Department for
Business, Energy
& Industrial Strategy

Combined Heat and Power – Operation & Maintenance

A detailed guide for CHP developers – Part 4

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1 Introduction

This document provides an overview of the Operation & Maintenance requirements of CHP systems. First, it focusses on packaged CHP units, and then on to custom CHP plant.

2 Packaged CHP Operation & Maintenance

Once the CHP package has been installed, it needs to be operated and maintained correctly if it is to provide the planned levels of cost savings. There are examples of CHP plants that have not achieved their expectations because of a lack of effective supervision and maintenance.

The following sections take an in-depth view of plant operations, plant maintenance, and performance monitoring & assessment.

2.1 Plant Operation

Plant operation includes a broad range of issues. These include:

- Plant Control.
- Monitoring & Advisory systems.
- Staff Training.
- Planning Plant Shutdown.
- Health & Safety.

Proper consideration of these issues ensures the CHP efficiency, operating life and safe operation are maximised.

2.1.1 Plant Control

Control of a CHP package is largely automated and requires little regular input from site staff. Provided the systems connected to the unit continue to function correctly, the unit should be capable of continuous operation using its own control system.

The unit’s control panel will usually incorporate shutdown and start-up facilities that can be initiated manually, although the sequence of events in both instances will normally be pre-defined and carried out automatically. The panel will also contain some displays giving information on operating parameters such as water temperature, exhaust gas temperature, electrical voltage and frequency. The panel may also show meter readings relating to the quantities of fuel, heat and electricity used or produced by the package, as well as an indication of operating hours.

Under normal circumstances, there is no requirement for active control by site staff, and the unit will continue to operate without constant attention. In the event of conditions changing beyond defined limits, the control system will usually sound an alarm to attract attention. If the event is potentially harmful to the equipment, the unit will shut down automatically.

2.1.2 Monitoring & Advisory Systems

To enable the CHP package to operate safely and effectively without supervisory staff, most units are fitted with a monitoring system that checks a range of operating parameters at regular intervals (usually every few minutes). The data collected can be either stored for later review or passed on immediately.

The main purposes of the monitoring system are:

- Plant condition monitoring – to check the reliability and performance of the CHP package, and to assist in planning unit maintenance.
- Plant performance monitoring – to check the inputs and outputs and to monitor the unit's energy efficiency.

The overall objective of plant monitoring is to ensure regular review of the data collected and use of the information to maximise the cost savings achieved.

An advisory system is an effective tool for providing a rapid review of the energy and flow data collected, and for advising on the optimum operating mode of the unit. The advisory system needs to contain data relating to the costs and values of the energy inputs and outputs, such as the cost of fuel, the avoided cost of purchased electricity, and the avoided costs of providing heat to the site. The system would also contain information relating to the overall maintenance costs of the CHP package, usually expressed as a cost per operating hour or per unit of electrical output. By using this information in conjunction with up-to-date data on the unit's performance and the site's energy demands, an advisory system can make recommendations on the most cost-effective mode of operation.

For example:

- At night-time, particularly outside the winter period, the cost of purchasing electricity from external, conventional sources can be quite low. If the sum of the fuel and maintenance costs associated with operating the CHP package exceeds the cost of the alternative option – buying electricity and using fuel to provide heat – it is clearly uneconomical to operate the CHP package.
- If the site heat load falls, and the only way to continue operating the CHP unit is to dump heat, it may be more economical to run the unit at lower output or to shut it down, and to purchase electricity from external sources.

In most cases, the factor having the greatest influence is the cost of purchased electricity from external sources, and this varies from time to time according to the selected tariff. The use of a fixed tariff, where the timing of tariff changes is known in advance, usually enables the advisory system to predict periods when shutting down the CHP unit is the more cost-effective option.

Because the CHP package is usually unmanned, any advisory system should be used in such a way that its recommendations can be promptly reviewed and acted on. Where a site operates some form of Building Energy Management System (BEMS), both the CHP package controls and the advisory system can be installed as components of the BEMS. This allows the CHP package to be controlled in a way that maximises the cost benefits.

