annual maintenance shutdowns). Energy losses are considered planned if they are scheduled at least four weeks in advance.

PCLF is equal to IEEE 762 Weighted Equivalent Planned Outage Factor (WEPOF).

Load Factor (LF)

Load Factor is the percent of maximum energy the unit actually did produce. With regards to EAF, EAF presents what the unit could be produce; LF presents what the unit actually did produce.

LF is equal to IEEE 762 Net Capacity Factor (NCF).

Unplanned automatic grid separations per 7,000 operating hours

This indicator expresses how often a generator is separated from the external grid, in both an unplanned and automatic (manual actions are excluded) manner; it is given as a rate per 7,000 operating hours, thereby taking into account the wide variety of operating regimes.

Utilization Factor (UF)

Utilization Factor is a calculated value and is the percentage of load that a unit experiences once the unit is breaker connected OR NOT to the grid and providing electricity. If the UR is greater than 40%, then the unit is considered base-loaded. The LF and EAF are net values.

- UL = (LF) / (EAF)

UF is comparable to IEEE 762 Net Output Factor (NOF).

Unplanned Energy Loss Rate (UELR)

Unplanned Energy Loss Rate is a probability of the chance of experiencing an unplanned energy loss during the time the unit is needed for load. It is used by planning departments for measuring the reliability of the unit to complete its assigned mission of generation before it has an unplanned event. The UELR assumes that if the unit were not on unplanned outage, then the unit would be operating and producing electric power. It is used for base-loaded units only. Peaking and cycling units would have an unusually large UELR because the UELR is very dependent on the hours of service. The higher the service hours, the more reliable the UELR number is. No outside management (OMC) energy losses are included in UELR.

- UELR = [(unplanned energy losses)] / [(Actual production supplied) + (unplanned energy losses)]
- UELR = [(UOH + EUDH) / (SH + UOH)]

UELR is equivalent to IEEE 762 Weighted Equivalent Unplanned Outage Rate (WEUOR).

4 Historical Data Reporting Groups

Fossil Steam Turbine Units

The five historical performance indicators are monitored on family groups, starting from the first full year of commercial service. Data is submitted anonymously using a unit "code", which is known only by the operator who supplies the data. To ensure complete confidentiality (no data can be used for commercial purposes), certain procedures have been defined for the exchange of this information.

Three historical categories of conventional thermal installations are:

A – Fossil steam turbines

B - Combined cycle, cogeneration

C - Combustion turbines.

Four types of fuel are:

1 - Coal (excluding lignite and others)

2 - Lignite and others

3 - Liquid fuels

4 - Gaseous fuels.

The power rating categories are those recommended by the former Joint UNIPEDE/WEC Committee.

Availability and unavailability statistics are provided for steam turbines units. Four basic fuel types are presented in Figure 2-2. Categories of capacity used in the analysis are described in Figure 2-3.

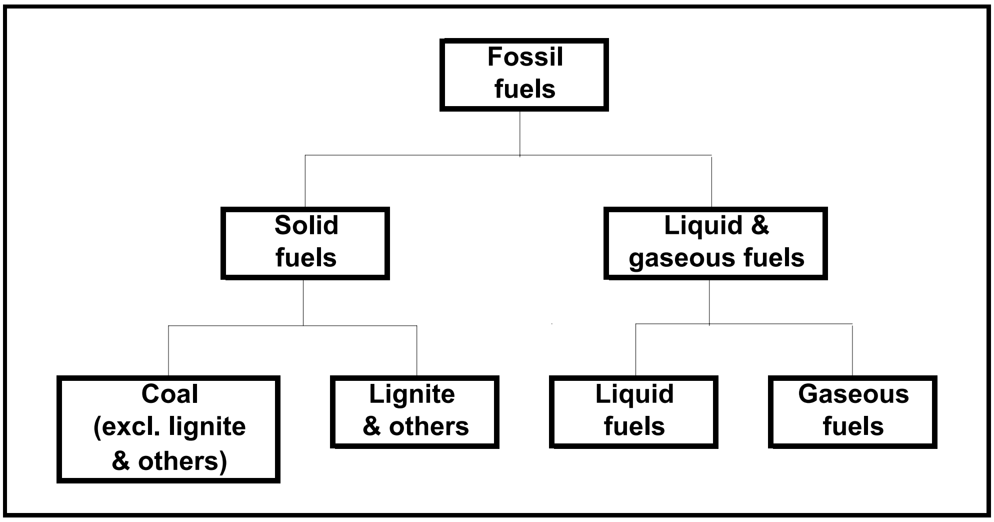


Fig. 2-2: Fossil Steam-turbine Fuel Types

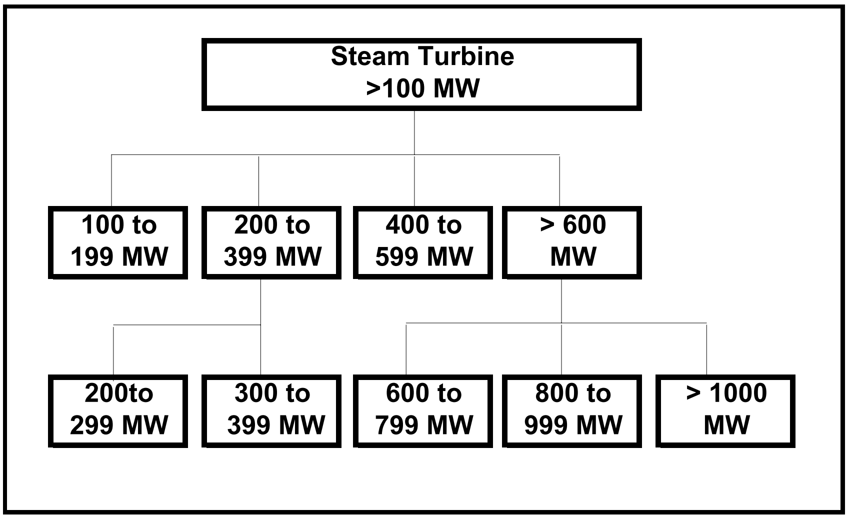


Fig. 2-3: Fossil Steam-turbine Class of Capacity

The 2003-2005 data collected on a unit-by-unit basis for each class of capacity is provided in Annex 2.

Base-loaded Combustion Turbines

The historical combustion turbine families are those machines between 30 and 150 MW in capacity. Traditionally, the family is then sub-divided into two smaller groups as shown in Fig. 2-4. Although they can be divided into different fuels, the gas turbines are not divided by fuels like the steam turbines.

The combustion turbines in the PGP database have design and operating filters just like the fossil steam-turbine units. Using some common design and operating characteristics for gas turbines, the 2003-2005 data collected on a unit-by-unit basis for each class of capacity is provided in Appendix 2A-5-1 of this section 2.

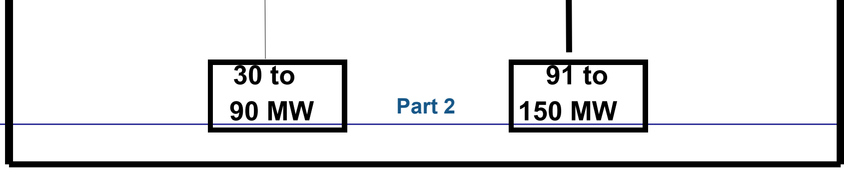


Fig. 2-4: Combustion Turbine Class of Capacity

Combined cycle and co-generation blocks

Combined cycle and co-generation blocks are much larger than the gas turbines. There are a number of block configurations but historically, the families of these units are divided into 100 MW increments as shown in Fig 2-5. Again, the blocks are not divided by fuels burned as was the steam turbine units.

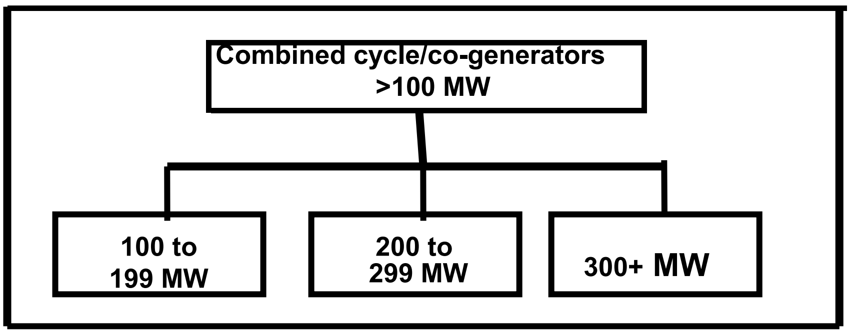


Fig. 2-5: Combined cycle/co-generator Class of Capacity

The combined cycle and co-generation blocks in the PGP database have design and operating filters just like the fossil steam-turbine units. Using some common design and operating characteristics for combined cycle and co-generation blocks, the 2003-2005 data collected on a unit-by-unit basis for each class of capacity is provided in Appendix 2A-6-1 to 2A-7-1 of this section 2.

Hydro and Pumped Storage Units

In prior reports, the hydro and pumped storage units were reported in a separate section of this the PGP report. Starting is this cycle, the hydro units are combined with the other generating plants.

For hydro and pumped storage units the PGP database has design and operating filters just like the fossil steam-turbine units. Using some common design and operating characteristics for hydro and pumped storage units, the 2003-2005 data collected on a unit-by-unit basis for new classes of capacity is provided in Appendix 2A-8-1 to 2A-9-1 of this section 2.

5 NEW DATA REPORTING DATABASE

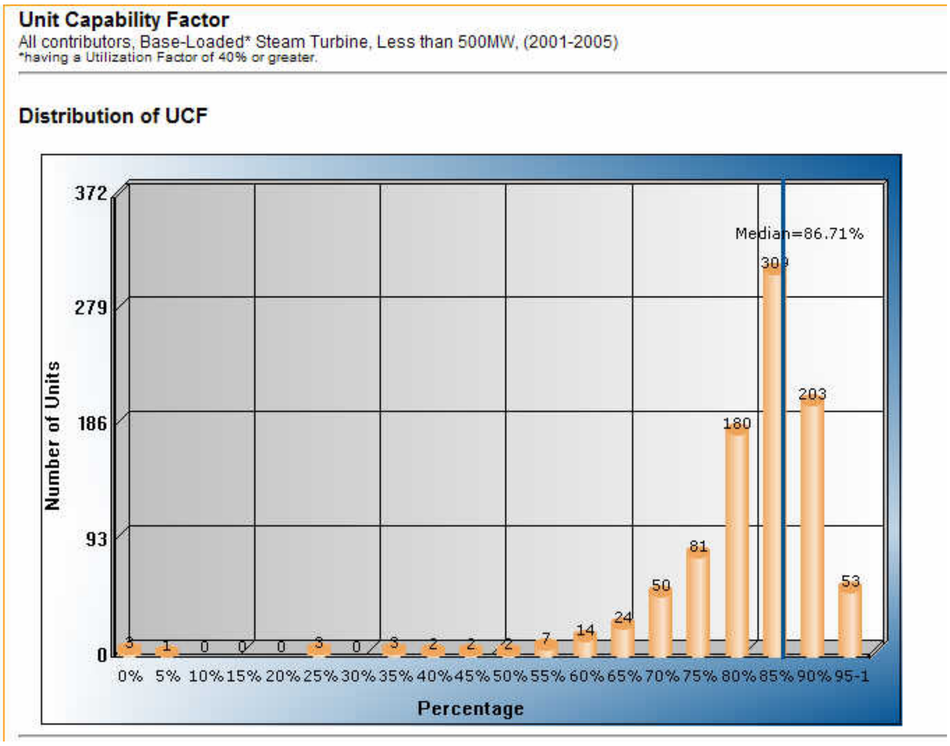
Fossil Steam Turbine units

Under the new criteria collected by the new WEC PGP database, the same historical families shown above can be produced. The data results will be the same because the sources of data may come from two different sources: 1) the countries calculating and creating the tables of data, and 2) the raw data sent to PGP on a unit-by-unit basis. If the data comes directly from a country in families, then the data that created the sources will not be in the raw data files.

