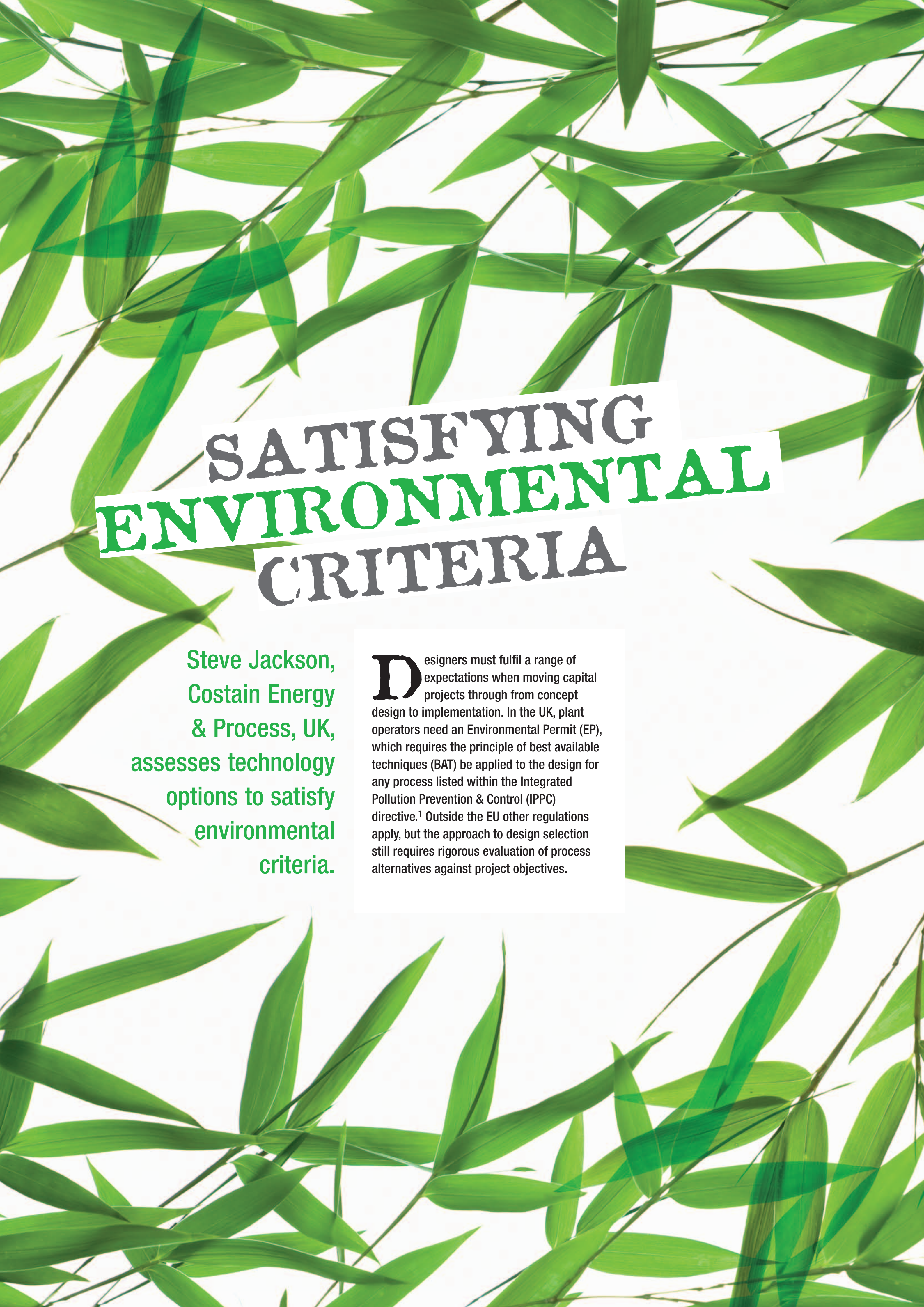

SATISFYING ENVIRONMENTAL CRITERIA

Steve Jackson, Costain Energy & Process, UK, assesses technology options to satisfy environmental criteria.

Designers must fulfil a range of expectations when moving capital projects through from concept design to implementation. In the UK, plant operators need an Environmental Permit (EP), which requires the principle of best available techniques (BAT) be applied to the design for any process listed within the Integrated Pollution Prevention & Control (IPPC) directive.[1] Outside the EU other regulations apply, but the approach to design selection still requires rigorous evaluation of process alternatives against project objectives.

This article looks at the evaluation process required to justify BAT using two examples: natural gas dehydration and volatile organic compounds (VOC) recovery from tanker loading.

