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UNIVERSITY of **HOUSTON**

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Selected from nine colleges across campus, the fellows work in collaboration with UH Energy and the Energy Advisory Board to shape the conversation on energy at UH and beyond. The fellows serve a term of one full academic year and contribute to an online blog forum hosted by UH Energy and Forbes.

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KNOWING THERE'S ICE IN OCTOBER

Leveraging Educational Benefits Of Diversity To Prepare A Well-Trained Workforce

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At the University of Houston's recent symposium on the future of arctic drilling, journalist and author Bob Reiss recounted the story of a war games exercise he observed. While gaming the scenario "what if there is a massive oil spill in Barrow, Alaska," none of the presented solutions accounted for the fact that ice comes to this part of the arctic in October. When finally prompted by a knowledgeable civilian sitting on the sidelines to consider this context, the military participants were stumped.

Reiss went on to say, "We have spoken about the Eskimos [in Alaska]…related to the environment…we've spoken to them as victims. Let's talk about them as a resource for a second. Because there should have been Eskimos in that room because Eskimos would have known in one second that ice comes in October…. I would suggest to anyone in the audience who is in an oil company or an engineering company or a shipping company or any kind of corporation that will do business in the arctic- don't ignore the most fabulous resource in the source of knowledge that is up there; it's the people."

The moral of Reiss's story is a critical one substantiated by a robust body of social science research affirming the benefits of diversity on a broad set of outcomes we value such as enhanced critical thinking, civic engagement, the promotion of understanding and the reduction of prejudice to name just a few. His story also reminds us of the intentionality needed to ensure that such diverse environments are created and cultivated. Strong leadership recognizes and implements policies and practices that see difference as an asset (see, for example, UH's NSF funded Center for ADVANCING UH Faculty Success,Diversifying Top Talent, and Center for Diversity and Inclusion). But, as Reiss's story emphasizes, we have a long way to go. Women, for example, still only hold one quarter of the STEM jobs in the United States, and that proportion is even lower for people of color.

The country's economic viability rests squarely on our ability to leverage the educational benefits of diversity in particular to prepare a well-trained workforce ready to take on the complex tasks associated with a global marketplace. Without such efforts, we run the real risk of being stumped by the ice of October.

STEPPING UP TO STEP DOWN ON CLIMATE CHANGE

NAIRAH HASHMI Undergraduate, Chemical Engineering

Recently, while browsing Snapchat Discover, I found an interesting article on climate change from the November 2015 issue of National Geographic. Although Snapchat is not the most conventional way of learning about the world, I did learn something: people should individually take responsibility for their impact on climate change, rather than wait for larger organizations to take action. According to the article, "climate change is a matter of personal consumption."

Each of us can make a difference if we limit the amount of energy we use on a daily basis.

This can be done in several ways. The most obvious is to cut pollution levels by using alternative travel (biking or walking), carpooling, or combining multiple trips. For those of us who commute to Houston from surrounding cities, walking is probably not ideal, (especially when it's 100 outside). However, combining your grocery trip, dry cleaning pickup, and return from work into one car journey is certainly possible. It's better for the environment and it saves time. Two trips is not better than one; more is not merrier!

Another suggestion is to reduce your individual cost of living by reducing the size of your living space. I've seen many pictures and floor plans of super tiny houses, and they're pretty neat. The point is, tiny houses use much less energy and have lower utility bills, compared to standard American homes.

If you're conscious of your impact on the environment, consider downsizing. Maybe not as extreme as below 100 square feet like the example above, but try something smaller.

What struck me as interesting is that simple adjustments in lifestyle are all we really need to get the ball rolling against climate change. It's easy to get overwhelmed by globally encompassing issues and as a result do nothing to help the situation. But I intend to become more environmentally conscious and energy efficient and I hope you do too!

Ask yourself if you're doing enough to fight climate change, because in the end, there really is no Planet B.

ARE HIGH EFFICIENCY AUTOMOBILES A MYTH?

RAMANAN KRISHNAMOORTI UH Chief Energy Officer | Professor, Chemical and Biomolecular Engineering
WILLIAM S. EPLING Professor, Chemical and Biomolecular Engineering

The controversy over Volkswagen's admission that it rigged pollution tests in the United States – causing the tests to show fewer emissions than the company's highly efficient diesel vehicles produced during normal operations – has raised many questions about the global auto-maker's operations. The future of high-efficiency clean diesel automobiles shouldn't be one of them.

Diesel automobile engines offer inherent benefits in fuel efficiency, allowing drivers to go farther on less fuel. That will be critical in coming decades, as efficiency plays an increasingly important part in our energy future.

Environmental concerns should not be ignored, and technological advances make it possible to take advantage of that increased efficiency without sacrificing air quality.

Here's why diesel should continue to have a role as a transportation fuel: Diesel automobiles fundamentally operate at higher efficiency than gasoline engines – that is, diesel cars can be driven farther on a gallon of fuel – because the combustion process happens at a higher engine compression ratio and consequently higher engine temperature, resulting in greater efficiency in converting chemical energy in the diesel molecules to mechanical movement.

There is a downside. This higher compression ratio and the combustion propagation in the engine cylinder also produces more pollution than that emitted by gasoline engines, as several unwanted chemical reactions combine with the simple combustion of the diesel and result in the release of soot and nitrous oxide compounds, known as NOx. NOx is a key ingredient of smog and is linked to respiratory illnesses, including asthma.

Still, the efficiency benefits of diesel engines are substantial. A gallon of diesel has about 10 to 15 percent more energy than a gallon of gasoline. Add to that the higher efficiency typical of a conventional diesel engine, and a diesel engine's fuel efficiency can be as much as 35 percent higher than that of a gasoline engine. Simply put, diesel engines can get 35 percent more miles per gallon than a comparable gasoline engine.

That shouldn't be ignored as automakers work to meet the higher automobile efficiency standards – known as the Corporate Average Fuel Economy (CAFE) standards – set by the U.S. Environmental Protection Agency and Department of Transportation. First enacted by Congress in 1975 in the wake of the Arab Oil Embargo, the standards are intended to reduce energy consumption by requiring greater fuel economy for the nation's cars and trucks. Using less fuel also helps to meet clean air goals by lowering carbon pollution.

Current standards call for cars to average 54.5 miles per gallon by 2025, and converting gasoline engines to diesel engines might prove to be the fastest way to get there. As a point of reference, transportation fuels account for a little more than a quarter of U.S. energy needs.

That, along with recent high prices for transportation fuels, made Volkswagen's low-emission diesel engine cars resonate with a sector of the car buying public, both in the United States and in Europe, where consumers traditionally have valued fuel efficiency. The German company's admission that it used software that fooled emissions testers in the United States puts that appeal in jeopardy.

It shouldn't. Technology makes it possible to have both the efficiency of diesel engines and lower emissions.
Advances over the last four to five decades have reduced the pollution from diesel engine exhaust. These have come from improvements in engine design, cleaner diesel fuel produced by reducing the sulfur content and additional emission controls technology, including diesel particulate filters, exhaust gas re-circulation, selective catalyst reduction and diesel oxidation catalysts.

The emissions controls technologies have lowered the conventional expected engine efficiencies of diesel, as some fuel is used to power the technology and the exhaust from the engine encounters higher back-pressure from the additional emissions control devices.

Emission control technologies also increase vehicle weight, and installation and maintenance can add significant expense.

Nevertheless, as numerous heavy and light duty engine manufacturers have demonstrated, these losses in efficiency are more than offset by increases in efficiencies resulting from improved engine design and strategies for fuel injection.

These technologies have resulted in diesel engines with increased power, acceleration and cold weather performance.

Those improvements in fuel, engine design and emissions controls technology have resulted in remarkably clean diesel vehicles that maintain their efficiency advantage over comparable gasoline engines and are clearly an important part of the portfolio of solutions to develop environmentally friendly and high efficiency automobiles.

Allowing the scandal over Volkswagen's actions to overshadow the promises of clean diesel engines would be an unnecessary setback in the global push for both energy conservation and cleaner air.

ENERGY - LIVING AT THE EDGE OF THE CYBER PHYSICAL WORLD

RAYMOND E. CLINE Professor, Computer and Information Systems

To witness evidence of the cyber physical revolution, all I need to do is walk the dogs. As I walk through my neighborhood, I see reclosers ("switches"), smart meters, take-out points (communication hubs for that meter data), and a fully instrumented substation. These are all elements that make the smart grid intelligent. I see cars that have keyless entry, keyless ignition, back-up cameras, automated self-parking, hybrid power plants, fully battery operated vehicles, and soon- fully autonomous driving. Coupled with the traffic cameras, pavement sensors, and traffic flow analysis, we could see fully optimized traffic patterns in the future.

As I walk, I reflect on the progress made in digital oil fields, made possible by a plethora of embedded sensors, complex analytics, and automated operations. The combination of sensing, modeling, controlling, and optimizing physical systems has been around for a long time, but even the traditional realms of process control and operation are being revolutionized using cyber physical systems approaches.

The latest phrases to describe such systems include Internet of Things, Industrial Internet, Industrial Internet of Things, Fog Computing, and many other emerging terms. Most of these concepts suggest that the goal is to connect All Things to the Internet.

The challenge with that concept is two-fold:

1) These things cannot always be connected to the Internet.

2) Centralizing control, modeling and optimization will produce performance delays that may degrade the reliability of these cyber physical systems.

Particularly in energy systems, the edge is often remote and degradation of decision performance can be catastrophic. So, perhaps the greatest challenge in energy-related cyber physical systems is providing the utility of the interconnection of things at the edge, perhaps a better definition of Internet of Things, with distributed operations, control and optimization, which utilizes the full power of connectedness when available.

Perhaps the clearest example of these two approaches to systems development is shown by the interaction of smart grids and microgrids. A fully "sustainable" design for local power (residential or commercial) would require power generation (usually solar, wind, or a combination), storage, sensors, controllers, and an intelligent operations system. In a stand-alone configuration this is often referred to as a microgrid. If I can connect my microgrid to other microgrids, or to a larger electric grid, then I can improve reliability by sharing power to cover imbalances that might occur by over or under production/utilization.

The All Things Connected architecture would view these microgrids connected to a larger smart grid, which itself has larger generation, storage and control capability. The Living at the Edge architecture would view the system as composed of interconnected microgrids, which could take advantage of a smart grid if it were available.

The All Things Connected approach is the system architecture of choice in the United States, Europe, and any location that already has an established electric grid. The vast majority of the emerging economies do not have the benefit, or the burden of an existing infrastructure. They will likely evolve using the Living at the Edge approach.

Living at the Edge is actually the approach many, if not most, energy systems need to utilize. Upstream oil and gas operations are seldom in areas with fully developed infrastructure. Even refining operations are often required to operate "off grid" when power demand reaches critical levels. Pipelines are often the conduits for infrastructure to and through remote areas. So, Living at the Edge of the cyber physical world is a common necessity for energy systems.

As we consider developing cyber physical systems which support Living at the Edge, we still want to leverage the qualities of the "internet." This may have many meanings, but at least it implies the use of flexible protocols, establishment of services support the rapid development and deployment of solutions, and a flexible set of "standards" that promote, in the words of my friend Ben Horowitz, "rough consensus and working code."

We must also incorporate the concept of "best effort" in a slightly different manner than the application of that term to Internet Protocol (IP). Living at the Edge best effort involves being able to live stand-alone or connected, and knowing/exploiting the differences. So, what are some of the system characteristics that we might need in this model of the Industrial Internet of Things (at the Edge)?

- Internet of interacting things – we should rely on things interacting with things, rather than demanding that all things interact over a single logical network.

- Modularity and self-assembly – our system components must have the flexibility to stand-alone and assemble in larger, more capable forms.

- System Awareness – in addition to providing situational awareness (information about the surroundings and those things the system is sensing) our systems must be aware of their level of self-assembly and the capabilities that this may offer.

- Data and service standards – data is the life blood of the system and services are the mechanisms by which data is produced, consumed, transmitted, stored, and transformed for use by the system. The life blood must flow smoothly and nourish all components if the system is to survive.

- Distributed control – stand-alone and partially connected operation will require models of distributed control, rather than reliance on centralized operation and control.

- User/utility experience – the concept of user experience must go beyond the interaction that humans have with the system to include the environment that other components experience when they interact with each other and the system.

- Behaviors and profiles – encapsulation and isolation will limit how components interact with each other, so the most flexible designs will seek to standardize behaviors and profiles, rather than detailed architectures.

As I walk the dogs and observe the burgeoning world of the energy cyber physical systems around me, these are the characteristics that come to mind. What is certain is that management of the edge is essential for energy systems. Living at the Edge design is perhaps necessary for the future of energy. You may agree or disagree, but this much I know, as long as they have food, water, toys, walks and cuddles, Buffy and Glinda don't much care. They will leave those details to me.

U.S. CRUDE OIL POLICY - THE CASE FOR AN EXPORT BAN AND AN IMPORT QUOTA

ED HIRS Lecturer, Finance and Energy Economics

Congress is considering lifting the crude oil export ban that prevents American oil from being sold overseas. The ban was enacted in the midst of oil market turmoil in 1975. Domestic producers of crude oil want the ban lifted; refiners want the ban to stay in place. Each side has a raft of studies from paid experts citing the supposed benefits of its position. Each is so deep into its position that it has missed the larger picture on both humanitarian and financial grounds. Here is why:

OPEC, the Organization of Petroleum Exporting Countries, was formed in 1960 as a response to a precipitous drop in the world price of oil. The drop resulted from President Eisenhower's strategic decision in 1959 to limit U.S. oil imports. Why did he do this? Simple; he realized that no matter who owned the oil in the Middle East, it would always be available on the world market. He had already rejected Great Britain and France in their 1956 war over the Suez Canal saying: "Let them boil in their own oil."

President Eisenhower knew that everything in the Middle East was about the money that oil brings. As former Federal Reserve chairman Alan Greenspan said in The Age of Turbulence, on page 483, "I am saddened that it is politically inconvenient to acknowledge what everyone knows: the Iraq war is largely about oil."

The price for cheap oil is the violence in the Middle East. Since the events of September 11, the U.S. has been embroiled in conflicts in which alliances shift every moment. As of the date of this posting, U.S. military casualties include 6,868 dead and 52,375 wounded.

The Cost of War project at the Watson Institute at Brown University estimates that the nations involved in the oil conflicts have seen more than 500,000 dead and over 7.6 million war refugees and displaced persons.

The Cost of War project puts the cost to the U.S. at $4.4 trillion. If the war cost were pay-as-you-go, it would amount to a surcharge of more than a dollar for every gallon of gasoline consumed in the U.S. since 9/11. Instead, the war is financed by the government printing press and the American public remains in the dark.

On the import side, see our paper "Crude Oil Imports and National Security."

There we made the case for going back to an import quota in order to alleviate the effects of a major, negative supply shock. This could result from something as simple and easy to implement as a blockade of the Strait of Hormuz. Today, the argument for the import quota is made stronger by very low crude oil prices. U.S. GDP will drop by more than $200 billion this year due to continued cheap oil. U.S. employment has already suffered the loss of more than 100,000 jobs. The impact of cheaper crude has also dampened the economic and climate benefits of switching to electric automobiles and other low-carbon modes of transportation.

The argument made by oil producers in favor of removing the export ban, i.e. that they require unfettered access to export markets, makes little sense. The U.S. will remain a net importer of crude oil even if the export ban is lifted.

Pronouncements by politicians that the U.S. will run OPEC out of business by exporting crude oil are simply nonsense, because U.S. producers of oil will never be able to produce it as cheaply as the Saudis and thus cannot compete in a global market. To produce almost 5.0 million barrels per day, U.S. shale producers operated about 22,000 wells in 2014. To produce almost 9.0 million barrels per day, the Saudis needed only 3,100 wells.

Lifting the current export ban will do nothing to make the U.S. more competitive, or to quell conflict in the Middle East. Accordingly, it should stay in place. Producers would do well to consider a return to President Eisenhower's import quota. Thousands of oilfield workers would return to work. U.S. GDP will increase. Higher domestic oil prices will encourage conservation and provide an economic support to alternative modes of transportation.

THE MORAL DIMENSION TO ENERGY AND ENERGY POLICY

JIM GRANATO Director and Professor, Hobby Center for Public Policy

Pick up books on energy policy and you typically find models, data, graphs, and tables. Science and data rule. But that ignores an important area that is harder to define but just as important in determining the correct policy.

James Griffin's 2009 book Smart Energy Policy is a case in point. There is much wisdom in his book. True to his background, Griffin, a professor of economics and public policy at the George Bush School of Public Policy at Texas A&M University, focuses on the trade-offs between "cheap, clean, and secure energy" and offers some solutions reflecting his view of a more appropriate way to price energy – particularly fossil fuels.

Yet, policy is more than an exercise in theory, data, and tests. Indeed, what is seldom emphasized in energy policy publications is the moral dimension and the competing visions of "what is right."

Often the so-called scientific "tools" – theory, data, etc. – lack sufficient acumen to provide policy prescriptions that make us better off. The question then, is if a policy needs to implemented, what can we do in the face of such scientific uncertainty?

Enter the moral dimension. We need to discuss the trade-offs about values, but this seldom happens. Imagine, for example, if someone argued there is a moral case for the use of fossil fuels. What would be the moral arguments for and against using fossil fuels. Is there any room for compromise between these competing arguments?

In his *The Moral Case for Fossil Fuels*, Alex Epstein, president and founder of the Center for Industrial Progress, presents useful and rare description of the competing moral visions regarding fossil fuel use. In Espstein's view, the moral dimension to support fossil fuel usage is "human flourishing," which involves answering the following questions:

- What will promote human life?
- What will help us realize full potential in life?

Notice the focus on a human standard of value. What would be an alternative moral viewpoint? It can be found in the work of environmental activist Bill McKibben. He places greater emphasis on the value of nature. As a result, and in McKibben's view, human flourishing needs to be temporized to minimize environmental impact.

Whatever your own view, what should not be missed is the added value of incorporating rival moral arguments to policy questions. Is give and take possible between these rival viewpoints? Maybe. Maybe not. The other important matter is that even if there are deep moral disagreements, it can only help having the factors that are the source(s) of the dispute open for rational discussion.

TO BOLDLY MONITOR WHERE NO ONE HAS MEASURED BEFORE

ROBERT STEWART Hugh Roy and Lillie Cranz Cullen Distinguished University Chair, Exploration Geophysics

Energy is fundamental to the great richness of life. The power of a country – literally, its ability to do work over a period of time – is associated with its energy capabilities.

The largest primary energy producers in the world are, in order, the United States, China, Russia, Saudi Arabia, and Canada. Some visionary authors even have ranked civilizations based on their ability to produce energy (the Kardashev Scale). In the United States, oil discovery and the internal combustion engine were critical parts of the development of the automobile and aviation revolutions in the early 1900s. The Lucas well at Spindletop, near Beaumont with its prodigious blowout in 1901, ignited the imaginations of many and led to the foundation of the Texas oil industry.

Blow-outs are less highly regarded now: We depend on new technologies to make energy discovery, production, and consumption as safe, clean, efficient, inexpensive and impact-free as possible.

That's a long list! And, at very least, the second law of thermodynamics teaches us that there is always waste and untoward consequence in energy's transformations. While we can't guarantee waste- and risk-free energy, we can go a long way toward that goal by conscientiously monitoring all steps of its journey. If there is something awry in the process, we can try to catch it and remediate. If there is a problem, the goal is to find and correct it rapidly.

One of the most exciting ways to do this is derived from fiber optics. Lasers have been used for decades to pulse light packets down hair-thin strands of glass to transmit information, lively conversations, and interesting videos.

But it turns out that laser light is also reflected back toward the source by small impurities or changes in the fiber. If the fiber is stretched a bit at a location, then the amount of reflected light varies with the stretch (or strain). The lasers can be pulsed very fast, allowing a record to be made of the motion at many points along the fiber. This is called Distributed Acoustic Sensing, or DAS. A fiber-optic line can be affixed to the pipe (casing) of an oil or gas well, and as the well produces, its flow can be characterized by the vibrations as they are recorded by the DAS system. If there are changes in the recorded vibrations along the well, they can be pinpointed and remediated.

Another remarkable technology is 4D reservoir monitoring. Motion sensors or seismometers (OBS) can be placed on the ocean floor and used to listen to vibrations from a nearby ship, inside the earth or events associated with a well's production. Most commonly, the sensors record vibrations generated by a vessel on the sea surface and then reflected from deep under the ocean bottom. These subterranean echoes are assembled into a 3D geologic picture. This remarkable representation of the earth's structure and rock type can be used to identify potential oil and gas deposits. By repeating the survey, small differences in the echoes can be used to infer changes in the saturation of a producing reservoir. Reservoir monitoring with 4D seismic, along with computer simulation of the reservoir and its fluid changes, can help identify inefficiencies and problems in production, then provide ways to solve them.