However, if the data comes to the PGP database in the raw data form as shown in Exhibits 2-1A to 2-1D and 2-2, then the families of data can be duplicated.

In the new unit-by-unit database, the families of reports are expanded greatly. The data requester can create a number of different reports based on characteristics of their own units and not based on general family categories. Here are examples of UCF reports using unit-by-unit data from the front screen of the new PGP database website as shown in Fig 2-6 and 2-7 below:

Fig. 2-6
Example of Graphs in New PGP Database



15-19.99%	0	4	0.43%
20-24.99%	0	4	0.43%
25-29.99%	3	7	0.75%
30-34.99%	0	7	0.75%
35-39.99%	3	10	1.07%
40-44.99%	2	12	1.28%
45-49.99%	2	14	1.49%
50-54.99%	2	16	1.71%
55-59.99%	7	23	2.45%
60-64.99%	14	37	3.95%
65-69.99%	24	61	6.51%
70-74.99%	50	111	11.85%
75-79.99%	81	192	20.49%
80-84.99%	180	372	39.7%
85-89.99%	309	681	72.68%
90-94.99%	203	884	94.34%
95-100%	53	937	100%

d4	85.03
Q2	86.71
d6	88.06
d7	89.63
Q3	90.32
d8	91.21
d9	93.77
Max	99.93

The examples above provide a new dimension to performance research and unit benchmarking. From the tables and graphs created, the data researcher will have more information for such projects as:

- Help in setting goals for production and maintenance.
- Benchmarking existing units to peers.
- Assisting in prioritizing repairs for overhauls.
- Help planners with outage down timing and costs.
- Provide insights on equipment problems and preventative outages.
- Provide energy marketers with data on the reliability of power units.
- Assist planning of future facilities.

How can this be done? The best way to demonstrate the new dimension of the PGP database is showing several examples of its capabilities. The following examples are what the new PGP database can do using design and performance raw data from fossil steam turbine, gas turbine, combined cycle/co-generation, and hydro/pumped storage files.

Example fossil-steam turbine retrievals

Suppose that you operate a base-loaded, natural circulation, coal-fired fossil steam unit. The unit has a tandem-compound steam turbine with a reference capacity of 350 MW. The furnace is balanced-draft. Using the new PGP database, you can search the database using the following criteria:

- Fossil -Steam units
- Loading: base-loaded
- Circulation type: controlled
- Steam turbine type: tandem compound
- Fuel: coal
- MW size between 250 and 450 MW
- Draft: Balanced draft.
- Study period: the year 2005 only.

PGP database site identifies 160 units that meet the criteria. The resulting data from the PGP database will provide you with the following information:

Table 2
Examples of PGP Database Research Results

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	50.50	74.20	81.39	88.01	92.43	95.44	98.57
UCF	50.60	74.20	81.39	88.01	92.43	95.44	98.57
UCLF	0.51	1.67	3.15	6.12	10.04	14.35	42.03
PCLF	0.00	0.00	1.51	5.73	9.23	15.20	24.40
LF	38.11	54.49	62.86	71.54	78.68	81.91	93.05

Now, you have some important results for benchmarking or establishing realistic goals for comparing your unit to others operating like your unit. Other graphs and other tables can be produced from the data for combustion turbines, combined cycles, co-generators, hydro and pumped storage units.

6 Status of Data Collection Efforts

The WEC PGP started collecting 2003-2005 data from its members in early 2007. The introduction of the new database was slower than expected so only a few countries contributed unit-by-unit data to the PGP database. Thus, the data tables in this report are limited. More countries contributed data in the G8 format than in the historical or unit-by-unit formats. Therefore, the information shown in the following tables comes from the G8 reports.

Whereas in the past, the PGP surveys were triennial, the new Internet-based system will allow data entry and data queries on an ongoing basis for all WEC Members who wish to update their data annually. New 2006 data will be added as it is made available. We will continue to encourage annual reporting of data to the PGP database so that the database will continue to expand and provide data contributors with valuable information for improving power facilities.

7 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 enhancing them. The underlying goal is to foster international support and participation.

Nevertheless, additional factors have to be taken into consideration, as there is a stronger need to reach a global but full picture of power plant performance, facing the grid and the needs of the users. These factors refer to the different kinds of responsibilities for each type of energy losses: external versus internal (for example, environmental constraints as opposed to equipment reliability and human performance), and technical versus commercial. In addition, the introduction of the concept of commercial availability could help to better address technical performance of generating plants in the competitive electricity market.

The WEC PGP Committee will continue producing statistics that will offer value to all electricity producers worldwide. As promised in the last WEC PGP report, the WEC PGP Committee has started work to widen the analysis aspects of the WEC PGP database. The new unit-by-unit database now includes data selections based on design and annual performance characteristics for use in benchmarking, reliability determinations, and evaluating new and old unit designs as well as other applications for increasing the productivity and reliability of plant equipment. This will follow the example of the NERC GADS software product, pc-GAR. pc-GAR allows the user to compare the performance and design of peer units based on the user's own selection criteria, not on predetermined criteria by others. The new PGP database is only in its infant stage at this point but will grow and more and more countries report data to the PGP on unit-by-unit bases.

8 Conclusions

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 new access to worldwide generating plant statistics will help power plant operators with the availability records of their plants global experience. New software for collecting and new, powerful software for analyzing the results is now available to bring the world electricity producers closer together in a cooperative manner. The results will bring about an exchange of information to better the quality of life for the world community.

Exhibit 2-1A

Brief Description of Fossil Steam Unit Design, year and month the unit was first commercially operated

- **Year and month the unit was first commercially operated**
- **Unit Loading Characteristics at Time of Design** (six options including 1-base load with minor load following; 2-periodic start-up, load follow daily, reduced load nightly; 3-weekly start-up, load follow daily, reduced load nightly; etc)
- **Boiler - Fuel Firing System** (nine options including *Front OR Back* - wall mounted burners on either the front OR the back of the furnace; *Opposed* - wall mounted burners on BOTH the front and back of the furnace; *Tangential* - firing from the corners of the furnace with burners capable of directing the fireball up or down; etc.)
- **Boiler - Type of Circulation** (three options including 1-*Natural* (thermal) - water flows through furnace wall tubes unaided by circulating pumps. Primarily used with subcritical units; 2-*Controlled* (forced or pump assisted thermal) - water flows through furnace wall tubes aided by boiler recirculation pumps located in the downcomers or lower headers of the boiler. Used on some subcritical units; etc.)
- **Boiler - Type of Furnace Bottom** (two options including 1-*Dry bottom* - no slag tanks at furnace throat area (throat area is clear). Bottom ash drops through throat to bottom ash water hoppers. Design used when ash melting temperature is greater than temperature on furnace wall, allowing for relatively dry furnace wall conditions; 2-*Wet Bottom* - slag tanks installed at furnace throat to contain and remove molten ash from the furnace.
- **Type of fuel**
- **Boiler - Balanced Draft or Pressurized Draft**
- **Boiler - Mechanical Fly Ash Precipitator System; boiler - Electrostatic Precipitator System**
- **Boiler – Electrostatic Precipitator**
- **Flue Gas Desulfurization Data** listing unit of FGD installation and type of FGD cycle.
- **MW nameplate rating.**
- **Steam Turbine - Type of Steam Turbine** (four options including 1-*Single casing* - single (simple) turbine having one pressure casing (cylinder); 2 -*Tandem compound* - two or more casings coupled together in line; 3-*Cross compound* - two cross-connected single casing or tandem compound turbine sets where the shafts are not in line.
- **Steam Turbine - Steam Conditions** for information on the Main, First Reheat, and Second Reheat Steam design conditions.

- **Auxiliary Systems - Main Condenser** describing the type of water (fresh, salty) and source of water (river, lake, cooling tower) for cooling the condenser.

- **NOX Reduction Systems** includes Selective Non-catalytic Reduction, Selective Catalytic Reduction, Catalytic Air Heaters, and Staged NOX Reduction, which is a combination of the three methods.

Exhibit 2-1B

Brief Description of Combined Cycle/Co-Generator Unit Design

- **Year and month the unit was first commercially operated**

- **Unit Loading Characteristics at Time of Design** (six options including 1-base load with minor load following; 2-periodic start-up, load follow daily, reduced load nightly; 3-weekly start-up, load follow daily, reduced load nightly; etc)

- **Total Nameplate Rating of all units in the block (in MW)**

- **Does the block have co-generation** (steam for other than electric generation)

- **What is the number of gas turbines/jet engines per Heat Recovery Steam Generator (HRSG)?**

- **What is the number of gas turbines/jet engines - Heat Recovery Steam Generator (HRSG) Train?**

- **Total number of gas turbines/jet engines in block.**

- **Total number of Heat Recovery Steam Generator (HRSG) in block.**

- **Total number of Steam Turbines in block.**

- **Type of fuel**

Exhibit 2-1C

Brief Description of Combustion Turbines Unit Design

- **Year and month the unit was first commercially operated**

- **Unit Loading Characteristics at Time of Design** (six options including 1-base load with minor load following; 2-periodic start-up, load follow daily, reduced load nightly; 3-weekly start-up, load follow daily, reduced load nightly; etc)

- **Engine type** - (three options including gas turbine single shaft; gas turbine split shaft; Jet engine (or aero derivative)

- **Type of fuel**

- **MW nameplate rating**

Exhibit 2-1D

Brief Description of Hydro or Pumped Storage Unit Design

- **Year and month the unit was first commercially operated**
- **Unit Loading Characteristics at Time of Design** (six options including 1-base load with minor load following; 2-periodic start-up, load follow daily, reduced load nightly; 3-weekly start-up, load follow daily, reduced load nightly; etc)
- **MW nameplate rating**
- **Type of unit** (three options including 1- Hydro; 2- Pump/turbine; 3- Pump)
- **Turbine/Pump reaction type** (four options including 1- *Francis*; 2-*Kaplan* – adjustable blade propeller; 3- *Fix blade propeller*; 4- Pump/turbine;
- **Turbine rated head to nearest foot**

Exhibit 2-2

Description of "Raw" Performance Data For All Unit Types

Required Elements for CORE KPI Calculations

- **Period Hours or Period Energy**
  For those collecting data in hours – The number of hours in the year that the unit was in the **active state**. The sum of Available Hours and Unavailable Hours must equal Period Hours.
  For those collecting data on an energy basis – The maximum energy that could be produced annually. This is calculated by multiplying the number of hours in the year times the reference capacity.
- **Reference Capacity**
  RC is the unit's generated capability less any capacity (MW) utilized for that unit's station service or auxiliary loads. This is equivalent to the IEE762 Net Dependable Capacity (NDC).
- **Actual Generation (AG)**
  AG is the actual MW generated and recorded at the revenue meter. It is the generator output less any generation utilized for that unit's station service or auxiliary loads.

- **Available Mode**
  For those collecting data in hours – The sum of the Unit Service Hours, Reserve Shutdown Hours, Pumping Hours (if applicable), and Synchronous Condensing Hours (if applicable).

  For those collecting data on an energy basis – The sum of the Unit Service, Reserve Shutdown, Pumping (if applicable), and Synchronous Condensing (if applicable) MWh for the unit. This is calculated by multiplying the number of hours the unit was in the service, RS, pumping and synchronous condensing mode times the reference capacity.

- **Planned Outage Loses**
  The total energy loss due to planned outages. To IEEE 762 reporters, this would be the MWh lost due to planned outages and planned derates. This is calculated by multiplying Planned Outage Hours and the Equivalent Planned Derated Hours by the reference capacity.

- **Unplanned Outage Losses**
  The total energy losses due to unplanned outages. This does not include those losses attributed to causes that are out of management control.
  To IEEE 762 reporters, this would be the MWh lost due to Forced and Maintenance outages and derates (U1, U2, U3, SF, MO, D1, D2, D3 and D4 events). This is calculated by multiplying the summed outage hours and the equivalent derated hours by the reference capacity.

