PI ENERGY & EMISSIONS LIMITED
FOR BERR

# ENERGY ASSESSMENT METHODOLOGY

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## ABBREVIATIONS USED

| | |
|---|---|
| BERR | Department for Business Enterprise and Regulatory Reform |
| PI-E2 | Performance Improvements – Energy and Emissions Ltd |
| PPC | Offshore Combustion Installations (Prevention and Control of Pollution) Regulations (PPC) 2001 |
| GHG | Greenhouse Gases |
| $CO_2$ | Carbon Dioxide |
| $CH_4$ | Methane |
| NOx | Oxides of Nitrogen |
| SOx | Oxides of Sulphur |
| VOL | Volatile Organic Compounds |
| MW(th) | MegaWatts thermal |
| BAT | Best Available Technique |
| DLE | Dry Low Emissions |
| EU | European Union |
| ETS | Emissions Trading Scheme |
| PFD | Process Flow Diagram |
| P&ID | Process and Instrumentation Diagram |
| OEM | Original Engine Manufacturer |
| NPV | Net Present Value |

## 1. **INTRODUCTION**

The Department for Business, Enterprise and Regulatory Reform (BERR) is the regulatory authority for the Offshore Combustion Installations (Prevention and Control of Pollution) Regulations 2001 (PPC). Performance Improvement Energy and Emissions Ltd (PI-E2) was contracted by BERR to prepare guidance to define the requirements for an independent energy assessment, in view of its experience in carrying out over 100 assessments for both onshore and offshore facilities. The requirement to undertake an energy assessment is a condition of most offshore PPC permits.

The energy assessment should incorporate three main elements:

- Independent review of emissions of Greenhouse Gases (GHG) and other atmospheric pollutants and investigation and quantification of any potential opportunities to reduce emissions;

- Independent review of the energy usage on an asset, and investigation and quantification of any potential opportunities to avoid energy wastage; and

- Demonstration to BERR's satisfaction that the whole plant is being operated in the most energy efficient manner that is financially viable.

These guidelines primarily focus on energy efficiency, but potential impacts on carbon dioxide ($CO_2$) emissions have been used as a surrogate as this is a more measurable outcome. The main objective is to identify opportunities which, if implemented, will eventually lead to a reduction in emissions from the installation.

The energy assessment is regarded as a preliminary study to present ideas to the operator for further study and consideration, with a view to developing viable projects that will lead to emissions reductions.

## 2. **LEGISLATION**

It is generally accepted that global warming and climate change are being triggered by human activity involving the use of fossil fuels, which releases (amongst others) the greenhouse gases $CO_2$ and methane ($CH_4$) into the atmosphere. The UK is a signatory to the Kyoto Protocol, whereby most (but not all) of the industrialised nations are committed to reductions in GHG emissions at a national level.

The PPC Regulations were introduced to ensure a high level of protection of the environment as a whole, by preventing or, where that is not practicable, reducing emissions into the air, water and land. The regulations encompass controls on atmospheric pollutants such as oxides of nitrogen (NOx), oxides of sulphur (SOx) and Volatile Organic Compounds (VOCs). Under the regulations, all offshore installations with an aggregated thermal capacity of greater than 50 MegaWatts thermal (MW(th)) are required to apply for a PPC permit.

Issue of a PPC permit is subject to BERR being satisfied that the operator has addressed all the requirements under the regulations. A number of those requirements should be addressed in the independent energy assessment;

The Operator is required to demonstrate Best Available Techniques (BAT) to minimise the environmental impact of the installation. A formal and independent energy assessment is seen as a foundation stone for demonstrating BAT.

The Operator may additionally be required to provide a cost-benefit analysis with regard to the potential opportunities identified in the energy assessment report. In particular, that analysis should include the replacement of existing combustion equipment with more efficient combustion equipment and/or equipment that would contribute to the reduction of emissions of pollutant substances. The BAT assessment for potential replacement of equipment would include replacing or converting existing turbines to Dry Low Emissions (DLE) technology. The requirement for this specific cost/benefit analysis does not need to form part of the energy assessment, if that assessment has clearly demonstrated that change out of equipment is not BAT. It should, however, be noted that BERR may request a cost benefit analysis for the replacement of existing equipment to DLE at a later stage, independent of the energy assessment, based on the findings of their internal review.

