The Hong Kong Institution of Engineers - Electrical Division

The Twelfth Annual Symposium, 1994

Great Expectations ?

As to the planning out from week to week, nobody can imagine what the difficulty is, without trying. But, as in all such cases, when it is overcome, the pleasure is proportionate.

..... Charles Dickens

THE HONG KONG INSTITUTION OF ENGINEERS ELECTRICAL DIVISION

The Twelfth Annual Symposium

Tuesday

25th October 1994

GREAT EXPECTATIONS ?

at

Silver Ballroom

Sheraton Hotel

Nathan Road

Kowloon

Hong Kong

SYMPOSIUM PROGRAMME

08.30 Registration and Coffee

09.00 Welcome Address
- Mr David C.M. Yuen
  Chairman, Electrical Division, The HKIE

09.05 Opening Address
- Mr Malcolm J. Matthews
  President, The HKIE

09.10 Keynote Speech
- Prof. Eugene Wong
  Pro-Vice-Chancellor
  for Research and Development
  Hong Kong University of Science and Technology

1. The Means

09.40 The Hong Kong Airport Core Programme
- Mr John Burrett
  Deputy Director
  New Airport Projects Coordination Office
  Hong Kong Government

10.00 Light Expectations
- Mr Ben Papé
  Director (Far East)
  Pirelli Cable Sector
  Pirelli Cavi S.p.A., Italy

10.20 Discussion

10.35 Coffee Break

2. The Link

11.05 New Public Transport Systems/Automated Transit Systems

- Mr Andrew S. Robbins
  Vice President
  Complete Transit Systems Business Segment
  AEG Transportation Systems Inc., U.S.A.

11.25 Lantau Fixed Crossing - Electrical and Mechanical Services

- Mr K.C. Yeung
  Project Director
- Dr K.M. Leung
  Senior E&M Engineer,
  Highways Department, Hong Kong Government

11.45 Basic Infrastructure for the New Airport at Chek Lap Kok

- Mr Chris Calton
  Project Engineering Manager
  Provisional Airport Authority, Hong Kong

12.05 Discussion

12.20 Lunch

3. The Block

14.10 Nuclear: A Great Expectation?

- Dr Jacques R. Pretti
  Senior Nuclear Technical Advisor
  Hong Kong Nuclear Investment Co. Ltd

14.30 The Black Point Combined Cycle Power Station

- Mr Peter N.K. Shum
  Project Manager
  Generation Projects Department
  China Light & Power Co. Ltd, Hong Kong

14.50 Discussion

15.05 Coffee Break

15.35 The Three Gorges Project

- Mr Wang Jiazhu
  Vice Commissioner & Chief Engineer
  Changjiang Water Resources Commission, PRC

16.05 Discussion

16.20 Summing Up

- Symposium Chairman
  Mr Peter Y.S. Wong
  Managing Director
  Yook Tong Electric Co. Ltd, Hong Kong

Closing Address

- Mr A.G. Eason, JP
  Secretary for Planning, Environment and Lands
  Hong Kong Government

Acknowledgement

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Speakers / Authors

Prof. Eugene Wong
Mr A.G. Eason, JP
Mr Malcolm J. Matthews
Mr John Burrett
Mr Ben Papé
Mr Andrew S. Robbins
Mr K.C. Yeung
Dr K.M. Leung
Mr Chris Calton
Dr Jacques R. Pretti
Mr Peter N.K. Shum
Mr Wang Jiazhu

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Paper No. 1
(Keynote Speech)

TECHNOLOGY POLICY AND INFRASTRUCTURE DEVELOPMENT

Speaker : Eugene Wong
Pro-Vice-Chancellor for Research & Development
Hong Kong University of Science and Technology

TECHNOLOGY POLICY AND INFRASTRUCTURE DEVELOPMENT

Eugene Wong
Pro-Vice-Chancellor for Research & Development
Hong Kong University of Science and Technology

Paper No. 1

ABSTRACT

The end of the Cold War coincided with the dawning of a major new era for the major industrial economics of the world. Globalization of business, unprecedented levels of competition, short product cycles, emerging economic power of the Pacific Rim, etc., all exert a high level of pressure on business decisions and government policy making. In this paper, we attempt to formulate a coherent framework for the role of technology in forging and sustaining economic growth. The paper will draw on the experience of the author in developing a technology policy for the United States during the Bush administration, but the issues have strong relevance for Hong Kong.

As used by economists, the term "industrial policy" means a deliberate government policy to favour certain industries and specific sectors of a nation's economy at the expense of others. Though widely practised, industrial policy is highly controversial, and few nations adopt it in its pure form. Those that practice it do so for reasons political as much as economic. Hong Kong, in particular, is justly proud of its success as a free market economy and by and large eschews the practice of industrial policy.

Technology policy has its origin in attempts to justify a governmental role in the development of newly emerging industries that cannot develop without some form of public investment and fostering. A coherent technology policy seeks to balance the needs of "industries of the future" for public investment against the perils of government interference of the free market. The underlying issues are of particular importance to Hong Kong at this juncture. Hong Kong is making major public investments in both human and physical infrastructures just as its economic and political structures are undergoing historical changes. There is indeed a need for a coherent technology policy.

Paper No. 2

THE HONG KONG AIRPORT CORE PROGRAMME

Speaker : John Burrett
Deputy Director
New Airport Projects Coordination Office
Hong Kong Government

THE HONG KONG AIRPORT CORE PROGRAMME

John Burrett
Deputy Director
New Airport Projects Co-ordination Office
Hong Kong Government

ABSTRACT

Hong Kong is making excellent progress with the construction of one of the world's largest infrastructure programmes. The Hong Kong Airport Core Programme, or ACP, consists of a dramatic series of 10 projects. It will provide the territory with a state-of-the-art international airport, 1,670 hectares of new land, 34 km of highways, bridges and railway, and a new town with an initial population of 20,000. The programme costs an estimated US$20.3 billion in money of the day price, to be financed by the Hong Kong Government, as well as the private sector, both local and international. This paper will show you the latest progress of works and details of international participation in the programme.

Paper No. 2

1. HONG KONG AND THE REGION
*(Slide 1 & *1)*

There are strong economic arguments for the ACP. Located in the southern part of the Chinese Guangdong Province, Hong Kong has successfully taken up an active entrepot role, with its own economy growing as the economy of China and the Asia region grows. China is now Hong Kong's largest trading partner, accounting for about one third of Hong Kong's total trade value. In 1993, the two-way trade continued to grow strongly, by 18% over a year earlier to US$95 billion. China is now the largest market for Hong Kong's domestic exports and re-exports and has become Hong Kong's largest external investor. Reciprocally, Hong Kong is China's second largest trading partner, accounting for 17% of China's total trade. It is also China's most important source of external investment, accounting for around two thirds of China's total. Hong Kong is now an important services centre for China generally and South China in particular, providing the supporting infrastructural facilities like port and airport and institutional services like financial and related business services. Its role as an entrepot for China has becoming increasingly important in recent years.

Hong Kong's externally oriented economy heavily depends on efficient communication, including air transport. Our present airport at Kai Tak is already the world's second busiest airport in terms of international cargo and the third busiest in terms of international passengers. However, the down town location of Kai Tak does not allow much scope for further expansion to cope with the fast growing needs of Hong Kong as an international and regional aviation and business centre and in particular the main gateway to China.

The proposal for a replacement airport at Chek Lap Kok was given the green light in late 1989. Negotiations with China started in late 1990 and concluded in September 1991 with the signing of the Memorandum of Understanding Concerning the Construction of the New Airport in Hong Kong and Related Questions. This Memorandum confirms the support from both the Government of the UK and the PRC for the development of the new airport and the related core projects. In accordance with the Memorandum, the Hong Kong Government is proceeding with the ACP, with a view to completing it to the maximum extent possible by 30th June 1997.

The ACP is designed to transform Hong Kong's infrastructure facilities and physical dimensions in a most cost-effective manner. It will ensure that the infrastructure will meet the demands in the next century.

2. AIRPORT CORE PROGRAMME
*(Slide 2 & *2)*

Of the 10 ACP projects, 7 are funded by the Government as public works projects at a cost of US$6.7 billion MOD. These include three reclamation projects in Tung Chung, West Kowloon and Central, two bridges and a series of highways - the North Lantau Expressway, the Lantau Fixed Crossing, the Route 3 and the West Kowloon Expressway. The remaining three, the New Airport, the Airport Railway and the Western Harbour Crossing involve private sector participation as they are capable of being operated on a commercial basis. These projects will be going through herebelow, with the help of slides.

3. THE NEW AIRPORT
*(Slides 3-4 & *3-*4)*

The new airport at Chek Lap Kok is scheduled to open initially with one runway operational 24 hours a day, with the second runway phased into operation in accordance with air traffic demand. Ultimately, the new airport will have a capacity of 87 million passengers and 9 million tonnes of cargo a year. This project is presently undertaken by a public corporation - the Provisional Airport Authority (PAA), which is fully owned by Government but runs on prudent commercial principles. The PAA will become a permanent body (Airport Corporation) later on.

The airport will cover an area of 1,248 hectares. If you visit the new airport site now, you will see the significant headway already made on the massive job - over 800 hectares of land, or nearly 64% of the airport site, is now visible above sea level. This site formation contract was awarded in November 1992. In parallel with the site formation work, the design for the passenger terminal building is nearly complete. Contract for the construction of the passenger terminal foundation has also been awarded.

4. TRANSPORT PROJECTS
*(Slides 5-11 & *5-*11)*

The ACP comprises six transport projects. These projects, when completed, will significantly develop the transport facilities in Hong Kong.

The first project, **North Lantau Expressway**, 12.45 km long, is to link Tung Chung New Town and the new airport to the Lantau Fixed Crossing. It will run along the northern shore of Lantau Island at sea level and is divided into three portions - Tai Ho, Yam O & Tung Chung sections. Overall, 51% of the project is complete.

The second project is **Lantau Fixed Crossing (LFC)** which links up Tsing Yi, Ma Wan and Lantau. The two main parts of the LFC are the 2.1 km Tsing Ma suspension bridge connecting Tsing Yi and Ma Wan and the 0.8 km cable-stayed Kap Shui Mun bridge spanning the channel between Ma Wan and Lantau. A 0.5 km viaduct over Ma Wan links the two bridges. The bridges and viaduct will carry three lanes of traffic in each direction on their upper deck and two rail tracks on their sheltered lower deck, which will also have two single road lanes for emergency use. Overall 44% of the project is complete.

Route 3 links the LFC and West Kowloon Expressway. The project includes a new 500 metre crossing of the Rambler Channel, a 1.6 km three-lane tunnel and a 8.1 km of dual three lane urban expressway. When fully completed and including part of Route 3 outside the ACP scope, it will provide a direct north-south link between the urban area and the border into China. Overall, 30% of the project is complete.

Then it comes to the **West Kowloon Expressway** which is a dual 3-lane highway running over the West Kowloon Reclamation (WKR) and linking Route 3 and the northern end of the Western Harbour Crossing. There will be interchanges near Mei Foo and Yau Ma Tei providing links with local traffic network serving to relieve traffic congestion

in the Kowloon urban area. Overall, 17% of the project is complete.

The **Western Harbour Crossing** will become Hong Kong's third road tunnel under the harbour. The tunnel will be 2 kilometres long and will be dual three lane. This project costs US$0.83 billion (MOD) and is currently undertaken by a private franchisee who has a 30-year franchise to operate the tunnel. Physical works started in September last year. Overall, 20% of the project is complete.

Finally, there is the 34 km **Airport Railway (AR)** which consists of two kinds of services. The Lantau Line links up Hong Kong Island and Tung Chung with intermediate stations at Kowloon, Tai Kok Tsui, Lai King (an interchange station with the existing MTR) and Tsing Yi. This service is projected to carry more than 260,000 passengers daily when it opens, which will ease congestion on the present Tsuen Wan Line. The Airport Express will carry passengers between the new airport and Hong Kong Island in 23 minutes, with stations at Kowloon and Tsing Yi. AR advanced works are being carried out under various Government ACP roads projects and the Immersed Tube Tunnel contract was also awarded in June 1994. The AR will go full stream ahead after an agreement is reached on financing with China.

5. LAND DEVELOPMENT

*(Slides 12-14 & *12-*14)*

The three land development projects, namely Tung Chung New Town Development, West Kowloon Reclamation and Central Reclamation Phase I are detailed as follows :

5.1 **Tung Chung Development Phase I** - Reclamation works for Tung Chung Development Phase I have been completed. On this newly reclaimed land, a new town will be built to support the airport. The new town will have an initial population of around 20,000. Contracts for construction of Government facilities have just been awarded. Overall, 32% of the project is complete.

5.2 **West Kowloon Reclamation (WKR)** - The West Kowloon Reclamation project will provide 334 hectares of urgently needed new land for construction of transport facilities for the new airport and for urban development. It will increase the size of the Kowloon Peninsula by about one-third and by now 80% of reclamation work is complete. The WKR project involves complex programming to maintain, reprovisional waterfront activities, drainage, seawater intake and pumping facilities. Overall, 60% of the project is complete.

5.3 **Central & Wanchai Reclamation Phase I** - It involves reclaiming 20 hectares of land to provide landfall for the Airport Railway - Hong Kong Central Station as well as land for expansion of the central business district. Construction work commenced in September 1993. Overall 32% of the project is complete.

6. CONTRACTS AWARDED AND INTERNATIONAL PARTICIPATION

*(Slides 15 & *15)*

As mentioned earlier, the ACP comprises 10 infrastructural projects at an estimated cost of US$20.3 billion MOD. To date, a total of 60 major ACP construction contract worth over US$6.5 billion is awarded. About 200 more contracts are to be awarded by the Government, the Provisional Airport Authority and the MTRC in the coming years. These range from construction of facilities at the new airport to works on the Airport Railway, highways and new town projects.

In line with Hong Kong's traditional free trade and 'open door' policy as an international commerce, trade, financial, aviation and communication centre, international participation in the ACP projects is encouraged. Indeed, the ACP has already drawn participation from countries worldwide. Taking the lead in major construction contracts awarded are companies from Japan (26% by value), to be followed by Hong Kong (20%), the U.K. (14%), the Netherlands (10%), PRC (8%) and France (6%). Key players in consultancies awarded

Pape No. 2

are Hong Kong firms with British, U.S. and other origins (66%), U.K. firms (22%) and U.S. firms (9%). International firms to participate in future tenders for the works will continuously be encouraged.

7. OVERALL PROJECT & COST MANAGEMENT

*(Slides 16 & *16)*

As seen from the above, each of the ACP projects is in itself a large and complex undertaking. The need for close interface is tremendous. To meet the prime objective of completing all projects on schedule and within budget, a project management system is set up under which the 10 projects are tightly managed, both individually and collectively. An overall baseline plan has been established which sets down the firm scope, critical programme objectives and milestones, and detailed budget for the whole ACP. This baseline plan serves as a fundamental reference point for the programme management, and is also a comprehensive road map to keep projects on track towards their completion targets and within budget constraints. Together with a firm cash limit on each project, and a regime of fixed price lump sum contracts awarded after open competitive tendering, it would be happy to say that, so far, the ACP is on schedule for completion and within budget. This is, by any standard, a remarkable achievement for an infrastructure programme of such scale.

While talks with China on the detailed financing arrangements for the Airport and the Airport Railway are continuing, remarkable visible progress has been made since the signing of the Memorandum Of Understanding in 1991. It is optimistic that the talks will soon lead to an agreement on financing arrangements, thus adding further impetus to the current momentum. From the progress which has just been outlined, you will see for yourself the terrific progress already being made on the ground. With participation from firms all over the world, the vision for Hong Kong's key infrastructural and transportation network is taking shape. With the transfer of sovereignty in mid-1997, vigorous efforts are being made to provide Hong Kong with the new basic infrastructural links for forging ahead as the gateway to China and as the international business and communications centre of the Asia Pacific region in the 21st Century. It is confident that the ACP is a sound investment in the future of Hong Kong, and is the key to ensure that Hong Kong's success story will continue into the next century.

DUAL SLIDE PRESENTATION

LEFT	RIGHT
1. Hong Kong & the World	*1. Hong Kong & Asian Pacific
2. Airport Core Programme	*2. Airport Core Programme Cost
3. Chek Lap Kok in 2040	*3. Passenger & cargo capacities for Chek Lap Kok
4. Chek Lap Kok in construction	*4. Chek Lap Kok - Passenger terminal building
5. North Lantau Expressway - Artist impression	*5. North Lantau Expressway - Construction (Yam O Section)
6. Tsing Ma Bridge - Artist impression	*6. Lantau Fixed Crossing - Construction (Tsing Yi site)
7. Kap Shui Mun Bridge - Artist impression	*7. Lantau Fixed Crossing - Construction (Ma Wan site)
8. Cheung Ching Tunnel - Artist impression	*8. Cheung Ching Tunnel Entrance for Route 3 - Construction
9. West Kowloon Expressway - Alignment	*9. West Kowloon Expressway - Construction
10. Western Harbour Crossing - Artist impression	*10. Western Harbour Crossing - Construction
11. Airport Railway & Lantau Line Stations	*11. Airport Railway - Compartment
12. Tung Chung - Construction	*12. Tung Chung - Future look
13. West Kowloon Reclamation- Reclamation boundary	*13. West Kowloon Reclamation - Construction (Overview)
14. Central & Wanchai Reclamation Phase I - Reclamation boundary	*14. Central & Wanchai Reclamation Phase I - Construction
15. Airport Core Programme contracts awarded	*15. International participation in contracts.
16. Work of Projects Divison	*16. Project Programming & Control Cycle

Paper No. 2

Paper No. 3

LIGHT EXPECTATIONS

Speaker : Ben Papé
Director (Far East)
Pirelli Cable Sector
Pirelli Cavi S.p.A., Italy

LIGHT EXPECTATIONS

Ben Papé
Director (Far East)
Pirelli Cable Sector
Pirelli Cavi S.p.A., Italy

ABSTRACT

This paper traces the development of optical fibre systems, their use today, new developments on the horizon and future possibilities.

The paper surveys recent product developments in fibre, in fibre cables and in optical amplifiers.

The paper reviews some pioneering projects including the underwater festoon interconnection of major coastal cities; designer cable systems for motorways, railways and electricity lines; and local networks for business operations.

The paper reflects on the growing demand for interactive communication and the role of optical fibres in realising this.

1. INTRODUCTION

The usage of optical fibre systems is now so widespread that it is easy to forget that this technology has been available to us for less than 20 years. If electricity is the lifeblood of civilised society, then optical fibre networks have become the central nervous systems of modern society.

Communication capability is an essential prerequisite to modern day business and social life as evidenced by our total frustration when phones or faxes fail to work. The ability to communicate is now regarded as a basic necessity of life almost as basic as food and shelter, all of which we take completely for granted. The developing technologies of communication have enabled us to become ever more interactive in our daily lives and ever more dependent on the reliable functioning of the communication systems. Our expectations then are enormous if not yet light orientated.

Communication may be defined as the transfer of information from one point to another. That definition supposes there be an information source, a medium for transmission and a receiver. The transmission medium quite evidently needs to be as efficient as possible in terms of loss or distortion of signal, of volume of information carried and of distance travelled. Why then optical fibres and how are they better than the alternatives?

Glass fibre, as a communication medium, has a number of distinct advantages over alternatives. It is a small, light, flexible conduit of low loss with enormous bandwidth capacity (currently 40,000 channels and shortly 120,000 channels); it is virtually immune to external electromagnetic interference and is free of crosstalk problems; it is electrically safe in that there is present no energy of sufficient strength to ignite explosive atmospheres; it has high security in that external eavesdropping is not possible without entering the system in a detectable way; it derives from a readily available and low cost source material (sand) and its transmission potential is limited only by the sending/receiving equipment. These are qualities as yet unmatched by any other communication medium.

2. THE EARLY HISTORY

Light has been a means of communication since the dawn of time. The stars, the moon and the sun have all been (and still are with some) immense influences on our lives not only on the physical aspects of day and night but also as our very communication with the heavens. As time passed, we learned to use the power of the sun to communicate with our neighbours by simple reflected signals and later we lit fires or beacons to alert our whole nation of impending disasters.

By the 19th Century, mankind was becoming more scientific and in 1880, Alexander Graham Bell experimented with speech transfer by light. In the early part of the 20th Century, experiments continued although only limited progress was made due to the lack of powerful reliable light sources and the restrictions of transmitting in an industrialised environment. In short, the air of modern cities was too variable and too obstructed to be of real use as a medium for the transmission of light from point to point within the cities.

Light as a carrier again aroused interest with the advent of lasers in the early 1960s. Lasers provided very powerful focused beams with little chromatic variation and seemed an ideal light source. Unfortunately, the urban atmosphere was becoming more imperfect with increasing pollution and decreasing line-of-sight potential. In reality then, another medium either natural or man-made was required.

The proposal for light transmission via a glass fibre was made in 1966 by Kao and Hockham and almost simultaneously by Werts. These initial glass fibres however exhibited attenuations of 100dB/km which placed them at a considerable disadvantage to coaxial copper with attenuations of say 10dB/km. Another disadvantage was the problem of joining these glass fibres without substantially increasing attenuation loss.

It was another ten years before glass fibre was able to be made with attenuations similar to coaxial copper and, at the same time, lasers were developed with life-times measured in the thousand of hours rather than the few hours of the earlier models. And so the age of optical fibre systems was born with first networks being installed in the later 1970s and with a proliferation starting in the later 1980s. Now optical fibre systems are the norm for all trunk networks in both the developed and developing worlds.

3. TECHNOLOGY DEVELOPMENT

Once the fibre transmission characteristic of attenuation descended to the level of copper coaxial, it started to be installed in the transmission networks. Once that happened, the quest was on to understand and improve the transmission characteristics of fibre.

The principle of light transmission along a glass fibre is complicated and involves quite complex mathematical equations evolved from a number of theories including quantum energy. For the sake of understanding, these are generally reduced to a simple "ray theory" which considers the effects on a light ray at the interface of a more/less dense medium and consequently is reflected and/or refracted. The purpose of optical fibres is to transmit the injected signal with the greatest efficiency (i.e. with the minimum loss or distortion). This light transmission efficiency is affected by such physical parameters as diameter of transmitting core, refractive indices of transmitting and reflecting media, signal injection angle etc. and all these need to be optimised for the best results.

It also rapidly became clear that fibre was not equally transparent to all the possible signal frequencies. In particular, there were three signal frequencies at which the fibre became relatively opaque and between which were three frequencies where the fibre became relatively transparent. So that fibre characteristic determined the operating frequencies of the optical fibre system and the search was then on to find optical transmitters for these frequencies.

The first signal generators of practical use were light emitting diodes (LED) operating at 930 mm and this wavelength became the "first window"of operation in widespread use. However, it never became possible to reduce the attenuation levels achievable below 2dB/km which seemed to be a theoretical limit. Due to the attenuation and dispersion of this "first window", information speed needed to be restricted generally to 140Mb/s with some short systems operating at 480Mb/s.

Attention was then turned to the "second window" wavelength at 1310nm when longer life and more reliable laser signal generators became available during the mid 1980s. This "second window" wavelength allowed

attenuation levels of 0.33dB/km to be achieved with information rates of 2.5Gb/s. An added advantage was almost zero chromatic dispersion of the signal.

As the need grew to increase the amount of information to be transmitted down each fibre so the pressure grew to utilise the "third window" at the operating wavelength 1550nm with theoretical attenuation levels of 0.15dB/km and information rates in excess of 10Gb/s (equivalent 120,000 channels). This "third window" has already become the principal operating system for high capacity transmission networks in the western world. There are some inherent problems of chromatic dispersion which can be overcome by reconfiguring the fibre and/or improving the chromatic coherence of the laser signal generators.

4. DESIGNER CABLES

The techniques of fibre production have now advanced to a level where attenuation levels of 0.25dB/km are achievable meaning that 100 km of fibre has less light loss along it than occurs across 1 m of household glass window-pane. The capacity of each fibre has already risen to 2.5Gb/s (30,000 channel equivalent) with 10Gb/s on the immediate horizon.

However this potential to carry vast information over great distances is only realisable if the fibre can be packaged into a usable form for the client. Therein lies the challenge to the cable maker.

Physically, the fibre is a fragile object possessing limited tensile strength, wide temperature range of operation and reasonable flexibility (only when suitably protected) but little else. It exhibits low resistance to impact, crushing or twisting forces or vibration.

Optically, the fibre is sensitive to all these physical constraints and a lot more besides. It doesn't like any physical strain or stress (it's apt to crack under stress) especially tensile and, in water, its performance can be degraded.

In order then to achieve a cable of the requisite quality, not only initially but sustainable over the cable lifetime, the fibre/cable manufacturer must have capability in a number of key areas. Firstly, of drawing a fibre to very precise physical and optical parameters. Secondly, of protecting and colouring those fibres for inclusion in a cable. Finally, of forming a cable usable to the client and allowing the fibres to operate in an inert stable cocoon deflecting or absorbing all the external dangers encountered. These external dangers might be temperature cycles from -50°C to +150°C, surrounding pressure up to 500ton/in^2 (i.e. in water depths up to 5000 m), immersion in water and/or more aggressive chemicals and general physical abuse during installation and/or subsequent activity in the vicinity.

Paper No. 3

With appropriate technology, it is not too difficult to make an initially acceptable optical fibre cable, if fibres are purchased from one of the leading fibre providers. What is more difficult is to make an optical fibre cable which sustains an acceptable performance over a lifetime of say 25 years or more. That requires a history of experience of cable manufacturing for many applications and in many environments.

5. INFRASTRUCTURE PROJECTS

The great attributes of optical fibre cables enable their consideration for many applications and in many environments. Initially, the demand was from national telecom authorities keen to upgrade their national and international trunk networks. This demand is growing as businesses/consumers demand ever more communication interaction and as ever more competitors enter the information services market. Similarly, the possibilities expand as the manufacturers improve the usability of optical fibre cable systems. This push-pull pressure has created brilliant expectations for the use of optical fibre systems in satisfying many communication needs.

The author's company has pioneered the development and use of optical fibre cables for

many innovative and challenging applications worldwide - a few of the more interesting are now enumerated.

A. UNDERWATER FESTOON NETWORKS

In some countries, it is becoming increasingly difficult to obtain approval for interconnecting cities if this involves unsightly overhead lines or excavation of the countryside. How then to interconnect these cities without the time consuming and costly legal processes involved and the inevitable outcry from the evergreen conservationists? Fortunately, most major cities of the world started life on the banks of a river or on the shore of a sea and so water can be considered a readily accessible route (always provided that the reproductive habits of some local endangered flora/fauna are not adversely affected).

Italy is a long narrow peninsular with most major cities within easy reach of the coastline. Given the acknowledged beauty of the Italian terrain and its strong environmental lobby, it was not too illogical to reason that the surrounding sea could provide the simplest and quickest means of interconnecting the principal coastal cities.

In the mid 1980s, the Italian Post Office (ASST) decided to realise a nationwide long distance optical network involving 6500 km of land cables and 1800 km of undersea cables. This latter undersea festoon project looped 17 principal cities along the western and southern coastlines and was completed in a mere 18 months - a considerable time improvement on a land-laid alternative.

The undersea festoon cable circuits were required to operate independently from the land circuits but at the same rate of 565Mb/s over unrepeatered lengths of almost 200 km. This required very sophisticated equipment and cables with zero dispersion whilst maintaining attenuation at 0.2dB/km. These subsea cables utilised the revolutionary optical amplifiers for maximum signal strength.

As with all subsea installations, it was necessary to design cables for differing water depths and varying sea fishing activity. In all, there were four designs of cable required for installation in water depths up to 1600 m and for protection against fishing activity likely up to depths of 35 m. This protection involved the embedment of cables in both sediment and rock sea floors.

Malaysia has a similar coastline profile and the same telecom network needs as Italy. It was hardly surprising then that the same solution has been decided and the second telecom operator TIME has opted for a subsea festoon project interconnecting 19 cities on the western, southern and eastern coasts. This US$100m project was awarded in July 1994 with commissioning scheduled for December 1995. The project comprises 1682 km of 24f submarine cable in 19 segments (longest 140 km) in water depths up to 60 m and the cable will be embedded along the entire subsea length. The system will initially operate at 622Mb/s with future upgrades to 2.4Gb/s and 10Gb/s.

B. FINDING NEW CUSTOMER ROUTES

In modern society concerned with the quality of life, it is becoming increasingly difficult to obtain virgin routes whether they are for transport, for energy or for tele-communications. However, many existing routes remain which can be used by another service if it does not interfere too greatly with the original service. The small size and flexibility of optical fibre cables makes possible the routing of telecom circuits along other service routes - notably roadways, railways and electricity lines.

