IERE Document No. 1

R&D in Electricity Worldwide Trends

May 23, 2003

at the Clamart Site, EDF, France

November, 2003

IERE Central Office

Contents

R&D in Electricity Worldwide Trends

Introduction

Yves BAMBERGER
Director of R&D at EDF

Some of the speakers you will be listening to this morning are board members of the IERE, an association made up of those in charge of the major laboratories and research organizations in the electric industry worldwide. The IERE Board met yesterday at IERE's Wagram headquarters to prepare workshops and forums on different topics, some of which will be covered this week.

Some IERE members agreed to come this morning to present their area of activity and the problems that they encounter within their respective companies. After three presentations, the speakers will discuss the various issues amongst themselves and take questions from the floor. Then there will be another three presentations, followed by discussion.

The first speaker is Mr. Mark Lauby, EPRI's Executive Director for southeast Asia. He is responsible for the design, follow-up and realization of the programs which EPRI is conducting with the electric industry in this part of the world.

Role of global and regional cooperation in supporting electricity R&D

Mark LAUBY
IERE Treasurer, Regional Director for EPRI Worldwide

I am very pleased to be able to talk about the issue of cooperation and its importance, especially at the regional level. I have chosen this topic because in many parts of the world where I have worked, especially in southeast Asia, there is a veritable need to work together at the local and regional level and to take advantage of global cooperation.

In the 1920s, Steinmetz said that the power system was the largest machine ever built by man. Today it would be more accurate to say that it is the largest computer ever built because of the way that some power system technologies and characteristics of the distribution system perfectly meet the needs of consumers.

I. Why cooperation is needed

Why is there a need for regional cooperation? We cannot deny it, the value which society grants to electricity is constantly on the rise. As proof, you need only look at the cost which EPRI has had to bear for its power outages in California and to compare it to the company's overall revenues. We are well positioned to know that the price of electricity is on the rise.

It is also important that we understand that the electrical industry must offset its impact on society against the benefits it brings it. In the United States, this was the major factor which led to the creation of EPRI in the early 1970s: make up for the industry's delay in solving the energy problem and become aware that this problem went beyond the state level.

In addition to the purchase and sale of electricity, the entire electric industry is going global. Globalization is especially evident in the activism of the NGOs. In the past, a local transmission or generation problem was not perceived as a global problem. The only exception was nuclear generating stations, where any significant event took on global proportions. Today, this trend is starting to affect all of the issues which the industry must deal with. I am referring to mercury, coal, the greenhouse effect, global warming, and climate change. The problems are becoming global and the industry itself is following the same trend by restructuring.

Companies everywhere are expressing a need to develop competitive infrastructures. If we do not invest in these areas, several studies show that productivity will decline. And productivity for us is a key factor. In fact, the unmet needs of end users and their demands are associated with improving reliability and quality and they will require this from the power system. The way in which we have viewed our trade in the past is therefore not the same approach that we should be adopting for the future.

Electrification is evidently an important topic. However, since you will hearing about it today at greater length, I will merely say that it represents a challenge for the industry and even for humanity.
The level of R&D investment is without doubt insufficient. The most recent reports reveal that R&D expenditure in the area of energy is on the decline throughout the world, with the exception of Japan.

II. The challenges of R&D

Globalization is an unprecedented occurrence: the human community is getting smaller. This brings to mind the Disneyland slogan of "It's a small world," which is proving to be increasingly true. To deal with these changes, the industry may be restructuring but chooses to adopt a short-term vision rather than a long-term one. We are therefore experiencing an accumulated delay as regards technical problems. We need to continue working on this together. Two major issues emerge: operational efficiency must be reinforced even more and the reliability of our systems must be optimized.

To give you an accurate picture of the situation, I would say that we are faced with technical problems on a larger scale and ones that present greater risks. A partnership is therefore needed to efficiently meet future challenges: a public/private partnership that calls upon manufacturers, system operators and nations. Significant investments are needed to improve the existing power system, but there is also an urgent need to strengthen research and development. For instance, with respect to the reduction of carbon emissions generated by their power plants, many regions are voicing their concern. If this problem is not resolved, these countries will not be able to benefit from direct – albeit vital – investments. In fact, investors are turning away from nations that do not meet a certain number of criteria, including this type of environmental standard.

Universally applicable solutions are required, especially for electrification. But when one looks at the solutions adopted in the past for the electrification of developing countries, one can see that these are miniature versions of the advanced technologies implemented in the developed world. We must therefore continue to develop technologies with multiple applications. Of course, access to electricity still needs to be more widespread; you will have an opportunity to hear about this later today.

Strategic investments are required, but we need to determine which ones, identify the shortcomings and determine who can fill the gap. To this end, we need to adopt a "technological road map."

The electrical industry has everything to gain with regional cooperation, which would enable it to:

- Strengthen electrical infrastructures at the regional level;
- Revolutionize the value of electricity services;
- Step up economic growth, productivity and prosperity at the regional level;
- Resolve the energy/environment conflict;
- Deal with the global sustainable development challenge.

These are global issues but with potentially regional or local implications. For instance, in southeast Asia, the main concerns pertain to pollution clouds and water. The difficulty, for the many countries of this region, lies in working together to solve these problems and in interconnecting their systems. Once again, additional technical difficulties must first be resolved, and also assume that there is cooperation.

The American Academy of Engineering has hailed the power system as being one of the greatest engineering achievements of the 20th century. But if we do not consider the challenges that I have mentioned seriously, this power system will become an archaic relic in the 21st century.

III. Interdependence between regional and international aspects

We must foster the conditions of sustained R&D investment for network-based industries, including the electrical and energy industries. All of their activities are interrelated, from coal mining, and oil and gas operations to the generation of electricity.

Manufacturers need to coordinate their investments so that long-term programs may be implemented. The energy sector must pool its resources and work together on crucial issues rather than working alone on solving problems of competitiveness. When I talk about resources that need to be pooled, I am not only referring to funds but also to personnel and time. Electrical engineers have succeeded in making use of such cooperation to build, over time, a network costing several billion dollars.

Regional and international issues must be considered simultaneously to create a link between the players and lead to the development of technologies with multiple applications.

All of the studies show that, without these investments, our facilities will rely less on advanced technology and productivity will decrease in the developed world. This will make it even harder to solve electrification problems.

Impact of electrical industry deregulation on R&D management

Yoshiharu TACHIBANA
General Manager in charge of R&D and deregulation at TEPCO

I will be speaking about R&D management in the competitive market which has arisen from the deregulation of electricity in Japan. In 1995, the wholesale industry was deregulated, followed by the retail sector in 2000 for consumers of over 20 kV or 2000 kW. In 2004, this level will decrease to 500 kW, while an additional decrease is already under way.

I. The impact of deregulation on management

Costs must be reduced throughout the electrical industry, in R&D as in operations and production.

R&D expenditure has traditionally been considered as a mandatory expense in the operation of a power system. R&D costs could be covered by tariffs decreed by government. In the new open-market system, these costs are easily absorbed through investment. No R&D projects must therefore be undertaken without the guarantee of an adequate return on investment.

Moreover, the relationship with eligible consumers must be reconsidered. In the 20th century, the level of electricity demand from Japanese manufacturers was high and the electric utilities' sales depended on these customers. Recently, however, the growth in electricity demand from these customers has decreased, then deregulation was introduced and many consumers turned to natural gas to meet their energy needs. We can therefore no longer count on loyalty from customers, with whom we must redefine a relationship.

