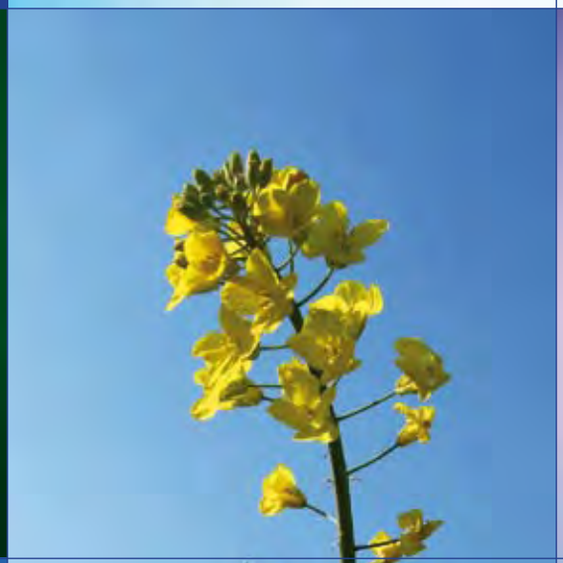
WORLD ENERGY COUNCIL
CONSEIL MONDIAL DE L'ÉNERGIE
For sustainable energy.

World Energy Insight 2010

Official Publication of the World Energy Council to mark the 21st World Energy Congress



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THE QUEEN'S AWARDS FOR ENTERPRISE 2010

Contents

Managing the energy transition to a sustainable future

By Pierre Gadonneix, Chairman, World Energy Council and Honorary Chairman, Electricité de France (EDF)

Our 21st World Energy Congress offers a unique opportunity for all stake-holders of the energy sector to meet and exchange visions, strategies and practices, during four days of very intensive and interesting sessions, round-tables and exhibitions. More than 3,000 energy leaders gather from around the world from both developed and developing countries, from all types of energy, from public and private companies and government organisations, in order to think together about how to bring about a sustainable and acceptable energy future.

The truth is that nobody has the choice any longer. All energy leaders have to take decisions every day, and they need to have a clear analysis of what is at stake, what the risks are, and what the solutions can be.

What is at stake? Energy security, sustainability, what else?

Even as we speak, all countries are working to develop strategies for putting the crisis behind them. And economic growth is an entirely legitimate and worthwhile goal for all countries. The problem is that the kind of growth we have pursued in the past forces us to address three fundamental issues. The first is security of supply. We must invest in new sources and infrastructure to meet demand. The crisis has negatively affected some investment plans, and the recent surge in oil and commodity prices may curb growth. The energy industry will need to go further afield and deploy ever more sophisticated technologies to tap into available resources, which will come at a cost.

Montreal: Host City of the 21st World Energy Congress

The second is environmental protection and climate change. Responsible for 60 per cent of global greenhouse gas emissions and much of regional and urban air pollution, the energy sector is clearly on the front line of climate change. We have to deploy cleaner technologies, and adapt our production and consumption systems, which will also come at a cost. And because energy goes hand in hand with development, the question of inequalities within and across countries is another central concern. Now more than ever, we must work to find a sustainable path that reconciles economic growth, protection of the environment and greater energy equity among peoples. The energy transition will be expensive and we have to make every effort to minimise the transition costs.

What are the assets, the risks and uncertainties in this transition?

We have the technologies we need at hand. Energy resources are not a major constraint but their uneven distribution across nations, and the fact that ensuring security of energy supply will lead to an increase in energy prices, are issues. And, as the recent events in the Gulf of Mexico dramatically reminded us, we will need to respect the highest standards of safety, which are more expensive. But other types of resources are genuinely scarce or under stress.

The environment is one example, and particularly the climate. Water and land use issues have also become real constraints. There is also a need for the skills to conceive, build and operate systems powered by efficient and clean technologies. The real shortage today relates to governance. We need effective rules and smart policy frameworks to update our energy policies and ensure that the right resources and technologies are available in the right place, at the right time... and at the 'right' price.

The role of energy and climate policies to manage the transition

Innovation in terms of policies, institutions and governance will be just as important as technological innovation. Copenhagen has rightfully put energy policy at the centre of the sustainability debate. The challenge is now to design

sound and effective regulatory frameworks to deliver national objectives. These frameworks must rely on two pillars, as shown in our second edition of our yearly *Energy and Climate Policy Assessment* that will be released in Montreal.

The first is the critical need to factor in thorough assessment of technologies to energy policy making. Updating energy policies will require planning the roll-out of different technologies, starting with those that are mature while preparing others for the market.

We could already organise a massive roll-out of mature technologies over the next 20 years with hydro power, wind, biomass, nuclear and high efficiency coal and gas plants on the supply side, and solutions like efficient lighting, insulation in buildings and heat pumps and more efficient engines on the demand side. These are competitive solutions with prices of up to a few tens of dollars per tonne of CO_2 avoided.

For technologies that are not yet mature, the cost of CO_2 avoided is usually five to ten times higher. So, our first step should be to encourage and support R&D and experimentation.

Assessing the maturity of each technology in each local context is a crucial element in controlling the costs of energy transition and ensuring the long-term viability of rules, which is essential for our sector (in contrast to some dramatic and costly 'stop-start' in policies).

The second element relates to the way regulatory frameworks can encourage behaviours and habits to change. The same WEC report highlights the need to set up bundles of complementary instruments. Norms and standards will play a vital role in encouraging business and consumers to incorporate energy efficiency into buildings and transport, for instance. At the same time, energy prices must do their part to stimulate investment, guarantee security of supply, and promote energy savings. This will require making sure the poorest members of society continue to enjoy access to energy, for instance by having subsidies specifically for them.

Some innovations like intelligent energy supply and use (smart grids and smart homes and buildings) can be real catalysts in changing energy behaviours, making people more aware of the value of resources and therefore more eager to be efficient and responsible.

Sustainable growth is no longer an option – it is a necessity. While the goal is clear, finding the best path to reach it will be a challenge for us all. I believe that to rise to the challenge, we will have to rely more than ever on cooperation and dialogue between all stakeholders – governments, business, research and NGOs. This is WEC's mission and spirit. ❑

The World Energy Council: meeting global energy challenges

By Dr Christoph Frei,
Secretary General, World Energy Council

It has become commonplace to state that the world has fundamentally changed over the past few years. Unlike during the nineties, when the oil price bottomed out at below 20 dollars per barrel and climate change was still an issue for environmentalists, energy security and climate change are today at the forefront of the global agenda. With these themes on the one side and the need for global dialogue to find solutions on the other, the founding vision of the World Energy Council is now coming to fruition.

Founded in 1923, the World Energy Council is the only truly global and inclusive forum for thought-leadership and tangible engagement committed to our sustainable energy future. We promote the sustainable supply and use of energy for the greatest benefit of all. Our network, through National Member Committees in more than 90 countries, includes over 3000 member organisations from public and private sectors, producing and consuming countries, and covering all aspects of the energy value chain. With our mission, impartiality, legitimacy and depth of network, the World Energy Council is uniquely positioned to catalyse new thinking and facilitate worldwide consensus on the very issues that the world is most concerned about namely:

- Risk Management and Responsibility: a global and all-energies priority;
- Managing the Energy Transition to 2030: the need for effective policies and long-term investments that keep technology options open and lead to a sustainable energy future;
- Improving the Living Standards of People: the aspirations and behaviour of the new energy consumer, poverty mitigation, and lifestyle changes (urbanisation).

Taking up these three vital challenges is paving the way to sustainable energy. In order to contribute effectively to global sustainable development, the stakeholders of the energy sector and beyond will have to address technological risks more responsibly, manage the complexity and uncertainties of environmental factors thanks to scenarios planning, and assess the potential impact of policies on the everyday life of people to ensuring their acceptance by society.

The World Energy Council: a brief history

In 1923, a small group of energy experts came together in London to plan a conference which would bring together experts from around the world to help consider how to rebuild the electricity grid in Europe following WWI. The first World Power Conference was then held in London in 1924. It was so successful that the meeting has taken place every three years ever since. Over the years the original purpose was widened, the organisation grew, and the name changed, eventually, to become the World Energy Council. The World Power Conference has evolved into the World Energy Congress and gathers every three years 3,000 energy leaders from 100 countries to assess the state of the energy world.

WEC's work is governed and legitimised through its Executive Assembly (with the principle of "one country one voice", forming an "Energy UN") and its Officers Council, presided by WEC's Chairman, with the Secretary General in the executive function. Our national committees are chaired by energy ministers, leading CEOs or experts. Our studies are complemented by views from a global energy business leaders group (Patrons Roundtable) and ministers (Ministerial Roundtable) which we facilitate during our Energy Leaders Summits.

The World Energy Council's activity areas

The World Energy Council addresses these challenges with activities in the following six areas: we survey resources, and technologies; we assess national energy policies across the world and identify which policies are effective and transferable to other countries; we explore possible global energy futures and analyse critical uncertainties; we look at how energy access can be improved; we promote best practices in the field of energy and urban innovation; and, we contribute to the dialogue on global frameworks, be it in the context of rules of energy trade or with respect to the global climate framework.

Surveying energy resources & technologies

When will the world run out of oil? What is the status and the potential of shale gas, biomass, wind, solar and other renewable and fossil energy resources? What are the issues with smart grids, energy-water linkages, carbon capture and sequestration, clean coal technologies, generation IV nuclear or e-mobility? How much difference can benchmarking and improving performance of existing power plant make? The World Energy Council has been conducting the Survey of Energy Resources for over 60

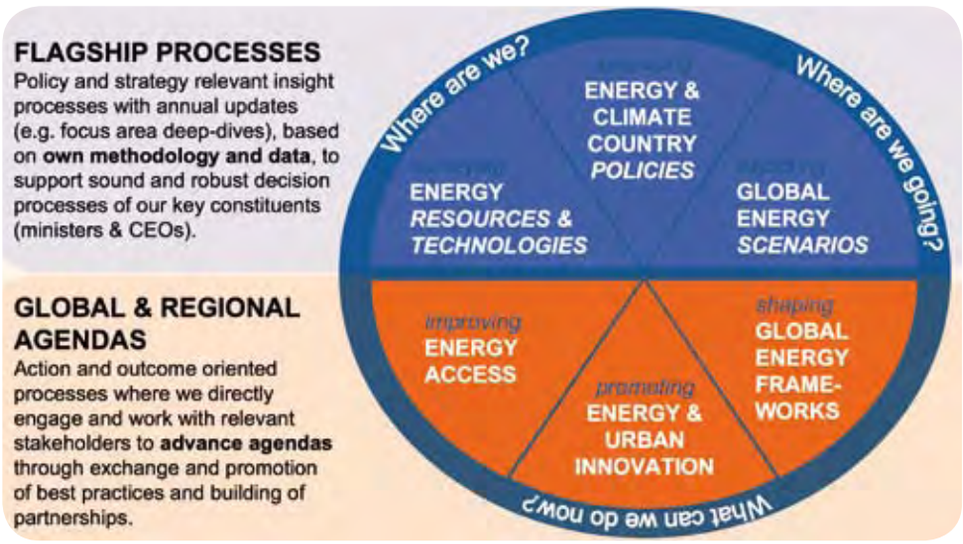


Figure 1 - six activities - WEC's 'activities wheel'

years and now also assesses current and emerging technologies and resources to provide a solid basis for policy and strategy decision making processes.

Assessing energy & climate country policies

We live in a world of change and energy and related policy innovation will affect our energy future in many ways. In the aftermath of the financial and economic crisis the world places more emphasis on policy than on Adam Smith's "invisible hand" to guide us towards a sustainable energy future. Which policies balance cost-effectiveness, social equity, environmental viability and effectively enhance the general welfare of the citizens of a nation or region? In the interest of our sustainable energy future, the World Energy Council has developed a methodological framework to identify effective polices around the world and how they can be transferred from one country to another. The methodology is founded on an index based on 22 indicators, an industry executives' survey, a review of over 200 individual policies in over 40 countries, as well as a survey conducted with our Member Committees in over 90 countries.

Exploring possible global energy futures (2050 scenarios)

What if…? We live in a time of increasing volatility and extraordinary changes, driven by new uncertainties and ambiguous value systems. The financial crisis, the technological shift from conventional to unconventional resources, shifting geopolitics, climate change and the likely future carbon price, the changing water footprint and its impact on the energy value chain, the urbanisation trend and new forms of mobility, competing value systems, armed conflict and ideological extremism … how will all these issues affect our future energy system and what will be the critical drivers to watch? The extrapolation of the past into the future is not a meaningful approach when trying to improve our understanding, especially in terms of effective energy policy and leadership. By drawing on the wisdom and experience of its global membership to develop a small set of distinct but consistent scenarios – "plausible stories of pathways into the future" – the World Energy Council enables decision makers to test the robustness of their own assumptions and to validate policies and strategies.

Shaping global energy frameworks

Resources and skills are unevenly distributed across the world and are not often at the places where they are most urgently needed. Energy access, energy security and climate change are global challenges and therefore have no economic and efficient solutions within national boundaries. This underlines the role of trade in goods and services and makes the global frameworks and rules that govern it an essential building block of the global public good. Nationalistic solutions that lose sight of the global picture and the need for a coordinated and collaborative approach delay the necessary international policy convergence. The resulting highly uncertain investment framework makes infrastructure investments unnecessarily risky and we will all pay the risk premium as part of higher energy prices and further delay in climate change mitigation. Critical issues in this context include defining "green goods and services", the legitimacy of "border tax adjustments" to avoid carbon leakage, or the promotion of technology transfer to developing countries. The World Energy Council promotes dialogue and develops constructive proposals.

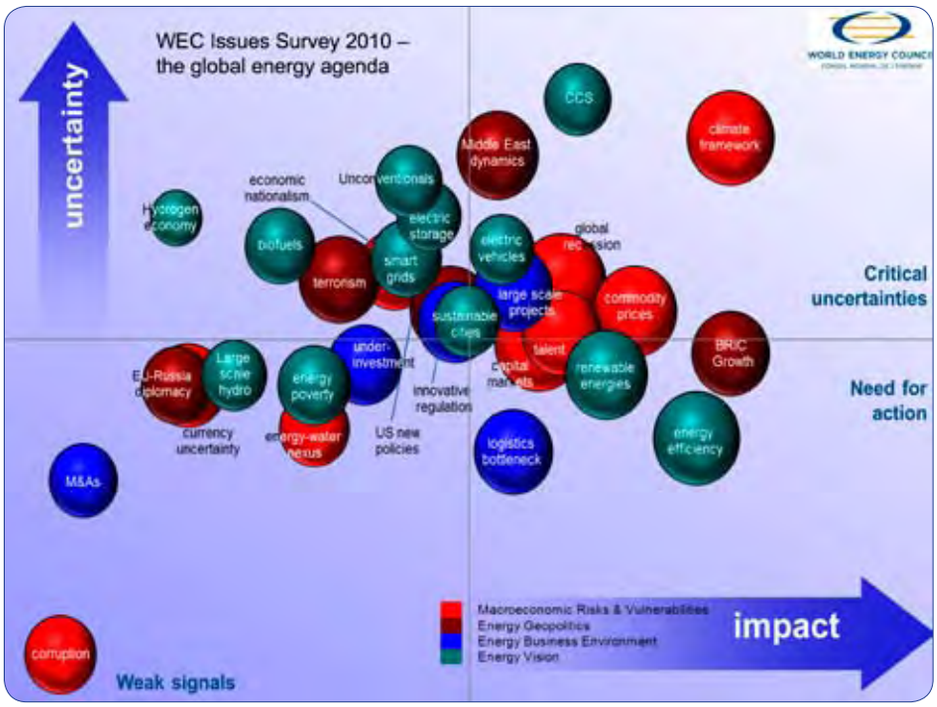


Figure 2 - The global energy agenda - the World Energy Council's issues map

Promoting energy & urban innovation

Today, 50 per cent of the world's population lives in cities and by 2030, this number will grow to over 60 per cent. Key concerns for the people leading cities include security, pollution, health, wealth and broader well-being for their citizens. These issues directly or indirectly link to energy and resource efficiency: transportation and traffic management, building heating and cooling, sanitation and waste management, and communication networks are among the key processes that determine the energy pattern of a city. Innovative approaches are being implemented in a number of cities across the world. The World Energy Council plays a constructive role through the facilitation of the best practices dialogue and the delivery of expertise to leaders, city planners, managers and leaders.

Improving energy access

With only five years left until the 2015 deadline to achieve the Millennium Development Goals the world is on a path to an "unacceptable failure, both moral and practical". None of the MDGs can be delivered without access to modern energy services for the 1.5 billion people who today live without it. A lack of basic energy service impacts all aspects of these people's lives, from healthcare to clean water, safe housing, education and the potential to earn a living. Rural communities account for 85 per cent of energy poor. Institutions, including the International Financial Institutions (IFIs), and also most governments focus on grid-expansion and densely populated urban areas. This simply leaves the rural poor perpetually exposed and in the dark. Key challenges include the lack of adapted financing mechanisms that can deliver on rural energification schemes; poor education and shortage of local skills for project initiation, implementation and system operation; the absence of easy local access to components for equipment maintenance and enhancement; the lack of understanding and political support necessary to replicate enduring local ownership models. The World Energy Council works with other relevant stakeholders on pragmatic approaches to promote energy access.

Assessing the global energy agenda

In order to assess the global energy agenda and its evolution, the World Energy Council conducts an annual issues survey with the Chairs of our Member Committees who represent their national networks in over 90 countries. They quantify the impact, uncertainty and urgency of approximately 30 issues, covering macro-economic risks, geopolitics and business environment as well -as energy vision in a high-level "helicopter perspective". The responses are translated into issues maps with the three assessed dimensions as its axes.

How to read the issues map: Issues with high uncertainty and high impact (in the upper right corner – "critical uncertainties") include these which will most benefit from multi-stakeholder dialogue and scenario analysis. The issues on the high-impact/low uncertainty side are these where immediate action finds easy consensus (bottom right – "need for action"). The low impact/low uncertainty issues include issues of perceived lesser importance but also "weak signals", which may be issues that are still badly

understood. Further, the urgency of an issue is proportional to the size of its bubble. Finally, the four different categories of issues – macro-economic risks, geopolitics, business environment and energy vision – are represented in four different colours.

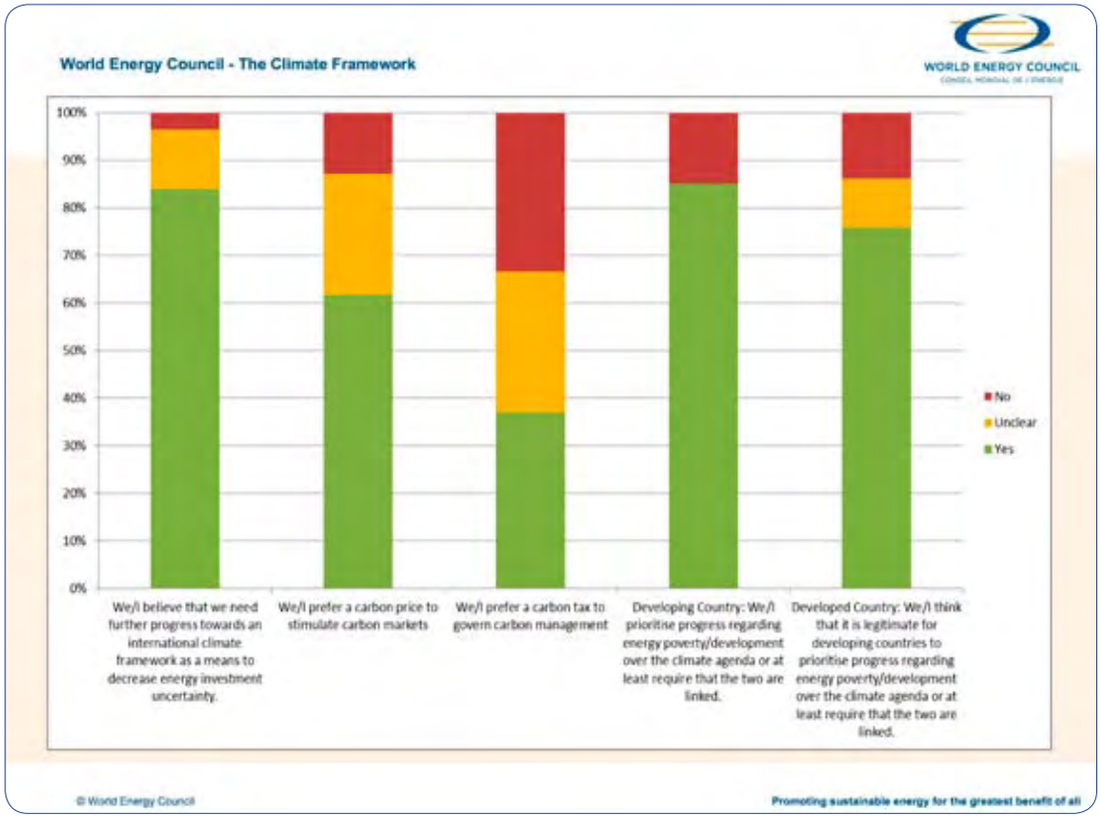
Interpretation: In comparison to last year's survey macro-economic risks related to the financial/economic crisis have lost their dominance as key concerns of WEC Chairs. The climate framework was already high in 2009 and in 2010 has become the dominant critical uncertainty for the energy sector. On the regional issues side, it is the growth of BRICS and regional dynamics in the Middle East that rank top. On the vision front renewable energies and efficiency are dominant issues. In comparison to last year, the trio of smart grid, storage or electric vehicles have made a jump upwards in terms of their perceived impact and uncertainty. Notably, carbon capture and sequestration (CCS) is still "taxed" with the highest uncertainty, which means that there is much more convincing work needed if the world is to become serious about CCS. Top perceived uncertainties also include unconventional resources. Innovative regulation and large-scale projects are perceived to be of higher uncertainty and impact compared to under-investment after the financial/economic crisis. Other notable issues include the energy-water nexus as a rapidly growing concern as well as sustainable cities as a key driver for future energy consumption.

Undertaken on an annual basis, the issues survey will show the evolution of the perceived importance of the assessed issues and enable us to define global and regional priorities for our work: to facilitate dialogue and build consensus around critical uncertainties and contribute to the implementation of issues that need action.

Climate framework – WEC's view on the dominant critical uncertainty

A recent survey of WEC's members globally has identified the carbon framework as the outstanding critical uncertainty for the energy sector. A vast majority believes that further progress towards an international climate framework is needed to decrease energy investment uncertainty. 60 per cent have a preference for a carbon price mechanism (such as cap & trade), 38 per cent prefer a carbon tax. A vast majority in both, developing and industrialised countries think that it is legitimate to prioritise progress regarding energy poverty and more broadly, development over the climate agenda, or at least require that the two are linked. ❑

Figure 3 - WEC stakeholders' view on the global climate framework



Investment needs for universal access to electricity and clean cooking fuels

By Nobuo Tanaka,
Executive Director, International Energy Agency

Energy poverty and the World Energy Outlook

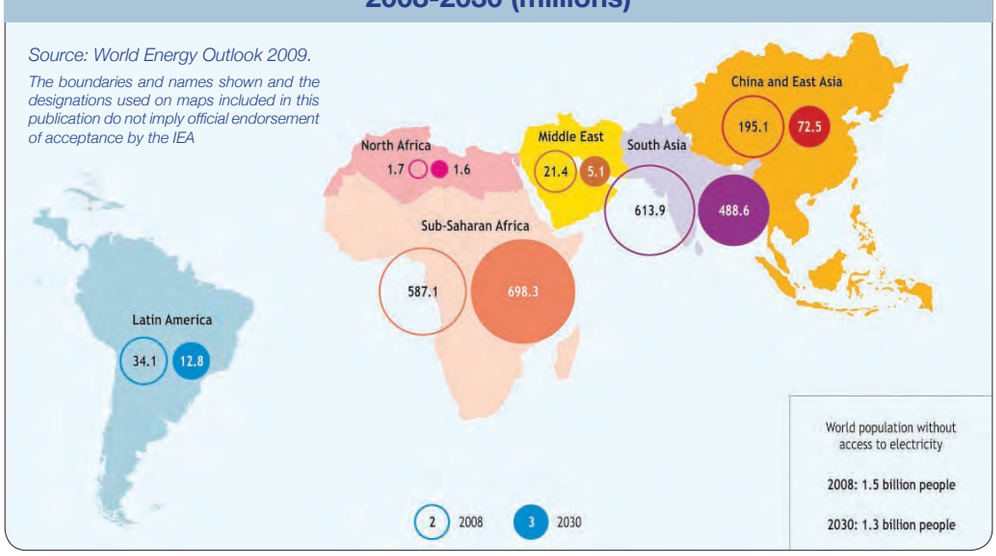
The International Energy Agency (IEA) has assessed the issue of energy poverty in its flagship publication, the *World Energy Outlook*, since 2002 (www.worldenergyoutlook.org). This year's edition, which will be published in November, will include a special focus on the role of energy in development, including the identification of a possible sustainable path towards universal access to modern energy services. The study, carried out by IEA jointly with UNDP and UNIDO, will provide updated cost estimates and investment requirements for universal access to modern energy services to 2015 and 2030. The analysis is aimed at informing national policy design and discussions at the MDG Review Summit to be held in September 2010 on the occasion of the 65th session of the General Assembly of the United Nations. The chapter will be released on 22nd September.