People produce and consume vast quantities of energy in their quest for happiness and prosperity. Monitoring every stage of this process can help make energy discovery, recovery and use more efficient and safer. Exciting science and engineering make monitoring happen in ways not previously imagined.

GREAT BOOKS, GRAND CHALLENGES: ENERGY EDUCATION IN THE 21ST CENTURY

ANDREW HAMILTON
Associate Dean for Student Success,
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BBC News maintains a web feature called 'The World at Seven Billion', with a thought-provoking feature: tell it your birthday and it will tell you approximately where you sit in the sequence of persons. I was the 3,809,767,193rd person alive when I was born, and the 78,017,472,949thto ever walk the Earth. Readers of Hitchhiker's Guide to the Galaxy might see shades of the Total Perspective Vortex in this. (The TPV destroys its victims by showing them their true place in the universe. To be subjected to this information is to be humbled to death.)

There's more humility to come. The United Nations is projecting that another billion people will have joined us by 2025. There are already nearly twice as many people on the planet as there were when President Nixon made his historic visit to China. Paul and Anne Ehrlich raised concern over mass starvation caused by overpopulation in 1968's The Population Bomb. That was two billion people ago. Their dire predictions turned out to be wrong, but perhaps we can see why they thought we should pay attention: the population has more than tripled in their lifetimes.

Population growth is news by itself, but it brings with it a host of further considerations. What will all these new people do? Where will they live? Where will they obtain sufficient energy, food, and water? How will they access education and healthcare? And how will we and they transform our cultural, civic, and biological landscapes?

A thorough transformation—and I mean that in its most full-throated sense — is already underway. In the US, city dwellers have been a majority for a little more than a century. This is not news in Houston, which grows by more than 30,000 people each year. Despite its reputation nationally, Texas is not a rural state: nearly three quarters of our population lives in the triangle described by I-35 on the west, I-45 on the east, and I-10 on the south. Urbanization is news globally, however. The world became majority urban on the 23rd of May, 2007, according to researchers at North Carolina State University.

This is definitely news: for the first time in human history, most of us live in cities. The vast majority of the next billion people will also live in cities (in Asia, India, and Africa, specifically). We are living differently than we used to, which points to grand challenges.

For all of our history, population growth has meant increased energy consumption. The bigger we get, the more energy we burn and the more waste we produce. Maybe this can go on forever—the population will likely level off at 10 billion. Perhaps necessity will not demand that our population growth is supported in new ways, but many of our current challenges will still become more acute, and it's likely that many more of us will be asking for solutions. If not managed carefully, changes in the climate, the energy economy, the culture, and the biosphere will not express the better angels of our nature. Instead they will reinforce and exacerbate current divides on how to grow sensibly, rationally, and equitably.

We've never been very good at this kind of careful management, as our environmental track record and highly polarized and often irrational public conversation about the relationship between energy and everything else demonstrates. Our students have grown up in an era in which political party is a very strong predictor of belief in anthropogenic global warming and they are rightly shocked to hear that the Endangered Species Act of 1973 passed unanimously in the senate.

One reason our public conversation has its current form is that colleges and universities generally don't address growth, urbanization, and the connection between city size and resource consumption in their curricula or programming. While we have majors and minors that address these challenges directly, including the minor in Energy and Sustainability here at the University of Houston, most college students regularly graduate with no—or next to no—understanding of even the fundamentals of consumption in relation to scarcity. We insist on numerical literacy as well as on facility with reading, writing, and reasoning, but not on the most basic familiarity with the forces that shape our world.

What if we addressed the grand challenges of population growth and increased energy demand as central to our educational core? What would the national debate then look like? How would we describe and address the human situation? What if our highest aspirations for teaching and learning in the arts, social sciences, and natural sciences—core requirements at most universities—included serious attention to energy and what it means for our relationships to each other and the environment?

This is not a new set of questions. Environmentalist David Orr argued in the early 1990s that the world had changed so much since the formation of the liberal arts core that we should rethink the curriculum. "No student," he said, "should graduate without a basic comprehension" of such principles as environmental carrying capacity and the law of thermodynamics, along with an appreciation of environmental ethics and the limits of technology.

There is a case to be made that the pace of change has increased over the past years. Yet, what and how we teach have not changed much. We continue to emphasize critical thinking, problem solving, and a store of facts, but not in a 21stcentury context. This isn't all bad news; the intellectual skills we need are those we've needed since the Enlightenment. The challenges to which we turn these skills, however, could use updating.

Today the 7,305,284,331st person on Earth has been born. It's probably time to take Orr's advice, and include serious thinking about what's next for energy, urban living, and a deeper study of our civic duties to each other as part of the core training of undergraduate students in our colleges and universities. There's no better place to start than at the University of Houston—the energy university in the energy city.

THE INTERNET OF THINGS: MAKING CITIES - AND THE WAY THEY USE TECHNOLOGY - SMARTER

WENDY W. FOK Assistant Professor, Gerald D. Hines College of Architecture

Minerva Tantoco was named New York City's first chief technology officer last year, charged with developing a coordinated citywide strategy on technology and innovation.

We're likely to see more of that as cities around the country, and around the world, consider how best to use innovation and technology to operate as "smart cities."

The work has major implications for energy use and sustainability, as cities take advantage of available, real-time data – from 'smart' phones, computers, traffic monitoring, and even weather patterns -- to shift the way in which heating and cooling systems, landscaping, flow of people through cities, and other pieces of urban life are controlled.

Think about the Nest Thermostat, which "learns" what temperature you like, and when you're home to need that heat or air conditioning. Systems across an urban area can use the same principles, considering vehicular patterns and individual habits to balance energy supply and demand. Electric grid operators already do that on a broad scale – they know demand will be higher on a hot August day than on a mild autumn evening.

But harnessing Open Innovation and the Internet of Things can promote sustainability on a much broader and deeper scale. The question is, how do you use all the available data to create a more environmentally sound future?

The term "Internet of Things" was coined in 1999 by Kevin Ashton, who at the time was a brand manager trying to find a better way to track inventory. His idea? Put a microchip on the packaging to let stores know what was on the shelves.

Gathering data from things isn't a new idea – think wireless networks in the '90s, networked sensors in the '80s, even the Defense Advanced Research Projects Agency (DARPA)'s satellites in the 1950s. Now, though, the Internet of Things includes all manner of what are called 'information and communication technologies', or ICT. That includes radio, television sets, computers, mobile phones and satellites, things that are already in use and that are evolving into more sophisticated models.

Technology has had real successes in changing city life -- Medellin, Colombia, was chosen as City of the Year by the Urban Land Institute in 2013 in recognition of its turnaround from a symbol of the drug wars into a high-tech hub promoting civic engagement and innovation.

Private real estate industry has led the way in many cases, with innovative developments like Hudson Yards on the west side of Manhattan, using Big Data to optimize energy use, traffic patterns, temperature and pedestrian flows, among other services, within their urban development project.

The ability to limit the amount of energy and other resources we waste has real value. But the constant monitoring involved in collecting Big Data across urban areas also raises the specter of Big Brother, and those concerns shouldn't be ignored.

Since 2005, my students and I have worked on the crossover between architecture and urban public policy, open innovation and data access, urban ecology and technological planning within cities.

We look at ways to generate smart cities, reducing carbon and moving to smart ways of digital mapping. We know Open Innovation and the ubiquity of networked electronics and other devices are affecting the world of architecture and design, construction and real estate development.

But too often, we have found, city planners, designers, policymakers and others start their work in a vacuum. If we are to scale up the successes of smart cities, to truly take advantage of so-called Open Innovation by engaging knowledge and ideas across a wide spectrum, this work should be done cooperatively.

Top-down management and lengthy decision-making processes may be too slow to allow individual communities to truly determine how to use their space.

The environmental and financial costs of that can be great. Last month, the U.S. Department of Energy announced the economic potential for renewable power has more than tripled as a result of technological improvements and cheaper technology. If renewable energy is becoming less expensive, cities have fewer excuses not to take advantage of it. But that, too, should be decided with input from all stakeholders.

Tough questions remain, in addition to privacy issues. Intellectual property often stimulates creativity, but at the same time it can hold back innovation. Issues of ownership and authorship play a role within the active use of data and privacy within the digital age. Architects and designers, as much as planners and policy makers, need to be held responsible for detailing the opportunities offered by the use of open source data and Open Innovation.

Open Innovation and the data created by the Internet of Things can offer a way for engaged residents to participate in the future design of their cities.

UPSTREAM BUST MEETS DOWNSTREAM BOOM IN HOUSTON: THE EAST SIDE EARNS SOME RESPECT

BILL GILMER

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The oil industry divides itself between upstream exploration, production and oil services, and downstream refining and petrochemical operations that turn crude oil and natural gas into useful products. Since 1980, Houston's upstream sector has been through five major downturns in drilling, all with adverse consequences for the local economy. The current drilling downturn — the worst since the 1980's – has hit Houston's West Side particularly hard.

Meanwhile, largely neglected compared to its upstream sibling, the downstream refining and chemical plants in East Houston are enjoying a massive and unprecedented $50 billion construction boom. A combination of strong US economic growth and this downstream construction may be just enough to keep the Houston economy out of recession, despite the current collapse of drilling. If, in fact, newfound economic diversity keeps Houston out of a drilling-driven recession in 2015 and 2016, who would have thought the key piece may turn out to be refining and petrochemicals?

Eastside/Westside

Blame it on the wind. In North America, prevailing winds follow the jet stream and blow from west to east. So if you were looking to locate a smoke-belching factory, you put it on the East Side of the city so the wind can blow smoke and soot right out of town. Put the nice homes and shops on the West Side, where smoke is hardly ever an issue. Of course, factory workers will live in more modest East Side homes close to the factories.

This is the history of many American cities, and what we mean In Houston, the split comes along Highway 59, and the Galleria, Energy Corridor, Katy and Sugar Land define the white collar, professional west, while Ship Channel cities like Pasadena, Baytown and Deer Park are inevitably tabbed as blue collar and working class. Since 1980, seven years out of 10 have seen the West Side out–perform the East Side, as drilling thrived, and the eastside refineries and chemical plants got little recognition.

This has been all the more true since 2004, as high oil prices set off a boom in fracking, and soaring drilling activity mostly worked to the benefit of West Houston. Petroleum engineers, geologists, geophysicists and high-level executive talent were in strong demand, local wages grew and tens of thousands of professional workers poured into Houston. Demand soared for high-end apartments inside the Loop, upscale retail, millions of square feet of new office space and shiny new suburbs around Beltway 8 and the Grand Parkway.

But now the biggest-ever drilling boom is over. OPEC announced in November 2014 that it would no longer act as swing producer in global oil markets, curtailing its production whenever a surplus of oil arose. OPEC would simply accept the market price and maximize revenue by producing oil at high levels. The price of crude quickly crashed to near $45 per barrel early this year and U.S. fracking and offshore drilling bore the brunt of the damage.

Spending for exploration and drilling is down by 40 percent, and the number of working rigs is down by over 60 percent. By most measures, it is the biggest collapse in drilling since the 1980s and Houston's West Side is ground zero for this reversal. Even the light industry that supports much of the upstream demand for machinery and fabricated metal production is located in the West, along the Hardy Toll Road or on Belt 8 between the Energy Corridor and George Bush Intercontinental Airport. Since last December, about 5,400 oil-related jobs have been lost and another 16,300 in manufacturing.

Houston's Business Cycle

Three factors drive Houston's business cycle: exploration and production spending, the U.S. business cycle and downstream construction spending. The table below lists the five periods of largest decline in drilling since 1980. Right now, as drilling bottoms out, Houston is lucky to have both a strong U.S. economy and a major boom underway in petrochemical construction. The only other time that the U.S. economy grew strongly during a drilling collapse was the Asian financial crisis, and it was enough to keep Houston out of recession. The only other time that downstream spending was strong was the combined 2001 U.S. recession and fall of Enron, but it failed

How Houston Fared During Five Episodes of Drilling Collapse

Event	When	Rig Count Decline*	US Recession?	Downstream Construction	Houston Recession?
1980's	1982-87	82.4%	yes	negative	yes
Asian Financial Crisis	1997-98	46.0%	no	negative	no
2001 Recession/Enron	2001-03	35.4%	yes	positive	yes
Great Recession	2008-09	50.9%	yes	negative	yes
Current Shale Bust	2015-?	55.3%	no	very positive	probably not

* Decline is through the third quarter of 2015. Based on weekly or monthly data, the fall in the rig count exceeds 60 percent.

to keep Houston out of recession. All these drivers turned negative during the U.S. financial crisis and Great Recession and Houston quickly lost more than 100,000 jobs.

Even with help from the U.S. economy, the current upstream collapse would probably be enough to pull Houston into a mild recession. But two out of three growth factors are positive, with a massive East Side construction boom also underway. Once we add in these construction jobs, Houston may well skirt recession. So far in 2015, the metro area remains on track to add about 15,000 new jobs, and we expect something similar in 2016. It is not the 100,000 jobs per year of the fracking boom, but neither is it the economic disaster of the 1980s, when more than one job in eight was lost.

Stimulus from Downstream

Where does the downstream construction activity come from? Consider the role played by these large plants in the oil industry. For example, the Texas/Louisiana Gulf Coast is a major center for refining crude oil into products such as gasoline, kerosene, diesel and jet fuel. With over 6.6 million barrels per day of processing capacity, about a third of it in East Houston and the Ship Channel, the Gulf Coast is the most important refining region in the U.S. measured either by quantity processed or by the sophistication of operations.

In contrast to the refiner, the North American petrochemical producer takes natural gas liquids (propane, butane or ethane) and

Continued on page 44

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Continued from page 44

produces intermediate products that ultimately become plastic or synthetic rubber. For example, ethylene is the major building block on the Houston Ship Channel. In the chain of production, ethane is the natural gas liquid, ethylene is the petrochemical, and ethylene is processed into plastics such as polyethylene or polyvinyl chloride.

If you are an integrated oil company, this downstream activity nicely balances out the drilling cycle. For example, suppose oil and natural gas prices are high: exploration and production are profitable, but the downstream industries see the cost of feedstocks rise. The refiner has to reprint company price sheets and call customers to explain why gasoline or jet fuel prices are rising. In contrast, with low oil prices, the exploration business suffers, but downstream feedstock costs fall. Refining and chemical margins grow, and downstream profits offset upstream losses.

Houston is unique among large U.S. energy cities in having very extensive operations both upstream and downstream. The obvious analogy is to a large integrated oil company that smooths its revenues by combining both upstream and downstream processing. If Midland and Odessa are analogous to independent producers like Apache or Anadarko, then Houston is Exxon, BP or Shell. In the current cycle, the timing of the swing from upstream debacle to downstream success has been extraordinarily good for Houston as a whole, but it has pushed boom times from the metro area's West Side to the blue collar East Side.

Construction of New Plants

The current construction boom in East Houston is primarily built on cheap natural gas. Fracking brought a bonanza of new domestic natural gas supplies that – unfortunately -- arrived just in time for a major U.S. recession followed by a prolonged period of slow growth. Worse, there was no means to export surplus gas to global markets. The result was a collapse in natural gas prices in late 2011 that slowed drilling but set the stage for an extraordinary period of high profits in the petrochemical industry.

The low price of gas quickly spurred two kinds of investment. The biggest push was for new petrochemical plants that use natural gas liquids (priced much like natural gas) to make plastics. Why the excitement? Outside North America, the rest of the world primarily uses oil-based naphtha to make plastics and until early this year naphtha cost $100 per barrel.

Meanwhile, the North American producer could make plastics with natural gas liquids at the equivalent of $20 per barrel. The result of was very large profits. From 2011 to 2014, ethylene's price was around 60 cents per pound and for the North American producer the all-in profit margin was 40 cents per pound. Needless to say, this generated a lot of excitement about new North American petrochemical capacity and over $32 billion in construction has been announced in the Houston metro area alone.

A second major source of industrial construction spurred by cheap gas is the export of liquefied natural gas (LNG). These plants are to move natural gas out of North American and into global markets. About $7 billion in construction is underway in Houston and much more in nearby Corpus Christi, Beaumont and Lake Charles.

Finally, cheap oil has improved refining margins, and refinery expansions have recently joined the long parade of East Houston construction projects. Nearly $5 billion in projects are now underway.

East Side projects now total about $50 billion and the list continue to grow. How big is this? Think of $250 million as the cost of a good-sized downtown office building and $50 billion is the capital equivalent of 200 office buildings. The employment impact? Each of a dozen large projects could easily peak with 2,000 or more workers on site and there are dozens of smaller projects. There may be another 10,000 construction workers hired in 2016. Indeed, this construction is a timely offset to the economic problems presented by the drilling downturn.

First, these are temporary jobs. The construction is timely, but it only will last a couple of years. As construction winds down, these large capital-intensive industries leave a much smaller number of permanent jobs behind. Construction will continue at high levels through 2016 but begins to wind down rapidly during 2017 and construction stimulus turns into economic drag as blue collar layoffs begin. It is a boom that comes with a well-defined expiration date.

The temporary nature of these jobs also means they have a different economic impact from the permanent; professional jobs that -- until recently -- made up the influx of new Houston workers. Additional construction workers won't contribute to the recent strong demand for luxury apartments, office buildings, high-end retail or expensive suburban homes. These are well-compensated jobs, especially for skilled crafts, but many workers will seek temporary housing and may send money home. While they are here, the broader economic impact of these workers on the local economy might be half that of full-time and permanent office or manufacturing workers hired with similar compensation.

All qualifications aside, it is time for a tip of the hat to East Houston and the boom-time conditions on the industrial East Side. Jobs are plentiful, wages rising, rents are up and properties with rail or Ship Channel access are in strong demand. A list of the largest projects put Baytown and Freeport squarely at the epicenter of this boom. As oil-industry profits move from upstream to down, all the Ship Channel cities will shine while west Houston's producers and oil service companies are in full retreat.

The wheel will turn again in a couple of years, oil and natural gas prices will rise and profits swing back upstream. Local economic momentum will once more shift from east to west. Meanwhile, the big winner is the entire Houston metropolitan area as the American oil industry delivers continued growth -- whether energy prices are high or low.

PREPARE TO PAY MORE FOR ELECTRICITY IN TEXAS

ED HIRS
Lecturer, Finance and Energy Economics

The low electricity prices enjoyed by most Texas consumers can't last forever. To understand why, you need first to understand a bit about the pricing structure in the Texas electricity market.

Under the supervision of the Texas Public Utility Commission, a co-op called the Electricity Reliability Council of Texas (ERCOT) sets the structure for the Texas electricity market. For a long time, ERCOT has used a model under which companies that generate electricity are paid only for the electricity they generate.

When electricity is plentiful, competitive pressure dictates that the price a generator can charge will be little more than the cost of generation. Only during times of electricity shortage can producers charge enough to enable them to invest in new plants and equipment. When shortages are rare, as is currently the case, very little capital can be accumulated to provide the financing for future growth.

Every electricity market has its own challenges. The situation in Texas came into stark relief when ERCOT's independent market monitor, in its July 15, 2015, annual report on the state of the energy market in Texas, noted that electricity prices in 2014 could not have provided sufficient capital for any generating company to invest in current generating technology without losing money, or "incurring negative cash flow" in accounting terms. The report excluded any comment on wind generation, which has expanded rapidly due to federal subsidies but which faces additional costs of transmission and storage. That is, when they are needed most, wind resources are not reliably present.

Electricity shortages are usually quite temporary. They may come from a spike in demand, such as a record heat wave, or a reduction in capacity, which might happen, for example, when a number of large plants go offline at the same time.

Relying on temporary shortages to provide the revenue needed to finance long-term capital projects is a risky business for generating companies. It is safer simply to sit back, make a modest profit, and let someone else take the risk that there will be enough shortages to finance their projects.

If someone else overestimates the revenue from temporary shortages, they will go broke. Then they will have to sell their existing generation facilities to the buyers who sat on the sidelines the longest and built up the largest piles of cash.

In this scenario, a few risk-taking companies will succeed, while others will fail. Since success provides only incremental growth and failure results in the end of the company, most companies will sensibly leave the risk-taking to others, continue to build their cash hoards and wait for the inevitable failures.

Growth for the safe players will come more slowly than for the risk-takers, but they won't suffer the consequences a "bet the company" player faces in the event of a miscalculation.