As for intellectual property, its importance is undeniable. If, in the past, it could be neglected without any repercussions, it has now become a strategic element for operators in a competitive environment.

Lastly, and most importantly, the *raison d'être* of R&D departments appears to be in question. As Mr. Lauby mentioned, the total R&D expenditure in Japan has not decreased. However, for some time the government has been spending more on nanotechnology, biotechnology, information technology and the environment to the detriment of energy. A decrease in public spending in our industry is therefore underway.

II. Dealing with challenges

My first action was to restructure research and development at TEPCO. Managers have had to set target objectives, intellectual property management was bolstered and an evaluation method was introduced. For the first time, guidelines have been set for the allocation of budgets.

1. Restructuring the R&D department

TEPCO had four research centres which we have grouped into one. The research groups have been reduced from 30 to 21. We then grouped them into three categories.

a. Project groups

Each group has a specific objective and its manager must realize the group's mission in two to three years, otherwise he/she is transferred within the company.

b. Sector-based research groups

Their design is fairly conventional. For instance, the thermal generation technology group is dependent on the thermal generation department and meets the needs of the thermal power plants.

c. Fundamental-research groups

These include a human factor group, energy system technology group, equipment group, etc.

2. Setting target objectives

Each manager is assigned target objectives. Naturally, the figures are confidential and I cannot provide them. The objectives for 2005 are as follows:

- Cultivate demand by developing new technologies to win back customers from natural-gas companies and other energy providers;
- Set cost-reduction objectives;
- Develop the market since energy demand in Japan is not increasing as quickly as in the past (TEPCO, like other companies, must diversify using the research and development centre);
- Reduce CO_2 emissions;
- Improve the recycling rate for household waste.

3. Strengthen intellectual property management

I myself have bolstered the intellectual property managerial function, clarified responsibilities and hierarchies, and promoted an incentive system and personnel management.

4. R&D evaluation method

I introduced an R&D evaluation method. For the time being the method is only experimental and we are not relying exclusively on this method, but it is one of the criteria that each group manager must meet. The idea is to quantify the contribution made by each research area before evaluating an R&D budget.

The evaluation method uses a graph in the form of a scatter diagram which takes into account the level of maturity of the projects and their respective cost. But some projects cannot be quantified in such a way: in this case, a grading system is used. For instance, environmental research cannot be easily quantified in yens; this is another lesson learned from the evaluation method.

5. Guidelines for R&D budget allocation

In the past, operators could obtain funding fairly easily for the research projects that they wished to carry out since their cost was absorbed by electricity rates. R&D investments must now be covered by revenues and market prices. Under these conditions, one can understand the importance of imposing guidelines and subjected research budgets to them. In 2003, TEPCO managed to allocate 64% of its R&D budget to areas covered by the scope of these guidelines.

III. A few examples of R&D in a competitive market

1. Developing applications aimed at retaining customers

To increase our competitiveness in the natural gas industry, we developed a heat recovery boiler that uses CO_2 as a coolant for industrial purposes. This is the result of a fruitful collaboration with CRIEPI, which handled a large part of the fundamental research. Another area that is highly competitive is household appliances, for which we have set up a performance evaluation laboratory. Lastly, we developed a battery system called NAS for electricity storage.

2. Increasing competitiveness to adapt to an open market

A reduction in thermal power plant maintenance costs is needed. Thanks to the methods we use to evaluate the lifespan of components subjected to high temperatures, we send our test results to the power plants so that they may reduce their costs.

We still have traditional research laboratories that use power system simulators combined with computer programs. We will need this type of technology, especially when decentralized generators must be connected to the power system.

To reduce transmission and distribution maintenance and operating costs, the availability rate of transmission infrastructures is in the process of being increased. We are testing CV cables to determine how much their maximum temperature can be increased without reducing their 30-year lifespan.

On the nuclear front, we have a laboratory where researchers study stress corrosion cracking. Monitoring this type of crack requires that all our nuclear power plants be shut down from time to time. Thanks to our researchers’ work, a new power plant has been designed that does not present this drawback.

3. Diversifying our activities

We have developed a technology where photographs are transmitted by solar energy, which was originally intended for transmission line maintenance. This system can be used to monitor the environmental impact of high-voltage lines on wildlife. The scope of application is vast and no doubt represents state-of-the-art technology.

4. Finding solutions to social and environmental problems

In terms of climate change, we have conducted a study on carbon wells and the storage capacity of carbon dioxide in the Japanese forest ecosystem.

We also did a study on the human factor in the nuclear industry.

Lastly, to deal with a competitive environment, we are trying to increase the authority of our managers. They must meet very high objectives or they are transferred. On the other hand, they are given more responsibilities.

In addition, we have implemented performance evaluation grids for our researchers, even if this initiative is not appreciated.

Yves BAMBERGER

There is much similarity in the activities and performance projects between what Mr. Tachibana has presented and what is being done at EDF.

We will now turn to the United States on a quite different topic. Mr. Hamid Elahi, who is in charge of power systems energy consulting at General Electric, will present a talk on wind energy.

State of wind energy

Hamid ELAHI
General Electric

Over the last five or six years, we have been witnessing spectacular development in wind energy generation in the U.S., with about 200 GW being added to an already impressive wind generation capacity. It is estimated that by the end of 2003, wind generation capacity shall attain 950-960 GW.

I chose to talk about this type of energy today because it has been the subject of growing interest in the United States, a country with substantial wind energy resources. I will be looking at economic and technological factors, as well as the prospects for this type of energy.

I. Economic factors

Wind energy generation costs have decreased considerably, most notably due to new technology, and these costs are now comparable to those of fossil fuel-based thermal plants. There have also been considerable incentives in the U.S. at the state and federal level to make the technology more attractive to developers and investors with an interest in this "green" energy.

The wind energy potential in the U.S. is substantial and all those worried about the United States' dependence on oil see this as an additional argument in favour of wind-generated electricity.

In terms of the cost of generating electricity, a comparison with means of generation based on natural gas and coal show that wind turbines compete well with an output of 28% and 40%. Given the volatility of the price of gas and fiscal incentives that favour wind energy, this technology is a competitive alternative, even when compared to efficient combined cycle plants or coal plants that use new technologies. One of the competitive aspects of wind energy is the absence, in its cost structure, of the cost of primary energy.

Fiscal policies are one of the major factors of wind energy development. Many states have established incentive policies that are both fiscal and regulatory in nature. By regulatory incentives I am referring to real-estate assistance programs, credit assistance programs or tax credit programs for producers and end users. At the federal level, the House of Representatives and Senate have adopted legislation that guarantees, up to 2007, tax credits that can be applied for existing producers and those investing in wind energy in the future.

As for wind energy resources in the U.S., the wind chart shows only one zone without much potential: the southeastern United States. However, wind energy resources are especially abundant in coastal regions.

A review of the means of generation used in the United States reveals that in 2002 net electricity consumption totalled 38,100 TW/h, 50% of which originated from coal plants, 20% from nuclear plants, 18% from natural gas plants, 7% from electrical power plants, and only 1% from wind energy, the remainder being provided by other forms of renewable energy. Based on these figures, one can see that we are still very dependent on coal, and concerns regarding coal emissions should favour the development of renewable forms of energy. The growth of wind energy stalled in the 1980s and early 1990s, but it has taken on new life again with a remarkable rise in 2002. It still does not account for much of our 960,000-MW generating capacity, but its progression is slow and steady.