When the second telecom operator (TIME) was appointed in Malaysia, it needed to find a quick and cost effective method of installing an initial backbone network. At about this time, a new north-south (PLUS) highway was being planned and so a

decision was taken to lay a cable system along this highway as it was being built. This US$30m project comprised 1000 km of 36f cable and was installed and commissioned during 1993/4.

Electricity utilities have a natural advantage in the world's drive to telecoms modernisation. Not only do they have the skilled staff and specialist equipment to maintain links often in tough terrain but they also have a ready-made cable route (i.e. the overhead power lines) available. Consequently, optical fibre products have been developed to wrap-around existing earth wires, to be incorporated into new ground wires (OPGW) and, more recently, to be all dielectric (i.e. completely metal free) and self supporting (ADSS) over spans up to 1000m.

When ENERGIS (the newly formed telecom subsidiary of the UK National Grid Co.) was establishing its basic network, it was natural that the supergrid power lines should provide the routes. That resolved the problem cross-country but how to reach the potential clients say in London where overhead electricity power systems are non-existent. A feasibility study undertaken by ENERGIS showed that two thirds of all central London businesses employing more than 200 people were situated within 500 m of an underground station - an average connection length of 250 m. And so the London Underground was the obvious route for the ENERGIS circuits to its London customers. A 65 km system of 64f cable has just been installed along the walls of the train tunnels with armour protection against possible damage in use or maintenance.

The world's railway authorities also recognise the potential for diversification into telecoms with their unique network of routes to virtually every major national city. Indeed, in China both the ministries of railways and power are major shareholders in the second telecom operator China UNICOM and doubtless their routes will be the basis for the UNICOM network of the future.

C. VALUE ADDED NETWORKS

As governments seek to gain more and more information on our daily business lives (we assume for tax reasons) so the need for automatic gathering and analysing increases. In China, the government has announced the "Three Golden" projects of which Golden Customs will be collating information for import/export duties and value added tax (VAT).

In UK also, the Customs & Excise has decided to upgrade its VAT operations with a new VAT HQ in Liverpool Docklands. Designed from the outset to accommodate the latest technology, the building has a hollow centre through which run the essential services. Each of the inner corners of the four main floors has a communications room to which is connected a 12f cable and from which is distributed a 4f cable linking 360 floor boxes on each floor. Every floor box has two voice and two data outlets which together with the 18 hubs form a 10Base-TEthernet system. To ensure resilience there are two separate fibre paths to each communications room with automatic switching between paths within milliseconds.

Paper No. 3

6. THE FUTURE

The future possibilities for optical communication systems are almost limitless thanks to the development of new technologies in PHOTONICS, such as optical fibre amplification, optical modulation, wavelength tuning, optical switching and dense wavelength division multiplexing.

The first of these innovations, erbium-doped optical fibre amplifiers (EDFAs) was developed as recently as 1986, but the benefits are so significant that EDFAs have already been industrialised and applied to the latest state-of-the-art transmission systems (e.g. MCI's 2500 km USA network operating at

2.5GB/s between Chicago Denver and Salt Lake City). EDFAs revolutionise the basis of long distance submarine and even CATV network design due to their ability to compensate for the intrinsic attenuation in fibre transmission - thereby reducing, or even eliminating, the need for expensive and space-consuming opto-electronic regulators.
The successful implementation of EDFAs in terrestrial systems will soon be followed by amplified submarine links across the Atlantic and the Pacific. Even in the "local-loop", as amplifier costs fall, EDFAs will find widespread application pushing fibre-to-the home (FTTH) for broadband services such as CATV and multimedia.

The concept of the next step, the ALL PHOTONIC NETWORK (APN), has already been proven in the laboratory and is moving into field trials; optical channels (hence services) will be routed automatically and optically, according to wavelength, between major switching centres at national and international level. Thanks to dense wavelength division multiplexing (DWDM) and optical switching, tens or even hundreds of optical channels will be packed into the 1550 mm window and will be real-time configured and re-routed to give the network infrastructure a new degree of flexibility. For the user, this will mean instantaneous bandwidth availability for new services such as Video on Demand (VOD), Video-conferencing, interactive multimedia (education, games, shopping at home) and even remote working.

Even though EDFAs and photonic networks have had an immediate and dramatic impact, the current state-of-the-art has been likened to the early stages of transistor development and we can foresee longer term integration of optical circuits (OLSI) in the same way as VLSI electronics followed the transistor. Optical computing then becomes a real possibility, as a "spin-off" from optical communications technologies.

7. THE EXPECTATION

The communications industry is facing a future of immense potential with the development of a new generation of broadband "information superhighway" networks delivering telephone, computer, television and other services. Using optical fibre and advanced electronics, these networks will enable visual and virtual reality images, speech, sounds and graphics to be communicated instantly between any two points on the globe.

Today, it can only dimly be visualised what would develop from this; a new dimension to commerce and industry; a revolution in education, medicine, shopping and leisure; quite possibly a decisive cut in the need for physical travel and thus in energy consumption, pollution and traffic congestion; and a new medium for political activity.

The UK House of Commons trade and industry select committee in submitting its report on "optical-fibre networks" called for radical changes to the regulatory regime for telecommunications and broadcasting to ensure the rapid construction of a UK "electronic superhighway".

New Brunswick Canada is not the sort of place where one expects to find a Ministry of Information Highway but if that ministry (created last February) succeeds in its role then New Brunswick will soon gain recognition as a pioneer in the unfolding world of multimedia.

So read recent articles in the UK Financial Times. Practically every week there is some reference in the world's leading newspapers to the oncoming multimedia revolution and the concomitant need for information superhighways. Also in China, there had been much recent public discussion on the already mentioned "Three Golden" projects, all of which involve considerable investment in substantial digital information highways.

So the age of interactive communication under the guises of multimedia, virtual reality, electronic shopping, home banking, mobile videotex, cashless services, etc. is dawning and broadband interactive communication is the seemingly lone prerequisite. How will this broadband communication be transmitted? Undoubtedly, there could be a broadband adaptation of the coaxial cable technology traditionally used in the cable TV industry. However, the superior gigabit bandwidth capacities of the optical fibre system together with all its other advantages suggest that this will be the prime medium for interactive communication into the 21st Century.

In that respect, it could reasonably by supposed that the expectations for communications will certainly be illuminating if not light and that the expectations for optical fibre cable systems will undoubtedly be bright if not brilliant.

Paper No. 4

NEW PUBLIC TRANSPORT SYSTEMS/ AUTOMATED TRANSIT SYSTEMS

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ABSTRACT

Today's urban metro systems must meet stringent requirement, both from the professional transportation planner's perspective, and from the perspective of the passengers. These perspectives typically are quite different.

The transportation planner may view these issues most importantly :

- Safety
- Reliability
- Performance
- Cost
- Constructability
- Schedule
- Environmental

The passenger view can be quite different, with these issues often seen as most important :

- Comfort
- Convenience
- Aesthetics.

For cities developing entirely new metro systems or feeder lines to existing metros, and where the ability to use tunnelling, or where space at surface level is severely limited or other environmental concerns may rule out conventional rail systems, AEG has developed Advanced Automated Rail System. The concept considers both planner's and passenger's perspectives to form a complete urban metro system. This system, typically operating on a dedicated, overhead guideway, combines the high performance, highly automated, tight turning radius and passenger comfort aspects of automated transit systems together with the high technology of rail systems to form a customized system well suited to special urban requirements.

The system draws its rail technology from high quality and well proven subsystems. It is unique in that it also includes the technology of automated transit systems, such as those in service on Automated People Mover Systems.

The system is usually implemented under a design-build, or turnkey arrangement, so that all aspects of the metro system, such as safety, reliability, performance, comfort, constructability and environmental concerns can all be considered concurrently. This systems approach allows all elements of the design and construction process to be considered together and to determine the effect of one design on another. Cost can also be reduced because a single contractor team is responsible for designing, building and, at option of the responsible authority, operating and maintaining the system.

Paper No. 4

1. INTRODUCTION OF TECHNOLOGIES

Over 25 years ago, AEG Transportation Systems, Inc., then known as Westinghouse Transportation, installed its first automated transit system in Pittsburgh, Pennsylvania in the United States, and demonstrated an innovative alternative to traditional transportation modes. In the years since, automated transit system technology has been refined through the use of microprocessors and solid-state electronics and extensive application experience.

In 1971, the first fully automated, driverless system went into operation at Tampa International Airport, Florida, USA.

And in 1972, the Bay Area Rapid Transit in San Francisco, known as BART, began public service. It was the first totally new

metropolitan rapid transit system to be built in the United States in almost 60 years and the first fully automated system.

Automated Transit Systems from AEG consist of attractive, comfortable vehicles operating on a dedicated guideway under a totally automatic control system and are available in differing system configurations.

The Automated People Mover Systems, designated as C45 and C100, consist of electrically powered, rubber-tired vehicles with four pairs of guidewheels which lock onto and are steered by a steel guidebeam anchored to the guideway.

The C100 is 11.89 meters long and features a spacious interior designed for passenger comfort and convenience.

The C45 is 8.5 meters in length and allows lighter, less expensive guideway structures for systems with lower passenger densities.

Both types can be used individually or coupled together to form multi-car trains, depending on system requirements.

The AEG Monorail technology is often referred to as a straddle-beam monorail. Individual cars are linked together into an articulated train unit with each car module supported by bogies placed between the individual cars, operating on pneumatic tires. The electrically propelled cars are steered by guidewheels along the elevated guideway providing total segregation from other traffic.

The C200 is a 28 meter articulated steel wheel system for urban applications. The C200 combines rail technology with the characteristics of automated transit systems.

2. APPLICATIONS/CAPACITIES

The AEG family of Automated Transit Systems serve a wide variety of applications which benefit from this relatively new form of transportation system. The applications include activity centers such as amusement parks and fairgrounds, transportation and circulation of passengers within airports and the movement of large numbers of peoples in urban corridors.

Automated People Movers and Monorails may be characterised by smaller vehicles and shorter trains operating on dedicated guideways and running at frequent intervals to provide a high overall level of operational capabilities. Due to the nature of their design, including their ability to turn in small radii, they can be integrated into existing downtown environments, into new or existing airports and can be routed through buildings or to stations within buildings. Operation can also be placed in tunnels.

The C200 Advanced Automated Rail System typically operating on a dedicated overhead guideway, maintains the people mover's high performance characteristics of automation, short headway, small turning radius and passenger comfort to form a customized system well suited to urban environments. The C200 may also be operated within tunnels.

All of the automated transit systems operate with passenger carrying capacities typically above that found with buses and below those of heavy rail (full metro) rapid transit.

The Monorail is usually applied to special activity centers with system capacity requirements up to approximately 6,000 passengers per hour per direction (pphpd). Train lengths up to 8 cars are possible with each car carrying about 20 passengers. The monorail may run with top speeds of up to 40 km/hr.

The Automated People Movers may also be applied to activity centers including airports and as downtown circulators with passenger carrying capacities of up to approximately 20,000 pphpd. Trains lengths may vary between one to four cars in most applications with the C45 accommodating 39 passengers nominally and the C100 accommodating 95 passengers nominally.

The C200 Advanced Automated Rail System has application in urban corridors, particularly in congested areas where concerns of the impact of construction, environmental concerns of aesthetics and noise, and the impact of placing a rail line is of concern. The C200 can provide passenger capacities of up to approximately 34,000 passengers per hour per direction with train lengths of 1 to 4 cars. The C200 vehicle nominally carries 208 passengers per car with top speed of up to 104.6 km/hr.

3. ROUTE CONFIGURATIONS

The increased use of automated transit systems, together with the variety of applications in which they are employed, has led to an assortment of possible network configurations. Planners have several basic configurations from which to create numerous routing concepts, and these decisions significantly affect system performance. Most automated transit systems in use today are either of the shuttle, loop (typically contra-rotating loop) and pinched loop (turnback) configuration.

Shuttle systems are ideal for connecting activity centers and for serving remote areas such as car parks. In airports, they have proven ideal for connecting "landside" functions such as bag claim and ticketing with "airside" gate areas. Shuttle systems generally fall within three basic types :

* Single lane, with one train shuttling back and forth.

* Single lane with bypass, allowing dual-train operation.

* Dual-lane, with trains operating on their own guideway.

The single lane configuration is the least expensive and serves applications where wait time and capacity are not major concerns.

The addition of a bypass in a single-lane shuttle system increases the system capacity and decreases wait time. Trains are synchronized so that they cross every time in the bypass area.

The most flexible shuttle system is the dual lane system. While each lane is independent and responds individually to passenger demand, the trains are continually synchronized with the goal of crossing mid-distance for maximum efficiency. System capacity is maximized and passenger waiting times are minimized with this configuration.

System maintenance for shuttle systems is normally accomplished on-line, typically below one of the stations. An added benefit of the dual shuttle configuration is that maintenance may be performed on one lane while service continues on the other lane.

Shuttle systems may also operate on-demand, utilizing call buttons similar to lift systems.

Loop systems have been used in applications where service to multiple stations is required. Two or more trains travel in the same direction at safe following distance, serving stations at close headways thereby allowing high system capacities. To improve system performance, contra-rotating loop systems have been used which reduces maximum travel time for passengers. An example is the downtown people mover employed in Miami, Florida, USA. Multiple trains travel in a clockwise direction on one lane and in a counter-clockwise direction on the other. This system is currently being expanded to include north and south travelling routes accessed from the outer downtown loop. Also note that this system is fed by a north-south metro system thereby providing convenient connections for suburban passengers into the downtown area.

The final configuration commonly used with automated transit systems is the pinched loop or turnback system, as seen with most urban metro systems. The use of automation allows trains to follow each other at close headways for maximum system capacity. Turnbacks at the ends of the line typically employ multiple switches to allow for the short headways and to maximize the system reliability. Bypass switches and sidings are also employed along

the guideway in the event of a train failure and to reduce system downtime.

Most automated loop and pinched-loop systems can be used bi-directionally for added flexibility. In off-peak hours, these systems can operate in alternate loop mode or in single tracking modes which allows for track and wayside maintenance to take place while still maintaining service.

4. MONORAIL CHARACTERISTICS

Monorail trains are of modular design using standard center and nose cars units to form a fully articulated train. Each car rests on its own bogie assembly rigidly attached to one end of the car. The other end receives a ball-joint coupler that is rigidly connected to the next car bogie.

The car body is a fully-enclosed, double-wall unit. It has a low-body frame design that permits a low floor to ground height of only 203 mm.

The all aluminum structure features generous use of glass and provides a pleasing appearance. Seating arrangements can be customized.

Lateral guidance is accomplished by four guidewheels per axle. Each guidewheel is preloaded against the side wall of the trackway beam by springs.

Train braking is accomplished by two independent braking systems, including an electrical regenerative system for normal service braking and a mechanical disk-type friction brake system for emergency braking.

The electrical propulsion control system is based on the use of thyrister control with continuously adjustable voltage regulating the DC traction motors to allow stepless acceleration and deceleration of the train.

Train propulsion power is obtained from a three phase rail at 500-600 volts.

The monorail guideway utilises a standard composite steel box girder formed by welding standard rolled steel plates into the box beam configuration. All steel sections are shop fabricated, pre-cut and contoured requiring only one field weld near each column to form a continuous guidebeam structure. The beam is supported by steel columns that are securely fastened to baseplates anchored to concrete foundations. Typical spans are 24 to 28 meters with special spans up to 49 meters possible with the use of deeper box beams.

Guideway switches are used for route network designs. Switching is accomplished by automatically aligning a tangent or curved section of box beam at the switching area. Switches may be of the pivot-type or rotating-type.

Control of monorails is usually performed semi-automatically, with a cab attendant overseeing various functions, although monorails have been implemented as fully automatic as well as in full manual operation.

Monorail stations may vary a great deal depending on the requirements with respect to their location, architectural theme and passenger interface. Stations must be accessible to elderly and handicapped persons and typically include fare collection, TV monitoring, public address and other passenger information systems.

5. AUTOMATED PEOPLE MOVER CHARACTERISTICS

Automated People Mover Systems are an innovative transportation technology adaptable to the requirements of any medium to high capacity activity center, including airports, industrial parks, recreation complexes, shopping/apartment or office complexes and business districts.

The automated people mover systems feature attractive, comfortable vehicles operating on a dedicated guideway under a totally automatic control system and are available in two standard vehicles configurations.

The C100 vehicle is 12 meters long and accommodates 95 standing passengers (using 4 passengers per square meter). The C45 car design is smaller and lighter than the C100, but utilizes virtually the same technology. The C45 is 8.5 meters long and accommodates 39 standing passengers.

For the purpose of this presentation, the C100 model will be specifically discussed.

The people mover vehicles ride on rubber tires. Four pairs of horizontally-mounted guidewheels lock the vehicle to a steel guidebeam anchored to the concrete guideway to prevent derailment and to provide continuous guidance for each moving vehicle. The people mover system allows system designs to include turning radii as low as 22.9 meters. This combined with low weight and negligible vibrations allows systems to be placed in congested areas and even cantilevered from or through buildings.

The interior of the vehicle is designed for passenger comfort and easy maintenance. A wide open space is provided making the people mover extremely efficient in terms of its passenger carrying capacity as opposed to its empty car weight of about 14,768 kg. Since travel times are typically short, most internal configurations provide for a large standee area, although seats may be provided in varying configurations.

Side windows make up about 35% of the vehicle wall, and large windows at both ends of the car provide a wide open feel for the passengers. Two wide door openings of over 2 meters each are provided on each side of the car. The wide openings allow for increased flow of passengers which in turn minimizes the time a train must be stopped in the station.

Cars may be operated in trains, typically up to 4 vehicles in length, and are designed to run in all weather conditions.

The C100 car body consists of a steel underframe and floor pan, and aluminum body, with fiberglass end pieces. These pieces can be customized to suit a particular requirement.

The guideway for the C100 system consists of twin concrete running pads on which the vehicle rides. The running pads are placed on top of a support structure which may be of steel or concrete construction. The steel guidebeam is set in-between the running pads.

Columns, typically of concrete, support the structure and are usually provided in span lengths of 27 to 30 meters, although varying span lengths can be used as required.

Propulsion and braking are performed in a similar manner as that on the monorail technology. Power is provided from guideway mounted power rails at 600V, 3 phase for the C100 and 480V, 3 phase for the C45.

Switching is also accomplished in a similar manner as that for the monorail, with curved and tangent guidebeam section that pivot or rotate to complete the switching operation.

Control of people movers is completely automatic, utilizing a sophisticated, microprocessor-based train control system, with electronic equipment mounted on board vehicles, in station equipment rooms and in a central control facility. The automatic train protection system utilizes a fixed block approach for safe train separation, and headways as low as 70 seconds have been implemented.

In the central control facility, large screen, high resolution color monitors and touch screen control consoles use real time display and control. Much of the implementation is by computer software, allowing for easier expansion capabilities.

The automated people movers are designed with service in mind. In fact, AEG provides operations and maintenance services on many of these systems after they are fully commissioned.

6. THE C200 ADVANCED AUTOMATED RAIL SYSTEM

Today's urban metro systems must meet stringent requirements, both from the

professional transportation planner's perspective, and from the perspective of the passengers. These perspectives typically are quite different.

The transportation planner may view these issues most importantly :

- Safety
- Reliability
- Performance
- Cost
- Constructability
- Schedule
- Environmental.

The passenger view can be quite different, with these issues often seen as most important:

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- Convenience
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For cities developing entirely new metro systems or feeder lines to existing metros, and where the ability to use tunnelling, or where space at surface level is severely limited or other environmental concerns may rule out conventional rail systems, AEG has developed the C200 Advanced Automated Rail System. The C200 concept considers both planner's and passenger's perspectives to form a complete urban metro system. This system, typically operating on a dedicated, overhead guideway, combines the high performance, highly automated, tight turning radius and passenger comfort aspects of automated transit systems together with the high technology of rail systems to form a customized system well suited to special urban requirements.

The C200 draws its rail technology from high quality and well proven subsystems. The C200 is unique in that it also includes the technology of automated transit systems, such as those in service on Automated People Mover Systems described previously.

The C200 is usually implemented under a design-build, or turnkey arrangement, so that all aspects of the metro system, such as safety, reliability, performance, comfort, constructability and environmental concerns can all be considered concurrently. This systems approach allows all elements of the design and construction process to be considered together and to determine the effect of one design on another. Cost can also be reduced because a single contractor team is responsible for designing, building and, at option of the responsible authority, operating and maintaining the system.

The C200 system operates fully automatically without drivers, and normally operates in a "pinched loop" mode, with trains servicing all stations. Stations are designed with either side or center platforms.

The C200 vehicle is a 28 m long articulated vehicle featuring a spacious interior with wide aisles, upholstered seating, air-conditioning and large tinted windows. The vehicle interior features a modern, clean look and incorporates sound-attenuating materials for a quiet ride. The carbody design draws upon AEG's experience in Germany and throughout the world.

The C200 suspension system utilizes the AEG design proven on over 2000 operating bogies on rail vehicles in service around the world. This AEG design uses the new noise-limiting steel wheels. The rail gauge is 1435 mm.

AC propulsion is used which permits energy efficient, low maintenance and quiet operations. The use of force-ventilated AC technology also ensures that the C200 will contribute to an overall low-noise operating system.

A state-of-the-art automatic train control which has been well proven on many automated transit systems, is utilized and will permit driverless operation. The ATC incorporates the latest microprocessor technology, including the use of fiber optic transmission techniques and multiplexing of signals.

The vehicles and stations feature electronic signs and automated voice announcements. The automatic train control system ensures the accuracy of train stops in stations, making

it easier for persons with disabilities to use the system.

The C200 system features the AEG Integrated Central Control. This computerized, completely automated system utilizes touch screen technology with advanced human interfaces. Thousands of system inputs are tracked by the system and an advanced diagnostic system is featured. The system is completely redundant for high reliability and also provides automatic reporting of events and calculates system availability. Train Control and Monitoring, Power Distribution Control and Monitoring, Communications and SCADA functions are all integrated into the system composed of OEM equipment configured for this application. A unique feature of this system is the ability for remote diagnostics, so that engineers who designed the system elements can assist operating personnel with the use of a personal computer from anywhere in the world.

AEG also provides operations and maintenance of the system once it begins service. This arrangement ensures that operational and maintenance considerations are made part of the rail system design and development, since the same team responsible for design and commissioning must also operate and maintain the system, largely using its own personnel.

AEG will provide the design and construction of the maintenance and yard facilities, as well as preparing detailed operations and maintenance plans during the design process.

The operational plan features the use of "roving" personnel. Becasue the entire rail system is automated, cab operators are not required, and in their place the roving personnel who understand all aspects of the operation are free to circulate within the system. They assist passengers, answer questions, provide security and watch for situations before they develop into problems.

The C200 systems approach to urban transit provides an efficient transportation solution which complements the environment while fitting into the already developed city landscape.

7. CONCLUSION

The Automated Transit Systems presented are designed to solve specific transportation problems and will complement higher capacity urban metro systems and light rail lines which may be implemented. You have seen how these systems can work in airport, downtown areas, amusement parks and fairgrounds, as well as in congested urban corridors. The systems approach to implementing modern transit systems is a powerful way to ensure that demanding requirements are met.

Paper No. 5

LANTAU FIXED CROSSING - ELECTRICAL AND MECHANICAL SERVICES

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LANTAU FIXED CROSSING - ELECTRICAL AND MECHANICAL SERVICES

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Senior E&M Engineer, Highways Department

ABSTRACT

This paper describes the scope of the electrical and mechanical works of the Lantau Fixed Crossing. It also presents the basic characteristic of various electrical and mechanical engineering systems to be incorporated into the project.

1. INTRODUCTION

The Lantau Fixed Crossing (LFC) is a major element of the Airport Core Programme, and the project is currently managed by the LFC Project Management Office of the Highways Department. The Lantau Fixed Crossing is one of the largest construction projects ever undertaken by the Government with the estimated total cost of HK$16 billion.

At the eastern end, the project comprises a complex N.W. Tsing Yi Interchange linking the airport access via the LFC to Route 3. The Tsing Ma Bridge is one of the longest suspension bridge with a centre suspended span of 1,377 m carrying dual three lanes of road traffic on the upper deck, twin rail tracks on the lower deck and two emergency road traffic lanes also on the lower deck, linking the N.W. Tsing Yi Interchange to Ma Wan Island. An elevated viaduct of 502 m across Ma Wan Island connects the western end of the Tsing Ma Bridge to the Kap Shui Mun Bridge. The Kap Shui Mun Bridge is a cable stay bridge with a main span of 430 m running across the Kap Shui Mun Channel. On the Lantau Island, the route is further linked by the Lantau approach road leading to the Lantau toll plaza. The layout and a typical cross-section of the Lantau Fixed Crossing and the current construction of the Tsing Ma Bridge are shown in Figures 1, 2 and 3.

The LFC Electrical and Mechanical Services contract is a 37-month fixed price lump sum contract which will provide all necessary services along the LFC as well as the approach roadway to the Lantau toll plaza. The scope of works includes :

- power supply and distribution system including five electrical sub-stations
- lighting for lower deck carriageways, maintenance and access walkways and passages
- aviation and navigation aids
- architectural lighting
- supervisory control and data acquisition system
- security systems including access control, intruder alarms and CCTV surveillance
- communication systems including telephone communication, intercom, public address
- inspection and access cages and cradles
- structural health monitoring system.

2. POWER SUPPLY AND DISTRIBUTION SYSTEM

There are altogether five electrical substations which will be interconnected to form a ring network at 11kV level. Two independent

sources of power supply will be fed by China Light and Power Co. Ltd's (CLP) Nga Ying Chau Street Substation on Tsing Yi Island and Sham Shui Kok Substation on Lantau Island to maximize system security. In the event of power failure from either one of CLP's high tension sources, the power supply through the crossing will still be maintained to ensure continuous operation. The power supply and distribution schematic is shown in Figure 4.

At each LFC substation, there will be two distribution transformers; one will be fed from the Tsing Yi source and the other will be fed from the Lantau source. The electrical and mechanical services throughout the crossing will be arranged in such a manner that approximately 50% of the plant and equipment are connected to either one of the CLP supplies. By this means, failure of either incoming supplies will render only 50% of the plant and equipment inoperable. This interruption of service will be resumed to normal after a few seconds when the low voltage switch-over unit operates.

The 11kV/380V distribution transformers will be designed to ensure that under normal operating conditions the power transformers are loaded with less than 50% capacity. In the event of a transformer outage, the remaining transformer unit in the same substation will be able to carry the entire load satisfactorily.

Additional protection against 11kV busbar fault at any of the substations has been provided by inclusion of a bus-section circuit breaker at each of the 11kV bus-section.

Mechanical and electrical interlocks for the incoming circuit breakers and the bus-section circuit breakers will be installed to prevent parallel operation of the two CLP supplies, and the interlocks shall enable the three incoming circuit breakers of each power source to be opened or closed together during a switching operation. The fault level at 11kV is designed at 350 MVA for 3 seconds.

The L.V. distribution system will be integrated to the H.V. distribution system to provide maximum reliability. Each L.V. system will be connected to twin transformers at each substation. Auto-changeover at L.V. level of the distribution system will be provided to reconnect the appropriate services from a failed supply system onto the healthy system to maintain the continuous operation of the crossing in case of failure of one source of supply.

The emergency lighting at lower deck, supervisory control and data acquisition system, traffic control and surveillance system (including traffic signs and signals and controls, emergency telephones, CCTV system, public address system, radio communication system, etc.), toll collection system, security system, fire services, navigation aids and all control room functions will be fed via battery type uninterruptible power supply systems (UPS) to avoid momentary total interruption of power supply. The capacity of the batteries will be sized for 2 hour operation.

The incoming circuits of the main L.V. switchboards in each substation will be protected by microcomputer-based protective relays. Outgoing circuits will be protected by either air circuit breakers or fused switchgear. The L.V. switchgear will be equipped with air circuit breakers for main switching functions, fused switchgear with contactors for control where required, and four-pole automatic transfer switches (incorporated with electrical and mechanical interlock) for interlocking facilities. Miniature circuit breakers will be provided for sub-circuit and final circuit protection.

Each substation will be earthed locally. In addition, the substations will be linked by earth continuity conductors routed along the crossing. Each distribution panel within the crossing will be bonded to the earth conductor. The estimated normal daily power demand for the crossing when operating to design capacity is 5 MVA, and the L.V. fault level is 24 MVA at 380V for 3 seconds.

