One hundred and fifty years ago, on August 27, 1859 Colonel Edwin Drake struck oil in Titusville, Pennsylvania, giving rise to the modern oil industry. What was sought as a replacement for depleting stocks of whale oil used as a fuel for lamps, gradually turned into the world's most strategic commodity. Today oil supplies 40% of global energy.

During its century-and-a-half long history, oil has been a source of both prosperity and global volatility. Petroleum has enabled the production of industrial chemicals, heating oil, medicines, plastics, asphalt and lubricants, all of them critical to our modern society (contrary to popular belief, the US uses very little oil today to make electricity. At present, only 2% of US electricity is generated from oil.) Most importantly, oil has enabled mobility, and hence a rapid flow of goods and services, perhaps the key contributing factor to the impressive global economic growth of the 20th century. Today, roughly two-thirds of the world's oil is used for transportation. Petroleum enjoys a near monopoly in this sector - most of the world's cars, trucks, planes, ships and trains are able to run on nothing but it.

On the other side of the balance sheet, global economic dependence on oil and its products has bred considerable trouble. Oil become a backdrop behind great powers' foreign policies and has been a driver of some of the past century's most seminal events. Imperial Japan's insatiable need for oil led it to adopt in the 1930s an expansionist policy that triggered an oil embargo by the US, then supplier of 80% of the island's oil imports. Tokyo's response, sending its navy to attack Pearl Harbor, provoked a four-year war in the Pacific which took two mushroom clouds to end. In Europe, Nazi Germany's need for oil compelled Adolf Hitler to invade Russia and later to divert his panzers from Moscow to the Soviet oil center in Baku, a decision that sealed the fate of the Third Reich.

With the war's end, attention shifted to the Middle East as the world's most important source of oil and the key to the stability of the global economy. Today, this tumultuous region produces nearly 40% of the world's oil and is home to two-thirds of proven global conventional oil reserves and to over half of undiscovered reserves. Since the historic February 1945 meeting aboard the USS Quincy between the ailing US President Franklin D. Roosevelt and King Abdul Aziz ibn Saud of Saudi Arabia, oil considerations have governed US Middle East policy, and the US has considered it essential to engage in military activity in order to ensure continued access to the Persian Gulf. The Carter Doctrine, the "reflagging" of Kuwaiti tankers during the Iran-Iraq War, the 1991 Gulf War and US military presence in Saudi Arabia, Qatar, Bahrain, Kuwait and, most recently, Iraq, have all been tied to America's energy security needs.

For the US, the dependence on oil comes at a cost. It has forced Washington to establish "special relations" with non-democratic and unpopular regimes, such as those of the Shah of Iran and the House of Saud, while US military presence in the region has been a lightning rod for the region's radicals. In February 2005, President George W. Bush conceded that "The policy in the past used to be, let's just accept tyranny, for the sake of […] cheap oil […] and just hope everything would be okay. Well, that changed on September the 11th. Everything wasn't okay. Beneath what appeared to be a placid surface lurked an ideology based upon hatred." Also on the negative side: the global oil industry is more than ever a government-dominated business. More than 80% of the world's reserves are controlled by governments and their proxies, and what was once the privately-owned Seven Sisters are now seven midgets in comparison to the 'new Seven Sisters,' all government run: Saudi Aramco, Russia's Gazprom, China's CNPC, Iran's NIOC, Venezuela's PDVSA, Brazil's Petrobras and Malaysia's Petronas. Such government control over the world's fuel supply makes oil a tool of foreign policy which was clearly demonstrated during the 1973 Arab oil embargo.

A world of high oil prices is a poison pill for everything the US and its allies are trying to accomplish abroad from democracy promotion and human rights protection to counter-proliferation of terrorism and nuclear weapons. With few exceptions, oil exporting countries' human rights records leave much to be desired. Only 10% of the world's proven reserves are concentrated in countries ranked "free" by Freedom House. In many countries highly dependent on oil revenues for their income, such as Sudan, Azerbaijan, Kazakhstan, Saudi Arabia, Iran, Angola, Nigeria, Chad, Venezuela and Russia, high oil prices enable authoritarian regimes to consolidate their power and erode progress toward freedom and democracy. As a result, in many parts of the world, millions of people have been enslaved, oppressed and denied basic freedoms by non-democratic oil regimes aided by the silence of the importers who depend upon them. Then Secretary of State Condoleezza Rice in 2006 offered Senators telling testimony revealing the depth of frustration with the toxic influence oil dependence has on America's foreign policy: "nothing has really taken me aback more, as Secretary of State, than the way that the politics of energy is […] 'warping' diplomacy around the world."

