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The Rise and Fall of Oil

It was like a scene out of a science-fiction movie: a raging fire surrounded by water. But this was not on some imagined planet. It was in the Gulf of Mexico on April 20, 2010, when the Deepwater Horizon oil rig caught fire and 11 crew members lost their lives. Over the next three months, the world watched as try after try failed to staunch the flow from the blown-out well. Finally, on July 15th BP and the U.S. Coast Guard managed to cap the well sitting about one mile below the sea surface, but not before more than 4 million barrels of oil had spilled into the Gulf ecosystem, contaminating it for years to come.

The Deepwater Horizon disaster illustrates the great risks the industry is taking to feed the world's oil addiction. Tapping early oil finds was practically as easy as sticking a straw in the ground and watching black gold flow out. Now the era of easy oil is over.

Oil production is constrained by geology. Each of the major fields discovered between 1940 and 1980 held more than 10 billion barrels of oil. Saudi Arabia's mighty Ghawar contained 75 billion barrels. Those days are gone. New finds today are few and far between. Now a

discovery is considered large if it contains more than 3 billion barrels of oil.

Production is also constrained politically. About 80 percent of the remaining oil reserves are held by national oil companies, those that are partially or completely owned by state governments, such as Saudi Aramco and Russia's Rosneft. Most of those reserves are conventional oil sitting in large underground fields. That leaves 20 percent of the remaining bounty for the private companies, including the majors like BP, ExxonMobil, and Total, along with smaller independent companies.

Exploration and development costs are climbing as oil companies are forced to turn to ever less accessible locations. Future prospects for conventional oil development include oil fields beneath the ocean floor and others scattered about the Arctic Ocean, where drillers must contend with floating icebergs and some of the harshest weather on earth. Turning to unconventional resources, such as oil locked in shale rock formations or mixed with sand and clay in tar sands, is another option. But bringing hard-to-get oil to market is not cheap.

Ed Crooks of the *Financial Times* writes that "as companies pursue the ever more challenging oil reserves that they need to increase or merely sustain their production, their costs have risen to the point that the most expensive projects, such as deep water development… need an oil price of at least $100 a barrel to be commercially viable." As John Watson, Chief Executive Officer of Chevron, puts it, "One hundred dollars per barrel is becoming the new $20, in our business."

One of the richest finds in decades, the Kashagan oil field in Kazakhstan under the northern Caspian Sea, was discovered amid a lot of excitement in 2000. It is estimated to contain 35 billion barrels of oil, of which about 13 billion may be recoverable. But conditions are

difficult. Sea ice forms in the winter, when temperatures can drop to 22 degrees below zero Fahrenheit. To make matters worse, the oil is mixed with deadly and corrosive hydrogen sulfide gas.

The oil companies in the consortium developing Kashagan—including ExxonMobil, Shell, Total, and Eni—have thus far spent $50 billion attempting to bring the oil field online. In 2013 the consortium finally started pumping, but this only lasted for a couple of weeks until a gas leak was discovered. After restarting briefly, it was closed down again, this time for much more extensive repairs. Pumping is set to resume in 2016, although some analysts are skeptical that it will happen even then. The Kashagan find is now known flippantly as "Cash-all-gone."

One area where unconventional oil is now being pursued is in Canada's oil sands, mostly located in Alberta Province. Also known as tar sands because of their semi-solid state, this viscous mixture of bitumen (a thick oil-based hydrocarbon), sand, clay, and water cannot be simply drilled and pumped. The easiest way to get it is to dig pit or strip mines, destroying the landscape. But many of the remaining deposits are now too far below the surface to use this method. Oil companies are using a technique to heat the bitumen underground to make it fluid enough to be pumped to the surface. Then more processing is required to make the tar sands oil ready to flow through a pipeline. The intensive production process requires a lot of energy. In fact, each unit of energy that goes into extracting and refining the tar sands yields just 5 units of energy. This poor energy return on investment is a far cry from the 16 or more units of energy yielded from pumping oil in conventional fields. Tar sands accounted for more than half of Canada's oil production in 2013.

In the United States, horizontal drilling and hydraulic fracturing ("fracking") in shale rock to get to previously

inaccessible oil and gas have created an energy boom. Talk of "peak oil" has been replaced with talk of a shale revolution. Led mainly by smaller independent oil companies instead of the big majors, fracking has increased U.S. oil production to over 10 million barrels per day in 2013, up from less than 7 million in 2008. The deposits are so diffuse that many wells have to be drilled, yet they dry up quickly—far faster than conventional wells. Like any boom, this will one day go bust.

