## Energy Issue Brief

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### INTRODUCTION

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Introduction

Terese is a 20-year-old mother living in a small village in Senegal. She spends most of her day laboring over simple everyday tasks that a woman living in a developed country with reliable access to energy could perform in minutes. In order to cook meals, Terese must grind her homegrown grains using traditional tools like a mortar and pestle. Even though the village has a grain-grinding machine, it requires several liters of expensive gasoline in order to function—resources Terese does not have and cannot afford. Cooking this meal into an edible form over a simple fire can take up to two hours, not counting the time it takes to gather the wood. In addition, she must spend several hours a day walking to and from a well to gather water because the village lacks the electricity to run a modern water pump.

Most people take energy for granted, never realizing how much they use—and waste—to accomplish even the most basic activities in their daily routine. Yet, energy is a scarce and valuable commodity, one that will play an increasingly important role in the lives of all global citizens in the coming years. One day, the forces of globalization may bring a supply of energy and thus greater opportunity to Terese’s village. But globalization is also complicating the global energy landscape in ways that we are only beginning to understand.¹

Energy usage has been such a basic element of human advancement for so long that it is perhaps not surprising it has acquired mounting significance in the era of globalization. It pervades every aspect of life: enabling the simplest everyday tasks, shaping the environment around us, underpinning economic growth, and increasingly affecting the geopolitical calculations of all governments. In addition, an estimated $38 trillion dollars needs to be invested in the energy supply infrastructure between 2011 and 2035 to meet the growing demand.²

First and foremost, energy in all its forms, perhaps more than any other commodity, has fueled the continuing integration of the nations of the world and their economies. Higher energy consumption has both influenced and been influenced by the forces of globalization, raising the stakes involved in the formation of national energy policies and the proper operation of global energy markets. Strong global economic growth and the need to ship more goods and services around the world have raised demand for energy in many sectors. If current energy agreements and policies are acted upon, it will have a marked effect on energy demand.

The economic turmoil of 2008-2009 created widespread uncertainty in the energy sector. Recovery has been uneven, though global primary energy demand increased five percent in 2010. Governments are still strapped with heavy debt and fear a double dip recession. Subsidies to encourage fossil fuel consumption reached $400 billion. The nuclear disaster in Japan and the turmoil in the Middle East bring to light the fragility of energy suppliers. While prospects for short-term economic growth are uncertain, demand is expected to grow in the long-term. The Energy Information Administration (EIA) projects that between 2010 and 2035 world primary demand will increase by one-third, Ninety percent of that increase is predicted to occur within non-OECD countries like China.³

Spikes in demand, due to increased transportation and trade, when matched with the declining level of supply in the short term, have created a “shock” that the average consumer feels deeply because high energy prices mean the cost of living rises and energy costs assume a growing share of household spending. The economic recession has hurt consumers more by augmenting the effects of the energy

¹ “A Day in the Life of Terese,”
² “World Energy Outlook 2011.”
³ “World Energy Outlook 2011.”
shock.

While the exact size of future global energy demand is in constant flux, all trends suggest that consumption of energy will grow at least as steadily as global population. Thus energy issues will only become more prominent in the global dialogue as emerging economies such as China and India continue to modernize and industrialize, and as developed countries place an ever greater premium on securing energy assets and achieving energy independence.

This Issue in Depth will provide an overview to the field of energy, surveying several of the most important types of energy and the issues specific to each type. It will also explore the relevance of energy considerations to three central aspects of globalization: the environment, development, and geopolitics. The Issue in Depth includes both description and analysis, providing both real-world examples and broader background concepts that contextualize them. Most importantly, the Issue in Depth will address the critical questions and controversies at the heart of the ongoing debate about the role of energy in a globalized world.

**Global Energy Usage**

**Total Consumption**

Global energy consumption has increased steadily for much of the twentieth century, particularly since 1950. In 2011, the world consumed 88 million barrels of oil per day, only a .7 percent increase from 2010.\(^1\) Total energy consumption was higher in 2011 than in 2010, in line with historical averages. Most of the increases came from non-OECD countries.\(^2\)

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\(^1\) Statistical Review of World Energy June 2012.

\(^2\) Ibid.
In 2013, for the first time, oil demand in the developing world is expected to be higher than in the industrialized world. The dynamics of energy markets are increasingly being determined by emerging economies. In recent years, there has been an explosion of growth in energy demand from Asia, which eclipsed North America for the first time in 2003 as the world’s most energy hungry region. Much of this increase in demand came from China and India. As China is rapidly industrializing, its need for energy is constantly growing. According to the IEA, China consumed 9.758 million barrels/day of oil in 2011, compared to the U.S.’s 18.835 million barrels/day. While the U.S. consumed twice the amount of oil as China, China’s growth in oil consumption represented 85 percent of total oil consumption in 2011.

Global energy demand is expected to be about 30 percent higher in 2040 than in 2010. Demand in OECD countries is expected to remain flat; while non-OECD countries are expected to see a 60 percent increase. China’s surge in demand will last for the next twenty years before it flattens. While China’s oil demand is rising, the country is being affected by the global economic downtown, posting its first drop in oil demand since 2009. Nonetheless, by 2035, China is expected to consume 70 percent more energy than the U.S. Furthermore, India, Indonesia, Brazil and the Middle East all have faster rates of growth in energy consumption than China.

Per Capita Consumption

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3 Chazen
4 British Statistical Review of World Energy June 2012
5 “2012 The Outlook for Energy: A View to 2040.”
6 Moore
7 WORLD ENERGY OUTLOOK 2011.”
Total consumption is only one measurement of energy usage. Others, such as per capita energy consumption and energy intensity, offer more nuanced information about differences among countries. Per capita energy consumption has remained relatively stable since 1980 both worldwide and in the United States. This indicates that, although the world’s total consumption has increased, most individuals in most countries use about the same amount of energy they did 20 years ago. From this, we learn that much of the increase in total demand can therefore be attributed to population growth and social transformation—e.g. the integration of millions of people into modern, urbanized communities in China and India.

With that said, per capita figures reveal important variations in the consumption habits of different societies. In 2011, Canada, Saudi Arabia, and Belgium all have higher per capita oil consumption than the U.S.

Energy Intensity

Energy intensity is a measurement of the amount of energy required to produce a unit of gross domestic product (GDP). This measure is typically calculated on a national basis. It shows that the economic efficiency of energy usage has improved or remained comparable throughout the world over the last two decades. In 1980, 15,000 British thermal units (Btu) of energy were needed for every dollar of GDP produced in the United States, compared with just under 9,000 Btu in 2006, a 40 percent improvement. Most countries, including China, have experienced similar gains in efficiency due to advances in technology and more sophisticated business management practices. According to BP, “since 1970, the amount of energy required to generate $1,000 of GDP has reduced by about a third on average worldwide - from approximately 230 to 155 kilograms of oil equivalent.”

There are several countries, like Iraq, Iran, and Haiti that are anomalies to this overall improvement. One speculation as to why there is a divergence is that political instability in the areas has disallowed for efficient energy use. This seems plausible, but other regions with political instability, like Sudan or Pakistan have improved their efficiency, negating this reasoning as a definitive answer.

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8 EIA “World Per Capita Primary Energy Consumption.”
9 British Statistical Review of World Energy June 2012
10 EIA “World Energy Intensity.”
11 Sanyal
Energy efficiency gains are also correlated to structural change in the economies of many developed countries that have transformed from producers of goods to providers of services. Increased global trade has helped make this possible.\textsuperscript{13} Some experts estimate that anywhere from 25-50 percent of improvements to energy intensity in the United States may be a result of the shift from a manufacturing to a services-based economy.\textsuperscript{14} By the energy intensity measure, energy usage has become more efficient even as total consumption has continued to grow.

\textsuperscript{13} Mantel 435.
\textsuperscript{14} ibid.; “Not So Shocking;”
The Evolving Concept of Energy Security

Open the daily newspaper, and you are likely to find an article about domestic oil prices or global warming featured prominently. But you are at least as likely to see an article about Russian energy supplies, or the threatened renationalization of an energy company in Latin America, or European worries about energy dependence – in other words, an article about energy security. Concerns about energy security are now at the forefront of many current debates on energy policy, profoundly influencing the way decision-makers think about a range of issues from national and economic security to international diplomacy.

Condoleezza Rice, the former U.S. secretary of state, has expressed her surprise at the extent of this influence in a statement saying, "I can tell you that nothing has really taken me aback more as Secretary of State than the way that the politics of energy is – I will use the word ‘warping’ – diplomacy around the world."1

After a long period of relatively cheap energy prices, the tightening of global energy markets in recent years has led energy consuming nations to realize how dependent they are on energy exporting nations that may not share their foreign policy and security agendas. This sense of uncertainty is deepened by the knowledge that many of these exporters are acutely vulnerable to a variety of disruptions beyond their control.

At the same time that anxious energy importers have begun to scrutinize the security of their supplies, the governments of many energy exporters have become more aggressive in reminding trading partners of the leverage they hold. They also are bolder in maximizing the profits that the state realizes from energy sales. The delicate relationship between energy importing nations and energy exporting nations has assumed an increasingly important role in international relations.

Stability of supply and demand has become an issue of national security for both parties to this relationship. As New York Times columnist and author Thomas Friedman has pointed out, “Thinking about how to alter our energy consumption patterns to bring down the price of oil is no longer simply a hobby for high-minded environmentalists or some personal virtue. It is now a national security imperative.”2

In this context, national security encompasses a broader range of ideas than just defense. This brief will not address defense policy issues specifically, but readers interested in this subject could start by looking at the sections on “Reprocessing and Breeding” (in Appendix D) and “Nuclear Nonproliferation” under “Nuclear Power.” The primary goal of this section is to examine the evolving concept of “energy security” to see how it fits into ongoing debates, particularly those about the need for energy independence.

Energy Security vs. Energy Independence

Many policymakers, particularly in the United States, seem to equate energy independence and energy security, arguing that one will necessarily lead to the other. Much of the political rhetoric of the Bush administration from 2001-2008 emphasized the need to decrease America’s dependence on oil from the Middle East and increase the stability of the nation’s energy supply, partially by boosting domestic production and partially by relying on new alternative energy sources and technologies, such as ethanol. This focus on energy independence can be misleading. A more comprehensive notion of energy security should take into account three principles that supersede the objective of independence: resilience, diversity of supply, and global interdependence.

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1 Mufson.
2 Friedman “The First Law” 36.
The Obama administration has tried a number of initiatives to decrease the U.S.-Middle East oil dependency. They sought to increase investment in research and development of green technologies to promote energy efficiency, oil independence, and promote U.S. competitiveness through CO₂ emissions reduction. Specifically, in 2012, the Obama Administration approved Shell's bid to drill exploratory wells in the Arctic (http://www.globalization101.org/arctic-drilling/). On the other hand, due to large protests from Native Americans and environmentalists, the Obama Administration had to slow-down its plans to adopt the Keystone Pipeline to get energy from Canada.

Resilience

Resilience is best thought of as a "security margin" that would allow a country to absorb any minor shocks to its energy supply and "facilitate[] recovery after disruptions." This “buffer” can take many forms, including “spare production capacity, strategic reserves, backup supplies of equipment, adequate storage capacity along the supply chain, and the stockpiling of critical parts for electric power production and distribution.” American proposals to drill in the Arctic National Wildlife Refuge (ANWR) or to boost strategic reserves, for example, are aimed at improving the U.S.’s resilience to threats of foreign supply disruptions.

Diversification of Supply

Rather than fixating on the idea of energy independence, many argue that champions of energy security should think more about how to achieve diversification of supply. If a country can broaden the base of suppliers from which it imports energy, it is less exposed to the risks of a major supply disruption. The United States, for example, has successfully managed to wean itself off complete dependence on the Organization of Petroleum Exporting Countries (OPEC) over the last 20 years, decreasing its share of energy imports from OPEC nations from 72 percent in 1977 to 45 percent in 2011. (For more on OPEC, see section “Oil Supply II: Producers”.

Global Crude Oil Flows

At the same time, because overall global supply and marginal prices are the determining factors in the energy prices paid by any country (see the section “Oil Markets”); diversification of supply does not protect an energy importer from fluctuations in global markets. In other words:

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3 The White House “Energy and Environment.”
4 Yergin section: “A New Framework.”
5 Doggett
6 Slack
Diversification of U.S. oil imports is not an adequate answer. Oil is like any other commodity – the last unit sold determines its price. The United States could shift all its purchases to sources that are relatively safe politically, such as Canada and Mexico, and it would still not be protected. The global price is what matters most.\textsuperscript{7}

Diversification of supply is a vital component of energy security, but only one of several.

\textit{Global Interdependence}

What has become clear in recent years as both importing and exporting countries have grown more sophisticated in their energy policies is that the new reality of the global energy landscape is one of interdependence far more than independence. According to one commentator, all countries, including the United States:

must face the uncomfortable fact that its goal of ‘energy independence’—a phrase that has become a mantra since it was first articulated by Richard Nixon four weeks after the 1973 [oil] embargo was put in place—is increasingly at odds with reality.\textsuperscript{8}

All countries are locked into one very tight, very complex global energy market. True security lies in the “stability of this market” for all participants rather than the narrowly defined interest of any one country in what the \textit{Washington Post}'s Sebastian Mallaby has called the “pipedream of energy independence.”\textsuperscript{9}

The key to understanding the concept of energy interdependence is realizing that producers desire security of demand just as much as consumers want security of supply. If, for example, it is true that the European Union imports 30 percent of its energy from Russia, it is also true that Russia depends on the European Union for 20 percent of its natural gas revenues.\textsuperscript{10} Both countries have an important stake in the transaction and in the stability of the environment that allows the transaction to occur. Anxiety on either side can lead to heightened tensions and defensive behaviors that not only damage the relationship between individual trading partners but also impact the broader climate of international relations.

Markets are the mechanism by which the competing and complementary interests of importers and exporters are reconciled.\textsuperscript{11} In other words, “[t]he question is not whether energy and politics are connected but how. We have to find the right balance between a market-driven and a more strategic approach.”\textsuperscript{12}

Governments must also recognize the important role energy efficiency plays in these negotiations as a bargaining chip for importers. If the European Union has no avenue for decreasing its use of Russian oil, for example, then Russia has all of the negotiating strength. A government policy of energy efficiency for importers gives the importer an exit strategy from negotiations by decreasing demand for foreign oil. A European Union that is totally dependent on one or two oil exporters, like Russia and the Middle East, only accords the EU the option to pit the Middle East and Russia against each other in a battle for consumer loyalty. In the past, when energy efficiency policies were not used as bargaining chips this strategy ended poorly for all parties involved, especially the importing country.

\textsuperscript{7} Wirth et al. section: “Declaration of Dependence.”
\textsuperscript{8} Yergin section: “Old Questions, New Answers.”
\textsuperscript{9} Mallaby.
\textsuperscript{10} Solana.
\textsuperscript{11} Stanislaw 17.
\textsuperscript{12} Solana.
\textsuperscript{13} Atkins.
The most significant point that emerges from this new perspective on energy security from a policy perspective is that energy consumers should cooperate with each other and with suppliers at least as much as they compete on nationalist or mercantilist grounds. A “resource-scramble” model urges countries to seek what is best for them regardless of the consequences for others. But a more accurate way to think about the problem is to see that each nation’s energy security is an integral part of every other nation’s security.\(^\text{14}\)

Take the case of China, for example. China needs vast amounts of energy to fuel the rapid growth of its economy. Consequently, it has been aggressively negotiating energy supply contracts around the world, an action that is viewed by many as a threat to the interests of the United States and its oil assets.\(^\text{15}\) Should the U.S. look to its own interests first and foremost or does it have a stake in China’s success?

Conventional wisdom might advance the former perspective, but the linkages that have been created by global economic integration make the interdependence model the more relevant one. If China’s economy were to falter because of a lack of energy, the U.S. would be hurt as much as any country: American consumers depend on cheap imports from China to maintain their high quality of life just as much as the U.S. government depends on China and other Asian countries to help finance its deficits.

The U.S. and China have a common interest in ensuring that each is able to find the energy it needs to prosper. Traditionally narrow definitions of national interest – still important, but largely a remnant of the pre-globalization era – might ignore this crucial point.

**Variable Definition of Security**

The definition of energy security is variable, meaning something different for each country. For the U.S., energy security means “producing energy at home and relying less on foreigners;” for China, it might mean “buying stakes in foreign oil fields;” for Russia, it is wrapped up in “restrictions on foreign investment in domestic oil and natural gas;” while for Japan the focus is on “offsetting its scarcity of domestic resources through diversification, trade and investment.”\(^\text{16}\) It is natural for each country to give priority to its own energy needs, but all of these needs must be reconciled if true energy security is to be attained. According to one expert:

> Most producers and all consumers have a shared interest in maintaining a stable, transparent framework in which the pricing mechanism can function as freely as possible. This means no unilateral measures and no ‘politicisation’ of energy exports to punish foes or reward friends.\(^\text{17}\)

To this end, a regular ministerial-level dialogue between consumers and producers was initiated in Paris in 1991. These meetings have since evolved into the International Energy Forum (IEF), which held its 13\(^\text{th}\) meeting in Kuwait in March 2012. The IEF focuses on generating “exchange of data, increased transparency of demand and supply information, cooperation between governments and industry, and a better understanding between the two sides of the market.”\(^\text{18}\) In a globalized world, energy security will depend on the ability of both consumers and suppliers to cooperate in protecting the stability of global markets.

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\(^{14}\) Mallaby.

\(^{15}\) Hu 2.

\(^{16}\) Mallaby; McNulty.

\(^{17}\) Solana

\(^{18}\) Stanislaw 18; see also, “International Energy Forum”
Types of Energy

In this section, we will consider individually several of the main types of energy and the issues unique to each. Many more topics could be discussed, such as natural gas and electricity markets, but this brief will focus on the role of fossil fuels (oil and coal), nuclear energy, and renewable energy (ethanol, hydrogen, solar, wind, tidal/hydro) in a globalized world.

It will consider a range of issues raised by these forms of energy, from the renewed emphasis on clean coal as a vital element of many countries’ energy portfolios to the risks associated with the proliferation of nuclear materials to the potential impact of biofuels on the environment.

The goal is to provide a foundation for better understanding of the many energy-related events that are constantly unfolding and the relationship between those events and globalization.

Fossil Fuels

The term fossil fuel is used to describe the broad set of fuels “formed in the earth from plant or animal remains” that have been transformed into raw energy sources over the course of many years as a result of geological processes. In effect, fossil fuels are the repositories of millions of years of energy that has been accumulated and shaped into a concentrated form. They are a finite resource that humans were fortunate to discover but likely they will probably not encounter again.

The Carbon Cycle

Source: http://earthobservatory.nasa.gov/Library/CarbonCycle/carbon_cycle4.html

1 “Fossil Fuel”
2 Parfit 7.
Fossil fuels come in three main forms: petroleum, or crude oil; coal; and natural gas. All have many uses, but each serves one main purpose. Crude oil is refined predominantly to make gasoline for transportation purposes, while most coal is burned by utilities to produce electricity. Natural gas, not covered in this brief because of space limitations, is mainly funneled to industrial sites and factories, though a sizable percentage makes its way into homes for residential heating.3

Coal has long been used as an energy source and was the hallmark fuel of the Industrial Revolution. It replaced more traditional sources such as wood (the original biomass, or biofuel) and water power (harnessed by mills). The origins of petroleum as an energy source also date from the middle of the nineteenth century, though it did not really come into its own until the automobile became popular in the United States in the 1910s and 1920s. Oil finally overtook coal as the nation’s leading energy source in the early 1950s. Most early oil exploration occurred in North America, though major deposits were quickly discovered in the Middle East.4

In 2009, fossil fuels accounted for approximately 80 percent of the world’s primary energy use, and supplied around 90 percent of the world’s commercial energy. Renewable sources provided around 12 percent of the balance and nuclear power about eight percent.5 Within the fossil fuel group, petroleum products accounted for 33 percent of global consumption, coal for 30 percent,6 and natural gas for 21 percent in 2011.7

For the United States, in 2010, petroleum products represented 36.2 percent of its fossil fuel mix, coal 21.2 percent, and natural gas 23.8 percent.8 Even with the heightened focus on renewable and nuclear power sources, experts predict that fossil fuels will continue to supply the vast majority of the world’s energy needs for much of the next century.

The Role of Renewable Energy Consumption in the Nation’s Energy Supply, 2010

Figure 1. Renewable energy consumption in the nation’s energy supply, 2010

Source: U.S. Energy Information Administration


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5 People and Planet Factfile.
6 Macalister
7 “FAQs Natural Gas.”
8 EIA “Monthly Energy Review 2011.”
U.S. Fossil Fuel Usage by Sector, 2007

Oil

Petroleum products are probably the most widely studied and measured type of energy in the global economy. They come in many different forms, though this is not immediately obvious from news reports that lump them all together under the banner of “oil.”

Crude oil is extracted through wells that tap into underground reserves where oil has been discovered. The extraction process is facilitated by the intense pressure found beneath the earth’s surface. The release of natural gas often occurs alongside oil removal. Once this initial pressure has been relieved, concentrated streams of water, steam, gas or other pumping mechanisms help displace the oil remaining in reservoirs.9

PETROLEUM & NATURAL GAS FORMATION

Although these techniques have been improved over the last 100 years, significant inefficiencies remain. Using the latest technologies, the average reservoir recovery rate has risen from 20 percent to a still modest 35 to 45 percent.10 This jump in efficiency has greatly increased the global supply of oil, but there is still plenty of room for improvement, which has been evident in the recent disastrous oil spill in the Gulf of Mexico.

Types of Oil

The quality of crude oil can be assessed in several ways and is an important determinant of how the oil can be used. Depending on the level of the chemical sulfur, crude is classified as either sweet (low sulfur content) or sour (high sulfur content). The ease with which the oil flows during the extraction process indicates whether the oil is heavy (flows with difficulty) or light (flows smoothly). Because heavy crude and sour crude are rawer forms, they are more difficult to process and refine. As a result, lighter and sweeter crudes are generally preferred, and are used to manufacture gasoline and diesel fuel for cars.

U.S. Energy Used for Transportation, 2010

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9 “Oil and Gas Extraction.”
10 IFP “Improving Field Recovery.”
The density of the oil distinguishes gasoline from diesel fuel. Diesel does not require as much refining as gasoline and is therefore cheaper to produce. Its greater density allows diesel to release more energy when burned, making it a more efficient fuel. On the other hand, this density also results in increased emissions of sulfur and greenhouse gases that are harmful for the environment.\footnote{Brain, “How Diesel Engines Work;” “Gasoline Works;” “National Clean Diesel Campaign.”}

Diesel is the preferred automobile fuel in Europe, where rigorous government emissions standards and generous tax incentives have led to the development of diesel engines that are cleaner and more efficient than their gasoline-fueled counterparts. The vast majority of American passenger automobiles, on the other hand, use gasoline, although there has been a movement in recent years to take advantage of the improved performance of the latest generation of diesel engines.

HOW MUCH ENERGY IS IN A GALLON OF GASOLINE?
A gallon of gasoline provides enough energy to:
- Run a 1,500-watt space heater for a full 24 hours
- Equal 31,000 calories, the equivalent of more than 100 McDonalds hamburgers (4)

Further Reading

Oil Markets

The global oil market is the most important of the world energy markets because of oil’s dominant role as an energy source. Understanding how it works will also shed light on the functioning of energy markets more generally. What does it mean to say that there is a global market in energy? Fundamentally, oil is a commodity, and contracts for its supply are usually traded through commodity exchanges such as the New York Mercantile Exchange and the Intercontinental Exchange.\(^1\)

How much does a barrel of oil cost?

What does it mean when newspapers report that oil is selling for $87 per barrel? Such numbers are often cited in discussions of energy policy, yet they fail to convey the complexity of global oil markets. Because it is impossible to synthesize the diversity of oil prices around the world, economists usually refer to benchmarks, a small number of carefully tracked prices that are considered industry standards and against which all other prices can be compared.

For oil, the two most common benchmarks are Brent Crude and West Texas Intermediate. Brent Crude is oil “sourced” from the North Sea and is the benchmark against which prices are set for oil coming from Europe, Africa and the Middle East.\(^2\) West Texas Intermediate is the price used for contracts traded on the New York Mercantile Exchange and is typically the price that the media has in mind in reports about oil.\(^3\)

Markets are designed to allocate efficiently resources between those who supply and those who demand a particular product. There are two economic concepts that are important to understanding how supply and demand function in global energy markets: the marginal unit and elasticity.

Marginal Unit and Price

Let’s say a company is currently producing 100 barrels of oil. As the company decides whether to pump out more oil from its stores, it will weigh whether each additional unit of production will be profitable. Each unit that is additional to current production is a marginal unit; the cost of producing this unit is known as the marginal cost, and the price at which it can be sold is the marginal price. What happens at the margins is important because it largely determines the behavior of producers and consumers, thus shaping the market. This principle holds true for all tradable commodities, including oil.\(^4\)

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\(^1\) Mouawad and Timmons “Commodity Trading.”

\(^2\) “Oil Markets Explained.”

\(^3\) “Oil in Troubled Waters;” “Oil Markets Explained.”

\(^4\) Wirth et al. section: “Bringing in the Market.”
In a globalized world where most countries are heavily dependent on a host of foreign suppliers to satisfy their demand for energy and where suppliers are already operating at peak capacity, the marginal unit of production might come from anywhere in the world. Globalization has, to borrow a phrase from New York Times columnist Thomas Friedman, “flattened” the world, such that the actions of minor oil exporters distant and often unstable countries such Nigeria, Sudan and Iraq can affect the price paid for a gallon of gasoline by consumers in every oil-importing nation. Many advanced economies find these developments destabilizing and therefore threatening. It does not matter where or by whom a barrel of oil is bought or sold: the marginal impact of this transaction will echo around the world. In the end:

No private oil company will sell oil to its domestic market for one penny less than it could realize in foreign markets, and the price that a barrel of oil commands will be based on pressures beyond any one government’s control.

Because of the influence commanded by the marginal unit, sovereign nations do not have much control over the price of energy. Claims by national governments that energy independence will provide such control are emptier than they might first appear. According to Washington Post columnist Sebastian Mallaby, “Because oil is traded globally, a supply disruption anywhere will affect gas prices” throughout the world. It follows from this analysis that “there’s no use thinking nationally.” Exemplary of this for American citizens are the wars in Iraq and Afghanistan that have created an almost continual rise in the price of oil coming from that area.

The tightness of energy markets in recent years, which stems from high demand and relatively stable supply (see sections on “Oil Demand” and “Oil Supply”), means there is even less room for a disruption in global supplies:

In a world where every single barrel counts, the actions of Chad’s president could threaten global energy security. Because the world is pumping at just about full capacity, the global oil market cannot afford the loss of exports from even the smallest producer.

In today’s market, every marginal producer has “unprecedented power and greater geopolitical influence” than ever before. This is one of the reasons why energy issues continue to become more prominent in debates about everything from national economic policies to international diplomacy.

Elasticity

Elasticity is the measurement of how responsive supply and demand are to fluctuations in price. The supply or demand of a good is considered relatively inelastic when price does not have a large effect on production or consumption, respectively. If price does have a significant effect, then the good’s supply and demand are called elastic. If you have difficulty thinking of elasticity in the abstract, imagine a rubber band: if it is easy to stretch and thus responsive to force, it is elastic.

Elasticity is largely determined by the availability of substitutes. If, for example, the price of coffee rose from $1 per pound to $1.10 per pound, consumers who are sensitive to price considerations might switch to tea. If many consumers are willing to switch based on such a relatively small change in price, then the demand for coffee is regarded by economists as “elastic.” If, on the other hand, a 10¢ increase in the price of a pound of coffee did not cause consumers to start buying tea instead, then demand would be

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5 Friedman, The World Is Flat.
6 Deucht 21.
7 Mallaby.
8 Mouawad “Kings of the Oil World.”
9 ibid.
10 “Economics Basics: Elasticity”
“inelastic.” For many forms of energy, such as oil, substitutes are not readily or cheaply available. Demand for oil is thus thought to be generally inelastic, requiring deeper structural changes to impact demand.

