Agreement No. CE44/2000
Investigation Study of
Increasing Power Interconnections in Hong Kong
Executive Summary of Final Report

1. Overview

1.1 Background and Objective of the Study

1.1.1 In February 2001, Mott Connell Limited (MCL) was appointed by EMSD to carry out an investigation study of increasing power interconnections in Hong Kong (the Study). The Study followed from an earlier feasibility analysis which considered that increased interconnection capacity was technically feasible, although there might be some logistical and timing constraints which needed to be studied further. The objective of this Study was to examine the technical aspects of the interconnector operating as part of the overall CLP Power/HEC's transmission system. A feasible route for the new interconnector[1] was also provided with due consideration of the likely physical planning and construction issues. An overall cost estimate and a probable project time frame were also evaluated. Furthermore the most effective planning mode was recommended.

1.2 Study Methodology and Approach

1.2.1 The various strands of the study were interrelated, and so they were carried out in parallel as the work progressed. The key tool used to assess the electrical impact of the proposed new interconnector was a model of the power system of Hong Kong that had to be constructed based on information supplied by the power companies. This, together with information gathered on the future generation and loads expected on the Hong Kong and Southern China systems was used to arrive at the optimum rating of the interconnector and to assess what reinforcements on the Hong Kong system were likely to be necessary to best accommodate it. The preferred route for the interconnector was identified to enable potential physical planning considerations to be highlighted and to allow costing to be carried out.

1.2.2 Following this, the transmission and generation planning assessment was carried out, drawing from the consultant's experience throughout the world. This assessment covered both the existing planning and possible future planning scenarios with the new interconnector in place.

2. Increasing Power Interconnection

2.1 The Hong Kong Power Market

2.1.1 The electricity supply and demand situation was studied to test the extent to which there was likely to be a need for increased interconnection in Hong Kong in the future. This study was conducted based on projected load growths, and available and planned generation capacity in the HEC's and CLP Power's supply areas. It led to the conclusions that new sources of power above that already envisaged by the power companies would be required to supply Hong Kong soon after 2010, but this could possibly be deferred if an adequately sized interconnector was installed with enhanced coordination of generation planning and utilisation between the two power companies. Furthermore, if suitable arrangements were made to utilise the possibility of spare capacity available in Guangdong in the longer term and the improving transmission network therein, there could be additional moderating effect on the need to install new generating units within Hong Kong. This would depend on the power supply and demand situation in Guangdong and on suitable trading and regulatory arrangements required to enable this to take place.

[1] Interconnector is a transmission line or cable or a set of transmission lines or cables between two power utilities.

2.2 The Existing and the Proposed Systems and Interconnectors

2.2.1 Following a review of the existing systems, including the existing interconnection arrangement and its usage, the study then provides a detailed assessment of what the new interconnector rating should be and what reinforcement in the two transmission systems would be required to utilise the new interconnector. These two issues are heavily interdependent since reinforcement of the transmission systems would be required to utilise the new interconnector and with the addition of standard sized transmission circuits as reinforcement, it might be possible to use an interconnector with higher rating.

2.2.2 A software model was constructed of the interconnected HEC/CLP Power system and was used to look at how the interconnector and the other main elements of the transmission systems might perform in 2010, 2015 and 2020. The two power companies have, of course, plans in place to reinforce each of the two systems towards 2010 as their respective loads grow. But to provide a baseline for comparison up to 2020, the reinforcements required to cater solely for load growth beyond then had to be projected by extrapolating the forecast data included by HEC and CLP Power in their plans. This baseline was then used as a comparison to gauge the impact of the new interconnector.

2.2.3 The analysis, using the above-mentioned model, showed that operating both the existing 132 kV interconnector and the proposed new interconnector together would adversely affect the transfer capability of the new interconnector. This is due to the configuration of the two networks, as the power is not shared between the two sets of interconnectors in proportion to their ratings. Also, by examining how much each power system could deliver to the other through the new interconnector , the model was used to reveal where the transmission systems would have to be reinforced, ahead of the schedule for the baseline system development, to remove constraints on the transfer of power across the new interconnector. The financial impact of this advanced/rescheduled reinforcement was then estimated. Additionally, other aspects related to the network performance as a result of the implementation of the new interconnector were assessed and it is predicted that a more stable power system will result with the establishment of the new interconnector.

2.2.4 An iterative procedure was used to arrive at the most appropriate rating of the interconnection combined with the most appropriate level of additional reinforcement that the two systems would need from 2010 to 2020. Various electrical configurations were examined and a plausible one emerged from the studies.

2.2.5 To take advantage of the new interconnector and allow bilateral trading between HEC and CLP Power (and possibly with Guangdong) there are a number of reinforcements, particularly on the HEC system, that have to be advanced from the time that they would be required if there were no new interconnector. The modelling also highlighted that the optimum way of eliminating the problem of unbalanced power flow sharing between the old and the proposed new interconnectors is to disconnect the existing interconnector, which can be kept for emergency purposes. In any case, the existing interconnectors may be reaching the end of service life by around 2011 although condition monitoring tests will indicate if extended service life is feasible.

