

# ATTAINABLE COMFORT FOR USERS IN SUSTAINABLE BUILDINGS

可持续建筑的用户舒适度实现



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# Content内容

- Benefits of Good Indoor Climate良好的室内气候
- Energy Efficiency 能源效率
- Chilled Beam Technology冷冻梁技术



# Need for Sustainable Office Spaces: Investors point of view

3

可持续办公空间的要求：投资者的观点

## Value : market & futureproofness

- Location
  - Connectivity infrastructure
  - Local services and shops (density)
  - Security
  - Attractivity ( image...)

市场价值和未来前景

- 定位

连通性基础设施  
附近的服务场所和商店  
安全性  
美观性

- Quality
  - Indoor environmental quality
  - Energy performance
  - Lifespan
  - flexibility

- 质量

室内环境质量  
能源性能  
预期使用寿命  
灵活性

**HVAC in sustainable  
office buildings**  
A bridge between owners and engineers



Wellbeing and health of people  
用户的幸福和健康

Environment friendly  
环境友好型

Life time cost effective  
运行成本效益

Sustainable Indoor Environment  
可持续室内环境

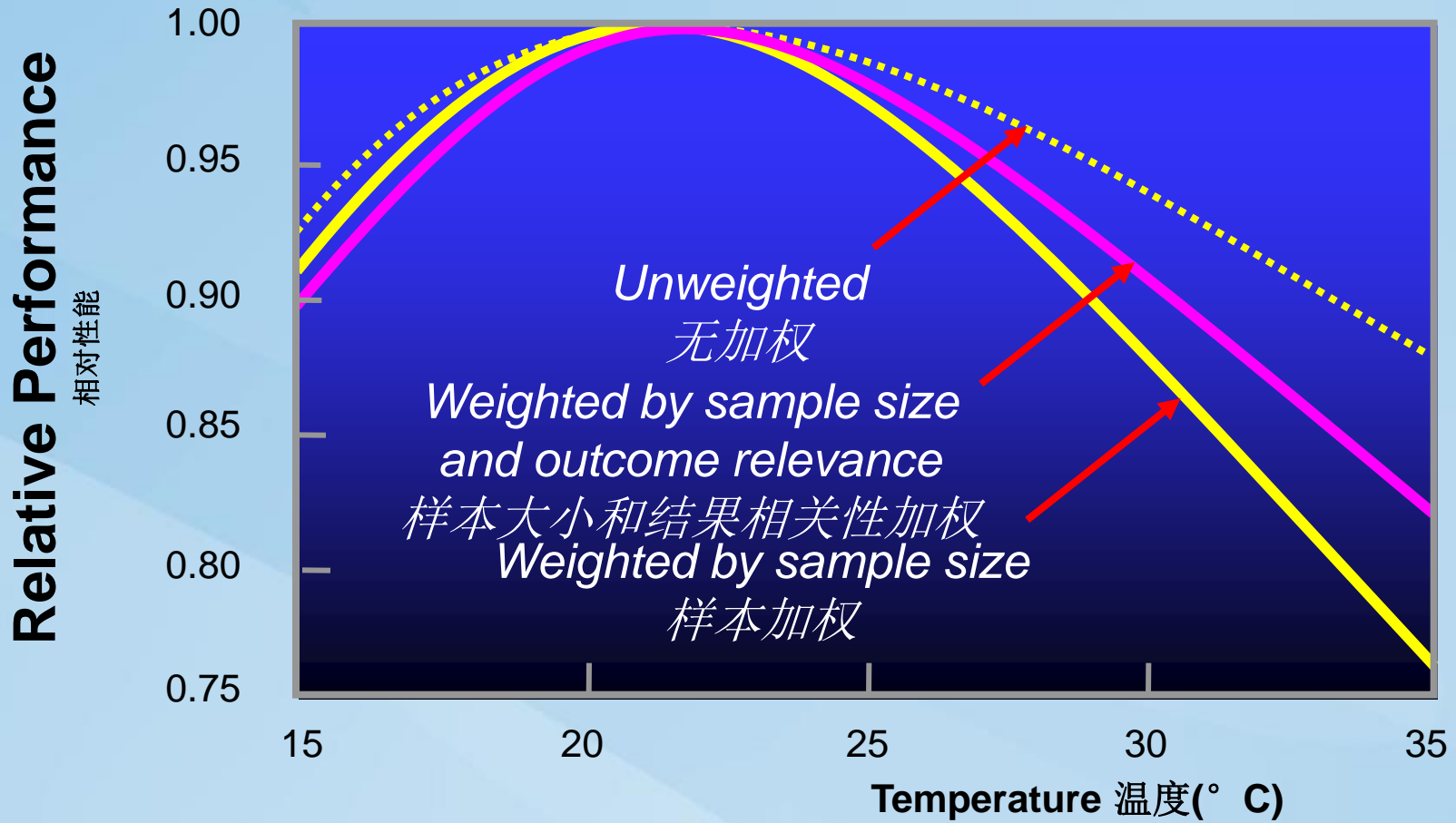
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# Relative performance vs. room air temperature compared to the maximum