Environmental design requirements

The IPPC directive defines BAT as:

- Best: the most effective technique for achieving a high level of protection of the environment as a whole.
- Available: techniques developed on a scale that allows them to be used in the relevant industrial sector, under economically and technically viable conditions, taking into account the costs and advantages.
- Techniques: includes both the technology and the way the installation is designed, built, maintained, operated and decommissioned.

Therefore, to demonstrate BAT the process designer must understand all environmental aspects associated with a process, how important these are, where process options affecting environmental impact are available and how the 'best' option can be determined.

Figure 1. UK gas processing plant adjacent to SSSI.

Figure 2. Rural setting for the construction of a new UK gas processing facility.

The environmental review process

To ensure that BAT can be demonstrated for the final plant design, environmental aspects must be considered from the first stages of design work. To ensure this is effectively carried out, plant designers must understand the assessment principles involved, ensure these are effectively applied throughout the course of a project and transmitted into the detailed design specification.

The environmental review process should include:

- Identify and understand available design options.
- Identify environmental aspects.
- Quantify environmental impacts.
- Compare options and identify BAT.

Identifying available design options

When developing a BAT justification, a review of all technology options must be made. Often, a number of possible technologies can be ruled out with a high level review if strong arguments can be presented. A more detailed review is required for a final decision between the selected options.

Guidance on BAT identification is provided by the Environment Agency (EA) and the European Commission in the form of technical guidance notes (TGNs) and BAT reference documents (BREFs). The industry specific versions of these documents provide examples of available techniques, and guidance on which ones are considered BAT. Reference to these documents may be enough to justify some elements of a design for simple systems, but where the alternatives considered are complex, a more detailed justification should be made.

Identifying environmental aspects

An important step towards a sound design (that is in line with BAT requirements) is to carry out an environmental impacts identification (ENVID) assessment. This forms the basis for further evaluation work and helps to highlight where detailed BAT justification work is required. It can also be used to identify environmental aspects that can be considered insignificant and where the proposed design will be in line with BAT requirements without needing detailed justification.

An important use of the identification process will also be to identify aspects of the design that are 'unknowns', which must be highlighted for further consideration. The ENVID review should act as a mechanism to highlight where further information is required so that the importance of all environmental aspects can be quantified.

Quantifying environmental impacts

Quantification of direct environmental impacts should be carried out as part of the ENVID review closeout work. Quantification is generally made by comparison against environmental benchmarks such as Environmental Quality Standards (EQSs) and/or Environmental Assessment Levels (EALs). This can often be carried out using simple techniques to model the impact of a release of a particular pollutant. Where simple techniques show the impact is 'insignificant' compared to an EQS or EAL, no further work may be required.

In the case of indirect impacts such as global warming potential (GWP), absolute quantification is not as straightforward. However, a relative comparison between the impacts associated with different options is an alternative approach that can be applied.

Comparing options and identifying BAT

EA guidance on options appraisal for BAT justification is provided in the H1 TGN.[2] The steps required in this assessment are:

- Rank options according to their environmental impact.

- Identify the option with the least environmental impact.
- Select the option with least impact or make a justification based on costs versus benefits.
- Resolve any cross media conflicts between options.

A BAT report summarises this process and provides a commentary on the justification for the final ranking of options. Justifying the basis used to compare cross media effects is especially important, as such comparisons can be complex.

Cost benefit analysis is required if the option with lowest overall impact is not considered to represent the BAT option. This analysis is necessary if high costs give a small marginal reduction in environmental impact. Guidance on the general structure of this analysis is also provided in the H1 TGN. A cost benefit analysis is not needed if the option with the lowest overall environmental impact is either the lowest cost option or is selected for some other fully justified reason.

Example 1: vapour recovery unit

The example assessment is for a vapour recovery unit (VRU) collecting vapour from an existing crude tanker loading facility.[3]

Identify available design options

Available techniques for benzene and VOC vapour recovery include: condensation, adsorption, absorption and membranes. In this example an initial high level review was used to obtain a short list for further detailed assessment comprising the following processes:

- Condensation against a liquid refrigerant.
- Adsorption on a carbon bed with vacuum regeneration and crude oil absorption.
- Absorption directly into crude oil with membrane separation on the tail gas.

Figure 3. UK VRU project.

Figure 4. UK gas plant with glycol dehydration.

Identify environmental aspects

The environmental aspects associated with these processes can be identified as: continuous emissions to air/deposition to land, accidental release, energy consumption (GWP), VOC release leading to photochemical ozone creation potential (POCP) and waste disposal.