2.3 The Optimum Rating of the Proposed New Interconnection

2.3.1 To cater for an increase in power transfers between the two companies and given the current transmission constraints on this transfer (even when the system reinforcements are taken into account), an interconnector capable of supporting at least a 700MW firm capacity is recommended. The choice of size and number of circuits has taken into consideration the economy of scale of cable size and the possible requirement of adding another circuit along the proposed route in the future. Thus two interconnector circuits each of 700MW rating are recommended to allow for the possible outage of one. Although 700MW is the 'firm' capacity, during severe unexpected generation outages on either side short term power transfers of between 700MW and 1400MW would be possible and indeed desirable. Future expansion would be possible by the addition of a third 700MW circuit, giving a total 'firm' capacity of 1400MW.

2.3.2 Based on the possibility of increased transfer capability being available from reinforced CLP Power and HEC networks, it is apparent that higher rated circuits should be considered. To achieve a higher rating per cable circuit, while still maintaining a practicable cable size, requires the use of 400kV cables. The recommended configuration of the new interconnector is therefore two 400kV cable connections between the 400kV CLP Power Substation at Yau Ma Tei to HEC's proposed new 275kV substation at New Wan Chai. The 400kV/275kV transformers required to connect the two systems have to be sited on the Hong Kong Island side of the harbour with the use of 400kV submarine cables. The use of higher rated submarine cables would increase the transfer capacity of the interconnection between CLP Power and HEC. A possible site between the cable landing and the New Wan Chai substation has been proposed. Once the new interconnector is operational, the existing 132kV interconnectors should not be used except under emergency or backup conditions.

2.4 The Route for the Cross Harbour Interconnector

2.4.1 The plausible electrical configuration mentioned in 2.2.4 above requires that the submarine cable crossing the harbour for the new interconnector should operate at 400kV and the voltage be transformed down to 275kV on the Hong Kong Island side. On the Hong Kong side, the HEC system currently does not have any 275kV substation at the eastern part of Hong Kong Island, which makes it difficult to accommodate the new interconnector from Kowloon without substantial network reinforcement and re-engineering of the HEC system. The alternative connection point on the western side is also problematic due to longer route length. In order to keep network reinforcement requirements to a minimum level and to achieve greater flexibility in future system capability enhancement, HEC's 275kV New Wan Chai substation and CLP Power's 400kV Yau Ma Tei substation are considered the most plausible and preferred connection points for the new interconnector. To accommodate the new transformers, space has to be found on the Hong Kong Island side of the harbour for the transformer equipment. The study of the route for the new interconnector from the selected connecting points in Kowloon to Hong Kong Island showed that there were no major issues that would prevent such an installation, provided that land is made available for accommodation of the transformer installation in an appropriate area, on Hong Kong Island.

2.4.2 Both the land cable routes to the connection points in the CLP Power and HEC systems, on each side and the submarine cable crossing itself would be by conventional installation techniques, largely following existing highway routes in line with common practice in Hong Kong and elsewhere throughout the world. Appropriate planning and environmental procedures would need to be followed. This is particularly so for the sea crossing since the seabed in the harbour would be disturbed during cable installation. There are no major foreseeable problems associated with the cross-harbour installation works.

2.5. Costs and Timescales

2.5.1 The estimated cost to supply and install the proposed interconnector is around HK$1.6 billion[2] at 2002 prices. The estimated cost[3] of rescheduling the necessary reinforcements in the HEC and CLP Power systems to accommodate the interconnector is around HK$0.5 billion. The overall estimated cost is around $2.1 billion over the case with no increase in interconnection. From initiation to completion of the interconnector, including the required planning procedures, it is estimated that some 5 years would be required. Even if the planning procedures could be accelerated the reclaimed land in Wanchai that is required for the connection point into the HEC system will not be available before 2006/7. Therefore, the earliest possible completion of the new interconnector would be around 2008 taking into account a construction period of 2 years upon possession of site.

[2] Land cost is excluded. In any event, the land premium will be assessed on the basis of industrial use and would unlikely be substantial in the overall context.

[3] This is the time value of money in advancing the reinforcement works that will be required in the HEC and CLP Power systems in any event in order to maintain security as load demand grows during future years.

3. Review of Power System Planning Criteria

3.1 Assessment Approach

3.1.1 The review of the planning criteria that are currently used and also those that could be used following the installation of the proposed new interconnector were carried out in two parts. Firstly the present and future generation planning criteria and practices were assessed. Secondly the present and future transmission planning criteria and practices were assessed. Following this the possibility and indeed desirability of coordinating generation and transmission planning was reviewed. Three planning modes were considered, namely 'Individual' planning, 'Co-ordinated' planning and 'Joint' planning. There is in fact a continuum between Individual and Joint planning depending on the extent of the co-ordination. Findings of the review and the consequent recommendations are described below.

