

Experts about Energy 2012 and beyond

Harry Brekelmans

Fossils will still be dominating
the energy mix in 2050

Tim van der Hagen

The last thing we want is an
energy squeeze

Coby van der Linde

Europe: used to two steps
forward, one step back

Gert-Jan Kramer

Carbon emissions and global
warming are heavily hyped issues

Ad van Wijk

Tomorrow's computers will
harvest energy from your
keystrokes

Deloitte.





Introduction

Welcome to our 'Experts about Energy 2012 and beyond' magazine.

Over the last 12 months, there has been no shortage of themes impacting energy and resources globally. These themes are as diverse as they are geographically dispersed. From political uprising, unstable financial markets, the Japanese nuclear disaster and the abundance of natural gas to the rethinking of nuclear energy and the growing geopolitical tensions in several regions of the world, 2011 gave us all reasons to pause and think about the challenges that lie ahead for the energy industry.

The world needs more energy, as is well known. Driven by GDP growth and population growth, demand for energy is expected to continue to rise sharply in the next decades. The International Energy Agency (IEA) expects 40% growth by 2035, and BP in its recently published Energy Outlook 2030 projected 39% growth by 2030. Vast investment is needed to meet this surge in demand. Investment is needed in all types of fuels and in all parts of the value chain. Fossil fuels will continue to play a critical role in the world's energy mix, even as renewable energy sources continue their rapid growth.

Carbon emission growth is slowing down, but we are not on track for achieving the CO₂ abatement goals. Although energy consumption per unit of GDP is on a downward trend that is expected to accelerate in the next decade, this gain in energy efficiency is outweighed by rapid GDP growth, especially in non-OECD countries. Current developments will lead to emissions well above the level recommended by scientists (around 450 ppm). More action is needed.

This magazine combines Deloitte's Energy Predictions for the year 2012 and the wisdom of some of the most widely known experts in the energy community in the Netherlands. The Energy Predictions are based on in-depth interviews with clients, industry analysts and senior energy practitioners from Deloitte member firms around the world. The ten predictions themselves are presented in summary at the bottom of the pages. For further reading please visit our website. Against the background of growing energy demand, growing carbon emissions and the challenges facing the energy industry, we have asked our interviewees for their analyses of and vision on the future of energy.

We hope you find this magazine 'Experts about Energy 2012 and beyond' interesting reading and a useful addition to your own discussion and debate about the future of energy.

Marcus van den Hoek
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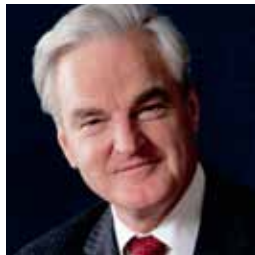


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And you thought gold was expensive? Prices of rare earth metals to remain high, but volatile

The exotic names of the 17 rare earth metals – including tongue-twisters like europium, dysprosium, terbium and neodymium - may not sound familiar now, but they soon could. They are increasingly being used in everyday

components that are vital to the green economy – everything from parts in wind turbines and batteries in electric vehicles to energy-efficient lighting. Sales of these high-tech, rare earth metals have more than doubled on average in the past year,



Thinking Big

More and more integrated oil companies see ‘demerging’ as the right response to today’s industry challenges. What about our own oil & gas giant Shell? Harry Brekelmans, currently the group’s Executive Vice President Russia and Caspian Region, still sees plenty of reasons why bigger is better. He explains Shell’s big thinking on this and other key issues from our Predictions.

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and demand is likely to outstrip supply at least until 2015.

What is driving high sales growth of these rare earth metals, and can high prices be sustained? First and foremost, it’s worth noting that China supplies roughly 95% of the

world’s rare earth metals and about 75% of them are sourced in Inner Mongolia. China controls 30% of reserves of rare earth metals, followed at some distance by the US. Traditional mining countries such as Australia, Canada and South Africa also have large rare earth reserves.

Since the beginning of 2011, China has held firm on rare earth export quotas, and this is likely to keep exports of these strategic metals at last year’s levels. To ensure that its domestic producers have enough rare earth metals for their own use, the Chinese government plans to

build 10 strategic reserves capable of storing more than 200,000 tonnes of rare earth oxides. As it will take other countries several years to ramp up production of their own rare earth reserves, supplies are likely to be tight for the foreseeable future, pushing up prices accordingly.

Marathon did it, Conoco Philips did it, and now the market is speculating on BP doing it: separating upstream from downstream activities. Shareholders are looking to cash in on the 'corporate discount'. Is Shell thinking about the demerger option?

We're really dealing with two questions here: about size and about the virtues of the integrated model. Looking first at just size, some of our peers have been downscaling. But size is not an end in itself. As the emphasis in exploration and production shifts to the Arctic and other frontiers, projects are becoming bigger and more complex. A company needs to have a certain scale to be able to shoulder the risk and investment involved, and to be seen as a credible partner for governments and huge national oil companies. So being big is a key competitive differentiator. Having said that, though, being the biggest has no added value for either business partners or shareholders.

Is the integrated business model going to last?

Not everybody is giving up on it! Oil companies need to think strategically about what the added value of integration is. Many in our peer group, us included, shed a lot of underperforming downstream activities in recent years. Some competitors were left with such a small downstream business that they were justified in wondering whether it was worth keeping. Our downstream is still well out of that danger zone, and I doubt we'll ever end up there. Right now, we're most successful precisely where upstream and downstream meet: our Gas to Liquids project is a case in point. A next step for us will be Gas to Chemicals. Similarly, our LNG business shows how the integration of gas production and transport, by sea and by road, adds considerable value. The lesson is that if the integrated organisation is kept intact, new value chains emerge. Being integrated, moreover, increases our bargaining clout with governments and national oil companies, which are usually integrated, too. We make a better fit with them, and are likelier to make propositions that will interest them. Our up- and downstream partnerships with Saudi Aramco, and more recently with Petrochina, are very successful. This aspect will become increasingly relevant in the years ahead.

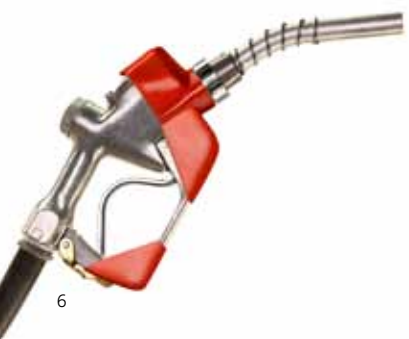
The Macondo spill has taught us the delicacy of deep-sea oil recovery. We have to be absolutely certain that we can operate in an environment like the Arctic before we go and do it

With so much potentially recoverable oil and gas being discovered worldwide in recent years – Brazil, shale gas, and now the Arctic - does their status as 'finite resources' need redefining?

It looks like we can keep postponing the exhaustion date of these 'finite resources', but the pace at which we're consuming energy still creates an ever-present tension between demand and supply, and price swings that destabilise economic development. This means that we need to work hard, constantly, to keep finding new reserves. We can't count on renewables filling the gap. If we sit back, price tensions will become unbearable. So the industry is serious about developing remote resources like the Arctic.

What about the geopolitical risks?

This creates certain dynamics, with some nations moving in and others not wanting to step aside. I wouldn't call the Arctic a tinderbox - in fact, parties are constructively negotiating. The Norwegians and Russians have carved up their Grey Zone and the Norwegians have immediately



Is a bigger oil company better?

For the last 50 years, the vertically integrated oil and gas company model has reigned supreme. By owning all parts of the value

chain, companies are able to control the entire spectrum of activity – from upstream, through midstream, all the way to downstream. This model has served the industry well, but some are now challenging the status quo by splitting their

upstream and downstream operations into separate units. Does this make sense?

It may for some oil companies. For example, one former integrated company had an enterprise value of 3.8 times its EBITDA. By contrast,



Marcus van den Hoek (left) and Harry Brekelmans

launched activities. It's a vast area, with massive reserves and few inhabitants, making it a less likely scene for conflict. Geopolitics aside, though, the Macondo spill has taught us the delicacy of deep-sea oil recovery. We have to be absolutely certain that we can operate in an environment like the Arctic before we go and do it. We're optimistic, however. Shell is planning its first exploration wells offshore Alaska next year.

We can't wish our way into a new energy future – nor can we spend our way there

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large E&P companies generally trade at around 6 times EBITDA, and refiners at around 5 times EBITDA. The company's spinoff of its entire refinery network has yielded shareholders a 69% windfall. This suggests that splitting upstream and downstream assets creates

value for shareholders. For another company, splitting into separate entities is part of the process of selling some 15 billion dollar's worth of assets to improve shareholder returns after a series of major acquisitions left its balance sheet strained.

An operational advantage of demerging is that management may find it easier to focus on each separate business, while internal difficulties inherent in allocating capital to different divisions within a business will disappear. Investors too, may benefit from greater

transparency of value and value drivers.

So, how likely do we think further big oil demergers are in the near term? We foresee a few in the next two or three years. Those companies severely

How is this affecting your company's relationship with the Oil Field Services industry?

The whole supply chain is rapidly reshaping itself at the moment. I'd be the last to say the current model is past its due date. Diversity is good! It stimulates competition and innovation. But the context is relevant. Shell feels very comfortable with large-scale, ground-breaking, end-to-end projects, such as the Sakhalin II projects, or the Pearl Gas-to-Liquids project. This has to do with the risks, the integrated nature, the big investments, and the long investment horizon. Developing the latest logging tool, on the other hand, is an example of innovation best pursued by service companies. On the whole, though, I do see a reversal of the strong tendency in the past decade to outsource as much as possible. In North America, for instance, shale gas triggered a huge boom in the service industry. But some operators are now starting to integrate their supply chain again. Why? To address volatility, guarantee availability and get a grip on skyrocketing costs. There are markets where we don't want to be dependent on service companies to hire equipment at a decent price, or at any price. Integrating services also means equipment can be better tailored to our needs. And finally, there is the issue of quality and meeting regulatory requirements. Ultimately, it's our reputation that's at stake, so in higher risk projects it makes sense to extend our operational influence to the max.