- **Unplanned Outage Losses due to External Causes**
  The total energy losses attributed to causes outside of management control.
  To IEEE 762 reporters, this is known as OMC Outage.

Required Elements for Additional KPI Calculations

- **Unit Service Mode (or Unit Operating Mode)**
  The number of hours the unit was synchronized to the system (breakers closed, providing power to the grid). For units equipped with multiple generators, count only those hours when at least one of the generators was synchronized, whether or not one or more generators were actually in service.

- **Reserve Shutdown Mode (or Economic Mode)**
  For those collecting data in hours – The sum of all hours the unit was available to the system but not synchronized for economy reasons. During the RS time, the unit is capable of generating but is not because it is not needed for load or management decides not to operate it.

  For those collecting data on an energy basis – The sum of MW hours the unit could have produced at full load if the unit was in operation but is not synchronized for economy reasons. During RS, the unit is capable of generating but is not because it is not needed for load or management decides not to operate it. This is calculated by multiplying the number of hours the unit was in economic shutdown mode times the reference capacity.

If not reported, this value is calculated as the difference between Available Energy and Actual Generation.

- **Pumping Mode**
  The number of hours the hydro turbine/generator operated as a pump/motor.

- **Synchronous Condensing Mode**
  The number of hours the unit operated in the synchronous condensing mode (applies primarily to hydro/pumped storage and some combustion turbine units). Do not report these hours as Unit Service Hours.

- **Number of Automatic Unplanned Outages**
  The count of unplanned automatic grid separations outage occurrences.

APPENDIX 2A

CORE PERFORMANCE INDICATOR FOR ALL UNITS REPORTING UNIT-BY-UNIT DATA, ALL COUNTRIES, BY UNIT CLASS AND FUELS

Figure 2A-1-1
Fossil Steam Turbine Coal Fuel, 100 MW or Larger, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	27.52	76.98	82.14	86.77	90.36	92.93	99.80
UCF	27.52	76.99	82.14	86.84	90.36	92.93	99.80
UCLF	0.00	1.99	3.64	6.21	10.01	14.28	43.71
PCLF	0.00	2.44	4.32	6.33	8.84	11.69	40.89
LF	29.09	53.00	61.25	69.15	76.11	81.58	99.76

(770 units)

Fig. 2A-1-2
Fossil Steam Turbine Coal Fuel, 100-199 MW, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	47.80	75.71	82.52	87.14	90.89	93.61	97.88
UCF	47.80	75.71	82.52	87.19	90.89	93.61	97.88
UCLF	0.52	2.07	3.58	6.79	10.72	15.54	43.71
PCLF	0.00	1.33	3.31	5.28	8.14	11.31	33.95
LF	29.09	47.07	55.38	63.79	70.85	78.09	89.10

(240 units)

Fig. 2A-1-3
Fossil Steam Turbine Coal Fuel, 200-299 MW, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	59.51	78.32	82.38	87.35	90.45	93.10	97.47
UCF	59.51	78.32	82.38	87.35	90.45	93.10	97.47
UCLF	1.07	2.14	3.59	6.10	9.67	12.78	40.49
PCLF	0.00	2.97	4.59	6.20	8.19	10.17	13.51
LF	40.50	54.40	63.04	68.59	74.05	77.48	85.82

(114 units)

Fig. 2A-1-4
Fossil Steam Turbine Coal Fuel, 300-399 MW, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	27.52	79.16	82.23	86.58	89.36	93.26	99.76
UCF	27.52	79.16	82.23	86.61	89.36	93.26	99.76
UCLF	0.00	2.01	3.95	6.39	9.16	12.36	31.60
PCLF	0.00	2.87	4.93	7.02	8.99	10.42	40.89
LF	30.01	54.63	63.50	68.99	77.11	81.06	99.76

(91 units)

Fig. 2A-1-5
Fossil Steam Turbine Coal Fuel, 400-599 MW, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	59.73	76.59	81.23	86.23	89.88	92.49	97.43
UCF	59.73	76.90	81.43	86.30	89.91	92.49	97.43
UCLF	0.00	1.87	3.67	6.21	10.77	14.49	35.31
PCLF	0.00	2.59	4.60	6.76	9.87	11.98	19.13
LF	40.58	58.35	64.61	72.39	78.90	83.79	98.45

(186 units)

Fig. 2A-1-6
Fossil Steam Turbine Coal Fuel, 600-799 MW, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	71.05	77.17	81.78	86.82	90.34	92.70	99.80
UCF	71.05	77.17	81.78	86.95	90.44	92.70	99.80
UCLF	0.01	1.68	3.50	5.47	9.07	12.49	22.26
PCLF	0.00	2.56	4.34	7.31	9.61	12.22	24.01
LF	38.35	63.14	68.63	74.49	79.99	83.42	98.63

(102 units)

Fig. 2A-1-7
Fossil Steam Turbine Coal Fuel, 800-999 MW, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	74.78	83.11	85.32	88.54	90.79	92.43	93.10
UCF	74.78	83.11	85.32	88.54	90.79	92.43	93.10
UCLF	1.08	1.68	2.69	4.19	6.64	7.87	13.67
PCLF	2.20	4.02	5.31	7.42	8.37	11.99	15.10
LF	63.89	67.42	70.84	77.02	81.26	83.79	86.07

(25 units)

Fig. 2A-1-8
Fossil Steam Turbine Coal Fuel, 1000 or Larger MW, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	61.95	68.30	74.95	82.46	86.32	91.72	92.26
UCF	61.95	68.30	74.95	82.46	86.32	91.72	92.26
UCLF	1.60	4.68	5.63	8.45	11.95	21.57	29.31
PCLF	2.63	4.83	6.55	7.96	11.04	13.74	20.52
LF	52.88	60.79	66.82	71.56	75.94	79.29	80.69

(12 units)

Fig. 2A-2-1
Fossil Steam Turbine Lignite Fuel, 100 MW or Larger, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	59.79	84.22	86.23	87.78	89.54	89.97	90.47
UCF	59.79	84.22	86.23	87.78	89.54	89.97	90.47
UCLF	4.06	5.13	5.68	6.44	8.44	11.72	32.85
PCLF	0.00	2.07	4.27	5.14	6.36	7.87	13.37
LF	49.30	69.90	74.68	78.46	79.94	81.35	85.91

(20 units)

Fig. 2A-3-1
Fossil Steam Turbine Liquid Fuel, 100 MW or Larger, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	0.52	43.52	74.86	77.82	87.53	91.88	94.51
UCF	0.52	43.52	74.86	77.82	87.53	91.88	94.51
UCLF	0.00	0.07	2.38	4.83	8.38	22.18	91.33
PCLF	0.00	2.19	5.36	14.09	20.01	35.34	56.48
LF	0.52	32.11	38.52	47.02	51.72	63.03	89.69

(33 units)

Fig. 2A-4-1
Fossil Steam Turbine Gas Fuel, 100 MW or Larger, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	0.13	70.58	82.34	86.60	89.85	93.09	98.10
UCF	0.13	70.58	82.34	86.60	89.85	93.09	98.10
UCLF	0.01	0.78	2.29	4.54	9.27	12.85	34.04
PCLF	0.00	1.25	4.13	7.22	12.34	20.14	99.86
LF	18.26	32.76	36.12	42.52	46.25	50.01	71.98

(43 units)

Fig. 2A-5-1
Combustion Turbine, All Fuels, 30-150 MW, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	52.85	80.82	93.26	94.99	95.86	98.67	99.03
UCF	52.85	80.86	93.28	95.01	95.87	98.67	99.03
UCLF	0.00	0.00	0.06	0.26	1.56	4.81	46.72
PCLF	0.00	0.57	1.95	3.98	4.84	7.53	23.15
LF	52.85	80.82	93.18	94.99	95.86	98.67	99.03

(37 units)

Fig. 2A-6-1
Combined Cycle Block, All Fuels, 100 MW and Larger, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	44.33	77.43	85.84	90.91	93.81	95.92	99.23
UCF	44.33	77.43	85.84	90.91	93.81	95.93	99.23
UCLF	0.00	0.71	1.46	3.75	7.26	12.97	55.67
PCLF	0.00	1.45	2.94	4.51	7.00	11.48	28.76
LF	27.55	40.39	45.00	54.58	65.76	77.55	99.11

(207 units)

Fig. 2A-6-2
Combined Cycle Block, All Fuels, 100-199 MW, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	44.33	81.28	87.17	91.17	94.15	95.92	98.50
UCF	44.33	81.42	87.17	91.17	94.15	95.93	98.50
UCLF	0.31	0.75	1.50	3.05	6.47	11.84	55.67
PCLF	0.00	1.69	3.00	4.56	7.00	10.08	28.76
LF	27.55	41.10	46.08	56.08	65.74	75.08	95.92

(122 units)

Fig. 2A-6-3
Combined Cycle Block, All Fuels, 200-299 MW, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	63.73	70.87	80.04	88.86	93.00	95.26	99.23
UCF	63.73	70.87	80.04	88.86	93.15	95.26	99.23
UCLF	0.42	1.04	3.18	5.86	10.90	22.92	32.08
PCLF	0.00	1.74	2.96	4.31	5.70	9.99	18.58
LF	35.42	40.66	45.50	54.76	72.30	75.14	93.00

(45 units)

Fig. 2A-6-4
Combined Cycle Block, All Fuels, 300 MW and Larger, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	58.40	81.12	86.35	91.23	94.09	95.94	99.11
UCF	58.40	81.12	86.35	91.23	94.09	95.94	99.11
UCLF	0.00	0.40	1.02	3.81	5.62	11.32	41.60
PCLF	0.00	0.00	1.95	4.73	7.01	14.54	17.08
LF	35.11	40.11	44.21	52.56	58.30	85.27	99.11

(40 units)

Fig. 2A-7-1
Co-generation Block, All Fuels, 100 MW and Larger, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	79.76	84.14	85.75	91.85	94.68	95.11	96.80
UCF	79.76	84.14	85.75	91.85	94.68	95.11	96.80
UCLF	0.24	2.17	2.46	4.65	9.84	11.57	13.96
PCLF	0.00	1.09	2.15	4.15	5.75	7.87	9.69
LF	39.18	44.43	49.48	66.47	75.96	78.31	84.41

(31 units)

Fig. 2A-8-1
Hydro Units, 50 MW and Larger, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	6.08	73.56	85.88	91.91	96.09	98.49	100.00
UCF	6.08	73.56	85.88	91.91	96.09	98.49	100.00
UCLF	0.00	0.13	0.38	1.08	3.56	9.42	41.03
PCLF	0.00	0.10	1.55	4.85	10.24	19.08	93.92
LF	2.63	37.50	42.93	50.19	61.87	74.56	91.90

(279 units)

Fig. 2A-8-2
Hydro Units, 50-99 MW, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	30.82	76.65	87.49	92.42	96.51	98.60	99.92
UCF	30.82	76.65	87.49	92.42	96.51	98.60	99.92
UCLF	0.00	0.23	0.48	1.18	3.66	8.12	41.03
PCLF	0.00	0.00	1.21	4.32	8.31	14.56	69.04
LF	21.79	39.44	44.62	51.77	64.62	77.30	87.01

(171 units)

Fig. 2A-8-3
Hydro Units, 100-149 MW, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	6.08	64.98	78.94	88.04	95.00	97.03	100.00
UCF	6.08	64.98	78.94	88.04	95.00	97.03	100.00
UCLF	0.00	0.00	0.17	0.83	5.98	16.40	40.92
PCLF	0.00	0.43	2.88	7.18	15.10	23.23	93.92
LF	2.63	33.53	37.55	43.72	52.76	61.78	72.03

(59 units)

Fig. 2A-8-4
Hydro Units, 150MW and Larger, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	45.58	75.46	87.24	93.56	97.02	98.68	99.45
UCF	45.58	75.46	87.24	93.56	97.02	98.68	99.45
UCLF	0.00	0.10	0.29	0.93	1.56	4.20	22.46
PCLF	0.00	0.39	1.41	4.92	11.33	24.35	54.33
LF	31.19	38.62	43.45	52.33	64.57	77.22	91.90

