ENVIRONMENTAL IMPACT ASSESSMENT

Teaching the Principles and Practices by Means of a Role-Playing Case Study

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Environmental impact assessment (EIA) is an important technique to help ensure that all the likely environmental effects of a new development are understood and taken into account before permission to proceed with a development is given. The governing legislation varies from country to country. In the USA, the 1969 National Environmental Policy Act (NEPA) requires that an EIA must be carried out for federally funded projects likely to have an impact on the environment. This policy set the precedent for European legislation (EC Directive 85/337). In the UK, the most recent regulations are Statutory Instrument 1999 No 293 (The Town and Country Planning [Environmental Impact Assessment][England and Wales] Regulations 1999) available from the HMSO web site at <http://www. hmso.gov.uk/si/si1999/19990293.htm>.

Since many developments in chemical engineering undoubtedly have the potential to create significant environmental impacts, EIA should form a key component of the undergraduate chemical engineering curriculum. Suitable texts are Wathern,[1] Petts and Eduljee,[2] Kreske,[3] Marriott,[4] *etc*. Environmental Impact Statements (EISs) to illustrate teaching are readily available in the public domain and for the USA are listed on the EPA Office of Federal Activity's web site <http://www.epa.gov/compliance/nepa/current/index.html> by date of distribution. A keyword search for environmental assessment information can be completed by searching the Federal Registry at <http://www.epa.gov/fedrgstr/index.html>.

Role playing provides an opportunity for students to understand in a practical way that there can often be opposing views on the impacts arising from a particular development. An ideal way of teaching the importance of understanding all viewpoints is to create an adversarial situation in which key issues of a proposed development can be researched and debated. Clearly, the most meaningful debates not only center around controversial issues, but also involve participants from a wide variety of backgrounds with a wide range of viewpoints. To facilitate this, a group of chemical engineering students (around 15) in the final year of their MEng program at the University of Bath is joined by a similarly sized group of students from an MS program in Environmental Science, Policy, and Planning.

The MS students bring to the case study a broad range of educational backgrounds that includes biology, chemistry, business management, estate management, environmental science, European studies, geography, geology, health education, mathematics, physics, psychology, zoology, *etc*. They strengthen the role-playing case study since they bring a much broader range of personal opinions, as well as expertise, than would come from chemical engineering students alone, who

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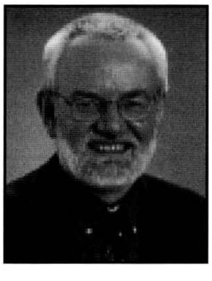

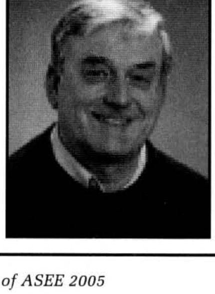

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tend (quite naturally) to be in favour of any development being made within their own discipline. If the case study were to be run with only ChE students, it would be necessary to provide additional teaching and time to allow them to take on roles that are outside the normal scope of chemical engineering.

In view of the complexity of environmental regulations, the role-playing case study would be strengthened further if law school students could also be involved. The two instructors at Bath are both experienced in environmental legislation and in giving expert opinions. Indeed, one has an educational qualification in law and is a coauthor of three EISs, including one on the regeneration of GAC. Both instructors teach on a parallel Environmental Legislation module.

AIMS AND OBJECTIVES

The educational aim of the Environmental Impact Assessment module (an elective) at Bath is to develop a deeper understanding of environmental, technical, and social issues associated with the preparation and defense of an environmental impact statement for a chemical (or bioprocess) development. For the student, the learning objective is an ability to critically analyze the content of an environmental impact statement and to prepare the outline of an expert opinion. It is not a learning objective for students to be able to actually prepare an EIA.

