GREEN BUILDING TECHNOLODGIES CONFERENCE
Towards A Sustainable Built Environment
Suntec Singapore
International Convention & Exhibition Centre
1 – 2 November 2006

CONTENT

1. **Challenges and Approaches in the Singapore Environment to Eco-Sensitive Design of Buildings**

2. **Technology Infrastructure – The Roots of Sustainability**

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5. **Indoor Environmental Quality, Energy Efficiency and Productivity**

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7. **Creating Sustainable Living Environment in Public Housing Development : HDB's Experience**

Design of Ecologically Sensitive Buildings – Singapore Experience

Russell Cole
Arup Singapore
1st November 2006

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- Importance
- Singapore's Climate and Impact on Design
- Initiatives
- Reducing Building Solar Gain

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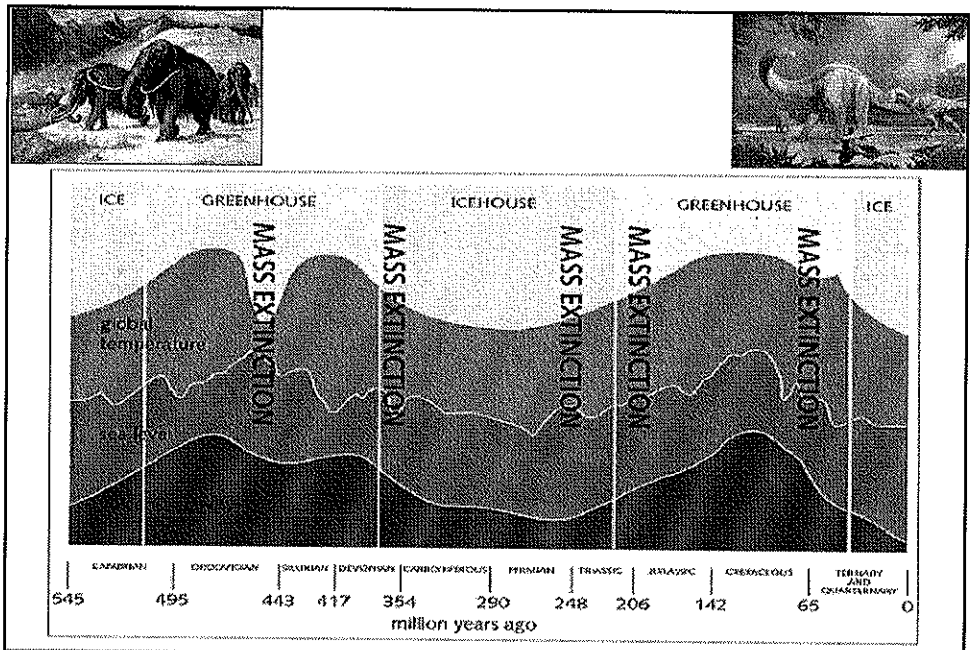

Climate history and life on Earth

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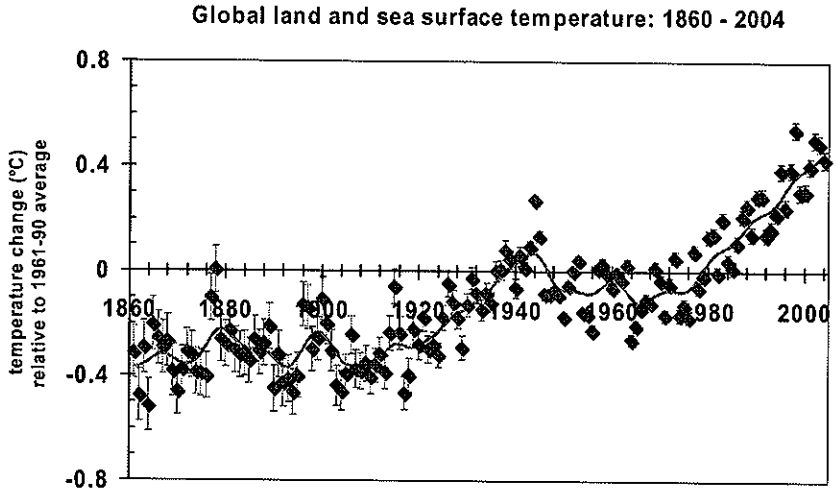
Global warming



Future Drivers - Climate change

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- Buildings Contribute 50% of CO2 emissions
- Reducing these will have a big impact
- Challenge for all cities
- Difficult to greatly improve existing building stock
- New Buildings must therefore perform at a very high standard

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A sustainable approach can consider many aspects

- Reduction in energy consumed over a building's life
  - Embedded Energy
  - Energy in use
  - Energy in demolishing
- Environmental Impact of materials and techniques used to construct
- Environmental impact during usage
- Ability to recycle materials and building fabric
- Energy cost / environmental impact of people using the building (proximity to public transport)

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Drivers for Buildings To Improve in Sustainability

- Statutory Requirements
- Building Performance Grades and Awards
- Commercial Drivers – Increased Rental, Reduced Energy Costs,
- Owner Initiative / Conscience

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Statutory Requirements

Building Codes
ETTV

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Statutory Requirements

Singapore Building Control Act

- Focus safety and development controls
- No minimum insulation – except through ETTV
- No controls on glass

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Statutory Requirements

ETTV

- Requirements for commercial buildings, eg. Offices, hotels, retail, etc
- No controls on residential buildings
- Only applies to air conditioned spaces
- Method of calculation for estimating heat gain through facades and roofs
- Minimum standard for compliance

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Statutory Requirements

ETTV

- Method considers the following:
  - Orientation of the façade (8 points of the compass)
  - Insulation effectiveness of main materials
  - Effectiveness of Overhangs and shading
    - Easy calculation is assumed solid
    - Can make a calculation based on blades / penetrations
    - Some interpretation required if a glass or other translucent material

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Statutory Requirements

ETTV

- Method requires
  - Consider each elevation in turn
  - Break up façade into a number of systems
  - Calculate for the full extent
- Some issues with interpretation – non-air conditioned spaces
- Typically completed by M&E consultants as part of role

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Building Grading

Energy Smart Buildings Scheme

aims to promote the active management of energy use by according recognition to buildings that are ranked in the top band of the total building cohort using an energy efficiency benchmarking system.

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Building Awards

Greenmark

Ties into a number of other initiatives

Grading related to number of points, but some are subjective

S/No.	Category	No. of Points
1	Design for Energy Efficiency	30
2	Design for Water Efficiency	20
3	Site/Project Development & Management	20
4	Design for Good Indoor Environmental Quality & Environmental Protection	15
5	Innovation	15
	Total	100

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Building Grading

Energy Smart Buildings Scheme - Little awareness in the market

Greenmark – Increasing prominence, popular with some developers

By contrast

AGBR – Australian Green Buildings Rating scheme – developing targeting a number of stars. Race to achieve first 5 star building

LEEDS

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Commercial Drivers

- Increased Rental – not aware of any premiums for eco-sensitivity
- Reduced Energy Costs
  - some growing awareness, but mostly to owner occupiers
  - Some awareness on payback times for enhanced facades
- Improved office environment – certainly becoming an issue
- Future-proofing – not an issue for many developers

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Current Focus in Building Development

- Energy Usage
- ETTV Compliance
- Internal Environment
  - Office user comfort
  - Daylighting

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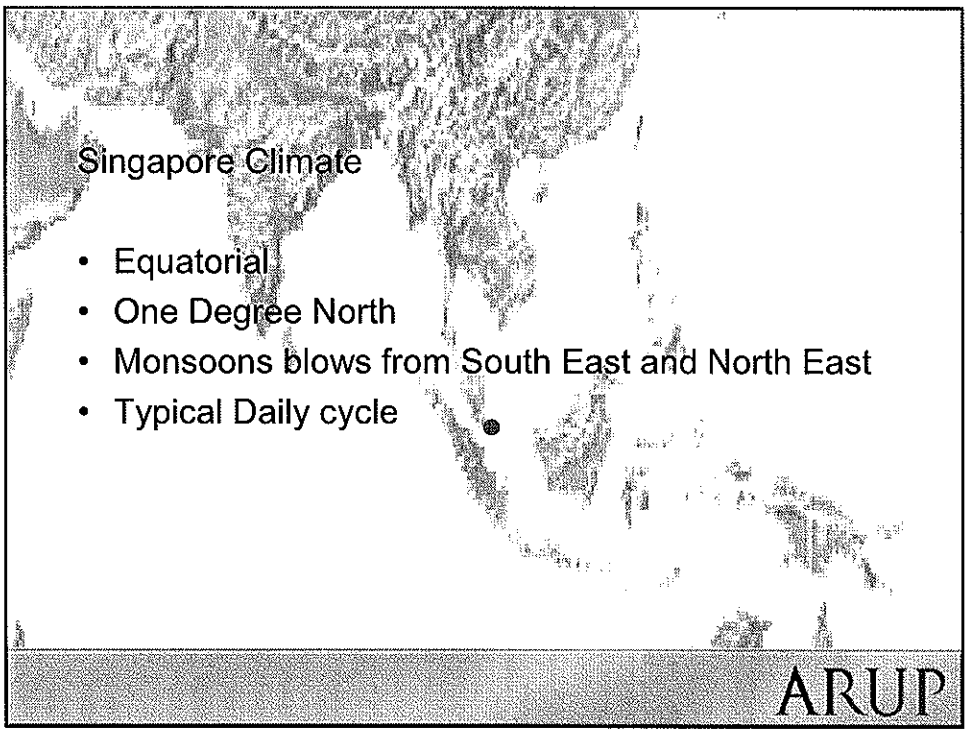

