Improving energy efficiency of existing buildings in Hong Kong

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Earth Hour 地球一小時
Introduction

• Buildings in Hong Kong
  • Account for 90% of the electricity used and over 60% of the carbon emissions

• Improving the energy efficiency of existing buildings is crucial for long-term sustainability
  • Also provide economic and environmental benefits to the building owners and users

• Energy Saving Plan for Hong Kong
  • Reduce energy intensity by 40% by 2025
Enhanced tax incentive to promote renewable energy and building energy efficiency

• Starting from the 2018-19 financial year, capital expenditure on related installations can be fully deducted in the first year of purchase, instead of five years as currently stipulated
• The building must be registered under the EMSD’s voluntary Energy Efficiency Registration Scheme for Buildings
• They must also reach specified standards under a green building certification system

(Source: http://www.info.gov.hk/gia/general/201803/01/P2018030100661.htm)
Relative energy saving priorities for different types of buildings in Hong Kong

<table>
<thead>
<tr>
<th>Commercial &amp; Institutional Buildings</th>
<th>Residential Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building design and structure</td>
<td>Appliances occupants choose to use</td>
</tr>
<tr>
<td>Occupants’ behaviour</td>
<td>2 Occupants’ behaviour</td>
</tr>
<tr>
<td>Appliances occupants choose to use</td>
<td>3 Building design and structure</td>
</tr>
</tbody>
</table>

(Source: Environment Bureau, 2017. Deepening Energy Saving in Existing Buildings in Hong Kong Through ‘4Ts’ Partnership.)
Energy efficiency

- For new buildings
  - Designing the building
    - Design strategy
    - Control strategies
    - Commissioning
- For existing buildings
  - Operating and upgrading the building
    - Building management
    - Refurbishment/renovation/retrofitting
    - Maintenance and monitoring
Lifecycle of a building and importance of existing buildings

Most significant impacts during the building in use.

New buildings will become existing buildings when completed.

(Source: World Resources Institute, http://publications.wri.org/buildingefficiency/)
### Stakeholder roles and engagement to enhance building efficiency

<table>
<thead>
<tr>
<th>Stakeholder Group</th>
<th>NEW BUILDINGS</th>
<th>EXISTING BUILDINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Land Use/Planning</td>
<td>Sale or Lease</td>
</tr>
<tr>
<td>Local governments</td>
<td>Design &amp; construction professionals</td>
<td>Buildings owners and managers</td>
</tr>
<tr>
<td>Developers and self-help builders</td>
<td>National and provincial governments</td>
<td>Design &amp; construction professionals</td>
</tr>
<tr>
<td></td>
<td>Construction</td>
<td>Tenant Build-Out</td>
</tr>
<tr>
<td></td>
<td>Design &amp; construction professionals</td>
<td>Buildings owners and managers</td>
</tr>
<tr>
<td></td>
<td>Building investors</td>
<td>Building occupants</td>
</tr>
<tr>
<td></td>
<td>Suppliers &amp; manufacturers</td>
<td>Design &amp; construction professionals</td>
</tr>
<tr>
<td></td>
<td>Building occupants</td>
<td>Energy utilities</td>
</tr>
</tbody>
</table>

- Buildings owners and managers
- Building occupants
- Design & construction professionals
- Energy utilities

(Source: World Resources Institute, http://publications.wri.org/buildingefficiency/)
Energy efficiency

- Barriers to energy efficiency:
  - **Market**: split incentives, price distortion, low energy tariffs
  - **Financial**: limited internal capital & operational budgets, high upfront costs, dispersed benefits
  - **Technical**: lack of affordable technologies or know-how suitable to local conditions
  - **Awareness**: lack of information & understanding
  - **Institutional**: energy utilities are compensated for selling energy, not efficiency
Energy efficiency

• An interesting article:
  • Why Energy Efficiency and Buildings Don’t Mix
  • 5 friction points:
    • Income valuation & credibility gap (developer-owner)
    • Seniority concerns/loan restrictions (owner-lender)
    • Split incentives (owner-occupant)
    • Capital priorities/perverse incentives (owner-manager)
    • Tenant comfort vs. energy management (occupant-manager)
Real estate industry interfaces and energy efficiency ‘friction points’

Energy efficiency

• Strategies to improve energy efficiency of existing buildings:
  • Measure and assess energy performance
  • Set up goals and targets
  • Understand energy use and end-use/system energy
  • Select energy efficiency measures
  • Refine financial analysis
  • Establish priorities
Examples of energy saving measures in an educational institute

