ENERGY CHALLENGES IN FRANCE

THE VIEWPOINT OF AN ENGINEERING FIRM

September 2012

SUMMARY

INTRODUCTION: TOMORROW'S ENERGY

Recent disasters such as the 2010 oil spill in the Gulf of Mexico, the accident at the Fukushima nuclear plant in 2011, and the huge gas leak in the North Sea in 2012, remind us that energy is an uncertain, risky, and complex business. Industry should of course keep aiming for "zero risk", even though energy demand keeps rising, especially in emerging countries. The development of renewable energy also faces significant challenges in terms of its competitiveness, how it is integrated into electricity networks, and the relocation to Asia of numerous manufacturing plants.

At the same time, energy has an extremely promising future, due to the development of innovation and the growing awareness of the public, policy makers and business leaders that we need to change our energy model while keeping a close eye on the environmental impact of major energy projects. Everything points to increasing our safety and security standards, not just in the West, but also in emerging countries, where governments cannot afford to ignore public opinion.

So far, there has been no form of energy - be it nuclear power, oil or wind power - that has run through its entire life cycle, from design and construction to decommissioning its infrastructure. In other words, we are working with economic and industrial models that have not yet been fully validated.

Drawing on the American experience, it is estimated that decommissioning a nuclear reactor costs $400M. How much will it cost by 2020-2030? The International Energy Agency (IEA) estimates that by 2040, we shall have to disassemble 500 oil platforms in the North Sea and nearly 8,000 end-of-life oil wells. Do we have any idea what kind of financial, regulatory and technical environment we shall have when these heavy-duty operations are carried out? How will we achieve the major technological and industrial developments needed to reduce the costs of renewable energy so that they can continue to grow significantly over time?

Independent engineering firms can make a unique contribution in this kind of context, due to their broad-based experience in mastering the inherent complexity of major energy projects for their various clients. The key challenge is to design a new energy model that although more complex, will also be more economically and ecologically efficient.

THE CHALLENGE OF COMPLEXITY

Complexity is intrinsic to the energy sector (oil, gas, clean coal, nuclear, offshore wind), especially in a period of energy transition. By virtue of the size and duration of energy projects, the amount of capital employed (about €6B for an EPR, and almost as much for a sea-based oil production and storage unit), the extent of the technological innovations to be implemented, and the multiplicity of stakeholders and rules governing respect for the environment, these projects require a fully-fledged systems approach.

From automotive and aerospace to energy, every high technology enterprise has to rise to the challenge of complexity. As an example, the new and highly complex offshore wind power industry is now spreading its wings in Europe, Three consortia made bids for the French government tender for the installation of five offshore wind farms with a total capacity of 3 gigawatts (GW); four 2 GW sites were selected. Unlike onshore wind power, this offshore sector is both technology- and capital-intensive, and each manufacturer will focus on its own industrial segment and costs.

This challenge also means that the requirements of the contractors have to be balanced against industrial constraints by controlling time and costs, and providing the best technology in a well-adjusted framework. There must also be practical and reliable responses to risk management requirements covering everyone from the general public to industry and government.

We have reached a new stage of complexity ever since governments, elected officials and community service groups decided to promote sustainable development agendas involving a more comprehensive treatment of major urban issues (e.g. clean energy, prudent water management, waste recovery and recycling, and clean public transport). Large French companies such as Veolia Environnement, Suez Environnement, EDF, GDF Suez and the Caisse des Dépôts et Consignations are all working in this area.

This kind of circular, comprehensive eco-system compared to the more linear previous economy inevitably requires help from engineering. Assystem has noted with interest European Union support for the development of twenty or so "smart cities" by 2020. This will ensure that the Old Continent will not lag behind the new energy technologies and grids emerging in China or the Middle East, which is also developing "eco-cities" (e.g. Masdar City).

These cities will be extremely complex. Large electricity suppliers (Siemens, Schneider Electric, ABB etc.) are in the running to provide equipment and solutions. But nobody is capable yet of choosing between the different technologies on offer, or integrating them into these "smart cities".

Surely engineering companies are the most qualified players to play the role of technology architect for our cities and our territories in the service of major contractors, be they local authorities or manufacturers.

SAFETY: THE STRENGTH OF A COMMUNITY

When it comes to industrial safety, there can be absolutely no compromise. Two major accidents in recent years remind us of the human and environmental risks inherent to the energy industry - the explosion of the Deepwater Horizon in the Gulf of Mexico in April 2010 and the destruction of the Japanese nuclear plant in Fukushima in March 2011. These disasters, like the explosions of the Piper Alpha platform in 1988 and the No. 4 reactor at Chernobyl in 1986, led to a drastic revision and severe tightening up of safety and security standards under the pressure of government and public opinion alike.