Singapore Climate

- Equatorial
- One Degree North
- Monsoons blows from South East and North East
- Typical Daily cycle

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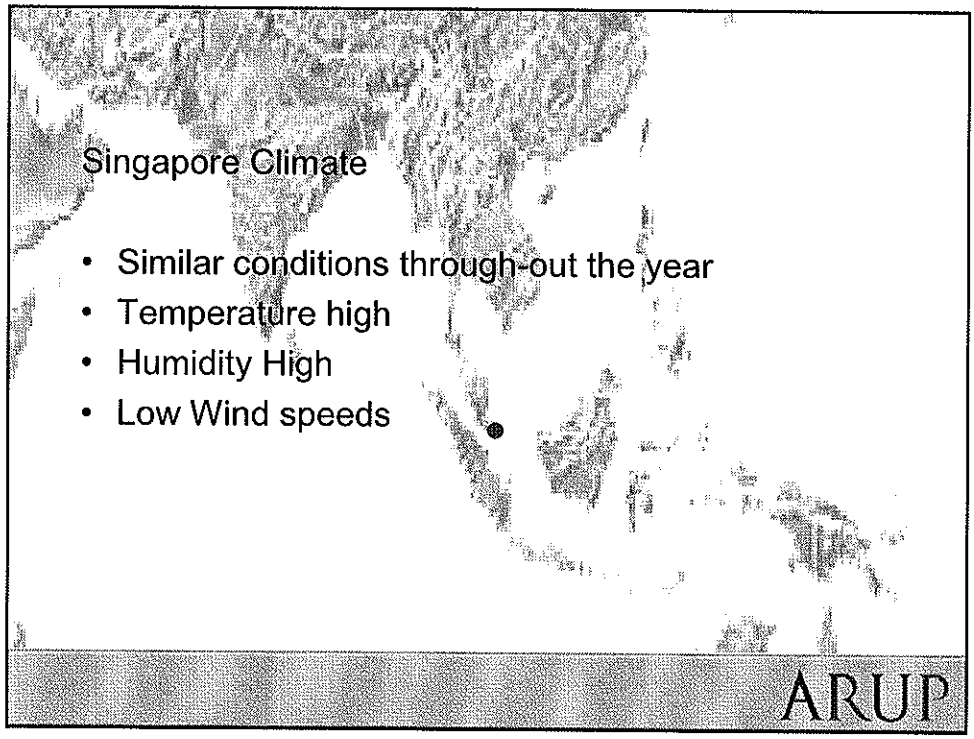
Singapore Climate
• Similar conditions through-out the year
• Temperature high
• Humidity High
• Low Wind speeds
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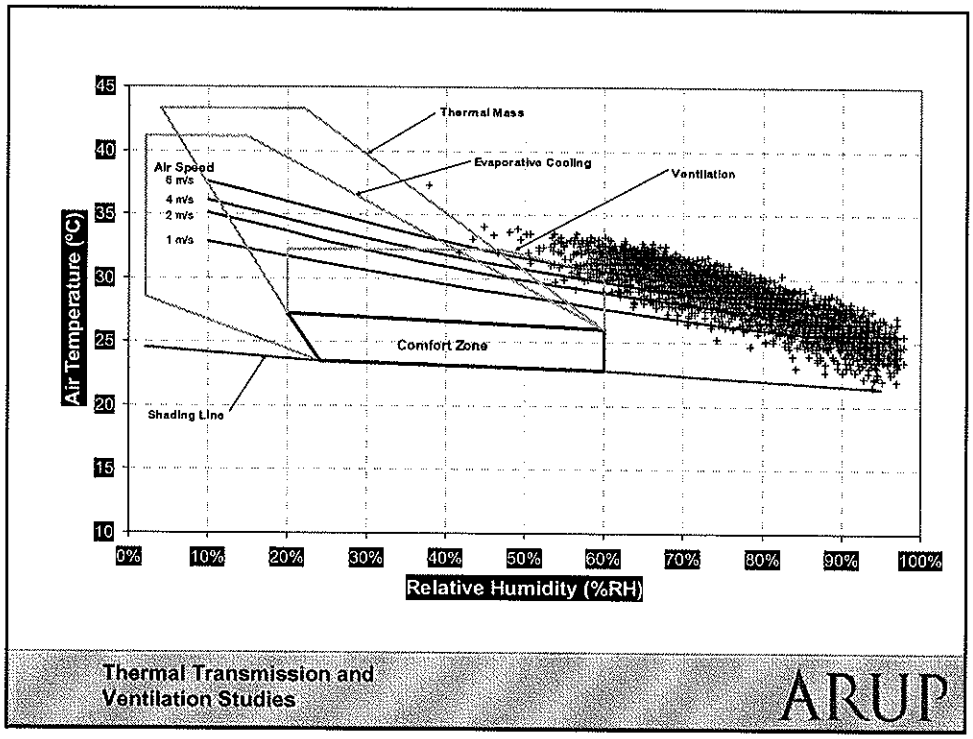
Thermal Mass
Evaporative Cooling
Ventilation
Air Speed
6 m/s
4 m/s
2 m/s
1 m/s
Comfort Zone
Shading Line
Air Temperature (°C)
45
40
35
30
25
20
15
10
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Relative Humidity (%RH)
Thermal Transmission and
Ventilation Studies
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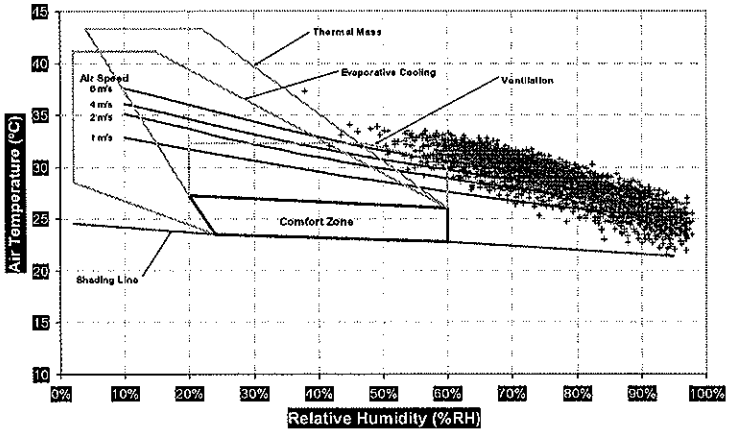

- Needs cooling to be comfortable
- Only high air speed make people comfortable in outside environment
- But standards set for Northern Hemisphere Dress

Thermal Transmission and Ventilation Studies

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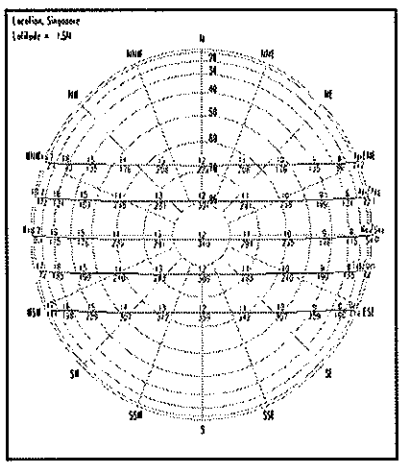
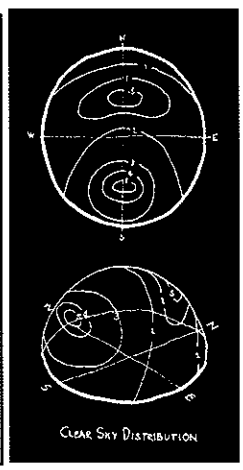
Characteristics of Sky
Singapore

- Sunlight Average 6 hours per day
- CIE Overcast Sky





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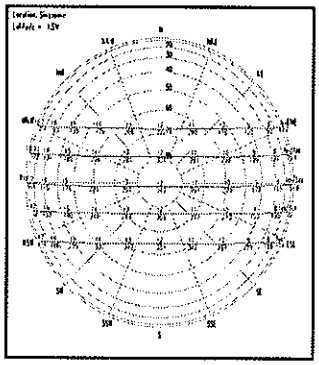
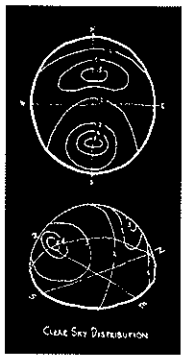
Characteristics of Sky
Singapore

- Sunpath East to West
- Implications for building orientation
- To cut solar penetration shading effective North and South
- Limit Windows on West and East





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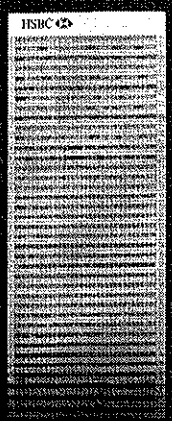
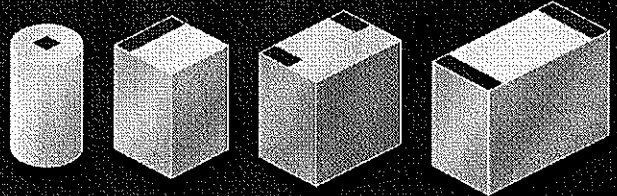


HSBC, London

Building Form & Orientation*



Cool Temperate Arid Tropical

CLIMATE

* Core location minimises climate impact

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Reduce Solar Heat Gain
Priorities