II. Technological factors

Technological factors are related to the increase in wind turbine size, increase in output, and the capacity to optimize their implementation.

We see many wind farms springing up, such as those found in Europe, Denmark, Germany and Spain. In the U.S., this is a new form of energy and we are learning how to meet quality requirements.

In terms of wind turbine size and output, over the past 15 years there has been an increase of a few hundred kilowatts, to 2.2 or 2.3 MW for the more recent units. To obtain these impressive results, the size of the structures has been increased, including turbines, blades and masts, which is not without environmental problems, especially in terms of aesthetics on the coastline. But there are undeniable technological advances, especially when the units are concentrated in farms.

Wind turbine implementation has become highly scientific. Not too long ago, it depended on real-estate speculators who set up wind turbines wherever they considered wind conditions to be adequate. We now have a multitude of atmospheric data and decisions are based on 10- to 15-year forecasts for a given area in order to choose suitable sites and altitudes.

At a given site, it is possible to determine the ideal number of wind turbines to be installed, and the potential prospects and revenue from the outset. It is therefore possible to know in advance a site’s potential in financial terms. One must then study the distance to the grid since suitable locations are often far way from 5- and 45-kV lines. This data must be taken into consideration.

Wholesale markets are found in the U.S. Based on the prices in these local markets, it is possible to determine the cost-effectiveness of an installation at a given location based on its size. Once the data has been gathered, a loan can then be negotiated with a bank. This is more or less what combined-cycle power plant developers have been doing over the last five years.

One of the major areas which has developed considerably over the last two years is solving grid integration problems. In the past, when an operator had wind turbines in his service area, he would elect to systematically shut down all of the facilities in the event of a disturbance, incident or storm. He would not make use of the wind turbines to increase the grid’s reliability or ensure continuous service. A reverse situation occurred recently: wind turbines are now not only being required to withstand disturbances but to restore the system while ensuring continuous generation. There is the example of the wind farm in New Mexico which consisted of 130 1.5-MW turbines located next to a high-voltage relay. The operator-host had required that, in the event of major voltaic disturbances or any other incident, the turbines would have to continue to operate at 100%. We were able to demonstrate through modeling that this was the case with our wind turbines, which constitutes definite progress.

III. Outlook for wind energy in the U.S.

In terms of growth forecasts, we have the figures for the end of 2003 which were provided by the American Wind Energy Association. Europe is still ahead in terms of wind energy development. The United States is progressing but still lags behind Europe. In the coming years, the growth in the U.S. should be comparable to the rest of the world, and by the end of 2003, 36- to 37-GW wind turbines should be available. When compared to total generating facilities, these are modest figures, but for those of us who believe in the environmental advantages of wind energy, it is very promising.

As regards the type of wind generation facilities being built in the U.S., there is an increasing number of wind farms, either alone or interconnected on networks of over 200 MW. Their implementation is determined using a highly sophisticated technique which I spoke to you about that ensures optimal cost-effectiveness. These wind farms are the result of a cooperative effort between electric utilities and developers, as was done for combined-cycle plants. There are also potential off-shore sites all along the Atlantic coast. A large-scale project is under way with the Long Island Power Authority. It has a potential of 5.2 GW, but the actual installed capacity remains to be determined.

The U.S. Department of Energy is investing considerably in the development of wind energy in low-wind areas (4 to 5 m/s). In the current state of the art, wind energy is not cost-effective in these zones. We are therefore developing the technical means to make use of the areas. We have designed a wind turbine with a short mast and blades which presents an advantage from both an aesthetic and technical standpoint.

Wind forecasting is becoming increasingly reliable, which is necessary when the electrical supply must be ensured even when wind conditions are less optimal. Thanks to technologies that combine meteorological science and electrical engineering, forecasts are improving. This is crucial for wind energy to exceed 1% of total generating facilities as is currently the case.

We have also been developing hybrid materials for the masts and blades to make them sturdier in high-wind areas or lighter in areas when environmental constraints affect the size and weight of the structures. This is a crucial area for R&D.

Lastly, for developing countries with wind resources, we are working on developing hybrid wind/diesel/battery systems that make use of this renewable type of energy.

IV. Questions

Yves BAMBERGER

Before opening the discussion to the floor, we agreed to bring up certain issues. I would like to ask Roger Lanoue from Hydro-Québec to begin.

Roger LANOUE

Mr. Lauby, you talked about the need for cooperation, especially at the regional level, to improve electrical infrastructure investments. I would like to know what you think about how cooperation has evolved between the states, operators and private industry. All three play a role in electrical R&D, but with an open market system, one notes that budgets and the involvement of the players is threatened, especially for operators and manufacturers. How do you perceive this trend?

Mark LAUBY

I was afraid that you would ask me about California... Your question is relevant since it touches upon what our research plans should be. Manufacturers appear to operate based on the idea that R&D investments made at the beginning of the year should result in major investments at the end of the year. This is a short-term vision of R&D. A long-term vision is needed of the industry's and society's views and needs. Once we have a clear picture of this, i.e. a plan, we need to determine what investments are required. These investments are substantial, risky in some respects, and widely exceed the capacities of a single company or even state. I believe that for long-term planning one needs to adopt a global or regional vision which assumes a closer relationship between groups; a public/private partnership is mandatory.

Yves BAMBERGER

Mr. Tachibana, one of your documents states that you have two technology groups centered on demand. Could you tell us more about this?

Yoshiharu TACHIBANA

The first group deals with heat pump technology that will be available two to three years from now, while the second group is conducting research on heat pumps of the future and other demand-oriented technologies, including a new heat pump design that uses water as a coolant.

I now have a question for Mr. Elahi. Mr. Lauby spoke about the need for international cooperation; how would such cooperation be useful for wind technology?

Hamid ELAHI

Wind turbine manufacturers support each other and work well internationally since they share a common heritage, the same problems. To become more competitive, we have been working with manufacturers from Europe to Asia. The problem with wind applications is that the distribution system must be designed in reverse. In terms of a distribution network, the supplier is at one end and the user at the other, whereas now there is another supplier at the end of the line. The greatest development opportunities are found in the differences in distribution systems throughout the world. The distribution systems in the United States are relatively different from those of Europe and developing countries in Asia, the Middle East and Africa. This is a field where harmonization is needed but engineers are sometimes headstrong and have their own way of doing things. Standardization will not be achieved overnight; this is a vast area open to research and development.

Audience

You brought up the price of wind energy and its competitiveness compared to other types of energy. But with the deregulation of markets, energy that cannot be forecast will have a low price on the market. Therefore, do you not think that a major R&D effort is needed to store this specific energy and that there is a strong incentive to find low-cost storage solutions?

Hamid ELAHI

I fully agree with you. This is an essential application for those of us eager for storage to become a reality. In fact, if one looks at the environmental impact in terms of emissions, for all facilities during daily or seasonal peaks, one can see that the advent of storage will have a very positive impact on the environment as well as consumers, and will improve the return on investment. So you are right: storage can be a cost-effective solution if proper use is made of it and wind energy is paving the way for this.

