

Uniting Africa for power



African countries are increasingly coming together. A landmark free-trade agreement was concluded earlier this year. East Africa has made great progress on free movement of people. And a commitment to a single market for air travel has been revived, potentially connecting countries better than ever before.

Each step toward greater co-operation and unity on the continent is, on its own, an important one. Together they show how a new generation of African leaders understand that power in the 21st century reflects strength in numbers.

But, for Africa, power requires power in another sense: a lack of electricity continues to hold back the continent's progress. And here, too, integration is essential to scale and connect markets, reduce consumer costs, and drive growth.

Despite advances in recent years, more than 600mn Africans still lack access to electricity. Solar technology has improved, and its declining cost has made it a viable option. Rising inflows of private capital have been accompanied by large-scale national energy-sector reforms, which should help increase the availability of electricity. But pushing down the

price of power and making it available across growing cities and vast territories remains a daunting, and yet central, task.

All of the African leaders with whom I speak tell me that making electricity affordable is a top-priority issue, and most have set ambitious targets for power generation and transmission. But achieving these targets requires adopting a mix of technologies, which is hard enough in the best circumstances, but even more so when countries try to go it alone.

The fact is that resources are not evenly distributed among countries. Some have gas, others hydrological resources. Some have no particular resources and build thermal power plants or import expensive liquid fuels to meet their needs. Added to this are planning issues, which usually go one of two ways: either too much or too little supply.

The most efficient way to overcome these costly electricity imbalances would be through a common energy market. Much like the European Union's internal market for electricity, power trading would ideally extend across Africa and form part of the continued evolution of the African Union, which Rwandan President Paul Kagame is so admirably pushing forward. But high-volume power trading from Ethiopia to Lesotho is unlikely in the foreseeable future, and a more realistic path forward would be at the sub-regional level.

One such opportunity is through the West Africa Power Pool. Little more than half of the region's population has access to electricity, and only around 3% of power generation currently crosses borders (based on current capacity levels). With an integrated market, however, power demand could be met as countries such as Ghana, Côte d'Ivoire, and Guinea produce surpluses, while others such as Burkina Faso and Mali are in deficit and reliant on costly liquid fuels.

Such a sub-regional market would yield significant benefits not only for families, but also for governments and investors. More people would be connected, exporting countries could generate more revenue, and imports would become less

expensive, more reliable, and cleaner. According to modelling by the Africa Governance Initiative (part of the Tony Blair Institute for Global Change) and the US government's Power Africa, an integrated energy market would save the region \$32bn in energy costs in the next decade. With better infrastructure and increased supply, this figure could be many times more.

Developing a sub-regional market would also spur economic growth, create jobs, and boost income for millions of people. Private capital would be attracted to new opportunities as national markets open up for economies of scale in the production and transmission of electricity. From an environmental perspective, an integrated market would save around 23mn tonnes of fuel oil – roughly the equivalent of the United Kingdom's annual fuel consumption by diesel vehicles.

But to realise the potential of power trading, four conditions must be met. For starters, the politics of trying to align national policies with a regional vision must change. Those of us with a long history in the EU will understand the difficulties of this better than most, and for some West African countries, rolling back costly and inefficient but politically popular subsidies will be difficult. The gains from trade would offset the effects, but this is likely to be a hard sell for politicians to make to their publics.

Second, infrastructure needs to be developed to connect national markets. International donors already are supporting much of this work. It is crucial to complete it, so that isolated grids are integrated into a unique regional market.

Third, gas must become increasingly available. Nigeria is the most likely source; another is imports of inexpensive Liquefied Natural Gas. Without the development of reserves, countries will need to revert to liquid fuels, at higher cost and larger carbon dioxide emissions.

Lastly, regulatory harmonisation is essential to ensure the right enabling environment. But so, too, is support for first-time, specific transactions – such as that along Africa's west coast all the way from Côte d'Ivoire to Mauritania – which can

help countries to overcome obstacles and open the door to future, more expansive power trading.

Developing this internal market is key to West Africa's energy future. Over the next decade, it could have a major impact on the lives of more than 300mn people. It would also be a significant step in Africa's push for greater unity, more self-reliance, and an economy driven more by trade and less by aid. And it would reinforce the progress African leaders are making toward projecting strategic power in the world today. – Project Syndicate

* Tony Blair, prime minister of the United Kingdom from 1997 to 2007, is Chairman of the Africa Governance Initiative.