- Insulation important
  - Good values possible for solid areas
  - Vision to Solid ratio important
- Invest in good glass
- Add shading
- Consider different layers

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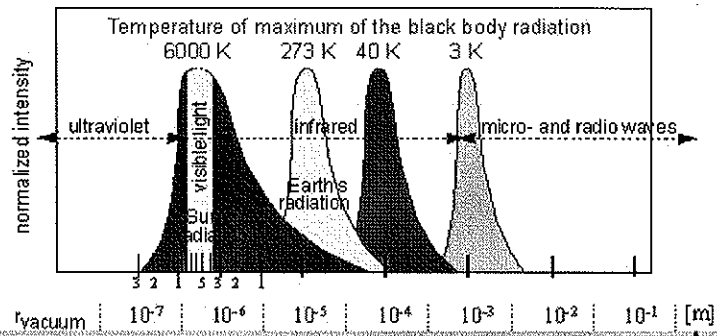
Heat Transmission

- **Energy**
  - **Solar Radiation**
  - **Ambient Temperature**



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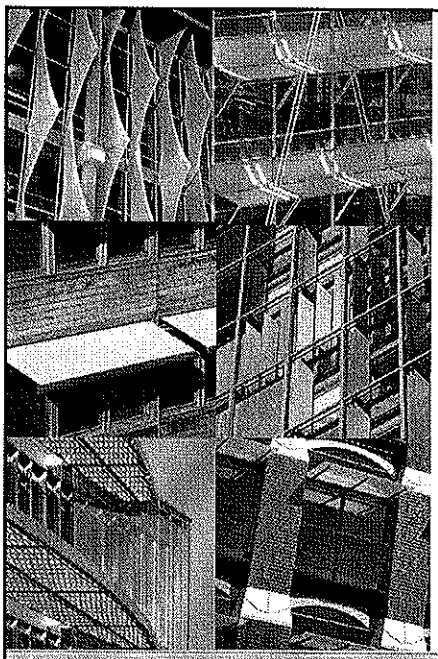

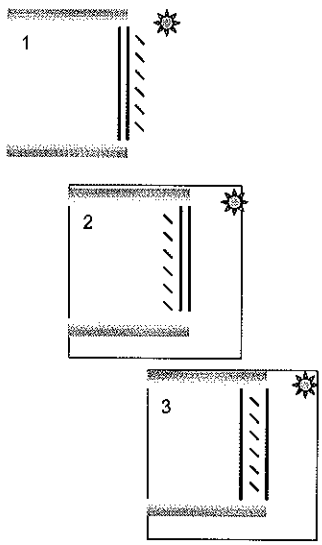

Façade Options

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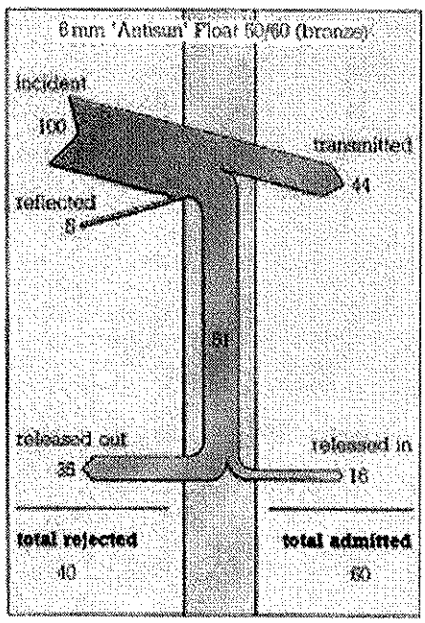

RAT Equation
R = Reflection
A = Absorbtion
T = Transmission
E = Emission
(in & out)

100% of solar energy distributed between R, A, T, E_{in} & E_{out}

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Reduce Solar Heat Gain
Priorities

- Glass
  - Double Glazing – improves U-value, makes low-e coats more effective
  - Body tints – cut energy transmission
  - Reflective coats
  - Low –emissivity and specturally selective coats

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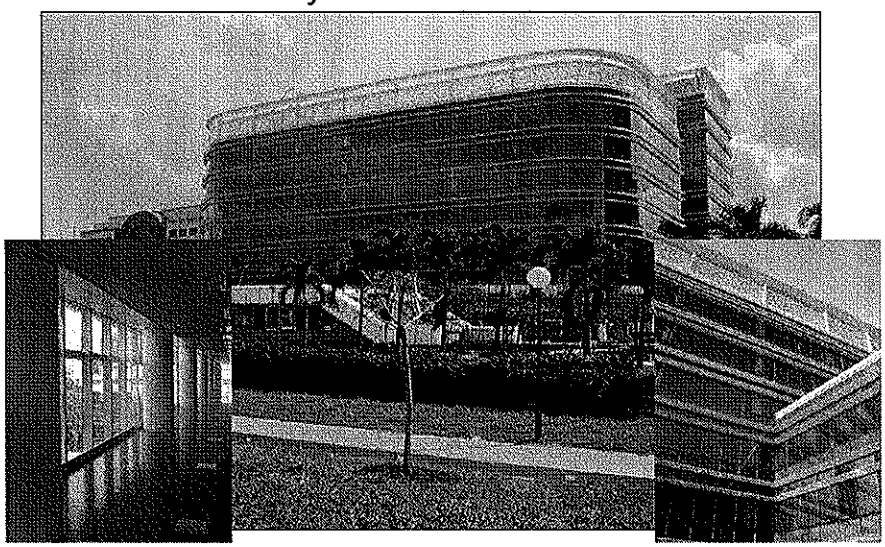
The Atria – Dhoby Ghaut



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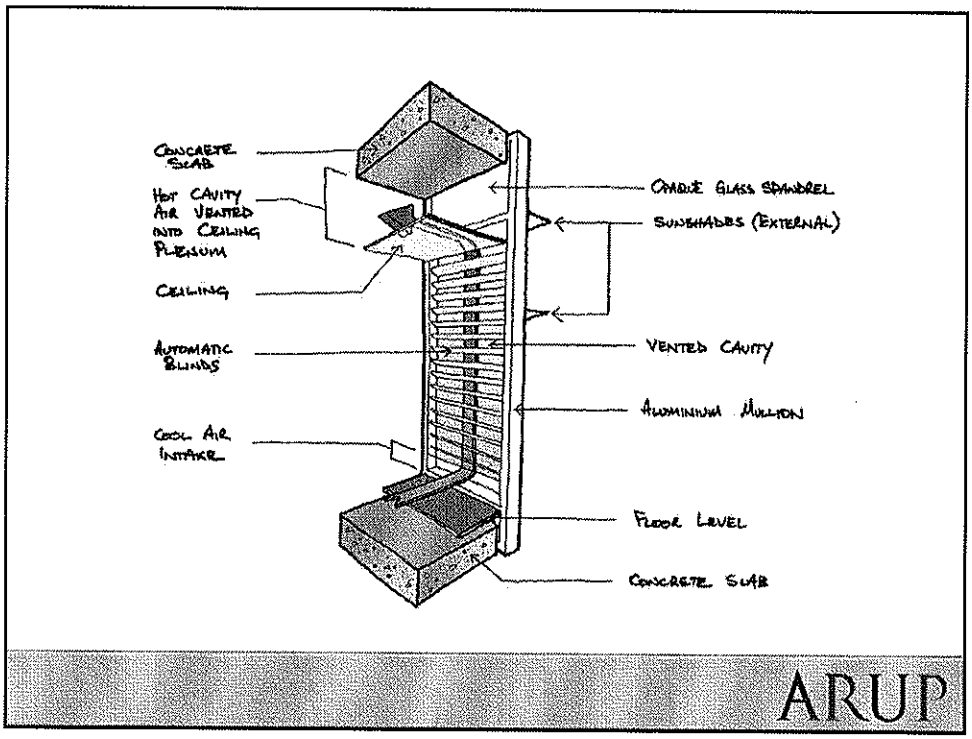
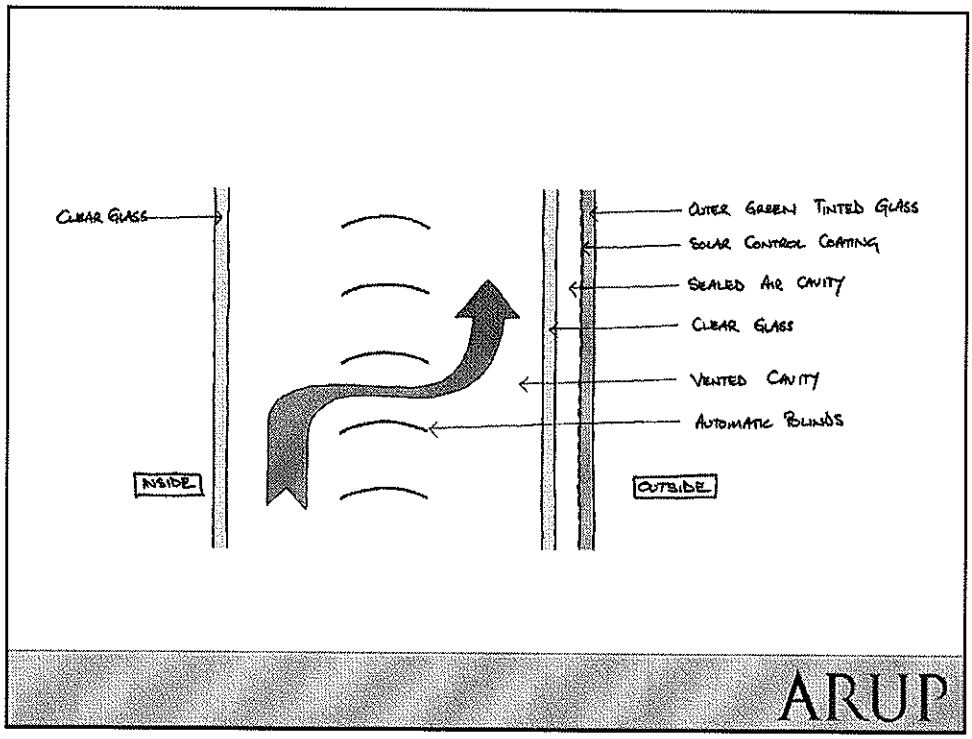
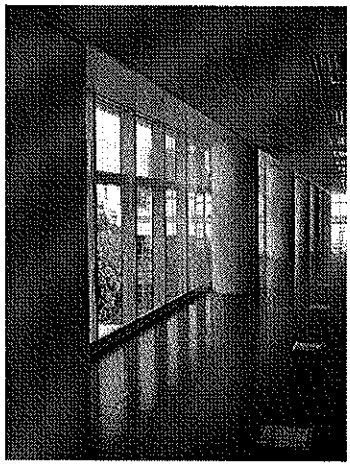

