Science Teaching Kit for Senior Secondary Curriculum

Visit : Hong Kong Wetland Park

Human Impact, Pollution Control, Sustainability and Energy Efficiency

[Teacher notes]

Organizer

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Community Project Workshop 社區項目工作坊

Contents

Topic 09
Visit : Hong Kong Wetland Park

Major teaching areas

Biology: Chapter VI Applied Ecology

- Human Impact on the Environment
- Pollution Control
- Conservation
- Sustainable Development
- Values and Attitudes
- STSE Connections

Physics: Chapter VIII Energy and Use of Energy

- Electricity at Home
- Energy Efficiency in Buildings and Transportation
- Renewable and Non-Renewable Energy
- Values and Attitudes
- STSE Connections

Related teaching areas

Physics: Chapter I Heat and Gases

- Values and Attitudes
- STSE Connections

Integrated Science: Module C1 Water for Living

- Effects of Human Activities on the Balance of Water Distribution and Water Quality

Integrated Science: Module C6 Balance in Nature

- Disturbance and Restoration
- The Hunt for Balance

Integrated Science: Module E1 Energy, Weather and Air Quality

- Energy Use and Air Quality

Interdisciplinary teaching area

Design and Applied Technology:

- Strand 3 Value and Impact

Liberal Studies:

- Module 2 Hong Kong Today
- Module 6 Energy Technology and Environment

Learning objectives

- To understand the comprehensive planning and measures of a world-class conservation region in Hong Kong, under the scope of conserving natural habitats and energy efficiency in buildings
- To get hands-on experience and witness how an environmentally friendly building and landscape can perform via on-site exercises

Teaching plan

Lesson	Contents	
Visit	• 1.1	Planned itinerary for the field trip
Hong Kong Wetland Park	• 1.2	Background information and environmental value of Hong Kong Wetland Park
	• 1.3	Master planning and landscaping work at HKWP
	• On-site exercise	Human impact and restoration of natural habitats
	• 1.4	Practical approaches to preserving ecology in HKWP
	• On-site exercise	Energy efficiency in buildings
These are supplementary teacher notes for guiding the field trip to Hong Kong Wetland Park.		

1.1 Planned itinerary for the field trip through Hong Kong Wetland Park

Source: Hong Kong Wetland Park

Pre-Trip Introduction (20 min)

- Background information of Hong Kong Wetland Park
- Objectives and on-site exercises introduction
- Planned route
- Points to note (e.g. equipment needed, meeting point, rules in HKWP)

Field Trip (approximately 2 hours)

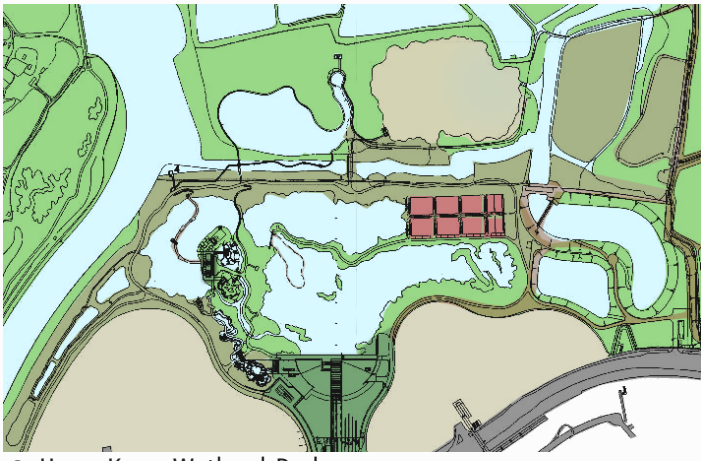
10 min	30 min	20 min	10 min	30 min
1	2	3	4	5
Ticket office	Visitor Centre	Satellite Building	Bird Hide	Outdoor Visitation Area

1.2 Background Information

Background Information
Hong Kong Wetland Park (HKWP) is Hong Kong's first major ecotourism facility and the first of its kind in Asia. The constructed wetland was designated by the Government of the Hong Kong Special Administrative Region as one of the Millennium projects.