Automatic on-off for lighting and fan coil units in classrooms

Fan coil unit group control and usage control

Replacement of existing chillers with better energy performance options

CO2 sensor and Variable Speed Drive for Primary Air-Handling Units

Automatic sensing device

T5 light fitting

(Source: http://sustainability.hkbu.edu.hk/index.php/wwrd/listing/cid/2/p/1.html)
Examples of energy saving measures in an educational institute (cont’d)

- Occupancy sensors for toilet
- Campus lighting review and adjustment
- LED exit signs
- LED outdoor lighting
- Water-cooled air-conditioning systems
- Lamp replacements

(Source: http://sustainability.hkbu.edu.hk/index.php/wwrd/listing/cid/2/p/1.html)
Hong Kong situation

- Energy end-use in HK (trend in 1984-2015)
  - Commercial sector: increases at 5% per year
  - Residential sector: increases at 3.5% per year
- Average consumption: (examples)
  - Office: 265 kWh/m²/year
  - Hospital: 200 kWh/m²/year
  - Post office: 170 kWh/m²/year
- How to control/manage this?
Energy end-use in Hong Kong by sectors, 1984-2015

(Data source: EMSD)
What are the major energy usages?

Energy consumption patterns in offices and retails
(Data source: Energy Efficiency Office, HK)
The Buildings Energy Efficiency Ordinance

(Source: EMSD)

(See http://www.beeo.emsd.gov.hk for details)
Energy efficiency labels in HK

Figure 4.8 Examples of mandatory energy efficiency labels in Hong Kong

Figure 4.9 Examples of voluntary energy efficiency labels in Hong Kong

(Source: www.energylabel.emsd.gov.hk)
BEAM Plus Existing Buildings (EB)

(Source: Hong Kong Green Building Council https://www.hkgbc.org.hk/)
Major considerations

- Leadership & building ownership
  - Vision of senior management
  - Commitment of the owner

- Energy management
  - Building operation, maintenance & retrofits

- Energy efficiency culture
  - Energy efficient behaviours
  - Building occupants & users
Building ownership

- Improve the insulation and reduce fenestration
- Regular asset management
- Implement best practice guidelines

Leadership

Building management perspective

- Set BMP & benchmarks
- Monitor energy use and take corrective action if necessary
- Advertise the success of the energy projects

Energy management

Building occupants/User perspective

- Energy efficient behaviour
- Support energy efficient culture
- Corporative commitment towards energy efficiency

Energy efficiency culture

Reduced energy costs

- Improved asset value
- Energy rebates/incentives
- Energy consumption reduction
- Emission reduction from generation

Economic value creation

Superior environmental performance

Improved public image of the organization

(Source: Renewable and Sustainable Energy Reviews, Volume 53, January 2016, Pages 1032-1045)
Major considerations

• Key persons in building energy efficiency
  • Building Developer or Owner (Client)
  • Architect
  • Building Services Engineer
  • Building/Facility Manager
  • End-Users
Good design practices

Integrated & total energy approach

Good housekeeping

User education & awareness

Efficient systems

Efficient operation
Major considerations

- **Occupant involvement**
  - Motivation and training
    - Managing PEOPLE
  - Occupant satisfaction
    - Comfort, health and safety of the occupants
    - Securing understanding and involvement of occupants
Major considerations

- **Planning maintenance**
  - Maintenance policy
  - Types of maintenance
    - Reactive or breakdown maintenance
    - Planned preventative maintenance
- **Maintenance contracts**
  - Performance specification
  - Use of maintenance contractors
Major considerations

- **Monitoring maintenance**
  - Maintenance records
    - Installation records: e.g. O&M manuals, plant details
    - Service records: include log sheets, job records, etc.
  - Checking maintenance standards
    - Such as breakdown frequency
    - Annual spend on building services maintenance
- **Post-occupancy evaluation (POE)**
  - Obtaining feedback on a building's performance in use
Major considerations

- **Good housekeeping**
  - Such as switch off lights when not needed
- **Maintaining for energy efficiency**
  - Building fabric
  - Controls
  - Heating ventilation & air conditioning systems
  - Refrigeration systems
  - Lighting systems
  - Motors and drives
Major considerations