The L.V. cabling for all essential services and those equipment backed up by UPS system will be fire resistant low smoke halogen-free copper cables for maintaining circuit integrity under fire conditions. Other L.V. cabling

running across the crossing will be low smoke halogen free armoured or non-armoured copper cables.

Bulk tariff summation metering is proposed for calculation of the electricity cost to minimize the operational expenses.

3. LIGHTING SYSTEMS

The LFC lighting systems comprise lower deck carriageway luminaires, architectural lighting, maintenance and access walkway lighting as well as aviation and navigation aids.

Lighting level of the lower deck carriageways is designed in accordance with the International Commission on Illumination Technical Report on Guide for the Lighting of Road Tunnels and Underpasses (CIE88-1990) as well as BS5489 Part 7 Road Lighting - Code of Practice for the Lighting of Tunnels and Underpasses. Each lower deck carriageway is divided into lighting zones including access zone, threshold zones, transition zones, interior zone and exit zone. The maximum access zone luminance (L_{20}) and the night time interior zone luminance are designed at 4,000 cd/m² and 5 cd/m² respectively. Other design parameters are detailed as follows :

(A) Carriageway Length 3620 m

(B) Carriageway width 6m

(C) Height
Distance between carriageway surface and lower face of base luminaires 4.75 m

(D) Reflection properties :
ceiling reflectance 0.1
side reflectance 0.1
road surface (CIE 30-2 classification) C2
average luminance coefficient Q_o 0.07

(E) Design speed :
normal operation maximum 50 km/h

(F) Stopping sight distance 55m

(G) Luminaires photometric data for each carriageway :
(a) Light output ratio (minimum) 0.6
(b) Maintenance factor 0.7
(c) Light distribution Asymmetrical
(d) Lamp lumens, minimum after 2000 hours. (220 V supply voltage, 40°C ambient):
400 W SON-T 55000 lumens
250 W SON-T 30000 lumens
150 W SON-T 16000 lumens
50 W fluorescent 5000 lumens

(H) Data and Requirements for each carriageway :
(a) Maximum daylight luminance (typical) L_{20} 4000 cd/m²
(b) Night time luminance (general) 5 cd/m²
(c) Threshold increment 10%
(d) Critical flicker 2.5 to 15 Hz
(e) Ratio $L_{20} : L_{in}$ 20 : 1
(f) Longitudinal uniformity of luminance ratio (L min/L max) 0.7

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The lower deck carriageway luminaires will be ceiling mounted off-setting to the corner adjacent to the railway envelope. The basic lighting will compose of 1600 mm long continuous twin tube fluorescent luminaires. The reinforced lighting will be SON-T high pressure sodium lamps. One in every ten of the fluorescent luminaires will be fed from uninterruptible power. The automatic control of the lower deck carriageway lighting will be performed by the SCADA system based on measured values of portal photometers. The fluorescent luminaires will also be automatic dimmer-controlled for fine adjustment of night time illumination.

For architectural lighting, the objective is to accentuate the outline of the suspension bridge and the cable stay bridge to give a distinct and impressive night time appearance to the Lantau Fixed Crossing. Various lighting schemes have been proposed and a specialised architectural lighting designer will

be engaged to prepare high quality computer simulated artistic impressions for these lighting options to enable final selection of a suitable architectural lighting scheme. The luminaires employed will generally be a combination of metal halide, high pressure sodium and induction lamps.

4. SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEM (SCADA)

The main team of operational staff of the crossing will be located at the control centre of the North West Tsing Yi Administration Building, whilst the control room of the Lantau Administration Building will act as a satellite control centre.

A computerised Supervisory Control and Data Acquisition (SCADA) system will be installed to monitor and record the status of the various electrical and mechanical plant and equipment of the crossing. The system shall also be capable of generating alarms and logging events as well as producing reports for real time and historical data. The engineering services which will be monitored by SCADA include the power supply and distribution system, uninterruptible power supply systems, emergency diesel generators, upper deck road lighting, architectural lighting, lifts, photometers and meterological sensors, etc. The SCADA system will also be used to provide essential command function to control the Ma Wan Viaduct and Kap Shui Mun side span longitudinal ventilation systems, road lighting system, aircraft lighting, lower deck carriageway lighting and some designated L.V. switchgear according to the operator's requirements.

The SCADA system employs a computer system for data collection and monitoring functions. The heart of the computer system is two sets of 32 bit 486 66MHz microcomputers operated in a hot standby mode situated in the control room of the Tsing Yi Administration Building. Four operator terminals, two at Tsing Yi Administration Building and two at the remote Lantau Administration Building will be connected to the two computers by an industrial standard Ethernet Local Area Network. The connection between Lantau Administration Building and the Tsing Yi Administration Building is performed via an optic fibre cable through underground ducting system and cable hanger within the bridge section. The system reliability is further enhanced with an automatic modem dial up link between the operator terminals at Tsing Yi Administration Building and Lantau Administration Building. Figure 5 shows the schematic of the SCADA system.

The computer system is connected to two programmable logic controllers in dual redundant hot standby configuration. The programmable logic controller will communicate with a number of input/output units installed in various locations along the crossing and within different buildings through a high speed full duplex serial optic fibre link of 115.2k baud. The function of monitoring and controlling various electrical and mechanical facilities is achieved through the optic fibre network.

5. SECURITY SYSTEMS

Security measures for the Lantau Fixed Crossing cover the Tsing Yi and Lantau Administration Buildings, the lower deck carriageways, towers and other structures relevant to the secuirty of the crossing. A sophiscated computerised security system comprising an integrated management system (IMS), optical transmission, CCTV surveillance, access control and intrusion detection will be installed to serve the purpose of security protection. The control consoles of the system will be installed in the control rooms of the two administration buildings on Lantau and Tsing Yi.

The security CCTV system will employ both fixed focus and zoom lens cameras, equipped with video motion detection, covering the lower deck walkways, main access and gate entrances etc. of the crossing. Electronic devices will be provided to restrict access to the two administration buildings and all permanent structures along the bridges and

viaduct. Intrusion detection devices include door contacts, vibration detection sensing cables and passive infra-red detectors which detect unauthorised access to restricted areas.

6. STRUCTURAL HEALTH MONITORING SYSTEM (SHMS)

The Structural health monitoring system is designed to achieve the purpose of monitoring the dynamic characteristics of the cable supported bridges for operational safety, predicting and assessing the potential locations of structural damage for planning of inspection and maintenance programme and verifying the design assumptions made in the design and construction stage.

The dynamic responses of the two long span bridges under various excitations including wind loading, traffic loading, railway loads, stresses due to thermal effect, and thermal sagging of the main suspension cables, etc. will be monitored, measured and recorded by this system. The SHMS comprises a wide range of sensors distributed throughout the Tsing Ma Bridge and Kap Shui Mun Bridge. Sensors used are mainly anemometers, strain gauges, accelerometers, deck level sensors, temperature sensors and displacement transducers. Data is acquired from these sensors using a series of microcomputer-based outstations distributed across the structures and connected to a central computer system located in the North West Tsing Yi Administration Building using a computer network based on optical fibre communications technology. The central computer system will be a dual redundant system. The central computer also collects traffic data transmitted by the weigh-in-motion systems to compute the traffic loading and volume.

The horizontal and vertical components of the gust and mean wind speed, the inclination as well as the power spectrum for downwind components and gust will be measured by the anemometers and recorded to study the bridge dynamic response under different turbulence and extreme wind conditions. The change in the bridge deck profile under various loadings will be monitored by a set of deck level sensors. Strain measurement at selected locations will form the basis for monitoring the bridge response due to traffic and railway loads over a long period of time. Regular monitoring of the traffic spectra by the weigh-in-motion systems and of the strain spectra by the strain gauges at different locations will establish sufficient figures for review of prediction of the fatigue life of the steel structures. Continuous logitudinal movement will occur at the Tsing Yi deck expansion joint and the movement of lateral bearings on the Ma Wan Tower due to temperature changes, traffic and wind loads will also be assessed by appropriately positioned displacement transducers.

7. MISCELLANEOUS SYSTEMS

The remaining systems include fire protection system, inspection and access equipment, weighbridges, communication systems, tower lifts and miscellaneous building services.

For fire protection, linear heat detection cables will be installed along the cable chamber located at each lower deck maintenance walkway of the crossing to continuously monitor sudden change in temperature of the power cables. On the lower deck, carbon dioxide fire extinguishers, emergency break glass alarms and emergency power sockets are housed inside stainless steel cubicles located at 100m regular interval for fire fighting and detection. The main fire alarm panel will be installed in the main control centre within the North West Tsing Yi Administration Building and a repeater fire alarm panel will be situated at the control room of the Lantau Administration Building. The main panel will also be directly linked to the Chubb control centre through a direct telephone line.

To enable regular inspection of non-accessible areas, the inspection and access equipment for the suspension and cable stay bridges requires a main suspension cable access cage. a vertical suspender access cradle and a set of substructure access cradles. In addition, maintenance gantries underneath the bridge

deck and cable stay access cages will also be installed to facilitate routine inspection and maintenance under the civil contracts.

A weigh-in-motion system and static axle weighscale will be installed at each side of the dual three-lane carriageway near the Lantau toll plaza area. Vehicle passing through the weigh-in-motion modules in each lane will be weighed and vehicle data will be recorded. When an overweight vehicle is detected, the system will trigger a variable message sign to instruct suspect vehicle to move onto the static axle weighscale at the lay-by for accurate weight measurement.

The communication systems comprise a PABX system and intercom system at the North West Tsing Yi Administration Building, the Lantau Administration Building and strategic locations of the LFC structures as well as a public address system solely for making announcement within the Lantau Administration Building

ACKNOWLEDGE

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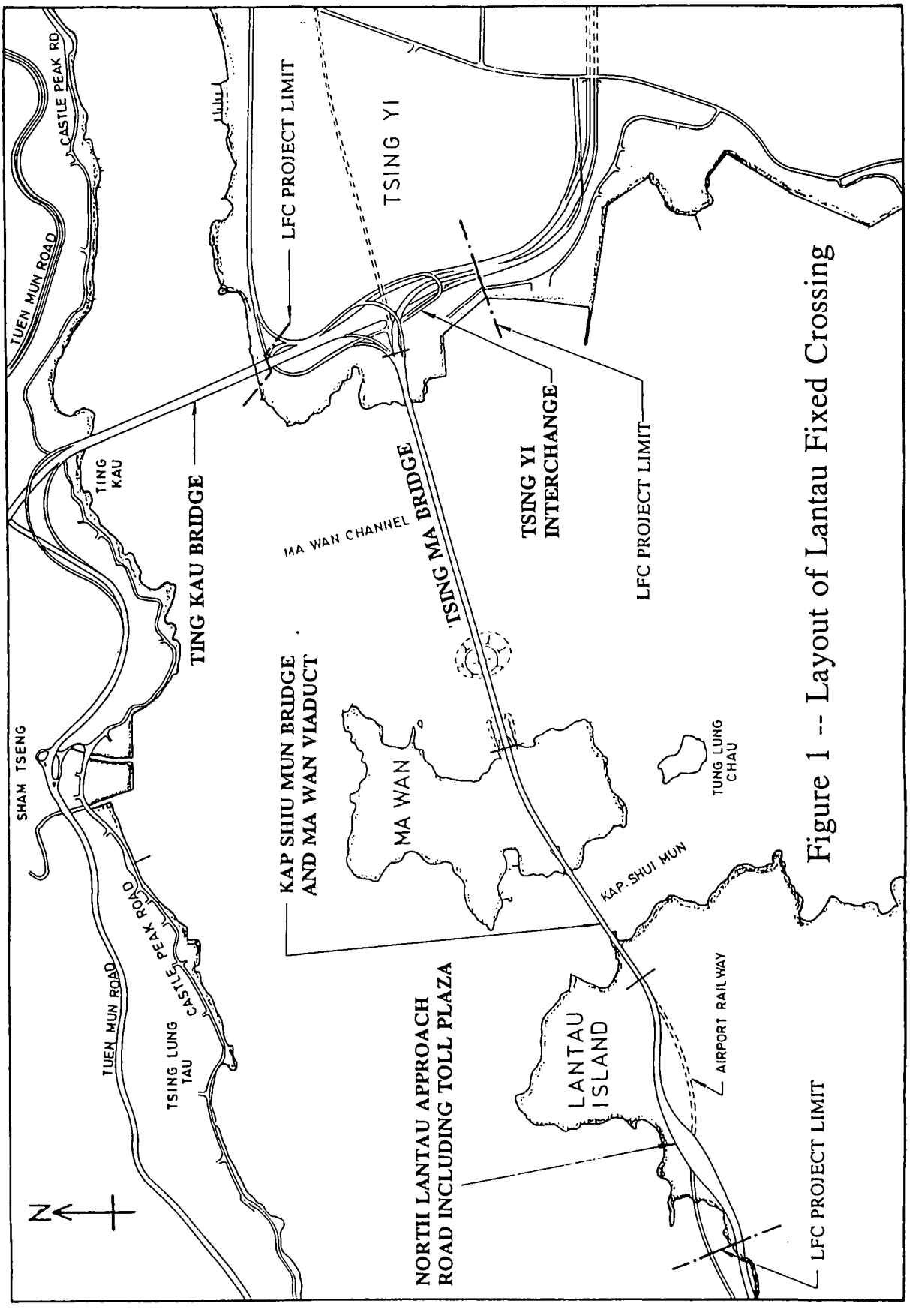

Figure 1 -- Layout of Lantau Fixed Crossing

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Tsing Ma Bridge Typical Cross Section

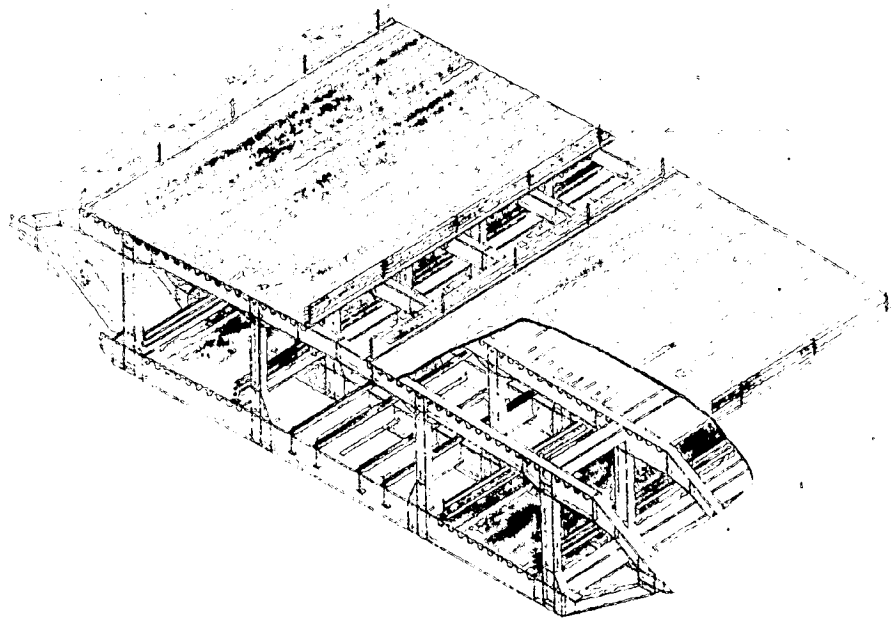

Figure 2 - A typical cross-section of the Lantau Fixed Crossing

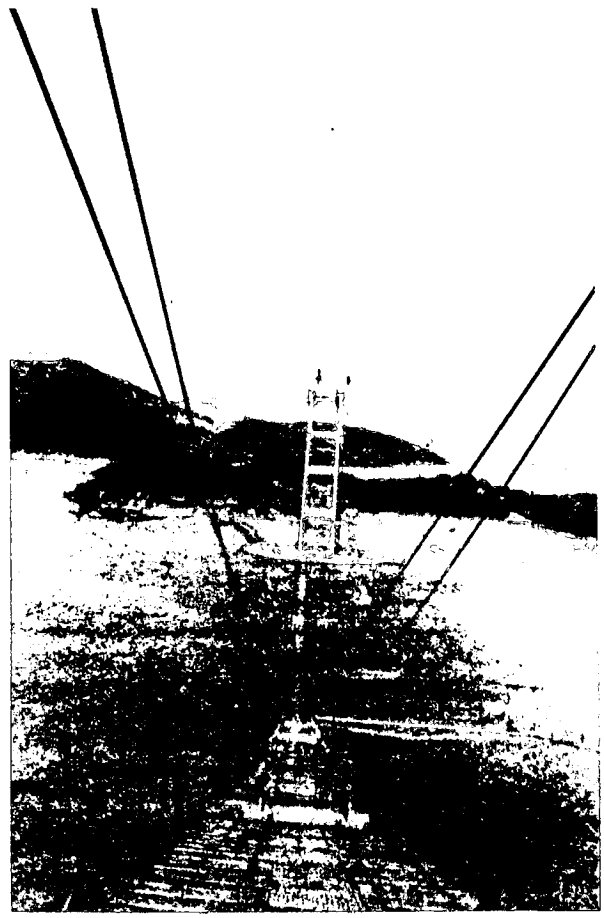

Figure 3 - Current Construction of the Tsing Ma Bridge

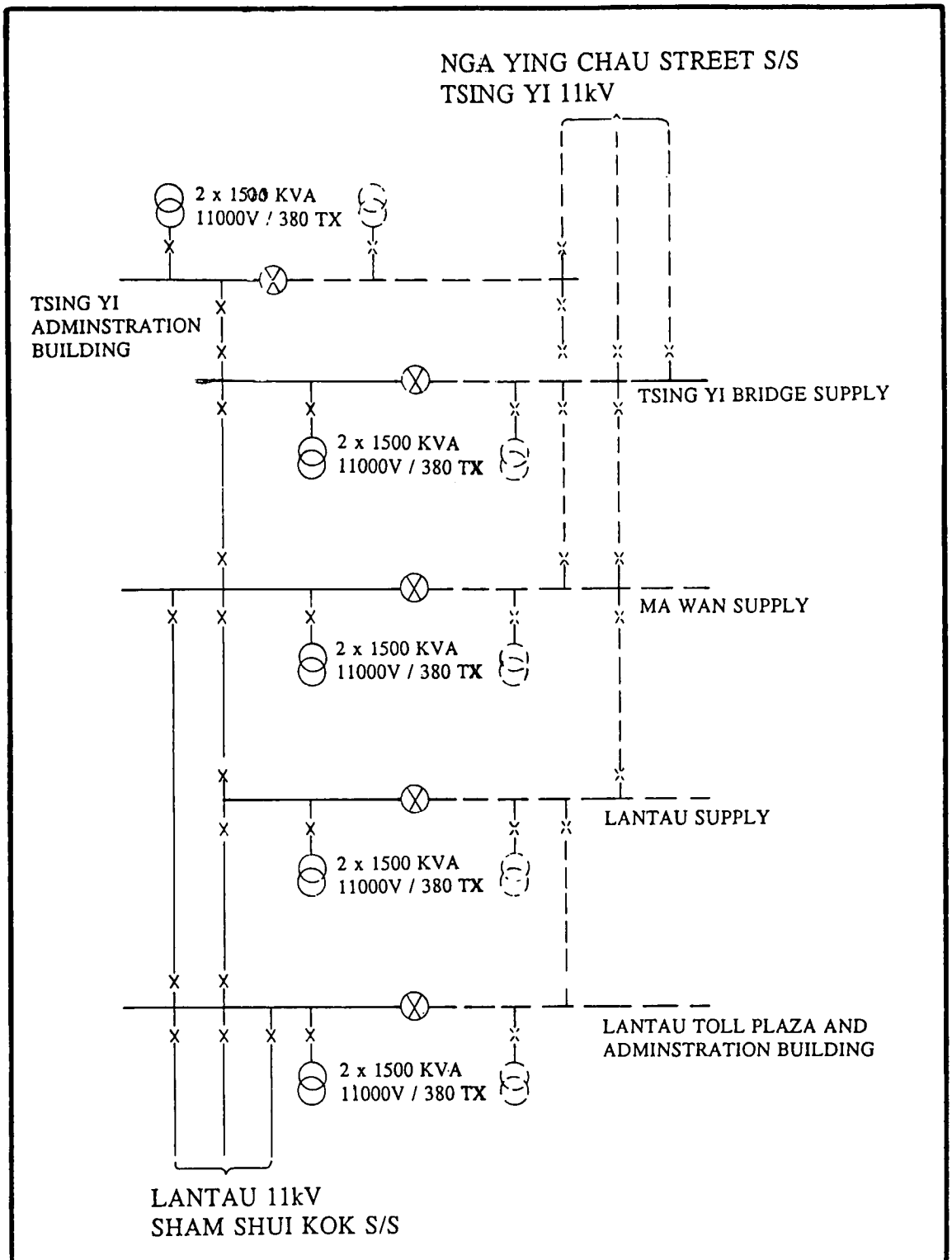

FIG.4 – 11kV SUPPLY DISTRIBUTION SCHEMATIC

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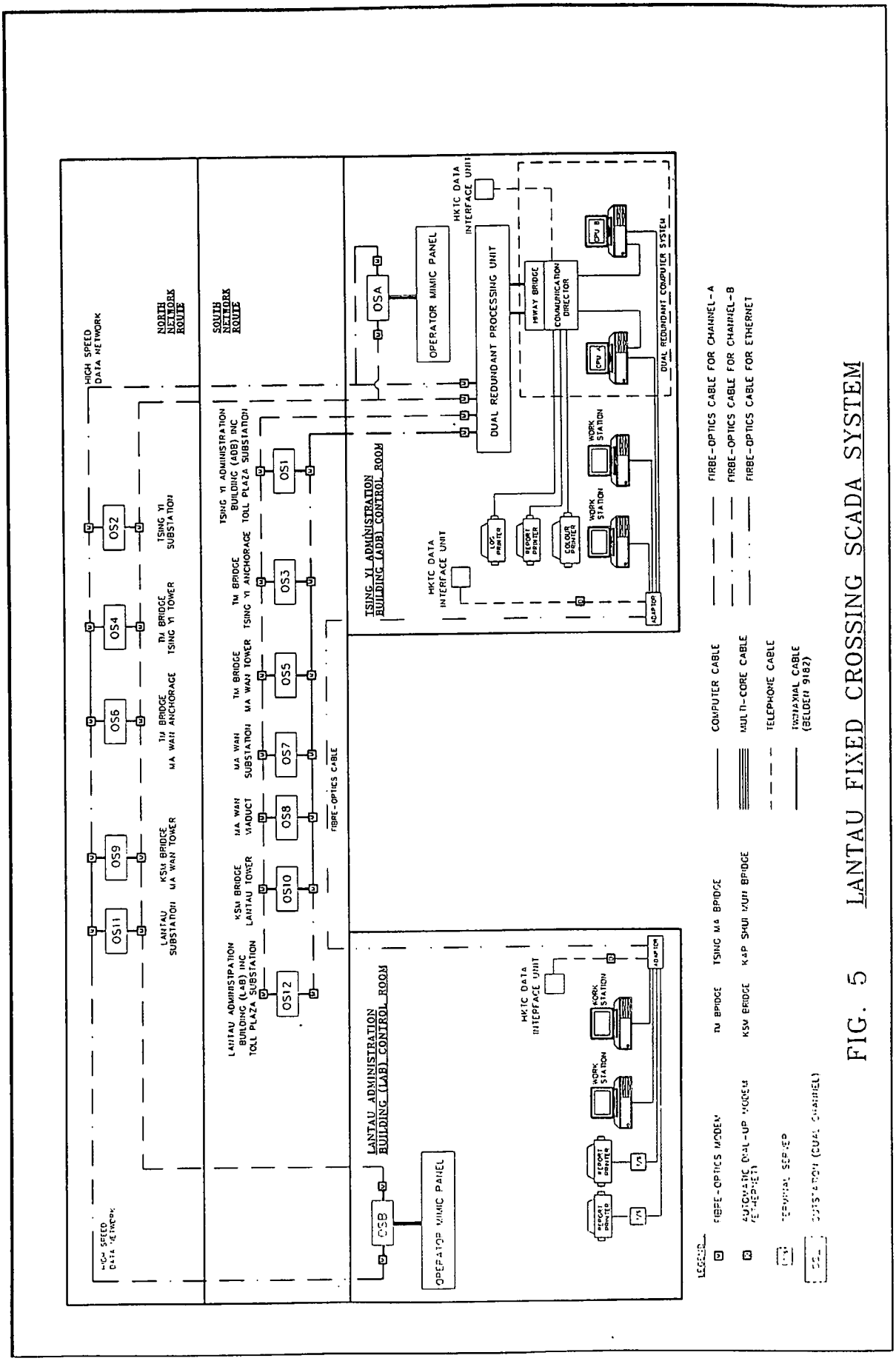

FIG. 5 LANTAU FIXED CROSSING SCADA SYSTEM

Paper No. 6

BASIC INFRASTRUCTURE FOR THE NEW AIRPORT AT CHEK LAP KOK

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BASIC INFRASTRUCTURE FOR THE NEW AIRPORT AT CHEK LAP KOK

Chris Calton
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ABSTRACT

The paper generally describes the new airport at Chek Lap Kok in the regional context of it satisfying an extensive growth in air travel demand compared with other regional centres. It presents an outline of the planning and design of the airport infrastructure, including discussion on the various airport-related buildings and associated provisions of airfield pavements, roads, drainage, utilities, and other systems. There is a general presentation of the airport operational land uses, including facilities for the handling of passengers, air cargo, aircraft catering, base and line maintenance, and the aviation fuel system.

The paper also discusses the landside ground transport system, the links to the urban areas, and how the transportation facilities will meet passenger demands. A particular area of interest covered in the paper is the design of the Airport Railway terminal station and the Ground Transport Interchange.

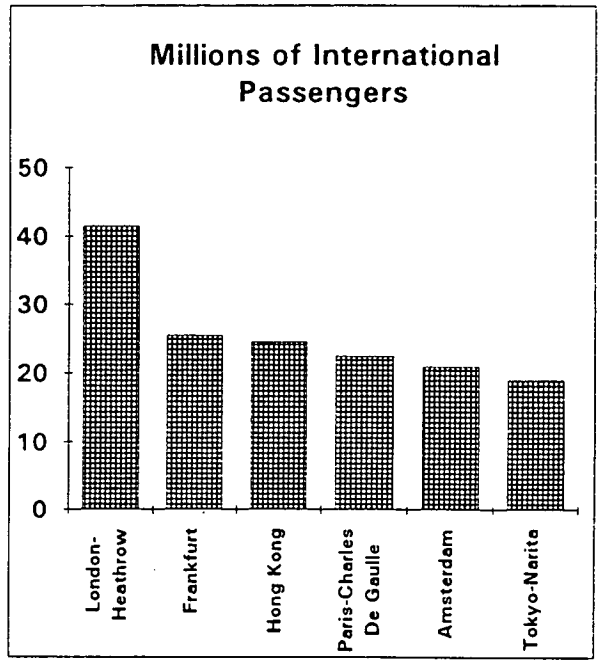

Fig.1 - Top Six in Passenger Handling

Paper No. 6

1. INTRODUCTION

Hong Kong is at the hub of a region that is experiencing a dynamic growth in aviation service demand. Almost 50% of the world's population live within an air travel time of 5 hours from the Territory. By the year 2010, it is forecast that the region will dominate the global market with 51% of the world's air passenger traffic.

Hong Kong's new airport at Chek Lap Kok will complement other major airport developments at Kansai, Seoul, Bangkok and Kuala Lumpur in meeting this potential growth. China is fast expanding its national airport network and there are significant infrastructural development programmes in our other neighbouring countries.

Today, Hong Kong's Kai Tak Airport is the third busiest international airport in the world in terms of passenger handling and the second busiest in terms of aircargo.

Clearly, the key factors influencing aviation demand and airport development in Hong Kong, which can be regarded as the primary international gateway to Southern China, are China's rapid economic growth, the impact of transfer and transit patronage and the roles of other competing airports.

In the Pearl River Delta, current attention is focused on four neighbouring airports being developed to serve specific catchments each having the potential for strong and prosperous economies:-

- Guangzhou's replacement airport
- Shenzhen new airport expansion

- Macau's international airport open in 1995
- Zhuhai airport reconstruction serving the Zhuhai Economic Zone.

The new airport under construction at Chek Lap Kok, and Hong Kong's strategic geographical location with its extensive and reliable transport infrastructure, will ensure that Hong Kong retains and expands its role as a leading centre of international finance, trade and tourism.

2. NEW AIRPORT MASTER PLAN

In July 1990, the Provisional Airport Authority commissioned consultants to prepare a Master Plan with the objective of developing a comprehensive and environmentally acceptable scheme for the phasing and implementation of an operationally safe and efficient airport at Chek Lap Kok.