Audience

Mr. Tachibana, you spoke of the importance of intellectual property for TEPCO. Can you give us more details, especially as regards your objectives? Are you aware of what your competition is doing in this respect?

Yoshiharu TACHIBANA

When we began about a year ago, the intellectual property division was very limited and included only a staff of six. This was a reflection of the electric utilities' lack of interest in intellectual property. We increased staff to 30, but we were still lagging behind manufacturers and natural gas companies, who had 100 to 200 researchers working in their intellectual property departments. We had increased the number of staff and called upon outside experts when necessary. The objective was to streamline, to become a run-of-the-mill company. TEPCO was an exceptional company and had to become more standard.

Audience

I wanted to thank the speakers for the quality and clarity of their presentation as well as for their frankness.

Mr. Tachibana, what is the nature of TEPCO's relationship with universities and the scientific community? For instance, do you use thesis students to maintain your course of development?

You mentioned that deregulation has forced you to implement a new human resources management policy. You said that if managers did not meet their objectives they were let go, and you have set up a performance rating scale for researchers. Could you tell us a little more about this scale since I work in R&D and believe that research is not ordered… It moves along one step at a time, it depends on team work, a string of small steps which lead to innovation. Therefore, I find that it would be difficult to set up either an individual or group rating system.

Lastly, has setting up such a new human resources management plan led to more innovation in your company?

Yoshiharu TACHIBANA

Thank you for your questions. They are all pertinent and would merit that we spend an hour or two on them…

Our relationship with universities should be strengthened, but a line should be drawn with the past. In the past, we have had to increase the voltage of transmission lines from 275 to 500 kV, and then 1100 kV. To do so, we have relied heavily on cooperation with the academic community. We now no longer intend to increase the transmission system voltage. On the other hand, we have been introducing new sources of energy such as combustion cells and wind energy. Power system analysis technologies are therefore crucial. We are working together with universities in this area. However, such joint ventures are shifting from traditional sectors to new areas such as information technologies, nanotechnologies, and biotechnologies, which could be used in the future by the electric industry. Our cooperation department will need to adapt.

In terms of how we treat our research centre managers, we do not fire anyone but ask managers to find new areas of research within TEPCO. However, it is true that the managerial appraisal process is very complex. As for the method used to evaluate researchers, you are right: team work is essential and no rating scale can be used to assess the human factor. Brilliant researchers may have interpersonal problems, and decisions are difficult to make. The evaluation grid that I spoke about is therefore only one of many assessment tools being used.

Audience

My question is for Mr. Lauby. You spoke of the global challenges which the energy industry has to face and stressed the importance of cooperation and international agreements in furthering R&D. I would therefore be interested in knowing your position and that of EPRI on the non-ratification of the Kyoto Protocol by the U.S.

Mark LAUBY

I do not know what EPRI's official position is and will not state my personal views. However, I have been able to note all over the world that it is through regional and international cooperation that environmental problems such as climate change can be tackled. Developed and developing nations recognize this need and seeking avenues of cooperation, whether the Vision 2020 coal program or IGCC technologies. The idea is to develop technologies that provide a balance between the industry's social advantages and disadvantages.

Audience

Mr. Elahi, you referred, with respect to wind energy, to improved meteorological forecasting. But what type of forecasting are you referring to? Is it daily, hourly? Furthermore, to better allocate wind energy resources, do you have any energy storage projects in mind?

Hamid ELAHI

Your first question deals with forecasting. In the U.S., there are many places for dispatching markets on a daily basis which require forecasts for the next day from 7 a.m. to 11 p.m. They need to know generating requirements and, based on the power producers' availability, forecast interconnections on an hourly basis. Many areas have effective and potential reserves. By monitoring wind on a daily basis, operators can commit to a certain supply, with contractual provisions in the event of non-delivery. None of this was available in the past, and we are working on making it a reality. Wind power producers thus are no longer non-distribution based and have become distribution-based. The technology is still not fully mature, but we are making considerable progress.

As for your second question, regarding storage, we are still in the early stages and no formal structure has been set up in this effect. However, many see this as a viable option. The seeds have been sown.

Audience

My question pertains to Mr. Tachibana’s presentation. You spoke about “monetizable” research versus research that cannot be evaluated in financial terms. Can you give us some idea of the proportion of each of these types of research?

Yoshiharu TACHIBANA

At present, half the projects involve objectives that can be quantified in monetary terms. Naturally, many managers were against the idea of having their research evaluated in such a way. But we convinced them, such that now half our projects can be assessed. We would like to increase this ratio to 70%.

Research contracts with third parties on the deregulated electricity market

Nano BOLT
In charge of production systems at KEMA

Before talking about contracts with third parties, which shall be the final part of my presentation, I would like to discuss R&D trends in the electrical industry in Europe and the Netherlands, as well as the resulting way in which the R&D structure has changed.

I. Market deregulation

The Dutch example is symptomatic of what has occurred over the last three to four years with the deregulation of markets.

In the Netherlands, three out of four power producers are now foreign and are based in Belgium (Electrabel), Germany (E-ON) and Texas.

There is a trend on the markets toward a decrease in size: the large regional companies are giving way to small players. In addition, markets tend to become fully deregulated and, while I cannot predict the consequences on power producers, I know that there will be some. Independent power producers, especially those involved in industrial cogeneration, are already increasing their market share, just like transborder exchanges, which about a year and a half ago accounted for over 20% of electricity consumption in the Netherlands.

The appearance of independent markets is another determining factor in this changing situation. The Amsterdam Power Exchange is thus a market where producers propose quantities in kWh and the respective prices to consumers, who choose their supplier for a 24-hour period. This market represents 20% of electricity consumption in the Netherlands during business days, which has a major impact on electricity generation.

The last crucial element is that of consumption peaks, which present a problem in terms of ensuring that the supply meets such massive demand. These peaks do not always occur at noon on business days and can be impossible to predict. On average, full hours are billed at 20 Euro cents per kWh and this is how power producers realize substantial profits.

Lastly, there is still talk about excess generating capability in Western Europe, but one needs to take into account the increase in consumption. The Netherlands will not have any excess generating capability next year.

II. Impact on R&D

In terms of R&D, cooperation and risk sharing are especially sought after in two areas: non-competitive R&D and pre-competitive R&D. The first pertains to issues such as environmental regulations, working conditions and health, and waste management (e.g. fly ash from coal plants, clinker). These issues are not perceived by producers as being part of their responsibilities, such that they are seeking to share costs and innovations. Pre-competitive R&D pertains to materials, for instance; the spread of a crack requires research into physical and mathematical laws which have nothing to do with issues of competition. On the other hand, when instruments used to study the expansion of cracks are used by competitors who incorporate their risk profiles and operational methods, then the tool becomes competitive.

The return on investment, previously anticipated over the long term, is now expected over the short term. The return on investment expected by our financial backers is usually calculated over two years starting from the start of the project, such that most of our projects are not more than six months long. This is no longer really R&D but rather a final development phase.

Finally, in all companies the trend is toward limiting spending, which serves as an incentive to applying for grants from national or European public organizations.

III. R&D issues in a competitive environment

Deregulation more than anything has led to a certain number of R&D objectives:

- Extending the lifespan of equipment to prolong the use of physical assets;
- Biomass co-combustion to meet the requirements of the Kyoto Protocol and replace 20-25% of coal-based generation;
- Operational flexibility, which is a major issue.