HKWP is built upon an Ecological Mitigation Area (EMA) that is intended to compensate for the wetlands lost to the Tin Shui Wai New Town development built in 1998. The 61-hectare HKWP comprises a 60-hectare wetland reserve with bird hides and various habitats, and a 10,000 square metre visitor centre offering exhibition galleries, resource centre, theatre, souvenir shop, and café.

At the time of the park's founding, the Government commissioned a feasibility study that concluded that it was feasible to develop a wetland park in this location without compromising the area's intended ecological mitigation functions.


© Hong Kong Wetland Park

▲ Hong Kong Wetland Park is adjacent to Tin Shui Wai New Town development

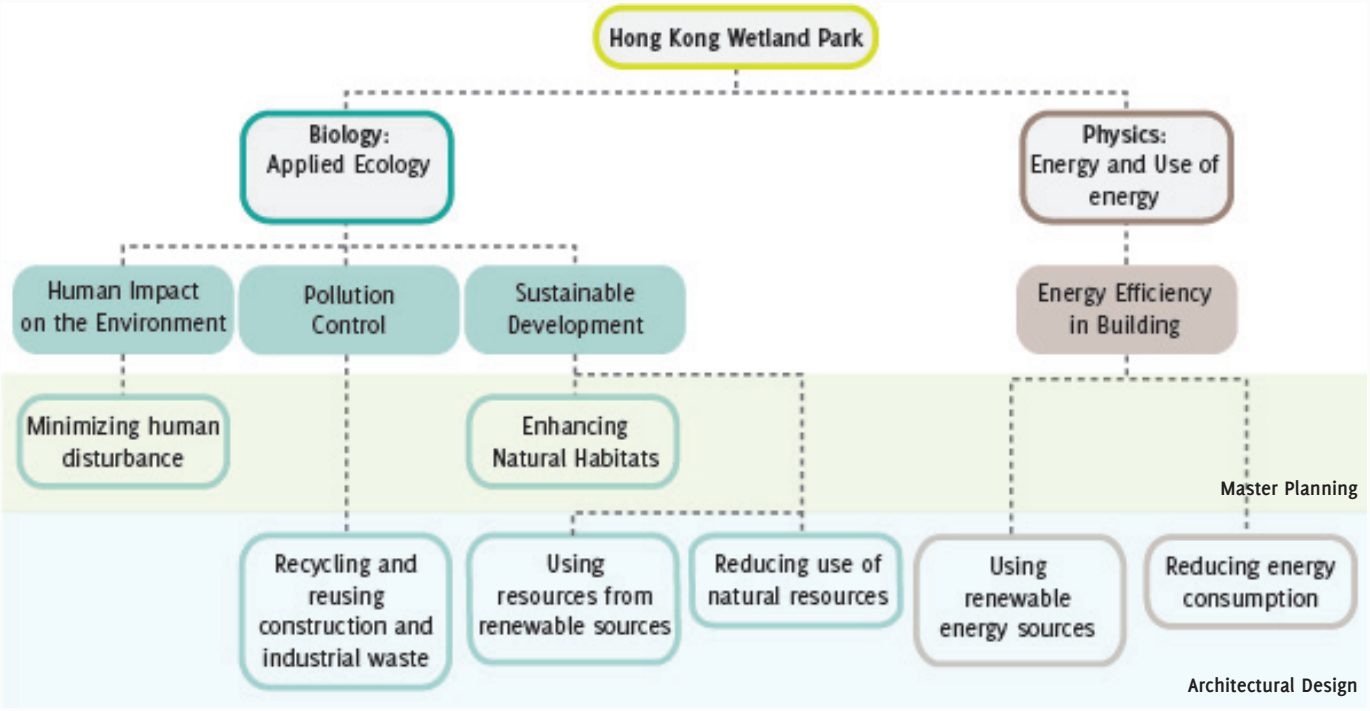
Architectural Merit

HKWP is an outstanding example of architecture in harmony with its landscape. The project has been recognized as a success, winning a number of awards including the Green Building Awards 2006, and the Hong Kong Institute of Architects' Medal of the Year in 2005.