The link between energy and the Millennium Development Goals

The international community has long been aware that access to energy is crucial to meeting the Millennium Development Goals (MDGs). But there is not a goal specifically related to energy, and there are no targets or indicators associated with the MDGs that would enable governments and the international community to monitor progress in expanding access to modern energy services over time. The only indicator related to energy is for CO_2 emissions: total, per capita and per US$1 GDP (PPP)[1]. Expanding access to modern energy is a necessary condition for each of the economic, social and environmental dimensions of human development. Modern energy services help reduce poverty, improve educational opportunities for children and promote gender equality.

There are important development benefits to be gained from expanding access to modern energy services. Modern energy services help reduce poverty (MDG 1) and can play a critical role in improving educational opportunities for children, empowering women and promoting gender equality (MDGs 2 and 3). The availability of adequate clean energy is important in reducing child mortality (MDG 4). Reducing the carrying of heavy loads of fuelwood improves maternal health (MDG 5). Inefficient combustion of fuelwood exacerbates respiratory illnesses and other diseases (MDG 6). Fuel substitution and improved stove efficiencies would help alleviate the environmental damage of biomass use (MDG 7). Finally, widespread substitution of modern energy for traditional biomass can be a rallying point for global partnerships (MDG 8).

Figure 1: Number of people without access to electricity 2008-2030 (millions)



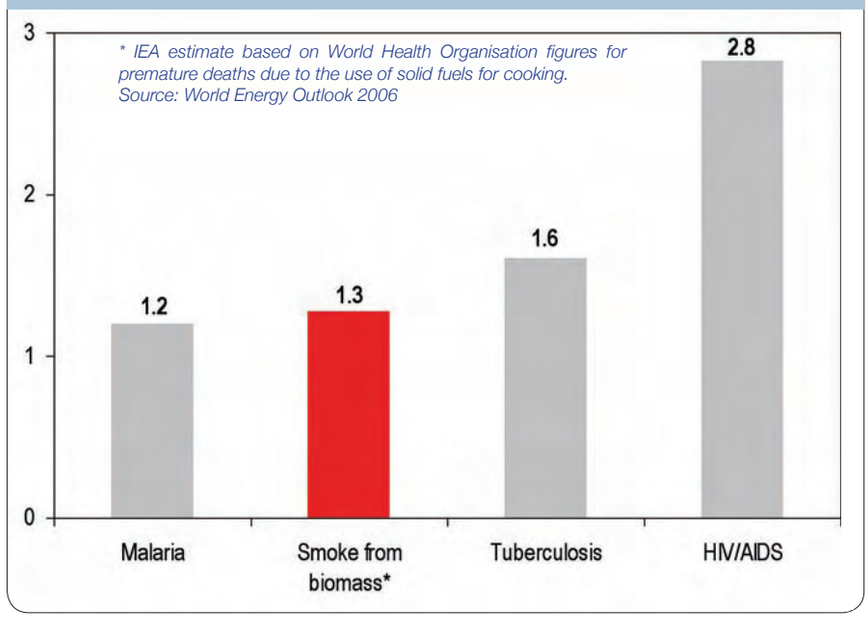
Access to electricity and modern cooking technologies and fuels

The IEA assesses two indicators of energy poverty: the lack of access to electricity and the reliance on the traditional use of biomass for cooking. Based on a detailed country-by-country database, the IEA estimates that, in 2008, the number of people without access to electricity was 1.5 billion, or 22 per cent of the world's population (Figure 1). 85 per cent of those people live in rural areas. In the Reference Scenario in the *World Energy Outlook 2009*, 1.3 billion people, or 16 per cent of the world's

population, still lack access to electricity in 2030. On the Reference Scenario figures, the electrification rate at the global level reaches 84 per cent in 2030, from 78 per cent in 2008. This represents a reduction in the number of people without access to electricity of 176 million compared to today, despite the substantial projected rise in global population.

Cooking a meal, a daily and routine task, can be a difficult chore and a danger to human health in some parts of the world. Today 2.5 billion people, or 37 per cent of the world's population rely on biomass as their primary fuel for cooking. Over half of those people live either in India or Sub-Saharan Africa. Use of biomass is not in itself a cause for concern. However, when resources are harvested unsustainably and energy conversion technologies are inefficient, there are serious adverse consequences for health, the environment and economic development. Reliance on biomass often results in regular exposure to harmful emissions of carbon monoxide, hydrocarbons and particulate matter. About 1.3 million people – mostly women and children – die prematurely every year because of exposure to household air pollution from biomass (Figure 2). Also in regions reliant on biomass, woman and children are typically responsible for fuel collection, an exhausting task that can result in long-term physical damage. Valuable time and effort is devoted to fuel collection instead of education or income generation. Environmental damage can also result, such as land degradation and regional air pollution.

Figure 2: Annual Deaths Worldwide by Cause



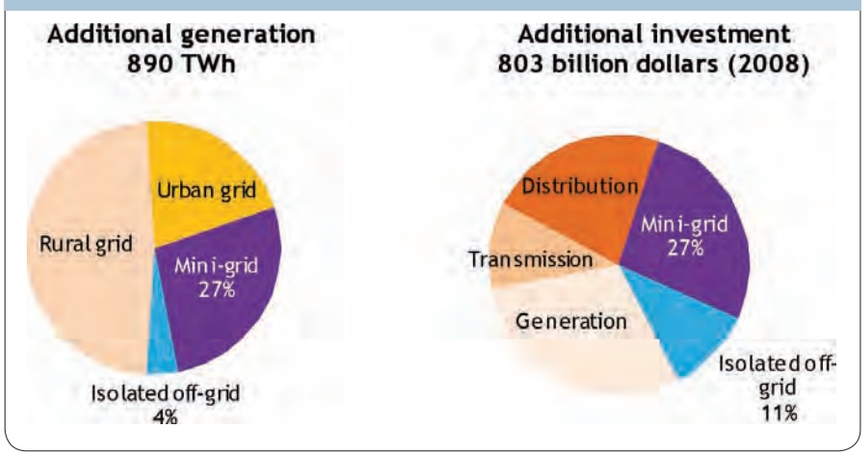
In the Reference Scenario in the *World Energy Outlook 2009*, the number of people depending on biomass for cooking is expected to rise to around 2.7 billion in 2030. However, these global trends mask significant changes at the country/regional level. The number of people depending on biomass increases steadily in Sub-Saharan Africa, from 608 million today to 765 million in 2030, by which time 30 per cent of the people using biomass worldwide live in the region. In developing Asia, the number of people using biomass increases from 678 million today to 731 million in 2030. In contrast, in China the number of people reliant on biomass has already peaked and continues to decline through to 2030. In India the number of people depending on biomass declines after 2020 as the country (like China) experiences a gradual transition towards modern fuels.

Investment needs for universal access to electricity and clean cooking fuels

The Millennium Development Goals include halving the proportion of the world's people living on less than US$1 a day by 2015. In the 2004 edition of the *World Energy Outlook*, we estimate that, in the Reference Scenario, the number of people without electricity in 2015 will be only fractionally smaller than in 2002. Thus, it is highly unlikely that the UN poverty-reduction target will be achieved unless access to electricity can be provided to another half-a-billion of the people we expect will still lack it in 2015. This would cost about US$200 billion. Meeting the target also implies a need to extend the use of modern cooking and heating fuels to 700 million more people by 2015.

In the 2009 *World Energy Outlook*, the Universal Electricity Access Case (UEAC) quantifies investment needs for universal access to electricity[2]. The UEAC is based on the assumption that new policies are introduced that result in a progressive increase in electrification rates to 100 per cent

Figure 3: Incremental electricity generation and investment in the Universal Electricity Access Case



Source: World Energy Outlook 2009

of the world's population by 2030. Relative to the Reference Scenario, global electricity generation in the UEAC is 3 per cent higher in 2030, an increase of 890 terawatt hours (TWh). Around 70 per cent of the additional supply is projected to be based on grid extensions, which remain the cheapest option in all countries, while development of mini-grids accounts for 27 per cent and isolated off-grid generation for 4 per cent (Figure 3). Compared to the Reference Scenario, in the UEAC there is an increase in global energy-related CO_2 emissions of just 1.3 per cent by 2030 — less than the current emissions of the United Kingdom.

Almost 90 per cent of the incremental supply is required in just two regions, Sub-Saharan Africa (448 TWh) and South Asia (315 TWh). Additional power-sector investment worldwide of US$35 billion per year on average is required in the UEAC in 2008-2030. This increase is equivalent to just 5 per cent of the annual average global investment in the power sector in the Reference Scenario, or around one-quarter of the annual investment required in China's power sector in the Outlook period. Almost 80 per cent of the incremental investment to meet the UEAC is needed in Sub-Saharan Africa and South Asia. Compared to the Reference Scenario, there is an increase in global energy-related emissions of just 1.3 per cent in 2030 in the UEAC.

In the *World Energy Outlook 2006*, the IEA estimates the investment needs for universal access to clean cooking fuels, using LPG as a proxy for all liquid fuels. The Reference Scenario projections imply that the Millennium Development Goals (MDGs) of eradicating poverty would not be achieved, as the number of people relying on traditional biomass for cooking would be higher than achievement of that goal would suggest. Combined with start-up capital costs, the total bill (capital plus fuel costs) for households switching to LPG would then be US$8 billion per year in the period to 2015 and US$18 billion per year from now to 2030. Although these costs are not negligible, they are small compared with allocations of resources elsewhere in the world economy. For example, the annualised capital and operating costs through to 2030 represent 10.6 per cent of what OECD countries spent on Official Development Assistance (ODA) in 2004, 3 per cent of the estimated US$278 billion that developing and transition economies spent on energy price subsidies in 2005 and 1 per cent of the US$808 billion that will need to be spent annually on global energy infrastructure in the Reference Scenario. ❑

1 See http://www.un.org/special-rep/ohrlls/lldc/MDGs.pdf for a complete list of the MDG goals, targets and indicators.

2 In the forthcoming World Energy Outlook, this scenario is updated and expanded to include access to modern cooking services.

Cooking meals can be a danger to health in many parts of the world

Global markets feel the force of North America's 'shale gale'

By Dr Daniel Yergin,
Chairman, IHS Cambridge Energy Research Associates (IHS CERA)

We are in an era of energy innovation. Never has there been so great an emphasis on innovation all across the energy spectrum – in terms of renewables and alternatives, but also in terms of conventional energy.

In terms of impact, the biggest innovation since the beginning of the new century, at least so far, is clear. It is a familiar resource – natural gas – but sourced in a new way. This is unconventional natural gas – more specifically shale gas. Some call its emergence a revolution.

The 'shale gale' is blowing powerfully all across the global energy industry. Yet this revolution arrived with no great fanfare, no grand opening ceremony, no ribbon cutting. It just crept up. In 1990 unconventional gas – from shales, coalbed methane, and so-called tight formations – was about 10 per cent of total US production. Today, unconventional gas is more than half of total production and is growing fast, with shale gas by far the biggest part. Shale gas alone was only one per cent of US supply as late as 2000! Today, it is almost 30 per cent of US natural gas, and could be 50 per cent within 10 years.

The potential of this 'shale gale' only really became clear around 2007. In Washington, DC, the discovery came later – only in the second half of 2009. A year later, it is changing the national energy dialogue and overall energy outlook in the United States. It is also affecting the global natural gas balance, and setting off a new exploration drive around the world.

This was not what was anticipated just a few years ago. From the time of the California energy crisis in 2000-01, it appeared that the United States was headed for an extended period of tight supplies, even shortages, of natural gas

While gas has many favourable attributes – as a clean, relatively low-carbon fuel – abundance did not appear to be one of them. Prices had gone up, but increased drilling failed to bring forth additional supplies. The United States, it seemed, was destined to become much more integrated into the global gas market, with increasing imports of liquefied natural gas (LNG). But a couple of companies were trying to solve a perennial problem: how to liberate shale gas – the plentiful natural gas supplies locked away in the impermeable shale. The experimental lab was a sprawling area called the Barnett Shale in the environs of Fort Worth, Texas.

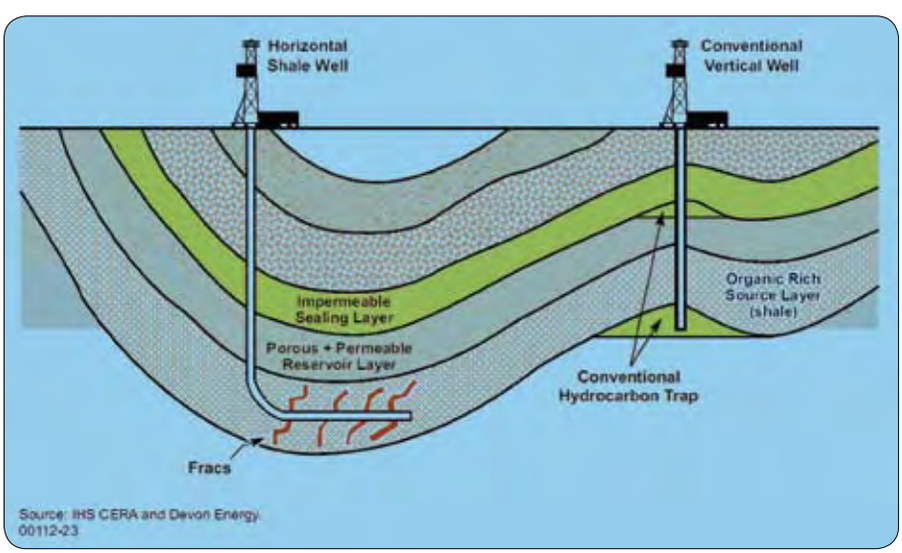
The companies were experimenting with two technologies. One was horizontal drilling, which opens up a much larger area of the resource-bearing formation.

The other technology is known as hydraulic fracturing, or 'fraccing.' Here, the producer injects a mixture of water, sand, and minute quantities of chemicals (typically less than 0.5 per cent of the total volume) at high pressure to create multiple fractures throughout the rock, liberating the trapped gas to flow into the well.

The critical but little-recognised breakthrough was early in this decade – finding a way to meld together these two increasingly complex technologies to finally crack the shale rock and thus crack the code for a major new resource. It was not a single eureka moment, but rather the result of incremental experimentation and technical skill – "trial and error," as one of the practitioners put it. The success freed the gas to flow in greater volumes and at a much lower unit cost than previously thought possible.

The shale gale also alters the way the industry operates. As IHS CERA observed in its new study, *Fuelling North America's Energy Future*, "Unconventional natural gas changes the supply risks from those of the traditional exploration and production business to those more akin to the manufacturing business."

In the past few years the revolution has spread into other shale plays, from Louisiana and Arkansas to Pennsylvania and West Virginia, and British Columbia as well. The province of Alberta has provisionally identified very large

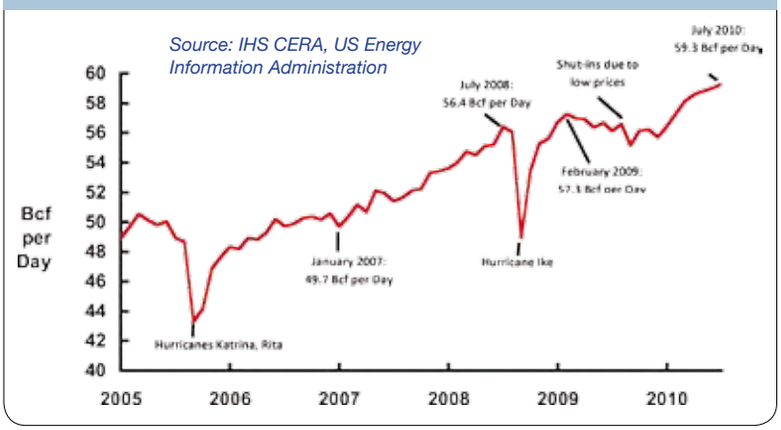


shale resources, and other resources have been identified in eastern Canada. The state of Michigan has recently held successful lease sales in its Collingwood shale.

The supply impact has been dramatic – and sustained. In the US Lower 48, states thought to be in decline as a natural gas source, production has grown by more than 20 per cent since the beginning of 2007. This increase is more than most other countries produce in total.

Equally dramatic is the effect on US reserves and resources. The numbers can be overwhelming. Proved reserves rose from 177 trillion cubic feet (Tcf) in 2000 to 245 Tcf in 2008, even while the US produced nearly 165 Tcf during those years. Estimates of probable, possible, and speculative US gas resources from the Potential Gas Committee, representing both academic and industry experts, rose by 800 Tcf over this same time period (from 1,091 Tcf in 2000 to 1,836 Tcf in 2008). When we add IHS CERA's own estimates of US shale and tight gas resources into the mix, we estimate that the total gas resource base in the United States exceeds 2,800 Tcf.

Unconventional Gas Has Led to Very Rapid Production Increases in the US Lower 48



While all of this new resource does not yet qualify as proved reserves, most of it is discovered – there is little exploration risk associated with shale gas. With more drilling experience, US estimates could rise dramatically in the next few years. At current levels of demand, the United States has about 120 years of proved and potential supply – a number that is bound to go up as more and more shale gas is found.

To have the resource base suddenly expand by this much is a game-changer. But what is getting changed? It transforms the debate over generating electricity. The US electric power industry faces very big questions – and great uncertainty – about fuel choice and what kind of new generating capacity to build. Given the long life of such facilities, utilities have to anticipate not only future demand, but also carbon policies.

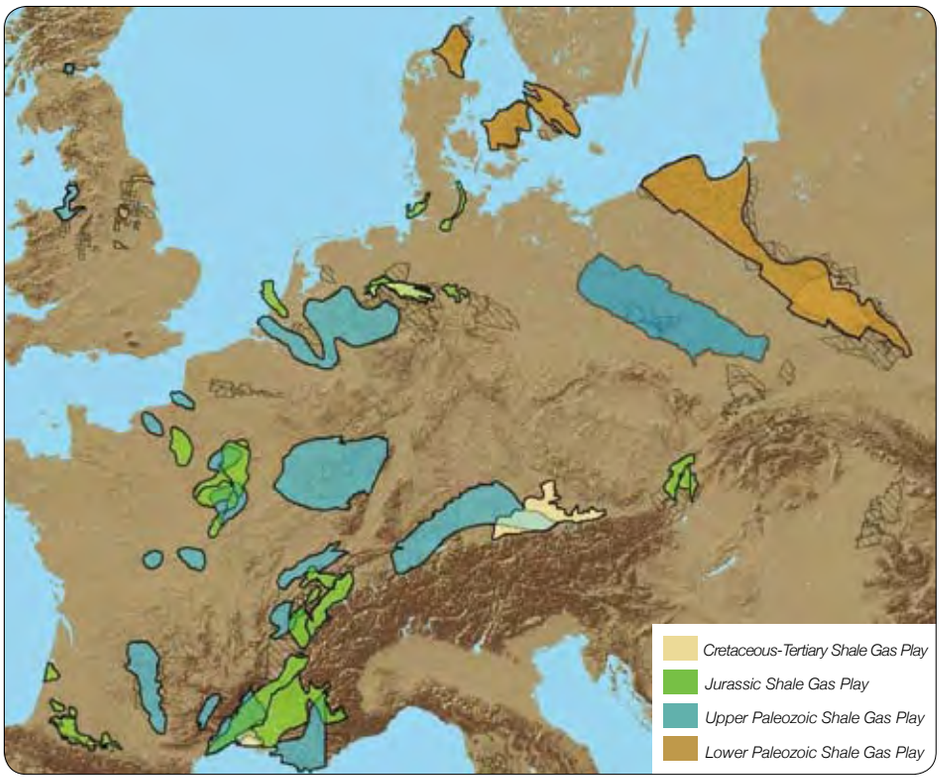
Yet, it seems likely that in the face of new climate regulations, the increased availability of gas will likely lead to more natural gas consumption in electric power because of gas's relatively lower carbon dioxide emissions. Natural gas-fired power plants can also be built more quickly than other types of plants.

Some areas such as the Northeastern states, which traditionally have imported the bulk of their energy from elsewhere, will find reliable gas supplies much closer to home. It could also mean that some buses and truck fleets will be converted to natural gas. Energy-intensive manufacturing companies, which have been moving overseas in search of cheaper energy in order to remain globally competitive, may now stay (or return) home. But these industrial users and utilities have long investment horizons. Both have been whipsawed by recurrent cycles of shortage and surplus in natural gas over several decades; and they are understandably cautious and will require further confirmation of a sustained shale gale before committing.

More abundant gas will have another, not so well recognised effect: facilitating renewable development. Sources like wind and solar are 'intermittent'. When the wind doesn't blow and the sun doesn't shine, something has to pick up the slack, and that something is likely to be natural gas-fired electric generation. This need will become more acute as the mandates for renewable electric power grow.

So far one potential political obstacle to development of shale resources across the United States has appeared: water. The most visible concern is the fear in some quarters that hydrocarbons or chemicals used in fraccing might flow into aquifers that supply drinking water. However, in most instances, the gas-bearing and water-bearing layers are widely separated by thousands of vertical feet, as well as by rock, with the gas being much deeper.

Therefore, the hydraulic fracturing of gas shales is unlikely to contaminate drinking water. The risks of contamination from surface handling of wastes, common to all industrial processes, requires continued care. Though fraccing uses



Source: IHS CERA, Breaking with Convention: Prospects for Unconventional Gas in Europe, Multiclient study, forthcoming

a good deal of water, it is actually less water-intensive than many other types of energy production. The impression is sometimes given that water issues involved in on-shore energy development are not regulated. In fact, they are highly-regulated, but part of that is done under state, rather than federal, regulatory authorities.

Unconventional natural gas has already had a global impact. With the US market now oversupplied, and storage filled to the brim, there's been much less room for LNG. As a result more LNG is going into Europe, leading to lower spot prices and talk of modifying long-term contracts. The traditional gas suppliers to Europe are trying to assess how much of this European over-supply is temporary, the result of the recession, and how much is more structural.

But is unconventional natural gas going to go global? A shale gas revolution in Europe and Asia would change the competitive dynamics of the globalised gas market. But will it? Preliminary estimates suggest that shale gas resources around the world could be equivalent to or even greater than current proved natural gas reserves.

Activity is picking up smartly outside North America, but it is still early days. Interest is rising in China. Initial efforts in Europe have been mixed. To bring greater clarity, IHS CERA is currently analysing 34 different plays in Europe to understand prospectivity, and we expect to have conclusions over the next few months.

But the physical resource will be only part of the answer in Europe. In the United States the independent oil and gas sector, open markets, and private ownership of mineral rights facilitated development. Elsewhere development will require negotiations with governments and potentially complex regulatory processes. Existing long-term contracts, common in much of the natural gas industry outside the United States, could be another obstacle. Extensive new networks of pipelines and infrastructure will have to be built. Many parts of the world still have ample conventional gas to develop first.

Moreover, major new LNG projects are coming on line, and some of that supply will be very competitive. In addition, there is an important consideration here. A growing European gas market would require additional supplies. If some of those are met by indigenous new European Union supplies, that would actually increase the sense of security on the part of importers in terms of being comfortable with the greater imports from outside that will be needed in a growth scenario.

This new innovation will take time to establish its global credentials. The United States is really only beginning to grapple with the significance. It may be half a decade before the strength of the unconventional gas revolution outside North America can be properly assessed. But what has begun as the shale gale in the United States could end up being an increasingly powerful wind that blows through the world economy. ❑

Daniel Yergin is Chairman of IHS Cambridge Energy Research Associates (IHS CERA) and author of The Prize: the Epic Quest for Oil, Money, and Power, *which is now in a new, updated edition.* The Prize *won the Pulitzer Prize and was a number-one bestseller. He is an author of IHS CERA's study* Fuelling North America's Energy Future: The Unconventional Natural Gas Revolution and the Carbon Agenda *and an advisor to the new IHS CERA study* Breaking with Convention: Prospects for Unconventional Gas in Europe.