The accidents at Three Mile Island and Chernobyl were due to management errors, while Fukushima was hit from outside by a tsunami, and this will lead to profound changes in the way risk is managed. For example, in addition to reinforcing the defence lines of the 58 French reactors in which Assystem is participating, EDF - following a decision by the French Nuclear Safety Authority - is setting up a Rapid Nuclear Action Force (FARN) capable of taking over control of any reactor in an emergency in under 24 hours.

Fukushima has led engineering specialists to think about the broader picture of the dissemination of nuclear technology. While there is no supranational authority that can prohibit a signatory to the Nuclear Non-Proliferation Treaty (NPT) from developing a nuclear power plant, the International Atomic Energy Agency (IAEA) and the 45 countries supplying nuclear technology ensure that they only disseminate such plants under strict control in countries able to develop a true safety culture backed by a robust regulatory framework.

The nuclear power industry has almost certainly pushed safety standards further than any other industrial sector. When a single operator is faced with an emergency, the entire industry on a global level rallies round as a community to help solve the problem. This collaborative reaction is one of the great strengths of the sector when it comes to security. This experience in nuclear power should be used to develop a broad vision of risk that can be applied to other industries – after all, risk is not just a nuclear issue. Security operations, for example, are taking an increasingly critical role in Oil & Gas.

In a world where energy production and consumption stand at the heart of the global conversation, and as we try to build a new, more efficient and environmentally-friendly energy model, the lessons learnt by the nuclear industry should become an increasingly valuable resource for everyone.

ENERGY EFFICIENCY: "SMART ENERGY"

The world must now solve the complex equation of producing more goods and services while consuming as little energy as possible, so as to overcome the problem of fossil fuel depletion and reduce global warming. Efficiency and simplicity have to varying degrees become the watchwords for politicians, oil magnates, electricity suppliers, manufacturers and defence and environment specialists. Waste-cutting, which was first mooted after the 1973 oil shock, has now taken on a new urgency in both developed and emerging markets.

Yet we don't have to start everything again from scratch. Between 1981 and 2010, energy intensity (the amount of energy needed to produce 1 per cent of GDP) fell by 20% worldwide. This decline even reached 65% in China, which is hampered by a very archaic industrial and housing fabric. This proves that industry, services and transport are in fact becoming more efficient and less greedy. In its 2008 "Energy-Climate package", the European Union set itself the ambitious goal of improving this efficiency by 20% by 2020. This approach has the virtue of reducing costs for consumers, curbing rising prices by reducing demand, driving down dependence on producer countries, making power systems more secure, and protecting the environment.

There are huge pockets of further energy savings. Everyone agrees that improvements to buildings (residential and commercial) are a top priority, and in fact, account for 42% of total energy demand (20% for both transport and industry). In this sector, the challenge lies less in educating the consumer as in improving their living conditions. Properly designed and equipped housing can lower consumption by 30%.

There is also a substantial margin for improvement: the average annual consumption of a building in France is 400 kWh/m² while the new standard will be 50 kW/h starting in 2013 for new construction. But with 30 million existing homes (and 300,000 new homes a year), it would take a century and huge amounts of money to solve this problem.

And yet we are undergoing a quiet revolution as the world gradually changes its energy model. The existing model, founded on the production of large plants injecting huge amounts of electricity into a grid of power lines, is being replaced by a new, more flexible, decentralized model, increasingly tailored to the way consumers actually use energy. Energy efficiency is key to this transformation.

Indeed, we have now entered the era of "smart energy". We have to inject intelligence into the infrastructure and the networks so as to optimize the production and consumption of energy in buildings. This entails installing sensors and smart meters, and then connecting these buildings to delocalized energy sources by means of equally smart grids. Consumers should also be able to control their consumption in an informed way. Rather than being an awareness-raising issue, this is once again a question that can only be only answered by innovative R&D focused on new practices. There are many on-going projects in this area and they will soon take on greater visibility.

In light of these developments, the future belongs to innovation champions who can invent and implement smarter energy management systems.

RENEWABLE ENERGY: PROMISE FOR FRANCE

France's decision to go "all nuclear" (75% of its electricity) came after the first oil shock in 1973. As the only country in the world to make this choice, energy derived from solar, wind and biomass sources has long been pushed into the background. France is now trying to catch up again, following a firm decision in 2007 to develop renewable forms of energy, particularly in offshore wind. This is a necessity, as in the long term fossil fuels cannot and will not satisfy our energy consumption requirements. The famous "energy mix" is gradually taking shape.