Redefining energy independence

The array of security, economic and environmental challenges associated with US oil dependence have popularized the call for "energy independence" beyond any other issue in America's political discourse. Public opinion polls show that Americans, regardless of their political affiliation, see energy independence as an urgent imperative. President Barack Obama's first budget proposal was tied to a renewable energy program "to help the US move toward energy independence." Yet, despite its popular appeal, in many circles the concept is met with skepticism-in some cases outright contempt. Energy independence has been referred to as a "pipe dream," a "misguided quest" and a "dangerous illusion." A Council on Foreign Relations task force went so far as to accuse those promoting energy independence of "doing the nation a disservice." The critics' skepticism stems from their literal interpretation of the

concept: they view "independence" as self-sufficiency, or not importing oil even though the US remains dependent on it. Under this interpretation, energy independence is indeed unattainable. The US consumes about 21 million barrels per day, 60% of which are imported. If these barrels were attached to each other they would make a pipe long enough to connect New York and Beijing. For a country that owns barely 3% of the world's conventional oil reserves replacing such a vast amount of oil with domestic resources is mission impossible.

But self-sufficiency is not what independence means. The problem of oil dependence is not about the amount of oil consumed or imported. The problem is that oil is a strategic commodity by virtue of its virtual monopoly over transportation fuel. This monopoly gives a small group of nations inordinate power on the world's stage. "Independence" as Webster Dictionary says, is "not being subject to control by others," or in our case, being a free actor by reducing the role of oil in world politics - turning it from a strategic commodity into one interchangeable with others.

This is exactly what happened to another commodity which was once monopolized, and considered critical to humanity's functioning: salt. Odd as it seems, for centuries salt mines conferred national power. Wars were fought over salt. Colonies were formed in remote places where it happened to be found. That was because salt had a virtual monopoly over food preservation. With the advent of canning, electricity, and refrigeration, salt lost its strategic status, and salt rich domains like Orissa, Tortuga and Boa Vista that once held as much sway as today's Gulf Emirates are no longer places of strategic importance. Countries still use, import, and trade salt, but salt is no longer a commodity that dictates world affairs. Turning oil into salt is what energy independence is all about.

When in a hole, stop digging

Oil's monopoly over transportation fuel is complicated by the fact that this monopoly is also married to a cartel. During the past four decades, members of the Organization of Petroleum Exporting Countries (OPEC), which collectively sit atop 78% of world oil reserves, have been producing far less than their geological endowment permits. In 1973, just before the Arab Oil Embargo, OPEC produced 30 million barrels per day. Thirty-six years later, with global demand and non-OPEC production having nearly doubled, and despite the fact that in 2007 the cartel swallowed two new members- Angola and Ecuador-with combined daily production capacity equivalent to that of Norway, OPEC's crude production has not increased. In fact, in 2009 it is expected to average 29 million barrels a day – less than in 1973.

For OPEC, oil's 150th anniversary is a somber one. It comes at a time of deep global recession which has shaved $100 per barrel off the historically high price oil hit last summer. Persian Gulf economies have been dealt painful blows by oil output cuts, heavy losses in their sovereign