相对性能与室内空气温度相比最大值

95% confidence range 20-24 °C 20 – 24°C 的95%置信区间



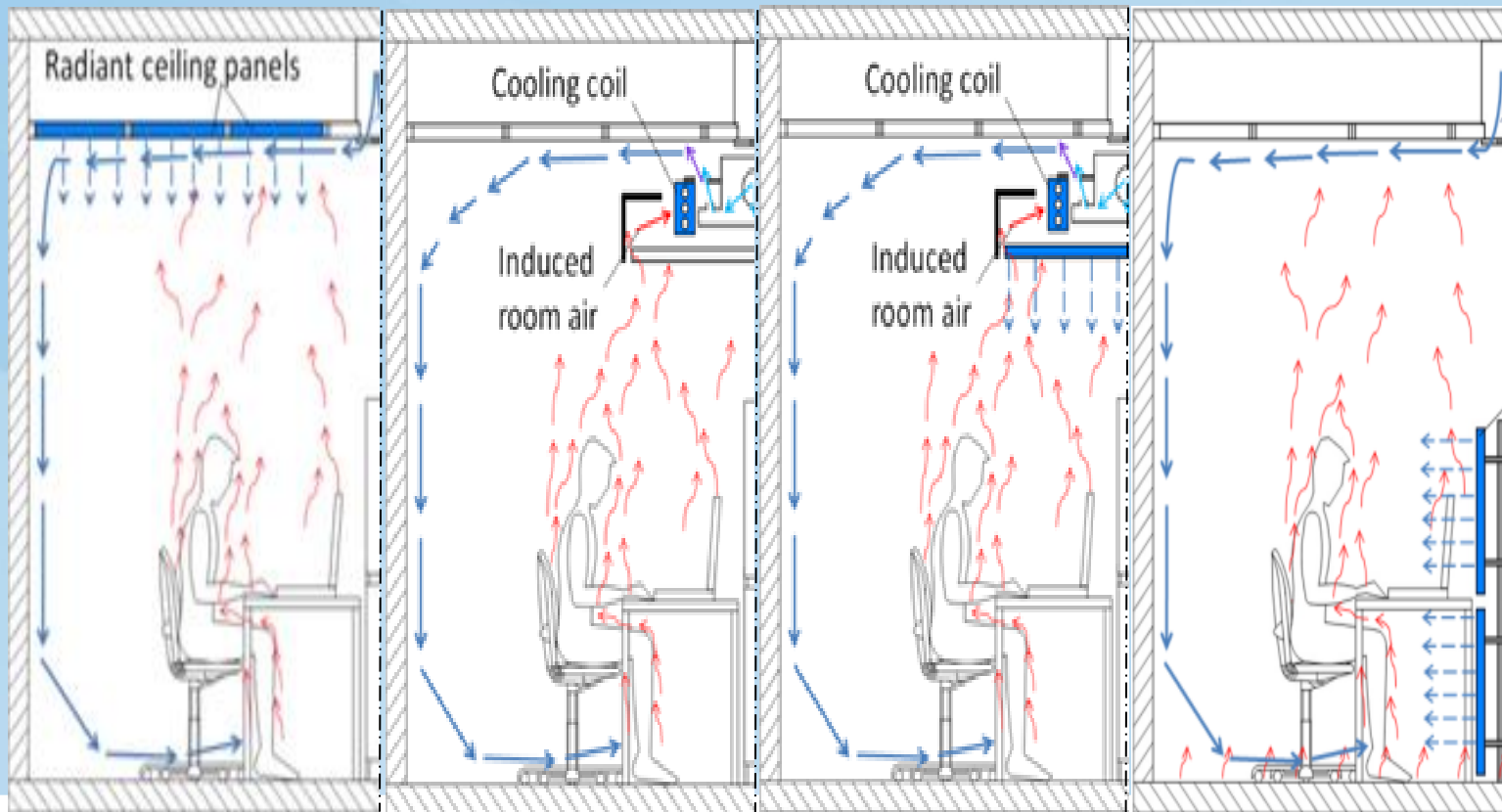
# Workers salaries are much higher than life-cycle costs of systems:

工人的工资远高于系统的生命周期成本

- Operation costs- FACTOR 1 运行成本-因素1
  - including energy 能源
- Life-cycle costs of systems- FACTOR 10
  - including investment, maintenance and operation 系统生命周期成本-因素10-包括投资，维护和运行费用
- Workers salaries--FACTOR 100 工人工资-因素100

# Thermal Conditions with Convective and Radiant Cooling Systems: 对流和辐射冷却系统的热力条件

comparison of radiant ceiling, local radiant cooling and chilled beam systems with and without radiant panel 与辐射顶板、局部辐射、有辐射板和无辐射板的冷冻梁系统、



# Thermal Conditions with Convective and

# Radiant Cooling Systems: 对流和辐射冷却系统的热力条件<sup>8</sup>

## Two tests conditions in Laboratory 两个在实验室的测试条件

Heat balance of office room test in	Maximum cooling conditions		Usual cooling conditions	
Occupants (about 78 W/occupant)	2	persons	2	persons
	156	W	156	W
	9	W/m <sup>2</sup>	9	W/m <sup>2</sup>
Computers (about 65 W/computer)	2	computers	2	computers
	130	W	130	W
	8	W/m <sup>2</sup>	8	W/m <sup>2</sup>
Lighting	160	W	160	W
	9	W/m <sup>2</sup>	9	W/m <sup>2</sup>
Solar load - window surface temperature	34	degC	30	degC
with 6.3 m <sup>2</sup> window and 26 degC room ~	404	W	202	W
Solar load - direct solar load on the floor	250	W	0	W
Total solar load	38	W	12	W
Total heat loads	1100	W	648	W
	64	W/m <sup>2</sup>	38	W/m <sup>2</sup>
Supply air flow rate	26	l/s	26	l/s
Supply air temperature	16	degC	16	degC
Supply air cooling power in 26 degC room	312	W	312	W
	18	W/m <sup>2</sup>	18	W/m <sup>2</sup>
Cooling power demand from water	788	W	336	W
	46	W/m <sup>2</sup>	20	W/m <sup>2</sup>