Because of the rising costs of access to resources, oil companies are pulling back on several fronts. Shell has cut back on shale drilling in the United States. After suffering several setbacks, Shell also temporarily suspended its Arctic drilling endeavors off the coast of Alaska, though it could resume attempts in 2015. Shell, France's Total, and Norway's Statoil have all stopped certain tar sands projects in Canada. Chevron has postponed an offshore drilling project in Indonesia. It has also lowered its overall oil production projections.

JBC Energy Markets in Vienna reports that while investment in pursuing oil and gas resources by the six largest oil companies rose 80 percent from 2007 to 2013, their oil and gas output fell 6 percent. This reversal in fortune is occurring against a backdrop of the growing use of oil. World oil consumption in 1983 totaled 58 million barrels per day. By 2013, it had climbed to 91 million barrels a day, an increase of 58 percent over 30 years. The United States, the world's leading oil consumer, uses nearly 19 million barrels of oil a day. Next come China, Japan, and India, which together consume another 19 million barrels daily. Following those countries are Russia, Saudi Arabia, Brazil, South Korea, Canada, and Germany.

In many emerging economies, including Brazil, China, India, and Indonesia, which have a combined population of 3.1 billion people, oil use is climbing steadily. In fact,

Indonesia was a member of OPEC, the Organization of Petroleum Exporting Countries, until its domestic oil use outpaced its production. Many other areas in Asia have seen tremendous growth in oil use. Hong Kong, Malaysia, Singapore, and Thailand have each almost tripled their oil use since 1990. China's oil use grew more than fourfold. Viet Nam increased its oil use more than fivefold.

But although global oil use is still climbing, in a growing number of industrial countries oil use has peaked and begun to decline. For example, Germany's oil consumption peaked in 1979 at 3.3 million barrels per day, then dropped to 2.4 million in 2013, a decline of 29 percent. In Japan, daily oil use peaked in 1996 at 5.8 million barrels. Since then, it has declined to 4.6 million barrels a day in 2013, a drop of 22 percent. And even in the United States, following decades of growth, oil use is now falling.

From 1950 to 2005, U.S. oil use rose more or less continuously, with only occasional interruptions, such as the 1970s oil price shocks. Between 1950 and 2005, daily U.S. oil consumption climbed from 6 million barrels to 21 million barrels, more than tripling. It then peaked, with consumption falling to 19 million barrels per day in 2013—a drop of 9 percent in eight years.

Several trends help explain how oil use by the world's largest consumer started to fall. With most oil used for transportation, two thirds of which goes to move passenger cars and trucks, changes in vehicle use and the way vehicles are powered translate into large changes in oil consumption.

During the twentieth century, the car played a central role in defining the American lifestyle. It became an integral part of U.S. culture. Cars not only provided unprecedented mobility, they helped define the people who owned them. Automotive historian John Wolkonowicz summed up the situation: "For people who grew up and lived in

the twentieth century, the car was freedom, it was status, it was an extension of you, a visible expression of you and your personality."

By the year 2000, the United States found itself with over 190 million licensed drivers and an even larger car fleet. It was consuming some 20 million barrels of oil per day—at that time, more than the next five countries combined. But now the United States, the country that led the world into the automobile age, is showing signs of leading it out.

The most basic ways to reduce gasoline use are by driving less and by driving more efficiently. Driving less means more people commuting by bike, on foot, or by public transportation or sometimes just working from home. That leads to people owning fewer cars. Driving more efficiently results from vehicle technology improvements, often prompted by government-mandated standards. The big efficiency jump comes from switching from the internal combustion engine to electric motors.

These shifts are starting to happen in the United States. Michael Sivak, who tracks automotive trends at the University of Michigan, points out that the annual distance traveled by solo drivers in the United States dropped 9 percent between 2004 and 2011. Some of the reasons for this were uncovered in an analysis for the U.S. PIRG Education Fund based on Census Bureau data. In 61 percent of the urban districts surveyed, the use of public transit has increased. The survey also found that a growing share of the workforce is working from home. Strikingly, in 99 percent of districts surveyed, the share of workers commuting by private vehicle declined. Indeed, the Federal Transit Administration measured a 20 percent increase in the number of people using public transportation in the United States between 2000 and 2011.