wealth funds and weak consumer demand. The cartel's revenues in 2009 are projected to fall by more than 60% from last year's one trillion dollar income. If the recession is prolonged, we could see the first signs of social discontent leading to political reverberations in petrodollar dependent economies. Adding to the producers' angst are the repeated calls for energy independence coming from Washington's political class and the Obama Administration's signals that the US would be part of a post-Kyoto climate agreement which would impose an additional cost on use of hydrocarbons. This leaves little appetite among producers to invest the billions of dollars necessary to prepare the oil industry for the post-recession era. The International Energy Agency (IEA) recently concluded that even with the current recession, by 2030 global demand for oil could increase by 25%. At the same time, the agency examined the status of the world's 800 top oilfields and reported an average annual depletion rate of 5.5% increasing to 8.6% in 2030. In order to meet future projected demand for oil four new Saudi Arabias will have to be added to the global oil market between now and 2030. But the current economic conditions have thwarted the much needed investment in new production. According to OPEC, since last year, 35 major exploration projects have been shelved. Ali al Naimi, the Saudi oil minister, during the March OPEC meeting warned of a coming "catastrophic" shortfall in petroleum production, raising doubts the world can count on the one Saudi Arabia that exists, not the least on the four that don't. Failure by producers to prepare the ground for the post-recession era could cause a severe oil-price shock reminiscent of that in 2008 once the economy recovers and demand for liquid fuels surges. This could, in turn, send the world into a new round of economic turmoil, leading to a W-shaped, double dipped, recovery instead of a traditional V-shaped recovery in which economic growth bounces back quickly from a slump. And yet, despite the geological, strategic, economic, and environmental indicators showing that in the coming decades the cost of maintaining the oil economy will grow exponentially, we ignore the dictum "when in a hole, stop digging": every year more than 50 million new petroleum-only cars roll onto the planet's roads, each with an average street life of 15 years, hence locking humanity's future to petroleum exporting nations and their whims for many years to come. The recent introduction of the $2,000 Tata Nano, the world's cheapest car, which aims to fulfill the aspirations for fast mobility of hundreds of millions of potential motorists in the developing world, is the latest manifestation of the mismatch between the growing number of gasoline-only vehicle platforms produced worldwide and the ability of the oil industry to power them.

From monopoly to fuel choice

Addressing the energy security challenge requires an understanding that much touted policies that aim to either increase oil supply through domestic drilling or the ones that decrease its use by boosting fuel efficiency, while helpful, are insufficient as they ignore the main enabler of the oil monopoly: the petroleum-only vehicle. In fact, experience of the past three decades shows that whenever non-OPEC producers increase their production, OPEC decreases supply accordingly. Similarly, when demand for oil drops OPEC quickly responds with production cuts. In other words, when we drill more, OPEC drills less; when we use less, OPEC drills less. Changing this vexing dynamic requires competition and fuel choice in the transportation sector which can only be achieved if new vehicles are built as platforms on which fuels can compete.

A few types of vehicle technologies already offer such a possibility. The first, and most affordable, is the flex-fuel vehicle that can run on any combination of gasoline and alcohol (alcohol does not mean just ethanol, and ethanol does not mean just corn.) The technology is a century old. Henry Ford's Model T was a flex-fuel vehicle. It costs an extra $100 per new car to make a regular car flex-fuel. All it takes is a fuel sensor and a corrosion-resistant fuel line, since alcohol is more corrosive than gasoline. In 2008, 80% of the new cars sold in Brazil were flexible-fuel vehicles. This opened the once petroleum dominated transportation fuel market to competition. Between 2005 and 2008 while fuel prices nearly doubled everywhere, in Brazil-where ethanol is cheaply made from sugarcane-they were almost frozen. When oil prices soared in 2008, ethanol became so popular in Brazil that gasoline became an alternative fuel.

Another big country that seems to be on its way to adopt the Brazilian model of fuel flexibility is China. Since 1993, the year it became a net oil importer, China's oil imports have grown by leaps and bounds. China imports nearly half of its oil, and it recently passed Japan to become the world's second largest oil importing nation after the US Until 2006, China invested in expanding its ethanol industry to become the world's third-largest ethanol producer, behind Brazil and the US But with soaring food prices in 2008, the Chinese government hit the brakes and banned the use of grain for alcohol production. With no hyperactive farm lobby and Iowa caucuses, China decided to veer toward another alcohol - methanol.

The distinction between methanol (wood alcohol) and ethanol (grain alcohol) is for many akin to the difference between Iran and Iraq - but one letter makes all the difference. Ethanol can be made from agricultural products like corn, sugar cane, sugar beet and cellulosic material like switch grass, wood chips and other agricultural and forest residue. Methanol can be made from all of the above plus an array of other energy sources including natural gas, coal, garbage and even carbon dioxide — one elegant way to address greenhouse gas emissions. Because of methanol's scalability, China's leading automakers are gearing up to produce methanol-enabled flex-fuel cars which can run on gasoline, ethanol and methanol in any combination. For the ailing US auto industry, making fuel flexibility a standard feature in every new vehicle would be as technologically and financially manageable as were the introductions of similar features like seatbelts, airbags or rear view mirrors. (Many of the flex-fuel cars sold in Brazil are made by General Motors and Ford). An Open Fuel Standard requiring that every new car sold in the US be flex-fuel would not only give rise to an industry of alternative fuels and the associated refueling infrastructure, but it would also compel foreign automobile makers to add fuel flexibility to all of their models, effectively making it an international standard.

