**Fracking Primer**

**Introduction**

Hydraulic fracturing, or fracking, is a method of oil and gas production that involves blasting huge amounts of water, mixed with sand and toxic chemicals, under high pressure deep into the earth. Fracking breaks up rock formations to allow oil and gas extraction. But it can also pollute local air and water and endanger wildlife and human health.

Fracking has been documented in 10 California counties with over 600 wells fracked in 2011. Oil companies have also fracked offshore wells hundreds of times in the ocean near California’s coast. When presented with the industry's own figures estimating that some 600 California wells were fracked in 2011 alone, the Division of Oil, Gas, and Geothermal Resources agency insisted the agency was overseeing the practice. Finally, the Director was forced to admit that the agency had no information about where or when oil companies were fracking, what pollutants they were releasing into the air and water, and what other risks they are taking.

Fracking allows access to huge fossil fuel deposits that were once beyond the reach of drilling. In California, rising oil prices are driving up interest in fracking on the Monterey Shale, a geological formation under the San Joaquin and the Los Angeles basins that may hold a large amount of recoverable shale oil.

Fracking routinely employs numerous toxic chemicals, including methanol, benzene, naphthalene and trimethylbenzene. About 25 percent of fracking chemicals could cause cancer, according to scientists with the Endocrine Disruption Exchange. Evidence is mounting throughout the country that these chemicals are making their way into aquifers and drinking water.

Fracking can also expose people to harm from lead, arsenic and radioactivity that are brought back to the surface with fracking flowback fluid. Fracking and similar techniques often release large amounts of methane, a highly potent greenhouse gas that’s at least 86 times more effective at trapping heat than carbon dioxide over a 20-year period.

Fracking requires an enormous amount of water, and because fracking waste water contains dangerous toxins it generally cannot be cleaned and reused for other purposes. Generally, 2-8 million gallons of water may be used to frack a well. Some wells consume much more. A well may be fracked multiple times, with each frack increasing the chances of chemical leakage into the soil and local water sources.

Especially during a historic drought, California cannot afford to permanently remove massive quantities of this precious resource from the state’s water supply.

**Fracking technology**

**How fracking works**

Let's first take a closer look at how energy companies actually use hydraulic fracturing to extract natural gas from shale rock:

1) First, a well needs to be drilled all the way down to the layer of gas-rich shale. This shale layer can sit more than 5,000 feet underground and drilling can take as long as a month. The well is typically lined with cement and a steel casing to prevent any leakage into groundwater near the surface.

2) Once the drill reaches all the way down to the shale layer, it slowly turns and begins drilling horizontally, for a mile or more along the rock.

3) A "perforating gun" loaded with explosive charges is lowered to the bottom of the well and punctures tiny holes in the horizontal section of the casing that's deep down in the shale layer.

4) Now comes the actual "fracking," or "completion" stage: A mixture of water, sand, and chemicals is pumped into the well at extremely high pressures and goes through the tiny holes in the casing. The fluids crack open the shale rock. The sand holds those cracks open. And the chemicals help the natural gas seep out.

5) The "flowback" stage: The water and chemicals flow back out of the well and are taken for disposal or treatment.

6) Finally, natural gas begins flowing from the shale and up out of the well, where it's eventually shipped to consumers via pipeline. A typical well can produce gas for 20 to 40 years, pumping out thousands of cubic feet of gas each day.

There are lots of different points during the above process in which gas or chemicals could potentially leak into the water supply:

For starters: Natural gas could migrate naturally from existing gas pockets into drinking water. This has nothing to do with drilling, but it can happen.

Alternatively, gas being pumped up from the shale layer could leak out of the well near the surface. Or, if a well is drilled through a gas pocket close to the surface, the gas could migrate up along the side of the well, especially if there's improper cementing.

There's also a more disturbing possibility: The cracks made deep underground during the fracking process could somehow migrate all the way up to the water table — allowing gas and possibly some chemical-laced fluids to seep into drinking water. This is the one possibility that's been widely feared.

**What is horizontal drilling, and how does it differ from vertical drilling?**

Horizontal drilling is a drilling process in which the well is turned horizontally at depth. It is normally used to extract energy from a source that itself runs horizontally, such as a layer of shale rock. Horizontal drilling is a common way of extracting gas from the Marcellus Shale Formation in California.

Vertically drilled wells are only able to access the natural gas that immediately surrounds the end of the well. Horizontal wells are able to access the natural gas surrounding the entire portion of the horizontally drilled section.

