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The costs of failure: A preliminary assessment of major energy accidents, 1907–2007

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Abstract

A combination of technical complexity, tight coupling, speed, and human fallibility contribute to the unexpected failure of large-scale energy technologies. This study offers a preliminary assessment of the social and economic costs of major energy accidents from 1907 to 2007. It documents 279 incidents that have been responsible for $41 billion in property damage and 182,156 deaths. Such disasters highlight an often-ignored negative externality to energy production and use, and emphasize the need for further research.

Keywords: Energy accidents; Externalities; Disasters

1. Introduction

On a quiet school day afternoon in March 1937, hundreds of students were preparing for the final hour of class in New London, Texas. A few minutes before the last bell, an undetected natural gas leak caused an explosion that completely destroyed the Consolidated High School and killed 294 of its students. On top of the wreckage, someone had scribbled in chalk the following words on a broken blackboard, written before the explosion:

> Oil and natural gas are East Texas' greatest mineral blessings. Without them, this school would not be here, and none of us would be here learning our lessons. (Castaneda 2004, pp. 214–215)

The story of such a tragedy brings into focus at least two important lessons beyond its irony. For one, it reminds us that natural resources bring with them great social and economic promise, providing financial growth for communities and energy services for local economies. Secondly, it also forces us to remember that the infrastructure currently in place to deliver energy services to society can surreptitiously breakdown, and in rare circumstances destroy the very communities it intends to serve.

Energy accidents represent a fundamentally different type of risk: they are systemic, recurring, and cumulative in nature. Given the energy intensity of modern lifestyles, major energy accidents like the New London disaster differ from calamitous events such as 11 September or the *Challenger* disaster precisely because they are common. Energy accidents are more analogous to traffic fatalities, deaths from smoking tobacco, and skydiving than large and singular catastrophes. They have become a more common theme as cultures embrace electrification, industrialization, economic growth, and higher standards of living.

This article, however, investigates one unintended consequence of such development by focusing on major energy accidents. It offers a more systematic assessment of the social and economic costs of failing energy infrastructure from 1907 to 2007. The article begins with a discussion of the study's research methodology before highlighting why large-scale energy technologies are prone to failure. Then, it documents 279 major energy accidents in the coal, oil, natural gas, hydroelectric, renewable, and nuclear sectors over the last century. It concludes that such disasters have been responsible for $41 billion in damages and 182,156 deaths.

A discussion of the social and economic costs of energy accidents is important for three interconnected reasons.

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First, while analysts and scholars have crafted dozens of indices to measure strengths and weaknesses of the energy sector—from energy intensity and dispersion of various airborne pollutants to kilowatt hours sold and amounts of imported fuel—none have yet cataloged even a rudimentary inventory of major energy accidents that looks beyond individual technologies (Brown and Sovacool, 2007). The Nuclear Regulatory Commission, for example, provides an excellent list of nuclear reactor incidents but focuses on nothing else, and the National Transportation Safety Board compiles extensive data on pipeline spills and failures but not on hydroelectric facilities or coalmines.

Second, economists often talk about the "externalities" associated with energy production and use. Externalities refer to costs (or benefits) not fully internalized or priced by the existing market system. When describing such externalities, however, most studies have focused on the impacts of smog, nutrient deposition, acid rain, and global climate change on agriculture, forestry, fisheries, recreation, water resources, wildlife, and human health. Such studies sometimes mention "energy accidents" as a type of externality, but seldom explore the topic in detail. This study is an attempt to reflect more fully on the costs energy accidents inflict on society and the economy.

Third, accidents need not be an inevitable feature of the modern energy landscape. The frequency of major energy accidents depends greatly on how communities and countries manage their energy resources. Thus, exploring "where" and "when" energy accidents have occurred offers a much-needed first step towards then asking "why?" and "under what conditions?" In his work on how humans experience catastrophe, Richard A. Posner (2004) remarks that most of us express a "psychological asymmetry" towards disaster enabling us to distance ourselves from tragic events. The risks inherent with different types of energy systems have become slowly naturalized to the point that they seem normal and necessary. One of the study's aims is to make them visible again so that they will be less likely to recur.

2. Research methodology

The claim that humans are imperfect needs no further citation. It is unsurprising, then, that major energy accidents occur. But what counts as an energy "accident," especially a "major" one? The study attempted to answer this question by searching historical archives, newspaper and magazine articles, and press wire reports from 1907 to 2007. The words "energy," "electricity," "oil," "coal," "natural gas," "nuclear," "renewable," and "hydroelectric" were searched in the same sentence as the words "accident," "disaster," "incident," "failure," "meltdown," "explosion," "spill," and "leak." The study then narrowed results according to five criteria:

- The accident must have involved an energy system at the production/generation, transmission, and distribution phase. This means it must have occurred at an oil, coal, natural gas, nuclear, renewable, or hydroelectric plant, its associated infrastructure, or within its fuel cycle (mine, refinery, pipeline, enrichment facility, etc.);
- It must have resulted in at least one death or property damage above $50,000 (in constant dollars that has not been normalized for growth in capital stock);
- It had to be unintentional and in the civilian sector, meaning that military accidents and events during war and conflict are not covered, nor are intentional attacks. The study only counted documented cases of accident and failure;
- It had to occur between August, 1907 and August, 2007;
- It had to be verified by a published source.

The study then adjusted all damages—including destruction of property, emergency response, environmental remediation, evacuation, lost product, fines, and court claims—to 2006 US dollars using the *Statistical Abstracts of the United States*.

Despite such criteria, however, the study likely *underestimates* the frequency and severity of energy accidents to a significant extent for six reasons.

First, the study assesses only major sources of energy production and distribution. Excluded are smaller forms of energy transportation (such as automobiles, trucks, trains), accidents at manufacturing facilities (factories and industrial buildings), and energy accidents relating to energy use (such as explosions from car crashes or electrical fires in the home). For example, the Centers for Disease Control reported in 2006 that 411 Americans die every year from electrocution, fatalities that the study does not count.

Second, excluding intentional attacks on energy infrastructure discounts hundreds of instances of sabotage, terrorism, civil disturbance, warfare, military accidents, and the damage inflicted by military weapons testing (such as the fallout from nuclear weapons experiments). For example, when Iraqi troops left the Sea Island Terminal in Kuwait on January 22, 1991, they released 240 million gallons of crude oil into the surrounding environment, inflicting $454 million in damages. These types of damages were not included in the study.

Third, the study searched only published sources in English from 200 American periodicals and 24 historical archives. This leaves out unpublished or nonreported accounts, accounts in periodicals not searched, and publications in other languages. Such omissions make the study's estimates *extremely* conservative. The World Wildlife Foundation (2007) reports, for instance, that more than 3300 accidents occurred in Chinese coalmines leading to 5938 deaths in 2005 alone, followed by 4746 mining deaths in 2006 and an additional 163 deaths per year resulting from coal-related pneumoconiosis. Since they could not be verified by published sources in English, the study excludes them.

Fourth, the study assesses only the loss of life and property damage from major energy accidents. The study