# Results of the comparison of thermal conditions

## 热力条件比较结果

Measurement results in occupied zone at heights 0.1 m - 1.7 m	Chilled ceiling with mixing vent.	Chilled beam	Chilled beam with radiant panels
Average air velocity [m/s]	<b>0.13</b> 0.11	<b>0.13</b> 0.12	<b>0.12</b> 0.11
Average of 5 highest velocities	<b>0.22</b> 0.20	<b>0.25</b> 0.25	<b>0.23</b> 0.25
Average air temperature [°C]	<b>26.1</b> 26.0	<b>25.8</b> 25.8	<b>26.1</b> 25.9
Average temperature of window side	<b>26.8</b> 26.4	<b>26.4</b> 26.2	<b>26.9</b> 26.4
Average temperature of door side	<b>25.7</b> 25.7	<b>25.4</b> 25.6	<b>25.7</b> 25.7
Average horizontal temperature diff.	<b>1.1</b> 0.7	<b>1.0</b> 0.7	<b>1.2</b> 0.7
Average vertical temperature diff.	<b>0.0</b> 0.3	<b>0.3</b> 0.4	<b>0.2</b> 0.2
Horizontal operative temperature diff.	<b>1.6</b> 0.8	<b>1.4</b> 0.9	<b>1.5</b> 0.9
Vertical operative temperature diff.	<b>-0.1</b> 0.3	<b>0.5</b> 0.5	<b>0.2</b> n.a.
Average operative-air temperature	<b>0.13</b> 0.12	<b>0.29</b> 0.13	<b>0.19</b> 0.10
Average draft rate [%]	<b>7.9</b> 5.7	<b>9.5</b> 7.8	<b>8.1</b> 6.9
Average of 5 highest draft rates	<b>14.3</b> 11.7	<b>18.9</b> 17.4	<b>17.1</b> 16.2

- No significant difference between the systems 不同系统间没明显差异
- Note: Also Operative Temperature almost the same 运行温度几乎相同

# Sustainable Living Environment 可持续生活环境

Energy	
Manufacturer Model	Fridge-Freezer
<b>More efficient</b>	
A	<b>A</b>
B	
C	
D	
E	
F	
<b>Less efficient</b>	
G	
Energy consumption kWh/year (Based on standard test results for 24h)	<b>325</b>
<small>Actual consumption will depend on how the appliance is used and where it is located</small>	
Fresh food volume l	190
Frozen food volume l	126
<b>Noise</b> (dB(A) re 1 pW)	<b>44</b>
<small>Further information is contained in product brochures</small>	
<small>Norm EN 153 May 1990 Refrigerator Label Directive 94/10/EC</small>	

## ENVIRONMENT

环境

Use of energy  
and other  
resources

使用的能源和其  
他资源

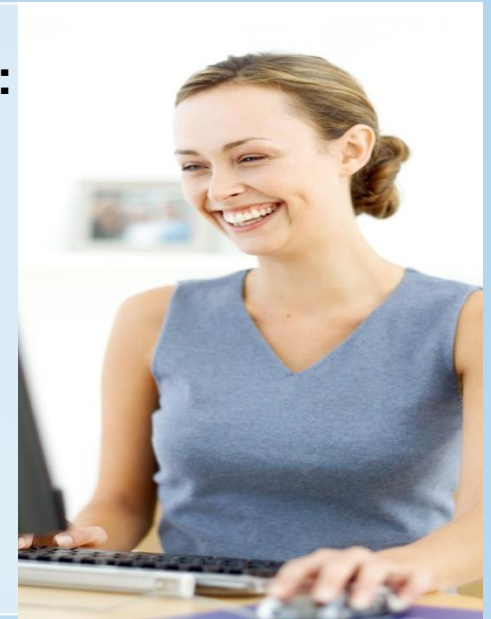
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## WELLBEING:

幸福

Healthy,  
productive,  
comfortable  
indoor  
Environment

健康的, 多效的, 舒适  
的室内环境



# Chilled Beam System 冷冻梁系统

- Chilled beam system is room air conditioning system for cooling, heating, and ventilation in spaces where good indoor climate and individual space control are appreciated. 冷冻梁系统是一种在空间冷却,加热,和通风相结合的房间空调系统,可以很好的通风良好的室内气候和个人空间控制。
- A chilled beam system provides comfortable thermal conditions with quiet and energy-efficient operation.
- 冷冻梁系统可提供安静和节能运行的热舒适环境。
- The system can be realised with active or passive chilled beams, integrated multi-service chilled beams, or bulkhead-installed horizontal induction units. 该系统可以实现主动或被动冷却梁、集成多种冷冻横梁、或隔板安装的水平感应单元