Since the horizontal section of a well is at great depth, it must include a vertical part as well. Thus, a horizontal well resembles an exaggerated letter “J.” When examining the differences between vertical wells and horizontal wells, it is easy to see that a horizontal well is able to reach a much wider area of rock and the natural gas that is trapped within the rock. Thus, a drilling company using the horizontal technique can reach more energy with fewer wells.

As you can imagine, drilling a horizontal well is a more complicated process that drilling a conventional vertical well. The driller must first determine the depth of the energy-rich layer. That is done by drilling a conventional vertical well, and analyzing the rock fragments that appear at the surface from each depth.

Once the depth of the shale is determined, the driller withdraws the drilling assembly, and then inserts a special bit assembly into the ground that allows the driller to keep track of its vertical and horizontal location.

The driller calculates an appropriate spot above the shale in which the drill must start to turn horizontally. That spot is known as the ‘kickoff point.” From there, the drill bit is progressively angled so that it creates a borehole that curves horizontally. If done properly, the well reaches the ‘entry point’ and makes its way into the rock where the natural gas is trapped. The horizontal portion of the well is drilled, and provides much more contact with the rock than a vertical well.

Historical records suggest that horizontal drilling dates back to as early as 1929. It was first used in Pennsylvania in 1944. It became an especially common practice during the 1980s when improved equipment, motors, and other technology were developed. In recent years, horizontal drilling has been shown in many cases to be more productive than vertical drilling, and a corresponding increase in the use of horizontal drilling has occurred.

**Why is it necessary to fracture the rock?**

The particles that make up shale are very small. They are tightly packed, with gas trapped in natural fractures and the tiny spaces between particles. In order to create a path for the gas to travel from the spaces to the well bore, fractures are widened and linked to allow gas to flow to the well.

New fractures are created through a process called hydrofracking. Water is forced into the rock at very high pressure, expanding existing fractures and connecting them to the well bore. Sand is added as a proppant that keeps the fractures open after the high pressure water is removed. Fracturing is necessary to recover as much natural gas from the rock as possible.

**What is hydrofracking?**

Hydrofracking refers to hydraulic fracturing, a technique in which large amounts of water, combined with smaller amounts of chemicals and sand, are pumped under high pressure into a drilled gas well. The purpose of hydraulic fracturing is to form tiny fractures in the rock by using water to force the rock to open along tiny existing fractures. When the pressure is released and the water removed, the sand remains behind, propping open the newly created fractures and allowing gas to flow more freely into the well. For that reason, sand is called a proppant.

Hydrofracturing was first used in Kansas in 1947. The Standard Oil Company injected a mixture of acid and oil into a well to stimulate production of oil. A patent was issued the following year, and Halliburton Oil Well Cementing Company was given the exclusive rights to using the fracturing method. Halliburton added sand to the oil mixture and began fracturing wells.

Initially, oil and other more viscous (thicker) materials were pumped into wells to complete a fracturing job. In 1953, water was introduced as a fracturing fluid, and various chemicals have been added over the years to increase the effectiveness of the fluid. Along with testing the usefulness of many chemicals, different kinds and sizes of proppants were tested for effectiveness. The first jobs were completed using sand, but materials tested have also included plastic pellets, steel shot, resin-coated sand, and various metal beads. While the concentrations of sand in the first hydraulic fracturing attempts were limited by the low pressure of pumps, the ability to use very high pressure has allowed current fracturing jobs to use much higher concentrations of sand. Higher pressure and concentrations mean that more fractures are able to be opened and more gas to be released from the well.

Natural gas extraction of shale gas reserves may involve multiple activities occurring over a period of months. These include drilling and casing of deep wells that contain both vertical and horizontal components as well as placement of underground explosives and transport and injection of millions of gallons of water containing sand and a number of chemical additives into the wells at high pressures to extract gas from the shale deposits (hydraulic fracturing). Chemicals used in the hydraulic fracturing process can include inorganic acids, polymers, petroleum distillates, anti-scaling compounds, microbicides, and surfactants. Although some of these fluids are recovered during the fracking process as “flowback” or “produced” water, a significant amount (as much as 90%) may remain underground. The recovered flowback water—which may contain chemicals added to the fracking fluid as well as naturally occurring chemicals such as salts, arsenic, and barium and naturally occurring radioactive material originating in the geological formations—may be stored in holding ponds or transported offsite for disposal and/or wastewater treatment elsewhere.