Development of the Airport Layout Plan began with forecasts of passengers, cargo, aircraft movements, ground transportation and all other airport-related activities. The runways, taxiways, aprons, buildings, roads and other infrastructural facilities required to accommodate these forecast demands were then planned and their locations optimised. The planning horizon for the Airport Layout Plan was the year 2040. The Master Plan provided a phased programme of implementation for this ultimate development.

The Master Plan and Airport Layout Plan development process involved three major workstreams :-

- Planning - Forecasts, Requirements, Alternatives, Plan Selection, Phasing/Costs.
- Civil Engineering - Reclamation, Seawalls, Airfield, Infrastructure.
- Environmental Impact Assessment - Construction & Operational Impacts, Mitigations, Monitoring/Audit.

The planning workstream established the basic airport development parameters, the scale and configuration of all facilities, and the phasing of implementation. This provided the essential focus for the engineering and environmental studies to develop and refine the infrastructure preliminary designs.

The engineering workstream produced the detailed design and tender documents for the airport platform site formation, and preliminary design guidelines and specifications for all the airport infrastructure.

Airport development plans were scheduled in relation to the demand forecasts. These forecasts continue to be updated and adjustments to the implementation plan will be inevitable during the longer term.

The phasing for staged construction was basically :-

- Phase 1(a) - Airport opens with a single runway and infrastructure to meet the projected year 2002 demand of 35 million annual passengers.
- Phase 1(b) - Second runway and associated taxiway system added (before the year 2000).
- Phase 1(c) - Additional aircraft gates and airport support facilities (before the year 2002).
- Phase 1(d) - More gates and support facilities (before the year 2006).
- Phase 2 - Add satellite terminal and expansion of all support facilities (post year 2008).

The completion of Phase 1 would satisfy projected demands to the year 2010.

3. AIRPORT SITE PLAN AND CONSULTANTS' DESIGNS

Since the formal approval of the Master Plan, design and construction effort has obviously concentrated on the Phase 1(a) works. An Airport Site Plan (ASP) has evolved which has recorded the planning development and detailed designs prepared by various appointed consultants for different sections and disciplines of the project.

The ASP is essentially a 3-D computer model of the airport in which planned layouts of infrastructure are continually updated or replaced by consultants' detailed design files. Eventually, the design information will be replaced by as-built records and the model will be used as a facilities management tool for the on-going airport operations and maintenance.

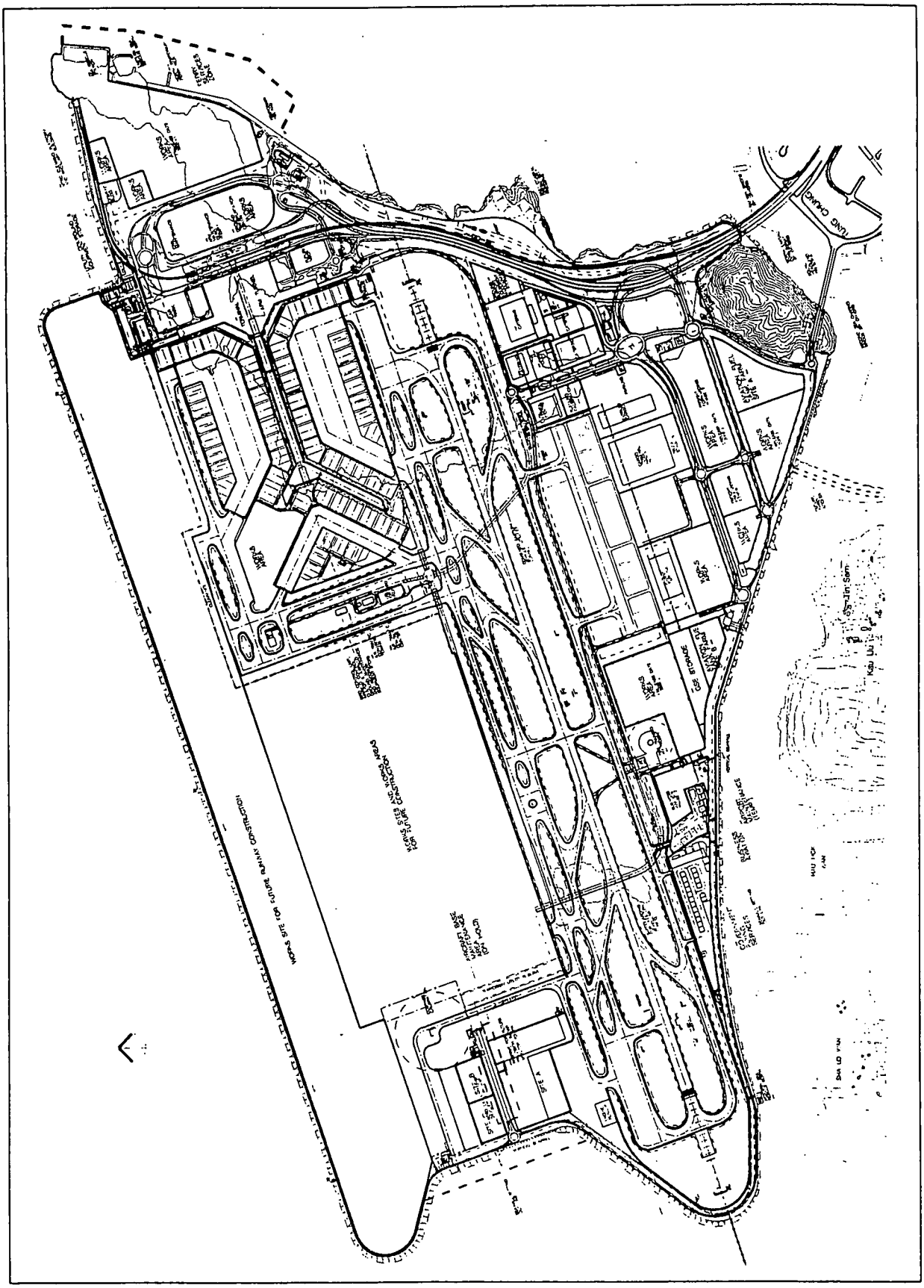

Fig. 2 - Airport Site Plan (Phase 1a)

Basic infrastructural elements for the airport can be grouped under the broad functional headings of :-

- Passenger and cargo handling
- Utility systems
- Surface transportation
- Airfield provisions

Two further classifications are important in the planning and design of airport infrastructure :

- The airside, comprising runways, taxiways, aprons, and all operational facilities on the airfield contained within the restricted areas defined by the airfield perimeter and security fenceline. It would also include the airspace used for takeoffs and landings which extends beyond the airfield boundaries.

- The landside, comprises all non-restricted public areas on the airport island including portions of the Terminal Building, the ground transportation systems, and airport-related facilities (eg.aircargo, aircraft maintenance, catering, freight forwarding, fuel storage, airport hotels, etc)

	Actual	Projected			
Passengers ('000)	**1989**	**1995**	**2000**	**2010**	**2040**
Arrivals/Departures	13,649	19,696	25,102	37,772	73,798
Transfer	2,555	4,924	5,141	4,668	9,121
Transits	1,228	1,572	1,760	2,234	4,364
Total Passengers	17,432	26,192	32,003	44,674	87,283
Crew	1,404	1,820	2,163	2,912	5,429
Total	**18,836**	**28,012**	**34,166**	**47,586**	**92,712**
Growth (%)	-	**48.7**	**22**	**39.3**	**94.8**

Table 1 **Total Air Passenger Forecast**

PASSENGER HANDLING

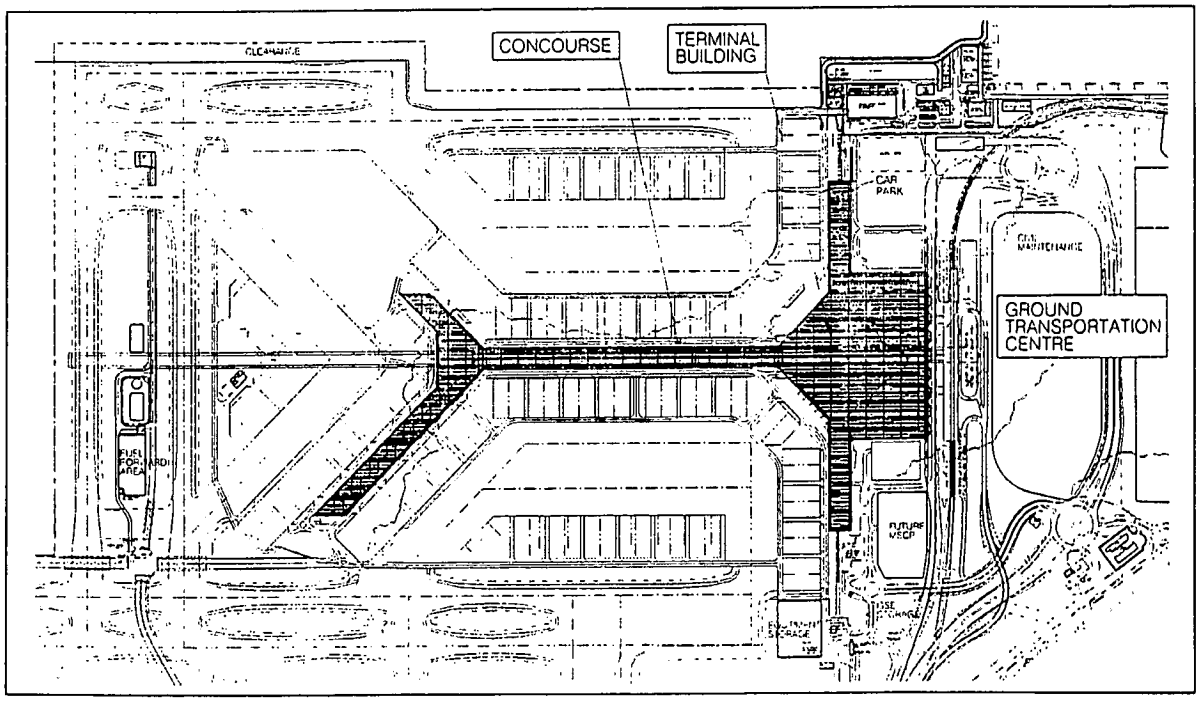

Fig.3 - Passenger Terminal Building

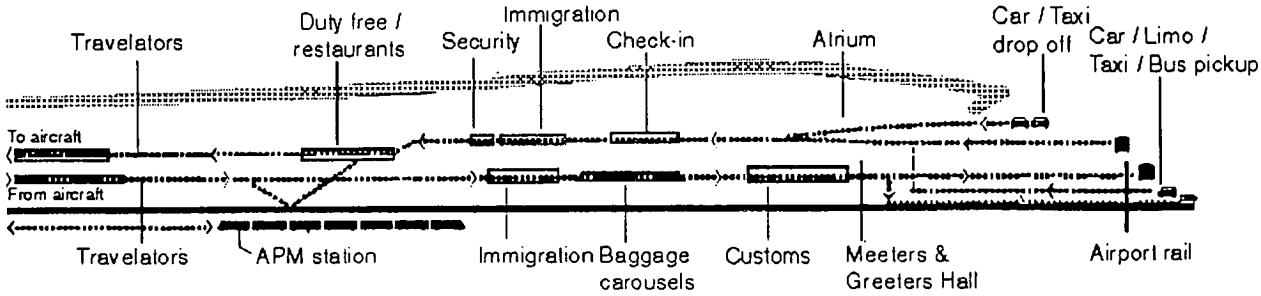

Fig. 4. Passenger Movement - Long Section

The passenger terminal complex will act as the focal point for the transition of air passengers between surface transport modes and air travel. The terminal will comprise all passenger processing facilities including check-in, immigration, security screening, baggage reclaim and customs. It will ultimately incorporate two separate terminal buildings having a combined capacity sufficient to meet aircraft and passenger forecasts to 2040. The Phase 1a passenger terminal and apron complex comprises :-

- Passenger terminal, processing halls and links to the Ground Transportation Centre
- Passenger concourse and aircraft gate areas
- Aircraft parking aprons
- Aircraft taxilanes and vehicle service roads and tunnels

The terminal facilities have been designed to meet strict performance objectives, for example:-

- Flexibility for accommodation of unforeseeen changes in demand, technological developments, or service characteristics.
- Access to the Airport Railway is given high priority with direct segregated access to separate departures and arrivals platforms.
- Processing facilities are optimised for maximum efficiency and value for money :-
  - Target throughput time for departing passengers and baggage is 30mins.
  - Target processing time for first arriving passenger and first baggage from carousels is 20mins.
  - Terminal operations shall be to International Air Transport Association (IATA) Level of Service C for passenger volumes at the Standard Busy Rate.
- Passenger flow routes are simple and direct with minimal level change. Where long walk distances or level changes are unavoidable, passeger movement is assisted with moving walkways, lifts, escalators etc. Ramp gradients do not exceed 1 in 20.
- Walking distances are minimised as far as practicable, with the acceptable maximum being 300m. Where distances exceed this, opportunity exists for mechanised transfer via the Automated People Mover (APM) and moving walkways.
- Provision for the disabled is made throughout.
- Opportunities for concessionaires are maximised without restricting passenger processing.
- Energy conservation is optimised. For example, thermal transfer level for the Terminal Building has been evaluated at 19 watts/square metre, compared with the Authority's target of 20 and the current Government guideline of 35.
- Natural light will augment interior lighting; the mechanical cooling system will air condition only those zones of the terminal that are populated and the high ceiling spaces will act as insulating zones.
- The aircraft apron areas are designed to accommodate large capacity, wide-bodied aircraft to International Civil Aviation Organisation (ICAO) Code F standards, and the terminal itself is also planned to accommodate the next generation of high capacity aircraft.

This paper will not describe the detailed internal building layout, but a list of pertinent information is presented in Table 2, Appendix 1.

The terminal will be opened with a capacity to handle 35 million passengers annually, a Y-shaped concourse with 38 aircraft gates and an aircraft parking apron with up to 24 remote stands, aircraft taxilanes and vehicle service roads and tunnels.

The terminal is approximately 1.3 kilometres in length covering an area of 490,000 square metres, making it larger than existing Heathrow and JFK terminals combined. The structural form of the building will be dynamic. The steel roof has been designed as a lightweight structure which can be pre-fabricated off-site for rapid final assembly.

The terminal's 468 metre long departures kerb will be divided into several operational zones facilitating direct access by the various transport modes. As the passenger approaches the airport, road signs will indicate the zone most convenient to the passenger's airline.

4. AIRCARGO HANDLING

The Authority aims to issue licences to provide for mainstream cargo handling and express cargo operations. Each licence will offer the right to design, finance, construct and operate an air cargo handling terminal, and each terminal will be required to be fully operational by airport opening.

The air cargo handling services will consist of continuous processing of all inbound, transhipment and outbound cargo.

The facilities will be located to the south of the southern runway. The overall land requirement for cargo handling-related activities has been estimated as 22 hectares at opening day increasing to an ultimate capacity occupying 80 hectares of land. The opening day throughput is likely to be approximately 1.6 million tonnes increasing to an ultimate capacity of around 9 million tonnes. Tonnage carried in 1993/94 already exceeds the Master Plan estimate for 1997, given in Table 3.

Year	Annual Air Cargo ('000 tonnes)			Growth	Busy day (tonnes)	
	Inbound	Outbound	Total	(%)	Cargo Aircraft	Passenger and Cargo Aircraft
1997	469	660	1,129	-	1,680	3,730
2010	979	1,361	2,330	106.4	3,460	7,690
2040	3,761	6,111	8,862	280.3	13,160	29,240

Table 3 Master Plan Air Cargo Forecasts

It is currently estimated that 55-60% of air cargo is transported belly-hold by passenger aircraft, requiring surface transfer between passenger and cargo aprons. The remaining cargo is carried by dedicated all-cargo aircraft with direct apron frontage access to the cargo terminals.

Areas of land south of the air cargo terminals have been reserved for freight forwarding developments.

5. RECLAIMED PLATFORM

The total area of the airport island will be 1248 hectares of which 940 hectares is land reclaimed from the sea. Formation varies between a general level of 5.5 mPD and 9.5 mPD at specific locations (eg. at the ends of the southern runway).

The Site Preparation Contract, awarded in December 1992, ranks as one of the world's largest dredging, seawalls and reclamation projects ever undertaken. Both marine and land operations were ahead of programme at the time of writing.

The contract involves the removal of 65.9 million cu.m. of mud from the site and a further 75.4 million cu.m. at marine borrow areas. The land excavation of the existing Chek Lap Kok island will yield approximately 86.4 million bank cu.m. of material, and 76.5 million cu.m of marine sand will be placed. 13.4 km of seawall will be constructed.

6. BASIC UTILITIES INFRA-STRUCTURE

The following utilities mains and services will be provided:-

- Potable and firefighting water
- Power supply & distribution
- Stormwater drainage and related oil interception system
- Sewerage system
- Irrigation
- Gas distribution
- Seawater for flushing and cooling
- Security system
- Integrated data communications
- Fuel receipt, storage and distribution
- Lighting

Generally on the landside, all utilities are placed within segregated reserves adjacent to primary road corridors. This was a planning objective to ensure that future maintenance and upgrading of the utility systems will have minimal disruption to public, operational and emergency vehicular access to the various facilities on the airport island.

6.1 POTABLE AND FIRE FIGHTING WATER SUPPLY

A dual feed potable water distribution pipe network will be installed at an anticipated minimum pressure head of 30m at the local area connection point. Two 600mm diameter mains will connect to the distribution rings of Tung Chung service reservoir via the two sea channel bridge crossings together with a 450mm direct back-up supply. Potable water is not planned to be used for flushing purposes or for irrigation of large landscaped areas.

A street fire hydrant system adjacent to public roads or public areas will be provided. Each hydrant will be capable of delivering up to 4000 l/min at 30m residual pressure.

For hydrants in the aviation fuel tank farm area, a total flow rate of 22,500 l/min from any six hydrants simultaneously will be possible. A flow rate of 20,400 l/min per six hydrants with a minimum hydrant discharge pressure of 15m is planned for the airside. The maximum spacing of hydrants serving the runways and taxiways will be 150m.

6.2 POWER SUPPLY & DISTRIBUTION

There will be an opening day demand of approximately 175 MVA (including 55 MVA for the terminal building) increasing to 365 MVA (77 MVA for the terminal buildings) by the year 2010.

China Light and Power (CLP) will provide 132kV supplies to the airport island, initially via cables laid along the North Lantau Expressway and across both sea channel bridges. These 132kV supplies will be routed to two primary sub-stations, "A" located at the north east corner of the island and "B" located at the south between the aviation fuel tank farm and the cargo area.

Sub-stations "A" and "B" will become operational in 1996 and 1997 respectively. A third primary sub-station "C" is also planned but is unlikely to be constructed before 2020. This sub-station will be located in the south-east corner of the island. CLP are planning to run a submarine cable which will provide supply to sub-station "A". Installation and commissioning of this cable is currently planned for 1999.

The 132kV supply will be transformed down to 11kV at the primary sub-stations from where it will be distributed to five switching stations. Distribution from these five switching stations will be to further sub-stations, typically located in tenants premises, and to an additional five switching stations which will form the upper level of the Authority's power supply network for its own facilities.

The proposed Authority's Power Supply and Distribution System is designed to aim at high supply security with emergency power backup. Emergency generators will be capable of supplying 31 MVA (including 15 MVA for the terminal building) at opening day.

6.3 STORMWATER DRAINAGE AND OIL INTERCEPTOR SYSTEM

A gravity drainage system will discharge all stormwater run-off, and outflow from seawater cooling plants, through a number of outfalls spaced around the perimeter of the airport island. Finished surface levels and the design of the drainage system will ensure that there is sufficient hydraulic gradient for discharge under high tide levels. The system will have a high degree of assurance against flooding.

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Return periods are typically 200 years for all main trunk drains on the airfield and landside areas, 50 years for apron collector drainage, and 10 years for temporary sub-soil drainage in the large grassed areas left vacant for future expansion.

Several areas may give rise to pollutants that require interception. These include the terminal and cargo aprons, the maintenance areas, and the fuel tank farm. An oil interception system will separate oil and other accumulated pollutants flushed from the surface during initial minutes of a storm. In the fuelling areas, spill trap containment will retain accidental fuel spillage.

The stormwater network consists of approximately 26 km of box culvert (cell-

length), 58 km of precast pipes and open channels (including tributory drainage), and 13 outfall structures. Of the 13 catchments, three non-pollutant areas outfall into the southern sea channel.

6.4 SEWERAGE SYSTEM

Sewage is pumped via rising mains across the primary sea channel bridge crossing to connect to the Tung Chung New Town trunk main and thence to the Siu Ho Wan sewage treatment works.

A number of on-island pumping stations and a pumped trunk sewer network was selected in preference to a combined gravity and pumped layout, largely due to gradient and self-cleansing difficulties. Pre-treatment of certain industrial-related liquid waste will be undertaken prior to discharge into the sewerage system. Aircraft sanitary waste will pass through trichurators (macerators) and combined with flushing water prior to discharge to the sewers.

A waste (grey) water treatment plant, located in the air catering area, will treat large volumes of kitchen waste water which will then be stored for irrigation purposes.

6.5 IRRIGATION AND LANDSCAPE

There are four basic sources of irrigation water: "raw" water from North Lantau catchments, potable water (for selected use only) from Water Supplies Department, collected rainwater from the airport island, and treated grey water from catering. Artesian supplies were not feasible.

Because of the expansive areas of the airport, considerable effort is being made to minimise the demands for irrigation. Landscape architects have been commissioned to produce a landscape design that is functional, in respect of airport operations (eg. avoidance of bird strike, minimisation of maintenance, minimal irrigation using drought-resistant plants, etc.) whilst providing excellent aesthetics and producing an impressive "gateway" for arriving passengers to Hong Kong.

The currently proposed areas for piped irrigation are a 10m wide strip adjacent to runways and taxiways (for the avoidance of dust-ingestion into aircraft engines) and amenity/ornamental areas notably adjacent to roads and footpaths. Estimated water requirements are of the order of 2000 cu.m/day at airport opening.

6.6 GAS SUPPLIES

Projected consumption for the Terminal Buildings for year 2010 is 20,500 cu.m/day, which is estimated to increase to 25,000 cu.m/day on full development. Ultimate demand for the entire island is estimated at around 80,000 cu.m/day.

The gas network will consist of a 300mm intermediate pressure towngas main from North Lantau extending from Tung Chung New Town and a secondary low pressure distribution system.

Gas on the airport island will be distributed by 7kPa low pressure secondary ring main system fed from pressure governors near the demand areas. Pipe sizes will range from 150mm to 450mm diameter and will be suitable for the ultimate demand. Branches, with pipework sized for ultimate usage, will be provided at each building location where gas supply is required.

6.7 SEAWATER FOR FLUSHING AND COOLING

A sea water supply network will be provided to all building areas of the airport for sanitary flushing purposes.

The Authority plans to provide cargo, catering and aircraft maintenance licensees with a pumped supply sea water for combined flushing and cooling, comprising intake structures, pump houses and pumps, and mains systems which will be routed along utility reserves.

Seawater will also be pumped to a central chiller plant located in the basement plantrooms of the passenger terminal building for general cooling of the terminal and concourse. Expansion of the cooling system is also facilitated for future terminal growth.

6.8 SOLID WASTE DISPOSAL

Consultants have developed a waste disposal strategy for the airport which involves the compaction of waste in ISO/Roll-on-off containers for transport to a North Lantau Refuse Transfer Station interchange point for

onward movement by boat to West New Territories Landfill.

Instead of a single centralised refuse transfer station for airport waste on the airport island as proposed under the Master Plan, a distribution of a number of smaller and dedicated compaction and loading units located closer to the sources is preferred.

Licensees will be required to provide their own refuse compaction and transfer facilities within their sites and dispose of the wastes at the North Lantau Refuse Transfer Station at Siu Ho Wan.

The strategy also aims to enforce environmental constraints and to promote a waste minimisation and recycling programme.

6.9 SECURITY SYSTEMS

The Authority intends to install a centralised security system for the whole Airport including CCTV, access control, and trunked mobile radio.

6.10 COMMUNICATION SYSTEMS

Territory-wide fixed communication needs for the island will be met by the licensed Fixed Telecommunication Network Providers. The Authority is installing a communications 12 x 100 diameter duct network for the use of these providers to service all lettable sites on the island, and has allowed an additional duct easement for expansion purposes. A site has been identified to accommodate the exchange equipment of all providers.

A single structured cable network consisting of a multi-mode fibre-optic and Category 3 UTP (unshielded twisted pair) backbone with Category 5 UTP distribution will service all communication needs in the Terminal Building. Access to this network will be arranged on a needs basis.

The Authority will install a wide-area communication network throughout the airfield. Based on a single-mode fibre optic backbone with Category 4 UTP and multi-mode fibre using multi-media ATM (Asynchronous Transfer Mode) switches to enhance network availability and bandwidth, this network will link all the Authority's essential systems such as CCTV surveillance, security systems, voice communication, and equipment control and monitoring.

The network will also provide broadband access to a common airport database, allowing all major tenants both on the airfield and within terminal building, all Government Departments, and the Authority itself to share information of common interest to the Airport Community.

6.11 FUEL RECEIPT, STORAGE AND DISTRIBUTION

The Authority intends to licence the design, financing, construction and operation of the aviation fuelling system to the industry specialists.

Two 450 mm diameter underground pipelines will bring Jet A1 aviation fuel onto the airport island where it will be received at one of two storage tank farm sites. On-airport storage facilities will cater for 15 days of fuel, approximately 200,000 cu.m. based upon the daily off-take predicted for the year 2010, and expandable to meet the predicted demands for the airport's ultimate capacity. The current estimated ultimate throuhput is 25,000 cu.m./day making a total capacity of 375,000 cu.m.

A fuel hydrant distribution system, suitably sized to cater for busy hour demands for the year 2010 expandable for future growth, will transfer fuel direct from the tank farm to the aircraft stands for into-plane refuelling.

7. BASIC TRANSPORT INFRA-STRUCTURE

The design of the airport transportation network has steadily developed with the passage of several transport studies. The policy of the Airport Railway providing the backbone to passenger access has remained a fixed parameter throughout.

Passenger and goods movements between the airport and the rest of Hong Kong and around the airport itself (both airside and landside) were sensitively analysed for a large number of planning scenarios, including changes in modal choice, employment and population distribution, road network, junction layouts, design year, and so forth.

The Airport Site Plan defines the rail corridor and also a road network capable of handling traffic growth to the year 2002, thereafter a programme of phased expansion of the road system (eg. lane widening, dualling, and additional links) will be necessary. Space is being reserved for this.

Some fundamental principles were adopted in the planning of the road network, including :

- Maximised segregation of passenger traffic from commercial/industrial traffic;
- Free flow traffic management;
- Minimal recirculation;
- Alternative emergency routes;
- Direct access to major land uses;
- Minimisation of construction costs.

Even with the Airport Railway hiving off 43% of arriving and departing passengers, by the year 2010 traffic flows on the main approach road to the passenger terminal will exceed 3500 passenger car units (pcu's) per hour in each direction. To the south, cargo and maintenance-related traffic will increase the flows to over 5000 pcu's/hour each way, making the corridor one of the busiest in Hong Kong.

7.1 GROUND TRANSPORTATION CENTRE (GTC)

The focal point of the landside road network is the GTC serving the passenger terminals. The GTC "hub" facilitates air passenger transport interchange between aircraft and the various ground transportation modes, including Airport Railway, public buses and Airbuses, tour coaches, hotel buses and limousines, baggage vans, taxis and private cars.

Segregated provisions are made for each transport mode with emphasis being placed on speed and efficiency of transfer, convenience, comfort and safety for all passengers, well-wishers and operatives. The level of service achieved must result in passenger satisfaction and elimination of any frustration. The aim is for minimum turnround time for passenger and baggage loading/unloading and queue/dwell times for vehicles. Road access to and from all facilities will be as direct as is feasible to avoid recirculation and "dead" mileage.