With the French Grenelle Environment Forum in 2007, France effectively committed to the European Union agenda to increase the share of renewables to 23% of its total energy consumption by 2020.

By this date, France plans to have wind farms in the North Sea, the English Channel and the Atlantic, aiming for a total of 6 gigawatts (GW).

The two consortia working on the initial projects (EDF-Alstom and Iberdrola-Areva) have everything to gain from outsourcing engineering skills right across the sector, including wind mills, installations, operating and maintenance, and decommissioning.

The French program will lead to the construction of six plants in Le Havre, Cherbourg and Saint-Nazaire, strengthening an already strong fabric of 180 SME-SMIs working in wind power, and creating 10,000 jobs. This nascent industrial sector will provide the amenities for French power plants, as well as the huge wind farms to be installed off the coast of the UK.

The development of offshore wind requires greater expertise than any other renewable energy engineering activity. There are many design challenges and only companies specialized in complex infrastructure will be capable of providing answers that balance out the varying interests of stakeholders in this process. Renewable energy, including offshore wind, will clearly create value in France. But it will require experience backed by specific, extremely challenging skills in complex infrastructures engineering, energy production and distribution that can factor in all the environmental constraints.

For such a massive investment – a total of €20B for 6 GW in France, €100B for 35 GW in the UK - it is vital to keep the cap on spiralling costs and calendar creep. It is absolutely crucial to build integrated teams from all the partners and rigorously plan and track the work so that any delays can be identified and remedied, and to manage the cultural differences between SMEs and large companies. This kind of organization will be able to avoid disputes such as the $477M at stake in the differences between the German-Scottish operating consortium of RWE-Scottish & Southern Energy and the US contractor Fluor on the Greater Gabbard project in the UK.

Finally, to ensure that offshore wind and renewable energy as a whole will continue to grow significantly over the long term, important technology and industrial development will be needed to reduce their costs.

Once these obstacles are identified and overcome, there is no reason why France should not play a major role in the global renewable energy arena.

THE ROLE OF NUCLEAR POWER IN THE ENERGY MIX

Nuclear power will clearly remain the centrepiece of the energy mix. The Fukushima accident cannot reasonably sign the death warrant for an industry that provides 14% of global electricity while emitting less CO2 during its life cycle. After all, one of its main advantages is that energy can play a key role in the fight against global warming. Today, about 435 reactors are in operation worldwide and there are another sixty under construction; a total of thirty countries are thinking about rolling out a civilian nuclear programme.

Although the initial investment for developing nuclear plants is still very high, nuclear power enjoys at least two major advantages. First, it assures greater energy independence to countries and operators that are only minimally dependent on fossil fuels. Second, the price of a kilowatt/hour produced by a nuclear power plant is both competitive with respect to other forms of electricity generation (see the report released by the Court of Auditors in early 2012) and stable, largely because of the relatively low cost of the raw material (uranium) as a share of the total cost of production (estimated today at about 5%). This means that the operator can keep control over the equipment's productivity.

Fukushima has nevertheless raised fundamental questions for the future of nuclear power about the responsibility of the players involved. Safety is at the heart of the concerns of stakeholders in the sector. Nuclear development will continue, but it will be focused on relatively stable countries, with a capacity to enforce regulations and backed by a strong industrial culture.

In addition to constantly improving the safety of both new and existing reactors, engineers specialized in complex infrastructures are focusing their attention and innovation efforts on another objective – making greater progress in the life cycle management of nuclear power.

Although some decommissioning projects have already been completed or are underway, they can be optimized for the future, and will continue to pose a challenge when it comes to managing large-scale projects and maintaining the quality of the skills base.

At the same time, there is the burning issue of how to treat high-level, long-lifetime waste. The capacity to solve this under optimal conditions of safety and environmental protection could help to reinvigorate a sector that is more than ever convinced that, in the current state of energy needs and technological capabilities, nuclear energy will continue to provide a highly reliable solution for the future.

In the context of higher global demand for electricity, it is only through continuous investment in research and development and by drawing on high-level engineering skills that the nuclear industry will be able to build a new future.

OIL AND GAS: THE NEW FRONTIER

Debates about the "end of oil" and on limiting greenhouse gas emissions tend to "bury" fossil fuels (coal, gas and oil) a little too quickly. Although they are growing scarcer and more expensive, and will contribute enormously to global warming, fossil fuels are still irreplaceable and will remain the lifeblood of the economy for decades. A glance at the different forecasts for the global energy mix shows that they tend to agree that in 2050, coal will represent 34% of primary energy and oil 27% (against 38% today). This is simply because energy needs will double during this period, driven by demand from emerging countries.