CONCRETE SLAB
HOT CAVITY AIR VENTED INTO CEILING PLENUM
CEILING
AUTOMATIC BLINDS
COOL AIR INTAKE
OPAQUE GLASS SPANDREL
SUNSHADES (EXTERNAL)
VENTED CAVITY
ALUMINIUM MULLION
FLOOR LEVEL
CONCRETE SLAB
ARUP


CLEAR GLASS
INSIDE
OUTER GREEN TINTED GLASS
SOLAR CONTROL COATING
SEALED AIR CAVITY
CLEAR GLASS
VENTED CAVITY
AUTOMATIC BLINDS
OUTSIDE
ARUP

The Atria – Dhoby Ghaut





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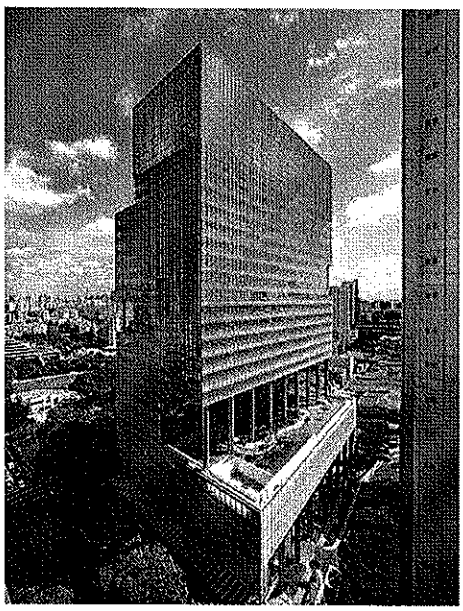

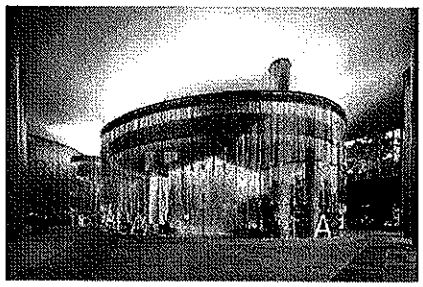

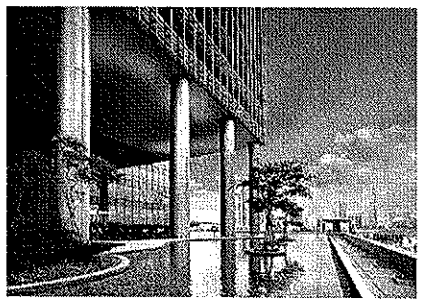

One George Street - Singapore

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National Library, Singapore – Image Courtesy of National Library Board

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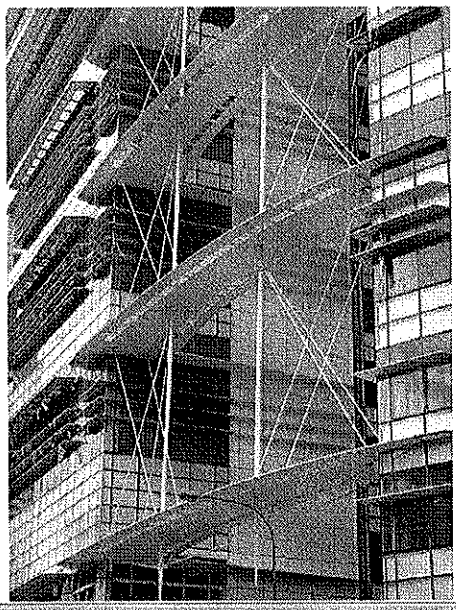

National Library, Singapore

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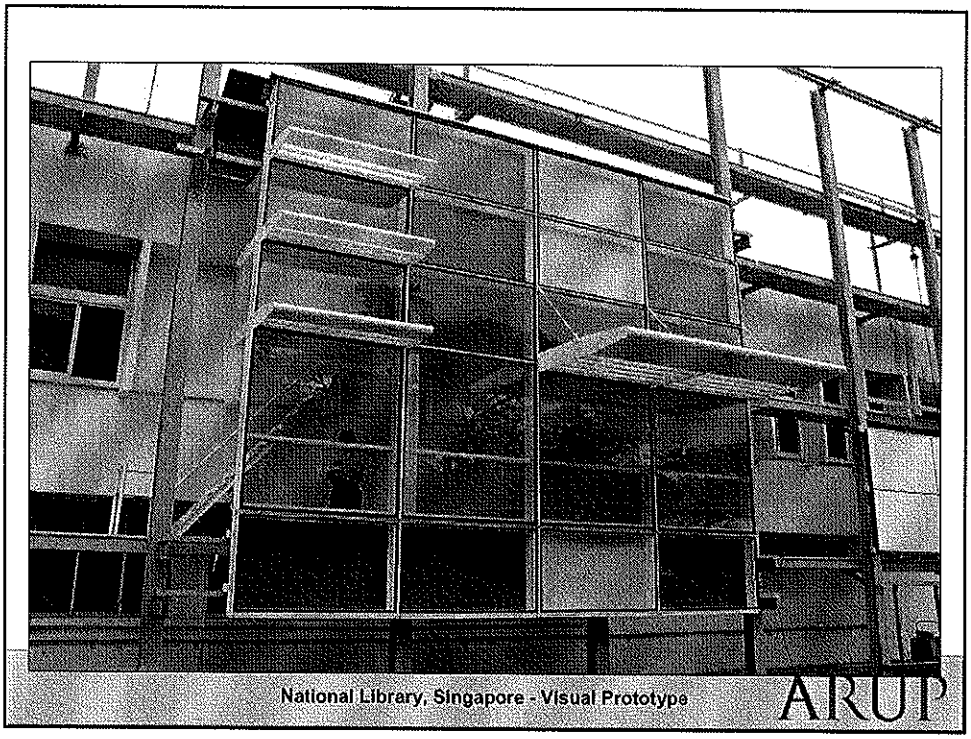
National Library, Singapore - Visual Prototype
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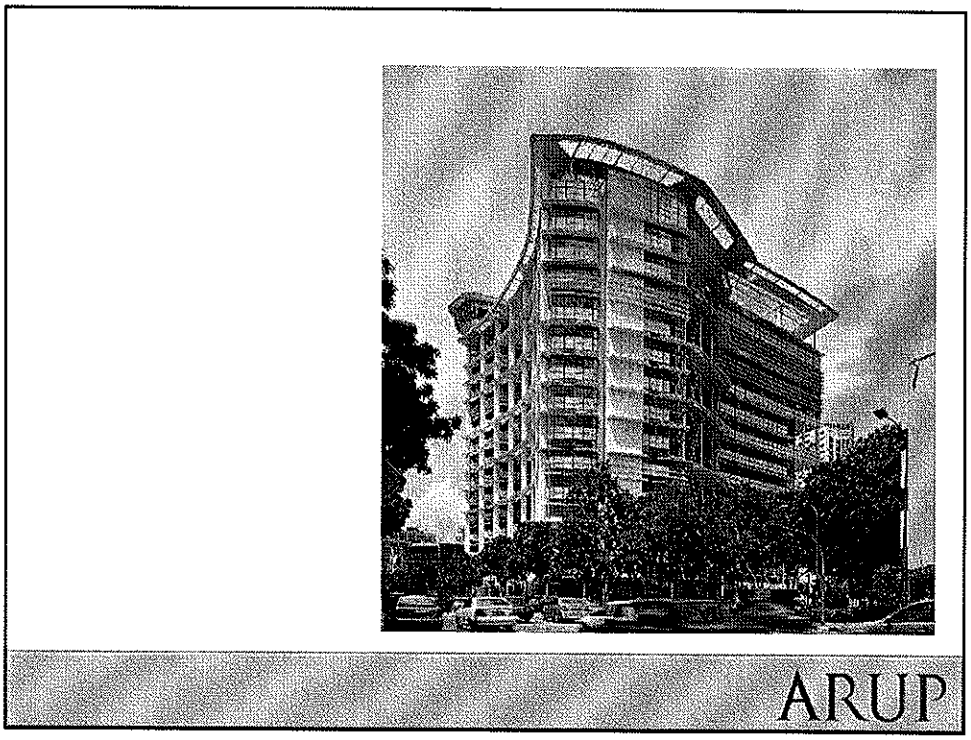
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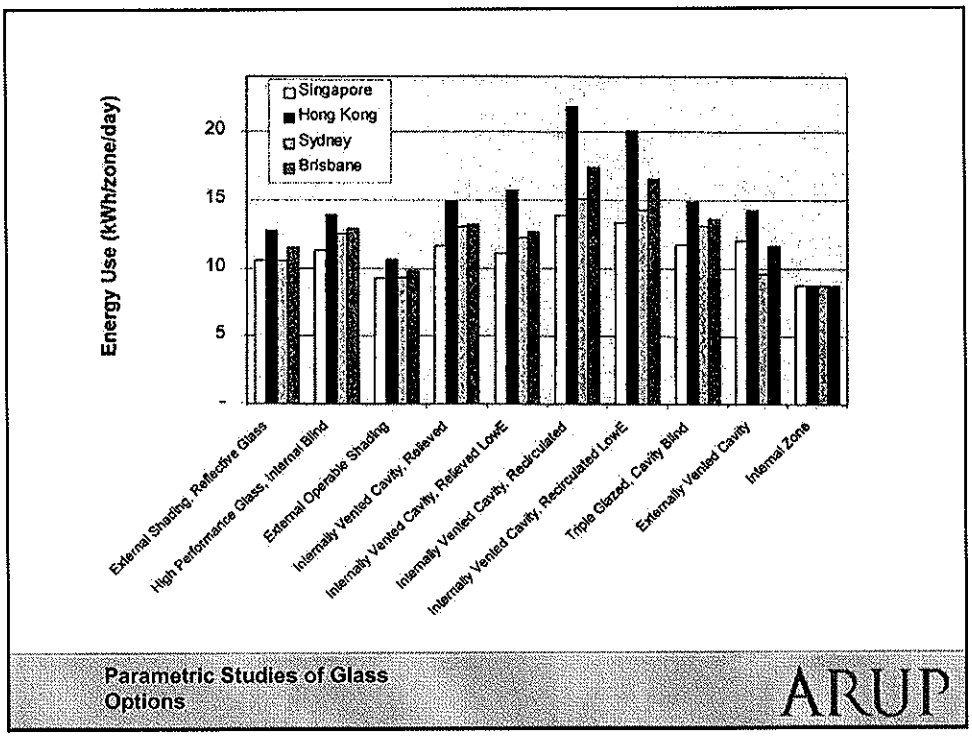