(49 units)

Fig. 2A-9-1
Pumped Storage Units, All MW Sizes, 2003-2005, UF > .40

Percentile -->	0%	10%	25%	50%	75%	90%	100%
Variable							
EAF	80.60	87.64	92.63	95.12	97.58	99.12	99.81
UCF	80.60	87.64	92.65	95.12	97.58	99.12	99.81
UCLF	0.01	0.09	0.41	1.03	1.85	2.99	7.28
PCLF	0.00	0.00	0.03	3.33	7.26	11.72	18.89
LF	38.71	64.21	68.12	74.13	93.94	97.30	102.53

(24 units)

APPENDIX 2B

DATA FROM AROUND THE WORLD

The following pages contains information provided the PGP Committee from various countries for several different types of generating plants. Not all countries provided generating data for all sizes and types of units. Therefore, not all countries have the eight types of units or fuels. The data comes from the G-8 Report sent to the WEC PGP in mid 2007. The eight divisions of units in order of appearance are:

- Steam turbine, coal
- Steam turbine, liquid
- Steam turbine, gaseous
- Combined cycle block
- Co-generation block
- Base-loaded combustion turbine
- Hydro
- Pumped Storage

The participating countries in this report are:

Appendix 2B-1	G-8 data from Belgium
Appendix 2B-2	G-8 data from Brazil
Appendix 2B-3	G-8 data from Canada
Appendix 2B-4	G-8 data from Czech
Appendix 2B-5	G-8 data from Egypt
Appendix 2B-6	G-8 data from France
Appendix 2B-7	G-8 data from Germany
Appendix 2B-8	G-8 data from Korea
Appendix 2B-9	G-8 data from Japan
Appendix 2B-10	G-8 data from Israel
Appendix 2B-11	G-8 data from Poland
Appendix 2B-12	G-8 data from Russia
Appendix 2B-13	G-8 data from South Africa
Appendix 2B-14	G-8 data from the United States

APPENDIX 2B-1 – Belgium

Fossil Steam Turbine 100 to 199 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	5	6	3	5	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.65	0.68	0.59	0.59	0.00
Availability Factor	0.00	0.85	0.93	0.80	0.87	0.00

Fossil Steam Turbine 200 to 299 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	1	3	3	2	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.66	0.62	0.62	0.60	0.00
Availability Factor	0.00	0.91	0.87	0.93	0.92	0.00

Fossil Steam Turbine 100 to 199 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	2	2	2	2	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.26	0.39	0.43	0.45	0.00
Availability Factor	0.00	0.84	0.91	0.90	0.90	0.00

Fossil Steam Turbine 200 to 299 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	4	2	4	4	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.25	0.22	0.31	0.27	0.00
Availability Factor	0.00	0.93	0.93	0.91	0.86	0.00

APPENDIX 2B-2 –Brazil

Combined Cycle 100 to 199 MW Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	2	2	5	0	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.87	0.88	0.89	0.00	0.00
Availability Factor	0.00	0.87	0.88	0.89	0.00	0.00

Combined Cycle 200 to 299 MW Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	1	1	1	0	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.87	0.89	0.93	0.00	0.00
Availability Factor	0.00	0.87	0.89	0.93	0.00	0.00

Base-load Combustion Turbine 30 to 49 MW Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	2	18	33	0	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.97	0.86	0.93	0.00	0.00
Availability Factor	0.00	0.97	0.86	0.93	0.00	0.00

Base-load Combustion Turbine 50 to 74 MW Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	0	0	2	0	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.00	0.00	0.92	0.00	0.00
Availability Factor	0.00	0.00	0.00	0.92	0.00	0.00

APPENDIX 2B-3 – Canada

Fossil Steam Turbine 100 to 199 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	0	4	0	0	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.00	0.64	0.00	0.00	0.00
Availability Factor	0.00	0.00	0.80	0.00	0.00	0.00

Fossil Steam Turbine 200 to 299 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	0	5	0	0	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.00	0.44	0.00	0.00	0.00
Availability Factor	0.00	0.00	0.48	0.00	0.00	0.00

Fossil Steam Turbine 300 to 399 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	0	4	0	0	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.00	0.23	0.00	0.00	0.00
Availability Factor	0.00	0.00	0.52	0.00	0.00	0.00

Fossil Steam Turbine 400 to 599 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	2	26	1	1	1
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.89	0.73	0.93	0.88	0.90
Availability Factor	0.00	0.92	0.82	1.00	0.93	0.96

Fossil Steam Turbine 200 to 299 MW
Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	0	0	1	1	1	1
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0	0	0.83	0.72	0.85	0.83
Availability Factor	0	0	0.97	0.91	0.96	0.92

APPENDIX 2B-3 – Canada (Continued)

Fossil Steam Turbine 300 to 399 MW
Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	0	6	6	3	3	3
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0	0.73	0.63	0.44	0.45	0.44
Availability Factor	0	0.81	0.81	0.75	0.68	0.80

Fossil Steam Turbine 400 to 599 MW
Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	0	0	2	0	0	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0	0	0.18	0	0	0
Availability Factor	0	0	0.78	0	0	0

Fossil Steam Turbine 400 to 599 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	0	2	0	0	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0	0	0.12	0	0	0
Availability Factor	0	0	0.70	0	0	0

APPENDIX 2B-4 – Czech Republic

Fossil Steam Turbine 200 to 299 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	4	4	4	4	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.45	0.38	0.30	0.29	0.00
Availability Factor	0.00	0.89	0.88	0.86	0.88	0.00

Fossil Steam Turbine 100 to 199 MW
Fuel: Lignite & Others

	1995	2001	2002	2003	2004	2005
Unit Count	0	3	3	3	3	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.78	0.68	0.61	0.67	0.00
Availability Factor	0.00	0.91	0.89	0.87	0.88	0.00

Fossil Steam Turbine 200 to 299 MW
Fuel: Lignite & Others

	1995	2001	2002	2003	2004	2005
Unit Count	0	16	18	18	18	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.69	0.65	0.67	0.65	0.00
Availability Factor	0.00	0.87	0.83	0.83	0.83	0.00

Fossil Steam Turbine 400 to 599 MW
Fuel: Lignite & Others

	1995	2001	2002	2003	2004	2005
Unit Count	0	0	0	1	1	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.00	0.00	0.63	0.63	0.00
Availability Factor	0.00	0.00	0.00	0.80	0.76	0.00

APPENDIX 2B-5 –Egypt

Fossil Steam Turbine 100 to 199 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	13	13	0	0	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.85	0.76	0.00	0.00	0.00
Availability Factor	0.00	0.85	0.76	0.00	0.00	0.00

Fossil Steam Turbine 200 to 299 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	2	2	0	0	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.82	0.83	0.00	0.00	0.00
Availability Factor	0.00	0.82	0.83	0.00	0.00	0.00

Combined Cycle 100 to 199 MW Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	14	14	0	0	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.87	0.82	0.00	0.00	0.00
Availability Factor	0.00	0.87	0.82	0.00	0.00	0.00

Base-load Combustion Turbine 30 to 49 MW Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	16	16	0	0	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.93	0.89	0.00	0.00	0.00
Availability Factor	0.00	0.93	0.89	0.00	0.00	0.00

APPENDIX 2B-6 – France

Fossil Steam Turbine 200 to 299 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	19	19	19	19	1
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.14	0.20	0.21	0.19	0.00
Availability Factor	0.00	0.84	0.82	0.83	0.82	1.00

Fossil Steam Turbine 400 to 599 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	5	5	4	5	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.26	0.34	0.30	0.22	0.00
Availability Factor	0.00	0.79	0.74	0.67	0.51	0.00

Fossil Steam Turbine 200 to 299 MW
Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	0	6	6	6	6	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.04	0.04	0.05	0.04	0.00
Availability Factor	0.00	0.95	0.85	0.89	0.86	0.00

Fossil Steam Turbine 300 to 399 MW
Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	0	5	5	5	5	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.02	0.01	0.04	0.03	0.00
Availability Factor	0.00	0.97	0.98	0.94	0.88	0.00

Fossil Steam Turbine 600 to 799 MW
Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	0	4	4	4	4	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.02	0.01	0.03	0.02	0.00
Availability Factor	0.00	0.97	0.87	0.70	0.75	0.00

APPENDIX 2B-6 – France (Continued)

Fossil Steam Turbine 100 to 199 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	3	2	2	2	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.53	0.57	0.51	0.37	0.00
Availability Factor	0.00	0.85	0.98	0.82	0.91	0.00

Combined Cycle 100 to 199 MW Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	0	2	2	2	2	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.00	0.01	0.01	0.01	0.00
Availability Factor	0.00	0.97	0.97	0.95	0.71	0.00

Combined Cycle 200 to 299 MW Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	1	1	1	1	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.00	0.00	0.00	0.01	0.00
Availability Factor	0.00	0.00	0.00	0.00	0.63	0.00

APPENDIX 2B-7 – Germany

Fossil Steam Turbine 100 to 199 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	15	11	14	12	11
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.67	0.72	0.74	0.68	0.74
Availability Factor	0.00	0.85	0.87	0.90	0.80	0.91

Fossil Steam Turbine 200 to 299 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	3	3	3	3	3
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.59	0.60	0.47	0.57	0.62
Availability Factor	0.00	0.89	0.93	0.85	0.81	0.91

Fossil Steam Turbine 300 to 399 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	13	12	13	13	14
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.60	0.60	0.70	0.66	0.65
Availability Factor	0.00	0.85	0.88	0.84	0.80	0.85

Fossil Steam Turbine 400 to 599 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	3	3	3	3	3
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.59	0.56	0.64	0.63	0.57
Availability Factor	0.00	0.91	0.88	0.88	0.88	0.77

Fossil Steam Turbine 600 to 799 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	7	7	7	7	6
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.54	0.54	0.61	0.58	0.57
Availability Factor	0.00	0.84	0.83	0.88	0.84	0.81

APPENDIX 2B-7 – Germany (Continued)

Fossil Steam Turbine 800 to 999 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	1	1	1	1	1
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	$0.00	$0.55	$0.58	$0.62	$0.58	$0.39
Availability Factor	$0.00	$0.81	$0.92	$0.90	$0.92	$0.60

Fossil Steam Turbine 100 to 199 MW
Fuel: Lignite & Other

	1995	2001	2002	2003	2004	2005
Unit Count	0	18	17	13	14	12
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.85	0.84	0.84	0.88	0.76
Availability Factor	0.00	0.90	0.87	0.86	0.88	0.77

Fossil Steam Turbine 200 to 299 MW
Fuel: Lignite & Other

	1995	2001	2002	2003	2004	2005
Unit Count	0	14	11	11	11	11
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.84	0.86	0.82	0.86	0.84
Availability Factor	0.00	0.89	0.91	0.83	0.87	0.86

Fossil Steam Turbine 400 to 599 MW
Fuel: Lignite & Other

	1995	2001	2002	2003	2004	2005
Unit Count	0	7	8	8	7	6
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.79	0.86	0.84	0.86	0.83
Availability Factor	0.00	0.88	0.91	0.88	0.88	0.85

Fossil Steam Turbine 600 to 799 MW
Fuel: Lignite & Other

	1995	2001	2002	2003	2004	2005
Unit Count	0	6	5	2	2	5
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.77	0.81	0.70	0.72	0.76
Availability Factor	0.00	0.82	0.86	0.70	0.72	0.77

APPENDIX 2B-7 – Germany (Continued)

Fossil Steam Turbine 800 to 999 MW
Fuel: Lignite & Other

	1995	2001	2002	2003	2004	2005
Unit Count	0	2	5	5	5	5
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.91	0.88	0.92	0.89	0.86
Availability Factor	0.00	0.94	0.91	0.94	0.91	0.88

Fossil Steam Turbine 100 to 199 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	1	0	2	2	1
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.78	0.00	0.22	0.49	0.68
Availability Factor	0.00	1.00	0.00	0.99	0.97	0.95

Fossil Steam Turbine 200 to 299 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	1	1	2	2	2
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.46	0.53	0.44	0.44	0.48
Availability Factor	0.00	0.86	0.93	0.91	0.89	0.92

