# IMPROVING THE SUSTAINABILITY PROCESS AT THE HONG KONG SCIENCE PARK, PHASE I

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**Abstract**

The paper addresses the holistic sustainable design approach used for the Hong Kong Science Park phase 1.
The master layout plan was prepared in 1998 with the requirement that the project be completed in three phases. Phase 1, recently completed in mid 2004, consists of one car park/utility building supporting nine innovative, adaptable buildings, connected and integrated on a reclaimed parkland site of 8 hectares facing the sea.

The paper describes the development of the design concepts in relations to the various aspects as follows :

- The setting of the project in the urban context, the environmental assessment of the site, the response to the planning and physical restrictions imposed by the site, the client needs, the use of semi basements, and elements that could be centralized including the central waste collection suction system and the service tunnel network.
- The overall design concept with the internal useable space grouped around central cores accessed through spacious atriums. Building services plant rooms are used as insulation space below the main feature roofs. Floor to ceiling height has been carefully considered and the raised floor system provides easy under floor adaptability.
- The innovative technical design of the building envelopes to maximize the use of natural daylight using insulated glass walls of different types designed to suit different locations and functions complying with the fire requirements.
- The use of photovoltaic panels for renewable energy as an integral part of the building envelopes in a variety of locations and components, façade elements, sun screens, and for roof shading on different buildings.
- The design for the interior comfort levels achieved through energy efficient systems including HVAC, lighting and management monitoring.
- The development of a glass building envelope sustainable design tool, tailor made for the Hong Kong situation with retrospective testing on one of the buildings. The results are briefly analysed to check if any improvements could have been made in the design or could still be made now, after completion.

Throughout the paper, the link between the developments of the design concepts in harmony with sustainability is made. The conclusion will reflect on the circle of future continuing improvement.

**Keywords :** Science Park, Building Envelops, Atriums.

## 1. Introduction

Hong Kong is a small country with very limited natural resources.  Basically it has mountains, islands and the sea.  In the past, there has been a double benefit cycle where mountains have been excavated to create flat plateaus for building and the removed soil has been used for reclamation from the sea, again forming new land.  In today's projects, it is necessary to import all building materials from outside Hong Kong, therefore to become more sustainable, it is necessary for designers to focus on long life, energy efficiency, re-useable or recyclable materials, and minimizing waste.

## 2. Background

The Hong Kong Science Park is to be completed in 3 Phases on 22 hectares of reclaimed land at Pak Shek Kok near Shatin in the New Territories.  The concept was first mentioned in the Chief Executives Commission on Innovation Report in 1998 and the first buildings in Phase 1 were opened in 2002. Phase 1 comprises of 9 buildings and 1 car park building, with roads and parkland providing 120,000 square meters of Research and Development (RD) facilities (Fig.1, Fig.2).  The last buildings in Phase I were opened in 2004, making the inception to completion period a very fast track 6 years.

Fig.1 Bird's eye view of Hong Kong Science Park, Phase 1

**3. The Client Needs**

The key client needs were:-

- to attract organisations to high tech modern facilities set in a park like atmosphere.
- to support small, medium and large organisations by permitting easy occupation and start up with excellent business back up.
- to provide flexible spaces and facilities, within nine separate fixed building envelopes, capable of taking different types of R&D functions and equipment.
- to create opportunities for human interaction/stimulation/innovation within the park.

**4. The Urban Setting**

The site was chosen for the following reasons:-

- Hong Kong always has a shortage of large flat sites. The site is on reclaimed land using public filling material from other construction sites and was becoming available at the correct time. An environmental impact study had previously been carried out and accepted for the site.
- Geographically, it is very central to the main population distribution. There are excellent road and rail links to the airport, China and the other major business districts in Hong Kong.
- The "sea in front and mountains behind", environment is very attractive for prospective tenants and the development parameters suited the outline zoning plan designation.

**5. Environmental Site Analysis**

The very desirable site has green mountain views behind and sea views in front. The very busy four lane Tolo Harbour highway and the Kowloon Canton Railway at the rear, generate noise which was taken into account in the design of the buildings. There is a good sun path, outstanding views, sea breezes and a pedestrian seaside promenade along the whole site frontage. No existing landscaping or vegetation existed. In summary, an excellent site for the project.