# Main Principles of Active Chilled Beam

## 主动冷却梁的主要原则

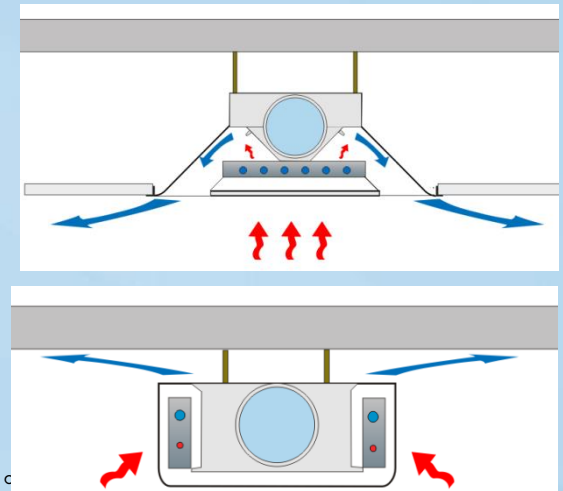
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- Active chilled beams are connected to both the ventilation supply air ductwork, and the chilled water system. When desired, hot water can be used in this system for heating.
- The main air handling unit supplies primary air into the various rooms through the chilled beam.
- Primary air supply induces room air to be re-circulated through the heat exchanger of the chilled beam. 一次空气通过诱导房间空气流通过冷却的热交换器循环。

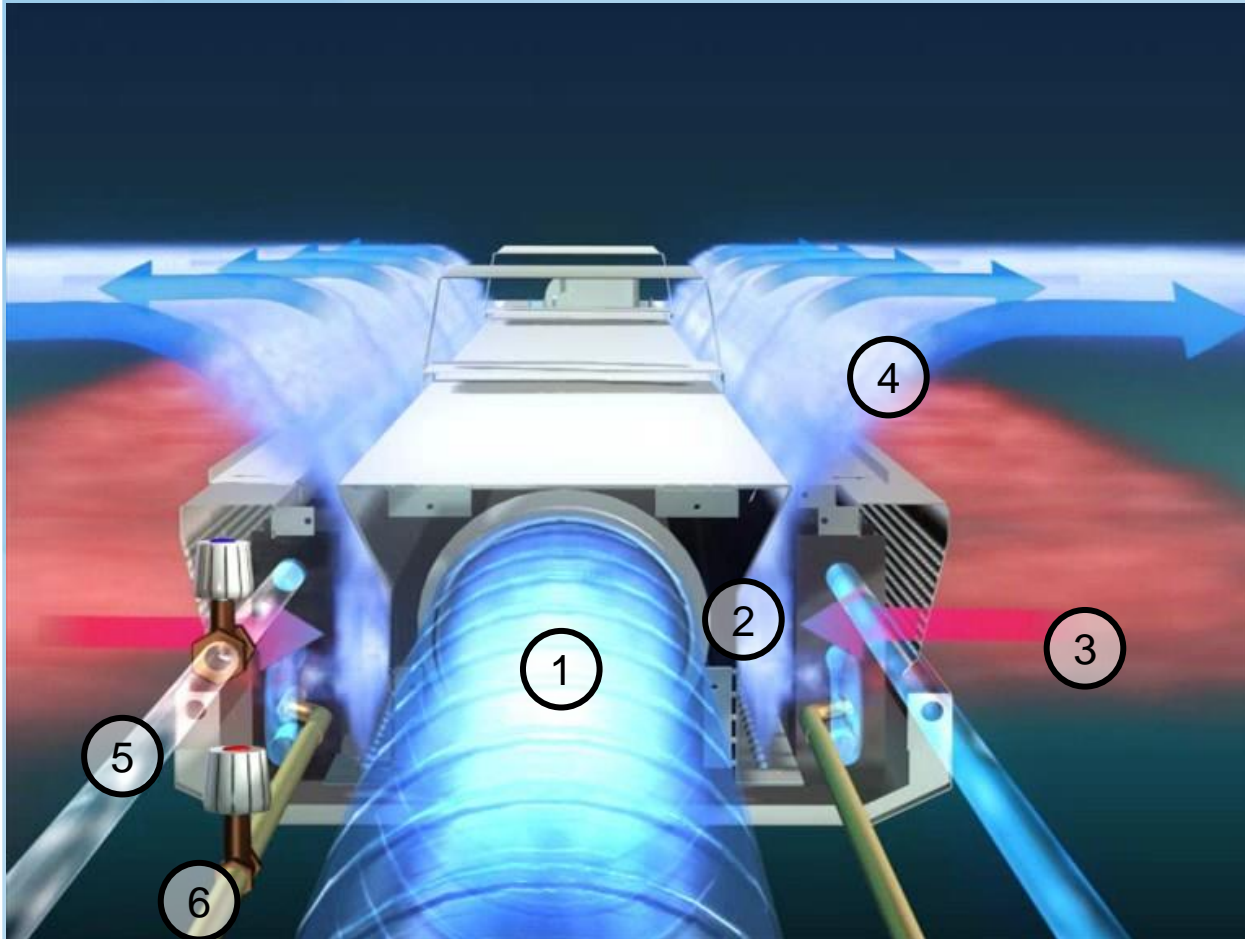
Re-circulated room air and the primary air are mixed prior to diffusion in the space.