If the integrated organisation is kept intact, new value chains emerge

constrained by the financial crisis and experiencing slow organic growth may find additional value in splitting their assets, as the two separate units may be worth more than a single entity.

On the other hand, some large

vertically-integrated companies may prefer to maintain their current structure. Why? Many of them own shipping assets, the value of which may be difficult to assess given the current state of vessel overcapacity. Some own renewable energy assets, which

Shell is betting heavily on innovation as a way to stay ahead of its oil & gas competitors, but oil & gas is just a part of the overall energy supply picture. What is the force of innovation doing there?

The realisation is dawning that the gap between energy demand and supply is so huge that we'll be needing everything we can invent just to limit the tensions. The drive to innovate in the energy industry is getting up steam. Last year investment in renewables totalled \$220 billion, half of the amount invested in oil & gas! On the other hand, expectations tend to run too high. Experience has shown that it takes 30 years for a new technology to capture 1% of the energy mix. We can't wish our way into a new energy future – nor can we spend our way there. Critics sometimes say allocating more investment into renewables will speed up their development, but it's wrong to pour unlimited amounts of money into a particular field. That stifles competition, money goes to second-rate ideas and the overall return on investment declines. Instead of driving innovation, you create a playground for investors. Looking at it that way, one is forced to conclude that fossils will still be dominating the energy mix in 2050. That's why carbon capture and storage has to stay on the agenda, whether we like it or not.

Shell's early and persistent focus on gas seems to be paying off as we enter what market watchers are calling the Golden Age of Gas. Will gas infrastructure be able to keep up with soaring demand?

The current energy infrastructure is outdated and under pressure, so it will take a lot of money to keep up what we have, let alone grow it. The global capital expenditure required looks positively scary - more than a trillion dollars a year for the next 25 years! The biggest risk, however, is inertia. If we put off making choices for another five years, we'll be in an even more serious fix. Shell launched its gas advocacy efforts about a year and a half ago to address a lack of awareness and action. I do see dialogue gaining momentum now, but will it be in time? To fully exploit the potential of gas as part of the solution to the environmental problems we're facing, we really need to start building more gas-fired power plants, storage and pipelines now. Decision-makers are also influenced by other lobbies, for more renewables or for coal.

will take time becoming profitable enough to sell. Finally, the most important reason to stay intact may simply be that many are amongst the largest and most profitable companies in the world – and maybe bigger is better.

Fossils will still be dominating the energy mix in 2050

Are the gas market dynamics any different outside Europe?

Don't underestimate Asia. The Fukushima meltdown has immense implications for gas demand and prices. In China, exploration and licencing for tight gas are gaining pace. Shale gas could really take off there in the next five years. I'm not worried about this leading to oversupply and price falls as it did in North America. Once the supply is there, there will be no issue with demand. The more gas China produces, the more its market will absorb. As confidence in the availability of gas grows, the Chinese will increasingly build gas-fired power plants – driven also by the potential of gas to help them solve their serious environmental problems.

Do you believe our country is doing the right things to maintain its traditional leading position in the gas industry?

The Dutch Prime Minister's recent visit to Russia revolved around gas. We were represented there, as was Gasunie. The feedback from my Russian contacts was very positive. Our country's relations with Russia are excellent. But are we vocal enough in Europe to protect our own interests, let alone influence European energy policy? We certainly have the potential to be leading, given our intellectual capital, investment levels, the relations we've built and of course our own resources. But we have to send a more coherent message.



Harry Brekelmans joined Shell in 1991, soon after graduating from Delft University. Starting as a geoscientist for Shell Research, he moved into operational positions in Egypt and Scotland. After a broadening assignment with Shell Internal Audit, he was first posted to Russia in 2007 as CEO of Salyem Petroleum Development. He returned to head office as Executive Vice President Strategy and Planning in 2009. This year, he was appointed to the key post of Executive Vice President Russia and Caspian.

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The future is getting smaller: energy breakthroughs using nanotechnologies

Nanotechnology can speed up the development of cleaner,

more efficient energy sources and uses. A few areas where it is likely to play a role are lighting, transport, renewable energy and energy storage.

Much of the electricity we generate is currently consumed

by incandescent and fluorescent lighting. These are now facing increasing competition from light-emitting diodes (LEDs), which are highly superior thanks to their compactness, durability, low heat generation and electrical efficiency. Newer discoveries –

A smart transition: the *do's* and *don'ts*

As part of its Top Sector initiative, the Dutch government set up a four-strong taskforce to help it step up innovation in the energy sector. One prominent scientist was asked to come aboard: Tim van der Hagen. He tells us what to do, and what not to, for a 'smart' transition to a sustainable society.

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such as a hybrid LED coated with a thin layer of quantum dots that yields warmer, white light similar to that of a traditional light bulb – could have wide commercial and industrial applications.

Where nanotechnology may really

prove its worth for transport is in diesel fuel additives for more efficient combustion. Already, commercially-available products containing nanoscale particles of cerium oxide, which catalyse the combustion reaction between the diesel fuel and air, have been

shown to cut fuel consumption by up to 10% and reduce exhaust emissions.

Nanotechnologies also show promise in increasing the efficiency of electricity generation directly from solar, wind and

geothermal resources. As such, they can play an important role in developing distributed electricity generation and thereby minimising transmission losses. But they can also make electricity transmission itself more efficient. Nanoenhanced transmission will

Do: take the time Everybody agrees we need to transition from our current society - relying on non-sustainable, polluting and increasingly expensive fossil-fuel based energy - to a new one in which energy is sustainable, clean, plentiful and increasingly cheap. But it's incredibly hard to alter energy supply patterns. If we decide today how we want to do this, it could take up to twenty years before the changes are in place. We're living in the wrong houses, working in the wrong factories, driving the wrong cars...our society needs nothing less than an extreme makeover.

Don't: overinvest in renewables What is not smart is haphazardly investing big sums in all kinds of new technologies without a clear picture whether this contributes towards achieving our ultimate goal in a cost-effective way. Doubling spending on renewables doesn't automatically double the speed of the transition. Because let's face it, renewable technologies are mostly still in their infancy. It's a mistake to rush into large-scale power generation with these technologies now. That could end in public disillusionment. If we invest carefully and roll out these technologies at a more measured pace, the ultimate result in 2050 is likely to be both cheaper and better for the environment. And while we're at it, we'll be building a decent market for the new technologies so we can generate jobs and income with them. That will be just as fundamental to our new society as it is to the current one.

Do: concentrate on one goal To keep things simple, I suggest we concentrate on just one goal: minimising carbon emissions. If the consensus forecasts are right, and carbon emissions are a massive threat to our climate and our very existence, our descendants will be very grateful for our foresight. If the consensus forecasts are wrong, and carbon emissions aren't a threat after all, so what? We'll have spent a lot of money on a non-problem, but we'll still have a nice new economy. For our energy supply, then, we need affordable, large-scale zero-carbon options.

Don't: give up on nuclear energy - yet Following this line of thinking brings us inevitably to nuclear energy. It already accounts for a third of Europe's power generation. Let's use this zero-carbon source of energy to buy the time we need to develop viable renewable alternatives. The nuclear disaster in Fukushima should not and will not make a significant dent in global nuclear expansion plans. Having said that, though, the cost of building nuclear plants is rocketing, mainly due to tighter security requirements. After Germany's Atomausstieg, moreover, European utilities are wary of governments closing down their nuclear plants before they recover the high up-front costs. And nuclear energy, all things considered, is not the ultimate energy option. So I'd be surprised if it was still around in 2100.

Do: invest in wind – for now Our country in particular can do profitable business in the offshore wind sector. Conventional onshore wind technology cannot simply be transferred to the high seas. The extreme conditions call for a radical redesign of turbines - just the job for us Dutch, with our extensive offshore expertise. Ultimately, though I see wind as a stopgap solution. It can contribute significantly to our energy supply for another 30 years, but beyond that it will be unattractive compared to other alternatives. I still think it's worth doing, though. With more and more of our planet's inhabitants claiming their right to prosperity, our energy supply is under mounting pressure, and we'll need all the alternatives currently available just to keep up. We can't afford to be choosy at this stage. The last thing we want is an energy squeeze.

Don't: set near-term targets Rather than focus on the next ten to twenty years, I believe we should work towards achieving our goal - a new, sustainable society – in, say, 2050. In the meantime, while we're building this new society, our aim should be to keep environmental damage, but also costs, to a minimum. Specifically, let's not set near-term targets for the share of renewables in the energy mix. The market will sort that out.

make it possible to generate more electricity in remote locations – with abundant renewable resources – and transport it to high energy demand areas. The biggest difference nanotechnology will make, however, is in the solar arena.

Replacing the costly crystalline-silicon wafers used in today's solar panels with quantum dot nanocrystal technologies could not only improve the efficiency of solar energy systems, but also make them dramatically cheaper.

Nanotechnology is part of efforts to make batteries, capacitors and fuel cells better, smaller and cheaper. This is critical for developing distributed electricity generation, as reliable local energy storage reduces the amount of electricity that needs

to be transmitted over power lines to meet peaks in demand and troughs in supply from inconsistent resources like wind and solar. Some have predicted a scenario for 2050 in which homes, businesses and office buildings have their own local

Nuclear energy, all things considered, is not the ultimate energy option. So I'd be surprised if it was still around in 2100

Do: **link science and enterprise** Looking back at how we lived in the 1970s, and what incredible changes we've seen since then thanks to big leaps in technology, we can hardly begin to imagine what advances the next forty years will bring. Based on the research already going on right now in solar and battery technology, I think energy, derived from the sun, will eventually be integrated into everything we use. There will be no such things as plugs and sockets. Our homes, our appliances, our cars, our roads will be able to generate and store their own energy. We will take energy for granted like the air we breathe – and simply pay the bill at the end of the month. But this isn't going to happen all by itself. The bright ideas of young university graduates need to cross the 'Valley of Death' in the innovation process – find capital to turn them into economic successes. Here in the Netherlands, the multinationals already work closely with universities, but small and medium-sized businesses don't. And that's typically where the true entrepreneurs are with a nose for interesting market niches. In the US, there's far more respect for the spirit of enterprise, and going bankrupt is seen not as a disgrace but as part of the game. Our country needs a bit more of that spirit. My university has assisted in the start-up of some 100 new companies in the past five years, so we've made a promising start.