So ERCOT's structure practically ensures that at some time in the future, after the number of "bet the company" players has grown too small, capital investment will lag behind the growth in demand that inevitably comes from continuing population growth in Texas.

That's when the public will clamor for more generating capacity, but it may be too late.

No one generating company will have enough cash to take on the cost of constructing significant new capacity. A company that wants to go it alone will leverage itself through borrowing, taking on the risk that the new capacity may not be needed at the exact time the new plant comes on line.

A more sensible approach might be to form a consortium with other cash-rich generators to build plants on a joint-venture basis. This reduces the risk that a host of companies will engage in projects due to come online at about the same time, with the winner being the one who gets to market fastest, while those who lag behind find themselves with half-finished plants that no longer make economic sense to complete.

THE PARADOX OF CHINA: RISING STANDARDS OF LIVING, MORE POLLUTION

ALEXANDER PANKIEWICZ
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It was my childhood dream to visit the East, and I was finally given the opportunity this past summer. I worked in Wuhan, China, as an English teacher. I took frequent trips across the country, and truly enjoyed all of the delicious food, learning about the rich history, and meeting so many incredible people. I also tried to note the differences in the way of life, economics, political system, etc. What shook me the most was the tremendous amount of consumption and economic development in China. As a student studying chemistry and chemical engineering, my conscience on pollution, energy consumption and natural resources tends to be a more critical. Seeing all of this development started to connect the dots on the meaning of the energy industry and the environment, suggesting many of the energy and sustainability issues that my generation will have to face.

I observed that Chinese public transportation is much more developed and extensive than in the United States. If I wanted to travel to another city, I could do so, since the eastern side of China has a system of high-speed trains that reach speeds of up to 186 miles per hour. Imagine getting from Houston to Atlanta in five hours on a train. This is no fantasy in China, and it allows tourists, businessmen and families to travel seamlessly.

On one of my trips between Wuhan and Beijing, I traveled through Shaanxi, a province nicknamed the "Coal Belt" of China, which houses much of the country's coal production and consumption. As I looked out the window, I expected the morning fog to clear but soon realized the thick gray mass wasn't crisp morning dew, but carbon emissions from the nearby coal plants.

I felt compelled to look into the effects of this pollution. Numerous reports and research document the people in Shaanxi have a statistically higher occurrence of lung and stomach cancer due to the intensely polluted water and air. If current climate change deniers believe the crisis is not a result of human behavior, I urge them to consider a trip to northern China to experience the harm coal consumption causes. With China's current political and economic agenda, this byproduct of economic development (water and air pollution) is largely overlooked and ignored.

After returning to Wuhan, I mentioned this to my coworkers, but they refused to talk about it. Under the current Chinese political system, questioning the government can be risky. Since energy policy and energy companies are controlled by the government, speaking out about pollution puts you at risk of trouble with the authorities. I managed to meet somebody working in the energy industry who was courageous enough to discuss this with me. From what I understood, China may seem to be trying to shift its largely coal-based economy to alternatives such as nuclear and hydroelectric, but coal is likely to remain a mainstay for the country's energy consumption.

This results from a growing middle class and rising living standards. Many Chinese are putting in a lot of hard work to improve their socioeconomic status and moving into larger residences, buying vehicles and showing off designer brands. The malls looked more exclusive and the designer stores were endless. The advertisements were everywhere, and the shopping markets were filled with them. Rolex stores sit amidst the gambling in casinos.

It's as if all of the speculative gambling and movement of wealth was centered on materialism. And it was. That's when the public will clamor for more generating capacity, but it may be too late.

No one generating company will have enough cash to take on the cost of constructing significant new capacity. A company that wants to go it alone will leverage itself through borrowing, taking on the risk that the new capacity may not be needed at the exact time the new plant comes on line.

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CERTIFICATES, CREDENTIALS AND COLLEGE DEGREES: TIME TO SHIFT OUR THINKING

CATHERINE HORN
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It's that time of year again. College students across the country are taking finals, turning in papers, finishing projects and anxiously awaiting news of how they've fared this term.

But while national efforts are ongoing to boost college enrollment, another movement is questioning the very premise of the "seat time" model of learning. Instead, those proponents suggest ditching the traditional semester and credit-hour for competency-based education and stackable certificates.

Research and experimentation are underway, and energy executives are watching, even as their companies shed jobs to survive the latest oil price bust. The training for their next generation of workers is critical, rapidly evolving, and energy has an important contribution to make.

Higher education in the United States has, for most of its history, relied on letter grades attached to a credit hour structure, born in the early 1900s to reflect what students have accomplished after between 10 and 15 weeks in a course. The aggregate of those classroom-based efforts – captured in a transcript and a certificate or degree to hang on the wall – indicates a graduate is ready to enter the workforce – as a petroleum engineer, off-shore oil rig operator or any other category of professional.

Especially during the last decade, policy makers, industry and universities have begun to challenge the standard models of learning and credentialing. Instead, several alternative approaches have been proposed and often focus on enhancing three key conditions: quality, portability and stackability.

Quality, as a study from the Carnegie Foundation reported earlier this year, is really about moving away from models that stress only exposure to material toward those that emphasize mastery of concepts. And it intersects with portability in discussions of educational reform, focused on the idea that not all valuable learning takes place in a traditional classroom or on a standard time-frame.

Competency-based learning may take two weeks or two months, happen at a university or in the field, and all depends on the student and the specific area of focus. Reformed teaching and learning opportunities allow for better understanding students' strengths and challenges and a flexibility that may result in better outcomes.

Researchers Evelyn Ganzglass, Keith Bird and Heath Prince considered the ramifications in a report for the Center for Postsecondary and Economic Success, noting that "Noncredit occupational education and training are estimated to make up nearly half of all postsecondary education.… Despite [the] potential parity in instructional rigor, workers and students who persist through demanding noncredit occupational education and training programs too often must repeat their coursework when they attempt to pursue postsecondary credentials, primarily because the credit hour and not competency, is the dominant metric for assessing learning."

Finally, "stackability" acknowledges the idea that not every student takes the same path at the same pace, even when they are working toward the same outcomes.

Consider this story from Inside Higher Ed about an innovative partnership between the Texas energy sector and community colleges. The program attempted to increase opportunities for students to receive training to meet immediate work force needs and, at the same time, to allow them to transfer that training toward a subsequent college degree.

There is much to be hopeful about when considering these ongoing reforms. First, the value of postsecondary education is clear, as the country's civic and economic future rests squarely on an increasingly academically prepared workforce. Current reform also recognizes the dynamic nature of learning and that knowledge, skills and attributes recognized as important by educators and employers alike can be developed both within and outside of a traditional educational setting.

But in the glow of this new postsecondary dawn, we as scholars, industry leaders and policy makers have to be vigilant in clearly understanding its results for all students.

A paper prepared for the American Council on Education's Center for Education Attainment and Innovation calls for a new postsecondary education credentialing system, which would provide tangible benefits for students, workers and employers.

The authors write, "A less confusing, high-quality system of portable, stackable credentials is a matter of equity for individuals of all skill levels seeking to climb the economic ladder and a matter of economic competitiveness for the nation as it seeks to increase workforce capacity and productivity."

The challenge we face, whether students pursue a traditional college degree or portable, stackable industry-recognized credentials, is this: We must take great care to systematically and rigorously evaluate whether those paths are indeed experienced as equally noble and born out of a choice rather than structural predestination. History and research, including work I have done with Stella Flores, suggests that great care has to be taken to actively deploy these different postsecondary options to ensure that they serve as equitable opportunity providers.

PARIS POINTS THE WAY FORWARD ON INTERNATIONAL ENVIRONMENTAL POLICY

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Regardless of your views on climate change, it is unprecedented that nearly 200 nations came together in early December for the Conference of Parties and the 21st United Nations Framework Conference on Climate Change (UNFCCC), known as "COP21." This meeting also served as the conference of Parties to the Kyoto Protocol.

It was just the latest in a string of efforts to reach international consensus on climate policy. Twenty-one years ago, in March 1994, an earlier UNFCCC international environmental treaty was forged after negotiations at the 1992 Earth Summit in Rio de Janeiro. This established the forum for future negotiations.

The most recent conference focused on ambitious goals: to limit the rise in global average temperature to less than two degrees Celsius above pre-industrial levels and to achieve net zero annual emissions of greenhouse gases by the second half of this century.

Looking to 2050, it is clear that the victory is mostly symbolic. The agreement is not binding, and given political conflicts about these hotly debated topics, the commitments will not be ratified by national legislatures. Domestic political support in many countries is not strong enough to ratify the negotiated measures.

Still, they are important, boosting efforts underway across the globe to reduce greenhouse gas emissions, including work here in the United States. The U.S. Congress continues to wrangle over Environmental Protection Agency (EPA) regulations that would limit emissions on coal-fired power plants. Natural gas or renewable energy technologies are suggested as alternatives but business planning and regulatory policy remain contentious.

Renewable energy – including wind and solar – will require additional technological innovation to become more widely used, including improvements to energy storage and transmission.

Historically, one of the most significant international environment pacts ratified by the U.S. legislature in recent decades was the Montreal Protocol. This international treaty to limit chlorofluorocarbons (CFCs), blamed for eroding ozone, was adopted by 46 countries, including the United States, and went into effect in 1987. A decade later, the Kyoto Protocol had nearly twice the national signatories. While the United States and China were noticeably absent from this agreement in Japan – the United States formally rejected the protocol in 2001 – the presence of both countries in Paris offered important evidence of a turning point and their renewed interest in leading the international dialogue on climate change policy.

The COP21 conference, which ran from November 30 to December 12, 2015, has been significant for three reasons:

- The spirit of cooperation, showing international solidarity after the tragic attacks in Paris on Nov. 13.
- The participation of China and the U.S. As the world's two largest economies and the countries with the most carbon emissions, other nations have looked to these international giants for leadership on international environmental policy.
- Showing the way forward on international environmental policy in a new era of broad global participation.

Despite the prevailing optimism, there was not universal agreement at COP21, as world leaders split on a variety of issues. Nur Masripatin, lead negotiator for Indonesia, told the Financial Times that the deal was too weak. "The deal is not fair… but we don't have more time, we have to agree on what we have now," she said.

Supporters such as Prakash Javadekar, Minister of State for Environment, Forests and Climate Change in India, told the newspaper the action marked "a historic day. It is not only an agreement, but we have written a new chapter of hope in the lives of seven billion people on the planet."

The U.S. lead negotiator, Secretary of State John Kerry, has praised the outcome as "a tremendous victory for all of our citizens. …It is a victory for all of the planet and for future generations. … I know that all of us will be better off for the agreement we have finalized here today."

In addition to its promises to reduce carbon emissions, the agreement pledged foreign aid to developing countries to support their move to more advanced electric generation sources including natural gas, wind and solar.

And the work continues. Morocco will host COP 22 next November in Marrakech. This meeting in North Africa will provide another opportunity for further commitments.

In addition to providing progress reports on the goals presented in Paris, advocates will continue to press for the parties to adopt a binding treaty.

COP 21 has shown the way forward with nearly all of the globe's nations embracing democratic principles to present their views on environmental policy. As the world becomes smaller, with enhanced communications and technologies, the commitment to cooperate on environmental policy becomes even more attractive. The Paris conference built a framework for our intentions to steward the environment while supporting energy sustainably that can show the way forward for climate change activists and skeptics alike. This is a unique opportunity for solidarity in international environmental policy.

U.S. HAS THE EDGE FOR DEVELOPING UNCONVENTIONAL RESOURCES

CHRISTINE EHLIG-ECONOMIDES William C. Miller Endowed Chair Professor of Petroleum Engineering

The upstream petroleum industry has achieved near miracles producing unconventional resources, using technologies developed in the United States mainly by independent oil companies.

Unconventional resources require technologies typically not used to produce conventional oil and gas reservoirs. In particular, the combination of horizontal wells and hydraulic fracturing has been key to gradually increasing success, starting in the 1990s. While the well completions may be more expensive than those typically applied in conventional reservoirs, the advantage for unconventional resources, including tight (low permeability) gas in sandstone or carbonate rock, coal-bed methane, and organic rich source rocks classed as shale gas and tight oil, is very large resource volumes.

While tight gas and coal-bed methane resources have shown important successes, shale gas enabled a stunning increase in domestic natural gas production of about 4 trillion cubic feet (TCF) per day in the five-year period from 2005 to 2010. In 2005, the United States needed to import natural gas to keep up with growing demand for natural gas to use in electric power generation.

Since 2010, a glut in natural gas production lowered the price sufficiently to 1) revitalize the petrochemical industry, 2) enable significant reduction of polluting nitrous and sulfur oxides and greenhouse gas emissions from electric power generation, and 3) inspire plans by Chenier and other companies to export U.S. natural gas this year as liquefied natural gas (LNG).

U.S. natural gas resources could sustain domestic natural gas use for nearly 100 years at current consumption rates.

A similar story followed for U.S. crude oil production.

Tight oil production ramped up nearly 5 million barrels per day over about five years, starting in 2008.

The production increase was comparable to conventional crude oil production increases by Aramco in the 1980s and by Russia at the turn of this century that used well known technologies imported largely from the United States and Europe.

When increased U.S. crude oil production volumes eventually affected global markets, the international oil price dropped, and we currently enjoy driving with much cheaper gasoline as a result.

The technologies that accomplished these near miracles were developed and implemented by petroleum engineers who specialize in drilling down to reservoirs, often miles underground, and producing crude oil and natural gas to the surface where it is transported to electric power plants, petrochemical plants, and refineries.

Right now, of course, profits have been all but erased for most producers working in unconventional reservoirs. Today the challenge for U.S. petroleum engineers is to find cheaper ways to produce unconventional resources. With the end of the ban on crude oil exports, U.S. oil can be sold at a global price. In time, the global price will creep up, but odds are the eventual equilibrium global price will be well below $100 per STB, or stock tank barrel. Some of the production costs will be met by belt-tightening economics involving employee reductions, corporate restructuring and reduced demand for essential oilfield services and products.

A role for academic research may be to reexamine data acquired by the operators with an eye on discovering ways to reduce well costs and increase hydrocarbon recovery efficiency.

Shale formations are found around the world, but it remains an open question as to whether other countries will be able to successfully develop their own unconventional resources. That's because in addition to significant financial investment, developing unconventional resources requires at least three other elements: the resource, the right technology and the necessary infrastructure, including the legal, logistical and political frameworks.

Any one of those issues can be a barrier to successful development, but they all align in the United States. The U.S. legal edge, for example, is that landowners also own the subsurface minerals; this means landowners have a stake in the profits from selling the minerals. No other country has this legal framework. Some landowners in Texas and other states have become overnight millionaires as a result of shale development.

In other countries, the profits go to the government.

WHY ARE OIL PRICES SO HARD TO FORECAST?

BILL GILMER

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For the oil forecasting community, the most recent collapse in oil prices marks one more failure. The long trail of forecast errors includes the market implosions of 1982 and 1986, not seeing the run-up in commodity prices after 2004 and now missing the end of the same commodity boom. For those of us who depend on oil price forecasts, this is a big problem.

Try to forecast the economic outlook for Houston or the Gulf Coast, for example, without a good handle on oil prices. Right now, I am coping with oil price uncertainty by preparing several scenarios for Houston's economic outlook, mostly conditioned by guessing when and how fast oil prices might recover.

The process took me through a number of current oil price forecasts from banks, investment houses and consultants, and the differences in opinion are wide and discouraging. I was left asking: Why is it so hard to forecast oil prices?

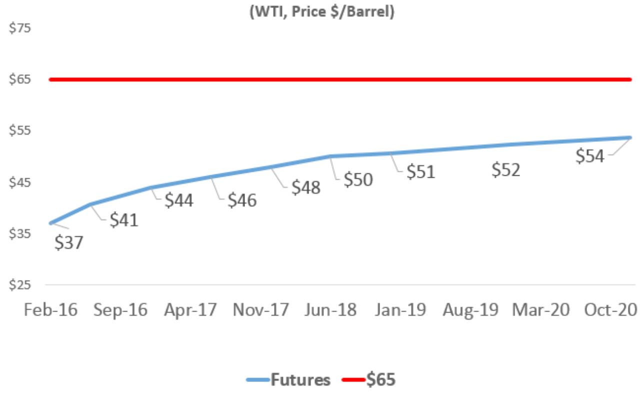
Oil Futures as a Spot Price Forecast

This latest forecasting led me to the crude oil futures market, an often-quoted and much-maligned forecast of oil prices. In principle, it should be a very good predictor. But in fact, using the futures price as a forecast of the spot price of oil is a very small improvement over predicting that oil prices will be the same tomorrow as they are today. That sounds terrible, until you learn that futures market predictions beat all the alternatives, including other financial models, statistical models and expert surveys. Why can't we do better?

Figure 1 shows prices on the futures strip for NYMEX crude oil on December 31, 2015. At each date, the price is the payment that would be made and received for a barrel of West Texas Intermediate (WTI) delivered at that time. In the 1930s, it was thought that the spot or current price and all futures prices were independent, each determined by economic fundamentals prevailing at that point in time.

Figure 1: Where the Futures Market Thinks WTI Oil Price Is Headed

(WTI, Price $/Barrel)



As of Dec 31, 2015

In the 1940s, agricultural economist Holbrook Working showed that spot and futures prices were closely linked by the cost of storage. If the 12-month futures price was higher than the spot price plus the cost of 12 months of storage, for example, I should buy inventory today, store it and sell it at a profit later. By the 1970s, economists had worked out how producers, consumers, hedgers and speculators take a history of past prices, inventories and market fundamentals, arbitrage across time, and the market simultaneously solves for the spot price and futures prices.

It also turns out futures prices can be regarded as a forecast of oil prices.

For example, the December 2017, futures price in Figure 1 is $48 per barrel, implying that will be the spot price on that date. If you live in Houston, this is a very gloomy outlook. We probably need $65 per barrel to put the fracking industry back to work, and perhaps allow it to grow moderately. Futures don't see a price near that level before 2020. How seriously do we take this forecast?

Futures as Forecaster

Work on futures prices as a forecasting tool is confusing because it swings back and forth between two concepts of "good forecaster." One stems from the efficient markets hypothesis, where if we can show futures markets are efficient, then by implication they are good forecasters.

Alternatively, we just ask if the futures price does a good job of forecasting the spot price. If we look at out-of-sample results, does it reproduce the past well? Better than other forecasting tools?

There are two important concepts of efficient markets:

Weak-form efficient markets reflect all publicly available data on past prices and market fundamentals, and arbitrage eliminates the profit opportunities. In theory, standard forecasting techniques relying on public data cannot improve on the futures price. Strong-form efficient markets contain all information, public and private. The weak form properties are subsumed here, but the question now becomes whether there are pools of private information that keep markets from being strong-form efficient. This might be a proprietary model, an analyst with extraordinary insight, or an investment bank that pours tens of millions of dollars into research.

In 1997, William Tomek, a pioneer of futures market research, reviewed decades of work on corn, soybeans, hogs and other agricultural products, and drew the following conclusion: "The preponderance of evidence suggests that markets are weak form efficient. Thus other publicly available forecasts cannot improve on futures quotes as forecasts. This does not mean, however, that futures quotes or other forecasts have a high degree of accuracy."[1]

Tomek's review was based on mature commodity markets that had been operating for decades. The question at hand is whether relatively new energy futures markets, and especially the market for crude oil, would allow us to draw similar conclusions.

Crude oil Futures

Futures markets for grains and cotton were in full swing by the 1870s, but exchanges for crude oil and other energy products weren't established for another century. Heating oil was the first NYMEX energy product in 1978, followed by WTI crude in 1983 and later by gasoline and natural gas. The delay for crude and oil products was because much of the world's oil changed hands at posted or official prices until 1986, with the prices negotiated between large national oil producers and major oil companies. The demise of this system allowed today's futures market for crude to grow and rival the largest exchanges in the world, including commodities such as corn and copper.

Early studies of crude oil futures as a forecast of spot prices were deeply divided. From one study to another, the markets are/were not efficient, or futures prices are/were not good forecasters. Many of these studies were premature, as it takes years to accumulate the data needed for good studies.

Continued on page 44

WHY ARE OIL PRICES SO HARD TO FORECAST?

BILL GILMER
Director, Institute for Regional Forecasting,
Bauer College of Business

Continued from page 44

To get around the lack of data, early studies too often relied on prices from the fixed-price regime of the 1970s and 1980s. To see what we know about these markets today, I found four relatively recent studies of crude oil and oil product markets; none of them used data from before 1990.[2] This brief summary sounds very much like Tomek's conclusions for agricultural products.