Furthermore, last December, the European Union adopted a guideline for CO_2 markets. Next year, CO_2 exchanges will begin, though many technical problems need to be resolved.

With respect to electrical power transmission, the advent of intelligent networks presents opportunities for increasing transmission capacity and security.

All of these issues are centered around short-term R&D, which creates a new need for long-term R&D. Last year, we drew up a technological road map for power system technology in the Netherlands. In it we attempt to determine the power system technologies that will be needed around 2005. This document was produced at the request of the state and high-voltage system producers and operators. Its main objective is to determine a research plan for the long term.

To do so, we have drawn up several long-term electrical supply scenarios, with two extreme scenarios: a total free-trade scenario, and an extreme environmental scenario. However, in the four scenarios that we studied, the following common trends emerge:

- Increase in electricity consumption from 60 to 70%;
- Increase in import and export capacity;
- Decrease in power plant capacity from 12,000 to 6,000-8,000 MW;
- Increase in decentralized generation (wind energy, especially off-shore generation);
- Biomass which is proving to be the main source of renewable energy.

A research plan provides an idea of what we would like to see in 2025 by forecasting target figures and by defining who will be in charge of financing. In most cases, funding will come from generating facility operators, with the government being the key player for more fundamental research. Lastly, users will be responsible for research regarding end use consumption.

IV. Electricity R&D trends in Europe

Last March, EURELECTRIC, the Union of the Electricity Industry, issued a report on R&D trends in Europe. The report includes a little of what I have talked about. The market factors that have been identified are cost reduction, energy efficiency, the security of the electrical supply, and environmental regulations.

In terms of R&D structure, the report notes that in Europe there is a trend toward downsizing the large departments in favour of small applied research units. The report also talks about a trend toward externalizing R&D.

Regarding projects in Europe, the report indicates that most R&D projects originate from bottom to top proposals, from researchers and approved by management.

The report's authors also note a lack of financial and human resources and a shift toward short-term projects. They also believe that there is a tendency to favour competition over cooperation. They state that projects are funded in part through self-financing and by an amount included in electricity rates. Lastly, it would appear that some companies are resorting to subsidies provided by the European Union.

V. The transformation of KEMA in 20 years

Just a short time ago, KEMA was still a public organization. In the 1980s, there were about 70 small electric utilities in the Netherlands that were vertically integrated (generation-transmission-distribution) and owned by local communities. KEMA's director was also chairman of the Producers' Council. At the time, annual growth in consumption was 10%. KEMA only had a branch in Arnhem and an R&D division which included 150 to 200 employees. Revenue came from our only customers, i.e. electric utilities. R&D accounted for over 95% of revenue. At the time, 50% of R&D in the Netherlands revolved around nuclear energy. Then came deregulation, independent power producers, the Amsterdam Power Exchange, and lastly a major privatization movement.

There were changes in our relationship with R&D clients. In 1994, we switched from a contract-based system with mandatory means to a system that required results.

Like TEPCO, we analyzed the return on investment for larger projects, which for us represents 40% of all projects. We used a probability of technical success and a productivity indicator. Naturally, this assumed that we had quantifiable objectives. But for long-term, exploratory research, we used a multi-criteria method. These days, financial backers use a competitive approach and do not wish to share potential profits. This is more difficult to achieve in a competitive environment.

To evaluate our quantifiable projects, we developed a method for calculating the investment/profit ratio. Based on a given budget, the projects are selected according to their productivity index and cost. The multicriteria analysis that we use for exploratory research is more qualitative in nature. It aims at providing management with an idea of the quality of the projects and more streamlined support in selecting projects to be developed.

As for KEMA's transformation process, it shows what can happen in a deregulated environment. KEMA has been operating independently since 1990 and is no longer tied to the Producers' Council. A structured based on business units has been adopted and we have set up a third-generation R&D management approach. KEMA became a multinational in 2003. In terms of its revenue, 60% comes from international sources and 4% from short-term R&D.

To conclude, a deregulated and open market appears to lead to a difference in size in producers, a reduction in costs, a greater impact from peak periods, and the need for flexible and reliable means of generation. In addition, the security of the electrical supply becomes a crucial issue.

In terms of R&D, the trend is toward an increase in externalization in our regard, and a return to the short term. Non-competitive and pre-competitive research becomes crucial, but in particular there is added pressure for more funding. Sources of funding are more diversified, while public funding is reserved for long-term projects and technologies.

In terms of organizational structure, the trend is toward using business units, a strengthening of commercial aspects, globalization, and the implementation of agencies that provide services and consulting.

Yves BAMBERGER

I would now like to introduce our next presenter, Roger Lanoue, who is director of research and strategic planning at Hydro-Québec. He will be talking about was Hydro-Québec is doing in terms of technological innovation. Mr. Lanoue is not an engineer by trade but has considerable experience in management and marketing.

Technological innovation at Hydro-Québec

Roger LANOUE
Vice President, Research and Strategic Planning at Hydro-Québec

My talk is an excerpt from a presentation I gave a few months ago to Hydro-Québec's board of directors in an aim to review the status of R&D within the company. The term "technological innovation" was being used to emphasize the need for economically quantifiable results.

Why does Hydro-Québec have an R&D centre? This was one of the questions brought up to the board of directors, just as in other companies which can still afford the luxury of having a research centre in electricity.

I. Background

Historically, Hydro-Québec has been at the forefront of a few technological breakthroughs. Some examples from the 1960s include the 735-kV transmission system, the design of a multiterminal 450-kV DC line linking James Bay to Boston, and the under-river crossing for this line.

Hydro-Québec saw changes to its status, and, in particular, when research was made a part of its corporate objectives. This was no chance occurrence; in fact, because development projects were basically hydro-based and hydroelectric resources were located far away from the loads centres in Montreal and Quebec City, there were few technical characteristics to deal with, such that expertise was developed over the years especially in large-scale transmission systems.

In terms of R&D expenditure, Hydro-Québec ranked among the top 15 Canadian companies in 2000 with a budget of about CAN$100 million, which represents about 60 million euros. The budget for 2002 was $110 million and was broken down as follows:

- $54 million for technological innovation, i.e. projects that meet the divisions' objectives;
- $14 million for strategic innovation and prospecting that is not directly covered by the divisions' budgets;
- $5 million for chairs and contracts with universities;
- $37 million for technical support to the divisions, i.e. support for technologies already implemented within the divisions.

Hydro-Québec is the only North American electrical utility to still have an integrated research centre of such size. But in the eyes of some at Hydro-Québec, this makes us a relic. Others, however, believe that this allows us to remain at the technological forefront to ensure the company's future.

Other solutions were retained elsewhere in Canada. In Ontario, for instance, electrical R&D was privatized in 2000. A joint venture was set up with a British firm. It ranks 44th among research centres in Canada, with R&D expenditure of CAN$42 million in 2001. In British Colombia, Powertech is a wholly owned subsidiary of BC Hydro. It is not very active and its annual budget is about CAN$12 million.

II. Achievements

Over the last 30 years, Hydro-Québec has had some success, especially in terms of commercialization, with the following:

- Power system software and simulators;
- Air gap measurement on transmission lines;
- System for detecting dissolved gases in transformers;
- Lithium-metal-polymer battery;
- Motorized systems designed at the time for electric vehicles.

