

# oil magazine

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## (the) new players

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■ **Photography**

Alamy, Corbis, Contrasto Reuters,  
 Cubo Image, Getty Images,  
 Sie Masterfile

■ **Editing and production**

Agi, via Ostiense, 72 - 00154 Roma  
 tel. +39 06 51996254 -385  
 fax + 39 06 51996286  
 e-mail: info@abo.net

www.abo.net

@AboutOil

www.facebook.com/ABOaboutoil

■ **Design**

Cynthia Sgarallino

■ **Graphic consultant**

Sabrina Mossetto

■ **Graphics and layout**

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# The new players



In this edition of *Oil*, we will provide a complete overview of the world of energy and take stock of some of the main questions being raised at a time of radical transformations that make the situation particularly complex and delicate.

The global economic crisis, the equilibrium between various countries, the emergence of new key players on the global scene, and technological progress that was unimaginable just a few years ago, are unsettling the world and the energy sector in particular. Countries that were traditionally exporters of crude oil are stressing their role as consumers as well; others, which have always relied on imports to meet their domestic requirements, are now striving towards self-sufficiency, while others, who have never previously been involved in the energy market, are now establishing themselves as serious purchasers, dramatically changing the historical equilibrium.

In the pages that follow, we have sought to collect testimonies, comments and reflections from authors and experts on these subjects to try and understand how the situation is evolving and what the future outlook will be. Let us take an initial look at some of the old and new leading countries on the energy scene: the United States, for example, which has always been in the foreground, but in recent years has changed its role decidedly on the basis of the availability of resources that were previously unthinkable; China, a well-established giant, or India, which is about to become one; Iraq, set on winning back the ground lost over the last twenty years; Egypt, which finds itself needing to win back the trust of international markets after its domestic political unrest; but also Poland, the new entry into the forefront of the energy world. All of them, in different ways, represent



by **GIANNI  
 DI GIOVANNI**

new players with a game-changing role for the fate of the world. What will that role be?

The new technologies developed in recent years are also driving change: fracking, in particular, has brought about a revolution in extraction techniques, with new resources made available as a result: the latest development being tight light oil. Progress in processes

of exploiting coal could give a fresh boost – and this would involve another revolution – to this still extremely plentiful resource, especially in an energy-hungry country such as China. In the background, are new energy sources still awaiting development, but which could constitute a huge innovation in the future (and provide the answer to many current agonizing questions). On the pages that follow, the reader will also find updates on the subject of wind energy and projects for the large-scale production of small photovoltaic plants, which will make electricity accessible to entire nations, to whom it is currently denied. Let us not forget the fancied goal of nuclear fusion, a mythical solution for every problem, which is, however, difficult to achieve without the joint effort of the entire international scientific community. Lastly, the environment, always in the background of all reflections on energy policy. The debate on pollution and climate change and possible remedies is always fierce. *Oil* has sought to make its own contribution on these subjects in this edition. The destiny of mankind is linked to the future of energy, the same energy it relies on to a large extent. The debate on these topics cannot be left to the pundits alone, it needs to be extended to include informed and educated public opinion. *Oil* wishes to confirm its commitment to playing its part in this process.

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# Conventional wisdom and the challenge of an unquiet future



**GEMINELLO ALVI**  
An economist and writer, he was columnist for the *Corriere della Sera* and *La Repubblica*; now he writes for *Il Giornale*.

All kinds of things have happened in recent years, often contrary to the predictions of pundits, who have been wrong at every turn due to an excess of optimism. Whether it's the euro or real estate bubbles or the internet economy, many economists and newspapers have persisted in preaching that the scenario *du jure* was generating its own internal equilibrium. But this has not been the case, and indeed, even now the remedies for the euro crisis or for the crisis of the English-speaking financial world are anything but conclusive or capable of restoring order and tranquility to the global economy.

The conventional wisdom on energy, we should assume, is no exception.. For some years, *Oil* has been monitoring the various changes brought about by shale gas and the shift towards renewable sources, without allowing itself to be swayed by passing fads. And as this issue demonstrates, these changes continue to have surprising and some times unanticipated effects. Look, for example, at the new opportunities opened up by shale gas in previously unimagined countries. "Argentina has world-class shale gas potential – possibly the one with the best prospects outside of North America," writes the IEA. And another element is added to the scenarios of Latin America, where Brazil's crisis, on the other hand, is deepening and even soccer is losing its normalizing function. Certainly the nationalization of YPF and other Argentinean difficulties are not making things any easier. All the same, there is no doubt that shale gas offers Argentina the opportunity to take a lead role, along with a real chance to emerge from its financial isolation.

But it is not only domestic innovation that will shape the future of energy – geopolitical trends will also be significant. Just think of the slowdown in

China's growth, and the manifest bankruptcy of an accumulation model based on state investment: the weakening of the Yuan and the crisis in the banking system are symptoms of this. Another important symptom is the recovery of Japan, whose return to a leading position in the Far East should, according to influential American research institutes, be welcomed by the U.S. However in this case, a stronger foothold for China in the energy scenarios of the Middle East would serve as a counterpoint for a significant rebalancing in the

**Many geopolitical factors will contribute to shaping the global energy scenarios, like the slow-down of Chinese growth or the Ukraine crisis**

Far East. And then there is the question of the Ukraine, which has been handled atrociously by the West and left to implode, producing another substantial change in the global order. Let us remember that if we were to draw a line between the Atlantic coast of Portugal and the Urals, it would be divided exactly in two by a center that extends right up against the western borders of Ukraine. It is therefore plain to see that the events in Kiev and the Crimea, now part of the Russian Federation, give rise to unexpected scenarios especially for Europe, and not only in terms of energy. And what strange turns of events can we expect from the combination of the likely triumph of the vote against the euro and the Europe of Brussels and the Ukrainian crisis? Especially in the light of the evident conflict between the aims of Washington and the energy interests of Berlin, which will not go back to nuclear and will not give up on renewables. ■

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● Welcome to *Oil*, a publication of news and ideas for the energy community and beyond. It provides authoritative analysis of current trends in the world of energy, with particular attention to economic and geopolitical developments.

● *Oil* is published by Eni with the aim of fostering open dialogue about the challenges of making energy a reliable and sustainable contributor to social and economic development.

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**ABDUL-KAREEM LUAIBI BAHEDH**

Abdul-Kareem Luaibi Bahedh has been the minister of oil of Iraq since December 2010. From 1982 to 1998, Luaibi worked in several oil companies. He began to work at state-owned South Oil Company in 1982. In 1998, he joined the ministry of oil, and served in different positions until 2009. He was appointed deputy minister of oil, in charge of the upstream operations in 2009, and was in office until 2010. During his tenure, he was instrumental in securing the oil and gas contracts with international oil companies and other oil-related agreements with neighboring countries of Iraq.

In December 2010, he was appointed oil minister, replacing Hussain Al Shahrstani, to the cabinet headed by Prime Minister Nouri Maliki. Luaibi is part of the Iraqi National Alliance. He acted as the president of OPEC's 162th ordinary meeting which was held in Vienna on 12 December 2012.



“All the OPEC countries are committed to ensuring the stability of prices and the stability of the market, as well as to making investments in the energy sector”



**Exclusive/Iraqi oil minister Abdul-Kareem Luaibi Bahedh**

# We will reclaim a leading role

Complex political and economic challenges await the government that emerges from April's elections. Iraq aims to resume a leading role in OPEC and in the global crude oil market

# A

by METHAQ  
AL FAYAD  
(AGENZIA NOVA)

s the hour approaches for Iraq's crucial parliamentary elections, scheduled for April 30, Iraq appears to be going through one of the most delicate periods of its recent history. On the one hand, attacks are becoming an increasingly commonplace feature of everyday life in all areas of the country, blood-staining the already bitter conflict between the Sunni community and the Shiite minority, currently in power with Prime Minister Nouri al-Maliki. On the other hand, complex political and economic challenges lie ahead for the next government. Naturally, the oil sector continues to be the best bet for supporting growth and de- →



“ We will sue all international companies that buy any volume of Kurdish oil exported outside the rules of the Iraqi State ”

“ We are trying to solve the bureaucratic problems and the difficulties encountered by international companies, and we hope to be able to simplify the energy legislation soon ”



# Iraq by numbers

**Area:** 438,317 km<sup>2</sup>  
**Capital:** Baghdad  
**Population:** 31,671,591 (2012)  
**Average age population:** 21 years  
**Language:** Arabic, Kurdish  
**Natural resources:** oil, gas, phosphates, sulfur, salt  
**Government:** federal parliamentary republic

**MAIN ECONOMIC INDICATORS (2012)**  
**Real GDP (purchasing power parity):** \$ 256.4 billion  
**Nominal GDP (official exchange rate):** \$ 209.7 billion  
**GDP growth rate:** 8.3%  
**Public debt / GDP ratio:** 31.30%  
**Inflation:** 6.1%

**Oil (2012)**  
**Production:** 3031 thousand b/d  
**Reserves:** 141.4 billion barrels  
**Consumption:** 741 thousand b/d  
**Imports:** 331 thousand b/d  
**Exports:** 2532 thousand b/d

**Gas (2012)**  
**Production:** 5.67 billion cubic meters  
**Reserves:** 3,158 trillion cubic feet  
**Consumption:** 5.67 billion cubic meters

Source: Eni WOGI 2013 (2012 data)

velopment of the potential of a country still undergoing reconstruction. However, political instability and the climate of insecurity threaten to complicate the task facing the country's leadership. Abdul-Kareem Luaibi Bahedh, Iraq's oil minister since 2010, is well aware of this.

**Iraq has greatly increased its oil production in recent years, to the point that it is preparing for a return to the OPEC quota system. What are the current prospects?**

Iraq is one of the OPEC countries, and for decades has been one of the organization's biggest oil exporters. It will remain one of OPEC's key members because of its production capacity and its plentiful reserves of crude oil. Unfortunately, what has happened in Iraq in recent years has prevented our country from playing its deserved role in this field, that same role that it could claim 30 years ago. For this reason, Iraq is now vigorously preparing to resume its place in the global crude oil market and in OPEC. Of course, all of the OPEC countries are committed to ensuring the stability of prices and the stability of the market, as well as to making investments in the energy sector. We too are committed to keeping prices stable, and have succeeded in doing so for the last three years.

**Political instability and low levels of security pose serious obstacles to attracting foreign investment. The jihadist attacks on the Iraqi pipelines are a case in point. Does this not threaten to have a negative impact on export levels? What does the government plan to do to protect its energy infrastructures?**

In December, there were a number of terrorist attacks on the oil pipelines that carry crude oil from Iraq to Turkey. In general, the attacks on the pipelines have had a negative impact on export levels, but the Iraqi government is committed to protecting the pipelines. The last decision taken by the executive was to deploy specialized military forces to defend the pipelines through the creation, a year ago, of special new units that we hope will become operational during the course of the year.

**Recently, oil exports to Turkey from the autonomous region of Iraqi Kurdistan have caused tensions between Baghdad and Erbil. The central government wants to retain control over exports, but is it prepared to reach a compromise with the regional Kurdish government? If so, on what conditions?**

With regard to oil exports from the autonomous region, everything is riding on Erbil. For our part, we are serious and clear in our proposals, which we believe are also well balanced, bearing in mind that the Kurds receive 17 percent of all of the Iraqi State's revenues, including those coming from oil exports. The autonomous region has to follow the same conduct as all the other provinces, which hand over whatever crude oil they produce to the State so that exports can be managed at the central level. The regions must hand over the oil they produce, and this point is not up for discussion, because it concerns the unity and sovereignty of the State. We cannot allow all our regions to export oil autonomously, because if we were to grant them this kind of power, there would be nothing left of Iraq but the name. We are extremely unhappy that the regional Kurdish government has decided to export oil unilaterally, without consulting us. We have tried to persuade them not to do so, and last week we sent a delegation to Turkey [the destination country for oil exported from Iraqi Kurdistan - Ed.] to remind them of the agreements signed in 2010, explaining the dangers that their position could involve and stressing the need for an agreement. We will sue all international companies that buy any volume of Kurdish oil exported outside the rules of the Iraqi State. We have law firms that specialize in this type of dispute, and we will use them.



**Many international companies have withdrawn from the south of Iraq. In particular, they complain about bureaucratic obstacles and legislation that is unfavorable to foreign investment. What can the Baghdad government do to solve these problems?**

There are some foreign companies, such as Italy's Eni, that remain in the south of Iraq in spite of these obstacles. The oil ministry is continuing to work to provide an environment that is secure and favorable to investment. We are trying to solve the bureaucratic problems and the difficulties encountered by international companies, and we hope to be able to simplify the energy legislation soon to make their work easier.

**The government recently approved the creation of two new regional companies in the province of Dhi Qar. Have any foreign companies shown an interest in investing in this part of the country?**

A number of companies, led by Malaysia's Petronas, are active in the development of the Gharraf field. We are also examining various proposals for the development of the Nassiriyyah

field, where there are plans to build a refinery with a capacity of 300,000 barrels of oil a day. We have set a deadline for international companies interested in the project, and the final tender procedure will take place in June. We have also carried out a lot of work to connect a new platform to the pipelines dedicated to exports, a project that we anticipate could be completed this month [February – Ed.]. The Japan International Cooperation Agency (JICA) is working on the second part of this project. Once the project is completed, the port of Bassora will be capable of exporting 5 million barrels of oil a day. Our government is talking and negotiating with China and South Korea, countries that intend to import Iraqi oil for their reserves. We have also received requests from Egypt, Eritrea and Sudan with regard to the African continent, which will be an excellent market for us in the future.

**BAGHDAD. On February 16, 2014, a few months before the elections, Muqtada al-Sadr, the Iraqi political and Shia religious leader, announced his withdrawal from politics. The photo shows a woman walking in front of portraits of Muqtada al-Sadr, and his father the Grand Ayatollah, Mohammad Sadiq al-Sadr (in the centre).**



Point of view/The United States Secretary of Energy, Ernest Moniz

Head and shoulders  
above the rest



**ERNEST MONIZ**

As United States Secretary of Energy, Dr. Ernest Moniz is tasked with implementing critical Department of Energy missions in support of President Obama's goals of growing the economy, enhancing security and protecting the environment.

Prior to his appointment, Dr. Moniz was the Cecil and Ida Green Professor of Physics and Engineering Systems at the Massachusetts Institute of Technology (MIT), where he was a faculty member since 1973.

From 1997 until January 2001, Dr. Moniz served as Under Secretary of the Department of Energy. From 1995 to 1997, he served as Associate Director for Science in the Office of Science and Technology Policy in the Executive Office of the President.

In addition to his work at MIT, the White House and the Department of Energy, Dr. Moniz has served on a number of boards of directors and commissions involving science, energy and security. These include President Obama's Council of Advisors on Science and Technology, the Department of Defense Threat Reduction Advisory Committee, and the Blue Ribbon Commission on America's Nuclear Future.



America's competitive advantage produced by shale gas, but also by its related infrastructures, will last for some time. But the Obama administration supports all sources of energy under its "all-of-the-above" strategy

**D**iversification of energy sources and reduction of greenhouse gas emissions are at the heart of the American administration's all-of-the-above strategy, according to U.S. Secretary of Energy Ernest Moniz, interviewed during the HIS CERAweek. And if the Stars and Stripes' assessment of the prospects for exporting LNG (liquefied natural gas) is correct, the shale gas revolution is an irreversible reality: a game changer for the economy and geopolitics.

by RITA  
KIRBY

**Will the U.S. have an incomparable competitive advantage because of the unconventional revolution?**

Yes, we obviously have a substantial competitive advantage today and we expect that to be sustained for some time. Our advantage relies not only on "rocks" but also on the infrastructures that we have. We have unparalleled infrastructures and, not only physical infrastructures, but also the market mechanism that we developed represents a huge advantage. →

The president, Barack Obama, said in the State of the Union address that he estimated close to \$100 billion would be invested in new manufacturing capacity because of moderate gas prices. I think that was a good statement and it may have been a little bit on the conservative side. I see it being more in the \$150 billion range

We are, by far, the location in the world that best aligns supply and demand. We see a substantial advantage. It comes from geography, market structure, infrastructure and we want to see that developed. The President said in the State of the Union address that he estimated close to \$100 billion would be invested in new manufacturing capacity because of moderate gas prices. I think that was a good statement and it may have been a little bit on the conservative side. I see it being more in the \$150 billion range. I think that on the electricity side we have seen tremendous growth in gas utilization with CO<sub>2</sub> benefits. We will see more of it.

**The administration has committed to an “all-of-the-above” energy strategy for the 21st century. What does it consist of?**

We are committed to a low carbon future but within that commitment we expect that all our fuel sources, all of our various technologies, all our efficiency opportunities will all be part of the low carbon solution. For the Department of Energy, that explicitly means that we are supporting technology development, and sometimes policy development, that allows all of those fuels and technologies to develop so that they can be competitive in that future market place. I am talking about fossil fuels, nuclear fuels, renewables, energy efficiency. We are not determining what the market share of any of these will be as long as we meet our low carbon goals. So we will continue to support all fuel sources and advanced technologies across the board even as we pursue a low carbon future. What we expect to have is a different energy mix in different places according to the circumstances.

**Oil producers have begun ramping up efforts to overturn rules restricting the sale of U.S. crude oil overseas. What is the administration's approach to this issue?**

Many questions need to be answered about oil exports and there is a complicated set of factors that need to be integrated in a clear and transparent way. There are options of expanding refining capacity and modifying refining capacity. There are infrastructure issues in moving the product from new geographical areas. There is the issue that – despite the surge in U.S. oil production in recent years – the United States still imports more than 5 million barrels of oil per day. Where would be the balance of exports and reimports? What would be the effect in terms of product exports versus crude exports? I think there are a lot of questions that have not been addressed in a clear way. The industry could do a better job talking about the drivers for, and what the implications would be of, exports. The industry could do a lot more to put that whole case together for public discussion.

**The shale revolution has also opened the door to U.S. exports of liquefied natural gas. Some lawmakers have called for the Obama**



**WHERE TO FIND THEM**  
The map shows the location of the main basins for the extraction of shale gas and tight oil in the United States.

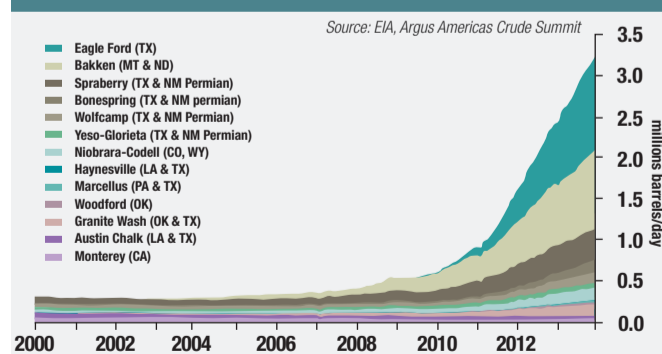
Source: EIA, Drilling Productivity Report

**Administration to use the nation's natural gas bounty as leverage in future crises such as the unrest in Ukraine. What is your point of view?**

I would certainly welcome consultation in terms of how to go forward. From my point of view, this is a situation that would merit discussion. Obviously, it is a very serious and important situation. We have a responsibility, ultimately, for those licenses, but the department does not have the authority to determine the destination of gas shipments. I think we have to think through, perhaps with the Congress, how we want to address that set of issues.

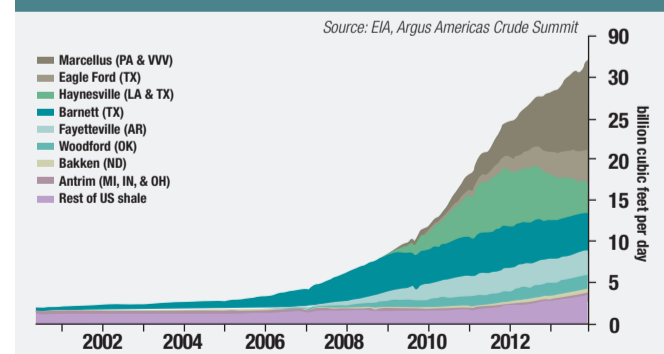
**Only one U.S. gas export terminal has a full operating license. The department has issued five additional conditional approvals for exports**

**TIGHT OIL PRODUCTION**

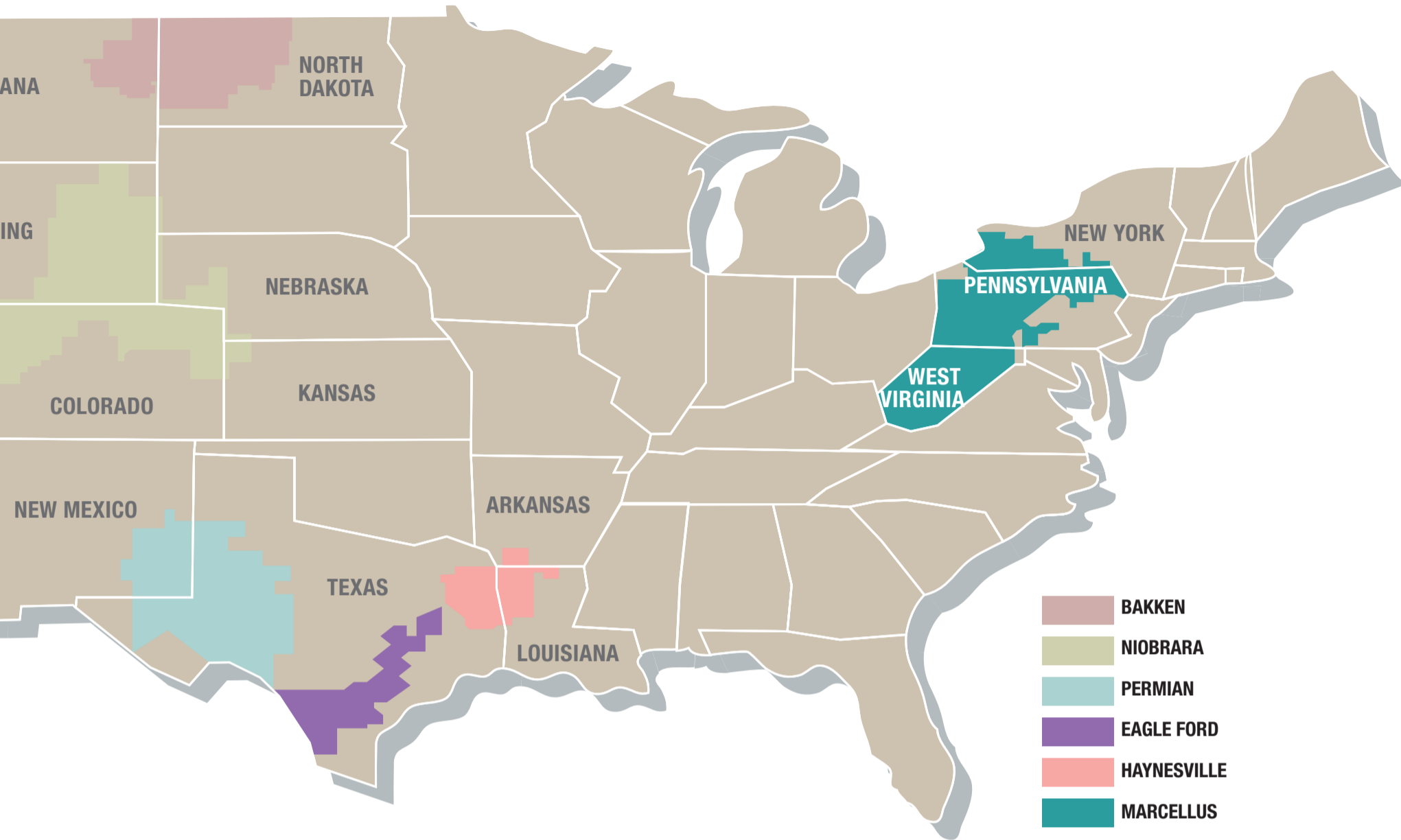


The rapid growth in the production of tight oil in the USA (divided into extraction basins in the chart) is related to factors such as the quality of the ground, the availability of technology and the range of the pipeline network.

**DRY SHALE GAS PRODUCTION**



Over the last ten years, the combination of horizontal drilling and hydraulic fracturing has allowed access to large volumes of shale gas, whose extraction would previously have been uneconomical.



- BAKKEN
- NIOBRARA
- PERMIAN
- EAGLE FORD
- HAYNESVILLE
- MARCELLUS

**to non-FTA countries, with two dozen other applications pending. Is there a potential step back reevaluating future projects?**

We obviously reevaluate. That is part of the job that we have to do in making the National Interest Determination. It may be that, at some point, we will need to refresh studies in terms of economic benefits. But that is all part of the continuous reevaluation. As we go forward, we are continuously evaluating and if we will have to update, we will.

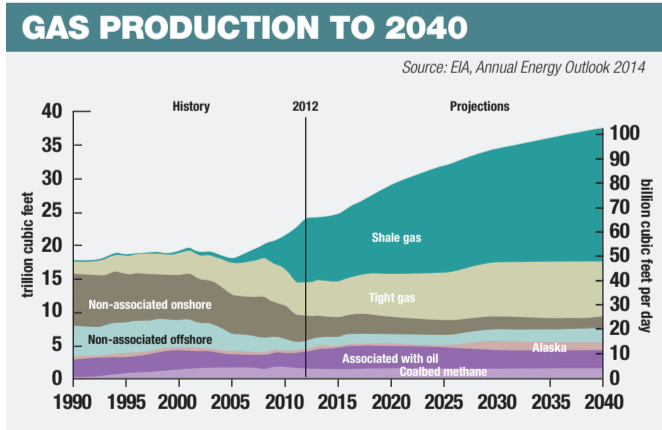
**Could the environmental footprint issue stop the unconventional activity in the U.S.?**

I don't see the environmental footprint issue ending U.S. unconventional activity, but it's certainly slowing down development of shale resources in some parts of the country.