There have been many debates about the elasticity of energy supply and demand. A surprising trend to emerge in recent years has been the seeming inelasticity of demand in the face of extremely high energy prices. One way to explain this inelasticity is to take a closer look at the factors driving high prices. Previous price spikes, such as those that occurred during the oil crisis of the late 1970s (see section on “Oil Supply II: Producers”), were caused by restrictions to global energy supplies, i.e. they were largely driven by supply factors.

In the present oil market, however, high prices are largely a function of record demand, much of which can be attributed to the rise of an energy-hungry China. Because the current situation is demand driven, high prices have not triggered corresponding decreases in consumption. This leads many to believe that the days of cheap energy are over and that expensive energy is here to stay.

Others contend that the elasticity of demand will gradually manifest itself. According to one experienced observer:

> For years, [economists] thought that petroleum consumption was inelastic and impervious to price fluctuations, only to discover later that this was not the case. In fact, price always affects demand, even if the connection takes time to manifest itself, as consumers try to maintain the lifestyle they are used to for as long as possible.\(^{11}\)

Consumption patterns will eventually adjust themselves to account for higher global prices. Such an adjustment may already be occurring, as oil prices have begun to moderate. OPEC cuts or adds millions of barrels of oil per day depending on demand. From December 2011 to June 2012, OPEC increased production by 1.4 million barrels a day. This increase in oil is taking place despite slumping oil prices, which are still relatively high compared to historic standards. OPEC fears higher prices will further dampen efforts to improve the economy, which is why it continues to add oil to the global market.\(^{12}\) Many future policy decisions will depend on how the question of elasticity is viewed.

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11 Maugeri
12 Mufson
Oil Demand

The predominant story line in global oil markets over the last five years has been surging demand. According to one analysis, “This is the first ‘demand-led’ oil shock.”¹ Most of this demand has come from a few countries in Asia (notably China) and from North America (notably the United States).

World oil consumption continues to rise, despite occasional drops of one to two percent. Consumption rose to record levels in 2010. Demand rose 700,000 barrels per day in 2011 and is expected to increase by 800,000 barrels per day in 2012, but is expected to only grow 100,000 per day in 2013 partially due to the Eurozone Crisis. The majority of the demand increase is attributable to developing countries that are not members of the Organization for Economic Cooperation and Development (OECD), notably Asia, the former Soviet Union, and the Middle East.² This section will discuss one important factor affecting global oil markets: growth in Chinese demand.

¹ “Oil in Troubled Waters.”
² Chazen
To read more about demand-related complications in the U.S. oil market, see Appendix B, “Demand Imperfections: Boutique Gasoline Regulations.”

Growth in Chinese Demand

The single biggest factor underlying recent increases in global demand for oil has been China. China needs vast amounts of energy to fuel its rapid annual economic growth rates of seven to ten percent. In the transportation sector alone, China is expected to double its demand for oil in the next 15 years as the number of cars in use in China grows fivefold. By 2020, China could be importing up to 63 percent of the oil it consumes, almost double the share it imports now. Though the global economic downturn has reached China; the IEA has lowered growth estimates for 2012.

Global Consumption, Measured by Carbon Dioxide Emissions

Source: http://www.epa.gov/climatechange/emissions/globalghg.html

These new supplies of oil must come from somewhere, and China has been aggressive in securing guaranteed long-term contracts for oil supplies around the world. The tightness of current markets means that supplies from established oil exporters are already going to meet record levels of demand. Therefore, China has been forced to look to more troubled suppliers that other nations have avoided such as Sudan, Angola, and Gabon. China’s strategy has been to use its "soft power" through loans and other diplomatic measures to develop economic alliances with these countries. China has invested over $20 billion dollars in Sudan since the mid 1990s.

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3 China’s Q2 GDP growth slows to 7.6 pct.
4 “China’s Oil Consumption to Hit.”
5 “Global or National?”
6 Hoyos.
7 Sharife
Some of China’s new partners, like Sudan, have been deliberately isolated by the international community to achieve strategic geopolitical objectives such as convincing the country’s government to take a more proactive role in curbing the activities of genocidal militias. Many find China’s willingness to “play by different rules” worrisome, arguing that it undermines the efforts of the international community to maintain moral as well as economic authority over rogue states.\(^8\)

The success of China in pursuing this strategy has emboldened other countries to show a similar disregard for international norms in their search for energy security: India, another energy-hungry Asian giant, has begun to develop closer ties with the regimes of Myanmar and Iran, both notorious for their poor records on human rights.

Not everyone agrees, however, in condemning China’s behavior. Some believe that Chinese “investment in the development of new energy supplies” should be encouraged because it strengthens global energy security. Such investment is “not a threat but something to be desired, because it means there will be more energy available for everyone in the years ahead as India and China’s demand grows.”\(^9\)

The case of Chinese demand is a clear illustration of the complexity of the calculus behind many energy issues. In striving to meet its own individual energy needs in ways that may be objectionable to the international community, China may nevertheless be performing the world an important service.

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\(^8\) Bader.

\(^9\) Yergin section: “A New Framework.”
Oil Supply I: Production

VIDEO: “Extreme Oil Drilling.” http://www.youtube.com/watch?v=QP2GejkLdwA

Levels of global oil supply have remained relatively steady over the last decade. Years of low oil prices discouraged investment in developing new production capacity and left producers largely unprepared for recent rises in demand. The oil industry is in the process of adjusting, using part of the flood of new cash from current high prices for research and exploration. These record profits make expensive investments in new technologies and energy sources, such as tar sands and oil shale, more economically feasible (see box "Canadian Tar Sands").

About 56 percent of the world’s proven oil reserves are found in the Middle East. Eighty percent of all production is concentrated in eight countries: six OPEC members, Russia, and Canada. In 2012, Venezuela surpassed Saudi Arabia as the world’s largest holder of oil reserves. The world’s top 15 oil producing nations in 2011 were: Russia, Saudi Arabia, the United States, China, Iran, European Union, Canada, United Arab Emirates, Iraq, Mexico, Kuwait, Nigeria, Venezuela, Brazil, and Angola.

Figure 39. World proved oil reserves by geographic region as of January 1, 2011
(billion barrels)

Middle East 753
Other Americas 237
OECD Americas 206
Africa 124
Non-OECD Europe/Eurasia 100
Asia 40
OECD Europe 11

World total: 1,471 billion barrels

2 Rowling
3 U.S. Energy Information Administration
The oil industry has faced growing uncertainty as production has declined in many advanced economies and the world has come to rely more heavily on developing or otherwise unstable countries. American crude oil production, for example, peaked around 1970. Declining production in Indonesia and Norway because of exhaustion of existing fields has been coupled with threats of terrorism in Saudi Arabia, political turmoil in Nigeria and Venezuela, increasing isolationism in Iran, and virtual chaos in Iraq and Libya to jeopardize global supplies.4

This section will discuss a number of topics relevant to global oil supplies, including: spare production capacity, the future of oil reserves, the role of the state in oil production, and market imperfections on the supply side.

The Question of Spare Production Capacity

In a tight oil market such as the current one, the question of spare production capacity is of signal importance. Does such capacity exist (a) to handle increases in demand and (b) to prevent potential supply disruptions?

For many years, Saudi Arabia, the world’s leading producer and exporter of oil, has served as a critical buffer, what some have called a “central bank of oil.” Saudi reserves are greater than those of Venezuela, Indonesia, Nigeria, and Libya combined.5 It alone maintains high enough levels of spare capacity to guarantee short-term supplies in the event of a disaster.6 Saudi reserves are one of the key pillars of global energy security and a “cornerstone of [American] oil policy.”7 Saudi Arabia has used this excess capacity effectively several times, notably during the Iran-Iraq War (1980-88), both Gulf Wars (1990-1, 2003-present), and various periods of turmoil in Venezuela.

Increased demand has, however, somewhat eroded the value of Saudi Arabia’s spare capacity. According to some experts, “For the first time in decades, production capacity failed to outpace demand, leaving the world with no cushion in case of a sudden prolonged shortage.”8 A chronic lack of investment means that, “The buffer has been in decline for some [time]...The world has been living off the legacy of spare capacity built up many years ago.”9 In response, Saudi Arabia launched a massive $50 billion investment program in 2005 to add significant production capacity by 2009.10 Some analysts are still questioning Saud Arabia’s spare capacity and predict that it might be depleted by 2013.11

Since 1995, Saudi production has ranged from 8,250 to 9,550 million barrels/day. Saudi Arabia is still the largest oil producer, but as Non-OPEC countries slip further behind their capacities there is a fear that world demand will not be met. Huge amounts of capital will need to be poured into the Persian Gulf and invested elsewhere if future reserves are to meet projected demand.

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5 Oil in Troubled Waters.”
6 Mouawad.
7 Morse and Richard section: “King of the Hill.”
8 Hoyos.
9 Oil in Troubled Waters.”
10 Dickey 39.
11 Wiggin
margins of spare production capacity by creating strategic reserves. The U.S. began to stockpile strategic reserves in 1975, storing the petroleum in large underground salt caverns in Louisiana and Texas. In 1985, the amount of oil stored there was sufficient to handle a supply disruption lasting 118 days. Because of increasing domestic consumption and sustained interruptions to global supplies, current reserve levels—696 million barrels as of February 2012—would only last about 80 days.

The U.S. has put its reserves to good use when necessary, most recently in the wake of Hurricanes Gustav and Ike (2008). But, because oil prices are dictated by the global **marginal price**, when the U.S. opens its reserves, any price benefit “is dissipated around the world.” This is because American reliance on its own strategic reserves will translate into a decrease in overall global demand and thus in global price. Some argue that, contrary to being a “tool of national self-sufficiency,” the use of strategic reserves requires coordination among several key players to be effective. Thus, strategic reserves may be, counterintuitively, a “classic multilateral instrument.”

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**The Future of Oil Reserves**

There has been much debate about whether reserve levels will continue to increase in the coming decades or whether most of the world’s salvageable oil has already been discovered. Proven reserves—“those quantities that geological and engineering analysis suggests can be recovered with high probability under existing technological and economic conditions”—increased 50 percent between 1973 and 1990. The strength of this trend leads many to believe that future discoveries of additional reserves are inevitable. The amount of oil reserves currently thought to be recoverable is significantly smaller than estimated in the 1970’s, 80’s or 90’s, as shown by the bar chart below.

![Proven versus recoverable and unconventional world oil reserves](http://www.runet.edu/~wkovarik/oil/)


In the 1970’s, major oil companies and the U.S. government made “doomsday” predictions, suggesting

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12 Cooper 82.
13 Department of Energy
14 U.S. Department of Energy “Strategic Petroleum Reserve FAQ.”
15 Mallaby.
16 Pirog, "World Oil Demand,” 5; Glover and Behrens
that oil prices could hit $100-250 a barrel by 2000. While this was not entirely true for the year 2000, statistics by the Energy Information Administration (EIA) show that crude oil prices averaged $72 per barrel in 2007. Furthermore, prices averaged $100 per barrel in 2008, $54 per barrel in 2009, $100 in 2011,¹⁷ and $87 on July 16, 2012.¹⁸ These numbers do not allow us to completely dismiss the “doomsday” predictions.¹⁹

### Annual average crude oil spot price, 2000-2011

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<th>Year</th>
<th>WTI</th>
<th>Brent</th>
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<td>2000</td>
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<td>2011</td>
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Source: [http://www.eia.gov/todayinenergy/detail.cfm?id=4550](http://www.eia.gov/todayinenergy/detail.cfm?id=4550)

The rapid pace of advances in science and technology give many hope that the oil industry will one day be able to exploit reserves that are currently considered unsalvageable. The “average oil recovery rate from reservoirs” has risen from only 20 percent thirty years ago to 35 percent today. Even with this improvement, “two-thirds of the oil known to exist in reservoirs is still abandoned as uneconomic, leaving room for tomorrow’s discoveries or innovations to lift recovery rates and magically push [projections of peak global oil production] even further towards the horizon.”²⁰

To read more about estimates of future global supplies, see Appendix C, “Hubbert’s Peak Theory.”

¹⁷ U.S. Energy Information Administration.
¹⁸ Crude Oil and Commodity Prices.
¹⁹ Historical Crude Oil Prices; World Oil Prices (EIA)
²⁰ “Bottomless Beer Mug”
Innovative technologies could enable future producers to look beyond traditional underground reservoirs for new sources of oil. The most promising of these new sources are the massive tar sands of Alberta, Canada. The sands are found in three deposits, each approximately the size of the state of Florida and have 173 billion barrels in reserves.21

This projection – combined with similar estimates regarding the potential of oil shale in the United States, heavier crude oil in Venezuela, and deep-sea oil in the Gulf of Mexico – lead some experts to believe that “non-traditional” sources of oil could serve as crucial insurance against future production cuts by OPEC.22 As oil prices rise, the expense of investments in non-traditional energy source becomes more justifiable.

Nonetheless there is significant push-back by environmentalists to the development of non-traditional sources of oil. The Keystone Pipeline from Canada to the U.S. was derailed due to environmental concerns, though many expect it to be built in the coming years.

Skeptics counter that “there are no more ‘killer applications’…left to transform the industry,” and the debate remains an open one.23

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21 Canadian Tar Sands
22 “Will the Oil Run Out?,” Krauss
23 “Bottomless Beer Mug”
Oil Supply II: Producers

From the broad perspective of global oil supplies, we will now turn to the behavior of individual companies and countries that produce oil. This section will divide into three parts: private oil companies, national oil companies, and oil cartels.

Private Oil Companies

For many years it was large private oil companies that dominated global oil production. In the late nineteenth and early twentieth century, America’s Standard Oil Company, the monopoly created and controlled by John D. Rockefeller, was one of the country’s industrial giants and accounted for almost 90 percent of total American oil sales.

In 1911, a Supreme Court decision based on the emerging body of antitrust laws ordered the monopoly to be broken up into 34 smaller companies. Three of these companies – Exxon (formerly Standard Oil of New Jersey), Mobil (formerly Standard Oil of New York), and Chevron (formerly Standard Oil of California) – would eventually join Royal Dutch Shell (Netherlands), British Petroleum (Great Britain), Texaco (United States), and Gulf Oil (United States) to form a group that became known as the Seven Sisters.1

The Seven Sisters, some of which merged with each other to form “supermajors”, would control most of global oil production for the rest of the twentieth century. When nationalized oil companies in many oil producing nations began to flex their strength in the 1970s, having learned the trade of oil production from partnerships with private firms, the Seven Sisters and other major private producers survived by investing in more unconventional oil sources in Alaska, the Gulf of Mexico and the North Sea.2

In recent years, private sector profits have skyrocketed thanks to strong oil prices. ExxonMobil earned the “largest annual profit in corporate history” in FY2005, netting over $32 billion. The company has continually beat this record, setting a new one again in FY2007 with $40.6 billion net income. “Exxon Mobil earned more than $1,287 for every second of 2007.”3 Profits decreased due to the recession, yet the company rebounded in 2010 and made $30.6 billion dollars for the year. Exxon earned record profits in 2011, earning $41 billion dollars, which were the fourth highest annual profits of all time.4 The supermajors have become so flush with cash that they are having trouble spending it productively.5

At the same time, the supermajors are facing increasingly fierce competition from national or renationalized oil companies (see “National Oil Companies” directly below). In an attempt to retain a greater share of oil profits for the state, many of these national oil companies have ended or renegotiated unfavorable terms for longstanding contracts with international partners. Since national oil companies are now in a position to extract oil from conventional sources largely without private sector assistance, the supermajors have seen their role in global production change.6

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1 Schifferes.
2 “Global or National.”
3 Mouawad “Exxon Mobil Profit Sets Record Again.”
4 Weiss
5 Catan; Hoyos,
6 Catan.
The loss of traditional revenue streams means supermajors must now offer unique specialized services or invest in the development of expensive unconventional oil sources such as *tar sands*, *oil shale*, or *deep-sea oil* if they want to remain globally competitive.7 So far, such “frontier projects” have not fared well.

According to one expert, “The once-proud giants may have to reconcile themselves to shriveling up over time as they fail to replenish reserves.” Though their ultimate fate remains unclear, the supermajors now have the capital to mount significant resistance in what some believe is the “coming age of ‘asymmetric warfare’” against the nationalized oil companies.8

**National Oil Companies**

Most oil producing countries have a national oil company. Oil production is a knowledge-intensive and capital-intensive industry. Therefore it makes sense in many cases for resources to be concentrated in a few firms or a single monopoly. In the early days of oil, governments granted private companies the rights to mine for oil in exchange for the transfer of expertise and technology and for a share of the profits. States formed their own national oil companies to handle their side of the partnership.

As national producers acquired skills of their own, they grew more reluctant to remain minority stakeholders in the natural resources of their own countries. Fortunately for them, they were backed by national governments which had the power to change the terms of partnerships and contracts as they deemed fit. Private companies either had to accept new terms or leave the country, in which case national producers gained sole control over the valuable oil assets.

The case of Saudi Arabia is an illuminating one. In the 1930s and 1940s, various remnants of America’s Standard Oil Company formed a joint venture with the government of the kingdom – the Arabian American Oil Company, or *Aramco* – to develop the country’s vast oil reserves. The private firms reaped the vast majority of profits from the venture until 1973, when the Saudi government successfully negotiated a 25 percent share. The government continued to consolidate its holdings in Aramco until it secured 100 percent control in 1980, at which time the company’s name was officially changed to Saudi Aramco.9

National oil companies now “dwarf” the supermajors in profitability and reserve holdings. Saudi Aramco, for example, has reserves equivalent to twenty times those of ExxonMobil, the largest private oil producer.10 At the same time, national companies still cannot match the expertise of the private firms and are unable to fully exploit reserves once the easier initial stages of mining have been completed.11 There are some exceptions to this rule among smaller, more advanced economies such as Brazil, Norway, and Malaysia. But, in general, the growing power of national oil companies at the expense of private firms translates into less oil on the global market. This trend constitutes a significant threat to the stability of global energy security.12

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**WAVE OF RENATIONALIZATION**

The recent spikes in oil and natural gas prices have emboldened the governments of several important energy producing nations to pursue an aggressive strategy of renationalizing their energy sectors. While Russia has been notorious for using state power to weaken rivals to the national monopolies in oil (Rosneft) and natural gas (Gazprom), the trend toward “resource nationalism” is most

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7 “Global or National.”
8 “Global or National.”
9 “Saudi Arabia: Brief History;” “Saudi Aramco.”
10 “Global or National.”
11 ibid.
12 Hoyos.
pronounced in Latin America.

The populist governments of Venezuela and Bolivia have not hesitated to renegotiate settled contracts and banish foreign companies. Venezuela alone secured $31 billion in new revenues for the state using such tactics and alienated several major European producers, including France’s Total and Italy’s Eni. In 2006, Bolivia dispatched its army to seize control of several oil and gas fields, effectively holding them hostage until private partners agreed to renegotiate contracts. By 2008, Venezuela’s oil revenue reached $85 billion. Oil is now 95 percent of Venezuela’s total export revenue. In 2012, Argentina decided re-nationalize YPF, a move that triggered angry reactions by investors worldwide.

The wave of renationalization has significant consequences for international energy security. The general consensus is that, “When national governments strengthen their grip, the outcome is more often than not a deterioration of the country’s industry and a drop in output.” The general population may see some benefits from renationalization in the form of increased social spending, but the primary beneficiaries of such rent-seeking behavior are often government officials and national treasuries. Both the individual country and the whole world are ultimately hurt by resource nationalism and the decreased production it inevitably yields.

Supply Imperfections: Oil Cartels and OPEC

While the demand imperfections we identified in the previous section (see “Oil Demand”) resulted in fragmentation, the supply imperfections this section will discuss result in a problematic concentration of power. In 1960, a group of the world’s leading oil exporters convened in Baghdad, Iraq to discuss ways of coordinating their production policies. The goal of these countries, as articulated in Article 2 of the chartering Statute of their association, was to develop a common oil policy that would determine “the best means for safeguarding [the] interests [of members], individually and collectively.” The group, now known as the Organization of Petroleum Exporting Countries, includes 12 members: Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela. It has been the dominant force in global oil markets since its founding.

The OPEC countries operate as a cartel, “a combination of independent commercial or industrial [actors] designed to limit competition or fix prices.” Each member nation is periodically assigned an export quota that sets the maximum amount of oil they can sell to other countries. Since OPEC controls about 40 percent of the oil traded internationally, its decisions regarding supply have a tremendous impact on global prices.

The cartel can control prices either by (a) directly increasing or decreasing the amount of oil it releases into the market, or (b) merely signaling that a shift in policy is forthcoming. In the estimation of one report, “The very existence of OPEC has influenced conditions in the petroleum market as buyers and sellers await decisions taken at OPEC meetings, and monitor the institution’s behavior.” OPEC’s unexpected decision to not increase production with the cost of a barrel hitting above $100 in 2011 has many analysts

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13 Pearson.
14 Hoyos and Blas.
15 Painter
16 Hoyos and Blas.
17 “Global or National.”
18 “OPEC Statute” 1.
19 “Cartel.”
20 “FAQ: How Does OPEC Oil Production Affect Oil Prices?”
21 Pirog 11-12.
worrying over the organization’s greater interest in reaping large profits over stabilizing the world energy market.

OPEC’s charter mentions other objectives that go beyond pure self-interest, highlighting the need to ensure “the stabilization of prices in international oil markets with a view to eliminating harmful and unnecessary fluctuations.” In practice, OPEC has played both a destructive and constructive role in the history of oil prices over the last 30 years.

In 1973, the Arab members of OPEC announced an oil embargo against any country that supported Israel in the Yom Kippur War against Syria and Egypt, including the United States and many European countries. The embargo triggered history’s most catastrophic oil crisis as the price of oil more than doubled almost overnight. Acute shortages led to long lines at the gasoline pump and strict government rationing policies. When the embargo was ended almost a year later, international relations between the West and the Middle East had been severely damaged. Many countries began to take steps to curb OPEC’s power by investing in oil development in non-Arab countries and researching alternative energy technologies.

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22 “OPEC Statute” 1.
23 “OPEC: History.”
24 Bamberger 3.
OPEC played a more constructive role in regulating supplies and prices during the Iranian Revolution in 1979 and the Persian Gulf War in 1990-1, largely thanks to the leadership of Saudi Arabia. The threatened losses of market share and revenue posed by developments in the 1980s led OPEC to increase export levels and stabilize the global market at a reasonable price level.\textsuperscript{25} Although OPEC’s power has waned from its peak in the mid-1970s, the group remains a dominant force in the world energy landscape. It will continue to be a key player in the years ahead.

**Gulf of Mexico Oil Spill**

One of the most disastrous environmental incidents in US history occurred in April 2010. Commonly known as the Gulf of Mexico Oil Spill, this major oil spill produced numerous environmental, economic, and cultural threats.

The oil spill resulted from an explosion aboard the Deepwater Horizon drilling rig, which was working on a well for the oil company BP. The explosion cost the lives of eleven people, working on the drilling rig. The spill began with an explosion on April 20th and did not stop until July 15th, almost three months later, when the well had finally been capped successfully. According to federal reports, nearly five million barrels of oil have been released from the damaged well, and about 800,000 barrels have been captured by containment efforts.

**Environmental Threats**

Apart from the devastating effects to marine life, the oil from the spill affected land as well, reaching the shores of Louisiana, Florida, Mississippi, and Alabama. Fortunately, the surface oil dissipated rapidly due to the gulf’s natural capacity to break down oil, but the impact of the oil that dissolved below the surface is unknown. Two preliminary government reports show only low concentrations of toxic compounds in the deep sea, however, they did find a decline in oxygen levels. Damage to local animal life has been extensive, as the area that has been affected is a habitat for many fish and bird species. Further information on the endangerment of animals can be found at the news analysis "Spill Baby Spill."

It is hoped that the negativity surrounding this incident will lead to an increased interest in renewable energy alternatives, and a movement away from overconsumption of oil for energy usage. Unfortunately, BP has been criticized of continuing to invest in oil drilling, despite current events. Specifically, BP is currently investing in the Arctic, an area that would be even more environmentally sensitive to an oil spill.

**Economic Threats**

The Gulf of Mexico Oil spill has impacted both local and international economies. Local economies have been most severely affected, especially certain areas of Louisiana that are solely dependent on tourism and fishing. Overall, the Gulf Coast states rely heavily on commercial fishing and tourism to sustain their local economies, and these states have experienced billions in losses.

Apart from the small businesses and families that are being impacted, this incident has cost BP $17 billion dollars. This is the largest corporate loss in UK history. BP has agreed to pay $20 billion for damages, and the negativity resulting from this spill has halted the Obama administration’s plans for the expansion of offshore drilling.

**Cultural Threats**

\textsuperscript{25} ibid 3-5.
Local ecosystems play a vital role in the cultural aspects of many areas affected by the oil spill. The Gulf Coast shores depend on tourism and fishing, and both are part of their culture. In many places severely affected by the oil spill, tourism has slowed down dramatically and there has been a fishing closure to many areas of the gulf.

For the second, third, fourth, fifth, and even sixth generation fishermen, guides, business owners, and boat captains of many areas of Louisiana, it is impossible to separate their jobs from their culture, and for many their profession is more than a livelihood, it is a way of life.

**Government Policy**

Governments have two types of tools at their disposal with which to moderate the supply and demand of energy: (a) taxes, and (b) standards and regulations. Standards and regulations will be considered in the context of energy and environment (see: “Fuel Efficiency Standards”). This section will discuss two types of taxes: the gas tax and the windfall tax.

**Gas Tax**

A gas tax is a surcharge levied on every unit of gasoline sold, the proceeds from which go to local and/or national governments. As long as demand for energy is relatively inelastic in the short-run, a fuel tax will provide a stable stream of revenue for the state. Over time, fuel taxes create incentives for people to decrease their energy consumption.¹

Many have criticized the United States, the world’s leading consumer of gasoline, for not effectively using fuel taxes to promote energy conservation. The federal gas tax in the U.S. has remained at 18.4 cents per gallon since 1994. This is supplemented by state and local taxes averaging 31 cents per gallon, bringing the overall nationwide average tax on gasoline to 47.7 cents.²

**Gas Tax Burden by U.S. State, July 2012**

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¹ “Fuel Taxation – International Experience.”
² API “Motor Fuel Taxes.”
When compared with much higher taxes in Japan and Europe, where a gallon of petrol or diesel can cost as much as $5-6, it becomes clear that the U.S. tax is not designed to bring about any structural changes in American demand. Some argue the federal tax should be raised to at least 50 cents per gallon.

**Windfall Tax**

Windfall taxes are special taxes a government imposes when it deems the profits made by an industry to be excessive. Such profits often result from a “financial windfall” such as a spike in oil prices. The U.S. government levied a windfall tax against oil companies in 1980 following the Arab oil embargo, and talks of another round of windfall taxes were revived during congressional hearings in November 2005, but failed to be enacted. Obama campaigned to enact a new windfall tax on excessive oil profits during his campaign, but his administration decided against it in 2008.

**U.S. Oil Company Profits**

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3 The European Union has not yet settled on a harmonized fuel tax, so each member country still sets its own tax rates. According to the EU’s energy organization, the average tax for a liter of gasoline as of June 2011 was approximately: $1.41 in France, $1.21 in Germany and $1.30 in Great Britain. The highest gas prices in the world, as of November 2008, were in Eritrea ($9.58/gallon); Hong Kong ($7.39/gallon), and Turkey ($7.08/gallon). The lowest prices during this same period were in Venezuela ($0.08/gallon); Iran ($0.38/gallon); and Libya ($0.53/gallon) (Vandam and Chan). U.S. political leaders have been reluctant to take the unpopular step of increasing the gas price (Calbreath; Farrell).