## 6. Site Constraints and Development Parameters

The site boundaries were fixed, as were the two vehicular entrance points. There is a large drainage box culvert dividing Phase 1 from the rest of the site. The development parameters of 30% site coverage, plot ratio 1:2.5 and a GFA of 120,000 square meters, dictated that the maximum site usage was required within restricted height limits. The end result is that the buildings are low rise in nature, maximum 8 storeys, but the opportunity for extensive landscaped parkland was very limited. The designers challenge was how to improve the environment.

## 7. Concept and Master Layout Plan

A master layout plan for the whole of the 3 phases was produced. It responded to the site analysis and environment by screening the noise from the rear, forming a feature entrance and providing vehicular and pedestrian access routes. The buildings were grouped around a large open central parkland space including a lake. Limited car parking was provided to encourage more pedestrianisation. Three specific zones, campus, core and corporate following the height restrictions of 40, 35 and 30 meters respectively, were planned to accommodate different tenant groups. This formed the basis for Phase 1.

## 8. Phase 1 Layout

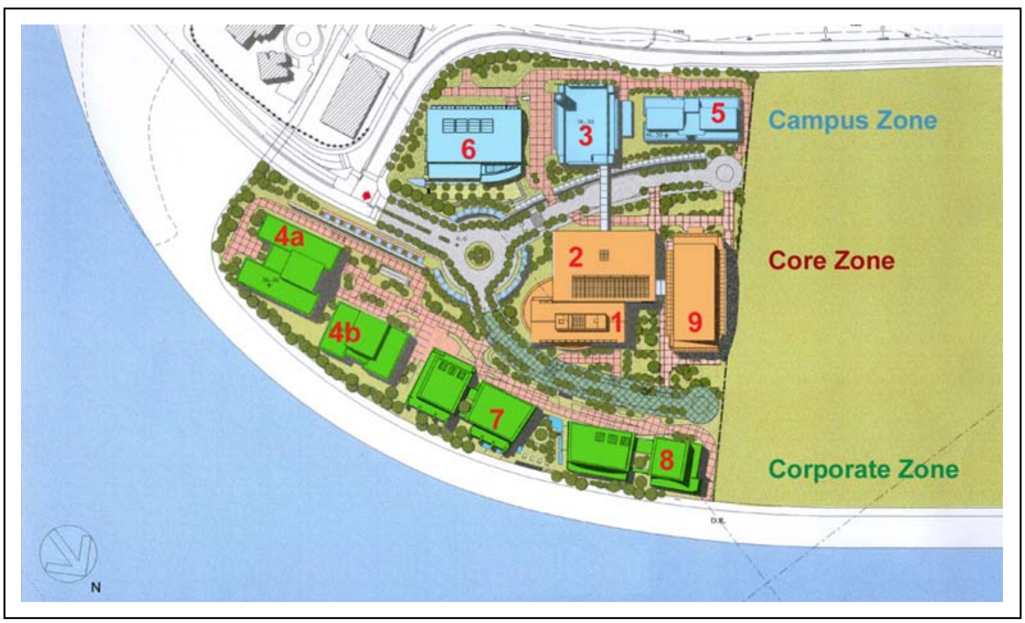


Fig.2 Phase 1 layout

The campus buildings at the rear of the site are specially designed with glass walls to screen out noise. The Icon tower at the car park advertises the logo of the Science Park in fibre optic lighting to passers by and visitors alike. The core facilities in the centre provide the central business functions, restaurants and sense of arrival linking to the future phases. The stand alone corporate buildings on the waterfront are orientated to suite the available site sizes, therefore the design has to minimise heat gain. The Client added a late requirement for individual carparks for each of the corporate buildings therefore the necessary infrastructure and roads take up valuable landscape space. Sea views, mountain views and breezeways feature in the design layout.

**9. General Shared Facilities**

Due to the requirement of the buildings to be as far as possible stand alone to allow maximum flexibility, we were only able to share carpark facilities, the service tunnels and the central suction refuse system. This refuse collection system is innovative in thus type of development in Hong Kong and is capable of serving the whole park in future. Sharing facilities is one aspect of sustainable design.