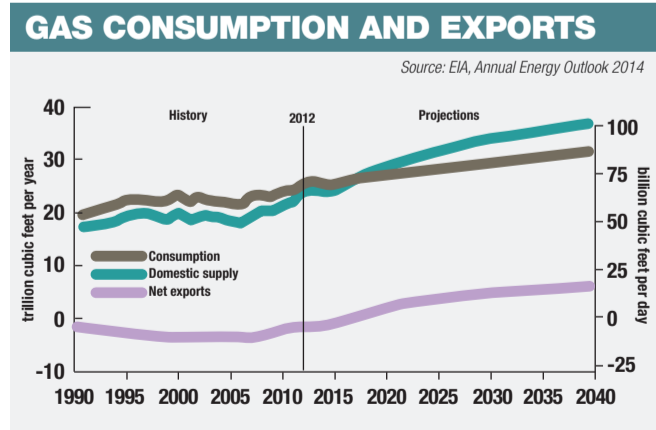
The fact is that different communities in the United States, and globally, will evaluate the economic benefits versus some environmental impacts differently. I do not see, at this stage, the environmental footprint issue ending unconventional activity, but it is certainly impacting it and the more we minimize it the better off we will all be.

**Can the industry do a better job to help some of that?**

The industry could be uniformly aggressive in pursuing best practices on well completion, surface water management and methane capture to improve air quality. There are a lot of things that the companies are doing and the more they pick up the pace the more beneficial it would be.



Over the next 25 years the production of shale gas will cover approximately half of the entire production of natural gas in the United States.



Projections claim that in 2040, the United States will be able to export gas, as it will be totally independent in terms of domestic consumption.



On [www.abo.net](http://www.abo.net), read other articles on the same topic by Molly Moore, Paul Betts, Edward Morse.

**Interview/Janusz Piechociński,**  
Deputy Prime Minister and Minister of the Economy



# Poland will keep its

The government is intent on moving forwards with shale gas in spite of the difficulties which have led to some international companies abandoning their exploration projects. Two laws are in the pipeline for attracting investors

**W**ith estimated reserves of shale gas of 346-768 billion cubic meters, Poland is one of the most promising countries in Europe. In spite of this, the enthusiasm of international companies for the possibility of developing this wealth of energy trapped in the Polish subsoil is waning on account of technical and regulatory problems. The government is trying to rush through two laws which will aim to create a favorable climate for foreign investors. If this unconventional gas is only a promise at the moment, the same cannot be said for coal, which represents one of the most valuable energy resources of the country,

by FABIO  
SQUILLANTE  
(AGENZIA NOVA)

**JANUSZ PIECHOCIŃSKI**

Janusz Piechociński is Polish Deputy Prime Minister and Minister of Economy. Since 1990, he has been a member of the Polish People Party (PSL). Deputy to the Sejm of 1st, 2nd, 4th, 6th and 7th term. Between 1991 and 1997, he was a member of the Sejm Finance and Budget Committee. In the years 1992-1993, he was the chair of the Extraordinary Committee for Preventing Pathology in the Economy. He was also deputy chair of the Economic Centre Reform Committee. In the years 2000-2001, he was a member of the National European Integration Board to the Prime Minister. In subsequent years, he was a member and chair of the Infrastructure Committee. At present, he is a member of Sejm Infrastructure Committee and the Innovation and New Technologies Committee.

# promise

but at the same time poses a problem. The Polish Deputy Prime Minister and Minister of the Economy, Janusz Piechociński, spoke about this and many other topics in an exclusive interview with *Oil*.

**Poland appears to be one of the most promising European countries as far as shale gas reserves are concerned, but some international companies (Marathon Oil, Talisman Energy and Exxon Mobil, Eni), abandoned all shale gas licenses they owned in Poland due to difficult geology and a tough regulatory environment. Will Poland keep on conducting its projects of shale gas development? What is the Polish government**

**doing to create a more suitable environment for foreign investments?**

Commencement of shale gas mining is extremely important for Poland in light of our long-standing policy aimed at diversifying energy sources and supply channels. Increased domestic supply will contribute to limiting our dependency on deliveries from a single source, allowing us to achieve, as a consequence, a higher level of energy security. Therefore, exploration of unconventional gas deposits remains one of the priorities of the Polish government's energy policy. At present, two draft acts that are of key importance for the exploration and mining industry are in their consultation phase. The first one is the Geology and Mining Law providing, inter alia, for the concession system, the transfer of →

# Onshore shale gas basins of Poland



## OIL&GAS



**Production:** 20 Thousand Barrels/Day  
**Reserves:** 157 Million Barrels  
 As of 31 December 2012  
**Consumption:** 538 Thousand Barrels/Day  
**Per Capita Consumption:** 3.13 Barrels  
**Imports:** 632 Thousand Barrels/Day  
**Exports:** 109 Thousand Barrels/Day



**Production:** 4.57 Billion Cubic Metres  
**Reserves:** 85 Billion Cubic Metres  
 As of 31 December 2012  
**Consumption:** 16.22 Billion Cubic Metres  
**Imports:** 11.98 Billion Cubic Metres

geological samples, and supervision over exploration and mining activities. The other is the Act on the special hydrocarbon tax, introducing two taxes imposed on the mining sector - a tax on positive cash flows and a tax on the value of the minerals mined. Both drafts underwent lengthy consultations with the investors and provide for a very friendly regulatory framework of a relatively low government take. All that will enable Poland to remain one of the most attractive European countries for investors from the mining industry.

**A report released by the Polish government in last November says coal will remain Poland's best energy option up to 2060. How can you integrate this policy with the limits recently imposed by the European Union to restrict its carbon emissions?**

The large share of coal in the Polish energy-mix constitutes one of the biggest energy challenges but also an opportunity for development. Extensive coal resources are an asset for Poland, ensuring the energy security of the country. Taking into account its considerable coal deposits, Poland is one of the most secure and energy independent countries in the EU. Poland believes that energy security can be highly assured based on using domestic resources to the greatest extent possible. The efficient use of the national potential of natural resources is an important factor of sustainable development of the country. We perceive implementation of clean coal technologies as an efficient way to reconcile targets of reduc-

ing the harmful impact of coal use on the environment with the objectives of energy security and competitiveness of the economy.

We also believe that improving energy efficiency of the whole national economy will be a key tool to achieving the targets of the energy and climate policy as it is the cheapest and most effective way to cut CO<sub>2</sub> emissions, increase energy security and maintain competitiveness of the industry. Nevertheless, Poland also carries on a policy aiming at the development of renewable energy sources (using first of all biomass and wind potentials). Apart from that there are plans concerning construction of nuclear power plants beyond 2020.

**Next July, Italy will assume back the EU presidency. What are the dossiers your government hopes to carry on in the political and economic fields?**

In my opinion, reindustrialization is currently the number one topic for Europe. There is no future for the European Union without industry. Therefore, in addition to concentrating on the climate and energy policy, we need to assign a higher priority to the industrial policy. The Commission's Communication on the policy framework for climate and energy in the period 2020–2030 that has been published recently is also of great importance for Poland. The European Commission's proposal will be the topic of the first discussions held by the European Council in March 2014. It has to be borne in mind, however, that it should be the balance between the three tiers: sustainable growth, energy security and competitiveness of the economy that should serve as a superior value while discussing the climate and energy framework until the year 2030. Moreover, European discussions should also attach sufficient significance to fostering economic growth and employment in Europe. In this regard, the European Commission's current proposal related to the climate and energy policy, posing a considerable threat to the competitiveness of the EU's market in the global context, is difficult to accept.

The imposition of additional restrictions on the industry may affect its global competitiveness, deteriorating the economic standing of the EU Member States and adversely impacting climate, for factories moved out of Europe will most likely emit more greenhouse gases than they do today.

**Poland represents a sort of European "economic miracle", thanks both to the reforms carried out and to a clever use of European funds.**

**Nevertheless, the government recently decided to seize \$51bn of privately run pension funds and transferred them back into state control. Could this move negatively influence the perception of the country among the investors?**

The provision of pensions is a constitutional obligation of the Polish state. Therefore, protection of the pension system and the interests of the insured, i.e., both current and future retirees, is one of the government's most important tasks.

In existence for ten years, the current system has turned out to be insufficiently effective and has generated an enormous public debt. The Polish government has performed a wide range of in-depth analyses, and has proposed adequate changes. These will be introduced, however, in a manner that will offer Polish citizens absolute freedom of decision and total security in this area.

It is worth highlighting that the government is not depriving anyone of anything. The citizens are free to choose whether to stay within the current system, or to take advantage of the new proposal. I do not consider our decision as potentially impacting, in an adverse manner, the way in which Poland is perceived by foreign investors. Poland is a stable and reliable country.

We are perceived in a very positive manner on the international scene. This is proven not only by dynamic and



continuing economic growth that we have been enjoying for over 20 years now despite numerous disruptions affecting global markets, but also by international rankings. Poland's efforts aimed at facilitating business activity have been appreciated by the World Bank. We have moved another 10 places up in the "Doing Business" list, ranking 45th. All that places Poland among the countries that are the quickest in changing their economic environment and in making it more business friendly. Poland has ranked just behind China and the United States in the FDI Benchmark ranking, as the world's third most attractive country for producers. Poland has also been appreciated in the last report assessing the investment-related attractiveness of Europe, drawn up by Ernst & Young in 2013. Foreign investors have named our country as by far the best location for new projects in Central and Eastern Europe. According to the report, over the next three years Poland will also become Europe's second - just after Germany - most attractive market for locating investments.

It is the mission of my ministry to create the conditions for conducting business activity that will be the most favorable in all of Europe. Therefore, the Ministry of Economy has come up with a number of instruments supporting investors in Poland. We have implemented new regulations and incentives for the SME sector, doing away, inter alia, with numerous barriers by means of continuous deregulation, and by offering an opportunity to set up one's own business online and free of charge. Businesses expect stable frameworks for operating on the Polish market, and require minimal administrative burdens. Much can be done with this respect on the EU level as well, since nearly 70 percent of legislative barriers are of EU origin. Hence, as Commissioner Antonio

Tajani has noticed, deregulation of the EU's legislation is necessary as well.

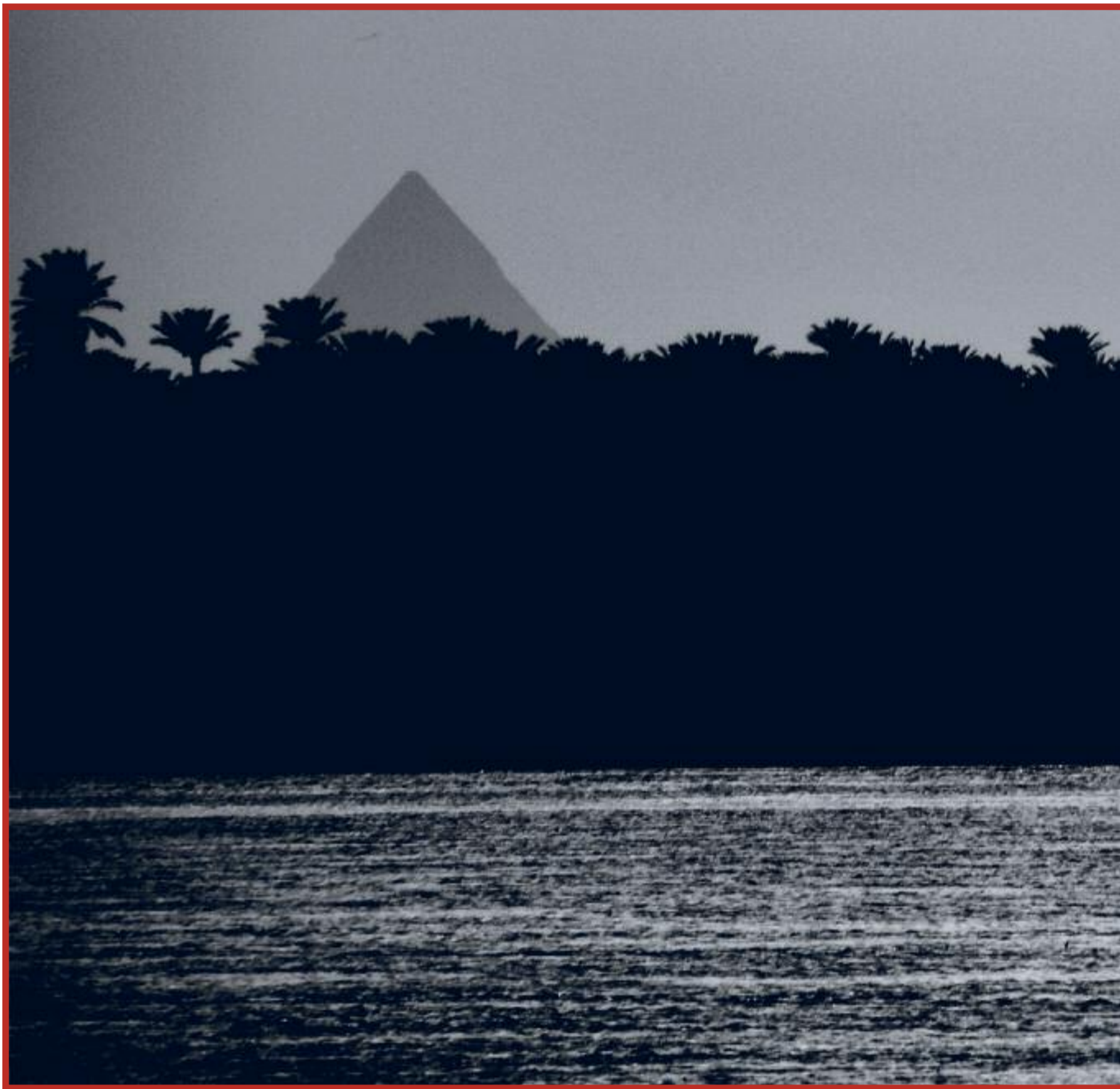
**Is Poland still expected to adopt the Euro, in spite of the crisis that in recent years brought most European Countries to recession? And when will Warsaw abandon the Zloty?**

While signing the accession treaty, Poland undertook to adopt the Euro as well. However, introduction of the common currency is neither possible nor advantageous for us today. We are now at the stage of adapting our economy to the requirements of the Euro zone, e.g., those related to the budget deficit. The current exchange rate fluctuations would have to be eliminated prior to our accession to the Euro zone as well.

In addition, a number of uncertain factors may be observed today. The Euro zone is in crisis, and the high exchange rate of the Euro against other world currencies adversely affects exports to third countries. The floating exchange rate of the Zloty, in turn, boosts the competitiveness of Polish exports, which cannot be underestimated as a factor stimulating economic growth in times of economic depression. Let me only remind you that last year's increase of Poland's total exports was considerable and exceeded 6.5 percent.

**AN ECONOMIC MIRACLE**

**Over the last twenty years, the economy has been growing steadily in Poland, in spite of the crisis weighing on global markets. It currently ranks 3rd in the world, after the U.S. and China for direct foreign investments. The photo shows the financial area of Warsaw.**



**Feature/**Egypt searches for foreign companies to take part in the new oil auction

# Chasing investments

The Deputy Minister, Sherif Sousa, provides reassurances: “We are introducing reforms that bring our energy standards into line with those of the West and we are repaying our debts”



**SHERIF SOUSA**

Sherif Sousa is the First Under Secretary for Gas Affairs at the Petroleum Ministry. He has had a distinguished career in the energy industry, as chairman of Egyptian Natural Gas Holding Company, chairman and managing director of Badr Petroleum Company, and of General Petroleum Company (GPC). Dr. Sousa holds degrees in Geophysics, Strategic Studies, Reservoir Geophysics, and Applied Geophysics.



**E**

by RITA  
KIRBY

gypt is inviting foreign countries to place a bet on its energy potential, by taking part in a new auction for the allocation, in 2014, of 22 licenses for the exploration and development of its gas and oil reserves.

Seeking to convince potential investors, Sherif Sousa, First Undersecretary for Gas Affairs at the Egypt Petroleum Ministry, is taking part in a roadshow in the United States.

Sousa explains the terms of the new auction in detail, giving reassurances about the stability of the country and stressing that the reforms introduced are bringing energy standards into line with those of the West.

**Could Egypt really become a game changer in the energy industry in spite of the problems facing the country?**

We are aware of the numerous challenges that lie ahead of us. The best way of dealing with them is to be able to rely on the support of our friends.

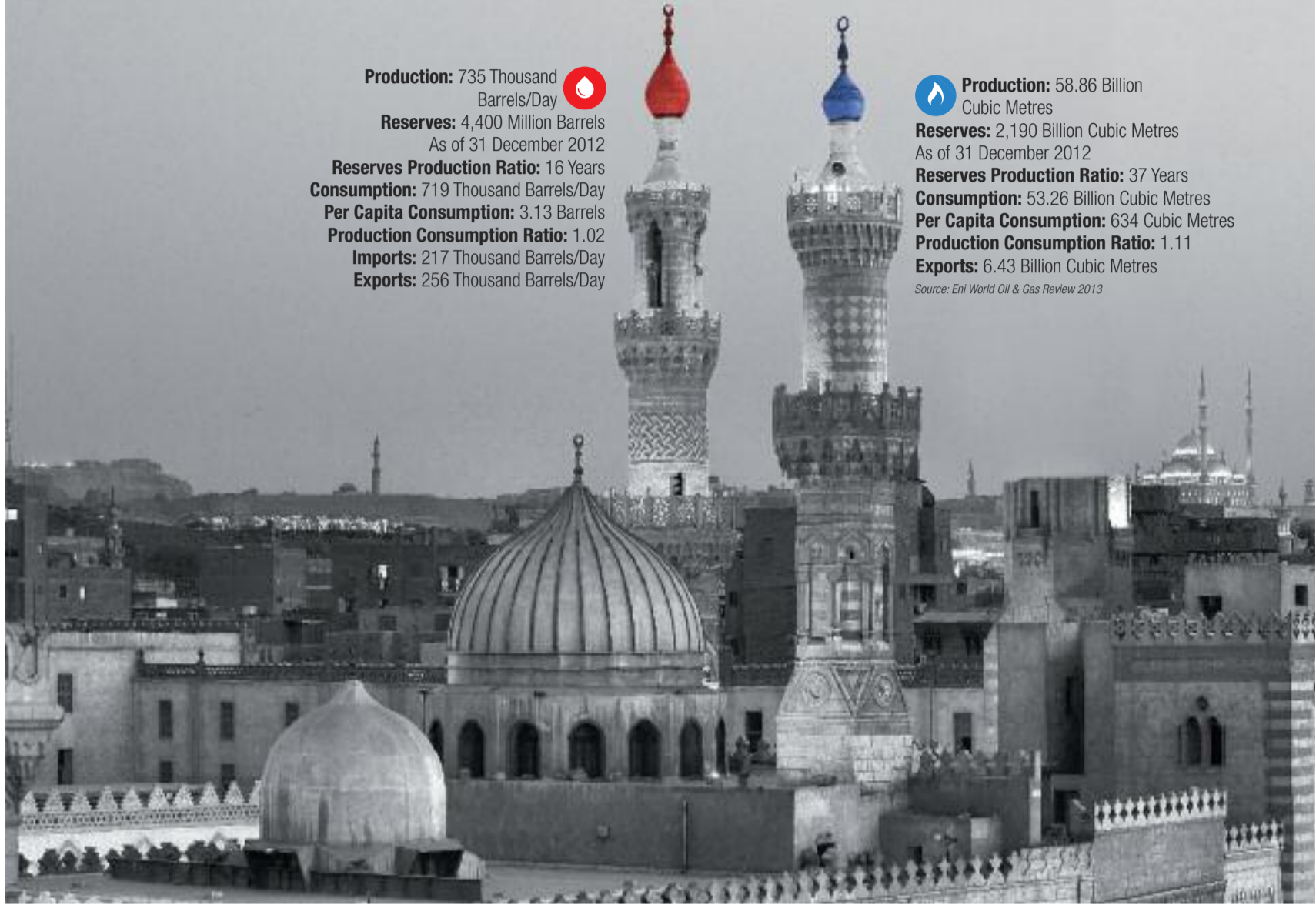
We wish to attract new companies, especially American ones, and we hope that the response to the auction launched by General Petroleum Corporation (Egpc) and Natural Gas Holding Company (Egas) will be positive.


**Where are the new auction blocks located?**

The concessions are for the areas of the Suez Canal, the Western Egyptian Desert, the Mediterranean Sea and the Nile Delta.



# Oil&Gas



**Production:** 735 Thousand Barrels/Day   
**Reserves:** 4,400 Million Barrels  
 As of 31 December 2012  
**Reserves Production Ratio:** 16 Years  
**Consumption:** 719 Thousand Barrels/Day  
**Per Capita Consumption:** 3.13 Barrels  
**Production Consumption Ratio:** 1.02  
**Imports:** 217 Thousand Barrels/Day  
**Exports:** 256 Thousand Barrels/Day

**Production:** 58.86 Billion Cubic Metres   
**Reserves:** 2,190 Billion Cubic Metres  
 As of 31 December 2012  
**Reserves Production Ratio:** 37 Years  
**Consumption:** 53.26 Billion Cubic Metres  
**Per Capita Consumption:** 634 Cubic Metres  
**Production Consumption Ratio:** 1.11  
**Exports:** 6.43 Billion Cubic Metres  
Source: Eni World Oil & Gas Review 2013

**In the past, prospecting companies were reluctant to search for gas reserves in Egyptian waters because the amount paid by the government barely covered investment costs.**

The contractual model that we are offering will allow investors to share production with Egypt. It involves a formula that many companies consider to be more favorable than the profit-sharing model. The objective is to sell 22 blocks in 2014 and the closing date for receiving offers is May 19, 2014.

**How are the contractual terms that you are ready to offer more advantageous?**

We are very flexible. We are open to different options and we are even willing to discuss new proposals for the actual terms of the agreements for the concessions, especially for non-conventional sources, shale gas and gas oil.

**Is this new auction focusing on gas?**

Egypt is currently the second largest producer of natural gas in Africa, with over 77 trillion cubic feet of proven reserves. We want to exploit this immense resource. We would like there to be large-scale participation in the gas auction, taking into consideration the vast potential of the Nile basin.



On [www.abo.net](http://www.abo.net), read other articles on the same topic by Daniel Atzori, Uri Dadush.

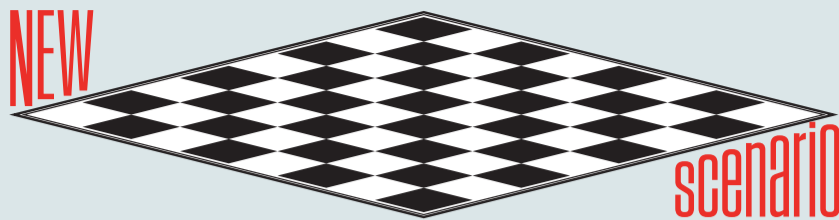
**According to U.S. geological surveys, the Nile basin could contain 200 trillion cubic feet of gas reserves, which could technically be recovered, but investors are concerned about political**

**instability in Egypt. How do you answer these concerns?**

I believe that it is wrong to talk about political instability in Egypt these days. We are outlining a road map and obviously the transition is complex. We have begun by approving the new Constitution and, in two or three months, we will have held presidential and parliamentary elections. We are moving towards a modern Egypt.

**The fears linked to the supply of Egyptian gas and also to the ability of the government to repay its debts remain. British Gas recently announced a cut in its supplies, which have been diverted towards domestic consumption, while Eni, for example, has had to close a plant in Damietta for several months because of a shortage of gas. The Texan Apache Corporation has sold off some of its Egyptian assets to the Chinese company Sinopec because it felt its exposure in Egypt was too big. How will you honor your commitments?**

We are paying off our debts. We have already repaid 20 percent of what we owe and we will continue to pay off our debts during the course of the year. I think that we will be able to honor all our commitments. There are problems, but it is also true that many companies believe in the progress we are making. Important discoveries continue to be made, like the recent BP one, which will supply the domestic market.



**Outlook/**The present and future solutions that will disrupt the energy status quo

# Allies, game changers and category killers



Over the next ten years, the energy market will undergo profound transformations, driven by revolutionary technologies that will significantly shift the balance between importing and exporting countries

**T**he dominance of petroleum as a source of energy has lasted almost a century and most analysts expect that it will continue. Oil, gas and coal are each expected to account for about a quarter of the global energy market in 2030.

by MOISÉS  
NAÍM

Yet, while current trends point to the persistence of this dominance, it is equally clear that there are many pow-

erful forces at work that can disrupt the status quo. Climate change, for example, may create unprecedented incentives to alter the production and use of energy. New technologies that can “change everything” are always a possibility. And geopolitical surprises, as transformational as they are hard to anticipate, have long been a feature of energy markets.