Though exact fracturing methods and materials may vary from well to well, most wells are fractured from eight to forty times during their lives. Some estimates claim that hydraulic fracturing has allowed for a more than 90 percent increase in recovering natural gas when compared to production of wells in which hydrofracking was not employed. However, concerns have been raised regarding the treatment of the resulting wastewater that is produced by the hydrofracking process, as well as the safety of the chemicals used to make the hydrofracking fluid.

The technology of hydrofracturing has also increased in complexity. Early wells were only a few hundred feet deep. Applications of the fracking technique consisted of using gelled crude oil and kerosene as the fluid injected into wells to force the fracturing. Screened river sand became popularly used as the “proppant,” or material used to hold open the fractures. Quantities of the materials used were small, consisting of approximately 750 gallons of fluid and 400 pounds of proppant.

In comparison, today, Chesapeake Energy, a company active in the Marcellus Shale, reports that an average well is now 5,300 feet deep. Drilling a typical well now uses between 65,000 and 600,000 gallons of water, and the ensuing fracking operation requires an average of 4.5 million gallons of fluids and hundreds of thousands of pounds of sand.

In common parlance, the term “fracking” encompasses the entire process of shale gas extraction, including these steps:

• leasing and clearing a prospective well site;

• building a well pad that can accommodate eight or more individual wells;

• digging containment pits and ponds for drilling and frack fluids;

• drilling the vertical portion of each well, which in southwestern Pennsylvania can be 6,000 to 7,000 feet deep;

• drilling the well's horizontal leg, up to a mile long;

• installing casing and cement in the well shaft to inhibit gas and chemicals from flowing freely into soil, streams, and aquifers; trucking or piping in millions of gallons of water for each well;

• ringing the well with 12 to 18 high-pressure diesel pumps on flatbed trucks;

• fracturing the shale to release the methane by using explosives and then injecting fracking fluids at pressures of up to 9,000 pounds per square inch (about nine times the pressure needed to crush the U.S. Navy's best submarine on its deepest dive), along with sand and ceramic "proppants" to keep the fractures open;

• capturing and removing or recycling the "flowback" of brine, hydrocarbons, sand, and toxic fracking chemicals; and

• controlling, processing, measuring, pressurizing, and piping the gas away from the completed wellheads.

When industry spokespeople talk about "fracking," however, they insist it means only the high-pressure injection of fluid and none of the other steps in the gas-extraction process. A recent University of Texas study as celebrated by the industry and reported in the national media as exonerating fracking as a source of water pollution, even though it reported that every step of shale gas extraction except for the injection of fracking fluid has been linked to incidents of environmental contamination.

**Fracking regulation**

Fracking occurs with little or outdated regulation from states and with significant exemptions from federal rules, including aspects of the Safe Drinking Water, Clean Water, and Clean Air acts. Both federal and state agencies lack adequate staff for monitoring and enforcement, to the extent that some states cannot pinpoint the number of active fracking projects within their borders. We do not have an effective regulatory system in this country to address the risks that gas drilling poses to our health and our communities. With little in its way, the natural gas industry is set on fracking our country's most precious jewels: national and state parks, state forests, and important drinking water supply areas.

The natural gas industry is exempt from aspects of:

1. The Safe Drinking Water Act (SDWA) was established to protect America's drinking water from being contaminated. However, the Energy Policy Act of 2005 -- also known as the "Halliburton Loophole" – exempted fracking from SDWA oversight, leaving drinking water sources in the 34 oil-and-gas-producing states unprotected from the host of toxic chemicals used during fracking, while exempting the industry from being held accountable for its pollution.

2. The Clean Air Act (CAA), adopted in 1970, is the comprehensive federal law that regulates air emissions from stationary and mobile pollution sources. Unfortunately, the CAA exempts oil and gas wells from controlling toxic air emissions by preventing the aggregation of multiple sources of pollution -- for example, multiple wells on one well pad. This lack of aggregation allow multiple facilities to operate in a small area, in some cases emitting large quantities of toxic air pollution, while going largely unregulated by the CAA.

3. The Clean Water Act (CWA), enacted in 1972, establishes the basic structure for regulating discharges of pollutants into the waters of the United States. Exemptions granted in 1987, and amended during the 2005 Energy Policy Act, define sediment as a nonpollutant and exempt oil and gas construction activities from storm-water permitting, leaving streams unprotected from the sediment runoff caused by the construction and operation of well pads, pipelines, drill rigs, and other infrastructure.