- Crude oil markets are probably weak-form efficient. Three of the four studies support the notion across all the futures horizons studied.
- The studies typically show that the futures price forecast can beat a random walk, i.e., it is better than a naïve forecast that says tomorrow will be the same as today.
- But futures are rarely better than a random walk by statistically significant margins. We can't be 90% or 95% sure futures are better.
- Both futures prices and a random walk predict spot prices better than other financial or statistical models. For example, the study from the IMF looked at two alternative financial models and six alternative time-series models. Once more, futures beat out the random walk by a small margin, but the accuracy of other models fell far short of either futures or a random walk.

Why oil prices are hard to predict

We have dug ourselves into a pretty deep hole. Futures prices are a poor predictor of spot prices, barely beating a random walk, but standard statistical models are even worse. Since futures markets are weak-form efficient, no financial model, statistical technique or subjective survey based on public data should do better.

Why are all the forecasts so poor? It is because the world will not stand still. All of the evaluations of crude futures markets assume that on a particular day the market takes past prices, inventory data and other fundamentals to produce a set of spot and futures prices. We write down the 12-month futures price, for example, then wait a year and check the spot market to see if the forecast was right.

But that forecast was completely predicated on information available a year ago. We can all think of moments that have suddenly and unexpectedly turned oil markets on their head: the Arab oil embargo, the fall of the Shah or the invasion of Kuwait. An efficient market scrapes together all available data and uses it to look forward, but no one should pretend it can somehow divine the future.

And it doesn't take big headlines to upset the forecast. The global crude oil market depends on the politics of dozens of producing countries, economic cycles in consumer countries and a vast infrastructure of pipes, ships and refineries. Even if we account for the known issues correctly, we could list 1,000 or more low-probability events that could push our forecast off course.

Suppose that each of these events has a probability of one in a 1,000 over the next 12 months. There is no reason to incorporate any of these possibilities into our forecast or even list them as a risk. But if these events are independent of each other, the chance that at least one will significantly and unexpectedly affect the oil market within a year is 1-(.999)1000 or 63.2%.

When I opened the newspaper December 31 and looked at the futures prices in Figure 1, what was I reading? Was the 12-month futures contract at $44 telling me what the spot price of crude oil will be a year from now? Probably not very accurately, because it is not clairvoyant; unanticipated events in crude markets over the next 12 months – those constantly changing facts – leave the futures price barely more capable than a random walk.

When important new information changes the December 31 outlook, has the futures forecast failed? No, the world changed and the futures market quickly updated its forecast to include new data – efficiently, as far as we know. As long as the world does not stand still, neither will the futures price.

But if on December 31, you wanted the best oil price forecast possible based on the facts available that day, you wanted the crude futures prices. The forecast is available daily, updated continuously and all for the price of a newspaper.

THE NEW YEAR MAY BRING A NEW FOCUS ON ALTERNATIVE FORMS OF ENERGY

NAIRAH HASHMI Undergraduate, Chemical Engineering

With the costs of solar technology development and solar panel installation dropping, will 2016 see a significant rise in the use of this alternative form of energy? The answer is yes.

Government policy, which has contributed to the increased use of renewable energy in the past few years, will continue to have a positive impact on solar energy in upcoming years. Just last month, Congress granted an extension to the 30 percent investment tax credit for the U.S. solar industry. The Solar Energy Industries Association predicts that solar generation will quadruple by 2020, supplying enough electricity to power 20 million homes and adding $132 billion to the American economy.

That’s a lot of solar.

Now that cost is becoming less of a barrier to the use of solar technology, the power of the sun may be employed more creatively in the future.

The other day, one of my classmates showed me an interesting example. Mahesh Rathi, a businessman in Mumbai, India, has developed a solution for street vendors who sell refrigerated goods, such as ice cream and cold water, in the heat of summer. His ‘Smart Kart’ refrigeration model relies on solar power to charge a battery that can last for over 24 hours.

Usually when I think of solar power, I associate it with stationary panels. However, an on-the-go solar model such as that envisioned by Rathi could easily become a practical and portable alternative. Two-way power calculators have been around a long time, where solar and battery-generated energy both contribute to power a calculator. But what if cellphones could function on two-way power? Or laptops?

One crucial advantage of solar is its usefulness as a power source in rural areas, where it costs less to install solar cells than to build a centralized grid and new distribution lines. I currently volunteer with a nonprofit organization, Sawayra Inc., which aims to empower people in poverty with low-cost solutions for basic necessities such as electricity and water. I stumbled across Sawayra, a relatively new organization, while looking for opportunities to gain experience in the field I am studying, engineering. It has been a mutually beneficial experience, as I am finally able to apply engineering principles to real life problems outside of the classroom.

One of Sawayra’s main projects involves providing homes in the rural village of Rashidabad, Pakistan, with their own water-generating units.

The design model my team is working on consists of an air dehumidifier that has been modified to run on power from a solar panel. The model should be able to produce enough water daily that a family can use it for drinking and cooking. Solar power is relatively easy to set up, and therefore makes this project more feasible. The project is still in its early stages, but my team hopes to produce a working prototype by the end of the year, with help from local engineers and students in Pakistan.

Although traditional hydrocarbon-based energy will likely remain the largest source of energy over the next few decades, there are several indicators of a rapid rise in the use of renewables including solar.

Renewed tax credits for solar and wind energy, rising global concerns about climate change and the reduced costs of installing and operating solar energy all point to a future where renewables pose a convenient solution in regions other than the most poverty-stricken ones targeted by nonprofits like Sawayra.

THE FUTURE OF TRANSPORTATION: NOT SO FAST MARTY MCFLY!

RAMANAN KRISHNAMOORTI UH Chief Energy Officer | Professor, Chemical and Biomolecular Engineering

Back when I was a college student in India, I was quite taken by "Back to the Future," the Steven Spielberg movie that promised hoverboards for personal transportation and fantasy nuclear powered cars to make time travel possible. Today, hoverboards are a reality, albeit as a toy for adults and not quite ready to serve as a personal transportation device. Tesla is selling cars with "falcon" wings, like the DeLorean in "Back to the Future," and the "insane speed" button. And I am left pondering the future of personal transportation.

Three fundamental changes are asking us to pause and consider the future of transportation: the ascendancy of alternate and sustainable forms of energy that look to replace fossil fuels, specifically crude oil-based gasoline and diesel; lighter and higher energy density storage batteries and the ubiquitous sweep of global positioning satellites, cellular data and the internet of things.

Is the future of transportation one where a driverless, ownerless, electric car is called up on demand, either from the road in the neighborhood -- a la Uber -- or from a nearby garage?

Very possibly and in the not so distant future. But only in niche markets. Expanding this to the whole realm of personal transportation still faces significant hurdles.

I see this happening in urban locations where space is limited, travel times are relatively short and significant advantages of scale can be used to replace the existing infrastructure of private cars, private garages and public parking lots. In fact, every time I visit New York City or Washington, D.C., I believe those cities are already living in a socialized era of personal transportation that reflects an ownerless car society. In a controlled urban environment – say within the city limits of any major metropolis where driving bans are common, such as Singapore, Beijing or New Delhi – it would appear that the remaining hurdles of driverless and electric cars would be most easily tackled.

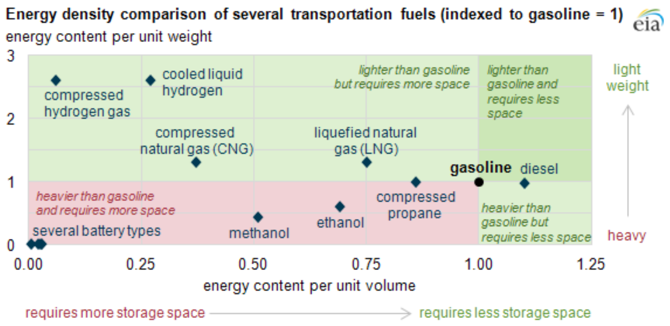
Google and Tesla are already experimenting with driverless cars. And yes, electric cars are becoming more commonplace. But an enormous challenge remains. These concepts, especially driverless cars, must be executed at full scale or risk failure, possibly disaster.

The question is whether human-driven cars and driverless cars can coexist. Testing is underway in California and Austin, among other places, and much of the preliminary data suggest accidents occur when the driverless cars are confounded by the driving patterns of cars driven by humans.

Even at scale, there are serious ethical questions about driverless cars and the decision-making that might be required of machines. It's easy to say the cars would be programmed to protect life over property. But what about avoiding an errant pedestrian while risking injury to the car's passengers? How do we feel about allowing those split-second decisions to be made by the algorithms maneuvering the car?

And then there are natural disasters (such as the 11-year cyclical solar flares) that could knock out all communications and significantly disrupt the power-grid. We will have to have safety features built in to the technology before large-scale deployment. The weakest links of this increasingly complex communications network will define the resilience of the technology. Even with all of that confronting driverless cars, replacing the entire fleet of internal combustion engine based personal transportation vehicles with electric cars will prove the more challenging issue.

First, why electric cars? The use of fossil fuels – gasoline, diesel, compressed or liquefied natural gas – and biofuels, including ethanol and biodiesel, lead to the widespread generation of carbon dioxide and in some cases pollutants such as nitrous oxides and particulate matter, including soot. Moreover, natural gas, either liquefied or compressed, faces two challenges: natural gas is intrinsically less energy intensive than petroleum-based gasoline and the infrastructure to switch to natural gas in a country as large as the U.S. are enormous – several trillion dollars, according to some estimates. On the other hand, biofuels production at scale in the U.S. would seriously raise the debate of food vs. fuel, and their use would pose some of the same challenges associated with the use of diesel, such as increased particulate pollution. Hydrogen-powered automobiles were considered the panacea about 10 years ago but have fallen behind because of the significant engineering challenges.



Today, with over 300 million automobiles and about three trillion annual vehicle miles driven in the U.S., a little over a quarter of the energy demand comes from the transportation sector. Cars, light trucks and motorcycles represent about 20% of all the energy consumed in the U.S. Even the most ambitious plans for the adoption of alternate energy platforms suggests that those platforms, if deployed at full throttle 50 years from now, would be able to provide the energy needs for personal transportation and nothing more.

In the meantime – until the alternate energy platforms mature – where will we build the electric power generation we would need to power all of those electric vehicles? And will those be powered by coal, natural gas or nuclear energy? These are critical questions that need to be confronted by all of us as we consider the future of transportation.

As daunting as those challenges are, there is one that looms larger for the broad-based electrification of the automobile fleet, and that is current battery technology. While significant improvements in battery storage technologies have been made over the last two decades, the challenge of weight, energy density, cost and reliability over an extended period of use have fueled significant anxiety regarding batteries and more broadly, electric vehicles. The technology improved, thanks to millions of dollars invested from both public and private sources, but it will take several years before widespread use might be expected.

Add in one last challenge – we are facing a generational low in gasoline prices, improvements in the efficiency of internal combustion engines and sorry, Marty McFly, but the anticipated widespread adoption of driverless, ownerless, nomadic, all electric automobiles is probably going to be later rather than sooner.

OIL & GAS | 44

GALACTIC TRAVEL OR A TRIP TO THE MALL: IT'S ALL ABOUT ENERGY

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Eight of the top 10 highest grossing movies in North America since 1977 have been (perhaps surprisingly) science fiction. There is "Star Wars – The Force Awakens," of course, and "The Martian" is rising. But really, these films are about energy, both the personal and physical kinds.

On the human side, the characters have profound drives, forceful personalities and perseverance. Then there are interplanetary trips and galactic travels requiring vast amounts of science, engineering and fuel. Our attraction to these stories lies in their combination of magnificent adventure, dazzling technology and people and energy undergoing transformation.

Our fantasies, via the movies, are fueled by energy. But in everyday life, the reality of that energy is naturally more complex, even though filling up at the gas station and driving to the mall seem pretty simple. How we produce, measure and use energy define much about life in the 21st century – and serve as a tribute to human ingenuity.

So, how do we measure energy? A basic unit is the calorie. It's the physical amount of heat required to raise one gram of water through 1 degree Celsius. In food consumption or dietary realms, the calorie is actually 1,000 physics calories or a kcal. Humans need about 2,000 (female) to 2,500 (male) calories per day for a normal active life. That's one human power. It takes about 10 humans to generate one horsepower. Your car thus has the power of about 2,000 humans.

Alex Epstein has an interesting observation in his book, "The Moral Case for Fossil Fuels," that given average U.S. energy consumption of 186,000 kcal/day, we effectively have about 90 humans working for us. Fortunately, the workers are actually machines with petroleum, coal, uranium, wind, sun and electricity as their "machine food."

In the metric system (SI - Système Internationale d'unités), the joule is employed to measure energy. An apple dropped from waist height would have about one joule of energy when it hit the ground. Natural gas is traded in GigaJoules (a billion joules, or one thousand million falling apples) and in Imperial volume units of Mcf (thousands of cubic feet). The "M" is the Roman numeral for one thousand, which is a little confusing as we now use M to denote Mega or one million in SI parlance.

Nonetheless, a GJ of energy is similar to an Mcf of natural gas or a million BTUs (British thermal units). A BTU is the amount of heat required to raise the temperature of one pound of water 1 degree Fahrenheit. When dealing with energy flow (or work or power), we use Watts or a Joule per second.

The United States consumes around 19 million barrels of petroleum products per day (MMbopd) or some 120 PetaJoules per day. According to the Energy Information Administration, we produce about nine million barrels of crude oil per day, so even with the remarkable shale revolution, the country still imports millions of barrels of oil per day. Oil self-sufficiency is challenging. Incidentally, the barrel size itself goes back to a standard container for wine (the tierce) defined in the 15th century. The width of a barrel is about 20 inches. Lining up 3,150 barrels would extend about one mile. From New York City to Los Angeles is around 2,500 miles. Thus, a string of 7.8 million barrels would stretch from New York to LA. Effectively, the U.S. consumes a row of barrels stretching from the east to the west coast and back every day.

Now let's inquire a little more about energy sources and power generation. Texas, the largest electricity generating state, has seen electrical demand as high as 70 gigaWatts (GW) on a hot summer day in 2015, serving a population of 27 million people. Keeping everyone comfortable and productive is no small task. A reasonably sized power plant of 1 GW could use coal (about one train of 100 cars per day), enriched uranium (150 pounds per day), oil (supplied by one Gulf of Mexico deep-water platform), wind (from about 4,000 one megawatt turbines) or solar (around 20 million panels measuring five feet-by-three feet). Each energy source has advantages and issues, and selecting one source will require considering factors including: availability, cost, reliability, land use and atmospheric impact. Certainly one of our greatest challenges is how to produce more energy with less impact.

Returning to the movies, the highest grossing film in domestic history, "Star Wars - The Force Awakens," depicts prodigious energy use – that of whole planets and stars. Even Matt Damon's misadventure to Mars required tons of fuel and billions of dollars. It's fascinating that most of the blockbuster movies in recent times are science fiction, including "Avatar," "Jurassic World," "Jurassic Park," "Transformers" and "E.T. the Extra-Terrestrial."

People have voted with their discretionary dollars to see glimpses of the future, suggesting that a large part of tomorrow will involve harnessing immense energy resources. Our health, comfort, security, imagination and destiny demand it.

TAXING OIL PRODUCTION? NO THANKS. WE'VE BEEN THERE BEFORE

ED HIRS Lecturer, Finance and Energy Economics

President Obama's budget proposal for a unilateral tax of $10.25 a barrel on all oil consumed for transportation in the United States will be, in effect, a direct tax on gasoline and diesel that will be passed through to the consumer at the pump. The White House's statement that the tax will be paid by "oil companies" is disingenuous. But this "dead on arrival" consumer tax proposal masks the larger issue for the industry that is also in the proposed budget: the elimination of long-standing subsidies and tax credits that will make U.S. producers less competitive in the world market. This elimination of subsidies and credits is an expropriation akin to the Crude Oil Windfall Profit Tax of 1980.

The Congressional Research Service in 2006 studied the impact of that tax, which was, like the elimination of subsidies and credits proposed by Obama, an excise tax and not based on profits whatsoever. Its findings weren't encouraging: The tax, which was supposed to recoup for the federal government much of the revenue that would have gone to the oil industry once price controls were lifted, made the U.S. oil industry less competitive.

The tax "had the effect of reducing the domestic supply of crude oil below what the supply would have been without the tax," the Congressional Research Service reported. "This increased the demand for imported oil and made the United States more dependent upon foreign oil."

It didn't help the government as much as predicted, either. Instead of the $393 billion it was projected to produce in gross tax revenues between 1980 and 1988, it generated just $80 billion.

The latest version of the tax, the elimination of subsidies and credits, will hasten the abandonment of stripper wells which produce more than 1.0 million barrels of oil per day in the United States. Allowing these wells to continue production is in our national interest and encourages the maximum recovery of resources already tapped. It makes little sense to abandon otherwise economically recoverable crude. More importantly, the elimination of the subsidies and credits would spot foreign producers a significant cost advantage and lead to less oil and gas development as the Congressional Research Service noted in a 2012 report. And just as happened in the 1980s, it would drive down U.S. production and make the United States more dependent upon foreign crude oil.

The Windfall Profit Tax was levied specifically on domestic crude oil production. As with Obama's proposal to eliminate subsidies and credits, it wasn't linked to profits, but to barrels of oil produced. And if the similarity leads anyone to think energy producers are making "windfall profits" now, think again.

The U.S. oil industry has lost more than 200,000 jobs and, at a minimum, $200 billion of direct contribution to U.S. gross domestic product. Billions of dollars of capital have been lost, and the impact of this loss on GDP is yet to be felt. The elimination of subsidies and credits will simply make it worse.

I use the term "expropriation" with deliberation. Changing the rules on an industry like this conjures what happened to U.S. producers in Russia under Vladimir Putin; to U.S. producers in Libya under Qaddafi; U.S. producers in Mexico; U.S. producers in Venezuela, and now in Israel.

It is, pure and simple, an expropriation. Imagine the United States changing the tax regime on iPhones, Microsoft Windows or aspirin.

Earlier on this blog, I called for the restoration of an oil import quota that would protect the domestic industry from the effects of predatory pricing by OPEC and also protect the consumer from the massive price hikes and dislocations caused by supply shortfalls in the world market.

Those import restrictions would accomplish conservation and encourage the development of alternatives to crude oil as a transportation fuel. Eliminating the current subsidies and credits is an excise tax, and an excise tax is a poor tool and that will cause lasting damage.

THE SUPREME COURT SUSPENDS OBAMA'S CLEAN POWER PLAN: CHANGING THE LAW ON STAYING PUT

TRACY HESTER
Professor of Environmental Law and Emerging Technology

In a surprising move, the U.S. Supreme Court has stayed implementation of the Environmental Protection Agency's Clean Power Plan rules. These rules – the centerpiece of the Obama Administration's climate change agenda – limit emissions of carbon dioxide and other greenhouse gases (GHGs) from large existing coal-fired or natural gas power plants. With the aftershocks of Justice Antonin's Scalia's unexpected death on Feb. 13 still reverberating, the issuance of the stay as one of the last Court rulings with Scalia's participation throws the Clean Power Plan's future and legality into doubt and confusion.

In particular, the Clean Power Plan would require states to reduce overall GHGs from electricity generators by 33 % (below 2005 emission levels) by the year 2030, and almost all states must submit a proposed plan on how they will achieve those reductions. If a state fails to provide its proposal or request an extension, the federal government will draft its own plan for the state and EPA will directly impose it. As a result, the Clean Power Plan is one of the most ambitious, sweeping and important environmental regulations EPA has ever promulgated.

If, that is, the courts ever allow the Plan to take effect.

The challenges to the Clean Power Plan before the Supreme Court are deeply unsurprising in one sense. When EPA published its final rules on October 23, a firestorm of lawsuits and administrative challenges immediately broke out. To date, 27 states, the U.S. Chamber of Commerce, numerous coal and electric companies and other groups have joined the lawsuit to halt the rules, while 18 states have jumped in to defend them. Given their importance, these rules are already probably the most aggressively contested environmental rules in U.S. history.

The fact that they would arrive before the Supreme Court was, in one sense, a foregone conclusion.

It is the way they arrived at the court that astonishes. In the long run, the vehicle that carried these rules to the court may overshadow the actual substance of its final decision about the Plan.

Why? Usually, when a federal court hears a challenge to an administrative regulation, the judge allows the agency to move ahead with the rule during the court proceeding. This standard approach makes sense if environmental, health and safety rules would protect the public during a long court case, and industry would not sufferable irreparable harm or ruinous costs in the meantime. The status quo's tilt towards implementation would therefore shield the public from harm if litigants tie up rules for years in protracted litigation.