#### TECHNOLOGICAL INNOVATIONS

The technological innovations that are currently attracting most of the ef-

forts fall into three broad areas. The first is the search for alternatives that could be defined as allies of the current market structure, since they do not seek to disrupt current arrangements and institutions, but rather boost the efficiency of hydrocarbon usage and ameliorate its undesirable side-effects, thus prolonging its life as an indispensable resource. A second set of efforts aims at finding energy sources, new production techniques and, very importantly, creating energy products that are friendlier to the environment.

These efforts can yield game changers that could significantly disrupt existing patterns of demand and supply. Finally, a third area of research is aimed at finding a radically different energy source that could actually render the use of petroleum obsolete; this is what can be called a category killer.

Obviously an innovation that can be considered a game changer will have different effects from one that facilitates the workings of the current system. Innovations in each of these three areas will have different con-



The improved Internal Combustion Engine (ICE) will make it possible to double the fuel efficiency of cars by 2025. The ICE is the best example of an **ALLY TECHNOLOGY**.



sequences—many of which are impossible to anticipate. But some of their impacts on the current energy market structure, on oil exporting countries or on those that are dependent on foreign sources of energy are possible to envision at a very general level and thus give us a glimpse of their likely ripple effects.

### ALLIES

Perhaps the best example of this type of technological innovation is the improved Internal Combustion Engine, ICE, which will make it possible for automakers to double petroleum use efficiency of cars, from a current 27 miles per gallon to some 55 miles per gallon by 2025.

This development will maintain petroleum as the main source of energy, notably in the transport sector. It will extend the life of existing petroleum reserves and promote stability in the existing markets, by allowing traditional petroleum producers to remain important actors in the global energy scene. The main beneficiaries will be the producers of light, high quality oil in the Middle East, while countries with large heavy or unconventional oil reserves, such as Canada or Venezuela, will find it harder to retain their traditional market share due to the high cost of upgrading their reserves. Countries like the U.S. and Japan, that have limited traditional oil reserves but whose consumers have the capacity to quickly switch and adopt

early and massively to new products that consume less fossil fuel, are also bound to benefit greatly.

### GAME CHANGERS

Technological innovations that promote the development of cleaner alternatives to oil such as hydrofracking, the result of the perseverant and pioneering work of George Mitchell, are making accessible the vast, previously unrecoverable natural gas resources of North America. Particularly in the U.S., there is a boom in the development of this alternative to petroleum and its impact on the global energy landscape is already being felt. As is well known, the world's largest petroleum importer, the U.S., is rapidly replacing imported oil with domestic production of natural gas, an environmentally friendlier energy source. This is having a large impact on the availability of petroleum for other markets such as China and Europe, pressuring global oil prices downwards. The development of shale gas in China and in some European and Latin American countries could further contribute to the displacement of petroleum as a source of energy in those countries. Naturally, countries such as the U.S., China, Mexico and Argentina, which can develop their domestic natural gas resources, increasing their energy security and decreasing their dependence on petroleum, will greatly benefit. Once again, however, producers of lower grade or more ex-

pensive petroleum, such as Canada, Russia and Venezuela, will face a less benevolent marketplace than the booming one they enjoyed in the first decade of this century.

There are, of course, other innovative alternatives to fossil fuels, which, although in a less advanced stage of development, have already shown to be economically viable under the right conditions. Solar and wind energy are a good example. Initially, the exag-

gerated promises of governments and companies overstated the readiness of these sources, which eventually led to widespread disappointment. Now, however, a more sober and realistic set of expectations has emerged and more economically sustainable approaches are being tested.

Wind and solar energy are already capturing an increasing share of energy production in Europe and the U.S. In America, the solar market has

Hydrofracking, one of the main technologies regarded as **GAME CHANGERS**, has made accessible the vast, previously unrecoverable natural gas resources of North America.



grown by 40 percent since 2009, thanks to the establishment of more efficient economic incentives, also being tried in Europe and China. Major challenges and obstacles still exist, but countries where favorable climatic conditions coexist with sound and sustainable government policies that provide strong incentives and effective regulation are poised to greatly benefit from innovations in this field. Not just large energy consumers such as China but also small consumers with limited or no hydrocarbon resources of their own, like the Central African or Caribbean countries, will come ahead as a result. Another innovation that provides a good illustration of a potential game changer is clean coal. In May 2011, draft legislation was introduced before the U.S. Congress, requiring the inclusion of coal-derived fuel at certain volumes in aviation, motor vehicle, home heating and boiler fuels. The bill seeks to promote the use of Coal to Liquids technology, CTL, which according to the document presented to the U.S. Congress, is already economically viable. The fact that the U.S., China and Russia possess the largest coal reserves in the world and are also among the largest energy consumers could make Clean Coal technologies a substantial game changer—if the promises of its sponsors prove to be valid.

### CATEGORY KILLERS

This type of technological innovation would create more efficient, more economic and cleaner energy sources than oil, thus making the use of fossil fuels a historic relic. One of these



potential category killers is fusion energy, through laser bombardment. This is being hailed as a major breakthrough by scientists, for its ability to generate more energy than the one used to put the process in motion. The scientific team at the federally-funded Livermore National laboratory in California revealed, in February 2014, that they had conducted experiments using a laser to “compress a pellet of fuel and generate a reaction in which more energy came out of the fuel core than went into it,” ac-

ording to a report by the Washington Post. The lead author of the study, Physicist Omar Hurricane, said: “We’re closer than anyone’s gotten before.”

### WHAT IS NEXT?

In the coming decade the energy market is more likely to be transformed by disruptive innovations than was the case in the past twenty years. The demand for such innovations—and therefore the incentives to create these new technologies—is clearly there. The supply of innovations to satisfy the enlarged demand will also be there, especially as non-traditional players, even outsiders to the oil industry, are actively investing in new energy technologies. Perhaps the most sobering example of how outsiders can upend the oil business is that the most disruptive innovation of recent times—fracking—did not originate in the R and D labs of the oil industry majors but was the brainchild of a dogged inventor with a strong entrepreneurial drive. In fact, the dominant players in the energy markets have been able to thrive and sustain their dominance without making R and D the priority that it is in other industries. Guy Chazan, the Energy editor of the *Financial Times* has noted that “according to the Breakthrough Institute, a California-based think-tank, US energy firms reinvest less than 1 per cent of revenues in research, development. In contrast, sectors such as IT, semiconductors and pharmaceuticals typically reinvest 15 to 20 per cent of turnover in R&D and product de-



Fusion energy, obtained through laser bombardment, is one of the potential “**OIL KILLERS**”. However, this technology is still at a rather embryonic stage.

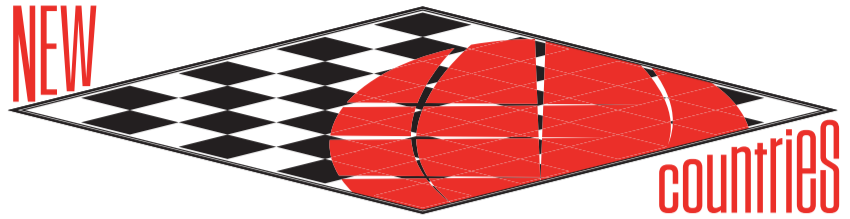
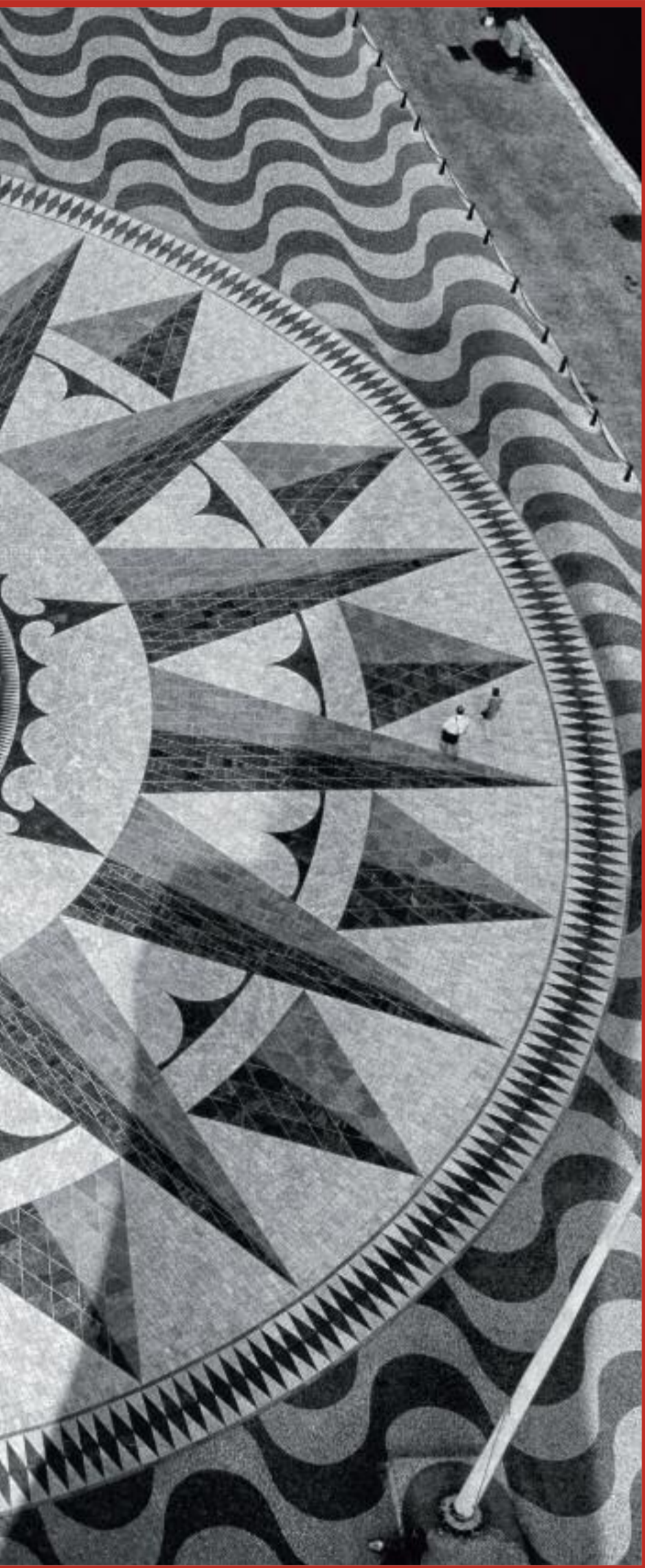
velopment.” Chazan also cites a study by the Boston Consulting Group (BCG) that found that only 64 per cent of energy companies rank R and D as a priority a figure. That stands in sharp contrast with the automotive sector, where 91 per cent of companies make it a priority, or for companies in media and entertainment, where 85 per cent do so.

We have entered a new era when innovations in energy production and use will be in high demand. And where there is demand, supply always emerges. ■

Moisés Naim is a member of the editorial board of OIL. He is a Senior Associate at the Carnegie Endowment in Washington DC, and recently published *The End of Power: From Boardrooms to Battlefields and Churches to States, Why Being in Charge isn't What it Used to Be* (Basic Books; 2013).







**Energy/**How the global energy map is being redrawn

# Orientation for a fast-changing energy world

The main importing countries are becoming exporters, while the exporting countries are establishing themselves as drivers of growth for global demand. New resources, like light tight oil, are having a profound effect on the markets

**M**any long-held tenets of the energy sector are being rewritten. Major importers are becoming exporters, while countries long-defined as major energy exporters are also becoming leading centres of global demand growth. The right combination of policies and technologies is proving that the links between economic growth, energy demand and energy-related CO<sub>2</sub> emissions can be weakened. And the rise of unconventional oil and gas and renewables is transforming our understanding of the distribution of the world's energy resources.

The center of gravity of energy demand is switching decisively to emerging economies, particularly China, India and the Middle East. Their growth will drive global en-

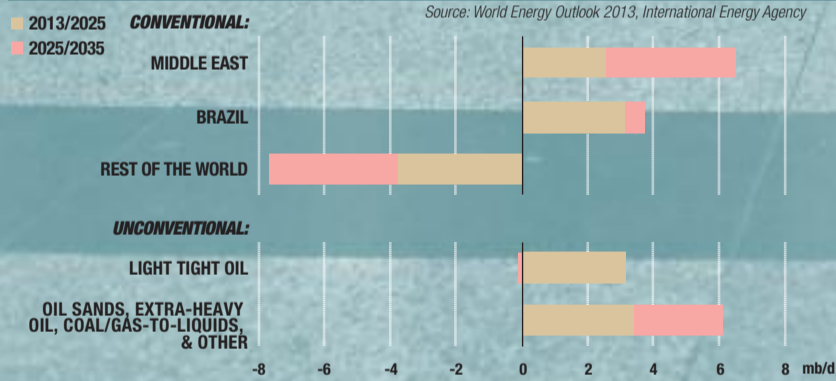
ergy use one-third higher between 2011 and 2035. In the New Policies Scenario, the central scenario of IEA *World Energy Outlook-2013*, China dominates the picture within Asia, before India takes over from 2020 as the principal engine of growth. Southeast Asia likewise emerges as an expanding demand center. China is about to become the largest oil-importing country; India is set to become the largest importer of coal by the early 2020s. Meanwhile the United States moves steadily towards meeting all of its energy needs from domestic resources by 2035. Together, such changes represent a re-orientation of energy trade from the Atlantic basin to the Asia-Pacific region.

Against the backdrop of this changing map, some of the key indicators of the health of the global energy system remain as worrying as ever. Despite some encouraging signs – particularly on energy efficiency →



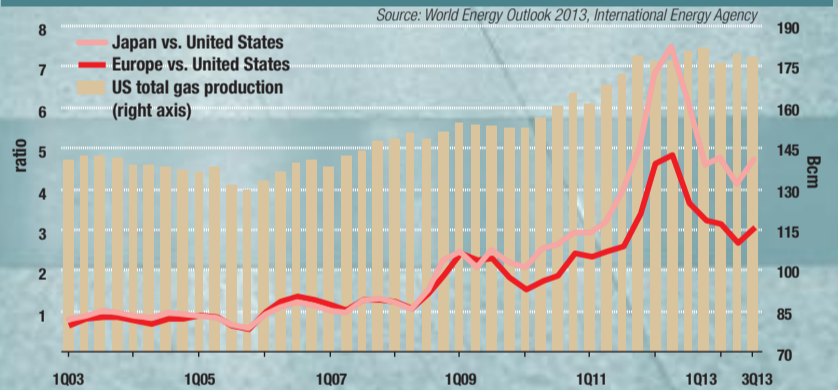
# How energy world is changing

## 1 - GLOBAL OIL PRODUCTION GROWTH



Projections on Middle East oil production indicate an increase of over 6 million bpd between 2020 and 2035, equal to the entire total growth of oil; production in other regions will fall by 1 million bpd.

## 2 - THE GAP IN GAS PRICES



In mid-2012, the price of gas imported in Europe reached a level more than five times higher than that in the United States, while Japanese prices were eight times higher.

– and some new policies, energy-related CO<sub>2</sub> emissions continue to rise at a rate that risks a disastrous warming of our planet. Fossil-fuel subsidies to end-users – estimated to cost \$544 billion worldwide in 2012 – continue to distort energy markets, burden government budgets and encourage wasteful energy use. High oil prices, persistent differences in gas and electricity prices between regions and rising energy import bills in many countries are focusing ever more attention on the relationship between energy and the broader economy. And some 1.3 billion people, nearly half of them in Africa, still lack access to

electricity, the most basic form of energy security.

### TWO CHAPTERS TO THE OIL PRODUCTION STORY

As the global energy map continues to be redrawn by unconventional oil and gas resources, the spotlight has turned from shale gas to light tight oil (LTO). LTO production in the United States has gone from close to zero in 2005 to 2.3 mb/d in mid-2013, equal to a quarter of total US production and almost 3 percent of world oil production. LTO is crude oil contained within low-permeability geological formations, often

shale or tight sandstone. Producing LTO requires the same hydraulic fracturing and, often, the same horizontal well-drilling technology used in the production of shale gas. Indeed, it is advances in shale-gas drilling techniques that have paved the way for the commercial exploitation of LTO, long thought to be too expensive to produce. This surge in output has had a major impact on global oil markets, dramatically reducing the US's need to import oil and lowering the call on oil produced by OPEC. LTO will continue to affect global oil-market dynamics, though the long-term impact should not be overstated.

LTO resources in the United States are large and are expected to support further production increases in the coming years: in the central scenario of our latest World Energy Outlook, US LTO output reaches a plateau of about 4.3 mb/d by 2025, dipping slightly by 2035. Canada also makes a small but growing contribution. In the rest of the world, most countries struggle to replicate the North American experience: LTO production in 2035 reaches 450 kb/d in Russia, 220 kb/d in Argentina and 210 kb/d in China, but elsewhere stays in the tens of thousands of barrels per day. Regulatory barriers and the absence in most cases of a





double. But the call on Middle East oil recovers after 2020 as the decline in conventional crude oil output in the majority of countries in the rest of the world outpaces the combined expansion of output from LTO, Canadian oil sands, deepwater fields in Brazil and natural gas liquids worldwide. In total, Middle East oil production is projected to rise by over 6 mb/d between 2020 and 2035, meeting all of the growth in global oil; output in other regions declines by 1 mb/d. World oil production in total is projected to climb from 87 mb/d in 2012 to 98 mb/d in 2035, with OPEC countries as a whole providing over two-thirds of the increase and their share of global production rising from 43 percent to 46 percent.

This highlights the continued importance of investment in the upstream oil industry, particularly in the Middle East, to ensure the long-term security of the oil supply. The major resources holders in the region, notably Saudi Arabia, could in principle increase crude oil production faster than we project: they unquestionably have the resources and the financial and technical means to do so. But short-term market-management policies, long-term depletion policies and, in some countries, resource nationalism, are likely to hold back investment in the future, as they have in recent decades. The risk, as always, is that investment across the region falls short of what is required to meet demand, which could push prices sharply higher. On the demand side, the onus remains on consuming countries to step up efforts to promote more efficient oil use and promote switching to more sustainable forms of energy, notably in the transport sector. Vehicles powered by electricity and natural gas could help to displace oil use, though scaling up their deployment hinges on the availability of supporting infrastructure and, in some cases, further cost reductions.

strongly competitive and innovative upstream environment tend to keep production costs too high to attract investment. Globally, its production is projected to peak at 5.9 mb/d around 2030 before falling to 5.6 mb/d in 2035.

The rise of LTO production is expected to crimp demand for Middle East oil over the rest of the current decade, even though the region remains the only large source of relatively low-cost oil. We project total Middle East oil production to barely increase between now and 2020; Iraq is the only country in the region that will see any growth in output; its production should almost

#### REGIONAL GAS MARKETS BECOME MORE INTERCONNECTED BUT PRICE-DIFFERENTIALS SET TO PERSIST

Whatever the policy landscape for the next quarter of a century, natural gas is set to grow in importance globally thanks to its widespread availability, competitive supply costs and environmental advantages. Total remaining technically recoverable resources of gas stand at 810 tcm, equivalent to more than 230 years of production at current rates, and the size of unconventional gas resources has been revised upwards in the last

few years thanks to continuous update of shale formations all over the world.

Over the last few years, regional gas markets have gone through profound changes, as the booming production of shale gas has resulted in falling prices in North America while sustained oil prices have determined rising prices in Europe and Far East, where prices remain largely set by oil-indexation mechanisms. By mid-2012, the price of gas imported into Europe reached a level more than five times higher than in the United States, while Japanese prices were an astonishing eight times higher. US prices have since rebounded, but remain significantly lower than Japanese and European ones.

These price differences are con-

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The USA does not currently have the necessary infrastructures to export gas outside of North America, but this situation will change before the end of the decade

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tributing to significant differences in electricity prices across regions, as gas is often an important fuel-input to power generation, and they are having a significant impact on the competitiveness of energy-intensive industry and economies more generally. It is no wonder energy costs have become a hot political issue – especially in Europe and Japan.

Is this unprecedented divergence in gas prices across the major regional markets a temporary phenomenon or will it persist over the longer term? Some degree of price convergence seems likely as physical interconnections between regions expand and gas-pricing mechanisms converge. For now, the United States has no facilities to export gas to countries outside of North America, but this will change before the end of the current decade as new liquefied natural gas (LNG) terminals already under construction are brought on line, allowing surplus gas to be exported. New pipeline connections between Europe, the Middle East and Central and Eastern Asia will also facilitate arbitrage across regional markets. In addition, we are likely to see greater reliance over time outside of North America on pricing mechanisms that reflect the supply-demand balance for gas itself, rather than the price of oil. In Europe, the clear trend is towards more widespread adoption of hub-

based pricing, more use of spot trading and shorter duration of long-term contracts. In the Asia-Pacific region, too, alternatives to oil indexation and more flexible trading arrangements are expected to gain ground, and second thoughts on Japan's nuclear energy policy might have a significant impact on the region's gas consumption and prices. Unconventional gas is set to play a growing role in natural gas markets, potentially accounting for almost 50 percent of the increase in global gas production to 2035, with new countries, notably China, Australia and Argentina, emerging as important producers.

However, in those countries there remains uncertainty over the quality of the resources, their production costs and, in some cases, public acceptance of their development. Despite these new sources of gas, and the emergence of new linkages between regional gas markets, the gas-price differential, though narrowing, will still be significant by 2035, in part because of the high cost of transporting gas over long distances between ex-

porting and importing regions.

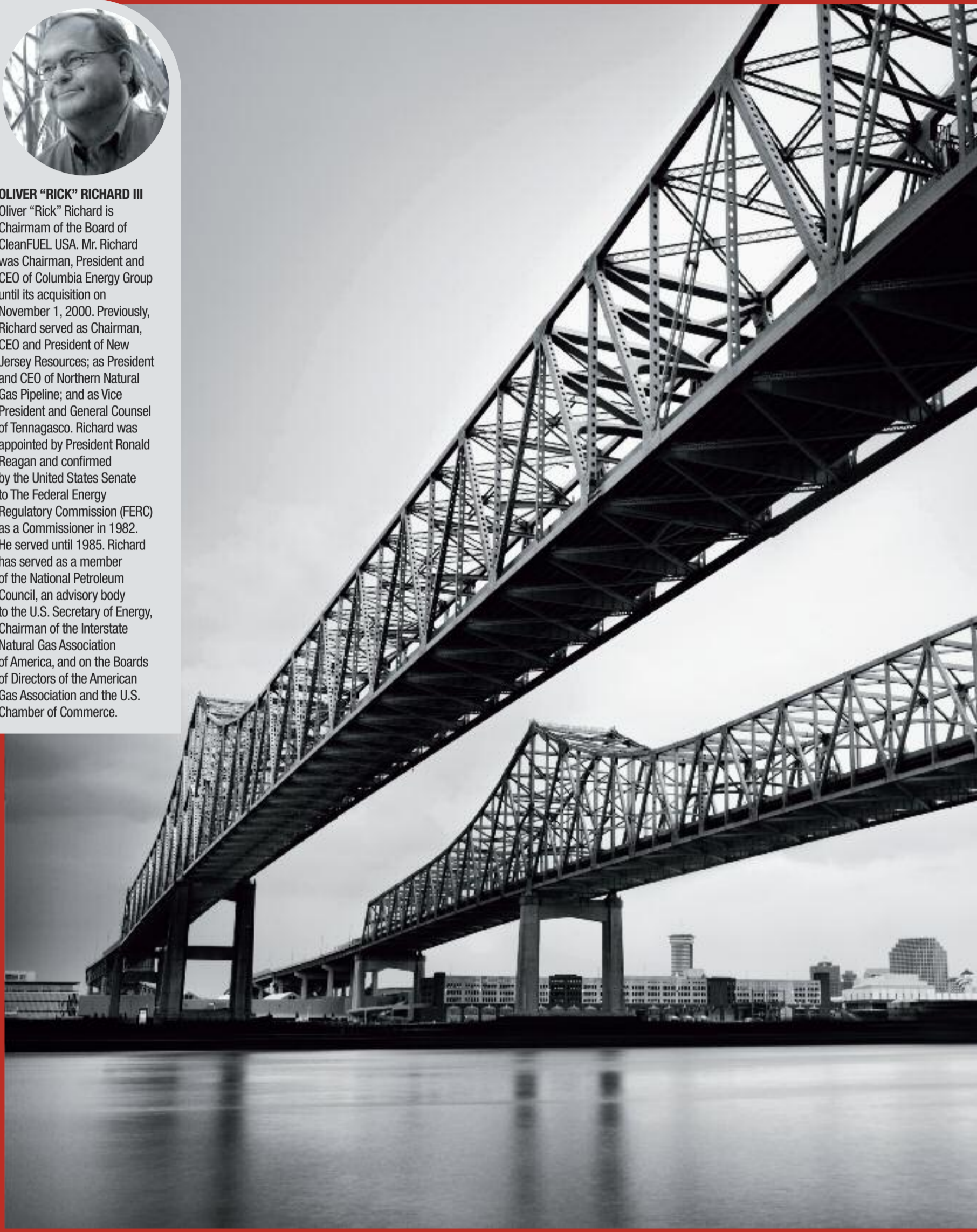
What emerges from this picture is that the structural energy price differentials are set to have far-reaching consequences on regional industrial competitiveness, with important knock-on effects for the rest of the economy, in terms of investment shifting, trade of goods and income prospects. Awareness of these changing dynamics is fundamental for decision makers attempting to reconcile economic, energy and environmental objectives. Those who anticipate global energy developments successfully can derive an advantage, while those who fail to do so risk making poor policy and investment decisions. ■

Fatih Birol is the Chief Economist at the International Energy Agency in Paris. He is responsible for the IEA's flagship *World Energy Outlook* publication. He is also the founder and chair of the IEA Energy Business Council.