4. The Resource Conservation and Recovery Act (RCRA) adopted in 1976, is the principal federal law that governs the disposal of solid and hazardous wastes. The law takes a cradle-to-grave approach to ensure that wastes are handled properly from the point of creation to transport to disposal. In 1980, Congress exempted oil field wastes (which include waste from natural gas production) from the RCRA and gave authority to states to regulate these wastes. This exemption leaves produced water, drilling fluids, and hydraulic fracturing fluids from oil and gas production unregulated under the nation's premier hazardous waste law. The Sierra Club supports the work of our coalition allies by petitioning the EPA to begin regulation of hazardous wastes from oil and gas development under the RCRA.

5. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as the Superfund law, makes companies liable for a spill or release of a hazardous substance into the environment. Included in the list of hazardous substances under CERCLA are benzene, toluene, ethylbenzene, and xylene (Btex). Yet CERCLA exempts these chemicals when they are found in crude oil or petroleum, which are both widely used in natural gas production. The definition of a hazardous substance under CERCLA also excludes natural gas, natural gas liquids, liquefied natural gas, and synthetic gas usable for fuel.

6. The National Environmental Policy Act (NEPA) established the broad national framework for protecting our environment. NEPA stipulates that the federal government must give proper consideration to potential environmental impacts before undertaking any major federal action. The Energy Policy Act of 2005 stripped NEPA's strong requirements for public involvement and environmental review of several oil-and-gas-related activities. Instead, the act stipulated that they should be analyzed and processed by the departments of Interior and Agriculture under a much narrower and weaker process known as a "categorical exclusion," rather than the most comprehensive Environmental Assessment (EA) or Environmental Impact Statement (EIS) processes. In 2006 and 2007, the BLM granted this exemption to about 25 percent of all oil and gas wells approved on public lands in the West.

7. The Toxic Release Inventory of EPCRA (TRI) was created by section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986. It requires most industries to report significant releases of toxic substances to the EPA, which then aggregates and disseminates the information to the public. However, despite the use of toxic chemicals throughout production, oil and gas facilities are not required to report to the TRI. This exemption leaves communities in oil- and gas-producing areas in the dark about what chemicals are being released -- making it difficult to attribute responsibility and seek remedy for resulting health and environmental problems. The Sierra Club and our coalition allies petitioned the EPA in 2012 to regulate oil and gas chemical releases under the TRI.

**Economic analysis**

Overproduction of shale gas, which now accounts for more than 30 percent of domestic natural gas production, has pushed the price of a million BTUs down to $2.50 as of spring 2012; in July 2008, before the boom drove down prices, they spiked as high as $13.68. This is great for consumers, but it's breaking the drillers' backs; prices that low can't cover the $7.6 million average cost of fracking a single well. The result is that some drillers in Pennsylvania's "dry gas" (i.e., methane-only) areas—notably giant Chesapeake Energy—are pulling out and heading for honeypot wet-gas leases in Ohio. The industry is also pushing to expand export facilities for sending liquefied natural gas to more-lucrative foreign markets. Doing so is good for the corporate bottom line but punctures the argument that rapid and lightly regulated shale gas drilling will lead to energy independence.

That argument took another hit when the initial sky-high estimates of the amount of gas in the Marcellus Shale were cut by two-thirds in the U.S. Department of Energy's January 2012 analysis. And the industry's claim of a 100-year supply—touted by President Obama in this year's State of the Union address—is based on counting not just known and technically recoverable reserves but also estimates of gas reserves that are variously termed "probable," "possible," and "speculative"—which means they are neither proven to exist nor known to be recoverable. What the U.S. Energy Information Administration calls "proven reserves" will yield a supply that will last only 11 years at current rates of consumption; add in "probable" reserves and the supply could last an additional 10.

**Fracking impacts**

The gas industry's argument in favor of extracting as much gas as possible as fast as possible is that methane is the cleanest fossil fuel. This appears to be true enough at the point of burning, and it's what initially persuaded many environmental groups to hop on the natural gas bandwagon. But it ignores all that happens before a fuel is burned: It ignores the added energy needed for fracking, as well as the large amount of raw methane that during drilling leaks into the atmosphere, where it is a far more potent greenhouse gas than carbon dioxide. Models of emissions from fracked wells by Ingraffea and his Cornell colleagues Robert Howarth and Renee Santoro demonstrate that nearly 8 percent of fracked methane can leak into the atmosphere, making fracked natural gas the dirtiest fossil fuel of all in terms of climate change.