Natural gas will play a growing role in electricity production at 28% and coal will remain at least at 50%. Oil will no longer be used for power plants, but will continue to fuel transport. Unless of course manufacturers have by then invented a revolutionary battery - powerful, lightweight and inexpensive – to power electric cars.

The evidence speaks volumes. Private and national enterprises continue to invest heavily in the exploration and production of oil and gas, and will spend a total of $600B a year by 2020. Total alone will spend $20B every year. A barrel at probably an average price of over $110 during the decade will ensure that the increasingly difficult and costly production process stays profitable. It is hardly surprising that banks lend to the Oil & Gas sector, whereas they are becoming far more cautious about financing major nuclear projects.

However, the oil era is drawing to an end. As with nuclear power, security costs will rise for a number of reasons. On the one hand, the public has rightly lobbied for stronger security to avoid another disaster like the BP oil spill in the Gulf of Mexico in 2010. On the other, because oil production has to exploit new deposits, it requires more and more high-tech equipment (seismic 3D, high pressure- and high heat-resistant materials etc.) as well as gigantic platforms (FPSO[1], FLNG[2]).

The oil industry now has to explore resources 3,000 to 7,000 meters underwater, or extract the oil from wells that must be upgraded, or be able to treat Canadian oil sands and the heavy oils of Venezuela. The presence of these "unconventional" types of oil has

[1] FPSO: Floating Production Storage and Offloading. FPSO platforms have the advantage of not requiring fixed infrastructure which means they can be re-used.

[2] FLNG: Floating Liquefied Natural Gas. **This type of platform is still in the design stage, and will first be put to work in 2017. They will help extract offshore gas reserves.**

tripled the size of proven reserves[3] to 3,000B barrels. New oil countries are emerging, especially in East Africa. The oil peak that we thought would be reached in 2015-2020 has now been postponed to a later date.

We cannot talk about the future of the gas industry without mentioning the potential of shale gas. Wherever this technology has been developed, it has profoundly reshaped the industrial future of the country in question. In the United States, for example, by providing industrial access to a highly competitive source of gas, it helped redevelop the petrochemical industry and created new jobs. If properly managed, shale gas offers a tremendous opportunity for the countries that can develop it. France, with one of the largest gas reserves, could find that using its gas deposits is an effective way to reduce a trade deficit that is severely weighed down by oil imports. Engineering is ready and willing to join in discussions and experiments that could kick-start environmentally-responsible operations, whether in managing water resources, for example, or in preventing groundwater pollution.

For industry, then, this is a considerable challenge. It means continuing to exploit natural resources by investing heavily in technologies that will allow us to respect the environment more effectively, while preparing for the future by developing renewable energy to support growing global energy requirements.

[3] Proven reserves are the amounts of hydrocarbons and coal that according to available geological and technical information have a strong probability (>90%) of being recovered in the future using known deposits and under existing technical and economic conditions (source: INSEE)

ABOUT ASSYSTEM

France's energy transition opens up exciting prospects, as the views expressed in this document suggest. A number of stakeholders - first and foremost the government – have seized on this as a critical concern for the future. There are many on-going projects and the top-level expertise and skills of French companies will be a key factor in driving the discussion to a satisfactory conclusion. The same goes for engineers. There are now more than 300,000 in France, with much-sought after skills that are appreciated internationally. This engineering firepower is just waiting to demonstrate how it could respond to the complexity of the energy question facing society today.

As an engineering company with a cohort of 10,000 experts, Assystem is ready to participate in the conversation and make a useful contribution to decisions about the energy transition. We expect to make a contribution on such issues as factoring life cycles into the design of energy production facilities, establishing stronger security audits, incorporating energy efficiency into our cities and regions, improving the performance of different French energy export industries or maintaining a steady stream of qualitatively and quantitatively appropriate skills in the years to come.

Stéphane Aubarbier

Member of the Board of Assystem, head of the Energy division

Assystem is an international Engineering and Innovation consultancy. Operating at the heart of industry for over forty-five years, the Group assists its clients in developing their products and managing the entire life cycle of their capital expenditure. Assystem has more than 10,200 employees worldwide and posted pro forma revenue in 2011 of nearly €850M.

