THE 21ST CENTURY NUCLEAR POWER PLANT MARKETPLACE

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ABSTRACT

This paper examines the restructuring of electrical generation, transmission and distribution utilities which is occurring in the Pacific Basin and elsewhere and their impact on the development of the nuclear industry in the region. While many structures currently forming are transitional, the framework of a new, internationalized global utility business is taking shape which profoundly alters the nature of the power generator marketplace. These changes have accelerated and have themselves been affected by recent developments in the technologies and economics of resource discovery and exploitation and power generation. They are occurring in a context of awakening concern for the environment on both local and global levels, rapid reduction of trade and investment barriers, the liberalization of energy pricing and currencies and the globalization of finance and capital markets. They have been both complicated and accelerated by the financial crisis which Asia is currently undergoing.

1. INTRODUCTION

After several decades of following a well established and stable industry structure which varied little across the globe, the electrical generation, transmission and distribution industry is undergoing a rapid evolution which is transforming the 21st century marketplace for nuclear power plants. The old line, state owned or private and state regulated monopoly utility is fast disappearing from the scene, especially in the more dynamic economies of Asia-Pacific, and a new breed of international utility is moving in to replace them. At the same time, Asia is industrializing at a blistering pace which puts extreme pressure on both resources and the environment. Awakening public awareness of these issues is forcing them to the forefront of decision making. The financial and banking crises which swept Asia-Pacific in 1997 and 1998 have redefined the financial landscape in which future business and investment in the region will take place.

This paper examines the utility environment that will face nuclear power plant vendors in the Pacific rim in the early part of the twenty-first century.

2. THE UTILITY ENVIRONMENT

2.1 The Monopoly Utility

Until the advent of large scale data processing and low cost distributed metering, the “public service” monopoly electricity generator, transmitter and distributor was deemed to represent the natural order. The sheer complexity of tracking the accounts of individual producers and customers made impracticable any of the competitive utility models now being contemplated.

In many jurisdictions, governments, on behalf of their constituents, aggressively expropriated privately owned facilities and delivered them into state or privately owned and publicly regulated monopoly utilities. These structures were considered to be most amenable to serving the public interest and seemed an appropriate vehicle for utilizing the common wealth represented by hydro-electric resources, which for a time were the source of a large fraction of new power generation in many regions.

State utilities in Asia and elsewhere have enjoyed the benefits of large size and government credit support, which allowed long term planning and low cost debt financing. They still own and operate the bulk of generation and transmission capacity in most countries in the region. However, throughout the world, the 1990s have seen a sea change in public sentiment away from state involvement in commercial activities, whether by ownership or regulation, and towards free markets. The role of government is shrinking almost everywhere. Some of the most aggressive utility restructuring has occurred in the United Kingdom, New Zealand, the state of Victoria, Australia and latterly in the U.S. states of California, Maine and Pennsylvania. In the U.K. and Victoria, most electricity generation and transmission is now in the hands of private companies, which operate at arm's length from each other. Victoria recently sold its grid to a private U.S. utility. Many more jurisdictions have indicated their intent to move in this direction, including several Canadian provinces and U.S. states, Indonesia, the Philippines and Thailand.

2.2 Independent Power Producers: The "Build-Own-Operate" Model

A common first step in breaking the integrated utility mold has been the creation of "independent power producers" or "IPPs", contracted to sell power and energy to a monopoly utility, frequently in parallel with generation by the utility. The first large scale application of this model was in the Philippines, which recovered from the brownouts and blackouts of the early 1990s by entering "power purchase agreements" or "PPAs" with a number of IPPs, mostly employing diesel generators, many barge mounted, to bring a quick fix to a crisis situation. The next phase of the fix has been to contract longer term solutions, based on geothermal, hydro or large coal or natural gas fired power plants, with lower fuel costs and less susceptibility to fuel price fluctuations, but with the same contractual model.

This "build-own-operate", or "BOO" business model, has also been extensively committed in Indonesia and Thailand. In some cases, transfer of ownership of the generator to the central utility is provided for in the PPA, usually timed to follow amortization of the investment. The PPA leaves the central utility carrying the marketing risk and often the fuel cost risks, as these are usually contracted on a pass through basis. In some cases the fuel supply is free issued or mandated to a national petroleum or coal producer. A major risk for the central utility is that it becomes locked in to large, long term purchase commitments, often heavily base loaded, which displace its own base load generators which are themselves usually the most profitable part of its business.