循环的空气和一次空气在空间扩散之前混合。

- Room temperature is controlled by controlling the water flow rate through the heat exchanger. 室温控制通过调节换热器内热水的流量实现。



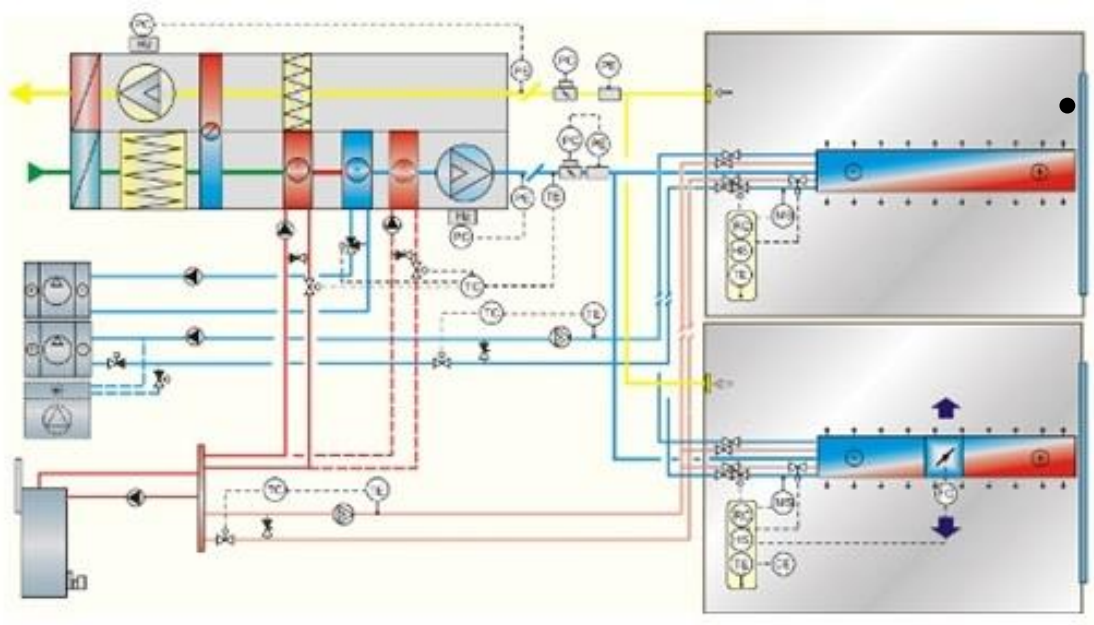
# Chilled Beam Operation 冷梁操作系统



1. Primary air (dehumidified outdoor air) supply into supply air chamber 一次空气(除湿后的室外空气)供应到送风室
2. Primary air is supplied through small nozzles. 通过小喷嘴提供一次空气
3. Primary air supply induces room air to be re-circulated through the heat exchanger of the chilled beam. 一次空气供给房间诱导空气流通通过热交换器冷却
4. Re-circulated room air and the primary air are mixed prior to diffusion in the space 室内循环空气和一次空气混合后扩散到空间
5. Cold water connection 冷冻水管路
6. Warm water connection 热水管路