As a result, courts have usually not stayed federal regulations except in extremely rare circumstances, and they usually require challengers to show both a high chance they will succeed on the merits as well as suffer irreparable and serious harm if the rules rolled ahead in the meantime.

The Court's unexpected stay of the Plan may augur a change in the federal courts' willingness to halt other environmental rules during litigation. If true, EPA may have helped bring this fate upon itself. When the Supreme Court wrapped up a long and fractious lawsuit in 2015 by striking down EPA's limits on mercury emissions from utility power plants, EPA publicly shrugged and declared victory anyway.

According to the agency, the vast majority of power plants installed mercury controls during the litigation rather than face prolonged regulatory uncertainty or postpone other capital investments. EPA's statements, as you might expect, immediately became the centerpiece in arguments that EPA was again using delay tactics and protracted litigation to force another environmental fait accompli with the Clean Power Plan.

Not only did the Supreme Court grant a stay here, it issued one with a ferocious bite. Remember that the case hasn't actually gotten to the Supreme Court yet. Instead, the D.C. Circuit Court of Appeals still must make its own decision on whether to uphold the Clean Power Plan. In fact, the D.C. court had already denied the states' and industry's request for a stay – which means the Supreme Court's decision to issue one anyway is literally the first time that it has reached down to impose a stay while the underlying case was still before a lower court. In addition, the Supreme Court's stay won't lift even if the D.C. Circuit upholds the Clean Power Plan. The clamp on the Plan's implementation remains in place until the Supreme Court decides whether it will hear an appeal – and, if it does, the Court will almost certainly extend the stay until it ultimately makes its own ruling.

What does all of this courtroom maneuvering mean? Most importantly, it's clear that the Clean Power Plan won't take effect for quite a while. Even though the D.C. Circuit has put the case on an aggressive timeline, it won't hear oral arguments until June 2016 and likely won't reach a decision until summer 2016, at the earliest. If it upholds the rule and the parties appeal successfully to the Supreme Court, the justices likely won't issue a decision until 2017 – again, at the earliest.

The complicated and potent political skirmishing over Justice Scalia's replacement will only add to this uncertainty. As a result, the stay stays until then.

But this startling outcome doesn't spell doom for the Clean Power Plan itself. First, states must still decide whether they'll prepare to implement the rules during the court proceedings and while the stay remains in effect. Awaiting the court's final ruling might risk a decision upholding the Plan (especially with the loss of Justice Scalia's likely vote against the Plan), and EPA could then require states to cobble together their proposed plans under accelerated time frames with less flexibility. Second, the timing of the Supreme Court's decision means that the ultimate fate of the Clean Power Plan may rest in the hands of the next presidential administration – be it Republican or Democratic. And last, despite the unprecedented nature of this particular stay, federal courts have previously stayed important EPA Clean Air Act rules during litigation – but then upheld the regulations anyway when the judges made their final decision.

For Texas, the ball is back in the state's hands. Will it undertake any effort – even contingency planning – to prepare for a possible revival of the Clean Power Plan's implementation? The state's recent bitter experience over its fight against greenhouse gas permits under EPA's Prevention of Significant Deterioration program might argue for some quiet back-up planning. Key officials at the Texas Attorney General's office and the Texas Commission on Environmental Quality, however, are publicly stressing their unified opposition to the Plan as an unprecedented overreach by the federal government, which doesn't bode well for attempts behind closed doors to quietly map out possible Texas compliance strategies if the Clean Power Plan, finally, escapes the stay.

KEEPING THE LIGHTS ON: CYBERSECURITY AND THE GRID

WILLIAM ARTHUR CONKLIN
Associate Professor, Information and Logistics Technology

Most Americans take for granted the national electric grid, one of the most important components of the U.S. infrastructure system, expecting it to reliably provide adequate power when and where it is needed.

Of all the critical infrastructure elements, the national electrical grid is one of the most important. Its reliability and ability to provide adequate power when and where needed is something most Americans take for granted. We assume the electric companies are properly prepared and that government oversight and regulation will protect us. Electric grids have been targets during conflicts since we became dependent upon them, and they are frequently first on bombing lists. Today, it doesn't take bombs to disrupt electrical service; this can be done via computer hacks.

The national electricity grid is now a valid target, one to be concerned about and protected. This is no joke. Before Christmas, a cyberattack shut down transformers of two Ukrainian electricity utilities, temporarily leaving 80,000 customers in the dark. Cybersecurity of the grid has become an issue demanding increased attention, and in my opinion, a fresh view on policy and regulatory options. In January I testified about one subset of cyber-related issues to the commissioners of the Federal Energy Reliability Commission (FERC). What follows is summary of my comments and further thoughts.

The FERC is a federal agency that oversees several energy related issues, including reliability of the nation's electrical grid. It performs in an oversight role over the North American Electric AEP -1.39% American Electric Reliability Corporation (NERC). NERC is the regulatory authority that for the North American bulk electric power grid. These distinctions are important, for they address the core question of who is minding our grid. In simple terms, FERC is limited to interstate bulk power, and then only by oversight of NERC. NERC passes regulations by a vote of its membership (hint – the regulated, so it is to some degree a self-regulating body) and is also limited in scope to bulk power system.

Our grid is more than just the bulk delivery system; local distribution is where it matters most, for this is where it connects to customers. This portion of our electric grid regulation and compliance is via the Public Utility Commissions in each state.

In prepping for my testimony, it became apparent that although FERC plays a role, it is very limited, and in many ways a prisoner to whims of the collection of utilities that it ostensibly oversees and regulates. All the while, the majority of the grid equipment and all of the customer connections are regulated by separate entities and separate schemes.

While formal testimony on the topic was safe or even staid, the unofficial discussion was lively and centered on a couple of major themes. First was an argument by each utility that they were already doing enough in the area of compliance and that further regulation was unnecessary and a waste of money. The second thrust was that the utilities felt or believed they are sufficiently secure. This was obvious as they were within regulatory compliance. The agreed upon goal then became to stonewall any further regulations.

What does this all mean? I think everyone would agree the electric grid is important. We all depend on it every day. We also all assume that the government has it properly regulated and has contingency plans in place to protect us. Upon examination, the regulatory framework is a patchwork of different agencies with differing responsibilities and legal authorities – in the end, each can adeptly point their finger to another with a statement of, "not my responsibility," or "outside our legal authority."

The firms involved in the grid themselves have moved from high reliability and redundancy to efficiency, as the era of deregulation made profit more important than reliability. If this sounds worrisome, it is. But wait. Our grid hasn't gone down – why worry? Isn't this just a case of the boy who cried wolf?

In the last couple of years we have had cyber-attacks on grids across the globe, control centers locked out of their systems, ransomware attacks forcing utilities to pay ransom to get back their control. This last December, malware was used as part of a cyberattack to block operators' ability to control the grid in Ukraine. The result was a major blackout. Here in the U.S. as well as elsewhere, malicious malware has been found, waiting for a signal to cause damage. Our electric grid is now interconnected to the Internet, and all of the problems and issues we see with cyber criminals and cyber spies applies to the reliability of our grid. The same attack used in Ukraine would not be stopped by our regulations, and it would be much harder for us to recover because of our greater dependency on interconnected automation.

I am not saying that the industry isn't doing anything – they have come a long way in the past decade to address these challenges. But when walking or running on train tracks, one must outpace the train – and it has been coming up behind us fast.

As an academic, I see this as an example of a "commons problem" – we all share in the need, use and resourcing for electrical energy. But our method of paying the true costs are stilted by a broken and incomplete regulatory framework. We should not expect our utilities to change on their own accord, for they have to remain competitive.

But we should expect the regulatory environment to move to one that protects our national interests. We need attention to align the regulatory schema to our desired security objectives – there should be effective oversight, without the blinders of "not in our legal authority" from the federal level. And this level should dovetail with NERC and the state Public Utility Commissions, so that when a problem occurs, a unified comprehensive response can be delivered.

One of the takeaways I got from visiting the commission is everyone is doing their job to the best of their ability; it's just that no one has engineered all the jobs to do what is necessary. For more information, I recommend Ted Koppel's new book (yes, the Nightline Ted Koppel), "Lights Out." Koppel asks insightful questions and isn't satisfied with the answers provided by government and industry. We shouldn't be either.

ECON 101 AND THE OIL MARKETS: WHERE ARE WE AND HOW DID WE GET HERE?

BILL GILMER
Director of the Institute for Regional Forecasting,
Bauer College of Business

Forecasting the future is next to impossible. It is hard enough just to figure out where you are and how you got there. But I think we can find some perspective on current oil markets by applying the elementary logic of Econ 101 to the current price collapse. Throw in a few facts about the size of oil markets and how they work, apply a little informed speculation and we actually know a lot about where oil prices are and why – and even where prices are going.

First, as scary as oil markets look today, there is no analogy to 1987. The 1970s saw a series of supply shocks, brought on by turmoil in the Middle East and the rise of OPEC. As oil markets worked their way back to long-run equilibrium by bringing on vast new oil supplies, and while OPEC grotesquely overplayed its hand as a cartel, it unleashed a flood of at least 8.0 million barrels of excess capacity, equal to 13 percent of global production.

It took a decade for the world economy to absorb this oil surplus.

Second, references to supply and demand shocks in oil markets are thrown around loosely these days -- and sometimes incorrectly. For example, the decline in oil prices that began in 2014 is sometimes called a U.S.-based shale supply shock. But it is really the messy endgame of a demand shock that began in 2004, driven by rapid economic growth in emerging markets. The 2014-15 drop in oil prices began as the return of oil prices from a short-run, price-signaling level near $100 per barrel to a long-run equilibrium near $60.

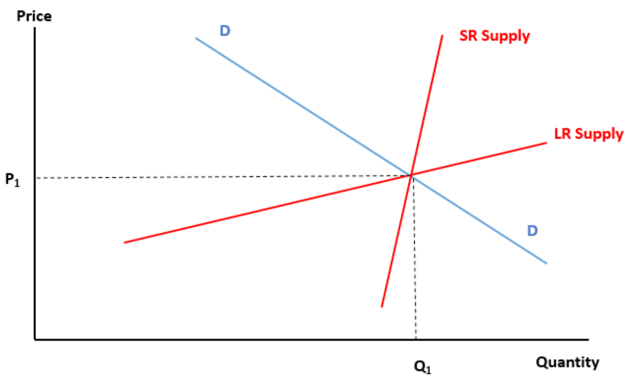
The market's recent overshoot to near $30 per barrel is a second phase of the ongoing price crash, and it results from events that weren't foreseeable as the correction began in 2014. In particular, oil markets now are struggling with the return of Iranian exports and a global economic slowdown. The current price correction is brutal, coming immediately on the heels of the long-run adjustment to $60, and the pain is most acute for marginal suppliers like shale and oil sands. But wherever oil prices are today, they should be headed back to $60 in a matter of months.

Three basic tools

Let's start with Figure 1 and three basic tools: the demand for oil, the short-run oil supply curve and the long-run supply curve. The per-barrel price of oil in today's dollars is on the vertical axis, and the quantity supplied or demanded is on the horizontal. We have many studies about how these curves behave in oil markets.

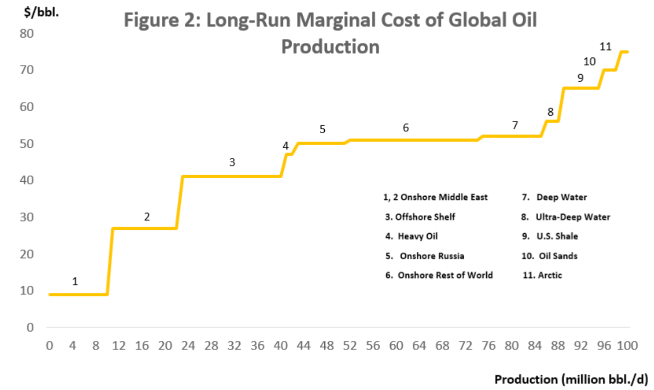
- The curve DD represents the demand for oil, sloping down and to the right. The shape of the demand curve varies over time. It is quite inelastic (close to vertical) in the short-run when the stock of energy-using capital is fixed, meaning that oil consumption barely responds to price changes. In the long-run, as the housing stock is upgraded, new energy-efficient machinery is installed or fuel-efficient cars are produced, the curve flattens and we get a larger response of oil consumption to price changes. Two widely cited studies by Dahl and Cooper say that a 10 percent increase in oil prices results in only a 0.5% to 0.7% fall in short-run consumption, but a 2-3 % response in the long run. For simplicity, I use only a single curve DD, since the important distinction in this analysis is between short- and long-run supplies.
- The short-run marginal cost or supply curve is also nearly vertical, so a spike in the price of oil brings on little new production in the short-run. A series of statistical estimates by Krichene, for example, failed to find any short-run production response at all. ***See figure 1.***
- The long-run adjustment of oil production to price appears to very long in oil markets. We might build a factory to expand widget production in 12 to 18 months. But the supply shocks of the 1970s persisted from 1973 until 1982, and the emerging market demand shock from 2004 to 2014. The stylized version of the curve in Figure 1 slopes up and to the right as new oil reserves come from higher-cost sources.

Figure 1: Three Basic Concepts for Supply and Demand In Crude Oil Markets



- Figure 2 is a more explicit representation of the long-run supply curve as we work to provide the world with 96 million barrels of oil per day.[2]

The first reserves developed are the least expensive, from the on-shore Middle East at $10-$25 per barrel, then the Offshore Shelf at $40, and then from a variety of sources that keep price near $50 until we need 85 million barrels per day. Then the price to bring on new supplies rises rapidly, with U.S. shale at $65, oil sands at $70 and Arctic oil at $75. These marginal suppliers all find themselves on the cusp of the 96.3 million barrels produced in 2015. Looking back, it is hard to imagine the long-run price of oil slipping under $50. Looking forward, global growth in demand at 1.0 to 1.5 million barrels per year will require higher prices near $65-$70.



The 1970s Supply Shock

In the 1970s, U.S. oil production began a long decline, while domestic demand continued to grow.

Continued on page 44

ECON 101 AND THE OIL MARKETS: WHERE ARE WE AND HOW DID WE GET HERE?

BILL GILMER
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Continued from page 44

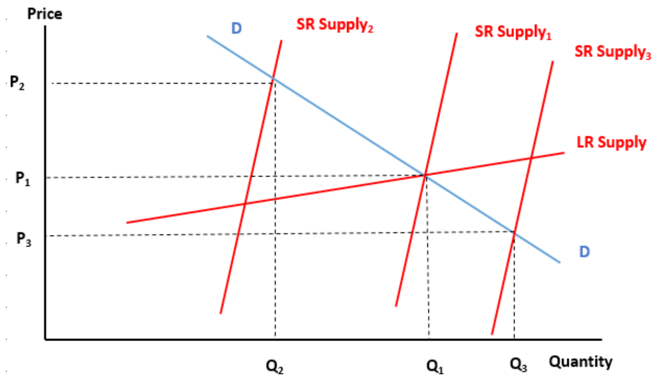
There were ample supplies of low-cost crude available from the Middle East, and the locus of power in world oil markets quickly shifted from the Gulf of Mexico to the Persian Gulf. One important result was the repeated

Using our simple tools in Figure 3, suppose we are initially in equilibrium at price P1 and quantity produced of Q1. The OPEC cartel constrains production, and the short-run supply curve is shifted back from SR Supply1 to SR Supply2. A new short-run equilibrium is found at a much higher P2, and this high price becomes the signal to markets to increase global oil production.

In this case, the new price signal was seen and acted on, triggering a frantic search for oil reserves. In the 1970s, Alaska, the North Sea and Nigeria all large delivered new oil supplies that put downward pressure on oil prices. OPEC fought weakening prices, cutting production as prices slid from $100 to $60 per barrel between 1982 and 1986. OPEC's share of global oil production declined from 49% to 28%, led by the Saudi decline from 15% to 6%.

In 1987, OPEC finally realized that – like King Canute – this rising tide of oil would never be reversed thorough their own efforts. To capture revenue, OPEC capitulated on price and began pumping at high levels; the price of oil collapsed to $20 in today's dollars.

Figure 3: Oil Supply Is Short-Run Inelastic, Prices Surge if OPEC Constrains Supply



With the cartel resigning its position, shouldn't we just return to the old equilibrium at P1, Q1? Unfortunately, no. By withholding its own reserves from the market for too long, and allowing the disequilibrium oil-price signal to stay too high, OPEC allowed production capacity to rise far above what was needed. Worldwide oil production in 1986 was 62 million barrels and the price was $60 and falling when OPEC suddenly added back 8.0 million barrels per day it had been holding off the market. World oil demand didn't reach 70 million barrels until 1995. In Figure 3, shift the curve SR Supply3 to the right, resulting in price P3 that now is below long-run equilibrium.

Figure 2 tells us that the long-run equilibrium price for 62 to 72 million barrels per day of production should have been near $50 per barrel in current dollars. Instead, OPEC left a decade-long hangover at a below-equilibrium price that averaged only $35 from 1987 to 1995.

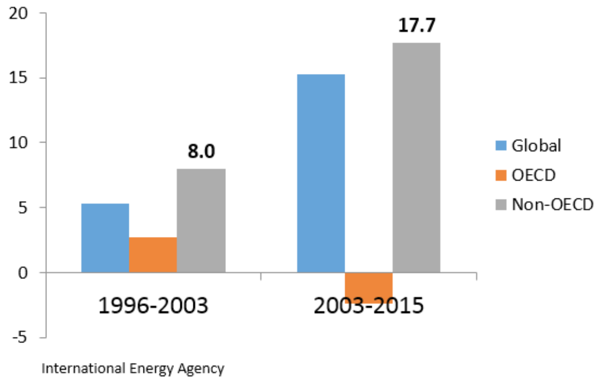
Emerging Market Demand Shock

The decline in oil prices that began in 2014 is sometimes described as a supply shock. It is true that from 2009 to 2015, oil production in the U.S. rose by 4.85 million barrels per day, accounting for all the increase in non-OPEC production. But I would argue that this new production was the response to a decade-old demand shock and the 2014-2015 price adjustment – at least initially – was the return to long-run equilibrium near $60 per barrel.

A supply shock in this context requires that the long-run marginal cost curve in Figure 2 shift down or to the right. In Figure 2, for example, if we found a new and unexpected source of 10 million barrels of $53 oil, it would displace all the higher cost sources on the right side of the curve – ultra-deep water, shale, oil sands, Arctic drilling – and we would not need them until global demand reached well over 100 million barrels. It is hard to argue this was the story for U.S. shale. There was some technological innovation, but shale staked out its place as a marginal option at a relatively high price. The $100 price signal did much more to expand U.S. shale production than any innovation along the long-run marginal cost curve.

A better way to understand today's decline in oil prices is as a response to the emerging market demand shock that began in 2004. Brazil, Russia, India and China accelerated growth, and as they raised their standards of living, they put upward pressure on the price of metals, food, agricultural raw materials and oil. The price of oil rose faster and further than other commodities, but prices all rose sharply. Figure 4 shows that since 2003, all of the increase in global oil demand has come from developing non-OECD countries, while demand from the developed nations was falling.

Figure 4: Growth in the Demand for Oil Comes From Emerging Markets (million b/d)



The textbook solution for a demand shock is shown in Figure 5. Demand shifts up from D1 to D2, and inelastic supply moves price up sharply from P1 to P2. Let's say that this new price signal to expand capacity is P2 = $100 per barrel, and stays there for several years.

Continued on page 44

ECON 101 AND THE OIL MARKETS: WHERE ARE WE AND HOW DID WE GET HERE?

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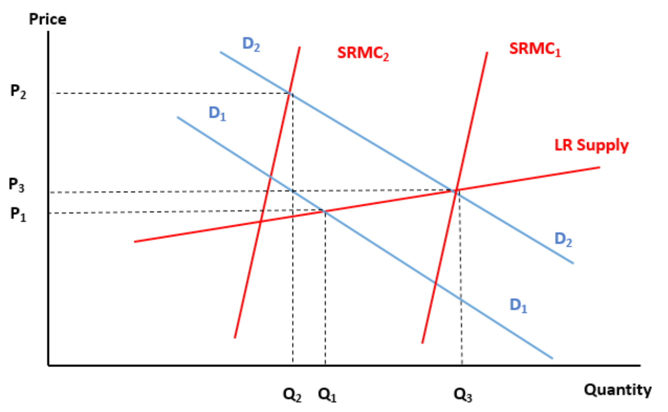
Continued from page 44

Figure 5: Oil Supply Is Short-Run Inelastic, Prices Soar With Demand Surge By Emerging Markets



We know this is well above the current long-term equilibrium price, which is $60 per barrels at 96.3 million barrels of global production. I am simply suggesting that the current price correction than began at the end of the 2014 marked the end of the 2004 demand shock and required a shift in oil prices to a new $60 long-run equilibrium. In fact, that seems to be exactly what was playing out between April and June of last year. The price of oil stabilized near $60 per barrel, the domestic Baker Hughes rig count bottomed in June as drilling turned up briefly and oil-related layoffs came to a halt. It was as if the equilibrium price adjustment had fallen into place and a V-shaped drilling recovery was underway.