Tim van der Hagen earned his PhD in 1989 at Delft University, where he is currently dean of the Faculty of Applied Sciences and professor of reactor physics. He is a key advisor to the Dutch government in energy matters through his membership of the Dutch Energy Council and TNO's Strategic Advisory Board on Energy. In 2011, he was appointed to a special government task force for energy, one of nine such teams created by the Ministry of Economic Affairs to provide input for targeted investment in innovation in nine Top Sectors.

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electrical storage device capable of providing 24 hours' worth of uninterrupted power supply.

Nanotechnology research will continue unabated over the long term with some economists predicting a trillion-dollar global

market for nanoproducts over the next 10 to 15 years. A market this large will have implications for the energy sector. Roof-top solar panels could become obsolete as sunlight is simply converted into electricity via a paint-like substance that can be sprayed on

rooftops. Researchers have already proven that nanocrystals can be as efficient as the most expensive solar cells, for a fraction of the cost.

The psychology of the energy transition



The global move towards sustainable energy will survive economic and political turbulence, says Coby van der Linde, our country's leading expert on geopolitics and energy. What we need to understand better is the difference in thinking behind the process from one region to the next. Chinese and American motives and expectations are very different from Europe's.



The 'Golden Age of Gas'

Over the past five years, success at developing previously uneconomic shale gas deposits has transformed North America into a gas producer's paradise.

This shale gas revolution now looks likely to go global and usher in a 'golden age of gas'. Before investing the huge sums needed to unlock the economic potential of shale gas resources, however, producers need an understanding of

the rapidly changing global supply and demand dynamics. For example, how will the anticipated increase in global liquefied natural gas (LNG) supply affect the US? How will China's insatiable energy appetite affect gas prices? How



As the climate debate reaches fever pitch in Durban, I've been spending my time reading up on history. I see parallels between the current state of affairs and the 1970s: big balance of payment deficits and surpluses, the end of the gold standard, energy producing and consuming countries at odds with each other. The Club of Rome wrote its Limits to Growth report – the discussion about scarcity seems very much like a repeat from then. It goes to show that problems don't go away if we take half measures or none at all. They may disappear from the agenda for a while, but the same problems return, in a different form. I see this process at work in the energy debate as well. What fascinates me, though, is how history helps explain why different countries have different ways of dealing with the issues, and why they have such difficulty getting on one wavelength.

The United States: it's all about security

In the US, the energy transition debate has never really been about

the climate, but about security. And not just security of supply, either. Under Bush, the Americans started taking an interest following a report from the Pentagon. The report pointed out that climate change could cause floods and draughts, setting migration streams in motion and destabilising countries. Considering American society's obsession with security risks, this was an effective angle to approach the issue from to get things moving.

Emerging markets: the blessed lack of a legacy

Until quite recently, developing countries in Asia, Africa and South America have been overwhelmingly agriculture-based and not involved in the energy debate. The consequence is that they look at the power generation technologies as they are now, without history getting in the way. For them, choosing nuclear power is not a matter of continuing to run outdated plants, but of building state-of-the-art ones. It's not surprising therefore that they have fewer qualms about it. Meanwhile,

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will the shutdown of nuclear power in Japan, Germany and other countries affect worldwide gas demand?

Under the reference scenario Deloitte has developed, using its World Gas Model, to address

questions like these, we assume that continued economic growth will boost gas demand in North America and especially in non-OECD economies such as China and India. Until 2030, gas demand is projected to grow by 1.9% a year, worldwide, and by

3% a year in Asia and the Middle East. In China, gas demand is projected to increase by 4.6% which is high compared to the projected global average, but well below the 13.8% annual growth seen during the past decade. US gas demand growth is likely

to be substantial, driven by the electricity sector.

We also projected gas production by region. The Middle East, with its massive resources and forecasted increase in export capacity, is projected to provide

countries that don't have an adequate, nationwide electricity grid are all the more interested in decentralised solutions that don't require one, such as renewable energy produced by consumers at home.

Internal market considerations are also a major factor influencing energy choices in these countries. They may subsidise energy in the domestic market as part of the process of lifting their population out of poverty. The gap between international market prices and domestic prices makes import of fuels a threat to political stability. Domestic solutions – nuclear, solar - are easier to manage.

Americans started taking an interest in climate change following a report from the Pentagon

China: looking for new ways to make money

Much of what's been said about the US and emerging markets also pertains to China, but there are factors that make it different. One is China's sheer size. China used to play down its dominance – project the image of a gentle giant - but lately it has been losing its inhibitions. Other countries in the Asia Pacific region feel threatened, or worried about their overdependence on China as a destination for their raw materials and products. When conflicts emerge, as we see in the South China Sea, they sometimes seek support from the US. There may be tensions in the short term, but in a region where one player is so obviously dominant, the rest will need to accommodate.

The other difference is China's role as the world's factory. Chinese interest in wind and solar power is about becoming a leader in these technologies and building a new national industry. They can upscale production and make it more efficient, bringing us closer to a real breakthrough.

China's growth means its hunger for energy is insatiable. It needs to pursue every energy option just to keep up. Consequently, the development of shale gas in China will go ahead – that is, if the Chinese government retains the backing of the people and the necessary financial clout going forward. Both these factors are under pressure as China integrates with the world economy and is more exposed to the economic cycle.

Europe: used to two steps forward, one step back

Integrating a giant country like China into the global energy market is not like integrating a small country. It changes the entire system. It's the Europeans who should understand this. The European Union pre-2004 is not the same one we had after having absorbed 10 members at once. The European energy debate changed swiftly. The new Eastern European member states were very dependent on gas supplies from Russia, due to their legacy infrastructure. There were concerns about solidarity in Europe. Adding Turkey to the union could have helped to diversify supply route problems. More's the pity now that Cyprus, an EU country, threatens to be pit against Turkey in a conflict over offshore oil and gas development in the eastern Mediterranean. Europe still hasn't decided what kind of project it really is. It has trouble speaking with one voice given the diverging interests within the group, the absence of political tools and the way it relates to neighbouring countries and their interests.

The energy mix differs considerably from one European country to the next. As we go sustainable, convergence will be slow and perhaps remain incomplete. Countries will always make their own choices based on supply lines. The biomass option, for instance, looks different to the Netherlands with its port of Rotterdam than to an Eastern European country with a large agricultural sector producing biomass.

much of the incremental supply, with production projected to nearly triple over the next two decades. The Asia/Australia region is where production growth is projected to be next fastest, but well behind that of the Middle East. The CIS, including Russia

and Caspian republics with prolific supply basins, is currently the largest producing region in the world. CIS production is projected to hold fairly steady and then grow moderately due to increased production out of Kazakhstan and Turkmenistan, both of which hold

significant resources and have relatively small domestic markets. Perhaps somewhat surprisingly, North American production is projected to remain flat. The much-anticipated rise in shale gas production merely sustains current production.

Gas will become the fuel of choice for several reasons: tightening environmental regulations, expectations of ample supply at competitive prices, and the need to back up intermittent renewable sources such as wind and solar to ensure reliability.

Europe is a continent of roadmaps and targets and verification and small steps. These are part of its institutional make-up. Once we've managed to hammer out an agreement, we're eager to take it to an international level. But the other players on that level have their own national priorities. They're not interested in committing to such a plan. Ultimately, Europe will continue to reshape its energy mix, regardless of the failure of climate tops. Creating jobs and reducing dependency on outside suppliers are motive enough.

In a region where one player is so obviously dominant, the rest will need to accommodate

Will globalisation iron out the differences?

There was a belief in the nineties that globally rolling out the principles of the Washington Consensus - rule of law, more market, less state - would eventually make political differences between countries disappear. Global market integration would put an end to energy supply constraints. Companies were politically neutral – or so we thought. They would oil the wheels of the geopolitical system. A naive idea, in retrospect. Among disenchanted voters and part of the political spectrum in the Western world, we currently see a move away from globalisation. The business community, by contrast, is still keen to continue operating in an international playing field. Companies base their decisions on the risk levels per country or region. They are prepared to enter the markets where the growth opportunities lie - even if it means meeting governments halfway. It will be interesting to see which force, globalisation or nationalism, will be stronger in the years ahead.



Coby van der Linde earned degrees in political science, international relations and public law, and a doctorate in economics at the University of Amsterdam. She held positions at Leiden University and spent time as a guest researcher in the UK and US. She is currently director of the Clingendael International Energy Programme, professor of Geopolitics and Energy at the University of Groningen, a member of various advisory boards and a member of the Dutch Energy Council. She has published several books and is a columnist on energy issues.

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View from the lab



The pace of our transition to a sustainable economy depends in part on how fast the world's scientists can develop new technologies. What's in the pipeline? And how long will the road to market be? Our country's prestigious research institute TNO has the big picture. Deloitte's Jasper de Bruin spoke to Mart van Bracht, Managing Director Energy at TNO.

What is TNO's role in the energy sector?

We are a state-owned independent Research & Technology Organisation. We conduct R&D projects on both fossil energy sources and renewable energy. In the Netherlands, we're also the government's own research lab for the sustainable management of the subsurface, including natural resources like oil and natural gas. For example, we provide expertise to back up decisions on oil & gas and geothermal exploration and production as well as carbon capture and storage. In the global market, we do a wide range of research and development projects for oil & gas companies, contractors and utilities. We develop logging tools. We develop smart fields technology to get more oil out of new and abandoned oil fields. We're currently involved in a project injecting CO₂ instead of water into oil wells to get the oil to the surface – this permanently eliminates the CO₂ from the atmosphere, and greatly



The corporate water footprint: The next 'tipping point' for energy companies

Water is climbing political agendas. This is no surprise,

with drought already causing acute water shortages in parts of Australia, Asia, Africa, South America and the Americas, while the world's population is predicted to grow to over 9 billion people by 2050.