# Beam System concept 梁系统概念



- **Beam *functions*:** 梁功能
  - Room sensible cooling
  - 室内合理的冷却
  - Room heating;
  - 室内加热
  - Room air distribution.
  - 室内气流组织

- **Primary air system functions:** 一次空气系统功能
  - Ventilation; 通风
  - Ventilation loads; 通风负荷
  - **Room dehumidification (latent load);** 室内除湿
  - **Room sensible cooling (small %).** 室内冷却



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# Exposed Multi Service Chilled Beam

多功能冷梁



**Cooling** 冷却

**Ventilation** 通风

**Lights** 照明

**PA speakers** 广播系统

**Cabling** 线缆

**Day light sensor** 光感系统

**Space for sprinklers** 喷淋系统

# Beam System concept 梁系统概念

- Typical values: 主要参数
  - Passive Beams up to 150 W/m; 被动梁150w/m以下
  - Active Beams up to 180 W/m<sup>2</sup>; 主动梁180w/m以下
  - Chilled water 14° C to 18° C; 冷冻水温度14到18°C
  - Hot water 30° C to 45° C; 热水温度30到45°C
  - Primary air temperature 13°C to 21°C; 一次空气13到21°C
  - Beam plenum pressure about 100 Pa; 梁内压力100pa左右
  - Room sensible cooling by the chilled beam water coil ≥ 60%; 室内冷冻梁冷冻水承担的冷负荷大于60%
- Non-condensing coils at the room level; 室内表面不结露
- Condensation prevention strategy required. 预防冷凝措施



# Condensation prevention 预防结露

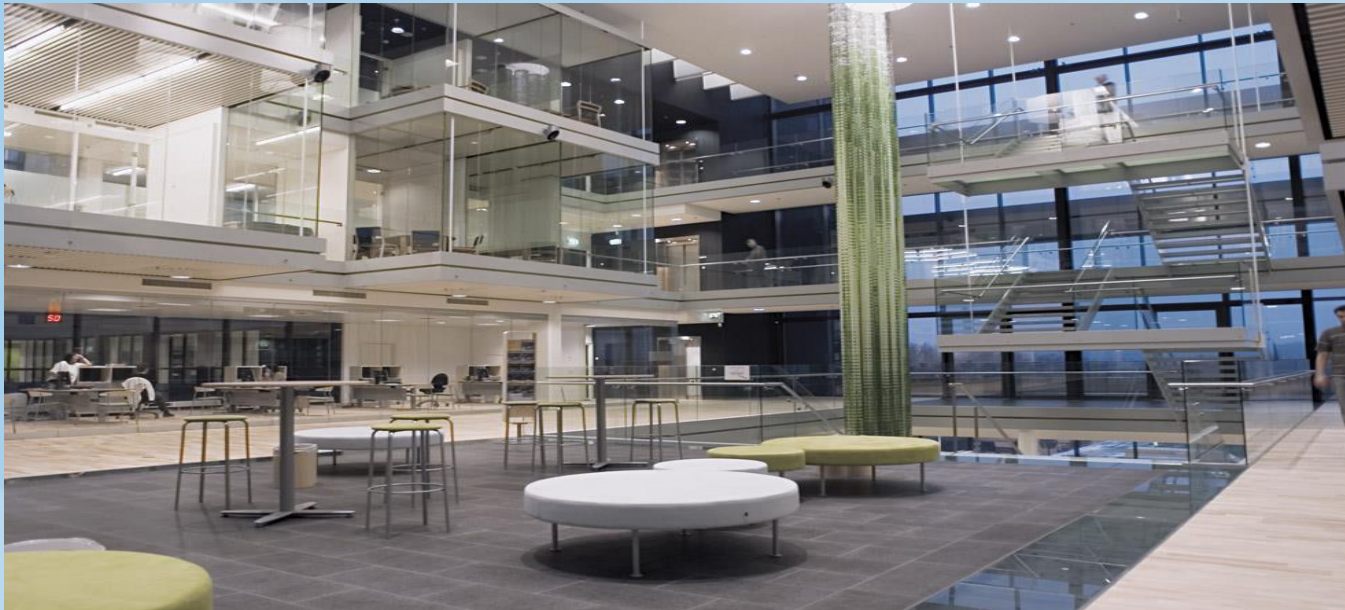
The occurrence of condensation on the beams is avoided by: 避免梁结露的措施