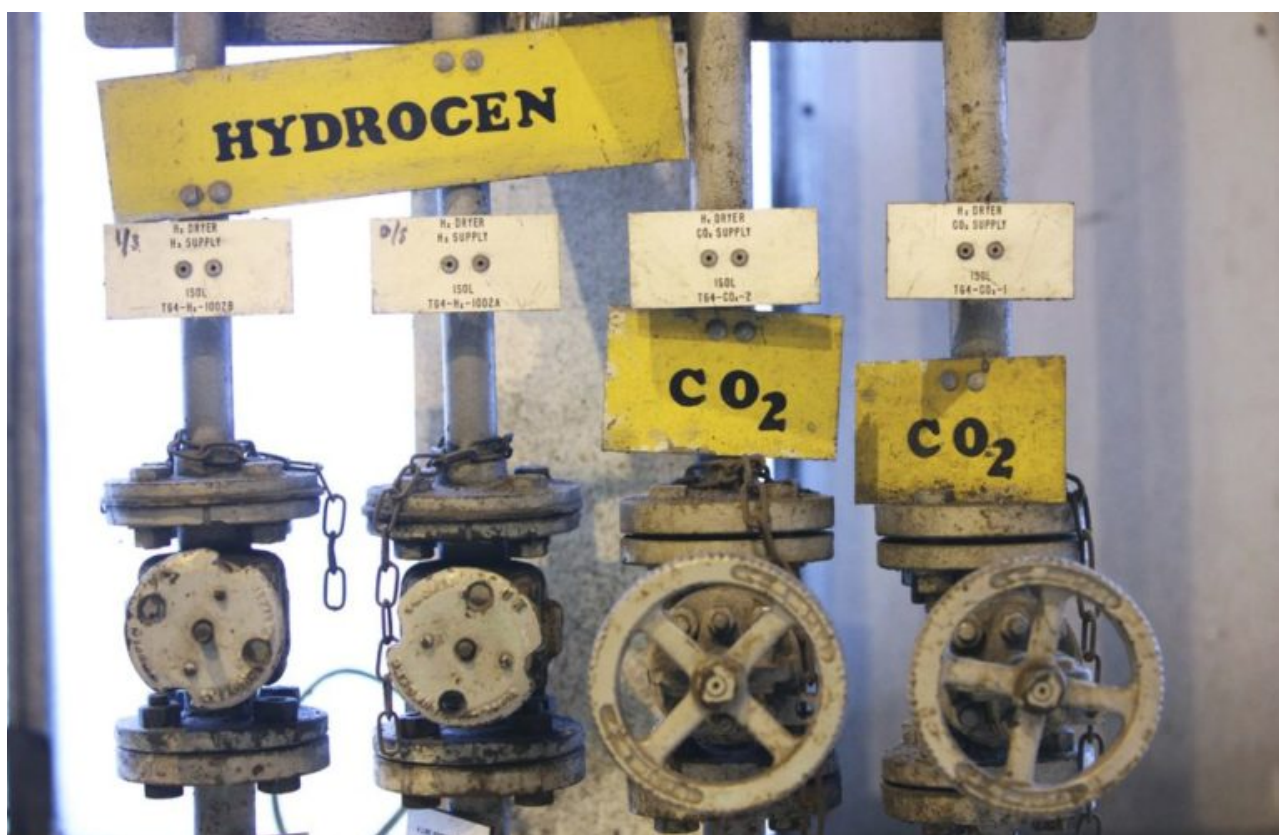
Oil-natural gas trade reappears, roiling US energy markets



Last week's stunning reversal in oil and natural gas markets brought out of the shadows a trade that used to be commonplace – a so-called relative value trade the two commodities. Oil reached a four-year high in early October on speculation

prices could reach \$100 a barrel as Iranian exports dried up. Meanwhile, natural gas burst out of its doldrums earlier this month, but the rally was being threatened by record US production. While it may not have been intentional, investors recreated what was once a popular trade based on a correlation between natural gas and crude oil markets. Crude's decline from its high turned into a rout and a cold-weather rally in gas grew into the biggest surge in nine years as large energy traders raced to unwind bullish crude and bearish natural gas bets, market participants said. The rush to the exits pushed the price ratio between the commodities to the narrowest since the financial crisis. "The crude-natural gas trade hasn't been a thing in a very long time, I'd say maybe a decade," said John Kilduff, a partner at Again Capital. "It appears to be inadvertent. The sentiment around the natural gas market got incredibly bearish because of the record production numbers. Then, all the analysts on the Street were calling for \$100 oil." A relative value trade bets on a price relationship between two commodities, rather than taking an outright position on a single one. In theory, it might be less risky. While crude and natural gas were fairly well correlated in the middle of the previous decade, due to direct competition for drilling resources at the wellhead, that has faded in recent years due to the US shale gas boom and subsequent oil boom. Earlier this year, the CME Group Inc wrote in a post on its website that the crude and natural gas link reached an inflection point in 2008, and have since decoupled. That all reversed last week in a hurry, with crude dropping 7.1% November 13, the biggest one-day decline in more than three years, the culmination of a record slide. The same day, natural gas jumped 8.3% to exceed \$4 per million British thermal units for the first time in almost four years, followed by a spike of 18% on November 14. "It's not a fundamentally driven rally," said Stephen Schork, president of Schork Group Inc, a consulting group in Villanova, Pennsylvania. "This rally is driven by someone large who had the wrong position."

U.K. Looks to Hydrogen as a Source of Green Energy



An influential panel of lawmakers in Parliament is encouraging the government to develop hydrogen as a way to provide a green form of heat for industry and homes.

The Committee on Climate Change, which advises the government on energy and environmental policies, said ministers should write a strategy for removing carbon emissions from heat in the next three years, starting with a roll out of hybrid heat pumps.