APPENDIX 2B-8 – Korea

Fossil Steam Turbine 400 to 599 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	0	0	6	0	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.00	0.00	0.95	0.00	0.00
Availability Factor	0.00	0.00	0.00	0.91	0.00	0.00

APPENDIX 2B-9 – Japan

Fossil Steam Turbine 300 to 399 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	2	2	2	2	2	2
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	N/A	N/A	N/A	N/A	N/A	N/A
Availability Factor	79.4	89.3	58.5	82.7	76.3	84.9

Fossil Steam Turbine 400 to 599 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	6	6	6	6	6	6
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	N/A	N/A	N/A	N/A	N/A	N/A
Availability Factor	86.4	83	86.1	87.2	86.8	79.4

Fossil Steam Turbine 600 to 799 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	8	12	12	14	15	16
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	N/A	N/A	N/A	N/A	N/A	N/A
Availability Factor	85.5	86.6	85.6	85.8	82.7	84.6

Fossil Steam Turbine 1000 MW & UP Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	2	7	8	9	10	10
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	N/A	N/A	N/A	N/A	N/A	N/A
Availability Factor	79.6	89.6	82.9	85.4	80.2	87.8

Fossil Steam Turbine <200 MW or Large, Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	45	46	46	44	43	43
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	N/A	N/A	N/A	N/A	N/A	N/A
Availability Factor	78.4	84.6	83.6	79.1	80.2	81.1

APPENDIX 2B-10 – Israel

Fossil Steam Turbine 400 to 599 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	2	2	0	0	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.68	0.88	0.00	0.00	0.00
Availability Factor	0.00	0.93	0.98	0.00	0.00	0.00

Fossil Steam Turbine 100 to 199 MW
Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	0	1	0	1	1	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.53	0.00	0.57	0.39	0.00
Availability Factor	0.00	0.99	0.00	0.96	0.95	0.00

Fossil Steam Turbine 200 to 299 MW
Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	0	3	4	1	3	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.48	0.40	0.32	0.54	0.00
Availability Factor	0.00	0.94	0.95	0.98	0.97	0.00

Combined Cycle 100 to 199 MW Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	0	14	14	16	16	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.05	0.09	0.10	0.08	0.00
Availability Factor	0.00	0.95	0.96	0.97	0.96	0.00

Combined Cycle 200 to 299 MW Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	0	0	0	0	1	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.00	0.00	0.00	0.01	0.00
Availability Factor	0.00	0.00	0.00	0.00	1.00	0.00

APPENDIX 2B-10 – Israel (Continued)

Combined Cycle 100 to 199 MW Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	1	1	1	1	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.06	0.07	0.05	0.03	0.00
Availability Factor	0.00	0.98	0.92	0.95	0.95	0.00

Combined Cycle 200 to 299 MW Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	0	0	0	1	0
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.00	0.00	0.00	0.27	0.00
Availability Factor	0.00	0.00	0.00	0.00	1.00	0.00

APPENDIX 2B-11 – Poland

Fossil Steam Turbine < 119 MW Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	0	150	149	148	146
Efficiency Rate	N/A	N/A	N/A	65.93	64.28	66.39
Load Factor	0.00	0.00	35.35	42.20	44.74	43.39
Availability Factor	0.00	0.00	86.82	91.94	87.37	91.47

Fossil Steam Turbine 120 to 199 MW Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	24	23	23	23	23	23
Efficiency Rate	N/A	N/A	N/A	43.52	38.80	42.42
Load Factor	60.64	51.27	55.34	55.23	51.47	50.07
Availability Factor	82.30	85.80	86.50	91.40	86.90	84.80

Fossil Steam Turbine 200 to 299 MW Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	63	63	62	62	60	60
Efficiency Rate	N/A	N/A	N/A	38.19	38.65	39.29
Load Factor	52.99	48.90	52.29	53.64	53.95	54.01
Availability Factor	80.90	83.70	85.90	83.80	86.60	86.20

Fossil Steam Turbine 300 to 399 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	14	16	16	16	16	16
Efficiency Rate	N/A	N/A	N/A	38.70	38.40	38.91
Load Factor	70.29	70.00	72.25	76.07	76.46	77.83
Availability Factor	86.00	86.60	88.30	87.70	88.10	87.30

Fossil Steam Turbine 500 MW & UP
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	2	2	2	2	2	2
Efficiency Rate	N/A	N/A	N/A	38.8	38.95	40.68
Load Factor	18.29	17.96	29.99	47.73	47.75	56.23
Availability Factor	89.70	48.90	92.20	92.50	91.50	86.30

APPENDIX 2B-11 – Poland (Continued)

Fossil Steam Turbine < 100 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	0	7	6	11	12
Efficiency Rate	0	0	62.00	60.09	64.00	64.07
Load Factor	0.00	0.00	84.10	67.16	78.51	64.75
Availability Factor	0.00	0.00	97.24	82.88	94.46	83.95

Fossil Steam Turbine 100 to 199 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	0	1	2	3	3
Efficiency Rate	0	0	72.00	72.01	59.38	60.08
Load Factor	0.00	0.00	61.03	59.91	64.3	67.11
Availability Factor	0.00	0.00	71.58	71.12	72.81	77.62

APPENDIX 2B-12 – Russia

Fossil Steam Turbine 100 to 199 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	18	17	19	19	19	19
Efficiency Rate	37.94	34.00	35.60	35.40	36.00	36.49
Heat rate	9488	10587	10111	10168	10001	9866
Load Factor	88.2	90.3	80.9	86.9	75.8	85.3
Availability Factor	38.7	44.4	37.6	54.3	39	48.6

Fossil Steam Turbine 200 to 299 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	24	22	24	23	23	23
Efficiency Rate	36.09	36.79	36.78	36.65	36.79	36.60
Heat rate	10891	10648	10639	10677	10648	10645
Load Factor	78.1	80.4	84.9	85.1	85.4	89.8
Availability Factor	59.7	61.4	66.9	63.5	58.8	66.1

Fossil Steam Turbine 300 to 399 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	12	12	12	12	9	9
Efficiency Rate	35.9	36.1	36.7	36.3	36.6	36.5
Heat rate	10724	10633	10458	10592	10469	10525
Load Factor	77.1	85.5	84.5	83.6	83.2	80.6
Availability Factor	60.7	51.8	52	49.9	64.8	64.4

Fossil Steam Turbine 400 to 499 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	6	6	6	6	6	6

Efficiency Rate	38.6	36.3	37.9	37.8	37.7	37.5
Heat rate	9837	10437	10039	10060	10068	10118
Load Factor	67.6	79.5	82.7	77.4	71.2	77.2
Availability Factor	49.2	63.2	58.9	59.0	52.2	51.0

APPENDIX 2B-12 – Russia (Continued)

Fossil Steam Turbine 500 MW & UP
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	2	2	2	2	2	2
Efficiency Rate	39.0	39.0	38.8	38.1	37.7	37.2
Heat rate	10256	9875.1	9927.8	9992.2	10089	10244
Load Factor	87.5	69.3	71.7	69.2	81.8	84.5
Availability Factor	30.5	48.6	57.7	66.3	57.1	69.3

Fossil Steam Turbine 100 to 199 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	14	10	10	14	14	14
Efficiency Rate	37.6	35.5	35.9	35.5	35.8	35.7
Heat rate	10109.3	10674.1	10571.7	10691.7	10615.6	10612.7
Load Factor	84.7	87.8	89.6	86.8	86.8	91.0
Availability Factor	59.5	77.1	75.7	74.7	75.5	79.5

Fossil Steam Turbine 200 to 299 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	42	45	43	40	43	46
Efficiency Rate	37.8	37.4	37.9	38.1	38.0	38.0
Heat rate	10098	10194	10051	10004	10030	10042
Load Factor	82.5	87.9	86.1	87.6	82.2	84.2
Availability Factor	58.2	61.5	66.9	68.3	67.4	67.5

Fossil Steam Turbine 300 to 399 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	50	49	49	49	50	50
Efficiency Rate	38.5	38.9	38.6	38.7	38.8	38.8
Heat rate	9729	9612	9673	9661	9632	9623
Load Factor	87.9	86.4	89.6	87.9	88.9	89.1
Availability Factor	58.4	55.9	56.9	54.6	58.2	61.7

APPENDIX 2B-12 – Russia (Continued)

Fossil Steam Turbine 500 MW & UP
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	12	12	12	13	13	13
Efficiency Rate	40.0	40.5	40.7	40.9	40.7	40.7
Heat rate	9269	9149.3	9099.5	9043.9	9085	9094
Load Factor	83.6	83.7	79.6	79.3	77.9	83.7
Availability Factor	64.8	76.6	75.4	75.6	72.6	77.3

APPENDIX 2B-13 – South Africa

Fossil Steam Turbine 100 to 199 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005	2006
Unit Count	10	10	10	10	10	10	10
Efficiency Rate	33.04	33.52	33.59	33.48	33.48	33.51	33.66
Load Factor	66.23	74.99	76.22	74.27	74.25	74.75	77.4
Availability Factor	75.02	89.45	85.94	82.08	89.17	86.29	87.95

Fossil Steam Turbine 300 to 399 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005	2006
Unit Count	3	6	6	6	6	6	6
Efficiency Rate	32.6	33.72	34.00	34.86	34.68	33.77	34.27
Load Factor	45.4	65.64	69.28	81.5	78.37	66.28	72.9
Availability Factor	62.7	93.1	91.03	90.33	86.22	77.13	87.27

Fossil Steam Turbine 400 to 499 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005	2006
Unit Count	6	6	6	6	6	6	6
Efficiency Rate	34.81	35.83	35.8	35.51	35.49	36.10	35.77
Load Factor	64.1	77.79	77.36	73.49	73.23	82.15	76.95
Availability Factor	81.5	93.9	91.14	82.37	79.18	89.08	80.51

Fossil Steam Turbine 500 MW & UP
Fuel: Coal

	1995	2001	2002	2003	2004	2005	2006
Unit Count	36	41	42	42	42	42	42
Efficiency Rate	35.16	34.88	32.00	35.32	35.55	35.61	35.84
Load Factor	64.74	60.15	62.02	67.23	70.91	71.84	75.59
Availability Factor	83.7	93.56	89.63	88.16	90.41	88.82	89.03

Fossil Steam Turbine < 100 MW
Fuel: Gas

	1995	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Unit Count	6	6	6	6	6	6	6
Efficiency Rate	<23	<23	<24	<25	<26	<27	<23
Load Factor	<1	<1	<1	<1	<1	<2	2.62
Availability Factor	96.40	98.54	98.98	98.82	98.70	97.72	94.51

APPENDIX 2B-14 – United States

Fossil Steam Turbine 100 to 199 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	229	216	215	218	220	220
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.53	0.58	0.61	0.62	0.6	0.62
Availability Factor	0.89	0.88	0.89	0.88	0.89	0.88

Fossil Steam Turbine 200 to 299 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	114	111	111	110	114	114
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.56	0.65	0.67	0.66	0.66	0.69
Availability Factor	0.86	0.89	0.88	0.87	0.89	0.9

Fossil Steam Turbine 300 to 399 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	78	68	72	71	77	77
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.53	0.64	0.66	0.68	0.67	0.69
Availability Factor	0.82	0.86	0.87	0.88	0.87	0.89

Fossil Steam Turbine 400 to 599 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	142	140	139	137	146	146
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.62	0.68	0.69	0.7	0.71	0.7
Availability Factor	0.84	0.85	0.86	0.87	0.87	0.86

Fossil Steam Turbine 600 to 799 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	91	83	84	84	87	86
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.65	0.69	0.7	0.72	0.7	0.73
Availability Factor	0.88	0.86	0.87	0.88	0.86	0.88

APPENDIX 2B-14 – United States (Continued)

Fossil Steam Turbine 800 to 999 MW
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	25	20	25	25	25	25
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.65	0.69	0.73	0.74	0.77	0.76
Availability Factor	0.85	0.86	0.86	0.87	0.9	0.89