For American teenagers in rural communities a half-century ago, getting a driver's license and something to drive—a car, a pickup, even a farm truck—was a rite of passage. That's what everyone did. Today's teenagers socialize much more through smartphones and the Internet. For many of them a car is of little interest. Twenty years ago, 68 percent of American teenagers had a driver's license at the age of 18. Today 59 percent do.

Michael Sivak writes that "it is possible that the availability of virtual contact through electronic means reduces the need for actual contact among young people." Ashley Halsey III, a reporter for the *Washington Post*, makes a similar point: "American teenagers seem to get no thrill from driving in an electronic age when their friends are a finger tap away 24-hours a day, an era when Twitter, Instagram and texting have displaced the mall and the malt shop as hangouts."

It is not just teens abandoning car culture. Data from the National Household Travel Survey indicate that the entire under-35 demographic is driving less. The number of miles driven by those younger than 35 fell by an impressive 23 percent between 2001 and 2009.

Phineas Baxandall, a senior analyst at the U.S. PIRG Education Fund, notes: "Government should support transportation initiatives that support these travel trends. Instead of wasting taxpayer dollars continuing to enlarge our grandfather's Interstate Highway System, we should invest in the kinds of transportation options that the public increasingly favors." This would result, for example, in a greater focus on such things as expanding public transit and creating more bike lanes.

Some cities around the world, recognizing the extra pollution, noise, and congestion an expanding car fleet brings, have begun to restrict the use of automobiles. In certain places this is done with an entry fee charged

when cars enter the city center. Cities like Singapore, London, and Stockholm have implemented such a "congestion charge."

Chinese cities feeling the pressure from the fast-growing car fleet are also trying to limit the rise of the auto. Shanghai began auctioning license plates in 1994. There, a license plate can easily cost more than the car. Beijing, Tianjin, Guangzhou, Guiyang, and Hangzhou have also imposed limits on the number of cars sold. Other Chinese cities are likely to follow.

After a certain point, more cars in a city mean less mobility and a diminished quality of life. In earlier times, urban transport was designed around cars. Now this is changing. The last few decades have seen hopeful new signs in the design and management of cities. Forward-thinking communities are beginning to plan their transport systems so that more residents have ready access to public transport and it is easier to walk and bike.

Cities around the world are also developing more parks and trails where people can walk and enjoy the outdoor environment. The ratio of parks to parking lots in a community is one of the best indicators of its livability. Cities that have many parks are pleasant places not only to walk, jog, and bike, but also to live. Those that have mostly parking lots designed to facilitate the use of cars are not nearly as attractive.

Recent years have also witnessed a surge of interest in bicycles and in their place in the transport system. Bicycles are competing with cars for short-distance travel. In the United States, bike commuting expanded 38 percent nationwide over the last decade. Cycling is growing fast in large cities like Baltimore, Chicago, Minneapolis, Philadelphia, and Portland, Oregon—all places where it has at least doubled since 2000. These cities have worked to encourage bicycling.

Portland, one of the most bike-friendly cities in the United States, has installed over 400 miles of bikeways and now has racks for more than 5,500 bikes. Cycling rates have grown threefold since 2000. But even here, only 6 percent of the workforce commutes to work by bike. Compare this with Copenhagen, Denmark's capital, where 36 percent of the workforce commutes by bike—a share that is still growing.

U.S. sales of bikes and cars are nip and tuck. Over the last decade, the sale of new bikes, excluding those for children, has been remarkably stable, hovering around 13 million a year. In 2012, this put them close on the heels of new-car sales of 15 million. Whenever a bike trip replaces one by car, it reduces air pollution, carbon emissions, and traffic congestion.

In Europe, where annual bicycle sales have hovered around 20–21 million, bike sales exceed car sales in virtually every country. Italy sold more bikes than cars in 2011, marking the first year this had happened since World War II. Climbing bicycle sales in Spain reached 780,000 in 2012—eclipsing car sales of 700,000.

Owning a bike is no longer a requirement for riding in many cities thanks to bike-share programs. In the United States, by the end of 2012 some 21 cities had 8,500 bikes in bike-share racks. By the end of 2015, this is expected to climb to over 70 cities with close to 40,000 bikes. The Washington, D.C., metro area, an early American leader, has more than 300 bike-share stations with close to 3,000 bicycles at the disposal of 18 million annual visitors and the residents of the District of Columbia and its neighboring suburbs.