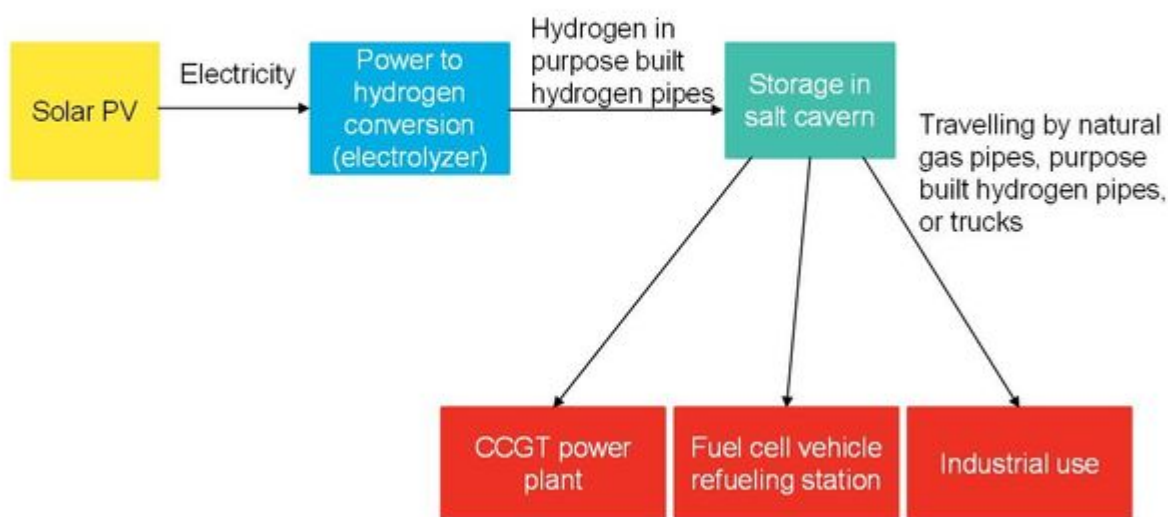
Heat is seen as one of the most difficult and expensive elements of the energy mix to wean off fossil fuels. It accounts for almost half of the U.K.'s energy use and a third of its carbon emissions, according to a government estimate.

While renewables such as wind and solar are spreading rapidly to generate electricity, those energy sources are less adept than oil, natural gas and coal in providing heat.

“Hydrogen has the potential to contribute to near-zero carbon energy emissions if used strategically,” said John Gummer, chairman of the Committee on Climate Change. “The government must now decide whether it wishes to develop a U.K. hydrogen option, taking decisions now that will see the first deployment in the 2020s.”

Heat pumps combine an electric pump with a natural gas boiler. They can reduce a building’s gas use by 80 percent, the committee said in a report published on Thursday. Eventually the gas boiler could burn hydrogen instead, achieving zero carbon heat. So long as the hydrogen is made without emissions, it can be counted as clean energy.

Illustration of the use of solar PV electricity to produce renewable hydrogen



Source: Bloomberg New Energy Finance

Hydrogen is emerging as a solution to difficult questions in the energy transition, such as how to plug the gaps between wind and solar generation without fossil fuels. Burning the lightest element doesn’t produce any carbon emissions, so it

could potentially displace gas and other fossil fuels both in power generation and transport.

The U.K.'s Committee on Climate Change expects that by 2050, hydrogen could provide 25 percent of heat for buildings with the remainder covered by electric pumps.

The U.K. is aiming to meet 15 percent of its overall energy needs with renewables by 2020 with 30 percent of electricity, 12 percent of heating and 10 percent of transport powered by clean energy. The country is on track to meet its electricity target, but unlikely to succeed on heat and transport unless major changes are enacted, a Parliament committee said in 2016.

The committee is also recommending that hydrogen be used in trucks and heavy industry.

"It's particularly useful for sectors of economy that's not possible to electrify or emissions are difficult to reduce," said Chris Stark, CEO of the committee, by phone.

Argentina set to become exporter of LNG with floating platform deal



Argentina will soon join the ranks of nations exporting liquefied natural gas and benefit from surging global demand for the fuel. YPF SA, the state-run oil and gas producer, has signed a 10-year contract with Belgium's Exmar NV to deploy a barge-based floating LNG, or FLNG, unit to produce and export the fuel. Exmar shares soared as much as 16%, the most in eight years. The deal helps Argentina tap a boom in domestic shale gas production and turn one of Latin America's biggest LNG importers into an exporter. The initial plan is to ship 500,000 tonnes of LNG per year, feeding the fastest growing fossil-fuel market led by demand from China. The barge will start operations in the second quarter of 2019 and produce as many as eight cargoes per year from the Vaca Muerta source at the Neuquen Basin, according to Exmar. "We are now able to add value to the resources extracted from Vaca Muerta, and take full advantage of the seasonal opportunity with Asian markets and our unique location to serve demand centres," said Miguel Gutierrez, president of YPF. Argentina follows the path of other nations, such as Egypt, which recently resumed exports after domestic output surged. The Tango FLNG, the new name of the vessel currently known as the Caribbean FLNG, will be located in the port of Bahia Blanca.

Justice Department Reviewing Anti-OPEC Legislation, Official Says



The Department of Justice is formally reviewing antitrust legislation aimed at reining in OPEC's power over oil markets, according to a department official.

While the study is ongoing, there is an understanding that the oil cartel's efforts to affect crude prices through production quotas has raised costs for American consumers, said the official, who spoke on condition of anonymity. That's traditionally the type of conduct the Justice Department would frown upon, the person said.

Bipartisan, anti-OPEC bills have been introduced in both the

House and Senate, though neither chamber has voted on the measures yet.

