Nuclear Power at Daya Bay

A report for Hongkong Friends of the Earth

By Walt Patterson

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Nuclear physicist and energy specialist

Mr Walter Patterson was born in Canada in 1936. He was educated in Winnipeg and gained a postgraduate degree in nuclear physics from the University of Manitoba. In 1960 he came to the United Kingdom to teach and write, and in the late 60s he became involved in environmental work.

In 1972 he joined the staff of Friends of the Earth in London, where he was an energy specialist until 1978. During this time he appeared as their lead witness at the Windscale Inquiry.

Since 1978 he has been an independent commentator and consultant, involved in energy and nuclear policy issues in many different countries. He is the author of [*Nuclear Power* (1976)], *The Fissile Society* (l977) and *Fluidized Bed Energy Technology: Coming to a Boil* (1978).

He is a regular contributor to the *New Scientist*, the *Guardian* and many other publications, and he broadcasts frequently on radio and television. He continues to be an adviser to Friends of the Earth; he is also an editorial adviser to the *Bulletin of the Atomic Scientists* and to *Newton,* a science magazine for teenagers.

Mr Patterson is married and has two daughters. His other interests include "music, from Josquin to jazz; travelling, the slower the better; learning languages to the level of intelligible mediocrity; growing vegetables, brewing beer and consuming both".

A note on the report by the author

No brief report can deal adequately with an issue as complex as that of the proposed nuclear plant at Daya Bay.

The following report offers only an initial survey of significant questions and problems, in an effort to stimulate long-overdue discussion.

There is, needless to say, a vast body of further relevant information. Those who feel that the issue is too important to go through virtually "on the nod" are invited to contact the Hongkong Friends of the Earth, who intend to pursue the matter in every available forum and with every responsible means.

Speaking personally I must admit that the Daya Bay proposal has already had one welcome side-effect: it has given me my first opportunity to visit Hongkong. Even a few fleeting days have left an indelible impression, and the feeling that I too have a stake in its future.

I am grateful for the opportunity given me by my friends in the HKFOE to contribute to what we hope will be - however belatedly - a well-informed and urgent public debate, about a key aspect of that future.

- WALT PATTERSON
Amersham, Bucks, UK

South China Morning Post, 14 March 1984, pg 2

Today we begin a four-part series of physicist WALT PATTERSON's report for the Hongkong Friends of the Earth on Nuclear Power at Daya Bay. The first of the series deals with nuclear activities in China.

Military sets the nuclear ball rolling

China has had a nuclear programme for more than three decades.

Until comparatively recently, however, Chinese nuclear activities were almost exclusively military. The Atomic Energy Research Institute of the Chinese Academy of Sciences was founded in 1958, near Peking.

Reports reaching the West stated that there were in operation by 1978 two research reactors, at Peking and Paotow, of 10 megawatts and 3.5 megawatts (thermal) output, and a 600-megawatt (thermal) plutonium production reactor at Yumen. In 1979 reports referred to research reactors of 700 and 350 megawatts (thermal) output, both at the institute near Peking.

In all there were more than 40 nuclear facilities, most of them associated with the weapons programme. China regarded nuclear energy as primarily of military importance. Unlike the industrial West, China had devoted little effort to attempting to establish a civil programme for the generation of nuclear electricity.

Some reports suggest that the first Chinese nuclear power project, the so-called 728 project, was given the go-ahead as far back as February 8, 1970 - hence, in reverse order, the digits of the number. It entailed design and construction of an indigenous 125-megawatt test reactor, at the Southwest Research Institute near Chengdu in Sichuan province.

In 1976, after the cultural revolution, China began to formulate plans for a nuclear power programme; and on February 26, 1978 the then Chairman, Mr Hua Guofeng, announced that China would embark on the development of nuclear power, to "catch up with the rest of the world".

This intention was conveyed to French visitors in February and July 1978, and to a party of American scientists and engineers in Peking in April 1978. The Chinese told the Americans of their interest in American nuclear experience, especially with pressurised-water reactors (PWRs).

In October 1978 a French delegation was in Peking to discuss the possibility of China purchasing a 900-megawatt (electric) PWR from the French reactor manufacturers, Framatome.

In January 1979 France signed a FFr60 billion (about HK$60 billion) economic cooperation agreement with China. The Chinese top leader, Mr Deng Xiaoping, confirmed that China intended to buy two 900-megawatt PWRs from France, at a cost of some FFr10 billion (about HK$10 billion), to be sited on the Changjiang River in Jiangsu province. As the months passed, however, no contract was signed.

Uncertainties about the cost and financing of the purchase were compounded by problems arising from US constraints on trade in strategic technology. COCOM, a US-controlled agency that supervises exports to communist countries, had to grant permission for Framatome to supply China with technology still under licence from Westinghouse.

In February 1979 a British delegation visited Peking, led by the then Secretary of State for Industry, Mr Eric Varley, accompanied by Lord Nelson of Stafford, the chairman of the British General Electric Co. They came away with the impression that China was eager to import Western technology, but that finances would be a severe constraint. Foreign exchange was in short supply, and China stressed the need to boost its exports in order to be able to pay for imports.

In July 1979 the financial constraints became abruptly apparent.

China informed a French delegation that it had shelved the plan to buy two PWRs from Framatome, partly because of concern raised by the Three Mile island accident in the US in March 1979, and partly because of what was called the revision of Chinese economic objectives. The French had already spent some FFr25 million (about HK$25 million) on the project.

A year earlier, however, the authorities in Peking had agreed that the state government of Guangdong could explore the possibility of building a nuclear power station in the province, to be financed entirely by selling electricity to Hongkong.

Guangdong embarked on discussions with China Light and Power, the largest electricity supply company in Hongkong.

In March 1979 the transmission system of China Light was interconnected with that of Guangdong, in order that the Hongkong company could supply power to the Shenzhen special economic zone in the southern part of Guangdong province.

In 1980 China Light and the Guangdong authorities agreed to carry out a joint feasibility study of the nuclear power proposal.