- **Refurbishing existing buildings**
  - Complete refurbishment
    • Total replacement of plant & major changes to fabric
  - Major refurbishment
    • Replacement of major plant & some changes to fabric
  - Minor refurbishment
    • Refitting the interior & making minor alterations to space layout and plant
  - Passive refurbishment
    • Passive methods: daylighting & natural ventilation
Major considerations

- **Retrofitting energy saving measures**
  - Identify high energy users
  - Establish the potential for energy saving through measurement, audits etc.
  - Identify practicable measures to achieve savings
  - Establish the financial case for introducing these measures, as well as other benefits
  - Implement the savings in a planned way
  - Monitor the savings to confirm
Major considerations

- **Retro-commissioning (RCx)**
  - A way for system optimization
  - Systematic process to periodically check an existing building’s performance
  - Resume the system efficiency back to design standard
  - Help identify operational improvements that can save energy
    - Review of building operation & original intended design; improvement & optimization

(Source: http://www.energysaving.gov.hk/en/retro_commissioning_rcx/)
A systematic approach to energy management

- **Get Commitment** (of top management)
- **Implement, Control and Monitor** (prioritise)
- **Plan and Organise** (policy, targets, roles)
- **Understand** (by energy audit, survey or studies)

*Energy audit* is a critical step for energy management
Energy management skills

• What is Energy Audit (能源審核)?
  • Examination of an energy system or equipment to ensure that energy is being used efficiently
  • Process to check for areas of inefficiency
  • It is a top-down initiative. Its result depends on the resources being allocated by top management
  • Aims to identify energy management opportunities (EMO) & means for improvement
  • In many ways, an energy audit is similar to financial accounting and auditing
Energy management skills

- Overview of energy audit
  - Collection and analysis of relevant information that may affect building energy consumption
  - Review the information, analyse the conditions and performances of existing equipment, systems and installations, and the energy bills
  - Compare with performances at relevant energy efficient modes of operation
  - Identify areas of energy inefficiency and the means for improvement
Energy management skills

• Two common types of energy audits:
  • **General walk-through audit**
    • Limited resources
    • Focus on major energy consuming equipment
    • Give an overview of potential saving options
    • Could identify areas for further investigation
  • **Detailed audit (full audit)**
    • More resources
    • Detailed planning
    • Practically investigating all equipment & systems
Energy management skills

- **Investment grade audit (IGA)**
  - Expand on the detailed audit
  - Analyses the financial aspects of energy savings and the return on investment (ROI) from potential changes or upgrades
  - Aim to justify the energy investment
  - Rely on a complete engineering study in order to detail technical and economical issues
Energy management skills

- Levels of effort of energy audit (ASHRAE)*
  - Preliminary Energy-Use Analysis (PEA)
  - Level 1 – Walk-Through Analysis
  - Level 2 – Energy Survey and Analysis
  - Level 3 – Detailed Analysis of Capital-Intensive Modifications
- Also, Targeted Audits (of a specific system or end use, such as the chiller plant)

Relationship of energy audit levels 1, 2, and 3

Level 1: Walk-through
- Rough Costs and Savings for EEMs
- Identify Capital Projects

Level 2: Energy Survey & Analysis
- End-use Breakdown
- Detailed Analysis
- Cost & Savings for EEMs
- O&M Changes

Level 3: Detailed Survey & Analysis
- Refined analysis
- Additional Measurements
- Hourly Simulation

Energy audit level summary: Process

<table>
<thead>
<tr>
<th>Process</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduct Preliminary Energy Analysis (PEA)</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Conduct walk-through survey</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Identify low-cost/no-cost recommendations</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Identify capital improvements</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Review M&amp;E design, condition and O&amp;M practices</td>
<td></td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Measure key parameters</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Analyse capital measures (savings &amp; costs including interaction)</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Meet with owner/operators to review recommendations</td>
<td></td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Conduct additional testing/monitoring</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Perform detailed system modeling</td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Provided schematic layouts for recommendations</td>
<td></td>
<td></td>
<td>●</td>
</tr>
</tbody>
</table>