The House Judiciary Committee in June approved the “No Oil Producing and Exporting Cartels Act,” or NOPEC bill, which would give the attorney general the authority to file a suit against OPEC for trying to control oil production or to affect crude prices. It would amend the Sherman Antitrust Act of 1890, the law used more than a century ago to break up the oil empire of John Rockefeller. A similar Senate bill hasn’t seen any action yet.

Although past presidents have threatened to use their veto power to prevent similar bills from becoming law, President Donald Trump has repeatedly attacked the cartel over high prices.

OPEC is scheduled to meet next month in Vienna amid a collapse in oil prices that’s spurred calls for the group to curb output in 2019. Saudi Arabia has already signaled it supports a deep cut and as a first step will reduce its shipments by 500,000 barrels a day in December.

Reliance said to expand world’s largest oil refining complex



Billionaire Mukesh Ambani-owned Reliance Industries Ltd. is considering a plan to boost its oil-refining capacity by about half, people with knowledge of the matter said.

The proposed plant, to come up at the world's biggest refining complex in Jamnagar, will be able to process as much as 30 million tons of crude a year, the people said asking not to be identified because the discussions are private. The company's shares closed 2 percent higher in Mumbai, compared with 0.9 percent gain in the benchmark BSE Sensex index.

Asia's richest man seeks to cement Reliance's dominance in the world's fastest-growing major oil consuming nation as rivals including Saudi Aramco, Abu Dhabi National Oil Co., and Russia's Rosneft PJSC acquire plants in India. Total SA and Royal Dutch Shell are also expanding into fuel retailing in India. International Energy Agency expects India's energy demand to more than double by 2040, making it the single largest source of global growth.

Demand Surge

Oil consumption in the South Asian nation has grown by half this decade. Reliance has begun discussions with global

refinery process licensors and equipment vendors for the new refining train at the Jamnagar complex, the people said. The plant of the size planned by the company may cost \$10 billion, they said. A Reliance spokesman didn't reply to an email seeking comment.

Saudi Aramco and ADNOC signed agreements to invest in a proposed 60-million ton refinery complex on India's west coast while Rosneft and partners acquired the country's second-largest private oil processor.

Shell has restarted retailing gasoline and diesel in the country, while Total partnered the Adani Group to set up liquefied natural gas import terminals and fuel retailing business. Last year, BP Plc expanded its partnership with Reliance to retail auto fuels.

Demand for fuel in India and the Middle East will make the two regions bigger oil consumers than the European Union by 2030, driven mainly by diesel for trucks and petrochemicals feedstock, according to the IEA.

Reliance is looking to process the dirtiest and heaviest crude and may focus on producing feedstock for petrochemicals, the people said.

The expansion plan is still under discussion and hasn't been finalized, the people said. A feasibility report is likely to be prepared by the end of next year, once the recently-expanded petrochemicals capacities stabilize, and Reliance is expected to make the final investment decision with an aim to start work in 2020, the people said.

The company had considered expanding its refining capacity in the past, and in 2013-14 it sought environment approval for the project. Reliance didn't move ahead with the plan as it focused on increasing downstream chemicals capacities and building the telecom business.

To lessen climate change, educate the public



s extreme weather strikes with greater frequency and ferocity – especially on the East and West coasts of the U.S. – media attention rightly focuses on the often heroic response of the emergency services. What is missing from these accounts, however, is a similar emphasis on climate change as a source of the increasing *extremity* of these events, and consequently, on preventing ever-worsening weather calamities. It is even more problematic when the causes of these events are misdiagnosed, as when the president attributed California’s worst forest fires ever to “poor forest management.”

The upshot of failing to make the climate change connection is that actions continue to be limited to dealing with disasters after they strike without taking urgent steps to contain runaway global warming. As climate inaction continues, weather disasters are poised to reach a point where no amount of good

management will be enough. The 2018 report from the United Nations is clear: Human actions and greenhouse gas emissions are contributing to global warming, and unless the planet's temperature increase (from pre-industrial times) is kept to below 1.5 degrees centigrade, weather catastrophes will go over the tipping point.

There are many policy and technological avenues for climate mitigation, but they all start with a change in our mindsets to link the new weather extremes to global warming. That is necessary if a winning political platform for climate action is to be created. Political support and resources for climate abatement will unleash the innovation and adaptation in ways we may not have anticipated. This has been seen time and again in other global crises, be it tackling terrorism or pandemics, where treating the problem had to be complemented by attending to the root causes.

But unlike terrorism and pandemics, climate change presents a fuzzier – and potentially deadlier – chain that connects cause and effect. The effects of climate change still tend to be viewed as something over the horizon rather than here and now. This perception must change: In 2017 and 2018 the worst floods and fires on record were seen not only across the globe but on United States' soil in California, Texas, Florida and Puerto Rico.

In addition to drawing broad links between anthropogenic warming and disaster trends, scientists are also beginning to attribute the higher probability of individual events to climate change, for example, the 2017 Hurricane Harvey in Texas, the 2013 Typhoon Haiyan in the Philippines and the 2013 Australian heat waves.