Meanwhile, in Peking in February 1980, the Chinese Nuclear Society held its first national congress. The 350 delegates issued a statement calling for the construction of nuclear power stations in China.

The statement was endorsed by Mr Qian Sangiang, a nuclear physicist who was also vice-president of the Chinese Academy of Sciences.

The Chengdu test reactor, which started up in 1980, became the main focus of design work for an indigenous 300-megawatt Chinese pressurised-water reactor. A delegation from the Japanese nuclear industry visited China in July 1980, and was told that China also had plans for a l25-megawatt heavy water power reactor, and would be interested in nuclear co-operation with Japan on this and other nuclear technologics.

In November 1980, after a visit by the French President, Mr Valery Giscard d'Estaing to Peking, in which he offered more generous financial arrangements, French hopes for the sale of two 900-megawatt PWRs to China were revitalised.

China signed a protocol agreeing to call on France should it be decided to build a nuclear power station in Guangdong.

But in December 1980 *Nuclear Engineering International* reported that the Chinese deputy President, Mr Fang Yi, had told the director of the Swedish Academy of Sciences, Mr Gunnar Hambraeus, that no decision had been taken about the purchase of a reactor from the French. He

expressed scepticism as to the future of the Franco-Chinese agreement or of any deal involving the construction of a plant in China by foreign companies.

Mr Fang also expressed reservations about French techniques for handling nuclear waste, and criticised French companies for their "excessive secrecy". In so doing he was adding his voice to a chorus long since echoing throughout Western industrial countries.

Tomorrow: Nuclear activities in the West

South China Morning Post, 15 March 1984, pg 2

In the second part of his report for Hongkong Friends of the Earth on Nuclear Power at Daya Bay, physicist WALT PATTERSON looks at nuclear activities in the West.

In the West disillusion sets in

As China was at last deciding to investigate the possible usefulness of nuclear power, enthusiasm for nuclear power in the West was turning to disillusion.

The oil price increase imposed in October 1973 by the Organisation of Petroleum Exporting Countries triggered a burst of nuclear euphoria; but it was short-lived.

For a year or so it seemed that the long-awaited economic breakthrough of nuclear power had at last arrived.

Elcetricity supply industries in many Western countries pushed ahead with plans for dramatic expansion of nuclear capacity. Orders poured in, and reactor manufacturers thought that their years of costly investment were on the verge of payoff.

It was not, however, to be. Within two years the plants ordered in 1974 were being cancelled, and new orders were becoming ever scarcer.

There is neither time nor space to review below the entire record. This report will focus accordingly on the three countries of particular interest in the context of the Daya Bay proposal: the United States, France and the United Kingdom.

South China Morning Post 15 March 1984, pg 2

United States: Rising costs and safety factors burst the boom

Whoops goes euphoria

The nuclear euphoria of 1974 was nowhere more marked than in the US.

For a decade, since the Oyster Creek order of December 1973, the US reactor manufacturers had been selling plants at prices that brought them little if any profit, in order to create a market.

The *Wall Street Journal* later estimated that until the mid-1970s Westinghouse had lost about US$l billion (about HK$7.8 billion) on its nuclear plant sales, General Electric about half that sum, and Combustion Engineering and Babcock and Wilcox each about US$200 million (about HK$1.56 billion).

In 1972 these companies received domestic orders for 38 reactors, and in 1973 for 41 more.

By the end of 1974, however, the surge had passed. There were, to be sure, a further 24 reactors ordered in the US that year. But in 1975 only four orders were placed; in 1976, only three; in 1977 only four; and since that time not a single reactor has been ordered in the US.

By last year every reactor ordered since l974 had been either deferred indefinitely or cancelled outright.

The reasons were not hard to identify.

The anticipated growth in electricity demand did not materialise. The rapid increase in fuel and electricity costs prompted users to seek ways to cut their use. The world economic recession produced double-digit inflation, making the extremely capital-intensive technology of nuclear power an unattractive investment. Construction times for nuclear plants were stretching out to more than a decade, making the cost of interest during construction dauntingly expensive.

Analysts demonstrated that the capital costs of nuclear plants completed by the mid-l970s were regularly twice to three times as high as the original estimates.

In the early years of the industry the manufacturers had undertaken to achieve capacity factors of 80 per cent or better. In practice the operating light-water reactors were found to have average capacity factors hovering around 60 percent.

Safety problems further reduced confidence on the part of the public as well as that of the electricity companies.

The fire at the Brown's Ferry plant of the Tennessee Valley Authority in March 1975 - caused by an open candleflame - cost some US$40 million (about HK$312 million) in replacement electricity alone, to say nothing of the cost of repairs and regulatory modifications, and of keeping the plant inactivc for 18 months.

The entire world heard about the accident at the Three Mile Island plant in March 1979. Less well known is the fact that the TMI accident is still unresolved. The shattered reactor remains full of loose and lethal radioactivity, with no clear idea of how or when the clean-up will be finished, how much it will cost or who will ultimately foot the bill, which is already nearing the US$1 billion (about HK$7.8 billion) mark. General Public Utilities, owners of the plant, are hovering on the edge of bankruptcy.

Other accidents, less widely publicised, have revealed other major safety hazards. In March 1978 a technician at the Rancho Seco plant in California dropped a small light-bulb into the control panel. lt shorted out a main electrical circuit, feeding spurious information into the control computer. The computer tried to respond, opening and closing valves and switches, and the plant went slowly berserk. It was completely out of control for some 70 minutes.

In February last year, the Salem l plant, a Westinghouse reactor in New Jersey, twice failed to shut itself down automatically in response to malfunctions. Only the operator's quick manual shutdown prevented a possibly major accident. The "scram failure" occurred because relays had not been lubricated since 1974; and the first failure was not even noticed by the plant staff.

Basic design details continued to yield unpleasant surprises. Westinghouse, trying to overcome the perennial problems with steam generators, came out with a design labelled D3. But the D3 proved likely to tear itself to pieces in only a few months.