Bike-sharing programs have sprung up worldwide in recent years. More than 700 cities in 57 countries now have fully operational bike-share programs. Europe has the most programs, but Asia has more bikes to share.

Perhaps not surprisingly, the leader in fleet size is China, which now has over half a million shared bikes.

The reasons for adopting bike-sharing programs vary from city to city. Consider New York's Citi Bike program that launched with 6,000 bikes in May 2013. It greatly increases mobility but costs very little. Janette Sadik-Khan, New York's Commissioner of Transportation, said, "Citi Bike isn't just a bike network; it's New York City's first new public transit system in more than 75 years." Bike-sharing programs are often designed to complement bus and rail systems, dealing with what planning officials call the "first mile/last mile" problem. In Hangzhou, China, where bicycles are highly popular, the city launched the bike-sharing program to facilitate connections by public transit riders on both ends of their trips.

Bike-sharing is even being put to use by General Motors (GM), one of the world's leading automobile manufacturers. GM has an agreement with a bike-share start-up company called Zagster to provide bikes to GM's 19,000 employees on its 300-acre GM Tech Center in Warren, Michigan. What's more, Bill Ford, the head of Ford Motor Company, is investing in Zagster through a venture capital firm. Tim Ericson, the 28-year-old CEO of Zagster says, "We're creating what is almost becoming a citywide bike sharing program, with no public funds and no use of public space."

Corporations, universities, and local governments are all participating in the bicycle renaissance. The World Bank, at its headquarters in Washington, D.C., fosters biking by providing changing rooms, showers, hair dryers, and a secure bike parking area.

The economic attractions of cycling are compelling. Bicycles not only save fuel, they also save land because 20 bikes can fit in the parking spot for one car. The 250 million cars in the United States require some 800 mil-

lion parking spaces. Adding parking together with road infrastructure, Americans' auto addiction has led to the paving of at least 61,000 square miles, an area larger than the state of Illinois.

Substituting a bike for a car reduces materials use—steel, aluminum, plastic, and rubber—from 4,000 pounds to 30 pounds. And of course there is the accompanying reduction in energy use in the manufacturing of these materials. It also benefits taxpayers simply because the road maintenance required for a bicycle is minuscule compared with that for a car.

The combination of biking, walking, and public transit options found in well-designed cities can give urban residents a great advantage: car-free living. The share of carless households increased in 84 out of 100 U.S. urban areas surveyed between 2006 and 2011. And as urbanization increases, this share will only rise.

After growing rapidly throughout the twentieth century and into the early years of this century, car numbers in some countries have plateaued over the last several years. For example, between 2001 and 2007 the number of licensed vehicles in the United States climbed from 217 million to close to 250 million. During the next seven years, this number has fluctuated narrowly around the 250 million mark. It is only a matter of time until the fleet slowly begins to shrink as the younger, less car-oriented generation gets older.

Europe's automobile fleet is not growing either. Indeed, new-car registrations are near a 20-year low. Several reasons for this include high fuel prices, longer-lived vehicles, slippage in the car as a status symbol, and the fact that fewer young people are getting a driver's license.

In Japan, car sales have shrunk in recent years. This is partly because of the high cost of operating and parking vehicles and partly because the population is aging. These

factors make it likely that the automobile fleet will begin to decline there.

With their high car ownership rates, industrial countries have a large potential for shrinking their car fleets. In the United States, there are 786 cars for every 1,000 people, including children too young to drive and adults who no longer do so. Italy, with 682 cars per 1,000 people, is not far behind. For both Germany and Japan, the number is 588. France follows closely with 582. Other countries with at least one car for every two people include Poland, Spain, and the United Kingdom.

Far on the other end of the car ownership scale are places where fleets are expanding. Ethiopia has just 3 cars for every 1,000 people. In Brazil, with 210 cars per 1,000 people, the car fleet doubled since 2003 to reach over 80 million cars as the middle class expanded and the government supported car buying. India had car sales of 2.5 million in 2013. It is projected to become the third largest car market in the coming years, dramatically boosting its car ownership rate of 18 per 1,000 people.

China, with 69 cars per 1,000 people, overtook the United States as the world's largest market for new cars in 2009. New-car sales in China reached 18 million in 2013, slightly higher than America's top sales year of 17.8 million in 2000. It is clear that if China were to have three cars for every four people, as the United States does, they would have roughly a billion cars—as many as there are in the whole world today. Long before this level of automobile ownership is reached in China, rising pollution and congestion will make it obvious that having a "car in every garage" is not a dream but a nightmare.