At the core of the GTC is the rail station with its direct links between platforms and the processing halls of the terminal building,

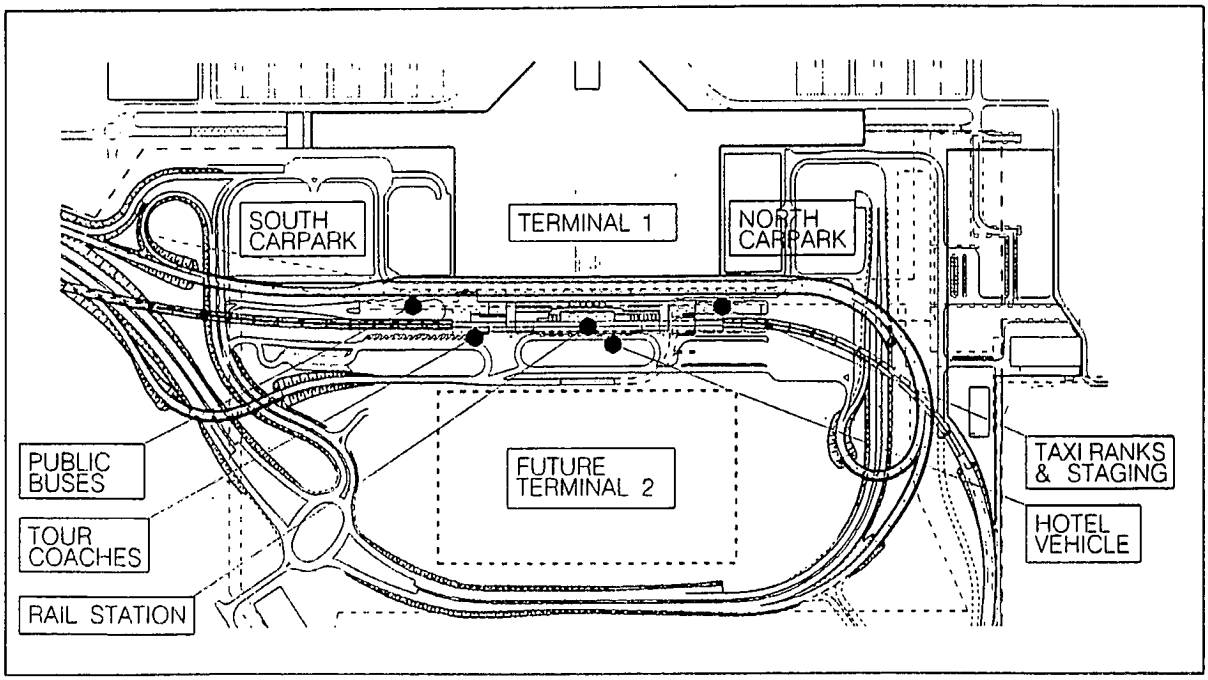

Fig.5 Ground Transportation Centre

involving no change of level. Provision is made for baggage handling either by passenger trolley or using the "In-Town Check In" facilities (if these are to be developed) which move baggage direct to the aircraft via the terminal's automated baggage handling system. The station will be expandable to serve the future second terminal with the equivalent level of service provided. Beyond 2010, up to 50% of air passengers and their well-wishers are expected to enter and leave the airport through this station.

There is obviously a limited frontage to the terminal building which makes the placement of all transport interchange facilities literally at the doorstep almost impossible. Nevertheless, facilities wrap around the building and walking distances which are largely dictated by vertical separation, and the constraint of 1 in 20 ramp gradients, have been minimised.

The highest level of the GTC is occupied by the road departures traffic. A departures kerb along the face of Terminal 1 accommodates taxis, public buses, hotel vehicles and the private cars that choose to drop off their passengers at this level. Private cars can also access the carparks directly. Tour coaches are directed to the ground level check-in facility located adjacent to the baggage handling facility of the Airport Railway. A totally separate baggage handling and check-in facility is provided for the departing tour groups.

The ground level of the GTC is occupied by road arrivals traffic. Separate pick-up areas are provided for taxis, public buses, tour coaches and hotel vechicles. Private car pick-up facilities for arriving passengers are provided in the car parks.

Multi-storey carparks are planned at the north and south ends of each terminal building. Pedestrian access will be via lifts, escalators and staircases within the carparks to transition links directly into the arrivals and departures halls. Planning of carpark layouts was not complete at the time of writing, but the objective will be to encourage pick-up and set-down of passengers and baggage at paid and unpaid areas of the parks respectively.

Year	Short-term	Long-term			
		Pax	Employees	Total	Actual
2002	1,000	300	500	1,800	1,800
2010	1,500	500	700	2,700	3,300

Table 4 Passenger Terminal Parking (No. of spaces)

8. AIRFIELD INFRASTRUCTURE

8.1 AIRFIELD PAVEMENTS, VISAIDS AND NAVAIDS

The airfield pavements comprise runways, taxiways, aprons and taxilanes. The Master Plan determined, after a series of planning studies and airport computer simulations, that there should be two 3.8 km runways each with dual parallel taxiways, rapid exit taxiways and pairs of crossfield taxiways serving a midfield development of passenger concourses and aprons. A single parallel taxiway to the south would serve the Air Cargo, Business Aviation and Government Flying Services facilities. Runway separation would be 1525m allowing fully independent flight operations thereby maximising aircraft movements and airport capacity.

Pavement construction and geometry is based on current dimensional criteria proposed for Code F aircraft by the International Civil Aviation Organisation (ICAO), incorporating the requirements for large, high-capacity aircraft currently under design. Pavement strengths are designed to ICAO Code F although the Phase 1a construction will be for Code E aircraft ensuring that future widening to Code F will not entail pavement demolition.

As construction will, for the most part, be on new reclamation, the runways and taxiways will be of flexible asphaltic concrete construction able to accommodate the anticipated small differential ground settlements without distress and with minimal reprofiling to stay within ICAO standards.

For the aprons, resistance to jet fuel and oil contamination and to the effects of extended duration loadings are very important, although ride quality is not a significant factor due to the slow aircraft manoeuvring speeds. Therefore, where ground settlement is not a problem, rigid

pavement has been selected. Rigid pavement is also selected in areas of tight turning radii (eg. runway ends) where greater resistance to rutting and scuffing is necessary.

For apron stands where ground settlement is likely to be a problem, a block pavement design has been proposed. Block paving is a relatively new innovation for airfield pavements and does demand high quality workmanship. Block paving consists of 80 mm thick precast concrete paving blocks bedded on a thin sand layer and supported on the same base and sub-base as conventional flexible pavement. Block paving can be easily reprofiled by lifting, regrading the base course and relaying the blocks.

A comprehensive airfield ground lighting, signage and marking system will be provided. The various lighting installations include runway threshold and wing bar lights, visual approach guidance system, touch down zone lights, runway centreline and edge lights (ICAO Cat II), taxiway centreline and edge lights, stop bars and clearance bars. Aircraft guidance lighting and markings will be provided to all aprons, which will also be floodlit to permit night operations.

The airport requires a comprehensive network of radio navigation and radar facilities. A precision approach Instrument Landing System (ILS), comprising VHF localiser, UHF glide path and distance monitoring equipment will be provided for all four runway ends.

8.2 ROADS AND TUNNELS

Access to aircraft and the various parts of the airfield will be provided by a network of roads and demarcation areas on the aprons. To permit rapid deployment of fire services, special egress routes will lead from the fire stations to the runways.

Because of the heavy and slow movement of vehicles between the midfield areas (ie. passenger aprons and aircraft maintenance) and the cargo, catering and ground equipment support maintenance areas in the south, two cross-field tunnels will be constructed to ensure minimal conflict with aircraft ground movements. Each tunnel will be of dual carriageway proportions with appended utility cells and will be of approximately 700m in length.

8.3 AIRCRAFT MAINTENANCE

Aircraft base maintenance and engineering services to be provided will involve the continuous servicing of aircraft that require repair and maintenance including aircraft airframes, engines, components maintenance and testing. Line maintenance operations, on the passenger and cargo aprons, will comprise the provision of technical support for aircraft, including cleaning, minor defect rectification and aircraft towing.

The aircraft maintenance site is to the extreme west of the airport island. Special facilities required include maintenance hangars, components workshops, parts/equipment storage, engine test cell, and administration support buildings. Other facilities include aircraft aprons and parking positions, washing bays, engine run-up areas, and possibly a compass calibration pad.

The Authority plans to issue licences for both base and line maintenance activities. Each licence will offer the right to design, finance, build and operate these facilities.

8.4 SUPPORT AND ANCILLARY FACILITIES

Airport operations and maintenance support facilities encompass a variety of roles which are essential for the airport to function effectively. Facilities in this category include:

(a) Provided by the Authority and its Licensees:

- Airport Maintenance
- Rescue, Firefighting, Fire Training and Sea Rescue
- Apron Control
- Isolation Pads
- Ground Support Equipment Maintenance and Storage
- Perimeter Gate Control

(b) Provided by the Government :

- Air Traffic Control Complex
- District Police Station
- District Fire Station
- Meteorological Facilities
- Customs and Excise
- Government Flying Services
- Air Mail Centre

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2. "New Airport Master Plan - Executive Summary", Greiner/Maunsell, December 1991.

3. "New Airport Master Plan - Civil Engineering", Greiner/Maunsell, December 1991.

ACKNOWLEDGEMENT

This paper is only a brief summary of the planned airport infrastructure and cannot adequately reflect the wealth of effort being expended by the various departments and officers within the Provisional Airport Authority, its consultants and contractors. Particular acknowledgement is given to those members of the PAA's Project Division who gave invaluable input to this paper.

APPENDIX I

General	
Passenger Handling Capacity	35 million per annum
Aircraft Operations	43 per hour
Number of Gates	38 Frontal + at least 24 Remote
Building area	495,500 sq.m.
Building length	1.27 km.
Building width across Processing Hall	330 m.
Arrivals Level	
Transfer / Transit Lounges	5 No.
Passport Control Positions	124 No. (cf. 90 No. at Kai Tak)
Baggage Reclaim Carousels	12 No. (cf. 6 No. at Kai Tak)
Customs Inspection Positions	76 No. (cf. 52 No. at Kai Tak)
Concession Areas	(Under development)
Departures Level	
Check-in Counters	288 No. (cf. 184 No. at Kai Tak)
Passport Control Positions	100 No. (cf. 76 No. at Kai Tak)
Security Screening Positions	16 No. (cf. 9 No. at Kai Tak)
Concession Areas (Landside & Airside)	(Under development)

Table 2 Terminal Building Selected Phase 1a Information

Paper No. 6

Paper No. 7

NUCLEAR : A GREAT EXPECTATION ?

Speaker : Jacques R. Pretti
Senior Nuclear Technical Advisor
Hong Kong Nuclear Investment Co. Ltd

NUCLEAR : A GREAT EXPECTATION ?

Jacques R. Pretti
Senoir Nuclear Technical Advisor
Hong Kong Nuclear Investment Co., Ltd

ABSTRACT

Is nuclear power a response to our tremendous need of energy? The answer cannot be simply "yes" or "no". Nuclear is safe, reliable, environmental friendly and produces electricity at stable and competitive costs, provided the appropriate human, industrial and economical framework are implemented. A Nuclear Power Station is more than a more or less sophisticated Thermal Power Station. It requires the involvement of different national and international organisations, a strong leadership, an intensive public education and a transparent communication policy.

1. IS NUCLEAR AN ANSWER TO OUR ENERGY NEEDS?

1.1 ENERGY NEEDS

Historically, energy production has represented some 5% of world GDP while energy investments have typically accounted for about 13% of total world investments.

Nowadays, electricity production accounts for approximately 30% of total worldwide primary energy consumption (Figure 1)

The development and diffusion of technology necessary for meeting global energy requirements and mitigating environmental impacts is of crucial importance.

According to the World Energy Council [1], the industrialised countries bear a major responsibility for developing the technologies required for the future, and for helping to make technologies appropriate to local circumstances widely available.

Nuclear power is definitely one of these technologies. It is safe, reliable, environmental friendly and provides electricity at stable costs.

It is likely that the contribution of nuclear power in electricity generation will increase as solutions found for nuclear waste management and public acceptance given to allow its expansion. Anyway, in the mid and long term (beyond Year 2020), there will be growing recognition for nuclear power, and, together with coal, as the two most readily available options in substantial quantities.

1.2 ENERGY AND THE ENVIRONMENT

For developing countries, the primary concern is the local environment. Regional and global (worldwide) environment issues being secondary.

It is nevertheless important to recognise the many benefits which industrialisation led by the application of commercial fossil fuels have brought to the world over the past two centuries, and these material benefits, presently so unevenly distributed around the globe, needs to be extended.

Paper No. 7

The supply and use of energy have positive and negative impacts. Pollution is the principal negative aspect with local and regional effects (smoke, acid rain, oil spills etc. - refer to Figure 2). These effects are particularly acute in and around urban areas. This is why we should strive for improved efficiency in an economically and politically practicable way to reduce local and regional pollution arising from energy provision and use. Keeping in mind that :

1 tonne of natural uranium = 10,000 toe,

contribution of nuclear electricity in reducing local and regional pollution is obvious.

Note : For global environmental concerns, refer to Appendix 1.

1.3 OTHER CONCERNS

Amongst the other concerns in the global setting, public opposition to nuclear power is a problem which the officials and utility have to deal with. It is a matter of an appropriate public education, including the media. The nuclear industry has to provide them with informative, impartial, intelligible and accurate messages. The utility concerned must convince the layman that it can be trusted and is not afraid of scrutiny.

Of course, it is easier to scare people than to reassure them. But that is only an excuse for nuclear industry failure. While there are risks, they are not the only risks that society encounters, and they are very likely much smaller than the general public perceives them to be.

A transparent communication policy, despite inherent difficulties, is probably the most efficient way of improving public confidence and trust in the ability of the operators to achieve an appropriate safety level.

2. DOES HONG KONG NEED NUCLEAR POWER?

Figure 3/1 shows the growth in electricity demand in the territory during the last decades, and Figure 3/2 shows the corresponding data in PRC [3]. As demand for electricity grows, it is essential to add generating capacity to the existing system in a timely manner to ensure a reliable supply.

Furthermore, as Hong Kong has to rely entirely on external supply of fuels for electricity generation, the diversification of fuels can save us from being affected by the changes in prices or even supply of one particular fuel (Figure 4).

The Daya Bay Nuclear Power project, therefore, aims at meeting the following objectives :

(a) to meeting electricity needs in both Guangdong Province and Hong Kong;

(b) to diversify the sources of electricity generation;

(c) to contribute to the reduction of environmental pollution and therefore support the environmental policy of Hong Kong utilities; and

(d) to provide electricity at stable costs for customers.

{(c) and (d) were not the stated objectives at the time}.
This is why China Light & Power decided, in late 1970s, to participate in the Daya Bay Nuclear Power project. This project was reviewed by the Hong Kong Government in 1981 and approved in 1984.

3. GUANGDONG DAYA BAY NUCLEAR POWER STATION

The Guangdong Nuclear Power Joint Venture Company, Limited (GNPJVC) was established in January 1985.

The shareholding and electricity sales agreement are presented in Figure 5.

A proven technology - Pressurised Water Reactor (PWR) was selected. At the end of 1993, 278 PWRs were in operation in the world, representing 63% of the 441 nuclear reactors worldwide.

The French standardised PWR technology selected for Daya Bay amounted to 54 operating PWR at the end of 1993.

The main contractors involved in the design and the construction of the station are listed in Figure 6.

However, a nuclear power plant is not merely a conventional station in which the steam generator is replaced by a reactor. It has to be designed and operated according to a whole set of stringent nuclear safety regulations and

standards. The presence of radioactive elements is a hazard the operator has to deal with. A nuclear power plant is safe when it is appropriately designed and properly operated**. This is why the GNPJVC has assured a long-term learning process including:

(1) a training programme of more than five years for each operator including training at overseas nuclear power stations and overseas contractors' factories, starting in 1988; and

(2) the involvement of French experts from "Electricité de France" (which is the French nationalised utility and the biggest electrical utility in the world) and Amercian staff from Bechtel Corporation during the project phase and the operating phase. Concerning the operation, about 70% foreign experts (French, American, South African, Korean) are presently working in the Operation Department with the Station Manager from France. The main aim of the foreign support is two-fold :

   (a) to provide the Chinese operators with a managerial organisation commensurate with a safe and reliable operation of a large modern nuclear power station; and

   (b) to provide the Chinese operators with the proper operating skills and qualifications.

HKNIC have also appointed some experienced CLP staff as line managers in the Operation Department organisation.

Moreover, the start-up and the commissioning of the station benefited from the feedback of experience of the French units. This is why, apart from usual set up problems encountered in the design and erection of large industrial facilities (essentially in the secondary side or Conventional Island), the main efforts focused on the training of the operating staff (operators, mechanics, electricians, chemists, control and instrumentation personnel etc.)

Chinese regulations and standards follow the international practices (mainly promoted by the International Atomic Energy Agency - IAEA - of the United Nations).
Let us consider, for example, the scrutinisation and the reporting process of the so-called "Reportable Events". Such events, in general, do <u>not</u> impair the safety of the unit. However, they have to be :

- <u>identified</u>, according to a series of precise criteria;

- <u>corrected</u>, as soon as possible, in order to prevent their recurrence;

- <u>reported</u> to the Guangdong Regional Office (GRO) of the Chinese National Nuclear Safety Administration (NNSA) by phone and fax within 24 hours. Then, a complete analysis report is prepared and sent to the GRO within one month.

A continuous assessment of the safety level of the whole station is performed :

- <u>Internally</u>, by the Safety Technical Advisor (STA), on shift, carried out independent of the plant operators and reporting directly to the Safety Branch Head and the Station Manager.

- <u>Externally</u>, by the permanent on-site residents of the NNSA.

Besides, at the request of the Chinese Central Government, the IAEA has already performed several assessment of the safety level of the station and the preparedness level of the operators. The final conclusions of these reviews highlighted significant improvements, and the recommendation issued by the IAEA experts show further progress.

*** Surprisingly, coal-fired stations, releasing 10% of the fly-ash, cause a collective dose of 4 man-sieverts per gigawatt-hour, about 40% more than nuclear! Modern plants with pollution control equipment like Castle Peak, release only 0.5% of the ash.*

4. CONCLUSION

The results of the operation of Daya Bay** for the first few months are very encouraging. It has achieved an excellent availability factor (more than 90%). It has its share of reportable events and the numbers are comparable to that observed in nuclearised countries. It has a staff who are committed to a high safety achievement. These are the main attributes of this start-up period.

Even if nuclear energy is expected to play a somehow modest role in the future growth of electricity generation in mainland China, it can take an important place in southern China by providing a safe, clean and reliable kWh to this part of the world which is rapidly expanding, thus contributing to the local environmental protection, by avoiding the emission of 5 to 6 million tonnes of waste per year, mostly in the form of gases (carbon/sulphur dioxide, nitrogen oxide) and about 160,000 tonnes of solids including fly ash and sulphur.

For the rest of the world, Daya Bay witnesses the Chinese ability to build a large and modern nuclear power station with international standards and operate it safely and efficiently.

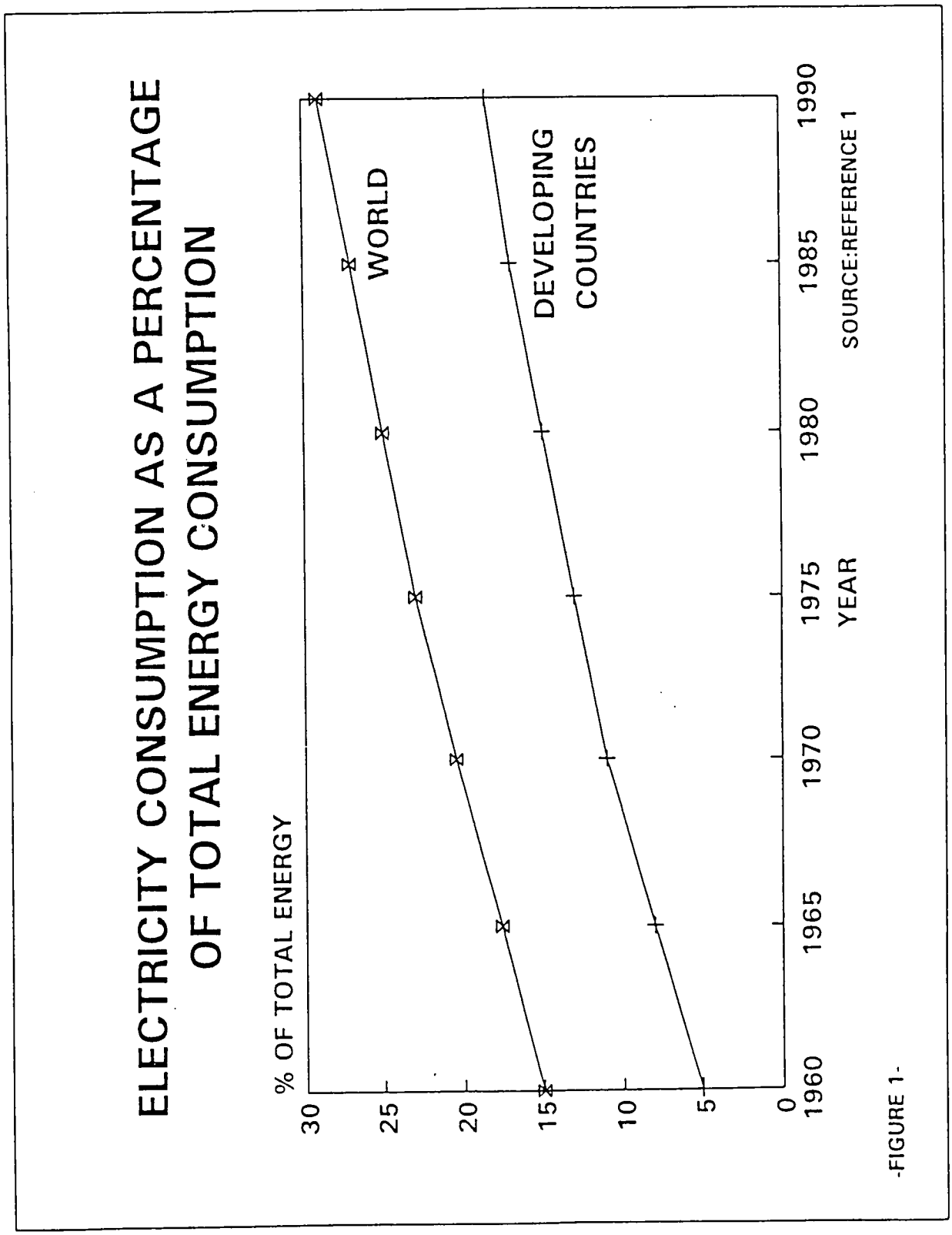
REFERENCES

(1) "Energy for Tomorrow's World" - World Energy Council (1993).

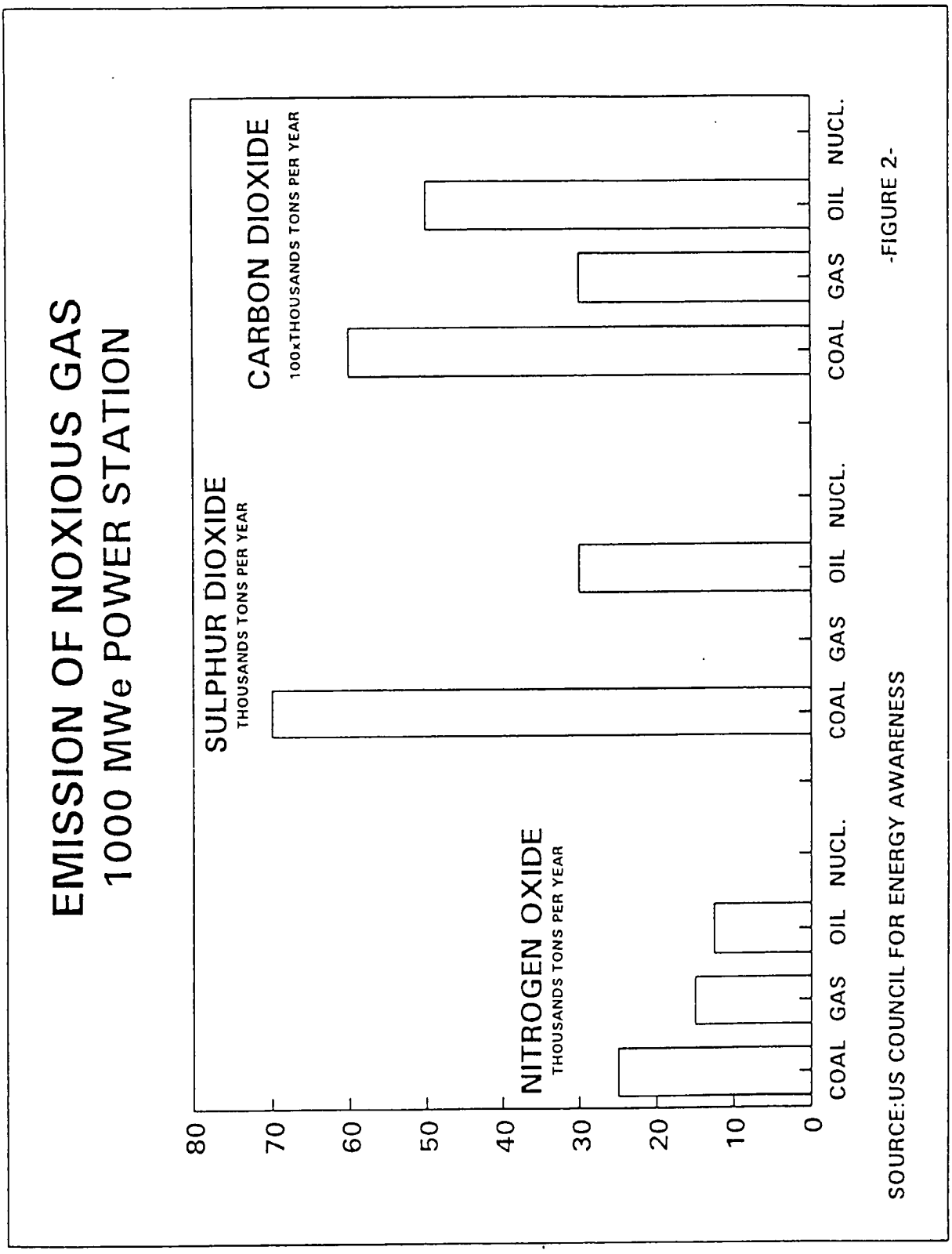
(2) "Climiate Change" - Intergovernmental Panel on Climate Change (1990).