In most cases, the CHP package supplier will offer a remote monitoring and advisory service. This is usually based on the use of a telephone line to transmit data between the site and the supplier's monitoring and control centre. This approach ensures that the condition of the CHP package is effectively monitored and that it is controlled to achieve maximum cost benefits. The system can also be configured to avoid a pattern of frequent stops and starts, as this may be harmful to the equipment.

2.1.3 Staff Training

Staff training is vital to maximising the benefits of CHP and reducing downtime. To maximise the benefits generated by installing a CHP package, there must be a proper familiarisation and training process for site staff who will be responsible for the plant. In practice, there is little or no requirement for on-site staff to know how to maintain or operate the CHP plant because this is usually done under an operation and maintenance (O&M) contract. But there is an important need for staff to be educated about the benefits of the CHP plant so that they make best use of the energy. A common example of this is to ensure that those responsible for the plant room realise that the CHP plant operates as the lead boiler and they do not inadvertently re-set boiler controls to defeat this. Failure to provide this familiarisation and training can be disruptive to the cost-effective and reliable operation of a CHP plant.

Staff need to understand the overall philosophy and purpose of a CHP unit. This could be part of an on-going energy efficiency awareness scheme. They also need to recognise the importance of condition and performance monitoring. Part of this training should include the establishment of good working relationships with the supplier and with those who provide on-going technical support.

Training must be undertaken as part of the CHP installation procedure, and refreshed annually. Since the on-site installation period can be brief, it is important for the relevant staff to be involved in the final stages of plant installation, when the plant is commissioned and tested by the installers.

2.1.4 Planning Shutdowns

Any CHP package will require planned shutdowns for servicing, and the preparation and scheduling of these outages are essential.

The costs of shutdown include not only the labour and materials for carrying out the planned work, but also the additional costs of meeting the site's heat and power requirements from other sources. These costs are not insignificant and should be given due consideration when deciding on the timing and duration of a shutdown. For example, it is not generally advisable to carry out planned maintenance on a CHP package when electricity costs are high, for instance during midweek daytime periods in winter. It is sometimes more cost-effective to minimise the duration of the shutdown by ensuring that work continues outside 'normal' working hours: in some instances, the extra cost of labour may be offset by the reduced costs and duration for providing alternative heat and power supplies.

Because packaged CHP is normally operated and maintained under a contract, it is wise to ensure that service vehicles and equipment have ease of access for when maintenance must take place. Downtimes can be increased, simply because no provision was made for this.

2.1.5 Health & Safety

The installation of a CHP package may require the adoption of some new safety systems and procedures, particularly regarding the operation and maintenance of the unit. The use of natural gas within an enclosed area will need a review of ventilation facilities, and the installation of gas detectors may be considered appropriate, possibly connected to an automatic gas shut-off valve.

Changes to the plant must be accompanied by an assessment of any risks and hazards that may arise as a result. It is important to keep proper records of plant safety tests, together with maintenance and equipment schedules.

2.2 Plant Maintenance

All CHP plant requires effective and reliable monitoring and maintenance to provide the required levels of reliability and efficiency.

The following sections explore in greater detail - packaged CHP maintenance requirements and maintenance contracts for CHP plant.

2.2.1 Maintenance Requirements

All CHP plants require effective and reliable monitoring and maintenance to provide the desired levels of reliability and efficiency. The following explains what is involved in the maintenance of CHP plant. However, this is normally part of an O&M contract and does not involve on-site staff beyond their being informed that service staffs are on site.

For a packaged CHP unit, relatively little routine maintenance is needed to allow the unit to operate continuously for long periods. Provided that supplies of fuel, water and air to the engine are kept at their required conditions, the unit should require maintenance attention at the planned service intervals. Regular brief visual checks by site staff are the only tasks required during operating periods. The rest are done by the O&M contractor.

However, a CHP plant may experience a slight degradation in output and efficiency between the stoppages for scheduled servicing. This is almost entirely caused by the gradual wear of components in the engine. Spark plugs in particular require regular attention and replacement to maintain engine performance. Other items that need regular attention include air filters, valve clearances and turbocharger operation.

A considerable amount of information on plant condition can also be obtained by the regular sampling and analysis of engine lubricating oil. The presence of water or other liquid contaminants, or of metallic or non-metallic solids, provides an indication of excessive wear or leakage, while the condition of the oil itself, such as its acidity and viscosity, gives valuable information on engine condition. It is common practice to take regular samples which are sent for testing.