Natural gas is a significant source of air and water pollution and greenhouse-gas emissions. In addition to its large climate footprint, the extraction of natural gas is having a big impact on rural communities, state forests, and protected landscapes. The primary goal is still to retire coal plants as quickly as possible and replace them with genuinely clean energy like solar and wind. Investing in gas actually hinders deployment of wind and solar, so we want to leapfrog gas as we move to a clean-energy future.

So we no longer view gas as a "bridge fuel"? No. We don't need a bridge. The recent and dramatic decline in wind and solar prices means these energy sources are ready for prime time now. Wind energy is coming in at prices that compete very well with gas across the country. South Dakota and Iowa already get around 20 percent of their power from wind. Five states get more than 10 percent of their power from wind. And prices for solar panels have dropped to the point where solar can now compete with gas plants in places where demand spikes during the daytime, which is most of the country.

Given all the problems associated with fracking, we want to make sure that a strong policy on gas doesn't inadvertently cause a switch back to coal or a renaissance of nuclear power. We need to move beyond all dirty energy sources.

**Fracking safety**

The vast majority of studies conclude that fracking worsens air quality, contaminates water sources and harms public health, according to a new review of scientific literature.

The studies in the compendium cover a wide range of impacts including the fracking process' contribution to accelerating climate change, worsening air pollution, causing earthquakes, contaminating water sources and endangering public health. Also reviewed were studies related to the social effects of increased gas drilling on communities, the impact of inflated reserve estimates on the economy and the risks to investors. The authors used research covering all oil and gas activity, from production to distribution, transport and waste disposal.

**Potential water exposures**

Although much of the hydraulic fracturing process takes place deep underground, there are a number of potential mechanisms for chemicals used in the fracturing process as well as naturally occurring minerals, petroleum compounds (including volatile organic compounds; VOCs), and other substances of flowback water to enter drinking-water supplies. These include spills during transport of chemicals and flowback water, leaks of a well casing, leaks through underground fissures in rock formations, runoff from drilling sites, and disposal of fracking flowback water. Studies have reported increased levels of methane in drinking water wells located < 1 km from natural gas drilling, suggesting contamination of water wells from hydraulic fracturing activities, although natural movement of methane and brine from shale deposits into aquifers has also been suggested. If contaminants from hydraulic fracturing activities were able to enter drinking water supplies or surface water bodies, humans could be exposed to such contaminants through drinking, cooking, showering, and swimming.

Drilling threatens the dwindling supplies of freshwater that California still possesses. This happens in three ways.

First, much of the water used for fracking becomes permanently entombed in deep geological strata. It exits the water cycle and will never again fall as rain or fill a reservoir. It’s just gone.

Second, the chemicals used in fracking can migrate through unseen cracks and fissures and contaminate groundwater. California is at particular risk for fracking-induced groundwater contamination because much of the oil-containing shale is located in shallow layers located close to aquifers. As snowpacks disappear and rivers run dry, groundwater is increasingly eyed as California’s salvation.

Third, the water that does return to the surface with the oil is, in California, not only toxic but especially briny. No technology exists to turn this wastewater into fresh drinkable water. Last summer, news broke that the Division of Oil, Gas and Geothermal Resources was negligent in its oversight of oil companies that were pumping fracking wastewater directly into protected aquifers. This wastewater contained high levels of carcinogenic benzene. Those aquifers are now ruined.

In September 2009, three spills of hydraulic fracturing fluid totaling more than 8,000 gallons polluted local wetlands and a creek, causing a fish kill.

**Potential air exposures**

The drilling and completion of natural gas wells, as well as the storage of waste fluids in containment ponds, may release chemicals into the atmosphere through evaporation and off-gassing. In Pennsylvania, flowback fluids are not usually disposed of in deep injection wells; therefore surface ponds containing flowback fluids are relatively common and could be sources of air contamination through evaporation. Flaring of gas wells, operation of diesel equipment and vehicles, and other point sources for air quality contamination around drilling activities may also pose a risk of respiratory exposures to nitrogen oxides, VOCs, and particulate matter. Release of ozone precursors into the environment by natural gas production activities may lead to increases in local ozone levels. Well completion and gas transport may cause leakage of methane and other greenhouse gases into the environment. Studies in Colorado have reported elevated air levels of VOCs including trimethylbenzenes, xylenes, and aliphatic hydrocarbons related to well drilling activities.

