Performance Synergy from Integrated Design, Construction and Operation. Case Study on a High Performance Grade A Office – Swire One Taikoo Place

Presented by Dr. Vincent Cheng

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Sustainability Synergy
Sustainability Synergy in Building Design, Construction & Operation

- All-round sustainable and Green design high-rise
- Low carbon emission through whole building life cycle
- Exemplar 30% total energy saving against BEC baseline
- Verified design performance suits for occupants and operational needs
Integrated Design Approach

- Common Goal
- Early Involvement of “Full Team”
- Care of User Needs
- Operational Consideration
- Enhanced Communication Channel
- Benchmarking and Target Setting
# Integrated Design Approach

## Design Charettes & Coordination Workshops

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<th>Sustainability idea input</th>
<th>Cross pollination of ideas &amp; experience</th>
<th>Design requirement:</th>
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<td>Project Manager</td>
<td>Local &amp; global benchmarks</td>
<td>• Measurable against goals</td>
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<td>Operation Staff</td>
<td>Landmark / Icon</td>
<td>• Environmental-responsive</td>
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<td>Building users</td>
<td>Strengths / weaknesses</td>
<td>Operational requirement:</td>
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<tr>
<td>Sustainability Consultant</td>
<td>Opportunities / threats</td>
<td>• Monitoring infrastructure</td>
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<td>Architect</td>
<td>Innovations</td>
<td>• Control</td>
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<td>MEP</td>
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<td>Structure &amp; Civils</td>
<td>Legislation</td>
<td>• Training or maintenance and operation staff</td>
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<td>Viability</td>
<td>• Budgets</td>
</tr>
<tr>
<td>Interior Designer</td>
<td>Buildability</td>
<td>• Lettability</td>
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### Building Design Target & Parameters

- **Resource requirement:**
  - • Energy consumption
  - • Carbon emissions
  - • Water consumption

- **Indoor environmental quality:**
  - • Natural light
  - • Air pollutants
  - • Staff contentment
  - • Acoustic requirements
  - • Ergonomics

- **Global benchmarks**
  - • LEED and BEAM
  - • Local Awards
  - • International Awards
Passive & Active Design
OTP – Energy Performance

- Adoption of 12 passive and active sustainable strategies
- 33% Saving Compare to BEAM Plus (Based on BEC Code 2012 as baseline)
- 28% Saving Compare to LEED (based on ASHRAE 90.1 2007)
- Energy use intensity = Lower than 150kWh per m² of GFA
High Performance Envelope (Passive)

Solar on Facade (before optimized)

The low zone of East Façade is partially shaded by surrounding building

Part of South Façade is shaded by One Island East

Shading Fin Design and Solar Heat Gain Reduction

700mm fin
- High zone

500mm fin
- Mid-zone

200mm fin
- Low zone

Ultimate OTTV ~15W/m² (equiv. to 2.6% bldg energy)
- External shading fins
- Optimized glazing of SC 0.19

1. Fins Profile
   - Maximize heat reflection to sky
   - Enhance drainage, avoid pooling/stains

2. Fins Angle
   - Maximize light transfer

Organizers:
- Construction Industry Council
- HKGBC
- SBE Series
- CIB
- II SB 10
- Global Alliance for Buildings and Construction
OTP – Active Energy Saving Strategies

Energy saving % shown is against BEC 2012

Efficient Office Lighting & Daylight Control
350lx design lux level
66% high LOR reflective fixture, 100lm/W efficacy T5
Wide lighting grid & 40% lighting energy saving

High Performance PV on Roof
PV coverage of 400 m2
Yearly solar radiation analysis with surrounding
Annual energy generation of 43,000kWh

EC Plug Fan in AHU & CO2 DCV
1.7W/L/s fan efficiency
(compared to 2.1W/L/s BEC2012)
Brushless EC motor
Higher efficiency during part-load
(5.7%)

Trigeneration & Adsorption Chiller
Biofuel combustion for electricity generation
Residual hot water for secondary cooling energy

Optimized Chiller and Plant Control System

Free Cooling & Air Economizer / Heat Recovery

Lift Regeneration & Destination Control

(0.3%)

(1.7%)

(9.7%)

(2.0%)

(0.3%)

(10.8%)
Chiller Optimization – Review on Existing Bldg

- Annual hourly cooling load analysis exhibits similar trend for OTP and OIE
- Daily cooling load characteristics for designing load-matching strategies and performance-based chiller and plant

Review of existing Swire building operation & cooling load profile and equipment performance to determine TKP2A target
Chiller Optimization – Plant Control

Optimised natural curve chiller sequencing
Building load and CDWT are monitored to compute optimum efficiency operating algorithm - dynamically adjusts chiller combination and load-sharing.