(3) "World Energy Outlook" - OECD/IEA (1994)

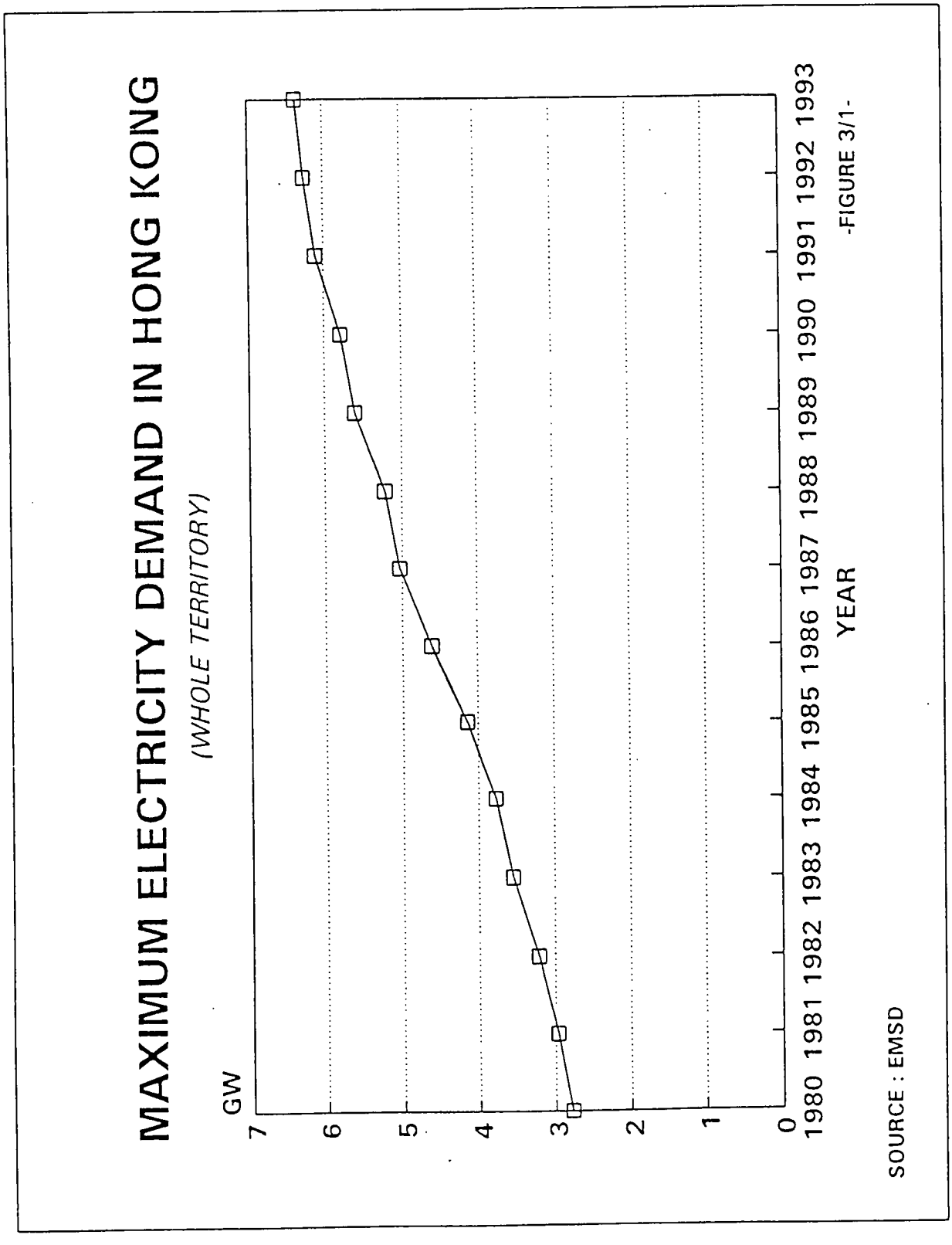
** *This paper has been written in mid-June 1994.*


ELECTRICITY CONSUMPTION AS A PERCENTAGE
OF TOTAL ENERGY CONSUMPTION
% OF TOTAL ENERGY
30
25
20
15
10
5
0
1960
1965
1970
1975
1980
1985
1990
YEAR
WORLD
DEVELOPING
COUNTRIES
SOURCE:REFERENCE 1

-FIGURE 1-

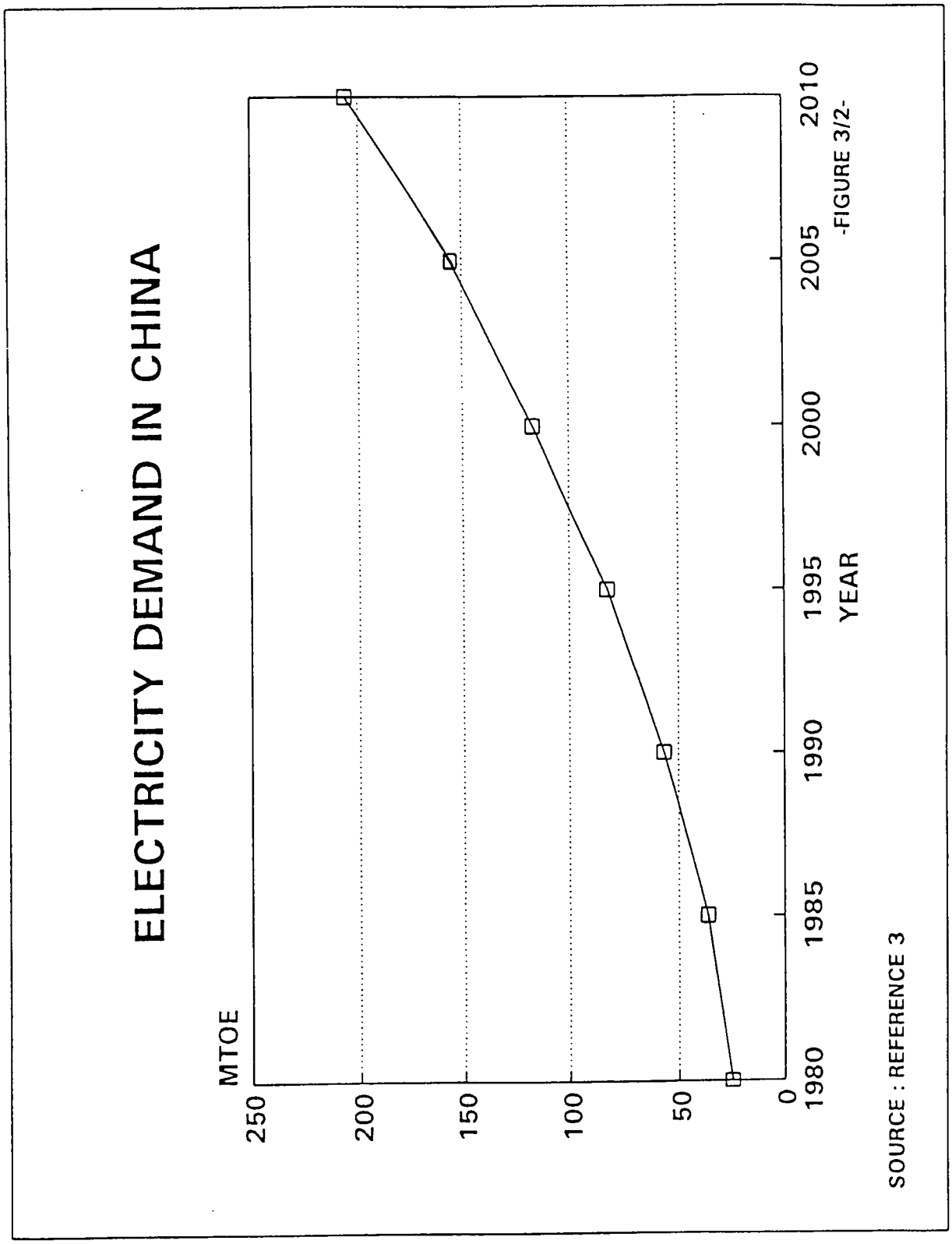

EMISSION OF NOXIOUS GAS
1000 MWe POWER STATION
SULPHUR DIOXIDE
THOUSANDS TONS PER YEAR
CARBON DIOXIDE
100xTHOUSANDS TONS PER YEAR
NITROGEN OXIDE
THOUSANDS TONS PER YEAR
80
70
60
50
40
30
20
10
0
COAL GAS OIL NUCL.
COAL GAS OIL NUCL.
COAL GAS OIL NUCL.
SOURCE:US COUNCIL FOR ENERGY AWARENESS

-FIGURE 2-

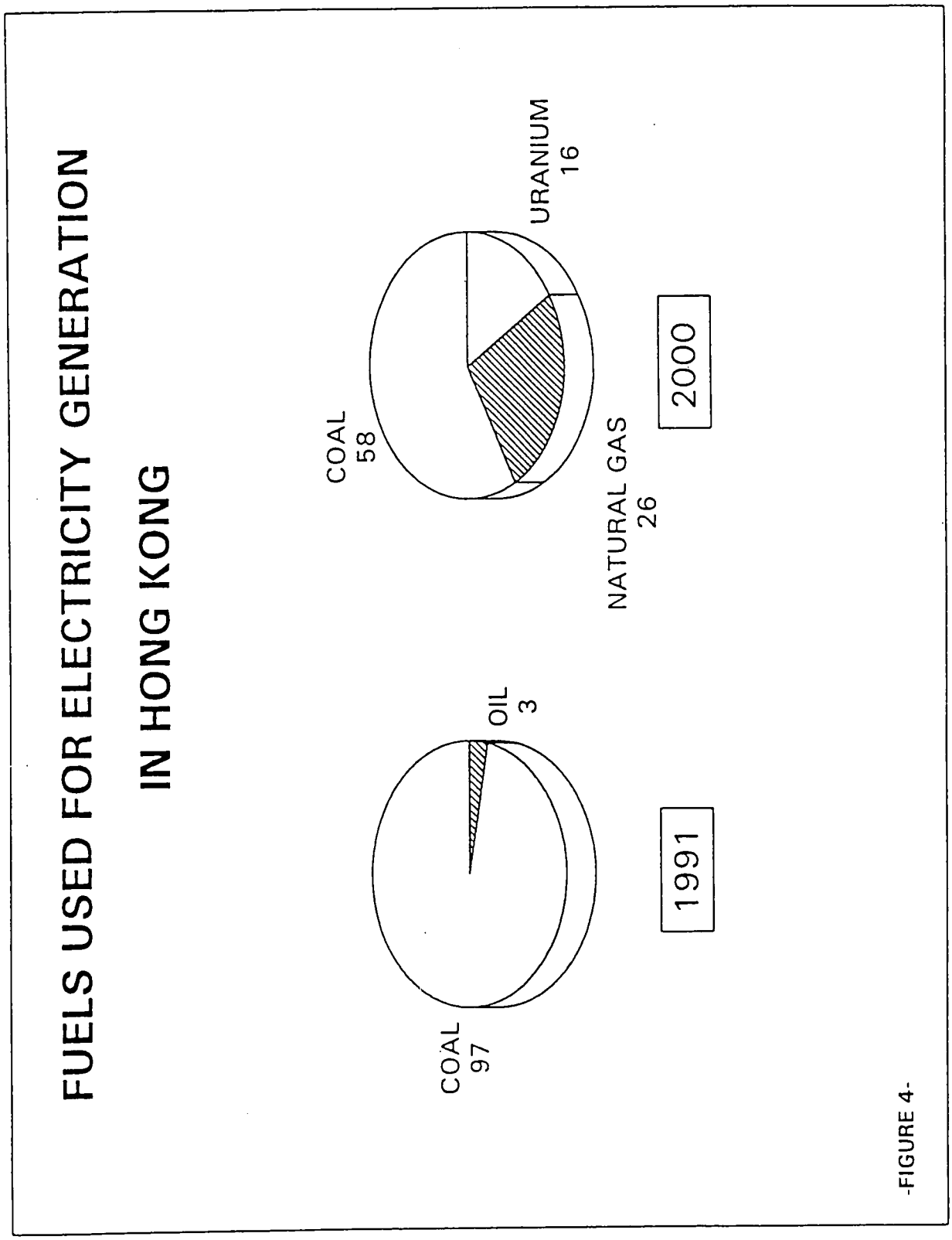


-FIGURE 3/1-

Pape
No. 7

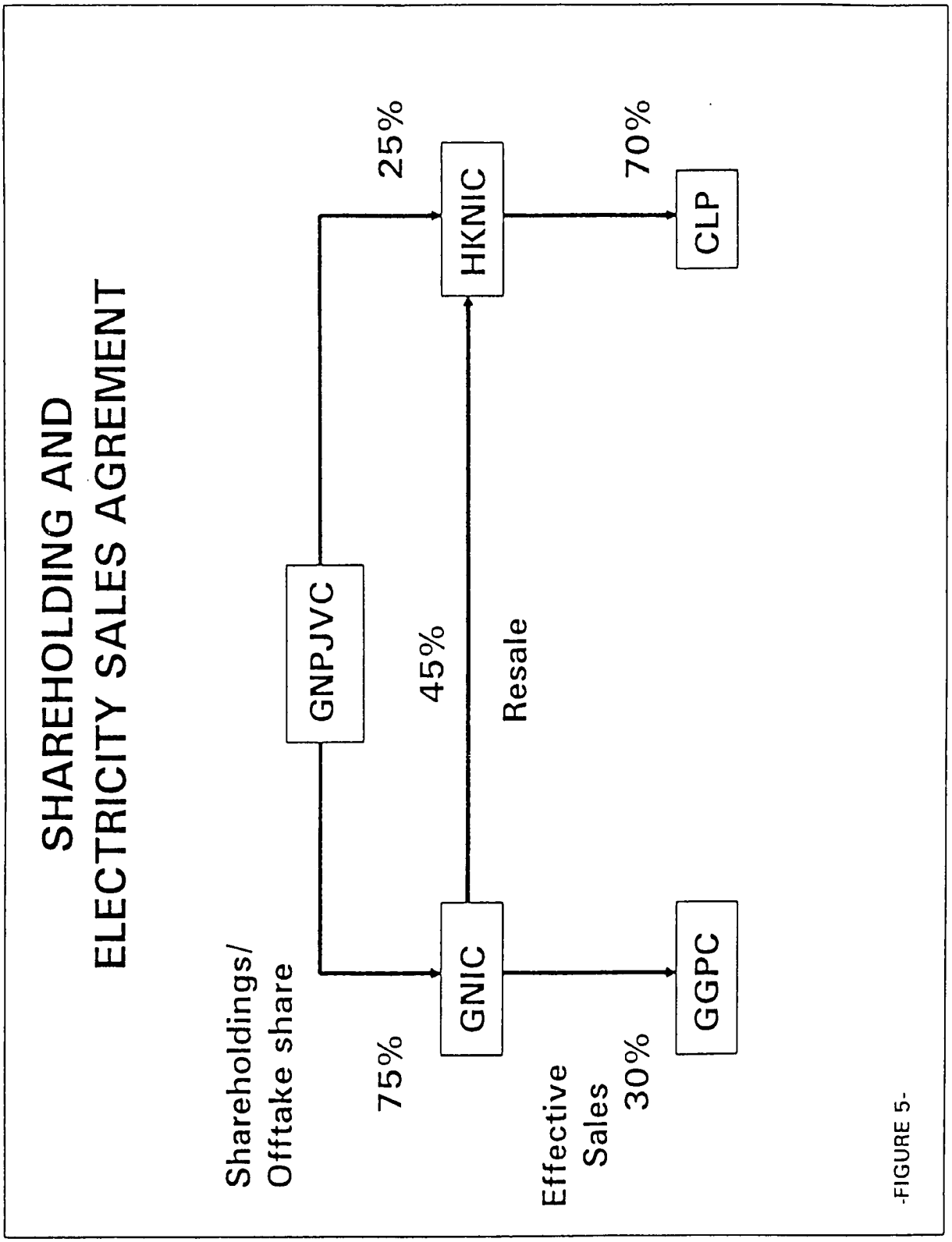

ELECTRICITY DEMAND IN CHINA
MTOE
250
200
150
100
50
0
1980
1985
1990
1995
2000
2005
2010
YEAR
SOURCE : REFERENCE 3

-FIGURE 3/2-



-FIGURE 4-

Paper No. 7


SHAREHOLDING AND
ELECTRICITY SALES AGREMENT
Shareholdings/
Offtake share
GNPJVC
25%
HKNIC
70%
CLP
75%
GNIC
45%
Resale
Effective
Sales
30%
GGPC

-FIGURE 5-

MAIN CONTRACTORS
DAYA BAY

ENGINEERING & MANUFACTURING

Nuclear Island Equipment	FRAMATOME
Conventional Island Equipment	GEC-ALSTHOM
Projects Services	ELECTRICIE DE FRANCE
Balance-of Plant	
* Transformers	MITSUBISHI
* Handling Equipments	DAVY MORRIS
* Full-Scope Simulator	THOMSON-CSF

ERECTION WORKS

Nuclear Island	Main Contractor	FRAMATOME/SPIE
	Sub-Contractor	23rd Co (CNNC)
Conventional Island	Main Contractor	SEPC
	Sub-contractor	GEC-ALSTHOM
Balance-of-Plant	Main Contractor	NEPC
	Technical Asssit.	BECHTEL

OPERATING PHASE

ELECTRICITE de FRANCE (EdF) is involved in the operating phase of DAYA BAY, according to the OPERATION SERVICES contract. Allowance is included to assign french experts to DAYA BAY, including the Station Manager.

NOTE : SEPC = SHANGDONG ELECTRIC POWER CORPORATION
NEPC = NORTH-EAST ELECTRIC POWER CORPORATION

-FIGURE 6-

PROJECT SCHEDULE AND COMPLETION

DAYA BAY

MAJOR MILESTONE	UNIT 1	UNIT 2
Construction Permit	07/01/88	07/01/88
Dome lifting	22/09/89	22/05/90
Polar Crane available	22/09/90	22/10/90
Fuel Loading (Start)	28/05/93	23/11/93
1st Connection to the Grid	31/08/93	07/02/94
End of Performance test	31/12/93	23/04/94
Commercial Operation	01/02/94	06/05/94

-FIGURE 7-

Appendix 1

POTENTIAL GLOBAL CLIMATE CHANGES

This is a very controversial topic.

Carbon dioxide (CO_2) and methane (CH_4), the two greenhouse gases primarily focused upon in discussions of the enhanced global warming hypothesis, have been rising for the past two centuries. Attention focuses mainly on carbon dioxide as it is believed by a number of leading specialists to be the main contributor to man-made radiative-forcing changes. Nevertheless, there is a belief that there is probably a missing carbon dioxide sink totalling around 100 gigatonnes of carbon, which may reflect increasing sequestration of carbon by trees and plants as atmospheric CO_2 have risen in recent decades. it is also suggested that there is an additional large northern ocean sink [2]. The significance of carbon sources and sinks can be gathered from the attached figure, which though close to such current consensus, represents the estimate of only a few scientists and is surrounded by large bounds of scientific uncertainties.

As it is, the huge magnitudes of non-atmospheric sinks and natural carbon emissions compared with carbon emissions from energy use suggest a more cautious evaluation of causes, effects and remedies than is often advanced. When sources and sinks are so finely balanced, it may be true that the small net anthropogenic contribution from fossil fuel combustion is sufficient to tip the balance. Alternatively, other forces may be at work (permanently or temporarily).

On the other hand, it is many of the poorest developing countries that have most of the fear from potential climate changes because they lie in tropical latitudes and are often afflicted by drought and famine already or by inundation of coastal zones and deltas.

Fossil fuels combustion probably accounts for the major part of authropogenic carbon dioxide emissions. Hitherto, man has made no effort to balance emissions by enhanced absorption. The large increase in atmospheric concentrations of CO_2 and CH_4 over the past two centuries have coincided with major industrialisation and world's population growth and therefore fossil fuel use.

The Intergovernmental Panel on Climate Change (IPCC) scientific assessment "Climate Change (1990)" reported that atmospheric concentrations have risen over the past 200 years as follows :

CO_2 : from 280 ppmv* to an estimated 353 ppmv in 1990.

CH_4 : from 0.8 ppmv to an estimated 1.73 ppmv.

But the unequivocal detection of the enhanced greenhouse effect from observations is not likely for a decade or more.

In examining sources and sinks of these gases, it is necessary to consider other possible causes such as :

- Cement production and land use of changes are significant contributions to carbon dioxide emission.
- Rice production is a significant source of methane.
- Rubbish produced by human activity (CH_4).
- Commercial fertilisers and nitrogen-fixing leguminous crops potentially increase emission of nitrous oxide (N_2O) from soil (nitrous oxide being a greenhouse gas).
- Nylon production and nitric acid production are other sources of NO_2.
- Etc.

The problem with greenhouse gas emissions is that their damaging effects have not yet been identified with precision or certainty. Yet potentially catastrophic real damage from their polluting effects and consequential climatic changes may already be occurring and getting worse.

* *ppmv : parts per million by volume.*

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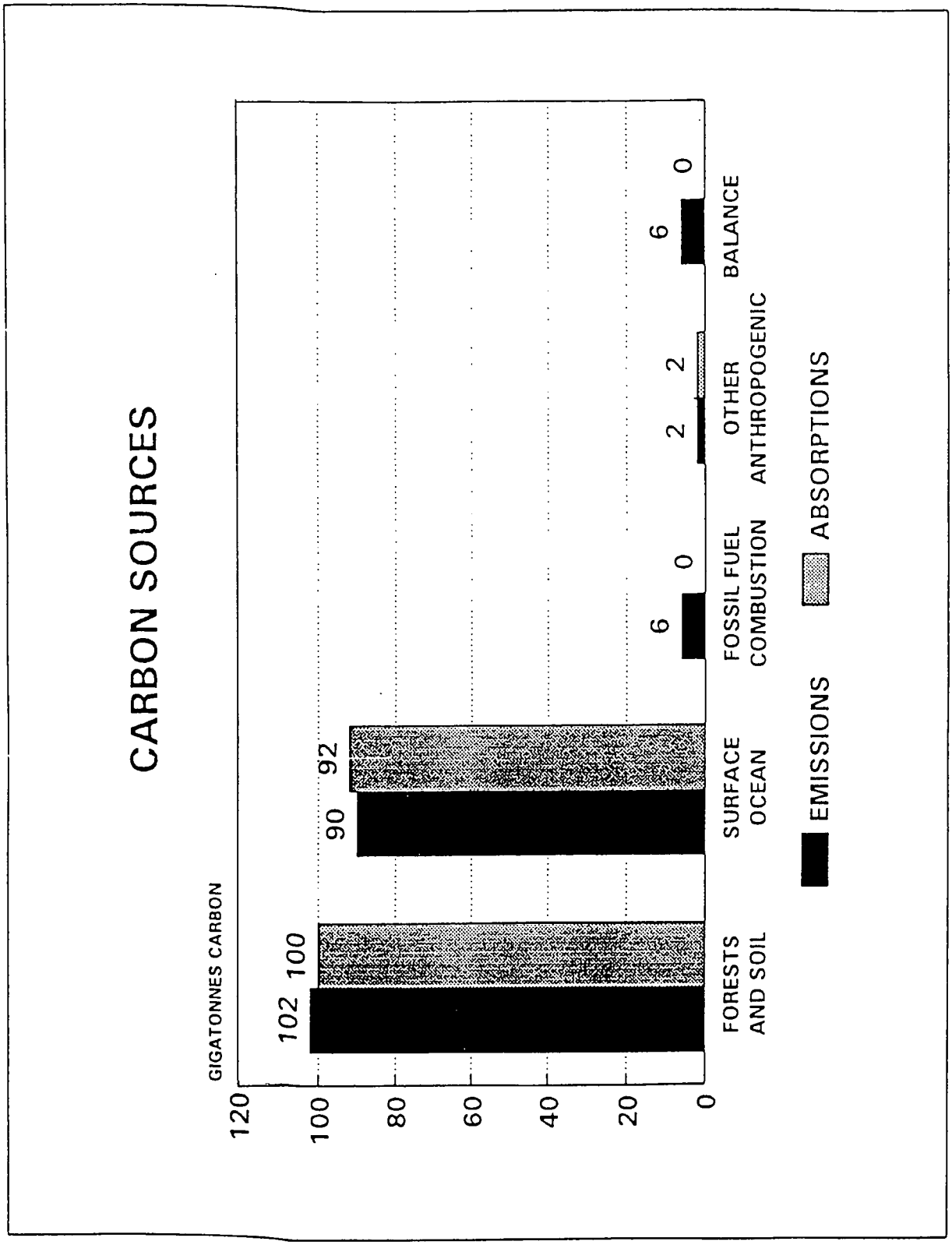
CARBON SOURCES
GIGATONNES CARBON
120
100
80
60
40
20
0
102
100
90
92
6
0
2
2
6
0
FOREST AND SOIL
SURFACE OCEAN
FOSSIL FUEL COMBUSTION
OTHER ANTHROPOGENIC
BALANCE
EMISSIONS
ABSORPTIONS

Paper No. 8

THE BLACK POINT COMBINED CYCLE POWER STATION

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THE BLACK POINT COMBINED CYCLE POWER STATION

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ABSTRACT

The Black Point Combined Cycle Power Station, when completed, will achieve a total installed capacity of 2,500 MW. The eight units of combined cycle power plant each generating 312 MW will be commissioned progressively from 1996 onwards with the last unit scheduled (subject to load growth) for 1999. The Black Point Power Station will be burning the cleanest hydro-carbon fuel available, natural gas. This paper gives an overview of the project and the background to the selection of the combined cycle power plant and natural gas for the new large thermal power station at Black Point. The scheme for the supply of natural gas and some of the environmental safety initiatives on the project are described.

1. INTRODUCTION

China Light and Power Co. Ltd (CLP) is the supplier of electricity to about 1.5 million customers in Kowloon and the New Territories. The existing stations at Tsing Yi and Castle Peak have been developed to meet growth in demand through the 1970's and 1980's respectively, and the commissioning programme of these units has closely matched the growth in load demand over that period. The last unit at Castle Peak was commissioned in 1989. In the early 1990's, Penny's Bay Gas Turbine Power Station was built for peak looping and emergency duties.

Commencing early this year, new generating capacity was made available through CLP's participation in the Daya Bay nuclear power project, and also from the participation of Exxon Energy Limited (EEL) and CLP in the Guangdong Pumped Storage Power Station.

The growth in demand from CLP's Hong Kong customers is forecast to continue, though at a lower rate than in the past. CLP's generation plan for the second half of the 1990's and into the next century called for the construction of a new large thermal power station (LTPS) with an ultimate capacity of 6,000 MW in Hong Kong to meet forecast increases in electricity demand. Preparations for the new LTPS project started in 1990 when CLP commissioned consultants to undertake a Site Search Study which recommended Black Point as the preferred location (See *Fig. 2*). The findings of the Site Search report were endorsed by the Lands Department Policy Committee and the reservation of a site at Black Point was subsequently approved by the Executive Council.

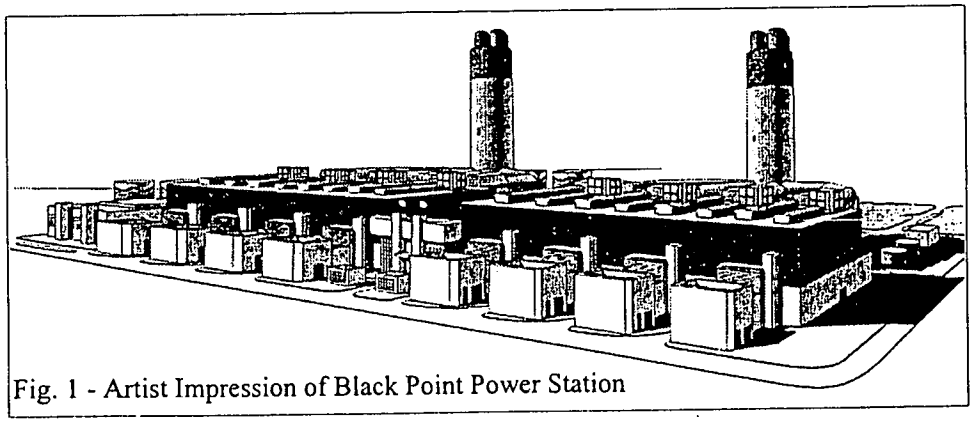

Fig. 1 - Artist Impression of Black Point Power Station

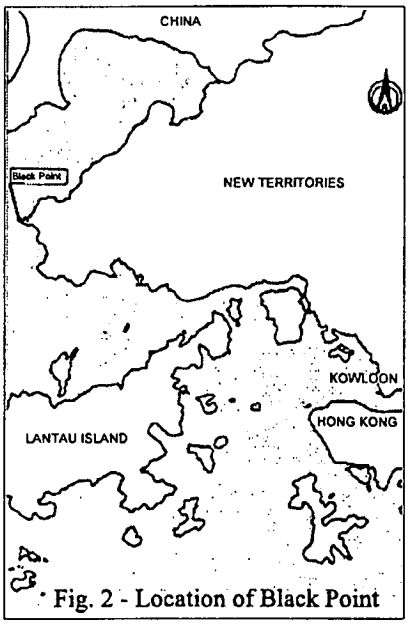

Fig. 2 - Location of Black Point

2. FUEL FOR BLACK POINT POWER STATION

Initial study of the Black Point Power Station project looked at coal as a source of fuel. At the same time the prospect of a direct supply of natural gas from the South China Sea for power generation emerged. A comparison between using gas and coal as the primary fuel for Black Point Power Station concluded that :

(a) the available gas would support around 2,500 MW of new generating capacity.

(b) the use of natural gas on the terms that could be negotiated with the seller would not affect the cost of electricity to the Hong Kong consumers in the long run.

(c) although adequate environmental controls were available to support the further use of coal, the use of natural gas would substantially lower environmental impact.

Castle Peak Power Company Limited (CAPCO), 60% owned by Exxon Energy & 40% by CLP, entered into negotiations in early 1992 with the developer for the supply of gas to Black Point Power Station. By March 1992 a Heads of Agreement was signed in Beijing with a consortium for the supply of natural gas to CAPCO. The gas supply consortium consists of the Beijing-based China National Offshore Oil Corporation (CNOOC), the Atlantic Richfield Company of USA (ARCO) and KUFPEC, who represent interests from Kuwait. The availability of the gas therefore coincided with the Black Point Power Station project needs.

Once commercial details were sufficiently clear, a proposal was made to the Government for phase 1 of the LTPS. The programme of previous units and the generation plan up to 1999 for the CLP generating system is set out in *Fig. 3*.