Energy for all: delivering on the promise of universal access

By Dr Kandeh Yumkella, Director General, and Morgan Bazilian, Special Advisor, United Nations Industrial Development Organisation (UNIDO)

Large parts of humanity – billions of people – live without access to modern energy services. These are services that most of us take for granted, like light, fuel for heating and cooking, and mechanical power. Despite the efforts of many committed people working on excellent programmes, about 1.5 billion people still don't have access to electricity, and around 2.5 billion people rely on traditional biomass as their primary source of energy – a clearly unsustainable position. It is widely accepted that this lack of access to affordable, reliable energy services is a fundamental hindrance to human, social and economic development – and is thus a major impediment to achieving the Millennium Development Goals (MDGs). The issue is also a stark illustration of the deep inequity that exists between the rich and poor – roughly, the poorer three-quarters of the world's population use only 10 per cent of the world's energy. The rich countries aim for a secure, environmentally acceptable, and affordable energy supply – but what about the billions without access?

A few success stories do exist – countries such as China have improved the access for their citizens substantially in the last decades – but all across sub-Saharan Africa, and in parts of Asia, people are living without basic energy services. The demand for energy in these regions is expected to grow dramatically with increases in population and improvements in living standards adding to the scale of the challenges. It is stunning to realise that, if 'business as usual' conditions are maintained, over the next decades the total number of people without access to modern energy services will not decrease (IEA, 2009). Current efforts are insufficient in scale and scope, and attempting to address the issue in the same way that we have in the past is clearly not remotely adequate. This is why in April 2010 the UN Secretary-General's Advisory Group on Energy and Climate Change in its recommendations called on the adoption of a target to achieve universal access to modern energy services by 2030 (AGECC, 2010).

Energy for development

Energy services have a profound effect on productivity, health, education, safe water, and communication services. Therefore, it is no surprise that access to energy has a strong correlation to social and economic development indices (e.g. Human Development Index, life expectancy at birth, infant mortality rate, maternal mortality, and GDP per capita, to name just a few).

The obstacles to energy access are well known. These barriers, while complex, can be overcome, and international cooperation can help this process. What cannot be overstressed is that there are no fundamental technical barriers – we know how to build power systems, we know how to design good cooking stoves, and we know how to meet energy demand efficiently. Equally important is a clear understanding that local communities must be deeply involved in the planning, execution, and end-use of energy services. Energy access interventions must be guided by an awareness of local communities' unique situations and needs.

What is now required is a sustained political focus. Energy access must move up the political and development agendas to become a central priority.

Supporting existing plans

We need to focus support for delivery of national and regional plans and targets. A recent UNDP paper showed that 68 developing countries have electricity targets (Figure 1), but in order to meet their targets, these countries will require financial support, capacity development, and better regulation and governance structures.

Money matters

The goal of universal energy access is achievable, if the right elements are put in place. The capital investment required for a 'basic human needs' level of access (US$35-40 billion per year to 2030) represents only around 5 per cent of the total global energy investment expected during this period. While even more people need access to modern fuels for cooking and heating, the capital costs of closing this gap are substantially lower than for electricity. AGECC estimated that, on average, grant funding of around US$10-15 billion a year and loan capital of US$20- 25 billion a year will be

	All developing countries	*LDCs*	*Sub-Saharan Africa*
Electricity	68	25	35
Modern fuels	16	8	12
Improved cooking stoves	11	4	7
Mechanical power	5	0	5
Total no. of countries	140	50	45

Figure 1: Countries with energy access targets (UNDP, 2009)

needed, with the remainder self-financed by developing countries. The incremental investment required to provide sufficient energy for productive use would be almost entirely for concessional loan capital rather than grant funding. This is because the additional energy capacity will provide people with opportunities for income generation and therefore increase their ability to pay for the energy services, thereby increasing the financial viability of these services. It bears repeating that this issue will require a large suite of financial mechanisms with a focus on addressing a large array of real and perceived risks.

Service problem	*Sub-Saharan Africa*	*Developing countries*
Electricity		
Delay in obtaining electricity connection (days)	79.9	27.5
Electrical outages (days per year)	90.9	28.7
Value of lost output due to electrical outages (per cent of turnover)	6.1	4.4
Firms maintaining own generation equipment (per cent of total)	47.5	31.8

Figure 2: Impacts of unreliable infrastructure (World Bank, 2007)

Looking at the challenges at a regional level, the Forum of Energy Ministers in Africa in 2007 stated: "To turn around the performance of the power sector there are three major challenges to be addressed – replacing existing project wish lists with bankable projects; establishing regulatory policies that improve country investment attractiveness; and establishing institutions that have clear roles and are appropriately resourced."

More than just a light

It is essential to remember that providing reliable and secure energy services to those currently without access is not simply about supplying electricity for lighting or improved cooking stoves. To promote economic development and growth, these energy services need to be put to productive uses that positively affect livelihoods – providing power for industry, improving health care and education, and improving transportation.

It is clear that access to energy is about more than quantity. Quality is essential. This is true for both electricity and fuels. As an example, high costs and unreliable electricity service constrain economic activity in many countries, and constitute a severe obstacle to business operation and growth. The World Bank indicators (Figure 2) show the scale of the issue in terms of connection times, outages, the value of lost output, and the need for on-site generation.

A new direction

Building on the recommendations from the last Vienna Energy Conference in 2009 (and Brew-Hammond, 2010), what is needed includes:

- International recognition and prioritisation of the energy access issue;
- A robust international framework that clearly articulates an energy access target;
- A detailed implementation roadmap, with interim targets and milestones;
- A mechanism for building in-country capacity;
- A dedicated funding mechanism for ensuring investment toward universal access;
- Designing an ongoing global energy dialogue focused on this area;
- Improving the performance of public utilities is critical;
- A requirement for monitoring and reporting;
- Ensuring a focus on productive uses.

In order to coherently implement some or all of these findings, the AGECC recommended, in addition to a target, launching a Global Campaign for Energy Access and ensuring delivery of several focused public-private partnerships. In addition, a small but useful step may be to design and test a new framework for national measurement and reporting on energy access – this work is just beginning (Bazilian et al, 2010).

The information and telecommunications sectors demonstrated an unanticipated explosion of demand in the developing countries, and a technological leap-frogging from a situation of no access to state-of-the-art communications. This can be used as a precedent for modern energy systems as well. We are convinced that we can accomplish this task, and at the same time support strong new green economies – not doing so is not an option. The scale of the issue, like poverty itself, is enormous, and sometimes daunting to address. But access to energy may be the best 'entry-point' for effectively tackling the problem in the short term. Its importance is widely recognised. Now we must use this consensus to build on the effective models that exist, and create new ways to unlock the opportunities. ❑

This article originally appeared in the UNIDO magazine ***MakingIt***

Towards a strategic approach for energy at the World Trade Organisation

By Pascal Lamy,
Director-General, World Trade Organisation

This year, I will be participating at the 21st World Energy Congress that will be held in Montreal. I very much appreciate the programme of the Congress, which revolves around the following four themes: access to energy; the availability of energy; the acceptability of energy, and accountability for our energy policies. All of these themes are important and will take the Congress to the key issues of energy demand and supply, and the good governance of the planet's renewable and non-renewable energy resource base.

The main message that I would like to convey to this year's World Energy Congress is that the international community has yet to take a strategic approach to the rules of the multilateral trading system with respect to energy trade.

Clearly the rules of international trade are relevant to the international supply and demand for energy, and trade policy is itself a fundamental component of energy policy. With non-renewable energy resources being heavily geographically concentrated around the globe, most people on our planet today meet their energy needs through imports. In addition, the growth of non-renewable energies, means that new types of energy are now beginning to enter international trade, such as biofuels, also positioning the multilateral trading system at the heart of the renewable energy debate. And, yet, until today, the energy sector has not been debated as such, within the four walls of the WTO.

Several portions of the WTO 'rule-book', so-to-speak, are relevant to the energy sector. But, as effective as these rules may be, they remain relatively dispersed across the rule-book, with little over-arching global policy consensus, or goal. A stronger WTO rule-book would benefit this area, because just as with any sector where trade is feasible, obstacles to trade are feasible too. Among the issues that come to mind, with respect to trade in energy goods, are subsidies that distort trade, state trading disciplines, transit rights for transporting energy, and export restrictions. All of these issues speak to your theme of energy 'accessibility'. And while the WTO rule-book already addresses, or touches upon, some of these obstacles, it remains incomplete. In what ways do such obstacles impair global access to energy, and are such policies wise and desirable, are some of the questions that the international community may wish to pose.

In the field of services, the WTO has established a framework of cooperation that includes services incidental to the extraction of oil and gas, services incidental to energy distribution, and the pipeline transportation of fuels. Indeed, the current negotiations on energy services, in the Doha Round, cover a broad range of activities relevant for energy suppliers and traders, encompassing all energy sources. Governments are seeking commitments from one another in services areas such as drilling, engineering, technical testing, pipeline construction, and distribution. These issues speak not only to your theme of energy 'accessibility' but also to international collaboration for the enhancement of energy 'availability'. In fact, they speak to the promotion of foreign-direct investment in enhancing energy production and distribution.

International trade in biofuels is putting the WTO at the heart of the renewable energy debate

The on-going negotiations of the Doha Round are addressing, amongst many other issues, energy services, transit rules, subsidies, and trade opening in climate-friendly technologies. But there are obvious questions which remain to be answered. More and more questions in the area of energy relate to competition and investment policy, on

which the WTO has presently little to no say. There are also no disciplines on export taxes, for the moment. And, as climate change concerns loom larger, the WTO becomes relevant in relation to the possible use of trade measures to manage leakage or competitiveness concerns arising from the costs of existing or expected carbon constraints on production. The potential development of international trade in carbon emission permits and the establishment of carbon offset arrangements, may also involve a WTO angle. Similarly, the emerging landscape of subsidies for renewable energy deserves to be explored. Putting these issues on an international negotiating table would allow for the emergence of a more coherent vision for energy trade. They would all speak to good energy governance, globally.

With the entrance negotiations of several energy producers into the WTO, a bargain between energy exporters and energy importers is being struck every day, with every negotiating document that is being exchanged. Countries such as Russia, Kazakhstan, Azerbaijan, Algeria, Libya, Iraq, Iran and Sudan are all in the queue to join the multilateral trading system's broad spectrum of rules. The terms of their accession to the WTO will bring structural changes to energy trade and use, and may impact the WTO agenda, if such countries ultimately choose to place the 'energy' questions more forcefully before the organisation.

It is, of course, not a coincidence that many countries that are significant exporters of energy are taking longer to join the WTO. The global thirst for their energy resources meant that their exports travelled relatively unimpeded, with relatively less need for international rules. And, yet, in today's changing energy landscape, where oil reserves in some parts of the world are dwindling, or where concerns about climate change are forcing a rethink of the existing energy paradigm and a greater diversification of their economic resource base, the incentives to become part of the WTO system are growing. The changing composition of the WTO will be one of the fundamental shaping factors of the energy debate within the organisation.

WTO Members, as we all know, can initiate negotiations to create or change the rules of multilateral trade at any time. But in order for them to do so, an informed debate, preferably a public one, is clearly advisable. How do we trigger a broad discussion on energy trade? Is there any issue that could act as a catalyst? I can think of one that is currently on the WTO negotiating table; it is also a low-hanging fruit that is waiting to be reaped. I am referring to the opening of trade to climate-friendly goods and services in the context of the Doha Round.

At the moment, many climate adaptation and mitigation technologies are on the WTO negotiating table. They include goods such as wind turbines, solar cooking appliances, and photovoltaic cells, and services such as climate consultancy. We can make these goods and services more accessible to all, by reducing the tariff and non-tariff barriers that hold them back. This would be one of the fastest, most effective ways, of demonstrating not only that trade can be put to the service of sustainable development, but that it is possible to frame the discussion on energy trade in new ways. In fact, it would take the WTO, and the international community, straight to your theme of 'accountability', by contextualising energy policy in environmental policy. Accountability to the planet that hosts us, and to future generations. And what better starting point for an energy discussion in the WTO? I look forward to the outcome of this year's World Energy Congress. ❑

The Canadian Province of Québec is a major exporter of electricity to its neighbours

Photo: Hydro-Québec

Time to get real: why we need a serious energy framework in Europe

By Dr Johannes Teyssen, Vice-Chairman, Europe, World Energy Council and Chairman and Chief Executive Officer, E.ON AG

The current hype in Europe about 2050-studies imposes increasing challenges upon the task of defining an energy policy framework to 2015. This observation can perhaps be explained by the fact that it has become increasingly fashionable in energy policy to learn to run before learning to walk or, in other words, to dream about long-term visions rather than doing the hard work of building the future today.

For a few years now, the concerns about the future development of energy markets have grown as a coherent common framework for energy policy in Europe is still lacking. Today we witness many blurring and contradicting messages from national governments and European institutions alike. Some advocate liberalised markets and the benefits of competition, while at the same time promoting technology-specific feed-in tariffs for renewable energy – without developing a clear perspective on when and how to integrate renewables into the common electricity market. Some concentrate on the generation market alone and ignore its consequences for the energy transport and storage system.

Energy policy, however, needs a fact-based foundation: this avoids the traps of ideologies and wishful thinking. Energy policy can neither be developed nor pursued in isolation: it has to be embedded in a larger context of social, economic and environmental aspects. I have often used the analogy of building a bridge from a more fossil-dominated world towards a strongly renewable-based energy environment. Bridges are among the most difficult but inspiring masterpieces of engineering – and one should not forget they are based on hard facts, serious calculations and tested models, never on visionary dreams. The same fact-based analysis is therefore needed if we want to transform our whole society.

What are the key prerequisites for an energy concept?

As Mark Twain famously said, "the art of prophecy is very difficult, especially with respect to the future." Since then, not much has changed – except that, thanks to the advances in modern information technology, mankind is now able to produce lots of forecasting material in a very appealing graphical form with many figures – with the obvious danger that the reader will be convinced by the design rather than the content. But paper doesn't blush. Consequently, many forecasts are taken for granted, neglecting that the underlying assumptions concerning fuel prices, population, energy savings and learning curves for technologies are crucially determining the output. Consequently, forecasts should be considered as scenarios, showing possible worlds – but they will always fail in the end. One example: In 1898 the first international urban-planning conference convened in New York. It was abandoned after three days, instead of the scheduled ten, because none of the delegates could see any solution to the growing crisis posed by urban horses and their manure: The larger and richer cities became, the more horses they needed to function. The more horses, the more manure. In The Times of London in 1894, one writer estimated that in 50 years every street in London would be buried under nine feet of manure.

Of course, technology leaps cannot be predicted – not even in which field of technology they will take place. Therefore, working with existing technologies is necessary, meaning that the technical feasibility is an issue. Concentrating on generation alone – while neglecting energy transport and consumption – is doomed to fail. Currently, the European Union is quite successful in increasing the share of renewable generation at an impressive velocity – this is certainly a good achievement. By the same token, the transport of renewable electricity production to the end customers via the grid is functioning very well. Today, only small amounts of electricity do not find their way through the grid. Naturally intermittent electricity sources, with their low load factor, need more grid capacity since they are only producing for a fraction of the time compared to conventional sources, for which the grids were built. Currently Europe is flooded with studies predicting 100 per cent renewable electricity by 2050 at the latest – and only some of them address the transport issue. Their assumptions mostly fall short compared to the complexity of capacity issues. For example, some go as far as: We only need to increase the grid connections between Spain and France from currently 1 GW to 39 GW, or Germany needs full and exclusive access to the Norwegian pump-hydro stations, or the electricity consumption of German households needs to be met by photovoltaics. And if this does not help, we will use some fancy storage equipment and smart technologies, that are neither yet fully developed nor really cheap.

So, the basic message of many studies is: In order to promote generation technology that is not fully developed yet and where we do not know the winning technologies, we definitely need transport and storage infrastructure, which is also not fully developed or even present at large scale.

A reasonable energy policy looks different. A reasonable energy policy would not only look at possible targets in the future and the intermediate steps required to get there, it would also consider the starting point. It would identify the advantages and disadvantages of the current system and map the most important steps approaching the target. It is not always necessary to re-invent the wheel; some of the conventional technologies are still an excellent solution. We already have well developed technologies to produce electricity without greenhouse gas emissions, to guarantee security of supply and to keep prices for customers within a reasonable range. Nuclear power certainly is one of those technologies. Nuclear could serve as an excellent bridge technology. Furthermore it is also an enabler for renewable production: it is flexible enough to cope with intermittent sources and it would secure supply at times when there is no renewable production, for example during a night without wind.

However, in the long run all technologies are bridge technologies – the better is the enemy of the good. A permanent change allows for development. However, we should not put all our eggs into one basket but preferably adopt a stepwise approach that allows the engineers and markets to learn from the existing system, and to draw the right conclusions. Changing too much too fast at the same time will spoil any learning efforts, endanger security of supply and waste resources to a significant extent.

Sustainability is pivotal for an energy concept. Often sustainability is reduced to environmental requirements. However, a sustainable solution is a lot more. Firstly, it has to be economic in order to avoid massive disruptions on the producer or consumer side. No generator will invest in new power plants when he expects markets which will not remunerate investors' costs. Similarly, industrial players will chose other suppliers or even countries, in the event that their energy costs are too high and do not allow profitable operations. Secondly, energy supply has to be safe. In most parts of Europe, customers are used to a very reliable energy supply. Even the most ecologically optimised energy system would be useless for future generations if it is not reliable at acceptable prices.

Certainly regions or countries with a framework which allows energy suppliers to run their operations in a sustainable way, i.e. environmentally friendly, with fair market prices and with secure supply, can act as a role model for other countries. Regions with a failing energy concept, however, will give a bad example. Even the good ideas of these regions will be forgotten, since the overall concept did not work.

"No man is an island" said John Donne. The same is true for countries and their macro-economies. Energy prices are no longer a mere national matter without any relevance to competitiveness. Certain environmental goals do have a global impact, for example climate change, and cannot be dealt with only on a local scale. And some regions are key for securing the global supply of energy goods. Certainly, countries can decide to reduce their import dependency in order to have a more secure supply – but this will have effects on their energy bills. And certainly countries can decide to have very ambitious greenhouse gas reduction goals – but if other countries do not follow, this leads to a higher energy bill for the customers, either directly or indirectly via taxes. Hence, energy policy is no longer a national task – an energy concept needs to address international questions from the outset.

From visions to investments

One should be very sceptical that national or European master plans alone will really help. Defining the energy world in 2050 in a sound way is difficult; delivering energy in 2015 is even more difficult. Combining both is the most difficult task, but this is the way it should be done. One should be very cautious: while concentrating on nicely formulated science fiction, we might not be able to convince the people that we have to act now and invest in this future.

The current experience with citizens' initiatives is a broad opposition against anything new: the NIMBY or 'not in my back yard' phenomenon. New energy infrastructure like coal-fired power stations, grids and increasingly wind turbines are not accepted. Sections of the public are no longer willing to accept some disadvantages, even though there are definitely advantages for a broader and larger public. Any master plan with 2050-goals has to face this public attitude. And currently, neither politics nor companies seem to find a reasonable answer to find public acceptance.

Visions can help to create this public acceptance. But they should be seen as possible worlds – and not as granted development. And they should be connected with strategies and frameworks to give a clear picture of how we can realise the long-term goals. It is my firm belief that those frameworks have to be based on competitive markets. Open markets have proved to be the best environment to foster new ideas and to give every idea a fair chance. Currently, there is the danger that with so much belief in visions, we will fail to cope with reality in the coming years. ❑

Oil shale – the unconventional which will become conventional

By Sandor Liive,
Chairman, Eesti Energia

Before I explain to you how countries like the US (not to mention Brazil, Jordan, Morocco and others) will turn the tables of the energy world and become significant oil exporters, I want to make sure that one key term is clear – oil shale. Oil shale is important, much more important than most people realise and will become even more important in the future. There is a lot of confusion today about what exactly people mean when they talk about oil shale – is it in fact oil, a rock, or are we talking about the new boom in shale gas? Oil shale is a sedimentary rock that contains significant amounts of kerogen, (organic matter formed from fossilised plant matter). Oil shale can be used for energy production in various ways, but the most common are either to produce electricity, through direct combustion of the shale rock similar to coal based power, or to produce liquid fuels, the all-important oil, or in this case shale oil. Various technologies using heat and pressure have been and are continuing to be developed to extract shale oil from the rock – or as it is often described, squeeze oil from a stone. Together with this synthetic oil, an energy-rich gas is also produced, somewhat similar to natural gas. While this may sound somewhat bizarre, my own country of Estonia has been utilising this resource for almost 100 years. Estonians are quick to point out that they produce enough power to cover the domestic electricity demand as well as export to the neighbouring Baltic energy markets and Finland, all based on oil shale. Estonians have also been commercially producing shale oil dating back to 1924. China has had industrial production since 1930, with a reinvigoration in 1989 and the Brazilian company Petrobras has proven its shale oil technology since 1981.

With our long history of development, Enefit, known as Eesti Energia in Estonia, has been seeking out market proven solutions to improve efficiency and environmental performance. In 2008 we started cooperation with Outotec, a world-leading process and plant engineering company with unsurpassed experience in metals and minerals processing, and together we have developed a new generation of the Enefit technology. This advanced technology relies on Enefit's significant operations experience, while delivering the most efficient commercial shale oil production technology available today. We have already started building the first plant to implement this new technology, which will be commissioned in Estonia in 2012.

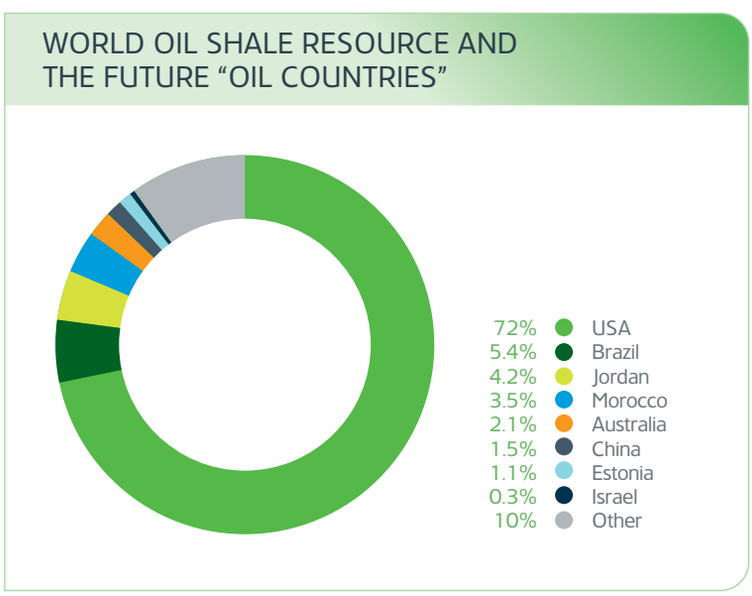


Figure 1. Extracting oil from rock isn't rocket science – there is still much room for improvement, but the 190 years of cumulative commercial production shared by Estonia, Brazil and China clearly demonstrates that the technology is proven

The world's next oil countries

Global proven conventional oil reserves total 1.2 trillion barrels[1]. Even larger is the world's supply of oil sands, in total estimated at 2 trillion barrels[2]. However, largest by far is oil shale; the US Geological Survey estimates the total world oil shale resources at 2.5-3 trillion barrels. So, why did I start by talking about the US? While the worldwide deposits of oil shale are huge, roughly 72 per cent of this is located in the US – primarily in Utah, Colorado and Wyoming. Based on their oil shale potential, other future 'oil countries', as shown in Figure 1, are likely to include Brazil (5.4 per cent), Jordan (4.2 per cent), Morocco (3.5 per cent) and Australia (2.1 per cent) not to mention of course China, Estonia, Israel, Russia and others[3]. As shown in Figure 2, although oil shale is hardly on the energy map today, it is expected to make up more than a third of the growth in unconventional oil by the year 2030, nearly as much as bitumen from oil sands. So, given the sheer size of the reserves and the 100-year track record, why haven't you heard more about oil shale and why isn't its projected growth a larger part of the future energy picture?

Historically, oil prices have been too volatile and conventional oil has been too readily available to support oil shale development in countries with other easier or cheaper energy alternatives. The key reason why oil shale has thrived and continued to be developed in Estonia, Brazil and China is its prioritisation at a government level as a strategic resource. Estonia, for example, has no other significant energy alternatives, yet has managed to secure its own energy independence in the power sector based only on oil shale. As demand continues to soar in India, China and other developing economies, and new conventional crude discoveries are in more extreme locations requiring significant investments and more technically challenging solutions, oil shale's role as a future energy solution will become more obvious.

How to measure energy independence

Energy independence is a hot topic today. When you take the US as an example, net import is roughly 13 million barrels per day[4]. If you consider an oil cost of US$65 per barrel, which is well below the year's average, the total cost to the US for importing oil was US$300 billion – this is roughly 50 per cent of the US trade deficit. Given that the US has at least three times more oil in its oil shale resources than all of the conventional oil remaining in Saudi Arabia, the importance of oil shale as a strategic resource cannot and must not be overlooked. In the near future, utilising all forms of domestic energy will become a priority and oil shale will become a key strategic resource for synthetic oil production for many more countries.