Business, too, is beginning to respond to the challenge of water management. Many of the world's largest companies have identified water reduction targets. Investors, in their turn, have started to assess the reliance of their portfolios on water



Jasper de Bruin (left) and Mart van Bracht

Solar is gaining ground faster than predicted. In Italy, it can already compete on price

reduces water consumption in the production process. The Chinese are very interested – sure proof that it's good business!

What about renewable energy?

A major focus for us. We're active in local (smart) sustainable energy systems in and outside the Netherlands. For example, we have a pilot project running on the Dutch Caribbean island of Aruba. It's an ideal testing ground because there is almost always wind and sun, and energy is currently very expensive there – they basically burn oil for electricity. Consequently, the government of Aruba, the local power company and customers in the tourist industry are really interested in renewable alternatives like wind, tidal and solar, which can save them money and make the island a frontrunner in sustainable energy supply. On Aruba, moreover, it's much easier than here in the Netherlands to get permits to build things like wind turbines. So we are dealing here with a real 'win-win-win' situation.

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resources and their vulnerability to problems of water availability and pollution. The US \$457 billion Norwegian Government Pension Fund recently announced that it would evaluate the water risk of the 1,100 companies whose equity it holds.

This has ramifications for the energy sector. Energy companies have long been significant users of water. Power plants need water to create steam for turning their turbines. Shale gas production consumes millions of litres of water per well. Producing one

litre of ethanol from corn costs 10 to 17 times that amount of water. Nuclear energy uses 1800 to 3200 litres of cooling water per MWh.

What steps can energy companies take now to seize control of their water usage? It's a matter

of analysing their overall water usage and water intensity, where their water use occurs, what their water sources are across the supply chain and how they can be modified. They need to identify specific kinds of business risk emerging from their water use,

The consensus among scientists seems to be that our future will be solar powered. Do you agree?

In the next few decades, energy demand will be growing so fast that all the available technologies will have to contribute, but in the long run, we see solar as very promising. Solar is gaining ground faster than predicted. In Italy, it can already compete on price with traditional power alternatives, and we expect grid parity to steadily extend northwards, reaching the Netherlands in about ten years. This implies more decentralised power generation. As the price declines, we see more and more local solar initiatives emerging led by small businesses and municipalities. More consumers will follow before long. And solar hasn't even reached the high end of its development curve yet! The latest advances in thin film technology mean that big, clunky solar panels will make way for paints, textiles and windows that contain tiny photovoltaic cells. We will absorb a lot of the energy we need on the go.

Our country could be home to the 'ASML' of the solar cell industry

Meanwhile, the Netherlands seems to have given up on solar. Dutch companies have sold off their solar subsidiaries. A bad bet?

It's always tricky to time the launch of innovative products. If you're too soon, the market isn't ready for them. I think that's what happened to some solar technology developments in the Netherlands. Our country needs to focus on an activity it can excel in, and accept that large-scale production of solar energy systems is not such an activity.

China has caught up with us and captured that market. On the other hand, designing and producing machines for solar cell production is an interesting niche for the Netherlands. We could be home to the 'ASML' of the solar cell industry.

And the Dutch government? Research budgets for solar projects are under pressure.

It's a matter of focusing investment where it will be most effective. A year ago, TNO teamed up with Dutch energy research centre ECN and Eindhoven University in a joint solar expertise centre called Soliance. It's located in the Eindhoven area, which thanks to the presence of industry players is developing into a kind of solar 'Silicon Valley'. Soliance is working on a number of innovations, with sponsoring from businesses and the Province of North Brabant.

What does all this mean for investments in other forms of power generation?

Gas will be the last fossil fuel to disappear from the energy mix. There are still large reserves available and the CO₂ footprint of natural gas is much smaller than that of oil or coal. So we would be wise to invest in gas infrastructure. It's also worthwhile to find out if our shale gas reserves are really significant and can be produced in a safe manner. We can always decide to save them for a rainy day. Building more coal-fired power plants is not a good idea, though, even if we fuel them partly with biomass. As a hedge against uncertainty, wind power should remain a constituent of the European energy mix, but I believe the turbines themselves are better left to the Germans and Danes, with the Dutch only contributing (offshore) wind expertise. Likewise, nuclear plants should be a French speciality.

Given the significant water footprint of energy production, managing the energy transition also involves water management. Does TNO see answers?

Water is a different issue from energy. There's plenty of it, but most of it isn't suitable for drinking. So the problem is easier to solve – it's essentially a matter of finding a cheaper way to make salt water potable.

but also opportunities that may emerge from adeptly managing their water use.

In recent years, we have already seen both companies and individuals adjust their energy usage behaviour to lower their

carbon footprint. Now, watch for businesses and consumers lowering their water footprint in the same way.

Traditional desalination techniques are very large-scale and only viable in areas where there is practically no natural fresh water supply. TNO has developed an energy-efficient microsystem – the size of a household appliance – that can turn salt or sweet surface water or even sewage water into drinking water, using a combination of membranes and distillation. We're looking for a company that wants to bring it to market. Ours is just one of the microsystems available at the moment. The beauty of these systems is that users don't need to be connected to a water supply network, as long as they have access to some kind of water. It's nothing less than a revolution in water management, as water transport is often the real bottleneck. Water supply is going to be organised locally, with existing water resources being recycled over and over again. It's already happening in Australia, China, India and South America.

Will this make the industrial water footprint irrelevant?

Yes, to a large extent it will, as industry will no longer be competing with consumers for limited water resources. In the oil & gas sector, this is particularly good news for water-intensive shale gas recovery. Moreover, new purification technologies will help companies clean up the huge tailing ponds of polluted water they generate when producing oil from tar sands in remote parts of the world.

So with revolutionary solar and water technology about to make the leap from lab to market, our sustainable future looks bright?

Ultimately, yes. That leap from lab to market is the tricky part, though. Energy and water are low-interest commodities. Marketing research has shown that even in countries with a low living standard, consumers given the choice will buy a flat screen TV or smartphone before they buy our water purifier. Companies willing to mass-produce sustainable solutions need strong marketing capabilities, and must accept that margins may be a little lower than they are on standard consumer products. But in terms of corporate social responsibility, activities like this make perfect sense!



Mart van Bracht (1954) joined TNO after earning his doctorate in Earth Sciences from the Free University of Amsterdam. From 2004, he has held a series of management positions, and he was appointed Managing Director Energy in 2010. As such he is responsible for all TNO's research pertaining to energy, one of the institute's seven focus areas. Alongside his other responsibilities, he is also Managing Director of the Geological Survey of the Netherlands, a public service delegated to TNO. He has been in this role since 2005.

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China's Globalisers in renewable energy

Backed by soaring energy demand and government support, Chinese wind and solar power companies are competing internationally and rapidly becoming the global leaders in their industries.

The Chinese government is serious about cutting the economy's carbon intensity in 2020 by 40 to 45% from 2005 levels, and is therefore determined to increase the share of renewable energy in the energy mix from 8% now to 15% by 2020. In this stimulating environment, highly successful wind and solar power industries have emerged.

Wind has outgrown subsidies

Indeed, Chinese-based wind power companies are doing so well that the Chinese government recently decided to end wind power subsidies. This decision came on the heels of pressure from the World Trade Organisation after the United States filed a complaint. The subsidies were meant to boost the industry during its infancy, but today the Chinese wind power industry is able to stand toe-to-toe with its international competitors. China now has over 80 wind turbine makers, and it has overtaken the US as the country with the greatest wind energy capacity reaching 44.7 GW.

To ensure continued growth, Chinese wind power companies are

increasingly looking abroad. Whether it is through M&A, partnerships, buying components or establishing subsidiaries abroad, Chinese companies are developing gateways to international markets. Xinjiang Goldwind, a leading producer of wind turbines, buys parts and services from The Timken Company (US) and blades from Denmark's LM Wind Power. Goldwind's executives said that the company expects to propel wind power technology development worldwide through cooperation. US company CleanTech Innovations is a supplier of wind tower products to China HuaNeng Group.

Venturing out of China

Sinovel Wind Group, China's biggest turbine manufacturer, purchases components and parts from global partners as well. But additionally, Sinovel has signed a strategic partnership with the Greek power firm Public Power Corp to construct a 200MW-300MW wind farm in Greece. Through this partnership, the companies also plan to build wind turbine manufacturing facilities. Longyuan, one of the world's largest wind farm developers, is partnering with Gamesa from Spain to build 200MW of wind plants in China by 2015. But the two firms hope to develop sites in Europe, Latin America, and the US as well.



Geopolitical risks have always been a fact of life for oil and gas companies, but the quest for new supplies of natural resources is increasingly taking them to areas without well-defined borders, where geopolitical disputes can easily

erupt. Two such areas are the South China Sea and the Arctic.

While borders in both regions have been disputed in the past, predictions that both are oil and gas wealthy have intensified the political tension between

disputing countries. Even though the South China Sea has yet to be explored in depth, early predictions put oil reserves at over 200 billion barrels and gas reserves at about 25.5 trillion cubic metres, which is equivalent to the proven reserves of Qatar.

At the same time, Chinese wind energy companies have also started to open up branches of their own outside of China. Xinjiang Goldwind established Goldwind USA in April 2010. Goldwind USA employs local workers and cooperates with local suppliers. So far, this strategy has proved successful. Goldwind USA won several bids to provide Chinese-made turbines for American wind farms.