Chilled water loop 7/12°C

Condenser water loop 32/37°C

Annual chiller COP 7.79
(simulated achievement verified by supplier chiller offer)

VSD chiller COP performance curve

Annual chiller COP 7.79
(simulated achievement verified by supplier chiller offer)
Free Cooling & Air Economizer

Two AHUs at East facade

• Plants at side core reduce solar heat gain at east facade
• Side core design with individual air intake and exhaust
• Free cooling capable of delivering 50% AHU design flow
• Total operation approx. 1256 hrs in a year under part-load condition
Renewable – Waste to Energy
De-carbonising the city

- Utilise waste oil as feedstock
- Transform 135,000L/yr waste oil to biofuel

Sustainable cycle of low emission impact
• **Higher Effective Electric Efficiency** than local power utility (ref: USEPA)
• Energy Cascade: outputs 200kW power from B100 bio-diesel burning with simultaneous heat supplied to 140kW cooling adsorption chiller for chilled water generation and domestic hot water use
• Clean electricity – 2% annual building energy use (Offset 278 tons CO2 = 1400 trees)
OTP - Bio-diesel Tri-generation System (CCHP)

Negligible Air Pollution Impact

• Comply to EU Stage IV non-road engine emission standard
• Implement emission controls such as SCR, NOx filter
• Bio-diesel is sulphur-free

Emission Comparison
Microclimate & Outdoor Comfort
Taikoo Open Space

Enhance microclimate:
• Sufficient wind corridor
• Rich landscape & water feature

Air Ventilation Pattern under Annual Prevailing Wind

Urban Heat Island Index reduced by max 1.8°C compared to before Somerset’s demolition
Green Construction
Low Carbon Construction

<table>
<thead>
<tr>
<th>Waste Avoidance</th>
<th>Office furniture donation to NGOs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Recovery</td>
<td>Metal Recycling</td>
</tr>
<tr>
<td></td>
<td>Concrete Recycling</td>
</tr>
</tbody>
</table>

CONSTRUCTION & DEMOLITION RECYCLING 75%
20% RECYCLED MATERIALS
20% REGIONAL MATERIALS
Beyond Design – Performance Verification
Performance Verification

Design & Construction Stages

- Sharing of whole building cooling load profile to Chiller Manufacturers
- The best and highest technology chiller offer
- Chiller COP Performance verified with manufacturer

Pre-installation Stage

- Extensive FAT ensures quality and performance of final products installed

### Chiller Specifications

<table>
<thead>
<tr>
<th></th>
<th>Chiller 1</th>
<th>Chiller 2</th>
<th>Chiller 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiller model</td>
<td>19XRV7777E53MCA5</td>
<td>VSD WCC-1000RT CVHF1070</td>
<td>YKKCKRH95CVGS</td>
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<tr>
<td>CSD/VSD</td>
<td>VSD</td>
<td>VSD</td>
<td>VSD</td>
</tr>
<tr>
<td>Chiller capacity</td>
<td>1000 Ton</td>
<td>1000 Ton</td>
<td>1000 Ton</td>
</tr>
<tr>
<td>Chiller input</td>
<td>591 kW</td>
<td>549.5kW</td>
<td>610kW</td>
</tr>
<tr>
<td>Rated COP</td>
<td>5.95</td>
<td>6.4</td>
<td>5.77</td>
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<tr>
<td>Refrigerant</td>
<td>R-134a</td>
<td>R-123</td>
<td>R-134a</td>
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<tr>
<td>NPLV</td>
<td>0.098 kW/kW</td>
<td>0.0904 kW/kW</td>
<td>0.09957 kW/kW</td>
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<tr>
<td>Weight</td>
<td>23424 kg</td>
<td>24169 kg</td>
<td>20139 kg</td>
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<tr>
<td>Evaporator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHWET</td>
<td>12.5 °C</td>
<td>12.5 °C</td>
<td>12.5 °C</td>
</tr>
<tr>
<td>CHWLT</td>
<td>7.0 °C</td>
<td>7.0 °C</td>
<td>7.0 °C</td>
</tr>
<tr>
<td>Flow rate</td>
<td>152.8 L/s</td>
<td>152.2 L/s</td>
<td>152 L/s</td>
</tr>
<tr>
<td>Pressure drop</td>
<td>73.6 kPa</td>
<td>72.6 kPa</td>
<td>72.6 kPa</td>
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<tr>
<td>Fouling factor</td>
<td>0.01761</td>
<td>0.01761</td>
<td>0.0176</td>
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<tr>
<td>Condenser</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>CWET</td>
<td>37 °C</td>
<td>37 °C</td>
<td>37 °C</td>
</tr>
<tr>
<td>CWLT</td>
<td>32 °C</td>
<td>32 °C</td>
<td>32 °C</td>
</tr>
<tr>
<td>Flow rate</td>
<td>196.8 L/s</td>
<td>196.8 L/s</td>
<td>196 L/s</td>
</tr>
<tr>
<td>Pressure drop</td>
<td>68.6 kPa</td>
<td>84.3 kPa</td>
<td>93.5 kPa</td>
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<tr>
<td>Fouling factor</td>
<td>0.04403</td>
<td>0.044026</td>
<td>0.044</td>
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<tr>
<td>Compressor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rated load amps</td>
<td>1033</td>
<td>1115</td>
<td>1025</td>
</tr>
</tbody>
</table>