The Operator may also be additionally required to provide an improvement plan, based on BERR's review of the recommendations or options detailed in the energy assessment and the findings of the cost-benefit analysis.

## 3. METHOD OF ENERGY ASSESSMENT

The energy assessment should be based around the findings of a site survey conducted on the installation, preferably during a period of normal operations. This will allow the assessor to gauge the performance of the equipment on the platform, in terms of BAT and deviation from design. There are three distinct elements to be addressed in the site survey:

- Combustion equipment (as defined in the Regulations);
- Driven equipment and any other plant (i.e. the rest of the equipment); and
- Operation and maintenance of the equipment.

A desk top study is not considered sufficient for this exercise, and it is essential that a site survey is undertaken to supplement such a study. This requirement may seem onerous when beds are at a premium, but sufficient notice of the requirement to carry out an independent energy assessment is provided by BERR in the permit conditions to plan for this eventuality. Experience has demonstrated that desktop studies generally only highlight original design deficiencies in the equipment, or where the latest technologies can be utilised. They do not highlight issues, for example, with underperforming equipment or where operational procedures could be modified to improve energy efficiency. Many ideas for improvement opportunities will come from direct engagement with the installation personnel, discussing the problems that occur; describing the procedures; and walking through the processes pointing out the problem areas etc.

Prior to the site survey, it is recommended that the desk top study should include an initial workshop with various specialists from the installation. This helps to focus the overall objectives and set expectations. It is also an opportunity to understand key issues, and to start creating the development plan.

The site survey should be carried out by specialist personnel to cover the following disciplines:

- Mechanical – turbines, compressors, pumps, heat exchangers, valves etc.;
- Process – commonly found chemical processes in the oil & gas industry;
- Controls – system architecture, configuration, tuning; and
- Monitoring – record keeping, strategies, Predictive Emissions Monitoring, stack or exhaust monitoring.

The following proficiencies should also be represented in the survey team:

- Knowledge equivalent to that of a senior discipline engineer employed by the operator;
- Working knowledge of the PPC Regulations; and
- Working knowledge of European Union (EU) Emissions Trading Scheme (ETS).

The survey team should be totally independent of the installation and operator, to ensure that they provide an impartial and objective assessment. However, it is recommended that platform personnel should contribute to the assessment, and an engineer representing the operator should be available during the survey period to answer any questions and assist with any information requirements.

Any changes to effect an improvement in energy efficiency must be in accordance with the operator’s management of change procedures. The survey team should not, therefore, recommend or request the offshore personnel to implement changes during the survey. It is always recommended that a programme should be compiled for any proposed modification, so that the effect of the change can be better measured and benchmarked.

The duration of the site survey will probably range from three to six nights offshore, depending upon the size of the installation and the information available prior to the offshore trip.

## 4. DOCUMENTATION AND INFORMATION REQUIREMENTS

The following information should be requested from/supplied by the operator prior to the site survey, in order that the assessors can carry out a preliminary onshore analysis. It is realised that some of this information may not always be available onshore.

- Process Flow Diagrams (PFD's);
- Relevant Process and Instrumentation Diagrams (P&ID's);
- Single line electrical diagram;
- Electrical load list;
- Equipment design information;
- Atmospheric emissions data;
- Listing of operational issues (e.g. Number of trips, days on diesel etc.);
- Recent daily production reports; and
- Relevant BERR permits and related documents (e.g. PPC permit, GHG Emissions Trading Scheme permit, GHG Monitoring and Reporting plans).

## 5. ENERGY BALANCE

An energy balance should be constructed for the installation. This should examine how the gross energy expended during normal operations (based on fuel used) is allocated to the main users.