Shifting to alcohol production from non-food biomass material like dedicated grasses, algae and forestry waste could enable scaled production to the tune of tens of billions of gallons in the US alone. According to a 2009 study by Sandia National Laboratories, greater productivity of

cellulosic feedstock should eventually allow biomass-based alcohol to displace nearly a third of all gasoline use by 2030. An even bigger potential for biomass production exists in the poor countries of Africa, Latin America and South Asia with their strong agricultural base and massive endowment of arable land. By cultivating their agricultural base to grow energy crops, provided that such an expansion is done in a sustainable manner, such countries – many of them on the receiving end of US development aid - would be empowered economically as they become net fuel exporters. This would improve their trade balance, create jobs and spare them the need to import expensive oil for their own economies.

Natural gas converted into methanol can also be used to power flexible-fuel cars. About a third of the world's emissions of methane, a greenhouse gas 23 times more potent than CO2, occur in coal mines and natural gas wells. According to the World Bank sponsored Global Gas Flaring Reduction Partnership, five trillion cubic feet of natural gas are being flared annually by oil companies, equivalent to 27% of total US natural gas consumption. Using as little as 10% of this gas would produce enough methanol to fuel five million cars.

For some countries compressed natural gas is already being used as a gasoline alternative on board bi-fuel vehicles. These cars have two fuels – liquids and gas – stored in separate tanks, and the engine runs on one fuel at a time. India, the fifth largest fleet of natural gas vehicles in the world, probably holds the highest potential for growth. Two thousand refueling stations are now being planned for construction and more than 220 cities projected to be connected to a nationwide distribution pipeline system. Interestingly, two of the leading countries in natural gas vehicle deployment are Venezuela and Iran. In both, significant parts of the domestic auto sales are mandated to be natural gas enabled; hundreds of natural gas fueling stations are been built as well as conversion centers which allow drivers to retrofit their gasoline-only cars to also run on natural gas. For countries like Iran and Venezuela that keep fuel costs artificially low even when prices rise, the shift to natural gas is a way to avoid the socially destabilizing removal of fuel subsidies. For Iran, there is also a strategic imperative. Due to lack of refining capacity, forty percent of Iran's gasoline is imported. As the world's second largest reserve of natural gas, Iran could become independent of imported gas and hence immune to sanctions.

Whether or not the US should emulate Iran, Venezuela, India and a handful of other countries which have decided to pit natural gas against oil at the pump is a matter of debate. American oilman T. Boone Pickens thinks this is a good idea, claiming that natural gas can displace thirty percent of US oil imports. Others doubt the wisdom of jumping from the frying pan into the fire by trading dependence on one commodity, the bulk of which is controlled by problematic regimes united in a cartel, with another that exhibits the exact same challenges and whose top exporters – Russia, Iran, Algeria and Qatar -- are already in discussions about the formation of an OPEC-like natural gas cartel. But whether or not the US is to adopt this option, worldwide, this source of energy is already displacing an ever increasing amount of petroleum.

Electricity used as a transportation fuel could displace a large amount of oil. It is cheap, domestically produced and can be made from multiple sources. Its refueling infrastructure is widely available. All that is needed for an electric car to connect to the grid is an extension cord. Most automakers have already committed to produce models of pure electric vehicles (EV) or plug-in hybrid electric vehicles (PHEV), essentially hybrid cars with a larger battery and a plug, a system that allows the driver to drive on stored electric power for the first 20-40 miles, depending on the battery size, after which the car keeps running on the liquid fuel in the tank, providing the standard three or four hundred mile range drivers are accustomed to. For the 50% of Americans who drive 25 miles per day or less, shifting from barrels to electrons would make the visit to the local gas station a rarity, assuming they plugged in their car the night before. If all of those Americans owned PHEVs, a population the size of New York, Florida and Pennsylvania combined would be off oil most days of the year. A PHEV would normally drive 100-150 miles per gallon. If it is also made as flex-fuel and is powered by 85% alcohol and 15% gasoline, each gallon of petroleum is stretched with alcohol fuel by a factor of five, and oil economy could reach over 500 miles per gallon of gasoline. As former Saudi oil minister Sheikh Ahmed Zaki Yamani observed nine years ago, "technology is a real enemy for OPEC."