Figure 1 Cooling load pattern on a summer day (2 July)
Design Performance Verification

*Design & Construction Stage*
- Third-party Laboratory Test for lighting performance between different brands of luminaire
- Blind test for candidate screening

*Pre-installation Stage*
- Advanced Quality Assurance Plan with self testing during production
- Sampling for laboratory test on batches of delivery

### Testing parameters

<table>
<thead>
<tr>
<th>Luminaire</th>
<th>1. LOR (&gt;66%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Beam angle</td>
</tr>
<tr>
<td></td>
<td>3. Efficacy</td>
</tr>
<tr>
<td></td>
<td>4. Lumen output</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nano coating</th>
<th>5. Reflectance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6. Diffuse reflectance</td>
</tr>
<tr>
<td></td>
<td>7. Anti-UV aging period (10yrs)</td>
</tr>
</tbody>
</table>

![Diagram of testing parameters](image)

- **LOR** = light output ratio
- **Nano coat**
- **UV aging test**
- **Beam angle**
- **Power of reflected ray**
- **Laser Spot diameter < 2mm**
- **7mm**
- **6 mW 635nm Red light laser**
- **Power meter**
- **350lux**
- **0.7m**
- **Nano coating**
- **Anti-UV aging period (10yrs)**

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![Conference Logo](image)
Design Performance Verification

Indoor CFD to verify MVAC design on air flow supply and diffuser location

- Thermal Comfort – achieve design temperature $24^\circ C$ on 1m occupant level
- Distribution effectiveness for human comfort – no stagnant zone
- Acoustic comfort – minimized noise from system by controlling air velocity $< 2.5m/s$ at RA diffuser

**Air Flow Pattern for Office Floor**

**Temperature Profile for Office Floor**

- $2.3m/s$
- $\uparrow$ Avg. $24^\circ C$
Design Performance Verification

Solar Geometry Analysis for PV Panel for TKP2A

When PV panel tilts at >20° (current design), **NO GLARE** resulted in Winter

When PV panel tilts at >20° (current design), **NO GLARE** resulted in summer

When PV panel tilts at >30° (Not Preferred), **GLARE APPEARED** at top floor of OIE in summer afternoon

TKP2A and the Surrounding Building at Taikoo Place
Thank you
Integrated Design Approach

- Common Goal
- Early Involvement of “Full Team”
- Care of User Needs
- Operational Consideration
- Enhanced Communication Channel
- Benchmarking and Target Setting
3. Multi-parties Coordination

- Pollinate sustainability concepts and gather multi-parties to evaluate, consolidate and refine design.
- Apart from client, building users and operators are invited to commit with their concerns addressed to manifest TKP2A design throughout design charette, coordination workshops.