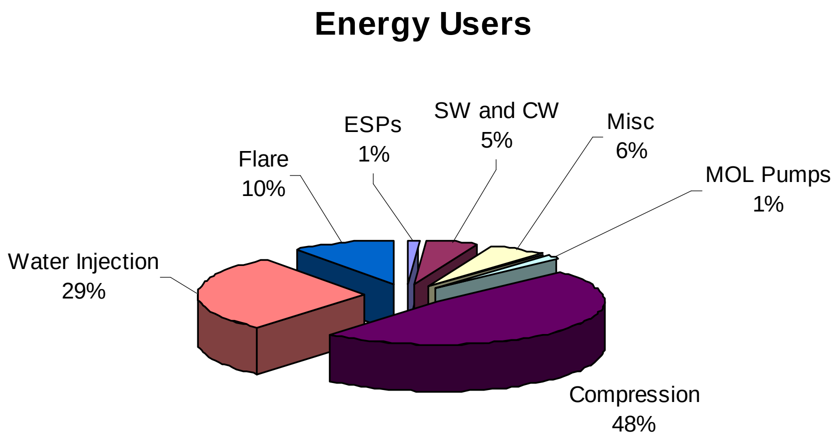
Where fuel consumption figures are not available, derivative calculations will be required to back-calculate the loads on the equipment and hence the fuel usage, based on Original Engine Manufacturer (OEM) design data or recent relevant field test data.

Areas to focus on should be:

- Total energy consumption – typical operations during visit;
- Total energy production;
- Energy users onboard;
- Electrical power users – target to identify 90% of electrical load down to 50 kiloWatt (kW) individual users; and
- Overall energy allocation.

The energy and electrical users can be shown in the form of a pie chart. This allows the main users to be identified easily. The main energy users in the example shown in Figure 1 are the flare and water injection.

**Figure 1 Generic Example of Energy Users Pie Chart**

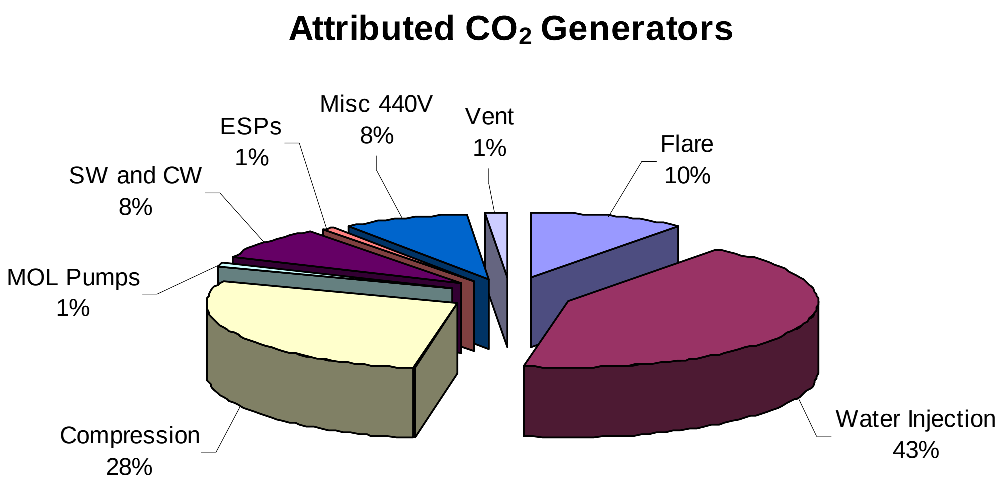



## 6. CARBON DIOXIDE PRODUCTION

Using the energy balance described in Section 5, it is possible to calculate the $CO_2$ production from the various processes on the installation. The total $CO_2$ produced based on this calculation will only be accurate if the installation is operating in normal mode. If it is not operating in normal mode, the assessor should state the deviation from normal operations and estimate the effect this has, and compensate for the effect in the $CO_2$ forecast.