Driving innovation

Traditionally the cheap manufacturing location for technology developed elsewhere, in this industry China itself is driving innovation. In recent years, Goldwind had been developing the permanent magnet direct drive (PMDD) generator. The PPMD helps eliminate the gearbox, which is the part of the turbine that is most likely to break and costly to fix. Improving efficiency while reducing costs, the PPMD is quickly becoming the standard for wind turbines.

Solar a thriving export industry

Compared to wind power, solar power's contribution to the Chinese energy mix has evolved at a much slower rate. The pace is accelerating, however, thanks to the advancement of solar power technology and the Chinese government's high renewable ambitions. The government has implemented a plan to double solar capacity from 5 GW to 10 GW by 2015. But even though China itself is not yet at the forefront of solar installed capacity, the Chinese solar power industry is already thriving. China is the largest exporter of solar panels, and China-based solar power companies are some of the biggest and most innovative in the global market. As of 2010, China's Suntech Power and JA Solar rank first and second, and Trina Solar ninth. Chinese and Taiwanese manufacturers account for over 60% of global solar cell production.

Chinese solar power companies, like their wind power counterparts, are actively seeking global expansion, establishing subsidiaries in foreign markets and signing strategic partnerships with other international players to steadily strengthen their foothold in those markets. At first, their efforts were focused on European countries, traditionally leaders in solar power generation. However, recent decisions by European

governments to cut incentives associated with solar power have caused demand to decline. The US solar industry is now seen to have the greatest growth potential with 10 GW of solar capacity likely to be installed each year by 2015.

This is good news for Chinese solar power companies. Suntech Power, Trina Solar, and Yingli Green Energy already have subsidiaries headquartered in California. Suntech currently controls a 20% share of the US market and was selected to power the data center at Google's global headquarters - the largest corporate installation in US history. To keep up with US market growth, Suntech is planning to increase the production capacity of its Arizona factory to 50 MW annually. While Suntech, Yingli, and Trina already have operations in the US, other Chinese firms are trying to break into the market by signing strategic partnerships or merging with other companies. JA Solar, for example, recently entered a two-year strategic partnership with Jabil Circuit (US) and China-based LDK Solar acquired a 70% stake in US-based Solar Power (SPI).

A new kind of globalisation

In most industries, globalising Chinese companies are nothing new. What makes their international expansion in the renewable energy business different is the pace at which it is happening and the innovations that are coming from the Chinese themselves. Chinese corporations have used the influx of government funding to create new designs of their own that have made them major players in the wind and solar power industry. In this sector, it certainly looks like Chinese companies have changed the game for good.

Frank Tak

Tax Leader Energy & Resources, Deloitte The Netherlands

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As for the Arctic region, it currently accounts for a tenth of the world's known conventional oil reserves. More importantly, estimates are that the region holds 13% of the world's undiscovered oil reserves and nearly a third of its natural gas

deposits. So far, disputes in both regions have been non-violent, but recently tensions between China and Vietnam have mounted dangerously. Other countries in the region are becoming increasingly uneasy as China

becomes more assertive in its claims to the waters. As a result, all countries involved in the dispute – which includes China, Vietnam, Taiwan, the Philippines, Malaysia, and Brunei – have ramped up their naval presence.

Jurisdiction over the Arctic is currently held by five nations: Canada, Russia, Denmark, Norway, and the US. While these countries have been more willing to negotiate with each other than the nations of the South China Sea, there are signs that conflict

‘Beware of hypes’

After 23 years leading Dutch success story Fugro, global provider of geo-services, retired CEO Gert-Jan Kramer is not easily shaken by alarming reports or carried away by utopian dreams. That’s probably why Dutch companies are so eager to have him on their supervisory boards. Deloitte served up a few energy soundbites for him to respond to.

could be ahead. Norway has moved its military headquarters to within the Arctic Circle, and Russia has plans to create two army brigades to protect its polar territory. Canada, meanwhile, is conducting its largest military exercise ever in the region.

While there are risks to establishing operations in the South China Sea and the Arctic, the potential rewards could be even greater. All governments involved in both regions say they are committed to peaceful

negotiations to solve all border issues. But what will happen once a major discovery is found in a disputed area? Will governments stay true to their commitments of peaceful resolutions, or is it just all rhetoric?



The near-term outlook for the oil field services industry is bright.

I agree. The pickup in tenders in 2011 translates into work in 2012 and 2013. The offshore sector looks particularly active with major projects like Sakhalin. The Macondo oil spill has left us with a moratorium on shallow offshore drilling and tighter regulations in the Gulf of Mexico, but has not slowed down deepwater drilling or drilling in other regions.

Oil field services companies should strive to be one-stop shops for their customers.

No. The one-stop shop model doesn't work in this line of business. Why? It's quite simple. The exploration and production of an oil field is a long

and many-staged process, and after each stage comes a cut-off point. You start by contracting seismics. If these are favourable, you continue, otherwise you abandon the project. Next comes an exploration well. If you like the result you take the project a step further, if not, it ends there. And so on. So oil companies will always want to contract one service at a time rather than a full range that they may need to partially cancel if the project disappoints – which it often enough does. Another reason why this model doesn't work is that if an OFS company offers the full range of services, from seismics to drilling and completion, that reduces the role of the oil company to a purely financial one. The OFS company is then a fully-fledged oil company itself, and a rival of its own customers.

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The Macondo spill was a typical example of ‘too many cooks spoil the broth’.

It’s going to take ten years before the claims related to the Macondo oil spill are settled. Four or five different firms are potentially responsible. Complexity is not the problem, but with multiple parties each making their own niche contribution – surveying, laying pipes, building platforms - coordination requires a lot of attention. All this is organised according to the classic contractor-subcontractor model, and this generally works just fine. I know projects are shifting increasingly to remote regions and becoming more challenging, and I know regulatory pressure is mounting, but I believe in the OFS industry’s ability to keep up. It remains manageable. The Macondo spill was a major disaster and shouldn’t have happened, but given the size of this sector, the number of accidents and the total damage is surprisingly low. We can never bring that down to zero, no matter what measures we take.

The Netherlands, still a net exporter of gas, can afford to postpone development of its unconventional reserves

Dutch OFS companies are so successful worldwide that they will take their head offices elsewhere.

I’m not afraid of that happening. The Dutch fiscal climate doesn’t prevent companies from growing. Dutch OFS companies typically realise 90% of their sales outside the Netherlands, but I don’t see why they would want to move their head offices - as long as this country continues to produce

enough engineers. As head of the supervisory board of Delft University, I’m doing my part to make sure that we do.

Fracking is scary and the French are right to forbid it.

Nonsense! The oil industry has been using the technology of hydraulic fracturing for over a decade now, and though environmentalists cleverly call it an ‘alternative’ production method there is nothing really alternative about it. People are being scared with baseless stories and misleading film footage – I’m thinking here of the all too well known Gasland movie. Oh well, the Netherlands, still a net exporter of gas, can afford to postpone development of its unconventional reserves. And the French, with their huge nuclear potential, don’t really need their unconventional gas either. The rest of the world is not standing still, though. Unconventional gas production has radically changed the energy supply picture for the US and could do the same for China. In Europe, Poland, Albania and Hungary are pushing ahead. When unconventional gas production starts just across our borders in Germany, the Dutch will go with the flow.

Oil majors are incapable of making money on small projects.

I’m afraid so. The big oil companies have spun off their drilling activities over the past 40 years. Their organisation just isn’t suited to small projects any more, and they’re gradually withdrawing from this part of the market. Midsized and small players are now achieving good results in fields that Shell was losing money on. This makes sense. Oil majors should focus their attention and their talent on large-scale projects that call for big up-front investments, an area where smaller players cannot compete.

With the US becoming self-sufficient, China likely to develop unconventional gas reserves of its own and demand in Europe flat, Russia’s vital gas exports could slump, making the country unstable.

I don’t see that happening. It is true that a really global gas market is coming into existence. With LNG technology, gas can be easily transported, making it almost as versatile as oil. Price differences will



A dynamic duo: Solar-enhanced oil recovery

Enhanced oil recovery has long been a proven technique for coaxing stubborn oil out of the

ground. The recovery process has traditionally relied on burning natural gas to produce steam, but now there may prove to be a viable alternative: solar-enhanced oil recovery (SeOR).

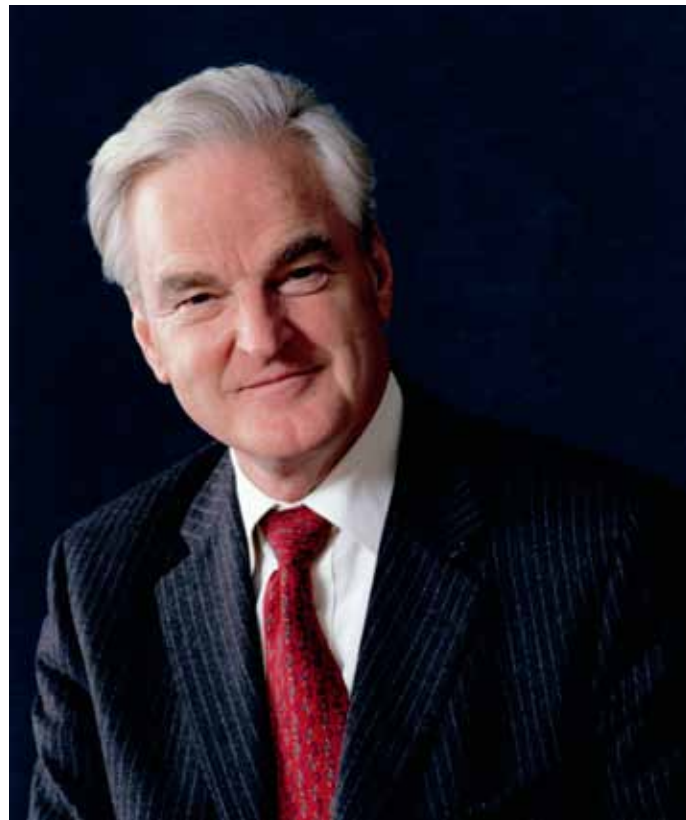
The process is currently being demonstrated in the middle of a 100-year-old oil field in California. In a glasshouse, adjustable solar-reflecting mirrors concentrate the sunlight and focus it on a network of water-filled pipes. The water boils into steam,

disappear. This means the Russians will have to sell at lower prices than they're now used to. But on the other hand, they don't have big investments to worry about any more, as the pipelines connecting them to their markets are already in place. They can afford to accept a lower price without getting into major financial trouble.

