

[Gasoline] has less than a generation of useful life left to it. If we can learn how to manage its death, we will have learned how to begin.

Frederick C. Thayer
World Future Society, 2 June 1975

INDUSTRY ISSUES

Putting the Heat on Gas

The pace of energy development in the West is staggering. Since 1990 Colorado alone has seen a 450% increase in natural gas production, and now has more than 27,000 active gas wells, according to a fact sheet from the Western Colorado Congress, a community action group. This explosive growth puts the energy business into more frequent conflicts with traditional surface uses such as ranching, wilderness recreation, and housing developments. Thus, public exposure to the many chemicals involved in energy development is expected to increase over the next few years, with uncertain consequences.

Both air and water quality are affected by extraction of natural gas rich in methane. Sometimes methane must be separated from fluids and other gases in processes that emit volatile organic compounds (VOCs). Chemicals containing VOCs may also be used when a well is drilled and during a process known as hydraulic fracturing ("fracking"), in which chemical mixtures are injected into wells to break up rock formations and release gases. VOCs are also emitted by compressors and other equipment. "Produced water," groundwater drawn from wells that can contain various salts as well as drilling and fracking chemicals, is usually reinjected underground or placed in evaporation ponds on the surface, from which chemicals including VOCs can be released to the atmosphere. Methane and fracking chemicals can also migrate into shallow aquifers used for drinking water wells.

Benzene, toluene, ethyl benzene, and xylenes are naturally present in many hydrocarbon deposits, and may be present in drilling and fracking chemicals. These VOCs can cause symptoms such as headache, loss of coordination, and damage to the liver and kidneys; benzene is a carcinogen as well. VOCs help create ground-level ozone, which can contribute to severe respiratory and immune system problems.

Although the EPA issued a 2004 report concluding there is very little risk that

fracking can contaminate drinking water, there are some documented contamination incidents. For example, in August 2006, drilling fluids and methane were detected emerging from a hillside in Clark County, Wyoming, from a gas well surrounded by a rural housing development. Ultimately 8 million cubic feet of methane were released, according to the 17 November 2006 *Casper Star-Tribune*. Subsequent tests showed contamination of shallow groundwater with hydrocarbon compounds.

The drilling boom in Colorado's Garfield County has triggered a rash of citizen



Petrochemical plats. Natural gas wells dot the landscape in Garfield County, Colorado. Such sites are the subject of citizen concerns about their release of VOCs and other harmful chemicals into air and water.

complaints that petrochemical pollution has caused adrenal and pituitary tumors, headaches, nausea, joint pain, respiratory problems, and other symptoms. Half the state's drilling rigs are in Garfield County, whose population is expected to increase by 62% over its 2000 census figure, according to the Colorado Department of Public Health and Environment. Because exposures to VOCs and other chemicals are largely unquantified, it is difficult to assess these claims. Still, VOC emissions in Garfield County rose 30% between 2004 and 2006, according to Mike Silverstein, deputy director of the Colorado Air Pollution Control Division. The county is currently conducting a health risk assessment and an ambient air quality monitoring study.

Theo Colborn, president of The Endocrine Disruption Exchange in Paonia, Colorado, believes that some drilling and fracking additives that can end up in

produced water are neurotoxic; among these are 2-butoxyethanol. "If you compare [such chemicals] with the health problems the people have," Colborn says, "they match up."

Brian Macke, director of the Colorado Oil and Gas Conservation Commission (COGCC), says that group tested numerous wells after residents complained. "In any investigations we've made in Colorado, we've never determined there have been any impacts from any hydraulic fracturing operation by any of the constituent chemicals," he says.

Activists counter that the COGCC has not tested specifically for the chemicals Colborn is concerned about, and that many drilling mud and fracking fluid recipes are proprietary and thus unavailable to the public. Without such tests, the true concentrations of these chemicals in produced water remain unknown, says Lisa Sumi, research director at the Oil and Gas Accountability Project in Durango.