The master planning, landscaping and building design in HKWP set high standard for ecological building in all the following areas:

Teaching Tips

Integrated Science teachers may wish to use teaching materials for Biology and/or Physics to explain the practical applications of environmentally friendly measures.



Ecological Building

Ecological Building is both design process and a result. It aims to create and sustain mutually beneficial relationships between architecture and the local ecology. The execution involves creating environmentally friendly, energy-efficient buildings and developments by effectively managing natural resources. This entails passively and actively harnessing renewable energy and using materials which, in their manufacture, application and disposal, do the least possible damage to natural resources like air and water.

Teaching Tips

Teachers are encouraged to combine the field trip with other topics. For more information on layout planning and architectural design, see the following:

'Conserve our wetland' tour organized by HKWP for S4 to S6 students:
http://www.wetlandpark.com/en/doc/Park_Experience_S4S7_outline.pdf

HKWP website:
http://www.wetlandpark.com/en/index.asp

Environmentally Friendly Features in HKWP

Proposed Route	Biology			Physics
	Human Impact on the Environment	Pollution Control	Sustainable Development	Energy Efficiency in Buildings
1. Ticket Office		• Recycled Chinese bricks • Reusing old visitor centre	• Sustainable timber • Rainwater harvesting • Recycling lake water	• Green wall • Natural ventilation • Shading device
2. Visitor Centre		• Recycled crushed concrete • Recycled aggregates and rock fill • Oyster shell infill walls • Recycled Chinese bricks • Recycled granite paving	• Sustainable timber • Water-efficient fixtures • Rain sensors	• Green roof and wall • Geothermal heat pump air-conditioning system • Natural lighting • Natural ventilation • Shading device • Sun-shading glass • Sensors for air quality and lighting quality • Energy saving devices • Circulation design • Building orientation
3. Satellite Building			• Sustainable timber	• Green wall • Photovoltaic panels • Natural lighting • Natural ventilation • Shading device • Sensors for air quality and lighting quality
4. Bird Hides	• Minimizing human disturbance		• Sustainable timber • Rainwater harvesting	• Photovoltaic panels
5. Outdoor Visitation Area	• Minimizing human disturbance • Enhancing natural habitats		• Sustainable timber	

1.3 Human Impact and Restoration of Natural Habitats

▲ Floating pedestrian boardwalks

Environmental sustainability
According to architect William McDonough, the ideal of sustainable architecture is to frame design as 'a beneficial, regenerative force—one that seeks to create ecological footprints to delight in, not lament.' Human activity is sustainable only when it can be performed or maintained indefinitely without depleting natural resources or degrading the natural environment, and many new design projects seek to make this possible.

1.3.1 Master Planning and Landscaping Work

Human impact on the environment: Minimizing human disturbance
The park serves as a natural habitat as well as for educational and tourism purposes, and so the park must protect wildlife from being disturbed by visitors . The master planning of the park contributes by

- locating the visitor centre near the main road while the outer habitat areas remain remote from urban development
- providing fixed and floating pedestrian boardwalks to minimize human impact on the habitats
- planting along the access path provides screening and habitat for the wildlife

▲ Isolating walkways protect wildlife

▲ Intertidal mudflat
© Hong Kong Wetland Park

Sustainable development: Enhancing natural habitats
At the wetland reserve, landscape work creates natural habitats for indigenous animal species to provide food, shelter and nursery areas for a number of birds, fish and aquatic invertebrates. The park also seeks to attract migratory birds, especially waders. The habitats are ecologically sustainable. Natural Habitats includes:

- Freshwater marshes
- Mangroves
- Intertidal mudflat
- Reed marshes
- Woodland

All the existing trees and many other plants from the site were either preserved or transplanted. Native wetland plants species are used extensively.