Figure 3

Year	Units Commissioned		Capacity Increase (MW)	Units Decommissioned		Capacity Decreas e (MW)	Total System Capacity (MW)
1982	Castle Peak	A1	350				3,006
1983		A2	350				3,356
1984		A3	350	Tsing Yi GT	GT1	42	3,664
1985		A4	350	Hok Un B	1-3	90	3,924
1986		B1	677	Hok Un B	4-7	240	4,361
1987		B2	677	Hok Un C	1-4	240	4,798
				Hok Un GT	HG5	20	4,778
1988		B3	677				5,455
1989							
1990		B4	677				6,132
1991							
1992	Penny's Bay	1-3	300				6,432
1993							6,432
1994	Pumped Storage	PS1&PS2	600				7,032
	Daya Bay Nuclear	N1	690				7,722
		N2	690				8,412
1995							
1996	Black Point	BP1&2	625	Tsing Yi A	1-6	720	8,292
1997		BP3&4	625	Tsing Yi B	1-2	400	8,492
1998		BP5&6*	625		3-4	400	8,692
1999		BP7&8*	625				9,292

* Tentative programme, subject to approval by the Government

3. POWER PLANT SELECTION

3. POWER PLANT SELECTION

The availability of natural gas for power generation opened up the choices of technology for the LTPS to consider the combined-cycle power plant. Advances in gas turbine technology in recent years in achieving high megawatt output, low heat rate, and high availability and reliability make combined cycle power plants an attractive option. In addition, the cost of constructing a combined cycle power plant is competitive compared with other power generation technologies. It requires a shorter construction time, lower investment, and lower operation and maintenance costs than coal fired thermal plants of equivalent capacity. Proposal by CAPCO for phase 1 of the LTPS comprising 4 blocks of 625 MW gas-fired combined cycle gas turbine (CCGT) units fired primarily on natural gas with diesel oil as backup, was approved in December 1992 by the Executive Council.

4. THE COMBINED CYCLE POWER PLANT

The diagram (See *Fig. 4*) shows a comparison of efficiencies with other types of power generation and the next diagram the basic configuration of the combined cycle units which have been chosen for Black Point Power Station (See *Fig. 5*).

Plant Type	Total Energy Input %	Rejection to Atmosphere %	Rejection to Cooling Water %	Electrical Output %
Advanced Combined Cycle GT	100	12	33	55
Simple Cycle GT	100	67	0	33
Fossil Steam Turbine	100	9	53	38
Nuclear	100	0	69	31

Fig. 4 - Comparison of Net Efficiencies & Losses (LHV)

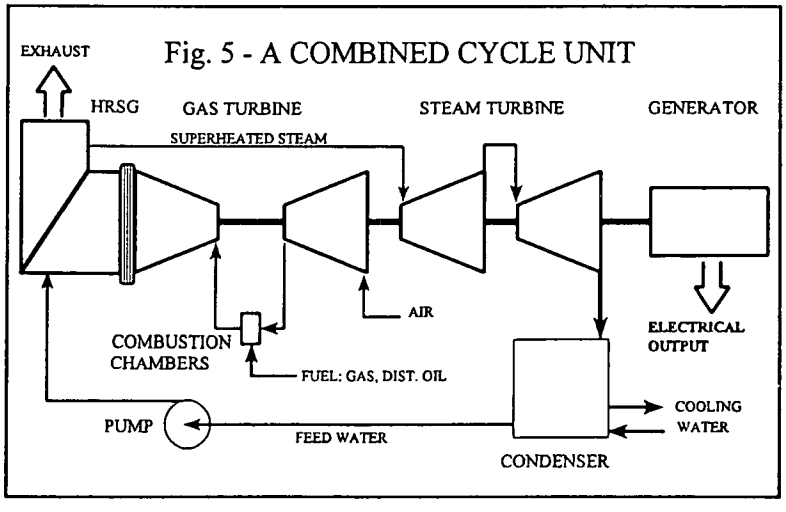

Fig. 5 - A COMBINED CYCLE UNIT

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5. THE PROJECT

The Black Point Power Station (BPPS) will be the first natural gas fired power station in Hong Kong and will be among the world's largest combined cycle plants. The station will be owned by CAPCO. CLP will be the operator of the power station and will act on behalf of the owner as project manager for the construction of the power station.

Following Government approval for phase 1 of the project in December 1992, contracts were signed by CAPCO for the design and supply of all the main and ancillary power generation equipment with an international consortium, and for the supply of natural gas with the gas supply consortium, in the month of December 1992. Application for the grant of land at Black Point began immediately and access to the site was given in March 1993. Various civil construction contracts were placed progressively from July 1993 onwards (See *Fig. 6*).

PREPARATION:	Submission of Generation Plan to Government	Jan 1992
	Gas Supply Heads of Agreement	Mar 1992
APPROVALS:	Site Selection	Nov1991
	Financing Plan	Oct 1992
	Environmental Impact Statement	Dec 1992
	Access to Site	Mar 1993
CONTRACTING:	Placing Civil Design Contract	Sep 1992
	Placing Main Plant Supply Contract	Dec 1992
	Placing Gas Supply Contract	Dec 1992
	Placing of Main Civil Works Contract	Jul 1993
COMMISSIONING:	Units 1&2 firing on distillate oil	Jul 1995
	Units 1&2 firing on natural gas	Jan 1996
	Units 1&2 commercial operation	Feb 1996
	Units 3&4 commercial operation	Jan 1997
	Units 5&6 commercial operation (*)	Jan 1998
	Units 7&8 commercial operation (*)	Jan 1999

Fig. 6 - Project Milestones *Tentative only

6. THE CONTRACTING PLAN

The project strategy adopted for the Black Point Power Station project followed in general the approach which has been successfully implemented by CLP on previous CAPCO power station projects. This strategy was carefully conceived to suit the particular priorities and conditions in CLP and in Hong Kong.

Essentially it allows procurement of imported plants in large packages which can be financed by export credit, placing at the same time a clear responsibility on a main contractor for the comprehensive design and supply of all equipment and information necessary for CLP to construct and operate the power plants. A turnkey approach was not favoured. Instead, CLP takes the lead responsibility on site, where CLP has the experience of managing local labour and local contractors. By CLP retaining the lead role in project management, close control on the project can be maintained at all stages of the project. The overall structure of the project and the contracting plan of the project is given in *Fig. 7*.

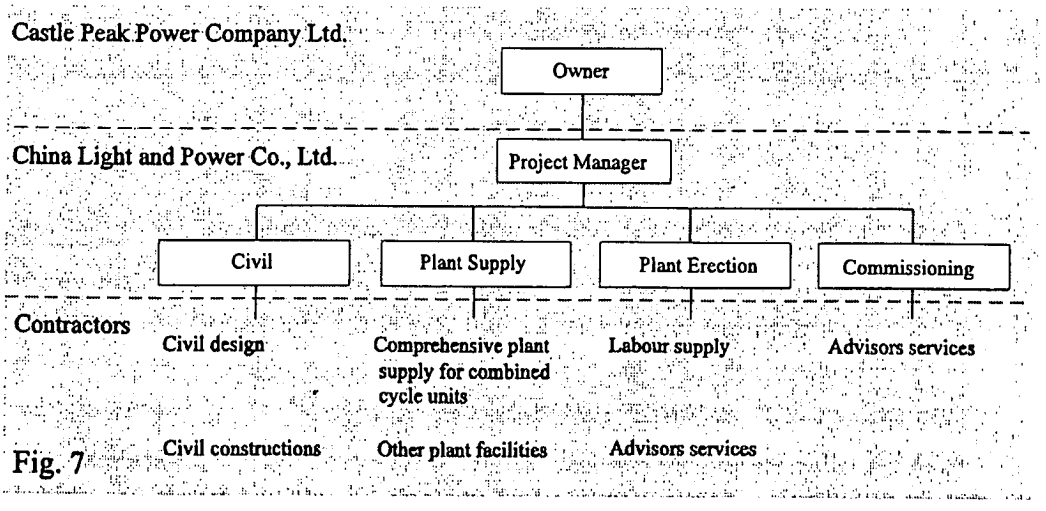

Fig. 7

7. CIVIL DESIGN

In common with civil works in many other countries, the conventional methods of implementation is to contract separately for civil design and civil construction. There are particularly strong reasons for this approach in power station projects because of the need to develop designs progressively and contract for construction in a number of well defined packages. The consultant engaged for civil design provides not only design services but also site supervision staff to supplement the in-house resources in project management during the construction stage.

The services to be provided under the consultancy contract include the preparation of conceptual designs. This is followed by contract designs which were used as the basis for competitive bidding for each of the civil construction contracts. As each construction contract is placed, the consultant produces the final designs in the form of working drawings and specifications which are released progressively to the construction contractors for use.

8. CIVIL CONSTRUCTION

SITE FORMATION - Black Point itself is a large projection with bays to the north and south. It is located between the Castle Peak Power Station 4 km to the south and the associated ash lagoons 2 km to the north. Detailed site investigations were conducted in 1991, involving both land and marine boreholes, geophysical and topographical mapping, hydrographic surveys and meteorological monitoring. Initial stage of site formation suitable for phase 1 of the project (2,500 MW of combined cycle plant) involved the creation of a site totalling 46 hectares in area. The site was formed by a combination of excavation and reclamation (cut and fill). The tight construction programme required that the site formation be completed in stages and released progressively for piling and foundation work. Work started in March 1993, and was substantially completed in February 1994.

PILING - Studies of the site formation and foundation programme concluded that the entire seabed to be reclaimed should be dredged. Whilst this will reduce settlement, it is still necessary to use piled foundations in the main building areas. Most of the piles are driven H-piles but in some areas it was necessary to use reinforced concrete bore piles. The work started in June 1993 and was completed April 1994.

MAIN CIVIL WORKS - This is the main bulk of the civil works for the project covering all foundation, the above ground structures, roads and services, plant enclosures and the buildings for personnel occupation. Construction methods vary from large structure steel frames with cladding to reinforced concrete buildings with the internal rooms and building services.

COOLING WATER SYSTEM - The CW system provides the seawater intakes and pumphouse, the culverts from the pumps to the condensers and from the condensers to the seal pit, and the outfall structures. Most of the works will be reinforced concrete with the exception of the pressure culverts which use coated steel pipes.

CHIMNEYS - The structures comprised of reinforced concrete wind shields with internal flues. The two wind shields are 100 m high and house four flues each. Each flue is designed to take the exhaust from a combined cycle unit.

9. PLANT SUPPLY

The plant supply is the key contract to the project, having the highest value of any single commitment and the dominant technical objectives and programme implications to the project. The contractor's responsibilities are :

(1) Engineering, design, manufacture and supply to Hong Kong of the complete plant in compliance with CAPCO's specifications.
(2) Guarantees of the delivery dates of all plant components and related

documentation, and guarantees against defects after delivery.

(3) Guarantees of the overall performance of the units and the performance of selected major components.

(4) Provision of site advisers for erection and commissioning, and liaison office in Hong Kong.

(5) Procurement of export credit financing to support the contract and commercial financing to support other parts of the project.

The overall technical objective is high availability, reliability, safe operation, technical excellence and operational simplicity. The main technical parameters are as given in *Fig. 8.*

Fig. 8 - TECHNICAL PARAMETERS	VALUES
Unit rating under summer conditions (32C air, 28°C water) with gas firing at new and clean conditions.	312 MW
Heat rate at full load and above conditions, based on LHV of gas.	6,811 kJ/kWh
Unit cold start time	180 mins
Unit warm start time	120 mins
Unit hot start time	80 mins
Unit load follow in range of 40% to 80% full load	8%/min
Nox emission at full load on gas	25 ppmvd
Nox emission at full load on distillate	65 ppmvd

10. GAS SUPPLY

The gas supply will be obtained from the Yacheng 13-1 field which is located 91 km south of Hainan Island in the South China Sea. The field is estimated to contain recoverable reserves of up to 100 billion cubic meters, sufficient to maintain supply to Black Point Power Station for 20 years. The gas developer, a consortium of the CNOOC, ARCO and KUFPEC, is responsible for developing the wellhead installations, the pipeline from the wellhead to the Black Point site and the receiving facilities at Black Point.

The pipeline will be 778 km in length, which is comparable to the longest sub-sea lines worldwide. The diagram (See *Fig. 9*) shows the basic gas supply system.

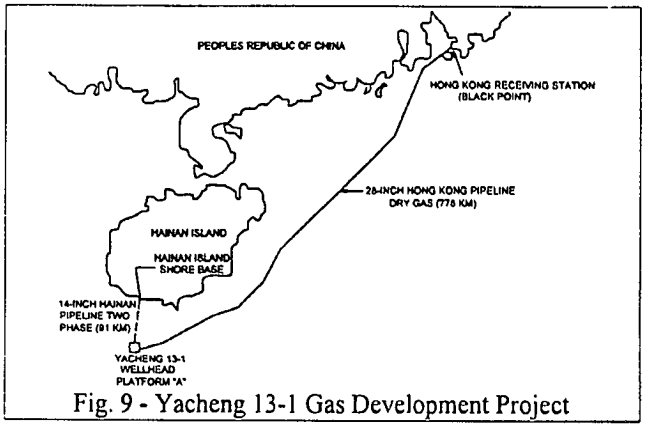

Fig. 9 - Yacheng 13-1 Gas Development Project

The gas is supplied dry from the production platform and is injected into the Hong Kong pipeline at 138 bargs (2,000 psig) for transmission to Black Point. The gas, when landed at Black Point will undergo further conditioning by separation and filtration, heating and pressure reduction before it is passed to CAPCO as sales gas at the boundary of the Black Point Power Station. The pressure of the gas at this point is at about 38 bargs (550 psig). Down stream of the transfer point the gas system is split into two legs, one supplying the combined cycle units at Black Point and one over land to Castle Peak to feed the boilers at units B2 and B3. The use of gas at Castle Peak is expected to be minimal once all units at Black Point are operational. The Castle Peak pipeline will then be used only in emergencies in the event that Black Point cannot take all or a part of the sales gas (See *Fig. 10*).

The pipeline between the wellhead platform and Black Point, and between Black Point and Castle Peak will both be provided with facilities (pig launchers and receivers) to allow the pipes to be cleaned and inspected regularly. In addition, safety devices will be installed to slam-shut the pipes to cut off gas supply in the event of pipe failure or major defects. Other safety monitoring and protection provisions will also be provided based on internationally accepted standards.

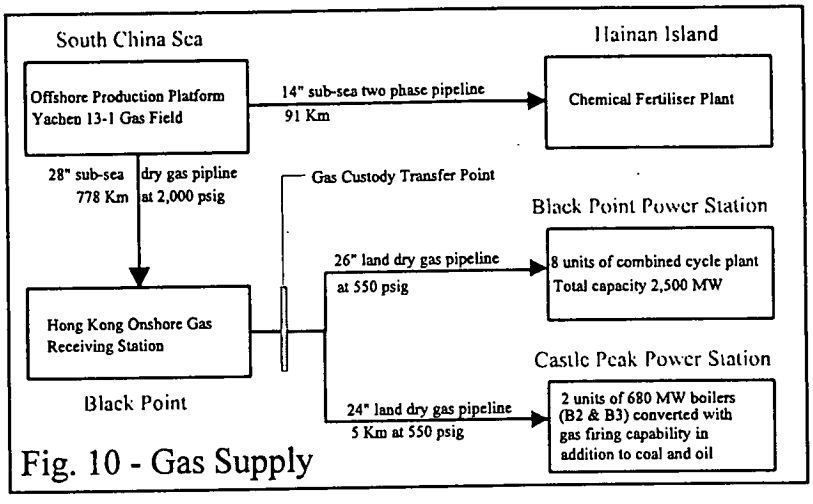

Fig. 10 - Gas Supply

11. ENVIRONMENTAL IMPACT ASSESSMENT

The site selection involved sufficient environmental work to be confident that the impact from a planned installation of 6,000 MW could be controlled within current Hong Kong environmental standards, particularly those relating to air quality. The site search study at the time assumed a predominately coal fired scenario. The findings of the site search report were endorsed by the Lands Department Policy Committee and the reservation of a site at Black Point was subsequently approved in principle by the Executive Council. A comprehensive and detailed environmental impact assessment (EIA) of the LTPS at Black Point was then undertaken by an independent consultant.

The EIA concluded that, subject to recommended mitigation measures being adopted in the design, construction and operation, the phase 1 development, which comprises 2,500 MW gas-fired units with industrial oil as backup fuel, would be environmentally acceptable. The findings were accepted in public consultations with the Tuen Mun District Board and Environmental Protection Committee (now known as the Advisory Council on the Environment).

12. ENVIRONMENTAL MONITORING AND ADUIT

The mitigation measures identified in the EIA were translated to an Environmental Monitoring and Audit (EM&A) Manual which sets down the framework for on site management of environmental protection. This manual was further devolved into a Quick Guide of monitoring and mitigation measures for the site staff as working instructions for the monitoring work. The importance of these environmental protection initiatives was reinforced through a workshop organised for the CLP and contractors' site management and supervisory staff to familiarise them with the objectives (See *Fig. 11*) and organisation of the environmental protection at the Black Point site.

Fig. 11 - Objectives of EM&A:

- To provide a data base against which to determine any short or long term environmental impacts of the site activities
- To provide an early indication that any of the environmental control measures or practices failing to achieve the acceptable standards
- To provide data to enable an environmental audit of the construction and operation of the project

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Key aspects of construction which are monitored for potential impacts include air and water quality, noise and waste disposal. Data are collected by independent laboratories based on the technical schedules of the EM&A Manual, and analysed by on site environmental officers for indications or trends. Reports are compiled for the use of management in monthly meetings conducted with site staff and contractors to review performance and to agree on mitigation measures. A copy of the monthly report is also forwarded to the Environmental Protection Department for their review. So far, the key aspects has stayed within legal target levels.

The EM&A Manual currently in use was prepared to cover the initial construction phase associated mostly with earth movements, dredging of sea bed and general civil works. The work on site has since moved to include an increasing amount of plant erection work. A new EM&A Manual is currently under preparation to reflect this change in work nature on site.

13. SITE SAFETY

Industrial safety has received increasing attention in Hong Kong during the last few years with the introduction of new legislation (the Factories and Industrial Undertakings Ordinance). The aim has been to increase the responsibility of proprietors of sites for their safety standards. Whatever methods were to be used for contracting and site management, CAPCO and CLP would inevitably be seen as the responsible party overall for power station projects and must therefore respond to the new emphasis.

Safety standards on Hong Kong construction sites (as opposed to operational plants and factories) are indeed a source of concern as may be illustrated by some simple statistics. The generally accepted measure of site safety is the so called Disabling Injury Incident Rate (DIIR). A top quality site in a developed country in Europe or USA would expect a level in single figures and the best site would achieve a level below 5.0. The 1993 average for all construction sites in Hong Kong is around 21. The level achieved by CLP on the Black Point Power Station sites has been consistently been better than this average (See *Fig. 12).* Black Point Project has in 1993, worked about 1.37 million man hours. The DIIR (cumulative) for the period stood at 1.01. There had not been a single fatal accident.

To raise the safety awareness and standard of the workers, a number of major initiatives has been introduced to the Black Point site. These are :

(a) *Five Star Health and Safety System* - an internationally recognised safety auditing procedure. A long checklist of points is used to score each site and ultimately a rating in stars is determined. The audit is carried out once a year. Contractors' and CLP's own safety organisations are encouraged to jointly participate in the audits and take ownership of the results. The last two audits have returned three stars, with improvements noted for the latter, despite the fact that the site work has actually become more complicated.

(b) *On Site Safety Training Programme* - each person entering the site must go through a one hour induction course covering:

Fig. 12 - 1993 Construction Industry Accident Statistics

LOCATION	ACCIDENTS PER 1,000 WORKERS	FATALITIES	DIIR
Hong Kong average	400	46	21.4
Canada (Power Utilities)	22	0	-
Black Point	12	0	1.01*

DIIR=No. of Accidents x 200,000 / No. of manhours worked in the period
(*) - Total manhour worked for the period = 1,373,564

Company safety policy, responsibilities under the Legislation, basic safety precautions, emergency procedures, causes of accidents, site conditions, site access procedures, welfare facilities, and security measures. Indoctrination of the safety culture at site applies to all levels of
staff, and extends to both CLP as well as all contractors' personnel, to ensure that all persons entering site have attained a minimum standard of training on safety and are familiar with site safety and emergency procedures. A refresher course is mandatory every three months. Access passes are issued/renewed to individuals only on completion of these courses.

(c) *Monitoring and Inspection* - A team of CLP safety officers monitors and inspects construction activities to ensure compliance with legislation, policy and procedures. Warning notices are issued for breaches of standards to both the staff and his supervisors to advise them of dangerous situations or practices. Repeated offences may lead to expulsion from site.

(d) *Contractual Leverage* - first issue in the pre-qualification of potential contractors is on the assessment of the contractor's safety policy, practices and records. They have to demonstrate in the pre-qualificaton process their understanding, ability and willingness to work to substantially higher standards than the Hong Kong norm. The linking of safety performance to payment terms is another contractual leverage used at Black Point site.

(e) *Safety Committee* - Health and safety committees, supported by a framework of safety representatives, provide an effective forum for health and safety concerns and messages from management to the workforce and vice versa.

14. CONCLUSION

Featuring the most advanced combined cycle technology, the most environmentally friendly fossil fuel available, combined with a professional work force committed to not only in completing the project on time, within cost and meeting technical requirements, but also maintaining high environmental and safety standards during construction and operation, the Black Point Combined Cycle Power Station is expected to be a showcase not only for CAPCO, but also for its partners and all contractors associated with the project.

In addition to its expected technical excellence, the Black Point project straddling over 1997 will also stand as a symbol of continuity in Hong Kong, supplying and meeting the electricity demands of CLP's customers into the next century. "Believing and Investing in Tomorrow" is the Company's motto.

The proejct has so far been achieving good progress. Both the safety and environmental performance has been satisfactory. With the dedicated workforce, committed management and cooperative contractors, CAPCO and CLP are confident that the project will be completed on time, within budget, whilst maintaining technical excellence and environmental safety performance.

Paper No. 9

THE THREE GORGES PROJECT

Speaker : Wang Jiazhu
Vice Commissioner & Chief Engineer
Changjiang Water Resources Commission, PRC

THE THREE GORGES PROJECT

Wang Jiazhu
Vice Commissioner & Chief Engineer
Changjiang Water Resources Commission, PRC

ABSTRACT

The Three Gorges Project (TGP) is a vitally important and backbone project in the development and harnessing of the Yangtze River. The dam site is situated in Sandouping of Yichang City, Hubei Province with a distance of 40 km upstream from the already completed Gezhouba Project.

The TGP is not only the largest of the type ever built in China, but also in the world. With normal pool level (NPL) at 175m, the total storage capacity of the reservoir is 39.3 billion m^3 (See the principal indices in Table 1 attached).

1. THE MAIN TASKS AND PRINCIPAL BENEFITS OF THE PROJECT

The TGP is a multipurpose hydro-development project producing comprehensive benefits mainly in flood control, power generation and navigation improvement etc.

1.1 FLOOD CONTROL

The TGP is a vitally important project functioning as a backbone in flood control system to protect the middle and lower reaches of the Yangtze River. Its favorite geographical location will make it possible to effectively control the flood from upstream of the Yangtze.

With a 22.15 billion m^3 of flood control storage capacity of the reservoir, the Jinjiang River section, the most critical section in flood control, will be able to improve the flood control capability from the present 10-year return period flood to a 100-year return period. Even should a 1,000-year return period or over flood occur, the vast plains on both sides of this river section, with the existence of the TGP, and with the assistance of an appropriate operation of the flood diversing and retention works, would be kept from destruction caused by the breaching of main dikes. The flood damages and loses in the mid and lower reaches of the river and threat of flooding to Wuhan Municipality would be reduced. And so will it create favorite conditions for a thorough harnessing and improvement of Dongtinhu Lake area.

1.2 POWER GENERATION

Being provided with a total installation of generating capacity of 18,200 MW, and with an average annual output of 84.68 TW•h, the TGP will supply a large proportion of its electricity mainly to the East China, Central China and a small proportion to east of Sichuan Province. This means a replace of 40 to 50 million tons of raw coal to be burnt each year. And this reliable, cheap and regenerateable energy will play a very important part in the development of economy and prevention of environmental pollution in these two parts of China.

1.3 NAVIGATION IMPROVEMENT

The 660 km long water way in the section from Yichang City to Chongqing City will obviously be improved after the completion of the TGP Reservoir making it possible for 10,000 tons of barge fleet to pass through directly to the city harbour of Chongqing. Thus, an increase of annual one way navigable capacity to 50 million tons from the present 10 million tons, with a decrease of 35% to 37% of navigation cost. Causing by the regulation of the reservoir, the minimum flow downstream of Yichang in

dry season will be increased from 3,000 m^3/s to over 5,000 m^3/s. That obviously benefits the navigation on the middle reach of the Yangtze River.

1.4 MISCELLANEOUS

The project will, for certain, promote the development of fishery in the reservoir, as well as tourism and recreational activities. It will evidently improve the water quality of mid and lower reaches of the river during dry seasons; and bring favorite conditions into being for the scheme of Southnorth transbasin water transfer.

2. THE PROJECT LAYOUT AND MAIN HYDRAULIC STRUCTURES

2.1 DAMSITE

After repeated study and analysis on 15 alternatives, the damsite of the TGP is finally selected in Sandouping with the crystalline rock as its foundation. The total catchment area hereof is about one million km^2 with 451 billion km^3 of average annual runoff and 530 million tons of annual sediment discharge.

Here at the location of Sandouping damsite, the river valley is relatively open and broad, the mounts on both sides of the river are fairly flat with a small island called Zhongbaodao in the river, which is favorite for water diversion scheme with phased construction. The outside traffic hereby will be a railway to Yichang, with a distance of 40 km to damsite, and a high standard highway from Yichang to damsite will be constructed. At the moment, there already exists the direct accesses by a low standard highway and waterway.

The bedrock of the damsite is hard and integral granite with 100 MPa of compressive strength. The faults and fissures in the bedrock are of no development, in fact, most of them are very well cemented. And the permeability of the rock mass is slight in nature. The weathered layer in the hills on both sides is a bit thick ranging from 20 to 40 m, while having little layer existed in major river bed.

In the vicinity of about 15 km around the damsite, there is no major disadvantageous geologic structures. The regional seismic activity is both small in intensity and low in frequency. Therefore, the whole area belongs to a slight seismic area ranking as VI degree of seismic intensity classified by the state authority department regarding this field.

2.2 THE LAYOUT OF THE PROJECT

The project is composed of a dam, two powerplants and navigation facilities. For a long time, efforts were engaged in the in-depth study and research on various schemes to determine the structural pattern, configuration and layout. And it was not until undergoing analysis by scientific researches and tests regarding hydraulics, sedimentation and structure etc., could these issues be finally determined. The overall layout of the project is as follows :

The spillway is placed in the centre of the river bed, i.e. on the main river course, while the intake dam sections and non-overflow dam sections are arranged on both sides. The powerhouses are placed on the back of the intake dams on both sides of the spillway section. The permanent navigation structures are located in left hill side. In addition, enough room is preserved for future expansion of underground powerhouse on the right bank side.

2.3 THE DAM

The water detaining dam is a concrete gravity type. The total length of the dam axis is 2,335 m, with crest elevation at 185 m and a maximum height 175 m.

The total length of the spillway section is 483 m. In this section, there are 23 bottom sluice gates and 22 surface gates. The dimension of the bottom outlets is 7x9 m, with an elevation of inlet at 90 m. The net width of the surface sluice gates is 8 m,

with sill elevation at 158 m. While in the downstream part of this section, trajectory bucket type energy dissipater is used.

On both sides of this section, there will be arrangement for intakes - dam and non-overflow dam.

The maximum discharge capacity of the project can reach 113,000 m^3/s, capable to discharge the possible maximum flood.

2.4 POWERSTATIONS

According to the scheme, the powerhouses will be placed at the toe of the dam, and divided into two, each on either sides. The total length of the powerhouse on the left is about 643.6 m, with 14 sets of turbine generating units being installed; whereas on the right, 584.2 m in total length, 12 turbine generating units installed. Thus, 26 sets of turbine generating units in total, each of 700 MW totalling 18,200 MW in installed capacity that will produce 84.68 TW•h of electricity output annually. 500 kV AC transmission line together with ±500 kV DC transmission lines will send electricity to Central China, East China and the east of Sichuan Province. In total, there are 13 transmission lines of 500 kV AC, and 1 ±500 kV DC transmission line.

2.5 NAVIGATION FACILITIES

The permanent navigation structures consist of a permanent shiplock and a shiplift.

The shiplock is schemed out as a double-way and 5 step flight locks, each lock chamber is dimensioned at 280x34x5 m (i.e. length x width x sill depth) capable of passing 10,000 tons of barge fleet.