This was no replay of 1987 with an OPEC build-up of surplus capacity – it now holds less than 2 million barrels per day – and no decade-long wait to work off that surplus.

Oil Prices at $30 and below?

How do we find oil at $30 per barrel today? Two subsequent events turned last summer's fragile equilibrium into a rout: the Iran Nuclear Agreement signed in July 2015 and the devaluation of Chinese currency that followed in August. Economic sanctions against Iran were imposed in 2011, and Iran's daily oil exports fell by about 1.2 million barrels. With the lifting of sanctions, Iran has made it clear that it plans to quickly regain its previous export position. Our long-run supply curve just got a million barrels per day longer, starting with low-cost onshore Middle East production that must be absorbed before high-cost shale oil returns.

Meanwhile, China is making a tricky transition from a manufacturing and export-led economy to a consumer-driven economy, and it has long been anticipated that annual Chinese economic growth would slow to near 6%. Concerns are frequently expressed that China might not make the legal, financial, labor market, energy and other reforms necessary to continue even on this more modest growth path. But the August devaluation of the yuan, accompanied by significant turmoil in Chinese stock markets, distilled these concerns into real fear about the Chinese economy – fear that quickly spilled into oil markets.

I leave it to you to guess if we should shift the oil demand curve down – and how far we lower the short-run equilibrium price. The forecast for 2016 from the International Energy Agency in Table 1 more or less dismisses the China growth problem, seeing India filling any demand void left by China. IEA points to slow growth in Europe and Latin America as the source of poor demand growth in the global economy.

That said, unless there is much more to the China story than is now apparent, this should be a routine correction for oil markets. There is no massive 1987 supply shock and the surplus currently driving oil prices should be resolved in a matter of months. How many months before oil returns to a long-run $60 or $65 per barrel? 6 months? 12? 18? That is the difficult and painful detail that remains to be resolved.

Table 1: The Growth of Oil Demand
(Percent Annual Rate)

	China	Other Asia	Rest of World
2003-2014	6.8	3.8	0.5
2015	1.8	4.8	0.4
2016 Forecast	4.4	3.8	-0.6

Note: Data and forecast from International Energy Agency

[1] Noureddine Krichene, "A Simultaneous Equations Model for World Crude Oil and natural Gas Markets," IMF Working Paper WP/05/32, February 2005.

THE SOLAR NET METERING CONTROVERSY: WHO PAYS FOR ENERGY SUBSIDIES?

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A huge controversy has arisen in California and other states over the way solar electrical generation is subsidized by net metering, or the way in which people who produce solar energy – usually through rooftop panels – are reimbursed for the energy they generate and send back to the electric grid. Proposed or already approved reductions have been greeted by public protests, lawsuits and even a proposed amendment to the national Energy Policy Modernization Act, which would limit the ability of states to reduce subsidies.

The fight pits solar rooftop owners and the solar industry against utility companies and free marketers.

The issue

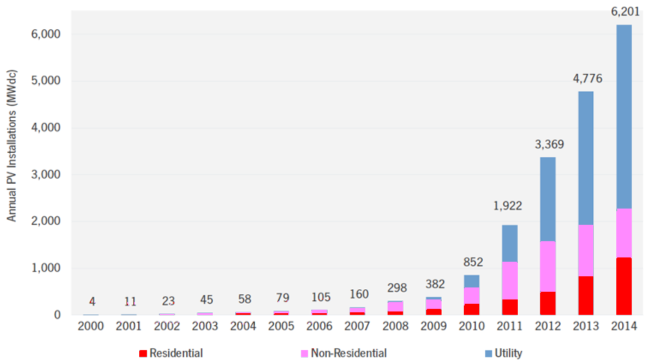
Forty-three states have mandatory net metering plans. Most net metering plans in the United States require utility companies to buy back excess electricity generated from distributed (residential and business) solar installations at the retail cost of electricity.

With the slightest bit of thought you will recognize that this is not a valid business model. No business can cover the cost of operation and profit necessary while buying their product at the same price that they sell it. In the case of utility companies, they must provide billing, support services, grid maintenance and other operational functions. For the amount of electricity provided by net metering, these costs are not covered. Typically, unrecovered costs are transferred to customers who do not have solar installations by raising electricity rates.

This is not a problem as long as the fraction of feed-in energy is small. Once solar capacity becomes a significant portion of electricity generated, as has happened in California, Nevada, Arizona and Hawaii, there is a free-for-all over who will pay these unrecovered costs.

The California example

California has by far the largest amount of solar generating capacity in the United States, representing over half of total U.S. installed solar capacity. The combination of government incentives and the decreasing costs of solar photovoltaic panels has made solar installations highly profitable, resulting in explosive growth of solar installations and the industry that markets, finances and installs the equipment.



Since solar electricity now represents 7.5% of California supply and is expected to continue to grow, the subsidy is no longer a trivial issue. A heated controversy began as a result of requests in 2015 by the major publicly traded utilities, Southern California Edison , Pacific Gas & Electric and San Diego Gas & Electric, to be compensated for unrecovered costs of net metering by additional fees and lowering the price they pay for net metered electricity. The solar industry and green power advocates responded with vociferous objections, with one spokesman calling it a "war on solar."

In a 2016 decision generally regarded as a victory for the solar industry, the California Public Utilities Commission retained net metering at retail cost but imposed certain fees on residential solar installations. To some extent, the Commission kicked the can down the road by indicating that they will reconsider net metering in 2019.

The bigger picture

Net metering applies to rooftop solar, which represents about one third of U.S. solar capacity. The issue of subsidizing renewable energy is much broader: utility scale generation is roughly twice the size of rooftop solar, and subsidy considerations also apply to wind power and other renewables. In addition, it is a worldwide issue. The U.S. only represents about 10% of installed solar photovoltaic capacity; the largest capacities are in Europe and the Asia-Pacific region.

Public discussion often focuses on economic analyses, which are typically slanted to the viewpoints of the authors. Analyses by utility companies tend to focus on the cost of providing generation; analyses by solar advocates often include imputed environmental benefit and avoided cost of transmission and other generation facilities.

Although pro-solar analyses may conclude that solar is currently economic, the IEA reports that only 4% of solar installations in 2014 were economic without subsidy. This means continued growth of solar in at least the near-term will be dependent upon subsidies.

How much should the subsidy be?

There is no reason net metering credits need necessarily be at full retail cost. Some international jurisdictions value credits below retail cost. A recent "value of solar" calculation by the Minnesota Public Utility Commission places the value above retail cost, largely on the basis on the value of avoided carbon emissions. Ideally, subsidies should be no higher than is necessary to achieve the desired utilization. As solar costs decrease, subsidies should also decrease.

The drafters of net metering legislation recognized the limitations discussed here and often included reductions when caps on the amount generated are reached. This has not prevented the beneficiaries of subsidies from complaining when they are reduced.

Who pays?

There is strong public support for alternative energy development and renewable energy incentives. This does not answer the question as to what the form and amount of incentives should be. Net metering at full retail cost transfers the cost to utility customers who do not install solar. Other forms of incentive, such as tax credits, are paid by state or local governments out of general tax revenue.

Continued on page 44

THE SOLAR NET METERING CONTROVERSY: WHO PAYS FOR ENERGY SUBSIDIES?

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Continued from page 44

Even if the imputed environmental benefits and avoided costs of future fossil fuel power plants are taken at face value, someone has to pay the up-front cost of new solar installations if solar capacity is to grow at the rate that solar advocates desire. It has been well demonstrated that the number of homeowners and businesses willing to install solar drops dramatically if subsidies are reduced. For example, when the Nevada Public Utilities Commission voted to reduce net metering credits, the solar installation companies SolarCity, Vivant and SunRun announced they would pull out of the state. Plaintiffs in a lawsuit filed against the changes were quoted as saying they would never have invested in their PV systems had they known Nevada's net metering program would be scaled back.

So, who is to pay? Will you and I pay through general taxes? Will utility customers pay through higher rates? At present, the utility companies would have solar users pay through lower credits. The solar companies would have utility customers and the general public pay. Free marketers would eliminate subsidies and have no one pay. As the late Sen. Russell B. Long said, "Don't tax you, don't tax me, tax that man behind the tree."

HOW THE PRESIDENTIAL CANDIDATES STACK UP ON ENERGY ISSUES

ED HIRS Lecturer, Finance and Energy Economics

Anyone who has been waiting for leadership on energy policy during this year's tumultuous Presidential campaign may be waiting in vain. There's little talk of energy and, even when the candidates offer a few proposals on their campaign websites or mention them during a debate, there is a dismaying lack of detail.

About the only talk of energy has come from Democratic candidate Bernie Sanders, who has called for a ban on hydraulic fracturing as the cornerstone of his energy and climate policy. Sanders' rhetoric has forced the presumed Democratic frontrunner, Hillary Clinton, to say she, too, would impose more restrictions on fracking.

This is in spite of numerous studies – by the Environmental Protection Agency and the administration's handpicked Secretary of Energy Advisory Board Shale Gas Production Subcommittee – both finding hydraulic fracturing to be benign for the environment and drinking water supplies in particular. To be fair, studies have determined that water disposal injection wells are linked to earthquakes, but hydraulic fracturing has not been so linked. And shale gas has been an enormous benefit for Americans. In 2012, my colleagues and I demonstrated that the annual gain to natural gas consumers from hydraulic fracturing is more than $100 billion—even more today.

On the Republican side, John Kasich is happy to tout the job growth drilling has brought to Ohio during his time as governor but otherwise has said little other than "we need everything" in energy development. Donald Trump has said he would end oil imports from Saudi Arabia if Saudi Arabia fails to step up its own military commitments.

Even Ted Cruz, the candidate from Houston, the oil capital of the world, has offered little more than promises to slash regulations and approve the Keystone XL Pipeline.

None of them has released a detailed and coherent energy policy, even as the impact of the oil bust – low prices, big layoffs and concerns about the global economy – collide with questions about mitigating climate change.

But whoever is elected president in November will no longer be able to ignore the subject, from the nuts and bolts of building new pipelines to balancing the climate impact of coal with policies to retire or retrofit our remaining coal plants.

And those are just the issues related to hydrocarbons. Nuclear and renewable energy should be part of a lower-carbon future. Both pose big challenges.

Public knowledge about nuclear power is largely confined to scare stories, Three Mile Island, Fukushima and "The Simpsons." Building support for fourth-generation reactors and safer fuels won't be easy. Neither will decommissioning existing nuclear plants. The Nuclear Regulatory Commission appears to have underestimated the cost of decommissioning the Vermont Yankee plant by more than one-half, or $600 million-plus.

Entergy, the owner of Vermont Yankee, plans not to begin cleanup until a trust fund of about $600 million grows to be $1.2 billion in some number of decades, long after current executives and shareholders have passed away.

Will the cleanup costs grow beyond today's $1.2 billion estimate also? Are there other such shortfall surprises across the current fleet of more than 100 nuclear power plants? The solution to long-term storage or remediation of nuclear waste has been avoided both by Congress and recent administrations. Such long-term thinking is usually outside the interest and beyond the competence of politicians.

Candidate Clinton has called for 500 million solar panels. Pundits have challenged the numbers behind her rhetoric, but integrating the growing amount of solar and wind energy into the grid will require re-engineering not only the grid, but reworking energy storage, intermittency, distributed generation and transmission solutions. As Spain and Germany found out with very successful subsidy programs, the success and costs of the subsidies can overwhelm taxpayers, ratepayers and utilities. Renewable and carbon free energy is not free of costs.

None of the presidential candidates has offered a blueprint for any of these priorities, or for helping the more than 200,000 people who have lost their jobs in the U.S. oil industry since prices began dropping. Federal Reserve Chair Janet Yellen recently pointed to the economic loss due to the decline in oil prices that appears to have more than offset the consumer gain of lower prices at the pump. The U.S., as one of the largest oil producers in the world, is suffering from the low oil prices even more than any member of OPEC. How to replace the conservatively estimated $200 billion cut from the nation's GDP due to lower revenues and less drilling activity? No one is offering suggestions.

Specific policies could help. My colleagues and I have demonstrated the costs and benefits of restricting imports, and we have called for the return to that policy to reduce the nation's reliance on foreign crude. An import quota imposed by President Eisenhower saw U.S. crude prices persist at double the world price charged by OPEC. A return to import quotas would encourage conservation and return U.S. workers to the oil industry.

Removing the impediments to new pipelines would help, too, ensuring that people in Boston do not continue to buy LNG like the residents of Tokyo. Expanding pipelines into the Northeast will hasten the end of coal fired power plants in the Northeast and the use of dirty fuel oil for heat.

All of these issues matter. They will require leadership. Doing nothing – and the resulting environmental damage from coal-fired power plant emissions, ash ponds and mining operations, for example, and the financial and human costs of U.S. military efforts in the Middle East – will cost far more than higher gasoline prices, higher electricity rates and higher taxes.

The question is, who among the candidates can lead the nation to address these challenges? So far, no one in either party has stepped up.

BOOTLEGGERS, BAPTISTS AND REGULATING CARBON EMISSIONS?

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Additional authors: Scott Mason and Kwok Wai Won, Hobby Center for Public Policy

Did you hear the one about the bootleggers and Baptists? What would these two groups have to do with energy policies, such as carbon emission regulation?

In what is now considered a classic piece of political economy, Bruce Yandle's "Bootleggers and Baptists: The Education of a Regulatory Economist," published in a 1983 edition of Regulation, sketched out a view of regulation showing how groups considered to be natural adversaries come together. Specifically, Yandle states:

Bootleggers, you will remember, support Sunday closing laws that shut down all the local bars and liquor stores. Baptists support the same laws and lobby vigorously for them. Both parties gain, while the regulators are content because the law is easy to administer (page 12).

Yandle expanded upon this theory of political economy in the 2014 book he co-authored with economist Adam Smith. And the "bootleggers and Baptists" theory sheds light on contemporary arguments over carbon emission policy. First, let us identify who fits the profiles of the two groups. The "Baptists" are members of the environmental movement and the factions therein. "Bootleggers," on the other hand, are certain members of the energy industry, and those that depend on the success of the energy industry, including labor and governments.

What, then, would cause these "unnatural" allies to unite? The answer lies in the way carbon emissions will be regulated. It is a certainty that any new regulations affect the prices of energy commodities.

The Baptists will want to encourage the use of energy commodities that have the lowest carbon footprint. Meanwhile, bootleggers – who are in the business of providing low-carbon commodities – will likewise support similar regulations, shifting market demand to their products.

As a consequence, carbon emission regulations give favored status to energy sources such as ethanol, bio-diesel, wind, solar and the like. Coal and oil production is discouraged with an emphasis on shifting to other fossil fuels, primarily natural gas.

What are the future consequences?

With the bootleggers and Baptist coalition tipping the regulatory scale in one direction – away from higher carbon emissions – the chance for meaningful energy innovations in response to emerging energy, environmental and developmental challenges is more difficult because of anti-competitive rules that both the bootleggers and Baptists support.

Worse, if Yandle and Smith are correct, the institutional rules developed will take on a life of their own – reinforced by the bootlegger and Baptist coalition – and feed new anti-competitive practices. One needs only to look at the evolution of the federal government's Interstate Commerce Commission (ICC) as an example. It was created in 1887 and, after morphing to regulate bus lines, telephone carriers and other forms of commerce, was ultimately abolished in 1995. If anything, the 100-year experience with the ICC shows how regulatory policies can start off well meaning, but gradually and perhaps inevitably, evolve into protecting certain bootleggers and higher prices for consumers.

As a final thought, carbon emission reductions – or the reduction of any potentially harmful emission – would seem to be far more likely to happen with an open and vigorous competitive environment, with winners and losers determined by consumers and not bootleggers and Baptists. Yet, bootlegger and Baptist coalitions have built-in advantages, particularly since in many cases the benefits they receive for the regulations they support are concentrated and lucrative, while the costs to the public are so spread out.

One way to level the policy playing field is to raise the cost to bootlegger and Baptist activity. On that score, Yandle and Smith suggest structuring policy processes so there is greater transparency (reducing the cost of the public acquiring information) but also giving states greater say, so that bootleggers and Baptists have to compete with the public in many places rather than just in Washington D.C. With the added policy diversity, some states will outperform others and, in doing so, provide avenues to a more innovative set of energy innovations.

INSTITUTIONAL INVENTORS WERE TOO LATE TO THE SHALE GAME. WILL THEY EVER LEARN?

ED HIRS
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Additional authors: David Pearlman, Retired

Few things bother institutional investors more than having to explain to their clients why they are sitting out the latest hot thing. There is no better example than their piling into shale oil in late 2013 and all through 2014 after all the warning signs pointed to the exits.

In June of 2013, I was quoted in a Forbes article pointing out that the Saudis would need to cut their production quotas to prevent a collapse in the price of oil.

Unfortunately, a large number of institutional investors ignored the warning signs and got into shale, often by investing through private equity firms. Not only were they getting into the wrong market, they were getting into it in the wrong way.

Private equity firms aggregate investments from pension funds, endowments, retirement plans and even mutual funds to invest in specific industries. In oil and gas, the amount of investment has been staggering. In 2006, five such private equity firms deployed twice as much capital as ExxonMobil XOM -0.7%'s entire exploration budget. Do private equity firms know more about oil and gas than Exxon? Of course not. But they position themselves by claiming that they know more about it than the institutional investors whose money they manage.

Private equity firms make their money by charging a fee against assets under management. This gives them an incentive to grow the assets under management, but it gives them an even greater incentive to bring in assets to manage, regardless of whether they expect those assets to grow. So, when institutional investors clamored for shale oil plays, the private equity funds were happy to pretend that the game would never end and that they were the smart way to get in.

Of course, the Saudis didn't cut their production quotas, and the price of oil collapsed, dropping more than 70 percent before the recent tentative recovery. At a meeting of the Texas Independent Producers and Royalty Owners Association, one industry wag put it succinctly: "There are 45 private equity backed portfolio companies operating in the Permian Basin [managing] assets that are worth only one-third of what they paid for them over the past three years. By year end, there will only be five of them."

Institutional investors justified their investments in oil and gas through private equity by claiming that such investments were more diversified than direct investments. They also placed money and paid more fees with "funds of funds" operated by their various consultants. The consultants promoted these as having less volatility than the underlying funds in which they invest.

If this were ever true, it is true no longer. The corrosion of the portfolio companies at the heart of the craze will also eviscerate these "funds of funds." Funds of funds have a dismal track record in multiple industries. They were outlawed in the mutual fund industry decades ago. They did horribly in the real estate market when the mortgage bubble collapsed.

Some people never learn.

IS IT 1987 YET? THE FRACKING BUST KEEPS ROLLING ON

BILL GILMER

Director of the Institute for Regional Forecasting,
Bauer College of Business

The 1982-87 oil bust is the industry standard for tough times. Complaints about falling oil prices and rig counts can always be countered with "At least it isn't as bad as the 1980s." But there is no question that times are very tough now.

The last seven quarters have been a brutal setback for American oil, with the price of crude falling by $64 per barrel, the rig count down 70.2 percent and capital spending off by nearly 60 percent. This downward spiral showed no signs of slowing in the first quarter of this year, as the 698 rigs working at year's end dropped by a third to 464 in late March. When the number of U.S. working rigs hit 488 on March 11, it set the low mark for the 67 years that Baker Hughes BHI +0% has conducted its weekly survey.

Early on, no one expected the current fracking bust to be this deep, and it is worth revisiting 1982-87 again for a careful comparison to the present. Among modern drilling downturns, if we use such measures as length or the percentage decline in oil prices and rig count, the current downturn has clearly moved into second place in terms of severity.

However, there are at least two dimensions in which this fracking bust is much worse – the speed of the fall in drilling activity and the decline in total capital spending for exploration and production. This downturn has come much faster and harder than any other.

Comparing tough times – then and now

Since the 1970s, the U.S. has experienced five major downturns in drilling activity: the Oil Bust of the 1980s, the Asian Financial Crisis (1997-98), the 2001 U.S. recession that came with the end of the tech bubble (2001-02), the Great Recession and Global Financial Crisis (2008-09) and the current Fracking Downturn that began in 2014.