Carbon emissions and global warming are heavily hyped issues

Fossil fuels will still dominate the energy mix in 2050.

I'm certain of it. Global oil reserves may have plateaued, but massive new gas reserves have been found, which are already sufficient to last us several hundreds of years. And we're likely to find even more. Shell made a smart strategic decision early on to focus on gas, and is now more a gas than an oil company. It's ten years ahead of its competitors in this field. Meanwhile, whatever scenario you look at, global energy demand is projected to rise by 50% to 100% in the next 20 years. It's hardly growing in the US and Europe, but in the emerging markets, it is skyrocketing. I'm all for expanding renewable power generation, as we'll need everything that can help us keep up with demand. But realistically, with demand soaring at this pace, the share of renewables in the energy mix, now 5%, may rise to something like 15%. That's not exactly a revolution. I'm not sure that gives us reason to be alarmed, though. Carbon emissions and global warming are heavily hyped issues. I don't blame environmentalists for exaggerating – it's necessary to create a sense of urgency. But my advice to our government would be to beware of hypes.



Gert-Jan Kramer has degrees in civil engineering and business administration. After serving in the navy, he moved up the ladder in the dredging industry before becoming CEO of Fugro, global provider of geological services. He held this position from 1983 to 2005. Now retired, he is a key advisor to the Dutch corporate and public sector through his membership of seven supervisory boards, including those of Fugro, EBN, ASMI and Delft University. In addition, he belongs to eleven executive committees of professional, cultural and religious organisations.

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which is continuously injected deep into oil wells, where it decreases the viscosity of, and thus enhances the recovery of, the crude oil. The technology is both more sustainable and more cost-efficient than the traditional one using gas.

While SeOR sounds like a promising solution, the technology does have its drawbacks. For the technology to prove itself on a large scale, a typical oil field would need roughly 40 hectares of glasshouses to satisfy its daytime

needs. Large fields would require even more. Besides, there remains a need for some natural gas after the sun sets.

While in its infancy, the cheap and simple SeOR technology has the potential of revolutionising

enhanced oil recovery. The technology is likely to show most promise in areas where there is an abundance of sunlight, where the oil is naturally heavy or where the easy oil has been extracted. The biggest potential for SeOR is therefore in the Middle East.

‘The North Sea is a goldmine’

As CEO of key Dutch energy research centre ECN, Paul Korting is just the person to tell us where the ‘sweet spots’ in the renewable energy space are. Deloitte’s Gwan Auw Yang and Jasper de Bruin asked him which of them the Netherlands should focus on.



December saw the publication of *Naar een schone economie in 2050: routes verkend*, offering the Dutch government a road map for our country’s transition to a climate-neutral economy. Authored by think-tanks PBL, and by Paul Korting’s own ECN. ‘ECN works across the entire spectrum of energy alternatives, and our contact with other researchers worldwide gives us a bird’s eye view of the entire energy landscape,’ Korting explains. ‘As such, we can provide much-needed information not only on the merits of various alternatives, but also how choices in one area impact the rest of the landscape.’

Vested interests

A bird’s eye view does not, however, imply that the study was performed at great distance from the players in the field. Paul Korting believes in involving all parties, from the pioneers of new technology to the most entrenched incumbents. ‘Vested interests are a fact of life. We can ignore or snub the incumbents, but I think we should keep them involved in the energy transition. It’s good to remember that they were prepared in the past to invest large sums in our energy supply. They have to recoup their investments. If we as a society don’t understand this principle, it’s going to be very hard to work out solutions together.’ Asked if this could ultimately mean slowing down the pace of the transition to accommodate incumbents, Korting inclines his head. ‘Let



The consumer has spoken: Energy use and the great recession of 2008-2009

In many parts of the world, the energy marketplace has been rapidly changing since the recession of 2008-2009. But in which direction is energy heading? Deloitte is completing a study to understand what US businesses and consumers are

doing to manage their energy usage and what motivates them to adopt new practices and technologies. Results from the consumer portion of the survey provide some interesting insights.



me put it this way. New players who are prepared to invest heavily in renewable energy want to minimise risk. A predictable growth path, determined by governmental regulation, is one of the elements that will reduce this risk. Changing the ambitions from year to year, on the other hand, undermines investment security.'

In Korting's view, there is still need for fossil fuels in the run-up to 2050. Whatever course we choose, it will take several decades to develop our alternative energy supply, time in which we still have to rely on our existing infrastructure that is based on fossil fuels. How to bring down emissions resulting from our current power plants in a cost-effective way is a major challenge.

Green gas is an ideal fuel – the versatility of regular gas without the CO₂ burden!

Betting on biomass

Our energy mix in 2050 will contain a variety of renewable technologies, Korting believes, with no out and out winner. Biomass is tipped in

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The recession has influenced the energy usage of US consumers, with 90% saying they have become more resourceful and are looking for savings in every spending category. Their efforts to conserve electricity are currently modest, however. Over

three-quarters cite turning off lights when not in use, even for just a few minutes, and setting thermostats lower in winter and higher in summer. Only 20% give high priority to replacing old appliances with more energy efficient ones and better insulating

their homes. All in all, though, energy demand may be down for good, as 68% of consumers have taken extra steps to reduce their electricity bill due to the recession, and 95% do not intend to increase their electricity usage if and when the economy picks up.

Of the 90% keen to use less energy, 55% claim to be very concerned about their personal carbon footprints. Approximately two-thirds would like their electricity companies to invest in wind and solar, and are willing to pay a surcharge for these

his report as an important one for our country. Excellent techniques have been developed here, and tested on laboratory scale, for torrefaction. This is a roasting process that transforms bulky biomass into a dry, energy-rich fuel that is cheaper and easier to move around and has a much longer shelf life. It is a key option to bring down high CO₂ emissions from existing coal-fired power plants. Gasification of biomass is another, even more interesting area where the Dutch have cutting-edge technology. 'ECN is running a pilot now at our own premises and we're planning a commercial demonstration with the local waste recycling plant in Alkmaar and various other partners. Green gas is an ideal fuel – the versatility of regular gas without the CO₂ burden! Producing green gas dovetails nicely with our country's ambitions to become the gas hub of Northern Europe.' Lately, however, biomass' credibility as a sustainable energy source has come under pressure. Asked for his view, Korting replies, 'It's retro-tech really. Burning wood is what our ancestors did. The difference with fossil fuels is that the carbon stays in a cycle. In my view we haven't thought through the full consequences of large-scale, world-wide use of biomass for our energy supply. Energy brokers are scouring the planet for feedstock, with potential adverse effects in emerging countries. We're developing so-called second generation bio-energy technologies in order to avoid direct competition with the food chain.'

For success in offshore wind, it helps to have a home market

Offshore wind the perfect niche

Offshore wind energy, Korting believes, is where the Dutch can be

successful niche players. The three most important arguments are location, location and location. 'For generating wind energy, the North Sea is a gold mine. There's lots of shallow acreage to build on with excellent wind conditions, and energy demand in the surrounding countries is high. An ideal combination.' We need to be careful not to lose the fight for market share, Korting warns, as happened with onshore wind. It helps to have a home market. Exporting the technology to neighbouring countries is nice too, and a good Dutch tradition, but it's not enough.

'Onshore wind energy can already compete with traditional energy,' says Korting, 'and our mission is to bring costs of offshore wind energy down by 40-50% to make it equally competitive. There's still plenty of room for technological improvement - bigger turbines, better anchoring, other materials. Parties reckon it will take at least five years.' A Dutch consortium called FLOW has been established, with significant public as well as private funding, to make this happen. This is just the kind of cooperation, Korting observes, that the government has in mind in its Top Sector initiative. A robust lobby is emerging.

Solar: the next generation

Solar energy is another area where the Netherlands has built a unique market position, Korting believes. 'Our country has been a leader in the development of fast production lines that turn out affordable, highly efficient solar cells with a modest environmental footprint. Dutch equipment builders are now doing good business with Chinese solar cell manufacturers.'

Solar power isn't competitive yet in the Netherlands, but the gap with traditional energy is closing faster than predicted. ECN's solar guru Wim Sinke expects solar to reach grid parity here two years from now. Will that trigger a consumer rush to buy solar panels? Korting thinks this will certainly pave the way for early adopters, but what could really make this option attractive is the introduction of building-integrated solar cells –about a decade from now. Besides its ongoing leading position in downsizing solar technology, our country has a modest position in the

options. Generation Y consumers are interested in new smart energy technologies. One-third of Generation Y respondents say they are willing to pay a small amount to have a meter/timer control system for some of their major household devices to manage electricity use

better, versus 22% of Baby Boomers and 16% of mature respondents.

The full study gauges customer interest, perception and receptiveness across regions and demographics regarding tactics for managing energy, smart

technologies, electric vehicles, the environment, and climate change in the US. The findings are likely to invite debate and discussion regarding the implications for policies, strategy and future investments. The consumer has spoken.

integration of these new cells in building materials, a position Korting feels we should work to grow.

Missing themes

There are several other innovation themes that deserve more attention in the Netherlands, Korting feels. Nuclear fusion is one of them. 'Dutch research institutes are involved in the construction of an experimental fusion reactor in France, and are doing their best to get their business contacts to participate actively. Dutch industry can and should supply more to this project than just the screws and bolts!'

Energy storage is another theme the Netherlands cannot afford to neglect. It covers battery technology and the use of renewable energy to create fuels - hydrogen or hydrocarbons - that can be stored. 'Other countries, in Europe and beyond, are taking a more structured approach to this theme. Our efforts in this area should be more than me-tooing, though. We need to find niches, preferably ones that tie in with other research we're doing.'