**OLIVER "RICK" RICHARD III**

Oliver "Rick" Richard is Chairmam of the Board of CleanFUEL USA. Mr. Richard was Chairman, President and CEO of Columbia Energy Group until its acquisition on November 1, 2000. Previously, Richard served as Chairman, CEO and President of New Jersey Resources; as President and CEO of Northern Natural Gas Pipeline; and as Vice President and General Counsel of Tennagasco. Richard was appointed by President Ronald Reagan and confirmed by the United States Senate to The Federal Energy Regulatory Commission (FERC) as a Commissioner in 1982. He served until 1985. Richard has served as a member of the National Petroleum Council, an advisory body to the U.S. Secretary of Energy, Chairman of the Interstate Natural Gas Association of America, and on the Boards of Directors of the American Gas Association and the U.S. Chamber of Commerce.





**U.S./** Oliver Richard III, Commissioner  
of the Federal Energy Regulatory Commission

# A great revolution

Thanks to fracking, the United States is about to achieve energy independence and plans to export oil in the future, a situation that was unimaginable in the last 25 years. New energy technologies are also transforming cities and communities, as evidenced by events in Louisiana

**N**ew energy technology is not only revolutionizing the energy industry, it is transforming the towns and communities that support the industry. Oliver “Rick” Richard III has been at the forefront of changes in the industry for

more than three decades as a commissioner on the Federal Energy Regulatory Commission, the CEO of a Fortune 500 traditional energy company and now as Chairman of CleanFuelUSA, the first company in the U.S. to develop liquid propane fuel injection systems. In an interview with Oil, Richard discusses the revolution in the energy industry and what that means for his southwestern Louisiana hometown of Lake Charles, which is on track to become the LNG capital of the U.S. and one of the largest LNG centers in the world.

**What are the most dramatic changes you’ve seen in the oil and gas business over the past two decades?**

The biggest, of course, is fracking. We did a National Petroleum Council study back in 1990. We were supposed to have 3 percent unconventional gas production. Well, we’re up to almost 50 percent now. So we completely misread that. We had a lot of people from the majors, we had a production

group, a transmission group, and a policy group, and we just missed the boat. It’s just incredible what fracking has done for the United States as far as oil and gas.

**Why do you think we didn’t see that coming? Did the technology just change more rapidly than anybody thought it would?**

I think there were people talking about it, but it just wasn’t at the forefront at the time. People were pretty busy doing conventional drilling. And then the Mitchell Energy & Development Corporation in Dallas started figuring it out. They’re a very creative company, and they figured out that horizontal drilling along with fracking is a really clever idea. It was a small company that actually pursued it and made it grow.

**How has this affected how the industry is doing business?**

It’s a completely different world turned upside down in my opinion. All the relationships that were pretty much one-directional – at least in the North American version – have been completely changed because of the flood of oil and natural gas coming into the system. That’s why we have the big emphasis on exports for mainly natural gas (but crude is out there) policy-wise. We’re seeing pipelines that are being turned around to go bi-directional in different areas,—the Cheniere Creole Trail Pipeline is a good example. It

can go bi-directional, whereas in the past, you put gas in a pipeline, you shipped it east to west, or west to east. Now they’re moving some of the old crude lines into natural gas pipelines because of shale. It’s just been a completely big turnaround in relationships.

And then, in the oil business, there is the tremendous growth in trains, with some of the problems that are occurring about safety which is being looked into by everybody. Most oil moved through pipelines and trucks, and look where it is now with train movement. So you’re seeing all kind of transportation relationships that are completely different than before. You have new parties that are getting into the oil and gas business that perhaps weren’t big players back before the shale revolution.

**Do you think that the industry is adapting quickly enough, both on the technology front, and the really important safety front?**

I don’t think they’re behind on the technical side. You could almost argue it’s more the regulatory hurdles that are holding up some future progress. But in saying that, it’s not all bad government at all. People doing a lot of fracking are starting to understand they need to talk to the communities, talk to the local governments. Train companies are needing to talk to the government and local communities to figure out →

what's the safest way to move these newfound large pockets of oil and gas. So I think it's a combination of technology moving along fine, and now the communication that is key in whatever business – whether it's extraction or transportation – needs to be fairly developed with the governments – federal, state and local.

**Do you think that this benefits, in particular, small companies over large ones, or is everybody benefiting from the change you're seeing now?**

There are a lot of small companies involved. Just to use the examples across the United States, where smaller companies have gotten into it at first, and then larger companies move on in, and move out as well. I think it's probably well played between the two. I mentioned Mitchell, who started the fracking, horizontal drilling near Dallas 25 years ago. They were a medium-sized company which turned into a very large company. Your MLPs, which is a phenomenon--mass limited partnerships--have formed to move more quickly on transportation issues. Of course, there are always the innovators, Mitchell being one, that once they figure out something they can grow very quickly.

**And where have these changes, do you think, placed the U.S. on the world stage in energy?**

I think we're in a wonderful position. When I was working in the Senate in 1978, it was after the '73 embargo, and then the Iranian crisis of 1979--it was all about energy independence. And for years and years and years, we tried to figure out how to do that. One of my favorite quotes was Winston Churchill, when he talked about Parliament not moving quickly enough, "Tinker, tax, and trifle, shuffle, shout and sham," and so we never really had an energy policy from the government, and they never really pushed one.

What's really changed is the industry that's really forced us to be much, much more worldly rather than taking a lot of imports of oil and gas without any kind of strategy. We're now looking to be energy independent with natural gas and oil, to where we're now debating whether we're going to be exporting oil, which was a no-no for 25 years.

**Your own career path really mirrors the changes in the industry. Describe how you made the transition, and the greatest challenges that came with it.**

Well, I cut my teeth on the Carter energy plan on Capitol Hill, and when I served on the Federal Energy Regulatory Commission. There were a lot of things that were left undone which needed some attention. One of the things that I'm most proud of, was I found this little red book at the Salvation Army bookstore in Washington about why we needed open access on natural gas in the markets. So in order to do that we needed to un-bundle pipelines, and I think what the FERC was able to do in un-bundling pipelines, it created a futures market because you had to guarantee transportation. That created, in my opinion, a true national market for natural gas along with the deregulation of the Natural Gas Policy Act, which has now led to the ability of producers finding natural gas, either associated with oil or by itself, to move it around freely, which they couldn't have done

**Railway companies should interact with governments and local communities to come up with the safest way to move the recently discovered gas and oil reserves**

before because of the regulatory setup. You signed a contract for 20 years and you just kind of put it in a drawer and left it there. To me, the open-access transportation like it existed in the oil business, was the most important thing that I've been a part of.

On the transition, you have to be pretty nimble. You have to be very creative about how you move products around the United States. The more we can share increasing our production year in moving around, and what we can export if it's reasonable, can really help our trade agreements with all of our European allies and in the Middle East. It's really giving us a strategic tool as well as a domestic tool.

**How are these technology changes and the U.S. position in the world affecting a city like Lake Charles, whose fortunes over the years have risen and fallen with the oil and gas industry?**

Well, it's outstanding. The infrastructure that was set up many years ago through pipelines and the Henry Hub, for instance, has a cou-

ple of advantages. With the boost in shale oil and shale gas, all that infrastructure was essentially here, including some of the LNG import facilities, which now are all turning around to be bi-directional. Cheniere Creole is the best example of that. They're going to have six trains in Cameron Parish, which is in the Lake Charles area, within two or three more years, so they'll be a great import-exports. With the other ones, when they all gear up, they could be exporting up to 9 billion cubic feet a day of gas, which is a fairly large sum of gas moving out into the world.

But they can also receive gas if there's anything on the oceans that looks like it's looking for a home, it could come into the state as well. So the tremendous boost in LNG facilities is, long-term and brought about because of what's already been done in the infrastructure.

Then you have the South African company Sasol coming in with a \$16-21 billion facility that they announced with their CEO and the governor of Louisiana a year ago. It is the largest single manufacturing announcement ever in Louisiana, and one of the largest in the United States. They're using natural gas for gas-to-

liquids, and also putting in an ethane cracker. So again, the infrastructure that brings the gas here can be made into a number of different types of fuels, in this case it's methanol to gasoline.

There's a large facility called Lake Charles Clean Energy, and they're doing petroleum coke to methanol with long-term contracts signed. So you're taking all this nasty petroleum coke and turning it into a clean fuel like methanol which is then taken overseas, and that money is returned, and a lot of it is kept in the community, so the infrastructure is incredible, when you start adding it up--about \$33 billion. In fact, the Louisiana economic development fund said the economic impact of just the \$16-21 billion Sasol plant, could be \$46 billion over 20 years. If you include the others, you could add another \$20 to \$30 billion in offshoots from that as far as economic activity. Southwest Louisiana is going to be a major hub in the world.

**Is this primarily because of the fracking revolution?**

Yes, it really is. When everything moved one direction, the natural gas moved from off-shore, and moved



from Texas, Louisiana, Oklahoma, generally, it all travelled north. Now that fracking is available in the Marcellus and around the different parts of the country, we're seeing gas come out of the ground where we didn't get very much before.

I think Appalachia's a perfect example. When I ran Columbia Gas Group, almost all of our gas came from the southwest and the outer continental shelf, and we had an import facility on Chesapeake Bay. So you can see, now that a lot of gas is coming out of the ground in those major consuming areas, that's why you've seen pipeline reversals. The announcement of the Texas eastern line through Ohio is actually going south, rather than south-to-north. So it's pretty much all fracking-related with associated gas with oil, or gas coming out of the ground by itself.

# Louisiana, the new gas capital

The city of Lake Charles, Louisiana, is set to become one of the world's main centers of LNG production. The South African company Sasol will be investing between \$16 million and \$21 million in the area (the biggest investment ever announced in Louisiana, and one of the biggest in the U.S.), mainly to develop two projects.

## WORLD-SCALE ETHANE CRACKER

- Ethane "cracking" is the process of breaking down large molecules of ethane contained in natural gas to create ethylene, one of the building blocks of the petrochemical industry
- The facility will produce approximately 1.5 million tons of ethylene per year
- The ethylene will be used in seven downstream derivative plants to produce a range of high-value derivatives used in everyday products such as synthetic fibers, detergents, fragrances, paints, film and food packaging
- Estimated project capital investment: \$5 billion to \$7 billion
- Construction phase: 2014-2017
- Final investment decision: 2014
- Project startup: 2017

## GTL – A GAME CHANGER FOR AMERICA'S ENERGY FUTURE

- It will be the first gas-to-liquids facility built in the United States
- Sasol's proven GTL technology chemically converts natural gas into GTL diesel for transportation, as well as other products
- The facility will produce more than 96,000 barrels per day of liquid fuels and chemicals including: GTL diesel, GTL naphtha, liquefied petroleum gas, paraffin, GTL base oils and medium and hard waxes
- Estimated project capital investment: \$11 billion to \$14 billion
- Construction phase: 2016-2020
- Final investment decision: 2016
- Project startup: 2019 (1st phase); 2020 (2nd phase)

Source: Sasol

**So for the international audience that reads this magazine, what is it about Lake Charles, La. that made a company like Sasol say, "Of all the places in the U.S., this is where we're going to go set up this huge facility?"**

Well, Louisiana's been helpful in locating facilities, but the major economic driver here in Lake Charles is the Port of Lake Charles, because a lot of these LNG facilities are on port property, and they've been very aggressive in making it easy for companies to come in on the Calcasieu River, where they can move ships in and out, as well as offer access to rail and pipeline capacity.

So I think the infrastructure for fracking, horizontal drilling, the quasi-government entity like the Port of Lake Charles, and a friendly state environment has really boosted

a lot of what's happening here. And also, because of the long tradition with Citgo and Conoco and a number of other major facilities from the late '40s, people around here understand energy, and they're not afraid of it. They're concerned about making sure it's clean and all the permits are done correctly, but they've kind of grown up living in the environment.

**And that environment always wasn't good. I'm sure you remember the days when you would wake up and you just smelled the petrochemical plants. How's it going to be different now from those days?**

That's a very good question. In that period the Spanish moss quit growing on the trees. I know that sounds kind of silly, but now moss is every-

where and all new permits are exceptionally closely monitored, in my opinion. The Clean Air Act and other federal regulations have done a lot toward cleaning up and making sure new plants are the cleanest that can be built going forward. So there's been some good technology forced by the Clean Air Act which has gotten the industry in a much better mode of putting that into their planning: 'Let's make sure everything is clean moving forward.' It's just like with fracking: I think there's been a lot more realization, the closer you are to your communities, the better chance your project's going to get done.

**And what do you think Lake Charles the city will look like ten years from now, after this explosion in industry?**

We hope that the quality of life will

be planned out very well, not only by the local government and the state government, but by the companies. There are a lot of people thinking through all of that, including the companies, about how we create a quality of life here that's attractive for people coming in. ■

Molly Moore is a senior vice president of Sanderson Strategies Group, a Washington, D.C., media strategies firm, and a former *Washington Post* foreign correspondent.



**China**/The impact of the American shale gas revolution

# The enigma of the Dragon

The energy requirements of the Asian giant are growing at an alarming rate and, with them, oil imports. But will the U.S.A., increasingly closer to independence, continue to defend global supplies at its expense?



**T**he word “disruption” has been used with increasing frequency in describing the technological changes that are now sweeping across many sectors of the global economy. The world’s energy sector is no exception. Even though the pace of change here is much slower than in the information industry, it would not be an exaggeration to

by MINXIN PEI

claim that two revolutions are radically altering the world’s energy landscape, with uncertain but profound implications for producers and consumers alike in the coming decades.

The first revolution is unfolding on the supply side. The epicenter of this revolution is, undoubtedly, the United States. To the outside world, the explosive growth of shale gas is perhaps the most well-known aspect of America’s energy revolution. In 2000, shale gas was only 1 percent of American domestic gas output. But

by 2011, it accounted for 30 percent. Largely thanks to this revolution, the U.S., boasting an output of 619 million tons of oil equivalent in 2012, has surpassed Russia as the world’s largest gas producer.

### NEW OIL RESERVES

While the explosive growth of American shale gas has dominated news headlines, there are other equally notable aspects of the supply revolution in the energy sector. In terms of oil, newly discovered reserves have subtly reshaped the future of this vital industry. From 2000 to 2012, proven reserves have risen from 1,016 to 1,525 billion barrels, according to the Energy Information Administration (EIA) of the U.S. Department of Energy. New oil fields around the world have not only alleviated fears of shortages, but also have reduced the relative importance of the Middle East in the future.

Of the new proven reserves, 62 percent lie outside the Middle East, which in 2012 accounted for 52.6 percent of the world’s proven oil reserves. In 2000, the region had 66.4 percent of the world’s proven oil reserves.

The region that has seen the greatest expansion of proven reserves is North America, which has found 151 billion barrels in new proven reserves since 2000. Africa and Eurasia have also seen their combined share of the world’s proven reserves rise from 13 to 16.2 percent in the same period. Needless to say, data on oil production reflected this structural change. From 2000 to

China now finds itself in a more vulnerable position compared with other energy consuming countries. The radical change on the supply front has practically bypassed it

2012, oil production rose from 77.7 to 89.3 million barrels per day (mmbd), registering a net increase of 11.6 mmbd.

The United States, which has increased its domestic oil output by tapping tight oil, accounts for 2 mmbd. Of the rest, 2.1 million bpd comes from Africa and 5.2 mmbd from Eurasia.

Collectively, the U.S., Africa, and Eurasia have contributed 80 percent of the increase in the world’s oil output, again reducing the relative importance of the Middle East.



**THE AUTHOR.** Minxin Pei is a professor of government at Claremont McKenna College in California and a non-resident senior fellow of the

German Marshall Fund of the United States. His research focuses on democratization in developing countries, economic reform and governance in China, and U.S.–China relations. He is the author of *From Reform to Revolution: The Demise of Communism in China and the Soviet Union* (Harvard University Press, 1994) and *China’s Trapped Transition: The Limits of Developmental Autocracy* (Harvard University Press, 2006).

### RENEWABLE SOURCES

Outside the traditional energy sector, renewables in general, non-hydroelectric in particular, have registered unprecedented growth. From 2000 to 2010, non-hydroelectric generation increased from 248 to 927 billion kilowatt hours (bkh). The European Union is indisputably the leader in the renewables revolution. Combined geothermal, solar, wind, and biomass renewables generated 306 bkh in 2010, representing 45 percent of the global total (and 4 times more than in 2000). In relative terms, China’s advance in adopting renewables has been the

most impressive. In 2000, non-hydroelectric generation in China was only 3 bkh. A decade later, it exploded to 107 bkh, a 35-fold increase.

The effects of the supply-side revolution in the energy industry will be felt for years to come. At the moment, they have increased recoverable reserves, di-

versified sources of supply, and brightened the prospect of renewables as a significant component of the world’s energy production system.

### THE CONSUMPTION REVOLUTION

The supply-side revolution in energy has been accompanied by an equally profound change in the world’s consumption of energy. The key drivers of energy consumption – economic growth, population increases, energy-intensive industri- →

# 2000-2012 The energy revolution

## CHINA

Chinese oil **PRODUCTION** recorded a net increase of 1 mbpd (from 3.4 to 4.4 mbpd).

Annual oil **CONSUMPTION** in China went from 4.8 mbpd to 10.48 mbpd.

The share of oil **IMPORTED** by China went from 29 to 57 percent.

The **PRICE OF CRUDE** in China increased from \$19 to \$220 billion.

The Chinese **HYDROELECTRIC GENERATION** capacity quadrupled.

China built more than **30 NUCLEAR PLANTS**.

**GAS CONSUMPTION** in China between 2000 and 2012 increased by more than five times (from 27 to 147 million cubic meters).

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alization, and rising standard of living – are much more powerful in developing countries, particularly in Asia, than in developed countries. As a result, energy consumption in advanced economies has been steadily declining while growing explosively in developing countries. In the case of oil consumption, the net increase from 2000 to 2012 was 12.41 mmbd. However, consumption in the United States during this period declined by 1.2 mmbd. In the European Union, the net reduction in consumption from 2000 to 2012 was 1.6 mmbd. A host of factors,

such as improved efficiency in the transportation industry, slower growth, changing life-style, were responsible for the combined reduction of 2.8 mmbd in consumption in the U.S. and the EU in the 12-year period. Offsetting declining consumption of oil in advanced economies is the rapid increase of consumption in developing countries. One noteworthy feature of the energy consumption revolution is that the Middle East is now a major consumer of oil. While oil consumption in the U.S. and the EU fell from

34.3 to 31.5 mmbd from 2000 to 2012 (an 8.2 percent decline), consumption in the Middle East rose 59 percent in the same period. The net increase in oil consumption in the Middle East – 2.8 mmbd – equals the net fall in consumption in the U.S. and the EU in this period. The rise of consumption in the Middle East is all the more remarkable since the region's production in 2000-2012 rose 3.71 mmbd. Once the region's consumption increase (2.8 mmbd) is subtracted, the Middle East's net contribution to global oil production was only 900,000 barrels

per day. As this trend is likely to continue, the relative importance of the Middle East as a supplier of oil will decrease since its own growing demand will consume a rising share of its output. The center of the energy consumption revolution is in Asia, specifically China. From 2000 to 2012, oil consumption in Asia-Oceania rose from 20.8 to 29.6 mmbd, a net increase of 8.8 mmbd (accounting for 71 percent of the global consumption growth in this period). China consumed 4.8 mmbd in 2000. Twelve years later, its annual consumption,



## THE REST OF THE WORLD

**PROVEN** global oil **RESERVES** have increased from 1,016 to 1,525 billion barrels.

The share of **MIDDLE EAST** proven oil reserves compared with that of the global share has fallen from 66.4 to 52.6 percent.

151 billion barrels of **OIL** have been **DISCOVERED** in North America.

The share of **AFRICAN AND EURASIAN** proven oil reserves compared with the global share has grown from 13 to 16.2 percent.

World oil **PRODUCTION** has increased from 77.7 to 89.3 million barrels per day (+11.6 mbpd).

World oil **CONSUMPTION** has increased by 12.41 mbpd.

A fall of 1.2 mbpd was recorded in the United States. The **NET REDUCTION IN CONSUMPTION** in the European Union was 1.6 mbpd.

Oil consumption increased by 59 percent in the **MIDDLE EAST**.

Oil consumption in the **ASIA-OCEANIA** region went from 20.8 to 29.6 mbpd (+8.8 mbpd).

Oil consumption in **INDIA** rose from 2.1 mbpd to 3.62 mbpd.

at 10.48 mmbd, more than doubled. Compared with China, India's oil consumption has grown less fast, but not by much, in this period (it rose from 2.1 mmbd to 3.62 mmbd).

### THE VULNERABILITY OF CHINA

This brief review of the twin revolutions in the global energy industry shows that the United States, which has seen its domestic supply grow and consumption fall significantly, has greatly increased its energy security. China, by contrast, now finds itself the most vulnerable among

major energy-consuming nations. The supply revolution, with the exception of non-hydroelectric renewables, has largely bypassed China, which has grown even more dependent on coal, a cheap but dirty source of energy, and imported oil, which is subject to price volatility and geopolitical insecurity. In a way, China may have been a victim of its own rapid economic development in the last three decades, in particular since 2000 (the Chinese GDP has quadrupled in real terms in this period). Energy consumption rose roughly two and

half times in 2000-2011 (from 41 to 110 quadrillion Btu). Although China has devoted considerable efforts to meeting its explosive energy demand, its options have been severely constrained by a lack of domestic reserves, soaring costs of imports, and technological barriers. Chinese domestic oil production from 2000 to 2012 recorded a net increase of only 1 mmbd (from 3.4 to 4.4 mmbd), forcing the country to import vast quantities of oil and raising its import ratio from 29 to 57 percent. Proven oil reserves in China in 2012 were 26 billion barrels, barely enough to meet the country's demand for a decade.

While imported oil may slake Chinese insatiable thirst for fuel, the cost of buying crude has soared (from \$19 to \$220 billion in 2000-2012). The Chinese government now estimates that imported oil will supply 75 percent of consumption by 2030, with total consumption 60 percent higher than in 2013. This means that China will be importing 13 mmbd, with an annual bill approaching \$500 billion at \$100 per barrel. In all likelihood, China could spend around \$750 billion a year on imported oil in 2030.

Other primary energy sources for China look equally problematic. Coal, which supplies two-thirds of the energy that powers the red-hot Chinese economic engine, is making Chinese air unfit to breathe. So for the Middle Kingdom, the only viable long-term solution to its energy conundrum lies in natural gas and renewables.

To be sure, this energy revolution will be long in the making. Currently, Beijing has committed huge investments to renewables and coal-to-liquids (CTL). In the renewables space, Chinese hydro-electric generation capacity has quadrupled between 2000 and 2012. The country is also building more than 30 nuclear power plants (about half of the reactors under construction in the world). Its wind and solar industries are the largest in the world. Unfortunately, given China's mammoth demand for energy, renewables and nuclear energy (jointly supplying 20 percent of the country's electricity today) may grow fast but will only make a small dent in altering the supply-side equation.

### IS SHALE GAS A SOLUTION?

That leaves natural gas as the most promising solution to China's energy problem. Chinese gas consumption in 2000-2012 rose more than five times (from 0.96 to 5.2 billion cubic feet), with increased domestic production meeting two-thirds of the higher demand.

Importing natural gas from Central Asia and Russia and liquefied natural gas (LNG) from Australia and Indonesia will meet China's short-term needs. For the long term, China will have to rely on its domestic shale gas as a new source of supply.

But can China make the next shale revolution?

The Chinese Ministry of Land Resources report that China has commercially recoverable shale gas reserves of 25 trillion cubic feet, about the same as the U.S. However, Chinese shale gas reserves are located in regions that pose significant hurdles for exploration and production – either areas with high population density or inaccessible places with hard rock formations, scarce water, and little infrastructure. Despite these difficulties, the Chinese government has announced an extremely ambitious plan: it seeks to produce 6.5 billion cubic feet of shale gas in 2015 and 60-100 billion cubic feet by 2020. In all likelihood, these targets are unrealistic, given that Chinese shale gas production in 2013 was only 200 million cubic feet. Yet, even the most daunting challenges should not make us write off China. The country has the talent, financial resources and, above all, powerful incentives to improve its energy mix and security. Even if China meets only half of its goals in clean and secure energy, the impact on the global energy sector will be revolutionary.

The real China energy conundrum, however, lies in America's response to the unfolding global energy revolutions. With its burgeoning domestic supply, the U.S. is approaching energy independence. Since the U.S. spends about 15 percent of its defense budget defending global energy supplies and China, America's strategic rival, enjoys a free ride, the most inconvenient question Americans will ask is why the U.S. should underwrite Chinese energy security. At the moment, few Americans are raising this issue, and no Chinese want the question to be ever asked. ■



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India/One third of the population does not have access to electricity

# Solar technology for all

Off-grid solar technology could soon offer a pretty stable solution for global cities and villages not reached by the grid. There are still, however, various obstacles to its distribution

**N**arendra Modi has a reputation as both a fiery orator and an energetic political administrator. But the politician many now tip to be India's next prime minister is also a champion for energy of a different sort: solar power, a technology with potentially far-reaching implications in Asia's third largest econ-

by JAMES CRABTREE

omy. Around 400m people in India live without electricity, more than any other country, even as the International Energy Agency predicts that power demand in the energy-starved nation will double over the next two decades. That same mixture of incomplete power infrastructure and fast-rising energy demand is widespread across large swathes of Africa as well, where the World Bank suggests that more than 550m have no access to power. Come polling time, politicians in

both places promise action. And here Mr Modi, who is currently campaigning in India's forthcoming election, due in May, has a better record than most, having brought reliable power to most citizens in the the state of Gujarat, where he is chief minister. If promises of the kind he has made often prove illusory over the long term, there are reasons to believe that he can pull it off. In addition to patchy power infrastructure and unreliable politicians, India and Africa share a third, more fortunate

trait: sunshine; plentiful sunshine. And it is this fact that leads many energy experts to argue that one particular form of renewable energy could soon provide a more permanent solution to the global problem of power-free towns and villages: off-grid, or distributed, solar.