**10. Building Design Concepts**

As a result of the constraints and client requirements, it was recognised that there would be little space left for the landscape parkland. The building design concepts therefore contrived to bring the park into the buildings as far as possible. To do this, a variety of double height entrance lobbies, atriums, internal landscaped streets, bridges and external courtyards were used. These elements also helped to maximise the use of daylight within the complex whilst at the same time created interesting interactive arrival spaces and easy orientation for people visiting the complex (Fig.3).

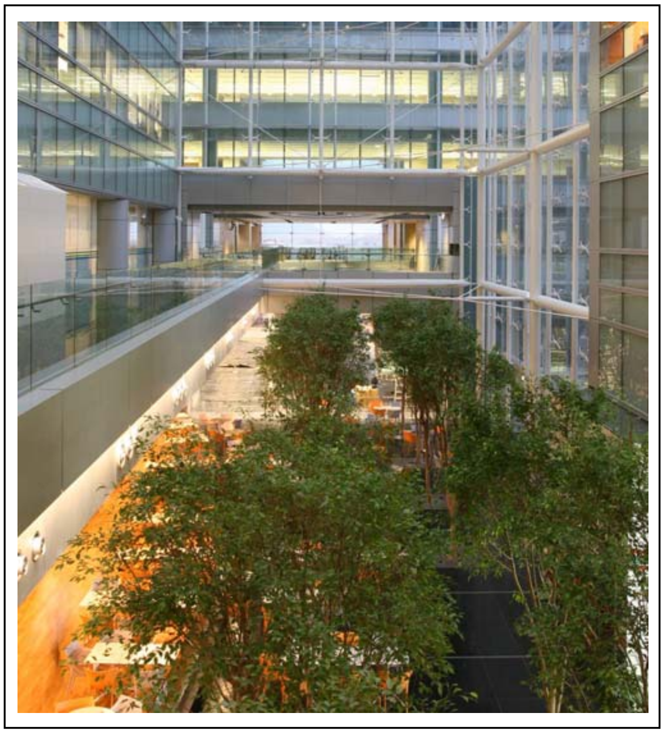

Fig.3 Internal landscaped street of building 2

For each building, the project teams used a similar language of materials, consisting of metal insulated roofing and glass curtain wall building envelopes, to create a family of high tech buildings. For energy efficiency, the overall thermal transfer value (OTTV) needed to be less than 23W/metre square. The building structures were to be concrete due to the short fast track programme. Basement areas accommodating building service plant and car parking, are linked by a comprehensive tunnel network allowing easy maintenance and modification to pipe work without disturbing the landscape and tenants above. The overall result is that the buildings have spacious entrance areas, offices grouped around cores with views out, daylight usage is maximised and major building services plant is located at the roof level allowing ventilation, easy access for maintenance and providing additional insulation against heat gain.

A key requirement was to have an efficient floor plate of office space grouped around a central core of backup facilities, lifts, stairs, toilets, pantry stores etc. The window to core depth was to be less than 12.5 metres, as this maximises the use of daylight and is a normal tenant preference. To add to the flexibility within the fixed envelope, a 4.5 metre floor to floor height is provided including a 200mm raised floor, a generous 2.7 metre floor to ceiling height and 1 metre allowance for building services.

The floor plan layouts were designed for easy subdivision to accommodate different tenants and are fitted out to a high quality of finish using long life materials to assist quick move in.

### 11. Landscape Design and Parkland Spaces

The overall landscape design aims for a subtropical parkland using species found in Hong Kong that have low maintenance and long life. Boundary planting encourages pedestrian entry at the main entrance and from the waterfront promenade. Roadside planting enhances directional flow and provides shading. Courtyards and node spaces including water features, provide immediate interest next to buildings. Roof terraces provide additional external spaces and more landscaping. The use of atriums and streets encourages the use of internal planting assisting the integration of the external and internal spaces (Fig.4). 4263 new trees have been planted in Phases 1 to add to the greening of Hong Kong.