Hong Kong Wetland Park Habitat Management Plan:
http://www.wetlandpark.com/images/wcms/HKWP_Habitat_Management_Plan_on_Website_20111124.pdf

▲ Native wetland plants

Sustainable construction is defined as "the creation and responsible management of a healthy built environment based on resource efficient and ecological principles".

— the World Commission on Environment and Development, 1987

1.3.2 Architectural Design Features

Sustainable Development

Using resources from renewable sources

1. Sustainable timber
   Timber from identified renewable sources is used throughout the whole project as louvres to provide shading for the buildings and external landscaping work.

   Where to see: Ticket Office, Visitor Centre, Satellite Building, bird hides, outdoor boardwalks

2. Rainwater harvesting
   The design of the Satellite Building is tailored for collecting rainwater for flushing purposes.

   Where to see: Satellite Building, bird hides

Reducing use of natural resources

1. Water-efficient fixtures
   Low capacity, 6-litre water closets are used to reduce water consumption for toilet flushing.

   Where to see: Visitor Centre

2. Recycling lake water
   Water feature in the park uses recycled lake water.

   Where to see: Ticket Office

3. Rain sensors
   Rain sensors are used for the automatic irrigation system.

   Where to see: greenery around Visitor Centre

▲ Various recycled materials are used in the buildings of HKWP
©Architectural Services Department

▲ Sustainable timber and rainwater harvesting in bird hides

▲ Louvres at the Ticket Office are made from responsibly harvested timber

Pollution control

Recycling and reusing construction and industrial waste

Hong Kong Wetland Park makes use of materials that are recycled or reused from other building sites.

1. **Recycled granite paving**
   The recycled granite paving around the Visitor Centre is originally from the walls of the old Hong Kong Police Headquarters.

   Where to see: Visitor Centre

2. **Recycled crushed concrete**
   For the site formation work, approximately 5000 tonnes of recycled crushed concrete were used. At the piling work and superstructure work, approximately 10,3000 tonnes of recycled crushed concrete were used.

   Where to see: Visitor Centre

3. **Recycled aggregates and rock fill**
   The Wetland Park is the first building in Hong Kong to make use of concrete incorporating recycled aggregates, including some 5600 tonnes obtained from the recycling plant at Tuen Mun Area 38.

   Where to see: Visitor Centre

4. **Oyster shell infill walls**
   Oyster shell walls were made of the abandoned oyster shells collected from nearby oyster farms in Lau Fau Shan. The walls help screen sunlight, which minimizes solar heat gain.

   Where to see: Visitor Centre

5. **Recycled Chinese bricks**
   Recycled Chinese bricks, taken from demolished traditional village houses, are used for the brick wall on the south face of the Visitor Centre and the Ticket Office. The wall screens the building from direct sunlight, minimizing solar heat gain.

   Where to see: Ticket Office, Visitor Centre

▲ Oyster shell infill wall

▲ Reused Chinese bricks outside the Ticket Office

Pollution control construction methods

Construction can cause water, air and noise pollutions to the surrounding area. It is essential to control potential hazards resulting from the construction process, especially in areas near natural habitats.

Noise and air pollution controls: Jacking machines and hydraulic hammers were used to mitigate noise and air pollution in the foundation works.

Water pollution control: To avoid any contamination to the existing lakes and water bodies during construction, a temporary double sheet pile barrier was installed to segregate the Visitor Centre from the water. A portable cofferdam system was used to allow construction of the boardwalks to proceed with the minimum environmental disruption, avoiding the need to drain any of the lakes whilst avoiding any incidence of pollution. Clay bunds were laid at the ends of an existing tidal channel to segregate the construction from the channel.