4 Bamberger.
While windfall taxes can be a boon to government treasuries and give the impression of an active government response to high oil prices, most observers believe such actions are ultimately detrimental to the nation’s energy security. These taxes mostly serve to curb investment, raise prices, and:

- distort long-term incentives. Worse, they purport to be able to distinguish between a healthy level of profits and an ‘excessive’ one—something specialist antitrust authorities, not greedy governments, are best placed to judge.5

So far, there has been no legislative follow up to the hearings.

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5 “An Oily Slope.”
Coal

Although coal is a fossil fuel, it has little in common with oil. Oil is extremely scarce, but coal is relatively plentiful. Some expert analyses predict that global coal reserves could last up to 118 years compared with only 46.2 and 56.8 years for oil and gas reserves.\(^1\) While oil is mostly found in unstable parts of the world, coal stocks are widely distributed on every continent and found in abundance within the borders of many of the globe’s largest energy consumers.

How Coal Was Formed


Over 75 percent of global coal reserves are located in the United States, China, and India, and various estimates hold that the United States has enough coal deposits to last for up to for 249 years. Recent geological surveys of the U.S. report that actual recoverable reserves may only last for half of the time previously estimated (119 years).\(^2\)

The world is by no means facing a coal shortage, but armed with this new knowledge, governments cannot be lured into a false sense of security about future energy needs. Coal, like our other fuel resources, is unsustainable at current consumption levels even though it "is easy to access, it’s in politically stable regions, and the technologies exist to eradicate environmental impacts."\(^3\)

While coal has long been an important element of the global energy mix, the great debate in recent years has focused on its future role as the nations of the world attempt to curb their harmful emissions and wean themselves off fossil fuels. One coal-fired electricity plant, for example, provides enough power for 500,000 homes but also releases as much pollution as 750,000 cars.\(^4\)

The coal industry has been revitalized in recent years by U.S. Presidents George W. Bush and Barack Obama, who have embraced so-called “clean coal” technologies as a way to harness an available resource in an environmentally sustainable way. In the United States, at least, Obama’s energy secretary has pushed for renewed investment in the project FutureGen to focus on the creation of the first “zero-emission” coal plant.\(^5\)

Clean Coal

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\(^1\) Statistical Review of World Energy 2011
\(^2\) *Energy Explained*
\(^3\) Deutsch.
\(^4\) Romero.
\(^5\) Garber. To read more about the FutureGen Project see: http://www.futuregenalliance.org/.
Clean coal technology is a broad term used to describe a series of processes that remove most of the pollutants when coal is burned, thus making it a more environmentally friendly energy source. There are three primary processes covered under the heading of clean coal: the integrated gasification combined cycle (IGCC), carbon capture, and carbon sequestration.

During the IGCC, coal is crushed and mixed with steam to produce a combustible fluid that is clean of many pollutants such as sulfur and mercury. When this fluid is used to make electricity, which it does far more efficiently than traditional coal-fired turbines, carbon dioxide is released as a byproduct and filtered out for later disposal.6

An alternative to IGCC is carbon capture, a method by which normal coal-fired plants are retrofitted with special absorbers that soak up carbon dioxide for subsequent storage. Various capture techniques can also be used when oil or natural gas is initially extracted from the ground. At that stage, huge amounts of carbon dioxide, which form “a proportion of the fossil fuel in its natural state,” are released into the atmosphere.7 The extraction process is itself one of the major sources of greenhouse gas emissions.

**Carbon Sequestration**

Once carbon dioxide has been isolated and contained using IGCC or another capture method, it is then converted into a “highly concentrated stream” or “supercritical” state between a liquid and a gas and stored deep underground. Typically, these streams are pumped into the ocean floor or into old oil or gas reservoirs. Sites capable of storing carbon dioxide in this form must be “deep, porous…covered by a layer of impermeable rock to prevent leakage.”

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6 Friedman and Homer-Dixon; Harvey.
7 Harvey.
Some fear that earthquakes or other geological disturbances could destabilize the storage areas. While leakages could have dire consequences for the environment, there is no way to judge what the level of risk is with any certainty.

Many supporters of renewable energy sources argue that clean coal and carbon sequestration technologies, while sounding promising, are untested and have limited potential in the near term. In August 2010 the Obama Administration announced it would refit an existing coal plant in Illinois into a plant that could capture most carbon dioxide emissions through oxy-combustion technology. Changing an existing plant is cheaper than the original FutureGen plan to build an original plant. Many hope that more than 500 other coal plants in the country will undergo a similar facelift.

Some critics feel the idea of clean coal is a “smokescreen, since it’s not intended to bring technology to the market at the pace required to deal with the problem.” It is estimated that retrofitting old coal-fired plants or building new ones equipped with clean coal technology as it is currently would add anywhere from 30-80 percent to the cost of electricity. The future of clean coal will ultimately hinge on whether these costs will prove acceptable to power utilities and consumers. New developments must be made on current technology to bring the extra costs down to 35 percent at most and ensure a higher probability of success for clean coal.

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8 Harvey; Friedman and Homer-Dixon.
9 DOE “Retrofitting the Existing Coal Fleet.”
10 ibid.
Since the 1950s, nuclear energy has been an important part of the world's fuel mix. In 2012, nuclear energy satisfied about 14 percent of global electricity needs.\(^1\) In 2011, there were 440 nuclear plants in operation worldwide with 60 under construction in 14 countries.\(^2\) There has been a slowdown since the Fukushima nuclear disaster in March 2011.

In 2011, some of the countries that rely most heavily on nuclear power for electricity generation include: France (77.7 percent), Slovakia (54 percent), Belgium (54 percent), Ukraine (47.2 percent), Hungary (43.3 percent), Slovenia (41.7 percent) and Switzerland (40.9 percent).\(^3\) Nuclear power generates 20 percent of the United States' electricity and represents 70 percent of its non-carbon power supply.\(^4\)

The development of the civilian nuclear power industry in the United States was fostered by the policies of the Eisenhower administration. President Dwight D. Eisenhower first articulated the idea of "Atoms for Peace" in a speech in 1953. Congress was quick to act. In 1957, it passed the Price-Anderson Act, which capped the liability of private operators for reactor accidents at $560 million.\(^5\) This was an important first step in providing the insurance required to make the risks undertaken when building a nuclear power plant acceptable to the private sector.

Shortly thereafter, Eisenhower spearheaded the establishment of the International Atomic Energy Agency (IAEA), the organization charged with promoting cooperation, safety, security, and technology in the global nuclear industry. In the 1970s, the newly created Department of Energy (DOE) took an active role in supporting nuclear power in the United States while the Nuclear Regulatory Commission was founded to regulate the adolescent industry.

A series of high profile accidents lessened the world's interest in nuclear expansion and were a sobering reminder of the risks to public health posed by nuclear power generation. In 1979, a reactor at Three Mile Island in Pennsylvania experienced a partial meltdown that unfolded over five days. Although no one was killed as a direct result of the accident, the debate about the safety of nuclear technology was rekindled.

Then, in 1986, in Chernobyl, Ukraine (then still a part of the Soviet Union), a full nuclear disaster occurred, unleashing a wave of radiation across Russia and Europe. The accident killed 31 people and caused lingering health effects for thousands more.

The most recent high profile nuclear disaster occurred on March 11, 2011 at the Fukushima Nuclear Power Plant in Japan when several of the plant's reactors began leaking radiation and entered a meltdown in the wake of a 9.0 earthquake. The scope of the disaster has been compared to Three Mile Island and Chernobyl, prompting governments to reassess their nuclear policies. Germany decided to stop using nuclear power by 2022, and other countries consider the disaster a 'big dampener' for their nuclear ambitions. According to former member of the U.S. Nuclear Regulatory Commission Peter Bradford, proponents of clean energy in the form of nuclear power will have to face a "greatly heightened skepticism [and] unwillingness to have nuclear power plants located in one's own neighborhood".\(^7\)

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\(^1\) World Nuclear Association "World Energy Needs and Nuclear Power"
\(^2\) World Nuclear Association, " Plans For New Reactors Worldwide"
\(^3\) Nuclear Energy Institute
\(^4\) Deutch.
\(^5\) Cooper, "Energy and the Environment," 165; Weeks 226.
\(^6\) Cole
\(^7\) Polson
Resurgence of Interest

In general, the last several years have seen a resurgence of interest in nuclear energy because of the steady rise of energy prices since 2002. President George W. Bush led the way with a series of new nuclear initiatives overseen by the Department of Energy. In addition, the Energy Policy Act of 2005 adopted by the U.S. Congress established new tax credits and loan guarantees for reactor construction, offered insurance against regulatory delays, and renewed the Price-Anderson Act by increasing liability coverage to $10.9 billion. From 1973-2005, there were no new nuclear plants commissioned, but four to six new units may come online by 2020. There have been six license applications made since 2007 to build twenty-four new nuclear reactors.

At the same time, there has been an increase in interest in nuclear energy among developing countries. Many governments view peaceful nuclear power generation as a right to which all nations are entitled and a vital component of their development strategies. There are more than 45 countries pursuing nuclear power programs in 2012, including twelve European countries, fifteen North African/Middle Eastern countries, six West and South African countries, three South American countries, and fifteen Asian countries.

India, with a population expected to eventually overtake that of China, has been one of the champions of this position. India currently has 20 reactors and is seeking to build an additional 16 to 25 reactors by 2020.

Iran has, in its own way, also adopted a version of the entitlement argument, though many remain skeptical about its true intentions. Consequently, the U.N. Security Council passed Resolution 1696 (2006) by a vote of 14-1 (Qatar dissenting) requiring that Iran suspend uranium enrichment activities by the end of August 2006, but Iran has yet to comply with this mandate.

The danger that nuclear technology and materials can be used to produce weapons now dominates the debate over the use of nuclear energy in developing countries.

Obstacles to Expansion

There are three primary obstacles to the development of the nuclear industry: cost, risk, and waste. A single reactor can cost between $5 billion and $12 billion to construct. As many power plant construction companies have learned, it is difficult to achieve any economies of scale that might boost profits.

A Boiling Water Reactor
But once the initial capital investment has been made, the costs of operating a reactor are relatively stable. This is mostly because, in contrast to coal- and gas-based power plants, the price of fuel for nuclear plants is only a minor component of a reactor’s operating expenses. Costs rise again when old reactors, containing large amounts of radioactive material, must be decommissioned and dismantled over the course of decades.16

Since Chernobyl, a steady stream of minor and major problems (Fukushima) has kept the dangers of nuclear power firmly in the public’s mind. Current forecasts predict that one severe accident will occur every 100 years in a network of nuclear plants such as that possessed by the United States, and there is much debate about whether this level of risk is acceptable.17

Finally, there is the issue of nuclear waste, probably the greatest hurdle to the expansion of nuclear power generation. Spent fuel units, while no longer capable of sustaining nuclear reactions, nonetheless continue to emit high levels of radiation for many years. They are cooled in underwater pools and then typically stored at sites at or near the reactor where they have been used.18 This method is, however, only a temporary resolution to the storage problem, and policymakers have long sought a more secure and permanent solution. In the United States, for example, a single repository site located under Yucca Mountain in Nevada has been proposed amid fierce controversy, which will be treated in the section on “The Cycle of Nuclear Power Generation.”

All three of these factors—cost, safety, waste—explain why the nuclear industry is so unique, requiring complex and wide-ranging partnerships between public institutions and private enterprises. The costs and risks to public safety are so enormous that governments must take an active role in supporting, regulating and monitoring the nuclear industry.

On a broader level, the implications of nuclear technology for global security make nuclear policy an increasingly central concern for all nations in the era of globalization. Globalization has dramatically increased flows of goods and people, making it more difficult for governments to control their borders. These developments, joined with the existence of large stocks of poorly secured nuclear weapons in the

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16 Bream.
18 Weeks 225, 232.
former Soviet Union and the emergence of rogue nuclear powers such as Pakistan and North Korea, has greatly increased the risk of nuclear terrorism faced by all countries.

To read more about how nuclear power plants work, see Appendix D, “The Cycle of Nuclear Power Generation.”

**Nuclear Nonproliferation**

Nonproliferation represents the intersection of nuclear technology and geopolitics. Once the awesome power of nuclear technology was fully understood, it immediately became apparent that its applications needed to be carefully regulated and controlled. From the early days of the nuclear age to the late 1960s, only five countries possessed the scientific knowledge and technical capacity to produce nuclear weapons: the United States, the Soviet Union, China, the United Kingdom, and France.

Realizing that the proliferation of materials and know-how represented a lethal danger to all nations, the U.S. and Soviet Union led the way in developing a set of principles for the protection of humanity that were enshrined in the Nuclear Nonproliferation Treaty (NPT).

The treaty, effective as of 1970, has three primary components: nonproliferation, disarmament, and the right of peaceful use of nuclear technology.\(^1\) In total, 191 nations have signed on to the NPT, including the five original nuclear powers. Three nations refused to join, however: India, Pakistan (both known to possess nuclear-weapons technology by 1974 and 1987 respectively), and Israel (which has not conducted public tests but has been suspected of possessing weapons since around 1967). North Korea also withdrew from the treaty in 2003.

**Possession of Nuclear Weapons**

The treaty acknowledged that only the five existing nuclear powers, also known as “nuclear weapons states” (NWS), were permitted possession of nuclear weapons. It was agreed that nuclear states would not to transfer weapons technology to non-nuclear states, while the non-nuclear states in turn promised not to seek access to such technology. In addition, NWS were not to attack non-nuclear countries unless provoked by a nuclear attack or an attack carried out with the support of a NWS.\(^2\)

**Disarmament**

The treaty expressed a general consensus that not only the use but even the threatened use of nuclear force was morally objectionable. It called for the five NWS to reduce their stockpiles of nuclear weapons, a process known as disarmament.

With the advent of the Cold War in 1945, the United States and Soviet Union had engaged in an arms race to increase and perfect their nuclear arsenals. Soon, each possessed tens of thousands of warheads, far more than would be necessary even if a major conflict were to erupt.

A delicate balance emerged thanks to the new strategy of deterrence: the certainty of mutually assured destruction (MAD) if either nation were to employ nuclear force encouraged both to avoid exercising this option.

The complete history of the disarmament movement is beyond the scope of this brief, but two landmark treaties deserve some attention. The first is the Partial Test Ban Treaty, signed in 1963. It prohibited the

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\(^1\) “Non-proliferation Treaty.”

\(^2\) ibid.
testing of nuclear weapons in the atmosphere, underwater and in outer space. While the partial ban was widely considered a success, no further action was taken to advance the disarmament agenda until 1996, when the **Comprehensive Test Ban Treaty** forbidding all forms of open nuclear testing came into effect. Notably, the United States has signed but not ratified this treaty.³

In 2002, Russian President Vladimir Putin and U.S. President George W. Bush agreed to limit their stockpiles of nuclear weapons to between 1,700 and 2,200 by 2012, but many details about how this arrangement will be implemented remain unclear. The final compliance deadline coincides with the expiration of the treaty, so it is possible that neither side will reduce their nuclear warhead capacity.⁴ President Obama reiterated the desire for both countries to reduce warheads by 80 percent, which led to the signing of a nuclear arms reduction treaty by Russian President Dimitry Medvedev and President Obama in April 2010.⁵ In general, Obama has stated that he would like to eliminate nuclear weapons, but he has not offered a timetable or specific steps.

**Right of Peaceful Use**

To compensate non-nuclear states for forsaking the ability to pursue nuclear weapons, all signatory nations were granted the right to use nuclear technology for peaceful purposes. Since many methods of nuclear power generation require enriched uranium fuel to operate, some believe this third pillar is a loophole that allows virtually any country to work with and purchase materials that could be used to produce nuclear weapons.

To address this concern, the United States has required since 1978 that “non-nuclear weapons countries [must] open their entire nuclear programs to ‘full-scope’ International Atomic Energy Agency (IAEA) monitoring before they can receive nuclear exports from the United States.”⁶

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**NON-PARTIES TO THE NPT**

The rejection of the NPT by India, Pakistan, and Israel has thus far prevented these nations from participating in the global market for nuclear materials. Thus, achieving the military goal of nuclear armament has come at the expense of the proper development of the civilian nuclear industry in these countries. Isolation from the international community has forced the three nations—India, in particular—to focus on reprocessing technologies and the perfection of an independent fuel cycle, creating precisely the kind of proliferation risks the NPT was engineered to prevent.⁷ (See box “The U.S.-India Civilian Nuclear Cooperation Agreement” in section title “Nuclear Energy and Development”.)

For its part, India has challenged the legitimacy of the NPT’s division of countries into nuclear “haves” and “have nots” by refusing to become a party to the agreement and then detonating a nuclear device in 1998.⁸ Diplomatic efforts to integrate India, Pakistan, and Israel into the global nonproliferation framework have thus far proven unsuccessful, though some important developments will be discussed below.

**North Korea**

Two countries have posed a particularly difficult challenge from within the existing nonproliferation framework. North Korea became the first signatory nation to withdraw from the NPT in early 2003,

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³ “History of the Comprehensive-Test-Ban Treaty (CTBT).”
⁴ “President Bush, President Putin Sign Nuclear Arms Treaty.”
⁵ “Russia and U.S. Sign Nuclear Arms Reduction Pact.”
⁶ Weeks 229.
⁷ Daalder and Levi.
⁸ Talbott.
citing a need to defend itself against deepening American hostility. North Korea had long been suspected of secretly developing a weapons program with help from Pakistan.9

Following North Korea’s withdrawal, six-party talks involving China, South Korea, Russia, Japan, the United States, and North Korea were initiated to seek a diplomatic resolution to the situation. A preliminary agreement was reached in late 2005 in which North Korea would forfeit its weapons in exchange for American assistance in upgrading its civilian nuclear power plants with modern light water reactors. But North Korea detonated its first nuclear device in October 2006, sparking universal condemnation among the international community and throwing the delicate negotiations over its nuclear program into turmoil.10

Ever since, there have been ongoing efforts by the U.S. to end North Korea’s nuclear weapons program. In June 2008, as a symbolic step to stop its nuclear weapons program, North Korea blew up the most renowned symbol of its plutonium production – a 60-foot cooling tower at one of the country’s main power plants. Around the same time, President Bush verified that North Korea had been removed from the U.S. list of “state sponsors of terrorism”. However, whether this means that North Korea will altogether halt its plutonium production remains to be seen: “It’s symbolic. But in real terms, whether demolishing or not a cooling tower that has already been disabled doesn’t make much difference,’ said Lee Ji-sue, a North Korea expert at Seoul’s Myongji University.” (New York Times, June 28, 2008).

Iran

The second nation that has posed a challenge to the global nonproliferation regime is Iran. The Iranians have always claimed not to want nuclear weapons but have had a contentious relationship with the international community about the nature of their activities for two decades while remaining a party to the NPT.11

Both the United States and European Union believe that Iran’s uranium enrichment activities are at least partially directed at developing nuclear weapons, a fear that is exacerbated by the fact that Iran could eventually become the first nuclear power in the unstable Middle East region. Iran announced it had successfully enriched uranium in early 2006 and subsequently barred the entry of a number of IAEA inspectors into the country. Talks over Iran’s nuclear program are ongoing and have been complicated by North Korea’s recent nuclear tests.12

Despite demands to stop, Iran continues to its nuclear program. According to the New York Times (July 31, 2008), “[the country’s supreme leader] Ayatollah Khamenei’s comments suggested that Iran might be preparing to take a hard line on the demands by six nations — the United States, Russia, China, France, Britain and Germany — that it stop enriching uranium by this weekend.”

Currently, the Iranian president, Mahmoud Ahmadinejad, admits to an active nuclear program. He has denied political interest in building a nuclear bomb, but many still see Iran and North Korea’s nuclear capabilities as a threat to global peace and security.

VIDEO: “Interview from Ahmadinejad on his current nuclear capabilities.”
http://www.cbsnews.com/video/watch/?id=3289364n

Proliferation and Globalization

9 “Fact Sheet: North Korea’s Nuclear Weapons Program.”
10 “North Korea Talks Set To Resume.”
11 “Long Half-Life.”
12 “Iran Declares Key Nuclear Advance;” “Iran Bars 38 Nuclear Inspectors.”
In the era of globalization, when the freedom of movement for people and goods has reached unprecedented levels, many consider nuclear proliferation to be the greatest threat to international security. A single terrorist armed with a nuclear weapon could unleash unimaginable destruction against virtually any target.

The power of **rogue** actors has become all too apparent in recent years, and the world’s only hope of avoiding catastrophe lies in destroying and securing nuclear weapons and regulating the circulation of nuclear materials before they fall into the wrong hands. As globalization continues to widen and deepen, concerns over proliferation will become more central to international relations and diplomacy.

**Nuclear Energy and Development**

It is widely acknowledged that traditional energy sources will be inadequate to meet the development needs of many poorer countries whose populations are large and growing larger. The number of cars, appliances, and power plants that would be required to support two billion people as they move into modern lifestyles in an industrialized society would be devastating to the environment. Many developing countries realize this and have sought to exercise the right specified in the third pillar of the NPT to develop civilian nuclear power industries.

Established nuclear powers have attempted to walk a fine line by facilitating the peaceful use of nuclear energy for development while at the same time staying true to the principles of nonproliferation. The nuclear states understand that the increased use of nuclear and **renewable energies** will be crucial to the growth of many countries in the coming years. This section will discuss one recent initiative that seeks to bridge the divide between nuclear energy and development for the country with the fastest growing population in the world: India.

**THE U.S.-INDIA CIVILIAN NUCLEAR COOPERATION AGREEMENT**

India has always posed a unique problem to the global nuclear regulatory regime. Though a peaceful democracy, it has steadfastly refused to accept the NPT and been one of its most outspoken critics. For many years, the international community tried to ignore the nuclear activities of non-official nuclear powers but was unsure how to deal with them.

Finally, in early 2006, President George W. Bush signed a "strategic partnership" with India that would eventually rescue it from the "international nuclear wilderness."¹ The partnership agreement lifts the ban on American sales of civilian nuclear fuel and reactor components to India without forcing India to join the NPT. In return, India will be partially included into the “non-proliferation mainstream” by bringing 65 percent (and eventually 90 percent) of its nuclear power generation capacity under international regulation. International inspectors have access to 14 of 22 civilian nuclear reactors. India’s concession for the inspection of 80 percent of the reactors was made through the United Nations as a step toward implementation of the U.S.-India agreement.²

Critics of the deal object to the fact that India is not required to limit its arsenal of nuclear weapons, nor are its **breeder** reactors included in the group to be placed under international oversight. They warn, “The rules had started to bite: India was running short of supplies of uranium for both civilian and military purposes. By allowing it to import nuclear fuel directly for its civilian

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¹ “Joining the Nuclear Family.”
² Tirone.
reactors, America will be directly easing the bottlenecks in its weapons programme. Furthermore:

[Bush] is gambling that the future benefits of accepting a rising India in all but name as a member of the nuclear club will outweigh the shock to the global anti-proliferation regime, already under severe strain…India could instead prove the exception that fatally weakens the rules.³

As the India, Iran, and North Korea examples show, the international community still has not figured out how to deal with nuclear states that choose to circumvent the framework established by the NPT. The proposed US-India nuclear cooperation agreement represents an attempt at a compromise solution, an effort to foster positive habits of compliance in a reluctant state. But the agreement may undermine the very nonproliferation regime it seeks to protect and remove the crushing pressures of isolationism just when that strategy was beginning to work. The agreement was passed by Congress and signed into law on December 18, 2006.⁴

³ “Dr. Strangedeal.”
⁴ Baker.
Renewable and Alternative Energy Sources


The quest for energy independence, economic growth, and environmental sustainability increasingly suggests the importance of renewable energy sources. Renewable energy is gained by tapping into “existing flows of energy” and “natural processes” in ways that generate more usable energy than is expended in the production process.

Most “renewables” harness the sun’s energy in some fashion, either directly (solar power) or indirectly by:

- Burning plants that lived by photosynthesis (biomass);
- Capturing the air currents that are created when the sun heats parts of the atmosphere differently (wind power); or
- Channeling flows of water that are created through the sun-driven cycle of evaporation, condensation, and rain (hydropower).

Two other notable forms of renewable energy are tidal power, derived from the gravitational effects of the moon on the earth’s oceans, and geothermal power, derived from heat produced in the earth’s core. Not all renewable energy sources are necessarily good for the environment. Biomass, for example, emits harmful greenhouse gases when burned. Similarly, hydroelectric dams and wind turbines can significantly disrupt local ecosystems. But most renewables of the type described in this issue brief offer significant environmental advantages over traditional fossil fuels.

Alternative Energy
Renewable energy sources are not exactly the same as **alternative energy** sources. Alternative energy is a broader category encompassing all non-fossil-fuel-based energy sources and processes, of which renewable energies are only a part. Forms of alternative energy not covered under the renewable label include hydrogen power and fission power. Since current levels of hydrogen and fission power generation are extremely low, renewable energies are now of greater interest to us.

**A Global Snapshot**

The natural materials and processes upon which renewable and alternative power sources draw have existed for countless years. But sophisticated technology is required to exploit them for commercial purposes. Investment in energy research and development was spurred by the oil crises of the 1970s and accelerated sharply during that decade.

Since 1980, the amount of renewable energy consumed by the world has increased by almost 1000 percent, having started from a very low base. In 2011, renewables accounted for 16.7 percent of the world’s global final energy consumption, with biomass (13 percent) and hydropower (3.2 percent) topping the list. In 2011, around 20 percent of global electricity needs were satisfied by renewable sources. This ranked third behind coal (40 percent) and natural gas (about 20 percent). A 2011 Intergovernmental Panel on Climate Change report noted that within 40 years, renewable energy could supply 80 percent of the world’s energy if governments pursue green energy policies.

Perhaps surprisingly, developing nations produce and consume far more renewable energy than industrialized or transitioning ones. This is due in part to massive levels of investment by China and India but also in part to the heavy use of biofuels, such as wood, by poorer countries. Approximately 118 countries, of which at least half are developing countries, have renewable energy targets in place, while 109 countries have policies for the use of renewables in the power sector.

Among individual countries, those with the largest capacity of renewable fuel supply (excluding large hydropower dams) are China, the United States, Canada, Brazil, and Japan. At the end of 2011, China had the largest renewable power capacity in the world, of which 25 percent was non-hydro power.

Among regions, the fastest growing group of countries in terms of renewable energy usage has been Europe, where governments have been aggressive in actively supporting the expansion of renewable energy industries. In 2011, renewables accounted for more than 30 percent of Europe’s electric capacity, a 70 percent increase from 2010. Germany leads Europe and much of the world by using renewables to provide about 12 percent of its final energy consumption and 20 percent of its electricity consumption. While, in 2011, renewables accounted for 11.8 percent of U.S. primary energy production. The share of U.S. net electric generation from non-hydropower renewables grew 3.7 percent in 2009 to 4.7 percent in 2011 and nine states generated more than 10 percent of their electricity from non-hydropower renewables.

Investment in the development of renewable energy sources has steadily increased since the 1970s, reaching $257 billion in 2011. In 2011, the top five countries for total investment was China, the United States, Germany, Italy, and India. India experienced 62 percent growth, the fast expansion in the world

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2 REN 21 Global Status Report 2010 “Graphical Representations of Energy Use and Demand.”
3 Harvey
4 Ibid.
6 REN 21 Global Status Report 2012 14
7 REN 21 Global Status Report 2012 13
8 Ibid.
for renewables in the market. Developed countries invested $168 billion in new investments in the renewable market, while developing countries invested $89 billion.  

To encourage more investments in sustainable energy, UN Secretary Ban Ki Moon announced the Sustainable Energy for All initiative to achieve the following goals by 2030: universal access to modern energy services, improved energy efficiency rates, and expanded use of renewable energy sources.

**Government Policy**

On the subject of renewable and alternative energies more broadly, two points should be noted. First, government policy has an important role to play in the development of this sector. It is universally agreed that “policy choices could substantially increase renewable energy’s market share.”