For more than two years Westinghouse has been replacing D3s in the US and elsewhere at a huge cost. Whether the latest replacement steam generators will work any better than their precursors remains to be seen.

Meanwhile a committee including representatives from the manufacturers, the electricity companies and the Nuclear Regulatory Commission has been sitting for more than two years considering a crucial metallurgical problem. Prolonged exposure to neutron radiation has caused the steel of pressure vessels on many of the early pressurised-water reactors to become "brittle".

If in a minor malfunction cold emergency cooling water were to be poured on to such "embrittled" steel, the consequent stresses might split the pressure vessel wide open, disgorging its radioactive contents with catastrophic results.

However, to order permanent shutdown of the endangered plants would cost their operators vast sums in lost revenue. Despite its protracted deliberations the committee has still come to no definitive resolution.

The impact of these uncertainties was spelled out bluntly in late l982, in a speech by Mr David Freeman, the chairman of the Tennessee Valley Authority, the Government agency that is the largest electricity supplier in the US.

Mr Freeman declared that electricity companies could no longer afford to invest in nuclear plants because they still had no idea how much a plant would ultimately actually cost.

Independent analyses of plant costs and performance found that even in the most geographically favourable areas of the US, nuclear electricity was no cheaper than coal-fired; elsewhere in the US nuclear electricity was more expensive, often substantially more.

Electricity companies gave such findings tacit endorsement, by directing their planning strategies toward demand management and conservation.

Most commentators now appear to agree that no further nuclear plants will be ordered in the US at least throughout the 1980s.

Reactor manufacturers have been able to hold on until now because of the backlog of existing orders; but almost all of these are now either complete or hearing completion.

Some analysts have concluded that the next few years will see one or more manufacturers drop out of the reactor business entirely.

The sheer scale of financial disaster possible in the nuclear business appears to have no other commercial parallel.

This was demonstrated by the grim history of the Washington Public Power Supply System in the northwestern US - known, all too appropriately, as WPPSS, pronounced "Whoops".

A consortium of electricity companies from five states banded together under this name in 197l to build a nuclear power station with five 1200-megawatt units, to supply all the member utilities. However, a combination of technical difficulties, site management problems, and dramatically escalating costs crippled the project. One unit after another was cancelled, even though well on the way to completion.

At length, in July last year, WPPSS defaulted on bonds worth US$2.5 billion (about HK$19.5 billion), leaving 88 member utilities and the towns they serve to pay off debts that may amount to thousands of dollars per person for nuclear plants that will never be built.

In January, the Atomic Safety and Licensing Board refused a fuel loading licence for the newly completed Byron plant of Commonwealth Edison, a PWR in Illinois, because of inadequate quality control during eonstruction.

In the following weeks, Cincinnati Gas and Electric announced it intended to convert its newly completed Zimmer plant to coal-firing.

Public Service of Indiana decided to abandon its Marble Hill plant; the plant was 97 per cent complete, but the cost of completing and operating it was judged to be more than the company could stand.

Commentators wondered how many more would be abandoned before completion, what the total costs would be and who would pay for them.

South China Morning Post , 15 March 1984, pg 2

France: excess capacity

Shock end to utopian dream

While the fortunes of nuclear power in the US were going from boom to bust, France appeared to be proceeding on course towards a nuclear utopia.

After the oil shock of 1973 the French Government embarked on a plan to substitute nuclear power for oil, ordering reactors in batches of up to nine at a time. For several years this strategy progressed with only incidental hitches.

One in particular illustrated the distinctive French approach to the issue.

In 1976 French engineers announced that they had chosen a certain alloy steel for sensitive sections of the primary circuit, because this steel was impervious to so-called "intergranular stress corrosion cracking", a metallurgical problem of increasing concern to reactor designers.

A number of plants were built incorporating the new alloy: whcrcupon it was revealed that this alloy, too, had developed cracks, in steam generator tube sheets and around pressure vcssel nozzles. The cracks had showed up in plants otherwise complete and ready for start-up.

In the US or the UK such a discovery would have led to a major regulatory intervention, at the very least.

In France the authorities decided summarily that the cracks were not a serious safety hazard. They gave the go-ahead to start up the reactors, declaring only that if in due course the cracks did prove to be unsafe something - otherwise unspecified - would then be done about it.

Nuclear supporters elsewhere looked enviously towards France as exemplifying the sort of commitment required to bring to fruition all the benefits of nuclear power.

In 1981, however, a top-level committee of independent academics, invited by the Government to comment on its nuclear strategy, failed to come through with the unhesitating approval apparently expected.

Instead the committee noted that electricity use in France was not increasing as had been anticipated, and that the plant ordering programme then foreseen would lead to a serious excess of electric generating capacity by 1990.

The burden of debt that would arise would have to be borne by electricity users; and the resulting cost increase would further reduce the use of electricity.

ln July 1982 Electricite de France confirmed that this was already happening. EdF was facing its worst financial crisis for 30 years, an annual loss of FFr8 billion (about HK$8 billion), because of the fall-off in electricity use coupled with the high cost of borrowing to finance the nuclear programme.

The incoming Mitterrand Government cancelled one plant, and suspended several others pending a rethink of the strategy; but the parlous financial position of EdF did not much improve, showing a further loss of FFr6 billion (about HK$6 billion) last year.

The Mitterrand Government last year announced a reduced ordering programme of further reactors; analysts pointed out that even on the most favourable assumption about future electricity use this programme would still lead to a serious excess of capacity by the end of the decade.

The French reactor manufacturers, Framatome, however, greeted this reduced programme with dismay, announcing that it would have to lay off staff and shut down some of its manufacturing plants.

The November 1983 issue of the French magazine *Science et Vie* published a devastating, detailed analysis of the impact of the French nuclear programme on France's economic performance and industrial structure.

The future shape of the French nuclear programme is now very much open to question, as is the future of Framatome.

South China Morning Post, 15 March 1984, pg 2

United Kingdom: fervour cools

Controversy dogs nuclear programme

The civil nuclear programme of the UK was already in obvious trouble before the end of the 1960s.