## A SOLUTION FOR ACCESS TO ENERGY

Enthusiasm for distributed solar stems from a mixture optimism and



taking notice, especially because grid costs will drift up over time, as fossil fuels gradually get more expensive and governments have to stop subsidising them," he says.

Yet these falling prices are also helping to spur a different segment of the solar industry, lowering the costs of making products that are suitable for hundreds of millions of poorer customers in developing countries with plentiful sunshine. From basic portable lanterns to more advanced systems capable of illuminating entire homes, it means that pioneering distributed solar businesses, such as Dlight Solar, Greenlight Planet and Nokero, can now offer lighting products in particular, that cost about the same to run as traditional kerosene lights.

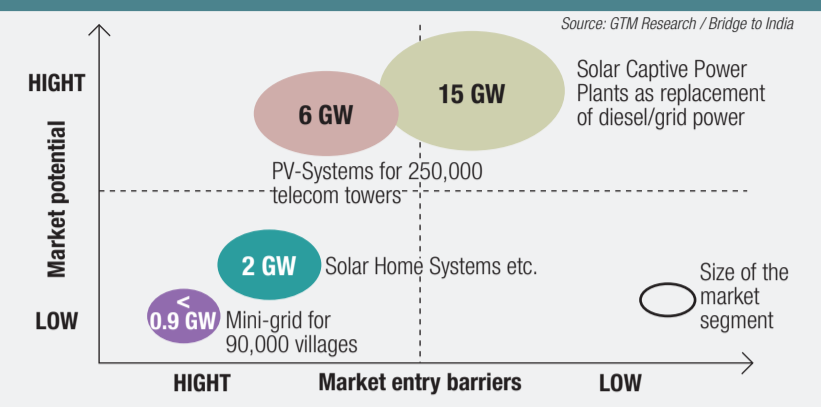
Distributed solar enthusiasts argue that such devices can have a profound impact in power-free areas. "There has been an extraordinary shift in the economics of solar in the last the years, which we have seen here in the UK," says Greg Barker, energy minister for Britain's coalition government, and a vocal advocate for solar energy. "In many parts of the world, and especially where the local alternative is a diesel based generator, distributed solar is now a genuinely attractive economic opportunity, even without subsidy. And for the hundreds of millions of people in India without connection to the grid, this type of solar is an important, life-changing opportunity."

Anish Thakkar, the Mumbai-based chief executive of Greenlight planet, manufactures one of the products that embodies this change. The Sunking is a chunky brightly-coloured plastic light that can either be attached to a stand for reading, or hung from a wall or a ceiling to illuminate a room. The lamps are sturdy and waterproof, and cost somewhere between \$11 and \$40, with the more expensive versions also acting as a mobile phone charger. "What you get is a solar panel, which is roughly the size of a paperback book. You put that panel on the roof. Then you get light, for somewhere between 6 and 30 hours," Mr. Thakkar says.

Such basic, reliable lighting allows children to study, or home-run businesses to extend working hours. Similar devices can improve agricultural productivity as well, for instance through solar powered water pumps for irrigation. The ability to charge a mobile phone, however, is an especially attractive selling point. "People spend a lot of money to charge phones," Mr Thakkar says. "You walk to the nearest market town, you go to the mobile shop, you hand the guy your phone, and you sit and wait.... peo-

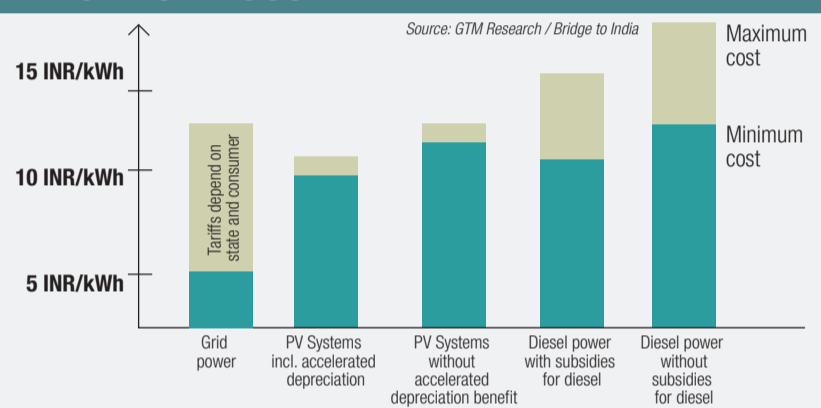
pessimism. The upbeat side of the argument is based on changing economics, where costs have fallen dramatically in recent years, largely because a glut of photovoltaic, or rooftop, solar panels from producers in China. This drop means that solar businesses in many developing economies can now produce power at levels roughly comparable to grid electricity made from fossil fuels, according to Alan Rosling, the founder of Kiran Energy, an India-based solar group. "People are now

## POTENTIAL AND MARKET ENTRY BARRIERS



**The segments of the Indian off-grid photovoltaic market that have the greatest potential and least barriers to entry are those of the restricted-use power plants and telecommunications transmission towers.**

## ELECTRICITY COST



**A kWh from an off-grid solar system costs INR 11 to INR 12 (\$0.28 to \$0.30). This is higher than a kilowatt-hour of grid electricity (\$0.10 to \$0.13) but competitive to a kilowatt from diesel gen-sets (\$0.25 to \$0.38).**

ple will spend half the day charging their phone. It is a really big time suck. It costs them."

### POLITICIANS' INABILITY TO CREATE AN ELECTRICITY GRID

For all the attractiveness of such devices, however, there is a second and more pessimistic rationale behind claims that distributed solar is the most likely means of bringing electricity to many of the 1.2bn who live without power worldwide: the inability of politicians in many developing nations to roll out formal electricity grid infrastructure. It is a topic that features prominently in India's latest election campaign, as in a typically barnstorming speech given by Mr Modi to his centre-right Bharatiya Janata party this January. "There is a power crisis in the nation," the opposition leader argued. "Can't we aspire for 'power on demand'? If the states take initiative and the center cooperates then every house can have 24 hours electricity, and life of the common man can be changed."

India's current government pledged to bring power to every Indian during both of the country's previous

two election campaigns in 2004, and 2009, but made little progress. Mr Modi has a little more justification in making such promises, having provided reliable electricity in his home state, and presided over its emergence as India's pre-eminent energy hub. He has been a reliable enthusiast for solar energy too. In February this year he launched →



**THE AUTHOR.** James Crabtree is the head of the *Financial Times'* Mumbai bureau, where he leads the paper's coverage of corporate India, having previously worked on the op-ed page as Comment Editor. Before joining the FT, Mr Crabtree was Deputy Editor at *Prospect*, Britain's leading monthly magazine of politics and ideas. Prior to returning to journalism, he worked as a policy advisor in the U.K. Prime Minister's Strategy Unit, and for various think tanks in Britain and America. He also spent a number of years living in the U.S., initially as a Fulbright Scholar at the Kennedy School of Government at Harvard University.



India's largest solar plant, a 130-megawatt facility in the neighbouring state of Madhya Pradesh. Two years previously he opened another major facility: the \$600m Gujarat Solar Park, a project that embodied India's ambitious plans to increase its solar capacity to 20,000 megawatts by 2022 — up from virtually zero a few years ago.

Yet while India has grand ambitions to become a solar superpower, the odds that much of this energy will end up reaching the country's "dark" areas — those 75m homes who have no access to formal grid power, around a third of all households according to India's 2011 census — remain slim. "There are around 2bn people in the world who don't have access to reliable power, roughly half of whom are completely off the grid," says Don Tice, the chief executive of Dlight Solar, a California-based company that manufactures entry-level solar lighting products. "The problem is that extending the grid costs many billions at the micro level.... and while China might have the money and capability to do this, India doesn't and neither does Bangladesh or Pakistan, or most countries in Africa," Mr Tice says. "And that is why our belief is that the only economic answer is some kind of small scale distributed solution."

The economics of electricity grids favour dense, urban areas, rather than the vast, unconnected rural hinterlands of countries like India.

For the hundreds of millions of people in the large remote rural areas of India who are not connected to the electricity grid, the sun represents an important opportunity

But building out formal electricity infrastructure means solving more complex issues as well, says Jayant Sinha, a technology entrepreneur who until recently led the Indian arm of the Omidyar Network, the social investment business set up by eBay founder Pierre Omidyar, which also invests in Dlight. "It isn't just a question of technology and capital, it is a question of whether we have the institutional infrastructure to put in place a far flung grid, and then to meter it and get people to pay for it," Mr Sinha says. "Can we realistically do this [the grid] for everyone? It seems like a wild goose chase to me, which is why off-grid has such revolutionary potential," he says.

#### THE OBSTACLES TO OFF-GRID DISTRIBUTION

Delivering that potential to the point where it is able to replace grid infrastructure means overcoming a number of other thorny barriers. The first is technological. At present, dis-

tributed solar devices are basic, and focussed largely around lighting. This is better than nothing, but also insufficient to meet the longer-term hopes of most people living in rural villages across India and Africa. In time, however, further cost reductions in

combination with innovations in areas like battery technology should see off-grid solar products capable of powering more advanced devices, ranging from televisions and refrigerators to cookers and air conditioning units — in short, providing something close to the standard of power that consumers would expect from a reliable grid connection, at comparable cost.

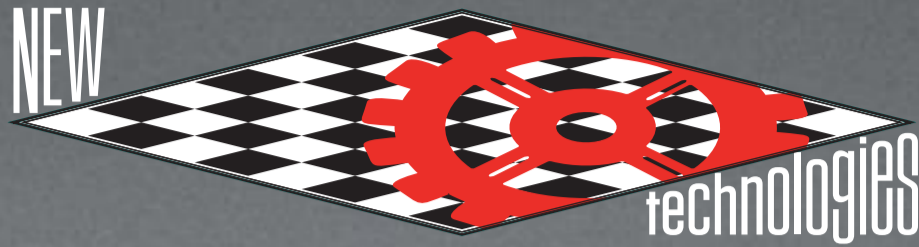
A second, and potentially more complex set of problems, relate to the sale and servicing of such off-grid systems. "The current type of lighting devices we offer are as cheap as the kerosene lamps people use today," says Mr Thakkar of Greenlight. "But they do come with a higher upfront cost, while the idea of solar is often foreign to people, as is the idea that it will pay for itself over a period of time. The whole thing is intimidating." Overcoming this requires the development of a distribution model capable not just of selling products in undeveloped rural areas, but also educating customers, and providing after-sales

services if equipment breaks, or if batteries need to be replaced. At present, Greenlight uses individual agents employed in specific villages, a model that Mr Thakkar says is similar to the way insurance used to be sold in America, with salesman going door-to-door. Other companies are running trials on different models, involving partnerships with small shops in local towns, for instance, or microfinance institutions.

The third challenge is financing, a factor that becomes especially important as off-grid solar products become more sophisticated, and thus more expensive. "Today we can offer a system which gives light power in the kitchen and in the bedroom, with two mobile lights as well, for about \$150. Most consumers can manage that," says Don Tice of Dlight. "But imagine a system that runs a TV or an AC? We aren't there yet, though that is coming. But that will be a \$400-1000 solution. And that requires finance."

Such sums may sound relatively small, but they are beyond the means of many consumers in rural India, and thus require more imaginative forms of support, potentially borrowing ideas from low-income credit unions and microfinance institutions. In one trial program, currently underway in Kenya, a company called M-Kopa offers DLight's solar lanterns for sale through the country's popular M-Pesa mobile payments system. It allows customers to buy a solar lamp or home lighting system, and pay off the purchase for a small amount each day through their mobile phone, rather than facing a large upfront cost. Similar solutions may soon be available in India, and other African countries.

A range of further problems remain to be overcome, especially those relating to subsidies, which in countries like India typically still favour fossil fuels and provide little help for the purchase of solar products. Despite this, enthusiasts for off-grid power remain confident that even the current range of more limited products, such as basic portable solar lighting units, can have an impact in power-free areas over the next two decades as profound as that achieved by mobile phones over the last two decades. "I think distributed solar can definitely happen," says Jayant Sinha. "If you look at phone infrastructure in India ten or twenty years ago, it was nowhere. And now that has been solved, because the business opportunity was so big, and potential growth was so huge. The same thing will happen here."



Shale gas/The last frontier of hydraulic fracturing

# Fracking. Offshore? Of course



The gas-oil industry is increasingly considering the possibility of using fracking in deep waters. The main obstacle is the prohibitive cost

**T**

by PAUL  
BETTS

hanks to its onshore oil and gas shale revolution driven by technological advances combining hydraulic fracturing and horizontal drilling, the US has enjoyed an impressive energy renaissance. On the eve of the International Petroleum Week in London in February, Bob Dudley, the chief executive of BP, noted that in 2013, the US had overtaken Saudi Arabia as the world's top oil producer as well as being the leading gas producer. For the second consecutive year, the US had also managed to tally the largest increase in production globally.

This achievement has stimulated other countries around the world - not least China, Russia, and the UK - to attempt to emulate the US by unlocking their own onshore shale resources, although many have been frustrated by local resistance and environmental objections. But if the booming and controversial onshore fracking business has dominated the headlines, the oil and gas industry is increasingly turning its attention to the possibilities of extending this technology offshore with deep-water fracking.

Many in the industry believe offshore fracking will provoke less opposition, given that it doesn't require difficult negotiations with local councils, communities and landholders.

## **NOTHING NEW. THE TECHNIQUE HAS BEEN AROUND SINCE THE NINETIES**

Offshore hydraulic fracking is by no means new and the American Petroleum Institute (API) points out that it has been in commercial use since the early 1990s. However, it remains quite limited compared to the booming onshore fracking industry, accounting for only around five percent of the fracking market as a whole. It has been principally used up to now to boost productivity from existing offshore oil and gas fields by providing improvements in well life and reliability and oil and gas recovery. As the API explains in a briefing paper on offshore hydraulic fracturing, the concept is similar to the one used to develop unconventional shale and

tight sand resources onshore. As in the case of onshore wells, hydraulic fracturing offshore has combined two mature oil and gas technologies, in this case hydraulic fracturing and gravel pack completion.

In many offshore regions, the geological formations that produce oil and gas are unconsolidated, which means the sand that makes up these formations is loose or poorly bonded much like the sand on a beach. "As a result," the API paper says, "this loose sand can end up inside production piping in the well or production equipment on the surface...Eliminating sand production has been one of the main challenges faced by engineers since the early days of offshore oil and gas development." Sand control technologies have been →

# Facts

**SINCE WHEN.** The process has been commonly used since the early '90s.

**ACTUAL USAGE.** Recourse to this technique remains rather limited compared with onshore fracking and accounts for approximately a mere 5 percent of the total fracking market.

**HOW IT STARTED.** Offshore fracking started from the union of two proven gas-oil technologies – hydraulic fracturing and completion with mechanical filters (gravel packs) – while for onshore wells the hydraulic fracturing and horizontal drilling processes were combined, making extraction and production operations from shale and tight oil tar sand formations economically viable.

**THE DIFFICULTIES.** In many offshore areas the geological formations that produce gas and oil are not amalgamated: this means that the constituent sand is not compact like that of a river bed. This yielding sand could end up inside the well production pipes or in surface equipment. Eliminating sand penetration, explains the American Petroleum Institute, “has been one of the toughest challenges ever faced by engineers since the start of sea-based gas-oil activities.”



evolving over the years, first with gravel packing completion that acts as a filter in the well at the depth of the productive formation to stop sand infiltration. When operators found that the bigger and thicker the filter, the better the well performed, they combined hydraulic fracturing and gravel completion technologies into what is now called a “Frac Pack” completion to achieve this and improve operational efficiency and oil and gas recovery.

Offshore fracking has taken place for some time in the Gulf of Mexico, the Santa Barbara Channel, Brazil, the Arabian Gulf, West Africa and the North Sea. It has involved the support of so-called stimulation vessels operated by leading oilfield services companies such as Halliburton, Schlumberger and Baker Hughes. As a measure of how such offshore fracking activities are expected to increase, Schlumberger announced last year the launch of five new stimulation vessels for work in the deep-water Gulf, Indian Ocean and

## Offshore fracking has taken place for some time in the Gulf of Mexico, the Santa Barbara Channel, Brazil, the Arabian Gulf, West Africa and the North Sea

North Sea. This is also reflected in the growing efforts by major oil companies to maximise the return on their investments in existing fields through enhanced oil recovery technologies. David Eyton, BP’s head of technology, suggested at the recent International Petroleum Week in London that the industry had probably reached a point globally when the potential for enhanced oil recovery from known hydrocarbon resources exceeded the potential from new discoveries. BP chief executive Bob Dudley also noted that when Prudhoe Bay in Alaska was

discovered in 1968 it was believed to contain 9.6bn barrels of oil. It has now produced 12bn – “and counting,” he said. He explained that in the upcoming Clair Ridge operation in the North Sea, BP was deploying its technology using low salinity

water to displace trapped oil to deliver an additional 42m barrels for an extra cost of \$120m or the equivalent of \$3 a barrel.

### THE CASE OF ENI: MULTI-STAGE TECHNOLOGY

Perhaps one of the most impressive examples of how hydraulic fracking technology can dramatically revive declining low performance offshore reservoirs is Eni’s massive hydraulic fracking campaign carried out between April and June 2007 on the Kitina 3A reservoir off the coast of

Congo.. Eni opted for multistage hydraulic fracturing technology that produced astonishing results with a 230 per cent production increase from the Kitina offshore field. According to a case study by Schlumberger, which provided services to Eni for this project, production from the Kitina field before fracturing was approximately 590 bbl/d. Ninety days after treatment, there was an overall steady-state increase in production to 1950 bbl/d. Eni also applied the technology in a virgin oil reservoir in the adjacent offshore Foukanda field. The wells in this field delivered an initial production rate of 3000 bbl/d which stabilised to 2000 bbl/d.

The Petroleum Oil and Gas Corporation of South Africa (PetroSA) sees fracking as a way to improve the productivity of three of the development wells in its F-O filed 110 km offshore of Mossel Bay. If it receives all the necessary regulatory approvals, it hopes to be able to extend the life expectancy of its gas to liquids refinery

**INCREASINGLY ADVANCED TECHNOLOGIES.**

The sand control technologies have evolved over the years, first through the completion process with gravel packs, which act as a filter in the well at the product formation level to prevent sand penetration. When the operators realized that the larger and thicker the filter was, the better the performance of the well, they combined hydraulic fracturing technology with gravel pack completion, creating the process which is now called "Frac Pack."

**MULTI-STAGE HYDRAULIC FRACTURING.**

An example of advanced technology is the one used in the Kitina 3A field off the coast of Congo. Eni opted for multi-stage hydraulic fracturing technology here, which has achieved surprising results, with an increase in production at this site to the tune of 230 percent.



in Mossel Bay by increasing output from the wells as a result of fracking. In the US, the federal government has just approved three new fracking operations in existing wells off the shores of California in the Santa Barbara Channel. This despite growing local and environmental opposition to offshore fracking. Ever since the disastrous 1969 oil spill in the Santa Barbara Channel, the issue has been highly controversial and divisive. For although the disaster prompted a moratorium on new drill leases and inspired federal clean water laws and the modern environment movement, oil companies have been allowed to frack to stimulate old existing wells into new oil production. This seems to have been carried out very quietly and away from the public gaze until the Associated Press disclosed last year that the federal government had permitted fracking in the Pacific Ocean at least 12 times since the late 1990s and is continuing to grant fracking approval at grandfathered-in platforms.

**TOTALLY NEW EXPLORATION PROJECTS**

If fracking has mainly been used to extend the life and boost output of mature offshore fields, some pioneering drillers are now planning to go one step further by applying the technology to completely new offshore exploration projects. In February, veteran shale pioneer Dr Chris Cornelius announced plans to drill offshore fracking wells in the Irish Sea. His new firm Nebula Resources was granted three licences by the UK's Department for Energy and Climate Change. Dr Cornelius was one of the founders of the UK shale gas company Cuadrilla, now chaired by former BP chief executive Lord Browne. The area covered by his licences in the Irish Sea stretch west from Blackpool into Morecambe Bay, not far from the site where Cuadrilla has announced plans to drill and fracture two new onshore gas wells. But Cuadrilla, too, has faced considerable local opposition, especially after it was

forced in 2011 to halt the UK's first ever fracking operation in the area after it triggered an earthquake. Dr Cornelius acknowledged that "over the last five years, we have seen that the onshore route is probably not the most beneficial route for the UK." This prompted him two years ago to look around at what opportunities were available in various parts of the offshore sector. When the offshore blocks were opened next to Cuadrilla's onshore play, he wasted no time to apply for them and was awarded the licences in January.

"Certainly offshore gas is a new concept," he told the BBC, adding "there is no reason with the UK's history of offshore development that we cannot develop these

used multiple fracture technology drilling up to five horizontal multi-fractured wells.

**A PROHIBITIVE OBSTACLE: OPERATING COSTS**

However, fracking experts caution that one should not get carried away about the potential of the offshore application of this technology. For while there is no obvious technical reason why offshore shale fracking cannot be done, the high cost of operating offshore is prohibitive for small independent drilling companies without the support from major oil companies with the necessary deep pockets and years of experience operating large offshore oil and gas

facilities and their related infrastructure.

But many of these major oil companies are now seeking to maximise existing investments and reinvesting in new spending.

At the same time, the fracking of offshore shale deposits has largely been seen by the big companies as uneconomic because

Small independent drilling companies cannot venture offshore without the support from major oil companies with the necessary deep pockets and years of experience

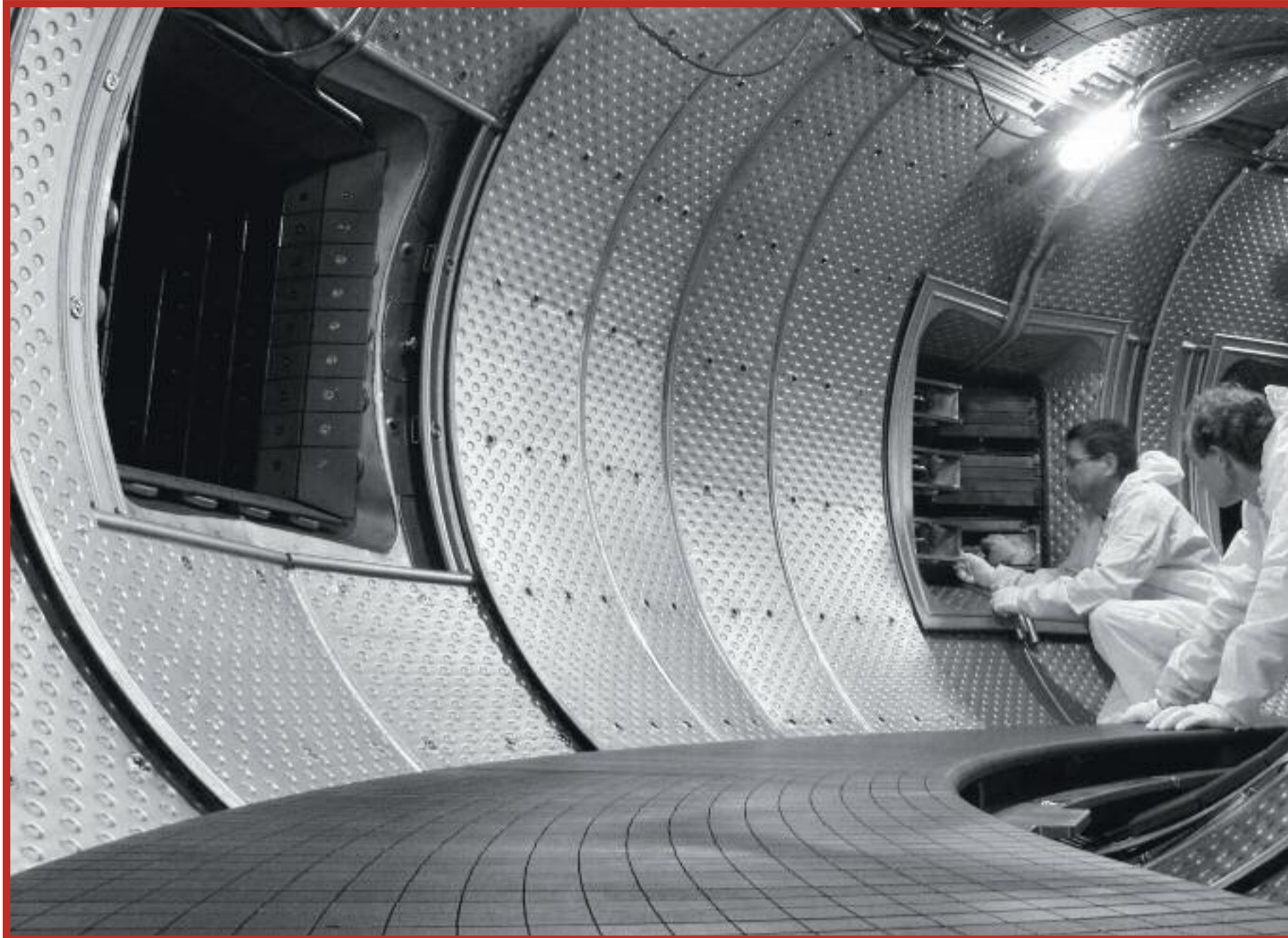
resources offshore." Based on existing geological data, he believes that a considerable amount of gas is in place in this area of the Irish Sea, up to 250 trillion cubic feet. This would be even more than Cuadrilla's estimates for its onshore resources. Indeed, the British Geological Survey has estimated that the UK's total offshore shale resources could be between five and ten times the size of the resources available onshore.