Our efforts in energy storage should be more than me-tooing

The social aspect

In building a sustainable energy future, Korting concludes, a far greater challenge than technology are the social and economic aspects: changing hearts and minds, creating lasting economic incentives and dividing the burden. 'Society has to really want this sustainable economy and be prepared to take all the steps along the way. Creating awareness and overcoming resistance are essentials in any transition strategy.'



After earning a degree in Aerospace Engineering from Delft University, **Paul Korting** joined research centre TNO, where he started his long and varied career in the rocket technology department and ended as Managing Director of Industrial Technology. In this capacity, he cofounded Solliance, an alliance on solar energy between research institutes TNO, ECN, Eindhoven University and Holst. In December 2010, he became Chairman of the Management Board of ECN.

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‘Consumers are prepared to change their behaviour’

Han Fennema calls himself ‘an idealist, and possibly a naive one’. But his impressive career in the energy industry suggests his voice is not one to be ignored. Deloitte’s Gwan Auw Yang gauged his views on the energy transition, including our most neglected challenge: energy conservation.



Learning to love complexity: The future of oil field services

The offshore business is one of the most complex in the

world. Very many, highly diverse, companies - from oil super majors to small service providers - have to work together seamlessly in circumstances that are highly unnatural to man. Nevertheless, the sector is pretty successful at

it. We expect that complexity of the offshore value chain will continue to grow in the next decade. Four factors will drive this trend.

First, as is well known, the days of easy oil are over. In order to



Han Fennema (left) and Gwan Auw Yang

What will the world's energy mix look like in 2050?

My hope is that the fossil fuel component will be down to 10%, with a variety of renewable technologies accounting for the other 90%. This looks farfetched, but the year 2050 is almost 40 years ahead and this is a long period allowing for many new technologies. Just think: 40 years ago oil prices had never been higher than 2 dollars a barrel.

Consensus is growing among experts that some alternatives – notably solar power - hold more promise than others – like wind. Isn't it time for a shakeout?

I think it's too early for that. I grew up along the Frisian coast, in a flat, wind-swept landscape like the one you see in the painting here. I

grew up with wind turbines. The first stood next to farmhouses, pretty insignificant, but they've come a long way since then: big 3 MW ones are common, and the state-of-the-art ones are now around 8 MW. I'm convinced that the development curve of turbines is still far from its peak, especially as we take them offshore. They'll get better and cheaper. Meanwhile, oil prices are bound to rise, and I hope at some point the emissions trade system will finally start to function as it should. We've put a price tag on CO₂, and while we may have given away too many rights at the outset, sooner or later CO₂ pricing will impact the competitiveness of wind versus fossil fuels. Onshore wind is already close to grid parity, but offshore wind is still heavily subsidised. Don't forget, however, that the playing field isn't level. A fifth of the price of

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supply the world with 50% more energy by 2025, the sector will have to go all out to find and produce more oil and gas. Already today, a large part of the world's 150 mega offshore projects are in technically complex areas like Brazil (22 mega projects), West

Africa (37) and the Arctic (6). And with the majority of offshore reserves in deep water, the share of complex projects is bound to increase.

Second, National Oil Companies (NOCs) are becoming more

demanding. Brazil is a case in point. Under new legislation for oil & gas contracts, it may require as much as 80% local content. Contractors either have to deal with local suppliers, set up their own operations or negotiate waivers with the Brazilian

government, one of the most complex bureaucracies in the world.

Meanwhile, Western governments are getting more demanding, too. They not only impose environmental, anti-corruption

an offshore wind park goes toward the cable connecting it to the grid. Onshore coal-fired plants don't get presented with the bill for their connection to the grid. You could call that a kind of subsidy, too.

But what about the spectacular advances in solar technology?

They are spectacular, thanks to the Chinese throwing so much money at solar. It's a bit worrying, actually: people may hesitate to buy solar panels today if they think they can get better, cheaper ones next year. This could seriously slow down progress. I think solar technology is in good hands in China, and Northwest Europe should concentrate on wind, biogas and liquid biofuels.

Every energy option has a downside: some are dirty, some are dangerous, some are dear

New technologies in oil & gas production mean that some countries are suddenly sitting on huge reserves. North America is practically self-sufficient now, and the same could happen in China. Will that impact local energy mix choices?

Geopolitics and protectionism may uphold price differences between countries for a while, but I'm sure market forces will even them out in time. Coal, oil and gas can be transported by ship. Energy is ultimately a liquid market. It may be my naive idealism, but I cannot imagine the decades-long trend towards more open trade and fair competition turning round now.

and safety standards on oil companies, but also hold them responsible for all the behaviour of all of their contractors.

Finally, the days are over that oil field service companies can shift risks to oil companies and

governments via reimbursable contracts. Lump sum contracts are back, and probably for good. A glut of new equipment, ordered before the financial crisis, is coming on the market now, increasing buyer power. And competition will further intensify

How does nuclear energy fit into the transition picture post-Fukushima?

My faith has been shaken by the events in Japan. In my perception, if anyone could be trusted to run a nuclear plant safely or deal with a nuclear crisis, it was the disciplined and technologically advanced Japanese. But they failed dismally. It has become clear that disasters on this scale are too big for governments to handle. That said, I don't think it's realistic to drop nuclear energy altogether if we want to achieve our CO₂ emission reduction targets. I see no good reason to build a new nuclear plant in the Netherlands, but the French should stay the course. Global warming will also cost lives, for instance in coastal flatlands like Bangladesh. Every energy option has a downside: some are dirty, some are dangerous, some are dear. Some options will fail, others will survive. And all the things we've just been discussing are only about the supply side. There's so much we can do about the demand side, too.

Can merely curbing the uptrend in energy demand make a structural difference?

Things like reducing fuel consumption in cars or improving the efficiency of coal-fired power plants can take us a very long way! It's a matter of getting energy conservation higher on the mental agenda. Consumers are prepared to change their behaviour. Look at how good we are at recycling glass. We lug those bottles to the bottle bank without the prospect of any kind of reward. Just because we want to be responsible citizens. And our democratically chosen leaders have recently outlawed the old-fashioned light-bulb. In an affluent society, people's needs transcend materialism, they're looking for meaning, and saving the planet is a mission with a great appeal. I'm hopeful, therefore, that energy awareness will gain momentum at grass-roots level and move upwards from there. The corporate sector is responding to the trend, to attract and keep customers and employees.

So how do we make consumers more energy-conscious?

Education can play a role. My company Enexis has developed colourful and fun lesson material for primary schools on energy and energy conservation. But above all, I see an opportunity in the introduction

as China scrambles for resources.

Our view is that oil field services companies will have to raise the bar. Though some will achieve this on their own, increasing complexity may very well trigger a new round of industry consolidation.

of smart electricity meters. We're rolling them out right now, and it's costing the Netherlands two billion euros. My fear is that they'll just disappear into the meter cupboards and be forgotten. They've got a communication port, though. What we need is smartphone apps that can interact with the meter, so consumers can monitor their energy consumption and manage it remotely. What will boost their awareness even more is generating electricity at home, with solar panels. Consumers will want to time their energy consumption so it's in sync with what their panels generate.

Will the smart grid sort that out eventually?

Our current network can handle two-way traffic, the problem is stability. Demand and supply will fluctuate constantly. It will certainly help if people are motivated to use energy when renewable supply (sun, wind) is plentiful. A major step forward will be the switch to electric cars. This will double consumer electricity consumption, but it will also connect the grid with a million batteries that can store and deliver back renewable electricity. In time, all consumers will need to do is programme when they need their car and their clothes again. The smart grid will choose the optimum moment to switch the dryer on and reload the car battery.

It's a matter of getting energy conservation higher on the mental agenda

When can we expect this scenario to materialise?

Once every household has a smart meter – we're aiming for 2020 – this will take off rapidly. The grid has a central enabling role to play in optimising the efficiency of our energy supply and making it sustainable. That's a big motivator for me and all the people who work here at Enexis.



Han Fennema earned a degree in business information technology from the University of Twente in 1986. He spent eleven years working in various roles for ExxonMobil. Han joined Eneco in 1999 as the company's Strategy Director, and was in charge of Eneco's grid from 2001 to 2006, when he joined the Board of Management. He left Eneco in 2009 and in 2010 became CEO of Dutch grid operator Enexis.

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A revolution in our blind spot

‘Old industry,’ says visionary, entrepreneur and professor Ad van Wijk, ‘makes forecasts by extrapolating existing trends. It’s largely blind to radically different models that our energy future could be based on.’ He gives us a taste of what’s happening in our blind spot.

It all starts with how we approach the energy demand issue. We think what we need is “energy”, so we look for energy sources in large quantities – typically beneath the earth’s surface. Next, we address the problem of getting energy to where we want to use it. Once it’s there, we convert it into the energy service we need: a warm house, a boiled egg. But why not start our thinking from the other end of the energy supply chain? With a warm house, a boiled egg?

The energy service as starting point

By taking the energy service we require as our starting point, we’ve redefined our demand. It’s not “energy” we need but, for example, a warm house. How do we achieve that efficiently? The first thing we do

is insulate it, so the energy already present isn’t unnecessarily wasted. Meanwhile, over an entire year, we have an oversupply of heat in the summer and a shortage in the winter. We don’t need energy, we need a way of redistributing the energy that’s already available. A seasonal thermal storage system. Germany already has extensive experience with Passivhäuser, zero-energy homes. Zooming out to the global picture, we see that 25% of our traditional energy consumption is currently related to heating and cooling buildings. From our new point of view we see how illogical that is. This is just one example, but it makes clear that if we design our energy supply chain starting from the energy service, the result will be radically different from what we’re used to. Decentralised and highly efficient.



Piracy on the high seas: Now it’s for real

Over the last decade, piracy has resurrected itself, with Somali pirates leading the way. Each year, attacks have steadily increased, and there are no

signs of this trend changing in the near future. The first six months of 2011 saw 266 attacks worldwide. Piracy costs the international community an estimated 7 -12 billion US dollars a year.

