

# 基於全生命週期 智慧優化及診斷的建築節能技術

## Life-cycle Smart Optimization and Diagnostic Technologies for Energy Saving in Buildings

### 加強空調系統控制,提高建築能效的系統

A system enhances air-conditioning control and improves building energy efficiency

建築是能源消耗大戶，而中央空調系統的耗電量通常佔建築物總耗電量的50%以上，但由於建築物全生命週期中的不當決策或實施方案，中央空調系統浪費掉的電力可達20至50%，因此，建築物其實存有許多節能空間。建築生命週期是指一幢建築的設計、建造、測試與調試，以及運行等各階段。

為減少能源浪費，善用節能空間，理大的研究團隊成功研發出一系列致力於建築物節能的智慧優化及診斷技術。這些技術為建築空調系統提供優化、診斷及虛擬測試的有效工具及平臺，能夠支援相關人員在建築物生命週期的各階段達致最佳決策和實施方案。這些智慧技術已經應用在許多不同類型的建築物中，實現節能15%至42%。

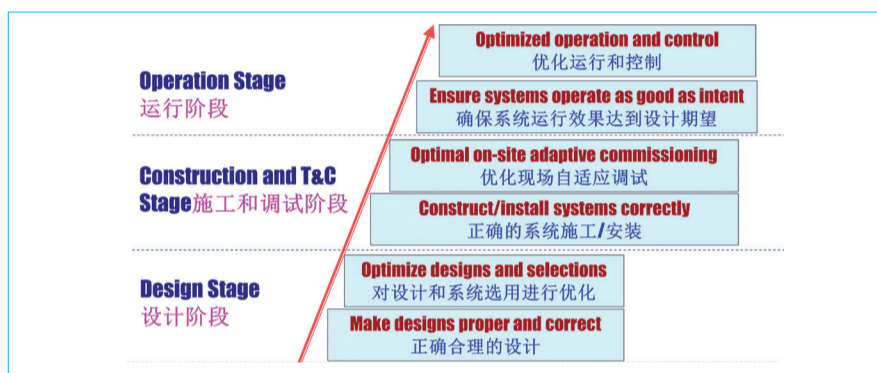


圖1 優化和診斷技術在建築物生命週期各階段的功能  
Fig. 1 Functions of optimization and diagnostic technologies for different stages of building life-cycle

優化工具 Optimization Tools	診斷工具 Diagnosis Tools	虛擬測試平台 Virtual Testing Platforms
<ul style="list-style-type: none"> <li>建築能源系統(空調系統)設計優化工具 Building energy system (HVAC) design optimization tool</li> <li>在線優化和能效控制策略 Online optimal and energy efficient control strategies</li> <li>優化現場自動適應調試 Optimal on-site adaptive commissioning</li> </ul>	<ul style="list-style-type: none"> <li>電網友善和電網響應建築的優化設計與控制 Optimal design and control of grid-friendly and grid-responsive buildings</li> <li>建築物層級能源性能快速評估和診斷工具 Building level energy performance quick evaluation and diagnostic tool</li> <li>精細評估和診斷工具 Detailed evaluation and diagnostic tool</li> <li>在線故障診斷策略 Online fault diagnosis strategies</li> </ul>	<ul style="list-style-type: none"> <li>建築系統實際性能模擬測試平台 Actual building system performance simulation testing platform</li> <li>控制和診斷策略的在線測試平台 Online testing platform for control and diagnosis strategy</li> </ul>

表1 系統優化、診斷和測試技術及平臺一覽  
Table.1 Summary of system optimization, diagnostic and testing technologies and platforms