Quantify environmental impacts

Dispersion modelling was carried out to identify the impact of each process on local atmospheric concentrations of benzene and VOCs. When combined with local air quality information and compared against the relevant benchmarks, this analysis indicated that the environmental impact of the condensation and carbon bed processes could be considered insignificant and that the crude oil absorption would require further detailed modelling to fully assess the impact.

Accidental release of process fluids from the VRU was a possibility for all options if a fire could cause relief valves to lift. In addition, accidental release due to compressor maloperation is possible for the crude oil absorption and condensation processes. However, for all cases the environmental risks were assessed as low.

Quantification of the associated POCP and GWP for each process was made using a conversion factor for electrical power consumption and showed the highest impact for condensation and the lowest for adsorption.

No significant environmental impact was foreseen in terms of waste disposal for all options.

Comparison of options

Based on benzene emissions, the crude oil absorption process was identified as having a substantially higher impact on local air quality than the other two options.

The impact of the release of greenhouse gas was considered to be low for all options as the total GWP of the new facilities represents only a small fraction of the total site contribution. The impact of waste disposal was also considered to be low for all three options.

The POCP score for all options was not considered to be a significant differentiating factor between the options because the VOC recovery from all schemes is relatively high.

BAT summary

Although the impact of both the carbon bed and condensation schemes are considered to be low overall, the carbon bed has less impact on local air quality, due to lower benzene levels and it consumes less power, giving a lower GWP. As both schemes have similar costs, carbon bed adsorption was identified as the BAT option.

Example 2: dehydration unit

The example assessment is for a dehydration unit drying gas to achieve National Transmission System specifications, located in greenfield development.[4]

Identify available design options

Gas dehydration processes are: adsorption (silica gel/molecular sieve), absorption (glycol) condensation, membrane separation and Twister supersonic technology.

There is no fixed pressure driving force available in this case, so Twister and condensation schemes based on Joule-Thomson effect or turbo expander cooling are not practical. Condensation schemes based on mechanical refrigeration with inhibitor injection require inhibitor regeneration in addition to a mechanical refrigeration package, which in this case offers no advantage over glycol absorption. Membrane schemes effect a bulk separation and are only suitable for much lower flowrates than the one considered.

Of the remaining options, silica gel adsorption offers lower energy consumption than molecular sieve alternatives. Therefore, a short list of silica gel and glycol dehydration can be taken forward for detailed consideration.

Identify environmental aspects

Environmental aspects in common for both selected schemes include: release to atmosphere (VOCs and combustion products), energy consumption (GWP), waste treatment and waste disposal. Glycol dehydration has special consideration due to potential release of benzene and VOCs to atmosphere from the regeneration gas system. For silica gel, a wastewater stream containing hydrate and corrosion inhibitor will be produced.

Quantify environmental impacts

Both schemes include a fired heater for regeneration. Preliminary dispersion modelling for combustion products shows that emissions will not represent a significant impact on local air quality, therefore this aspect will not be a key differentiator between options.

For glycol dehydration, the VOCs and benzene released from the regeneration system can be recovered to the regeneration heater and incinerated, thus eliminating any significant impact. Both units contribute to fugitive releases of VOC from pipework and valves, but the overall impact of this will be low given the implementation of BAT principles to the selection of sealing techniques.

For silica gel adsorption, a continuous flow of wastewater will be produced. Methanol from this stream can be reclaimed on site, but the remaining wastewater containing hydrocarbons and corrosion inhibitor will require offsite disposal. A glycol unit also generates waste streams, normally as a result of maintenance activity, but the volume generated will be much lower.

In this example the silica gel scheme consumes roughly double the energy required for the glycol dehydration scheme. As a result, the environmental impact in terms of GWP is a significant differentiator between the two schemes.

BAT summary

Overall, the environmental impact of both schemes is relatively low. BAT justification of glycol absorption can be made based on the relative performance of the two schemes in terms of energy consumption and waste generation. In addition, the use of glycol dehydration allows the selection of a more environmentally benign glycol based hydrate inhibitor, and this reduces the impact of any accidental release of process fluids.

Conclusion

The two examples presented above give an outline of how BAT principles can be used to select between process technology options.

It is important to remember that each of the two process units considered also contain many equipment items that have design alternatives with varying environmental impact (e.g. control valve selection). As part of the environmental review process for a complete plant design, all available technology and equipment options should be understood and BAT principles applied.

Regardless of the methodology applied in the environmental review process, the important steps that need to be followed include: identify and understand the alternatives and their environmental aspects, quantify the impacts, carry out an effective comparison of technology options and conclude with a robust BAT justification including cost benefit analysis when required.

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