Drawing on this type of evidence, news reporters must make the climate-disaster connection so that people see the extremity of the episodes as manifestations of global warming. The resulting shift in understanding should also trigger a political movement to see climate action as a pro-progress

agenda, and a political platform that can help win elections. Florida's Democratic candidate for governor, Andrew Gillum, developed a plan to preserve the state's natural resources, curb harmful blue-green algal blooms and red tide, and invest in renewable energy to fight climate change. We need to see environmental agendas like this among the criteria for winning elections.

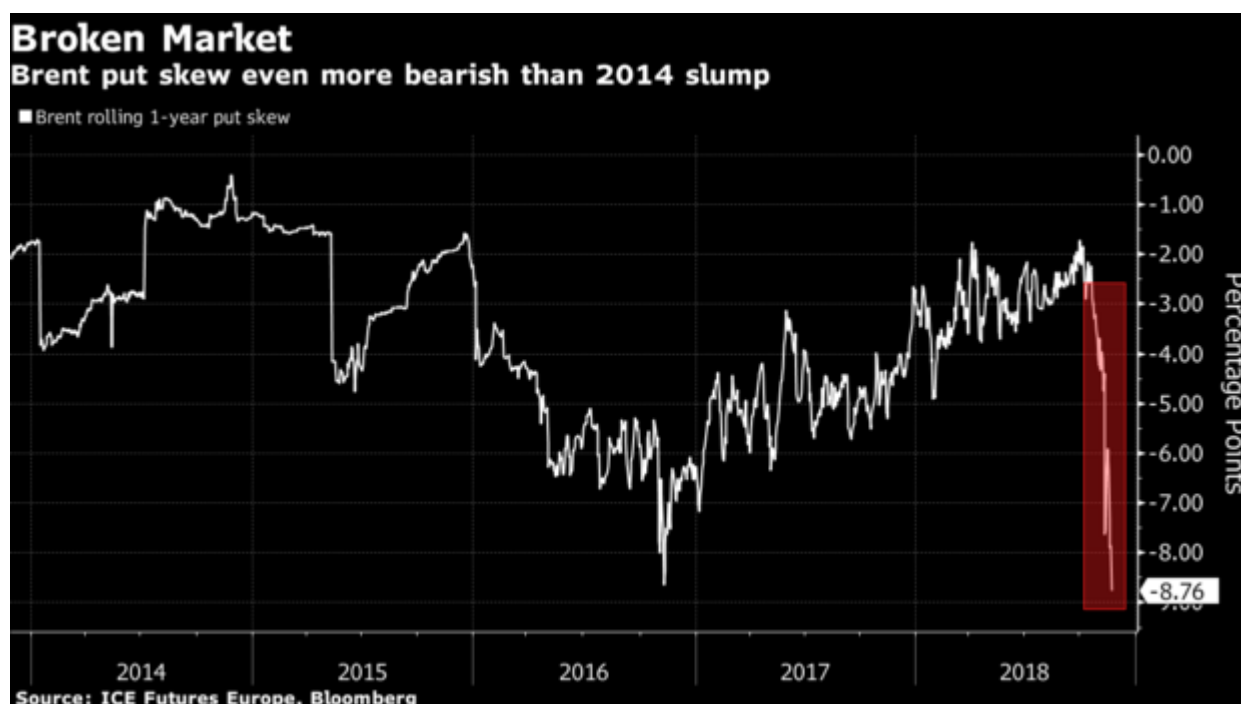
To spur action, we also need to view weather disasters as local affairs. The wildfires that swept across the town of Paradise in California in just eight hours are every bit local. So is Hurricane Michael, which hammered Florida's Panhandle. These events also need to be seen as *national* disasters rather than *natural* disasters. The United States is the second largest emitter of greenhouse gases after China. The lowering of power plant emissions standards by the administration and encouraging the use of fossil fuels will only aggravate sea-level rises along the country's long coastlines.

Television and newspapers have the biggest bully pulpit in the United States. The current administration's policies show a reckless disregard for the factors behind the increase in weather disasters, endangering the well-being of people for years to come. The media can make a difference in this unfavorable setting by connecting the dots between climate and disasters in real time and helping to make environmental care a live political agenda.

If enough people recognize the true climate-disaster link, positive actions will follow.