Dr. Cornelius is not alone in eyeing the potential of fracking offshore shale deposits. Last year, Trapoil, a small oil drilling firm, announced its intentions to develop offshore fracking in the central North Sea. The company has claimed that there could be more oil and gas from unconventional technology than all the output so far produced from the North Sea. This at a time when conventional production in the UK North Sea has peaked with the government now anxious to support ventures to stem the decline. The acreage granted to Trapoil is close to the giant North Sea fields like Brent and Ninian so that if the test well is successful, it could be tied to the existing infrastructure, prolonging its life and making extraction commercially viable. And further south, Germany's RWE Dea has already started delivering gas from its Clipper South field in the southern North Sea. The company says the field contains around 13.4bn cubic metres of gas in place. RWE Dea

of the costs and the relatively small size of shale reservoirs compared to conventional oil and gas deposits. In short, there may be vast shale reserves offshore but it is not going to be cheap. For creating offshore shale wells would require a significant scaling-up of existing offshore fracking capabilities.

While small independent drillers such as Dr Cornelius are "very comfortable" that the resources are there and the numbers absolutely huge, the big question is whether any of this is ultimately exploitable. We are unlikely to find out the answer for many years. Professor Dieter Helm of Oxford University told the BBC: "It is perfectly plausible that in 20, 30 or 40 years, the fracking technology will have so advanced and the way in which we deal with the offshore environment will have so advanced that this could be a really big industry. The task in the next 10 years is to try these things out, see if they work." Another expert said he was delighted to see a company taking the plunge in the Irish Sea but added "the challenges to extract will be as immense as the potential rewards."

Paul Betts has worked for the *Financial Times* for the last 36 years, including 28 years as the paper's foreign correspondent in Rome, Paris, New York and Milan. He is currently based in London.



**Research/**Nuclear fusion to surpass the coal era

# The judgment of future gen

Competition between countries in some areas of science, ostensibly in the name of national pride, is incomprehensible. We must leave our grandchildren a new and safe source of energy and the opportunity of a truly global community, and this can best come through cooperative efforts

**O**ur grandchildren will find much of our early 21st century behavior strange. Profligate carbon emissions, destruction of countless species, slaughter in the name of religion, tribalism, primitive nationalism, and the production and consumption of trivia for example.

But nothing will seem stranger to them than wasteful competition in the name of national sovereignty and pride, rather than multi-national collaboration, in such fields as space exploration, medical research, ocean

conservation, and the frontiers of energy.

## COOPERATION OR COMPETITION?

Some scientists argue that competition drives invention, that the more sources looking for new ideas and solutions, the more likely the most favorable outcomes will be produced. But others argue that national competition in the search for new answers almost invariably involves wasted resources in scientific creativity and brainpower, in laboratory time and equipment, and most of all in unnecessary duplication. Many prizes in chemistry, biology, and





collaboration. The fields of health and medicine and particularly the eradication of communicable diseases would seem to be an ideal realms for much greater international collaborative research.

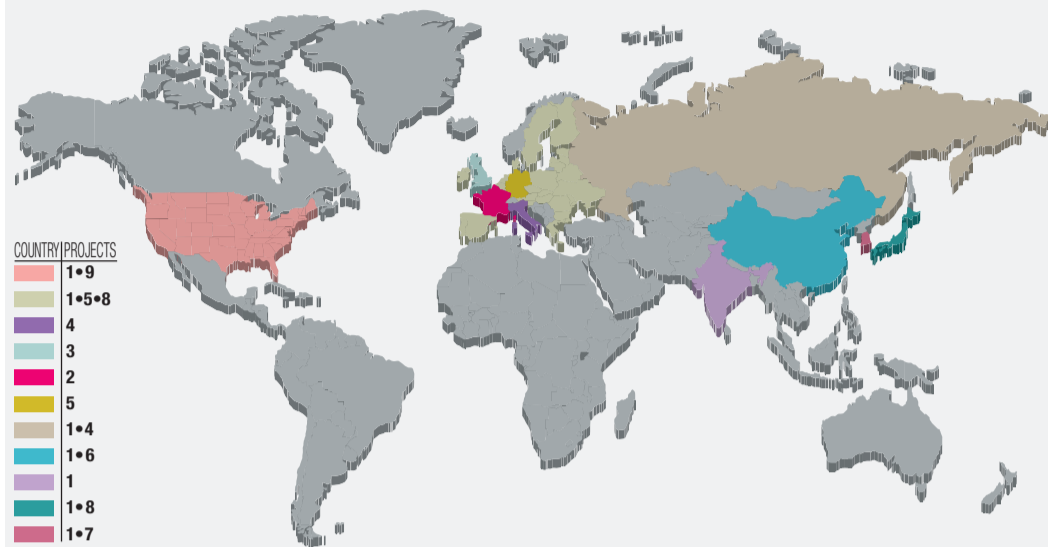
### RESEARCH INTO NUCLEAR FUSION

But for purposes of this publication, the field of post-carbon energy, especially in such technologies as fusion, also offers enormous hope for full-scale international research and development. So far, large sums of money have gone into cracking the code of an energy supply—fusion that meets the collection of nirvana goals—inexhaustible, clean, affordable, and ubiquitous. But even the most optimistic promoters of fusion admit that it is still years away. Skeptics say it is many decades away, if ever.

Nevertheless, the international scientific community is pursuing advanced fusion research through collective projects and national operations. The International Thermonuclear Experimental Reactor (ITER), located in France, is supported by the European Union, China, India, Japan, Russia, South Korea, and the United States, at an estimated cost of 13 billion Euros. In addition, France maintains the Laser Megajoule and Tore Supra projects. Like France, the United Kingdom hosts the Joint European Torus (JET) project that began in 1983. Russia's fusion research, dating to the early Cold War years, involves a collaborative project with Italy called Ignitor. Funded by the European Union and Germany, the Wendelstein 7-X project originated in 1988. Partners in the ITER also are conducting national fusion research. The People's Republic of China is operating the EAST and SG Laser Series of experimental research. South Korea is developing the K-DEMO project and the KSTAR advanced plasma projects. Japan has constructed the Large Helical Device (LHD) as a superconducting stellarator, the FIREX program, and in collaboration with the European Union, the JT-60SA project.

The principal United States fusion research is being carried out through the National Ignition Facility (NIF) operated by the Lawrence Livermore Laboratory in California. To encourage greater national effort by the United States, the American Security Project (ASP), among others, has made fusion energy one of its major projects. Founded by then Senator, now Secretary of State, John Kerry in 2006, ASP is a leading privately-funded, public policy center in Washington. Its board of di-

## Wikiprojects



These are the main projects launched throughout the world for the purpose of producing nuclear fusion.

- 1 European Union, China, India, Japan, Russia, South Korea and the United States: **ITER** (International Thermonuclear Experimental Reactor) nuclear fusion experimental reactor in France.
- 2 France: **Laser Megajoule** and **Tore Supra** projects.
- 3 United Kingdom: **JET** (Joint European Torus) project, launched in 1983.
- 4 Russia and Italy: **IGNITOR** project.
- 5 European Union and Germany: **WENDELSTEIN 7-X** project.

6 People's Republic of China: **EAST** and **SG Laser Series** experimental research projects.

7 South Korea: **K-DEMO** project and **KSTAR** plasma advanced research project.

8 Japan: it has constructed a superconductor called LHD (Large Helical Device), launched the **FIREX** program and, in conjunction with the European Union, has launched the **JT-60SA** project.

9 United States: the main research in the field of nuclear fusion is being conducted by the **NIF** (National Ignition Facility) in California. To promote greater activity at national level in the United States, the **ASP** (American Security Project), among others, has made energy from nuclear fusion one of its key projects.

rectors includes national political, military, and diplomatic leaders.

### A MODEL FOR THE FUTURE

International scientific projects to make fusion the post-carbon energy source of the 21st century, as coal was in the 18th and 19th centuries and oil was in the 20th century, may prove what the nations of the world, and particularly their scientific geniuses, can do when they pool their time, energy, insights, and imagination. The scientists of no single nation, including the United States, are so brilliant that they cannot profit from intense collaboration with their global counterparts.

It is not too much to imagine that all current international fusion research can become the prototype for a mul-

tiplicity of other endeavors in the scientific and technological world, a world drawn together by common interest, common needs and common humanity. Rather than question our judgment and wisdom regarding destruction of the planet and dissipation of their natural inheritance, our grandchildren instead might honor our memories for the legacy of new, safe energy and the possibility of a global commons we have left them. ■

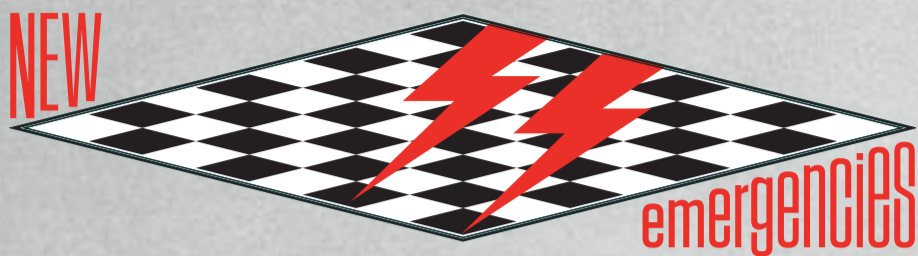
Gary Hart is a former United States Senator. He is currently Chairman of the American Security Project and a member of the U.S. Energy Security Council.

# erations

physics have been awarded to two or more researchers who coincidentally arrived at groundbreaking insights more or less at the same time. There seem to be more awards, Nobel and otherwise, for multi-national partners or teams who collaborate to produce profound results.

For those of us who are not scientists, it makes little sense for several nations to be sending manned spaceships to the moon or for other nations to repeat the U.S. experience simply for the acclaim of having done so. Rather, the international space station, involving the intellectual horsepower, the operating manpower, and the resources and energy of a number of nations, points toward the benefits of

NEW



Climate change/The scientific approach

# Use my four out of five rule



Whatever conclusion is reached on the “reality” of global warming it is subject to possible errors of judgment, but the consequences of this phenomenon appear so serious that “caution is never enough”

**T**

by HAROLD W. KROTO

here is much debate, sometimes highly contentious, about climate change in general and global warming in particular and much controversy abounds with regard to the claims on one side or the other. But there is in fact consensus among many in the scientific community studying the issue that:

- The biosphere does appear to be getting warmer
  - The climate does appear to be changing and
  - Human activity, mainly starting with the industrial revolution, may be responsible, at least in part.
- The consensus among the scientific community is not however 100 percent but it does appear to be over 90 percent. I am not going to discuss whether a), b) and/or c) are or are not correct but I am going to take a quite different (scientific) tack, indeed one based



"I should like to see a different emphasis put on the teaching of science, an emphasis that would reflect the truth that the sciences are different from nearly all other subjects taught. Languages, literature, religion, law, art, music, even pure mathematics are all human constructions, and they can be taught on the basis that "these things are so because men made them so. "But the sciences deal with the natural world, which men did not make at all; and the honest way to teach them is "these things are probably so because of this, and this, and this." The student will become a scientist all the faster by doubting the teacher and looking at the evidence: no lesson is learned so well as the one you teach yourself. And for students who will not become scientists, the habit of asking questions like "Who says so? How do they know? What's missing? What are the assumptions? What is the scale? Is it all about the same thing? Do the figures make sense?" will make them more receptive to the message of science for the rest of their lives."

From "Scientists as Citizens" Sir John Cornforth (1975)

#### A PHILOSOPHICAL POINT

At the outset let me come clean and point out that I am not speaking as a scientist who works on this problem or one who has a vested interest in the veracity of the claims one way or another, but rather as one who is much like any other person interested person with the ability to understand straightforward scientific issues. I do however, have, a vested interest in the sustainability of modern living and the survival of the human race.

In such cases I start with a favourite aphorism:

I seek not the answer but to understand the question.

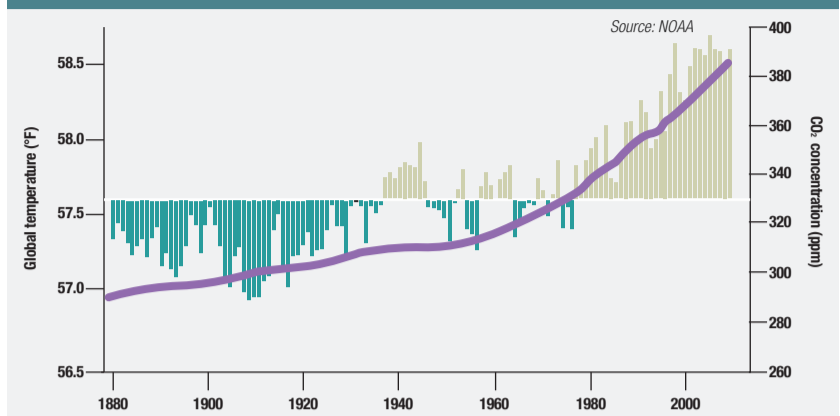
This quote may have been first stated by some ancient Taoist philosopher, although Google often ascribes it to me(!) as I have quoted it in my lectures so often or in its plural form to Kung Fu!

#### THE QUESTION (OR THE PROBLEM)

First of all there are some important general observations to make with regard to the nature of the climate change problem:

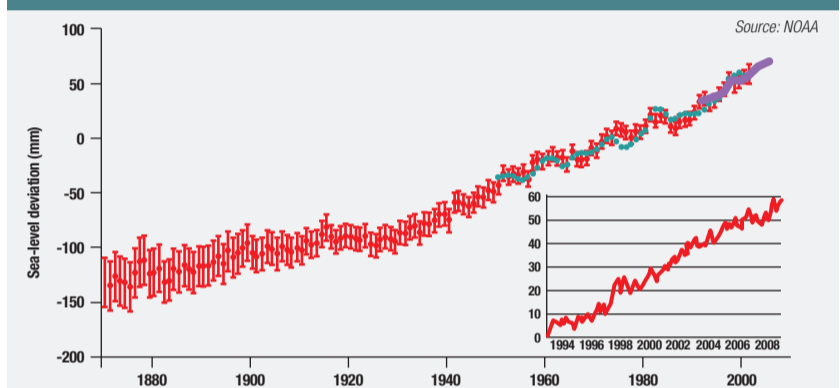
The issues are incredibly complex, and the "Change(s)" might be small and extremely difficult to quantify reliably, but the physical consequences on a global scale might be catastrophic. One simple point: A 1 °C rise in temperature of the atmosphere corresponds to a colossal increase in the energy stored in the atmosphere, in particular increased water vapour (and not

#### GLOBAL TEMPERATURE AND CO<sub>2</sub>



**Global average temperature shows an increase of approximately 1.4°F since the early 20th Century. Notably, the 20 warmest years have all occurred since 1981, and the 10 warmest have all occurred in the past 12 years.**

#### SEA LEVEL



**Global mean sea level has been rising at an average rate of approximately 1.7 mm/year over the past 100 years (measured from tide gauge observations), which is significantly larger than the rate averaged over the last several thousand years. Since 1993, global sea level has risen at an accelerating rate of around 3.5 mm/year.**

just in the clouds). This energy will obviously be dissipated relatively chaotically, indeed in countless "ways" and countless "others." It seems pretty obvious also that the energy will inevitably be distributed highly inhomogeneously throughout geographically and dissipated in either a large numbers of moderate hurricanes, tornadoes etc and/or a smaller numbers of highly ferocious ones. For a reliable estimate of any overall air temperature changes, one must take into account winter/summer changes and all major factors governing climate, such things as the repositioning of the Jet Stream. Other issues abound such as the effect of warming of the oceans on aquatic life and the repositioning of Jet Stream analogues such as the Gulf Stream. All in all a very, very complex problem indeed, and so complicated and multifaceted that most careful scientists would probably not touch it with a barge pole unless, as in this case, it is a massively important issue of great importance to the human race. A curious factor that is, it seems to me, worth pointing out is that the scientists who

have concluded that climate change is "problematical" (a euphemism for a catastrophic issue of global proportions!) on the face of it seem really to be driven by humanitarian instincts whereas the phalanx of climate change deniers are in general not scientists but individuals with vested financial and political interests.

#### FOR CONTEXT, A PERSONAL ANECDOTE

My colleagues and I proposed in September 1995 that our experimental observations indicated that a chaotic plasma of carbon atoms could spontaneously self-assemble into a closed cage structure with the geometric pattern of a football ("Football" as defined by John Cleese [http://www.youtube.com/watch?v=2sD\\_8prYOxo](http://www.youtube.com/watch?v=2sD_8prYOxo)). As the geodesic domes of Buckminster Fuller were a clue, at least for me, as to what the structure might be I proposed the molecule be called "Buckminsterfullerene," a long but prescient name that has caught on and neatly shortened to the name "Buckyball" a form which a kids tend →

on one of the thoughts presented by the Nobel laureate Sir (Kappa) John Cornforth in his wonderfully prescient article "Scientists as citizens," which is to be found on my Vega Science website ([www.vega.org.uk](http://www.vega.org.uk)). I often advise young people to read this great article, indeed I encourage anyone who is interested in science, the culture that shaped the modern world, and the consequences of science and technology from an intrinsically humanitarian viewpoint. Kappa makes the following suggestion on education:



# 2013. A year of weather anomalies

## 1. ALASKA

Wet conditions affected the state in 2013, resulting in the third wettest year in the 96 years for which we have records on the state.

## 2. CANADA

Torrential downpours on June 19th triggered floods that caused billions of dollars in damages. This was Canada's costliest natural disaster.

## 3. UNITED STATES

Drought conditions improved across the south-east and central U.S., but deteriorated in the Far West during 2013. California had its driest year.

## 4. EASTERN NORTH PACIFIC HURRICANE SEASON

Above-average activity: 18 storms. 8 hurricanes.

## 5. MEXICO

For the first time since 1958, two tropical systems made landfall in Mexico nearly simultaneously on September 15th.

## 6. EL NIÑO-SOUTHERN OSCILLATION (ENSO)

Neutral ENSO conditions persisted throughout the year.

## 7. BRAZIL

Below-average rainfall was observed in northeastern Brazil in early 2013. Some nations experienced their worst drought in the past half century.

## 8. ARGENTINA

The warmth felt throughout the year contributed to 2013 ranking as the second warmest year on record, behind 2012.

## 9. ARCTIC SEA ICE EXTENT

Arctic Sea Ice Extent  
During its melt season, the Arctic reached its sixth smallest sea ice extent on record.

## 10. GLOBAL TROPICAL CYCLONE ACTIVITY

Near-average activity:  
92 storms  
41 hurricanes/typhoons/cyclones

## 11. BRAZIL

During December 2013 many states had record rainfall for the month. The city of Aimores received over 400 percent of the average December rainfall. The torrential downpours resulted in 45 fatalities.

## 12. ATLANTIC HURRICANE SEASON

Near-average activity: 13 storms. 2 hurricanes. For the first time since 1994, there were no major hurricanes in the basin. The number of hurricanes was the lowest since 1982.

## 13. TROPICAL STORM CHANTAL

July 7th-10th  
Maximum winds 100 km/hr Chantal was the fastest-moving tropical cyclone observed in the deep Tropics (south of 20°N) in the Atlantic basin on record (1966—2013).

## 14. SPAIN

In March, Spain received more than triple its monthly average precipitation -the wettest March since national records began in 1947.

## 15. FRANCE

Experienced its second coldest May on record.

## 16. GREENLAND

Maniitsoq Recorded the highest air temperature ever observed in Greenland when temperatures soared to 25.9°C on July 30th.

## 17. SOUTH AFRICA

Temperatures rose to 47.3°C on March 4th in Vioolsdrif—the hottest March temperature recorded anywhere in Africa.

## 18. SOUTHWEST INDIAN OCEAN CYCLONE SEASON

Near-average activity:  
10 storms. 7 cyclones.

to like very much. When we proposed the structure we did not have unequivocal proof, and so we set about building up a plethora of circumstantial evidence as well as developing various approaches to creating sufficient material to prove the structure by standard chemical analysis techniques. In the five-year interim period before the structure was extracted by the elegant work of the Heidelberg/Arizona group and simultaneously by my group at Sussex, I developed what I called my 4 out of 5 Rule.

### THE 4 OUT OF 5 RULE

If one makes a novel observation. Develops a hypothesis to explain it Then carries out further experiments

to test the validity of the hypothesis...5 would be good!

If 4 observations out of 5 fit ...One is almost (the accent on the word almost) certainly right

If only 1 out of 5 fits ... One is almost (the accent again on the word almost) certainly wrong!

When I proposed this (as I have often done) in a lecture in Australia, Matt Coller of Monash University, who had been in the audience, decided to analyse my conjecture by probing it statistically. Matt subsequently emailed me with the following observation:

Hi Harry, I met you briefly after your wonderful seminar at Monash yesterday, and speculated on how well 4 out of 5 confirming experiments can

be considered to support a hypothesis. I've crunched some numbers, to work out the exact probabilities. I started with a couple of assumptions:

That to begin with, the hypothesis has a 50:50 chance of being right or wrong.

That a typical experiment would have a 10 percent chance of giving a false positive or false negative result.

Here's how the results from five experiments would confirm or debunk your hypothesis:

- 0 positives: hypothesis has 0.002 percent likelihood of being correct
- 1 positive: hypothesis has 0.13 percent likelihood of being correct
- 2 positives: hypothesis has 10 per-

cent likelihood of being correct

- 3 positives: hypothesis has 90 percent likelihood of being correct
- 4 positives: hypothesis has 99.86 percent likelihood of being correct
- 5 positives: hypothesis has 99.998 percent likelihood of being correct.

Even I was a bit surprised just how strongly 4 positives out of 5 will support a hypothesis (99.9 percent). I realise what matters is not so much how likely it is that four out of five experiments would give true answers, but how very unlikely it is that those four experiments would give false positives (which is 0.04 percent). So if you get four concurrent answers, and one which disagrees, it's a thousand times more likely that only one ex-



**19. AUSTRALIA**

Recorded its warmest year on record.

**20. NEW ZEALAND**

Observed its third warmest year since national year since records began in 1909. Also experienced its 4th warmest July and warmest August.

**21. SOUTHWEST PACIFIC CYCLONE SEASON**

Well-below-average activity: 5 storms. 4 cyclones.

**22. TYPHOON HAIYAN**

November 3rd—11th  
Maximum winds - 315 km/hr  
Haiyan was the strongest tropical cyclone on record and was also the deadliest Philippine typhoon on record, killing over 5,700 people.

**23. TYPHOON USAGI**

September 16th-24th  
Maximum winds - 260 km/hr

Usagi made landfall in northern Philippines, severely damaging the agriculture and causing floods and landslides that claimed 30 lives.

**24. WESTERN NORTH PACIFIC TYPHOON SEASON**

Above-average activity:  
31 storms. 13 typhoons.  
2013 was the most active season since 2004.

**25. RUSSIA**

Experienced its warmest November & December since national records began in 1891. Overall, Russia observed its sixth warmest year on record.

**26. CHINA**

Parts of southern China experienced one of their most severe heat waves during July and August.

**27. NORWAY**

Had its second wettest December, behind 1975, since national records began in 1900.

**28. UNITED KINGDOM**

Experienced its coldest March and May since 1962 and 1966, respectively. Overall, spring was the coldest since 1962.

**29. JERUSALEM**

Heavy snow fell during mid-December. This snow storm was unusually early and more intense than usual.

**30. GHANA**

Temperatures on March 6th reached 43.0°C in Navrongo, the hottest temperature ever measured in Ghana for any month.

**31. AFRICA**

The southern African countries of Botswana, Namibia and Angola experienced a large rainfall deficit causing one of the worst droughts in 30 years.

**32. ANTARCTIC SEA ICE EXTENT**

During its melt season, the Antarctic reached its second largest minimum sea ice extent.

**33. AUSTRALIAN CYCLONE SEASON**

Below-average activity:  
10 storms. 4 Cyclones.

**34. NORTH INDIAN OCEAN CYCLONE SEASON**

Below-average activity: 5 storms. 3 cyclones.

**35. CYCLONE PHAILIN**

October 4th-14th  
Maximum winds - 260 km/hr  
Phailin was the strongest storm in the North Indian basin since the Odisha Super Cyclone in 1999.

**36. CHINA AND RUSSIA**

Parts of eastern Russia and northeastern China were impacted by heavy rain in August. Nankougian In Russia, more than 140 towns were affected by their worst flooding in 120 years.

**37. SOUTH KOREA AND JAPAN**

Experienced their warmest summers (June-August) on record.