Schedules of typical maintenance requirements are available, however in practice this work is carried out by the maintenance company according to a schedule derived from engine data.

2.2.2 Maintenance Contracts

A contract with the equipment supplier or one of the specialist O&M CHP companies is often considered to be an effective way of providing the necessary maintenance support that will ensure the long-term reliability and performance of the plant.

Consideration should always be given to the availability of a suitable long-term maintenance contract when selecting a CHP package. The best time to negotiate a long-term maintenance contract is at the time of purchase. When the unit is old, the contractors will be less willing to take on an unfamiliar unit. Various levels of maintenance agreement may be available, but the choice of service must be considered in conjunction with the degree of responsibility that comes with the contract. Typical options could include the following:

- Planned maintenance only, whereby the supplier carries out only a predefined list of maintenance tasks to a predetermined time schedule. This would include all labour costs, and may include or exclude the cost of providing replacement parts and materials.
- Remote monitoring of plant parameters to provide a diagnosis of plant condition.
- Call-outs to unplanned outages or breakdowns within a specified time period.
- Comprehensive maintenance cover, to include all parts and labour costs associated with both planned and unplanned maintenance requirements.
- Availability and installation of exchange or replacement unit to cover periods of prolonged outage associated with failure or servicing requirements.

The actual range of options available will vary from one manufacturer to another, and can be varied according to the levels of on-site staffing and expertise available.

Where a comprehensive service and warranty package is available that covers all the maintenance needed to achieve a defined level of plant performance and availability, it should provide some assurances regarding the availability of both service response and the necessary replacement parts and components. The costs of such a package should be expressed in simple terms, such as total cost per unit of output or cost per hour of running time. These figures are an important component of the costs and savings analysis.

2.3 Performance Monitoring & Assessment

Performance monitoring is essential to check that the CHP package is performing as specified. Plant performance should be monitored and recorded to show changes in key parameters such as output and fuel consumption, and to provide information on other factors that affect performance such as air temperature and pressure. It is also important to monitor the rate at which plant performance changes, as this provides an important basis for planning maintenance tasks and plant overhauls. Performance monitoring is an essential input into an effective advisory system.

Performance monitoring requires the inclusion of accurate metering facilities within the design of the CHP package and its equipment. These will allow the accurate monitoring of:

- Fuel consumption.
- Electricity output.
- Heat supplied to the site.
- Hours of operation

As well as monitoring for plant management purposes, it is also necessary to monitor the inputs and outputs of the CHP plant to assess its overall annual performance. This monitoring component is essential if the plant is to achieve the necessary quality standards for exemption from the Climate Change Levy (CCL) on supplies of fuel and electricity. Metering installed for CCL registration must be able to differentiate between heat used by the site and heat rejected to atmosphere via a cooling system, and the meters should be positioned correctly to achieve this.

Exemption from the CCL for Good Quality CHP schemes will be based on certificates issued by the DEFRA’s CHPQA programme. Details of monitoring requirements for the CHPQA programme are available on the CHPQA programme’s website

3 Custom CHP Operation & Maintenance

The following sections provide an overview of the operation and maintenance requirements of a custom CHP plant.

3.1 Plant Operation

Once plant installation has been completed, the required levels of performance and availability, and the associated economic benefits, can only be achieved and optimised if the plant is correctly operated and maintained. There are examples of effective and efficient CHP plants failing to deliver the anticipated benefits because of a lack of emphasis on the on-going management of plant operations and maintenance.

Effective operation of a CHP plant requires the continuous monitoring both of site energy demands, and of the tariffs and costs associated with meeting those demands. Monitoring must be used as a means of continuously evaluating the most economic use of the plant, taking into account its performance and efficiency, its maintenance costs, and the costs of external energy sources such as electricity and gas. One typical scenario arising from this is that, during the overnight period, it may be cheaper to supply electricity from external sources and to use back-up heat supply plant, compared to operating the CHP plant.

It is equally important to be aware of the future maintenance costs that are being built up by operating the plant. This is particularly important where the costs of plant operation and maintenance are managed by separate budget holders. At the same time, plant operation must not be constrained by inadequate maintenance budgets that prevent the optimum energy performance of the plant from being achieved.