Ken Wonstolen, senior vice president and general counsel of the Colorado Oil and Gas Association, denies that the industry threatens public health, but concedes that oil and gas emissions may be bothering some nearby residents. "There could be localized topography and certain atmospheric conditions so that some of the odors are pooling in a low area," he says, adding that these "tend to be transient events."

Most oil and gas industry emitters of VOCs are considered minor sources, and the EPA does not regulate them, says Silverstein. State and local agencies are now attempting to clarify the extent of industry emissions. In 2002 the Colorado Air Pollution Control Division conducted a preliminary survey of VOCs at several sites in Grand Junction, concluding that none of the chemicals measured posed "significant health risks to area residents." Even so, reported the 18 December 2006 *Rocky Mountain News*, the Colorado Air Quality Control Commission voted to require VOC emission controls on more types of oil and gas equipment, and to require a 75% reduction of VOC emissions from certain gas storage tanks rather than the 47.5% reduction set in 2004 by the Pollution Control Division for the oil and gas fields near Denver. —Valerie J. Brown

MERCURY

Tipping the Scales Toward Fish

The benefits of eating moderate amounts of fish greatly outweigh the risks associated with intake of their potential contaminants, researchers report in the 18 October 2006 issue of *JAMA*. “People have heard that eating fish, especially oily fish, is good for them, yet they also hear that fish are often contaminated with mercury and other harmful pollutants,” explains lead author Dariush Mozaffarian, a professor in the Department of Epidemiology at the Harvard School of Public Health. “So what should one do? Our study compares the benefits and risks of fish consumption in order to provide an answer.”

The investigators searched the literature for studies evaluating the effects of fish or fish oil consumption on cardiovascular risk, mortality, and neurodevelopment, and the health risks associated with intake of methylmercury, polychlorinated biphenyls (PCBs), and dioxins from fish. Pooled and meta-analyses were then performed to better determine their associations.

The results indicated that modest consumption of fish or fish oil reduced the risk of death from heart attack by 36% and overall mortality by 17%, according to Mozaffarian. “For developing babies and infants, improved brain development seems to occur when mothers consume modest amounts of fish. Health benefits would be greatest from oily fish such as salmon, herring, or sardines; these have larger quantities of eicosapentaenoic acid and docosahexaenoic acid.” Many studies have linked these n-3 polyunsaturated fatty acids to such health benefits.

The researchers found that an average daily intake of 250 mg of eicosapentaenoic acid and docosahexaenoic acid,



Health benefits are no fish tale. A study comparing the benefits of eating fish with the risks of consuming environmental contaminants in this food found that moderate intake, for most people, is safe and more healthful than no fish at all.

which can be gained from eating just one 3-oz portion of farmed salmon or one 6-oz portion of wild salmon per week, was sufficient for optimum protection against heart attacks. “Eating more is not necessary; there seems to be a threshold effect,” explains Mozaffarian.

The health risks associated with methylmercury (a bioactive form of mercury that accumulates in body fat and concentrates in the tissues of top predators) were less clear-cut. “Methylmercury has clear health risks when people are exposed to extremely high levels—for example, following industrial accidents,” says Mozaffarian. However, his analysis showed no clear health effects of lower levels of exposure in adults, such as seen

with modest consumption of fish. This, he says, suggests the benefits of modest consumption outweigh the risks.

The same may be true for possible health effects of PCBs and dioxins. For example, the researchers report that eating wild or farmed salmon regularly over a lifetime could lead to 8 to 24 extra cancer deaths per 100,000 people, but more than 7,000 fewer cardiac deaths. They suggest, however, that women who might become pregnant should avoid eating too much shark, swordfish, or other fish with higher methylmercury levels,

to reduce the risk of fetal neurodevelopmental problems.