A thermal model can be constructed to forecast the $CO_2$ for the year, based on expected production and gas rates. Using this model, it is possible to allocate $CO_2$ production more accurately, based on the gas turbine efficiency and the individual electrical loads. See Figure 2.

**Figure 2 Generic Example of Attributed $CO_2$ Generators Pie Chart**




It should be noted that, in some circumstances, the $CO_2$ producers chart may closely follow the energy users' chart. However, the $CO_2$ chart is still required, to provide a visual representation of the emissions and highlight differences between the two charts, for example vented gas may form a large percentage in the $CO_2$ chart.

# 7. BAT REVIEW

The BERR PPC Regulations guidance indicates that, having regard to the matters set out in Schedule 1 to the Regulations. BAT constitutes both the most advanced stages in the development of combustion plant and their method of operation, where either or both can be practically applied to reduce or, where possible, eliminate emissions to, and the effects of those emissions on, the environment. Energy efficiency is therefore an essential element of BAT, particularly where the combustion plant cannot be upgraded or replaced.

## 7.1. Combustion Equipment

This should provide an independent review of BAT for the combustion plant on the platform. The application of BAT is an integral part of the EU Integrated Pollution, Prevention and Control (IPPC) Directive, and the energy assessment report should cross reference opportunities that would result in BAT being applied where this is currently not the case.

The requirement to undertake an assessment to determine whether the existing combustion equipment should be replaced with, or converted to, low emissions or DLE equipment should be covered briefly in the BAT assessment. In cases where equipment replacement or conversion is considered to be viable, a separate detailed review and cost benefit analysis may be requested by BERR, but this would not be regarded as a component of the energy assessment.

## 7.2. Driven Equipment

This equipment is not directly considered under the PPC regulations. The main emphasis here should be to reduce the load on the driven equipment, which in turn would reduce the fuel consumption of the gas turbines or other major energy users or power providers. The energy assessment should therefore identify potential opportunities to reduce power consumption by driven equipment, which could include, for example, replacing pumps.

## 7.3. Operation and Maintenance

This should include a review of operational issues such as controls, instrumentation, and performance monitoring, and maintenance practices, to establish whether there are any “easy wins”.

## 7.4. Check Lists

There are numerous check lists published which provide an indication of BAT information for various applications. The EU BAT Reference Lists (see references) provide information on energy efficiency. Over time these check lists will be expanded through experience.

## 8. OPPORTUNITIES FOR IMPROVEMENT

The energy assessment report should provide a brief outline of the potential opportunities that have been identified during the site visit to improve the energy efficiency and minimise emissions. Although this should concentrate on the combustion equipment, it is also beneficial to identify opportunities that may reduce flare/vent emissions, even though these are not included in PPC, as they will contribute to the overall $CO_2$ profile.