The pattern for financing large scale BOO IPPs became established after the U.S. and Japanese export credit agencies, USEXIM and JEXIM, issued their final commitment letters for the Paiton I project in East Java, Indonesia in April 1995. This 2 x 600 MWe coal fired plant, a US$2.6 billion project, was financed without recourse to sovereign loan guarantees against a PPA between the project company and Indonesia's state utility PLN, based on an equity of 30% of the overall project value. The only direct involvement by the state was a "comfort letter" from the Ministry of Finance, recognizing the PPA and the requirement for currency conversions to service debt loads. This commitment broke the logjam, and many other BOO projects followed, initiating the commitment of several thousand megawatts of new geothermal, hydro, coal and gas fired plants in Indonesia using this model in the last three years.

The short term appeal of this structure has been the ability to proceed with projects without incurring sovereign debt or appearing to disturb the existing order of state control of the overall utility. However, by early 1997, Indonesian legislators were expressing concerns that PLN had become overcommitted to base load purchases at the expense of its own generators [Jakarta Post, 1997]. PLN subsequently reduced drastically the take or pay component of new purchase commitments, offering to take the balance only on an as required basis. There is even a trend towards placing this component on a daily bidding basis, thereby transferring a larger part of the market risk to the generator.

In addition to these issues, as Indonesia, the Philippines and Thailand are discovering in the wake of their recent currency devaluations, the indirect but de facto hard currency pricing in the PPAs leads quickly to major electricity price rises following currency realignments, without the mediation of a marketplace. The utilities in several Asian countries are expected to renegotiate the terms of PPAs following the crisis. Indonesia has announced the suspension or cancellation of several major IPP/BOO projects and its intention to renegotiate existing PPAs [Power in Asia, 1998]. It remains to be seen whether these are viable structures in the long term.

2.3 The Power Pool

A step beyond the BOO with a long term PPA is the use of a central power pool, administered by an independent entity, to which IPP generators bid to supply power on a daily basis. The pool operator then passes on the power, taking a small, incentive based bonus, to the transmission and distribution system. The power pools which operate in the U.K. and Victoria typically accept bids from generators to supply half or one hour power tranches 24 hours ahead, against a declared aggregate demand level. Typically, the unit energy price for all suppliers of that tranche is struck as the price of the incremental bid which meets the declared supply requirement. There is no capacity payment in such a system.

The pool operator may be a private or a state corporation, usually regulated and sometimes non-profit. Utility restructuring has been under way in Indonesia, the Philippines and Thailand to separate generation, transmission and distribution functions, paving the way for the operation of a competitive power pool. Concerns have been expressed that the existence of a large block of committed long term power purchases to BOO projects could complicate the process of conversion to a competitive pool structure.

While this IPP/pool market structure avoids many of the rigidities of the BOO/PPA model, the pool operator as broker still imposes what is essentially a bureaucratic intervention between the power producer and the final customer.

2.4 The Open Market

The final stage in deregulation is the open market, where generators compete directly or through resellers and a grid operator to deliver power and electricity to the final users. The only remaining monopoly is typically physical transmission and final distribution, which are usually subject to some form of regulation. Generators, known as “Merchant Generators”, are free to enter or leave the market at will. Prices and contract terms may be confidential to buyer and seller. Such systems have been in operation for several years for the sale of natural gas and telecommunications services in the U.S., Canada and elsewhere. The states of California and Maine planned to open their electricity markets on this basis from the beginning of 1998, starting first with large consumers and moving down to smaller retail consumers (householders) within a few years.

Newly developed market mechanisms include the advent of an electricity futures market on the New York Mercantile Exchange [Thompson, 1997]. Futures contracts can be purchased at delivery points at the California-Oregon border and at the Palo Verde nuclear power plant switchyard, both major interconnection points with active cash markets. Additional delivery points are likely to be added in the near future. Futures markets can provide useful transparency and liquidity to markets, permitting both buyers and sellers more pricing certainty to facilitate investments and purchases. Planned linkages between natural gas and coal futures and electricity futures will permit moderation of risk in making generating fuels purchases.

According to a recent count, [Farlinger, 1997] some 17 countries and 34 U.S. states are restructuring their grids to accommodate competition. It is estimated that 35% of new generating capacity committed world-wide in the year 2000 will be derived from IPPs [ASEA Brown Boveri, 1997].

2.5 The International Utility

In response to these new electricity market structures, a new class of international utility is emerging, exemplified by Enron, Mission Energy, CMS Energy and National Power plc. These utilities typically have over 10,000 MW of generating capacity located in several countries and are growing rapidly, both by acquisition or merger and by commitment of new capacity. They often combine direct ownership interests in both generation facilities and in production, distribution and marketing of generation fuels such as natural gas or coal. In some cases these utilities are also marketing natural gas, positioning themselves as total energy providers. The wave of mergers which has swept the US utility industry in the last two years in anticipation of competition has resulted in major utility consolidations which have furthered this trend.