Most renewable energy industries are still young. They face low demand from consumers as well as stiff competition from other well established energy industries such as the coal and nuclear industries. The production of clean energy also entails high setup and operating costs. Companies in many undeveloped renewable energy industries find it very difficult to recover these high costs over the life cycle of a facility, even though such life cycles can be decades long.

As strong growth in renewable energy capacity in Europe shows, wise government policies and encouraging incentives can have a real impact on the fortunes of these technologies. One expert noted, specifically with regard to the U.S. but in terms that are applicable globally, “Most of the modern technology that has been driving the U.S. economy did not come spontaneously from market forces…If we don’t have a proactive energy policy, we’ll just wind up using coal, then shale, then tar sands, and it will be a continually diminishing return, and eventually our civilization will collapse.”

**No Silver Bullet**

Second, it must be remembered that there is no silver bullet that will solve the world’s energy problems, “There’s no single great new fuel waiting in the heart of an equation or at the end of a drill bit.” As the Director of the National Bioenergy Center put it:

> We’re going to need everything we can get from biomass, everything we can get from solar, everything we can get from wind…And still the question is, can we get enough?

Although renewable and alternative energies cannot save the day on their own, they will be a central part of any long term energy strategy on both the domestic and global levels.

Discussions follow on biofuels, wind power, hydrogen power, solar power, and hydro/tidal power, only a few of the many renewable energies.

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9 REN 21 Global Status Report 2012 15  
10 REN 21 Global Status Report 2012  
11 Weeks 222.  
12 Wirth et al.  
13 Parfit 29-30.  
14 ibid 7.
Biofuels and Ethanol

Biofuels come from recently living organisms. They can be manufactured from animals or their byproducts (e.g. manure), but are usually made from plant matter. The highest profile biofuel in discussions about both globalization and the environment is ethanol.

Ethanol is another name for ethyl alcohol, a chemical compound produced from a wide variety of feedstocks including corn, sugar, and cellulosic materials such as switchgrass, straw, and plant waste. To produce ethanol, enzymes are first added to the feedstock to isolate the valuable sugars. This mixture is then combined with yeast, which causes the sugars to ferment and create a substance containing alcohol. This substance is distilled to raise the alcohol content to the 85-95 percent range. Finally, a cocktail of chemicals is blended with the ethanol to make it undrinkable.1

The Carbon Cycle


Ethanol is by no means a recent discovery. It has a long history dating back to the “dawn of the automobile age, [when] Henry Ford predicted that ‘ethyl alcohol is the fuel of the future.’”2 Rarely used on its own, ethanol typically serves as a fuel additive to gasoline. Combining ethanol with traditional fuels optimizes engine performance and enables fuel to burn cleaner, thus decreasing emissions of carbon monoxide and ozone.3 Ethanol and biodiesels are the primary renewable fuels in the transportation sector.4

Ethanol blends come in many forms:

- **E10** (90 percent gasoline/diesel, 10 percent ethanol), which accounts for 99 percent of ethanol consumption in the United States
- **E15** (85 percent gasoline, 15 percent ethanol), a new fuel blend which was approved by the EPA in 2012 to be used for cars with a model year of 2001 or later and is now available at one gas station in Kansas5
- **E25** (75 percent gasoline, 25 percent ethanol), which dominates the Brazilian market (along with E20)

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1 Yacobucci 3.
2 Rohter.
3 Yacobucci 1.
4 REN 21 Global Status Report 2012 17
5 Koenig
- **E85** (15 percent gasoline/diesel, 85 percent ethanol), which can only be used by flex fuel vehicles (FFVs) (As of March 2012, there were 10 million FFVs in the U.S., though they only used on average one tank of E85 per year).  

While E85 is capable of reducing harmful emissions by up to 20 percent, E10 has a much less dramatic impact, accounting for a mere one percent improvement. E15 is still somewhat controversial, while some believe it will cost less per gallon than the E10 mix, others are skeptical. Most automakers are telling customers to avoid the E15 stating it is not safe for engines. A study by the Coordinating Research Council concurs.  

Ethanol production levels have been steadily rising across the world, with Brazil and the United States dominating the young global market. 2011 saw the first global ethanol production decline of the past decade (-.5 percent), though biodiesel production continued to rise (16 percent). While global production was down slightly, production still increased in the U.S., though not in Brazil whose production decreased 18 percent since 2010 due to decreased investments in plantations, poor sugarcane harvests and high worldwide sugar prices. Brazil began aggressively laying the foundation for a globally competitive ethanol industry in the 1980s with extensive government assistance. The United States was a bit slower to adopt ethanol, but has since caught up in most measures of production capacity. With rising exports, the U.S. continues to gain international market share from Brazil.  

Ethanol has displaced the chemical known as **MTBE**, which used to be the most widely distributed fuel additive in the United States until a series of findings determined that it might cause cancer in some animals. As part of the MTBE phase-out, the U.S. Congress established ambitious targets for ethanol usage in the Energy Policy Act of 2005. This provided a huge lift to the American ethanol industry until the economic recession and high gas prices hit this industry particularly hard.  

**Government Support**  

As with most **renewable fuels**, governments play an important role in the development of the ethanol industry. **Renewable fuel standards**, drafted by the Environmental Protection Agency and enacted into law by Congress, mandate that all gasoline contain a renewable component. These were first introduced in amendments to the Clean Air Act of 1990 to address concerns about the effects of **greenhouse gas** emissions on air quality and have been updated in successive energy policy legislation. The latest standards mandate a heavy component of ethanol. This standard is critical to creating demand.  

**Net Energy/Environmental Gains**  

There are several factors that make ethanol’s continued expansion problematic.  

The most frequently cited reason for developing the ethanol industry is that it decreases fossil fuel consumption by substituting for some gasoline usage and is thus a more environmentally-friendly fuel. But this argument glosses over the fact that ethanol must itself be manufactured.  

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6 Motavelli  
7 Yacobucci 2, 18, 16.  
8 Koenig.  
9 REN 21 Global Status Report 2012 17  
10 REN 21 Global Status Report 2012 36  
11 Ibid.  
12 McNulty; Yacobucci 2, 13.  
13 Yacobucci 2; “Fuels and Fuel Additives.”
The ethanol production process, like many other forms of manufacturing, must be powered by natural gas or electricity generated by burning fossil fuels. Consequently, some experts believe there are few overall net energy gains from ethanol usage, meaning the benefits for the environment are often minimal. Ethanol may help decrease petroleum dependence, but it will not decrease energy consumption or contribute much to a nation's overall energy independence. The problem of net negative gains provides ammunition to those who question the motivations underlying huge ethanol subsidies.

The type of feedstock used to produce ethanol largely determines how big the net energy gains will be. Corn yields the lowest gains but continues to be the favored feedstock in the United States because of the size and political power of the American corn industry. Cane sugar, which is usually grown in more tropical climates, is a much more efficient feedstock, but costs almost twice as much as corn to process.

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Total Costs*</th>
<th>Processing Costs*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn (wet milling/dry milling)</td>
<td>$1.03/1.05</td>
<td>$0.63/0.52</td>
</tr>
<tr>
<td>Raw Sugarcane</td>
<td>2.40</td>
<td>0.92</td>
</tr>
<tr>
<td>Raw Sugar beets</td>
<td>2.35</td>
<td>0.77</td>
</tr>
<tr>
<td>Molasses**</td>
<td>1.27</td>
<td>0.36</td>
</tr>
<tr>
<td>Raw sugar**</td>
<td>3.48</td>
<td>0.38</td>
</tr>
<tr>
<td>Refined sugar**</td>
<td>3.97</td>
<td>0.36</td>
</tr>
</tbody>
</table>

*Per gallon **Excludes transportation costs


According to some estimates, “For each unit of energy expended to turn cane into ethanol, 8.3 times as much energy is created, compared with a maximum of 1.3 times for corn.” In addition, increasingly sophisticated Brazilian producers have found ways to process sugar without the use of fossil fuels, adding to ethanol’s positive environmental contribution.

The net energy gains from cellulosic ethanol are less well understood. But cellulose-based feedstock has the unique benefit of not requiring much energy to grow. In contrast to corn and sugar cane, agricultural byproducts like switchgrass need not be farmed using energy-intensive methods and can be harvested under naturally-occurring conditions. Switchgrass, for example, grows faster, uses less fertilizer, can grow on land unfit for other agricultural purposes, and also double as a source of animal feed.

Switchgrass

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14 Yacobucci, 15.
15 Rohter.
16 Parfit 23.
Unfortunately, the enzymes and processes used to break tough, cellulose-rich materials into usable sugars are not yet commercially viable. But the rapid pace of advances in biotechnology suggests that costs will likely eventually decrease to acceptable levels.

With government incentives and loans, cellulosic ethanol could take off within the next ten years. It would be more beneficial because cellulosic ethanol can use materials that are readily available and can use more parts of the corn already being planted. There are continued payoffs for the corn industry while better renewable fuels produced with less fossil fuel are made commercially accessible.\(^\text{17}\)

**Global Trade in Ethanol**

In 2012, the U.S. government did not renew the controversial, 30-year, multi-billion dollar federal ethanol subsidy. Ethanol blenders received 45 cents a gallon tax credit, which is about 4.5 cents for the amount of ethanol blended in a gallon of E10 gas. Congress also dropped the 54 cent per gallon tariff on ethanol imports. The impact of decision has yet to be felt since corn prices remain high, particularly for exports to China and because E10 gasoline has become standardized. Additionally U.S. demand remains high because of the alternative fuel mandate.\(^\text{18}\)

**Impact on Farming**

The United States would need to produce and consume a lot of ethanol if it really wants to change its energy mix. Some experts believe that production would have to rise from current levels of 14 billion gallons a year\(^\text{19}\) to 50 billion gallons a year, to replace oil imports from the Persian Gulf.\(^\text{20}\)

Globally, some estimates hold that “powering all the world’s vehicles with biofuels would mean doubling the amount of land devoted to farming.”\(^\text{21}\) Even approaching these targets with existing technological expertise would require a radical shift in thinking and practices for the agriculture sectors of many nations. Under such a scenario, farming would increasingly be viewed as a source of energy production as much as a source of food, thus putting those two priorities in competition with one another.

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\(^\text{17}\) Bullis.  
\(^\text{18}\) Woodyard.  
\(^\text{19}\) Ethanol 101  
\(^\text{20}\) Barrionuevo.  
\(^\text{21}\) Parfit 23.
Others disagree with this perspective, one American farmer notes in his blog:

Proponents and opponents of ethanol often agree that 40% of US grown corn goes to ethanol production...40% of the crop going to ethanol, no wonder food prices are rising! Once again it’s not that easy. Ever heard of dried distiller’s grains or DDGs? This is the by-product of corn ethanol production. It’s a concentrated feed stock that is sold to the livestock industry. When you take into account the amount of DDGs going to livestock, therefore putting that corn back into the food market you bring that 40% of corn going to fuel down to 23%. So we’ve cut that usage number nearly in half, and we’re just talking about the United States. If we look at grain use on a global scale, only 3% of grain is going to ethanol production.22

Transportation and Cost

Also hindering the expansion of ethanol use is its high transportation cost. Ethanol corrodes the pipelines used to carry it and is therefore often diluted by water when traveling long distances. While it can be hauled by trucks, trains, or barges, cost dictates that it is mostly refined and consumed close to the main feedstock suppliers.23

In the United States, for example, 68 percent of ethanol production occurs in only six states in the Midwest (Iowa, Illinois, Nebraska, South Dakota, Indiana and Minnesota).24 This geographical reality is an “obstacle to the use of ethanol on the East and West Coasts,” where energy consumption is highest.25 Until transportation methods are improved or cellulosic feedstocks that are widely distributed can be exploited, ethanol use will likely remain local and limited.

To read more about cars that run on ethanol blends, see Appendix E, “Hybrid Cars and Flexcars.”

22 Corn Use, Food Prices, and Ethanol
23 McNulty.
24 “Ethanol Facilities’ Capacity by State.”
25 Yacobucci, 3-4.
Wind Power

Wind has been harnessed to produce energy for hundreds of years. The use of windmills to catch air currents and translate that force into mechanical energy dates back to medieval Europe, and perhaps beyond. Today wind power is the second fastest growing energy source in the world and "one of the most mature technologies for generating energy from renewable sources."  

In 2011, 50 countries installed wind power capacity. This expansion is largely the result of technological innovations that have reduced the costs of constructing wind turbines by 80 percent since the 1980s and created economies of scale. In 2012, the world had about four times the amount of wind power capacity than it did in 2005. In 2011, China increased its percent share of global capacity (43 percent), as did the U.S. (17 percent), India (7 percent), and Germany (5 percent). The top five global producers of wind energy in 2011 were China, the United States, Germany, Spain and India. These days, wind power is predominantly used to produce electricity using turbines. Most of these turbines are oriented on a horizontal axis and are shaped like the propeller on an airplane. But an increasing number are built around a vertical axis and look like an “egg-beater.” Employing vertical-axis turbines raises the capacity of wind harvesting from 25-40 percent to 43-45 percent. While

1 REN 21 Global Status Report 2012 13
2 Cooper 181; Harvey, “Tide Is Turning.”
3 REN 21 Global Status Report 2012 13
5 REN 21 Global Status Report 2012 13
6 “China Leads Growth in Global Wind Power Capacity”
8 American Wind Energy Association “Wind Web Tutorial.”
this might not initially seem like a significant increase, it makes wind power much more economical and allows turbines to harvest more high-speed winds. This is important because “each doubling of wind speed results in an eightfold increase in available energy.”

Wind power generation facilities are generally land-based, though the number of offshore facilities has been rising in recent years, especially in Europe. Locating wind turbines offshore is more expensive, but it also allows for the construction of larger facilities and increases their capacity to generate power. The fact that many of the best land locations are already occupied has further spurred the development of offshore sites.

In May 2009 the first off-shore wind farm was approved by the state of Massachusetts. “Cape Wind” has been a controversial topic in communities around Cape Cod and the Nantucket Sound for almost ten years. The wind farm seems to have high public approval, so there is optimism that “Cape Wind” will expand the possibility for more offshore wind farms. “Cape Wind” received federal approval in 2010, and in 2011, received the necessary permits from the Environmental Protection Agency (EPA), Army Corps of Engineers and the Bureau of Ocean Energy Management, Regulation and Enforcement. Despite Cape Wind’s early start, Virginia might be the first state to have an operating offshore wind farm. Other U.S. offshore wind projects are in development in Maryland, Delaware, Massachusetts, New Jersey, Rhode Island and Texas.

Cost and Efficiency Management

Despite its benefits, expanding wind power also has costs. Some argue the industrial materials and processes needed to build wind farms require so much conventional energy that the net energy gains yielded by wind power are too small to be significant. Others argue that production costs for a turbine are recovered within six months of the start of operations.

There is also the problem of intermittency and storage. Wind energy is only as reliable as the wind itself. Because of this and because it often experiences a more variable demand than traditional coal- or gas-based power plants due to its more localized distribution, wind farms require sophisticated methods of managing and storing energy. This can often decrease the efficiency and raise the cost of wind power. It is likely that better ways of managing these energy flows will be discovered as the technology continues to mature.

Aesthetics and Ecological Impact

More serious concerns about wind power center on its aesthetics and environmental/ecological impact. Some people find the sight of wind turbines attractive but many do not, considering them a form of “visual pollution”. The fact that turbines are often located in more remote and sometimes scenic areas can make their appearance more objectionable to local residents.

For example, inhabitants of England’s northwest Lake District region, a large area made up of national parks of striking natural beauty, have been particularly vocal in objecting to wind farms in their backyards, even though the District’s many hills would provide ideal sites for an extensive development. The plan was eventually thrown out.

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9 “Turning Wind Power On Its Side.”
10 “Governor Patrick Hails Cape Wind Permit Approvals.”
11 “Cape Wind Completes Permitting Process”
12 “Offshore wind farm near Cape Cod, first in U.S., gets federal approval.” Capewind.org
13 “U.S. Offshore Wind Farms: The Race is On?” AOL Energy
14 Harvey, “Tide Is Turning.”
15 “Vast Wind Farm in Lake District; “Giant Wind Farm Plan Thrown Out.”
Perhaps even more pressing than aesthetics, however, are environmental and ecological concerns. Because significant distances must be placed between each turbine in order for wind harvesting to be efficient, turbines are considered to have a large “footprint” on the ground. Translated into practical terms, this means that, wind farms require far more territory than conventional power plants to produce the same amount of energy. Especially in more remote areas, this footprint can interfere with the local ecology, disrupting the habitats of both plants and animals.

In addition, the action of the blades on a turbine poses serious safety risks to birds, especially during the night. Defenders of the environment feel it is their duty to protect these creatures from harm, because "the seagulls don’t vote."17

A Landscape for Development

Wind power is an excellent example of how renewable energy technologies that are generally environmentally-friendly can also create new environmental problems of their own. The benefits of clean energy production must be carefully weighed against the environmental impact and effects on local quality of life.

According to Stephen Tindale, Executive Director of Greenpeace UK, “It’s a major psychological and cultural challenge for the environmental and conservation movement…What we need to combat climate change is a complete transformation of our energy system, and that requires a lot of new stuff to be built and installed, some of it in places that are relatively untouched.” In other words: “The biggest hurdle is creating a landscape for development.”18 This is both the challenge and the opportunity presented by many forms of renewable energy.

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16 “Wind Farm Area Calculator.”
17 “Blowing Strong;” Parfit 22.
18 Timmons.
Hydrogen Power and Fuel Cells

The potential of hydrogen as an alternative fuel source has been trumpeted for many years, but the technology has still not caught up with the dreams. Hydrogen is a naturally-occurring element that is found in abundance in many common chemicals, such as water. But hydrogen is difficult to obtain on its own. It must first be isolated using various processes. This is frequently done by passing an electrical current through water using a technique known as “reverse electrolysis” or by applying steam to natural gas using a process known as “reforming.”¹ The main benefits of hydrogen energy are that, when used as a fuel, it greatly simplifies the process of combustion and gives off completely clean emissions.

Fuel Cells

The great hope for hydrogen is that it could eventually supplant gasoline as a means of powering automobiles. In order to do so, hydrogen-based fuel would need to be stored in a fuel cell that would be incorporated into the car’s engine design. A fuel cell is similar to a normal battery with the exception that its capacity for energy storage can be replenished by external fuels rather being limited to a set amount of internal fuel.² Fuel cell technology is not, however, very well advanced. This has prevented the development of hydrogen as an energy source.


The Hydrogen Economy

Former U.S. President George W. Bush made the creation of a “hydrogen economy” a centerpiece of his energy policy for the future. Through the Hydrogen Initiative and FreedomCAR program, several billion dollars have been devoted to researching production of hydrogen and fuel cell technologies during the next decade, spurring the growth of a new industry.

Hydrogen fuel cars may hit showrooms in 2013. Major car manufacturers viewed hydrogen fuel cars at 2012 World Hydrogen Energy Conference in Toronto. Some manufacturers noted they will roll out the vehicles in 2015, while others announced plans to roll out hydrogen cars by 2014.³

¹ Deutch.
² “How Fuel Cells Work.”
³ Duarte
President Obama made the decision to cut $100 million in funding for the hydrogen fuel cell program. Energy secretary Steven Chu explained the decision saying, "We asked ourselves, 'Is it likely in the next 10, 15, 20 years that we will convert to a hydrogen car economy?' We felt the answer was 'No.'"  

The Costs of Innovation

There are three major concerns about the current emphasis on hydrogen as a potential replacement fuel capable of meeting the world’s transportation needs. First are cost and technological uncertainty. Not only do critics claim that hydrogen will not be a short-term "silver bullet" solution for reducing global dependence on fossil fuels, they also argue that real implementation of hydrogen technologies could be as many as 30-50 years away.

The internal combustion energy is a highly efficient mechanism that has been gradually improved over the course of a century, and it will be difficult to displace as a source of motor power. In addition, “the internal combustion engine is not a fixed target: the conventional cars of 2020 will be far cleaner, more efficient and therefore much harder to dislodge than today’s new cars.” If this is the case, then much of the funding currently being devoted to research in hydrogen and fuel cell technologies might be better spent in other areas, “Some energy experts say the current drive to develop fuel cells depletes the [U.S.] federal budget for bringing to market other non-polluting, renewable energy sources that are on the verge of becoming commercially viable.”

Net Energy Gains

The second major concern about hydrogen power, familiar to us from our discussion of biofuels, involves net energy gains. As was the case with ethanol, significant amounts of energy must be expended to transform hydrogen in a state in which it is consumable as fuel. More often than not, the energy powering the fuel fabrication process is derived from traditional fossil fuels, resulting in small or even negative net energy gains. In other words, “If the hydrogen is made from processes involving carbon-based fuels all that has happened is that the emissions of globally-warming carbon dioxide have moved from a car’s exhaust pipe to a power station chimney.”

Delivery Infrastructure

Finally, and perhaps most important on a practical level, is the problem of delivery infrastructure. Assuming that engineers eventually learn how to design new engines that take advantage of fuel cells, a completely revamped network for distributing hydrogen would be necessary in order for it to gain wide acceptance as a fuel for vehicles. Existing pipelines could not be used because hydrogen is highly corrosive. Special modes of transmission and new fueling stations would have to be built at tremendous cost to both suppliers and consumers.

In 2012, there are 227 hydrogen fueling stations in operation and 57 planned stations worldwide. Many of them service special urban buses in Europe that have been equipped to run on hydrogen. As of 2012, there are 83 operational hydrogen fueling stations in the United States (with 35 additional stations in planning), 40 percent of them in California. In fact, California has led the way with an ambitious program for development of a delivery infrastructure, labeled the “hydrogen highway” by Governor Arnold

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4 Biello.
5 Cooper, 180.
6 “Squeaky Clean.”
7 Cooper 180; Griffiths, “Accelerating Along the Road to Nowhere.”
8 Griffiths, “Accelerating Along the Road to Nowhere.”
9 International Hydrogen Fueling Stations
10 U.S. Hydrogen Fueling Stations
Schwarzenegger. While the goal was to build 200 fueling stations, 14 stations have opened, two are under construction and an additional ten have been funded.11

Hydrogen has the potential to be the fuel of a new global economy. In the meantime, it provides a warning about overselling what alternative fuels can accomplish.

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11 California Hydrogen Highway.
Solar Power

Energy from the sun’s rays can be manipulated in many ways in order to perform a variety of functions. The most common means of capturing solar energy is the photovoltaic (PV) cell. These cells are made of silicon semiconductors that absorb sunlight and channel it, thus exciting the electrons contained in the chips to rapid motion and generating electricity.

When a collection of photovoltaic cells is encased in glass and installed, it is known as a solar panel. These panels can be connected either to a battery for local usage and storage or to a larger electricity grid for distribution elsewhere. In 2011, the world’s leaders in terms of solar PV capacity were Italy, Germany, Japan, United States and Spain. From 2006 to 2011, solar power photovoltaic cells were the fastest growing renewable energy technology, increasing its operating capacity at an average rate of 58 percent per year.

Efficiency and Storage Technology

In general, the problems with solar power are less pronounced than those with biofuels, wind power, and hydrogen power. The two main issues hampering the development of solar energy are efficiency and storage technology. For all of solar energy’s benefits, current methods of capturing sunlight are only between 14 percent and 20 percent efficient. New materials for making more efficient semiconductors are under development, but it remains unclear when or whether they will become commercially available.

Detractors point out that, “At present levels of efficiency, it would take about 10,000 square miles of solar panels—an area bigger than Vermont—to satisfy all of the United States’ electricity needs. … [But] all those panels could fit on less than a quarter of the roof and pavement space in cities and suburbs.” In order to ensure that space and cost considerations are not prohibitive, further technological advancements will be required.

12 “Solar Basics.”
15 “History of Solar Power.”
16 Parfit 18
Partially because of this poor efficiency, partially because of the unpredictability of weather conditions (clouds, storms, etc.), and partially because of the absence of sunlight at night, storage is a particularly important element of solar energy production. Battery technology must also continue to improve if solar power is to achieve broader penetration in the global energy mix. There have been recent breakthroughs in which some solar cells reached a 40 percent conversion efficiency rate.\(^\text{17}\) Japanese and European companies have recently announced they are striving to achieve an efficiency rate of 45 percent. The problem now, once these new technologies are commercially viable, is the ability to efficiently store this energy.

**Scalable Energy for Development**

One of the unique benefits of solar energy is its **scalability**. Solar panels can be installed on a house-by-house basis and do not require the same level of **capital** investment as some other **renewable** technologies such as wind power.

![A Flat-plate Solar Panel Collection Capable of Using Direct and Reflected Sunlight](http://www1.eere.energy.gov/solar/pv_cell_light.html)

This is undoubtedly an expensive proposition for any homeowner, but solar panels hold great potential for communities that are remotely located and widely dispersed, including many in the developing world. According to Solar Energy International:

> Providing power for villages in developing countries is a fast-growing market for photovoltaics. The United Nations estimates that more than 2 million villages worldwide are without electric power for water supply, refrigeration, lighting and other basic needs, and the cost of extending the utility grids is prohibitive, $23,000 to $46,000 per kilometer in 1988.\(^\text{18}\) ($43,942 to $87,864 in 2011 dollars).

The advancement of solar energy has potentially revolutionary implications for the developing world as much as the developed one. Technological developments in the past few years have made solar panels more inexpensive and a cost competitive option for many rural areas. In developing nations, where kerosene is expensive and there is no national electricity grid to speak of, those who are self-installing solar panels in their houses and communities are saving much needed resources and money.

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\(^{17}\) Volynets.

\(^{18}\) “Energy Facts.”
Hydropower and Tidal Power

VIDEO: “Tidal Power: How it Works.” http://www.youtube.com/watch?v=qRUI1mJQHmc

Human control over flows of water accounts for two very different types of renewable energy. The first, hydropower, is already a major component of the global energy mix and supplies about 20 percent of the world’s electricity needs.¹ The other, tidal power, currently represents a negligible portion of the world’s overall fuel share and less than one percent of the growth in renewables from 1971 to 2009.² Though each is very different, both will play an important role in the future of energy.

Hydropower

Hydropower is considered the “granddaddy of green energy” because of its long and distinguished history.³ Hydropower’s most common incarnation is the dam, which places an artificial obstruction in a flowing waterway to create the pressure that turns a turbine.

The first dam designed to produce electricity was built in Cragside, England in 1878. The United States soon followed suit, eventually experiencing a boom in dam construction in the 1930s and 1940s that produced the famous Hoover and Grand Coulee dams.

In recent years, Brazil, Canada, and China have embarked on massive hydroelectric power projects, culminating in China’s Three Gorges Dam, which became operational at the end of 2011. The Three Gorges Dam will be the largest dam in the world, about five times the size of the Hoover Dam.

It has been the subject of fierce protests by those who fear the ecological and cultural damage it might wreak on an area of great historical and archeological significance to the Chinese people. Many also object to the fact that more than one million people in the surrounding environs have been displaced and many more adversely affected by flooding further up the Yangtze River directly caused by the changing water flows.

At the same time, it was acknowledged that the dam will be a necessary part of any strategy for powering China’s rapid economic development. Currently, China depends overwhelmingly on electricity produced by coal.⁵

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¹ Hydropower Internationally
² “Renewables in Global Energy Supply,” 2.
³ Aston.
⁴ “Hydro-electric Power,” “Hydroelectric Power.”

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While hydroelectric power will continue to be an important engine for growth, especially for large emerging economies like Brazil, China, and India, it will not be immune from controversy because of the complex impact of dams on local communities and the environment.