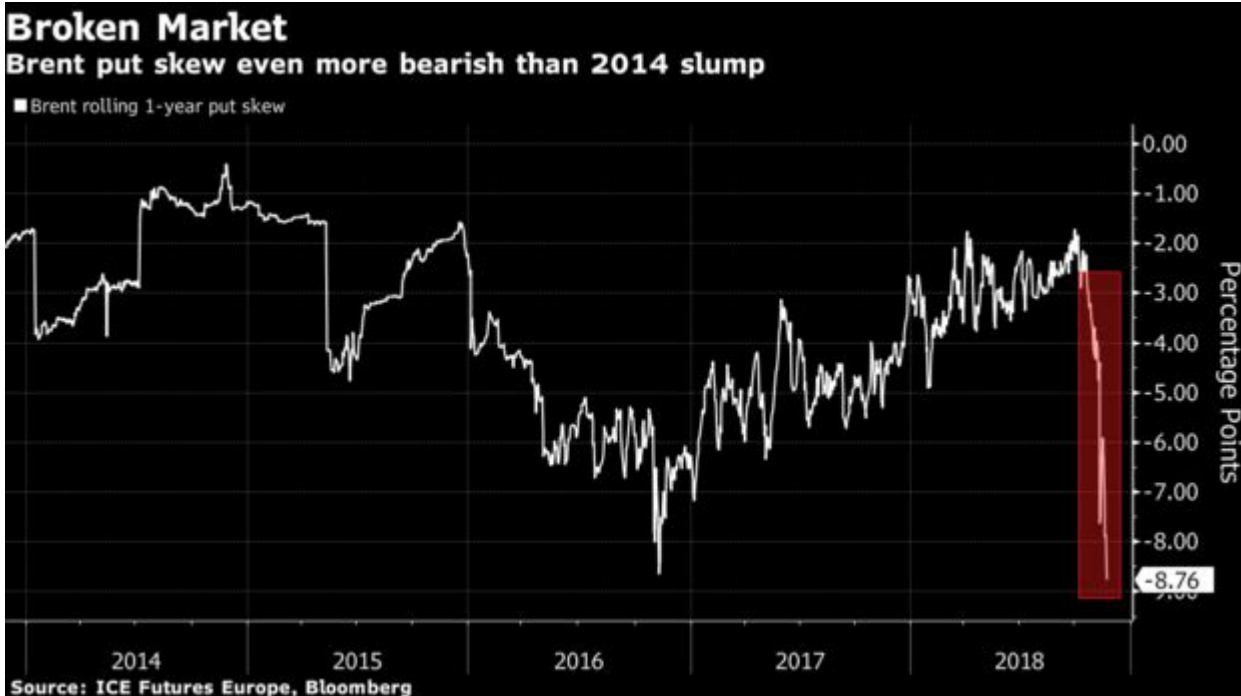
Vinod Thomas (Vndthomas91@yahoo.com) is author of a 2018 book "Climate Change and Natural Disasters" (Routledge) and a former senior vice president at the World Bank.

Oil Options Traders Turn More Bearish Than During 2014 Crash



Oil options traders have turned more bearish than when prices plunged back in 2014.

The premiums they're paying for bearish put options over bullish calls over the next 12 months has reached the largest in data compiled by Bloomberg since 2013. The skew, as it's known, indicates demand for protection against a slump. The negative bias is far greater than during four years ago, when Saudi Arabia adopted a pump-at-will production policy, helping prices crash to \$47 from \$115 in a matter of months.



The crude market has been roiled by surging U.S. output and Donald Trump’s unexpected decision to allow buyers of Iranian oil to continue purchases, thereby adding unexpected supply. At the same time the Saudis, under pressure from the American president to help keep prices down, has signaled that it may be producing at a record pace.

Thrown into the mix has been frenetic selling from banks who’ve been forced to sell futures contracts after options contracts that they sold to producers came close to being valuable. The resulting moves have seen crude swing rapidly from talk of \$100 a barrel just a few weeks ago, deep into a bear market. Brent traded at about \$61 on Friday.

“It shows you the extreme change in perceptions that we’ve just had, the disappointment in expectations,” Thibaut Remondos, founder of hedging strategies adviser Commodities Trading Corp. in London said of the shift in options markets. “The options volatility market in Brent is broken right now.”

While the premium paid for puts over calls is the biggest in at least five years, it’s not the only corner of the oil options market that has been buffeted by tumbling prices. The CBOE/Nymex Oil Volatility Index, a measure of near-the-money

crude options, hit nearly 56 points earlier this week, the highest level in 2 years and almost double where it reached in early November.

The move brings into focus the decisions of some producers to lock in their output when prices were at multi-year highs in recent months.

Remoundos said some producers could have locked in their output for 2019 at \$72.50 without any outlay on options contracts, a strategy known as a costless collar. A 128 million barrel hedge by Petroleo Brasileiro SA, as well as Mexico's national oil hedge – the biggest oil deal of the year – are among those said to have roiled Wall Street banks in recent weeks.

OPEC's Worst Nightmare: Permian Basin About to Pump a Lot More



The map lays out OPEC's nightmare in graphic form.

An infestation of dots, thousands of them, represent oil wells in the Permian basin of West Texas and a slice of New Mexico. In less than a decade, U.S. companies have drilled 114,000. Many of them would turn a profit even with crude prices as low as \$30 a barrel.

OPEC's bad dream only deepens next year, when Permian producers expect to iron out distribution snags that will add three pipelines and as much as 2 million barrels of oil a day.

"The Permian will continue to grow and OPEC needs to learn to live with it," said Mike Loya, the top executive in the Americas for Vitol Group, the world's largest independent oil-trading house.

The U.S. energy surge presents OPEC with one of the biggest challenges of its 60-year history. If Saudi Arabia and its allies cut production when they gather Dec. 6 in Vienna, higher prices would allow shale to steal market share. But because the Saudis need higher crude prices to make money than U.S. producers, OPEC can't afford to let prices fall.

Cartel Decision

Even so, Saudi Arabia's output swelled to a record this month, according to industry executives. That means the three biggest producers – the U.S., Russia and Saudi Arabia – are pumping at or near record levels.

A similar scenario unfurled in 2016, when Saudi output rocketed just before OPEC agreed to cuts. This time the cartel's 15 members, and allies including Russia, Mexico and Kazakhstan, will discuss the possibility of their second retreat from booming American production in three years.

OPEC helped create the monster that haunts its sleep. After it flooded the market in 2014, oil prices crashed, forcing surviving U.S. shale producers to get leaner so they could thrive even with lower oil prices. As prices recovered, so did

drilling.