Fossil Steam Turbine 1000 MW & UP
Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	11	11	11	11	11	11
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.52	0.66	0.7	0.67	0.71	0.75
Availability Factor	0.79	0.84	0.85	0.79	0.83	0.88

Fossil Steam Turbine 100 to 199 MW
Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	59	53	51	48	47	43
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.29	0.35	0.33	0.30	0.31	0.33
Availability Factor	0.86	0.82	0.8	0.79	0.86	0.84

Fossil Steam Turbine 200 to 299 MW
Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	13	8	7	7	7	7
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.19	0.27	0.20	0.20	0.17	0.20
Availability Factor	0.82	0.85	0.69	0.71	0.70	0.73

Fossil Steam Turbine 300 to 399 MW
Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	20	10	10	11	11	10
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.31	0.31	0.31	0.33	0.30	0.34
Availability Factor	0.83	0.83	0.82	0.85	0.84	0.86

APPENDIX 2B-14 – United States (Continued)

Fossil Steam Turbine 400 to 599 MW
Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	27	16	14	13	13	13
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.25	0.38	0.34	0.31	0.32	0.33
Availability Factor	0.85	0.88	0.87	0.87	0.85	0.88

Fossil Steam Turbine 600 to 799 MW
Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	9	9	9	9	9	9
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.12	0.21	0.17	0.21	0.22	0.19
Availability Factor	0.82	0.84	0.79	0.84	0.87	0.76

Fossil Steam Turbine 800 to 999 MW
Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	6	7	7	7	7	7
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.17	0.21	0.19	0.20	0.18	0.22
Availability Factor	0.91	0.89	0.90	0.91	0.88	0.89

Fossil Steam Turbine 1000 MW & UP
Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	1	1	1	1	1	1
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.26	0.33	0.29	0.25	0.27	0.21
Availability Factor	0.70	0.83	0.71	0.68	0.76	0.70

Fossil Steam Turbine 100 to 199 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	116	104	96	90	86	85
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.20	0.23	0.15	0.14	0.14	0.14
Availability Factor	0.86	0.85	0.88	0.89	0.89	0.88

APPENDIX 2B-14 – United States (Continued)

Fossil Steam Turbine 200 to 299 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	39	36	32	32	33	32
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.28	0.30	0.25	0.21	0.20	0.20
Availability Factor	0.86	0.83	0.89	0.85	0.86	0.86

Fossil Steam Turbine 300 to 399 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	36	32	32	33	36	36
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.28	0.31	0.22	0.18	0.15	0.12
Availability Factor	0.81	0.82	0.85	0.85	0.82	0.89

Fossil Steam Turbine 400 to 599 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	51	49	50	51	56	51
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.33	0.34	0.26	0.20	0.15	0.17
Availability Factor	0.83	0.86	0.85	0.85	0.85	0.89

Fossil Steam Turbine 600 to 799 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	12	12	12	12	11	11
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.41	0.40	0.27	0.17	0.10	0.08
Availability Factor	0.82	0.76	0.76	0.83	0.82	0.87

Fossil Steam Turbine 800 to 999 MW
Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	4	4	4	4	4	4
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.19	0.43	0.30	0.28	0.31	0.21
Availability Factor	0.76	0.89	0.84	0.85	0.86	0.84

APPENDIX 2B-14 – United States (Continued)

Combined Cycle-100 to 199 MW Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	1	1	1	1	1	1
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.15	0.05	0.07	0.07	0.01	0.03
Availability Factor	0.88	0.90	1.00	0.88	0.88	0.88

Combined Cycle-100 to 199 MW Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	3	15	34	49	129	142
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.42	0.52	0.45	0.33	0.35	0.39
Availability Factor	0.97	0.87	0.89	0.88	0.90	0.92

Combined Cycle-200 to 299 MW Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	0	1	1	0	1	1
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.63	0.94	0.00	1.00	0.80
Availability Factor	0.00	1.00	0.96	0.00	0.99	0.99

Combined Cycle-200 to 299 MW Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	13	18	19	28	44	41
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.38	0.39	0.41	0.30	0.37	0.36
Availability Factor	0.86	0.90	0.88	0.87	0.91	0.87

Cogeneration-100 to 199 MW Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	1	3	3	3	23	22
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.67	0.61	0.6	0.34	0.40	0.41
Availability Factor	0.85	0.98	0.95	0.96	0.93	0.94

APPENDIX 2B-14 – United States (Continued)

Cogeneration-200 to 299 MW Fuel: Coal

	1995	2001	2002	2003	2004	2005
Unit Count	0	1	1	1	1	1
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.62	0.58	0.63	0.79	0.82
Availability Factor	0.00	0.93	0.93	0.83	0.89	0.91

Cogeneration-200 to 299 MW Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	0	2	2	2	16	16
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.79	0.56	0.34	0.52	0.51
Availability Factor	0.00	0.97	0.80	0.77	0.92	0.87

Base-load Combustion Turbine-30 to 49 MW Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	0	12	12	12	12	15
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.14	0.26	0.18	0.16	0.16
Availability Factor	0.00	0.88	0.92	0.98	0.98	0.96

Base-load Combustion Turbine-30 to 49 MW Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	1	6	7	8	9	9
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.72	0.13	0.16	0.07	0.05	0.07
Availability Factor	0.93	0.92	0.93	0.94	0.97	0.95

Base-load Combustion Turbine-50 to 74 MW Fuel: Liquid

	1995	2001	2002	2003	2004	2005
Unit Count	0	2	2	2	1	5
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.00	0.01	0.11	0.11	0.00	0.01
Availability Factor	0.00	0.94	0.99	0.98	0.95	1.00

Base-load Combustion Turbine-50 to 74 MW Fuel: Gas

	1995	2001	2002	2003	2004	2005
Unit Count	1	4	4	11	12	19
Efficiency Rate	N/A	N/A	N/A	N/A	N/A	N/A
Load Factor	0.01	0.07	0.04	0.03	0.02	0.08
Availability Factor	1.00	0.94	0.97	0.96	0.98	0.93

Section 2

Introduction

Nuclear reactors have provided electricity since 1954, and the technology has been advancing since that time. Today the nuclear energy is an important part of a global energy mix. In 2006 nuclear power supplied about 15.2% of the world's electricity. During more than 50 years nuclear power plants producing electricity have accumulated 12 500 reactor-years of operating experience. World energy demand is expected to more than double by 2050, and expansion of nuclear energy is a key to meeting this demand while reducing pollution and greenhouse gases.

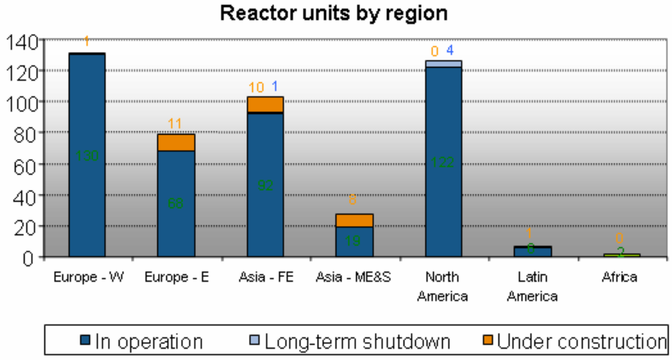
1 Nuclear Power Information at the IAEA

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. Performance data cover operating reactors and historical data on shutdown reactors since beginning commercial operation.

The PRIS can be used to assess nuclear power performance as it provides information on plant utilization and planned and unplanned unavailability due to internal and external causes. Due to detailed classification of energy losses and a comprehensive outage coding system, a set of internationally accepted performance indicators are calculated from the PRIS performance data. The indicators can be used for benchmarking, international comparison or analyzes of nuclear power availability and reliability from reactor specific, national or worldwide perspectives. These analyzes can be utilized in evaluation of nuclear power competitiveness compared with other power sources. Special care should be taken not to give priority to a single performance indicator as this could distort an objective overview. Performance indicators are a tool to identify problem areas, where improvements are necessary, but they do not provide either the root cause or the solutions.

PRIS provides many products to the IAEA Member States and international organizations: such as PRIS-PC (front-end tool interface with on-line connection to PRIS through the Internet), PRIS on CD-ROM, web-based application PRIS-Statistics and through a public web-site at the address: http://www.iaea.or.at/programmes/a2/. Currently, these products are distributed to more than 700 organizations. In addition the IAEA Secretariat answers daily to a considerable number of ad-hoc requests on nuclear power plants information and statistics.

Figure 1
Number of Reactors by Region



Source: IAEA

2 Current Status of Nuclear Power

In October 2007 the nuclear industry is represented by 439 operational nuclear power plants (NPP) totaling 371.7 GWe of capacity. In addition there are 5 operational units in long-term shutdown with a total net capacity 2.8 GWe. There are 31 reactor units with a total capacity 23.4 GWe under construction.

To date, in 2007 three new units have been connected to the grid, Kaiga-3 in India, Tianwan-2 in China and Cernavoda-2 in Romania. Browns Ferry-1 was reconnected to the grid in USA after 22 years long-term shutdown. Construction of five new units has been started in 2007: Qinshan II-4 and Hongyanhe 1 in China, Shin Kori-2 in Republic of Korea and two reactors in Severodvinsk, Russia as the world first floating NPP. Figure 1 shows that nuclear energy is concentrated in Europe, North America and the Far East (FE) where 412 of the total 439 reactors are located. Asia and Eastern Europe are expanding their installed capacity by constructing new NPPs whereas North America and Western Europe are, in recent years, benefiting instead from power uprates of existing units.

Current expansion in Asia can be illustrated by facts that 18 of the 31 reactors under construction are in Asia and, during the last 7 years, 23 of the last 31 grid connections were in Asia

In the current fleet of operational power reactors the Pressurized Water Reactor (PWR) is the dominant reactor type, as shown in Figure 2. PWR units represent 60.4% of installed nuclear capacity. The PWR category includes also the Russian PWR design (WWER).

The Boiling Water Reactors (BWR), including the Advanced Boiling Water Reactors (ABWR), represent 21.4% of installed capacity. Only 18.2% of installed nuclear capacity belongs to all other reactor types

Figure 3 provides distribution of reactor types in different regions. PWR is the prevailing type in all regions especially in Europe. Some reactor types like GCRs (Gas Cooled Reactors), LWGRs (Light-Water-Cooled, Graphite-Moderated Reactors), and FBRs (Fast Breeder Reactors) are currently operated only in Europe.