Fig.4 Parkland view towards building 7

### 12. Innovative Design

The innovative technical design of the glass curtain wall envelopes is the use of a double skin on the southwest facades of some buildings. The main functions are to screen out solar gain and reduce noise whilst letting in daylight and allowing views out. The outer skin, which reduces solar gain, is made up of point fixed 19mm tempered glass with 5mm gaps on all sides supported on aluminium frames cantilevered from the main structures. There is a 1.0m space before the inner double glazed skin which normally uses a 10mm heat strengthened outer panel, a 6mm air spare and a 6mm heat strengthened inner pane. The aluminium catwalk between the outer and inner skins acts as a sunscreen and is also used for access for internal cleaning and maintenance.

The chimney effect created in the void allows the warm air to rise thus reducing heat gain on the inner skin. The design required a fire engineering study approach to obtain Building Code approval. Heat gain is reduced by 1.56w/meter square and the anticipated energy consumption is reduced by about 7.5%. The noise levels are reduced by 6 to 7 decibels.

Integrated Photovoltaic panels have been used in different ways as sunscreens, on the outer skin of the double façade as sunshading, as a part of the spandrel panel of the elevation, on canopies and for roof shading elements (Fig.5). Currently the power generated is fed back into the grid or used for lighting. The integration ensures that the photovoltaic panels are serving double functions, therefore they become much more cost effective and therefore sustainable. The total amount of renewable energy is estimated at 260kW.

It is predicted that no other buildings will be built in the future which may block the solar path for the Science Park, therefore the panels will always be in use. It is also a fact that when integrated in the design, unlike traditional building services plant, no additional space is required for the equipment for the energy source. This is a useful sustainable design point.

Fig.5 Double skin with integrated photovoltaic panels building 5

## 13. Interior Comfort and Energy Efficiency

With the building envelope design reducing heat gain, the building services are designed to the most up to date requirements to minimise the consumption of energy and water thus reducing recurrent costs. The maximum use of daylight is used and occupancy sensors automatically control or dim artificial lighting as required (Fig.6). Energy saving lamps are used with electronic ballasts. Zone lighting is on progressive reduction and fibre optic external lighting gives high impact visual effect with efficient recurrent costs.

The air-conditioning system creates indoor air quality designed to best practice with successive filtering techniques. Evaporative cooling is used as in Hong Kong this has about 20% lower running costs than other systems. Chillers have heat reclaim wheels to preheat the hot water supply and thermal wheels reduce humidity and recovery energy from exhaust air from air conditioned spaces. Zones in offices are subdivided using VAV's and variable frequency drives. All fan discharges are fitted with silencers. Exhaust emissions from kitchens are treated with electrostatic participation.

Saving in water usage is through use of bleeding water from the cooling tower being reused for flushing water in toilets. Electronic automatic sensors are used for controlling water flow for hand washing and flushing in toilets. There is an automatic sensor which reduces water output after rainfall for the irrigation system for the landscape areas.

The Centrally Central Controlled Building Services Management System uses computer adjustments and scheduling for energy efficiency. Infrared sensors are used on escalators to minimise usage in quiet periods. The buildings are designed with very high IT backbone capability with the flexibility include through the raised floor system and spare vertical duct space. The intention was to allow for the paperless office in future, another sustainable design target.

