May you now guard Science's light
Kindle it and use it right
Lest it be a flame to fall
Downward to consume us all

CAROL MARTIN

SEE ALSO *Science, Technology, and Literature.*

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# BRENT SPAR

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The Brent Spar was an oil storage buoy built and owned by Royal Dutch Shell (Shell Oil) in 1976. The spar (or large cylindrical storage buoy), 147 meters tall, was used in the North Sea to temporarily store crude oil. A new pipeline made the spar unnecessary and over time Shell Oil chose to dispose of the spar by sinking it in deep water off the west coast of Great Britain. During the mid-1990s this proposal became a major environmental issue in Europe.

## Disposal Options

Sinking was the cheapest (approximately $18 million) and safest option for the workers who would be performing the task. Other options, however, existed. At a greater expense, the spar could have been refurbished to perform other functions. At two to four times the cost of sinking it, the spar could have been cleaned and dismantled, with the steel then recycled. Dismantling operations, however, posed up to six times more risks to workers and the immediate coastal environment where the dismantling would be performed.

Shell Oil chose to dispose of the spar in more than 2 kilometers of water and received permission to do so from the British government in 1994. Both Shell Oil and the British government agreed that the potential damage to the local environment from oils, waxes, and other materials still inside the spar would be limited to the immediate area and that the impact would be short lived.

In April of 1995, Shell Oil began towing the Brent Spar to its deep-water burial at which time protesters associated with Greenpeace boarded the platform. The protesters demanded that Shell Oil cease its dumping plan in favor of what they contended were more environmentally benign choices and argued that disposal at sea was wrong on principle. Greenpeace and other environmental groups called for the boycott of Shell Oil gas stations across Europe and in some places sales at those stations fell by half. Two such stations in Germany were attacked with fire bombs.

On June 20, 1995, due to intense public pressure and negative publicity, Shell Oil temporarily halted its deep-sea disposal operations. Over the following years, the company evaluated a number of different disposal options, finally dismantling the Brent Spar in a deep bay in Norway, beginning in January 1998. Sections of the spar were recycled in the construction of a new ferry terminal in Norway. Total disposal cost was approximately $96 million.

During the protests, Greenpeace claimed the spar contained large amounts of dangerous chemicals that would cause serious harm to the environment. Shell Oil and the majority of independent scientists argued that deep-sea disposal was in fact the safest option. After the decision to cancel the disposal in 1995, Shell Oil hired an autonomous firm, Det Norsk Veritas, to assess the alternatives. The firm determined that the actual amount of residual oil and some heavy metals still inside the spar was slightly higher than originally claimed by Shell Oil, but significantly lower than the amount claimed by Greenpeace. Media reports discovered other inconsistencies in the organization's arguments. Greenpeace was successful in stopping the disposal operation, but lost legitimacy after its story began to unravel. The debate also left Shell Oil's reputation with the public significantly damaged.

## Ethical and Policy Lessons

The Brent Spar incident has a number of ethical and policy implications. Disposal of the spar could have set a precedent for disposal of other oil facilities, and potentially caused environmental damage. Some argued that Shell Oil's risk-benefit analysis could not adequately gauge the effects of disposal. At issue was the company's ability to determine environmental harm versus its bias toward monetary benefits to it and its shareholders.

Furthermore some saw trade-offs between harm to the environment and benefit to the company as completely illegitimate and nonfungible. The feasibility of the business ethic of the triple bottom line of business, society, and environment, in which corporations consider all three outcomes in their decision making, was also at stake.

Finally a number of ethical issues arise concerning the dialogue itself. Did Greenpeace have standing to protest a legal action by Shell Oil? Was Greenpeace a legitimate speaker for the environment? Was Shell Oil obliged to speak with different stakeholders or groups, and what process should the company have pursued? These questions highlight the difficulty of convening legitimate, representative groups, and carrying out group decisions when all parties are free to opt out or otherwise dissent.

The saga of the disposal of the Brent Spar combined debate over scientific information with a political dispute over environmental values. Greenpeace was able to use inaccurate scientific information to buttress an ethics argument against dumping waste in the sea. It also argued that dumping the spar would allow Shell Oil to avoid the full cost of the spar's use and disposal. Shell Oil disputed the scientific information Greenpeace presented, but failed to adequately counter the ethics argument. The public and media largely failed to grasp the scientific dispute, and sided with Greenpeace on ethical grounds. The Brent Spar incident illustrates the difficulty of introducing scientific evidence into essentially political arguments.

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SEE ALSO *Engineering Ethics; Environmental Ethics; Nongovernmental Organizations; Oil.*

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# BRIDGES

Bridge building as a human activity predates recorded history, and bridges are among the earliest structures described in the historical record. In the fifth century B.C.E. Herodotus reports on a bridge over the Euphrates River made of timber resting on a stone foundation. Roman stone bridges at Segovia (Spain) and Nîmes (France) are still standing 2,000 years after their construction. In the Middle Ages, bridge building became the province of specialist monastic orders. Medieval bridges were conceived as places to live, not just as a means of passage from one side of a river to another. London Bridge in 1594 supported 100 houses and shops.

## Bridge Engineering

In the nineteenth century, bridge building became a scientific discipline, after a backlash brought about by notorious disasters in which bridges failed to endure mathematically predictable loads. A fascinating 1887 monograph by George L. Vose (1831–1910) reflects the period in which bridge building crystallized into a scientific and mathematical discipline. Vose complained that any charlatan could proclaim himself a bridge builder and find customers, while ignoring the mathematics that made the calculation of safety margins simple. "There is at present in this country absolutely no law, no control, no inspection, which can prevent the building and the use of unsafe bridges" (p. 12). He pointed out that the science of bridge loads was well understood: A dense crowd of people creates a load of up to 140 pounds per square foot, while soldiers walking in step double the strain; snow and ice can create a load of 10 to 20 pounds per square foot, while heavily loaded freight trains can create a strain of 7,000 pounds per square foot.

Vose was a pioneering proponent of safety margins. He argued that bridges should be designed to carry a load four to six times greater than the actual loads they are likely to carry under any foreseeable circumstances. Many existing bridges did not meet these standards; some, in fact, were capable of carrying only the predictable load. Of these, Vose acerbically noted that such a bridge is warranted "to safely bear the load that will break it down" (p. 55). The country, in his estimation, was full of highway bridges "sold by dishonest builders to ignorant officials" and awaiting only "an extra large crowd of people, [or] a company of soldiers" to collapse (p. 16).