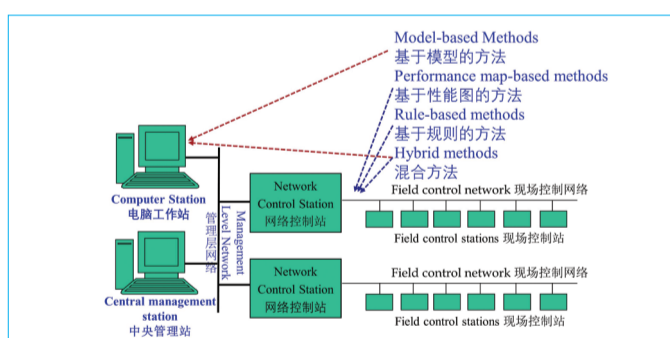


圖2 優化控制方法及其在樓宇自動控制系統中的實施  
Fig. 2 Optimal control methods and their implementations in building automated systems (BASs)

Buildings are a major energy consumer while central air-conditioning systems consume over 50% of total energy in buildings. However, due to unfavourable actions taken or decisions made throughout the building life cycle, 20 - 50% of that is wasted and can be saved potentially. The life cycle of a building includes the design, construction, testing and commissioning (T&C) and operation stages.

To reduce energy waste and realize saving potentials, PolyU has developed a series of smart optimization and diagnostic technologies for energy saving in buildings. These technologies provide effective tools and platforms for building energy optimization, diagnosis and virtual testing, allowing the best decisions to be made and proper actions to be taken at different stages of the building life cycle. They have already been implemented in many buildings of different types, saving 15 - 42% of energy for them.

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### 特色與優點

- 優化系統設計:確保系統能在不確定設計資訊及變化的工作條件下的高能效運行並具備現場優化適應調試的靈活度
- 現場優化適應調試:根據實際系統特性，在設計時所預備的調試方案中選取最佳方案
- 優化的在線自動控制技術(圖2):考慮了測量數據的準確性和不確定性、在線優化策略的穩健性和敏感性，而設定的高效且穩健的在線控制方案，實現高能效的運行控制
- 耗能表現和故障診斷技術:為資訊匱乏的建築物提供建築級節能診斷；及用大數據分析技術為超豐富資訊建築物提供高效的節能診斷；以及在低質量測量條件下的空調組件及系統故障診斷
- 電網友善及電網響應的優化設計與控制，以及響應智慧電網緊急需求的建築物限電控制策略:支持建築物與智慧電網之間的有效互動，實現電網-建築物生態系統的最佳整體能源效率

### 應用

新建和既有的各類型建築物，包括辦公/商業大廈、醫院、酒店、工業大廈、數據中心、潔淨室空調系統、鐵路站的供冷/空調系統，以及區域供冷系統



綜合式商業大樓：  
年省電逾一千萬  
度電  
Commercial  
building: over 10  
million kWh annual  
energy saving



位於香港的酒店：  
空調系統省電逾  
25%  
Hotel in Hong  
Kong: 25% of air-  
conditioning system  
energy saving



位於大埔的製藥工廠：降低建  
築總能耗(電和氣)42%  
Pharmaceutical factory in Tai  
Po: 42% of the total building  
energy cost saving



香港理工大學第5期：降低  
空調用電約38%  
Phase 5 of PolyU: 38% of  
the air-conditioning energy  
saving

### Special Features and Advantages

- Optimal design provides robust energy performance and flexibility for optimal on-site adaptive commissioning under various uncertainties and conditions
- Optimal on-site adaptive commissioning allows selection of the best commissioning solution from among a range of options prepared at the time of design
- Online control optimization (Fig. 2) takes into account the precision and uncertainties of online measurements, the robustness and sensitivity of control, as well as effective and reliable online optimization techniques to achieve effective operation control
- Performance and fault diagnosis technologies provide building-level diagnosis for information poor buildings; and effective diagnosis using Big Data analytics for information super-rich buildings, and component/subsystem fault diagnosis with low quality measurements
- Optimal design and control of grid-friendly, grid-responsive buildings as well as building power demand response control strategy for urgent requests from smart grids facilitate the effective interaction and maximization of overall energy efficiency of entire grid-building eco-system

### Applications

Cooling/air-conditioning systems in new and existing buildings of different types, including office/commercial buildings, hospitals, hotels, industrial buildings, data centres, cleanrooms and train stations; as well as district cooling systems



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