- The supply of an adequate amount of correctly conditioned primary air; 供给适量的正确热力状况的一次空气
- The implementation of an adequate chilled water temperature control system; 实现适当的冷却水温度的控制系统
- At morning startup, first turn on the AHU and run the beam CW pump only when the indoor air dew point is below the CWT setpoint. 在启动时,首先启动AHU,当室内空气露点低于CWT定位点时运行梁CW泵
- However, condensation prevention systems are normally applied as a safety measure. 然而,预防冷凝系统通常应用作为一项安全措施



# Survey results: 30-40% seat occupancy

调查结果：30-40%的座位空间

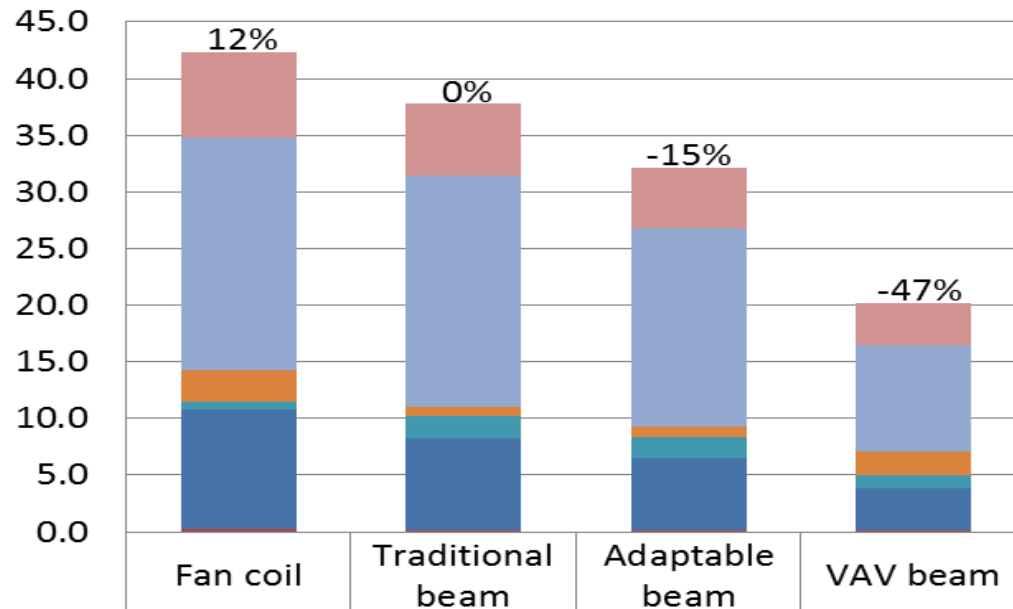


**A lot of effort is put into estimating proprieties of the building elements and adjusting the systems, less effort is spent on considerations regarding the users and their activities.** 很多努力投入估算建筑局部和调整系统方面,致使更少的精力花在考虑关于用户感受和他们的活动方面。

# Comparison of different chilled beam concepts with fan-coil system in Stockholm climata

在斯德哥尔摩气候条件下不同形式的冷梁系统和风机盘管系统的比较

## Delivered energy consumption, kWh/m<sup>2</sup>,a Stockholm



	Fan coil	Traditional beam	Adaptable beam	VAV beam
Heating of spaces	7.6	6.3	5.4	3.7
Heating of ventilation	20.5	20.5	17.5	9.5
Cooling of spaces	2.9	0.8	0.9	2.1
Cooling of ventilation	0.7	1.9	1.9	1.2
Fan energy	10.5	8.2	6.5	3.7
Pumping	0.2	0.1	0.1	0.1

**Buildings are built for people to live and work comfortably, effectively and safely - not only to save energy and environment!**

建筑的建造是为人们的生活和工作提供舒适,有效和安全的环境-并不是仅为了节能。