_Tidal Power_

Tidal power, while very modest in penetration at the moment, has great potential for the future: "Tugged by lunar gravity and stirred by wind and currents, the oceans' tides and waves offer vast reserves of untapped power, promising more oomph than wind and greater dependability than solar power." While relatively undeveloped now, "Offshore wave and tidal power are where wind was 20 years ago, [and] they'll come of age faster."6

Tidal power can be generated in two ways. The first, a method known as "ebb generation," uses a _sluice gate_ to fill a basin when the tide is at its high mark. When the tide begins to ebb, a difference is created between the water levels inside and outside the basin. As water is released from the sluice, the flow is used to spin turbines and generate electricity.7

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6 Aston.
7 "What Are Tidal Barrages."
A second method, known as tidal or wave farming, anchors turbines in the seabed and exploits underwater tidal currents. This method salvages a whole class of sites that were previously off-limits for electricity generation: “To draw energy from the ocean, [turbines] often need to be rooted on sea floors relatively close to shore, or mounted on rocks on the shore – places that have not traditionally been used for energy generation.” Adding to the benefits of tidal power are the inherent advantages that water power has over other forms of renewable energy, including its density: “Since water is heavier than air, marine systems pack a bigger punch than wind power.”

Although there are currently few tidal projects in operation around the world the number is increasing. The first wave farm opened off the coast of Portugal, but was shut down two months later due to technical problems. Funding for wave farms off the coast of Scotland and England were approved. Plans to develop wave farms in Australia are under way as well. Even the United States is starting to take notice, committing federal funds to research wave energy technology.

As with most forms of renewable energy, tidal power has its downsides and detractors. Usually, criticisms focus on the damage to aquatic ecosystems that tidal barrages and wave farms threaten. The entrepreneurs backing tidal projects, such as the proposed East River facility, pledge that they will invest millions to address these concerns. Exactly how the tidal power industry will develop is anyone’s guess, but all can agree that its potential is enormous.

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8 Timmons.
9 Aston.
Energy and the Environment

Energy and the environment have always been and will continue to be closely linked. All energy is, at bottom, either derived or captured from the environment around us. Once used, it is eventually returned to the environment as a harmless byproduct or, more often than not, as harmful emissions or waste. As energy usage has increased around the world, so too have the stresses this usage imposes on the environment intensified. Globalization has accelerated the pace of these developments and ensured that the actions of one country are felt more acutely in many others.

The relationship between energy and the environment is largely defined by the economic concept of externalities. An externality is a hidden or indirect cost associated with an activity or the transaction of a good or service. Because the burden of this cost often falls on outside bystanders who had no part in the activity or transaction, it is not reflected in the market price encountered by the buyer or seller. Thus, for example, the price an individual pays for a gallon of gasoline does not reflect the full costs that carbon emissions from the burning of that gasoline impose on the broader community (global warming, adverse health effects, etc.).

Beyond the market price set by supply and demand is a broader notion of cost that takes into account the “full social costs” paid by those directly involved in a transaction as well as any external parties affected by it.¹ This full social cost is particularly relevant when public goods such as clean air and clean water are concerned.

Conventional reasoning holds that because a communal resource belongs to everyone in theory, it belongs to no one in practice. The benefits of an action that exploits the environment, like burning coal or driving a car, are highly concentrated among those directly involved, e.g. the energy company or the driver.

But the real-life costs of such actions are widely distributed among the population at large, e.g. affecting people in neighboring countries who have to deal with acid rain or pedestrians who are forced to breathe in a car’s exhaust fumes. This distribution means that no individual feels responsible for the full social costs of his or her activities.

Governments can step in to help bring the market cost of an activity in line with the full social cost. They often do this by assessing the difference between the two and levying a tax that artificially raises the market cost. In economic terms this is known as “internalizing the externality.” As will become clear over the course of this section, externalities and the ways governments handle them are in many respects the central threads connecting energy and the environment.

More generally, it must always be remembered that the competing needs of energy users and environmental protection must be carefully balanced if economic growth is to be sustainable as well as robust.

¹ Wirth et al.

ANWR

One of the fiercest debates in recent years about the need to balance energy demands with environmental protection has focused on a relatively obscure stretch of land in Alaska known as the Arctic National Wildlife Refuge (ANWR). ANWR comprises 19 million acres of pristine land that various legislative measures have brought under the control and protection of the U.S. Congress.

Over the last decade, a steady chorus of lawmakers has urged that ANWR be opened up for oil
exploration as a response to America’s declining oil production and increasing dependence on foreign oil. Advocates of this position cite projections that the Refuge’s coastal plain could contain up to 16 billion barrels of oil, but by the time production reached peak levels around 2027, conservative estimates hold that ANWR reserves could only supply one or two percent of U.S. daily oil consumption.²

Opponents of drilling make two counterarguments. First, they dispute optimistic projections about the region’s potential as an energy source. They point out that total ANWR reserves will likely represent less than a year’s supply based on current levels of American oil consumption and that it would take approximately 10 years for production to come fully online. Thus, the oil that could be extracted from ANWR would not measurably improve America’s energy independence.

More importantly, they say, exploration would destroy a unique ecosystem that is worthy of vigilant federal protection. ANWR’s coastal plain is home to a variety of rare species of animals, from polar and grizzly bears to Arctic wolves, caribou, and “the endangered shaggy musk ox, a mammoth-like survivor of the last Ice Age.”³ The region is also an important transit area for thousands of migratory birds. In the minds of many, the potential gains from developing ANWR’s oil reserves are not worth the costs of jeopardizing this valuable part of the country’s natural inheritance. Several attempts to open ANWR to exploration over the past five years were repeatedly defeated in Congress.

According to Anchorage Daily News, in March of 2008 the U.S. Senate "rejected a Republican energy plan that promised to open the Arctic National Wildlife Refuge to oil exploration, an option that was part of an overall package to increase domestic energy development." The debate still remains unresolved. President Obama refuses to allow drilling there citing environmental degradation as his reasoning, and has left it out of his energy bill.

The impact of energy usage on the environment can be evaluated at three stages: (1) the preventative stage prior to consumption; (2) the act of consumption itself; and (3) the aftermath of consumption. Grouping the first two together for convenience, this section will first cover conservation and energy efficiency. It will then proceed to consider the issues surrounding energy emissions and climate change, including the Kyoto Protocol.

For more information about globalization and the environment, see the “Environment” in Depth, <http://www.globalization101.org/issue/environment/>.

² “Arctic National Wildlife Refuge.”
³ ibid.
Energy Conservation

The conservation and energy efficiency movements share the common goal of reducing energy consumption. But they go about achieving this goal in slightly different ways. Conservation focuses on reducing the need for energy, often by trying to alter the mindset and behavioral patterns of energy users. In contrast, the push for energy efficiency recognizes that, if energy must be used, its consumption should at least be as productive as possible. Both are strategies designed to save energy and minimize the damage caused to the environment.

Conservation Under Carter

The energy conservation movement, an early part of the larger environmental movement, was born in the United States in the 1970s. It emerged in response to growing political instability in the oil producing states of the Middle East and gained momentum in 1977 when President Jimmy Carter declared to the nation that the U.S. energy crisis was the “moral equivalent of war.”

In that same year, Carter announced the creation of a new Department of Energy and proposed a series of federal conservation initiatives. These included the installation of solar panels in the White House, an audit of government energy usage by the General Services Administration, and tight controls on thermostats in many government and commercial buildings. Carter himself took to wearing a trademark cardigan sweater to symbolize his rejection of wasteful home heating.

The public response to Carter’s calls for conservation was mixed at best. Many subsequently believe that “memories of the public’s adverse reaction to Carter’s conservation initiatives still haunt some lawmakers, who say the Carter experience proves Americans would never accept radical conservation proposals.”

Carter’s successor, Ronald Reagan, declined to adopt energy conservation as a priority, and it has never received the same degree of sustained national attention since 1977. But the idea of conservation had been raised and was picked up by many individual citizens and businesses.

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1 Carter, “President’s Proposed Energy Policy.”
A Missed Opportunity

Many feel that the past U.S. leadership did not do enough to promote conservation as a way of life. Vice President Dick Cheney, for example, has said, “Conservation may be a sign of personal virtue, but it is
not a sufficient basis all by itself for a sound, comprehensive energy policy.\textsuperscript{4} But many disagree, arguing that conservation’s role in continued American prosperity should not be dismissed:

Although often underrated, the impact of conservation on the economy has been enormous over the past several decades. Over the past 30 years, U.S. GDP has grown by 150 percent, while U.S. energy consumption has grown by only 25 percent.\textsuperscript{5}

Proponents of conservation say that the government is missing a valuable opportunity.:

Today’s leaders are not tapping into that patriotism by asking this generation to make sacrifices like their parents and grandparents did during World War II…Many of those flags, after all, are flying from the antennas of SUVs that only get 13 miles to the gallon.\textsuperscript{6}

\textit{Conservation in the Home}

Energy conservation can be an empowering tool for the informed global citizen because it can start in the home by cutting down on waste. A person can easily decrease the amount of energy he or she consumes at home using commonsense methods. Being reasonable with the thermostat in both winter and summer is a good first step, as is ensuring that windows, doors, and other openings to the outside are well insulated. Smart use of appliances, electronics, refrigerators, laundry machines and lights can also make a significant contribution.

Sometimes conservation requires a sizeable upfront investment, e.g. for new windows or insulation. But it is often possible to recover these costs gradually through savings in future energy bills.

\textit{U.S. Residential Energy Usage, 2009}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{residential_energy_usage.png}
\caption{Residential Energy Costs in the U.S.}
\end{figure}

\begin{itemize}
\item \textbf{Computers}: 1% \\
\item \textbf{Cooking}: 3% \\
\item \textbf{Electronics}: 5% \\
\item \textbf{Wet Clean}: 5% \\
\item \textbf{Refrigeration}: 6% \\
\item \textbf{Space Heating}: 31% \\
\item \textbf{Water Heating}: 12% \\
\item \textbf{Space Cooling}: 10% \\
\item \textbf{Lighting}: 9% \\
\item \textbf{Other}: 18%
\end{itemize}

\textsuperscript{4} Ellis. \\
\textsuperscript{5} Yergin. \\
\textsuperscript{6} Cooper 77.
The potential benefits to the environment when individual acts of conservation are added together can be huge. Some experts estimate, for example, “Buildings could be up to 30 percent more efficient within the next decade relying on technologies ‘already in the market and known to be feasible and cost-effective.’”

To read more about how you can start conserving energy at home, see Appendix F, “Energy Audits.”

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7 Mantel 437.
Energy Efficiency

Many believe that pursuing greater energy efficiency is a much easier and more potent strategy for decreasing energy consumption than conservation. This is partially because efficiency does not need to overcome the challenge of deeply-rooted individual habits. Rather, increasing energy efficiency means producing goods and utilizing processes that "use less energy but deliver the same or better service. It doesn't mean turning down the thermostat and shivering; it means installing an energy-efficient furnace and keeping the thermostat setting the same."\(^1\)

Improving efficiency may even be a more effective solution than investing in new renewable and alternative energy technologies. This is true because efficiencies not only lower costs, they also have the benefit of reducing overall emissions. According to one expert, "Dollar for dollar, you get more reduction of carbon dioxide from efficiency measures than from using nuclear power, and I think the same [will hold true of] carbon capture and storage."\(^2\)

There are many ways in which a person can improve the efficiency of energy usage in daily life. Carpooling is one way. And the spread of carpool lanes in many cities around the world is certainly an encouraging sign.

Online shopping is another way of performing a common task with greater energy efficiency. It is estimated that, as a result of saved fuel costs, "The purchase of a single book from a virtual bookstore like Amazon.com consumes 16 times less energy than buying one at a bricks-and-mortar retail store."\(^3\) Buying from online stores is in a sense the shopping equivalent of the carpool.

To read more about one of the most successful energy efficiency campaigns, see Appendix G, "The ENERGY STAR Program."

**Standby Power**

Most people would probably be surprised to learn that standby power, the energy consumed by electronic devices when idling and not operating, accounts for between five percent and 10 percent of total residential electricity consumption in the United States. This represents an annual cost of $3 billion to the consumer. Eighteen dedicated power stations would be required to supply the needs of standby power in the United States alone.\(^4\)

The average microwave, for example, is idle more than 99 percent of the time and expends more energy simply running its clock as it does heating food. According to some estimates, "Using the most efficient designs could reduce average household standby-power consumption by 72 percent....Applying this reduction [among the richest developed nations] would reduce [global] carbon-dioxide emissions by nearly 0.5 percent."

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\(^1\) Mantel 435.
\(^2\) Browne; Harvey, “Science Rises to the Challenge.”
\(^3\) Cooper, “Energy and the Environment,” 173.
\(^4\) “Pulling the Plug.”
<table>
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<th><strong>Globalization</strong></th>
<th>A project of [SUNY LEVIN Institute]</th>
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| | Such a reduction would be equivalent to the emissions of 18 million cars.⁵ |
| | The problem of wasted standby power has been created by the transition from “an electromechanical world that’s on and off to an electronic world that’s never off.” Only recently have governments begun to tackle this problem, led once again by the state of California. The California Energy Commission established the first rigorous standby power standards in the world in January 2006. As a result, new technologies are being developed to further enhance standby performance. Individual consumers can contribute by unplugging electronic devices when they are not being used.⁶ |

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⁵ “Pulling the Plug.”
⁶ ibid.
Fuel Efficiency Standards

One way that governments can encourage greater efficiency in energy usage is by setting fuel economy standards. These mandate the number of miles/kilometers a vehicle must be able to travel for every gallon/liter of fuel it consumes. Fuel economy is not to be confused with fuel efficiency, which technically relates to engine performance, though the terms are often used interchangeably.

Corporate Fuel Efficiency Standards

Fuel economy standards have been used to improve energy efficiency in many places, most notably in the United States. The first Corporate Average Fuel Economy (CAFE) standards, as they are known, were created in 1975 by the National Highway Traffic Safety Administration (NHTSA) and the EPA. Between 1978 and 1987, CAFE standards improved on-the-road fuel economy in U.S. vehicles by 40 percent. But then standards languished at 1987 levels for almost 20 years, with economy hovering at 27.5 miles per gallon (mpg) for passenger cars and 20-22 mpg for light trucks and sport-utility vehicles (SUVs). According to current standards, cars and light trucks are considered separately and are held to different standards. As of the beginning of 2009, the ‘car average’ has to exceed 27.5 mpg, and the average for light trucks must exceed 20.7mpg. By 2016 though, there will be CAFE average of 35.5 mpg and, by 2025, the CAFE for vehicle fleets will be 54.5 mpg.

Because these standards remained the same for so long, manufacturers focused on size and performance at the expense of efficiency. Over the last two decades, vehicles became 20 percent heavier and 25 percent faster. These developments on their own may have increased greenhouse gas emissions in the United States by up to five percent. Though the tides may be changing, reporters who attended the 2021 Detroit Auto Show reflected that automakers are now shifting to smaller and lighter cars to boost gas mileage. Fuel economy has the potential to increase 50 percent with some of the newer designs that use lighter steel.

THE SUV EXCEPTION

Many critics of American fuel efficiency standards have complained that the standards for light trucks and sports utility vehicles are not rigorous enough. In the 1980s, these two classes of vehicles were far less common than they are today. The exemption of light trucks and SUVs from the strict standards required of passenger cars can be traced back to the origins of their use as farming vehicles in rural areas. As sales of these vehicles skyrocketed, manufacturers began to make them heavier and faster to attract new buyers. Over the next 20 years, fuel economy performance for these classes actually decreased.

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1 “CAFE Overview.”
2 “Consider the Alternatives.”
3 Mantel 439.
4 Del-Colle
5 Mantel 439.
6 Plumer
8 Glover and Behrens 21.
Recent revisions to the CAFE standards in early 2006 sought to bring economy standards for light trucks and SUVs in line with the stricter car requirement. But even so, Daniel Becker of the Sierra Club, says, “This new standard is like telling a two pack-a-day smoker to cut out one cigarette.”

The potential efficiency gains from fuel economy standards like CAFE are substantial, but many feel they have not been pursued aggressively enough. The Union of Concerned Scientists, for example, is not alone in suggesting that economy rates of 40 miles per gallon could be attainable by 2015.

Within the last few years, the increased gas prices have led to a decrease in SUV purchases within the United States. Nissan, much like General Motors, Ford and Toyota has announced that it will downsize production of SUVs and trucks in favor of fuel-efficient cars. According to Automotive News Europe, this trend can also be witnessed in the European market. The increasing fuel prices in combination with CO2-based taxes applied by various governments has led to a decrease in SUV sales in Europe.

Standards vs. Taxes

Standards are, however, only one economic tool at the disposal of governments for the regulation of fuel usage. The other is taxes (see the section on “Government Policy” above). Many economists feel that standards are a relatively blunt tool compared to taxes because they alter price levels only indirectly. Similarly, critics of the CAFE standards complain that:

Bizarrely for the banner carrier of capitalism, Washington declines to use the price mechanism of tax in favour of an administrative system of fuel efficiency standards that would do credit to Soviet-era Gosplanners, who would at least have imposed such norms more effectively on Detroit than have U.S. bureaucrats.

Critics of fuel economy standards also cite the Jevons Paradox in advocating higher taxes on gasoline. According to Jerry Taylor of the Cato Institute:

CAFE standards actually decrease the marginal cost of using energy…you’ve made it cheaper for me to drive, and so I’ll drive more. If your idea is to reduce consumption, the

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9 “Vehicles & Equipment;” Johnson and Simon.
10 Mantel 439.
11 “A Real Energy Market”
only way you’re going to get people to use less energy is to make it more expensive for them to use it.\textsuperscript{12}

Ideally, fuel economy standards and proper levels of taxation would be combined in an effective energy policy. Both elements will be very important to large developing countries such as China as their increasingly wealthy populations take to the roads in greater numbers than the world has ever seen before.

\textsuperscript{12} Cooper, “Energy Security,” 81.
Climate Change

We now move from strategies for minimizing energy usage to methods of dealing with its aftereffects. The main byproducts of energy usage are material waste and emissions of gases. Harmful emissions are often known as **greenhouse gases**. When these gases are released into the atmosphere, they trap heat that would otherwise radiate into space and produce warmer temperatures, a phenomenon known as the **greenhouse effect**.


The greenhouse effect is a main contributor to **global warming** and part of the broader disruption of weather patterns referred to as **climate change**. Many fear that climate change constitutes “the greatest single threat to the environment today.”¹ Climate change should be a central part of anyone’s thinking about energy issues, because “preventing catastrophic climate change is, at its core, an energy challenge.”²

**Catastrophic Effects**

A growing number of scientists worry that, “A warmer climate could lead to rising sea levels, the spread of tropical diseases in previously temperate climes, crop failures in some regions and the extinction of many plant and animal species, especially those in polar or alpine areas.”³ Possible consequences of climate change could affect a range of areas from agricultural yields to the frequency of storms and natural disasters to the survival of many land- and marine-based ecosystems.

Of particular concern is the fact that global warming is already causing the polar ice caps to melt, thus discharging large amounts of extra water into the world’s oceans. The situation could get much worse over time. Even small changes in sea levels could wipe out entire coastal regions. This is because “coastlines are shallow slopes, not firm walls, so a rise in water levels of just tens of centimeters would erase kilometers of wetlands and beaches.” A report by the EPA concludes by 2050 the sea level will rise

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¹ Cooper, “Energy and Environment,” 165.
² Wirth et al.
³ Bradsher and Barboza.
by six inches due to global warming. Some models predict that sea levels could rise between five and thirty-two centimeters by 2050, with potentially catastrophic effects.4

Developed nations, such as the United States, would undoubtedly suffer as a result of such effects. But, given the gradual nature of the change, most rich countries would probably be able to adapt accordingly.

On the other hand, overpopulated developing countries such as India or Indonesia could be devastated. Residents of the small South Pacific nation of Tuvalu, for example, believe higher ocean levels will likely swallow their entire island. They have already concluded an immigration compact with New Zealand to prepare for this possibility.5 A 2009 report, The Anatomy of a Silent Crisis: Human Impact Report Climate Change estimates that 26 million of the 350 million people displaced worldwide was due to climate change. In the coming century estimates range from fifty million to one billion people will lose their homes and lands due to climate change.6

Policy Response

The scientific debate over the nature and extent of climate change is highly complex. Consequently, this Issue in Depth will not delve into the many controversies surrounding the evidence of climate change.7 Our primary concern is the policy response by global leaders to accepted evidence.

4Titus and Narayanan.
5Kirby.
6CLIMATE CHANGE DISPLACED PERSONS AND HOUSING, LAND AND PROPERTY RIGHTS PRELIMINARY STRATEGIES FOR RIGHTS-BASED PLANNING AND PROGRAMMING TO RESOLVE CLIMATE-INDUCED DISPLACEMENT
7Some of the evidence for global warming includes: satellite observations confirming that spring arrives a week earlier than it did in the 1970s, a drop in the number of glaciers in Montana’s Glacier National Park from 150 in 1910 to 30 today, and reductions of up to 80 percent in the snow caps of Tanzania’s Mount Kilimanjaro. See John Browne, “Beyond Kyoto,” Foreign Affairs 83 (4), July/August 2004; Marcia Clemmit, “Climate Change,” CQ Researcher 16(4), Congressional Quarterly Press, 27 January 2006, 75.
For a long time, the debate about climate change focused on whether it was actually occurring. From complete denial, skeptics then acknowledged the phenomenon in principle but disputed the assertion that climate change was being driven by factors related to human beings. After all, the earth has gone through many periods of extreme climate change, cycling from Ice Ages to more tropical “interglacial periods.” These cycles occurred naturally, without any help from human beings. The current debate recognizes that at least part of the causes of climate change can be attributed to human activity.

The main point of contention now is how the nations of the world can act in concerted fashion to address a problem that will affect all of mankind. In other words, “Arguments now center not on whether human-induced global warming is occurring but whether it is enough of a threat to warrant spending money to stop it.”

*The Problem of Collective Action*

If, by and large, most scientists, citizens, and political leaders agree that climate change is a serious problem, why has the global policy response been so ineffective? Part of the reason is because climate change is perfect example of what social scientists call a “collective action” problem. All nations have a collective interest in mitigating climate change, but the individual costs faced by each nation in contributing to this effort are very high, perhaps greater even than the benefits it expects to receive. Because of these steep costs, each nation is reluctant to act on its own before it knows that all others will commit to acting as well. The desired outcome cannot be achieved without cooperation, but cooperation requires a temporary suspension of self-interest and a measure of trust that are rare in international relations. These issues will be further considered below in the regard to the *Kyoto Protocol*.

*A Tipping Point*

As discussions about climate change continue, many scientists feel we are approaching a “tipping point” beyond which the effects will be permanent and corrective action futile. The sense of urgency is steadily intensifying, according to one expert, “Anybody whose solution includes the phrase ‘in 20 years,’ hasn’t quite caught on to where we are.” One recent British study, for example, predicted that, “A rise of 3 degrees [Celsius] from current temperatures could lead to the irreversible destabilization of the Arctic ice sheets or reversal of the Earth’s ability to absorb carbon dioxide.” The notion that this possibility can be prevented without “taxing and regulating carbon” is looking more farfetched every year.

An expanding chorus of voices is calling for decisive action, coordinated on a global scale before it is too late. As George Marshall of the environment group Rising Tide warns, “We have no right…to argue to future generations…that we were waiting to achieve a full scientific understanding” before addressing climate change simply because it is a costly and formidable problem.

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8 Clemmit 75
9 Mantel 436; Mouawad, “Green Guys.”
10 Mantel 436.
11 Mallaby.
12 Clemmit 76-7.
THE STERN REVIEW
Sir Nicholas Stern, a former chief economist at the World Bank, released a lengthy report to the British government in late October 2006 detailing the potential impact of escalating climate change on the global economy within the next 50 years. This landmark study warns that global warming could eventually “devastate the world economy on the scale of the world wars and the Great Depression” by decreasing global GDP by five to twenty percent each year in the coming decades.13 The report recommends investing one percent of current global GDP in reducing greenhouse gas emissions, arguing that such a move to reduce global warming could result in trillions of dollars in savings in the long term.

Problems highlighted by Stern for special attention include the heavy use of carbon fuels in power generation and rampant deforestation, which single-handedly accounts for more harm to the environment than transportation. Though Stern admits the majority of the burden of achieving these investment targets should fall on rich countries, his report emphasizes that the participation and cooperation of all major economies, including the U.S. and China, will be required to effectively address global warming.14

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13 Wagner.
14 Peston.
Emissions Standards and Air Quality

Before considering the difficulty the international community has faced in regulating the emission of carbon dioxide across borders, we will first look at some strategies that were employed at the national level to purify the air of other harmful pollutants.

The Clean Air Act

The United States emerged as an early leader in the effort to improve air quality with the passage of the first Clean Air Act in 1963. This landmark piece of legislation was updated in 1970 to regulate the emissions of 189 pollutants known to cause smog. Tough standards were established for a host of harmful air contaminants including nitrogen oxide, carbon monoxide, sulfur dioxide, and lead.

Cycle of Toxic Air Pollution

![Cycle of Toxic Air Pollution](http://www.epa.gov/oar/oagps/takingtoxics/p1.html#2)

A subsequent revision to the law in 1990 sought to tackle the problem of acid rain, which was largely caused by emissions of sulfur dioxide from coal-based power plants. It established a new system of tradable “emissions allowances” in the hopes that a market-based solution would be both effective and lasting. The tradable emissions concept was introduced as an integral part of the international law, the Montreal Protocol. This protocol seeks to control the same issues as the Clean Air Act but under international consensus. As a result of these new federal standards, the coal industry, which has long produced the bulk of American electricity, was forced to adapt. Most importantly, coal-burning facilities were required to install scrubbers in their smokestacks to capture sulfur before it could be released into the open air.

In 2012, after more than 20 years of deliberation, the EPA issued the Mercury and Air Toxic Standards (MATS), the first national standards in the U.S. to regulate power plant emissions of mercury and other toxic air pollutants. These standards were required by the Clean Air Act, but took 20 years to finalize. These new standards require power plants to deploy pollution control technologies to prevent 90 percent of mercury emissions and 88 percent of acid gas emissions.

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2 ibid 163.
As a result of these new federal standards, the coal industry, which has long produced the bulk of American electricity, was forced to adapt. Most importantly, coal-burning facilities were required to install **scrubbers** in their smokestacks to **capture** sulfur before it could be released into the open air.³

The Clean Air Act has been unable to eliminate the problem of acid rain completely, but it did achieve significant gains. The introduction of low-sulfur **gasoline** and widespread adoption of catalytic converters, which “trap smog-causing pollutants,” also helped improve America’s air quality. Today’s vehicle emissions are 98 percent cleaner when it comes to such pollutants than their counterparts from the 1970s.⁴

Thus, the United States was able to dedicate itself effectively to the reduction of acid rain and smog by eliminating sulfur from the emissions of vehicles and factories. Achieving goals like this on the national level has proven quite feasible for an advanced country like the United States.

To read more about the worsening problem of air quality in China, see Appendix H, “Chinese Coal.”

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**AIRLINE EMISSIONS**

Many people might not think about exhaust fumes when they fly on a plane, but aircraft are a major source of **greenhouse gas** emissions. Aircraft emissions represent only a small share of overall greenhouse gas pollution—about three percent of global totals and ten percent of transportation emissions—but that share is the fastest growing of any sector.

The new line of “super-jumbo” jets being produced by Boeing and Airbus emits as much pollution as a “14km (nine-mile) queue of traffic on the road below.” Within two decades, 1,500 or more of these planes could be in service.

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³ ibid 163.
⁴ ibid; “Consider the Alternatives.”
producing an amount of carbon dioxide equivalent to the emissions of five million cars.\textsuperscript{5}

Since there are more than one billion cars on the road, it may seem like aircraft emissions are still insignificant in comparison. But, there are several factors that even the scales:

"Whereas cars are used roughly for about an hour or so a day, long-haul jet airlines are on the move for at least 10 hours a day. And they burn tax-free, high-octane fuel, which dumps hundreds of millions of tons of CO2 into the most sensitive part of the atmosphere…Although cars and aircraft discharge roughly the same amount of CO2 for each passenger-kilometre, the aircraft travel an awful lot farther."\textsuperscript{6}

Compounding the problem is the fact that the popularity and frequency of air travel only continue to grow. It is estimated that the "annual increment in air travel as 2020 approaches will equal the total number of miles flown in 1969."\textsuperscript{7} Because of these factors, aircraft emissions loom as a troubling problem on the horizon.