In its energy business, Assystem employs nearly 2,500 people, 1,500 of them in nuclear power and ranging over safety, testing and commissioning, general plant installations and control systems. Assystem operates via assistance missions, project contracting, project management and delegated operations on both existing nuclear plants and on new projects. It also provides services for the fuel cycle and decommissioning, and in research centres such as ITER. To meet its customers' needs in a newly active global market, and to ensure that the experience gained by its senior experts, seasoned by decades of practice, is passed on to young engineers, Assystem has created its own training institute - the Assystem Nuclear Institute - which trains 400 new engineers and technicians every year.

The energy business accounts for about 33% of Assystem's revenue. *For more information about the company, go to www.assystem.com*

EXPERTS IN ENERGY ASSYSTEM

Martine GRIFFON-FOUCO

An engineering graduate from ENSMA (National School of Mechanical and Aeronautical Engineering) Poitiers, Martine Griffon-Fouco began her career as a researcher at the CEA before joining the EDF Group for 20 years, mainly in the nuclear sector where she was Director of a power plant. Martine joined Assystem in 2007, and since 2010 has been a Board Member of the Assystem Group. She was appointed Executive Vice President Corporate & Business Development in January 2011.

Stéphane AUBARBIER

Aged 44 and an engineer by training (INSA) with an MBA from ESCP-EAP, Stéphane Aubarbier has since 2005 been Executive Vice President of the Assystem Group and member of the Board. He presides over the Infrastructure Engineering & Operations business. He has also been Vice-Chairman of the Export group, chaired by EDF, of the Strategic Committee for the French nuclear industry since September 2011. Stéphane Aubarbier was elected Chairman of Syntec Engineering in September 2012.

Jean-Louis RICAUD

A graduate from Ecole des Mines de Paris et a PhD in maths of Ecole Normale Supérieure, Jean-Louis Ricaud have spent 20 years at Areva, starting at Cogema in 1978. Ricaud then worked with Assystem as Head of La Hague's nuclear fuel reprocessing plant. Executive vice-president of Usinor in 2000, he joined Renault in 2002 first as Senior VP, Quality, then as EVP in charge of Engineering, Quality and IT. In 2009, Ricaud was appointed COO of Alstom Transport. He joined Assystem in April 2012 as VP in charge of Strategy and Innovation.

Thomas BRANCHE

A graduate of the Ecole Polytechnique and Ecole des Mines, Thomas Branche began his career at Total Exploration & Production, before working for the French state, notably in the Directorate General for Energy and Climate. Previously Deputy Director in charge of the Energy division in the office of Eric Besson, former Minister of Industry, Energy and the Digital Economy, Thomas joined a subsidiary of Assystem that supervises Energy activities as Deputy Director General in July 2012, with responsibility for the development of the French market.

Hubert LABOURDETTE

An engineer, Hubert Labourdette began his career at PSA and later ABB Robotics as CEO France and head of global engineering at ABB. Since 2009, Hubert has been Managing Director of engineering at Assystem in charge of assistance in project management and project ownership in energy and infrastructure. He is also Director of Engage, the company in charge of the ITER Building project, and of N.Triple.A, the joint venture between Atkins and Assystem in charge of developing global engineering services. He is also engaged in developing proposals in the area of wind energy and energy efficiency.

Bernard BLANC

A graduate of the École Nationale Supérieure d'Arts et Métiers, Bernard Blanc joined the Assystem Group in 1983. During his career, he has participated in industrial projects in the automotive, shipbuilding, infrastructure and nuclear fields. Bernard Blanc is now Director of Development and Assystem Major Projects, and a member of the executive committee of N.Triple.A. His contribution was decisive in having the consortium led by Assystem win the Engineer Architect contract for the ITER buildings, the largest nuclear fusion research project in the world.

Christian JEANNEAU

Trained as an engineer (INSA Lyon), Christian Jeanneau joined Assystem in 1995 as a test engineer working on French nuclear plants and in the naval sector. After an experience in South Africa in infrastructure and then with Renault, he took over as head of the Engineering branch in 2008. Since 2011, Christian has been Director of Assystem nuclear activities. He is also Director of the Assystem Nuclear Institute, a training institute established in 2008 to transmit to new generations of engineers the skills and knowledge developed by the Group in the fields of dependability, commissioning and decommissioning.

Franck LADEGAILLERIE

A business school graduate, Frank Ladegaillerie joined Assystem in 2005 as the Renault account manager. He then took responsibility for developing Assystem activities in the automotive sector. He is currently Director of Marketing and Sales, with a special responsibility for the international development of engineering and services activities for Assystem production in the Energy sector.

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