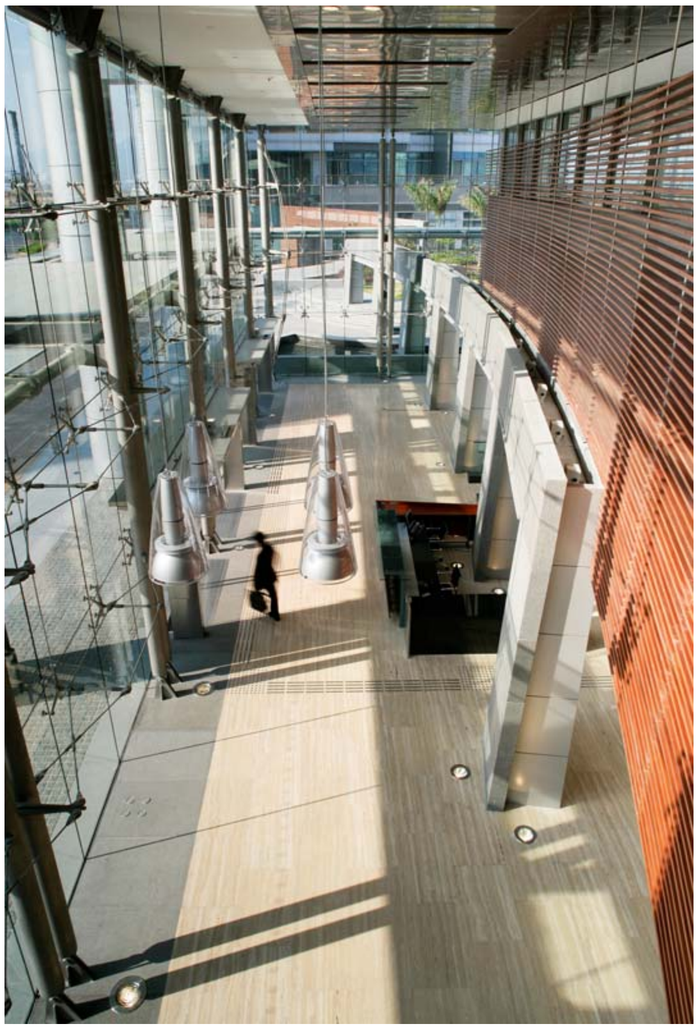

Fig.6 Use of daylight and integration of external and internal space

The central suction refuse collection system allows separation of waste paper from other waste though a double pipe system. It reduces odour and due to the compacting system, reduces waste and minimises the removal of the waste containers, thus saving vehicle trips. The reduction in waste also reduces the amount required to be taken to landfills.

All buildings have been submitted for a performance assessment grading under the established Hong Kong Beam System and they have achieved the highest rating “Excellent”.

### 14. Materials and Construction

Because of the need to import materials and achieve a quality building, prefabrication and long life materials were chosen. Prefabricated concrete floor slabs, staircases and other elements were used in the structure. Metal roofs were supported by structural steel. Curtain wall and interior wall claddings were all prefabricated. The use of a 1.5m modular system reduced waste and minimised cutting of materials. Timber was not used in large quantities but was from sustainable sources. Road pavers had 70% glass content. Paints had low VOC content and environmentally friendly carpets were used.

### 15. Glass Building Façade Rating

The Department developed with the assistance of Ove Arup Partners Hong Kong Ltd, a sustainable design assessment tool for glass building facades. The main objective was to be able at the design stage to quickly compare the performance from broad sustainable energy efficient criteria. Some sample assumptions were made i.e. façade being open, (full heat gain) high rise location and the building using VAV HVAC system. The tool provides an analysis of the following:-

- Thermal Energy – predicts annual cooling and heating load with impact of external/internal shading and ventilation.
- Thermal Comfort – investigates outcomes of comfort conditions by different glazing systems.
- Energy Saving and Glare – tests the response of facades to different daylighting situation using simulation.
- Others – embodied energy, acoustic expectation and life cycle cost.

The fast rating requires only simple input from its pull-down menu on room properties (orientation, façade width & floor height), window properties and glazing details for full curtain wall systems. A test study on Building 9 demonstrates the results (Table 1). A summary report of North East Elevation generated from the system indicates that ratings in the elevation generally support the Hong Kong Beam Assessment.

Table 1. Facade rating for North East Elevation of Science Park Building 9

**Summary Report of Fast Rating Results**

| | | Results Evaluation |
|---|---|---|
| Title of Rating | SP9-NE | |
| Description | Test only | |
| User Name | 2004/4/23 | |
| Date | LL | |

| INPUT AREA | Variable(Unit) | Input Value |
|---|---|---|
| **Room Properties** | | |
| *Orientation* | ( - ) | NE |
| *Façade Width* | $W_f$ (m) | 1.50 |
| *Floor/Ceiling Height* | $H_f$ (m) | 4.50 |
| *Window to Wall Ratio* | *WWR* (%) | 66.67 |
| **Window Properties** | | |
| *Height* | $H_w$ (m) | 3.00 |
| *Width* | $W_w$ (m) | 1.50 |
| *Shading Coefficient* | *SC* ( - ) | 0.37 |
| *U value of Glazing Unit* | *U* (W/m²·K) | 0.37 |
| *Visible Light Transmission* | *VLT* (%) | 25 |
| *External Visual Reflectance* | *VLR* (%) | 12 |
| *Number of panes* | ( - ) | 2 |
| **External Shading Device** | | |
| *Type of Shading Device* | ( - ) | Eggcrate |
| *Offset* | (m) | 1.30 |
| *Lightshelf* | ( - ) | No |
| **Vented Cavity** | | |
| *Type of Struture* | ( - ) | No vented cavity |
| *Type of Airflow through Cavity* | ( - ) | N/A |
| **Solar PV as Façade Element** | | |
| *Position of Solar PV Cells* | ( - ) | 0 |
| *Solar PV Material* | ( - ) | 0 |
| **Daylight Linking** | | |
| *Daylight Linking* | ( - ) | Yes |
| **Glazing Acoustics** | | |
| *Total Number of Panes* | ( - ) | 2 |
| *Pane mode* | ( - ) | 2 pane system |
| *Noise Exposure Category for Site* | ( - ) | Low (65 dBLaeq) |
| *Glazing Type* | ( - ) | Double glazed unit |