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\textsuperscript{5} "Sky's the Limit."
\textsuperscript{6} "Sky's the Limit."
\textsuperscript{7} ibid.
The Kyoto Protocol

In 1992, the United Nations Conference on Environment and Development, known as the “Earth Summit,” was held in Rio de Janeiro, Brazil. At that meeting, more than 150 countries signed a treaty called the U.N. Framework Convention on Climate Change (UNFCCC) in which they agreed to work together to stabilize harmful greenhouse gas emissions. The agreement was non-binding, but it represented the broad acceptance of a goal. Specific targets were not established, with the understanding that future negotiations would produce implementing protocols. The treaty was notable for drawing a clear distinction between developed and developing countries, each of which would have different sets of obligations.¹

Beginning in 1995, annual Conferences of the Parties (COPs) were held among signatory nations to develop the implementing protocols. The first meeting, called COP-1, resulted in the “Berlin Mandate,” a set of principles that set the stage for future negotiations. The mandate recognized the need for binding commitments with “common but differentiated responsibilities” for developed and developing countries.² It was assumed that developing countries would be exempted from many obligations.

The details of treaty commitments began to take shape in the protocol drafted in Kyoto, Japan in 1997 (COP-3). The foundation of the Protocol was an agreement that signatory nations would cut emissions of greenhouse gases, including carbon dioxide, by an average of 5 percent below 1990 levels by 2012. Each country was assigned an individual target for cuts based on its share of global pollution. Additional details of how the Protocol would operate in practice were hammered out over the course of the next three COPs, and the Protocol officially entered into force in 2005.³

U.S. Energy-Related Carbon Dioxide Emissions by Sector 2011

¹ “Guide to the Climate Change Convention,” 6, 8-9; “Brief Introduction.”
² Fletcher 1.
³ ibid, 3; “Kyoto Protocol Comes Into Force.”
In total, 192 countries have ratified the Kyoto Protocol, representing 64 percent of global greenhouse emissions. The United States and Australia have been conspicuous in refusing to ratify the accord. The United States under President George H.W. Bush was one of the early supporters of the UNFCCC in 1992. But by the time of the Kyoto meeting, mounting opposition within Congress had reinforced reservations within the executive branch about how the treaty would be implemented. As a result, the United States remains a party to the Protocol, having signed it.

Because the U.S. has not ratified the Protocol, Kyoto’s commitments are not binding on the United States, which remains the world’s largest source of greenhouse emissions. In the eyes of many, the Protocol’s effectiveness has been seriously undermined by the lack of American participation.

We will consider several key points of contention that emerged regarding the Protocol, some of which have been addressed by the UNFCCC and some which have not.

**Natural Carbon Sequestration and Carbon Sinks**

Much of the debate on the Protocol naturally focused on the methods by which countries might meet their emissions reduction targets. During COP-6, held at the Hague in the Netherlands in 2000, the United States put forth a proposal that countries be given credit for the positive effects of natural carbon sinks within their borders. Carbon sinks, such as oceans and forests, absorb or sequester carbon dioxide through natural processes removing it from the atmosphere.

The European Union, among others, objected to this proposal because the acceptance of carbon sinks would allow forest-rich countries like the United States to meet a substantial portion of their emissions requirements without instituting any actual reforms. Many scientists believe that allowing such business as usual practices to count as progress will not help solve the problem of climate change. Despite these concerns, the use of carbon sinks was permitted in the final version of the Protocol. Although the United States has still yet to ratify the Protocol, the inclusion of natural carbon sequestration as an available option makes the prospect of eventual ratification more likely.

**Joint Implementation and the Clean Development Mechanism**

Other proposals for alternative ways of meeting emissions targets that emerged during the negotiation of the Protocol were the Joint Implementation (JI) mechanism and the Clean Development Mechanism (CDM). In each case, a developed nation would invest in an emissions reduction project in another country. Even though the emissions reductions would not be achieved within its own borders, the investing country would receive credit for its action to help meet its own reduction target. Emissions credits would be transferred between the two partners (see box on “The European Union’s Emission Trading Scheme”). The recipient country could either be another developed country, as in the case of JI, or a developing country, the requirement for CDM.

Why would an investing country be interested in taking advantage of JI or CDM? Reducing emissions is a costly proposition and can require significant restructuring for many industries. In addition to the capital costs it requires, such restructuring can damage a nation’s overall economy. The United States, for example, would have had to make twenty to thirty percent in real emissions cuts by 2012 to meet its target of a seven percent reduction below 1990 levels. Achieving deep cuts in this range would cost

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4 “Essential Background: Kyoto Protocol.”
5 Fletcher 6.
6 ibid 8-10.
7 ibid 4-5.
between $67 billion and $400 billion.\(^8\) It would also likely apply a brake to the growth of the U.S. economy. Before it refused to ratify the Protocol, the United States was a major backer of the JI and CDM options during negotiations because it wanted to avoid such a brake.

As with carbon sinks, the worry was that countries would be able to meet their obligations without implementing any actual domestic reforms. The final language of the Protocol permitted the use of joint implementation and clean development mechanisms. But it stipulated that these schemes “shall be supplemental to domestic actions.” This proviso was included “to make it clear that a nation cannot entirely fulfill its responsibility to reduce domestic emissions by relying primarily on emissions trading or joint implementation…domestic action must constitute a significant element” of overall efforts.\(^9\)

**Scope of Ambition**

While carbon sinks and joint action problems were eventually resolved in COPs subsequent to Kyoto, the United States remains reluctant to ratify the Protocol. One U.S. concern is the scope of the Protocol’s ambition. American negotiators argued that Kyoto was “too modest in its scope and at the same time unrealistically ambitious in its timetable for the United States.”\(^10\) Put another way, the U.S. position was that the short-term cuts sought for the 2008-2012 period were too deep and potentially destructive to the economy.

As if this were not bad enough in the U.S. view, long-term targets after 2012 were left ambiguous. Even if the United States were to accept the obligations for 2012, there would be no guarantee that this investment would lead to a worthwhile outcome since no post-2012 strategy had been formulated.

The first part of this criticism, regarding the ambition of short-term targets, has proven to be largely unfounded. Both the United Kingdom and Germany, for example, were able to reduce emissions below levels required in the 2005-7 period with relative ease. This has led some to argue that short-term goals actually are not ambitious enough to inspire radical change in the international business community.\(^11\) The second element of this criticism, the lack of a post-2012 strategy, has been preliminarily addressed at a June 2009 conference in Bonn, Germany.

A 2009 conference in Copenhagen attempted to cement the post Kyoto framework. The summit was criticized for failing to produce a treaty to curb global warming, but analysts claim that it did succeed in generating a significant amount of emission-reducing commitments from countries, such as China and India. Specifically, current analyses show that the Copenhagen summit has generated more pledged emissions reduction than the Kyoto Protocol.\(^12\)

Because of the inaction of the U.S. federal government, many states and localities in the United States have taken independent action to implement carbon regulation and trading schemes. Most notably, in August 2006, the state of California under Governor Arnold Schwarzenegger set ambitious targets that would roll back the state’s greenhouse gas emissions to 1990 levels by 2020. Several other states, including Massachusetts, Oregon and Connecticut among others have since followed suit.\(^13\)

COP-16, a gathering of parties to the Kyoto protocol, was held in Cancun, Mexico from November 29 to December 10, 2010. While only considered a modest success, the meeting reaffirmed the goal to keep global temperatures from rising more than two degrees from current levels. Another agreement, the

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\(^8\) ibid 3; Clemmit 81.

\(^9\) Fletcher 4, 10.

\(^10\) Wirth et al.

\(^11\) Landler.

\(^12\) Tankersley

\(^13\) “Going Deeper Green;” Martin; Freeman.
“Green Climate Front,” was made as well, pledging to raise $100 million dollars to help developing countries reduce emissions. It is unclear how this money will be raised.

At COP-17 held in Durban, South African from November 28 to December 9, 2011, attendees adopted the Durban Platform, a roadmap to a legal agreement. Emissions reductions are to be carried out by all countries, not just developed ones. Negotiations are supposed to be completed by 2015. Attendees also agreed to a second commitment period of the Kyoto Protocol from 2013 to preserve the Kyoto architecture. Furthermore, the conference launched a work program to address the gap between existing emission reduction pledges and the global goals. COP-18 will be held in Doha, Qatar from November 26 to December 7, 2012.

Establishing the right balance between what is necessary and what is realistic will be a subject of continuing dialogue as the parties to the Kyoto Protocol continue the process of implementation. But many praise Kyoto for at least creating a “legal framework for more significant future reductions” and a forum through which the problem of climate change can be confronted.

Role of Developing Countries

Perhaps the biggest U.S. complaint about the Protocol was the fact that developing countries were largely exempted from emissions cuts. On the one hand, “It would be morally wrong and politically futile to expect countries struggling to achieve basic levels of development to abandon their aspirations to grow and improve their aspirations to grow and improve their people’s living standards.” Industrialization and development require significant inputs of energy. It would be foolish to make it that much more difficult to climb the development ladder by imposing strict emissions standards on poor countries.

At the same time, carbon dioxide emissions from emerging economies with huge populations, such as China and India, will likely exceed those of the developed world by 2025. Pollution from China alone will eventually begin to eclipse that of many developing countries. Emissions from its coal usage “will probably exceed that for all industrialized countries combined over the next 25 years, surpassing by five times the reduction in such emissions that the Kyoto Protocol seeks.”

Greenhouse Gas Emissions Projections: Developed vs. Developing Countries

14 COP17 Durban - Key achievements
15 Clemmit 79.
16 Browne.
17 “Power to the Poor;” Bradsher and Barboza
The exclusion of developing countries from rigorous obligations is probably the main reason the United States has dismissed the idea of ratification beyond the claimed potential impact on the U.S. economy. With the recent agreement at Durban in 2011 to begin negotiations on a new accord that would require all emitters, not just developed countries, to reduce emissions, the U.S. may begin to re-think its position.

To read more about Europe’s efforts to implement a carbon trading system, see Appendix I, “The European Union’s Emission Trading Scheme.”

Climate change and the Kyoto Protocol are also covered in the Issue in Depth on “Environment,” <http://www.globalization101.org/global-warming/>.


**Energy and Development**

Energy is the raw material needed to fuel any country’s economy growth. Advanced economies have the capacity to develop new sources of energy production or to secure imports of foreign energy to meet their needs. But many poorer countries lack this essential capacity. It is estimated that one third of the world’s population, about two billion people, are without access to “modern energy services: lights to read by, refrigeration to store medicines and food, transportation to get products to market, let alone telecommunications and information technology – all prerequisites for economic growth and poverty alleviation.” Compounding this lack of access is the population explosion that is expected to occur in the developing world. Some predict that the population of the world’s 50 poorest nations could triple in the next few decades.¹

To make matters worse, the world’s poorest inhabitants are particularly ill-equipped to adapt to high energy prices and the increasingly volatile fluctuations of global energy markets. High oil prices tend to

¹ Wirth et al.
hurt developing countries disproportionately. This is because energy-intensive manufacturing constitutes a major part of the economies of many developing countries and because these countries are highly dependent on imported oil.²

In addition, purchases of foreign oil often must be paid for in U.S. dollars, a currency that is in short supply in most developing countries. These dollars could be put to better use buying a variety of foreign products that would contribute to economic growth such as modern machinery for factories.³

Some believe that the challenge of supplying energy for development is a hopeless one because the poor will never be able to pay commercial rates for the energy they consume. This contention has been disputed by the World Bank. Bank analysts estimate that, of the two billion impoverished people currently without modern energy services, one billion could afford to pay commercial rates while the other one billion could likely make partial contributions, with the difference being met by government subsidies. Even conservative estimates suggest that 500 million people could be helped if the right policy choices were made.⁴

A typical energy consumer spends one-tenth of his or her income on energy every month. For someone living in absolute poverty, defined as $30-60/month in income, this would be $3-6/month.⁵ Targeted aid and foreign investment could meet this need.

Some argue that the poor are already paying steep prices for “inefficient, dirty energy… from kerosene, candle wax and batteries.” In fact:

They often pay more per kilowatt than do middle-class, urban households or wealthy farmers who benefit from heavily subsidized grid electricity. For example, families in Peru’s remote highlands on average spend about $4 a month on candles.⁶

Kerosene Lamps

Source: http://www.alpharubicon.com/primitive/oillampsstryder.html

Thus, the situation for the world’s poor is not entirely helpless. But many factors combine to make their plight particularly difficult. A comprehensive treatment of energy and development is beyond the scope of this issue brief, but three dimensions of the problem will be considered below: geography, economics, and politics.

It should be noted that several topics relevant to energy and development have already been covered in this issue brief. For more, please see: “Nuclear Energy and Development,” “Wind Power” (especially

² “Not So Shocking.”
³ Wirth et al.
⁴ “Power to the Poor.”
⁵ “What is Poverty.”
⁶ “Power to the Poor.”

Further Reading:


Rural Development and Micropower

It is now widely accepted that geography can have a decisive impact on a country’s potential for economic growth. Countries that are endowed with easy access to the ocean, manageable terrain, an abundance of natural waterways for shipping and commerce, a temperate climate, and a good mix of natural resources have a readymade foundation for development. Those that are landlocked, mountainous, tropical, and resource-poor are at a relative disadvantage. They face formidable hurdles to prosperity, even before they begin to climb the first rung of the development ladder.

Rather than focus on a specific geographical constraint or a particular country, we will examine a social landscape that is common throughout the world, the rural landscape, and its unique constraints on energy usage. Those who live in rural landscapes are, almost by definition, less connected to one another and to the outside world in ways that we would consider fundamental to modern societies. They often lack transportation links and telecommunications links as well as access to the kinds of networks that transmit power and fuels through electricity grids and gas stations. Creative solutions, carefully tailored to overcome the challenges specific to such a landscape, are needed if modern energy services are to contribute to rural development.

A Microhydropower Plant

Source: [http://www1.eere.energy.gov/windandhydro/hydro_plant_types.html](http://www1.eere.energy.gov/windandhydro/hydro_plant_types.html)

Fortunately, recent advances in renewable energy technologies, combined with a greater willingness of governments and private businesses to invest in rural development projects, are giving hope to those without energy throughout the world. As discussed in the section on “Scalable Energy for Development” under “Solar Power,” one of the great benefits of renewable energy is its scalability. That is, renewable energy facilities need not be massive and centralized like traditional power plants. They can be built on a smaller scale in areas close to the consumer and configured for local distribution. An installation of solar panels, for example, can be built on any surface with access to the sky.

The idea that the problem of power supply can be addressed in a smaller, more localized fashion that is still economical has led to the concept of micropower. According to one formulation:
Micropower is one piece of a wave of “micro”-movements that is sweeping across the developing world. This group of development strategies includes financial tools such as microcredit.

It also includes attempts to construct wireless telecommunications networks in many developing countries. It is, for example, much cheaper to erect a single cell tower that provides someone in rural poverty with mobile phone and wireless internet service than to build an entire network of conventional phone lines and cables. What all of these micro-activities share is the goal of empowering individuals directly in a way that makes financial sense for both suppliers and consumers.

Several international organizations are now funding micropower projects, including the United Nations’ African Rural Energy Enterprise Development Project and the World Bank’s Renewable Energy and Energy Efficiency Fund to name just two. Many private enterprises, non-profit organizations, and charitable foundations have also joined the effort.

To read more about some specific micropower projects, see Appendix J, “Examples of Micropower.”

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1 “Here and Now.”
The Resource Curse

There is a flipside to the geographical case presented above. Some countries in inhospitable landscapes find that geography makes the struggle to acquire natural resources and energy supplies more difficult. Others in similar circumstances have been endowed with an abundance of energy resources within their borders. Many of the most forbidding parts of the world from a geographic point of view are also some of the most resource rich: the deserts of Saudi Arabia, the mountainous jungles of South America, the snowfields of Russian Siberia, to name just a few that are known for producing oil.

While possession of such vast deposits of resources virtually guarantees a certain level of prosperity, many of the countries in which these deposits are found are relatively underdeveloped politically and economically. What happens when a country that is poor in terms of income levels and governance receives a sudden influx of energy wealth after the discovery of oil or other valuable energy resources? As it turns out, even in the best of cases, such wealth can be a curse as much as a blessing. This is known as the resource curse.

Too often, when a country strikes it rich as an energy supplier, the collective attention of both the government and the civil society can become devoted solely to maximizing profits from the energy industry. This single-minded focus comes at the expense of other economic and development priorities, and can begin to dominate a country’s political and social life. In the formulation of Thomas Friedman, a columnist for the New York Times, the resource curse is:

The way a dependence on natural resources always skews a country’s politics and investment and educational priorities, so that everything revolves around who controls the oil tap and who gets how much from it—not how to compete, innovate, and produce real products for real markets.¹

The Case of Saudi Arabia

Most countries that become major energy suppliers, especially when oil is involved, have nationalized their energy production industries (see “Oil Supply II: Producers”). Thus, proceeds from these industries go directly into government treasuries. In some cases, dominant political interests keep most of this wealth for themselves.

Saudi Arabia is a good example of this: its large royal family has reaped enormous gains from oil sales in the thirty years since it seized control of the national oil company Aramco, now called Saudi Aramco (see “Oil Supply II: Producers”). To be sure, oil revenues are distributed to Saudi Arabia’s citizens through an array of generous social programs. But the creation of a complex welfare state with direct payments from the government to the people has stunted the country’s broader economic development. According to Central Intelligence Agencies estimates, “[Saudi Arabia’s] petroleum sector accounts for roughly 80% of budget revenues, 45% of GDP, and 90% of export earnings.”² Those are certainly not the characteristics of a healthy, balanced economy.

The Biggest Losers are Ordinary Citizens

Saudi Arabia’s lopsided economic profile is only one manifestation of the resource curse, however, and probably not the most troubling one. Other countries, such as Venezuela and Nigeria, two of the world’s leading oil producers, have slipped even deeper into poverty as a result of increased revenues from oil sales. This leads some to believe:

¹ Friedman, “First Law of Petropolitics.”
² Central Intelligence Agency “Saudi Arabia: Economy.”
The biggest losers from the rise in oil nationalism may be the citizens of countries blessed with hydrocarbons...Ordinary Venezuelans, for example, are poorer than they were 30 years ago, despite hundreds of billions of dollars their country has earned from oil; and Nigeria is famous for its oil-fired corruption.³

These countries, located in less developed parts of the world, do not have the experience and institutions necessary to handle the exploding revenue streams that frequently accompany discoveries of natural resources. The temptation to seize a part of this wealth for personal gain can lead to corruption and even worse governance.

To read more about how Russia has safeguarded its energy profits, see Appendix K, “The Russian Stabilization Fund.”

To read more about the civil unrest that misspent oil revenues can trigger, see Appendix L, “The Nigerian Backlash.”

For many, the most distressing aspect of the resource curse is its tendency to undermine and erode the basic social contract between a people and its government. Once faith in government has been lost, it can be difficult or impossible to regain, “Not only do all politics [come to] revolve around who controls the oil tap, but the public develops a distorted notion of what development is all about...because someone is getting the oil money and they are not” (see also “The Wave of Renationalization” box in the section on “Oil Suppliers II: Producers”).⁴

**DUTCH DISEASE**

The so-called “Dutch Disease” is a particular form of the resource curse that emerged during the Netherlands’ experience with a large oil discovery in the 1960s. When a rich country is faced with an influx of wealth from oil or any other natural resource, the value of its currency rises. This can have a negative impact on its balance of trade as goods imported from other countries become cheaper and the prices of its own manufactured exports become more expensive for foreign consumers.

The resulting changes to the domestic economy can be disastrous, as certain industries suddenly become uncompetitive internationally. The overall economy can deindustrialized, thus further intensifying the dependence of oil. In the words of Thomas Friedman, “The citizens, flush with cash, start importing like crazy, the domestic industrial sector gets wiped out and, presto, you have deindustrialization.”⁵ Most developed countries are capable of adjusting to these changes over time, but the short term costs of adjustment can be painful.

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³ “Global or National.”
⁴ Friedman, “First Law of Petropolitics.”
⁵ ibid; Kramer.
“The First Law of Petropolitics”

If the **resource curse** describes the economic pitfalls that can come from resource riches, then what *New York Times* columnist Thomas Friedman calls the **“first law of petropolitics”** deals with is the potential political ramifications. Friedman applies the law to **“petroli st states,”** which he defines as “states that are both dependent on oil production for the bulk of their exports or **gross domestic product** and have weak institutions or outright authoritarian governments.” Examples of states that meet this criterion include Egypt, Iran, Nigeria, Russia, Saudi Arabia, Sudan, and Venezuela, among others.¹

Friedman’s proposed law suggests that there is a negative correlation between the “price of oil and pace of freedom,” which “always move in opposite directions in oil-rich petrolist states.” In his framework, the “pace of freedom” means the development of the elements of a democratic government, such as free speech, free press, free and fair elections, an independent judiciary, independent political parties, and general rule of law.²

The law of petropolitics seems logical for a number of reasons. As the price of oil rises and money floods into state treasuries, petrolist governments gain the upper hand in their relations with the international community. They are less dependent on maintaining positive diplomatic and trade relationships with other countries because other countries desperately need the natural resources they can provide.³ Free from such pressures, they can do what they please in the domestic sphere.

The historical record seems to provide strong evidence for Friedman’s law:

Suddenly, regimes such as those in Iran, Nigeria, Russia, and Venezuela are retreating from what once seemed like an unstoppable process of democratization, with elected autocrats in each country using their sudden oil windfalls to ensconce themselves in power, buy up opponents and supporters, and extend their state’s chokehold into the private sector.⁴

The aggressive behavior of petrolist governments is in evidence in all of these countries. In Russia, former president Vladimir Putin renationalized the oil and natural gas sectors, attempted to crack down on the operations of foreign NGOs, exerted control over national media outlets, and otherwise undermined the independence of large segments of the Russian private sector. In Nigeria, the president was accused of using oil dollars to bribe legislators into amending the constitution to grant him a third term in office. Many such worrying developments could be cited. Friedman and others consider this trend a mounting threat to global stability.⁵

On the other hand, in the oil-rich Middle East region, some resource poor states, such as Bahrain, have made great strides toward democratic government. Bahrain was the first state in the Persian Gulf to hold free and fair elections in which women were allowed to vote. It was also the first state in the region to reform its labor laws in accordance with international standards and to sign a free trade agreement with the United States. It was forced to do these things, in Friedman’s opinion, because its oil supplies are already near exhaustion.⁶

To learn more about Friedman’s theory, see Appendix M, “Freedom in Petrolist States.”

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¹ Friedman, “First Law of Petropolitics.”
² ibid.
³ ibid.
⁴ ibid.
⁵ ibid.
⁶ ibid.
Appendices

A. The Refining Challenge

In thinking about global oil supplies, the problem of refining capacity is at least as important as that of production capacity. This is because all crude oil must be refined before it can be used as a fuel. A shortage of refining capacity, particularly acute in the United States but also prevalent in many nations throughout the world, is a key cause of the global supply crunch. It has also caused many to wonder whether an energy crisis might not be looming just over the horizon.

Globalization and increased investment have brought into play new or previously unavailable sources of oil, many of which require sophisticated refining techniques to exploit because of their low quality. At the same time, a comparable investment in capacity to refine this diverse array of raw materials—particularly for production of high-demand, labor-intensive fuels such as diesel and gasoline—has been absent.¹

A cheaply constructed simple refinery, for example, might be capable of producing a mix of 20 percent gasoline, 30 percent “middle distillates”, and 50 percent “heavy residuals,” while a more complex and expensive one might be capable of producing 60 percent gasoline, 35 percent middle distillates, and 5 percent heavy residuals.² Since only 20 percent of crude oil is of the light or sweet variety, significant investment is required to build advanced facilities capable of transforming an increasingly wide variety of crude stocks from around the world into the fuels that consumers demand.³

The Refining Process

¹ Pirog, “Petroleum Refining,” 2.
² ibid 3.
³ Maugeri.
Capacity versus Utilization

In the United States, by far the world’s leading oil consumer, no new refineries have been built in more than 30 years and refining capacity has been stagnant since 1981.\(^4\) In the 1970s, generous government incentives extended through the Emergency Petroleum Allocation Act of 1973 encouraged the construction of many small refineries. Over time, it became clear that an excess of capacity was hurting utilization rates and making many refineries unprofitable. Over the last 20 years, the industry has undergone a wave of consolidation, to address this problem. As a result, while the net capacity decreased by nine percent during this period, average utilization rates jumped from a low of seventy percent in 1981 to record highs of ninety percent or greater from the 1990s to 2004.\(^5\) The trend has begun to reverse, though, as utilization rates drop below 85 percent due to massive decreases in demand in 2008, 2009, and 2010.\(^6\) In 2012, utilization rates began to rise again, reaching 92.6 percent in the last week of June 2012, the highest levels since 2007.\(^7\)

The shift from excess capacity to higher utilization rates has important consequences for energy consumers everywhere. Although refineries might be more efficient and profitable, many believe that “high capacity utilization rates leave a slim margin available to meet any increase in demand, raising, at least the potential, of market disruptions, either shortages or price spikes, in the retail market.”\(^8\) The smaller number of refineries means that the risk of a supply disruption is now greater than ever before. More and more, damage or disruption to any one refinery can have a devastating impact on overall refining capacity.

The risk of a supply disruption is increased by the localized nature of consumer demand for petroleum products. Whether the tailored nature of demand is the result of national preferences (e.g. diesel engines in Europe vs. gasoline engines in the United States) or the fragmented markets that have been created by different local standards (see “Demand Imperfections: Boutique Gasoline Regulations” below), it is undeniable that oil refining is a very local affair. More than ever before, local events can have disproportionate effect on a nation’s overall refining capacity. This was evidenced when American refining capacity in the Gulf of Mexico was crippled in the aftermath of Hurricanes Katrina and Rita.

Bridging Supply and Demand

To ensure the efficient operation of the global oil market, it is vital to have the right amount and mix of refining capacity so that supply can adequately meet the wide range of consumer demand. Regardless of how much oil is produced, if flexible refining capacity is not in place the prospect of a supply shortage can become very real.

Daniel Yergin, Chairman of Cambridge Energy Research Associates, has highlighted this point:

“What additional oil might be produced cannot be easily sold because it would not be of sufficiently good quality to be used in the world’s available oil refineries. Refining capacity is a major constraint on supply because there is a significant mismatch between the product

\(^4\) Pirog, “Petroleum Refining,” 12; Maugeri.
\(^6\) “The American Oil Refinery Shortage Myth.”
\(^7\) Zhou
\(^8\) Pirog, “Petroleum Refining,” 11.
requirements of the world’s consumers and refineries’ capabilities. Although often presented solely as a U.S. problem, inadequate refining capacity is in fact a global phenomenon.”

Further Reading


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9 Yergin.
B. Demand Imperfections: Boutique Gasoline Regulations

Previous sections of this Issue in Depth have highlighted the central role of properly functioning markets to every nation’s energy security (see “The Evolving Concept of Energy Security”). But not all markets function properly. In fact, some have inherent flaws that distort the way they operate. This section will examine one such imperfection that fragments demand in the American market for oil: “boutique” gasoline regulations.

The constitutional power of states and localities in the United States to regulate commerce within their borders has created a complex patchwork of different fuel standards that vary from region to region. Fuel suppliers must tailor gasoline to the exact specifications of each area in which they want to sell their product. Thus instead of one unified national supply chain for oil there are many individual distribution arrangements for 18 boutique gasolines.¹

The danger is that the proliferation of boutique gasolines makes it difficult to allocate oil stocks during a supply disruption because available gasoline might not meet local specifications. Shortages created by such artificial fragmentation of the market can lead to price jumps that hurt all consumers, as was the case in the aftermath of Hurricanes Rita and Katrina in 2005.²

Many argue that the various fuel regulations of different states should be harmonized into a single national standard. But harmonization would be a complicated and costly process. Local standards were developed largely as a result of the differing needs of localities in the U.S. with respect to air quality. Some areas have worse air quality than others and require the use of more refined, expensive gasoline to avoid further damaging the environment. Since any national standard would probably fall on the more rigorous end of the spectrum, harmonizing local standards would raise energy costs for consumers who live in regions with clean air but who would nonetheless be forced to pay premiums for more refined fuel.³

Although boutique standards do indeed complicate the oil market, harmonization is not necessarily the best solution. This dilemma is another example of the complexity involved in many energy policy debates.