**Design requirement:**
- Measurable against goals
- Environmental-responsive

**Operational requirement:**
- Monitoring infrastructure
- Control
- Ongoing commissioning
- Training or maintenance and operation staff
- Budgets
- Lettability

**Resource requirement:**
- Energy consumption
- Carbon emissions
- Water consumption

**Indoor environmental quality:**
- Natural light
- Air pollutants
- Staff contentment
- Acoustic requirements
- Ergonomics

**Global benchmarks**
- LEED and BEAM
- Local Awards
- International Awards

**Building Design Target & Parameters**

- Landscape
- Interior Designer
- MEP
- Structure & Civils
- Architecture
- Sustainability Consultant
- Building Users
- Operation Staff
- Project Manager
- Sustainability idea input

**Cross pollination of ideas & experience**

**Sustainability idea input**

**Design requirement:**
- Local & global Benchmarks
- Landmark / Icon
- Strengths / weaknesses
- Opportunities / threats
- Innovations
- Future Trends
- Legislation
- Viability
- Buildability
- BIM

**Operational requirement:**
- Strengths / weaknesses
- Opportunities / threats
- Innovations
- Future Trends
- Legislation
- Viability
- Buildability
- BIM

**Resource requirement:**
- Local & global Benchmarks
- Landmark / Icon
- Strengths / weaknesses
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- Future Trends
- Legislation
- Viability
- Buildability
- BIM

**Indoor environmental quality:**
- Local & global Benchmarks
- Landmark / Icon
- Strengths / weaknesses
- Opportunities / threats
- Innovations
- Future Trends
- Legislation
- Viability
- Buildability
- BIM

**Global benchmarks**
- Local & global Benchmarks
- Landmark / Icon
- Strengths / weaknesses
- Opportunities / threats
- Innovations
- Future Trends
- Legislation
- Viability
- Buildability
- BIM

**Building Design Target & Parameters**
- Local & global Benchmarks
- Landmark / Icon
- Strengths / weaknesses
- Opportunities / threats
- Innovations
- Future Trends
- Legislation
- Viability
- Buildability
- BIM

**Local & global Benchmarks**
- LEED and BEAM
- Local Awards
- International Awards
1. Outcome-oriented

- To become the high performance sustainable building frontier to satisfy building occupants, the surrounding and the environment in rounded aspects

- TKP2A designs for Integrated Sustainability, leading to sustained and measurable increases in operating efficiency, occupant contentment and marketability

- Building occupants
- The surrounding
- The environment
2. Integrated Sustainable Design Process

**Timeframe**
- **Pre - Concept Design**
- **Concept Design**
- **Scheme Design**
- **Detailed Design**
- **Tender**
- **Construction**
- **T&C**
- **Operation**

**Process**
- **Options**
- **Analyze**
- **Refinement**
- **Design Evolution**
- **Assess Tender**
- **M&V**
- **Life-cycle costing**
- **Demolition & Construction Monitoring**
- **Documentation for LEED and BEAM+**
- **Maintain and Update modeling tools**

**Parties**
- Swire PM, Architect, MEP, Civil, Structures, Sustainability, QS
- Swire TSSD, TPMO
- Other Specialists (Lighting, Facade, Landscape, Interior Design etc)
- Demolition Contractor
- Contractor
- Occupants - feedback

**Coordination**
- **Design Charette**
- **Design Workshops (Biweekly)**
- **Sustainability Coordination Workshop (Monthly)**
- **Senior Management Meeting**
- **Site Meeting**
- **Post Occupancy Review Meeting**
4. Coordination Meeting Intent & Outcome

**Design Charette**

- Vision statement – high performance sustainable building
- Set target – OTTV 15W/m² (impact from surrounding buildings included), 30% total building energy saving, 40% potable water reduction, 75% C&D waste recycling
- Outline strategies – high efficient HVAC equipment, improved operation control, lighting optimization, renewable energy, radiant cooling
- Design options / schemes

**Sustainability Workshops (Monthly)**

- Comprehensive analysis – radiance simulation, energy modeling, facade parametric study
- Evaluate option study and selection – R&D research
- LEED & BEAM Plus assessment – credit evaluation

**Design Workshops (Bi-weekly)**

- Project team
- Facade team, other design parties

- Design requirements – SC 0.19, VLT 0.22, outdoor air condition for free cooling
- Design coordination and implementation into detailed design

Sustainability Designs Coordinated in Meetings

**Passive Design**
- Facade (glazing properties, fins, OTTV, building orientation)

**Active Design**
- Energy (system, innovations, renewable)

**Rating Tool**
- LEED & BEAM+
Design Performance Verification

Solar Heat Gain at 11:00am at Summer Season

- Combined effect of solar insulating glazing and shading effect of horizontal fins.
- Solar radiation map onto office space during summer

Solar Heat Gain at 15:00pm at Summer Season

Annual Solar Heat Gain Reduction about 27%
Compare to Baseline OTTV 24W/m²