[On-site Exercise: Human Impact and Restoration of Natural Habitat]

Biology students should work individually to find out how HKWP contributes to the conservation and sustainable development of Mai Po Wetland. The following principles should be considered:

- Human impact on the environment
- Pollution control
- Sustainable development of the local ecological system

Students should observe the surroundings during the field trip, record any findings on site and hand in a report after the field trip.

Equipment needed: camera, pencil, notebook

Teaching Tips
Teachers are advised to analyse students' findings and give supplementary information.

Due to the nature of HKWP, teachers are suggested to combine other relevant topics under the subject Biology. Other ecological survey activities are appropriate.

Applied Approaches in conserving the ecology of Mai Po Wetland		
Human impact on the environment		What environmental approach can you see? Pedestrian Boardwalks Where can you find it? Outdoor Visitation Area How can it help conserving the ecology? Providing pedestrian boardwalks to minimizing human traffic through the habitats
		To be finished by students

1.4 Energy Efficiency in Buildings

1.4.1 Energy Efficiency in Buildings

There are two major ways to increase energy efficiency in a building:

- Use renewable energy
- Reduce energy consumption

An energy-efficient building can

- Lower greenhouse gas emissions
- Minimize waste heat generated to the surroundings
- Reduce operation and maintenance costs in the long term

Geothermal Heat Pump Air-Conditioning System

1. Geothermal Heat Pump Air-conditioning (GHP A/C) System
   Visitor Centre makes use of a GHP A/C System. This system has multiple advantages: it requires no visible, noisy A/C plant outside the building and it gives the project architect greater flexibility in designing the building façades. More importantly, it uses the steady temperature of the earth as a renewable energy source. In this system, the ground serves as a large heat sink and there is no direct rejection of waste heat into the atmosphere. In summertime, the condensing water from the A/C units is used for temperature and humidity control. Surplus heat energy, if any, is rejected to the ground via buried water pipes. In wintertime, heat is extracted from the ground to provide heating for the building.

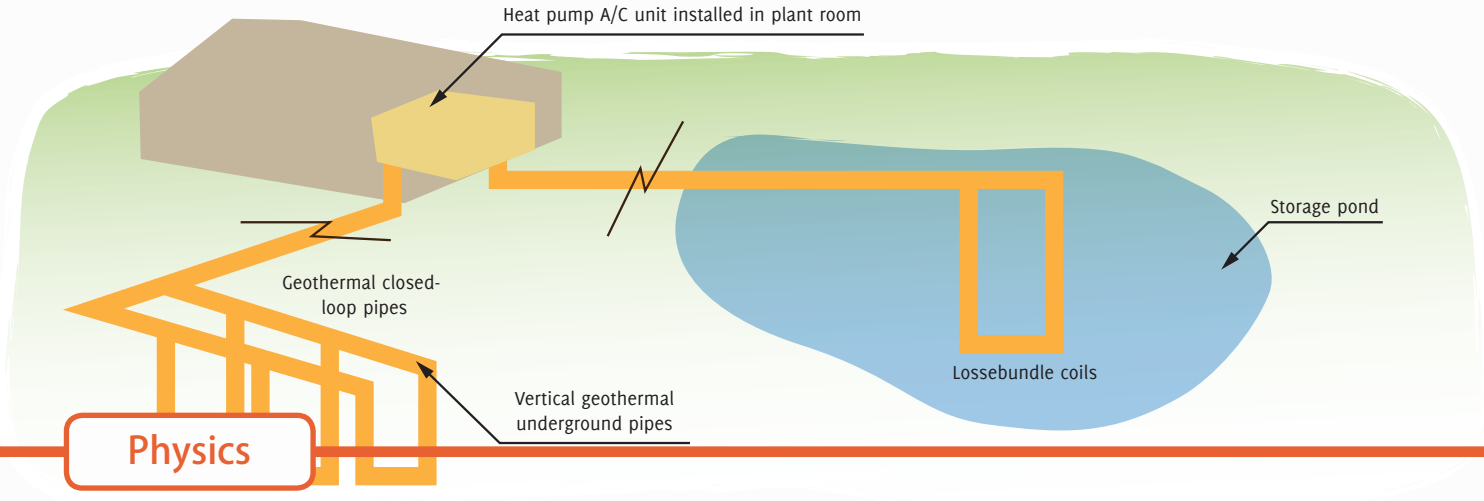
Problems caused by typical air-conditioning systems