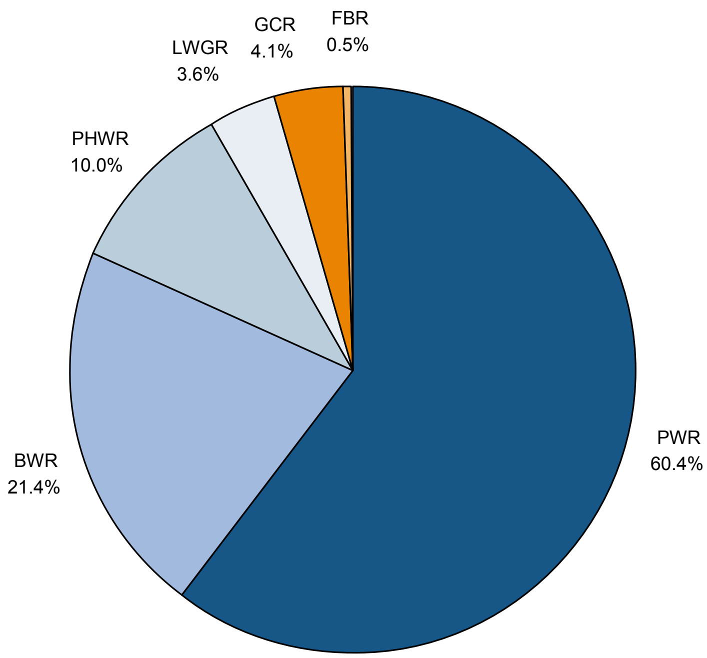


Figure 2
Distribution of Nuclear Capacity by Reactor Type

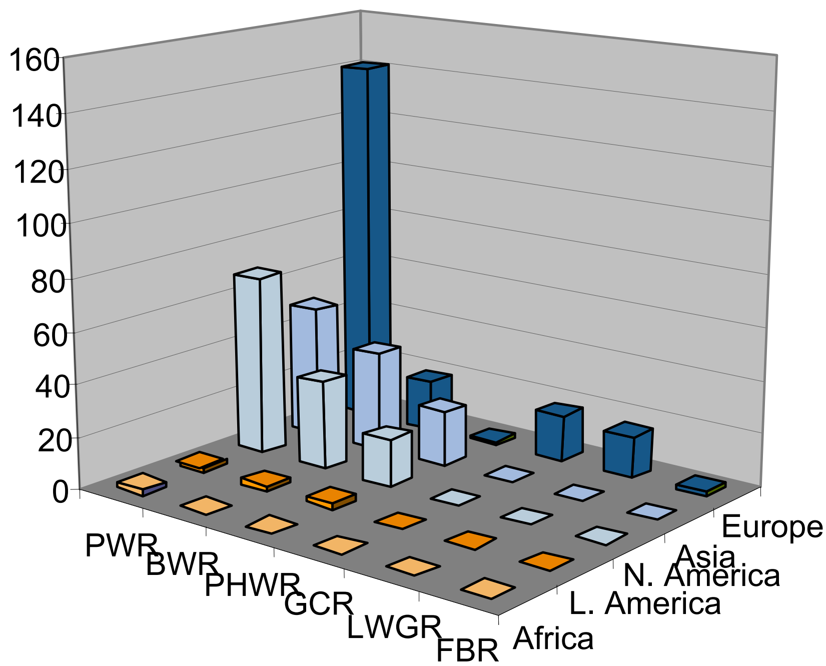


Figure 3
Reactor Units by Type and Region

Table 1

Nuclear Power Reactors in Operation and Under Construction (10/2007)

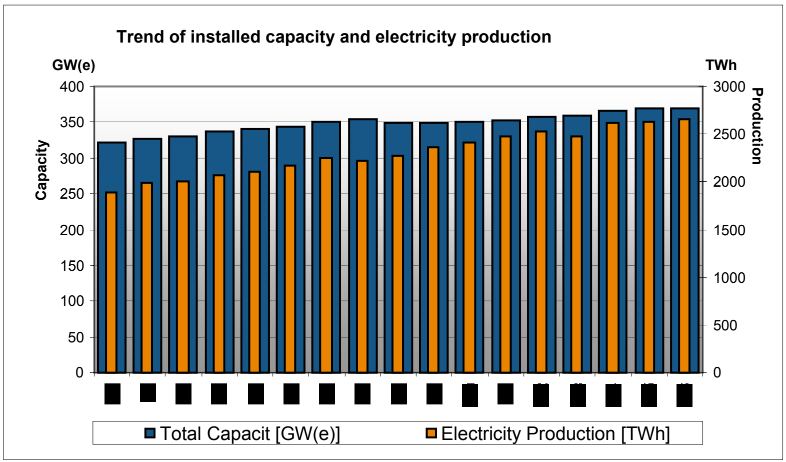
COUNTRY	Reactors in Operation		Long-term Shutdown Reactors		Reactors under Construction		Nuclear Electricity Supplied in 2006		Total Operating Experience at the end of 2006	
	No.	MWe	No.	MWe	No.	MWe	TWh	%	Year	Month
ARGENTINA	2	935			1	692	7.15	6.93	56	7
ARMENIA	1	376					2.42	41.95	32	8
BELGIUM	7	5824					44.31	54.43	212	7
BRAZIL	2	1795					12.98	3.31	31	3
BULGARIA	2	1906			2	1906	18.15	43.64	141	3
CANADA	18	12589	4	2568			92.43	15.81	528	1
CHINA	11	8572			5	3220	51.81	1.93	66	7
CZECH REP.	6	3523					24.50	31.48	92	10
FINLAND	4	2696			1	1600	22.00	27.99	111	4
FRANCE	59	63260					429.82	78.07	1523	2
GERMANY	17	20339					158.71	31.82	700	5
HUNGARY	4	1755					12.51	37.70	86	2
INDIA	17	3779			6	2910	15.59	2.62	267	7
IRAN					1	915				
JAPAN	55	47587	1	246	1	866	291.54	29.97	1276	8
KOREA, REP. OF	20	17454			2	1920	141.18	38.64	279	8
LITHUANIA	1	1185					7.94	72.30	40	6
MEXICO	2	1360					10.40	4.86	29	11
NETHERLANDS	1	482					3.27	3.47	62	0
PAKISTAN	2	425			1	300	2.55	2.74	41	10
ROMANIA	2	1310					5.18	9.00	10	6
RUSSIA	31	21743			7	4585	144.64	15.91	901	4
SLOVAKIA	5	2034					16.60	57.16	118	7
SLOVENIA	1	666					5.29	40.26	25	3
SOUTH AFRICA	2	1800					10.07	4.41	44	3
SPAIN	8	7450					57.43	19.82	245	6
SWEDEN	10	9034					65.05	47.98	342	6
SWITZERLAND	5	3220					26.37	37.41	158	10
UKRAINE	15	13107			2	1900	84.91	47.53	323	6
UK	19	10222					69.39	18.40	1400	8
USA	104	100322					788.31	19.42	3188	2
Total	**439**	**371671**	**5**	**2814**	**31**	**23414**	**2660.86**		**12599**	**1**

Notes: The total includes the following information from Taiwan, China:

- 6 units, 4921 MW(e) in operation; 2 units, 2600 MW(e) under construction;
- 38.3 TWh of electricity generation, representing 19.5% of the total electricity generated in 2006
- 152 years, 1 month of total operating experience at the end of 2006

The total operating experience includes also shutdown plants in Italy (81 years) and Kazakhstan (25 years, 10 months).

Figure 4
Nuclear Energy Production



3 Development of the Nuclear Industry since 2004

Two new reactors were connected to the grid in 2006: Tarapur-3 in India and Tianwan-1 in China. This compares with four new connections in 2005 (plus the reconnection of one laid-up reactor) and five new connections in 2004 (plus one reconnection).

Eight reactor units were shutdown in 2006. There was one nuclear power reactor retirement in Spain in April and seven retirements just at the end of the year: Dungeness A-1&2 and Sizewell A-1&2 in the UK, Kozloduy-3&4 in Bulgaria and Bohunice-1 in Slovakia. The total of eight retirements compares to two retirements in 2005 and five in 2004. Difference in capacity of new reactors connected to the grid and shutdown reactors during 2006 resulted in decrease of nuclear generating capacity by 746 MW(e). This decrease was fully compensated by power uprating of existing plants and the total installed capacity of nuclear reactors has risen from 368.2 to 369.7 GWe

There were four construction starts in 2006: Lingao-4 and Qinshan II-3 in China, Shin Kori-1 in the Republic of Korea, and Beloyarsk 4 in the Russian Federation. In 2005 there were three construction starts plus the resumption of active construction at two reactors whose previous classification had been ‘construction suspended’. In 2004 there were two construction starts plus the resumption of active construction at two other reactors.

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%.

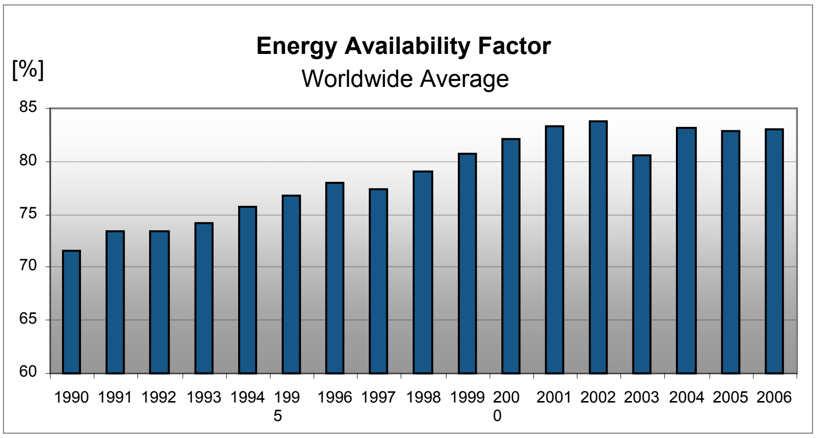
In North America, where 121 reactors supply 19% of electricity in the United States and 16% in Canada, the number of operating reactors has increased in last three years due to re-connection of two long-term shutdown reactor units in Canada (Bruce-3 in 2004 and Pickering-1 in 2005) and one in USA (Browns 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. The shutdown capacity was partly compensated by power uprating. In Eastern Europe the same number (4) of shutdowns and grid connections 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.

4 Trends In Nuclear Electricity Production And Capacity

Nuclear electricity production has grown almost continuously since the nuclear industry’s inception. The reasons for its growth are: new capacity installation, uprating of operating plants and energy availability improvement.

Figure 5
Energy Availability Factor Trend



From 1975 through 2006 global nuclear electricity production increased from 326 to 2661 TWh. Installed nuclear capacity rose from 72 to 369.7 GW(e) due to both new construction and uprates at existing facilities.

In Figure 4 the red bars show the growth in global nuclear electricity production since 1975 (measured against the right scale). The yellow bars show the growth in installed capacity measured against the left scale.

Different trends of installed capacity and energy production indicate that since the beginning of the 1990s, when the construction of new units slowed down, the utilization of nuclear capacity has become more efficient.

5 Worldwide Energy Availability

The basic performance indicators for this study are the Energy Availability Factor (EAF) and the Planned and Unplanned Energy Unavailability Factors (PUF and UUF). EAF is the percentage of maximum energy generation that plant was available for supply to the electrical grid. Energy unavailability is related to energy loses under and beyond plant management control when the unit is not able or not allowed to be operated at reference unit power to meet demand of the grid.

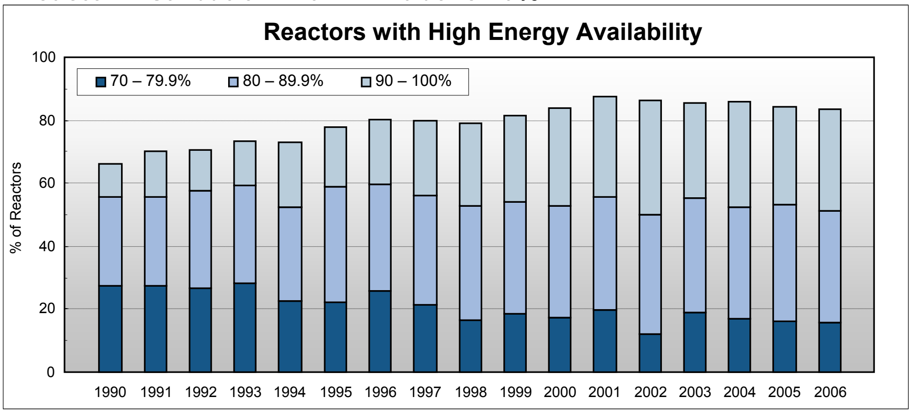
Energy losses under plant management control are divided to planned and unplanned. Main contributors to planned energy losses that should be scheduled at least four weeks in advance are planned outages for refuelling, maintenance, testing and refurbishment. Unplanned energy losses are caused mainly by outages due to equipment failures and human factors.

In 2006 the worldwide EAF was 83% in 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 stopped and now is stagnating on about 83%. This indication has to be analysed in details and the following break downs provide additional information that should be considered in nuclear power plant availability and unavailability analyses.

The number of plants presenting higher EAF (greater than 70%) provides information how EAF results are spread within the operating plants. Since 1990 the percentage of reactor units with EAF above 70% has risen from 66% to 83-86%. The main increase was in the category 90-100%, where the percentage has risen from 10.7% in 1990 up to 36% in 2002. In 2006 32.3% of NPPs were operated with EAF above 90%. In absolute numbers the distribution in 2006 was that out of 442 operating reactors 69 presented EAF between 70 and 79.9%, 153 reactors between 80-89.9% and 140 reactors higher than 90%.