“People who are allergic to fish or don’t like it could get their n-3 fatty acids via supplements or foods enriched with them,” says Rosa Ortega, a professor of nutrition at the Universidad Complutense in Madrid, Spain. “There are now many foods enriched in this way. However, it remains to be seen whether they provide the same benefits as whole fish.” She says people should also remember that cooking with used frying oil, as many restaurants do, can increase free radical damage in cells, “so fast-food fish-burgers may not be the best way to protect your heart.” —Adrian Burton

Dirty City Roundup

In October 2006, the Blacksmith Institute released a report identifying the world’s 10 most polluted cities based on factors such as toxicity of the pollution involved and clear evidence of health impacts. In Dzerzhinsk, Russia, which was a chemical weapons manufacturing site during the Cold War, people have a life expectancy about half that of people in the world’s richest nations. Linfen, China, another of the top 10, lies in the heart of that country’s coal-producing Shanxi Province; its residents suffer from bronchitis, pneumonia, and lung cancer thought to be the result of the area’s poor air quality. The other eight cities are Norilsk and Rudnaya Pristan, Russia; Haina, Dominican Republic; Ranipet, India; Mailuu-Suu, Kyrgyzstan; La Oroya, Peru; Chernobyl, Ukraine; and Kabwe, Zambia.



Linfen, China

Lead Lightens Up

Since 1993 the U.S. Department of Housing and Urban Development has awarded grants totaling approximately \$1 billion for lead-based paint remediation in private low-income homes across the country. After six years, researchers led by Jonathan Wilson of the National Center for Healthy Housing looked at four such sites to measure the effectiveness of these programs. Their findings, published in the October 2006 issue of *Environmental Research*, show that dust lead levels on floors and window sills declined continuously over the six years since the intervention; levels of lead dust in window troughs, while gradually increasing over time, were still 75% lower than before the intervention.

Hospitals Trigger Asthma

At least 20 million Americans suffer from asthma. Now the group Health Care Without Harm has released a report showing that hospitals abound with substances that can trigger or even cause asthma. These include cleaners such as disinfectants and sterilizers, fumes outgassing from building materials, pesticides, and latex gloves. Nurses are at particular risk from the disinfectant gluteraldehyde and the sterilizing agent ethylene oxide. Safer alternatives to these substances are described in the report, available at <http://www.noharm.org/>.



REPRODUCTIVE HEALTH

Pesticides and Anencephaly

Anencephaly is a nightmarish neural tube defect in which the fetus does not develop a forebrain, and the rest of the brain is not covered by skin or bone. Most anencephalic children die in the womb or within hours of birth. A study published in the October 2006 issue of *Occupational and Environmental Medicine* now confirms a suspected epidemiological link between parents' occupation and this defect.

The study took place in Mexico between 2000 and 2001. Mexico has the highest occurrence of anencephaly in the world, with 8.05 cases per 10,000 live births in 2002, according to the International Clearinghouse for Birth Defects Monitoring System.

A review of fetal and infant death certificates identified cases of anencephaly of at least 20 weeks' gestation. Of these, 157 cases were paired with 151 malformation-free

cases. The mothers and fathers of the children answered questions on their age, occupation, reproductive history, food and vitamin intake, cooking methods, geographic location, and on-the-job exposure to pesticides. Principal investigator Marina Lacasaña, a professor at the University of Granada Andalusian School of Public Health, and colleagues at the Mexican National Institute of Public Health divided parental exposures into the acute risk period (from three months before the mother's last menstruation before pregnancy through one month after) and the nonacute risk period (the time before the acute risk period).

The results showed a nearly fivefold increase in risk of anencephaly for mothers exposed to pesticides while working in agriculture during the acute risk period. Fathers who were exposed to pesticides at any time while working in agriculture had twice the risk of having an anencephalic child. Some of the more heavily used pesticides reported by the parents, including chlorpyrifos and methyl parathion, have been previously linked with possible reproductive effects.

Rudy Rull, a research scientist at the Northern California Cancer Center who has researched birth defects and pesticides exposure, believes the study has some strong points. "One of the strengths of the study is that in the exposure section they focus in on timing, which is a really sensitive issue for neural tube defects . . . especially the months before and after conception."

However, the challenge for this and other studies will be to identify what pesticides are causing the defect. Many studies have shown that working in agriculture increases the risk of neural tube defects, says Rull, "but there's a lot you can be exposed to [in any given farm field]. We need to know which pesticides increase the risk."