Parametric Studies of Glass Options

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	Sydney			Brisbane			Singapore			Hong Kong		
	Daylighting	Thermal Comfort	Energy	Daylighting	Thermal Comfort	Energy	Daylighting	Thermal Comfort	Energy	Daylighting	Thermal Comfort	Energy
External Shading with Reflective Glass	○	●	●	○	●	•	○	●	•	○	•	•
High Performance Glass with Internal Blind	●	○	•	●	○	○	●	•	•	●	○	•
External Operable Shading with LowE Glass	●	●	●	●	●	●	●	●	●	●	●	●
Clear Triple Glazing with Cavity Blind	●	○	○	●	○	○	●	•	○	●	○	○
Internally Vented Cavity - Clear	●	○	○	●	○	○	●	●	○	●	○	○
Internally Vented Cavity - LowE	●	•	•	●	•	○	●	●	○	●	•	○
Externally Vented Cavity	●	●	●	●	•	•	●	•	○	●	○	•

Legend: ● Good • Average ○ Poor

Parametric Studies of Glass Options

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Lighting

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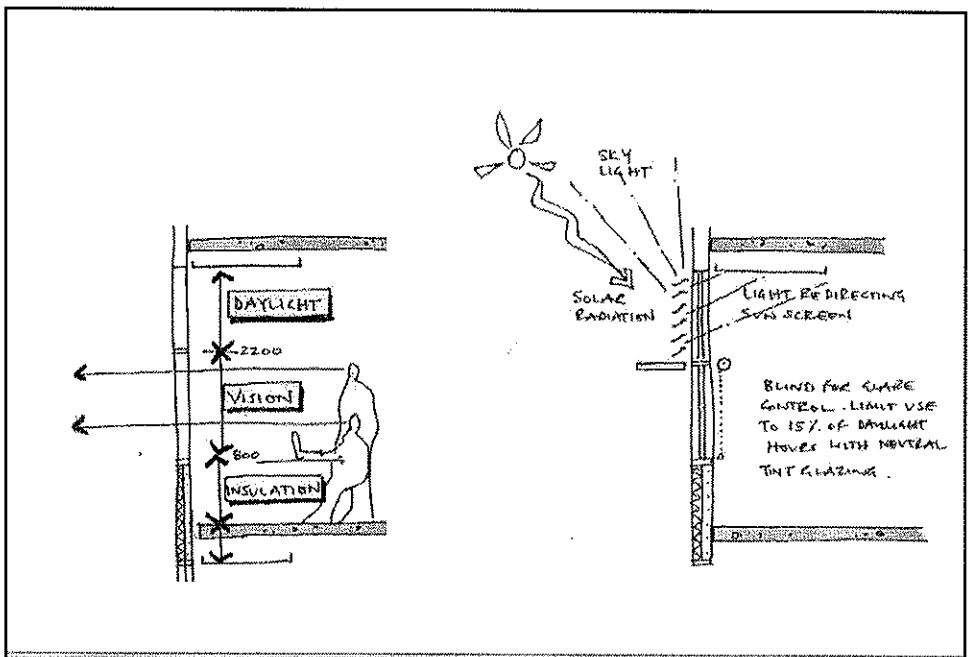

Daylight

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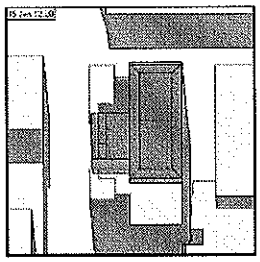
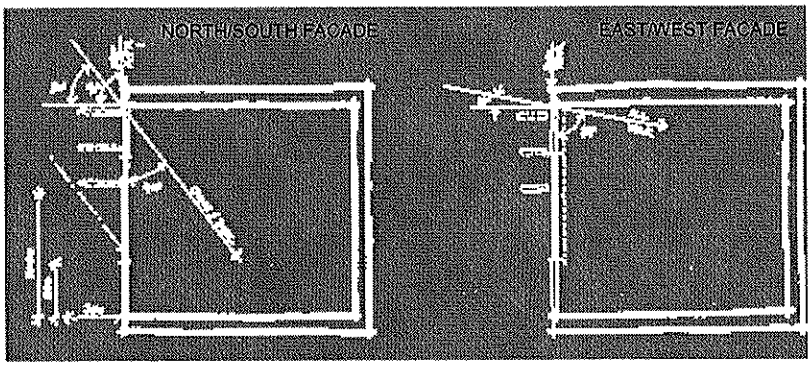
- Arrangement of Sunshades
- Penetration of Sunlight
- Overshading from Adjacent Properties





Sun Path Studies

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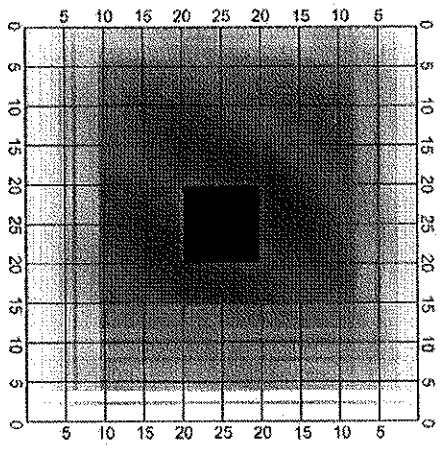
- Implications for shading design
- Ability to maximise useful daylight
- Recent Study Considered a number of geographies including Singapore
- Each considered a 50m square building



Floor Plate Configuration

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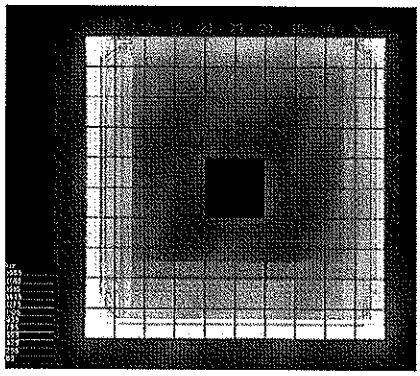
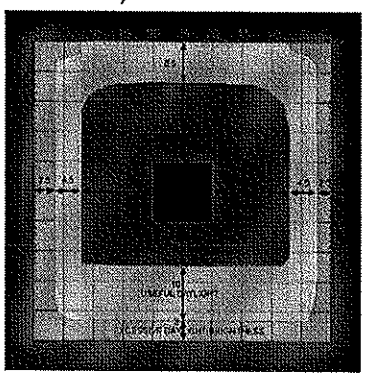
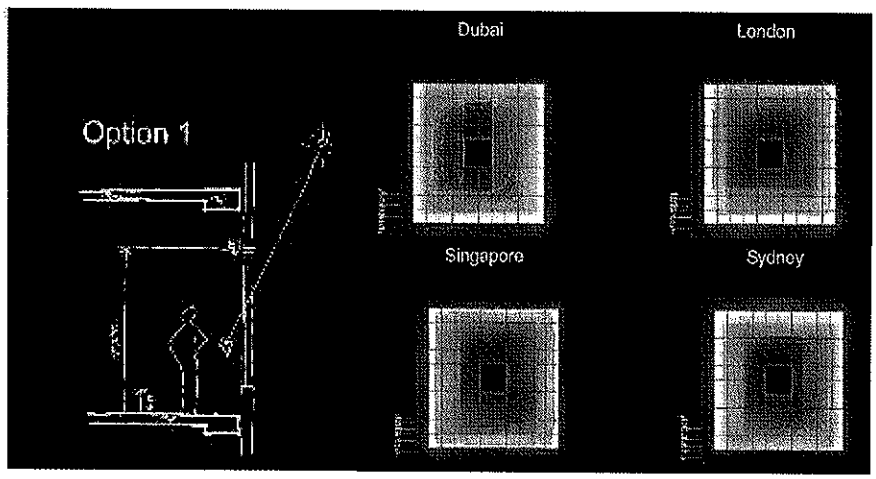
- Grade A office space has good daylight
- Zone limited by penetration
- Shading patterns can improve this
- Aim to maximise useful daylight (200 – 1000 lux)