## Energy audit level summary: Report

<table>
<thead>
<tr>
<th>Report</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Estimate savings from utility rate change</td>
<td>●</td>
</tr>
<tr>
<td>Compare EUI (energy use index) to that of similar sites</td>
<td>●</td>
</tr>
<tr>
<td>Summarize utility data</td>
<td>●</td>
</tr>
<tr>
<td>Estimate savings if EUI met target</td>
<td>●</td>
</tr>
<tr>
<td>Estimate low/cost / no-cost savings</td>
<td></td>
</tr>
<tr>
<td>Perform detailed end-use breakdown</td>
<td></td>
</tr>
<tr>
<td>Estimate capital project costs and savings</td>
<td></td>
</tr>
<tr>
<td>Complete building description and equipment inventory</td>
<td></td>
</tr>
<tr>
<td>General description of considered measures</td>
<td></td>
</tr>
<tr>
<td>Recommended M&amp;V (measurement &amp; verification) method</td>
<td></td>
</tr>
<tr>
<td>Financial analysis of recommended EMOs</td>
<td></td>
</tr>
<tr>
<td>Detailed description of recommended measures</td>
<td></td>
</tr>
<tr>
<td>Detailed EMO cost estimates</td>
<td></td>
</tr>
</tbody>
</table>

Defining Scope of Energy Audit

Forming Energy Audit Team

Estimating Time Frame and Budget

Collecting Building Information

Conducting Site Inspection and Measurement
  - Strategic measuring points
  - Instrumentation

Analysing Data Collected
  - Identification of energy management opportunities
  - Costing
  - Normalisation of data
  - Maintain thermal and lighting comfort
  - Already scheduled maintenance and refurbishment works

Preparing Energy Audit Report

Implementation of Energy Management Opportunities

Monitoring and Review
Typical structure of an energy audit report

Executive Summary
- Overview of the audit, EMOs identified
- Recommended actions, briefing on implementation plan

Introduction and Building Information
- Objectives, energy audit scope, audit team
- Building characteristics (type, floor areas, operation)

Description of the Equipment/Systems Audited
- System types, capacity ratings, zoning, operation hours etc.

Energy Data and Survey Findings
- Historical energy consumption of the building
- System performance evaluation, O&M practices

Energy Management Opportunities
- Identification & evaluation of potential EMOs
- List of recommended EMOs and implementation plan

Conclusions and Recommendations
Energy management skills

• Energy performance contracting (EPC)
  • = energy savings performance contracting
  • A financing technique to raise money for energy efficiency investments based on future savings

• Energy services companies (ESCO)*
  • Offer EPC services, without upfront capital on building owners
  • Becoming an important trend in many countries like USA and Japan

Basic concept of energy performance contracting (EPC)
ESCO (Project Developer) → Capital → Financier (Secured Party) → Payments → Customer (Project Owner) → Fees → Energy services and savings guarantee → Finance contract (lease or loan) → ESCO

Financial structure used by ESCO
Energy saving technologies

• **Energy information system** 能源信息系統
  - Better data and reporting
  - Inexpensive sub-metering
  - Wireless devices + remote assessment

• **Energy data analytics**
  - “Big Data (energy)”
  - Monitoring and assessment
  - Software and cloud services
An example of energy dashboard for buildings

建築能源儀表板的例子

(Source: https://hbsmicrosites.honeywell.com)
Example of analysing the electricity billings