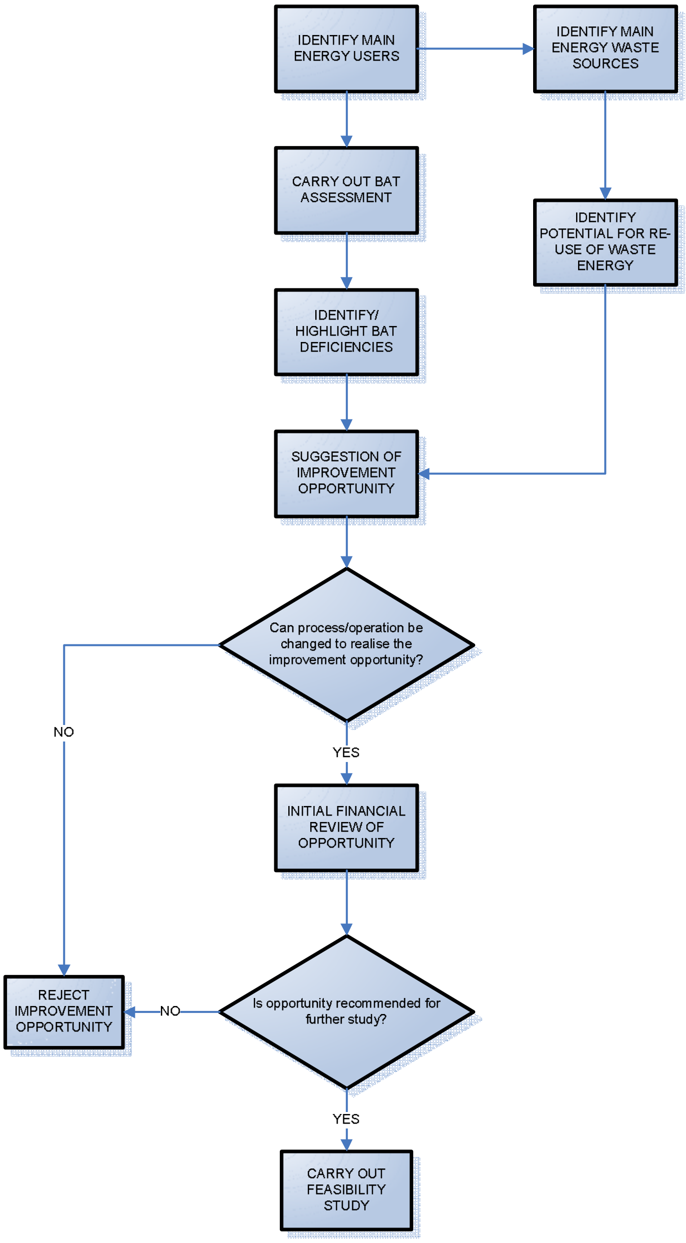
The most significant reductions in $CO_2$ production can usually be achieved for projects based around the major energy consumers. It is therefore often useful to look initially at the highest energy users to assess ideas for improvements, and to regard the smaller individual consumers as a secondary objective.

As a guide, there are three main areas which should be screened for opportunities, these are:

- Operations and controls – the way the installation is operated and controlled;
- Equipment – what equipment changes could be made to improve operation; and
- Awareness – increase awareness of energy wastage and pollution.

The opportunities can be developed further following the flow chart shown in Figure 3.

**Figure 3 Opportunity Identification Flow Chart**




Any opportunities identified which could be viewed as a production improvement, although there would be no energy saving or emission reduction, should be separately listed in an appendix to the energy assessment report. As noted above, flare and vent reduction are not covered under PPC, although flare is included in the EU ETS, and opportunities to reduce these should therefore also be detailed in the appendix of the energy assessment report. (The 'big wins' in terms of reducing flare will come from a reduction in background flaring and operation trips).

It is considered essential that all potential opportunities are discussed with and potentially endorsed by operations personnel before writing the final report, and a stand-alone workshop held onshore after the site survey is highly recommended.

The following information should be provided for each opportunity identified:

- Description;
- Capex;
- Effect on Opex;
- Production benefit;
- Ease of implementation;
- Consequential effects;
- $CO_2$ saving (tonnes/ year and value at agreed trading price);
- Mitigation costs (£/ tonne $CO_2$ reduction); and
- Means of cost benefit analysis.

It is also considered essential to consider the potential effects of any consequential modifications. For example:

- Ensuring safety of personnel and environment is not compromised;
- Interruption to production if a shutdown or slowdown is required for implementation;
- Effects on maintenance; and
- Any other effects not immediately apparent.

The Capex estimates should be a first order evaluation, based on experience and very provisional estimates. As such, the accuracy should be treated as no better than ±50%. Estimates should also be provided in relation to the value of the potential benefits. Net Present Value (NPV) and/or a low, medium and high cost/benefit Boston Chart may be used (although BERR may request a full NPV instead of the Boston Chart if a more detailed cost benefit study is requested at a later date). If the NPV method is used, the NPV of each opportunity should be estimated based on each individual operator's set discounting rate. e.g. 7% discount rate for 5 years.

Following identification of the opportunities, ranking should be undertaken to form the basis of any potential detailed cost/benefit analysis or improvement plan. It is recognised that some environmental opportunities (e.g. flare reduction) may have a negative cost / benefit.