Technology development has lowered production costs, while increasing demand has driven up conventional oil costs. Studies show that developing new oil fields, including deep sea and oil sands are all more expensive alternatives[5] than industry estimates for oil shale. Future energy projections from reputable sources[6] show that even by 2030, the average oil price will more than support oil shale development. The figure varies by the specific deposit and technology, but Enefit is confident that its Enefit technology is a competitive alternative at an oil price of around $65/bbl, including a reasonable return on invested capital.

Why is oil shale different?

It is also important to address the unjustified stigma that oil shale suffers. Technology development has driven environmental improvements, yielding impacts that are very similar to other standard mining operations and industrial processes. This doesn't mean that the industry doesn't have work to do, but if mining for coal and other minerals is allowed and refineries and chemical production facilities are accepted, then there is absolutely no reason that oil shale should not also be an acceptable industry. A clean and efficient oil shale industry can and will be a responsible party in the global energy future. Air emissions, for example, can be reduced to acceptable levels. CO_2 emissions cannot be ignored, but face the same challenges and solutions as in other industries. The one key environmental difference with

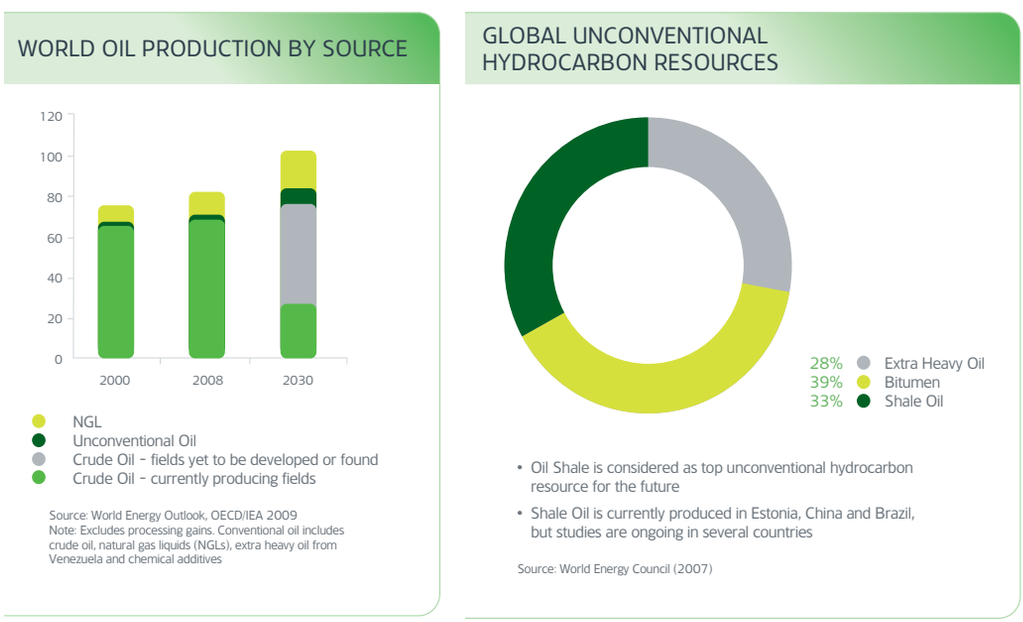


Figure 2. Traditionally, low oil prices have limited growth in unconventional fuels, but oil shale looks set to buck this trend and will undoubtedly become a top unconventional resource in the future

Eesti Energia Oil and Gas's Enefit 140 Plant in Narva, Estonia. The plant currently operates two production lines, each consuming 140 tonnes of oil shale per hour. The new Enefit 280 plant (consuming 280 tonnes per hour) is currently under construction

oil shale is water. As many of the top oil shale regions also have considerably restricted water availability, minimising water use and impacts on water resources is of the highest importance. A key point is that Enefit's shale oil extraction process itself is water-free. This is in stark contrast to the significant[7] water demands that are integral to oil sand's bitumen production. While Enefit's retorting technology is water-free, not all technologies are created equal and not all water demands arise directly from the technology. Again, similar to all mining operations and industrial processes, water is needed for mine de-dusting, ash disposal and cooling[8]. However, as water is not an integral part of the oil production process, at least with the Enefit technology, methods to maximise water reduction and recycling, such as dry ash transport and air cooling, for example, are already available and will further reduce water consumption.

Oil shale will play a leading role

Looking forward to the next World Energy Congress in 2013 brings me back to where we started. By 2013 I expect that we will already start to see the beginning of the shift. Rather than the future of the world's energy supply resting with conventional crude, we will see an increased emphasis on the very realistic role that non-conventionals such as oil shale and oil sands will play. Instead of the OPEC countries dominating the list of 'oil countries' I believe we will see Canada in the leading position, with strong developments from countries such as Estonia, Jordan, China and, hopefully, the US. To look back specifically to the US, the significant trade deficit, fuelled by 5 billion barrel a year oil imports, is a strong contributor to the declining dollar. If the US were to activate its oil shale resources, domestic production of 5bn bbl/y of shale oil would cover current imports and last for 400 years. This is an aggressive example and development needs to be carried out thoughtfully, but I am confident that oil shale will play a leading role in the world's energy future and that this can be done in an economically justifiable and environmentally responsible manner. ❑

[1]*Source: BP Statistical Review of World Energy, 2010*
[2]*Source: US DOE - Oil Shale and Tar Sands Programmatic EIS*
[3]*Source: US DOE, 2005*
[4]*Source: BP Statistical Review of World Energy, 2009*
[5]*Source: Cambridge Energy Research Associates, 2009*
[6]*Source: US Energy Information Administration (EIA)*
[7]*Source: Alberta Energy - oil sands mining requires 2.2-5 barrels of water for each barrel of synthetic crude oil (SCO) produced, insitu requires 0.5 barrels of water for each barrel of SCO produced.*
[8]*Source: US DOE, Fact Sheet - Oil Shale Water Resources - Current estimates for oil shale technologies are roughly 1-3 barrels of water per barrel of oil.*

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Entering a new age of electricity

By Wolfgang Dehen,
CEO, Energy Sector and Member of the Managing Board, Siemens AG

Not the least significant effect of last December's world climate conference in Copenhagen was to demonstrate the importance of a sustainable, reliable, cost-effective energy supply.

Where the 20th century was distinguished by growing energy demand, and thus a growing consumption of fossil fuels, today at the beginning of the 21st century we face the question of how we can put our energy system on a sustainable foundation in the face of demographic change, declining fossil fuel resources, and climate change.

Electricity is the future

The resulting challenge is to balance out what is known as the 'energy triangle'. That means ensuring a reliable, cost-effective, yet also environmentally friendly energy supply.

Paradoxically, the solution is to increase the consumption of electricity. The reason is simple: Electricity is the most flexible, most efficient energy source. And it is the only energy source that makes regenerative energy production directly usable, without detours. It can be used virtually anywhere energy is needed, and its efficiency is incomparably greater than that of fossil fuels.

Additionally, more electric energy is needed due to a simple equation of demographic change. More people need more electricity. In 2005, the world's population reached the 6.5 billion mark – by 2030 it will top 8.3 billion.

Put in simple terms: we are entering a New Electricity Age! By 2030, consumption of electrical energy will grow from 20,000 terawatt-hours today, to roughly 33,000 terawatt-hours – a dramatic 65 per cent increase!

But what does the soaring demand for electricity signify for the current technical development of infrastructure systems? For us at Siemens it is obvious: It is essential to optimise the entire energy chain – and every single component in the chain. Therefore, we have defined three clear steps for accomplishing this: First: an optimised energy mix, second: greater efficiency along the entire energy conversion chain, and third: a systemic optimisation of the energy system.

Step 1: Optimised energy mix

An optimised energy mix means tapping more renewables and retrofitting fossil-fuelled power plants with carbon capture and storage technology.

Offshore wind energy is an example. Here Europe has the potential for 100 GW – only 2 per cent of which is installed today. Which is why building the London Array offshore wind farm is such an important step into the future. Here Siemens Energy will build the largest offshore wind farm in the world, with a capacity of 630 megawatts (MW) in the first step and with the option to further expand up to 1,000 MW. Another outstanding example is Gwynt y Môr. When completed in 2014, this offshore wind farm will generate approximately 1,950 gigawatt hours of electricity annually, enough to supply around 400,000 British households.

But although renewable energy sources will play a bigger role in years to come, the dominance of fossil fuels will not change within the foreseeable future. In that regard, carbon capture and storage (CCS) technologies are a vital bridge technology for coal-fired power plants.

One example of an all-around approach to increasing the share of renewables used for the electricity supply is the Dii Industrial Initiative, which has the goal to provide 15 per cent of Europe's electricity needs by solar and wind power generated in the deserts of North Africa. Renewable energy bridging continents is the claim of this initiative. But for that, electricity first has to be conveyed for some 2,000 km into the European centres where it is consumed.

This is technically feasible with high-voltage direct current transmission (HVDC). The world's first HVDC system, at a voltage of 800 kV went online in China at the end of 2009. Thanks to 800 kV DC transmission, about 95 per cent of the energy fed into the system will arrive at the centres where it is consumed.

Step 2: Greater efficiency

Technical improvements can help reduce fossil fuel consumption and increase the yield of Renewable Energies. For example, the latest generation of combined cycle power plants, with efficiencies of more than 60 per cent, will save so much fuel compared to today's conventional plants (with 58 per cent efficiency) that each year each plant will save roughly the equivalent in carbon emissions of 10,000 cars driving 20,000 km. And in power grids too, the natural losses of electric power during transport can be reduced with power electronics components, meaning that significantly less electricity has to be produced.

But greater efficiency isn't limited to power generation and transport. Increasing the energy efficiency in end-use application is even more important. Buildings are a good example – as they are responsible for 40 per cent of the world's energy consumption. Especially in cities, where for the past two years more than 50 per cent of the world

population is living, buildings provide the greatest energy saving potential – more than industry, transportation, or energy production.

For many years, Siemens has proven with its energy efficiency solutions that every building has already today an energy efficiency improvement potential of 20-30 per cent on average. This can be achieved by optimising the building envelope, lighting, heating and cooling system, water and energy distribution and many more areas. This not only lowers operating costs, but also cuts CO_2 emissions, increases property values and enhances operating safety. And energy-efficient buildings with guaranteed lower energy costs can be operated at no cost for the customer, because the savings pay for the investment. Siemens' 6,500 building projects alone have realised guaranteed savings of around €1 billion, as well as CO_2 reductions of 2.4 million tonnes.

Step 3: Systemic optimisation

The resulting steep expansion of society's use of electricity, with many small producers and consumers, will result in an increasingly decentralised type of energy production. As a key factor for success, this new configuration will require high-performance information, communication and sensor technology – a 'Smart Grid.'

And there emerges another central trend: Today's generally passive consumers in the energy system will develop into interactive 'prosumers' – who both produce and consume electricity. Balancing all these distributed generation units will require a flexible, intelligent and optimally controlled grid in a new bi-directional energy system.

This is needed because in the future, power consumption will follow generation, rather than vice-versa. And this is when e-cars come into play: Thinking in visionary terms, you can even imagine the e-car of the future as the buffer for the fluctuating loads on the grid. This can be illustrated by a simple example: 200,000 e-cars with 40 kW capacities apiece can quickly provide 8 gigawatts of power to the grid, if needed. That is more than all of Germany currently needs as controlling power for buffering load peaks.

The course has been set

Taken all together, the three segments of optimised energy mix, higher efficiency, and systematic optimisation paint a picture of a fascinating future – a new electric age when electricity becomes the all-around energy source. Electricity that is produced in extremely environmentally friendly ways, carried with high efficiency even across long distances, and used with little conversion loss. So electricity is an ideal basis for achieving a smooth transition over a few decades to a carbon-free, efficient energy industry, and thus countering climate change. ❑

The e-cars of the future could act as a buffer against fluctuating loads on the grid

The great disconnect on energy policy

By Chris Kearney,
Chairman, President and CEO, SPX Corporation

There is a fundamental disconnect between the ongoing discussion on energy policy and the clear and present energy requirements of the 21st century global economy.

The energy debate typically centres on how to reduce carbon emissions. At last December's Copenhagen Conference, for instance, countries around the world pledged dramatic reductions in carbon emissions: The US promised a 17 per cent reduction below 2005 levels by 2020. India pledged 20 to 25 per cent. China doubled down on that with a 40 to 45 per cent target. Brazil, South Korea, the European Union and many others all swore to reduce emissions well below 2005 levels.

That's all well and good, if the only issue is carbon emissions. But rarely are those reduction goals compared to the inescapable need to meet what many predict will be a massive increase in energy demand and consumption in the coming decades.

According to the US Energy Information Administration (EIA), world energy consumption is projected to rise by 49 per cent *above* 2007 levels by 2035. And the most rapid growth will be in non-OECD countries such as China, Brazil and India, where energy consumption is slated to increase 84 per cent. The problem is obvious. How do you cut emissions between 17 and 45 per cent when you need to increase energy use by as much as 49-84 per cent?

I believe both can and must be done, but we'll only be able to do it if we take a realistic view of our energy needs and begin to examine where and how we can achieve real cuts in carbon emissions.

Most often, the answer of pundits and policy makers is increased investment in and reliance on renewables. I strongly believe that renewables must be part of the energy mix. My company makes and markets the infrastructure for many of the most promising renewable technologies, from geothermal, to solar to wind. But we have to ask ourselves if renewables can possibly, from a realistic point of view, provide the massive amounts of new energy we need in the near future.

A little over 7 per cent of the world's energy supply currently comes from renewable energy sources. The vast majority of that, however, is produced by hydropower (3 per cent of all energy) and biomass (4 per cent). Both these energy sources have limitations, however: It's unlikely that many new dams will be built in the developed world and the emerging and developing nations are increasingly concerned about the environmental damage large-scale hydropower infrastructure entails. Meanwhile, the food shortages and unrest that occurred around the world in 2007 and 2008, which many attributed in part to the diversion of cropland to corn ethanol production, suggest that there may be real limits to biofuels as well.

This leaves us with solar and wind, which is in any case what most people think of when they think "renewable." Solar and wind, however, account for less than one per cent of all energy use. Wind power currently accounts for less than one-third of one per cent of global energy output. Solar cells currently produce less than four hundredths of one per cent of global energy output – an almost infinitesimal quantity.

The situation is no better in the developed world, where massive subsidies have yet to seriously increase the contribution of wind and solar. In the US, for instance, wind and solar together contribute about one half of one per cent of our energy. These facts, while uncontested, are somehow rarely mentioned. And I would say, the difference between 1 per cent renewable energy contribution and the 49 to 84 per cent increase in energy needed in the next 25 years is the measure of the disconnect in our energy policy conversation.

There's a joke about a tourist who is driving in Maine and stops to ask a grizzled old farmer how to get to a town along the coast. The farmer begins to suggest a route, then stops and says, "Nope, that won't work." He thinks for another moment, then shakes his head again and says, "Nope, that won't work either." Finally he shakes his head again and announces, "I guess you just can't get there from here." But we have to get there from here. We have to come up with that energy from somewhere. Failure is not an option.

The developed world is still reeling from the real estate collapse and credit crunch. Unemployment in the US and Eurozone are hovering around 10 per cent and there is growing concern the economy will fall back into a double dip recession. Imagine what an energy crunch of 49 per cent would mean. Imagine what an energy crunch of 84 per cent would mean to the emerging economies of the world.

A few years ago, the World Bank predicted that the global middle class would expand to over a billion people by 2030. That trend – the most dramatic and widespread advance in human prosperity and well-being in history – has most likely been slowed by the current economic downturn. But without adequate sources of cheap and abundant energy this revolution in prosperity will ultimately decline and may even slip into reverse. Clearly we need to be focusing our

efforts on energy sources that are both abundant and that can provide significant CO_2 reduction.

There seems to be no question that nuclear is way up on that list. Nuclear power plants today are safer than ever and produce zero emissions. Importantly, they produce electricity on a continuous basis, 24 hours a day, seven days a week, regardless of whether the sun is shining or the wind blowing, so they provide a reliable and vital source of necessary base power until we build up renewable power capacity.

Not only do nuclear plants emit no greenhouse gas themselves, they can help us dramatically reduce them in other areas – particularly the fossil fuels we burn in our car and truck engines. As we move from gasoline to electrically powered transportation, nuclear can provide the massive new amounts of electrical energy required. And it can do it without releasing one CO_2 molecule into the atmosphere.

Many countries are moving ahead in modernising and expanding their nuclear power fleet. In the US, however, all the talk about a nuclear renaissance is, so far, just talk. Decades go by, and no new nuclear power plants are built. According to the Nuclear Energy Institute, simply meeting the increased demand on electrical energy with nuclear power would require hundreds of new power plants. We should start building now.

Clean coal combined with carbon sequestration must be another focus of our efforts. For many, this is counter-intuitive. Coal is the poster child of CO_2 emitting technology. Ageing power plants that are now 30 or more years old have an average efficiency that is extremely low – 33 per cent – essentially the same as it was a century ago. But new plants have dramatically improved their ability to reduce emissions. New coal plants can operate at 44 per cent efficiency or more. And new technologies hold out the possibility of effectively sequestering CO_2 as well.

We really have no choice. According to the EIA, coal will remain the world's largest energy source, accounting for some 38.3 per cent in 2030. Just as with renewables, advances in technology will be key. But shouldn't we be looking to find technological remedies where the great bulk of our energy is produced?

Updating our world's antiquated energy grids is another imperative. Last January, northern India was blacked out for 12 hours because of a collapse of their grid. But failing and inadequate infrastructure not only plagues the developing world. In the US, electricity blackouts are skyrocketing, and losses on transmission lines are so great that some 10 per cent of all the electricity generated is simply wasted. Ten per cent saved, in this case, would be 10 per cent earned – with zero additional emissions.

SPX provides solutions that support the expansion of global infrastructure, with particular emphasis on the growing worldwide demand for energy and power

Photo: SPX

As important as the big investments and new technologies are, we shouldn't discount the gains we can make though concerted, small improvements. Something as seemingly insignificant as better ways to tighten bolts on wind turbines could have a powerful effect on the efficiency of wind energy.

I have no doubt we will able to "fill the gap," providing energy to a growing world while cutting CO_2 emissions. But that will require that we put every option on the table – including nuclear and coal – and examine their pros and cons without "fear or favour." It will demand talking realistically about what our future energy needs are and realistically examining how we can meet them. And the sooner we begin that discussion, the better. ❑

Québec hydropower: the largest source of renewable energy in the North American market

By Thierry Vandal,
President and Chief Executive Officer, Hydro-Québec

Hydro-Québec is one of the largest power generators in North America, with hydropower installed capacity and available supply of over 40,000 MW. Our Strategic Plan calls for the development of new hydropower projects and the integration of a considerable quantity of wind power to maintain a high-quality electricity supply for our customers.

Since 2000, a total of 5,216 MW of new hydropower generation has been commissioned or is currently under construction. Hydropower represents about 16 per cent of the world's electricity generation. In Canada, about 60 per cent of electricity is generated from hydropower. Hydro-Québec generates almost a third of the electricity in Canada, and a full 98 per cent of our output comes from hydropower.

Generating clean, renewable, reliable energy

Hydropower generated in Québec offers numerous advantages. It is the only source of renewable energy in North America capable of providing reliable, base-load and peak-load electricity on a large scale.

Hydropower installations with reservoirs are flexible, responding rapidly to variations in electricity demand. Water is stored when demand falls and released to produce electricity when demand rises. Water can also be run through turbines to compensate for variations in wind power production. Having hydropower as an energy base actually encourages the development of intermittent sources of renewable energy, such as wind power.

From an economic point of view, hydropower offers an alternative to the price volatility of fossil fuel and contributes to energy security. The advantages of hydropower do not end there. Generating electricity from water doesn't produce any pollutants that affect the quality of the air we breathe. As a result, hydropower does not contribute to atmospheric problems such as smog or acid rain.

In the fight against climate change, hydropower makes an important contribution. Hydroelectric generating stations with reservoirs emit 40 times fewer greenhouse gases (GHGs) than natural-gas power stations and 100 times fewer emissions than coal-fired generating stations. According to life cycle analysis, GHG emissions from a reservoir generating station in a northern region are comparable to those from wind generation and less than a quarter of those from photovoltaic solar generation, for equivalent energy output. Thanks to the extensive use of hydropower, the electricity sector in Québec accounted for only 2.7 per cent of GHG emissions in the province in 2007.

Helping Québec's neighbours reduce their carbon footprints

Hydro-Québec is working with its neighbours to make more of its hydropower available to their markets. The 2009 commissioning of a 1,250-MW interconnection with Ontario will allow Hydro-Québec to increase energy deliveries to Ontario, but also to New York State and the US Midwest. With its partners Northeast Utilities and NStar, Hydro-Québec is currently studying a project for a 1,200-MW direct-current line into New Hampshire to increase energy exports to New England.

Since 2001, more than 39 million metric tonnes of greenhouse gas emissions have been avoided in northeastern North America as a result of electricity exports from Québec alone. This is roughly equal to the annual emissions of close to 10 million automobiles.

Building new electricity transmission infrastructure

Ensuring that clean energy reaches its export markets requires increased investment in electricity transmission infrastructure. Currently, market rules in place in North America are designed to ensure that the appropriate parties pay for the cost of building or upgrading transmission. This ensures a level-playing field among all power generators and wholesalers.

Hydro-Québec has constructed and operates the largest electricity transmission grid in North America with 33,244 km (20,657 mi.) of lines, 515 substations and 16 interconnections with neighbouring markets.

Large-scale generation of hydropower and exports to regions with fewer renewable resources goes a long way to lowering GHG emissions. However, to further reduce our carbon footprint, we have to use energy much more efficiently in other economic sectors.

Electrifying public and personal transportation

Public and personal transportation account for about a quarter of greenhouse gas emissions in North America. In Québec, the transportation sector accounts for more of Québec's GHG emissions than any other sector: 36 million tonnes in 2007, or 42 per cent of total GHG emissions.

If a majority of our personal vehicles and public transit were powered by electricity, GHGs associated with transportation would decrease, as would urban pollution and smog.

Hydro-Québec is well placed to contribute to the electrification of transportation. It generates clean and

renewable energy, operates a reliable grid and has access to world-renowned expertise and promising technologies. Our transportation electrification action plan has four main focuses: financial support for the development of electrical infrastructure for public transit; development and marketing of advanced technologies; test-driving and experimenting with integration of electric vehicles into the power grid; and planning of support infrastructure for vehicle charging.

Hydro-Québec is currently participating in feasibility studies conducted by various public transit authorities to determine exactly what electrical infrastructure is needed and what Hydro-Québec's level of investment might be in this infrastructure. Certain public transit systems – the Métro in Montréal, for example – already run on electricity. But more could be done to bring electrified streetcars, commuter trains and trolleybuses into our urban landscape.

As for personal transportation, in Québec it would cost seven times less to run a car on electricity than it does now to fuel it with gasoline. Hydro-Québec's distribution grid could handle the increase in demand brought about by electric vehicles. A single hydro generating station the size of Eastmain-1 could provide the electricity for a million electric vehicles (3 TWh per year).

Hydro-Québec is partnering with various car manufacturers, including Ford, Mitsubishi Motors Toyota and Renault-Nissan, to test and use various electric and plug-in hybrid vehicles before they are marketed on a large scale. The studies underway are designed to determine the recharging performance of vehicles, particularly under northern conditions, and the driver experience and overall satisfaction. Renault-Nissan Alliance, the Québec government, Hydro-Québec and city administrations have established a working group to study various aspects of charging infrastructure required for electric vehicles.

However, electric vehicles will only be successful if the engine technologies, the batteries and the electronic components meet market needs. Hydro-Québec's research institute, IREQ, has done extensive work to improve the performance and reduce the cost of lithium-ion batteries. Hydro-Québec patents the advanced materials it develops and then grants licences to battery manufacturer suppliers. Sony has recently launched a battery incorporating chemical components developed by Hydro-Québec.

Contributing to the fight against climate change

To ensure continued sustainable economic growth, the world doesn't only need more energy – it must also reduce GHGs. We need to be more efficient in our energy consumption and ensure that regions with sources of renewable energy have the transmission infrastructure necessary to export that clean energy to areas still dependent on fossil fuels. The use of clean and renewable energy must also make its mark in sectors of the economy such as transportation that have traditionally been dominated by fossil fuels, especially in regions like Québec where the energy sector is already low-emitting. In a world where the threat of climate change is fast becoming a reality, sustainable hydropower, the most flexible and reliable renewable energy, is one of the means to move towards a low-carbon economy. ❑

Manic-5, a 1,596MW generating station on the Manicouagan River, was commissioned in 1970-71

Photo: Hydro-Québec

Energy sustainability: the new rules

By John Drzik,
Chief Executive Officer, Oliver Wyman Group

What country leads the world in providing stable, affordable and clean energy? The answer is that no one does. And that's a problem.