Source: NOAA

periment is giving a false negative, rather than that the other four are giving false positives - i.e., you can be 99.9 percent certain that your hypothesis is correct. So it turns out your rule of thumb has a good mathematical basis indeed!

**OBSERVATIONS EXPECTED TO BE INDICATIVE OF CLIMATE CHANGE**

Do not simply say dogmatically to those who are skeptical as to whether that climate change is or is not occurring...after all skepticism is THE primary Law of Science. Suggest to them that they make up a list themselves of as many as possible observations which might be pointers to climate

change...for instance here are a few:

- Is there more or less **RAINFALL** in general around the World?
- Are the annual average **TEMPERATURES** rising or falling?
- Are more **GLACIERS** receding or advancing?
- Is the **SEA LEVEL** rising or falling overall?
- Are **ANIMALS MOVING** or not moving from their natural habitats?
- Is the amount of **CO<sub>2</sub>** in the atmosphere increasing or decreasing?
- Are Incidences of **HURRICANES/TORNADOES** increasing or decreasing?
- Is there more or less **ICE** in the **ARCTIC** and **ANTARCTIC**?

Think of as many as possible indicators and check them out. Then let draw your own conclusions on the basis of my 4/5 Rule.

Of course there is one over-riding general point to make which relates to the huge timescales involved in making reliable estimates of rather small variations in such properties as average global temperatures. Thus "climate change" scientists realise if change is taking place and we are responsible, then we are effectively making measurements in the middle of a several hundred year experiment and are extrapolating into the future. However, there is a final observation which I should like to highlight and it is this: Whatever conclusion one draws whether it is "occurring" or is

"not occurring," the conclusion must be subject to some error estimate. Even with this in mind, the consequences of climate change appear to be so grave that one should consider the following: Should we not err on the side of caution?

Sir Harold W. Kroto is an internationally renowned scientist; he won the Nobel Prize for chemistry in 1996 for having discovered fullerenes. He currently teaches chemistry and biochemistry at Florida State University.



**Pollution/China's energy mix must be rebalanced**

# The clean coal route

The promotion of clean coal and the launch of projects for the production of gas from coal could be the most logical choice for the sustainable development of the country

# H

by LIFAN LI

Heavy coal use has shrouded much of China in smog, negatively affecting the health and quality of life of a large number of the nation's residents. The nation's energy mix must be transformed in order to put it on a more sustainable path of development. The Chinese energy industry called on the rebalance of the national energy structure and asked to substitute coal for gas. However, their appeal did not quite accord with the situation of China, which lacks oil but has an abundance of coal. In 2012, coal provided 70 percent of all energy used in China, whereas gas provided only 5 percent. According to the National Coal Source Potential Assessment, launched by China's Ministry of Land and Resources at the end of 2013, China possesses 5900 billion tons of coal, with 2880 target prospected blocks whose area reaches nearly 45000 kilometers and offers a potential yield of 38800 billion tons. The assessment suggests that in the next several decades, coal will account for roughly 75 percent of primary energy source production and 70 percent of consumption. Simply put, the leading role of coal in energy production and consumption will not change. With the country facing pressing environmental health issues stemming from coal use, its decision-makers set the priority to further

and actively push in a given period of time the production and use of clean coal and coal gas. The coal companies may take the chance to break away from the coal-oil profit and loss cycle, gaining both economic and environmental benefits. China Energy Development Report 2013 proposed to further the reform of the country's energy mix while using quality energy in key areas. For example, in eastern China, where the economy is more developed, renewable energy, nuclear, gas, coal oil, coal gas and other clean energy can play a larger role. For the medium to long term, China's energy mix cannot be changed fundamentally. Therefore, raising coal use efficiency, reducing the discharge of sulfur dioxide and nitric oxygen dioxide, and decreasing the discharge of greenhouse gases offer the best way forward. Clean coal power technology, which includes coal choosing, clean combustion, desulfuration, denitration and many other processes, will be the necessary choice for the industry.

## THE HISTORY: FROM THE 1997 FIVE YEAR PLAN TO THE PRESENT

Clean coal technology, aimed at reducing pollution and increasing efficiency, involves the entire process from development to consumption. The main technology refers to direct coal burning clean technology and clean coal transforming technology. China's central government has attached importance to clean coal tech-



nology for a long time. In 1997, a "China Clean Coal Technology 'Ninth Five Year Plan' and a 2010 Development Plan" were passed by the State Council. In 2005, the State Council published Advice to Push the Solid Development of Coal Industry, which proposed that the National De-

velopment and Reform Commission undertake planning to improve clean coal policies and organize and support sample projects to push the development of clean coal. In 2006, the efficient clean coal utilizing technology was listed as an advanced energy technology in the



Catalogue of Key Technology and Products Whose Proprietary Intellectual Property Rights Should be Mastered. In March of 2009, the industrialization of clean coal technology was listed as a top agenda concern by the National Development and Reform Commission, Ministry of

Environment Protection and Ministry of Science and Technology in their policies to implement the Government Work Report.

Currently, China is applying clean coal technology in four areas, including coal processing, coal efficiency clean burning, coal transforming, and dis-

charge controlling and disposal managing. The commission has established a large number of sample projects, and some leading technology has already been mastered.

However, in spite of all these promising developments, clean coal is slowing down. The technology has

not spread widely. The strong competition of relatively lower-priced and cleaner gas has made the spread of clean coal technology impossible without subsidies. Following the big success in the use of shale gas in America, many in China started to call on giving up on clean coal and de- →

velop shale gas. There are evidences that exploiting natural gas and the technology of fracking may pollute ground water on a large scale, so, from this point of view, shale gas cannot be considered “clean” energy. Without suitable policies in place and because of the high investment and a long period needed for return the development of clean coal technology and its use has not met expectations.

**US: TECHNOLOGY AND POLICY SUPPORT**

The Clean Coal Technology program began in 1985 as an effort by the U.S. and Canada to solve the problem of cross-border acid rain. The U.S. Department of Energy created a partnership program between the government, states and companies to test new methods of burning coal more cleanly. Over time, the methods developed would take on the name “clean coal.”

As in the case of shale gas and oil technologies, the U.S. has made important breakthroughs in clean coal technology. In the beginning of 2013, a research team at Ohio University announced a breakthrough that would capture 99 percent of the carbon dioxide produced in coal burning. According to the U.S. Department of Energy, the power cost of clean energy technology should not exceed 35 percent of current power technology while capturing more than 90 percent of carbon dioxide. Therefore, the technology of Ohio University can push the U.S., which possesses rich coal sources, to realize energy independence. With the support of carbon capture technology, the newest and most cost expensive coal power factory in the U.S. successfully separated dioxide carbon and can be listed as one of the world’s cleanest factories. America’s policies on clean coal technology have been improved continuously since 1985. Recently, the government has taken steps to promote clean coal technology. Energy Policy Law ensures tax preferences for companies who utilize clean coal technology. Clause 1307 of the law allocates 1.65 billion dollars for clean coal projects.

**BRITAIN: FULLY IMPLEMENT LAWS AND REGULATIONS**

Recently, Britain took steps toward promoting carbon capture and sequestration technology in coal production. In 2005, Britain devoted 350 pounds to a small sample foundation charged with developing strategies to reduce carbon emission. In 2007, the government launched a larger sample project for developing carbon capture and sequestration technology. Then, in 2013, things really took

off, as Britain declared a new policy that all new power stations use carbon capture and sequestration technology. It was the first time that the technology was enforced by law. The policy will have a positive impact on global weather change.

The carbon capture and sequestration technology captures gas with carbon producing during coal burning, liquifies and then sequesters it. The process also reduces carbon dioxide, methane and other greenhouse gases. The cost of the technology is relatively low, allowing the extensive use of fossil energy. The British government is considering installing carbon capture and sequestration equipment in new power station with installation of 300 megawatts. After the technology is confirmed, all the new power stations should capture and sequester all the gases discharged after 2020.

**DEVELOPMENT AND USE IN CHINA**

The utilization of clean coal technology can reduce carbon emission, protect the environment and achieve the goal of energy saving and emission reduction.

In 2012, the Ministry of Science and Technology issued the “Twelve Five-year Special Program on Developing Clean Coal Technology,” which listed clean coal technology as an important trend and pointed out a primary focus: efficient coal burning power technology, advanced coal transformation technology, advanced power-saving technology and disposal control and utilization technology.

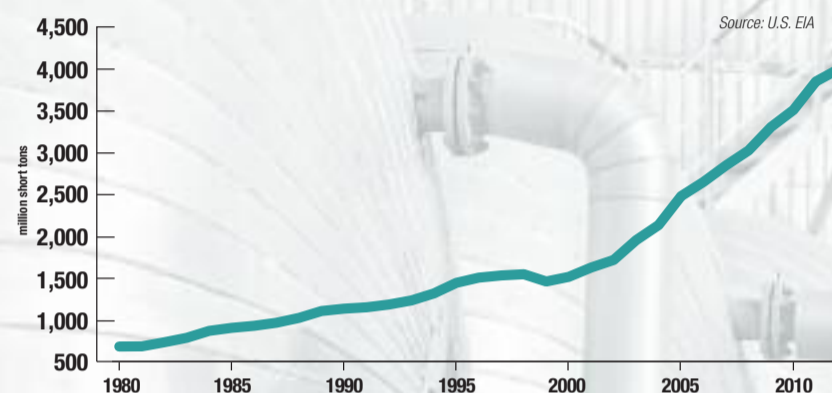
**NEW LAYOUT OF COAL CHEMISTRY INDUSTRY**

Currently, China imports 56.5 percent of its oil, and that number will increase in the future. This increasing dependency on foreign oil obviously threatens the nation’s energy security. Thus, the development of a coal chemistry industry is of great significance to China. Coal is a basic material for many important chemicals. With rapid and continuous economic development, the need for energy and chemicals is rising.

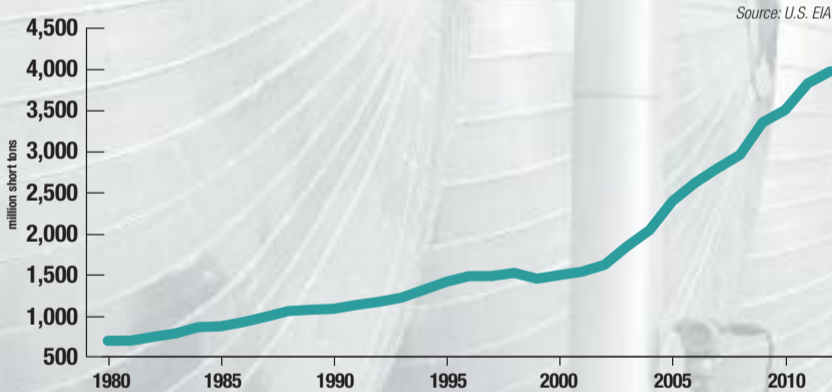
The coking industry is located mainly in coking coal and steel producing areas, such as northeastern China. Coal-made fertilizer is produced by coal fields and provinces good at agricultural, such as the southeast of China. The middle provinces mainly produce methane made by coal, including the new type DME (10 million tons produced every year). Oil products made by coal are gaining popularity in China, especially in Inner Mongolia, which launched cooperation with Mongolia on coal.

# The energy of the Middle Kingdom

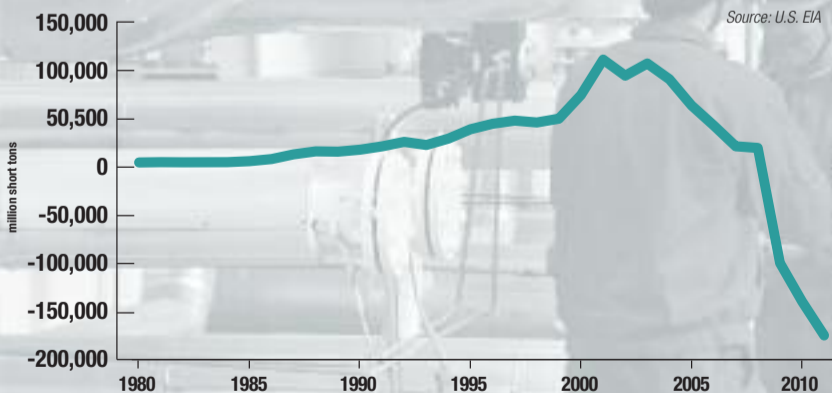
**COAL PRODUCTION**



**COAL CONSUMPTION**



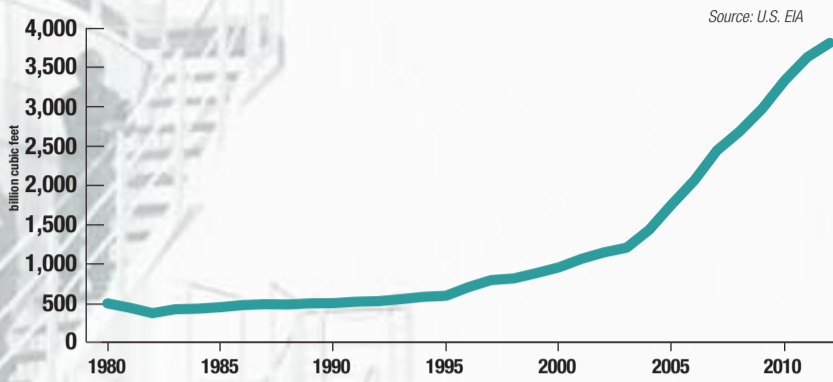
**NET EXPORTS/IMPORTS**



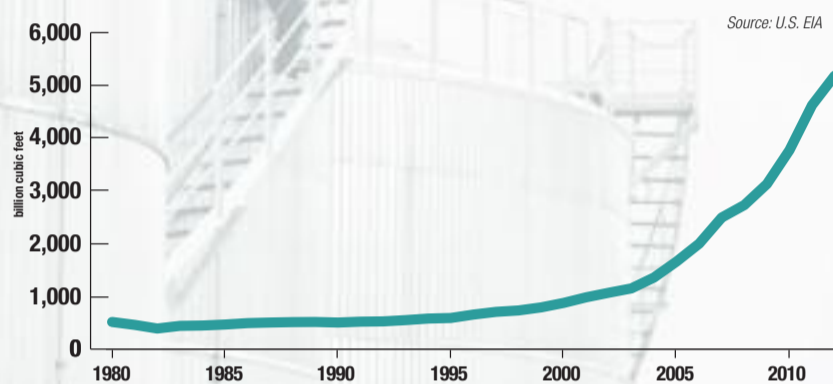
The three graphs show the ever-increasing trend of production and consumption of coal in China over the last thirty years and the balance between exports and imports which shows a vertical drop after 2000. According to the evaluation of the Ministry of Resources and Territory, in the coming decades coal will represent 75 percent of energy produced and 70 percent of energy consumed.



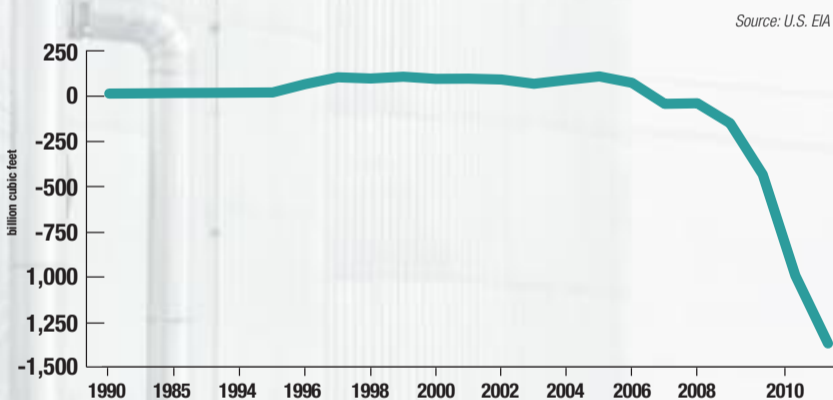
## NATURAL GAS PRODUCTION



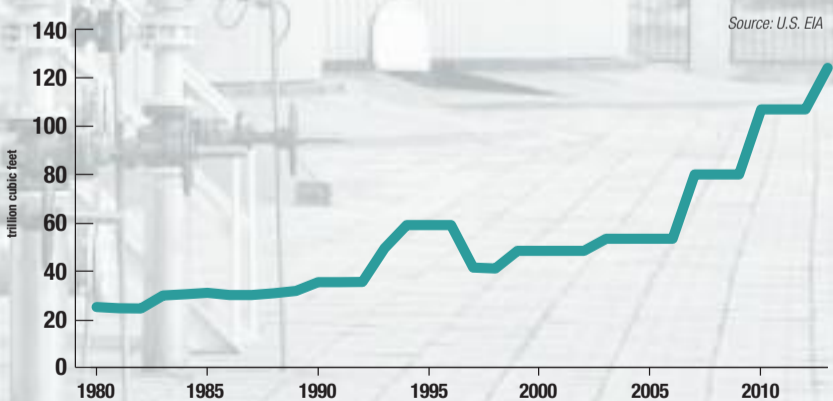
## NATURAL GAS CONSUMPTION



## NET EXPORTS/IMPORTS



## NATURAL GAS PROVED RESERVES



From 1995, Chinese production of gas recorded a surge, but the increase was not enough to cover the increase in consumption, which went up tenfold in the same period. Over thirty years, proven reserves went from slightly more than 20 to over 120 trillions of cubic feet. In 2012, the use of gas in China generated only 5 percent of total energy.

## THE TRANSFORMATION OF COAL GAS

The cleanness of coal gas, whose calorific value reaches 37-38 trillion joule/standard cubic meters while leaving little carbon monoxide, is well known. China decided to build a large project to develop coal gas, achieving a productivity of 50 billion cubic meters every year.

Coal gas can be used in many areas. If the methane made through coal gas technology is used in automobiles, the cost of coal mining and automobile consumption is far less than when using imported oil. Replacing oil with coal methane in automobiles can achieve four purposes: reducing oil imports, increasing energy security, lowering fuel cost and decreasing the pollution in people-intensive areas. Clean coal industry should be developed in Xinjiang Province. Several elements, such as coal source, water source, ecological environment, product transportation and target market, should be considered. The clean coal industry should stick to high efficiency, low emission and clean transformation. The coal gas program should take priority. Xinjiang plans to produce 13.5 billion cubic meters of coal gas in 2015.

In the next five to ten years, China should improve district advantage and competitiveness, increasing the utilization of clean coal and coal gas. Since the gas can be transferred easily through pipelines, the coal gas programs can be launched in Xinjiang and Inner Mongolia, where the cost of coal is low due to the area's remoteness. The gas produced can be very competitiveness with imported LNG.

The development and utilization of new technology and independent innovation should be encouraged. For example, IGCC, a new technology of coal gas and recycling that can capture more carbon with less effort, can be used in power stations, though it requires the upgrading of the chimneys. The issue of property rights is of great importance to Chinese companies, who expect to hold the technology when cooperating with foreign companies. However, due to the protection of property rights, Chinese companies should focus more on independent innovation.

## INTERNATIONAL COOPERATION

The coal companies should be encouraged to go out and international companies should be attracted to push mutual development. In July of 2012, Shell and Sinopec agreed to invest about 1.2 billion to build a second coal gas production line in the Yueyang petrochemical company. In August of the same year, GE and Shenhua signed their first cooperation

program – Shenhua Xinjiang Coal-Based New Material Program (0.68 million tons/year). International companies come to China's market with their capital, technology, equipment, management and concepts. Chinese companies should consider how to maximize the benefits of cooperative efforts.

Of course, China possesses its own new technology, and this can be used to broaden international cooperation. In 2011, the largest refinery company Valero, after inspecting the coal gas technology in many companies, bought multi-nozzle gasification technology created by the Yanzhou Mining Group. It was the first time that China sold coal gas technology abroad.

In 2015, China will achieve a coal gas productivity of 20 billion cubic meters/year, taking 10 percent in gas consumption. The coal chemistry industry will play an important role in sustainable energy utilization in the next 20 years. The need for energy will keep growing due to rapid economic development, while energy consumption poses great danger to the environment. Promoting clean coal technology and launching coal gas projects, which can reduce pollution and China's dependence on imported oil, will be the most realistic choice for China to realize sustainable development.



On [www.abo.net](http://www.abo.net), read other articles by the same author.

Li Lifan, Associate Professor for Eurasian Studies, Shanghai Academy of Social Sciences, Assistant Director of the Institute of International Relations, Executive Director of the Center for Russian and Central Asian Studies, The Secretary-General of the Center of Shanghai Cooperation Organization Studies.



by DANIEL  
ATZORI

# Middle East: the impact of the shale gas revolution

**T**he impact of the shale gas revolution is profoundly changing global geopolitics, and forecasts about the twilight of U.S. world hegemony are now met with growing skepticism. The consequences of this revolution will be particularly impactful in the Middle East, given its historical role as energy producer and exporter. In the meantime, many analysts believe that U.S. energy independence could cause a decline in Washington's interest in the region, just as China's involvement is growing. These two major developments should be taken against the background of the broader tectonic shifts taking place in the Arab world.

## The fragility of the Arab inter-state system: a systemic crisis that involves the entire region

We are now witnessing a systemic crisis involving the whole region. Explanations that interpret the current phase as a struggle between freedom and authoritarianism, or between Islamism and secularism, are not adequate to describe what is happening. Rather, the Arab state system as such, as it came into existence during and after the First World War, is showing signs of frailty. Nazih Ayubi wrote in his 1995 book *Over-stating the Arab State* of "the failure of Arab regimes to sustain their legitimacy in the context of the modern nation-state." The so-called Arab Spring precisely highlighted this "failure." The collapse of Ben Ali in Tunisia, Mubarak in Egypt and Gaddafi in Libya, as well as the civil war in Syria, are nothing but symptoms of an underlying,



An intersection of the pipelines that lead to the plant for the separation of gas from the oil in the Shaybah field in Saudi Arabia, located in the Rub' Al-Khali desert.

and still on-going, illness. The outbreak of sectarian strife, which is currently taking place, represents the most serious threat for the future of the Middle East, and for its nation-states.

## The Gulf countries can count on oil revenues to guarantee legitimacy for governments

The situation of the Gulf countries is different: the stability of their social contract is assured by energy revenues, which allow governments to sustain their legitimacy through the implementation of a system of incentives and disincentives devised to co-opt and repress dissent. National oil companies can be conceptualized as the backbone of these states. What is more, energy revenues allowed them, not only to weather the storm

of the Arab uprisings, but to expand their influence over the region. It is yet to be seen whether the shale gas revolution will have an impact on their revenues and, consequently, on their power and wealth.

On the whole, were the crisis of the Arab state to worsen, the whole region would be affected. It is in this sense that a withdrawal of the U. S. from the Middle East, for example abandoning Egypt, the most populous Arab country, to itself, could be dangerous. Instead of weakening the Egyptian government, it could only dramatically decrease Washington's leverage over Cairo in favor of other powers, such as Russia, which seems persuaded that the only way to preserve stability in the Middle East consists of backing the regimes. In this regard, Moscow's decision to support Field Marshal Abdel Fattah el-Sisi is crucial.

It is still not clear whether it will lead to the rebirth of the alliance between Cairo and Moscow, as it was at the time of Nasser's Soviet-Egyptian alliance. But the growing assertiveness of Russia on the global stage, demonstrated by the Ukrainian crisis, poses new challenges in the Middle East, where the friends of the U.S. are worried by Washington's perceived weakness, as much as its foes are emboldened.

## Violence, and not greater freedom, is the result of the weakening of the regimes

On the whole, the experience of the last three years has shown that the weakening of the regimes has not led to greater freedom or to an expansion of political participation, but rather to the unleashing of violence and sectarian strife. For

example, the internecine struggle in Syria is clearly not merely a local conflict: tensions are also rife in neighboring countries such as Lebanon and Iraq. Libya has also shown the risks associated with the fall of the regimes, having difficulties in re-establishing the monopoly on legitimate violence which, according to Max Weber, constitutes the essential prerogative of the state. What is more, in the whole region, Islamism, which put the pan-Islamic ideal before the nation-state, could represent an existential threat to the latter. Many hoped that Islamist movements, such as the Muslim Brotherhood of Egypt, would have been swayed by nation-state ideals, thus giving rise to religiously inspired, yet democratic, parties. Unfortunately, this transition has not yet occurred.

## China is keeping a watchful eye on stability in the Middle East, concerned to ensure energy supplies

Today, the stability and security of the region should be a priority for the international community. China's desire to preserve the stability of the Middle East could contribute to preventing the on-going tectonic shifts from escalating into an earthquake, since Beijing is persuaded that the best way to secure its energy supply from the Middle East consists of preserving the status quo, out of the conviction that turmoil and upheaval could present a threat to its economic growth. Both the United States and Europe should also be committed to this goal, in order not to lose their leverage in the region. ■

Daniel Atzori has been a Senior Researcher at the Fondazione Eni Enrico Mattei (FEEM) and he is currently Editorial Team Coordinator of the magazine *Papers of Dialogue*. Atzori earned his PhD in Government and International Affairs from the University of Durham (UK).



by ANTONIO GALDO

# Europe: from failed politics to failed energy policy

2014 is going to be a very important year, perhaps even a turning point, for the future of the European Union. European Parliamentary elections will be held, key top jobs at the European Commission will be handed out, and very tense and uncertain negotiations will determine how to share among Member States operations capable of combining strong balance sheets, economic growth, development and new employment. Europe's incompleteness, suspended between the reality of a single currency, a precarious economic alliance and the utopia of a federal state, has come to the end of the line. It is an unresolved equilibrium that does not work and cannot work, with an extremely high price that the Union as a whole is paying: the wave of public opinion which, exasperated and battered by the knock-on effects of the Great Crisis, is fuelling populism and even driving the break-up of the great united dream born after the end of the Second World War.