One of Hydro-Québec's more recent and noteworthy achievements is MATH, a software program that simulates fluid flow in turbines. It will allow us to improve the design of the curve of turbine blades and increase the output of in-service turbines by 1%. This is strategically important for a company such as Hydro-Québec, whose generating facilities are 95% hydroelectric.

III. Scope of activity

1. Background

IREQ was founded in 1967 and began operating in 1972. At the time, it was a quasi-university institute specializing in electrical engineering. In 1985, a valorization and commercialization company was set up to make use of the developments originating from IREQ. It had limited success. In 1987, an electrothermal and electrochemical research laboratory was created. Its area of specialization would be energy applications, on the end-user side, along with energy use technologies.

The same period saw a major restructuring to set up a client/supplier approach between R&D and IREQ and Hydro-Québec's divisions or business units. This was followed by a period of little change, and then a period of progressive downsizing of R&D personnel. The client/supplier approach was given up in 1999-2000. In fact, seen in a slightly humorous vein, you could say that we had come to a point where we were maintaining a research centre with several hundred staff members who provided "high-end plumbers" to the project engineers in the various divisions for $50,000 projects. It had become a very large and costly in-house consulting service. In the late 1990s, we came to the conclusion that it was pointless to keep such a large research centre for such small projects. We needed to target greater breakthroughs, more ambitious projects, allow the imagination to rule by taking greater risks but with more control than in the past.

2. Current scenario: innovation that serves the company's needs

Here is the current framework in which we are attempting to give meaning to technological innovation at Hydro-Québec.

R&D in the electrical industry exists outside of Hydro-Québec, such as in small and medium-sized businesses, in universities, in government research centres, in industrial research centres (e.g. ABB, General Electric, Alstom, Siemens), and obviously within public utilities.
At Hydro-Québec, we are naturally aiming for profitability within our divisions and business units by cutting costs, increasing sales, developing reliability and creating new avenues of growth. Within this context, R&D is first and foremost centered around its core area: innovation projects. This function is structured into four portfolios which form partnerships with universities and other research centres. Their objective is to implement new products and practices thanks to a support service and testing laboratories.

The emphasis on R&D within small and medium-sized businesses is based on partnerships as well as access to emerging technologies through the venture capital provided by our subsidiary Hydro-Québec Capitech, which currently has about CAN$200 million invested in 38 companies. Capitech is also a way to gain access to a thousand business plans from worldwide companies seeking its financial backing. Without Capitech, we would not have access to small and medium-sized businesses and to their technological development projects. The subsidiary allows Hydro-Québec to acquire technologies and to have its divisions benefit from them.

Furthermore, a group of strategic innovation projects, i.e. not directly related to the needs of Hydro-Québec's divisions or business units, may lead to marketable innovations and therefore growth prospects for Hydro-Québec. In this respect, we have a subsidiary, Industech, which invests CAN$200-300 million primarily in two companies:

- Avestor, which markets a lithium-polymer battery being developed for the past 15 years;
- TM4, which is responsible for the marketing of technologies associated with the development of a wheel motor project (rather than the motor wheel, it is the miniaturization of the motor, which we have succeeded in developing, which may result in applications).

3. Redesigning innovation management

Outside of projects, R&D involves a considerable amount of upfront work: e.g. technological vision, prospecting, technological road maps. Innovation is the core and to capture its value, we must:

- Center research on topics that are of strategic importance to the divisions;
- Reinforce the managerial role by bringing up issues of project direction and selection at the highest level;
- Develop an integrated innovation management process, from ideas to application, so as to not pursue projects which have no application within the divisions;
- Emphasize innovation that targets core trades.

4. Technological innovation: a lever of growth

We have four innovation project portfolios: generation, transmission, distribution networks, and energy use by end users. The net discounted value for these projects is about CAN$566 million for an annual cost of about $100 million. Each project's net discounted value must be determined but does not necessarily constitute a selection criterion. An "80/20" rule applies, where 20% of the projects represents 80% of the discounted value.

There are 74 projects that are currently active. Their average length, from idea to application, is 4.5 years, the average payback period is 6 years, and the average budget is $4 million, not including implementation costs.

5. Redesigning innovation management

Four teams were set up to manage the portfolios. The research institute was restructured so that it is centered around expertise that uses a matrix-based approach, with those with the know-how on one side, and those that issue orders on the other. A technology valorization division was set up to handle marketing and intellectual property management. Innovation portfolios were set up. Finally, integrated innovation management processes were developed.

A stage-gate™ process is used to set up projects and shelve them if required. The major difference was that of being able to put an end to projects which had no application. Grids are now used to evaluate a project and invest the necessary funds if the project is considered to be useful. If the project has no practical application, funds and human resources are reallocated to promising projects.

A portfolio management process ensures that the projects are of high quality and that there is a backlist available if research is stopped.

Lastly, an industrialization and marketing process is used when a technological breakthrough is achieved and patents are filed. All of this is managed by a "platform team." Every month, each portfolio is reviewed and the project stages analyzed by a committee which I co-chair with one of the managers from the unit involved. The brainstorming sessions by the committee members allows recommendations to be made to the platform team in each area. This allows innovation areas to be identified, a multi-year development plan to be proposed, projects to be realized, ensure that intellectual property is protected, etc.

Each team has a team leader. Thus, there are 74 team leaders from IREQ or the division involved who manage researchers, engineers, technicians and specialists from various Hydro-Québec units corresponding to the project's progress. At each stage of the process, the project leader produces a report to the platform team.

6. Portfolio management objectives

The portfolio management objectives are as follows:

- Allocate resources so as to maximize the portfolio's value;
- Ensure that there is a balance;
- Ensure that there is a sufficient number of projects;
- Make sure that innovation is in line with the divisions' business strategies.

A portfolio's composition is reviewed on a regular basis by determining the share of innovation, the share of means (which should be reduced) and the share of financial resources earmarked for prospective monitoring. Another criterion used to achieve a balanced portfolio is the type of innovation involved. Are we targeting innovation that can be easily attained over the short term – known as incremental innovation – or major or radical innovation that involves some technological risk but has greater added value?

Finally, the last criterion is that of spinoffs, over the short, medium and long term. These are the three “filters” through which the portfolios are assessed.

We regularly monitor innovation spinoffs using 10-year net discounted value forecasts of our projects.

7. Project-based management

This is the stage-gate™ process: from ideas to implementation, resources are allocated in stages based on decision points. Several aspects are assessed at each stage such as, of course, technological data, as well as commercialization prospects, implementation risks, intellectual property, legal issues, etc.

8. Implementation and expertise

Some 50 projects have already been implemented, for which those in charge of technological innovation, including IREQ, continue to support the divisions in several areas. In addition to researchers involved in the innovation part, there are equipment testing laboratories, for the support and expertise part, which can test equipment not related to projects associated with technological breakthroughs.

Prior to this, there is the road map process which mirrors to some extent what is being done at EPRI; it is used to determine major technological changes so that we can anticipate the factors that will influence technology within each division. It allows us to determine the areas which the company should be monitoring and helps identify, for the next 20 years, future technological developments likely to affect Hydro-Québec’s technology. Based on this, the potential losses and gains can be determined for each project.