Worldwide, in 1980 there were 320 million licensed cars on the road. By 2012, this number had more than doubled to 770 million. But even with car sales climbing in emerging markets, growth at the global level is slow-

ing. Some analysts expect the world fleet to peak within the next few years.

Helping to hasten that peak is the rise of car-sharing. Car-sharing programs are expanding rapidly in many parts of the world. They reduce the need for automobile ownership by allowing members short-term use of a car, sometimes for trips measured in minutes. Many of today's drivers simply want access to a car when they need it. Unwilling to be burdened with the responsibilities of vehicle registration, insurance, fueling, parking, and maintenance, not to mention the cost of buying a car, they are turning to car-sharing operations such as Zipcar, Car2Go, Enterprise CarShare, and others. Zipcar, in addition to being found in large U.S. cities, is available on over 250 college and university campuses.

The Frost and Sullivan research group projects that the 3.5 million drivers enrolled in car-share programs worldwide in 2013 will soar to 26 million by 2020. As of 2013, some 39 percent of car sharers were in Europe and 10 percent were scattered across Asia. An analysis in North America, home to just over half of the world's car-share members, concluded that each car-sharing vehicle removed at least nine privately owned vehicles from the street. Other estimates go as high as each shared car replacing 32 private vehicles. In the United States, 1.2 million car-share members participated in 24 programs in 2013, with a total of 17,000 vehicles. One bonus of car sharing is that as people get used to doing without their own car, they tend to drive less overall.

Another development that will reduce oil use is that new cars hitting the road have the potential to be far more efficient than the ones headed for the scrapyard. In the United States, for instance, this will be accelerated because the federal government set ambitious fuel efficiency standards for new cars. In 2013, the average new

car sold was getting roughly 24 miles per gallon (mpg). By 2025, this will rise by mandate to 54 mpg. During a 12-year span, the distance a new car can travel on a gallon of gasoline will more than double.

The big jump in efficiency will come from the growing prevalence of electric cars. It is beginning with plug-in hybrids that can run on both gasoline and electricity, such as the Toyota Prius Plug-in Hybrid now on the market. Still in the early stages, hybrid-electric and fully electric cars now cost more than those burning gasoline, but over time their cost will decline. Analysts at the global financial services firm UBS expect battery costs, a major portion of an electric vehicle's price tag, to be cut in half by 2020. This will make it feasible to substitute the highly efficient electric motor for the wasteful internal combustion engine, which produces more heat than traction. The rule of thumb is that an electric motor is three times more efficient than an internal combustion engine.

Norway is the unquestioned national leader in the transition to an electrically powered vehicle fleet, with a goal of 50,000 zero emissions vehicles on its roads in a matter of years. At the start of 2014, the best-selling vehicle in Norway was the Tesla Model S, an all-electric car. The government is providing strong incentives for electric car owners, including free road tolls, free parking, and free charging stations. Electric vehicles are also exempt from the high tax levied on conventional vehicle purchases. This strong, broad-based package that is simultaneously encouraging the use of electric cars while discouraging the use of gasoline or diesel is making for a fast transition.

Some automotive market analysts are beginning to think that the transition to an electrically powered transport system will come much faster than widely expected. As this shift proceeds, the source of the electricity to

power the cars becomes increasingly important. If the vehicle gets its electricity from a rooftop solar installation or a wind farm, this would make it carbon-free. Running a car on electricity costs roughly the equivalent of $1 per gallon. For most Americans, plugging their car into the existing grid will already produce fewer greenhouse gas emissions than filling it up with gasoline would. A transportation sector powered largely with solar- and wind-generated electricity is not yet in full view, but it is taking shape. We can see it coming.

For developing countries still in the early stages of building their transport systems, the smart path—for public health, for urban livability, and for the climate—is not to maximize the number of cars on the road but rather to maximize mobility. At some point the current oil-based transport system will prove untenable, either because of increasing traffic congestion and urban air pollution or because the geological and political constraints surrounding oil production will come to a head. The new goal is to jump quickly to a diversified and electrified transport system that is powered by locally available solar and wind energy.

Data, endnotes, and additional resources can be found at Earth Policy Institute, www.earth-policy.org.