Canada is a world leader in terms of supplying stable and affordable energy, though it doesn't rank in the top ten nations when it comes to clean energy, according to research conducted by the World Energy Council in collaboration with Oliver Wyman. Switzerland, a big user of nuclear and hydro power, is one of the top five in terms of delivering stable and clean energy. But it does not lead the pack when its energy is measured in terms of affordability. Brazil and Italy excel at providing energy that is both clean and reasonably priced. But no countries score well on all three measures.

One fundamental reason why countries are not leaders in terms of all three of these criteria is that no form of energy satisfies all of these requirements. As a result, energy policymakers, accustomed to operating in a relatively stable environment with a clear direction, are struggling to balance the often conflicting agendas of developing secure, affordable and clean energy. In the process, the worst thing possible for long-term energy investments is happening: Energy policy is becoming clouded by potentially paralysing uncertainty. The traditional model for energy policymaking is no longer working. Policymakers need to cut through the ambiguity these tensions are creating by rethinking their approach to energy sustainability – and soon.

The world needs more energy. Global demand for energy is expected to grow by 1.5 per cent every year from now until 2030, according to the International Energy Agency. That growth is already testing the limits of existing energy resources and infrastructure. New energy sources must be opened up, ageing infrastructure upgraded, and new plants and networks developed – all in the context of ensuring that energy remains clean and affordable for consumers. The IEA estimates that countries need to invest an estimated US$1.1 trillion, or 1.4 per cent of the world's GDP, each year to maintain and replace existing systems as well as to meet growing demand and environmental objectives.

And yet, while investment in energy overall is increasing, many crucial initiatives are being scratched or postponed worldwide. Changing market circumstances and national priorities are contributing to significant levels of variablility in policymaking and in the quality of policy implementation. In July, for example, the Ontario government announced a dramatic cut in how much it will pay some producers of solar energy, creating uncertainty around potential future investments in its clean energy programmes.

The recession has underscored the dilemma that policymakers now face by making the trade-offs that exist between different energy criteria more contentious. Germany and Spain, some of the world's leaders in renewable energy, have been forced to reduce financial incentives this year for clean energy technologies to lessen the short-term burden on their nations. At the same time, in California, citizens have launched a ballot initiative to halt the enforcement of the state's law mandating greenhouse gas reductions until its unemployment rate improves.

Embracing complexity

The challenge for policymakers then is to figure out how to embrace this complexity. Energy policies need to be designed to fit agendas that are much broader and more fluid than they have been in the past. That means they must incorporate many options rather than be based on fixed commitments to a single technology, type of energy, or strategy.

The first critical step to achieving this is for policymakers to conduct a much fuller cost benefit analysis that examines measures to improve both their energy supply and demand characteristics. If countries conduct this more comprehensive portfolio analysis and

Top five leaders measured by sustainability dimensions*

Energy security	Social equity	Environmental impact mitigation
1. Canada	1. United States	1. Switzerland
2. Switzerland	2. Japan	2. Sweden
3. Denmark	3. Germany	3. Norway
4. Finland	4. Canada	4. France
5. Japan	5. United Kingdom	5. Denmark

Source: World Energy Council/Oliver Wyman. Blue font indicates top five leaders in 2 dimensions
**WEC member countries with GDP/capita > US$33,500.*

Clean energy sources such as wind are becoming an increasingly important part of the global energy mix

use it to frame their policy choices, they may take different courses of action.

Diversifying resources

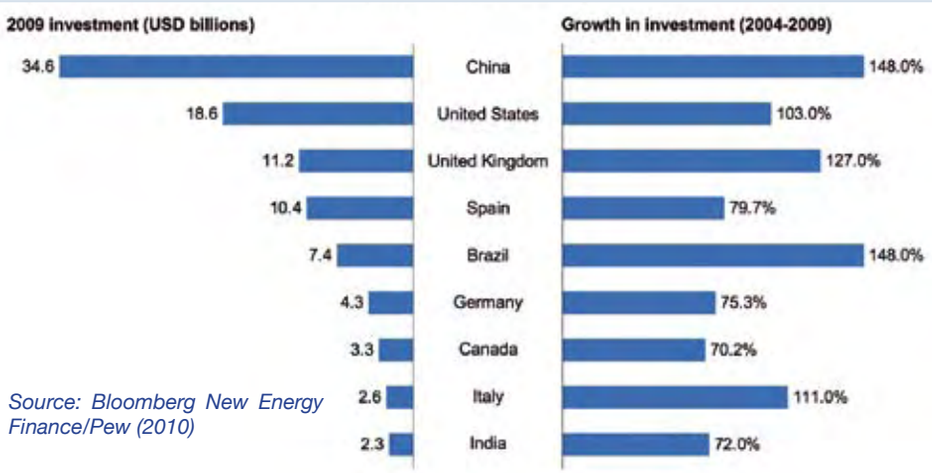
On the supply side, countries' energy policies need to reflect how drastically the world's energy mix is changing. Over the last two decades, the overall mix has remained relatively stable. But now, a wide range of alternatives are disrupting that natural order. That means countries need to commit large sums of money to long-range plans on which the final verdict will often be uncertain for many years to come. Renewable energy is becoming more popular in a number of countries. Natural gas has also become comparatively more attractive. And there is an expected 30 per cent increase in nuclear capacity worldwide by 2020. Fifty-two nuclear reactors are under construction worldwide, with a further 140 on order or planned and an additional 344 at the proposal stage, according to the World Nuclear Association.

China's approach to supplying the energy necessary to keep up with its breakneck economic growth illustrates how more countries appear to recognise the need to develop a wide range of energy resources. It could have just developed gas and coal resources which are inexpensive and expedient. But the country has also focused on developing cleaner types of energy such as nuclear, wind, biomass and solar energy.

As a result, China is becoming better positioned to provide energy on a sustainable basis no matter what the future may hold. In 2009, China invested US$34.6 billion in clean energy – more than any other nation and pushing the United States into second place, according to research by the non profit The PEW Charitable Trusts.

More countries are also beginning to embrace international cooperation to cope with potential risks to their energy security. To reduce the risk of repeated supply disruption from Russia's disputes with the Ukraine and Belarus, Europe has made significant efforts to develop alternative supply routes. Germany's active sponsorship of the Nord Stream pipeline between Russia and Europe may make the country, which imports 86 per cent of its natural gas needs, a new hub for Russian supplies. At the same time, plans have been proposed to develop a "super-grid" to connect planned concentrated solar power generators in North Africa and the Middle East with European consumers. If this grid achieves the scale anticipated by its proponents, it could meet as much as 15 per cent of Europe's electricity demand

Top 10 countries in terms of clean energy investment in 2009



Source: Bloomberg New Energy Finance/Pew (2010)

by 2050 while powering desalination plants in North Africa.

The greater challenge for many policymakers seems to be managing energy demand. Policymakers should devote as many resources to managing their demand for energy as their supply. To date, most countries' programmes designed to reduce greenhouse gases focus on promoting renewable technologies. But energy efficiency programmes have been proven to be the cheapest, fastest, and cleanest way for utilities to meet customers' energy needs. Instead of incurring economic costs, nations gain immediate economic benefits and savings when businesses and individuals simply begin to conserve energy.

Conserving energy

California's energy efficiency programmes, for example, have provided hundreds of millions of dollars in savings to customers and reduced the annual global warming pollution equivalent to emissions from three million cars, according to the Natural Resources Defence Council. By focusing on energy efficiency, California has managed to cut its growth in demand for energy to one quarter of what it was projected to be.

To be effective, policies designed to conserve energy need to cut through layers of subsidies based on past priorities so that consumers can become aware of the true cost of their energy and make informed choices. One way to achieve this is by introducing so-called smart grids. When California tested smart meters several years ago, customers reduced their consumption by 4-7 per cent. Based on these results, California decided to introduce smart meters on a permanent basis. Ontario, too, is in the midst of a large-scale smart grid initiative, installing smart meters in homes and small businesses across the province. By the end of 2010, the system will serve 1.3 million customers.

Policymakers should also develop decision frameworks that integrate a much broader range of factors than they have in the past. Effective efficiency programmes need to be based on the structural make up of a nation's entire economy and reflect its consumption patterns. To achieve that, policies need to be coordinated across sectors that have not traditionally been considered part of energy policies. Efficiency programmes require the coordination of everything from the impact of upgrades to heating systems to low emission vehicles to green appliances.

Rewarding efficiency

Finally, energy efficiency improvements should be rewarded equivalently to energy supply development to encourage strong public and private sector cooperation. Utilities need financial incentives for helping customers use less of their product. One way to do that would be to permit them to earn a small percentage of their efficiency programmes' net benefits. Policymakers should also play a role in encouraging manufacturers to make more 'intelligent' devices that will enable everything from a refrigerator to an elevator to use less energy.

In summary, today's energy agenda is being shaped by a wide range of competing policy interests. Policymakers need to strike the right balance across potentially conflicting objectives and chart a course to create an energy supply which is at the same time stable, affordable and clean. In doing so, they should develop incentive frameworks that both help diversify their country's energy sources and encourage energy efficiency. We are in a new age of uncertainty, with a wide range of possible outcomes. These steps should help position a country for success in whatever the future might bring. ❑

Energy trends: facts and priorities

By Elena Nekhaev,
Director of Programmes, World Energy Council

Performance of Generating Plant (PGP)

Power plant performance is often overlooked in the political and public debates, as it is perceived to be too technical. However, it is a major factor for the electricity industry, in particular in developing countries, where performance improvement potential is particularly large.

Technology or management?

WEC has calculated that by improving the availability/performance of existing power generation park around the world to the performance levels currently attained by the top 25 per cent of plant operators, the power industry worldwide could save approximately US$80 billion per year and avoid about one billion tonnes of CO_2 emissions (around 4 per cent of the total global CO_2 emissions). Moreover, this could be achieved at the cost/benefit ratio of 1 to 4, and would require only minor equipment replacements. Main savings would come from the improvement of operational practices and managerial decision-making. Analytical studies and documented practical experience demonstrate that;

- technology/mode of operation account for 20-25 per cent of the overall improvement, while
- human factors/management for 75-80 per cent.

Furthermore, even the most modern and efficient plants will not achieve their design efficiencies if they are not properly operated and maintained, hence training/capacity building is of vital importance to ensure that plants reach their operational potential.

Value of data collection and use

A recent survey of 450 executives representing 370 companies from 35 countries and 19 industries conducted by the Wall Street Journal has demonstrated that while business today is awash with data, only a few companies use data strategically and realise that the ability to collect, analyse and act on data is at the core of any company's competitive advantage. The survey identified a strong link between extensive and sophisticated use of data analysis and sustained high performance: top performing companies were five times more likely to single out pro-active use of data as critical to their competitive edge.

The analysis of plant's technical performance is one of the most important tasks at any power plant. Without its availability records, the plant staff cannot determine ways to improve performance of the equipment. Key factors influencing plant performance should be identified and evaluated to allow a cost/benefit analysis of any activity/programme before its implementation and upon its completion.

For many years, the WEC Committee on the Performance of Generating Plant has been promoting international power plant availability data exchange and collecting availability statistics from countries around the world. Today the data is stored in an interactive internet-based database. The access to worldwide generating plant statistics provided by the database can help power plant operators benchmark their units using the availability records of their plants and comparing them with other similar units in the database. The ultimate objective of the database is to facilitate international exchange of information to improve the performance of power generating assets around the world.

Energy efficiency policies

Energy efficiency is a winning strategy which can help address a variety of policy objectives at the same time: security of supply, climate change, competitiveness, balance of trade, investment and environmental protection.

This is the main message of the forthcoming WEC report, produced together with ADEME and supported by Enerdata, based on input from 88 countries around the world. Improving energy efficiency can help:

- reduce energy imports and thus improve the security of supply,
- make up half of the reduction needed to reduce GHG emissions by 2050 in scenarios with strong CO_2 constraints,
- increase competitiveness of industries, especially for energy intensive industries, by reducing energy costs,
- limit the macro-economic impact of oil price fluctuations for oil importing countries in terms of balance of payments, and public budget,
- reduce the huge need for investment in energy infrastructure in emerging economies and free capital for other purposes,
- contribute to the environmental protection by reducing local pollution and deforestation.

To be successful, energy efficiency programmes and projects need appropriate strategies. The report introduces eight main recommendations to improve the effectiveness of energy efficiency policies development and implementation:

1. Incentive prices: a condition for successful energy efficiency policies,
2. Innovative financing to support consumers at a limited cost for the public budget,
3. Regulations need to be regularly strengthened, enforced and expanded,
4. Measures should be combined in packages of complementary measures,
5. The situation of less developed countries should be better addressed,

6. The achievements and impacts of measures should be monitored,
7. Consumer behaviour should be addressed as much as technologies,
8. International and regional cooperation should be enhanced.

Biofuels: policies, standards and technologies

The world's transport system is based on one single fuel – oil and today there does not seem to be any realistic alternatives to oil. Demand for oil is expected to grow for decades to come, and while biofuels can help meet this demand, they will not replace oil. The use of biofuels is growing strongly, although drivers for a wide deployment of biofuels vary across the world and include a broad range of issues from land-use to energy security, to economics and environment. The main challenge for the future is to develop biofuels which do not compete with the food chain, which are sustainable and efficient in terms of costs, energy use and the carbon footprint.

Technology is a key factor to enhance both food and bio-energy production and increase the output without adverse economic and environmental implications.

International Standards

Many barriers that today constrain world trade in biofuels can be removed by introducing international specifications and standards. Not only must properties of final biofuels products be harmonised but also methodologies for measuring these properties. The International Standards Organisation (ISO) is currently working on developing certain biofuels standards and the outcomes of this effort are eagerly awaited.

Outlook

Despite the projected tripling of biofuels production from 20 million tonnes of oil equivalent (Mtoe) in 2005 to almost 60 Mtoe in 2015 and over 90 Mtoe in 2030, their share in the total road-transport fuel is not expected to surpass 4-5 per cent by 2030. Biofuels production costs still remain comparatively high and substantial reductions are required for them to become commercially competitive.

Impact on food prices and land use

The spreading concerns about the impact of increasing production of biofuels on the food prices and possible competition for agricultural land require a holistic assessment since there are a number of various factors at play, including poor management of the agricultural sector during the last decades, unfavourable weather conditions, lack of investment in production capacity and infrastructure, distorted agricultural markets and the dismantling of support policies for domestic market in developed countries which all might have contributed to the recent increases in food prices all over the world. The United Nations Food and Agriculture Organisation estimated in 2008 that globally biofuels accounted for approximately 10 per cent of the recent food price increases. In certain countries biofuels have had a more significant impact on food prices, however it was mainly because of national agricultural support programmes and protectionist measures rather than increased production of biofuels. The key success factors for the future of biofuels will be gradual expansion in cultivated land and considerable increases in agricultural productivity. This will require a broad political commitment, including introduction of badly needed land reforms, better irrigation, use of fertilisers and further development of transport infrastructure.

Interconnectivity

Our modern society could not exist without a reliable, clean and affordable supply of electricity. It has taken several centuries to develop electricity into its modern form and this development continues, as demand for electricity is soaring all over the world and new requirements, mainly related to efficiency or environment, are being introduced. In the vast majority of countries, the electricity sector used to be owned and run by the state, and it is still the most common arrangement. In terms of the electricity value chain, transmission on average accounts for less than 10-15 per cent of the final cost paid by the end-user for per kilowatt hour (kWh). However, today transmission is becoming a key issue for effective operation of liberalised markets and for their further development. An integrated and adequate transmission infrastructure is of utmost importance for ensuring the delivery of the most competitively priced electricity to customers, both near and far from the power generating facilities.

The development of interconnection capacity between two separate countries (or areas) allows greater flexibility in the generation mix. In particular, the availability of cross-border transmission capacity may help select power from cheaper units located in another area or country.

Market integration issues

Greater integration between different transmission systems increases the overall benefits, but it also requires a greater degree of harmonisation. The development of cross-border energy trading may increase dependence on the import and

create concerns about security of supply. This is a critical issue that affects the development of numerous large-scale projects. But there are good examples of successful policy approaches. Thailand, for instance, is negotiating long-term contracts with IPPs located in Laos. The hydro project Nam Theum 2 in Laos, with an installed capacity of 1,088 MW, is close to commissioning and nearly 90 per cent of its electricity production will be exported to Thailand based on a long-term Power Purchase Agreement (PPA). The peak demand of Laos was 415 MW in 2007, and it would have been impossible to develop the project only for the internal market.

Security of Supply and Climate Change

In liberalised electricity markets it may be more beneficial to invest more in cross-border expansion than in a centrally planned system. In this case the additional cross-border capacity may encourage generators to bid their actual variable costs and thus create a more competitive market. The larger the cross-border capacity, the less likely it is that large generators can exercise market power. Thus, increased cross-border capacity can contribute to a reduction in prices through the reduction of market power. In any case, the increase in cross-border capacity helps improve the efficiency of the electricity system, since the merit-order dispatching system can achieve a better allocation with the increase of the generating power capacity that supplies the electricity system.

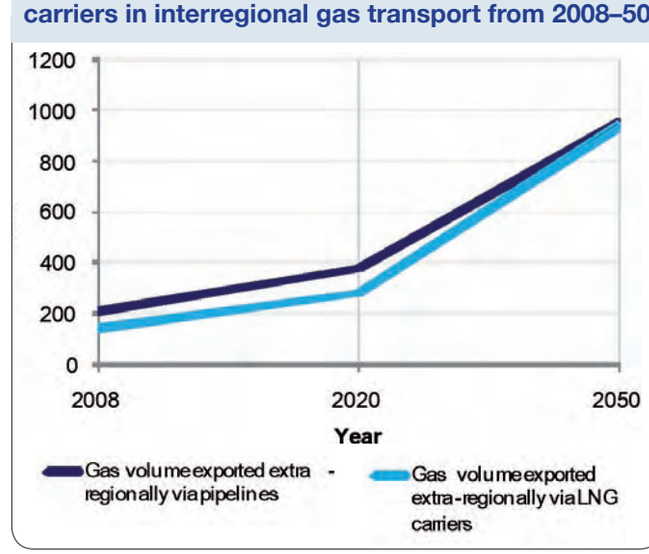
Some power grid interconnections can contribute to sustainable development, others can damage them. For electricity exporting countries, the construction and operation of power plants to feed an interconnection may have significant social impacts. Displacement or resettlement of population caused by new facilities (particularly hydropower) can lead to social impacts such as migration from rural areas to the already overcrowded cities, unemployment and other problems.

The many challenges posed by the necessary expansion of transmission infrastructure in different parts of the world are usually outweighed by the benefits that the interconnected systems bring to the consumers, both near and afar. ❑

More than US$900 billion in infrastructure investments needed

Over the next four decades logistics bottlenecks are expected to occur almost everywhere in the World, if policymakers, industry and society are not able to find solutions in dealing with the impediments to reaching a global supply-demand balance. In its *Logistics Bottlenecks* report WEC has identified three crucial bottlenecks: oil movement, natural gas and LNG movement, and electricity transmission. To manage these expected bottlenecks, significant infrastructure investments need to be made in the next few years. To develop the required oil pipeline and tanker networks, gas pipelines and LNG carriers systems, as well as smart grids boosting the efficiency of electricity distribution, more than US$200 billion will have to be spent in the next ten years and an additional 700 billion in the 2020–50 timeframe, signifying average annual outlays of US$21 billion. Policies and concrete actions that allow for timely investments in the respective infrastructures and build bridges between the private and public sectors in various regions have to be designed and implemented. This will help ensure that the money is spent effectively, generating desired results for both companies, governments, and society. ❑

Projected requirements for gas pipelines and LNG carriers in interregional gas transport from 2008–50



The outlook for carbon capture and storage

By Barbara McKee,
Chair, World Energy Council Cleaner Fossil Fuel Systems Committee

The World Energy Council (WEC) Committee on Cleaner Fossil Fuel Systems (CFFS) promotes knowledge worldwide on the research, development, demonstration and deployment of cleaner fossil fuels systems to meet global energy needs. Carbon Capture and Storage (CCS) is an innovative set of technologies currently under development to reduce emissions from large stationary sources of carbon dioxide (CO_2), notably fossil energy power plants and industrial facilities. Raising worldwide awareness of CCS is now a major focus of the CFFS Committee's activities.

CCS is projected to play a large, critical, unique role in reducing CO_2 emissions adequately to avoid significant implications of climate change. There is now a broad global consensus, reflected in decisions by the G8, to set a goal of making CCS widely commercial by 2020. The G8 agreed "to commit by 2010, to a diverse portfolio of at least 20 fully integrated industrial-scale demonstration projects (larger than 1Mt CO_2 per year) for the broad deployment of CCS by 2020."

Work to develop CCS technologies and practices has been ramping up considerably throughout the world over the last decade or so. In addition, global collaboration on CCS is increasing through such organisations as the Carbon Sequestration Leadership Forum and the WEC Committee on Cleaner Fossil Fuel Systems.

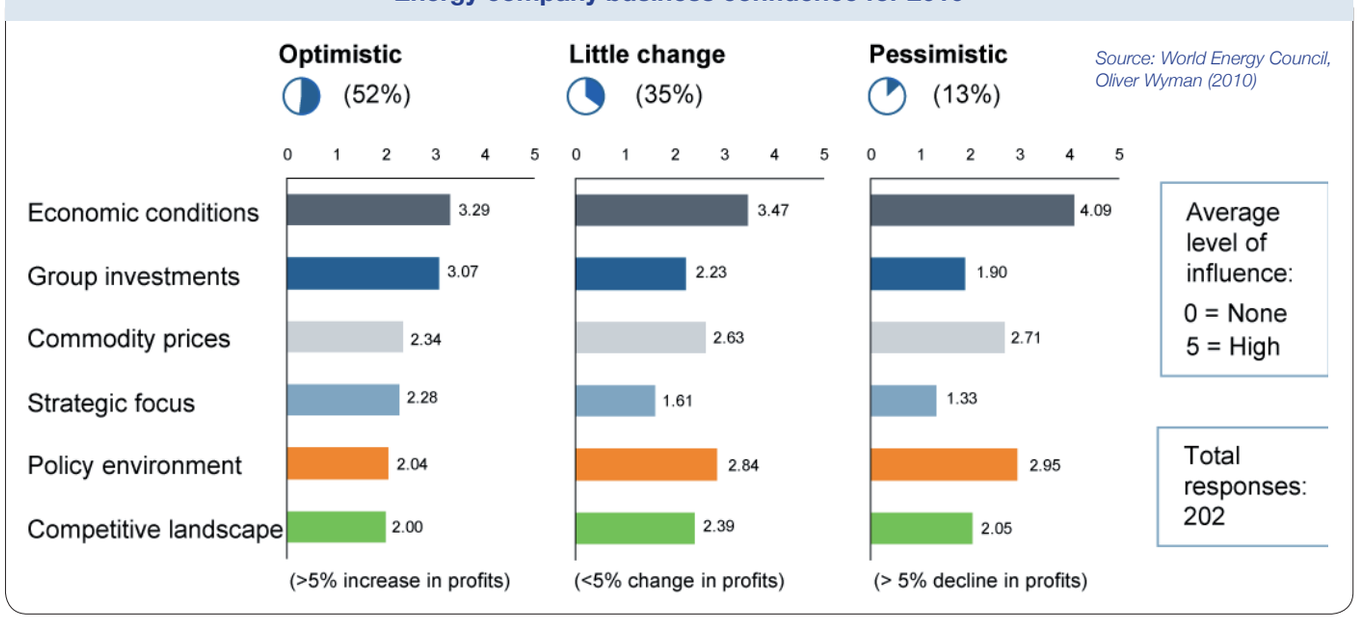
CCS involves the separation and compression of CO_2 from an exhaust stream, its transportation to a storage site and injection into a deep geologic storage formation. Several pilot-scale capture projects are currently in operation and numerous tests of geologic storage have been undertaken and are proving successful in demonstrating safe and secure long-term storage. CO_2 transportation by pipeline has been commercial for decades. The first commercial-scale demonstration projects for power generation that fully integrate capture, transport and storage are currently being developed and will be in operation in the early-to-mid 2010s. Legal and regulatory frameworks for CCS are being put in place in several countries.

While considerable progress has been made, a number of significant challenges have yet to be overcome. They are:

- Reducing the cost of capturing CO_2;
- Fully developing the legal and regulatory frameworks for CCS throughout the world;
- Creating mechanisms to finance CCS in both industrialised and developing countries; and
- Securing public understanding and support.