The nine civil Magnox stations had cost substantially more than an equivalent programme of fossil-fired plants. The five original construction consortiums had shrunk to three, and then to two with the bankruptcy of Atomic Power Constructions in 1969.

The Dungeness B power station, ordered from APC in 1965 as the first of the advanced gas-cooled reactor stations, did not in fact start up until December 1982,17 years later, at a final cost of five times the original estimate.

The other four stations of this second nuclear programme were all at least four years behind schedule and far over budget, and their output was reduced from the intended l320 megawatts to only 1000 megawatts, further raising their unit capital cost. For one faction in the UK nuclear establishment the implication was clear. Having demonstrated a comprehensive inability to build indigenous designs to time and cost, the UK ought to turn to the imported pressurised water reactor.

The controversy had split the UK nuclear establishment irreconcilably ever since 1964.

In December l979 the new Conservative Government at last gave the PWR promoters the opening they had been waiting for. The Government announced that it would invite the Central Electricity Generating Board to apply to build the first civil PWR in the UK; it was to be ordered by 1982, with further reactors to be ordered at one a year for the ensuing decade.

At the time the CEGB had generating plant capacity some 40 per cent higher than that required to meet the peak demand on the system.

Meanwhile, electricity demand had virtually ceased increasing, indeed had actually fallen below that reached in 1973. By mid-1980 both the Government and the CEGB were denying that they were considering a programme of new nuclear stations. The only new plant was the PWR proposed for the site called Sizewcll B.

In February l98l the all-party Parliamentary Select Committee on Energy published a severely critical report on the Government's nuclear policy - the more striking because the committee was known to consist almost entirely of supporters of nuclear power.

The committee was particularly concerned about the safety of the PWR: "The evidence and opinions received by the committee during this enquiry suggest that, in order to achieve the necessary degree of safety, the PWR requires a very high standard of quality control, involving tests, inspections and analyses extending throughout its construction and subsequent operational life - a period of approximately 30 years.

"During this period inspection must be made and faults recognised, recorded and set right by qualified critics if safety is to be assured. A system for doing so must be devised in which human failures, intentional or otherwise, can be detected and remedied.

"All reactor types require regular inspection but, to the best of our understanding, in none of the others can a small failure in the inspection procedure lead so directly to the risk of a major emergency or accident as is the case with the PWR."

ln May 1981 the independent official Monopolies and Mergers Commission, reporting on the performance of the CEGB, was uncompromising: "...while we find that the board's demand forecasting has improved, we consider that there are serious weaknesses in its investment appraisal.

"In particular a large programme of investment in nuclear power stations, which would greatly increase the capital employed for a given level of output, is proposed on the basis of investment appraisals which are seriously defective and liable to mislead.

"We conclude that the board's course of conduct in this regard is against the public interest."

By the time the public inquiry into the Sizewell B proposal opened in January last year, the CEGB had prepared revised economic analyses that attempted to meet the official criticisms.

Nevertheless, during the course of the inquiry to date, even the most recent CEGB economic arguments have come under sharp and substantive attacks from many well-qualified critics.

Meanwhile, the very status of the inquiry itself has been drastically undermined. Two different Secretaries of State for Energy and the head of the official Health and Safety Executive gave assurances that all necessary documentation about the safety of the plant would be made available to objectors well in advance of the inquiry.

It subsequently emerged, on the contrary, that major safety questions were still unresolved, and that the official Inspectorate of Nuclear Installations did not expect to complete its assessment until a year after the inquiry had ended.

In the absence of key features of the official safety case, Friends of the Earth, the main objectors to Sizewell B on the grounds of safety, moved to have the inquiry adjourned; but the application was refused.

The inspector will now have to report back to the Government about the proposal without having heard vital arguments about safety.

Last month, the inspector in charge of the Inquiry sharply criticised the official Inspectorate of Nuclear Installations for their failure to notify the inquiry about safety issues still unresolved.

The status of the UK nuclear programme thus remains in doubt.

One argument much canvassed by supporters of Sizewell B was the need to build a PWR in the UK to serve as a demonstration to foreign customers for the PWR - notably China. The implications of this argument will be considered later.

Tomorrow: The Hongkong and Guangdong connection

South China Morning Post, 16 March 1984, pg 2

In the third part of his report for the Hongkong Friends of the Earth on Nuclear Power at Daya Bay, physicist WALT PATTERSON looks at the Hongkong, Guangdong connection.

Rising fears of inflated bills

The electricity used in Hongkong, Kowloon and the New Territories is supplied by three privately-owned electricity companies, China Light and Power, Hongkong Electric and Cheung Chau Electric.

Of course the largest is China Light and Power which supplies Kowloon and the New Territories. It is also the company of particular interest in this report, as it has been involved since 1978 in joint examination of the proposed nuclear plant at Daya Bay.

CLP itself owns Hok Un A and B stations. It also owns 40 per cent of Peninsular Electric Power (PEPCO) and of Kowloon Electricity Supply (KESCO); Esso owns the other 60 per cent.

PEPCO owns Tsing Yi A and B stations and Hok Un C; KESCO owns Castle Peak A and 504 megawatts of gas turbines.

At the end of 1982 the generating capacity of CLP and its associated companies was 3006 megawatts. CLP also has a similar 40-60 interest in Castle Peak Power (CAPCO), created to own the new Castle Peak B station. Castle Peak B will have four 660-megawatt units, due on stream by 1989.

The tariff charged for electricity supplied by CLP is determined by a scheme of control overseen by the Executive Council.

Last revised in 1978, the Scheme of Control allows CLP to set its tariff to produce a return on investment of 13.5 per cent for assets acquired before October I978, and 15 per cent for assets acquired with shareholders' funds since that date.

The arrangement has come in for outspoken criticism in light of CLP's plans for further major capital investment. In July 1982, the Federation of Hongkong Industries warned that the electricity bills of CLP's customers might reach HK$5.5 billion by 1989.

It based this claim on the likelihood that CLP's fixed assets might by that time total HK$37 billion, almost entirely eligible to a return of 15 per cent.