Development of such companies starting from the utility end is being met from the other direction by the entry of large international oil and gas companies such as Shell International, Mobil and Texas Gulf to the electrical generation business. These companies view the conversion of gas or coal into electricity as a means of adding value to their primary business, the fuel marketing chain. Such vertical integration enables the supplier to better withstand fluctuations in the price of fuels and permits them to contract without pass through fuel price provisions, or to enter markets as merchant generators, confident that they can meet any fluctuation in fuel prices or competitive challenge from other fuel suppliers. Some oil companies are notoriously cash rich, and have the ability to self-finance large investments in-house. This permits them very rapid responses to market opportunities.

Some of these international utilities include nuclear plants, but only one (British Energy) has a preponderance of nuclear generators in its mix. An emerging trend in the United States is towards nuclear plant owners contracting out the operation of their plants, often to utilities from other regions which have established a good operations track record. The recent experience of North American utilities demonstrates clearly the key role played by operating management in the economic viability of nuclear power.

3. CHALLENGES AND OPPORTUNITIES IN THE NEW ENVIRONMENT

3.1 The Financing Environment

National governments of non-OECD countries have traditionally financed new generating capacity by borrowing directly or guaranteeing borrowing by their national utilities. The scope for additional funding by this route is limited in most of the developing Pacific rim, with governments generally unwilling or with limited capacity to assume further sovereign debt. Ironically, the liquidity and banking crisis which started in 1997 was precipitated mainly by irresponsible private borrowing excesses. The crisis has exposed very large speculative and unproductive private debt, most of it hidden from view, which came to light only as business failures multiplied. The extent of these liabilities had been grossly underestimated.

The crisis marks the end of an era in Asia spanning over thirty years which placed faith in “Asian values” as the driving force for economic growth. This period was characterized by a dirigist approach to major capital investment, with governments identifying favoured companies to be the key players in a given industrial sector. The lack of accurate and uniform information on economic and business matters left investors highly dependent on cultivation of relationships with those holding political power. Equity capital markets were small and lacked depth, with a large fraction of equity being in the form of essentially speculative and volatile foreign portfolio investment. Lenders counted on the political connections of their borrowers to provide security for their loans. Bond markets as they exist in North America and Europe, with sophisticated regulation, stringent disclosure requirements and credibly independent rating agencies are almost non-existent in developing Asia.

The International Monetary Fund (IMF) assistance to Thailand, Indonesia and Korea organized in late 1997 is on an unprecedented scale. Although it started with the usual assurances of “business as usual”, as

it developed and the extent of the problems unfolded, it became clear that a profound transition in financial management was required and is now being undertaken. The countries which will emerge quickly from this crisis and which will represent the potential customers for nuclear power in the future will be those that most effectively restructure their financial laws, regulations and institutions to create conditions which will channel future investment into productive assets such as power plants, and away from unproductive investments such as speculative real estate development.

The capital required to support projected generation capacity growth in Asia of some 1,300 GWe in the next 25 years [DRI/McGraw-Hill, 1997] will exceed one trillion US $. This is in addition to all other infrastructure investment requirements, including transportation and communication, not to mention the social capital required for education, health, justice and other expenditures. Future large scale financing of infrastructure will require the development of high capacity equity and debt markets, comparable to those which financed power schemes in OECD countries in the past. They will prosper in jurisdictions offering transparency, open provision of and access to information, well regulated banking systems and impartial and effective systems for enforcing contract and property rights. In particular, bankruptcy laws, which are weak in most Asian countries, require strengthening to assert the rights of creditors. Moves have been and are being taken by Indonesia, Korea and Thailand to implement more responsive bankruptcy legislation.

Nuclear generation capacity requires two to three times the capital required for a similar sized coal or gas fired plant, with significantly longer lead times. If governments respond appropriately to the current financial crisis, capital will be accessible in future on terms which can allow the industry to compete with less capital intensive alternatives. Nuclear power plant investments require predictable cash flows over long amortization periods. Their investor and customer payoff comes following plant amortization, when stable flows of inflation resistant energy with modest variable costs generate healthy investment returns. Perceived nuclear plant investment risks relate to large investment size, the perceived level of technical maturity, licensing and the long term liabilities of decommissioning and radioactive waste disposal, which are not presently available commercially.