Of the 167 hours involved in this double module, the majority (147) are assigned to private study, while 15 are given to the role-playing exercise and 5 are devoted to tutorials and seminar support by two senior members of the academic staff. While at the final-year MEng and MS levels, students at Bath are expected to work in a substantially independent manner; their work on EIA is nevertheless supported beyond the required hours by almost unrestricted access to both the library learning facilities and the two instructors.

THE CASE STUDY

The case study concerns a planning appeal for a proposed development to regenerate granular activated carbon (GAC), which is used in packed beds to remove triazine pesticides (such as atrazine and simazine) from drinking water. The removal of pesticides is the duty of the regional, private water companies. Once spent, the GAC must be regenerated because it is too expensive and environmentally unsatisfactory to be disposed of in a landfill. Thermal regeneration is the most commercially viable technology for removing organic contaminants from GAC to a level where it can be safely returned for reuse in water-treatment works. For economies of scale, GAC regeneration plants are built in only a few locations strategic to a number of water-treatment works in which the pesticides are removed. Thus, the spent and regenerated GAC must be transported as an aqueous slurry in tankers to and from the regeneration plant. No one can dispute the need to provide wholesome drinking water. On the other hand, both the technology (involving combustion) and the siting of the thermal regeneration plant is often controversial. To many observers, a thermal regeneration plant with its chimney is viewed as nothing other than an incinerator.

TABLE 1
Six Environmental Issues

- Emission of carbon monoxide, hydrogen chloride, oxides of nitrogen, particulates, and dioxins
- The possibility of the GAC being contaminated by polychlorinated biphenyls
- The increase in traffic on a minor access road
- Access to and from the site by large articulated trucks (carrying the GAC) at a very busy junction with a main highway through a residential district
- Alternative sites for the regeneration plant, including the "do nothing" option
- Visual impact

The case study involves an appeal by a GAC regeneration company against an adverse planning decision made by a local authority. The principal reason for using an appeal is that the case study becomes adversarial since the local authority must defend its original decision in the appeal. The appeal process thereby demands that both sides of the argument must be debated unless prior agreement can be reached by the two principal sides (the developer and the defendant).

The original planning application was to build two 17.5 tonne/day thermal regeneration plants in a common building on unused low-quality industrial land owned by the company. The site is in close proximity (about 300 m) to a residential housing area, an old but operational iron foundry, and a relatively modern metal fabrication factory in a heavily populated region of the UK. The land was previously used for effluent treatment and the sewerage connection to a modern treatment facility remains in existence.

In the case study, the local authority refused planning permission for the development because inadequate attention had been paid in the original Environmental Impact Statement to six environmental issues (shown in Table 1). Each of these issues is debated in the appeal, and other aspects surrounding the issues, such as industrial accidents, are naturally drawn into the debate. The environmental and health risks center around the six issues in Table 1. Thus, for example, the uncertain, controversial, and emotional aspects associated with the impact of dioxin releases on human health, animals, and the food processing factory are researched and debated by the students.

The GAC thermal regeneration process is a waste disposal and recycling process that is prescribed by the UK's Environment Agency for Integrated Pollution Control (IPC, to be superseded by Integrated Pollution and Prevention Control

(IPPC)). While the agency's Guidance Note S2 5.03[5] describes matters relating to what must be done in order to obtain an authorization (permit) to operate, the contents of this 21-page document provide substantial information on what would constitute an acceptable design. Students are informed that conformation with provisions in this document does not, by itself, constitute sufficient grounds to win the appeal. This is because an authorization (permit) to operate can only be granted if permission to build the plant has been granted in the planning process.

THE GAC THERMAL-REGENERATION PROCESS

A simplified process-flow diagram is shown in Figure 1. Students are provided with a more detailed diagram. GAC granules are typically 0.5-1 mm in size and are probably loaded to no more than 30% by weight with organic matter, of which only a very small fraction is pesticide (about 10 μg/kg of GAC). Each of the two 17.5 tonne/day plants is planned to operate continuously between periodic shut-downs for maintenance. Between three and six purpose-built 38-tonne road tankers would arrive at and leave the GAC regeneration plant each working day, excluding weekends. The incoming carbon slurry is pumped to a bulk water-carbon separator located at the top of the regeneration furnace, which is of the multiple-hearth type.