The federation was concerned particularly that the planned growth in generating capacity might far exceed the growth in use, leaving existing customers to foot a much inflated bill.

It pointed out that tariffs were increasing at up to 46 per cent a year, and called for the creation of a standing commission to investigate the status of the scheme of control in the light of CLP's expansion plans.

As of June last year the maximum demand on the CLP system was 2500 megawatts. CLP‘s latest published projections of future demand are based on growth rates of five, 7.5 and 10 per cent to the year 2000.

Even allowing for the retirement of old inefficient capacity, the generating plant already in service or under construction would provide adequate supply to accommodate a growth rate of 7.5 per cent until 1994, and of five percent until the year 2000. Allowing for the effects of steady tariff increases and other uncertainties, the possibility of a growth rate of 10 per cent continuing into the l990s is remote. The growth of demand in 1981 was six per cent, and in 1982 only four per cent.

In 1979, the CLP transmission grid was interconnected to that of Guangdong Electric across the border. Since that time CLP has exported about four million units (kilowatt-hours) of electricity into Guangdong province a year.

In 1980, after preliminary discussions and with approval from Peking, Guangdong Electric and CLP undertook a joint feasibility study of the possibility of building a nuclear plant in Guangdong, to supply both Guangdong and CLP.

The UK Department of Industry, the UK Atomic Energy Authority and the UK Central Electricity Generating Board all contributed to the study, which duly found in favour of such a plant.

The crucial question from the outset was how the plant might be financed. It would require a very large outlay of capital, possibly amounting to tens of billions of Hongkong dollars.

There would presumably be loans available from the exporting countries' governments; but the private capital market would also be called upon for a major investment.

The suggestion put forward was that loans might be raised using as security the contracts for sale of electricity from the plant to Hongkong.

Official opinion in China was believed to be divided about the desirability of the proposed plant in Guangdong.

A delegation from the American Nuclear Society which visited China in October 1980 had identified a number of different government departments with an interest in the issue.

The Second Ministry for Machine Building bore the primary responsibility for the Chinese nuclear programme.

In October 1980 a meeting at vice-premier level had created a new Office of Nuclear Energy, reporting directly to the State Scientific and Technology Commission. The Power Ministry was responsible for coal and hydroelectricity, and the railway and other transport ministries for transporting coal.

The Petroleum Ministry was responsible for the suddenly important development of China‘s offshore oil.

All these ministries and others were competing for financial support for their activities, and their interests would also interact with those of the State Planning Commission and the State Energy Commission.

Be that as it might, in August l982 the Governor of Guangdong province, Mr Liu Tianfu, was reported to have told the Governor of Hongkong, Sir Edward Youde, that "the central Government (of China) has approved a nuclear power plant to be built in Shumchun," and that Peking had also

approved a proposed joint venture between Guangdong Electric and CLP to construct and operate the plant.

Talks had taken place in July between Chinese and British Government officials, regarding possible British industrial involvement in the project and the financial and commercial arrangements required.

The proposal was for a plant including two 900-megawatt PWRs, at Daya Bay on the Guangdong coast, just outside the Shumchun special economic zone.

CLP estimated the cost of the plant at US$4 billion (about HK$31.2 billion). The feasibility study indicated that 60 per cent of the output would be fed into the transmission grid of CLP and the remaining 40 per cent into the Guangdong system.

But one industry observer suggested that the CLP share might be as high as 80 per cent.

Before the end of 1982 the road to Peking was being heavily travelled by delegations from the UK, France and the US.

Various possible packages were reportedly on offer.

The particular combination which appeared to be favoured included reactors and ancillary equipment from Framatome of France, and turbogenerators from GEC of the UK.

Other reports, however, suggested that China would still prefer to obtain their PWRs from Westinghouse. Unfortunately such a deal was at the time ruled out by US domestic nuclear legislation. There was nevertheless an alternative route apparently available.

In January last year the Granada television programme *World in Action* broadcast a programme that stirred considerable attention in the UK.

The official UK Government policy was to support the Anglo-French bid. Confidential documents that came into the hands of the *World In Action* team offered an unexpected gloss on this policy.

The CEGB had been preparing for months to present a case for the construction of a Westinghouse PWR at Sizewell B.

The National Nuclear Corporation of the UK was a licensee of Westinghouse PWR technology, and Westinghouse made no secret of their eagerness to get a foothold in the UK market, whatever it might be. But the *World In Action* programme revealed that Westinghouse interest in Sizewell B also had a further dimension not hitherto apparent.

In company with the major British merchant bankers, Kleinwort Benson, Sir Walter Marshall, the chairman of the CEGB, had been striving for many months to persuade the British Government to back a quite different offer to China.

The US Nuclear Non-Proliferation Act of I978 made it illegal for Westinghouse to sell nuclear technology to China, since China refused to accept international safeguards on its nuclear activities. Accordingly, Westinghouse and Sir Walter wanted the British Government to offer China a Westinghouse PWR built under licence by the National Nuclear Corporation, with engineering by the massive US firm of Bechtel.

However, for such an offer to have any chance of success, the NNC would first have to demonstrate that it could build a Westinghouse PWR. Sizewell B would be the necessary demonstration plant. It would not, of course, actually be built in time to win the hoped for order from China. But a favourable outcome of the Sizewell B inquiry would be a powerful vote of confidence from the UK Government.

Sir Walter was outraged at the television programme, to the extent that he shortly thereafter sacked his chief of public relations, presumably for letting him submit to a damaging interview included in the programme.

Sir Walter denied any impropriety, and disputed the interpretation of events presented in the programme.

But the memoranda shown on screen, and the interviews with Westinghouse and Bechtel executives, made the story difficult to challenge.

The final shot of the programme was a memo from Kleinwort Benson that stated flatly: "We should keep well in mind that an essential precondition for Anglo-American PWR exports is a firm commitment by Her Majesty's Government to a PWR in this country."

It did not address the question of whether it was appropriate for British electricity users to become pawns in an international corporate power struggle.