¹ Yacobucci “Boutique Fuels” 1.
² ibid 1.
³ ibid 2
In 1956, a geophysicist named Marion King Hubbert hypothesized that all rates of oil production follow a bell-shaped curve and will eventually peak and decline according to predictable patterns. This theory, now known as **Hubbert's Peak Theory**, applies to both individual oil fields and to global oil reserves as a whole. When global production reaches the highest point of the bell curve, it will have reached the point of **Peak Oil**. Hubbert correctly predicted that U.S. oil production would peak around 1970. His guess that global production would begin to decline by 2006 has been widely discussed and criticized.\(^1\)

Many experts reject the idea that the world has reached Peak Oil. They point out that, even with current levels of technological sophistication, there is still much that engineers do not know about oil reserves in many parts of the world. Just as there was “much more oil hidden under the earth’s surface than most people imagined back in the 1970s,” so too are there probably additional reserves that have not been identified by today’s oil producers.\(^2\)

The most optimistic observers claim that, “For the next 25 to 50 years, the oil available to the market is for all intents and purposes infinite.”\(^3\) They point out that, “Thanks to the cold war and other political constraints on western investment, much of the world has yet to be explored with the aid of the latest technologies.”\(^4\) The vast majority of exploration over the last two decades has been in North American countries scrambling to reverse declining production. Only three percent of global oil exploration has occurred in the Middle East, “even though the region holds about seventy percent of proven reserves.”\(^5\)

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\(^1\) “Peak Oil Primer.”

\(^2\) “Will the Oil Run Out?”

\(^3\) Ibid.

\(^4\) “Bottomless Beer Mug.”

\(^5\) Maugeri.
D. The Cycle of Nuclear Power Generation

The nuclear fuel cycle contains seven basic steps:

- Uranium mining and milling
- Conversion
- Enrichment
- Fuel fabrication
- Power generation
- Reprocessing
- Storage.

Most nuclear fuel is derived from the element uranium. Uranium deposits are found all over the world, but most mining occurs in Kazakhstan, Canada, and Australia.1

Mills grind the mined uranium ore into a concentrated form known as “yellowcake.” This substance is then converted into a gas that is enriched to raise the percentage of fissile uranium that can be used in reactions for power generation.

Nuclear Fission

Source: http://www.eia.doe.gov/kids/energyfacts/sources/non-renewable/nuclear.html

Enriched gas is transformed into a powder, which is compressed into fuel pellets. These pellets are placed in fuel rods, which are then bundled into assemblies that serve as the energy source for nuclear power plants.

In the core of the reactor, the uranium fuel contained in hundreds of assemblies is split, releasing vast quantities of heat that are used to create steam and to power an electric generator. Spent fuel assemblies are removed and stored in on-site pools, where they continue to emit radiation as they cool from superheated temperatures.2

**REPROCESSING AND BREEDING**

Spent fuel can either be stored immediately or reprocessed. Reprocessing employs certain advanced techniques to separate the fuel into its various chemical components and recombines these elements to create new fuel. The standard method for reprocessing is known as Plutonium and Uranium Recovery by Extraction (PUREX). Because this process results in the isolation of plutonium, the main ingredient in nuclear weapons, it can easily be used to produce fissile material for military purposes and is considered a serious proliferation risk.3

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1 “World Uranium Mining.”
2 Weeks 223.
3 Weeks 232.
Other techniques have been developed that address concerns about proliferation. The most common one is known as MOX after the mixed oxide fuel it produces. The fuel and byproducts created using this method remain highly radioactive. In addition, more plutonium is removed from spent fuel when MOX is burned than in the case with other reprocessing techniques. For these reasons, MOX is considered a more proliferation resistant and thus politically acceptable method of reprocessing.

Several countries, notably the United Kingdom, Japan, and France, engage in reprocessing activities, and Japan has announced that it is engaged in building the first reprocessing facility designed solely for peaceful purposes. Official policy dating back to the Carter administration ensures that reprocessing does not occur in the United States because it could lead to the proliferation of plutonium and other materials used to make nuclear weapons.

Weapons-grade plutonium can also be produced by special reactors known as breeder reactors. As the name indicates, these reactors are capable of ‘breeding’ more fissile material than they consume. Breeder reactors have, at various times, been in operation in the United States, France, the United Kingdom, Russia, and Japan, but are now rare in developed countries.

Of late, India has been one of the only countries openly developing a network of breeder reactors to the dismay of many in the international community. India’s tense relationship with Pakistan and refusal to join the Nuclear Nonproliferation Treaty, described in the section on “Nuclear Nonproliferation” below, make the prospect of proliferation in South Asia a troubling one. As was the case with reprocessing technologies, the United States has placed a moratorium on the commercial development of breeder reactors, citing nonproliferation grounds.

WASTE STORAGE

The final stage in the nuclear fuel cycle for fuel that is not reprocessed in some fashion is the storage of nuclear waste. As mentioned above, most waste is temporarily stored on-site to be cooled, but long-term storage is a serious problem for many nations.

In 1982, the United States Congress enacted the first Nuclear Waste Policy Act, which expressed a commitment by the federal government to assume joint responsibility with private operators in addressing the problem of waste disposal. Congress commissioned a series of studies to evaluate the potential of selected sites to serve as a permanent repository for radioactive waste from American power plants.

Eventually a single site at Yucca Mountain, Nevada was settled on as the prime candidate for continued Department of Energy analysis. Development of the site was enabled by the creation of a Nuclear Waste Fund in 1982. Contributions to the Fund are drawn from proceeds.

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4 Parfit 26.
5 Weeks 230.
6 “Breeder Reactor.”
from a 0.001 cent tax per kilowatt/hour paid by consumers of electricity generated from nuclear power. After 20 years and billions of dollars of investment, however, Yucca Mountain is still not ready to open and has emerged as an important lesson in the difficulty of not only predicting the suitability of sites for long-term storage but also securing public support for keeping nuclear waste in the neighborhood.

There are four issues involved in the controversy over Yucca Mountain. The first is the “not-in-my-backyard” argument and the problem of public opinion. Despite many years of research that went into finalizing the location of the repository site, residents of Nevada remain unconvinced they alone should provide a home for the nuclear waste produced by the entire country.

Nevadans feel especially aggrieved because there are no nuclear power plants in the state. It is not surprising that, even though everyone acknowledges that the waste must be put somewhere, no one wants to volunteer his or her own backyard. Consequently, the state of Nevada has taken the federal government to court to challenge the designation of Yucca Mountain.

Second, there is the issue of Yucca Mountain’s capacity. It is estimated that existing collections of waste, which are housed at 72 reactor sites across the country, would entirely fill up Yucca’s projected capacity. At present levels of nuclear power generation, some believe that nine additional sites equivalent to Yucca Mountain would be necessary to store the waste that will accumulate over the next century. Based on this information, many argue that the development of reprocessing technologies will be not only wise but also necessary if nuclear energy is to continue to be a sustainable source of power.

Third is the issue of transporting waste materials from the sites where they are currently stored. Bringing existing waste to Yucca Mountain will require shipments passing through 43 of the 50 states. Many worry about the possible health risks that even low levels of exposure might pose to the large segments of the country’s population that live along slated transportation routes. A recent National Academy of Sciences study has dismissed this fear, with

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8 Weeks; U.S. DOE “Nuclear Waste Fund Fee Adequacy: An Assessment” 1-2.
the finding that the risks of accidental radiation leakages during transportation are minimal. Nevertheless, substantial reservations among policymakers remain.

Finally, there are concerns about the long-term safety of the site. The initial Environmental Protection Agency (EPA) standards created in June 2001 mandated that limits on radiation emissions would remain in effect for a 10,000 year period. These standards were challenged in court by a number of environmental groups and by the state of Nevada, and a federal court ruled that they were inconsistent with recommendations issued by leading scientific authorities.

The Yucca Mountain nuclear waste site was dropped in early 2010 due to budget cuts that eliminated federal funding for the project. It was decided that the site would be shut down despite future plans for the formation of new nuclear plants.

In response, the EPA revised its guidelines to apply for a period up to one million years, far longer than the U.S. government has ever attempted to regulate anything in the past. Scientists find it very difficult accurately to predict that far into the future, so the new standards have proven contentious. The controversy delayed any action on the site and has pushed back its opening date to 2017 or beyond, many years later than was originally intended.

Consequently, the federal government was sued by several nuclear utilities for violating the obligations spelled out in the Nuclear Waste Policy Act. The Yucca Mountain nuclear waste site was dropped in early 2010 due to budget cuts that eliminated federal funding for the project. It was decided that the site would be shut down despite future plans for the formation of new nuclear plants.

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12 Weeks 224.
14 Whittell
### E. HYBRID CARS AND FLEX CARS

Hybrid cars and flex cars have become phenomenally popular in the last few years. Hybrid engines utilize electric batteries in addition to petroleum burning processes (oil, diesel, ethanol) in order to make cars run. They are more environmentally friendly because they require less gasoline to operate and generate reduced amounts of harmful emissions. The Toyota Prius was the first hybrid vehicle to achieve widespread popularity, and there are now over one million of Priuses on the road worldwide.

To encourage the adoption of **hybrid** vehicles, many local governments have established attractive **incentives**, including free use of the carpool lane by solitary drivers of **hybrids** (Virginia, California, Florida, Utah), exemption from city-driving congestion charges (London, England), and free city parking (San Jose, Los Angeles and Santa Monica, California).¹

**Flex cars** contain engines that can run on different petroleum-**ethanol** blends containing anywhere from 0 percent to 85 percent **ethanol**. These vehicles are not only more energy efficient, they also give “consumers the autonomy to buy the cheapest fuel.” Although a relatively new technology, **flex cars** are now widely used in **ethanol**-rich Brazil, accounting for 77 percent of the country’s cars. According to one expert, “The rate at which this technology has been adopted is remarkable, the fastest I have ever seen in the motor sector, faster even than the airbag, automatic transmission or electric windows.”²

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1 Hakim; Webster; “Hybrid Incentives and Rebates.”
2 Rohter.
F. ENERGY AUDITS

With the resurgence of high energy costs in recent years, many consumers have rediscovered an easy way to decrease costs: perform an energy audit to see if their home or business is using energy in the most efficient manner possible. Many utility companies have trained professionals to perform audits for their customers, but there are plenty of ways for individual consumers to evaluate their own energy needs and usage.

The U.S. Department of Energy recommends that consumers focus on four areas:

- Air leaks around electrical outlets, window frames, baseboards, fireplaces, attics, and air conditioners, which can result in energy savings of up to 30 percent;
- Proper insulation around ceilings, walls, and windows;
- Efficiency of heating and cooling equipment; and
- Efficiency of lighting, a type of energy usage that typically accounts for 10 percent of monthly electric bills.1

Once the evaluation has been performed, the auditor provides recommendations for improving efficiency. Although implementing these recommendations can be an expensive process, increased efficiency often saves money in the long term and helps protect the environment.

G. THE ENERGY STAR PROGRAM

On the supply side, manufacturers of many electronic goods have also adopted the principle of efficiency for their products. The ENERGY STAR certification program, a voluntary partnership between businesses and governments in many countries, provides a good example. Manufacturers who are willing to meet ambitious efficiency requirements are rewarded with the right to place a logo on their producers that is widely recognized by the public. ENERGY STAR certifications are now available for more than 60 product lines, including computers and other types of office equipment, home entertainment devices, refrigerators, dishwashers, clothes washers and dryers, light fixtures, and air conditioners.2

Although the program originated as a collaboration between the U.S. Environmental Protection Agency and the Department of Energy in 1992, it has since expanded its reach into Europe, Canada and Australia. It is estimated that in 2008 the reduction in greenhouse gas pollution as a result of the ENERGY STAR program was equivalent to the emissions produced by 29 million cars, with savings to consumers in the range of $19 billion.3

Further Reading


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1 “Do-It-Yourself Home Energy Audits."
2 “ENERGY STAR."
H. CHINESE COAL

China's air quality is worse than that of the United States ever was. And as a developing country it has fewer resources with which to attack the problem. Coal is an abundant energy source in China so it is not surprising that coal-based power plants are mainly responsible for fueling the country’s rapid economic growth.

Even at this relatively early stage of its development, China consumes more coal than the United States, the European Union and Japan put together. Coal consumption has jumped 14 percent in recent years as part of “the broadest industrialization ever.” To give this figure some context: “Every week to 10 days, another coal-fired power plant opens somewhere in China that is big enough to serve all the households in Dallas or San Diego.”

In fact, levels of sulfur pollution from Chinese power plants are so high that they counterbalance the warming effect produced by greenhouse gas emissions, perhaps by as much as one-third.

This counterbalancing effect occurs when sulfur concentrations in the atmosphere create a protective layer that reflects the sun’s rays and keeps the region below cooler, thus mitigating the effects of carbon emissions. It can take up to 10 years for local carbon dioxide levels to offset the cooling effect created by constant sulfur pollution.

But this protection comes at a steep price. Sulfur dioxide pollution contributes to 400,000 deaths a year in China, and 55 percent of the country is blanketed by acid rain. This has created a virtually unprecedented dilemma for the Chinese, according to one expert, “It’s sort of unethical to expect people not to clear up their air quality for the sake of the climate.”

China has responded to the challenge posed by sulfur pollution with an aggressive set of initiatives for energy conservation. These include strict fuel economy standards, extensive use of home insulation technology and advanced light bulbs, and a proposed goal of “cut[ting] the average amount of energy needed to produce each good or service by 20 percent over the next five years.”

Despite China’s expressed commitment, many of its ambitious goals are not practical. In 2002 the government pledged to reduce sulfur emissions by 10 percent by 2005. The blistering pace of China’s economic growth, however, meant that emissions continued to rise by almost 30 percent during this period.

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1 Bradsher and Barboza.
2 Ibid; Mengfei Zhao.
3 Bradsher and Barboza.
4 Ibid.
China may need help from the international community to cut sulfur emissions in a meaningful way. It is in the world’s interests to provide this help, not only because pollution will eventually overwhelm China, but also because air currents have a tendency to drive smog clouds over neighboring countries in East and Southeast Asia.

Recognizing this, both Japan and the World Bank have stepped in with millions of dollars in loans and grants to help China cope with the aftereffects of its coal usage. Unfortunately for all parties, China has not taken full advantage of this assistance. The government prefers to buy older, cheaper coal-processing equipment produced by domestic manufacturers. It also demands that foreign firms transfer advanced electricity-generating technology to Chinese companies as a precondition for considering more expensive imports.\(^5\)

The effectiveness with which China copes with its air pollution will have ramifications for the region and the world. All nations have a stake in ensuring a positive outcome.

This problem has become more of an issue as the Kyoto Protocol commitment period draws to a close. The Chinese foreign minister had several meetings with President Obama and UN climate change executives about the country’s carbon emissions. Chinese officials told the UN conference in Bonn that China will not make any binding agreements to cut emissions. Other countries, like Japan, have also made significantly smaller commitments than expected.\(^6\) This has created much anxiety for those hoping to slow global warming.

In early 2010, India and China submitted letters to the United Nations agreeing to be part of the Copenhagen Accord. This nonbinding agreement calls for an annual budget of $100 billion to help emerging countries adapt to climate change, develop low-carbon energy systems, and to protect tropical forests.\(^7\)

In 2011 at COP-17 held in Durban, China, India and the U.S. all agreed to address emissions as part of the agreement to begin negotiations on a new agreement.

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\(^5\) ibid.
\(^6\) Carl Mortished
\(^7\) Broder
I. THE EUROPEAN UNION’S EMISSION TRADING SCHEME

One way for countries to meet their Kyoto obligations is carbon trading. Allowable emissions levels are translated into commodities, such as credits or permits, which can then be bought and sold on a regional or global market for carbon dioxide. If a country or factory wants to exceed its emissions target, it can purchase additional emissions credits from another country or factory that is under the cap. In this way, emissions reductions are not only captured but also allocated in an efficient way.

The European Union established the first mandatory carbon trading market among its members when the Kyoto Protocol came into effect in 2005, the Emission Trading Scheme (ETS). It is based on the model described above. In the first phase running from 2005 to 2007, 12,000 factories representing about 40 percent of EU carbon emissions were integrated into a permit-based European market.

Phase two of the Emission Trading Scheme began on January 1, 2008 and is proposed to run until December 2012. This phase witnesses the addition of other greenhouse gases and industries to the market and also incorporates permits from the Kyoto Protocol’s joint implementation and clean development mechanisms. The ETS is a bold experiment and “provide[s] a benchmark by which the world’s trade in carbon can be judged.”

So far, the ETS has experienced a number of problems that are illustrative of the difficulties of implementing any carbon trading scheme. First, the number of credits initially dispersed to EU factories was overly generous. Before the market could open, government regulators had to guess how much pollution more than 13,000 factories were emitting. As it turns out, they guessed too high. When it became clear that the supply of credits exceeded the demand for them in May 2006, the price of the credits plummeted and the market collapsed. Though discouraging, this problem can eventually be addressed by adjusting the supply of permits.

The second problem to emerge was grandfathering. Existing polluters in the EU were initially given free credits in compensation for the fact that their business practices would have to adjust to meet the requirements of the new system. Rather than using these EU issued emissions credits as they had been intended, many businesses sold them and used the proceeds to purchase cheaper credits from developing countries through the Kyoto Protocol’s Clean Development Mechanism. The price of the CDM permits was low because a market for them has not yet been established and because they are considered a high-risk investment. Businesses who exploited the system in this way were able to meet their emissions targets using the CDM permits but also make a profit from the sale of the free ETS credits. This loophole will need to be closed if the ETS is to develop credibility as a market.

Finally, the short timeframe of the initial phase of the ETS, which is slated to last only three years, discouraged aggressive investment by European companies in emissions reduction technology. Stable markets lend greater certainty to transactions in a variety of ways. But if the nature or ultimate fate of a market is itself a source of uncertainty, many potential gains can be lost. Since the ETS’ current time horizon is only three years and “the payback period for cleaner power-generating technology is at least five years, there is no incentive for producers to invest in cleaner technologies.”

Observers understand that the ETS is still in its early stages and that plenty of time remains for the problems discussed above to be resolved. But it is also a powerful lesson about the difficulties of translating a good theory into practice.

1 Harvey; “EU Emissions Trading Scheme.”
2 Gaming Gases.”
3 ibid.
4 ibid.
J. EXAMPLES OF MICROPOWER
Here are a few examples of micropower projects from around the world:

- In Yemen, one of the United Nations’ 50 officially designated least developed countries (LDCs), local citizens have begun to set up small, privately owned and operated electric generators “to service households not reached by the [country’s] inadequate grid system.” Although this kind of power is relatively expensive, it is an example of people taking their energy needs into their own hands.\(^\text{1}\)
- In India, the Tata Research Energy Institute has helped develop energy supply links across many small villages. Its programs for rural development, conservation initiatives, and renewable energy projects are a model for other non-governmental organizations (NGOs) based in developing countries. One project sought to improve the efficiency of energy usage in 35 villages in a variety of household activities, including wood burning, lighting, and water heating, with the goal of conserving “kerosene, diesel, and biomass and greening of the village.”\(^\text{2}\)
- In a remote part of the Philippines, a non-profit organization called Preferred Energy Incorporated is trying to initiate and support “development efforts and investments in renewable energy and other clean development projects.”\(^\text{3}\) In one project, Preferred Energy worked with the local councils of two neighboring villages to build a micro-hydroelectric facility on a nearby creek. The project was jointly undertaken by several donor agencies and local residents. The donors supplied the necessary equipment while the villagers “pitched in ‘equity’ in the form of labour and local materials…[and] organized themselves into a management committee to run the plant.”\(^\text{4}\)

K. THE RUSSIAN STABILIZATION FUND
A few advanced countries have been more adept at dealing with the resource curse. Russia, for example, decided to prevent the “Venezuelaization” of its economy when oil prices spiked in 2005 by following the model pioneered by Norway. Russian President Vladimir Putin created a Stabilization Fund so that the country would not “blow its oil windfall on profligate government spending, risking an unpleasant fiscal and economic crunch when oil prices fall.”\(^\text{5}\) In February 2008, the $150 million dollar fund was split in half: the Reserve Fund has the original fund’s goal of maintaining long term economic stability while the new National Welfare is used to bolster the country’s national pension scheme.\(^\text{6}\) It represents an attempt to create internal pressure to keep the government honest.

L. THE NIGERIAN BACKLASH
Popular backlashes against the misuse of revenues derived from energy sales are becoming increasingly common and fierce in many parts of the world. In Nigeria, the Movement for the Emancipation of the Niger Delta launched a violent insurrection with support from those who have been impoverished by the government’s “failure to fulfill promises to deliver benefits to communities in the oil-rich Niger Delta.”\(^\text{7}\) The movement is primarily directed at the private company that worked with the Nigerian government to develop the country’s oil sector, Royal Dutch Shell.

According to one report, “Between 50 and 70 Shell employees have been kidnapped” by rebels between

\(^\text{1}\) “Power to the Poor.”
\(^\text{2}\) ibid; “Case Studies”
\(^\text{3}\) “Capability Statement.”
\(^\text{4}\) “Power to the Poor.”
\(^\text{5}\) “Russia: The Curse of $50 a Barrel.”
\(^\text{6}\) Kramer; “Russian Government to Decide.”
\(^\text{7}\) Catan and Mahtani.
2005 and 2006 while an estimated "$1bn a year of oil revenues [was] diverted to corrupt officials" by the Nigerian government. The rebels blame Shell for their misfortunes, accusing the company of exploiting the local population, destroying the environment, and "collud[ing] with a corrupt 'political contraption.'" They demanded $1.5 billion in compensation from the Dutch oil firm. But it is widely agreed in the international community that the government and not the private sector is to blame, "Corruption, theft and poor management at the state government level ensures that little of that money [in oil revenues] makes it to the local communities."

In 2009, the rebels agreed to lay down their arms in return for amnesty. Attacks began again though in 2010 and have continued intermittently since then.

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8 ibid.
9 ibid.
M. Freedom in Petrolist States

How exactly does Thomas Friedman’s “law” of petropolitics affect the behavior of petrolist states and their citizens in real terms? Friedman offers four “effects” to explain how the law functions on the ground.

The Taxation Effect

Because petrolist governments are so flush with oil wealth, they do not need to levy high taxes against their citizens. This is good for the pocketbooks of many people, but it means that the population as a whole feels like it has less of a stake in the government. It also means that the government does not feel beholden to the wishes of its people because it is essentially self-sustaining. In Friedman’s words:

Oil-rich governments tend to use their revenues to ‘relieve social pressures that might otherwise lead to demands for greater accountability’ from, or representation in, the governing authority….Oil-backed regimes that do not have to tax their people in order to survive, because they can simply drill an oil well, also do not have to listen to their people or represent their wishes.¹

The Spending Effect

Closely related to the taxation effect is the spending effect. In general, citizens are unlikely to take an active role in the political life of their country when they are not financially invested in the state or politically empowered to participate in civic life. They are even less likely to be critical of their government when lavish welfare programs satisfy most of their material needs. Revenues from energy sales can often lead to “greater patronage spending, which in turn dampens pressures for democratization.”²

The Group Repression Effect

In addition to spending large amounts of money lulling people into a comfortable submission with welfare programs, petrolist governments can also take a more sinister approach by actively repressing the development of civil society. Oil money gives the state the freedom to “spend excessively on police, internal security, and intelligence forces that can be used to choke democratic movements.”³ Civil society is fragile enough in most petrol states. This kind of government activity can prevent a real civil society from ever developing or challenging the state’s power.

The Modernization Effect

Finally, vast energy revenues can have a direct impact on the incentives that citizens themselves face in making decisions about their lives. In a state with only one dominant industry, there is little incentive to pursue a career in other fields. That is, there is a decrease in “social pressures for occupational specialization, urbanization, and the securing of higher levels of education—trends that normally accompany broader economic development” and the development of a civil society. This lack of diversity impoverishes a society in ways that are not purely political and economic but also cultural. Such societies have great difficulty modernizing and find themselves at odds with many advanced nations around the world. This phenomenon is partially responsible for some of the grave security threats faced by the

¹ Friedman, “First Law of Petropolitics.”
² ibid.
³ ibid.
international community as a whole in the twenty-first century. Therefore, it is of paramount concern to all policymakers and global citizens, even those outside the energy sector.

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4 ibid.
Glossary

**Acid rain:** Precipitation containing dangerous levels of sulfur and/or nitrogen; acid rain is often caused by emissions from the burning of fossil fuels, particularly coal. China is facing a growing acid rain problem.

**Alternative energy:** Generally, any source of energy that is not derived from traditional fossil fuels and thus results in less pollution.

**Antitrust laws:** Laws designed to promote robust competition by regulating monopolistic enterprises and outlawing unfair business practices.

**Aramco:** The joint venture established by several U.S. oil companies and the government of Saudi Arabia to develop Saudi Arabia’s oil reserves. Over time, the Saudi government purchased shares of Aramco until it achieved full ownership in the 1970s, renaming the company Saudi Aramco.

**Arctic National Wildlife Refuge (ANWR):** A 20 million acre expanse of land in Alaska protected by the U.S. federal government as a refuge for many rare animal species. Many believe ANWR should be opened for oil exploration, but environmentalists argue the potential gains in energy independence are not worth the destruction of an important natural habitat.

**Arms race:** In a nuclear context, the competition between the United States and Soviet Union in the aftermath of World War II to develop a superior arsenal of nuclear weapons.

**Assemblies:** In a nuclear energy context, a bunch of fuel rods.

**Atoms for Peace:** The title of a speech given by U.S. President Dwight Eisenhower at the United Nations in 1953. It opened the door to the use of nuclear technology for peaceful energy generation in the wake of World War II.

**Balance of trade:** The difference between a country’s imports and exports. If a country imports more than it exports, as the United States currently does, it has a negative balance of trade; if, on the other hand, a country exports more than it imports, as is the case with China, it has a positive balance of trade.

**Bell curve:** In statistics, a bell curve represents a distribution of data or probabilities that display a single peak before and after which there are steadily declining slopes forming the shape of a bell; this distribution is often known as a “normal” distribution.

**Benchmark:** “Something that serves as a standard by which others may be measured or judged.” See “Benchmark,” Merriam-Webster Online Dictionary, <http://www.m-w.com/dictionary/benchmark>.

**Berlin Mandate:** The Mandate that established the framework for negotiations on reductions in **greenhouse gas** emissions that would eventually lead to the Kyoto Protocol; the Mandate is notable for introducing the principle of “common but differentiated responsibilities” between developed and developing countries.

**Biomass, or biofuel:** Fuels derived from organic matter, such as corn or sugar cane; biomass is one form of renewable energy that not necessarily more environmentally friendly than traditional **fossil fuels**.

**Breeder:** A type of nuclear reactors that is capable of producing more fissile material than it consumes. Several countries have developed breeder technology in the past, and India is currently working on it, to the dismay of many in the international community.
Boutique gasoline: A type of gasoline whose chemical composition has been tailored to meet specific local regulations.

Brent Crude: A benchmark basket of oils produced in the North Sea that is important in determining prices in Europe, Africa and the Middle East.

British Thermal Unit (BTU): A unit used to measure energy usage. One barrel of crude oil is equivalent to 5.8 million BTU, while 1 gallon of gasoline is equivalent to about 124,000 BTU. See “Energy Calculator – Common Units and Conversions,” Energy Information Administration, U.S. Department of Energy, <http://www.eia.doe.gov/kids/energyfacts/science/energy_calculator.html>.

Capacity: In the context of wind power, the share of wind a turbine is able to harness and translate into energy.