**Human health impacts**

Concerns about the impact of natural gas extraction on the health of nearby communities have included exposures to contaminants in water and air described above as well as noise and social disruption. A published case series cited the occurrence of respiratory, skin, neurological, and gastrointestinal symptoms in humans living near gas wells. A convenience sample found that a number of self-reported symptoms were more common in individuals living near gas facilities, including throat and nasal irritation, eye burning, sinus problems, headaches, skin problems, loss of smell, cough, nosebleeds, and painful joints. Stress was the symptom reported most frequently.Studies have shown gas extraction has caused smog in rural areas at levels worse than downtown Los Angeles.

New research suggests increased risk of adverse pregnancy outcomes closer to active unconventional natural gas wells. Expectant mothers who live near active natural gas wells operated by the fracking industry in Pennsylvania are at an increased risk of giving birth prematurely and for having high-risk pregnancies, new Johns Hopkins Bloomberg School of Public Health research suggests.

**Environmental Impacts**

**Leaky gas wells**

Leaky gas wells — not fracking itself — are polluting water in Pennsylvania and Texas.

It's also not entirely clear why there might be problems in the well's piping. Are many companies just in a hurry to drill and do a shoddy job with the cement? Or is there something about the wells themselves — say, the high pressure involved in fracking or the bends caused by horizontal drilling — that make them more susceptible to leaks?

But the researchers didn't find any evidence that cracks deep down in the shale layer, where fracking occurred, were migrating up to the surface (the proportions of neon, helium, argon and other noble gases that appeared in the groundwater would have been different if the leaks were coming from deep underground.)

The Department of Energy study found that the chemicals and fluids used to crack open shale rock and extract gas remained 5,000 feet below any drinking water aquifers. (They did, however, find that the cracks could migrate as far as 1,900 feet up from the base of the well — farther than anyone had previously thought — but not enough to contaminate supplies.)

**Other Impacts**

The oil and gas industry is rapidly expanding production accompanied by massive new infrastructure to move, process, and deliver oil and gas, together bringing full-scale industrialization to often previously rural landscapes.

Oil and gas production have been linked to risk of increased seismic activity.

Constant massive truck traffic associated with large-scale development disrupts communities and creates significant hazards.

Methane -- a potent climate change pollutant -- leaks rampantly throughout the extraction, processing, and distribution of oil and gas.

**Priority actions to advocate for include:**

1. Moratoria on fracking to give states and communities time to fully evaluate the risks and determine whether it's possible -- and if so, how -- to protect against them.
2. Moratorium on fracking on public lands, which are not only home to America's last wild places, but public and private drinking water supplies for millions of people
3. Putting sensitive lands and watersheds completely off limits to oil and gas production;
4. Additional independent science is critical in order to understand how to protect against these risks.
5. Curbing air pollution across the entire system, from drilling and production to distribution, by setting strong clean air standards that minimize methane leakage and prevent dangerous smog-forming and cancer-causing toxic air pollution;
6. Mandating the strongest well siting, design, construction, and operation standards and other drilling best practices;
7. Protecting the landscape, air, and water from pollution by closing clean air, clean water and safe drinking water laws loopholes, reducing toxic waste and holding toxic oil and gas waste to the same standards as other types of hazardous waste, funding robust inspection and enforcement programs, and requiring that oil and gas companies post adequate bonds or other financial securities;
8. Mandating full public disclosure of information regarding chemicals used in fracking;
9. Prioritizing renewables and efficiency to replace fossil fuels;
10. Ensuring full transparency and public participation in permitting and regulatory processes associated with oil and gas development, and allowing citizens to bring enforcement actions against lawbreakers; and
11. Allowing communities to determine their own future by restricting fracking through comprehensive zoning and planning.

**Appendix**

**Is Fracking Safe? The 10 Most Controversial Claims About Natural Gas Drilling**

**We are the Saudi Arabia of Natural Gas**

Less than a decade ago, industry analysts and government officials fretted that the United States was in danger of running out of gas. No more. Over the past several years, vast caches of natural gas trapped in deeply buried rock have been made accessible by advances in two key technologies: horizontal drilling, which allows vertical wells to turn and snake more than a mile sideways through the earth, and hydraulic fracturing, or fracking. Developed more than 60 years ago, fracking involves pumping millions of gallons of chemically treated water into deep shale formations at pressures of 9000 pounds per square inch or more. This fluid cracks the shale or widens existing cracks, freeing hydrocarbons to flow toward the well.