Many industrial CHP plants incorporate numerous items of equipment, which may include fired boilers and auxiliary items such as compressors, chillers etc. Overall plant control techniques need to be flexible enough to ensure optimum performance of the whole installation. There are varying levels of automation that can be used to achieve the required level of control.

Particular attention should be paid to:

- Control strategy.
- Staff training.
- Shutdown planning.
- Health & safety.

3.1.1 Control

CHP plant operation requires the effective use of an overall control strategy to ensure that key objectives are achieved. This strategy must include the means of achieving:

- Plant condition monitoring – to ensure optimum reliability and performance.
- Efficiency of energy conversion and recovery.
- Minimised costs and maximised savings.

Power generation differs from the operation of conventional boilers and requires different skills and techniques, particularly in relation to the control and monitoring associated with operating electrical generators in parallel with the local electricity system. A CHP plant also incorporates heat transfer systems that must be correctly controlled to ensure the safe long-term operation of the equipment, and to recover heat for beneficial use. Furthermore, a CHP plant may incorporate auxiliary equipment such as supplementary firing and gas compression.

Consideration should be made for individual plant control systems, monitoring & advisory systems, total control through distributed systems and manual control of individual plant.

3.1.2 Individual Plant Control Systems

The capabilities of individual plant control systems to be integrated within overall plant monitoring schemes should be a key factor in plant and system selection.

Industrial CHP plants consist of a number of core plant items – gas turbines, engines, boilers, compressors etc. Each will be installed with its own control panels and systems to provide basic control functions such as start-up, shutdown, modulation etc. These systems also provide alarms and automatic shutdown as part of system protection, and it is common for certain key condition parameters to be fed from one plant control panel to another. Each control system needs to have a range of inputs and outputs in order to function as part of an integrated control and monitoring system.

Operating features normally incorporated in the control systems of individual plant items may include:

- Start-up and shutdown procedures.
- Normal operating parameters, with alarms and automatic shutdown facilities.
- Protection of individual motors and components.
- Input and output of condition signals.
- Modulation in response to control inputs.
- Synchronisation with local electricity supply system.
- Monitoring of vibration.

Some plant control systems can also store historical data of plant conditions. This provides important information for maintenance scheduling and failure diagnosis.

3.1.3 Monitoring & Advisory

Some CHP plants use a centralised monitoring and advisory system that provides a continuous flow of information to the plant operator. The system may also be configured to provide advice and warnings to the plant operator but without making automatic changes to plant operation. Such a system is based on the extensive monitoring of a wide range of plant operating conditions: some of these may be integral to individual plant control systems, while others may be site-specific additions to improve overall system operation. Monitoring and advisory systems are often preferred where plant operating decisions have to take account of factors that cannot be defined for computer-based control. The use of this type of control and monitoring regime requires constant attendance or the immediate availability of a plant operator or supervisor to make decisions and to initiate the appropriate control actions.

Figure 1: A control room

A plant monitoring system will collect current and historical data for a wide range of plant parameters. It can also store and process data to provide information for evaluation and plant diagnostic purposes. Typical parameters would include:

- Heat and power outputs.
- Fuel consumptions.
- Water consumption.
- Ambient air conditions.
- Gas pressure and temperature.
- Exhaust and cooling system conditions.
- Exhaust gas constituents.
- Site energy and utility consumptions.
- Electricity import and export metering.

- Predictions of site energy load patterns.

In order to make effective use of the monitoring and data collection facilities, an on-line computer system would contain additional management information, together with the necessary programming to enable the system to provide advice to the operator, or to make and implement plant operating decisions. The management input to such a system would include:

- Fuel tariffs.
- Water costs.
- Electricity purchase and export tariffs.
- Plant maintenance costs.
- Utility sale revenues.
- Costs of alternative supply provisions.
- Fixed costs associated with start-up or shutdown.
- Environmental constraints on operations.

The combined use of monitoring and advisory functions enables reliable and cost-effective plant operation to be achieved by manual operation. This would include decisions on optimum plant operation and on plant priority and sequencing. It may also include total shutdown at times when alternative energy supplies are more cost-effective.