### Electricity Consumption Data

**Location:** ABC Facility

<table>
<thead>
<tr>
<th>Billing Date</th>
<th>Metered kVA</th>
<th>Metered kW</th>
<th>Power Factor</th>
<th>Billed Energy kWh</th>
<th>Days</th>
<th>Daily kWh</th>
<th>Load Factor</th>
<th>Demand Cost</th>
<th>Energy Cost</th>
<th>Adjust (+/-)</th>
<th>Sub Total</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/01/99</td>
<td>1,800.0</td>
<td>1,800.0</td>
<td>1,006,703</td>
<td>30</td>
<td>33.577</td>
<td>78%</td>
<td>$21,250</td>
<td>$50,365</td>
<td>($11,147)</td>
<td>$71,615</td>
<td>$64,701</td>
<td></td>
</tr>
<tr>
<td>02/01/99</td>
<td>1,900.0</td>
<td>1,900.0</td>
<td>1,206,383</td>
<td>31</td>
<td>38.916</td>
<td>85%</td>
<td>$22,750</td>
<td>$56,441</td>
<td>($9,203)</td>
<td>$71,945</td>
<td>$70,607</td>
<td></td>
</tr>
<tr>
<td>03/01/99</td>
<td>1,400.0</td>
<td>1,400.0</td>
<td>1,102,176</td>
<td>31</td>
<td>35.554</td>
<td>80%</td>
<td>$22,000</td>
<td>$53,315</td>
<td>($12,132)</td>
<td>$75,315</td>
<td>$67,606</td>
<td></td>
</tr>
<tr>
<td>04/01/99</td>
<td>1,870.0</td>
<td>1,870.0</td>
<td>1,213,021</td>
<td>30</td>
<td>40.434</td>
<td>90%</td>
<td>$22,300</td>
<td>$56,641</td>
<td>($13,252)</td>
<td>$79,941</td>
<td>$70,287</td>
<td></td>
</tr>
<tr>
<td>05/01/99</td>
<td>2,200.0</td>
<td>2,200.0</td>
<td>1,339,599</td>
<td>31</td>
<td>43.213</td>
<td>82%</td>
<td>$27,250</td>
<td>$60,438</td>
<td>($14,716)</td>
<td>$87,688</td>
<td>$80,080</td>
<td></td>
</tr>
<tr>
<td>06/01/99</td>
<td>1,560.0</td>
<td>1,560.0</td>
<td>850,195</td>
<td>30</td>
<td>28.340</td>
<td>76%</td>
<td>$17,650</td>
<td>$42,540</td>
<td>($9,438)</td>
<td>$60,190</td>
<td>$54,304</td>
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<tr>
<td>07/01/99</td>
<td>1,570.0</td>
<td>1,570.0</td>
<td>948,747</td>
<td>30</td>
<td>30.605</td>
<td>81%</td>
<td>$17,800</td>
<td>$47,467</td>
<td>($10,429)</td>
<td>$65,267</td>
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<td>1,950.0</td>
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<td>39.155</td>
<td>84%</td>
<td>$23,500</td>
<td>$56,664</td>
<td>($15,111)</td>
<td>$86,412</td>
<td>$76,699</td>
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<td>2,300.0</td>
<td>2,300.0</td>
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<td>45.768</td>
<td>83%</td>
<td>$28,750</td>
<td>$61,442</td>
<td>($13,308)</td>
<td>$90,192</td>
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<td>10/01/99</td>
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<td>2,100.0</td>
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<td>31</td>
<td>43.454</td>
<td>86%</td>
<td>$25,750</td>
<td>$60,662</td>
<td>($14,731)</td>
<td>$86,412</td>
<td>$76,699</td>
<td></td>
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<td>11/01/99</td>
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<td>2,400.0</td>
<td>1,024,475</td>
<td>30</td>
<td>34.149</td>
<td>59%</td>
<td>$30,250</td>
<td>$50,984</td>
<td>($11,685)</td>
<td>$81,234</td>
<td>$74,418</td>
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<tr>
<td><strong>Totals/Max</strong></td>
<td><strong>2,400.0</strong></td>
<td><strong>2,400.0</strong></td>
<td><strong>13,467,496</strong></td>
<td><strong>364</strong></td>
<td><strong>339,577</strong></td>
<td><strong>78%</strong></td>
<td><strong>$274,500</strong></td>
<td><strong>$639,104</strong></td>
<td><strong>($148,415)</strong></td>
<td><strong>$913,604</strong></td>
<td><strong>$818,752</strong></td>
<td></td>
</tr>
</tbody>
</table>

(Source: Department of Minerals and Energy, South Africa)
Cloud-based energy and sustainability analytics for buildings

Navigator – the cloud-based energy and sustainability platform
Turning data into results across your entire building portfolio

Data analysis
Apps to track energy & sustainability KPIs

Data connection and collection
Gathering the data you need

Leverage transparency
Make insight-based decisions with self-service dashboards

Uncover opportunities
Take action to optimize your buildings

High-performing building

Data-driven services from Siemens

Energy saving technologies

• Intelligent devices 智能設備
  • Intelligent lighting fittings
  • High efficient systems
  • Smart meters

• Smart operation 智能操作
  • Demand control/response
  • Energy recovery
  • Variable speed/frequency
Evolution of lighting technology

Edison lamp
愛迪生燈

Incandescent lamp
白熾燈

Compact fluorescent lamp
緊湊型熒光燈

LED lamp
發光二極管燈

OLED lighting
有機發光二極體照明
Intelligent luminaires have the potential to integrate various sensors.

智能燈具可能整合各種傳感器。

- 佔用傳感器
- 電錶
- 射頻識別
- 溫度傳感器
- 自然採光
- 保安

[Image Source: http://www.ledsmagazine.com]
Demand control ventilation

Demand Control
Reduces energy costs without compromising production, quality, or safety

Energy recovery system

Variable speed/frequency
THANK YOU 謝謝 !!