Now growth is speeding up. In Houston, the U.S. oil capital, shale executives are trying out different superlatives to describe what's coming. "Tsunami," they call it. A "flooding of Biblical proportions" and "onslaught of supply" are phrases that get tossed around. Take the hyperbolic industry talk with a pinch of salt, but certainly the American oil industry, particularly in the Permian, has raised a buzz loud enough to keep OPEC awake.

Price Tumble

"You've got an awful lot of production that can come in very economically," said Patricia Yarrington, Chevron Corp.'s chief financial officer. "If you think back four or five years ago, when we didn't really understand what shale could do, the marginal barrel was priced much higher than what we think the marginal barrel is priced today."

That shift makes shale resilient to a price tumble. After touching a four-year high in October, West Texas Intermediate, the U.S. benchmark, has fallen by more than 20 percent.

Shale Boom

Only a few months ago, the consensus was that the Permian and U.S. oil production more widely was going to hit a plateau this past summer. It would flat-line through the rest of this year and 2019 due to pipeline constraints, only to start growing again – perhaps – in early 2020.

If that had happened, Saudi Arabia would've had an easier job, most likely avoiding output cuts next year because production losses in Venezuela and sanctions on Iran would have done the trick.

Instead, August saw the largest annual increase in U.S. oil production in 98 years, according to government data. The American energy industry added, in crude and other oil liquids, nearly 3 million barrels, roughly the equivalent of what Kuwait pumps, than it did in the same month last year. Total output of 15.9 million barrels a day was more than Russia or Saudi Arabia.

Rail Cars

The growth was possible because oil traders decided not to be stymied by the dearth of pipelines. They used rail cars and even trucks to ship barrels out of the region. But pipeline companies unexpectedly increased capacity, in part because they added chemicals known as “drag reduction agents” to increase flow. A new pipeline came online earlier than anticipated, and with three more expected between August and December next year, production is poised to soar.

“The narrative has shifted significantly,” said John Coleman, a Houston-based oil consultant at Wood Mackenzie Ltd. “Six months ago, the market expected the bottleneck to ease in the first quarter of 2020. Now, it expects it in the second to third quarter of 2019.”

Knowing that more transportation would be available next year, Permian companies are drilling wells but, for now, aren’t fracking many of them. Those wells are becoming a reservoir of ready-to-tap production once the new pipelines – Gray Oak, Cactus II and Epic – come online.

“We’re going to see a re-acceleration of well completions in the Permian in the second half of 2019,” said Corey Prologo, head of oil trading in Houston at commodity merchant Trafigura Group Ltd. “The pipelines are going to fill up very quickly.”

The only obstacle for another surge is export capacity, as most of the incremental output will need to ship overseas. With terminals nearly full, Permian barrels could end piling

up in the ports of Corpus Christi and Houston.

Transportation Bottlenecks

Even so, few in Houston, or in Midland, Texas, the hub of the Permian region, believe that growth will be anything but gangbusters next year because of the clearing of transportation bottlenecks.

“It will be a series of events throughout 2019 that occur,” said Jeff Miller, chief executive officer of Halliburton Co., the world’s biggest provider of fracking services. “But it’d be easy to see, as we finish the year, things being perfectly normal.”

American Oil Renaissance

By the end of 2019, total U.S. oil production – including so-called natural gas liquids used in the petrochemical industry – is expected to rise to 17.4 million barrels a day, according to the U.S. Energy Information Administration. At that level, American net imports of petroleum will fall in December 2019 to 320,000 barrels a day, the lowest since 1949, when Harry Truman was in the White House. In the oil-trading community, the expectation is that, perhaps for just a single week, the U.S. will become a net oil exporter, something that hasn’t happened for nearly 75 years.

Saudis Concede

Saudi officials concede that the tsunami is coming. OPEC estimates that to balance the market and avoid an increase in oil inventories, it needs to pump about 31.5 million barrels a day next year, or about 1.4 million barrels a day less than what it did in October.

Global oil demand has so far absorbed the extra U.S. crude

barrels, limiting the impact on prices. The loss of output from Venezuela and to a lesser extent, Iran, even allowed Saudi Arabia, Russia and a few others to boost production. But for the cartel, U.S. shale remains as intractable as in the past.



Khalid Al-Falih

Photographer: Simon Dawson/Bloomberg

In early 2017, Khalid Al-Falih, the Saudi oil minister, told an industry forum that Riyadh has learned the lesson that cutting production “in response to structural shifts is largely ineffective.” The kingdom would only make one-time supply adjustments to react to “short-term aberrations,” he said, and otherwise allow “the free market to work.”

Nearly two years later, Al-Falih has lost enough proverbial sleep. He’s about to make a U-turn. He’ll battle what increasingly looks like a structural problem: booming U.S. production.