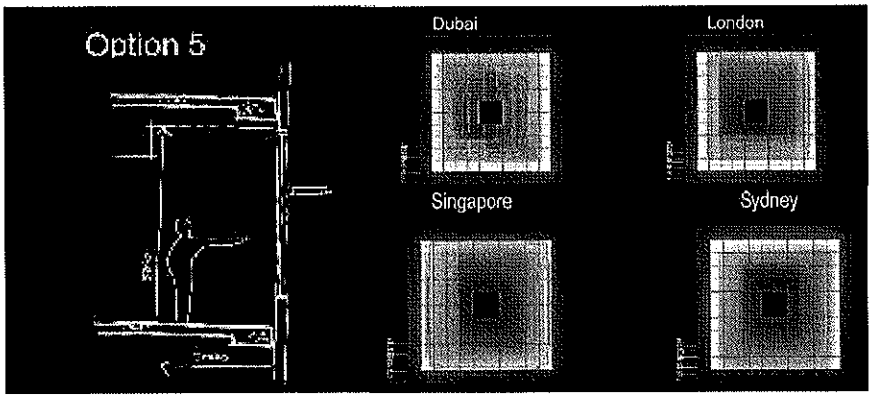




Floor Plate Configuration ARUP



Floor Plate Configuration – Option 1 ARUP



Floor Plate Configuration – Option 5

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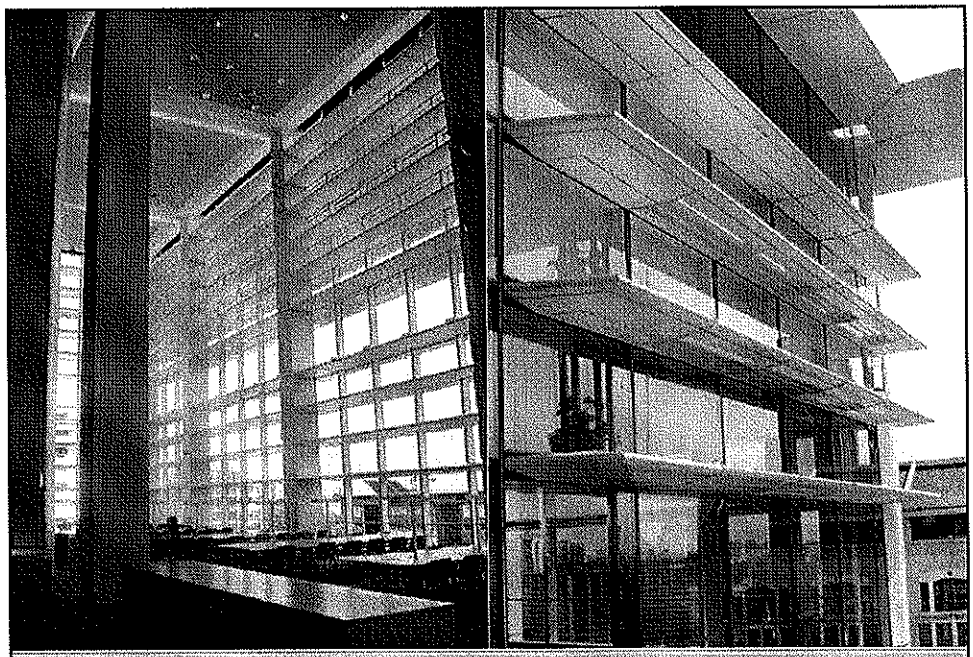

National Library Building

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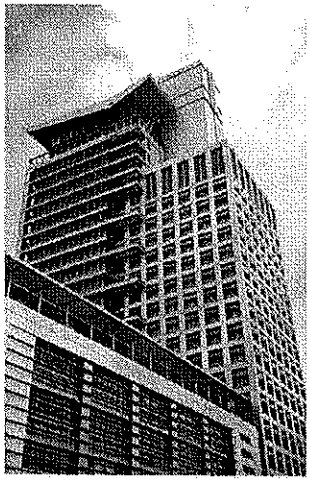
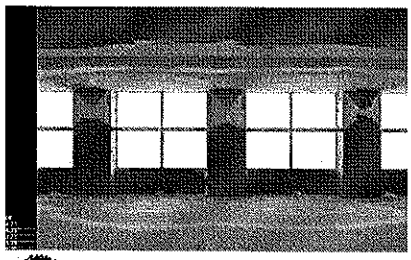
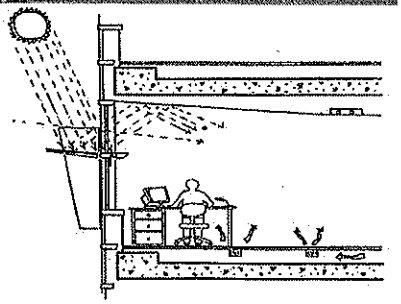
Daylight Level - Quality of Light







External shading and internal light-shelf

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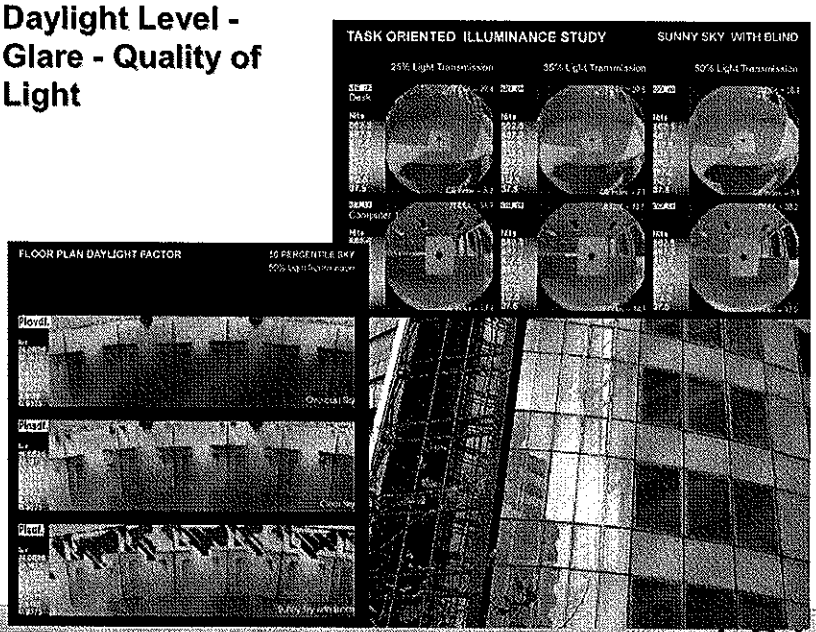
Daylight Level - Glare - Quality of Light