The number of opportunities identified during an initial energy efficiency review is likely to be approximately 10 – 20 for an average offshore facility, and it is recommended that the description of each should be a maximum of two pages. More than half of these opportunities will be unlikely to proceed following operator screening, because of the cost, the technical viability or the relevance to the future production profile. The opportunities which are most likely to proceed are those that are easy to implement; have a low cost; and will result in a significant reduction in $CO_2$. An example of an opportunity description is provided in Appendix 1.

Overall the initial report is likely to be approximately 40 - 60 pages. The emphasis should be on clarity, rather than padding, and obtaining operator management approval. A typical contents listing for an energy assessment report is provided in Appendix 2.

## 9. REFERENCES

1 EU BAT Reference Lists http://eippcb.jrc.es/pages/Fmembers.htm

## APPENDIX A - EXAMPLE OF ENERGY ASSESSMENT OPPORTUNITY

## Opportunity No. 1: Optimise Compressor Anti-surge Controller to Reduce Recycling

| CAPEX | Annual Benefits (£ 000's) | | | Payback | NPV | CO2 Mitigation |
|---|---|---|---|---|---|---|
| (£)000's | Prod'n | OPEX | CO2 (t/yr) | (Years) | (£)000's | £/tonne CO2/yr |
| 25 | 514 | 0 | 10,052 | 0.04 | 2,056 | 2.5 |

Background

The installation has two parallel trains of variable speed, turbine driven compressors.

The basic duty of any surge control system is to prevent forward flow of gas through a compressor falling to a level at which surge will occur. This is achieved by testing the machine to determine the surge point at a variety of conditions, then programming the surge controller to maintain forward flow of gas at a level higher than this. The margin between the actual surge point and the surge control set point is called the surge control margin and is typically set at 10% of the actual surge flow. If the operation of the surge controls is poor or not very sophisticated, a larger margin may be required and for a well configured and tuned system being used in a relatively stable process, a smaller margin (say 5%) may be used.

The surge controllers on the installation define the surge control margin with a dimensionless parameter called the B1 value. While it is difficult to relate the B1 value to an actual surge margin flow, a typical B1 value of 20 will usually deliver a surge margin of 10% flow. In the case of these compressors, the B1 value is set at 28 for the LP compressor first stages, 29 for the LP compressor second stages and 25 for the HP compressors. These values mean that there is a certain "extra margin of safety" incorporated into the surge controls, but with the controls adequately tested and tuned, there is the possibility of reducing this extra margin and delaying the point at which the compressors go into recycle. Any such reduction in the onset of compressor recycle will have a direct impact on fuel gas consumed by the compressor turbine drives.

Since the installation gas production has decreased to the point where the compressors are starting to slip into recycle on a regular basis, it would be prudent to carry out a surge control tuning exercise and to optimise the surge margin accordingly. It should be noted that from a brief review of the surge control parameters, the surge controls appear to be fairly well tuned, but with a tuning exercise using a software-based control analyser, improved performance may be achieved. Once this analysis has been carried out, a controlled reduction in the surge margin would be a simple matter.

Proposal

Carry out a software based tuning exercise on the compressor surge controls. Once this has been done, reduce the surge control margin (the B1 value) to a more typical level.

In the long term this solution may not be sufficient and the operator should consider re-wheeling.

Ease of Implementation/ Consequential Effects

The work can be carried out on line by suitably experienced personnel with no impact to production envisaged. Approach to surge testing may be used to verify new surge control positions.

Benefits

Reduce the flow rate of gas through the compressors at which recycle starts to occur. This will deliver a direct reduction in compression power.

Financial benefits arise from a nominal reduction of 10% in the gas flow at which compressor recycle occurs. Since the LP compressor first stage and the HP compressors are recycling for extended periods of time, this saving can be achieved on both of these compressors. A saving of 10% compression power for 80% of the time is assumed for each of the compressors that are currently recycling.

## APPENDIX B – SAMPLE CONTENTS PAGE

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