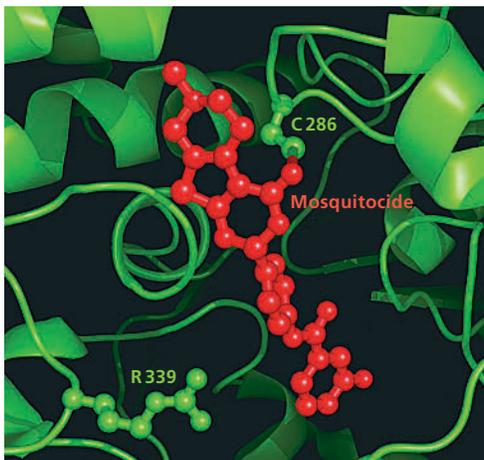
The authors also noted there were few cases where workers wore adequate protective clothing. They hope their research will have policy implications; as they concluded in their paper, "Women involved in agricultural work, or who are living with men who work in agriculture, should be protected from direct and indirect pesticide exposure, especially during the periconceptional period, if they are planning to have a child." —**Graeme Stemp-Morlock**

PESTICIDES

Cysteine Assistance

The organophosphate and carbamate pesticides used today act by blocking acetylcholinesterase (AChE), an enzyme needed for proper functioning of the nervous system in insects, humans, and other animals. These pesticides, which contaminate air, water, soil, and food, are toxic not only to insects, but also to people and other animals. Now Yuan-Ping Pang, director of the Mayo Clinic's Computer-Aided Molecular Design Laboratory, has discovered an insect-specific region on AChE that could presage a new generation of better-targeted pesticides.

Current pesticides bind the amino acid serine at the active site of AChE. In work described in the 1 January 2007 issue of *Bioorganic & Medicinal Chemistry Letters*, Pang created three-dimensional computer models based on genomic information of AChEs obtained for the greenbug (*Schizaphis graminum*) and the English grain aphid (*Sitobion avenae*), which decimate wheat, barley, and sorghum worldwide. Models of the active site revealed that the amino acid cysteine occurs at a particular location (dubbed C289) in the two insects, but not in people. "We inspected the entire active site of the human enzyme and couldn't find one cysteine residue," says Pang. A sequence analysis of AChEs from 68 species obtained from GenBank also detected C289 in cockroaches, lancelets, rice beetles, bollworms, silkworms, honey bees, moths, and armyworms.



Bug-specific breakthrough. A model shows two active sites (C289 and R339) where mosquito-specific pesticides may bind with the AChE enzyme. These two sites are found only in insects and thus may lead to pesticides that are safer for humans.

Because C289 is located at the entrance to the active site of AChE, it potentially could react with chemical pesticides designed to target that enzyme. Some early experiments in Pang's laboratory have shown that the lone cysteine can snag reactive chemicals and damage the enzyme. "For the first time, we have a blueprint to make a new generation of pesticides that are toxic only to pests," Pang notes.

Next Pang created a computer model of AChEs in the malaria-carrying *Anopheles* mosquito. In addition to the insect-specific C289 detected in the first study, he identified an insect-specific arginine, R339, at another location of the active site. The discovery of these two targets makes it possible to "create an effective new pesticide that specifically kills mosquitoes," says Pang, "and potentially revolutionize the way we control mosquito-caused diseases." The discovery of other such combinations could yield any number of new pesticides that target particular pests while sparing beneficial species such as honey bees. The mosquito study appears in the December 2006 inaugural issue of the online journal *PLoS ONE*.