3.2 Existing Power System Planning Criteria

3.2.1 The existing generation planning can be described as largely individual, although some level of co-ordination does take place between CLP Power and HEC in that generation that is kept ready for immediate use by one company (in case a generating set fails) is shared with the other company (through their shared spinning reserve agreement). This is good practice and means that the total amount of generation that has to be kept in this state of readiness is reduced, hence operating costs are reduced.

3.2.2 The way in which the level of co-ordination could be improved at present would be for the power companies to co-ordinate more with all the interconnected parties on the generation planning function. There is already some trading of power between CLP Power and Guangdong in addition to the current contract to take a portion of the output of Daya Bay nuclear power plant in Guangdong (which CLP Holdings in fact partly own through the Hong Kong Nuclear Investment Company Limited). Through closer co-ordinating of generation planning, further cost savings could be realised while ensuring that the planning margins are adequate for the interconnected systems, and bearing in mind the present limited interconnection between HEC and CLP Power. Differences in reliability criteria between the two would however limit the level of co-ordination to some extent.

3.2.3 The study reviewed the current primary generation planning criterion (i.e. Loss of Load Probability, LOLP) and assessed that the criteria adopted by the power companies are within the range of those adopted by developed countries around the world. The study also revealed that there is an inconsistency in the secondary criterion. In addition, the capacity reserve requirement offers scope for savings with co-ordinated or joint planning after the new interconnector is placed in service. For example, joint planning could provide the most effective means to reduce the overall generation capacity margin requirement.

3.2.4 When assessing the transmission system planning that is currently adopted by the power companies, it was found that the criteria used by HEC and CLP Power were broadly similar and reasonable.

3.2.5 The existing reliability of the transmission system is currently what would be expected from a system in a fully developed economy. There is presently little co-ordination of transmission planning between HEC and CLP Power. This is to be expected given the existing conditions of independence within their own region of supply and the current level of weak interconnection.

3.3 Future Power System Planning Criteria

3.3.1 In future, with the new interconnector in place, the degree of co-ordination could be improved and the costs to the two companies reduced. Methods of achieving this are proposed in the report, utilising essentially a common method of assessing system reliability between the two companies, and to some extent with the Guangdong system too. Additionally it is proposed to use joint planning to achieve further savings. Both HEC and CLP Power would benefit in terms of the reduced costs accruing from deferred capital expenditure on generating plant addition.

3.3.2 After the proposed new interconnector is installed and is in operation, the aim should be to maximise the benefits that are then obtainable. Thus generation and transmission will have to be planned and operated in such a way that the best use is made of the cheapest power sources, taking into account the limitations of the transmission network. Various ways of achieving this are discussed. They all essentially mean that the co-ordination between the interconnected parties has to be increased significantly and in addition there would have to be some form of regulation applied in the form of a Hong Kong 'grid code' which the two power companies will have to observe. (A 'grid code' is a set of rules that governs the co-ordination between the parties). Besides, the concept of appointing an independent Power Network Manager to facilitate the implementation of Grid Code and, the planning and management of the overall transmission network is introduced.

3.3.3 While the existing generation planning criteria of the two power companies appear to be adequate and within the range of those adopted by developed countries, there is room for enhancement such as criteria harmonization within Hong Kong SAR. It is desirable to establish a multi-area LOLP model to re-evaluate the LOLP criterion with an objective to assess the appropriate level of a harmonized criterion for use before and after the commissioning of the new interconnection. The reliability of the network would be maintained by the use of standard planning techniques and also an Asset Risk Management strategy. In addition, the secondary criterion can be reviewed and revised if necessary for a consistent secondary criterion of the two power companies,

3.3.4 A review of the transmission planning criteria indicated that the basic criteria currently adopted by the power companies, namely being able to meet maximum demand under a transmission contingency condition, are essentially the same. CLP Power, however, adopts additional criteria to avoid out of merit generation and restrictions on its generation output. It is recommended that the two utilities adopt a harmonised set of transmission planning criteria so as to enhance flexibility in the utilization of the overall generation resources within Hong Kong.

4. Summary of Findings

- New interconnection comprising two 400kV cables rated at 700 MW each is recommended to enhance the interconnection transfer capability between CLP Power and HEC.

- The interconnection points should be CLP Power's Yau Ma Tei substation and HEC's proposed New Wanchai substation. Given the constraint of the reclaimed land in Wanchai, completion of the new interconnector before 2008 is precluded.

- The proposed route for the new interconnection is achievable with existing technology and will, with the appropriate precautions, be environmentally acceptable.

- The overall cost of the interconnection is estimated at around HK$2.1 billion over the case with no increase in interconnection at 2002 prices. It includes the cost to supply and install the proposed interconnector of around HK$1.6 billion, and the additional cost of rescheduling the necessary system reinforcement of around HK$0.5 billion.

- The new interconnector will enable enhanced sharing of reserve capacity and it will also improve Hong Kong's ability to exchange power with Guangdong in future.

- Some improvements in the way that the HEC and CLP Power systems are planned and regulated are proposed to make best use of the new interconnector's potential to improve the cost effectiveness of the electricity supplies to Hong Kong.