9. Expertise

Expertise is a crucible of ideas, a doorway to researchers’ imagination. Good ideas for new projects start there. We try to ensure that researchers each have 10 to 15% of their time free for developing projects that could be included into a portfolio.

10. Capitech

Capitech, as a venture-capital company, tries to conduct “profitable” technological monitoring, which has become difficult in today’s venture capital market. Capitech allows us to be active on the market and to make emerging technologies available to the divisions, invest in niches that meet the divisions’ needs. We are aiming for a return that is higher than the average compared to similar venture-capital companies. Capitech’s authorized capital is CAN$420 million, of which $200 million has already been invested, mostly in U.S. companies.

11. Industech

Industech is pursuing technological breakthroughs made during the 1980s when we were involved in research on electric vehicles. This accounts for the development of battery technology and a 50% share in Avestor. The target market over the short term is telecommunications and, over the long term, vehicles and electrical power systems.

TM4, a wholly owned subsidiary of Hydro-Québec, is developing motorized systems. Outside of automobiles, other applications for motorized systems involve decentralized energy generation, such as motors used for wind turbines.

IV. Issues

Our issues stem from our road map with its outlook 20 years from now, our venture capital with its outlook 15 years from now, and the actual projects with their outlook seven years from now. The idea is to cover everything that may affect Hydro-Québec's technological future.

Our challenge is to realize the major innovation spinoffs for the company while keeping track of the changes begun in technological innovation management.

R&D at EDF

Yves BAMBERGER
Director of Research and Development at EDF

You will note similarities and differences between what Roger Lanoue and Mr. Tachibana have talked about and what I will be presenting on EDF.

I am in a bit of a situation: though my IERE colleagues would like to know more about what accounts for EDF's success with R&D, most of you already know what I will be talking about. I will therefore be brief.

Similarly to my colleagues' presentations, I will be mentioning a few of our successes. I will be talking about the current status of R&D at EDF and on the company's situation. Lastly, I will briefly review our concerns about what the future holds.

I. Examples of successes

Increasingly, R&D is helping line personnel choose and specify new materials so that the right types of suppliers are chosen. I stress the importance of this role since this is not something that naturally comes to mind. Last year we succeeded, by pooling our efforts with the purchasing department and distribution system personnel, to specify new cables. A well-managed call for tenders further allowed us to reduce the cost of the cables by 10%. Given that we purchase thousands of kilometers of cable each year, this is no negligible amount.

I would like to mention a second, more scientific example of this role which some would refer to as "high-end consulting" but which is nonetheless necessary. It pertains to nuclear energy. One weekend, slightly contaminated water had leaked from a power plant. We needed to determine, through quick calculations, that the water table presented no risk of contamination for users and riverside dwellers. Thanks to a software program developed by the R&D division, we were able to solve the problem in 48 hours.

My third example is completely different. As you know, we have thermal plants in many countries, some as far away as Mexico. We implemented a system whereby power plant control and operational data can be gathered remotely. This system is designed to remotely mobilize the top experts to help an operator experiencing problems, whether in Mexico, Port Said, or elsewhere.

As a final example, I would like to mention the development of an exceptional calculation program that combines fluid and solid mechanics. It has enabled us to understand the origin of the large cracks that appeared on the auxiliary pipes of the Civaux power plant and to find a way to modify its geometry, when it was being repaired, in order to prevent such an incident from recurring.

So there are four relatively different examples which, while being operational, assume some upfront long-term development work with scholars and research centres from other electric utilities or French or foreign universities.

II. The role of R&D within the organization and R&D activities

Just like our colleagues, our work involves careful balancing – one that is at times difficult to maintain – between the short, medium and long term, and between monitoring and operations. This is a concern shared by management, which must be relayed to the teams so that they resist the temptation of focusing exclusively on helping the operator, even if this is undoubtedly useful and profitable to EDF.

Note that EDF has 100,000 MW in installed capacity and 30 million customers in France, but it is also an international organization with over 40% of its installed capacity and about 20 million customers abroad. For several years, in fact, we have been providing the Queen of England with electricity to boil water for her tea… and we also supply power to many others throughout the world.

1. EDF's structure

For our IERE colleagues who are not familiar with it, I would like to briefly review the way our company is set up. We are structured in branches that are primarily operational in nature. Headquarters are in Paris, in Wagram, and R&D is primarily concentrated in France. However, we are also expanding outside of France:

- In Karlsruhe, Germany, where we share a laboratory with the University and EnBW;
- In some subsidiaries whose activities are both internal and external, and with which we are working on developing shared programs.

2. Key players in research

I will limit myself to a national scope, which includes the locations of Clamart, Chatou and Renardières. In France, the R&D branch has a staff of 2,400, including:

- 2,000 researchers, engineers and technicians;
- Researchers teaching abroad;
- Doctoral students, whose numbers should be increased.

3. Our expertise

Our expertise matches that described by our colleagues. It touches upon the company's various areas of activity, both industrial and service-related.

Naturally, generation – in particular nuclear energy – is our primary focus. But we are also active in other types of generation, some of which, such as renewable energy, are emerging.

We are also working on commercial development. EDF is known for its personnel's work in this area and the support it provides should be reinforced.
We are still working on developing our transmission systems so that the structural changes imposed by deregulation in France can be realized.

We are obviously concerned about the environment, striving to limit the environmental impact of our power plants and complying with regulations, while adopting even more stringent standards.

Finally, we are looking into using information technologies to optimize EDF's operations.

4. Budget

Nuclear research takes up almost 40% of our R&D budget. Note that part of the research in this area is done in conjunction with the Commissariat à l'Energie Atomique. Electrical power research accounts for one fourth of the budget, and commercial development slightly more than one fourth.

5. R&D internal structure

R&D is structured around a laboratory division and program managers who are in charge of optimizing the portfolio of activities in each core area: business customers, generation, and transmission systems/environment. The managers discuss with the line staff which projects should be initiated, pursued or shelved. They also ensure the integration, into the portfolio of activities, of medium- and long-term projects which extend beyond operational projects.

The breakdown of activities over the short, medium and long term are as follows:

- 15% for long-term projects involving the acquisition and development of expertise and new tools;
- 17% for front-end studies which represent projects of three to five years in duration, depending on whether the field is power systems, nuclear energy or commercialization and information technologies;
- 54% for projects involving completed products or services, leading directly to operational applications (improved facilities or new services offered by the commercial teams);
- 14% of services provided to line staff, for whom we are "putting out fires" to some extent.

6. Funding and regulations

Regulations have changed and will continue to do so systematically and intelligently since people are involved behind the standards. It is therefore better to properly apply regulatory systems than forever changing them.

Currently, 75% of our activities are covered by the branch budgets and are therefore funded directly by the branches. It is through discussions with line staff that the subsequent year's program is defined and an agreement signed with the branches. This system was set up last year. The agreement is signed at the highest level of the branch, and I am in charge of signing the agreement for R&D.

The remaining 25% is spread out between activities conducted at the request of the company's main directorates (e.g. strategy directorate, environment directorate), complementary activities which we are responsible for, such as standardization and documentation, and activities that we decided to carry out for future needs (consisting of innovation activities which we call "level 1").

For the current year, we worked on a performance project that has almost been completed aimed at estimated the net discounted value of 83 projects which were completed in 2003.