In this respect it gave an intriguing insight about the attitude of the nuclear salesmen towards those who would ultimately pay for their product. The point might well be taken on board also by electricity users in Hongkong and Guangdong.

A very different view of the preferred posture for the UK Government was held by the British firm of GEC, who have long been in bitter competition with Westinghouse for export sales of turbo-alternators.

The GEC chairman, Lord Nelson of Stafford, after a visit to Peking in November 1982, declared that the Anglo-French proposal was the best for China.

He did, however, point out that repaying the then estimated capital cost of US$4 billion (now about HK$31.2 billion) would require sales of electricity from the plant to Hongkong for some 25 years. What effect this would have on electricity tariffs in Hongkong remained hotly controversial.

Tomorrow: nuclear exports, safety, and the current status of the Daya Bay proposal.

South China Morning Post, 17 March 1984, pg 2

Today we wrap up the report by physicist WALT PATTERSON for the Hongkong Friends of the Earth on Nuclear Power at Daya Bay.

What price the risk?

Industry must export or die

The role of exports has been fundamental throughout the entire history of civil nuclear power.

Never before, however, has it been so crucial for the very survival of the nuclear industry.

In the 1950s, nuclear exports from the United States to Europe were the key to establishing the technology not only in Europe but also in the US.

At the time the abundance of cheap oil, gas and coal meant that nuclear electricity looked a very unpromising option.

But the US Government sent nuclear emissaries to Europe, with offers of enriched uranium at giveaway prices, coupled with training for nuclear technicians, and easy access to US technology under licence.

European countries such as France, West Germany, Italy, Spain and Sweden all took advantage of this nuclear largesse: whereupon nuclear promoters in the US pointed across the Atlantic and insisted that the US must build nuclear power plants to keep the Europeans from stealing the lead.

The history is recounted in a study by Bupp and Derian, of the Harvard Business School and the University of Paris respectively, with the ironic title *Light Water: How the Nuclear Dream Dissolved*, published in 1978.

The importance of nuclear exports took on a new urgency after the mid-1970s. The collapse of the domestic market in the industrial countries, eventually even including France, meant that reactor manufacturers had to export or go out of business. But the nature and function of the nuclear export business must be clearly understood.

It works like this. A reactor manufacturer and the customer go to the export credit agency of the exporting government, for instance the US Export-Import Bank or the UK Export Credit Guarantee Department. This agency offers the overseas customer a loan to finance part or all of the proposed purchase of the nuclear plant. The terms of the loan are invariably generous, sometimes extravagantly so: low interest, long payback times and deferred repayment, terms that no householder or small business could possibly get from a bank.

The finances are granted to the overseas customer; but the customer passes them on immediately into the coffers of the reactor manufacturer. In short, such a nuclear export serves to channel funds - in l0 digit sums - from domestic taxpayers - via an overseas customer - back to the domestic nuclear manufacturer.

This roundabout subsidy is now the only buffer that stands between survival and extinction for the world's reactor manufacturers. It is analysed in detail in *NucIear Power Struggles*, by Lonnroth and Walker; and they conclude, as noted earlier, that the next few years will see more than one manufacturer disappear from the stage.

The scarcity of potential customers for nuclear power plants, not only in the industrialised countries but all over the world, has made the competition for nuclear export orders a desperate, cut-throat battle.

On the face of it the international nuclear auction, with different export credit agencies vying to offer the most generous terms, would appear to be to the advantage of the overseas customer.

lt is, to be sure, true that the customer may as a result acquire a nuclear power plant at what looks to be a bargain price. But the bargain must be seen for what it is.

In the first place, to get any long-term benefit from the plant, the customer will be tied thenceforth to the foreign supplier, for fuel, spares and many aspects of maintenance. Such dependence in respect of a single plant is likely to bring about further dependence in respect of any further plants, since the customer will be under pressure to stay with the same supplier for subsequent plants. rather than multiplying its dependency.

The consequence may be an effective "technological colonisation" of the customer, who will thereafter be subject to any changes of policy on the part of the foreign supplier.

It need hardly be added that international nuclear policy has in recent years swung wildly from one pole to the other and back. Laissez-faire acquiescence has alternated with abrupt unilateral imposition of constraints, such as interruption of fuel supply, causing severe friction even between close diplomatic allies.

In the current political climate internationally, this controversy is more likely to intensify than to abate.

In particular, Chinese dependence on an imported nuclear power plant might give the foreign supplier country considerable leverage in other diplomatic contexts.

South China Morning Post, 17 March 1984, pg 2

Designed for submarines, the PWR gives cause for concern

Heated debate on safety

As the above has outlined, there is good reason to question the desirability of the proposed Daya Bay plant on purely economic grounds.

A further grave uncertainty, however, arises as to the safety of the type of installation proposed.

The basic problem goes back to the 1950s. The pressurised-water reactor, as a design concept, was not originally intended for a stationary land-based power plant.

It originated as a power unit for a nuclear submarine, and the design parameters were chosen accordingly. It had to be very compact, and to produce a very high heat output per unit volume. This meant that it had a high so-called "power density."

Its modern successors have a power density upwards of 100 kilowatts per litre - as much heat as 100 one-bar electric fires coming out of the volume of a milk bottle. This heat must be removed as fast as it is generated; the so-called "coolant" or heat-removal fluid is ordinary water.

But in order to stop the water from boiling it must be kept under a pressure of 150 atmospheres. This in turn requires that the reactor core, where the chain reaction is taking place, must be enclosed in a pressure vessel made of steel more than 30 cm thick.

Three attributes inherent in this design give rise to concern. The high power-density means that if anything goes wrong in the reactor, it can do so very fast indeed. The accident at Three Mile Island was already serious 30 seconds after it started.

Even if the chain reaction is shut down automatically, the heat output from the radioactive fission products in the fuel may still be up to eight per cent of full power.

In the design proposed for Daya Bay that would mean more than 200 megawatts of heat output that cannot be shut down. If it is not reliably removed the temperature of the fuel will soar, as it did at Three Mile Island, melting the tubes containing the fuel pellets, and possibly even melting the ceramic uranium oxide fuel pellets themselves.