Benefits such as supply diversification, long term pricing stability and increased domestic content are most appreciated by governments, rather than by the private sector, with its shorter term investment horizons and disinterest in national currency accounts or strategic issues. For this reason, governments are likely to continue to be involved in at least the initial nuclear investments in developing countries.

Successful attraction of private capital into such investments will depend on highly predictable plant construction, licensing and operating performance, combined with competitive economic performance. This will favour an evolutionary approach to continued development of plant designs. Few opportunities remain in the industrialized world, with its mature grid systems, to demonstrate new plant designs. The next generation of nuclear plants to be built will be conservative, evolutionary designs incorporating proven features, built by nuclear vendors with strong utility links. While the cost of finite fossil fuel resources must eventually rise, for the time being, further significant improvements in unit costs of nuclear energy will be necessary to maintain competitiveness with fossil fuelled IPPs and, at least in some locations, with the improving economics of wind and solar power.

3.2 Regulation

Of the perceived investments risks associated with nuclear power, the most problematic is that associated with regulation. A competent, stable and impartial regulatory framework is an absolute requirement for a successful nuclear program. Countries commencing a nuclear power program need to take special measures to compensate the uncertainties associated with a new and inexperienced regulator. These will probably include reliance on close association with and dependence on established regulators in countries with mature nuclear programs. This concern will favour the choice of reactor types with well established

pedigrees, licensing records and reference plants, such as AECL's CANDU 6 reactor model. This is currently undergoing licensing in China, the fifth country to build and license this reactor design.

Adoption of pre-project licensing regimes, coupled with some government indemnifications for remaining licensing risks and the assumption, for a fee, of decommissioning and waste disposal liabilities. This is becoming known as the "modified build-own-operate (BOO)" participation model in the context of a power purchase agreement (PPA), but the concept would also function in a competitive pool or free market grid.

A large financial commitment by the host government to a nuclear project constitutes the most effective means of maximizing the comfort level of foreign investors. Such involvement could be compatible with any of the utility market models described above. It would provide some comfort to both equity investors and lenders that the regulatory process would not be subject to political manipulation at the expense of investors.

Notwithstanding such measures, it will likely continue to be necessary for host governments to provide some protection to investors against regulatory risk, whether the plant is state or privately owned. This could take the form of indemnification in the event of regulatory requirements resulting in significant post-commitment design changes. Design completion and licensing prior to the start of construction will become standard practice.

3.3 Energy Demands and Resources

Energy demand growth and its implications for society have been widely discussed [World Energy Council, 1995]. The consensus view [Giraud, 1995] is that strong electricity demand growth will continue to accompany economic and demographic growth and that over half of global growth for at least the first quarter of the 21st century will be in the Asia-Pacific and South Asia regions. He concludes that "the increase in …consumption of energy in (South and South-East Asia to 2020) will be greater than the current total consumption of North America, Europe and Japan".

Asia is modestly endowed with fossil fuel resources, as shown on Table 1, which compares resources available to the 60% of the world's population who live in Asia with that of the rest of the world.

Table 1. World and Asian Fossil Fuel Reserves [BP, 1997]

Fuel	World Reserves, as measured billion tons	World Reserves BTOE	Asian Reserves BTOE	Asian Reserves as % World
Coal	1,032	678	205	30.2
Oil	141	141	6	4.1
Gas	101	123	8	6.4

Note: "Asia" includes South Asia, but not Russia

The comparison is even more dramatic when expressed in per capita terms, in Table 2.

Table 2. Per Capita Fossil Fuel Reserves, Asia vs. the World [BP, 1997]

	Reserves BTOE	Population million	TOE/ capita
Asia	219	3,200	68
Rest of World	722	2,100	344
World	941	5,300	177

These figures underline the reality that, in the long term, Asia must develop alternatives to oil, gas and coal for electricity generation. The only question is when and with what sources. In countries with no or limited domestic fuel resources, there is already a concern to diversify with options which minimize both day to day and long term dependence on imported fuels. A large scale, long term nuclear power program offers significant potential for a high domestic energy content. Even a medium sized economy such as Korea has achieved remarkable levels of domestic content in its nuclear electricity product, exceeding 75% localization on the fourth unit of its CANDU program, for example, with even higher levels anticipated for later units. Korean experience during the recent won devaluation has shown the benefit of nuclear generation investments. The Won cost of operating nuclear powered generation has remained stable, while the cost of fossil fuelled generation has increased dramatically.