If we are looking for the most serious downturns in depth and length, the Big Two easily stand out as 1982-87 and the on-going setback in fracking.

Beyond severity, the Big Two share another important characteristic. Both were driven by large new oil supplies. Oil came from the North Sea, Nigeria and Alaska in the 80s, and the new oil comes from fracking today. In contrast, the other three downturns were brought on by recession and a collapse in oil demand. The Asian Financial Crisis, the 2001 recession and the Great Recession all triggered a major drop in oil demand, oil prices and drilling. The 1982-87 bust was initially triggered by a severe U.S. recession in the early 80s but soon assumed a life of its own based on large new oil discoveries. The Fracking Downturn is accompanied by solid U.S. growth and weak but continued global expansion. Like the 1980s, today's drilling collapse isn't about the economy, but about too much oil in the market.

The table in the next column compares the 1982-87 Oil Bust and the fracking downturn on three dimensions: the decline in the real price of oil, the fall in the rig count and the cut in real capital spending. Dollar values are in constant 2015 dollars, and quarterly averages are used to avoid the brief extremes that often come at oil market peaks or troughs. Sources of data are described in a box at the end of this post.

Comparison of Oil Market Events

	1982-87 Oil Bust			Fracking Downturn		
Oil Price Decline ($2015)	**Period**	**Number**	**Percent**	**Period**	**Number**	**Percent**
Peak	'80 Q2	$114.13		'14 Q2	$102.89	
Trough	'86 Q3	$29.55		'16 Q1	$34.53	
Change in Price	25 Q's	$84.58	74.1%	7 Q's	$68.36	66.4%
Working Rigs						
Peak	'81 Q4	4,222		'14 Q2	1,916	
Trough	'86 Q3	742		'16 Q1	571	
Rigs Laid Down	19 Q's	3,480	82.4%	7 Q's	1,346	70.2%
Cap Ex ($2015 Billion)						
Peak	'82 Q1	$87.3		'14 Q2	$240.4	
Trough	'87 Q2	$12.7		'16 Q1	$97.0	
Fall in Cap Ex	21 Q's	$74.6	85.5%	7 Q's	$143.4	59.7%

At first glance, 1982-87 looks worse, especially if you focus on percentage declines. Oil prices fell 74.1 percent in 1982-87 and today – so far – they are down 66.4 percent; for the rig count, the drop in the 1980s was 82.4 percent vs. 70.2 percent now; and capital spending in the 1980s was cut 85.5 percent, vs. the current 59.7 percent.

The 80s also come out far ahead on the length of decline, lasting between 19 and 25 quarters, depending on the measure you choose, while the current downturn still covers only seven quarters. That said, the fracking bust is now longer than any of the other three demand-driven events. The only exception in any of the other three downturns, for any measure, is an eight quarter drop in oil prices in 1997-98.

However, there are two important measures that argue the Fracking Downturn is worse than the 1980s. One is the speed of decline.

After seven quarters in 1982-87, oil prices had fallen only 30 percent, the rig count by 47.5 percent and capital spending was down only 48.4 percent. For each of these measures it would be 1986 before that decades oil bust matched the percentage declines already registered in the last seven quarters.

The drilling collapse in 2008-09 is the only rival for the rate of speed of the current drilling implosion, and it was triggered by a very fast-moving financial crisis. It lasted only four quarters.

The second measure that sets this downturn apart is the $143.4 billion fall in capital spending for exploration and production.

The figure below illustrates an issue with our comparisons, showing the behavior of both real capital expenditures and the rig count from 1973 to the present. The rig count peak in the fourth quarter of 1981 was 4,222, a figure never matched again, while the 1980s capital expenditures peaked at $87.3 billion. Compare that to 2008, with the rig count near 2000, and real capital expenditures having soared to more than $300 billion.[1]

The difference, of course, is the change in industry technology. In 1982, a simple vertical well cost less than $500,000 in today's dollars, while drilling and fracturing a modern horizontal well might cost between $6 and $8 million. Running 2,000 rigs today runs up a much bigger bill than 4,400 rigs in the 1980's.

Continued on page 44

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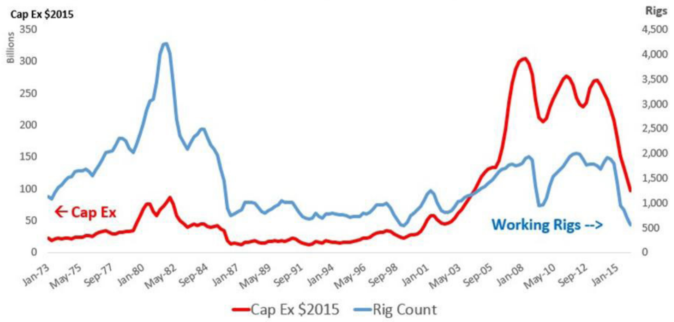
Continued from page 44

Rig Count and Real Capital Spending Compared, 1973-2016



Note: Capital expenditures are quarterly data stated at annual rates

So how bad is it now? This downturn is not yet as deep or long as 1982-87, but it has come much harder and much faster than anything that followed the 1982-87 peak. The $143.4 billion of capital spending lost in the last seven quarters is nearly twice the total losses in real capital expenditures sustained between 1982 and 1987. In fact, the inflation-adjusted losses already exceed – and by a wide margin – everything being spent on U.S. exploration and production at the 1982 peak. No wonder that 2015 saw the entire U.S. economy briefly shudder with the sudden collapse of oil-related spending and employment.

Data Used for Drilling Cycle Comparisons

All data are quarterly from 1973 through the first quarter of 2016. Quarterly data are used to avoid the extremes that oil prices, in particular, can briefly reach at market peaks or as they find a bottom.

Oil price is a combination of West Texas Intermediate prices based on posted prices (before 1982), prices published in the *Wall Street Journal* commodity section (1982-85), and spot prices at Cushing, Oklahoma (1986 and after). Quarterly averages are deflated by the U.S. Consumer Price Index, the price base is moved to $2015 dollars and seasonally adjusted.

The weekly Baker Hughes ***rig count*** is converted to a quarterly average and seasonally adjusted.

The ***capital expenditure*** data are U.S. oil industry capital spending for exploration, drilling, and production since 1970. They are based on the annual capital expenditure issue of the *Oil and Gas Journal* since 1970, and use the latest revision available. The annual estimates are deflated by the non-building capital expenditure deflator from the National Income Accounts, and converted to $2015. Quarterly estimates are interpolated annual data based on the Chow-Lin least squares method, and use the seasonally adjusted rig count as the indicator variable.

In the figure, note the double-dip after 2008, and the decline in cap ex that continues afterward. The first dip is the 2008-09 drilling downturn, and the second is the collapse of natural gas prices and gas-directed drilling in 2013. Roughly 15 percent of the rig count was quickly lost to low gas prices, and only about half those rigs returned to work directed to oil. But cap ex continues to fall after 2013 for three likely reasons: fewer gas-directed rigs, productivity gains in fracking that reduced costs per well, and growing price competition for fracking services with new entrants to the service industry. These trends makes it difficult to time the decline in cap ex specifically associated with oil prices, and to mark the peak in cap ex in the present oil-price cycle. I conservatively set the cap ex peak in 2014 Q2, the same quarter as the peak in oil prices and the rig count.

OIL MARKETS: DON'T MISTAKE SHORT-TERM CHANGES IN 'FUTURES AND OPTIONS PRICES' FOR LONG-TERM CHANGES

ED HIRS Lecturer, Finance and Energy Economics

The global market for crude oil is roughly 34 billion barrels per year, or about 93 million barrels per day. Journalists ponder and report every flicker on the screens of oil traders, akin to the play-by-play analysts for sporting events.

In a recent article, Reuters' senior market analyst John Kemp points to a very large increase in net long positions by "hedge funds," raising fears that hedge funds are pushing up prices too soon and setting up the market for a quick fall.

Kemp further states that "Hedge funds and other money managers held futures and options contracts equivalent to 791 million barrels of crude betting on a further rise in prices and just 128 million barrels gambling on a fall."

But he oversimplifies.

Traders in crude oil futures and options contracts fall into two broad categories: oil companies or "market participants" on the one hand, and all others, "financial participants," on the other.

For one thing, not all financial participants are hedge funds, because many other players fall into the financial participant category, including airlines, trucking and shipping companies, utilities and industrial users of petroleum products.

Second, financial participants aren't necessarily "gambling" but doing just the opposite. Many are simply hedging against future price movements in order to bring some certainty to an aspect of their overall business.

Finally, there is the implication that the total long position by financial participants is a significant number relative to the size of the overall market. It is anything but; 800 million barrels – roughly the amount Kemp notes as subject to options and futures contracts betting on higher prices – represents less than 10 days of worldwide consumption, and the oil futures and options markets have contracts that extend for more than seven years. That 800 million barrels is less than 2.4 percent of the annual global market and less than 0.35 percent, just thousandths of the expected consumption over seven years.

The key point is this: the small size of the options and futures markets relative to the overall size of the market is what makes the options and futures markets so volatile.

Academic research indicates that the Brent and WTI forward price curves are poor predictors of future prices — very much like the forward prices in foreign exchange markets or agricultural commodities markets are poor predictors of prices realized in the future. The dynamics of the oil markets are played out day-to-day at the wellhead and refinery gate for producers, and at the pump for retail consumers. The volatile oil commodities markets provide some indication of prices in the very near term — days and weeks — but less so for months-ahead prices and hardly any guidance for years-ahead prices.

The real usefulness of the oil commodities markets is to provide a very small group of risk-averse consumers and producers the ability to lock in prices and assure level costs and profits at least until it is time for the annual bonus review. Those who mistakenly think that they indicate anything more are simply off the mark.

HOW SHOULD WE EDUCATE THE FUTURE ENERGY WORKFORCE? EXPERIMENTS ARE UNDERWAY

CATHERINE HORN
Associate Professor, Educational Leadership and Policy Studies

The skills required for petrochemical jobs are rising, as today's plant technicians are more likely to troubleshoot with a laptop computer than with a wrench. And because U.S. oil and gas employment has dropped precipitously since oil prices began to fall, only people with those top skills – the best grades and internships out of college, the most relevant community college training for technical jobs – are being considered. The education sector has sought to respond to these increased skill needs in many ways. For example, many community colleges – certainly in the Houston area – have poured resources into those training programs.

I recently had an opportunity to participate in a panel discussing the film, "Most Likely to Succeed." This award-winning documentary tells the story of one public charter high school's effort to transform the learning experiences of its students to maximize the likelihood that they will be prepared to enter college and, eventually, an increasingly technology-driven workforce. Their approach is laudable – problem-based learning, Socratic teaching and prioritization of depth over breadth.

These strategies are not new; education activists like Ted Sizer argued for them 40 years ago with his Coalition of Essential Schools movement (now a network of more than 100 schools, including High Tech High, featured in the film). And they are grounded in a research base that finds them successful in lots of ways, including improved attendance and academic performance as well as increased college attendance rates. The energy industry has put a strong voice behind the "business case" of these kinds of education reforms, especially in states and cities where the economy depends heavily on this sector (See, for example, Oklahoma's Business Case for Education Reform or the Greater Houston Partnership's Upskill Houston initiative).

They identify the workforce need for skills such as communication, teamwork, and logic alongside math, reading and science knowledge.

For good education reform ideas to move to scale, meaningful, mutually supportive and sustained relationships have to form among the corporate (including energy), education and community sectors and focus on the policies that shape classroom practice. As Richard Elmore describes in "Getting to Scale with Good Educational Practice," there is value in incubating and rewarding concentrated pockets of innovation excellence in education. Such a strategy won't be enough if the goal is to maximize opportunities for all students, however, because it ignores the influence of the context in which community is situated.

Instead, policies that take community needs into consideration have a better chance to succeed for two reasons. First, as Elmore notes, it "broadens notions of evidence allowing for good the dissemination of good teaching practices with 'family resemblances' in different settings." Second and related, it empowers teachers and schools to engage in thoughtful and proactive reflection on best practice for teaching and learning for their students.

What does that mean in practice? Education is not a "one size fits all" enterprise, and community and sector needs can and should have a role in determining what type of education reforms are best. While care must always be taken to ensure that it does not simply mean unequal opportunity to learn, meaningfully infusing flexibility back into teaching opens up all sorts of good possibilities for learning.

There are interesting tests of this idea underway. Take, for example, the passage of Texas House Bill 5 in 2013 - a product of joint efforts and public calls among business and industry, parents, and the K-16 education sector for change to the current accountability expectations placed on students. The result was a piece of legislation that shifted the education landscape substantially by reducing the number of standardized tests needed for promotion and graduation and establishing a set of endorsements students could pursue in areas such as STEM, business and industry or public services. While still rigid and traditional in many ways, this legislation is an interesting one to watch in the ways it shapes the experiences of K-12 students in the state.

In sum, why the need to collectively focus on policy? If we want to prepare our students to be nimble in the face of an evolving energy industry, we need to build the foundation for such opportunity by collaboratively developing policy that maximizes opportunity for great learning and minimizes the unnecessary constraints we put on teachers and students toward that goal.

OIL BUST BLOWBACK: WHY ARE THE BOARDS OF DIRECTORS STILL HERE?

ED HIRS
Lecturer, Finance and Energy Economics

The spate of bankruptcies among oil and gas producers has reached epic proportions — more than 69 since January 2015 by one count. And the bankruptcy of Energy Future Holding Corp., a group of electricity companies undone by the low price of natural gas, and the recent filing of solar energy company SunEdison, Inc., illustrate that financial crisis and questionable management is not confined to oil and gas.

In all of these recent bankruptcies, not only are the shareholders wiped out, but bondholders and banks that provided senior debt have lost money. So what happens to the directors and senior management in those companies, the people who made the decisions that ultimately led to financial crisis and bankruptcy? In the United Kingdom, leading a company into bankruptcy generally leads directors and management team to jail. In the United States, that almost never happens.

History suggests that for many U.S. energy companies, life after bankruptcy may be temporarily uncomfortable, but it seldom leads to exile.

The great bankruptcy of Texaco in 1987 came after the company lost a $10.5 billion judgment in litigation resulting from its acquisition of Getty Oil, breaking a prior deal Getty had made with Pennzoil. The Texaco management and board remained relatively intact after the company emerged from bankruptcy a year later, following a $3 billion payment to Pennzoil.

Northeast Utilities barely averted bankruptcy in the late 1990s, another case unprecedented in size and scope and threat to the public — company management pursued aggressive cost-cutting, finally to the point of the Nuclear Regulatory Commission declaring its operations unsafe. Nuclear power plants were shut down, costing the company billions in losses; the corporation pled guilty to 25 felony counts. The management was removed, but no one went to jail.

The failure of Enron in 2001 broke ground, with members of the management team convicted of felony charges and the Enron board of directors ordered to personally pay to settle charges brought by the U.S. Department of Labor. The business model of Enron, a Houston-based energy trading and utility company, ultimately failed to produce ever-growing profits. Management hid the true performance from shareholders and debt holders for four years, while board members professed their profound ignorance. The ex-CEO is still in prison.

What do these textbook cases of energy companies on the brink and beyond tell us about their corporate governance?

The late Paul W. MacAvoy, former dean at the Yale School of Management, described the failure of corporate governance in syllogism: The CEO sets the strategic direction of the company in consultation with the board of directors. The board is then tasked with monitoring the CEO's execution and implementation of the strategy. If the company does not meet its performance metrics, there are two possibilities with one common outcome: 1) The strategy is sound, but the CEO is ineffectual and must be fired, or 2) The strategy is bad, and the CEO who is responsible for the strategy must be fired.

In my experience, the directors of failed companies do not think critically about their companies' business models. It is usually a matter of incompetence, negligence, gross negligence (as the law defines it) or laziness — exacerbated by being cronies of the CEO and not having the personal integrity to act independently on behalf of the shareholders. In the 2012 shakeup of Chesapeake's board of directors — a full 10 ½ years after Enron — I pointed out, "It's like they at last realized that no one on the board had ever leased an acre or drilled a well."

No one on the Chesapeake board was competent in the company's business.

Looking at the energy bankruptcies now in process, the management teams and boards appear so far to have been relatively unscathed. If removed from one company, they enter the revolving door to reappear as part of a newly reconstituted management team or board for another company. The notion that the same CEOs and boards of directors that steered the companies into bankruptcy and wiped out shareholders — who now can no longer vote to change out the board directors — remain in place for the company's new owners seems preposterous. Is there any accountability? The decline in oil and gas prices is not an act of God but a real business risk faced in the normal course of business. These companies' strategic plans should have adequately managed that risk.

We know where these boards of directors were. The question is: Why are they still here?

DELTA CEO ADMITS TO $4 BILLION LOST IN HEDGING FUEL COSTS

ED HIRS
Lecturer, Finance and Energy Economics

Delta Airlines' new CEO Ed Bastian admits glibly "We've lost over the last eight years about $4 billion cumulatively on oil hedges" in a recent Bloomberg interview. When asked if he would consider hedging, or locking in oil prices in the future, he states "I don't get paid to make those kinds of bets." Given that fuel accounts for between 23% and 33% of Delta's costs from year to year, that is an incredulous statement.

To be profitable Delta must price its airline tickets above its costs. Revenue from tickets can generally be forecast with reasonable accuracy, and labor costs are easy to forecast. How much jet fuel its airplanes will consume is also easy to forecast.

The challenge is in predicting the cost of jet fuel, or, alternatively, hedging against price increases. It is not a "bet." Hedging is easily accomplished by buying futures contracts or call options at fixed prices on an options exchange. It can also be accomplished by acquiring the commodity producer such as U.S. Steel did with Marathon Oil Corporation and Texas Oil & Gas Corporation, or as R. J. Reynolds did with Aminoil. The buyer then profits from rising oil prices to offset its increased fuel costs.

In 2012, Delta bought an old petroleum refinery in an attempt to control its fuel costs. Presumably, the Board of Directors decided that outside consultants and the self-interested traders and bankers advocating this action knew what they were talking about. As I noted at that time, the refinery would not be an effective hedge because the refinery itself was subject to swings in the price of crude oil because it does not own oil and will always have to buy oil. In addition, it had a host of other challenges.

After years of red ink, Delta now reports that the refinery has finally made an operating profit. If this is really true it is no thanks to any wisdom on Delta's part, but to the decline in crude oil prices that has benefitted all refiners.

However, Delta does not provide arm's length accounting of transactions between itself and the refinery. Delta shareholders thus cannot determine if the refinery is truly profitable. Did the refinery make a "profit" by selling above market priced fuel to Delta? The costs associated with the refinery continue to mount as Delta continues to expense the cost of the unused rail terminal that it helped build to bring "cheap" crude from the Bakken shale, and from the rising but unknown amount of damages due to environmental issues created by the refinery's previous owner, damages for which Delta assumed responsibility when it purchased the refinery.

No U.S. airline but Delta owns a refinery.

What will happen when oil prices increase? If other airlines have effectively hedged and Delta has not, will there be yet another Delta bankruptcy?

Ed Bastian has been Delta's President since 2007. He was certainly onboard with the acquisition of the refinery as a hedge strategy, and that has failed. A majority of the Delta Board of Directors is the same as it was in 2012 so I wouldn't hold my breath waiting for an objective review. If Bastian isn't paid to make the decisions, who is? Maybe Carl Icahn?

DRIVING TO WORK IS A COSTLY HABIT, SO WHY DO WE KEEP DOING IT?

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In Houston, a quick way to get agreement in a conversation is to bring up the subject of traffic. You'll almost certainly get comments about how bad it is and that it's getting worse.

And it's not anybody's imagination. Statistics show that despite considerable expansion of the freeways and the addition of HOV, or high occupancy vehicle, lanes, commute times are increasing.

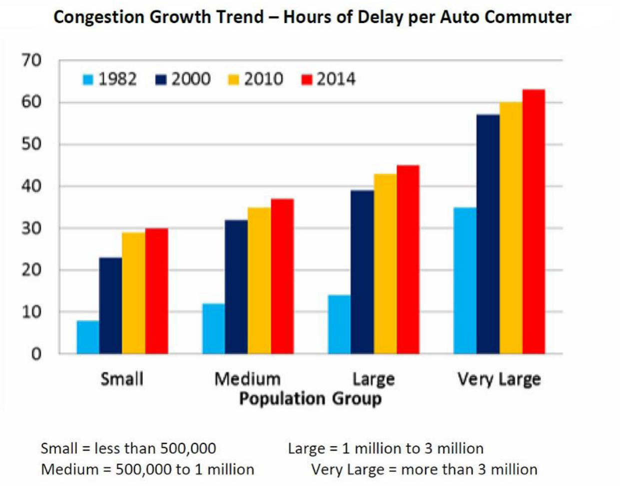
And the largest increase has come over the past few years.