These advances have led to an eightfold increase in shale gas production over the past decade. According to the Energy Information Administration, shale gas will account for nearly half of the natural gas produced in the U.S. by 2035. But the bonanza is not without controversy, and nowhere, perhaps, has the dispute over fracking grown more heated than in the vicinity of the Marcellus Shale. According to Terry Engelder, a professor of geosciences at Penn State, the vast formation sprawling primarily beneath West Virginia, Pennsylvania and New York could produce an estimated 493 trillion cubic feet of gas over its 50- to 100-year life span. That's nowhere close to Saudi Arabia's total energy reserves, but it is enough to power every natural gas—burning device in the country for more than 20 years. The debate over the Marcellus Shale will shape national energy policy—including how fully, and at what cost, we exploit this vast resource.

**Hydraulic fracturing squanders our precious water resources**

There is no question that hydraulic fracturing uses a lot of water: It can take up to 7 million gallons to frack a single well, and at least 30 percent of that water is lost forever, after being trapped deep in the shale. And while there is some evidence that fracking has contributed to the depletion of water supplies in drought-stricken Texas, a study by Carnegie Mellon University indicates the Marcellus region has plenty of water and, in most cases, an adequate system to regulate its usage. The amount of water required to drill all 2916 of the Marcellus wells permitted in Pennsylvania in the first 11 months of 2010 would equal the amount of drinking water used by just one city, Pittsburgh, during the same period, says environmental engineering professor Jeanne VanBriesen, the study's lead author. Plus, she notes, water withdrawals of this new industry are taking the place of water once used by industries, like steel manufacturing, that the state has lost. Hydrogeologist David Yoxtheimer of Penn State's Marcellus Center for Outreach and Research gives the withdrawals more context: Of the 9.5 billion gallons of water used daily in Pennsylvania, natural gas development consumes 1.9 million gallons a day (mgd); livestock use 62 mgd; mining, 96 mgd; and industry, 770 mgd.

**Natural gas is cleaner, cheaper, domestic, and it's viable now**

Burning natural gas is cleaner than oil or gasoline, and it emits half as much carbon dioxide, less than one-third the nitrogen oxides, and 1 percent as much sulfur oxides as coal combustion. But not all shale gas makes it to the fuel tank or power plant. The methane that escapes during the drilling process, and later as the fuel is shipped via pipelines, is a significant greenhouse gas. At least one scientist, Robert Howarth at Cornell University, has calculated that methane losses could be as high as 8 percent. Industry officials concede that they could be losing anywhere between 1 and 3 percent. Some of those leaks can be prevented by aggressively sealing condensers, pipelines and wellheads. But there's another upstream factor to consider: Drilling is an energy-intensive business. It relies on diesel engines and generators running around the clock to power rigs, and heavy trucks making hundreds of trips to drill sites before a well is completed. Those in the industry say there's a solution at hand to lower emissions—using natural gas itself to power the process. So far, however, few companies have done that.

**There's never been one case—documented case—of groundwater contamination in the history of the thousands and thousands of hydraulic fracturing wells**

In the past two years alone, a series of surface spills, including two blowouts at wells operated by Chesapeake Energy and EOG Resources and a spill of 8000 gallons of fracking fluid at a site in Dimock, Pa., have contaminated groundwater in the Marcellus Shale region. But the idea stressed by fracking critics that deep-injected fluids will migrate into groundwater is mostly false. Basic geology prevents such contamination from starting below ground. A fracture caused by the drilling process would have to extend through the several thousand feet of rock that separate deep shale gas deposits from freshwater aquifers. The fracking fluid itself, thickened with additives, is too dense to ascend upward through such a channel. EPA officials are closely watching one place for evidence otherwise: tiny Pavillion, Wyo., a remote town of 160 where high levels of chemicals linked to fracking have been found in groundwater supplies. Pavillion's aquifer sits several hundred feet above the gas cache, far closer than aquifers atop other gas fields. If the investigation documents the first case of fracking fluid seeping into groundwater directly from gas wells, drillers may be forced to abandon shallow deposits—which wouldn't affect Marcellus wells.