3.1.4 Total Control: Distributed Systems

Some CHP plants use distributed control systems, with semi-autonomous, computer-based control of the individual plant control panels, and the higher level supervision of plant operating procedures in an overall plant control protocol. Systems of this type will incorporate a wide range of automatic responses to defined events, such as component or plant failures, changes in heat and power system conditions, and variations in site load. In other words, they will make and carry out automatic control decisions regarding plant operation.

As with the plant monitoring and advisory systems, this system is based on extensive monitoring of a wide range of plant operating conditions, some of which may be integral within individual plant control systems, while others are site-specific additions.

A distributed control system ensures effective monitoring and operation, including remote control where appropriate. Interventions by site staff tend to be infrequent, and staffing levels can be low with only shift supervision required. This type of system tends to be used in plants that have relatively uncomplicated plant control requirements, such as those that operate continuously without changes in load or output.

3.1.5 Individual Plant: Manual Control

The other option is where a CHP plant has no overall control or monitoring system but is operated and controlled manually according to the information provided by each plant control panel. This is sometimes the preferred option where it is compatible with other site operation and control methods, and where the installation of centralised monitoring or control is not cost-effective.

3.1.6 Staff Training

Irrespective of the type of plant installed, effective operation requires proper training of the site staff who will be responsible for that plant – not only plant operators and maintenance staff, but also site managerial staff. Depending on site manning levels and operating hours, there will need to be enough trained people to provide cover for shift working, for planned or sudden staff absences, and for the progression of staff to other jobs.

Lack of training can be disruptive to the cost-effective and reliable operation of a CHP plant. Staff need to be trained not only in the hands-on use of the plant, but also in the overall philosophy and purpose of the plant, in the monitoring of its condition and performance, and in building good working relationships with the suppliers that provide on-going technical support.

Training must be undertaken as part of the CHP installation procedure, so that staff are skilled and ready to operate the new plant as soon as it is ready to run. This can be complemented by ensuring that staff are involved in the final stages of plant installation, when the plant is commissioned and tested by the installers.

It is usually considered essential for staff to undertake the training provided by equipment suppliers, who often specify a training programme with regular updates and refresher courses as part of the overall service provided. Off-site training, at the suppliers' works or at other plants, can also be highly beneficial.

3.1.7 Shutdown Planning & Management

Any CHP prime mover/electrical generator will require planned shutdowns for servicing, and the preparation and scheduling of these outages is essential. The costs of shutdown include not only the labour and materials for carrying out the planned work, but also the additional costs of meeting the site's heat and power requirements from other sources. These costs are not insignificant and must be taken into consideration when deciding on the timing and duration of a shutdown. For example, it is not generally advisable to carry out planned maintenance on a CHP plant when electricity costs are high, for instance during midweek daytime periods in winter. Furthermore, it may be cost-effective to minimise the duration of the shutdown by having work continue outside 'normal' working hours: the extra cost of labour is usually more than offset by the reduced costs and duration of alternative heat and power supplies.

3.1.8 Health & Safety

Some CHP plants are the subject of guidance issued by the Health and Safety Executive – a helpful source of information on safe operating and maintenance procedures.

The installation of a CHP plant usually requires the adoption of new safety systems and procedures, particularly regarding the operation and maintenance of the prime mover/electrical generator. Regular testing of plant conditions will be required, and all changes to the plant must be accompanied by an assessment of any risks and hazards that may arise as a result. It is important to keep proper records of plant safety tests, together with maintenance and equipment schedules.

3.2 Plant maintenance

All CHP plant requires effective and reliable monitoring and maintenance in order to provide the required levels of reliability and efficiency. Maintenance can be broken into two key groups: prime mover maintenance requirements and site maintenance requirements. The complexity and frequency of maintenance varies for different plant items, and this influences the options for selecting the best source of maintenance and repair expertise.

Responsibility for plant maintenance usually rests with the plant owner or operator. This may be the site owner, a contractor that has installed the plant under an energy services company (ESCO) contract or equipment supplier finance arrangement, or a contractor to whom all aspects of plant operation and maintenance have been subcontracted.

It is common for some maintenance work on specialised plant such as gas turbines and engines to be contracted out to the equipment manufacturer or supplier, or to other specialist organisations. The level to which a plant owner or operator will retain or subcontract these responsibilities will depend on the expertise available in-house and on the degree to which there is a desire to subcontract the risks and liabilities associated with plant performance and availability.