The most commonly employed refrigeration systems for air-conditioning installations in Hong Kong are either air-cooled or water-cooled. The heat energy generated by these systems is usually dissipated either directly into the atmosphere, into a watercourse, or into a re-circulating water system and then to the atmosphere. These arrangements not only waste energy but also induce adverse effects to the environment. In addition, noisy refrigeration plants such as air-cooled condensers or cooling towers are often visible from the outside of a building and sometimes require expensive acoustical and architectural treatments.

Where to see: Visitor Centre
(Source: Architectural Services Department)

▼ Geothermal Heat Pump Air-conditioning System

Conceptual schematic diagram of Geothermal Heat Pump A/C System for The Hong Kong Wetland Park



2. Photovoltaic panels
Photovoltaic (PV) cells convert energy from sunlight photons directly into electricity without mechanical parts. The panels generate electricity for oscillating fans in the bird hides.

Where to see: Bird Hides

▲ Photovoltaic panels in bird hides © Hong Kong Wetland Park

▼ The green roof of the Visitor Centre effectively reduces the cooling load on the building. © Hong Kong Wetland Park

Reducing energy consumption

1. Green roof and exterior wall
The green roof and exterior walls reduce heat gain effectively through the building envelope. The Visitor Centre achieves an energy efficiency performance of approximately OTTV 16 W/m^2. Greenery can remove the heat gain via evaporation and thus the building is cooled down.

Where to see: Ticket Office, Visitor Centre, Satellite Building

2. Natural lighting
Skylights are installed to bring in natural illumination, lowering power consumption.

Where to see: Visitor Centre, Satellite Building

▲ Skylights in the atrium of the Visitor Centre

Teaching Tips
About the impacts caused from the pollutants, information can be obtained from Science Topic 8 'VIDEO: Urban Heat Island'.
Also, about the calculation of the Overall Thermal Transfer Value, reference can be made on Science Topic 06 'Calculation and Application of Overall Thermal Transfer Value (OTTV) and U-value'.

3. Natural ventilation
   High ceilings and elevated windows facilitate natural ventilation. Sustainable timber louvres allow natural ventilation through the buildings.

   Where to see: Ticket Office, Visitor Centre, Satellite Building

4. Shading device
   Sustainable timber screens and louvres are used to minimize solar heat gain.

   Where to see: Ticket Office, Visitor Centre, Satellite Building

5. Sun-shading glass
   High shading performance glazing is used to reduce solar gain inside the building.

   Where to see: Visitor Centre

6. Sensors for air quality and lighting quality
   - Wind sensors for toilet ventilation
   - CO_2 sensors for fresh air supply
   - Photo sensors for the lighting system
   - Occupancy sensors for office lighting

   Where to see: Visitor Centre, Satellite Building

▲ Deep overhang on the roof to shield sunlight

▲ Wooden vertical screens with horizontal louvres installed at the perimeter of the Visitor Centre to screen out sunlight so as to reduce solar heat gain

High ceilings and elevated windows in Satellite Building facilitate natural ventilation.

7. Electricity saving devices
   Variable Voltage Variable Frequency drive is used in the lift installation

   Where to see: Visitor Centre

8. Circulation design
   Circulation ramps encourage visitors to walk instead of using escalators and mechanical lifts.

   Where to see: Visitor Centre

9. Building Orientation
   Buildings are not directly south-facing. The form of the roof construction works with the careful orientation of the building to minimize solar gain.