While measured uranium nuclear fuel reserves of 3 to 7 millions tons appear modest, these reserve estimates are based on selling prices below $130/kg U, corresponding to a fuel material cost of less than one third of a cent per kilowatt-hour [Pendergast, 1993]. The scope for additional reserves to be developed with higher fuel prices is enormous, as is the potential for advanced fuel cycles. Potential fuel cycles for the highly neutron efficient CANDU reactor include use of plutonium and uranium recovered from spent light water reactor fuel and thorium, a widely available potential fuel which cannot be used in light water reactors.

3.4 Environment

The Rio de Janeiro and Kyoto environmental summits have dramatically elevated the priority of environmental considerations in most countries, particularly with respect to issues such as carbon dioxide emissions which have global implications. While most governments are presently reluctant to endorse the use of nuclear power as a part of the solution to the greenhouse gas issue, its key competitor, coal, will increasingly be penalized as a fuel choice by environmental preferences. Introduction of costing the so called “externalities” into economic analyses of energy options will increasingly favour nuclear power over the alternatives.

Constraints on the use of fossil fuels for electricity generation arising from greenhouse gas concerns are only now being contemplated. The future course of public policy in the region is still evolving, but it is probable that there will be increasing policy pressures to move away from extensive reliance on coal combustion. While major improvements have been made in reducing sulphur and nitrogen oxides emissions from coal burning plants, the chemistry of combustion leaves improved plant efficiency as the only practical avenue to widespread reduction of CO_2 emissions. Even the most promising coal gasification/combined cycle gas turbine (CG/CCGT) schemes only boost overall thermal efficiency to the 43 to 45% range, resulting in atmospheric carbon emissions in the order of 230 kg carbon per MWh_e.

This compares with emissions of 87 kg carbon/MWh_e from a combined cycle gas turbine plant operating at 60% efficiency (and assuming zero methane emissions).

Application of even a modest tax to carbon emissions would sharpen the competitive edge of nuclear power dramatically. While greenhouse gas emission control enforcement mechanisms are still only in the discussion phase, it appears that some monetization of carbon emissions, whether in the form of a carbon tax or tradeable emissions permits, will develop, at least on a national level and probably internationally.

3.5 Public Acceptance

Public support for nuclear power has almost everywhere been strongest close to nuclear power plants and amongst educated populations. In much of Asia and the Pacific, public trepidation has resulted from ignorance and lack of familiarity with nuclear plants, of which only a handful operate outside of Japan and Korea. There have been few attempts by the industry to develop public understanding and support and resources are usually modest. One such program in Thailand is described in another paper at this conference [Keyes, 1998].

The most direct and reliable route to public acceptance in Asia-Pacific is continued economic, safe and environmentally superior performance of the industry as a whole and by continued positive acceptance by the publics in established nuclear nations in North America, East Asia and Europe. Despite cultural particularities, the publics of all of these regions have similar concerns for health, safety and the economy and respond positively when given appropriate information. Public acceptance will be enormously assisted by growing awareness of both air quality and greenhouse gas emission concerns. These are becoming particularly intense in the region, which includes some of the most heavily polluted urban air in the world and areas which are particularly vulnerable to rising sea water and drought conditions.

4. CONCLUSIONS

The factors described above suggest that governments will continue to be involved in initial nuclear investments in developing countries, at least until both the private utility industry and capital markets mature in each country and reach a size which can manage the large investments required. This role will likely take the form of outright host government ownership of plants or participation by host governments in independent power producer ("IPP") plants in joint ventures with the private sector. In the long term, nuclear plants will likely be built and owned by large, private international utilities having depth of expertise in nuclear plant management and the long term perspective needed to realize the excellent returns which such investments can generate.

To succeed in this environment, nuclear power vendors must continue to hone their products' economic performance, while maintaining and improving safety margins. A key to attracting financial backing for nuclear investments will be the elimination of "surprises" by the use of well established designs, advanced design and construction tools and sophisticated operational management. Vendors must also join with their potential customers to educate their publics in issues surrounding energy production technologies and nuclear technology in particular

Despite the challenges of the new landscape which will face nuclear power in the 21st century, its inherent advantages of low and stable unit costs, flexible and extensive fuel resources and minimal effect on the environment remain valid and have been enhanced by recent events. As resource constraints start becoming apparent, the advantages of power reactors able to adapt to lower grade fuels will be enhanced. The potential for resource poor countries to achieve a high degree of domestic content in nuclear electricity production will be a major driver of nuclear development, especially in Asia.

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6. KEY WORDS

Nuclear power, independent power producer, build-own-operate, merchant generator, international utility.