## In a nutshell, an incomplete Europe does not count on the geopolitical chessboard

It is possible to escape from this tunnel? There is only one way out, one that could open up precisely when the political terms come to an end in 2014. Europe must regain the realism, the substance and the vital force of the "founding fathers" of a united Europe through the actions of governments and individual states. It must start not with institutional structures that have not yet been established, from utopian



Mario Draghi, President of the European Central Bank.

dreams, but rather with what is on the table. Rather than suggesting grand theories, we must be led by concrete initiatives. Let us think about the objective of the banking union with the necessary support tools in the hands of the European Central Bank, joint projects for employment and the modernization of welfare, and the birth, once and for all, of a shared industrial policy, starting with an energy policy that is not the disorganized and unsustainable result of individual egos and interests. This is the Europe that could emerge in 2014, and this is the Europe necessary to create a better geopolitical equilibrium. Sound energy policy is vitally important to Europe and the world's future. The shale gas (and shale oil) revolution is in full swing in the United States; America outstripped Russia in 2012 as the number one producer of gas in the world and in 2015 it will overtake Saudi Arabia on the podium of oil-producing countries. Self-sufficiency has various implications, in terms of the competitiveness of country systems (specifically, the balance between the United States and the European

Union member states), and in terms of the geopolitical power structure. In Europe, gas costs three times more than in the United States, and this penalizes businesses, households, and individual consumers (more expensive energy bills also translate into less disposable income for consumer goods creating recessive effects).

## According to reliable estimates, the EU's total energy dependency in 2030 will be 67 percent

95 percent of Europe's oil will be imported, while natural gas imports, which were 60.3 percent in 2007, will be 84 percent. Europe's energy mix strategy has recently been updated by new targets set by the European Commission in a directive, which must be confirmed in a vote by Parliament and given the green light by the Council, following the long-winded institutional procedures that deprive the Union of authentic and effective political direction. The Commission has set two important goals for 2030: a 40 percent reduction in greenhouse gas compared to 1990 levels, and a binding quota for member

states for the production of energy from renewable sources equal to 27 percent. As far as geopolitics are concerned, American energy self-sufficiency will drive the United States increasingly towards isolationism and protectionism of national industrial and economic interests, with a tendency to be "reluctant" to intervene in hot areas of the planet. With gas and oil in abundance, America could more easily release itself from the quick sands of the Middle East, while Europe, which has witnessed the outbreak of the crisis in Ukraine, must increasingly reckon with its dependence on energy supplies. Putin's gambits in Ukraine (while on the subject of dreams), seemingly designed to build Eurasia, demonstrated the impotence of the European Union. The EU's irrelevance, ultimately, results from the 40 percent of gas and oil that Germany bought from Russia to meet its domestic consumption requirements. But let us return to the realism that is needed, and let us measure it with regard to the energy policy of the European Union. At the moment, it leads to disappointing conclusions.

## The member states' energy policies continue to move in a random fashion, driven by partial interests and, at times, unfair internal competition

Germany has decided to abandon nuclear energy, while France continues in that direction. On the other hand, the French are cold, if not decidedly hostile, to the American shale gas revolution, while the English are intent on following in the

footsteps of the United States. Italy appears to be out of the energy policy game, owing to the chronic instability of its governments. Is it possible to find a common denominator for this journey, which is going more backwards than forwards, by proceeding in a random fashion? The answer is yes, it is possible. Starting, for example, from a few firm principles: the confirmation of a basic choice along the energy mix process; the improvement of efficiency in the entire industry, the reduction of costs and waste; and the protection of the environment. It is, above all, a flexible modulation of the objectives in the individual countries, where public opinion, social and economic contexts, and the strengths and weaknesses of the respective country systems carry different weight. For example: the importance of renewable fuels is now considered strategic, for all European Union countries, even if the policy of subsidies (which have currently cost up to euro 60 billion) must be better calibrated, and therefore shared, and one cannot leave the choices at European Union level and not that of individual states aside, which favor storing energy produced from renewable sources. If we only managed to share some essential elements, with consistent choices, on the subject of energy policy, the European Union would take an important step forwards and – hopefully, with advantages for businesses, households and individual consumers – it would also appeal more to public opinion. The Europe of energy is the Europe of politics, before the new technologies currently available to all: if we realize this, we will move forward with the shared project; if we do not realize this sooner or later we will break the bank. And at that point, only the remnants of the forward-looking dream of the "founding fathers" will remain.

Antonio Galdo recently published *L'egoismo è finito* (Einaudi) and runs the website [www.nonsprecare.it](http://www.nonsprecare.it)



Istituto Affari Internazionali

by NICOLÒ  
SARTORI

## Iraq, India and Iran: key players in the new global energy scenario

The energy trajectories of the two main global players – the United States and China – are currently the focus of much attention. Thanks to the intensive exploitation of non-conventional resources, the United States will, in a short space of time, become the leading world producer of oil and natural gas, drastically reducing its dependence on international markets. China, for its part, confirmed as the main driver of global energy demand, is set to replace the United States as the number one world importer of crude oil. However, in the medium-term, the emergence of new energy players will rebalance the global order. Iraq and India are preparing to receive the baton from Washington and Beijing and to play a key role on the international stage. At the same time, the possible return to the scene of Iran could shake up the current global energy system right down to its roots.

### **Iraq will bring the Persian Gulf back to the center stage of the global energy scene**

In the space of a couple of years, the United States will overtake Saudi Arabia and Russia and will become the number one producer of crude oil in the world. At the same time, the growth in the production of shale gas will allow Washington to export volumes of liquefied natural gas (LNG) to international markets. In spite of the great impact on its national energy security, America's non-conventional boom will have limited effects in the international context. After 2020, daily production will stop growing and reach

a plateau of around 11 million barrels. In order to deal with the increased global demand for crude oil, which does not seem to show any signs of slowing down, new sources will have to be brought to market. Iraq will play a key role in this situation, with the Persian Gulf once again taking the center stage of the international energy scene. In spite of serious security problems, caused by tensions between the different ethnic and religious groups and disputes between the federal government and local administrations, Iraq is currently the third largest global exporter of oil. Thanks to the quantity of resources available and the geological characteristics of the deposits, the country has the potential to become a key player in the international energy system post-2020. With agreements already signed by international companies, Iranian production over the next decade could increase exponentially, going from the current 3 million barrels per day to a maximum of approximately 15 million. These figures are hypothetical, and can only be achieved in optimum political, industrial and security conditions, and so it is more likely that Baghdad will rise in the ranks of exporting countries in the years to come. China, constantly searching for new sources of resources to fuel its economic growth, has already caught on to the opportunity and is in pole position to exploit Iraq's energy potential. Thanks to the initiatives of the energy giant PetroChina –



**Hassan Rouhani, President of Iran. The possible return of the country onto the international scene would have an extraordinary impact on the equilibrium of the global energy system.**

first alongside BP in Rumaila, and then with ExxonMobil in the West Qurna deposit – Beijing has become the leading foreign investor in the country.

### **New Delhi will compete with China for access to stable and secure energy sources**

In the near future, however, China will have to face up to a serious new international energy competitor: India. According to the International Agency for Energy, New Delhi will overtake Beijing in the next decade to become the main driver of global energy consumption (in the period 2025-2035, India will contribute to 26 percent of growth, against 18 percent for China). Over the next twenty years, primary Indian consumption will double, driven initially by demand for coal. In a second period, growth in demand will be driven by crude consumption, which will reach 8 million barrels per day in 2035. Unlike China, India has

limited energy resources available. What resources it does have contribute only marginally to the energy security of the country, exposing New Delhi to the volatility of international markets. It should be stressed, however, that only 30 percent of Indian deposits are adequately mapped. In order to better cope with the anticipated future surge in consumption, the Indian government has launched an initiative to assess the country's energy potential. For two and a half years, the Keshav Dev Malviya Institute of Petroleum Engineering – under the supervision of a committee presided over by the Minister – will guide the mapping of twenty-six sedimentary basins located in an area of over three million square meters. In spite of its efforts to promote domestic production, accompanied by ambitious policies for the dissemination of renewable energy in the country, New Delhi in the coming years will be at the center of the

international competition for access to stable and secure energy sources. The Persian Gulf, once again, will be the main object of contention, and India (with its energy companies) will have to fight to secure its place among the major international players, including the Chinese companies operating in the region.

### **The possible return of Iran could have an extraordinary impact on the current balance of the global energy system**

The temporary agreement on the Iranian nuclear program reached last November has ignited strong hope for the return of Iran to the global scene. The rehabilitation of the Ayatollah's regime by the international community and its role as a new global energy player alongside Iraq and India, appears, at the moment, to be a remote likelihood. Even if political dialogue should accelerate, efforts to guarantee the necessary administrative, financial and industrial standards for the development of the Iranian energy industry would probably take some time. That said, Iran's return to the international scene could have an extraordinary impact on the current balance of the global energy system. Thanks to its immense potential, Iranian crude and natural gas production could overshadow the American non-conventional revolution, causing the global demand to explode and pushing prices downwards, considerably reducing levels of uncertainty and competition on the international energy scene. ■

**Nicolò Sartori is a researcher in the Security and Defense Department at the Istituto Affari Internazionali [Institute of Foreign Affairs] in Rome, with a special focus on the evolution of technologies characteristic of the energy industry.**

THE MOST ANCIENT SOURCE IN A CHANGING WORLD

# Coal is still with us

**Coal currently provides 30 percent of the worlds' primary energy requirements and generates 41 percent of global electricity; there are no signs that it will become less important in the near future**

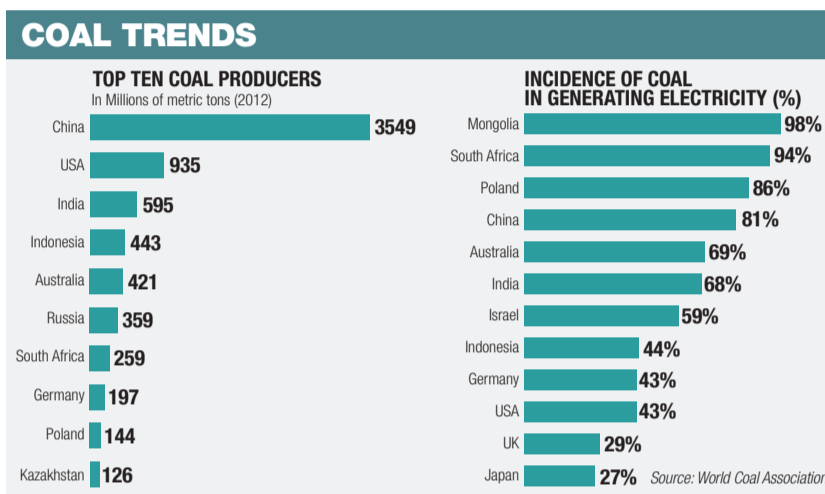
**C**oal, to the degree that it can be said to have an image, is the stepchild of the hydrocarbons industry, oil's unlovely little brother. No one seems to want to go to war over it, coal appears rarely in newspaper headlines; the original "black gold" seems

by **JAMES HANSEN**

somehow antiquated and forgotten. This is peculiar since, as the World Coal Association – an industry trade group – points out, coal provides around 30 percent of global primary energy needs, generates 41 percent of the world's electricity and is used in the production of 70 percent of the world's steel. Further, there is no sign whatever that coal will go away anytime soon. According to Euracoal – the European Association for Coal and Lignite – in the decade between 2000 and 2010, its use grew more strongly than any other primary energy resource, up 28 percent. Data appearing in the *2013 BP Statistical Review of World Energy* indicate that in 2012 alone, global coal consumption increased by 101 million metric tons of oil equivalent (Mtoe) to an all-time record of 3.7 billion tons – a doubling of global coal consumption in the past 20 years. Worldwide oil consumption in the year increased only by 49 million tons. Coal continues to be the fastest growing fossil fuel.

**Growth in coal consumption depends primarily on the Chinese hunger for energy**

While the world as a whole in 2012 saw a jump in coal use of 101.3 Mtoe, China's increase alone was 112.5 Mtoe. India accounted for another 27.7 Mtoe, but no other country experienced a rise in consumption superior to 10 Mtoe. In other words, without China world coal consumption would have fallen by 11 Mtoe over the year. Two decades ago the Chinese share of global coal consumption was only 17 percent, by 2012 that figure had risen to 50.2 percent. The US was the second leading coal consumer, at 11.7 percent of the global total, but coal use in the two countries is showing dramatically different trends. While China increased coal



**Coal, whose main world producer is China, generates 41 percent of global electricity: it is used in very high percentages in the production of electricity in Mongolia, South Africa, Poland and China.**

consumption the most in 2012, the US actually saw coal use drop by the greatest amount. American consumption fell by 58 Mtoe in the year, more than any other national market. With natural gas and renewable energy eating into coal's market share in the US, American coal producers have had to look abroad for sales. About 50 percent of their exports now go to Europe.

**Many of the countries that saw the sharpest percentage increases in consumption from 2011 to 2012 were European**

If China has led the way in increased coal consumption, many of the countries of Europe have also seen a significant increase. Portugal led all countries with a 31.4 percent increase in coal consumption in 2012, while Spain saw a 24.2 percent increase, the UK a 24.0 percent increase and France a 20.1 percent increase. Outside of Europe, 26 percent of American coal went to Asia, 11 percent to North America and 10 percent to South America. At the end of this February, the Energy Information Administration released new energy trade data showing that the overall dollar value of US coal exports has tripled since 2005, generating a billion dollar trade surplus. The point of this avalanche of numbers is to underline the epochal shift underway in the coal industry worldwide. After many years of substantial stability, two phenomena have collided to set this change

underway: Chinese economic growth on the one hand and the huge impact in North America of the introduction of hydraulic fracturing – "fracking" – on the other. The introduction of fracking technology has hugely increased North American production of oil and natural gas, to the point where, according to credible estimates from the International Energy Agency, a Paris-based adviser to 28 energy-consuming nations, the US will surpass Russia and Saudi Arabia as the world's top oil producer as early as 2015, and come close to energy self-sufficiency in the next two decades.

The Bloomberg agency cites IEA data suggesting that US oil production will rise to 11.6 million barrels a day in 2020, from 9.2 million in 2012, as it taps rock and shale layers in North Dakota and Texas with the use of horizontal drilling and hydraulic fracturing.

Over the same time period – once again according to the IEA – Saudi Arabian production will fall to 10.6 million from 11.7 million and Russia slips to 10.4 million from 10.7 million barrels. These figures include natural gas liquids, condensates and crude.

**For the immediate future, the US Energy Information Administration (EIA) does not expect booming American coal exports to maintain their spectacular growth**

It's not that rapidly climbing US gas and oil production, together with

American regulatory intervention, haven't made coal cheap. But the factor that will most significantly affect demand for American coal is "Continuing economic weakness in Europe, slowing Asian demand growth, increasing coal output in other coal exporting countries and falling international coal prices." Read another way, what the EIA is saying is that, beyond the fact that overall price dynamics may not continue to favor American coal with respect to other coal producers as they have in recent years, a broad increase in international production will also begin to cut into US sales over time.

According to the International Energy Agency's annual *Medium-Term Coal Market Report* released in December, tougher Chinese policies aimed at reducing dependency on coal will help slow global coal demand growth over the next five years. Despite the reduced pace of growth though, coal will meet more of the increase in global primary energy than oil or gas – continuing a trend underway for more than a decade.

"Like it or not, coal is here to stay for a long time to come," IEA Executive Director Maria van der Hoeven told journalists. "Coal is abundant and geopolitically secure, and coal-fired plants are easily integrated into existing power systems. With advantages like these, it is easy to see why coal demand continues to grow." Coal is unlovely stuff, messy to mine and use, but it is a cheap and reliable source of energy. The world might prefer to do without it, but that is not likely to happen anytime soon.

**James Hansen provides financial reporting and international relations consulting to major Italian companies. He came to Italy as the U.S. Vice-Consul in charge of economic affairs at the U.S. Consulate General in Naples. He became a correspondent for various leading foreign press organizations, including the *International Herald Tribune*. Then he was appointed spokesman for Carlo De Benedetti, Silvio Berlusconi and, finally, head of the press office of Telecom Italy.**

## MARKET TRENDS

# Brent stable and markets in turmoil

## Geopolitics and U.S. tight oil represent factors of strong disruption for the global oil market

### Oil prices

In 2013, the average Brent price was 108.6 \$/b, barely 3 \$/b below the 2012 level, which was the all-time high in nominal terms (111.7 \$/b). This is the second consecutive year that the Brent curve is relatively stable and features low volatility.

On demand side, the signs are conflicting, with the U.S. recovery taking center-stage and the slow-down of Chinese economic growth. From the point of view of supply, increasing North American volumes of production more than offset decreases in the countries in crisis (Iran, Libya, Syria and Nigeria). However, in terms of international trade, geopolitics and U.S. tight oil are factors which create strong disruption in the oil market. With Brent prices "stagnant," there has been high volatility in the differentials between crude oils, which reflects the uncertainty of flows and production. In the eye of the storm, the West Texas International (WTI), U.S. benchmark, records extensive fluctuations in the discounting of Brent. The development of transport capacity within the country has lightened stocks and kick-started the production surplus to refining coastal areas, only partly strengthening the WTI prices, which continue to be affected by the exponential growth of tight oil production, buoyant compared with domestic absorption capacity. The result is a U.S. crude market that is totally disconnected from international markets, providing refiners with record profits, while the future of new production could be compromised. There is also high volatility in the Mediterranean for the price of Urals crude

(sour medium marker for the area), which in spite of the weakness of European refining margins continues to "act as a catalyst" for the tensions of competitive crude, the Iranian embargo, and Iraqi export instability. Russia also continues to shift the focus toward Asian markets: 2013 signaled, among other things, volumes going to the East overtaking those destined for the Mediterranean for the first time in history.

2013 left a legacy of three important questions: a new round of negotiations, starting in November, between Iran and P5+1, to overcome the disputes over the Iranian nuclear issue; the climb-down in the recovery of Libyan production; the opening up of the debate on removing the ban on U.S. crude exports, with the lobbyists on one side opposed by the producers and refiners on the other side.

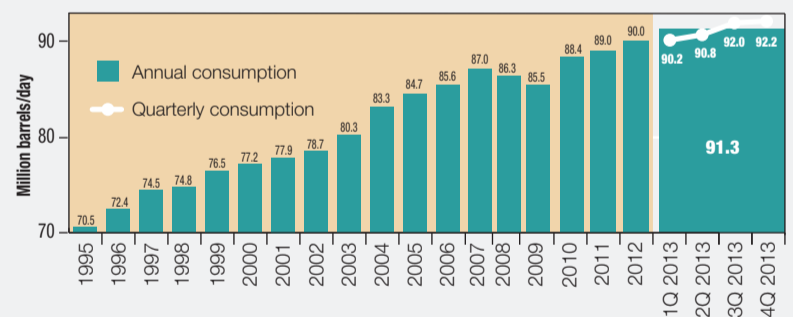
2014 began with Brent prices at the same levels as in the last months of 2013 (January average 108.1 \$/b) with a slightly increasing trend, linked to fluctuations in Libyan production and the improvement in global economic prospects. Instability reigned in the first months of the year in Libya: while for the majority of fields in the east of the country the recovery seemed far away. The El Sharara field went back on stream in January, doubling production (0.5 Mb/d), which was then interrupted again in February. In coming months, alongside positive forecasts in terms of demand, volumes in countries in crisis will fluctuate, which will be central to the dynamics of crude prices.

### Oil demand

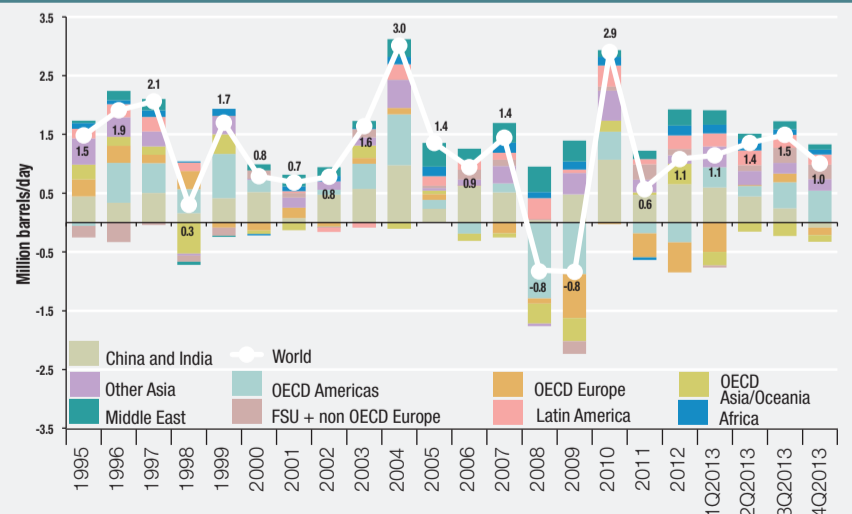
In 2013, global oil demand reached 91.3 Mb/d, with growth higher than in 2012 (+1.3 Mb/d in 2013 against +1.1 Mb/d in 2012) as a result of the improvement in economic activity in the main advanced economies. In 2013, the Organization for Economic Co-operation and Development (OECD) countries returned to positive ground with an increase of 0.1 Mb/d after two consecutive years of falls, but global demand continues to be driven by non-OECD countries (+1.2 Mb/d).

Among the major industrialized countries, only the U.S. recorded an increase in oil consumption. Gasoline, in particular, increased for the first time after the peak in 2007, positively affected by the fall in prices at the pump and the increase in disposable income. The recovery in economic activity and commercial transport supports the growth of diesel fuel while the relaunch of petrochemicals – enhanced by the boom in tight oil/shale gas – has a positive effect on the consumption of ethane and LPG. In Europe, overall demand remains negative for the seventh consecutive year with an accumulated total loss of more than 2 Mb/d from the all-time high in 2006. Note, however, there is a slackening in the negative dynamics with a return to growth for diesel fuel, which goes hand in hand with the gradual coming out of the recession of the euro zone in Q2. The drop in Asia and Oceania is mainly due to the sharp fall in oil consumption in Japan, replaced in heating and electricity generation by coal, a cheaper source. In the non-OECD area, China, with economic growth among the lowest in the last twenty years, recorded a slow-down in the dynamics of oil consumption (+0.3 Mb/d in 2013 compared with +0.5 Mb/d in 2012), although it still remains the main consumer nation. A new phenomenon that featured in 2013 was growth in diesel fuel consumption in emerging countries that was decidedly more contained than historical trends. In China, there has actually been a fall in demand, which has come about not only from the impact of lower economic growth, but also from the replacement of diesel fuel by gas in all sectors (including heavy transport); the acceleration in car registrations (2013 +15 percent compared with 2012) on the other hand, continues to drive gasoline consumption upwards.

### TOTAL GLOBAL CONSUMPTION

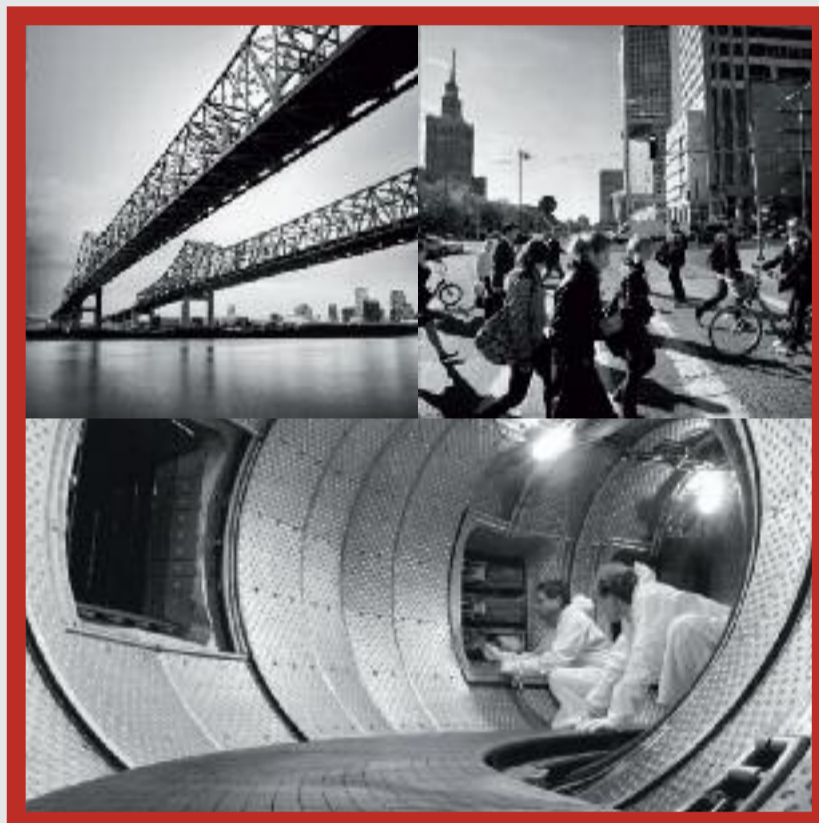


### CHANGE IN TOTAL GLOBAL CONSUMPTION BY AREA



Source: Eni's processing of International Energy Agency data; change vs the same period of the previous year





March 2014

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