The cylindrical, refractory-lined steel shell of the furnace carries a series of refractory hearths one above the other. A revolving central shaft, with attached rabble arms, sweeps the carbon from the inlet port on the outside of the top hearth to the center, where it drops onto the hearth beneath. It is then rabbled to the outside and falls to the next hearth, and so on. The upper hearths form a heating zone where water and volatiles are driven off. The carbon regeneration and reactivation occurs on the lower hearths under a controlled range of temperature and composition conditions. Steam and some air are added as required so that the combustion conditions are non-oxidizing and the atmosphere contains significant concentrations of carbon monoxide. Red hot regenerated GAC falls from the bottom hearth into a water-quench tank, from which it is pumped as a slurry into road tankers to return to the water treatment facility.

Gases leaving the top of the regeneration furnace pass directly into a separate afterburner that is designed to operate with an outlet temperature of 850°C. The afterburner contains natural gas burners and an excess of air to create 6% by volume of oxygen at the outlet. The residence time of gases in the afterburner is set to be two seconds, conforming with information in the Environment Agency Guidance Note.[5]

The process is designed not only to generate all the steam, which must be injected into the furnace, but also to put sufficient energy into the gases entering the base of the stack in order to ensure that the plume leaving the stack is invisible except for the occasional appearance of water vapor in exceptional meteorological conditions. The gases leaving the afterburner pass through a waste-heat boiler and then through a heat exchanger in which air is heated prior to injection into the stack. This air (which is not in contact with the GAC being regenerated) is taken from the hot central shaft of the multiple hearth furnace.

Gases leaving the energy recovery unit pass into a venturi scrubber (to remove particulates) and then to a trayed scrubber (to remove acid gases) before passing into a 20-m stack via an induced draft fan. The fan provides for a pressure slightly below atmospheric throughout the process and does not allow carbon monoxide to escape from the multiple-hearth furnace. Should the fan cease to operate for any reason, then (after some predetermined time as the pressure increases) the emergency by-pass stack would open, an alarm would be sounded, and the plant would automatically go into shutdown. During this period, of course, the contents of the multiple-hearth furnace would burn, thereby releasing gases into the atmosphere that had not passed through the gas-cleaning parts of the process. This aspect is inevitably one of the more hotly debated aspects in the case study.

The benchmark release levels set by the Environment Agency[5] are given in Table 2. They are not emission limits.