Data from the Texas A&M Transportation Institute's latest Mobility Scorecard illustrates the problem, and the cost in our daily lives. More than 2.4 million Houston-area commuters are trapped by congestion every day, costing the average commuter 61 hours a year in 2014. That's up by almost one-third since 1982, when congestion cost commuters about 42 hours a year.

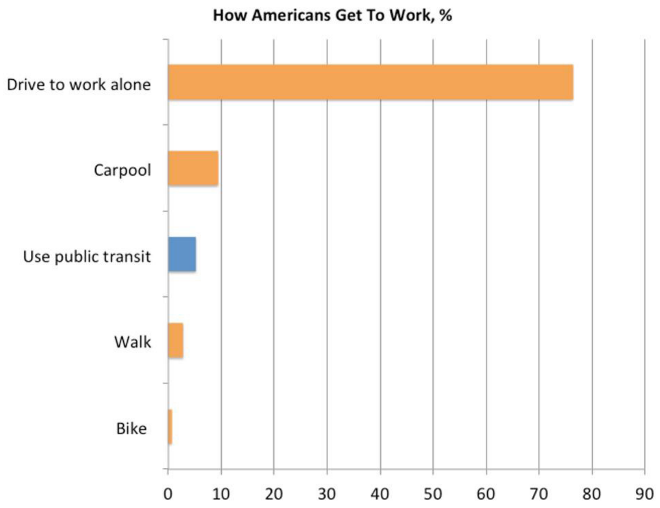
About half of that increase occurred between 2010 and 2013.

It's not just Houston. Cities of all sizes from around the country have seen similar trends, as this graph from the Mobility Scorecard shows. It illustrates trends in traffic congestion in 471 urban areas.

But more than personal inconvenience is at stake. The institute reported that all this time in traffic adds up to $160 billion in additional costs nationally, or $960 per commuter in lost time and wasted fuel. The researchers project that will grow to $192 billion by 2020.

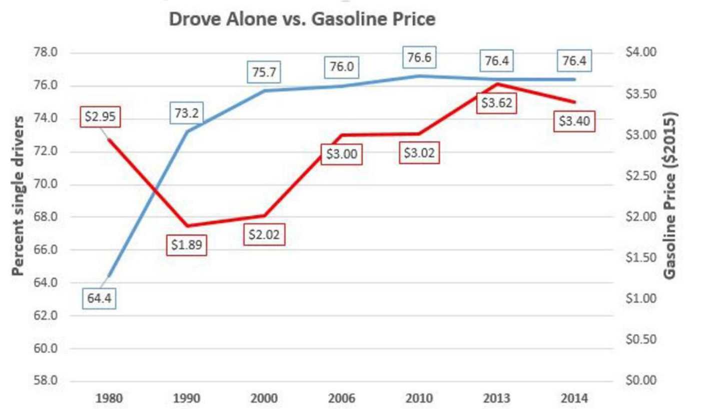


There is no shortage of literature extolling the virtues of mass transit, carpooling, bicycling and other alternatives to driving to work. Despite these virtues, and in spite of complaints about congestion and significant expenditures on mass transit ($69 billion in 2014, according to the Congressional Budget Office), we continue to not only drive to work, but overwhelmingly drive by ourselves.



There is a wealth of statistical analysis of U.S. and international driving habits. You can see how we drive by location, income level, ethnicity, age, gender, price of gasoline, state of the economy and virtually any other category you can imagine, but the literature does not have good agreement on why we choose to drive alone. Some articles attribute it to a preference for independence or convenience. Elon University economists Stephen B. DeLoach and Thomas Tiemann mentioned the possible influence of the cultural trend described in Robert Putnam's Bowling Alone. They also cite "assembly time," effectively a measure of the added duration of commute, as a factor.

Cost of operation, including gasoline prices, is often cited as a factor, although this seems to have a minor influence.



Single driving increased from 1980 to 2000 despite a significant decrease in gasoline price. The flattening from 2006 to 2014 is likely partly due to gasoline prices, and partly due to the 2008 recession. The increased price did not materially change driving patterns.

Similarly, demographic factors, such as population density and length of commute, have some influence, but they do not change the strong preference for driving alone. The graphic below shows the fraction of commuters carpooling from the 2011 American Community Survey.

Continued on page 44

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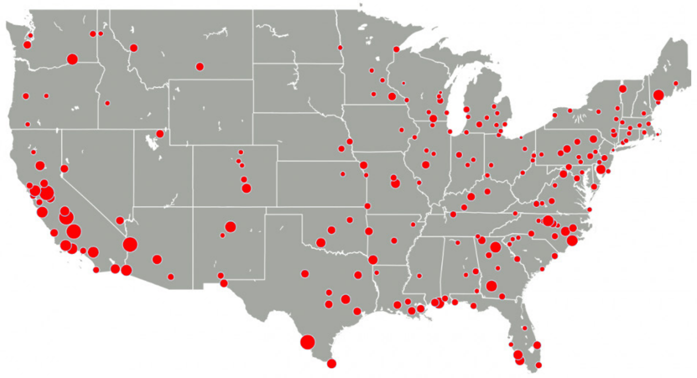
Continued from page 44



By way of scale, the value for Chicago is 8.6 percent; for Houston, it's 11.1 percent. Nationally, almost twice as many people carpool as ride public transportation, although proportionately more commuters in a few densely populated cities, such as New York, San Francisco, and Chicago, use public transportation. Washington. D.C., Boston, Seattle and Portland stand out as having high public transportation usage relative to their population density. This suggests local attitudes can affect commuting mode.

Some insight into the psychology of commuters is provided by a 1976 study of ride-sharing from Abraham D. Horowitz and Jagdish N. Sheth.

They identify differences in attitudes between solo drivers and carpoolers, with solo drivers perceiving ride-sharing as significantly less convenient, reliable, pleasant and time-saving than carpoolers did. Interestingly, there was not a significant difference in perception regarding cost, energy use, traffic and effect on the environment. They conclude that arguments of cost saving and pollution reduction would have little influence on solo drivers.

Apparently, a significant majority of drivers perceive the convenience, independence and time savings of driving alone to outweigh cost and environmental considerations. This would explain why HOV lanes, expanded light rail, ride matching services and the numerous arguments for mass transit have not decreased single driving.

Drivers haven't been convinced by the argument that increased carpooling and mass transit usage would decrease traffic and commute time.

Some environmental advocates want to raise gasoline prices, thereby forcing people to reduce automobile usage, citing the European model. Based on the evidence above, this would require a large increase and is not likely to be politically acceptable in the U.S.

Of course, not all of the factors influencing commuting choice can be covered in this brief article. I believe that significant potential for improvement exists in carpooling, something I will address in a later post.

INTELLECTUAL PROPERTY IN THE AGE OF OPEN SOURCING: WHO OWNS IT AND HOW DO THEY GET PAID?

WENDY FOK
Assistant Professor, Gerald D. Hines College of Architecture

The Internet of Things, as you may have noticed, is changing the world. Architecture, design and construction aren't immune, as young architects no longer line up to work for the field's undisputed stars, instead launching self-directed crowd-sourced projects and using Kickstarter campaigns as a means to fund their own projects and seeking collaborators for projects big and small.

With projects like WikiHouse and the Resilient Modular Systems 2.0 digital platforms, now people can use a smartphone to connect with a manufacturer to order their house.

In some ways, that makes sense. Design no longer lives in a locked filing cabinet. The conversation I'm interested in is the virtual estate – what becomes of the ownership of digital property? (Who owns digital property). If you design a digital system, do you lose ownership if it's widely reproduced in manufacturing?

The question arose in the 1990s with Napster, the internet company that allowed people to share music, in the form of MP3 files, with their peers. The industry panicked: Would people still pay for music if it wasn't in the form of a physical compact disc?

The answer to that is still evolving, although iTunes and other music streaming services suggest a qualified "yes."

But the details of how the internet and open source software changes who performs specific tasks and, perhaps equally important, who gets paid for that work, are still unresolved. Ownership at this stage in the contemporary digital conversation, therefore, becomes a more active concern than Authorship.

How do you protect your work?

That already is disrupting traditional views of innovation, and the global movement toward building a more sustainable future – increasing use of alternative energy, designing "smart" buildings that automatically adjust lighting, heating and air conditioning to conserve power – is a key example.

Current intellectual property law favors the creator and suggests work can't be taken without payment or changed. That's outdated. (Current law favors creators with privatized venture funding, or corporate backing, with deep pockets, i.e.: Google and companies that have funds to patent and trademark their designs and ideas.)

What happens, for example, if a product is translated into code and produced on a 3D printer? Are digital footprints developable concerns for creators of the built environment? Organizations, including the U.S. Library of Congress, are dealing with the thorny issue of sharing digital properties while still protecting their value.

The implications are enormous for medical privacy, private property rights, energy efficiency and other areas.

So-called "smart" building systems are a hot topic of research, as scientists work to develop living buildings, which can learn how occupants behave and adapt to that behavior automatically, without the intervention of a building manager.

But the concept relies on data collected from sensors located throughout the building. To whom does that information belong?

Similarly, what happens when an architect designs a house, and the plans end up online? It's easy, and common, for people to download the files and buy the plans. Common, too, for a contractor to copy the design of a house built and designed by someone else.

John Locke, the 17th century English philosopher and political theorist, established common theories about ownership – back then, it was ownership of land, cattle and other physical properties – which influenced the founding fathers of the United States.

But there is no virtual line in the sand with digital property. You might own a building, but information harvested from that building detailing energy use and similar data, can be equally important. It's the same with data collected by toll road agencies about the use of your EZ Tag.

Who owns that? Maybe Elon Musk has suggested a middle ground, registering the Tesla battery as open source software, meaning anyone can access the information and work to improve or change it, while retaining the patent. Or, Alejandro Aravena's Elemental Open Sourced social housing construction plans, which open up the field of architecture for social good. Those allow for innovation without giving away the company.

"We believe that Tesla, other companies making electric cars, and the world would all benefit from a common, rapidly-evolving technology platform," Musk wrote on the Tesla website.

"Technology leadership is not defined by patents, which history has repeatedly shown to be small protection indeed against a determined competitor, but rather by the ability of a company to attract and motivate the world's most talented engineers. We believe that applying the open source philosophy to our patents will strengthen rather than diminish Tesla's position in this regard."

Today's millennials share that sense of social good as they seek to make a difference. They are interested in creating products, but they want something bigger than an app or a new sneaker. A lot of people in their 20s and 30s think of design, product development and architecture as bigger than real estate.

So the culture shift is well underway. Even architecture, long a field that values ownership, originality and being the first to do something, is getting there.

The work itself is evolving, too, from traditional "architect" to more of a creative director, such as myself, where the responsibility of the architect becomes a conductor of a plethora of issues, not only for the design of a structure but for what happens within that structure, from heating and air conditioning to coding the technologies for a building to the storage of digital data within a building.

My students know they need more business savvy than architects of a past era in order to successfully work with the community.

The role of the architect continues to become an integrated design proposition. Architects have always been salesmen. Now we need to be hustlers and entrepreneurs.

IMPENDING ELECTRIC SHOCK? CONSUMERS AND INVESTORS SHOULD BRACE THEMSELVES

ED HIRS
Lecturer, Finance and Energy Economics

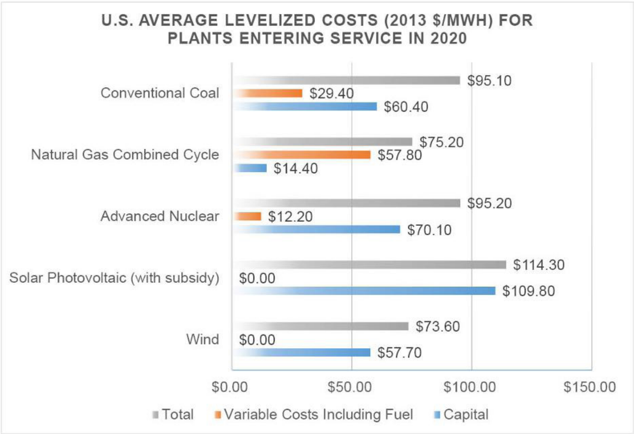
What happens when governmental regulation dictates that producers charge less for something than the cost of creating it? Shortages, of course: no sane producer is going to make something just to lose money in the process.

That is the road we appear to be headed down with electricity in the United States. Costs are increasing partly because of increased environmental regulation, but the principal factor is that the cost of building new generating plants has in many cases outstripped the price at which generators can sell their product.

The industry is in a transitional phase. Gas-fired plants can operate cheaply, but there aren't enough of them to go around. Renewable sources, such as wind and water, continue to increase, but not quickly enough to make up for the increasing closures of older coal and nuclear plants, and they still cannot come close to competing on cost with gas-fired ones.

The result is that grid managers and utility regulators are worried that capacity will diminish to the point where scarcity will result in dramatic price spikes.

In 2016, no region of the country has an average wholesale price of electricity greater than $32 per megawatt hour. (One megawatt hour is equal to the amount of electricity used in about 330 homes during one hour.) This does not compare well with the costs of new generation as compiled by the Energy Information Agency. These levelized costs then provide us a way to compare the all-in costs of producing one megawatt per hour of power as summarized in this chart.



Gas is the winner by a mile on its current low price, and gas is also attractive because generation facilities can be built in less than two years, less than half the time of a coal plant of the same size, and for less than half the capital investment to boot.

Unlike the old days, when utilities were highly regulated and regulators made sure they were profitable, in today's world utilities are subject to free market competitive forces. The Supreme Court has ruled that utilities are not guaranteed to recover their costs or investments.

How did we get here?

In the past, electric utilities were generally monopolies and limited to a regulated return on invested capital — for example, a $1 billion power plant would be limited to electricity rates no higher than those that would generate a 16 percent return on invested capital.

The incentive for utilities, then, was to build larger plants in the guise of ever increasing reliability. The overbuild included generators, transmission lines and local distribution lines. There were obviously cross-subsidies built into this system, because running one line to a rural area would not pay for itself with that one customer at the end of the line, but with every customer on the system paying to string the line to until it reached the last customer in the boondocks, utilities always had the incentive to keep stringing the line. This led to an overbuild of generation capacity, and sharp operators including Enron and other energy traders convinced governors, legislators and regulatory bodies that by unbundling the various services provided by the industry — "deregulation" — they could open up wholesale power markets and provide lower costs to consumers. That is, generators would have to offer their electricity for sale into a market under strict rules and regulations. Wholesale purchasers would then bundle purchases and resell the electricity to consumers. Generators would be separate from transmission companies and vice versa.

The transmission companies generally remain under old regulations as common carriers; think of them as toll highways for electricity supplied to the consumer. Access and exit are controlled. Payments and profits are guaranteed. Consumers collectively still pay for the last mile of transmission lines.

For the companies that generate electricity, however, it's a brave new world. Deregulation began when natural gas was scarce and therefore expensive, making it noncompetitive versus coal and nuclear. However, because natural gas plants were relatively quick and cheap to bring online, they became the go-to solution for short term power supplies necessary to balance the grid during peak periods. These peaker plants extracted monopoly prices from the grid operator simply because they could, and these high costs were spread across all consumers in the market.

Shale gas – and the resulting bonanza of cheap natural gas – upended the old order of electricity generation economics. Beginning with the shale gas revolution, utilities could consider using gas-fired plants not just to manage peak demand, but to compete directly with coal and nuclear for all levels of business. Peaker plants have now been repurposed to also provide continuous electricity supply when required.

Today, nuclear facilities Diablo Canyon (PG&E), Pilgrim (Entergy), Fitzpatrick (Entergy), Clinton (Exelon) and Quad Cities (Exelon) are slated to close. Dominion Resources has requested that the state of Connecticut consider economic incentives to keep open the Millstone nuclear power plants, which can provide more than one-half Connecticut's daily electricity requirements. Nuclear power plant operators cannot cut costs any more. They are acutely aware of Northeast Utilities' 25 felony convictions for unsafe reactor operations due to zealous cost cutting.

Continued on page 44

ENERGY ECONOMICS 88

IMPENDING ELECTRIC SHOCK? CONSUMERS AND INVESTORS SHOULD BRACE THEMSELVES

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Continued from page 44

Nuclear operators had expected salvation from the Obama administration's promises to impose a cap-and-trade scheme or carbon tax on fossil fuels. But the Great Recession interfered, and no congressman could vote to increase electricity prices and expect to be re-elected.

Coal-fired plants received a temporary reprieve when Supreme Court stayed the implementation of EPA's Clean Power Plan, but the future for coal still looks dim.

Grid operators are in the unique position of managing electricity supplies and distribution, but they cannot force utilities to continue to operate at a loss. Utilities know the history of the state of California forcing Pacific Gas & Electric to sell electricity below costs and driving the company into bankruptcy.

The challenge for grid operators in regulated and "deregulated" markets will come when their grids come up short on hot or cold days. Eventually, costs to consumers will begin to increase and be realized either at the meter or by consumers turning to their own solutions, such as rooftop solar, battery storage, backup diesel and gasoline generators. Come up one megawatt hour short at a data or medical center on a hot summer day and prices will skyrocket. One grid manager for a "deregulated" market that has experienced such shortfalls has imposed an old-fashioned regulated price cap of $9,000 per megawatt hour on generators in those circumstances, or about 300 times the average price across the grid.

Prudence dictates planning ahead, but grid operators and regulators can only encourage new generation sources. Rising prices will make new generation capacity happen.

HOW THE "LIGHT COMPANY" GOT SMART ON ENERGY AND CONSUMERS

ELIZABETH KILLINGER
President, Reliant and NRG Retail; Member, UH Energy Advisory Board

When was the last time you bought ice? Unless you're planning a party, chances are you simply push a button on your freezer door and get what you need. You even have the choice of crushed or cubed. Not bad, considering how we got ice in the past. Homes had iceboxes, ice was manufactured in a large facility and a deliveryman brought blocks of ice to your home.

But when modern refrigerators came along, suddenly you didn't need the iceman. You could make ice at home.

Home power is going through a similar transformation. Our parents were considered "rate payers" by their electricity companies, and they only needed power in their homes – for lights, air conditioning and, in some cases, heat. They didn't have connected devices, instead relying on metal wire landlines, rolodexes, paper maps and calendars. They got a bill from their "light company" for their power – and that was the only company that sold electricity in the whole town.

They didn't know how much power they used or what they owed until the bill arrived, 30 to 45 days after the fact.

Today's reality is light-years removed from that scenario. Here in Texas, my company, Reliant, is among dozens of power providers that compete for customers. As a result, these businesses focus on innovating and anticipating, understanding and responding to consumers' power needs and desires. They must provide product and service options that fit different individual routines and preferences, plus energy and related services to empower a mobile device-driven world.

To keep pace with these shifting preferences, the relationship with the power consumer has greatly evolved. That's the reality in the "Era of Personal Power," where people increasingly will relate to electricity providers as partners and allies, and count on them to energize their homes and lives.

Now in some regards, the electricity industry has been slower to innovate than other industries, but that's changing. We're starting to make a much bigger difference in people's lives, and in competitive electricity markets we're seeing more innovation and offerings from power providers. Indeed, anyone – regardless of whether they get power in regulated or deregulated markets – can begin to see how noncompetitive "one-size-fits-all" home electricity plans are truly "one-size-fits-none."

Many consumers want to be free to make energy choices, desire real-time access to insights on their energy usage and have different behaviors that influence their buying decisions. Most consumer energy considerations focus on the home, where we now have the opportunity to make the living environment "smarter" with mobile controls. And that's why mobile connectivity is, and will remain, the crucial ingredient that unites the smart home product ecosystem. We can't power a mobile, digital economy on the back of a grid built in Thomas Edison's day.

Just like the hundreds of daily actions we take on palm-sized screens, a growing number of consumers now love that their phones provide home energy management tools (a critical gateway into the smart home), receive text alerts, display real-time projections of monthly bills, have the ability to adjust thermostats remotely, pay bills, access customer service channels and more. That same online platform enables power providers to integrate other products and services that put more control in consumers' hands, such as home security.

This all adds up to an immense set of choices, more than our parents ever have had or our grandparents could even have imagined. For power providers, this means we must serve as trusted advisors to help consumers navigate the product landscape.

Smart technology will continue to grow, and our interconnected world will reach heights unimaginable today. The future is one where customers make their own choices about how they get their power – whether to buy it, make it themselves, sell extra back to their retail electricity provider, store it for later and who knows what else.

No matter what tomorrow holds, power companies must adapt and develop deeper relationships with their customers, the kind of connection "rate payers" of the past never expected from their "light company."

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