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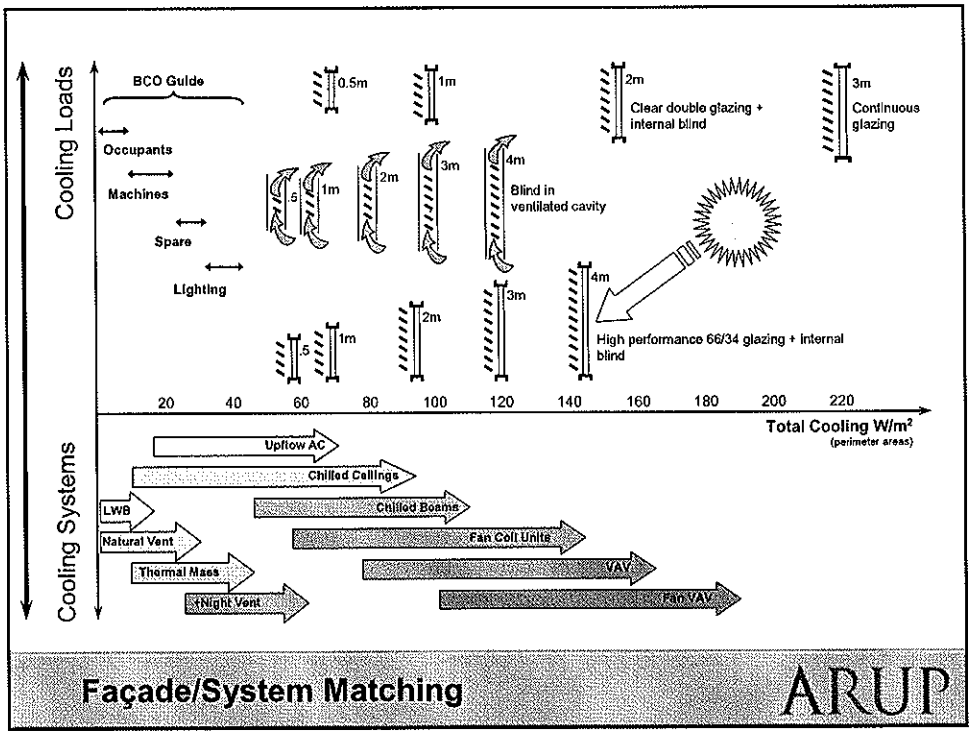
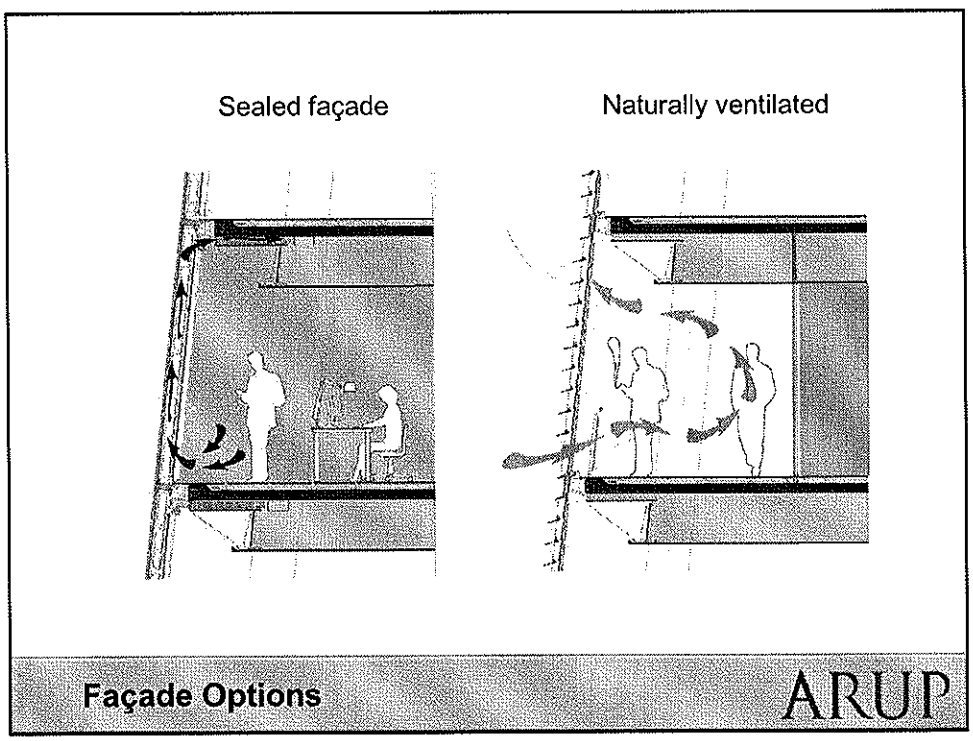
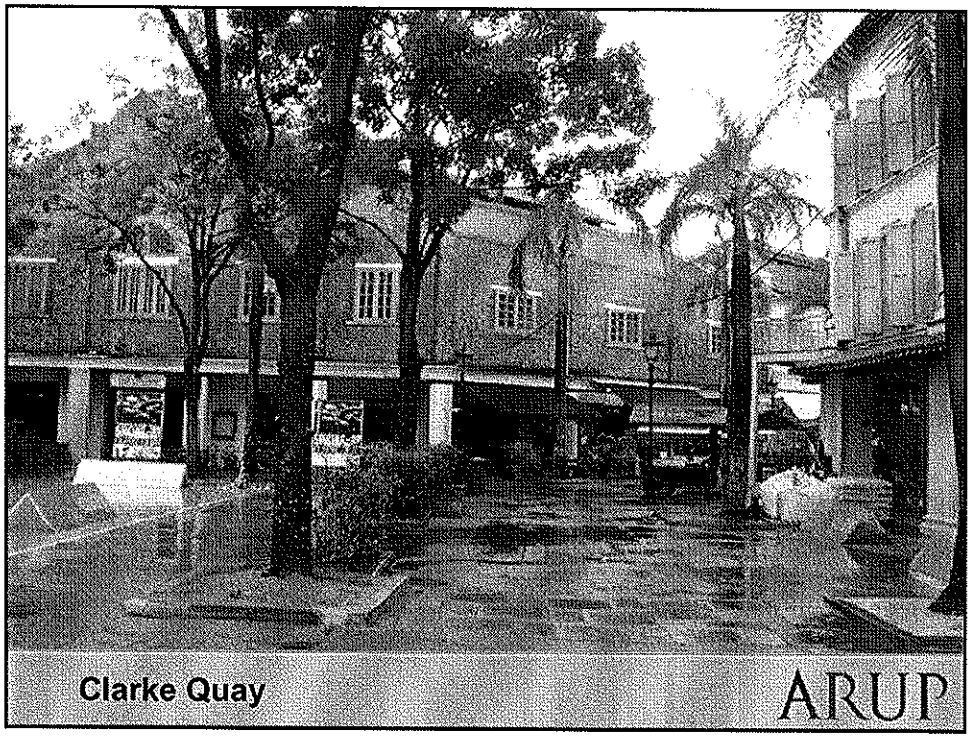
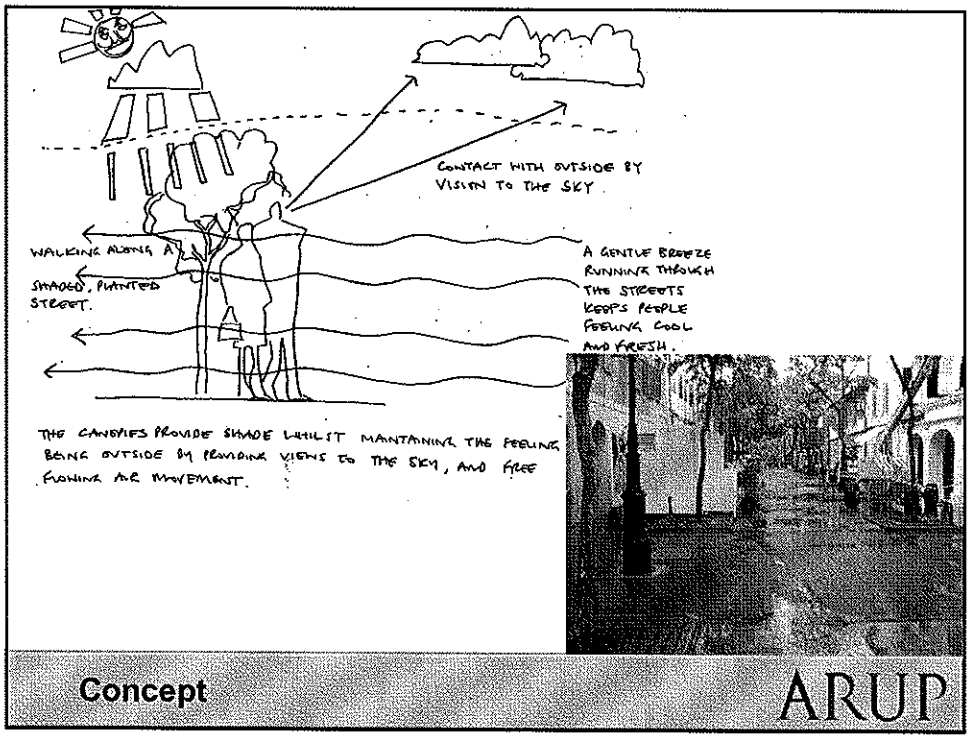
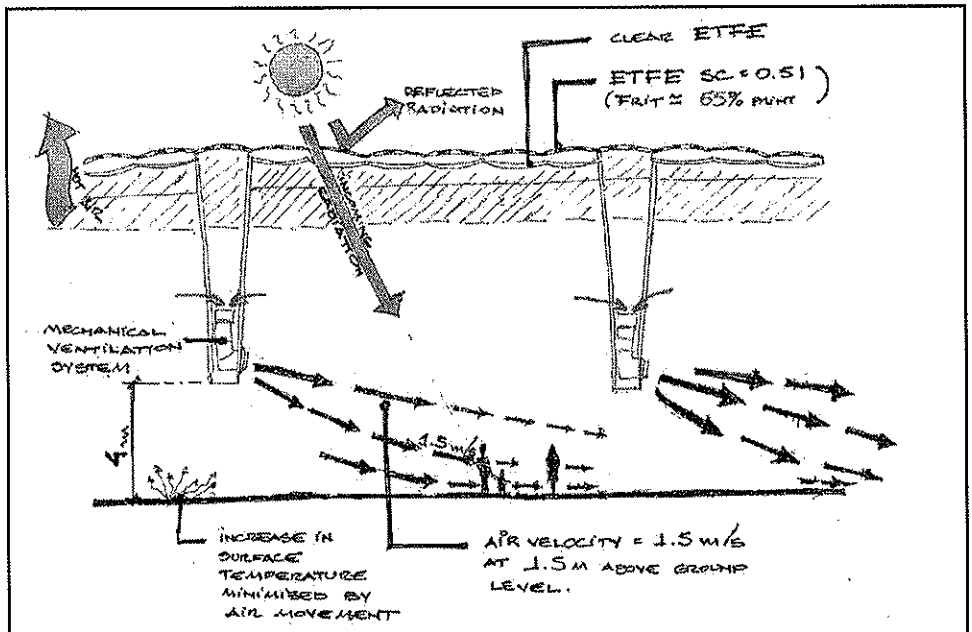