The WEC Committee on Cleaner Fossil Fuel Systems is continuing its mission to raise global awareness of CCS. ❑

Energy company business confidence for 2010



Scenario Planning – turning critical uncertainties into strategies for the future

By Karl Rose,
Senior Fellow, Scenarios, World Energy Council

The desire to know the future is as old as mankind itself, one only has to look at ancient Greece and the stories around the Oracle of Delphi to be reminded of this. Unfortunately, we are not able to predict the future… which does not necessarily mean that the future must always be unknown. Some important factors that influence future developments are well known, many others are just as important, but more uncertain. Hence we tend to make assumptions about the future when developing a strategic plan. Many of the tools that we use, like 'trend extrapolation', work under the assumption that we know the structure of the system we are studying, and can therefore reliably predict outcomes. The environment of today, however, is often too complicated to be captured in a framework of workable laws. We are therefore faced with a dilemma – how does one formulate strategy in the face of seemingly overwhelming uncertainty? Determining the future of energy pathways, and resolving the climate debate are good examples of such dilemmas. It is in situations like this, that the use of scenario planning can make a valuable contribution by challenging our assumptions and benchmarking our vision about the future.

In essence, scenarios are plausible, pertinent, alternative stories of the future, which portray a range of potential outcomes and help in understanding how different factors interact to shape the future. Forecasters extrapolate from the past, imposing patterns from past onto future. Scenarios attempt to look beyond our limited mind-sets, recognising that possibilities are influenced by a wide range of people and views different from our own. The general purpose of building scenarios is therefore to widen the perspective of decision-makers, and in doing so, to widen and clarify their options for action. What makes scenarios so powerful, if done correctly, is that they seek the critical "what if?" questions to explore a range of possible futures. By doing so, they can change the way people think about the future and the assumptions they hold about it. Scenarios, if they are insightful can have an impact, can change people's minds on how the world works, and even encourage them to rethink their own roles and contributions. Lawrence Wilkinson[1] states, "… the purpose of scenario planning is not to pinpoint future events but to highlight large-scale forces that push the future in different directions. It's about making these forces visible, so that if they do happen, the planner will at least recognise them. It's about helping make better decisions today."

People can make assumptions without ever imagining that their view may be inconsistent with the views of others, or for that matter, inconsistent with reality. One important element of scenario methodology is therefore to make assumptions explicit – to understand the current perspectives of relevant stake holders, most likely decision-makers. In particular, it is critical to understand what is considered to be important and beyond that, assumptions about what is likely to persist and what is likely to change.

Pierre Wack recommended separating the future into "predetermined and uncertain elements"[2]. Predetermined elements are those events which are "already in the pipeline" and can be expected to persist.

This first stage of scenario building is very intensive and requires careful studying to determine what is predetermined and what is uncertain. This helps in comprehending the driving forces of an environment's future which often fall under five categories – society, technology, economics, politics, and environment. After determining an environment's predetermined elements, the planner is faced with the challenge of identifying "critical uncertainties", the resolution of which results in the manifestation of different futures, namely scenarios. When we can distinguish between what might persist and what might change, we can use this to expand our understanding of how the world works. This is important for both activists and entrepreneurs, because, as Ged Davis, former head of scenario planning at Royal Dutch Shell once stated, "...a trend is a trend until it bends..." – and at the bends are risks and opportunities for change. Following the identification of predetermined trends and critical uncertainties it is important to make interactions explicit. It is here where often the greatest opportunity for learning lies. This facet of the scenario method requires strong analytical skills and a capacity to understand systems.

Once scenarios are built we face a communications challenge. How can the complexity of alternative futures be made transparent and insights conveyed? How can the breadth of alternative futures be captured whilst maintaining relevance to the practical questions at hand? How can stories be made challenging and compelling without loss of credibility? The answer usually lies in a combination of words, pictures and numbers, depending on the subject matter and the audience.

The last facet of scenario planning is the evaluation of implications, and the generation and testing of options. Scenarios are very useful in helping draw out discontinuities and insights, which can then be turned into new strategies.

Looking at implications is therefore part and parcel of any scenario process, but not part of scenario planning methodology itself. Scenarios are a tool for helping decision-makers plan for the future – or rather for different possible futures – in cases of great uncertainty where the outcomes are ambiguous.

The World Energy Council has decided to launch a new global energy scenario exercise, following the Congress in Montreal this September. The last WEC energy scenario publication, *Energy Policy Scenarios to 2050,* was published in 2007. WEC energy scenarios are flagship publications, outlining WEC's own vision of developments in global energy. They are meant to increase visibility for WEC and to allow the inclusion of new developments and insights into WEC thinking in a structured way. They are also a platform for engaging policy makers and energising WEC member committees in regular discussions on topics of special interest, for example mobility, impact of renewable energies, water-energy nexus.

Drawing on the wisdom and experience of its global membership to develop a small set of distinct but consistent scenarios – "plausible stories of pathways into the future" – the World Energy Council, in the interest of our sustainable energy future, wants to provide a tool for stake-holders to test the robustness of their own assumptions and to benchmark the potential outcome of policies and strategies. The scenario work will start post-Montreal and will stretch over the better part of two years.

The project core team will consist of two staff members in London, supplemented by 6-8 regional members. It is planned that in each region a scenario team is set up and that at least one member per region joins the project core team. WEC is also in discussion with some industrial partners and research institutions to obtain additional resources for the scenario exercise. Energy companies Saudi Aramco and Petrobras have already confirmed participation and will commit staff resources to the scenario effort.

It is planned to hold at least five scenario workshops and several meetings on topics of special interest and concern for WEC members, for example urbanisation and mobility, access to energy and water/energy linkage etc. The workshops and meetings will be evenly spread across the regions and special topics will be chosen, based on current significance for the region. This will allow the deepening of regional insights and options for action.

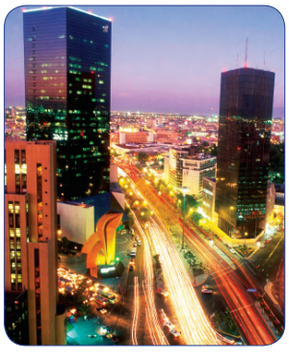
In order to provide quantification of the scenario stories, it is our intention to build a web-accessible open-source framework/global energy model, which can be used and expanded on by third parties like companies, governments, and experts. For this innovative approach to be possible, the framework has to be structured in a modular architecture so that third parties can develop and dock their own modules where they see fit. It is envisioned that an industrial partner with relevant experience in software development and providing web based solutions, takes a leading role during this phase of the project.

If you want to know more about this exciting new project, you can contact the Project Manager for Scenarios, Philip Thomas (thomas@worldenergy.org), or the Senior Fellow Scenarios, Karl Rose (rose@worldenergy.org). ❑

1 Wilkinson, L. 'How to Build Scenarios'. Wired Magazine

2 Wack, P. 'Scenarios: shooting the rapids', Harvard Business Review. November - December 1985

The desire to know the future is as old as mankind itself



Energy innovation and urban growth

By Robert Schock,
Director of Studies, World Energy Council

The expanding number of large cities face significant energy-related challenges, now and in the future. Technical and policy actions must be taken in order to meet these challenges. In this context, energy companies play a crucial role in the design and implementation of efficient solutions. The 2010 WEC report *Energy and Urban Innovation* examines business and policy actions that can be taken in order to meet these challenges. The report studies the growth, development, and energy-linked issues of large cities, and develops concepts for a secure and sustainable energy supply and distribution system, including transportation, and recommends norms and the necessary steps to ensure sustainability. Cities studied include Tokyo, Mexico City, Delhi, Cape Town, Toronto, Shanghai, the London – Ile de France area, and the San Francisco Bay Area.

Rapid urbanisation of the world population, already taking place, will be a widespread and strong trend during the coming decades. In the next 20 years, the equivalent of seven cities with ten million people will be added every year. People generally prefer to be in a city slum rather than in a remote rural area, as the city provides more economic opportunities and better health and education benefits. Cities thus concentrate a large part of a nation's population and contribute disproportionately to the national and world economy.

Even without anthropogenic climate change, the rapid urban growth in emerging and poor countries is a massive sustainability challenge and involves bringing urban services to all, as well as dealing with local pollution of air and water, and the production of solid waste. On the other hand, the mature and more slowly growing cities of the developed world need policies to retrofit existing buildings, reshape development to stop urban sprawl, and use a more systemic approach to energy networks. Cities, particularly coastal, do also have to anticipate their adaptation to the effects of climate change.

There are many technical solutions that are already mature and whose costs are known in different contexts. For example heat pumps, insulation, and high efficiency gas boilers can be used more effectively in buildings. Bus rapid transit (BRT), metro rail, tramways, and hybrid cars can move people and goods. Solar photovoltaics, energy from waste, and combined heat & power can be used to generate electricity. Yet costs and potentials vary widely and there are no 'best solutions' for all cities. In implementing technologies, consideration needs to be given to building stock, climate, urban shape, cultural behaviour, dynamic changes, and financing possibilities.

Technologies alone are not sufficient to improve all the dimensions of an energy system. Sustainability demands different aspects (social, economic, environmental) that often cannot be entirely fulfilled. Efficient urban planning is required as technologies are dependent on usage and behaviour. For example, hybrid cars with an occupancy rate of 1.3 (average for Paris) yield congestion and significant emissions. Efficiencies in buildings are deeply dependent on household behaviour, for example, the heating and cooling level. Also, difficulties often remain because of immature markets (workforce education, lack of healthy competition between firms), transaction costs, coordination problems, or lack of planning. Efforts to better support the implementation of existing technologies (coordination, education, market transformation, investment mechanisms, etc.) are as important as those for technical innovation.

The challenge is to shape the rapid growth of cities in emerging countries and to reshape existing 'rich' cities. In doing this, the strength of market forces on the land and building markets, as well as on the city's labour market, must not be underestimated. Planning at the appropriate stage is an absolute necessity! While there is no 'ideal' city form, density thresholds do exist. There are, for example, robust density thresholds (50-150 inhabitants/per hectare), below which mass transportation systems are simply not economically feasible. Market forces and urban planning must also go hand-in-hand.

At the city level, local authorities have options to reduce greenhouse gas (GHG) emissions. They can target the emissions over which they have direct control as an organisational entity (energy use in public buildings, public transport fleet, etc.). They can use their capacities and policy levers to reduce the GHG emissions stemming from those socio-economic activities over which they have administrative influence. Local authorities also have significant direct and indirect influence over policy areas such as land-use zoning, transportation, natural resources management, buildings, waste and water services.

Instruments available to local-level governments include direct policy actions, enabling different groups involved in the policy process, as well as providing the information necessary to foster behavioural change by consumers. Policies instituted should be packages of measures. It is not enough for technical solutions to be available if no one can afford them. Strong and early public intervention is required to meet the challenges of urban development. And objectives must be kept simple and stable.

The challenges can be met with a package of technical, institutional, policy and financial measures. Regulations must be combined with incentives, information and other actions, aimed at improving market efficiency. Policies dealing with funding and financing cannot be separate from policies for design and/or implementation. Governance and accountability with appropriate targets must go hand in hand. Sustainability policies must be part of a coherent policy framework. Finally, regulations must be based on long-term and stable objectives, not short-term ones. ❑

Water: a complex vulnerability of the energy system

Human civilisation has always rested on the utilisation of water, and, more specifically, on access to water. To contribute to a better understanding of the critical linkages between water and energy – and the impact on both of climate change, the World Energy Council has identified areas of opportunity in its *Water for Energy* report, where investment and probably new regulations are needed in order to foster faster and more equitable global development.

Water is used in energy production and supply, and, in turn, energy is used for pumping, moving and treating water. In recent decades, the combination of more users, with more uses of water has transformed the traditional water-energy 'ladder' that underpins all human, social and economic development into an 'escalator'. As a result, as the linkages between both energy and water systems have grown more complex and interdependent, water must be viewed as a complex vulnerability of the energy system – and vice versa.

In addition, human-induced climate change is increasingly understood to be a key driver for change in energy and water availability, allocation, production and consumption. This carries significant implications for managing water and energy security challenges. Climate change impacts will likely exacerbate water stress in many countries, cities and communities, creating the prospect of greater competition between different uses, as well as individual users of water.

With the threat of water scarcity and water stress, exacerbated by climate change, two challenges have developed: Water for Energy and Energy for Water.

A situational analysis of the current 'water for energy' contexts in a variety of countries/world regions sets out the water needs of Africa, Asia, Europe, Latin America and the Caribbean, and North America in the context of their energy production, water withdrawal, and population size. By examining the growth of global population, changes in final energy consumption and water requirements needed to produce and generate the necessary amounts of energy over the next decades, the report identifies: the future water needs related to energy production and conversion are not beyond the expected available supply; other uses, in particular agriculture, are stressing the supply of useable water for everything, including energy, now and this stress will increase in the future as increasing populations require more and more food. In setting policies to make water available for food, governments need to ensure that water is also available for energy production and conversion. And as energy resources are stretched, increasingly unconventional sources become attractive. Many of these (for example oil sands, oil shales, deep gas shales) require large amounts of water, further stressing current and projected systems. When setting policies for energy production, policymakers must consider what water supplies are available: they need to consider the needs of these technologies and their impact on other uses.

At the same time, the increasingly integrated world of shared resources and trade requires a new paradigm of operation interregional and international (co-)operation between governments (regional and national), between businesses, as well as between governments and businesses.

Many existing and new technologies show promise for making water more available and its use more efficient. However, in order to accelerate the entry of these technologies and their benefits, policymakers in business and governments as well as independent institutions must carefully examine policy measures and conditions which will achieve this, while at the same time engage on a close level to maximise the efforts and reduce redundancy in their RD&D (Research, Development and Demonstration) efforts. ❑

Including energy in the rules of trade and investment

By Robert Schock,
Director of Studies, World Energy Council

The World Energy Council has been actively involved with issues in trade of energy and energy services since before 2007, in concert with a number of international organisations.

Historically, neither the GATT (General Agreement on Tariffs and Trade) nor the WTO (World Trade Organisation) Agreement had a direct bearing on international energy trade. Trade in hydrocarbons, fissionable materials and cross-border transmission of electricity largely took place outside the multilateral trading system. The GATS (General Agreement on Trade in Services) covers only limited kinds of energy services involved in trans-border movement. While a few issues involving energy goods reached the GATT and WTO dispute settlement stage (for example reformulated gasoline), these were relatively rare.

There are however, important developments that show a convergence between the international energy business and the rules embodied in the WTO regime. First is the accession of some and impending accession of other major oil-producing states to the WTO. The second is climate change and the recognition that progress in reducing greenhouse gases through the UNFCCC and various national measures directly engages the application of WTO rules. This was an important issue at the COP meeting in Copenhagen in December 2009 and will likely be on the agenda for COP-16 in Mexico this year.

The WEC 2009 Task Force report on Trade and Investment Rules for Energy (www.worldenergy.org/publications) stresses the importance of WTO rules for maintaining open energy markets, more crucial than ever in the context of the financial crisis and efforts aimed at stimulating economic recovery. The report emphasises the benefits of completing the Doha Round, particularly as a means of promoting trade in energy-related goods and services in general and in climate-friendly goods and services in particular, both of which can assist in the economic recovery and in GHG reduction through stimulating exchanges in "green" technologies.

There are three guiding principals to more efficient management of energy resources. The first is that open trade in energy goods and services is indispensable for economic progress generally and for meeting the needs of developing countries in particular. There is thus an intertwining of trade in energy and issues of economic development as parts of a whole. The second is that to meet economic development objectives, energy markets must be allowed to operate as efficiently as possible. This requires a rules-based system that guarantees the operations of market mechanisms through non-discrimination (meaning national and most-favoured-nation treatment), regulatory transparency and access to fair, open and impartial adjudicative processes. These rights and obligations are embedded in the WTO system and, because of that, the WTO and the interests of the energy sector converge.

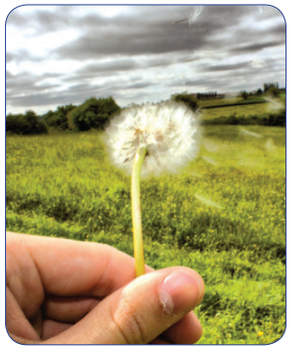
The third principle is that structural factors unique to the energy sector constrain or at least qualify the full application of WTO rules, the most important being that energy resources typically belong to the state and that many countries have structured their petroleum and electricity sectors around state-owned enterprises. State ownership and sovereignty interests differentiate energy goods from typical goods and services in international trade.

Open trade in energy goods and services is indispensable for economic progress generally and for meeting the needs of developing countries in particular

Two specific actions can be negotiated immediately: First, as the global community looks for solutions to the challenge of climate change, agreement to reduce trade barriers and open markets in energy services, including environmentally-friendly goods and services, should be pursued as a priority. Such action should be within the WTO and be as broadly-based and cover as many like-minded countries as possible.

Second, in ongoing consideration under the UNFCCC and elsewhere, it will be important to ensure the integrity of the rule of law under the WTO Agreement, both to ensure stability of international energy markets and to promote the realisation of global development priorities under the principles referred to above. The WTO should bring its unique expertise to bear on the question of what, if any, forms of border measures could legitimately be applied by countries that adopt domestic greenhouse gas reduction measures.

With rapid changes in the energy sector, combined with challenges of climate change, a more comprehensive discussion by the international community of this and other areas of potential WTO 'governance' relevant to energy markets is crucial. ❑



Pursuing sustainability: 2010 assessment of country energy and climate policies

By Robert Schock,
Director of Studies, World Energy Council

Global population growth and the importance of limiting global warming mean energy policymaking has to accommodate multiple agendas: economic development, national security, social welfare and environmental protection. As a result, policy approaches to the national primary energy mix, infrastructure development, market operation and demand management need to be governed by principles relating to long-term energy sustainability.

Many countries are pursuing energy sustainability through ambitious and versatile programmes

The review of country policy frameworks and their implementation has revealed a wide range of successful approaches. In terms of fossil fuel-based energy security policies, China, Japan, and Russia have effective, yet different, approaches to developing resource-oriented partnerships with other countries, based on strategic alliances, technological expertise, and financial strength. US technology investments have resulted in rapid advances in opening up new domestic natural gas resources through the hydraulic fracturing of deep shale, and the ability to take advantage of that expertise overseas. The Republic of Korea and Germany have mitigated security of supply risks by increasing levels of import diversity and storage capacity, respectively.

In terms of alternative energy supply, several regimes stand out. Using different policy approaches, Germany and Texas (US) have made strong progress in the deployment of renewable energy within their transmission infrastructure. Brazil and Ghana have been particularly successful in using off-grid renewable energy to increase access to electricity for rural populations. France's carefully planned approach to renewing and enhancing its nuclear capacity is a model for an established nuclear nation, whereas the UAE has demonstrated a clear-sighted approach to building new capacity and taking advantage of external expertise.

In terms of energy efficiency and demand-side management, Japan's programmes, directed largely at industry, have achieved significant reductions in consumption, while innovative schemes in Brazil have encouraged domestic manufacturers to develop low-energy consumption appliances. Denmark provides a benchmark for building design standards and France has put considerable effort into reducing energy consumption in its building stock. California (US) and Ontario (Canada) are front-runners in the development of smart grids; the Republic of Korea aims to catch up through high levels of R&D investment.

The scale and complexity of the energy sustainability challenge is increasing

Developments in four interrelated areas mean the world has reached a critical juncture for energy policymaking. Energy demand is rising from non-OECD countries that are undergoing both rapid population growth and economic development. Domestic fossil fuel reserves are declining in many countries, and the remaining large-scale oil reserves are difficult to access. Strong measures are needed to mitigate the impacts of climate change. Much energy infrastructure in OECD countries needs to be renewed, while many non-OECD countries are still seeking to extend access to energy across their populations.

Both the recent economic downturn and the failure to reach a binding international consensus on reducing greenhouse gas emissions have impeded policy solutions to these issues. Although the global financial crisis caused a dip in global energy consumption and a temporary stabilisation of emissions, it also reduced the availability of investment capital and increased uncertainty about infrastructure project economics. The impasse at Copenhagen has also checked some of the momentum in the efforts to decarbonise economies.

This has placed considerable strain on the pursuit of energy sustainability

- The issue of energy-supply security has become more of a priority in net importing countries.
- Across OECD countries the wholesale adoption of the environmental agenda is only patchy; beyond this group programmes in many countries remain at an early stage.
- Investment is returning to many parts of the energy sector, despite nervousness about the fragility of the global economic recovery.
- Changing market circumstances and country priorities have contributed to significant levels of volatility in policymaking and affected the quality of policy implementation. The energy sector should undertake a number of measures to address these issues.

At this critical juncture in global policymaking, when hard choices have to be made and multiple benefits secured, there is great value in international dialogue around the pursuit of sustainable energy solutions. As its policy assessment work continues, WEC will look to facilitate such interactions among policymakers and the energy industry, hoping to deepen the current extensive exchange of ideas.

Key Implications for Policymakers

▶ *Rebalance strategic ambitions in light of energy sustainability goals, through a transparent consideration of policy trade-offs (for example, consumer affordability versus emissions reduction, incentives for policy preferences versus economic distortions).*

▶ *Develop policy frameworks that are sufficiently flexible to respond both to strategic market disruptions (e.g., emerging gas supply opportunities) and tactical developments in fast-moving areas (e.g., renewable energy installation).*

▶ *Encourage technology transfer and partnership arrangements by leveraging foreign expertise and financing to support the long-term success of domestic energy industries.*

▶ *Strengthen regulatory frameworks that support the development of new infrastructure to reduce construction lead times and ensure the reliable connection of new generation assets to transmission grids.*

▶ *Plan for the completion of economic-crisis stimulus funding and the gradual removal of subsidies for thermal generation, and, in due course, maturing sources of renewable energy. This will encourage ongoing investment.*

▶ *Draw lessons from the growing body of experience around the deployment of renewable energy and energy efficiency to pre-empt potential issues in the implementation of policies and to reduce the likelihood of hesitancy about, or changes in, policy.*

▶ *Review governance structures and decision-making processes with a view to enhancing stakeholder engagement and securing greater acceptance for critical energy sector transformations.*

Key implications for the Energy Industry

▶ *Maintain or pursue diversity in the generation mix to cope with long-term disruptive changes in resource availability, the likelihood of significant regulatory impacts, changing policy priorities, and more volatile commodity markets.*

▶ *Leverage competitive technologies and strong balance sheets both to respond to the ongoing opening of energy markets across the globe, and to support the growth ambitions of non-OECD countries.*

▶ *Increase energy-efficiency efforts and identify areas of potential leadership (including through participation in cross-industry alliances) to hedge against regulatory scenarios, secure cost savings and generate revenues through ancillary businesses.*

▶ *Explore with governments how the risks of major investments can be reduced, resulting in lower costs for consumers.* ❑

Photo: Hydro Québec

22nd WEC Survey of Energy Resources

By Elena Nekhaev,
Director of Programmes, World Energy Council

The 22nd edition of the *World Energy Council's Survey of Energy Resources* (SER), is the latest in the series of reports on the status of the world's energy resources. It covers 15 sources of energy, and provides the most comprehensive resource and reserves assessments and other relevant information for each of them. WEC published the first *Statistical Year Book* in 1933 which already then included information from more than 50 countries. Nearly 80 years later, the Survey remains a unique global document and a flagship publication of the World Energy Council which also is an essential tool for governments, industry, investors, academia and NGOs.

The 22nd WEC *Survey of Energy Resources* contains a chapter for each energy resource, ranging from the conventional fossil

The water-energy nexus: a hot topic for the Middle East

By Dr Hisham Khatib, Honorary Vice Chairman, World Energy Council and Former Energy, Water and Planning Minister, Jordan

The Middle East, mostly the Arab region, consisting of countries in the eastern Mediterranean and North Africa (MENA), including the Gulf countries and Iraq, is the world's driest region. Renewable water resources are estimated at around 335 km^3 per year for population approaching 400 million people; more than half of this originates outside the region and is conveyed through shared rivers. The same applies to cross-boundary water basins which are also shared among neighbouring countries. Correspondingly MENA is designated a 'super-arid region'. All this calls for water cooperation among the region's countries and their neighbours, as well as calling on energy and technology to improve future water availability prospects, mainly through developing non-conventional water resources.

Simultaneously the MENA region has one of the world's highest birth rates, approximately 2 per cent annually; it is the world's centre for producing oil and other petroleum products and is rapidly developing and improving its economic prospects.

Correspondingly, the energy-water nexus is very strong and growing. Energy utilisation in the water use cycle involves extracting and conveying water, treating and distributing it, using water in irrigation systems as well as dealing with waste water. Most important in the region is water use in the energy cycle: exploration and production of oil, electricity generation and desalination.