Such a "meltdown" releases into the reactor system enormous quantities of radioactive materials. If the system is breached, the emerging cloud of radioactivity will drift with the wind, producing death, illness, and long-term health effects for many kilometres downwind of the plant, and depositing contamination that may make the land uninhabitable for decades.

The prevailing wind over the South China Sea is such that Hongkong is downwind of Daya Bay for much of the year.

As well as the high power-density, two other attributes of thc PWR design raise basic safety questions. The coolant, ordinary water, must be kept under high pressure lest it boil. If the pressure is allowed to drop - perhaps because of a pipe-break or a sticking valve, as happened at Three Mile Island - some of the water will flash to steam.

Steam is much less effective as coolant, and cannot remove the heat from the core adequately. The behaviour of a turbulent mixture of steam and water inside an accidentally depressurised reactor is extremely difficult to predict.

One possibility is that steam bubbles between the fuel pins will keep additional emergency cooling water from reaching some of the pins, leading to the danger of a partial meltdown.

The third attribute of the PWR which raises doubts is the steel pressure vessel itself. To withstand a pressure of 150 atmospheres it must be, as mentioned, upwards of 30 cm thick.

Fabrication of such thick steel is demanding in itself. Even very minute cracks may present a serious safety hazard. Furthermore, in steel so thick, a crack within the steel may not reach either the inner or outer wall.

Instead of betraying its presence by causing a minor leak of water, the crack may reach its so-callcd "critical length" unnoticed: at which moment it may suddenly rip open with explosive speed, and split the entire pressure vessel, disgorging its radioactive contents with catastrophic results.

The phenomenon of "embrittlement", caused by prolonged exposure of the steel to neutron radiation, adds a further grave uncertainty. If a pressure vessel becomes "brittle", the working life of the plant may have to be cut short, with a severe economic penalty.

If this penalty is refused, an alternative and much more devastating penalty may be paid by those living near the plant.

As recently as November, a former senior executive of the UK Atomic Energy Authority, Sir Alastair Frame, now chairman of the major mining company Rio Tinto Zinc, expressed his concern about PWR safety.

He told the Sizewell inquiry that he was disturbed that at this stage of the inquiry the UK Nuclear Installations Inspectorate still considered so many issues of PWR safety unresolved.

In September, the *SCM Post* quoted an unnamed official of the Hongkong Government to the effect that the Hongkong Government had no idea as to what safety regulations would be in force at the proposed Daya Bay plant.

Other commentators noted that China does not yet appear to have formulated nuclear safety criteria of the kind laid down in Western industrial countries. It is, however, only fair to note that even in those countries that have laid down such regulations unnerving incidents continue to occur.

One further implication of such safety questions should also be noted in the context of the Daya Bay proposal.

Nuclear insurance, both for the investment in the installation itself and for possible third party liability in the event of an accident, is still an intensely controversial matter even in industrial countries with long-established nuclear programmes.

The status of insurance for Daya Bay is as yet unknown. Given its international implications it is unlikely to be easy to establish.

South China Morning Post, 17 March 1984, pg 2

All or nothing factor loads dice against a plant

The hidden trip switches

The impact of a nuclear power plant on the electricity system, and on other development in a region, should not be taken for granted, or assumed to be beneficial without close examination.

A power plant of the size proposed for Daya Bay would include two units each of which would represent more than 10 per cent of the total generating capacity of the system.

The sudden loss of the output from even a single unit of this size, as a result of a "trip" or emergency shutdown, would be a significant threat to the stability of the entire grid.

In France, in December 1979 for instance, a minor electrical malfunction triggered a wave of progressive overloads; automatic protectivc devices tripped, the grid "collapsed" and shut itself down, and the whole electricity supply of the country failed, in a matter of some three minutes.

On December 27 last year, a similar minor malfunction triggered the complete shutdown of the entire electrical system of the industrial region of Sweden, including all 10 nuclear power stations. The blackout lasted several hours.

Earlier this month, China Light and Power itself experienced a major grid failure over the whole of Kowloon and parts of Hongkong Island and the New Territories.

The additional vulnerability of dependence on a single large station at a remote location need hardly be emphasised.

To guard against such an occurrence it is necessary to provide backup capacity large enough to take over rapidly in the event of a sudden outage of the nuclear plant.

The scale and cost of such backup for an 1800-megawatt plant is so daunting in the context of Hongkong and Guangdong that it seems unlikely to be provided.

Yet the frequency of "trips" at nuclear power plants suggests that reliance on the proposed Daya Bay plant will lead to a precariously vulnerable power supply over the entire region.

A nuclear power plant is designed to operate at full output continuously, for both financial and technical reasons. Since fuel costs constitute a comparatively small proportion of the total cost of the electricity produced, the maximum return on the capital invested will be achieved by operating at the highest possible "capacity factor."

Furthermore, a nuclear plant is unsuited for "load following" - raising and lowering the output to match the instantaneous electrical demand on the system.

Repeated cycling of the plant, with the accompanying changes of temperatures and pressures, creates stresses that may shorten its service life significantly, and lead to maintenance and safety problems.

Accommodating the proposed Daya Bay plant on the existing interlinked grids of Guangdong and Hongkong will undoubtedly lead to difficulties in system operation, especially if almost all the smaller units available are permanently shut down, as appears to be the present plan.

The "all or nothing" output from the proposed Daya Bay plant will represent a cumbersome impediment as the supply output is continuously matched to users' requirements as they change from moment to moment.

On a longer timescale this "all or nothing" characteristic will also entail difficulties for planners in Guangdong and Hongkong.

Last year the electrical load supplied by Guangdong Electric was met in part by electricity supplied by the generating units of China Light and Power.

If the Daya Bay plant were built, its abrupt advent on the system would not be matched by a similarly abrupt increase in the total electrical load either in Guangdong or in Hongkong.

There would therefore be a transitional period, possibly lasting a good many years, during which a significant proportion of the total available generating capacity on the two systems would be substantially underused.