While the use of in-house resources may be appropriate for minor maintenance tasks such as routine plant checks, lubrication, oil changes, filter changes, set point adjustments etc., it is normally necessary to have major work, whether planned servicing and overhauls, or breakdown repair work, carried out under maintenance contracts with the original equipment supplier. In all cases, the establishment of a suitable long-term maintenance contract should be considered as part of the equipment procurement procedure. It should cover all the maintenance needed to achieve a defined level of plant availability. This approach allows a CHP operator to make better decisions on the total life-cycle costs and benefits of the project. The contract should also provide for some assurance regarding the quality and suitability of replacement parts and components.

3.3 Performance Assessment

Condition monitoring of the CHP plant is an important part of preventive maintenance, while performance monitoring is essential to ascertain whether plant outputs and efficiencies are consistent with those demonstrated in the performance tests prior to handover. These two concepts are explored in the following sections.

3.3.1 Condition Monitoring

Monitoring the temperature levels of various sections of an engine or gas turbine can give indications of component deterioration or advance warning of maintenance requirements.

A considerable amount of information on plant condition can be obtained by the regular sampling and analysis of engine lubricating oil. The presence of water or other liquid contaminants, or of metallic or non-metallic solids, provides an indication of excessive wear or leakage, while the condition of the oil itself, such as its acidity and viscosity, gives valuable information on engine condition.

Monitoring the frequency and amplitude of vibration and noise from a plant gives an indication of its condition.

On-line condition monitoring is now applied to nearly all gas turbines, and to a wide range of the larger engines. The monitoring also extends to the alternators that are connected to these prime movers. Monitoring is generally carried out using sensors with electrical outputs that feed information to a data collection and logging system attached to the plant control system. The data can be extracted and collated for local or off-site review. Condition monitoring will also provide alarms and automatic shutdown instructions to the plant control system.

3.3.2 Performance Monitoring

Performance monitoring is essential to ascertain whether plant outputs and efficiencies are consistent with those demonstrated in the performance tests prior to handover (which should themselves reflect the performance and efficiency of the original equipment specification). Plant performance should be monitored and recorded to show changes in key parameters such as output and fuel consumption, and to provide information on other parameters that are known to affect performance, such as air temperature and pressure. It is also important to monitor the rate at which plant performance changes, as this provides an important basis for planning maintenance tasks and plant overhauls.

In addition to monitoring for plant management purposes, there will be a need to monitor the input and outputs of the CHP plant in order to assess its overall annual performance. This procedure will be required if the plant is to demonstrate the necessary standards for exemption from the Climate Change Levy on supplies of fuel and electricity.

However, the original performance data will have been specified – and demonstrated during site performance tests – under ‘new and clean’ conditions, and plant output and efficiency will deteriorate between both minor and major servicing activities. For a gas turbine, actual plant performance on-site is significantly affected by the back-pressure in the exhaust ductwork and chimney. This is particularly relevant in the case of a CHP scheme that has heat recovery equipment installed in the exhaust system.

A gas turbine will suffer a long-term degradation in efficiency and output as a result of a gradual deterioration in the condition of the turbine blading and other components. This degradation would typically be 3-4% of electrical output during the period between major services, and would largely be restored by work carried out as part of a major service. A degradation of up to 5% over the total life of the turbine would be typical.

In addition, a gas turbine will suffer from short-term degradation of output caused by fouling of the blades in the compressor section of the turbine. This problem is caused by contaminants in the combustion air drawn into the turbine, and the rate of degradation is affected by local air quality and the efficiency of filtering. The degree of degradation can be up to 5% of output within a week, but this can be alleviated by use of the compressor washing systems that are built into any CHP gas turbine.

A gas turbine is usually fitted with both online and off-line washing systems:

- The on-line system injects washing fluid into the turbine compressor during normal turbine operation, and the procedure can usually be carried out in less than 30 minutes. The washing fluid evaporates and is discharged with the exhaust gases.
- The off-line system requires a turbine shut down for a period of between one and four hours: the system operates with the turbine spinning at slow speed, and a quantity of liquid effluent is produced. The off-line system is obviously more costly to carry out, but it is a more effective method of cleaning the turbine and restoring power output levels.