A looming face-off

The pace of market diffusion of new transportation technologies leaves no doubt that in the coming years the transportation sector will become decreasingly captive to oil. Petroleum exporting countries wishing to prolong the economic system on which they thrive will be forced to fight for their market share in the face of deepening cracks in their strategic dominance. But for all its challenges, oil is not likely to easily vacate its pedestal, and the arrows in the quiver of its producers are still many.

The world may no longer be awash with conventional oil, but the amount of reserves off-shore and in the universe of non-conventional sources like oil shale and tar sands, can extend oil's play for many years to come, albeit at potentially high environmental cost. Producers will have to do more to flatten the roller coaster of oil prices seen in recent months mainly through closer coordination between OPEC and Russia, mothballing (preparing oilfields for recovery but not touching them unless there is clear demand) and by increasing spare production capacity. Their fortunes will be bolstered by non-trivial and often unexpected challenges alternative fuels and advanced automotive technologies will face on their way to mass market penetration. For automakers, flex-fuel capability may be no more than a low cost adjustment in the assembly line. But while the cars are easily deployable, supplying them with fuel in sufficient quantities to make a dent in the oil economy will be a monumental challenge. Refueling stations would have to retrofit their pumps – today only 2,750 of 170,000 refueling stations in the US offer alternative fuels – a network of pipelines would have to be built to move the fuel from production facilities to the distribution centers and, most importantly, fuel supply would have to increase in spades. Hundreds of new alternative fuel plants will have to be sited, engineered and built, and a gigantic amount of feedstocks of various sorts will have to be grown, collected and mined. This massive undertaking will take a long time to mount.

Electric transportation poses challenges of its own. It is the fuel and the refueling infrastructure that are relatively easy to obtain but the vehicle ramp up is costly and slow. Consider this: even if industry succeeded in meeting President Obama's goal and deploy one million PHEVs by 2015, this would barely constitute one half of one percent of the US auto fleet. Electric motors may be cheap, reliable and easy to manufacture but the rechargeable batteries needed to power them still face hurdles on the road to mass production related to their capacity, safety, reliability, longevity and, perhaps most challenging, cost. Depending on the size, a Lithium Ion battery, the leading battery chemistry to power PHEVs, costs $8,000-$15,000 (roughly $1,000/kWh) while a 30kWh battery needed to power an EV costs about $18,000 ($600kWh). To prevent such cars from becoming money losers, their battery cost should come down to under $300/kWh. Notwithstanding the impressive progress that has been made in recent years in rechargeable battery manufacturing and the US Congress' recent allocation of $2.4 billion in taxpayers' funds to produce PHEVs and advanced battery components, the US is nowhere near being a global leader in battery manufacturing. Last year Japan produced 39% of the world's supply of advanced lithium-ion batteries, China 36%, South Korea 20% and 5% was shared by the rest of the world including the US.

As importers chart their way away from oil, they will likely discover that along with the geopolitical benefits associated with such a shift come new challenges of growing dependence on alternative commodities. While Asia controls the market for advanced batteries, South America is the source of the materials from which batteries are made. More than 80% of the world's reserve base of lithium is concentrated in South America. Bolivia, a drug producing country that last year expelled the US ambassador, owns nearly half of the world's economically recoverable lithium. Shifting the epicenter of the world's energy system from the Persian Gulf to East Asia and South America will over time recalibrate nations' foreign policies, reshuffle political alliances and create new strategic interests as was the case in previous centuries when humanity traded one dependence with another. Whether or not this new energy landscape will improve America's posture abroad is premature to determine. But from today's vantage point -- heading toward a situation in which, in the words of the chief economist of the IEA "95% of the world relying for its economic well-being on decisions made by five or six countries in the Middle East" -- such over-the-horizon risk seems worth taking. The prospects of a nuclear Middle East, with massive youth bulges, lurking social discontent and persistent oppression, holding the key to global mobility should be enough of an impetus to ensure that on its 200th anniversary oil be no more central to the world economy than salt is today.

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