The shiplift is designed as one stage vertical hoisting type. The ship container of the shiplift has a dimension of 120x18x3.5 m, being able to carry one 3,000 tons passenger ship or freighter each time.

In addition to the above navigation facilities, another temporary shiplock is schemed during the construction period with effective chamber size of 240x24x4 m.

3. CONSTRUCTION PLANNING AND SCHEDULING

3.1 CONSTRUCTION WORK QUANTITY

The main work quantity to be done in construction of the principal structures and diversion works is roughly as follows :

- rock-and-earth excavation	102.59 million m^3
- rock-and-earth backfill	29.33 million m^3
- concrete placing	27.15 million m^3
- metal work	280.8 x 10^3 tons
- installation of turbo generators	26 sets (totalling 18,200MW)

quantities breackdon into detail according to structure list in the following table

Clarifi—cation of structures	excavation (million m^3)	embankment (million m^3)	concrete (million m^3)	steel bar (ton)	metal work (ton)	install of units (MW)
Dam	5.77	—	14.86	107,500	29,900	
Powerhouses	17.15	2.09	2.93	98,300	128,600	18,200 (26 sets)
Navigation facilities	58.12	5.51	5.67	144,800	103,500	
Diversion works	21.55	21.72	3.71	3,700	18,800	
Total	102.59	29.33	27.15	354,300	280,800	18,200

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3.2 RIVER DIVERSION

During construction, phased river diversion are chosen, and the construction works are divided into three stages.

In the 1st diversion stage, the subriver on the right side of the island will be closed, by making advantages of the island to build rock and earth cofferdam. Inside the 1st phase foundation pit the open diversion channel is to be constructed and the longitudinal RCC cofferdam will be completed. Meanwhile, the temporary shiplock construction is finished on the left bank of the river. In this construction period, the river flow and navigation still goes through the main river course.

In the 2nd diversion stage, the construction is focused on building the 2nd phased transverse cofferdams in both upstream and downstream, so as to form, together with the completed RCC longitudinal cofferdam, into a 2nd phase foundation pit, within which, the spillway, intake dam and the powerplant on left bank will be undergoing construction. Simultaneously, the permanent shiplock will be constructed through the mount on the left bank. During this period, the river flow shall be diversed through the open diversion channel, and barge fleet and passenger boats might pass through either via the open channel, or the temporary shiplock.

In the 3rd diversion stage, the upstream 3rd phase RCC cofferdam is to be built to cut off the open channel, and to impound the reservoir till 135 m in elevation. It is at this point, commissioning for the left bank powerstation and permanent shiplock will be commenced.

During the period the 3rd phase cofferdam together with the longitudinal cofferdam are to form a 3rd phase foundation pit in order to build the main right bank dam and powerplant, the river flow will be diversed through the bottom outlets and temporary diversion outlets in the spillway.

3.3 SCHEDULING

The period of construction is divided as follows :

- the preparation period and 1st phase construction	5 years
- the 2nd phase construction	6 years
- the 3rd phase construction	6 years

Therefore, the total duration of construction shall last 17 years taking into account the time for preparation. However, at the 11th year according to the construction schedule, the first two turbine generating units will be put into operation (commissioning) starting their yielding of electricity. (See master construction schedule in Table 2 attached).

The construction peak intensity is as the following :

- 23 million m^3 of excavation appears in the 3rd year;
- 8.0 million m^3 of backfill appears in the 5th year;
- 4.1 million m^3 of concrete placing appears in the 8th year;
- 46,000 tons of metal work installation in the 10th year;
- 4 sets of unit installation with total 2,800 MW in the 12-17th year.

4. RESEARCH OF SEDIMENT PROBLEMS

The sediment issue of the TGP is one of the major technical problems needed to be tackled. Since 1950's, many organisations and experts have conducted extensive studies over this issue. The solid foundation for TGP has been laid by successful experiences of the sediment treatment for Gezhouba project in 1970's to 1980's.

The research works of the sediment issue of TGP were organised by whole nation's famous sediment institutes and experts, including in-situ investigations, mathematic

model computation, proto-type observations over some constructed reservoirs, and a large amount of physical modelling tests.

Based on the long-term detailed research works, it is concluded that the sediment problem is resolvable.

4.1 SEDIMENT LOAD

According to the observations of the Yichang Hydrologic Station over 40 years, the sediment discharge of suspended load on average is about 526 million tons a year, with median diameter of 0.033 mm. The bed load of which constituted only a small part of the total sediment load. The annual bed load is about 8.6 million tons, including 0.76 million tons of cobbles.

The total discharge of sediment at the TGP damsite is large, the water discharge, however, is even more larger so the sediment charge is only about 1.2 kg/m^3, which is far lower than that of the Sanmenxia damsite in Yellow River at 37 kg/m^3.

The water runoff of the Yangtze River is about 10 times of that of the Yellow River, but the sediment load of the Yangtze is only one third of it. Therefore, the sediment problem of the Yangtze River is different in nature with that of the Yellow River.

In recent years, some people considered that the sediment yield in the Yangtze River tends to increase, however, it is not entirely true. According to the long term observation and checking results, the sediment discharge in the Yangtze River changes periodically and there is no obvious residual effect of increase nor decrease.

4.2 PERMANENT USE OF THE RESERVOIR

The Yangtze River has abundant runoff, and the Three Gorges Dam is to be equipped with 23 large low level outlets (bottom el. 90m), so it possesses great capability of discharge at low pool level. These two characteristics allow the application of a strategy of reservoir operation summed up in China as "discharging the turbid and impounding the clear". During the flood season from June to September, when the river carried 84% of the annual sediment load and 61% of the annual runoff, the reservoir will draw down to FCL (145 m) that creates a condition in favour of sediment sluicing, allowing a large discharge of sediment out of the reservoir. At the end of flood season when there is less sediment content in water, the reservoir will be impounded to NPL (175 m) for enhancement of power generation and navigation. In this operation manner, most of the sediment will be moved out, the large part of deposit of sediment is remained in dead storage of the reservoir, and most part of effective storage can be preserved permanently.

The length of the TGP reservoir is over 600 km and average width is only about 1,100 m. It looks like a ribbon in plain. So it is still a river, and not a lake like reservoir. The whole reservoir is quite uniform in width and for the most part less than 1,000 m wide, only one seventh of the reservoir is about 1,000 to 1,700 m wide. The morphology of the reservoir is favourable to the removal of sediment. Since the estimated width of the equilibrium channel corresponding to the hydrological conditions of the TGP reservoir is 1,300 m, little flood plain is expected to form along the main channel in the TGP reservoir. Thus, large percentages of effective storage can be preserved permanently.

The deposition in TGP reservoir has been investigated numerically by a one-dimensional mathematical model. The result is quite good. According to calculated results, after a century of operation when the reservoir sedimentation already come to balanced state, the reservoir's effective storage capacity would remain at 86-92%.

It is believed that the conclusion is reliable, not only because the mathematical model is developed on a large number of researches and observations and checked by many

experts at home and abroad, but also it is based on several successful engineering practices.

4.3 SEDIMENTATION IN NEIGHBOURHOOD OF THE DAM AND BACKWATER FLUCTUATING REGION

Owing to the complexity concerning hydraulics and sediment deposition problems in neighbourhood of dam and in backwater fluctuating region which made the computation of math model almost impossible, so 11 physical sediment models (2 for neighbourhood of dam and 9 for different sections of the backwater fluctuating region) have been established to conduct detailed studies.

The testing of physical sediment model in China had made a great progress during the construction of the Gezhouba project and achieved world advanced level in this field. Now the Gezhouba reservoir had impounded for more than 10 years, contrast have been made on real observation vs. model testing results, generally, they are quite in consistence but the results of model have some security. The physical sediment model testing of the TGP has adopted basically the same method of the Gezhouba project with a model scale generally of 1 by 100 to 1 by 300.

The results of the model tests for the TGP demonstrate that within 30 years' reservoir operation, the cumulative sediment deposition will have no serious impact on the project's normal operation both in dam area and in backwater fluctuating region. But several decades later, sediment deposition might affect the navigation and harbour operation during extremely dry years when the reservoir's water level drops down to its lowest level. Even there are such problems, they can be solved by optimized reservoir operation, proper training and regulation works and harbour transformation. In the neighbourhood of dam area, the negative effects of sediment deposition can be solved by engineering measures.

4.4 THE EFFECT ON FLOOD WATER LEVEL AT CHONGQING

After several decades of operation, the flood water level at Chongqing City might be increased, caused by the sediment deposition. Through computation analysis and model testing, it is estimated after 100-year operation, that the flood water level at Chongqing City will increase from the present 194.3 m to 199 m by 100-year flood frequency. But because Chongqing is a mountainous city, most of the urban areas are over 200 m elevation, with the center part around 250 m, therefore, the increased flood water level will not affect it very much.

In addition, the above estimation does not take into account the positive impact by building reservoirs upstream of Chongqing. As a matter of fact, according to the overall planning of the Yangtze valley, a large number of large-sized reservoirs will be built on upstream of the Yangtze and its tributaries, such as Xiluodu project, Xiangjiaba project on main stem and Hechuan project, Tingzikou project on tributary of Jialing River and Goupitan project, Pengshui project on Wujiang River, etc. All these under planning projects shall be constructed in the near future, say 10-30 years, and will play a very evident role to reduce the sediment deposition in the reservoir, especially in the river section near Chongqing. This will surely lower the flood water level at Chongqing City. At the same time, these projects will also simplify the tackling measures of the sediment deposition in backwater fluctuating region.

5. ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

The impacts of Three Gorges Project (TGP) on environment and ecological system attract worldwide attention.

The EIA of TGP began in 1950s. It has been almost 40 years since then. Since 1980s, the EIA of TGP has been deepened along with the improvement of legislative

system of environmental protection and development of environmental science. In December 1991, the "Environmental Impact Statement of TGP" prepared by cooperation of the Environmental Assessment Department of Science Academy of China and the Research Institute of Water Resources Protection for the Yangtze. At the beginning of 1992, the National Environmental Protection Agency (NEPA) of China approves the EIA according to the legislation.

5.1 CHARACTERISTICS OF THE RESERVOIR AND THE CHANGES IN HYDROLOGICAL REGIME

5.1.1 The total capacity of the TGP Reservoir amounts to 39.3 billion m^3, accounting for 8.7% of the yearly runoff at the damsite. and effective capacity of 16.5 billion m^3, accounting for 3.6%, which indicates that the Reservoir is of seasonal regulation one with low regulation capability.

5.1.2 The Reservoir is of river-like reservoir in gorge area. The total length of the reservoir will be about 600 km with average width of 1.1 km which will be less than twice of the width of natural river channel. The surface area of the Reservoir will reach 1,084 km^2. the inundation terrestrial area will be 632 km^2.

5.1.3 The annual runoff downstream of the dam will not change after operation of the Reservoir. The project will not affect the annual inflow gone into the sea. The monthly flow downstream of the dam will be basically kept unchanged except in October when the flow will slightly decrease because of impoundment and in the period from January to May when the flow will slightly increase. The monthly flow after the operation of the Reservoir will still be within the natural amplitude (See Fig. 5-1) so that the influence on hydrolocial regime downstream of the dam will not be significant.

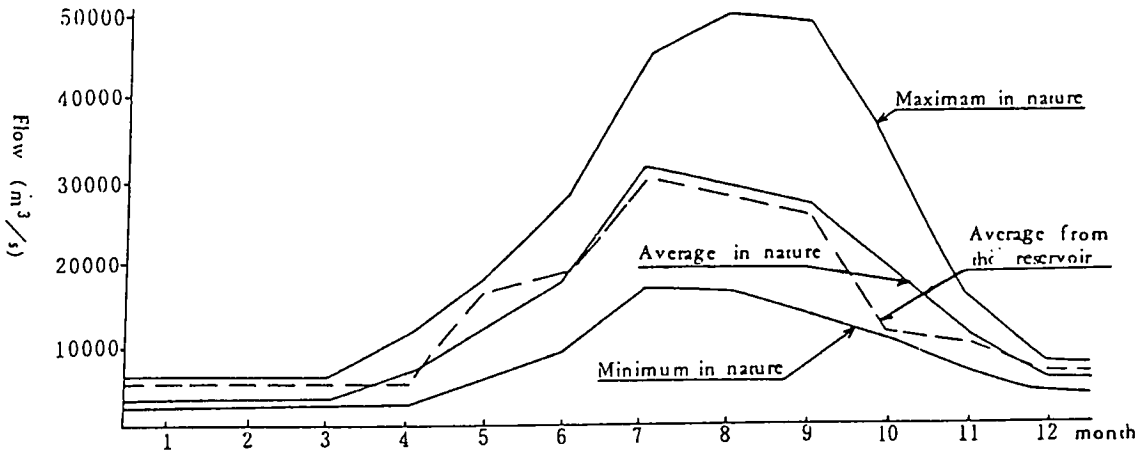

Figure 5 — 1 Average monthly flow in yichang

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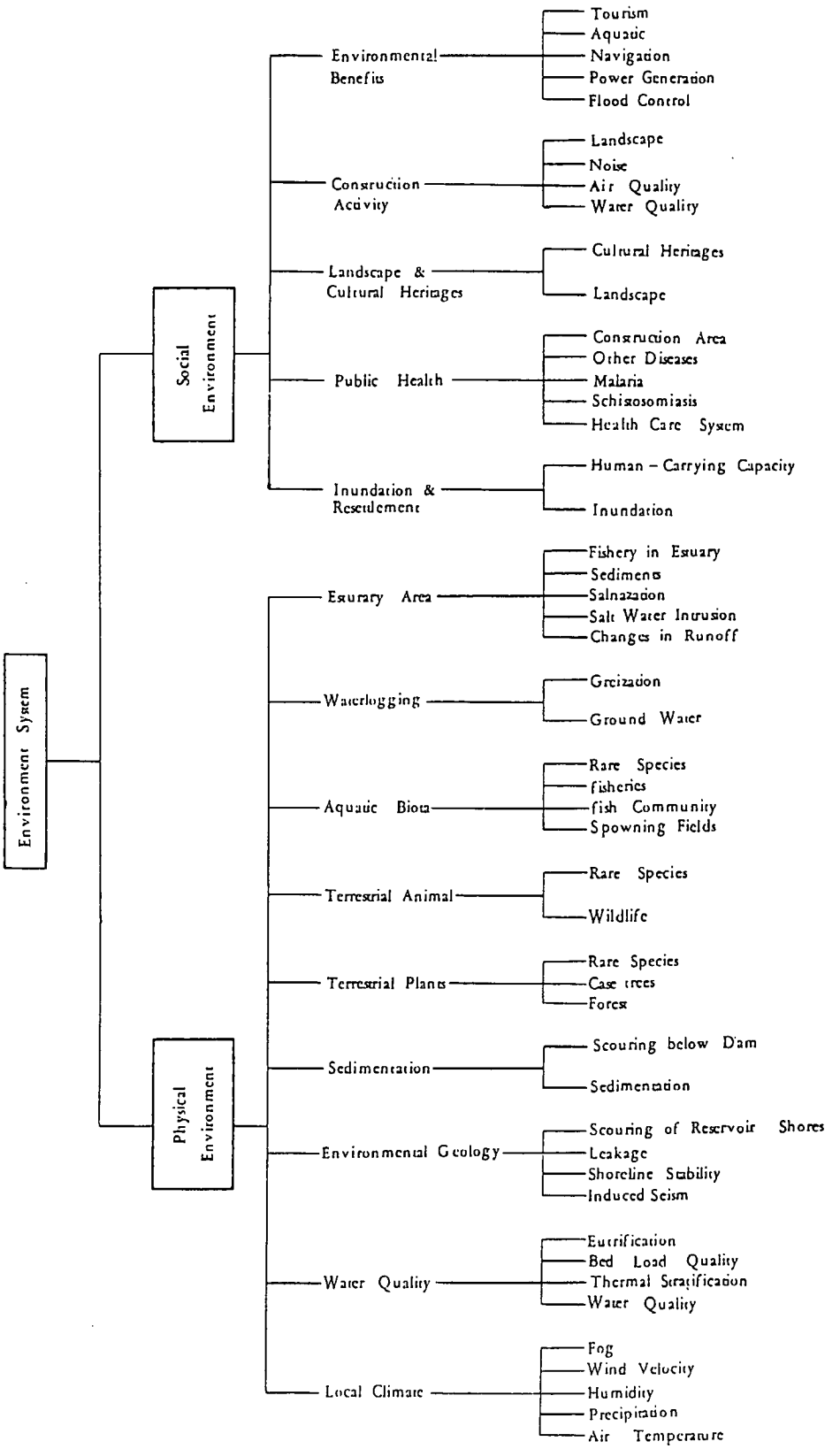

Figure •5 — 2 Environmental Impact Asseement System

5.2 ASSESSMENT SYSTEM AND MAIN CONCLUSION

The EIA takes the Yangtze Basin as an integral system and divides it into sub-system as reservoir area, middle and lower reaches region, and river mouth region. The impacts on the physical and social environmental parameters (Refer to Fig. 5-2), such as local climate, water quality, biota, inundation and resettlement, landscape and cultural heritage, have been comprehensively analysed, qualitatively and quantitatively, by using math modelling, characteristic values, analogue, etc., according to the legislation of the country and international experiences. Furthermore, the mitigation measures have also been recommended in order to alleviate the negative impacts. Finally, the suggestion of ecological and environmental monitoring system has been raised.

The main conclusion of the EIA indicates that the Project will exert both positive and negative impacts on environment and ecological system. The positive impacts will be mainly in middle and lower reaches of the Yangtze, and negative impacts will concentrate in the Reservoir area. Most of the negative impacts can be greatly reduced by taking suitable counter measures. The environment issues will not affect the feasibility of the Project.

5.3 MAJOR ENVIRONMENTAL BENEFITS

5.3.1 The Project is primarily aimed at flood control. After completion, the flood control standards in Jingjiang reaches of the Yangtze will be raised from less than 10-year frequency to 100-year frequency. In case flood like that happened in the year of 1870, large amount of losses of living stocks can be avoided. TGP will improve an environment for living and further development in this densely populated and economically developed area of many cities and towns with a 14 million population and about 1.53 million ha fertilized farmland. Meanwhile, there will be several other benefits from the regulation of the Reservoir such as the prevention and cure of schitosomiasis, extension of lifespan of Dongtinhu Lake due to less deposition of sediments.

5.3.2 The TGP will provide huge quantity of clean energy. The hydro plant would reduce about 50 million tonnes of raw coal to be burnt annually which would produce about 100 million tonnes of carbon dioxide, 1.2~2.0 million tonnes of sulphur dioxide, 10,000 tonnes of carbon monoxide, 370,000 tonnes of nitrogen oxides, and large amount of waste water and residues as well. This contribution to the improvement of environment is worth to be mentioned.

5.3.3 The Project would favour the improvement of local climate, enhancement of water quality below the dam during the dry season. Moreover, the operation of the Project would ease the salt water intrusion in river mouth region. The increase of water surface area will promote the aquatic culture in the forth coming reservoir.

5.4 MAIN NEGATIVE IMPACTS AND THEIR MITIGATION MEASURES

5.4.1 LANDSCAPE AND CULTURAL HERITAGE

After impoundment, higher water level and wider channel width would modify the scenary of the canyon to a certain extent. The elevations of mountains and peaks along the banks in gorges reaches range from 800 to 1,100 m. The elevations of famous 12 peaks in Wuxia Gorge are around 1,000 m. The best reputed Goddess peakkis more than 900 m above sea level. The normal water level of the Reservoir would be 175 m, 40 to 110 m higher than present. The steep canyon enclosing the river valley would be basically untouched. Better navigation condition will provide access to new scenic views, e.g. "Little Three Gorges" in Daning River.

Impoundment of the Reservoir will affect 44 archaeological sites and ancient monuments. Of them, Baihetiang, the famous ancient low-water record tablets

near Fuling City, is protected by the nation, other 5 by provinces. The most famous ones, however, will not be inundated such as Ghost City in Fengdu county, Baidicheng in Fengjie county and Huangling Temple in Yichang city.

According to the planning, a major effort would be made to salvage the cultural heritage that may be inundated. For example, the Baiheliang low-water tablets and Zhangfei Temple will be relocated and exhibited in suitable place. Because only the foundation would be affected, Shibaozhai in Zhongxian county and Quyuan Temple in Zigui county will be protected by foundation consolidation and strengthening.

5.4.2 RARE SPECIES

There are 47 rare or endangered plant species protected by the Nation in the surrounding area affected by the Reservoir, most of them are growing between 300 to 1,200 above sea level. There is almost no natural vegetation in the inundated area. The impoundment will not cause serious losses.

Total 26 rare animals in category I and II protected by the Nation are living in mountain area will not be affected by the Project.

The rare animals in the Yangtze such as Chinese dolphine and Chinese sturgeon have been protected by nature reserves and artificial spawning. The construction and operation of TGP will affect their habitats in certain degree so it is necessary to strengthen the counter measures continuously.

Systematic survey and research indicate that the habitats of Yangtze alligator and Siberian crane will not be affected.

5.4.3 WATER QUALITY IN RESERVOIR REACHES

The total waste water discharged into the Reservoir reaches amounts more than 1 billion tonnes annually. The water quality of the Yangtze, however, remains good in general due to huge quantity of runoff, except for pollution belts along the banks near cities. The slower flow velocity and higher water level caused by the TGP will aggravate shoreline pollution. This impact needs to be mitigated by better waste water treatment measures.

5.4.4 INUNDATION AND RESETTLEMENT

The large amount of farmland inundated and large number of population relocated are of critical importance for construction of TGP. This is also the key environmental issue associated with the project, and must be treated very cautiously.

According to the 1992's survey, the TGP reservoir will inundate 25.9 thousand ha of farmland and orchard and 846 thousand of residents living in the inundated area. Taking into consideration of population growth and subsequent relocation during the construction period, the total population resettled would be over 1 million. Improper arrangement of such a large number of resettlement would cause serious problems of environmental and ecological system. In order to avoid or mitigate the negative impacts as far as possible, a preferential policy and practical resettlement plan have been carefully formulated after long term research.

Government of China defines that the development - oriented resettlement policy should be adopted for TGP. The new policy indicates that the resettlement programme should not be merely a compensation operation but should be actively in charge of relocatees' living and production ability and promote economic development of the reservoir region to benefit both relocatees and hosts. The programme should not only maintain relocatees' living standard and also give the opportunity for them to achieve a higher standard in future. It also assures the protection of the host communities from adverse impacts.

The favourable conditions for resettlement include that the relocatees are living along the reservoir shores of 2,000 km long and

that 58% of them live in township. The 357 thousand of rural population is most difficultly to be resettled because they will lose their means of living due to inundation of farmland, which needs to be carefully arranged.

The remote sensing interpretation and field verification indicate that although the spare land resource is limited, but about 45,000 ha of unused land existed in resettlement area can be developed. The resettlement programme arranges about 60% of rural population to continue agricultural production and a need to create new job opportunity in 2nd and 3rd estates for the remaining 40%. Considering the characteristics of spare land resource, it is suggested that citrus, tea trees and other cash plants are suitable to grow. So there are about 120 to 150 thousand tons grains shortage for this area each year which should be alloted from other regions by the Government.

Abundant minerals, hydraulic resources, forests, agricultural products and tourist resources in the region offer the favourable conditions for development of 2nd and 3rd estates. The lack of capital and technology and low educational level (25% of illiterate and semi-literate) determine that the Government has to support them. During the construction period, the Government will thus invest in the region quite heavily and will give them preferential policy. Besides, after completion of TGP, a portion of profit from power generation will be allocated as development funds for the region to promote local economy.

In order to protect the environment, the 2nd and 3rd estates thus established should be carefully selected. Only those producing no/few pollution ones would be allowed to be developed in the region.

Till now, the resettlement programmes at county and township level in feasibility stage have been prepared under the guidance of overall planning of local socio-economic development. Based on the experience of pilot projects begun from 1984, the implementation programmes for each county and township, in which environmental protection is an important context, are now under preparation. Because of the importance of the project and the difficulty of the resettlement, the State Council has made a decision that all counties should support the construction of the reservoir area. Now a large amount of advanced provinces and cities have already made agreement with counties in reservoir area.

6. INVESTMENT AND ANALYSIS ON ECONOMY AND FINANCE

6.1 STATIC PRICE ESTIMATE

Based on the price at the end of May 1993, the static price estimate of TGP is 95.46 billion yuan (excluding the escalation and interests during the construction period), among which 50.09 billion for project itself, 30.07 billion for inundation treatment and resettlement, 15.3 billion for power transmission.

The construction period of the whole project is 20 years, but from the 11th year, the project could benefit itself from power generation. That could be the main channel of the project investment in later construction period. So the key investment problem is the fund source for the 11 years before power generation, that is, 54.4 billion yuan based on the price at the end of May, 1993.

6.2 FUND SOURCE

The project needs extremely big sum of funds, but with its huge quantity of generation, the project is in a strong position to repay. The construction funds will come from several channels.

6.2.1 FUND SELF-FINANCED

This fund includes the income of the power generation of Gezhouba power plant and TGP power plant during construction.

6.2.1.1 It has already been approved that the Gezhouba Power Plant is owned by Three Gorges Development Corporation (Owner of TGP). The Gezhouba Power Plant has an annual generating output of 15.7 billion kW•h. At present the electricity rate is quite low, only 3.9 cent/kW•h. It has been decided that the price should be increased by 1 cent/kW•h per year from the year of 1993, to 8 cent/kW•h by the year of 1996. So the Gezhouba Power Plant can raise about 14 billion yuan for TGP in 20 years, and about 7 billion in the first 11 years.

6.2.1.2 TGP itself can produce 507.95 billion kW•h of electricity from the 11th to 20th year, and can raise about 150 billion yuan. This electricity income not only can satisfy the later construction, but also can be used to repay the loan.

6.2.2 The State Council has decided that a tariff of 0.3 cent/kW•h must be taxed all over the country as the construction fund for TGP (excluding the electricity usage for agricultural irrigation and drainage in poverty areas).

This fund is the investment for TGP by the State, and is free of tax and other fees.

The electricity generation in China reached 600 billion kW•h in 1990, and will increase year by year. According to estimation, the State can raise about 25 billion yuan for TGP construction fund in 11 years before commissioning of TGP, 60 billions yuan in the 20 years of construction period.

6.2.3 LOANS FROM BOTH DOMESTIC AND ABROAD

The above mentioned are the main funds of the TGP construction. The shortage part can be obtained by loans from domestic and abroad, and from issuing bonds and shares.

6.3 ECONOMIC AND FINANCIAL ANALYSIS

During the feasibility and initial design stage, the economic and financial justification for TGP has been studied comprehensively.

Calculated with the international and domestic general economic evaluation method, adopting the shadow price and 12% social discount rate, the TGP's economic internal rate of return is 15.6~14.8%, which are more than the legal social discount rate in China.

According to the domestic financial regulation at present and calculated with the financial price at present, the TGP's financial internal rates of return are all more than 10% in different fund-raising sources. All the loans can be repaid before the completion of the project (the 20th year) and all the investment can be recovered at least within 1-2 years after the project's completion.

Table 1. List of Principal Indices of the Project

Item Description	Unit	Index
1. Reservoir		
NPL	m	175 (156 m in the initial stage)
FCL	m	145 (135 m in the initial stage)
DCL	m	155 (140 m in the initial stage)
Overall storage capacity	10^9m^3	39.3
Flood control capacity	10^9m^3	22.15
Surface area	km^2	1084
2. Dam		
Type		concrete gravity
Crest elevation	m	185
Max. height	m	175
Length of dam axis	m	2335
3. Powerstation		
Type		dam—toe powerhouse
Installed capacity	MW	18200
Ave. output annually	TW · h	84.68 (70 in initial stage)
Unit capacity	MW	700
Number of units	set	26
4. Shiplock		
Type		double way 5 stages
Dimension of chamber	m	280×34×5
5. Shiplift		
Type		one way, 1 stage vertical
Dimension of container	m	120×18×3.5
6. Reservoir inundation		
Farm land	10^3ha	25.9 (based on 1992 survey)
population	10^3man	846 (based on 1992 survey)
7. Construction		
Rock & earth excavation	10^6m^3	102.59
Rock & earth backfill	10^6m^3	29.33
Concrete	10^6m^3	27.15
Metal works	10^3t	280.8
Steel bars	10^3t	354.3
Total construction duration	year	17
1st units commision	year	11
8. Total static price estimate	10^9yuan	95.46 (1993 year unit price level)
Project	10^9yuan	50.09
Transmision works	10^9yuan	15.3
Inundation compensation	10^9yuan	30.07

Table 2

Construction Schedule of The TGP