   Where to see: Visitor Centre

▲ Circulation ramp

▼ The orientation of the Visitor Centre allows sufficient natural light without excess heat gain from sunlight.

[On-site Exercise: Energy Efficiency in Buildings]

Physics students are divided into four groups. Each group examines the building performance of one of the following buildings:

- Ticket Office
- Visitor Centre
- Satellite Building
- Bird hides

Students should fill in the below worksheet, share their findings on site and hand in the report after field trip.

Equipment needed: thermometer, camera, pencil, notebook

Teaching Tips
Teachers are advised to analyse students' findings and give supplementary information.

Name of HKWP buildings that adopt energy efficiency approaches: Visitor Centre

Building Assessment

Outdoor temperature: 32 degrees Celsius

Indoor temperate: 24 degrees Celsius

Outdoor and indoor temperature difference: -8 degrees Celsius

Lighting: Too bright / Sufficient / Too dark

Indoor Comfort: Too hot / Comfortable / Too cold

Energy Saving Feature

© Hong Kong Wetland Park

What is the architectural feature:
Green Roof

How can it help in energy efficiency:

The green roof can reduce heat gain of the building from the sun. Therefore, interior of the building is cooler than the outside of the building.

To be finished by students

[Discussion]

1 What is the positive influence of the wetland reserve on the natural surroundings?

Possible perspectives
To provide varied wetland habitats with enhanced ecological functions to replace those habitats lost during the development of Tin Shui Wai, and to attract different species to rest in the wetland.
It also acts as a buffer between the Tin Shui Wai development and the Mai Po Marshes which can reduce disturbances to birds, thus enhancing the ecological function of the Mai Po Marshes.

2 Which do you think is the most creative sustainable construction in HKWP?

Possible perspectives
The use of oyster shells to construct the walls screening sunlight is very creative; the atrium has a lot of skylights which makes the area very bright and pleasant; the use of Chinese old bricks on the south face of the Visitor Centre and the Ticket Office is beautiful and also helps to make the interior cooler.

3 What are the economic and environmental considerations of green technologies? Which do you think is more important?

Possible perspectives
When installing green technology, we should consider the long term effects instead of the short term economic returns. Usually the installation of green technology is very costly. It can only provide a little electricity and save a little money yearly. For instance, a tensile photovoltaic (PV) system can be installed on the roof of a building for transferring solar energy to electricity which helps saving 3000 dollars per year. However, the cost of the PV system is so high that it takes 224 years to payback. Nevertheless, the long term effect towards the environment is incalculable and significant, which is more important.

Alternatively, we can adopt passive environmentally friendly design, such as orientation of buildings, high ceiling and cross ventilation windows. These features are low cost and able to reduce the environmental impacts during energy consumption.

Teaching Tips
To learn more about environmental issues related to architecture, please refer to Liberal Studies Topic 07 'VIDEO: Environmentally Friendly Green Buildings', Arts Topic 05 'VIDEO: Form and Space in Architecture' and Design and Applied Technology Topic 05 'VIDEO: Sustainable Architecture'.

Summary

Hong Kong Wetland Park sets a role model for conservation of our natural ecology through environmentally friendly design. It showcases:

- how human impacts on the environment can be minimized,
- how natural habitats can be restored,
- how to reduce pollution, and
- how to minimize the use of energy,

via thoughtful master planning and architectural design.

Key words

Sustainable development
Energy efficiency
Renewable materials
Renewable energy
Geothermal energy
Photovoltaic

Further reading

1. 'Our Sustainable Practices–Case Study One – Hong Kong Wetland Park', *Sustainability Report 2006*. Architectural Services Department (ArchSD), 2006. ‹http://www.archsd.gov.hk/english/reports/sustain_report_2006/e/our_sustainable.html›.

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