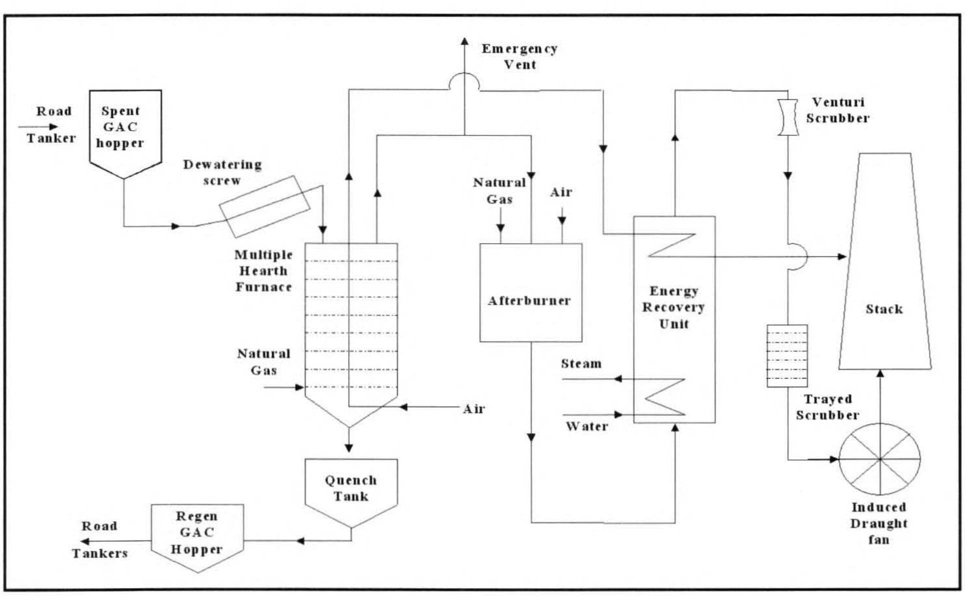

Figure 1. *Schematic of the granular activated carbon regeneration process.*

They are values that are subject to consideration of site-specific environmental issues by the Environment Agency when framing conditions in an authorization (permit) to operate. The Guidance Notes state that the emissions of polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) should be reduced as far as possible by progressive techniques. The aim should be to achieve a guide International Toxicity Equivalent (ITEQ) value of 0.1 ng/m^3.[5] Controversy is introduced into the case study by including some fictitious emission data from a similar plant showing that some of the benchmark levels of carbon monoxide and dioxins are periodically exceeded.

THE ROLES AND THE TIMETABLE

Typical roles for the students, together with the written (and assessable) material each must produce, are shown in Table 3 for both the GAC Carbon Company (the appellant) and the local authority (the defendant). The full range of environmental issues is covered with matching experts on opposing sides, thereby helping to ensure lively debate on all the issues in Table 1. In addition, two students take the roles of lawyers, two students act as journalists (one for a local newspaper, the other for a national newspaper), and the remaining students take third-party roles that include, among others, the chairperson of a local environmental pressure group, a professional chemist residing in the area, an elderly resident, and a lawyer acting on behalf of a local food-processing company.

TABLE 2
Environmental Agency Benchmark Release Levels to Air

Substance	*Achievable*
• Total particulate matter	20 mg/m^3
• Hydrogen chloride	30 mg/m^3
• Sulphur dioxide (as SO_2)	50 mg/m^3
• Oxides of nitrogen (as NO_2)	350 mg/m^3
• Carbon monoxide (after last injection of air)	50 mg/m^3
• Volatile organic compounds	20 mg/m^3
• Dioxins and furans (International Toxicity Equivalent - ITEQ	1 ng/m^3
• Smoke	Free from smoke during normal operation and within five minutes of start- up

The ChE and MS classes are divided more-or-less equally between the three groups, so that each side can bring expert opinions on the full range of subjects and facilitate the required debate. Thus, for example, a chemical engineering expert for the appellant would provide an expert opinion on the technology with which emissions will be abated on the proposed GAC plant, while a technology expert for the defendant would try to expose weaknesses in the appellant's proposed technology. Quantitative work is required of many experts. For example, either new calculations or checks on the values in the Environmental Impact Statement (EIS) would be carried out on the emission and dispersion of gases, particulates, and dioxins released through the emergency vent. This is a very difficult area for debate, not only because the frequency with which the vent opens is ill-defined but also because rather uncertain estimates have to be made for the quantity and duration of each emission. Working in this way, in areas of uncertainty, is a thought-provoking exercise for ChE students.

The appellant and defendant teams are provided with separate offices to maintain confidentiality but the press officers publish daily releases for the benefit of the opposing side, the journalists, and the third-party group. The journalists try to get interviews to help them prepare their daily articles. Daily press releases and newspaper articles are posted on a notice board for all to read.