| OUTPUT AREA (Per m² of Façade Area) | | Variable(Unit) | Estimated Range | Approximate value | Rating |
|---|---|---|---|---|---|
| **Annual Energy Consumption** | | | | | |
| *Total Estimated Annual Energy Use (with daylight linking)* | | *TEAE* (KWh/m²) | 130 | | Good |
| **Overall Thermal Transfer V** | | | | | |
| *Overall Thermal Transfer Value* | | *OTTV* (W/m²) | 18 | | Excellent |
| **Thermal / Visual / Acoustic Comfort** | | | | | |
| *External Visible Light Reflectance* | | *VLR* (%) | 12 | | Good |
| *Thermal Comfort* | *with blind in summer* | *PPD* (%) | PPD < 20 | ≈ 12 | Excellent |
| | *without blind in summer* | *PPD* (%) | PPD < 20 | ≈ 1 | Excellent |
| | *with blind in winter* | *PPD* (%) | PPD < 20 | ≈ 10 | Excellent |
| | *without blind in winter* | *PPD* (%) | PPD < 20 | ≈ 11 | Excellent |
| *Visual Comfort* | | *PDU* (%) | 50 < PDU < 70 | ≈ 56 | Average |
| *Acoustic Comfort* | *Cellar Offices* | | | | Acceptable |
| | *Open Plan Offices* | | | | Acceptable |
| **Embodied Energy** | | | | | |
| *Estimated Embodied Energy* | | *EE* (KWh/m²) | EE > 1150 | ≈ 5124 | Average |
| **Life Cycle Cost** | | | | | |
| *Estimated Internal Rate of Return* (Compare to fully glazed/single glass system with metal frame) | | *IRR* (%) | 0 < IRR < 20 | ≈ 10 | Average |
| **Solar PV Energy Output** | | | | | |
| *Annual average Daily Output* | | (Wh/m²_day) | 0 | FALSE | |

| OUTPUT AREA (Per m² of Floor Area) | | Variable(Unit) | Estimated Range | Approximate value | Rating |
|---|---|---|---|---|---|
| **Annual Energy Consumptio** | | | | | |
| *Total Estimated Mechanical Energy Use* | | *ME* (KWh/m²) | 163 | | |
| Made up of | *lighting* | KWh/m²) | 42 | | |
| | *equipment* | KWh/m²) | 62 | | |
| | *HVAC* | KWh/m²) | 60 | | |
| *Total Energy Saved from Daylight Linking* | | *DE* (KWh/m²) | -17 | | |
| *Total Estimated Annual Energy Use* (with daylight linking) | | *TEAE* (KWh/m²) | 146 | | Good |

## 16. Conclusions

In the urban setting, the buildings are appropriate in scale and height, however the master plan layout once approved was very restrictive. Perhaps if the number of buildings could have been reduced or the heights increased slightly to reduce the site coverage, a reduction of hard paved areas and more parkland might have been created. The difficulty however was the phased opening requirements and different tenant types. The envelopes and building services exceed current local standards and provide quality finishes and good comfort levels. With a longer design time, more studies on the elevation treatments may have resulted in slightly lower future operational costs. On balance, the technical solutions do provide quality, sustainable buildings for the future. The Department and project teams were very proud to have been able to improve the sustainability process in Hong Kong on this unusual fast track programme.

Fig.7 Night view of courtyard and buildings

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