Capital: An economic term denoting investment-intensive goods that are used to generate income, often through the production of other goods.

Carbon capture: A clean coal process that uses new technology to capture harmful emissions before they are released into the environment.

Carbon sequestration: A process by which harmful byproducts of the burning of fossil fuels are safely stored underground.

Carbon sink: An area, such as a forest, that absorbs large amounts of carbon dioxide; the role of carbon sinks was hotly debated in the negotiations over the Kyoto Protocol.

Carbon trading: A market-based system of permits designed to allow for flexibility in schemes aimed as reducing levels of carbon emissions; the European Emission Trading Scheme is the first practical implementation of such a system, though many feel carbon trading will be central to future efforts to mitigate the effects of climate change.


Cellulosic: In an energy context, types of biomass that require large amounts of energy to break down into usable constituents for fuel.

Clean coal: Coal burned used advanced processes that reduce harmful emissions and waste.

Clean Development Mechanism (CDM): Similar to Joint Implementation, this provision of the Kyoto Protocol allows countries to claim credit for emissions reductions they help achieve in third-party developing countries.

Climate change: The broader phenomenon of which global warming is only a part; many fear that the earth’s climate may be changing in irreversible and deadly ways.

Collective action problem: “A situation in which everyone (in a given group) has a choice between two alternatives and where, if everyone involved chooses [to act selfishly], the outcome will be worse for everyone involved…than it would be if they were all to choose” to cooperate. See William Talbott, “Collective Action Problems,” University of Washington, <http://faculty.washington.edu/wtalbott/phil240/trcap.htm>.
Commodity: A good that can be bought or sold, usually through the trading of contracts on a commodity exchange. Commodities are often agricultural or mining products, such as sugar or gold.

Commodity exchange: A market, either physical or electronic, in which contracts for the future supply of commodities are traded.

Comprehensive Test Ban Treaty: An international treaty signed in 1996 that banned all open testing of nuclear weapons.

Condensation: The partner process to evaporation, by which water vapor is transformed back into its liquid state.

Conference of the Parties (COP): The annual conference of parties to the U.N. Framework Convention on Climate Change; the most recent COP was held in Nairobi, Kenya in November 2006.

Corporate Average Fuel Economy (CAFE) standards: First passed in 1975, these are the U.S. government’s primary fuel economy standards; many believe they are not rigorous enough, especially with respect to sport-utility vehicles. They are calculated based on the average fuel economy of a manufacturer’s entire fleet of cars or trucks in a given model year.

Cost of living: “The cost of purchasing those goods and services which are included in an accepted standard level of consumption.” The cost of living varies depending on the given location. It is more expensive to live in Manhattan than Wichita, or in Western Europe instead of India. See “Cost of Living,” Merriam-Webster Online Dictionary, <http://www.m-w.com/dictionary/cost%20of%20living>.

Crude oil: Oil that has been extracted from the ground but not yet refined into usable form.


Deep-sea oil: Oil found at depths of up to 30,000 feet below sea level. Such deposits require advanced drilling, harvesting, and processing technologies to exploit.

Delivery infrastructure: The main challenge to widespread use of hydrogen fuel cell technologies; hydrogen cannot be transported or transmitted using the same infrastructure (pipelines, etc.) used for petroleum products. The costs of building a new global infrastructure for hydrogen are thought to be enormous.

Department of Energy (DOE): The Cabinet-level department of the U.S. government, established by President Jimmy Carter in 1977, to establish American energy policy and enforce U.S. energy laws. It has important responsibilities in the oversight of the national nuclear industry and the development of alternative energy technologies.

Deterrence: A security strategy by which the mutual possession of potentially devastating weapons prevents countries on either side of a conflict from actually using those weapons; this was a cornerstone of U.S. defense policy during the Cold War.

Diesel: A denser, less refined form of oil that is widely used to fuel trucks, airplanes, and other industrial-strength machines. It is also the preferred fuel for passenger automobiles in many parts of the world, including Europe.
**Disarmament:** In a nuclear context, the goal of reducing a country’s arsenal of nuclear weapons. There have been many rounds of disarmament negotiations between the United States and the Soviet Union/Russia.

**Distillation:** In an energy context, the process for raising the concentration of alcohol in a liquid.

**Dutch Disease:** A form of the resource curse experience by the Netherlands in the 1960s; discoveries of oil can cause the value of a country’s currency to rise, thus hurting its balance of trade with other nations and potentially crippling non-energy related sectors of the industrial economy.

**Duty:** In a trade context, usually a tax on imports.

**E10:** A fuel mixture containing 90 percent gasoline/diesel and 10 percent ethanol; also known as “gasohol,” this is the brand of ethanol most widely used in the U.S.

**E25:** A fuel mixture containing 75 percent gasoline/diesel and 25 percent ethanol; this is the brand of ethanol most widely used in Brazil.

**E85:** A fuel mixture containing 15 percent gasoline/diesel and 85 percent ethanol; while this form of ethanol is the most environmentally friendly, it is not commonly used anywhere in the world at the present time.

**Earth Summit:** Another name for the United Nations Conference on Environment and Development, held in Rio de Janeiro, Brazil in 1992. The main result of the Summit was the signing of the U.N. Framework Convention on Climate Change, which eventually led to the Kyoto Protocol on curbing greenhouse gas emissions five years later.

**Ebb generation:** A method of harvesting tidal power that exploits the difference between high and low tides through the use of a basin and sluice gate.


**Economies of scale:** “A reduction in the cost of producing something…brought about especially by increased size of production facilities.” See “Economy of Scale,” Merriam-Webster Online Dictionary, <http://www.m-w.com/dictionary/economy%20of%20scale>.

**Elasticity:** An economic concept that measures the responsiveness of supply or demand to changes in price. If either supply or demand for a good is significantly affected by changes in price, then they are called elastic.


**Emission Trading Scheme:** A market for carbon trading established by the European Union in late 2005 as a means of meeting commitments made through the Kyoto Protocol; it is the first scheme of its kind. Implementation of the ETS has been plagued by early problems, including the amount of credits initially distributed, abuses resulting from “grandfathering,” and the short length of its initial timeframe.

**End-user:** The person who uses a good or service; as distinguished from the consumer who merely purchases a good or service.
**Energy independence**: The condition in which a country is not beholden to foreign nations or fluctuations of the market in meeting its energy needs. Most countries would like to have a greater degree of energy independence.

**Energy intensity**: The amount of energy required to produce a unit of gross domestic product and is partially related to a country’s economic efficiency. High intensity indicates that a significant amount of energy is required to produce each unit of gross domestic product. See “Intensity of Energy Use,” Economic and Social Development Agency, United Nations, <http://www.un.org/esa/sustdev/natlinfo/indicators/isdms2001/isd-ms2001economicB.htm>.

**Energy interdependence**: The idea that oil producers and consumers are mutually dependent on one another. An appreciation of interdependence in an important component in the evolving conception of energy security.

**Energy security**: A complex concept meaning many things, energy security is most often used in a narrow sense to indicate the stability of a country’s supply of energy. In this sense, it can be easily confused with the idea of energy independence. Many now believe energy security has broader implications for the mutual security of supply and demand. It is dependent on such factors as resilience, security of supply and interdependence.

**ENERGY STAR**: A voluntary certification program designed to increase incentives for companies to develop energy efficient electrical products.

**Environmental Protection Agency (EPA)**: The Cabinet-level U.S. department with jurisdiction of environmental policy and enforcement of environmental laws; it was established by President Richard Nixon in 1970. It also has some responsibilities for the protection of human health and safety, notably from pollution.

**Equity**: In an economic sense, “The money value of a property or of an interest in a property in excess of claims or liens against it.” See “Equity,” Merriam-Webster Online Dictionary, <http://www.m-w.com/dictionary/equity>.

**Ethanol**: A type of alcohol that can serve as the basis for fuel.

**Evaporation**: The process by which water in transformed from a liquid state into a gaseous state (vapor).

**Externality**: A hidden or indirect cost associated with an activity or the transaction of a good or service. Pollution is the classic example of an externality. The role of governments is to help “internalize” the externality so that market prices conform as closely as possible to the full costs paid by society.


**Fermentation**: A chemical process by which sugars are broken down into alcohol; an important step in the creation of ethanol.

**The First Law of Petropolitics**: Thomas Friedman’s theory that there is a negative correlation between the “price of oil and pace of freedom…[which] always move in opposite directions in oil-rich petroliost states.” See Thomas Friedman, “The First Law of Petropolitics,” Foreign Policy (154), May/June 2006.

**Fissile**: “Capable of being split;” when atoms are split through nuclear processes, they release vast amounts of energy. See “Fissile,” Merriam-Webster Online Dictionary, <http://www.m-w.com/dictionary/fissile>.
**Flex cars:** Cars with engines that can run on a variety of petroleum-ethanol blends; flex vehicles are very popular in Brazil.

**Footprint:** In an energy context, footprint often refers to the amount or surface area on the ground occupied by a turbine.

**Fossil fuel:** Fuel that is formed from the remnants of organic materials (animal and plant matter) that have been converted over time into combustible fuel through various geological processes. Oil, coal and natural gas are the primary forms of fossil fuel.

**Fuel additive:** Something added to gasoline or diesel fuel, usually to make it burn more efficiently and cleanly.

**Fuel cell:** A concentration of hydrogen that be used as fuel to generate power.

**Fuel economy standards:** Regulations that mandate the number of miles/kilometers a vehicle must be able to travel for every gallon/liter of fuel it consumes; not to be confused with fuel efficiency.

**Fuel efficiency:** The efficiency with which an engine is able to produce power from the fuel it burns; not to be confused with fuel economy.

**Fuel rods:** Rods that contain the fuel pellets used in nuclear reactors.

**Fuel share:** The share a type of energy constitutes in total global usage or in the usage of a particular country.

**Gasoline:** A form of highly refined oil that is primarily used to fuel passenger automobiles, especially in the United States.

**Generator:** “A machine by which mechanical energy is changed into electrical energy.” See “Generator,” Merriam-Webster Online Dictionary, <http://www.m-w.com/dictionary/generator>.

**Global warming:** The hypothesis that the earth’s average temperatures are rising; part of this phenomenon can be attributed to natural causes, but many believe that human activity is exacerbating the change in dangerous ways; most scientists and lawmakers now admit that global warming is indeed occurring. The effects of global warming, from melting glaciers and rising sea levels to the destruction of entire ecosystems, could be devastating.

**Gosplanner:** A Soviet manager; this term is sometimes used to suggest the inefficiency of broad-scale central economic planning.

**Grandfather clause:** “A clause creating an exemption based on circumstances previously existing.” The complex system of exemptions for companies that were grandfathered into the European Union’s Emission Trading Scheme have been a major problem. The term originated with the “Jim Crow” laws passed after the Civil War that sought to prevent many former slaves from voting. Exceptions to strict new literacy requirements and poll taxes were made for those who had voted before the war, thus excluding the ex-slaves. See “Grandfather,” Merriam-Webster Online Dictionary, <http://www.m-w.com/dictionary/grandfather>; “Grandfather Clause,” Wikipedia, <http://en.wikipedia.org/wiki/Grandfather_clause>.

**Greenhouse effect:** The heating of the atmosphere due to increased levels of certain gases that absorb and trap sunlight; so-called because of the similarity to a botanical greenhouse.
Greenhouse gases: Gases that are responsible for the greenhouse effect; these gases help trap heat in the atmosphere and contribute to global warming. The most important greenhouse gas is carbon dioxide.


Heavy crude oil: Oil that does not flow readily and is thus not easily extractable.

Heavy residuals: Oil that have been lightly refined and is really only suitable for industrial uses.

Hubbert’s Peak Theory: The hypothesis that oil production – both in individual fields and in global reserves considered broadly – will eventually peak and decline according to predictable patterns based on a bell curve.

Hybrid cars: Cars that run on a combination of gasoline/diesel fuel and battery-generated electricity; hybrid vehicles, such as the Toyota Prius, are increasingly popular worldwide.

Hydrogen economy: A goal articulated by U.S. President George W. Bush according to which the nation’s economy will one day be powered by clean technologies such as hydrogen fuel cells.

Hydrogen highway: A proposal by California Governor Arnold Schwarzenegger to build a stretch of 200 hydrogen fueling stations in the state by 2010; if implemented, this ambitious plan would make the use hydrogen fuel cell technology in cars more feasible.

Industrial Revolution: A series of developments in the eighteenth and nineteenth centuries that introduced greater mechanization and the modern urban factory into the industrial economies of many countries in Europe and in the United States. The Industrial Revolution vastly increased the amount of energy consumed by advanced societies as well as the amount of damage inflicted on the environment as a result of human activity.

Integrated gasification combined cycle (IGCC): One of the processes used to burn coal in a cleaner, more efficient way.

Interglacial period: A period in between two ice ages.

Intermittency: In an energy context, a weakness of many forms of renewable energy that depend on natural processes. Wind and sun, for example, are not steady sources of energy: they can be compromised by calm weather and clouds, respectively. The challenge of intermittence makes efficient storage an even more important focus of renewable energy producers.

Internalizing an externality: Reconciling the market price for a good or service with the full costs paid by society as a result of the consumption of that good or service.

International Atomic Energy Agency (IAEA): The international organization, chartered in 1957, responsible for promoting cooperation, safety, security, and technology in the global nuclear industry.
International Energy Forum (IEF): A regular dialogue where top officials from energy producing and consuming nations gather to exchange information and foster greater cooperation; the 10th meeting was held in Doha, Qatar in April 2006.

**Jevons Paradox:** The theory that increased efficiency actually provides people with incentives to increase their energy consumption and is thus, in a sense, self-defeating

**Joint Implementation (JI):** A provision in the Kyoto Protocol that allows countries to claim credit for emissions reductions they help achieve in third-party developed countries.

**Kerosene:** A form of oil usually burned to generate heat for the purpose of lighting or warming, often in areas without electricity

**Kyoto Protocol:** Drafted in 1997 at the third Conference of the Parties to the U.N. Framework Convention on Climate Change, the Kyoto Protocol set schedules and targets for cuts in greenhouse gas emissions. One hundred and sixty four countries are now a party to the Protocol, representing 55 percent of global emissions, but the United States has pointedly refused to ratify the agreement. The U.S. has objected to the scope of the Protocol's ambition and the exclusion of developing countries such as China and India from mandatory cuts. The Protocol went into force in 2005.

**Least Developed Countries (LDCs):** A group of the world’s 50 poorest countries as designated by the United Nations based on three criteria: low income, human resources weakness and economic vulnerability; the term is often extended to refer to the world’s poorest countries more broadly. See “UN-OHRLLS Mandate for LDCs,” United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States, <http://www.un.org/special-rep/ohrlls/ldc/default.htm>.

**Liability:** In the sense used here, the responsibility assumed by legal entities, whether persons or corporations, for damages that result from their actions.

**Light crude oil:** Oil that flows smoothly and is thus easily extractable.

**Marginal cost:** An economic term for the cost of producing the marginal unit.

**Marginal price:** An economic term for the price commanded by an additional unit of production.

**Marginal unit:** An economic term for each unit of production that is additional to current production levels. Many business decisions are heavily influenced by the supply of and demand for the marginal unit.

**Mercantilist:** Relating the philosophy of mercantilism, a political-economy strategy that urged “the accumulation of [cash reserves], a favorable balance of trade [more exports than imports]…and the establishment of foreign trading monopolies.” Mercantilism is often associated with the exploitation of colonies by empires in the seventeenth through nineteenth centuries. See “Mercantilism,” Merriam-Webster Online Dictionary, <http://www.m-w.com/dictionary/mercantilism>.

**Methyl tertiary-butyl ether (MTBE):** A common fuel additive in the U.S. that came into fashion after the passage of the Clean Air Act Amendments of 1990; it is now being phased out due to suspicions that it may have carcinogenic properties.

**Microcredit:** A form of microfinance in which small loans are given to impoverished entrepreneurs who would not otherwise be able to secure loans because of unemployment, lack of collateral or lack of credit history. When many microloans are extended in a village or locality, the risk pool is diffused; if one person cannot repay a loan, other members of the community can help service the debt. Microcredit has proven
to be a powerful tool for development and the empowerment of women, who constitute the majority of the recipients of microloans. See Bruck, Connie. “Millions for Millions.” New Yorker 82 (35), 62.

**Micropower:** Power that can be provided on a small scale and in a fashion tailored to localized needs.

**Middle distillates:** Oil that has not been extensively refined and is primarily suitable for industrial uses.

**Mixed oxide fuel (MOX):** The fuel involved in new methods of reprocessing nuclear materials; because it allows more plutonium to be burned off during reprocessing, techniques using MOX are viewed by many as relatively proliferation resistant and thus more politically acceptable.

**Monopoly:** A company that is the sole dominant force in a particular market and uses the unfair advantages provided by this position to undermine competition, often keeping prices artificially inflated for its own gain. Some industries are naturally suited for monopolistic control, but most are not. Monopolies were outlawed in the United States by the antitrust legislation that emerged in the early twentieth century.


**Mutually assured destruction (MAD):** An important element of Cold War deterrence strategy; the U.S. and Soviet Union both recognized the risk that any nuclear conflict would likely result in the annihilation of both countries.

**Net energy gains:** A situation in which more energy is produced than expended; the presence of net gains is an important consideration in debates about ethanol policy.

**Non-governmental organizations (NGOs):** A very broad category of organizations, either national or international, that are not directly affiliated with a government but engage with typical government concerns, including development, the environment, social issues, health issues, etc. NGOs are playing an increasingly prominent role in finding solutions to many social problems in a globalized world.

**Nonproliferation:** A term used to describe efforts to prevent the spread of nuclear materials and weapons to non-nuclear nations.

**Nuclear Nonproliferation Treaty (NPT):** An international treaty created in 1970 and designed to prevent the spread of nuclear materials and technologies for use in developing nuclear weapons. The treaty rests on three pillars: nonproliferation, disarmament, and the right of peaceful use of nuclear technology. Currently, 188 countries are parties to the NPT.

**Nuclear Waste Fund:** A federal fund established in the early 1980s whose purpose was to save money for the eventual storage of nuclear waste. Contributions to the Fund come from a small tax on electricity generated using nuclear power.

**Nuclear Waste Policy Act:** A piece of U.S. legislation signed in 1982 in which the federal government acknowledged its joint responsibility with the private sector for the safe disposal and storage of nuclear waste.

**Nuclear weapons states (NWS):** The five countries that possessed nuclear weapons technology prior to the signing of the Nuclear Nonproliferation Treaty, sometimes also known as the “nuclear powers;” this group included: the United States, the Soviet Union, China, the United Kingdom and France. After the signing of the NPT, they were the only countries officially allowed to retain possession of nuclear weapons technology.
Oil shale: A type of rock found primarily in North America that could yield oil but requires expensive processing.

Organization for Economic Cooperation and Development (OECD): A group of the world’s most advanced and wealthiest economies that is both a forum for and an active participant in debates about international economic policies. It was established in 1961 and now has 30 members, including the United States, Canada, Mexico, Japan, South Korea, and most members of the European Union.

Organization of Petroleum Exporting Countries (OPEC): A cartel of a number of the world’s leading oil exporting nations that exerts significant control over world oil prices by limiting the supplies made available by member nations through a system of quotas. The members of OPEC are: Algeria, Angola, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela. OPEC was founded in 1960.

Partial Test Ban Treaty: An international treaty signed in 1963 that banned the testing of nuclear weapons in the atmosphere, underwater, or in outer space; it was an important first step in achieving the goal of disarmament.

Peak Oil: The theoretical point at which production from global oil reserves will begin to decline. There is an ongoing debate about when this point will be reached or whether it has already been passed.

Per capita: Per unit of population. Per capita energy consumption, for example, is the amount of energy that is used on average by each person in a given country.

Petrolist state: Defined by Thomas Friedman as, “states that are both dependent on oil production for the bulk of their exports or gross domestic product and have weak institutions or outright authoritarian governments.” See Thomas Friedman, “The First Law of Petropolitics,” Foreign Policy (154), May/June 2006.

Photosynthesis: The process by which plants transform light, water, and carbon dioxide into sugar and oxygen.

Photovoltaic (PV) cell: A semiconductor that converts solar energy or radiant energy from another light source into electricity.

Plutonium and Uranium Recovery by Extraction (PUREX): The standard process for uranium reprocessing; it is dangerous because it produces isolated plutonium and thus creates a proliferation risk.

Price-Anderson Act: First passed in 1957 and subsequently updated several times, this important piece of U.S. congressional legislation capped the liability of nuclear power companies for reactor accidents; it was an important and many would argue necessary protection offered by the government to encourage development of the private nuclear energy sector. It is now in force until 2025.

Proliferation: In an energy context, proliferation generally refers to the uncontrolled spread of nuclear materials and technologies, often outside the bounds of international regulations and safeguards. Many view nuclear proliferation as the greatest threat to international security.

**Proven reserves:** Reserves whose existence and size have been confirmed by expert analysis, as opposed to unproven reserves whose existence may be mere speculation.

**Public good:** A good for which consumption by one person does not diminish the availability of a good for consumption by another. Classic public goods include clean air and water and national defense.

**Reforming:** In an energy context, the process used to isolate hydrogen by applying steam to a natural gas.

**Renewable energy:** Energy derived from processes naturally occurring in nature in ways that generate more usable energy than is expended in the production process. Wind power, solar power, and hydropower are all examples of renewable energy sources.

**Renewable fuel standards:** Standards drafted as a result of the Clean Air Act Amendments of 1990 mandating that all fuel in the U.S. contain a renewable component.

**Rent-seeking behavior:** Rents are one of the three types of income identified by Adam Smith in his landmark study, *The Wealth of Nations* (1776). Rent is "money paid for the use of a capital asset" and is to be distinguished from other types of income such as profits and wages, both of which are directly linked to productive activity. Rent-seeking behavior focuses disproportionately on the collection of rents without consideration for whether the capital from which those rents derive is being used productively. Such behavior is often a characteristic of corrupt governments. See "Rent-Seeking, Public Choice, and the Prisoner's Dilemma," The Friesian School, <http://www.friesian.com/rent.htm>.

**Reprocessing:** Using advanced technology and techniques to process spent nuclear fuel for reuse.

**Reserves:** In an energy context, reserves refer to deposits of energy that have yet to be exploited and are thus still in storage.

**Reservoir recovery rate:** The share of energy that can be successfully extracted from a given deposit.

**Resilience:** In the context of energy, resilience refers to the presence of a "security margin" that would protect a country against the adverse effect of a supply disruption.

**Resource curse:** The theory that influxes of wealth from the exploitation of natural resources, including energy deposits, can be a burden as much as an opportunity to countries that lack the political, economic and social infrastructure to handle such revenues effectively.

**Resource nationalism:** A strategy associated with the renationalization of energy companies that seeks to hoard the benefits of energy production for the state instead of allowing foreign companies to retain and expatriate profits. Many see this as a disturbing trend that eliminates important incentives for private sector investment.

**Retrofit:** "To install (new or modified parts or equipment) in something previously manufactured or constructed." See "Retrofit," Merriam-Webster Online Dictionary, <http://www.m-w.com/dictionary/retrofit>.

**Reverse electrolysis:** A technique for using electricity, often from a battery, to separate water into its constituent elements, hydrogen and oxygen; large amounts of hydrogen must be created if fuel cell technologies are to become feasible.

**Rogue:** "Of or being a nation whose leaders defy international law or norms of international behavior.” See “Rogue,” Merriam-Webster Online Dictionary, <http://www.m-w.com/dictionary/rogue>.
Scalability: The ability to translate something from a small scale to a larger scale.

Scrubber: A device installed in smokestacks at industrial plants designed to filter out certain undesirable waste byproducts, such as carbon emissions.

Semiconductor: Man-made chips which allow for the control of electric currents; these are the building blocks of most electrical devices.

Seven Sisters: The seven largest and most powerful private oil companies in the world; these companies dominated the global oil industry for much of the twentieth century. They included: Mobil, Exxon, Chevron, Royal Dutch Shell, British Petroleum, Texaco and Gulf Oil.

Shock: In economic terms, a disturbance in the stability of a market.


Social contract: The legitimacy and accompanying responsibilities a government derives from its relationship to the citizens that have instituted it; social contract theory was popularized by the English philosopher John Locke and is a cornerstone of modern liberalism.

Soft power: Power that derives from persuasion and cooperation rather than confrontation and the exertion of force.

Solar panel: A collection of photovoltaic cells, usually encased in glass, used to generate electricity from solar energy.

Sour crude oil: Oil that has high sulfur content and thus requires more extensive refining to be usable.

Sport-utility vehicles (SUVs): Vehicles that are a hybrid between a truck and a van; these were originally used by small farmers but have become phenomenally popular among upscale urban drivers. SUVs have some of the worst fuel economy ratings of any class of vehicles.

Stabilization Fund: A fund created by Russian President Vladimir Putin safeguard the huge profits derived from sales of oil and natural gas in recent years; these funds, now totaling $60 billion, can only be used to reduce Russia’s national debt or to support the national pension system.

Standard Oil Company: The oil monopoly created by John D. Rockefeller that dominated American markets in the late nineteenth and early twentieth centuries. The company was broken up into 34 parts in 1910.

Standby power: Power used by an electric device when idle.

Strategic reserves: A quantity of energy that has been stored by a country to provide supplies in case of an emergency. The existence of reserves can also serve other strategic ends.

Super critical: A state of matter produced by high temperatures that is between a liquid and a gas.

Super majors: The giant companies formed by the merger of several of the major private oil companies in recent years. Examples include ConocoPhilips and ExxonMobil, which posted the largest annual corporate profit in history in FY2005.

Sustainable: In an energy context, sustainability refers to the creation of a relationship between human activity and the environment that is not overly destructive and can be maintained over a substantial period of time.

Sweet crude oil: Oil that has low sulfur content and thus requires less refining to be usable.

Utilization rate: Generally speaking, the share of existing capacity that is being used.


Tar sands: Vast, molasses-like deposits, mainly located in Canada’s Alberta Province, which could provide new sources of oil if the expensive technology and advanced processing techniques they require can be made economically feasible.

Tax incentives: Benefits offered by governments to decrease the tax burden faced by a company. Incentives are often employed by a government to encourage certain types of socially desirable activity.

Tidal barrage: A larger scale version of the sluice gate used in ebb generation methods of harvesting tidal power; barrages are usually major civil engineering projects that can have a significant adverse impact on the surrounding aquatic ecosystem. See “Tidal Power,” Energy Systems Research Unit, University of Strathclyde, <http://www.esru.strath.ac.uk/EandE/Web_sites/01-02/RE_info/Tidal percent20Power.htm>.

Tidal, or wave, farming: A method of harvesting tidal power that relies on underwater turbines.

Tipping point: A critical point in many processes at which the rate of change rapidly accelerates and the process may become irreversible.

Turbine: A device similar to a windmill or water wheel that uses a set of blades to harness flows of wind or water to power a rotary engine. Turbines are an important technology for producing clean, alternative energy.

U.N. Framework Convention on Climate Change (UNFCCC): A treaty signed at the Earth Summit in 1992 that established a framework for international cooperation on preventing climate change through the reduction of harmful greenhouse gas emissions.

Weapons-grade: Nuclear materials that have been enriched to the point where they can be used in weapons.

West Texas Intermediate: A benchmark basket of oils used by the New York Mercantile Exchange. This is typically the price referred to by the media when reporting the price of a barrel of oil.

Yellowcake: An intermediate form of processed uranium that can eventually be used to fuel a nuclear reactor or, if enriched, a nuclear weapon.

Yucca Mountain: The site, located in Nevada, selected by the U.S. Department of Energy to serve as the official federal repository for the nation’s nuclear waste. According to most estimates, the amount of waste currently stored at reactor sites across the country would already fill Yucca Mountain's planned capacity. No waste has actually been stored at the site yet due to ongoing legal controversies.

Zero-emissions: The optimistic notion that fossil fuels can be burned in a completely clean way that does not harm the environment through emissions.
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