AChE is one of the most important targets for the chemical control of many agricultural and medical insect pests, according to entomologist Kun Yan Zhu at Kansas State University, whose laboratory first sequenced the cDNA that encodes AChE in the greenbug. The discovery of insect-specific AChE regions "could potentially lead to the development of novel pesticides that would be expected to be toxic to insects but nontoxic or less toxic to humans," Zhu says. —**Carol Potera**

ehpnet

Bioenergy Feedstock Information Network

Oak Ridge National Laboratory hosts a web-based resource center, the Bioenergy Feedstock Information Network, that assembles a wealth of information from the Department of Energy, the laboratory itself, Idaho National Laboratory, the National Renewable Energy Laboratory, and other research organizations working on alternative fuels. The site, <http://bioenergy.ornl.gov/>, can be navigated using either the top toolbar, which features information grouped by seven topics, or the links down the left side of the homepage, which group resources by type (some browsers do not allow use of the top toolbar).

The Biomass Basics topic from the toolbar offers a collection of fact sheets, journal articles, weblinks, presentations, and reports that provide general insight into the biofuel production industry. One of the fact sheets, "The Bioenergy Cycle: A Vision of the Future," details how the bioenergy cycle works in a best-case scenario. The Economics selection in the tool bar has much more



information in this vein, with a number of presentations on the topic that have been developed and presented by collaborating members. One presentation discusses how bioenergy crop production might impact the U.S. agricultural sector, including effects on crop prices and changes in land area allotted for crops.

Impacts of bioenergy production on air, biodiversity, soil, water, and other areas are subtopics within the Environment section of the network website. Among the items in the Environment section page is a document titled "Energy Crops and the Environment," which looks at how growing crops for energy purposes can positively impact the environment by improving water quality and decreasing erosion and runoff. Other reports in the Water subsection of the Environment section address environmental benefits of cellulosic energy crops (such as switchgrass) and soil and water quality aspects of herbaceous and woody crop production.

Within the Biomass Resources section of the website are several other reports, databases, weblinks, presentations, and fact sheets that address environmental issues. One is a National Audubon Society report, *An Analysis of the Environmental Impacts of Energy Crops in the USA*, which explores the tipping point at which biomass crop cultivation would begin to negatively affect the environment. Other reports examine research priorities for energy crop production and ways of ensuring the sustainability of feedstock production.

The Supply System portion of the site offers information on the various stages of biofuel production, including harvesting, pre-processing, storage, systems integration, and transportation. Finally, the Glossary section lists not only terms used in the bioenergy industry, but also a seven-section assortment of Frequently Asked Questions on topics ranging from the basic to the more technical. —Erin E. Dooley

Ballast Water Ballyhoo

Alien species of fish, mollusks, and aquatic weeds in U.S. waters—many introduced from ballast water discharged from ships—are believed to cost the nation nearly \$8 billion. In a move to quell the further introduction of such species, a federal district judge in California ruled in September 2006 that the EPA must begin regulating ballast water as a biological pollutant beginning in 2008. Until now, the EPA has claimed a clause in the Clean Water Act exempts it from regulating discharges that are "incidental to the normal operations of a vessel." The judge ruled, however, that this exemption is "plainly contrary to the congressional intent" of the act.



The Ouch of ARGs

According to the WHO, more than 2 million Americans are infected each year with antibiotic-resistant pathogens, and 14,000 die as a result. A study in the 1 December 2006 issue of *Environmental Science & Technology* puts forth the idea that antibiotic resistance genes (ARGs)—pieces of DNA that make bacteria resistant to common antibiotics—should be considered emerging environmental contaminants. ARGs are rapidly spread by horizontal gene transfer among bacteria. Even if cells containing ARGs are killed, DNA released from them can spread to other cells. The study authors found tetracycline and sulfonamide ARGs in several types of waters in northern Colorado, including treated drinking water and recycled wastewater, both of which could be potential pathways for human exposure.

Plateau in Smoking Rate Decline

A years-long decline in the adult smoking rate stalled between 2004 and 2005, according to the most recent report by the CDC. Reasons for the plateau may include smaller annual increases in cigarette prices, a 26.5% reduction in funding for comprehensive state programs in tobacco control and prevention between 2002 and 2006, and a doubling of tobacco company advertising and promotional spending between 1998 and 2003. The report also notes that 42.5% of current smokers stopped smoking for at least a day during the past year, and that just over half of all smokers successfully quit.