The usual approach is to use the plant monitoring system, in conjunction with an assessment of the operating costs and benefits, to produce a planned schedule of both on-line and off-line washing procedures. It is often more cost-effective to carry out off-line washing overnight when the costs of purchasing electricity from alternative outside sources are lowest.

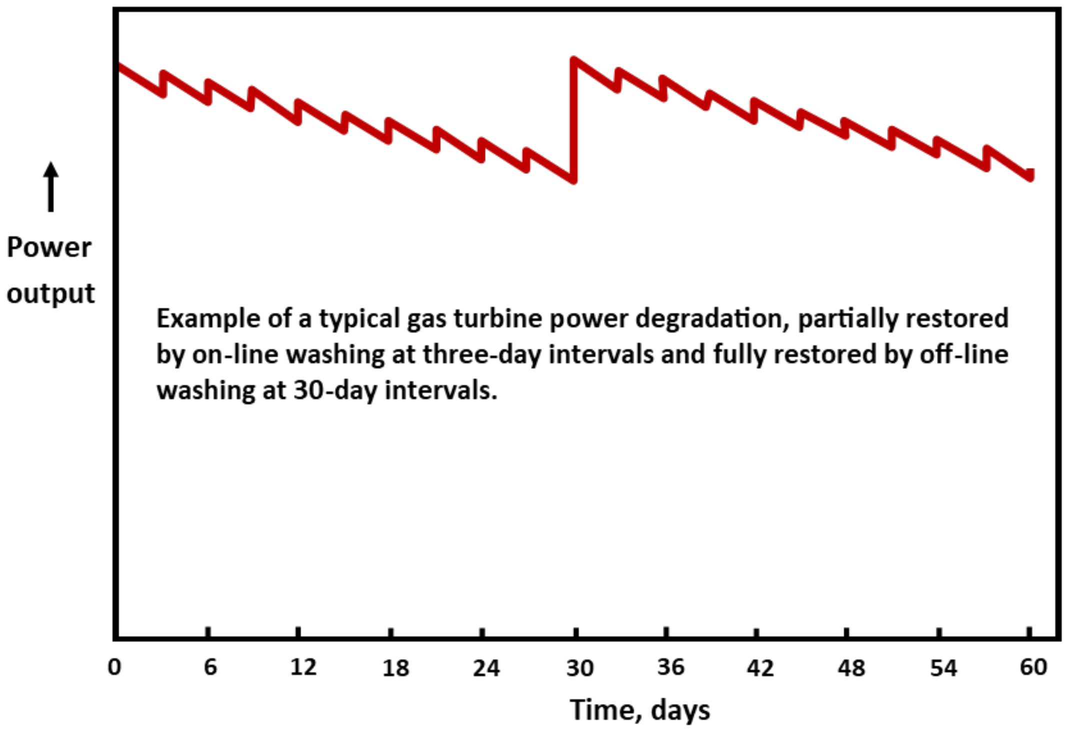

Figure 2: A graph showing electricity output

The effect of the short-term degradation and the washing procedures is that turbine output varies in a way that is illustrated in the ‘saw-tooth’ graph shown in illustration opposite. The short-term drop in output is restored almost to its original level by the on-line washing, and this cycle occurs typically over a period of one week or less. The more gradual longer-term decline in output, which is restored by off-line washing, occurs with a cycle time of typically 2-4 weeks. In addition, there is the long-term degradation of turbine performance which is largely restored by the major overhauls at around five-yearly intervals.

An engine will also suffer from degradation in output, but for different reasons. An engine is largely unaffected by small amounts of contamination in the combustion air, although it is important to change the inlet air filter as recommended. Engine performance degradation is almost entirely caused by the gradual wear of components in the engine: spark plugs, in particular, require regular attention and replacement to maintain engine performance. Other items that need regular attention include air filters, valve clearances and turbocharger operation.

The degradation in engine performance varies in a similar ‘saw-tooth’ pattern to that associated with a gas turbine, but with a much lower rate of output decline and a longer time period for each cycle. Short-term degradation, typically 3-5% of output, occurs over a period of around 1,000 running hours and is restored by routine attention to spark plugs, valves etc. Longer-term degradation occurs during the period between major overhauls, which are carried out, typically, every 5,000 running hours.

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