US says economy to be hurt by climate change denied by Trump



The Trump administration just published a major report documenting the advance of climate change, weeks earlier than expected and on a day many Americans are occupied with family and holiday shopping. The news is predictably bad, but this time the tally comes with a price-tag – one significantly larger than you’ll find at the mall. The report catalogues the observed damage and accelerating financial losses projected from a climate now unmoored from a 12,000-year period of relative stability. The result is that much of what humans have built, and many of the things they are building now, are unsuited to the world as it exists. And as time goes on, the added cost of living in that world could total hundreds of billions of dollars – annually. “The assumption that current and future climate conditions will resemble the recent past is

no longer valid," the authors write. President Donald Trump has rejected without evidence the global scientific consensus that humans are doing grave damage to the planet. The Republican has sought to roll back Obama-era initiatives to slow greenhouse gas pollution in favour of fossil fuel interests. In recent years, thousands of Americans have died during, or as a consequence of, extreme weather tied to climate change – from powerful hurricanes fuelled by extremely warm seas to calamitous conflagrations stemming from drought. "The Trump administration can't bury the effects of climate change in a Black Friday news dump – effects their own federal government scientists have uncovered," said Senator Sheldon Whitehouse, a Democrat from Rhode Island, in a statement. "This report shows how climate change will affect every single one of our communities. The president says outrageous things like climate change is a hoax engineered by the Chinese and raking forests will prevent catastrophic wild fires, but serious consequences like collapsing coastal housing prices and trillions of dollars in stranded fossil fuel assets await us if we don't act." Part of the fourth US National Climate Assessment since 2000 (the last one was in 2014), the report departs from predecessors in that it focuses on money, and how much of it America stands to lose to climate change. The costs assessed range from household expenses to the availability and pricing of food, energy and other goods people use in modern society. And it's not just the effects at home. "The impacts of climate change, variability, and extreme events outside the US are affecting and are virtually certain to increasingly affect US trade and economy, including import and export prices and businesses with overseas operations and supply chains," the authors write.

"Now it's seen much more as a societal or economic issue than a narrow environmental one." A chapter on how to avoid worst-case scenarios, called mitigation, looks at estimates of economic losses across the economy by sector, pinned to the end of the century. They suggest that policy, technological

and behavioural changes that lead to significantly lower emissions can cut potential financial damage across many sectors roughly by half. Nevertheless, such a best case-scenario will still leave Americans in a country where they are paying tens of billions of dollar more annually to address the fallout of accelerating climate change. A scenario with dramatically less pollution could slash projected losses in 2090 by 48% (\$75bn) a year in labour costs, 58% (\$80bn) in heat-related deaths and 22% (\$25bn) in coastal real estate, according to the report. When the first NCA came out in 2000, researchers were still thinking through how different parts of the US might be vulnerable to natural and human-driven changes. Almost two decades later, the assessment incorporates a grim accounting of actual damages, which in turn allows firmer projections of what's coming. "A lot has happened in 20 years," said John Furlow, a contributing author and deputy director of Columbia University's International Research Institute for Climate and Society. "Now it's seen much more as a societal or economic issue than a narrow environmental one." Climate change's impacts, the report states, are presenting painful financial choices for every region of the country: In Pennsylvania, ageing bridges may not fare well against more extreme storms, and water and wastewater systems need almost \$30bn in investment. In general, about 90% of the northeast is built on infrastructure poorly suited to adjust to rising seas.

"Projected future costs are estimated to continue along a steep upward trend relative to what is being experienced today," the report states. More than 60% of big southeastern cities see heat-wave trends above the national average, and three of them, Birmingham, Alabama, New Orleans and Raleigh, NC, are exceeding the rest of the country across all major heat-wave measures. Anchored by California's clean-tech economy, the Southwest is seeing much of the nation's new energy investment. Legacy power technologies, such as water-cooled power plants, will continue to work for decades,

however, and will be less effective as temperatures make cooling sources too hot. Hot water could reduce efficiency of these power plants by 15% by 2050. In the Midwest, a major producer of corn and soybeans, increased temperatures, rainfall and humidity have eroded soil and allowed harmful pests and pathogens to thrive, according to the report. Rising growing-season temperatures in the region are projected to be the largest single factor contributing to declines of US agriculture production. A new chapter of the NCA addressing US interests abroad emerged from the previous report's work on agriculture. The sector directly contributed \$136.7bn and 2.6mn jobs to the US economy in 2015. It's also a significant source of pollution – about 9% of the US total in 2016 – and vulnerable to its impacts both at home and from abroad. "The US food system is a globalised food system, and we import a lot," said Diana Liverman, a Regents' professor at the University of Arizona. Since the global nature of food-system risk drew interest during the 2014 report discussions, researchers conducted deeper analysis "on things like the vulnerability of US supply chains." Strange phenomena are playing havoc with the US food supply, including "the loss of synchrony of seasonal phenomena," the report states, including an emerging disconnect between crops and pollinators. While scientists are developing climate change resistant crops, the progress has been "modest," according to the NCA. It calls for more public investment in these projects and notes that – against the claims of some environmental groups – "genetically engineered crops have shown economic benefits for producers, with no substantial evidence of animal or human health or environmental impacts." The NCA differs in important ways from similarly weighty, periodic reports from the UN's Intergovernmental Panel on Climate Change. The most recent of these studies explored the difference between a world that warms 1.5 degrees Celsius and 2 degrees, the long-time international goal (slower sea-level rise, more Arctic sea ice, some coral left). The NCA authors express concern about growing threats to global trade, supply chains and the price

of goods. Other international issues addressed beyond trade include national security, humanitarian aid and what the report calls “trans-boundary resources,” such as fish, water and minerals managed jointly by neighbouring countries.