Thus to leave expensive existing plant underused will raise significantly the effective cost per unit of electricity generated.

Official comments have referred to the role of the proposed Daya Bay plant in the planned development of Guangdong - the "four modernisations."

This, however, presents an implicit dilemma. If the electricity is to be available for use by new industries and other developments in Guangdong, it cannot be sold to Hongkong.

On the other hand, if it is not sold in sufficient amounts to Hongkong, on an agreed, long-term basis, the plant will not earn enough foreign currency to be able to repay the loans required to finance its construction.

Anticipating the probable balance of load, as between Hongkong and Guangdong, for a plant that is not even scheduled to come into service until 1989, is an acutely risky basis on which to make the necessary financial commitments.

The authorities in Guangdong would also do well to note the impact that such large construction projects have had on local development in countries such as the UK.

They involve a very large workforce for at most a few years, after which the workforce is no longer required.

A nuclear power plant is one of the most capital-intensive of all industrial installations, employing at most a few hundred technicians, most of whom have special skills.

In that respect nuclear power represents a fundamental philosophical departure from almost every other aspect of China's modernisations, which depend above all on the skills of the Chinese workforce.

South China Morning Post, 17 March 1984, pg 2

Too many questions remain unanswered

Throughout last year the proposed nuclear plant on Daya Bay was the subject of a ferment of activity within China and internationally.

Early in the year Mr Peng Shilu, formerly in charge of the Chinese nuclear submarine programme, was appointed project director.

He and senior engineering colleagues from Peking set up a project office incorporating staff from the Nuclear Bureau of Guangdong Electric.

The office was located in Canton, but a new block to accommodate 1000 people was to be built within the Shumchun special economic zone. Preliminary site work at Daya Bay was undertaken.

Diplomatic activities reached a climax with a visit to Peking in August by the secretary-general of the International Atomic Energy Agency, Mr Hans Blix.

His visit bore fruit in October, when the member countries of the IAEA voted to accept China as a member. This did not, however, indicate any willingness on the part of China to accept international safeguards on Chinese nuclear activities.

From month to month the prospects of the competing foreign manufacturers oscillated. As Chinese accession to the IAEA became a probability, bilateral discussions between China and the US suggested a change in the status of trading agreements affecting nuclear exports.

Westinghouse, eager for the Daya Bay order, suddenly revealed a facet of its sales pitch not hitherto visible.

While US policy forbade it from approaching China directly, it had been working through supporters in the UK, on the basis of an order for Westinghouse reactors built by the UK National Nuclear Corporation and coupled to GEC turboalternators.

However, with the change in climate in Washington accompanying China's application to join the IAEA, Westinghouse let it be known in September that, should its bid succeed, it would take the entire order itself, leaving its erstwhile British partners out in the cold.

Finances continued to be the immediate critical issue. Merchant bankers Lazard Bros were commissioned to prepare a report for the Hongkong Government.

It was duly delivered in late October, but not published; and within a few days, on November 9, the Hongkong Government announced that it was in principle willing to allow Hongkong‘s electricity companies to enter into a long-term arrangement to buy some 70 per cent of the electricity output from Daya Bay.

The cost of the plant, which had been put at US$4 billion (about HK$31.2 billion) in late 1981, was by this time being quoted at an estimated US$4.6 billion (about HK$35.88 billion).

The financial structure proposed will entail 10 per cent equity and 90 per cent debt. China will hold

75 per cent of thc equity, and a Hongkong consortium led by China Light and Power the remaining 25 per cent. This consortium is called the Hongkong Nuclear Investment Co (HKNIC).

Although agreeing to put up a certain amount in equity, China is likely to pay for this stake in infrastructure, labour and materials, not in cash.

The majority of the debt, at an interest rate of 10 to 10 1/2 per cent, is expected to be raised from the export credit agencies of the exporting governments. At the moment these are expected to be France and the UK, with Framatome supplying two 900-megawatt PWRs and GEC the turboalternators. No orders, however, have yet been placed. Some months of intense competitive salesmanship from the various interested manufacturers are likely to pass before any contracts are signed.

In December, the Chinese authorities revealed that they intended to build not one twin reactor at Daya Bay but two. The other plant, including two more PWRs, would be entirely of Chinese design and construction.

According to the Chinese authorities, the second plant had to be built virtually at once, without waiting for the first plant to be completed, to meet the demand in Guangdong province. Its entire output would be for use in the province, not for export.

The announcement raised many questions.

What would be the relationship between the two plants simultaneously under construction at Daya Bay? Would imported design information and data in the first plant be used in the second? If so, what arrangements would the Chinese make to reimburse the foreign supplier of the first unit? How would a supplier react if such reimbursement were not forthcoming?

If foreign data was not used for the second plant, why was the first plant being imported at all? How would the second plant be financed, given that virtually all the capital for even one plant had to be raised outside China?

If Guangdong province needed only 30 per cent of the output of the first plant, how would it use the entire output of the second?

lnscrutibility reigns.

In 1981, with a price tag of US$4 billion on Daya Bay, the GEC chairman, Lord Nelson, calculated that repayment of this sum through sales of electricity to Hongkong would take 25 years.

Now that the price tag has risen to US$4.6 billion, the repayment period on Lord Nelson‘s figures would presumably be around 29 years. It is worth noting that the maximum working life of a commercial nuclear power plant is expected to be 30 years. None has yet operated that long.

The increase from US$4 billion to US$4.6 billion represents a l5 per cent jump in two years. But that does not tell the whole story. For in 1981, US$4 billion was worth approximately HK$20 billion. Now, as a result of jitters about Hongkong‘s political future, US$4.6 billion is worth HK$36 billion.

So in terms of Hongkong dollars, the price for Daya Bay has gone up [HK]$l6 million, an increase of not 15 per cent but 80 per cent.

It would be interesting to know how much - in Hongkong dollars - it is now estimated Hongkong consumers will have to pay for their electricity to enable China to pay off the cost of Daya Bay.