TABLE 3
Roles for the Appellant and Local Authority

Appellant	*Local Authority*	*Material to be submitted*
Lawyer #1 (barrister/advocate)	Lawyer #2 (barrister/advocate)	Opening and closing statements
GAC company project engineer	Engineering consultant	Statement on process technology
Engineering consultant #1	Engineering consultant #8	Statement on PCBs
Engineering consultant #2	Engineering consultant #9	Statement on dioxins
Engineering consultant #3	Engineering consultant #10	Statement on particulates
Engineering consultant #4	Engineering consultant #11	Statement on CO
Engineering consultant #5	Engineering consultant #12	Statement on HCl
Engineering consultant #6	Engineering consultant #13	Statement on N_{ox}
Engineering consultant #7	Engineering consultant #14	Statement on water quality and pesticides
Planning consultant	Deputy Chief Planning Officer	Statement on land quality, planning, and transport
Press Officer #1	Press Officer #2	Series of press releases

The case study runs over a two-week (full-time) period commencing on a Monday morning when students select their preferred roles. Students acting as experts then have one full week to research their roles and to become experts. During this period, the two lawyers guide their teams in preparing thorough and expert cases. At a set time during the Monday of the second week, the expert statements are exchanged. Between this exchange and early Wednesday morning, each side needs to determine how to counter the now-declared, opposing arguments and the lawyers need to prepare their opening statements. The two instructors assist the appellant and defendant groups in developing their research and arguments, as well as advising what constitutes good practice in an expert opinion.

The appeal is formally held on the Wednesday and Thursday of the second week in a room that is laid out in the style of a courtroom. Each expert, in turn, is led through his/her expert opinion by his/her lawyer and then is cross-examined by the opposition lawyer. If the expert has experienced a difficult cross-examination, another chance is given for re-examination. The two lawyers finally present their closing statements.

The two instructors sit in judgment over the appeal process (and can ask questions of the experts to clarify points made), but they do not make a final decision on the Thursday as to whether or not the appeal should be upheld; this reflects UK practice whereby further research might be required before the final decision is made by the appropriate Government department.

MATERIALS SUPPLIED TO STUDENT GROUPS

Several documents are provided in order to enable the student groups to prepare their expert opinions and for the lawyers to prepare their arguments. The principal document is an adaptation of the original Environmental Impact Statement (EIS), an 85-page report containing a six-page nontechnical summary, together with descriptions of the proposed development, measures proposed to abate pollution, residual environmental impact, benefits to the local community, and appendices comprising site plans, a survey of flora and fauna, likely conditions to be imposed on discharges to sewer, air-emission surveys from a similar plant already in operation, dispersion calculations from the chimney and emergency vent, drawings of the building elevations, and a noise survey. The original EIS has been adapted firstly to avoid using references to actual company and individual names, and secondly to bring it up to date in terms of the new European IPPC legislation. The EIS is supported by a 20-page document containing maps, plans, and photographs of the area before development. The scale of the maps ranges from 1:625,000 (showing the location of the site in the context of the UK and its major highways) to 1:5000 (showing the proposed site and its neighborhood in detail).

Other documents supplied include the IPC Guidance Note,[5] a practical guide to IPC,[6] a guide for incorporating environmental assessments into chemical engineering projects,[7] a guide for assessing releases to the environment,[8] and a guide on discharge-stack heights for polluting emissions.[9] Students are also shown examples of written expert opinion and provided with specialist references to aid research in their roles as experts.

ASSESSMENT

Each student submits the written material required for each role (some of which is listed in Table 3) as well as a 1000 word critique, which identifies the strengths and weaknesses of both sides in the appeal. The overall assessment is divided equally between the two. No attempt is made to assess oral activities. Assessment of the role-playing material is subdivided equally into quality of presentation, content, structure, originality, and conclusion in the context of the role played. The second submission is a critical evaluation of the strengths and weaknesses of both sides to the appeal. This reflective exercise is set to be the same for all students; its assessment is subdivided equally into quality in setting out aims, degree of impartiality in reflection, quality of arguments, quality of conclusion, and quality of English and presentation.

CONCLUSION

A lively review and feedback session is held at the end of the second Friday. Refreshments are provided and discussion centers around both the quality of the technical arguments and the emotional aspects of cross-examination. Informal and written feedback from the MEng and MS students confirms that not only is the role-playing case study a most enjoyable way of learning the subject, but it also provides a firm basis for the need to understand all sides to the argument on environmental issues.

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