With 20% of the world’s commercial shipping passing through the Gulf of Aden and the Suez Canal, piracy has a big impact on economies, especially in Europe. 80% of the trade on this route is with Europe and includes one third of its oil supply.

A quantum leap in energy efficiency

In recent years, we've been making great progress enhancing the efficiency of the equipment we use. Not by a few percentage points, but by a factor of three, or four. The LED lamp is just one such innovation. At the same time, we're also increasingly building energy generation technology into devices. For example piezoelectric material, which responds to pressure. Tomorrow's computers will harvest energy from your keystrokes. Pacemakers will no longer need batteries. Most importantly, solar cells are becoming smaller and easier to integrate in the things we use. Cordless is going to be the norm. So efficiency and renewable energy dovetail very well.

Tomorrow's computers will harvest energy from your keystrokes

Boosting the efficiency drive

The problem with most energy-efficient innovations is that the initial investments are high. They can be recovered in just a few years, thanks to the drastic fall in energy consumption, but it's a difficult hurdle for users to take. They base their investment decisions on what they have to pay at the outset. Our current pricing and financing methods make a poor fit with new technology. We need innovation in this area too.

To date the efficiency of the electric devices we buy has been left to the market. Producers will only bother to make more energy-efficient equipment if consumers are prepared to buy it and pay the extra costs. Sometimes, the extra cost is negligible. Our internet routers, for instance, typically use almost as much electricity in standby as in active mode. One tiny switch, costing just a few cents, could reduce this to near

zero. But nobody has thought to include it because there was no gain for the producer and only a minimal one for the individual consumer. But energy conservation has public benefits that transcend near-term economics. That's why I think the energy consumption of devices should be regulated in the same way that their health and safety effects are.

Electric transport is the future

Energy-saving innovations have never caught on purely because they brought down the energy bill. Likewise I see far more reasons to switch to electric cars than just saving the planet. Obviously, they improve air quality in cities and drastically reduce noise levels. But they can also shift gear far more quickly and flexibly than traditional cars. This means they can drive much more closely together, in train formation, so we can fit more cars on the same roads.

Electric car technology is evolving fast. The engine will eventually be integrated in the wheels, eliminating loss of energy in the transmission from axis to wheel. This innovation, already on the drawing boards of all the major manufacturers, ensures that 95% of the electricity input is converted into motion – and it will give drivers the most perfect control ever.

Power plants on wheels

The next question is, how do we supply electricity to these cars? They will have fuel cells. A kind of reverse batteries, fuel cells chemically convert hydrogen, methanol or some other fuel into electricity. Mercedes Benz is one of the first car manufacturers with a fuel cell model on the market. The fuel efficiency of current fuel cells is already 50%, better than most of today's power plants. Just think: a car's engine has a capacity of 80 kW. Our country now numbers seven million cars, and we buy half a million new ones every year. Half a million times 80 kW is 40 MW. That's twice the total power generation capacity of our current power plants. You and I are going to buy these mini power plants on wheels. If we have that sitting in the driveway, who's to stop us using the electricity in our homes? So why then would we want to buy power supplied by a utility company?

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Even more worryingly, this year a new piracy hotspot has emerged on Africa's Gulf of Guinea coast. Pirates there tend to be much more violent than their Somali counterparts and focus their attacks on the offshore oil and gas industry. Continued attacks in

the region could impact oil supply to the US and result in a spike in global oil prices.

For now at least, shipping companies are bearing the brunt of the attacks. Each year, more and more of their crews are

taken hostage, and ransoms are spiralling higher. Shippers passing through risky waters are now regularly being asked to pay their insurers an Additional War Risk Premium (ADWRP).

So, what can be done to prevent

piracy? International cooperation has led to an increased naval presence in the Gulf of Aden, but now Somali pirates, using hijacked ships as 'mother ships', have extended their reach to the Indian Ocean, which is nearly impossible to patrol. The Gulf of Guinea, in

Tomorrow's utilities

We may well wonder what sense there is in building new power plants as we now know them. I call that destruction of capital. Instead, energy companies could decide to lease our cars from us to generate electricity with them when they're parked in car parks. These companies will need to radically reinvent themselves, more along the lines of internet. Software applications in homes will match our surplus energy with the nearest demand. Energy will become a kind of currency. Google is looking to tap into this market and has already invested 16 billion dollars in energy infrastructure.

Energy will become a kind of currency

The global picture

Emerging countries in particular are investing vast amounts of capital and human resources in decentralised, renewable energy solutions. India has had a Minister of New and Renewable Energy for the past twenty years. Brazil is busily building its bio-based economy. There are more Chinese engineers now working on the fuel cell than Delft University has turned out in its entire existence. Japan, in the wake of the Fukushima nuclear disaster, cannot deliver sufficient peak capacity, and wants every household to maintain at least eight hours' worth of backup electricity - Japanese carmakers are poised to roll out millions of electric cars, which can neatly provide this backup.

The Netherlands ranks very low on the sustainability ladder. That anything at all is happening here is only thanks to the EU. Germany, by contrast, is setting a shining example that I believe we should follow rather than scoff at.'



Physicist **Ad van Wijk** studied at Utrecht University, where he also worked as an associate professor while in the meantime launching a career in business. His consultancy firm Ecofys, established in 1984, later became Econcert, everybody's favourite company, active in a wide range of cutting-edge green technologies. Ad van Wijk was Dutch entrepreneur of the year in 2007. Following the shock bankruptcy of Econcert in 2009, he became an advisor to energy company Eneco. He is currently professor of Future Energy Systems at Delft University, still a sustainable energy entrepreneur and continues to work as a consultant on sustainable energy issues.



its turn, falls under the jurisdiction of West African countries that do not have the military capacity to patrol effectively.

Shipping companies have started to take matters into their own hands. More and more have

installed citadels, or fortified rooms, on their ships for the crew to retreat to while they wait for help. Some companies hire armed security for the voyages, but most are reluctant to do so for fear of lethal shootouts endangering the crew.

Unfortunately, fighting piracy is a complicated matter. It remains a financial and business risk issue with no clear-cut solutions.



In Conclusion

To supply the world's growing demand for energy and at the same time reduce carbon dioxide emissions is a formidable challenge for our industry. On a gloomy mid-winter morning, the challenge may seem to be altogether too big. Luckily, our experts see bright spots.

Transition to a low-carbon economy: not on track

Carbon emissions growth is slowing down, but not enough to stay within levels recommended by scientists. In its recent World Energy Outlook, IEA says that under current policies and developments 'the world is on a trajectory that results in a level of emissions with a long term average temperature increase of 6°C or more.' BP's recently published Energy Outlook 2030 pretty much builds on the same analysis. More action is needed, but it is hard to conceive how that will happen. Conditions cited in IEA's 450 Plan to keep temperature rises within 2°C include carbon pricing, ending subsidies for fossil fuels, strict energy efficiency measures and carbon capture and storage. But the summits in Copenhagen, Cancun and Durban have so far shown that the world can't come to agreement on ways to tackle emissions. Governments, already distracted by worries about their economies, are more likely to delay, yet again. Developments in energy efficiency and conservation in OECD countries and especially in the EU, though seemingly encouraging, are not where it's at. After all, it's the growing economies outside the OECD that will account for 90% of energy demand growth in the next decades. So it's those countries that will increasingly hold sway over what the world does about manmade climate change.

Uncertainties

Extrapolation of current trends in population and GDP growth, energy intensity and governmental carbon abatement policies all make for a worrying future. Obviously there are uncertainties that have to be dealt with: in the supply and demand balance in the regions around the globe, in consumer behaviour and in the future for nuclear power. These are however all minor compared to the potential that China and India – the two most important growth markets - have to change the global energy outlook. The pace and scale of developments in China and India will largely shape the world's energy future. Both China and India are expected to see their industry composition shift towards less energy-intensive sectors. What if that does not happen? Energy demand growth in China and India is expected to slow down, in China to less than half the rate of the previous decade. What if energy demand growth in both markets does not level off? In China

and India, coal is the predominant fuel. In the next decades, the fuel mix is expected to diversify away from coal and with that the growth in carbon emissions is expected to decline. What if the market share of coal does not decline? Both countries do seem to be making significant progress in reducing the carbon intensity of their economies, and have plans and policies in place to support a transition to a lower carbon economy. What if these plans are not realised and the policies are not upheld?

Technology and Innovation: bright spots

While government policies and consumer preferences each play a role in the evolution of energy supply and consumption, the biggest factor is technological progress. This has been a leading topic in most of the expert interviews in this magazine. And it is probably the wildcard in any energy prediction. All energy projections and every outlook are based foremost on extrapolation of historic developments and current trends. And we all know the outcomes are hardly ever in line with the predictions. New disruptive technologies and break-through innovations are by nature unpredictable. Over the long timeframe of the energy outlook, however, it is hard to imagine that no break through innovations will occur.

All the stakeholders in the energy debate are more aware than ever that our future depends heavily on technological advancement and innovation. More attention and investor money is being devoted to technology and innovation than ever before. And not just in the OECD, but in the last decade also in China and other non-OECD countries. Bright spots can be identified in every domain: renewables, energy conservation, energy efficiency, energy storage, hydrogen fuel cells, carbon capture and storage and in downstream industries replacing petrochemicals by bio-based feedstocks.

I would like to thank our interviewees for giving us their time and sharing their wisdom with us. More than analyses and predictions, they have offered us inspiration with their optimism and drive.

Marcus van den Hoek



Burn fossils?
Sure
Think like one?
Never

Progressive energy companies are looking for innovative solutions to meet the world's growing energy needs, and reduce carbon emissions. Deloitte's deep industry experience and innovative solutions can help you achieve sustainable, profitable growth. Find out more about our view on energy and visit us at www.deloitte.nl/energy to tap into an inexhaustible resource.