Electricity generation in the region, which is presently half that of world average per capita, greatly varies from one country to another. However all over the region it is growing at a rate of 6-8 per cent annually, this is three times that of world average, mainly due to subsidised electricity rates but also the harsh summer weather and growing urbanisation and population. Thermoelectric generation utilising fossil fuels is water-intensive mainly for cooling purposes. Water consumption can be halved by using wet cooling towers rather than once-through cooling but at half a cubic metre per MWh this is still high. Some new facilities are utilising air cooling which is both expensive and less efficient in energy use.

Water is intensively used in petroleum production and refining. It varies by process, geology and technology. It is mainly consumed for oil recovery. Most of the region's oil production is on-shore, necessitating utilisation of fresh water. In the region, water consumption is around half a cubic metre per barrel for production and refining. This adds to ten million cubic metres of water consumed per day, which is quite challenging in an arid region.

Because of scarcity, water has to be withdrawn from deep wells or remote aquifers and other sources, conveyed over long distances, purified and pumped to high places. In some countries like Jordan almost one fifth of electricity is consumed by water cycle use, mainly pumping.

The scarcity of fresh water promoted and intensified the technology of desalination and combined co-production of electricity and water. The Gulf region has become the world's centre for desalination. The region now produces almost 4,000 million cubic metres of fresh water by desalination, mainly utilising the multi-stage, flash evaporation process (MSF), which is most suitable for bulk production of large quantities of desalinated sea water. However, for brackish water, the economical but more cumbersome reverse osmosis (RO) process is utilised. Both methods are energy-intensive and very costly. The MSF (with commercial energy prices) costs one dollar per cubic metre of desalinated sea water, plus another third dollar for delivery. The RO costs can be as low as US$0.60 per cubic metre, and its prospects are increasingly improving. The dilemma is that most consumers pay only 4 cents per cubic metre.

Now, mega-projects of combined water and electricity production are being planned and executed in the region. These account for tens of billions of dollars worth of investments in energy and water infrastructure, which are straining government financial resources. Increasingly private investors are invited to invest in what is termed as independent water and power projects (IWPPs). A typical mega-project is that of Saudi Arabia's Ras Al-Zour water and power project, expected when finished at the end of 2013 to produce 2,400 MW of electricity and over one thousand million cubic metres of water per annum, at a total cost of six billion dollars.

The MENA region experience in dealing with scarce resources of water in an arid region and relying on the extensive use of energy in the water cycle is a learning example to other regions of the world. Globally, fresh water is becoming scarcer and demands are growing with increasing calls on energy consumption in all aspects of the water use cycle. Simultaneously, energy production, particularly the use of fossil fuels such as coal, oil and gas for electricity demand a lot of water consumption. With the increasing future demand for non-conventional sources (including biofuels), demand for water in the global energy business is growing and the water-energy nexus is tightening. ❑

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August 2010

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United Arab Emirates
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Uruguay

R&D and innovation in South Africa to meet energy challenges

By Mpho Makwana,
Chairman, Eskom Holdings

The energy challenges facing South Africa are diverse and range from achieving universal access to a high carbon intensity of the energy mix. The regional resources for the generation and operation of energy facilities are abundant but there are constraints on a geographical basis, for example variations in the availabilities of water and coal resources.

In general, technologies which are developed elsewhere are adopted in South Africa, but given the scale of the challenge and the particular set of energy resources in the region, there is a need for local technology development or adapting existing technologies for the region's specific needs and circumstances. There are also significant opportunities in the region to grow the energy access and availability in a cleaner and lower-carbon way and develop regional markets and local content supply chains for clean technologies. Eskom has a long and proud history of innovation. For example, dry cooling for power stations was pioneered and developed in South Africa, as was the use of high altitude, high voltage transmission line infrastructure. At one stage its electrification programme was the biggest and most effective in the world and Eskom's ability to burn low-energy coal is still leading edge.

Eskom still has an active programme of technological innovation which assists in making the decisions so vital to the future. In this regard Eskom is developing a number of innovative technologies that will improve the effectiveness of current operations, and provide the business with new, more attractive options for the future. Firstly, Eskom is considering at how to improve the way coal is used in power stations. This includes technologies which reduce erosion in boilers, welding technologies to reduce outage times for repairs and live line maintenance techniques which enable the maintenance and repair of power lines without interrupting supply to customers.

However one of the biggest challenges facing South Africa is the large-scale technologies to use in the future. No longer can businesses base technology choices on simple operational or cost drivers. Investments need to be made in technologies which will maximise the social, economic and environmental returns for the business and society as a whole. This means ensuring that the technologies which will maximise these returns are mature and familiar when required. In this regard Eskom is undertaking a suite of exciting technology demonstration projects aimed at defining a different future for our business, society and environment. Some of these are described below.

Underground coal gasification

Southern Africa has extensive coal reserves. Underground Coal Gasification (UCG) is one of several advanced clean coal technologies being investigated by Eskom. UCG is a process where coal is gasified in situ. A matrix of boreholes is drilled into the coal seam, sealed wells are created, the coal is ignited and air is pumped into the injection wells. Fire is essentially used to "mine" the coal, and produce a gas which can be used directly as a fuel for power generation.

The UCG process avoids the need for coal mining, transportation, preparation, the gasifier equipment, and the transportation and disposal of ash. This optimisation has cost, labour and environmental benefits. UCG is also able to utilise the enormous local resources of coal that are regarded as 'unminable' by conventional miners. The use of UCG gas as a fuel for advanced clean coal technology power generation enables several key strategic drivers.

The Eskom pilot plant was commissioned in January 2007, and continues running successfully until present, delivering 15,000 Normal Cubic Metres per hour (Nm^3/hr) of gas, proving the technology and verifying performance for the phases to follow. The next phase of the demonstration is a 100-140MW open-cycle gas turbine. Stakeholder engagement and a full environmental impact assessment (EIA) are already underway. The plant will be able to prove and quantify the technical, environmental and commercial performance of the technology, and will be able to predict design and performance of a full-scale, commercial UCG plant. In parallel to the demonstration plant design, the pilot plant is presently ramping up gas production, in order to prove the concept of co-firing the UCG gas with coal in Majuba power station's unit 4 – a 600MW unit in a 3,600MW power station. The interconnecting pipe work between the power station and the UCG gas field has been installed, and will be commissioned as soon as unit 4 is scheduled for an outage. The pilot plant is gaining incredible interest locally and globally given the technology's potential for clean and lower cost electricity production.

Utility Load Manager

In South Africa, the reserve margin will be low over the next few years and will only improve after new baseload coal plants come on line. The country therefore needs to put in place measures to decrease the demand by effective demand management measures. The Utility Load Manager (ULM) is an innovative device that has been developed entirely in South

Africa jointly by Eskom and EON Consulting. The ULM was principally developed as a total solution to assist in alleviating generation capacity, network and system constraints by limiting the residential sectors load and averting any future load shed conditions. The systems control methodology is patented locally and is regarded as a world first. A global patent application has also been awarded.

The ULM system is designed to operate as a Virtual Power Station (a stand-alone fully integrated system) and is a real time, residential load management system that allows the utility to limit residential loads as opposed to block load shedding. The residential sector represents 17-20 per cent of the total system load and is a significant contributor to both the morning and evening peaks resulting in an overall national load factor of 72 per cent. The ULM targets the residential sector by actively engaging the customer and installing a system of hardware devices in the LV network. When the power utility has a supply or network constraint, a message can be sent to the display unit, instructing the household user to limit their power usage. If the household conforms to this limit, by switching off appliances and conforming to the required power limit imposed, the household will continue to get this limited power for the period/duration of the load limit period (the period whereby the supply/network constraint is experienced). However, if the household does not conform to this imposed load limit, and continues to exceed the limit in terms of power usage, that household will be automatically disconnected from the electrical network.

The ULM will be used as a tool to avert load shedding as mentioned above and once there is sufficient generating capacity to assist in managing revenue and energy streams with real time reconciliation of all parameters

Concentrated Solar Thermal (CSP)

CSP comprises a family of technologies that concentrate the sun's energy through large mirrors and utilises the concentrated thermal energy to produce steam to drive a conventional steam turbine for electricity generation. Eskom has focused on the "Central Receiver" or "Power Tower" type technology.

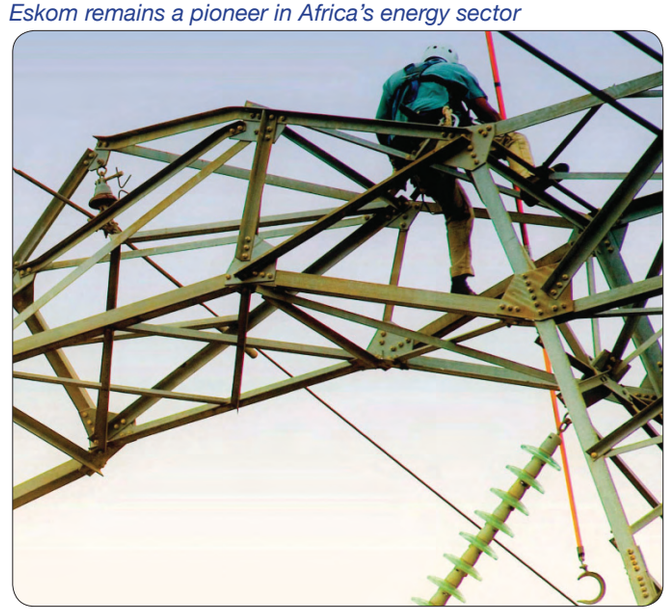
Eskom has actively participated on the international CSP stage since 1999, when it joined the International Energy Agency's programme on solar power. Initial efforts were directed at assessing the various CSP technologies and at identifying the option most promising for application. The World Bank's approval in April 2010 for a US$3,75 billion loan to help South Africa achieve a reliable electricity supply includes financing for a CSP pilot plant and the planned wind power plant along the west coast of South Africa.

Conclusion

Africa is populated by over 700 million people who constitute approximately 12 per cent of the global population, but consumes only 2 per cent of all electricity produced globally. Almost all of Africa's diverse and abundant fossil and renewable energy resources are under-utilised due to economic, technical and environmental constraints. The opportunity exists for innovative technologies to be explored, to ensure sustainable development and growth for the continent.

Eskom's innovation and demonstration programme supports the infrastructure expansion programme through research that improves quality, reduces cost and reduces the time taken from conception to commission. It also drives and challenges our capital expansion technology – choices based on the knowledge gained through demonstration – by ensuring that key technologies that can fundamentally change Eskom's current technology path and improve performance are well understood and part of our technology plan. The programme has also been focused on technologies that optimise the use of our natural resources and reduces our carbon footprint. ❑

Eskom remains a pioneer in Africa's energy sector



How South Korea is positioning itself for the Nuclear Renaissance

By Ssang-su Kim,
President & CEO, Korea Electric Power Corporation (KEPCO)

At present, many countries are participating in the international cooperation to cope with climate change, which is caused by CO_2 emissions from fossil fuels. From the view point of CO_2 reduction, nuclear power is in the limelight again because it can generate electricity with little or no CO_2 emissions. Nowadays, environmentalists suggest nuclear power as a viable option for environmentally-friendly energy to solve the global warming issue.

In Korea, since the first nuclear power plant began operation in 1978, nuclear power has been an essential solution to the issue of national energy security, as well as an environmentally-friendly source of energy. In the same way, many countries are now realising that nuclear power is essential to achieve energy security, to solve global warming, to replace old power plants and to respond to the increasing demand for energy. In this regard, developed countries have promoted the life extension of existing nuclear plants, as well as the construction of new nuclear stations and many developing countries are now also considering the introduction of nuclear generating facilities. According to the IAEA's forecast, some 300 nuclear power plants will be constructed by 2030, and OECD/NEA also forecasts that the total capacity of nuclear power plants will increase 3.8 times by 2050, from 372 GW to 1,400 GW. Nuclear power, which is now recognised as an environmentally-friendly, economical and stable source of energy, will enjoy a renaissance for the next few decades until renewable energy is fully developed enough to replace fossil fuels.

The Korean nuclear industry

Since the commercial operation of Kori 1, Korea's first nuclear power plant began in 1978, the number of nuclear power plants has increased substantially. Currently, 20 nuclear power plants with a total capacity of 17,716 MW are in operation at four sites in Korea. A further eight nuclear power plants are also under construction at three sites, with a capacity of 9,600 MW in total. Also, a further 10 nuclear power plants are planned by 2030, with a total capacity of 15,000 MW. These efforts will increase the share of nuclear power generation from 34 per cent (2009) to 59 per cent (2030) in Korea. In terms of installed capacity, Korea ranks 5th with 17,716 MW as of now, while its capacity factor ranks 1st place with 91.7 per cent, compared to a world average of 79.4 per cent. In addition, its unplanned shutdown rate is 0.3 times per year, easily surpassing the world average of 5.3 times per year.

Korea has continuously accumulated experience in construction and operation since its first adoption of nuclear power. In addition, many skilled engineers have been trained for decades owing to the continuous construction of nuclear power plant, almost one unit per year on average, while the US and EU have suspended construction of new nuclear power plants since the Three Mile Island and Chernobyl accidents. As a result, Korea has achieved stable project management skills, design standardisation, relatively short construction periods and cost reduction, leading its nuclear power plant to strong economic competitiveness and a high performance operating record. Based on these achievements, Korea has entered into the contract to build four 1,400 MW units for nuclear power plants in the United Arab Emirates, thereby capturing the attention of the world nuclear industry.

Challenges for the global nuclear renaissance

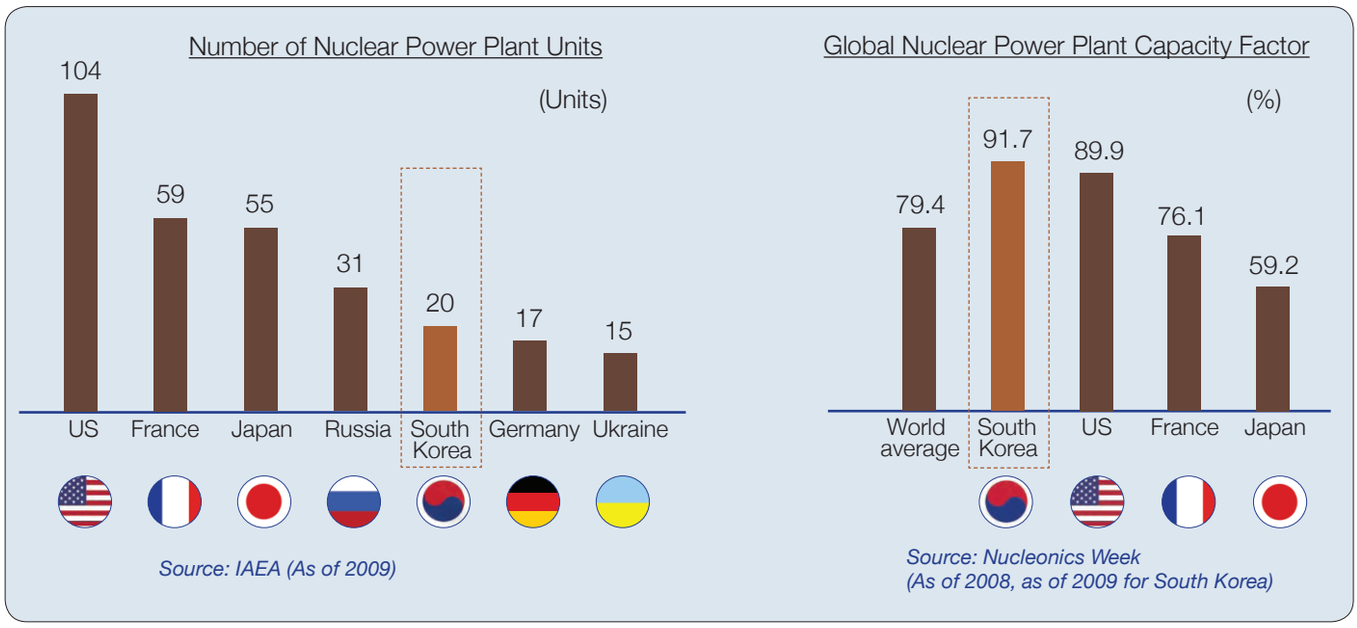
As nuclear power has been proposed as a solution to both global climate change and energy security, the following should be considered for nuclear power to play a substantial role in the world energy environment.

International design standardisation and safety

International design standardisation and certification is a way to secure the safety of a nuclear power plant. By standardising international design and certification for safety-related components, equipment and parts upon designing a new nuclear power plant, it is possible to secure a safe operation, simplify the official construction and operation process, and save time. Although there is a variety of laws and regulations on nuclear power plant construction and operation in the world, economic construction and safe operation of nuclear power plants should be a common goal. Therefore, both economic feasibility and safety have to be achieved by close cooperation among the exporting and importing countries, such as standardising nuclear design through international cooperation.

Training nuclear experts

For the safe operation of nuclear power plants, it is crucial to secure trained technical manpower. However, it takes a long time to train the relevant personnel because nuclear professionals have to be developed through years of training and experience in each field. With the demand for nuclear power growing rapidly all over the world, there is likely to be a shortage of manpower in the area of nuclear power plant design, construction, and operation. In particular, the imbalance between supply and demand of manpower in nuclear operation may act as a critical variable in guaranteeing



the safe and stable operation of nuclear facilities.

To respond to the growing demand for nuclear experts, KEPCO has planned to establish the KEPCO International Nuclear Graduate School (KEPCO-INGS) since 2008. The goal of the KEPCO-INGS is to train leading nuclear professionals in each field of the nuclear industry in order to meet the needs of professional manpower, especially in the age of 'Nuclear Renaissance'. The KEPCO-INGS will operate Masters and Doctoral courses and teach expert knowledge as well as on-site practice-based skills. During the course, full-time professors, technical professors and students will perform the assigned projects, which would be hands-on and very practical. For the application, a bachelor of engineering degree and five years' working experience are required. The class size will be 100 students each year, including 50 per cent students from abroad. All the qualified students will live in a dormitory for focused training.

The roles of these professionals are to be the backbone of global nuclear technology and to build an international human network as working-level nuclear professionals as well. In addition, they will be the driving force for the new era of low carbon and 'green growth' future.

Nuclear industry and financing

As huge funds with a long project period are required to construct a nuclear power plant, it is usually too much for a utility company to take on such investment risk. In this regard, to boost the nuclear power industry in the countries constructing or planning to construct new nuclear power plants, the financing issue should be discussed first. A way to solve this is that the government guarantees profits to the utility companies from nuclear power plant construction and operation. In addition, the reduction of construction cost and a shortening of the construction period should be pursued at the same time, to ease the financial burden.

Conclusion

After a long-time standstill, nuclear power is now recognised as one of the solutions to climate change in respect of global warming. In contrast to the global nuclear trend, Korea has continued to promote its nuclear power industry through the construction and safe operation of domestic nuclear power plants since it first introduced nuclear power plant in 1978. For the sustainability of nuclear power, which is now proven to be an environmentally-friendly, economically feasible, and stable energy source, such efforts as international design standardisation and certification, nuclear power experts training, and the financing issue should be managed at the same time. The harmonious efforts made through international cooperation will enable nuclear power to enjoy a true Rennaissance in the coming years. ❑

Nuclear power: the Japanese experience

By Sakae Muto, Chief Nuclear Officer and Executive Vice President, Tokyo Electric Power Company (TEPCO)

Tokyo Electric Power Company (TEPCO) has more than 28 million customers and the company's aggregate sales total roughly 300 terawatt hours (TWh). Currently, our 17 nuclear units comprise nearly 30 per cent of our total generation. We plan to build three more nuclear power plants by 2017 and another one around 2020 as we focus on creating a low-carbon energy mix. Japanese Power Utilities plan to derive 50 per cent of our energy from non-fossil sources and to reduce CO_2 emissions per kWh to 0.33kg by 2020. In September 2006, we applied for a reactor installation permit for the Higashidori 1 plant and have since been implementing on-land preparation work and port work. TEPCO together with the Japan Atomic Power Company (JAPC) established the Recyclable-Fuel Storage Company in November 2005. An interim storage facility for spent fuel is planned to begin operations in 2012. In Japan, spent fuel that exceeds the annual reprocessing capacity of Rokkasho Reprocessing Plant is stored for future reprocessing. In FY2009, the two nuclear power stations in Fukushima Prefecture achieved a capacity factor of 82.5 per cent. Recently, regulations were revised so that the operating period, which was previously set at 13 months for all plants, was extended to a maximum of 24 months. We can therefore anticipate the capacity factor to improve even further. In August 2010, Fukushima Daiichi 3 loaded mixed oxide (MOX) fuel, which proves that we are making steady efforts towards the establishment of the nuclear fuel cycle.

Nuclear power generation and low-carbon policy

Nuclear energy, with its superior characteristics in terms of energy security, environmental protection, and economic competitiveness, holds the key to promoting and sustaining a low-carbon society due to the following:

1) Supply stability

Japan's energy self-sufficiency rate is only 4 per cent. Nuclear power plants can generate a large amount of energy from a small amount of fuel. Operations alone can be maintained for 2.5 years using our domestic storage. Nuclear fuel is also recyclable. We can increase our energy self-sufficiency ratio by using spent fuel as a resource. Of the total content of spent fuel, 95 per cent is reusable materials and the remaining 5 per cent is 'real' waste. Reprocessing spent fuel will reduce the volume of high-level waste and produce domestic energy resources. MOX fuel use will save 20-30 per cent of total uranium resources. There will effectively be no resource limitations with the full-scale use of a fast breeder reactor.

2) CO_2 reduction abatement cost

Nuclear power does not release CO_2 through electricity generation. Even if fuel mining and plant construction are taken into account, CO_2 emissions are still extremely low. The annual CO_2 reduction of one 1,000MW nuclear power plant is estimated to be approximately 5 million tonnes of CO_2 compared with oil-fired power plants. Improving Japan's nuclear capacity factor by merely 1 per cent reduces emissions by approximately 3 million tonnes. The CO_2 reduction benefits of nuclear power account for about 171 million tonnes per year (Japan's total emissions account for 1,214 million tonnes of CO_2).

3) Economic performance

Nuclear generation cost was at par with any fossil-fuel-fired power source when the oil price was US$27. With the rise of fossil fuel prices, the cost advantage is stronger. Nuclear power also has positive impact on GDP. When 10 NPP units are constructed, it has been estimated that this would generate a ¥38 trillion increase in income due to an increase in capital expenditure, reduction in fuel imports such as oil, income effect of lowered rate, and spillover effects.

Current status of nuclear power plants and fuel cycle in Japan

In Japan, 54 reactors are currently in operation, with a total capacity of 49GW. This gives Japan the world's third largest nuclear power capacity, after the US and France. An additional 14 reactors will soon be in operation.

The Japanese government has chosen a closed fuel cycle as the national policy. Japan Nuclear Fuel Limited (JNFL) is operating a nuclear fuel cycle facility in Rokkasho village of Aomori Prefecture, where a Uranium Enrichment Plant, Low Level Radioactivity Waste Disposal, and a Vitrified Waste Storage Centre have begun operations. A Reprocessing Plant is now undergoing a final commissioning test.

Status of Kashiwazaki-Kariwa NPS after earthquake

On 16th July 2007, an earthquake with a magnitude of 6.8 struck the Niigata Chuetsu-oki area. TEPCO has been conducting an inspection and evaluation of all facilities and implementing the necessary restoration work for upgrading

seismic safety. The analysis and tests reveal that the reactors and other core safety items have the durability to resist an acceleration rate exceeding 1,000 galileo units (gal). However, the pipings require approximately 3,000 individual reinforcements attached to each reactor in order to be able to withstand a seismic acceleration of 1,000 gal. Unit 7 resumed commercial operation in December 2009, followed by Unit 6 in January 2010 with the approval of the government's safety authorities and consent from local governments. In addition, Unit 1 resumed commercial operation in August 2010. Unit 5 is ready to commence start-up tests. The seismic upgrading work for the remaining three reactors is also making steady progress. We are applying the same initiatives to the other nuclear power stations.

TEPCO is also sharing the knowledge and data they have acquired in dealing with this earthquake with specialists around the world. Seismic Safety Workshops organizsed by the International Atomic Energy Agency (IAEA) took place in Kashiwazaki City, where global experts gathered to reassess international seismic safety standards such as Guidelines for Seismic Safety Assessment for Existing Plants and Guidelines for Plant Restart after Earthquake. TEPCO's earthquake-related expertise is highly valued.

ABWRs and next-generation reactors

Units 6 and 7 at the Kashiwazaki-Kariwa Nuclear Power Station were the first Advanced Boiling Water Reactors (ABWRs) built in Japan with home-grown technology. ABWR technology was developed, with the support of the Japanese government, by the manufacturers and power companies that have had experience in building and operating Boiling Water Reactors. The development objectives were: enhancing safety and reliability; reducing occupational radiation exposure and radioactive waste; enhancing operability and manoeuverability; and improving the economy. Over a decade ago, in 1995/96, we already achieved a work schedule of 40 months from bedrock inspections to fuel loading, which is a substantial shortening of the normal work schedule. As of August 2010, four units are in operation, another four units under construction, and ten units in the planning phase.