**The gas era is coming, and the landscape north and west of New York City will inevitably be transformed as a result**

Much of the political opposition to fracking has focused on the Catskill region, headwaters of the Delaware River and the source of most of New York City's drinking water. But the expected boom never happened—there's not enough gas in the watershed to make drilling worthwhile. The shale is so close to the surface that it's not concentrated in large enough quantities to make recovering it economically feasible.

**Natural gas is affordable, abundant and american. It costs one-third less to fill up with natural gas than traditional gasoline**

Vehicles powered by liquefied natural gas, propane or compressed natural gas run cleaner than cars with either gasoline or diesel in the tank. According to the Department of Energy, if the transportation sector switched to natural gas, it would cut the nation's carbon-monoxide emissions by at least 90 percent, carbon-dioxide emissions by 25 and nitrogen-oxide emissions by up to 60. But it's not realistic: Nationwide, there are only about 3500 service stations (out of 120,000) that offer natural gas—based automotive fuel, and it would cost billions of dollars and take years to develop sufficient infrastructure to make that fuel competitive with gasoline or diesel. And only Honda makes a car that can run on natural gas. That doesn't mean natural gas has no role in meeting the nation's short-term transportation needs. In fact, buses in several cities now rely on it, getting around the lack of widespread refueling opportunities by returning to a central terminal for a fill-up. The same could be done for local truck fleets. But perhaps the biggest contribution natural gas could make to America's transportation picture would be more indirect—as a fuel for electric-generation plants that will power the increasingly popular plug-in hybrid vehicles.

D**o not drink this water - Gasland movie**

A Colorado man holds a flame to his kitchen faucet and turns on the water. The pipes rattle and hiss, and suddenly a ball of fire erupts. It appears a damning indictment of the gas drilling nearby. But Colorado officials determined the gas wells weren't to blame; instead, the homeowner's own water well had been drilled into a naturally occurring pocket of methane. Nonetheless, up to 50 layers of natural gas can occur between the surface and deep shale formations, and methane from these shallow deposits has intruded on groundwater near fracking sites.

**The Marcellus Shale, state officials have made a potentially troubling discovery about the wastewater created by the process: it's radioactive**

Shale has a radioactive signature—from uranium isotopes such as radium-226 and radium-228—that geologists and drillers often measure to chart the vast underground formations. The higher the radiation levels, the greater the likelihood those deposits will yield significant amounts of gas. Tests conducted earlier this year in Pennsylvania waterways that had received treated water—both produced water (the fracking fluid that returns to the surface) and brine (naturally occurring water that contains radioactive elements, as well as other toxins and heavy metals from the shale)—found no evidence of elevated radiation levels.

**Claiming that the information is proprietary, drilling companies have still not come out and fully disclosed what fracking fluid is made of**

Under mounting pressure, companies such as Schlumberger and Range Resources have posted the chemical compounds used in some of their wells, and in June, Texas became the first state to pass a law requiring full public disclosure. This greater transparency has revealed some oddly benign ingredients, such as instant coffee and walnut shells—but also some known and suspected carcinogens, including benzene and methanol. Even if these chemicals can be found under kitchen sinks, as industry points out, they're poured down wells in much greater volumes: about 5000 gallons of additives for every 1 million gallons of water and sand. A more pressing question is what to do with this fluid once it rises back to the surface. In Texas's Barnett Shale, wastewater can be reinjected into impermeable rock 1.5 miles below ground. This isn't feasible in the Marcellus Shale region; the underlying rocks are not porous enough. Currently, a handful of facilities in Pennsylvania are approved to treat the wastewater. More plants, purpose-built for the task, are planned. In the meantime, most companies now recycle this water to drill their next well.

**The increasing abundance of cheap natural gas, coupled with rising demand for the fuel from China and the fall-out from the Fukushima nuclear disaster in Japan, may have set the stage for a 'golden age of gas.**

There's little question that the United States, with 110 years' worth of natural gas (at the 2009 rate of consumption), is destined to play a major role in the fuel's development. But even its most ardent supporters, men like T. Boone Pickens, concede that it should be a bridge fuel between more polluting fossil fuels and cleaner, renewable energy. In the meantime, the U.S. should continue to invest in solar and wind, conserve power and implement energy-efficient technology. Whether we can effectively manage our natural gas resource while developing next-gen sources remains to be seen.