Figure 6
Reactor Distribution with EAF above 70%



In last four years the steady decrease in both planned and unplanned energy unavailability factors has halted. The average planned unavailability factor decreased 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 of 8% to 4% during the last 15 years. In 2006 the median of UUF was 1.32% more then 45% of reactors were operated with UUF less then 1%.

Survey by Region

The analysis of energy availability by since 1990 is presented on Figure 8 by 3-year averages with double weight to a related year.

The Figure 8 illustrates an increase of energy availability factor since 1992 in almost all world regions. In special, in North America the yearly EAF increased from 74% (1992) to a very high availability around 90% since 2000. This increase was mainly due to the USA units, which have improved considerably its performance in 1990s. In Western Europe, the yearly EAF has also increased since 1992, although at a lower level, from 74% in 1992 to 83% in 2000 but without further improvement from this year. This could be due to the uncertainties given by the different country energy policy in the region.

In Eastern Europe, where the majority of units are of PWR (WWER) and LWGR (RBMK) type the yearly EAF has increased from 62% to 77% in the last ten years. The plants in Latin America have also improved the EAF from 63 to 87 % but because of low number of operating units there is a high variation in annual values. Similar variation in annual values is in Africa where only two reactor units are in operation. Improvement of availability of these two units is remarkable – from around 55% at the beginning of 1990s to values above 80% in last years.

The reactor units in the Far East improved EAF from 73% to 83% during 1990s. In 2003 and 2004 the high availability dropped due to a long-term shutdown of 17 TEPCO plants, and in 2006 the EAF was 77% - still significantly less then before 2003. In the Middle East and South Asia where currently 18 reactor units are in operation a very fast EAF improvement occurred during the second half of 1990s, when EAF increased from 45-50% to 78%. However, this reversed to a negative trend and it was only 57% in 2006. One of contributing factors is extensive refurbishment of some reactor units in this region.

It is noteworthy that world regional analysis are difficult to make because the operating plants in such large regions are of different type, operate in different countries and under different economic and energy market conditions. More in depth analysis should consider smaller regions or countries and other criteria used in benchmarking analysis, for instance. The determinant factors on a regional basis depend on the energy and economic situation, on the regulatory philosophy of the countries and, worldwide, the quality of the operators more than the plant location.

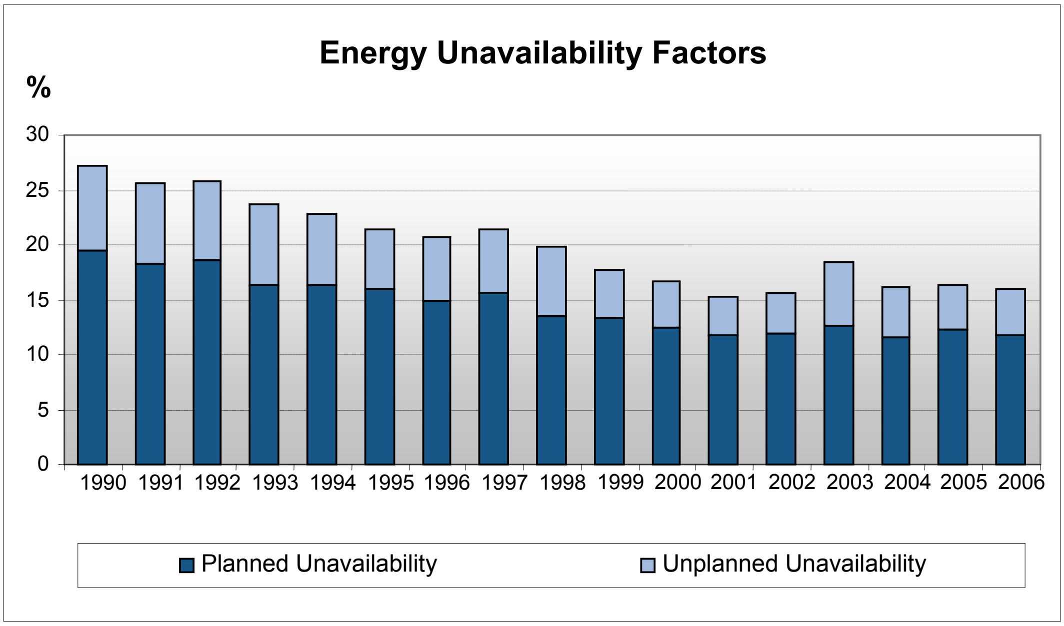


Figure 7

Planned and Unplanned Availability Factors

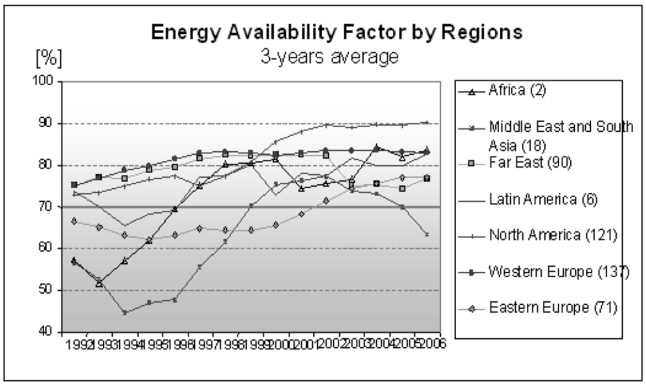


Figure 8

EAF Regional Trends

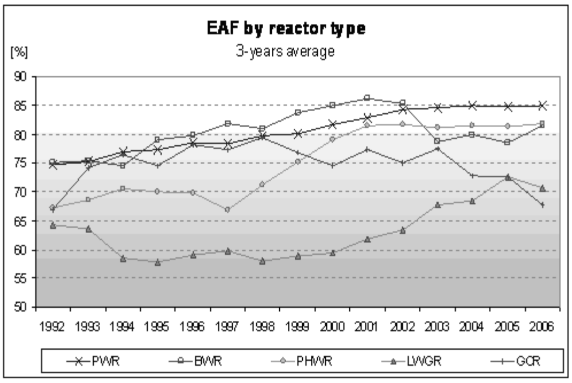


Figure 9

EAF by Reactor Types

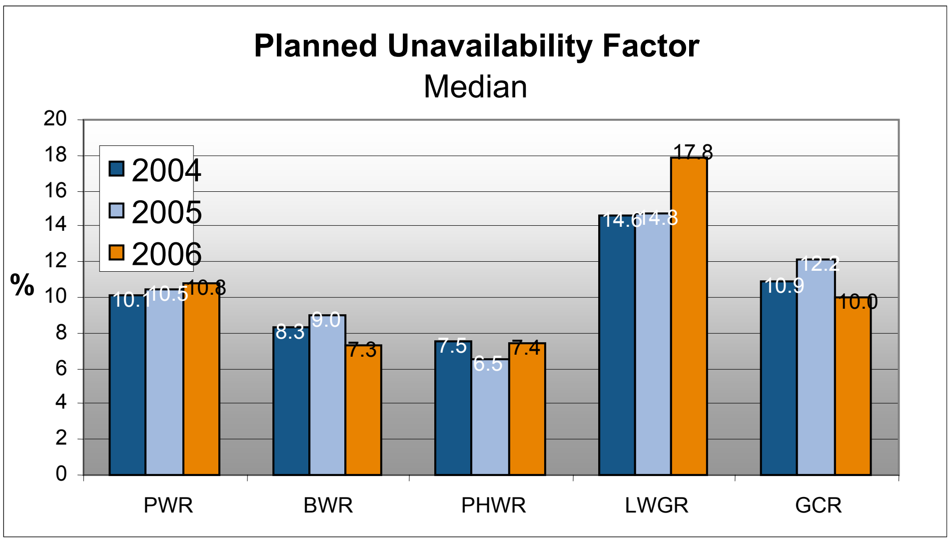


Figure 10

Unavailability due to planned maintenance

Survey by Reactor Type

A survey of the Energy Availability Factor by reactor type shows that there is considerable increase in the availability of PWR and PHWR units.

The PWR units have improved the energy availability factor from 73.1% in 1990 to 84.8% in 2006. The three years average also increased considerably from 74.3% in 1990-1992, to 84.9% in 2004-2006. For PWR units, the three years average of planned energy unavailability factor (PUF) was 10.9% in the period 2004-2006, while the unplanned energy unavailability factor (UUF) was 3.2%. The PUF median values in last three years were around 10.5%. In 2006, 68 out of 267 PWR units presented EAF higher than 90%.

Since 1990, the average energy availability factor of BWR units has varied from 74.9% in 1990 to 86.4% in 2000. In recent years the availability of BWR units was significantly affected by the TEPCO case (all TEPCO units are BWRs or ABWRs). In 2003 EAF dropped to 72% and in following years rose back above 80% reaching 82% in 2006. The last three years (2004-2006) average is 81.3%. In 2006, the average EAF of all operating BWR units was 82% and 43 out of 93 units presented EAF higher than 90%.

The PHWR units also increased the energy availability factor from an average of 67.9%, in 1990-1992, to 81.8% in 2004-2006. Since 1997, the EAF has continuously recovered and increased.

The three years the average of PUF was 10.2% in 2004-2006 and half of reactors were operated with PUF bellow 7.5% in these years. In the same period the average UUF was 5.5%.

LWGR (RBMK) reactors have increased availability significantly during the last seven years. In 1992-199 the availability was affected by longer planned outages for refurbishment and backfittings and averaged of about 60%. Since 2000 availability has increased from 61.4% to 75% in 2006.

The main area for further improvement is the management of planned maintenance as PUF is quite high. In 2004-2006 the average value was about 25%.

The positive trend of availability of GCR units in 1990s reversed in last ten years and has dropped from 79.6% in 1996 to 64.9% in 2006.

The energy losses related to planned outages are the main contributor to plant unavailability. Figure 10 shows significant differences in Planned Energy Unavailability Factors for different reactor types. The scope, frequency and organisation of planned outages are determined in principle by reactor design (on-line and off-line refuelling) but maintenance management and optimisation is a common are for improvement.

6 Conclusions

Nuclear plant operators are achieving high availability through integrated operation and maintenance programmes.

Currently, the global average EAF is over 83% and more then half the world's units operate with an EAF over 86%. Generally, as EAFs improve and approach the ceiling of 100%, each incremental improvement becomes ever more difficult and expensive. But there is still room for improvement. Using the performance of the world's ten best performers over the last five years to define a practical limit yields a value slightly over 96%.

These achievements show the efforts made by the nuclear industry for a reliable and safe operation of nuclear power plants. These improvements also reflect the impact of de-regulation and privatisation of the electricity market which have affected all electricity producers, but mainly it is a result of optimised operation and maintenance of nuclear power plants.

Many reactor units have optimised the frequency of refuelling outages by implementing longer fuel cycles. Others have implemented improved outage strategies, which also enable shorter duration of refuelling outages. Some of them perform refuelling outages in less than two weeks, while others in more than a month. The IAEA has also assisted its Member States to exchange information on good practices for outage optimisation, improving nuclear power plant performance and other activities, which have contributed to reduction of outage duration.

The main factors contributing to improvements in reactor availability are:

The elimination of unplanned energy losses through effective failure prevention (root cause analyses), 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 refueling and maintenance outages, and risk oriented maintenance.

The continuing exchange and dissemination of operating experiences.

Additional consolidation in the nuclear industry so that more plants are operated by those who do it best.

The IAEA activities, which include nuclear power plant performance assessment and feedback, information exchange on outage optimisation and effective quality management, are important examples of international co-operation to improve the performance of operating nuclear power plants. The World Association of Nuclear Operators (WANO) also plays an important role in maximising the safety and reliability of the operation of nuclear plants by exchanging information and encouraging communication of experience.

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World Energy Council
Regency House 1-4 Warwick Street
London W1B 5LT United Kingdom
T (+44) 20 7734 5996
F (+44) 20 7734 5926
E info@worldenergy.org
www.worldenergy.org

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