This project was based on core areas. The results are relatively close to those presented by Roger Lanoue in terms of the ratio between the net discounted value and the total discounted cost. Once the final figures are available, the document will be published and widely disseminated since it is important for us to continue along the lines of this project.

In addition to gains valued at millions of euros, for each project we took the non-quantifiable gains into account. I will only mention the example of nuclear energy which, thanks to R&D, has allowed EDF to establish a relationship based on trust with the Autorité de Sûreté from a technical perspective. When our experts state their opinion on the condition of in-service materials, the Autorité de Sûreté takes their views into account.

III. Future prospects

R&D prides itself, not without reason, on creating the future. The future is uncertain; we are hoping to help build it.

This is the aim of some of our current projects, whether they target our customers, deal with environmental issues and sustainable development, or with performance through nuclear energy.

We have and intend to keep test facilities, and we develop simulation tools; either we create them ourselves, acquire them, or develop them in partnership with others. Naturally, we are concerned about generating cleaner energy. We will therefore step up our efforts on the environmental front since this is a universal problem.

Lastly, we are trying to be part of scientific breakthroughs, not only for our researchers' benefit, but also because we are convinced that the most advanced scientific methods will boost our revenues and improve services to our customers, as well as our relationship with the community and governments.

The most advanced scientific methods become operational over the years and of standard use. In this respect, R&D attempts to anticipate the investments needed in advanced fields. This is the direction of a project I initiated a few months ago entitled "Défi" ("challenge") to define what needs to be done over the medium and long term, i.e. within the next 5 to 10 years and even beyond.

IV. Questions

Yves BAMBERGER

I am reprising my role as session chair to resume discussion. Mr. Lauby, you have the floor.

Mark LAUBY

Mr. Bolt, thank you for your presentation. One point in particular caught my attention: the implementation of a technological road map. How do you think its applications can be extended and how do you perceive the progress made by European joint ventures in dealing with technological challenges over the next 20 to 30 years?

Nano BOLT

I believe that IERE has a role to play in assessing global needs, and with respect to Europe in adapting the research programs of the member states to meet these needs.
I have a question for Mr. Lanoue. Correct me if I am wrong, but it would appear that Hydro-Québec is not encountering much competition, which is understandable due to your low costs, which discourage potential competitors. However, would a competitive market still be possible and what would be the impact on your R&D?

Roger LANOUE

Last year, Hydro-Québec Distribution launched a call for tenders for the distribution of 7 TWh a year starting in 2007. Hydro-Québec Generation was only awarded half this market. Independent power producers and private thermal power producers are therefore arriving on the scene to compete. By law, Hydro-Québec Distribution is allowed 165 TWh of electricity at a set price. Beyond this amount, the market is open to the competition. The market will develop in the future, and if new hydroelectric resources can be developed at a lower cost, the generation output will be sold at market prices.

R&D will most likely be affected to some extent. I believe that we will have to develop opportunities for the new players on the major markets, but I am still not sure to what extent.

Mark LAUBY

In many multinational companies in the U.S. and in Europe there has been a shift in research towards world centres, with laboratories in China, India, etc. Does EDF intend to follow suit? Furthermore, does EDF have any plans to supply Mr. Bush with electricity?

Yves BAMBERGER

I will respond to the first question. We intend to build laboratories outside of France. We already have one in Karlsruhe, which was created in conjunction with the Karlsruhe university and EnBW. We would like to set up other laboratories abroad where opportunities present themselves, i.e. where we are already established in terms of generation or distribution and where joint ventures with universities are possible.

Audience

Mr. Lanoue, among the activities that you mentioned, you stressed the development and commercialization of industrial products such as batteries or miniature motors. What do you expect from these activities? A direct return on investment through the commercialization of the product? An increase in electricity sales? In other words, how do these activities fit into Hydro-Québec's overall strategy, as a company that generates and sells electricity?

Roger LANOUE

With the criteria that I presented to you, these products would not have been developed. They were developed in the 1980s because management at the time believed it could provide TWh for electric vehicle applications and realize profits equivalent to the sale of these components. The issue of extending Hydro-Québec's research objectives is based on future commercial success, since currently, with the divisions' objectives, such developments could only occur by chance or serve as complementary applications.

Audience

Deregulation creates specific R&D needs in terms of generation. Does EDF intend to give priority to this sector between now and 2004 or 2007?

Yves BAMBERGER

New technological developments, which have been stepped up in our core areas, and deregulation lead to many new needs. How are these needs met within the company or for others? The debate is ongoing, but as our people have shown, there is a trend and deregulation is only one aspect. Changes in regulation occur incrementally, as was seen in England; they also occur through technological advances. Without information technology, there would be no deregulation.

Audience

Mr. Tachibana and Mr. Lanoue, do you have a patent filing strategy? Can you give us an idea of the number of patents you file and whether they generate any revenue?

Roger LANOUE

We do not use a strategy but rather operate on a case by case basis. Based on what is done in Tokyo, however, I get the idea that we should be bolstering the management of our intellectual property. As for revenues, they are modest and total less than $2 million per year. The real value of technological breakthroughs is reflected in Hydro-Québec's balance sheet.

Yoshiharu TACHIBANA

All our patents are filed numerically. For the time being, we have no specific objectives as to the number of patents per year. We have just begun inciting researchers to file patents, which they were not previously doing. Last year, revenue from patents totalled about 1 million euros. I know that this is not very much, but it equals Tokyo University, so we are fairly proud of it.

Audience

Mr. Bolt, you told us that you reduced exploratory research. Meanwhile, it is an essential element, as the egg comes before the chicken. As exploratory research is the egg, how can you hope to get a chicken?

Nano BOLT

Naturally, you need to have an egg before you can have a chicken, raise it and sell it. But these days, we are looking for an egg in universities or in industrial processes. We then try to quickly adapt to the market by adding innovation. The stages, however, are always the same: egg, chicken, sale.

Audience

Can Mr. Lanoue tell us how much of R&D is in Hydro-Québec's revenues? This is an interesting indicator since it shows how much of profits go to innovation.

I think that one of the major roles of an R&D centre is to pave the way for the future. Meanwhile, one of Hydro-Québec's major resources is hydroelectric energy, and climate change is becoming a threat to this means of generation. Do you intend to invest in research on climate change to safeguard your interests?

Roger LANOUE

Hydro-Québec has annual revenues of $8 billion in Quebec and $13 billion in North America. You can compare this against the $100 million represented by R&D.

With respect to climate change, there are two aspects of concern to Hydro-Québec: changes in temperature and precipitation. Of the 74 projects which I spoke about, one of the most important is called Uranos. It consists of a joint venture with six universities, Environment Canada and several Quebec government departments. It represents total costs of $10 million and is spread out over seven years. This shows you that Hydro-Québec is serious about this issue.

Yves BAMBERGER

This round table represents what I would like R&D to become at EDF. As EDF is an international organization, involved on a global scale, our R&D should be part of this context characterized by exchanges with the worldwide scientific community. I would like to thank the presenters and audience.

R&D in Electricity Worldwide Trends

May 23, 2003, at the Clamart Site, EDF, France

IERE Central Office

2-11-1, Iwado Kita, Komae-shi, Tokyo 201-8511 JAPAN
Phone: +81-3-5438-1717
Fax: +81-3-3488-5100
e-mail: office@iere.dcc.co.jp
http://www-iere.dcc.co.jp