Furthermore, towards the commencement of commercial operation in 2030, next-generation reactors are being jointly developed under public-private partnership. We have set development goals such as the unit construction cost of approximately 130,000 yen/kW, plant life of 80 years, and availability factor of 97 per cent. Given the achievements we have made so far, these goals are likely to be accomplished.

Overseas business opportunities

In July 2010, TEPCO established the International Nuclear Project Group in the company's Nuclear Department. It will provide advice to other countries interested in ABWRs and seek new business opportunities. On the premise of obtaining a conditional guarantee of liabilities from the US Department of Energy (DOE), in May 2010, TEPCO decided to make investments in the South Texas Project (STP) Units 3 and 4 construction project. Taking into consideration the long-term benefits such as CO_2 reduction, stable energy supply, and economic efficiency, we believe that investments in nuclear power will pay off in the long run. We are committed to sharing our 40 years of experience in safe and stable nuclear power plant operation with operators all over the world. As active participants in the Nuclear Renaissance, we continue to be involved in overseas development projects as well. TEPCO remains continually committed to advance the safe operation of nuclear power in order to secure the stable supply of energy, both at home and abroad.

Social trust

Nuclear energy is the key to sustaining a low-carbon society due to its superior characteristics in terms of stable supply, CO_2 reduction and economic performance. However, while the latest opinion polls in Japan show that 60 per cent are for the promotion of nuclear power, as in Europe and the US, over 50 per cent are still anxious about nuclear power. TEPCO recognises the need for continuous efforts to promote public understanding. Transparency and proactive information disclosure are important to reassure and win social trust. All 'nonconformity events' such as irregularities and malfunctions that occur at the company's nuclear power stations are released to the public through press releases and on the company's website. In addition, the daily efforts of the power stations in respect of safety and quality control are communicated to local communities through public relations magazines and newspaper advertisements. Such initiatives are valued by the local residents. The trust of society is indispensible for nuclear power operation and development. Thus, TEPCO aims to establish a brand that is trusted by society, through safe and stable operation, proactive information disclosure and dialogue with public. ❑

Connecting the continent: creating a pathway to low-carbon growth for Africa

By Hela Cheikhrouhou, Director for Energy, Environment and Climate Change, African Development Bank (AfDB)

With the greater than ever prospects for energy demand in Africa resulting from the relatively strong economic performance of the past ten years, as well as the projected 5 per cent economic growth trend of the continent for the year 2011, it has become imperative for governments to take definite steps to end energy insecurity and to set the African continent on a path of sustainable energy production and consumption.

In this context, the African Development Bank's (AfDB's) programmes in the energy sector are targeted at scaling up access through increased energy production and cross-border energy trade, while putting Africa on a sustainable path to a low-carbon economy. Therefore, the AfDB's strategy in the energy sector aims at gradually eliminating energy poverty through increased generation and better interconnectivity of the electrical grids across regions, while ensuring a scaling up in the development of renewable energy sources and the mainstreaming of energy efficiency measures and practices. Because of the limited scope of most national transmission and distribution infrastructure, the development of stand-alone renewable energy sources is often the least-cost solution to meeting the particular circumstances of rural areas which need electricity to strive and to develop. In addition, starting from a relatively low base, Africa has the opportunity to pursue a low-carbon intensive development pathway which is in line with the international concerns over climate change.

Despite the fact that Africa has significant natural resources, energy production remains low. With important natural resources including hydro-potential (estimated at around 1,750 terrawatts per hour (TWh)), geothermal (estimated at 9,000 megawatts (MW)), uranium (19 per cent of world potential), solar and most of all, 9.7 per cent, 7.7 per cent and 5.5 per cent of world oil, gas and coal reserves respectively, the energy resources on the African continent are diverse and considerable. But despite these abundant resources, Africa's energy production remains only about 9.5 per cent of the world's total output, including 12.1 per cent of the world's crude oil production; 6.6 per cent of natural gas output; 4.7 per cent of the world's hard coal; and 3.1 per cent of hydro-electric power.

Access to energy is closely linked to poverty reduction, both in a national and regional perspective. Insufficient energy is a central aspect of practically all core conditions of poverty, such as poor health, insufficient access to water, poor sanitation and inadequate education. In addition, connectivity also fosters growth in a regional perspective. The African Development Bank's Research indicates that there are positive effects of electricity consumption by a country on other countries' economic productivity. The results of AfDB's analysis show positive outcomes of the *regional* electricity consumption on an *individual* country's GDP per capita, implying a need for regional cooperation with respect to electricity generation, connection, and consumption. To the extent that projects promote regional integration by increasing capacity to generate power and extend connectivity, they help each country benefit from positive economic spill-overs. Results from empirical analyses of the effect of electricity generation, and connectivity, indicate that increased access to energy increased economic productivity.

Africa has the opportunity to pursue a low-carbon intensive development pathway

Increasing Clean Power and its trade in East Africa

The East African region has large renewable energy potential, especially for hydro, wind, and geothermal electricity, yet its potential remains unexploited due to a lack of transmission infrastructure and investment. East Africa is marked by high system losses due to overloaded transmission lines, and suppressed demand due to inaccessibility to and high tariffs of electricity. Despite the large excess of production over consumption in East Africa, apart from Burundi, Rwanda, and Uganda, trading of electricity among countries remain minimal, largely due to lack of interconnection of grids. For instance, currently less than 10 per cent of hydroelectricity potential in Ethiopia, Sudan, and Uganda has been exploited. The Bank's activity in the East Africa region focuses on expanding East Africa's clean power capacity generation. For instance, the Bank's Bujagali hydroelectric power project in Uganda includes a 250-MW run-of-the-river power plant and the construction of around 100 km-long transmission lines, upgrades to an existing line, a switchyard at the project site, a new substation to the north of Kampala, and an improvement to the existing substation southwest of Kampala. The total project cost is estimated at about US$ 735.5 million. The project is expected to be commissioned in 2011. The Bujagali project does not regulate the outflows from Lake Victoria, making it all the more feasible as it will not impinge on the current lake levels. The power generation project will benefit both existing and new electricity consumers, who will receive sufficient, least-cost and reliable power supply. Private industry will benefit from more cost-effective electricity supply and reduced load shedding. Fewer blackouts and brownouts will reduce the need for expensive and air-polluting back-up generators. The government will be able to direct fiscal revenues generated as a result of the proposed project to meet poverty alleviation and other social needs. As connectivity is a main precondition for trading clean energy, the Bank has an interest in helping countries in the region install substations and grid lines on both a national and a regional level. Bank-financed projects are intended to increase the capacity and maintain the reliability of the power transmission system to allow the efficient evacuation of power from new and cheaper generation plants. For instance, in Tanzania the Bank supports the Iringa-Shinyanga Backbone Transmission Line Project, which will interconnect four substations at the Iringa, Dodoma, Singida and Shinyanga towns with a 670 km line of 400 kV, a project expected to be completed by the end of 2013 and at an estimated cost of US$476.82 million.

As pooling energy resources through regional power trade promises to reduce power costs, the Bank also supports multinational interconnectivity projects. The East African Power Pool, created mainly to support power trade efforts, includes the Interconnection of the electric grids of 5 Nile Equatorial Lakes countries – Kenya, Uganda, Rwanda, Burundi, and the Democratic Republic of Congo (DRC). The Bank provides US$151.5 million to finance these projects. The benefits of interconnection projects include fuel cost savings; both associated with the replacement of expensive supply sources as well as related loss reduction in generation and transmission as a result of the interconnection. In addition, there are environmental benefits associated with the replacing of thermal energy with hydro energy.

Yet, access to energy in Africa remains scarce. Recent studies estimate that 80 per cent of the world's 1.5 billion people without electricity live in mostly rural areas of Sub-Saharan Africa. Chronic power shortages plague 30 African countries. Only one in four Africans has access to electricity. The entire installed generation capacity of 48 Sub-Saharan African countries is 68 gigawatts, no more than Spain's. Outside of South Africa, power consumption is barely one per cent of the level in high-income countries.

As a result of low access to energy, Africa currently only contributes about 4 per cent of global greenhouse gases. However, if industrial and economic development continues along a 'business as usual' course, Africa's emissions can increase significantly; concrete actions are therefore needed now to chart a low-carbon development pathway. Africa has the opportunity to grow a low-carbon economy and avoid being locked into the high-carbon growth path experienced by developed nations.

As a consequence, the African Development Bank Group strives to be the lead financier for increasing access to energy for Africans, in ways that support low-carbon development on the continent. The Bank directly contributes

Inga - The Hope of Africa

The Inga hydropower site in the DRC alone accounts for the largest hydropower potential of the continent, nearly 45,000 MW. Inga currently has an installed capacity of 1,774 MW consisting of two power plants (Inga I and Inga II), the first having a capacity of 351 MW and the second with a capacity of 1,424 MW. Yet, these two installed plants represent only 4 per cent of the potential of this site. Two more phases are planned for the site: Inga III, with a capacity of 4,300 MW and Grand Inga with around 40,000 MW, or about double the installed capacity of what is today the largest hydroelectric facility in the world (the Three Gorges station in China).

Inga represents a unique potential for renewable energy which could be sufficient to meet the current demand for electricity of the entire continent. The major advantage of the site lies in the relatively low production cost of electricity (US$76.16/kW/year) which remains very competitive compared to other production alternatives, even when the costs of implementation of associated transport infrastructure are taken into account. Ultimately, the proposed development potential of Inga would also constitute an interconnected grid, and thus allow the development of an effective energy market across the continent.

Since 2008, the Bank has been collaborating with the government in making the hope of Africa a reality. The main objective of the ongoing operations of the ADB in the development of Inga are two-fold: refurbishment of the already existing plants as well as assisting the government to weigh the options at hand for further exploitation of the site. The Bank supports, jointly with other donors, the rehabilitation of the already existing power plant Inga I, that currently can only produce at 60 per cent of its capacity. The Bank has approved an operation on the rehabilitation and strengthening of the Inga hydroelectric power and distribution network in Kinshasa (EDI) to the tune of US$54.2 million.

The Bank is first financing a comprehensive feasibility study that takes into account all aspects of alternative ways of exploiting the site fully. The Bank has granted the government of the DRC, in April 2008, a grant of US$14.4 million to fund the feasibility study, a key element of decision support for selecting the solution to implement. In addition to assessing the technical, environmental and social, economic and financial options for developing the site, the study will establish a platform of analysis and recommendations of a strategic nature, as a basis for multiple decisions that will incorporate a large number of actors. These include governments, primarily the government of the DRC but also those of countries that are potential customers of energy producing countries, and those whose transport infrastructure electricity will pass through. The National Energy Society of the DRC would be the linchpin for the implementation of the project, together with private investors, donors and potential customers.

The Bank's involvement comes at a crucial time, marked by the return of peace in the country and in the Great Lakes region in general, as well as the favourable evolution of the controversy concerning the construction of dams, the creation of power pools in Africa and soaring oil prices.

to the expansion of access to energy in Africa, particularly for the poor. Bank Group projects identified as increasing energy efficiency include grid interconnections, notably in East and Southern Africa. Grid interconnections ensure that electricity reaches users. Also, in ensuring access to energy for all Africans, AfDB's operations show significant results. For instance, the Rural Electrification Project for Ethiopia helped increase Ethiopia's rate of access to electricity from 13 per cent in 2001 to 22 per cent in 2009. In low-income countries alone, AfDB-financed projects completed between 2006 and 2009 installed or rehabilitated 5,811 km of transmission lines, constructed or rehabilitated 658 distribution substations and transformers, installed 42,500 service lines and energy meters and provided energy to almost 17 million Africans.

Working through its public and private sector departments, the Bank Group has substantially increased its investments in renewable energy in Africa. The Bank's private sector operations in the energy sector started in 1998, resulting in ten recently approved projects amounting to approximately US$1 billion to finance energy in various forms and countries. For 2011 to 2012, the pipeline (public and private) for renewable energy has increased even further and amounts to US$1.4 billion. A key role for the Bank is to leverage financing from other sources, providing comfort to investors on the financial viability of

The Lake Turkana Wind Power Project in Kenya

Kenya's electricity sector services only an estimated 14 per cent of the population. The generation of more electricity is necessary for energy to reach more people and support economic growth. The situation is aggravated by Kenya's over-reliance on hydropower (hydropower supplies approximately 50 per cent of the country's energy), which is often unreliable, especially in the dry seasons.

To meet its energy needs, the country will have to import nearly half of its energy by 2020. The Government of Kenya is seeking to reduce its reliance on imported energy and fossil fuels while ensuring a reliable supply of electricity, particularly clean, low-cost energy. The Lake Turkana Wind Power Project will build 365 wind turbines, reinforce 200 km of roads and bridges to transport the turbines from the port of Mombasa to northeastern Kenya, and add an estimated 426 km of transmission lines to supply power to the national electric grid.

The reliable, continuous, clean power thus produced will provide the country with 300 MW of relatively cheap energy and increase Kenya's power by 30 percent. The project is forecast to reduce carbon emissions by 16 million tonnes during its 20-year lifespan. Costs are projected at approximately €459 million. The African Development Bank, which is the lead broker, will facilitate the entire debt tranche through the African Financing Partnership. The AfDB has also committed to a loan of up to €100 million.

projects. The perceived risks in these projects are high, due to the relative long-term maturity of such investments and the sometimes new or expensive technology. Also important is targeted support for improvements in policies and regulations. These improvements are necessary to drive energy efficiency actions and increase the uptake of renewable energy in Africa.

However, expanding access to clean energy requires significant resources. Bridging Africa's gap in energy infrastructure requires more than doubling current investment efforts for the next 20 years. The cost of putting Africa on a low-carbon growth path have been estimated at US$22 to US$31 billion per year between 2010 and 2015

RIsing power: Africa has only begun to realise its energy potential

and between US$52 and US$68 billion per year by 2030. Funding will be a deciding factor in our path to reach the clean energy goals.

Climate finance thus needs to be an imperative for all stakeholders, ensuring access to funding climate-relevant energy projects in Africa. To construct a robust, low-carbon growth pathway for Africa, the continent will need significant additional external financing. The AfDB stands ready to explore several potential funding sources, including the additional resources pledged under the Copenhagen Green Climate Fund. All will be explored to implement actions complementing those for which the Bank is already the preferred partner of choice in Africa, such as the Climate Investment Fund and Global Environment Facility.

Cooperation by the countries, regional communities, and donors at regional level will help make the development of electricity and national economies sustainable all together. Given its enormous endowment of renewable resources, there are significant energy-related business opportunities for Africa, leading to economic and social growth. As an example, Africa has one of the world's highest potentials for solar. Costs of CSP power generation is three times less in North Africa than in Germany. More efforts are needed to fully utilise the Continent's potential for clean power. ❑

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Urbanisation, megacities, and energy poverty in Latin America

By José Antonio Vargas Lleras, Chairman of the Colombian Committee, WEC and Chairman of the Board, Codensa

According to the United Nations, in 2007, for the first time, the world's population living in urban settlements exceeded that living in rural areas. More than three billion people live in the cities of the world, and five hundred million people live in megacities (of more than ten million inhabitants) or in cities with more than five million inhabitants.

Future population growth will be mainly urban, reaching 60 per cent in 2030, and 70 per cent in 2050, almost twice today's level. By then, the world's population will reach nine billion people, and 98 per cent of population growth will take place in the developing and emerging countries.

This urban transformation will affect the most populated poor regions in a significant way, causing new social stratifications and intensifying the transformation of the world's ecosystem. The rapidly growing use of energy based on fossil fuel and the extensive use of natural resources will imply environmental degradation, making supply of food and water for human consumption more complex.

These demographic and urbanisation phenomena challenge the capacity to produce public goods and services and pose a threat to a healthy environment for the population, an essential condition for sustainable development.

Urbanisation is a complex process that entails a series of material and psychological profits and losses, and gives privileges to certain groups and disadvantages to others.

The World Energy Council (WEC), concerned with the problems related to the Four A's' main goals (Accesibility, Availability, Acceptability and Accountability), recently completed a global study to develop a concept for a secure energy supply and distribution system for large cities based on modern developing technologies, including transportation, in order to ensure a sustainable future. Some of the conclusions of the report *Energy for Megacities* are that according to the map of energy access, based on final energy availability and share of non-commercial energy, as shown in Figure 1, most of the population in the Latin American region belongs to the 'poor' or 'less poor' strata. In particular, the megacities have the potential to increase their per-capita energy consumption from 15-25 GJ/person to 25-75 GJ/person.

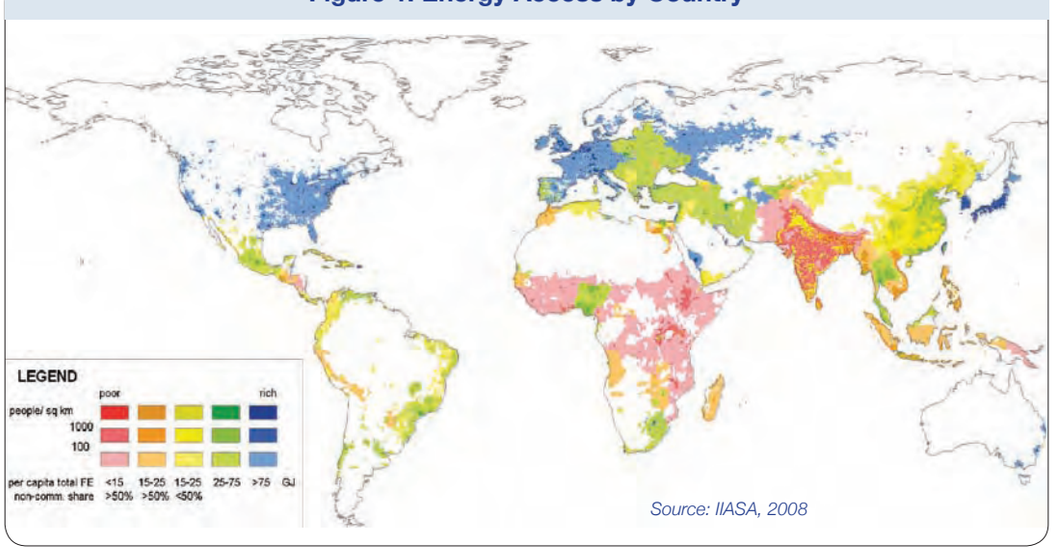
The UN Habitat Study in 2008 estimated that the energy infrastructure investment for halving the slum population of almost 1 billion people is about US$700 billion.

Urbanisation in Latin America

In 2007 Latin America had 570 million inhabitants, of which 77 per cent lived in urban areas. In 2009, the poor population was close to 189 million (34 per cent of the population) and indigenous inhabitants up to 76 million (13.7 per cent of the population), while 40 per cent of the population lived in unsuitable housing. In 2030, the Latin American and Caribbean (LAC) region is expected to have more than 600 million people living in cities (84 per cent of the population), exceeding the urbanisation level of the developed countries.

The LAC region will

Figure 1: Energy Access by Country



Source: IIASA, 2008

Billions of people:
Abject poverty: 1.3
Poor: 0.6
Less poor: 1.4
3.3
Middle class: 1.4
Rich: 1.2
2.8

São Paulo, Brazil: one of Latin America's four megacities

become the most urbanised in the world. However, this urbanisation will be extremely different from that of the developed countries because, besides being fast and lacking of planning, it will entail deep economic, social, and environmental problems.

According to the most widely accepted definition of a megacity, currently there are 19 of them in the world, and by 2025 the number is expected to increase to 27, out of which 11 are capitals of their respective countries. Asia has eleven megacities; North America, two; Africa and Europe, one each; and Latin America has four: Mexico City Metropolitan Area, Greater Buenos Aires, and the Metropolitan areas of São Paulo and Rio de Janeiro (see Table 1).

Those cities and others such as Bogotá, Santiago, Lima and Caracas, present problems related to the environment, exclusion and poverty, in a context of rapid urbanisation processes that deserve attention. These cities have been populated without any public space and with overcrowding.

Urban poverty and social inequality are processes clearly identifiable in most of the large Latin American cities. There is a proven high correlation between available commercial energy and poverty. The supply of modern, reliable, and reasonably costly energy services for the economic sectors and for household use is essential to increase production, productivity, income and quality of life of the population. This is why public policies focused on increasing energy access must be urgently encouraged in developing countries.

WEC study: Latin American Energy Poverty – Mitigation alternatives. April 2006 report

In this pioneer work, three case studies were carried out in major cities of three South American countries: Greater Buenos Aires in Argentina; Rio de Janeiro in Brazil; and Caracas in Venezuela.

Thanks to the variety of subject matter and approaches in the three case studies, the report provides guidelines for the discussion of strategies necessary to handle the problem of energy poverty in urban areas, not only in the Latin American region but all around the world. The general conclusions of the three studies highlight the cooperative solutions by means of which governments and companies work together in actions that represent benefits for the companies and also for the consumers.

Regarding social and economical issues, the report concluded that the subject of energy should not be studied in isolation. Energy policy decisions must take into account the specific social and economic reality of the population and focus particularly on the causes of poverty and not only its effects. The design of subsidy-oriented social policy must be guaranteed in the long term and not distort market performance. It also should integrate with other social programmes, particularly those that encourage education and employment. Any benefits should not be seen as a right but as a privilege, subject to a specific circumstance.

Another important issue that relating to energy efficiency. It is well known that access to energy and efficiency in consumption are two sides of the same coin. Good habits and a consumption culture linked to efficient equipment

Table 1: Megacities in Latin America

Mega city	Population (millions of inhabitants)
Mexico City, Mexico	19.0
São Paulo, Brazil	18.8
Buenos Aires, Argentina	12.8
Rio de Janeiro, Brazil	11.7

guarantees better and more economic access to commercial energy. Table 2 shows problems related to poverty and energy access from the authorities', companies' and users' point of view.

Table 2: Obstacles to Energy Access	
Problems from the point of view of the authorities and the companies	**Problems from the point of view of poor users**
• Precarious employment situation, irregular income, unemployment, lack of opportunities and education • Illegal land tenure • Vandalism • Organised crime and violence • Favourable environment for bossism and political clientelism • Clandestine connections • Lack of governability • Urban planning, lack of safety and illegality problems • Energy theft • Losses due to energy not billed • Adulteration of subsidy programmes (political management of the subsidies, subsidies seized by organised crime, etc) • Frequent delayed payments	• Lack of training and education • Culture of 'political clientelism' and perception of injustice • Personal and family lack of safety • Precarious land tenure • Lack of legal access to energy • Supply interruptions • Prices and tariffs unsuitable to make the service sustainable • Lack of access to efficient equipment • Excessive consumption in relation to performance • Low quality service • Feeling of exclusion and marginality due to the lack of attention to their problems, translated into resentment and an environment favourable for social violence.

The case of Colombia

Colombia, with an estimated population of 45 million people in 2009, is the third most populated country in Latin America, after Brazil and Mexico.

It has undergone a fast urbanisation process from the second half of the 20th century. During this period, Colombia changed from being a country whose largest population was congregated in rural areas to having more than 75 per cent of its inhabitants living in urban groups. Its average population density is of about 41 inhabitants per km^2, but it is distributed throughout the country in an irregular way, with more density in the Andean region.

In this context, the study *Urban Poverty and Energy in Colombia* commissioned by the WEC Colombian Member Committee for publication in 2011, makes a proposal to be carried out in the five largest cities of the country. They are characterised by a rapid population growth and receiving a displaced population that currently exceeds 3 million people.

Most large cities, at all development levels, have to expand their energy supply systems, especially electricity to meet growing demand; subject to more prohibitive environmental regulations for investment decision making.

In that sense, the distributed power generation from non-conventional sources, efficient energy use and smart grids for distribution networks will be necessary practices and technologies to be promoted by the energy policies and power utilities in order to assure the Four A's.

Enel-Endesa's commitment to Latin America

The international energy group Enel-Endesa has the major challenge of ensuring full coverage of electricity services, complying with the highest quality standards and adequate tariff schemes for consumers in large cities in five major Latin American countries; Buenos Aires in Argentina, Rio de Janeiro in Brazil, Lima in Peru, Santiago in Chile and Bogotá in Colombia.

Experience shows that the solution of energy problems in the large cities of Latin America requires close collaboration between national and local authorities, industry, opinion-builders, research institutions and other stakeholders. Introduction and enforcement of high environmental standards is a critical success factor, but above all, significant investment is needed in the expansion and upgrading of the entire electricity system, including appropriate 'smart' technologies for efficient management of the grid. A strong commitment to Corporate Social Responsibility on behalf of participating companies will secure public support and contribute to successful implementation of such initiatives. ❑