Cooling Loads
BCO Guide
Occupants
Machines
Spare
Lighting
0.5m
1m
2m
3m
4m
Clear double glazing + internal blind
Continuous glazing
Blind in ventilated cavity
High performance 66/34 glazing + internal blind
20
40
60
80
100
120
140
160
180
200
220
Total Cooling W/m²
(perimeter areas)
Cooling Systems
Upflow AC
Chilled Ceilings
Chilled Beams
Fan Coil Units
VAV
Fan VAV
LWB
Natural Vent
Thermal Mass
+Night Vent
Façade/System Matching
ARUP


Sealed façade
Naturally ventilated
Façade Options
ARUP

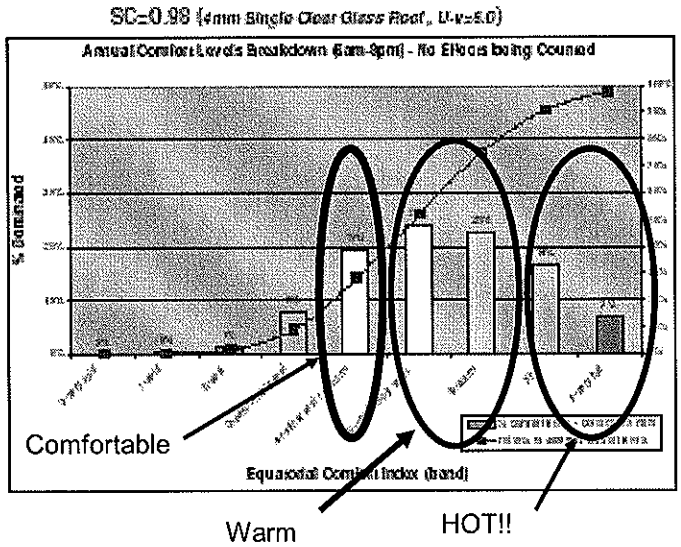

Clarke Quay
ARUP


CONTACT WITH OUTSIDE BY VISION TO THE SKY
WALKING ALONG A SHADED, PLANTED STREET.
A GENTLE BREEZE RUNNING THROUGH THE STREETS KEEPS PEOPLE FEELING COOL AND FRESH.
THE CANOPIES PROVIDE SHADE WHILST MAINTAINING THE FEELING BEING OUTSIDE BY PROVIDING VIEWS TO THE SKY, AND FREE FLOWING AIR MOVEMENT.
Concept
ARUP



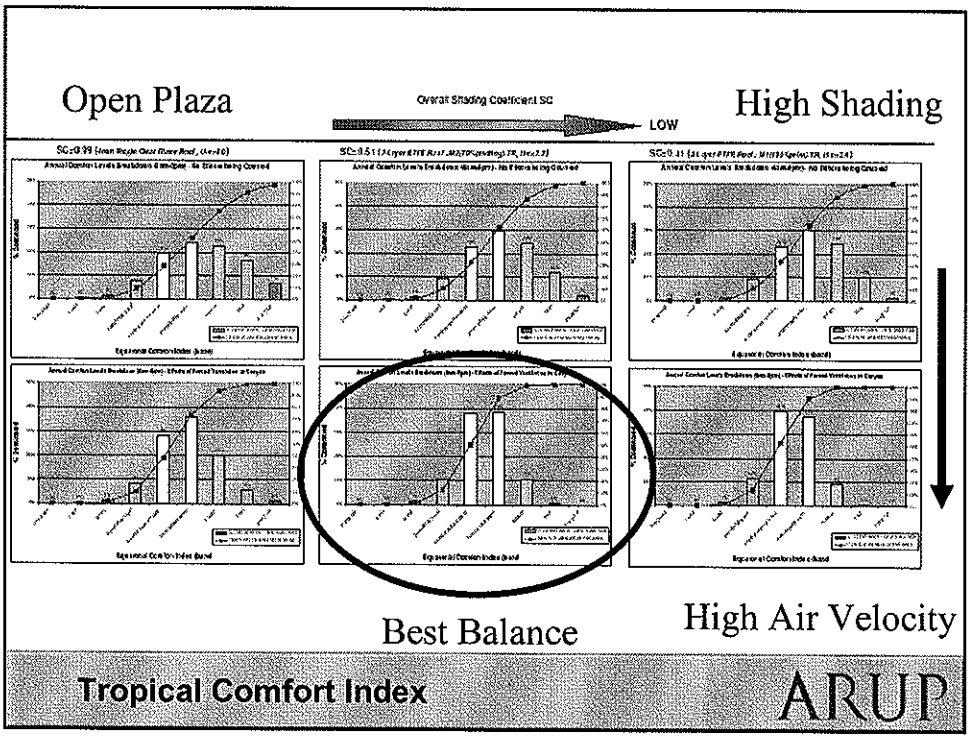
Concept

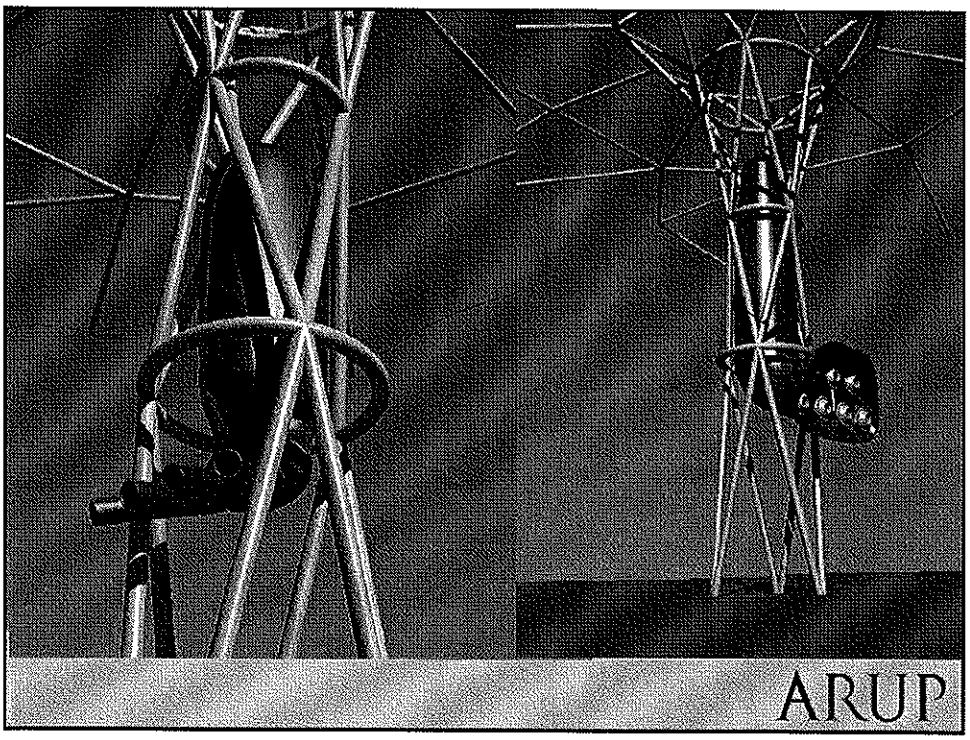
ARUP

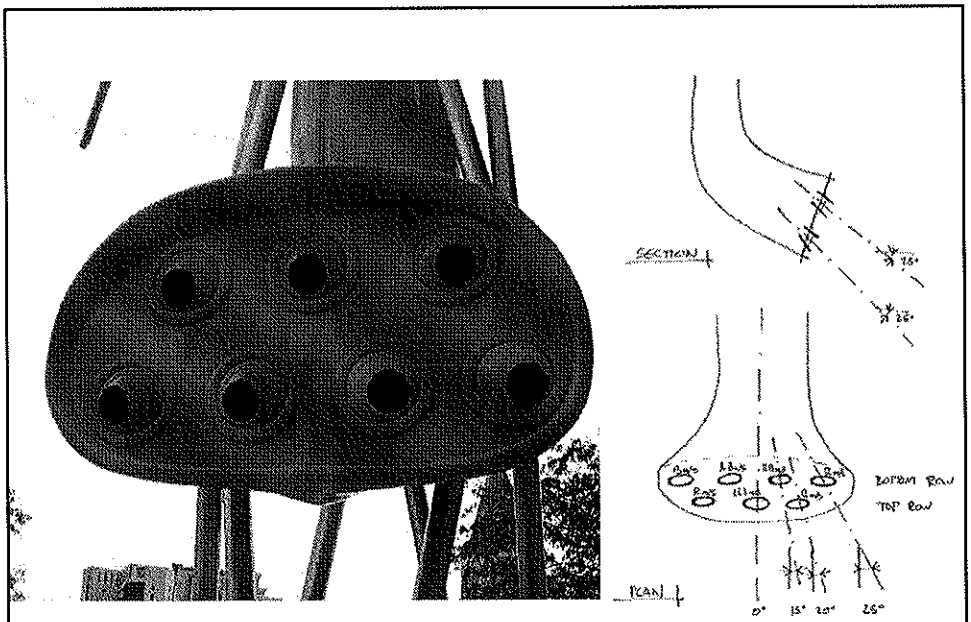


Tropical Comfort Index

ARUP

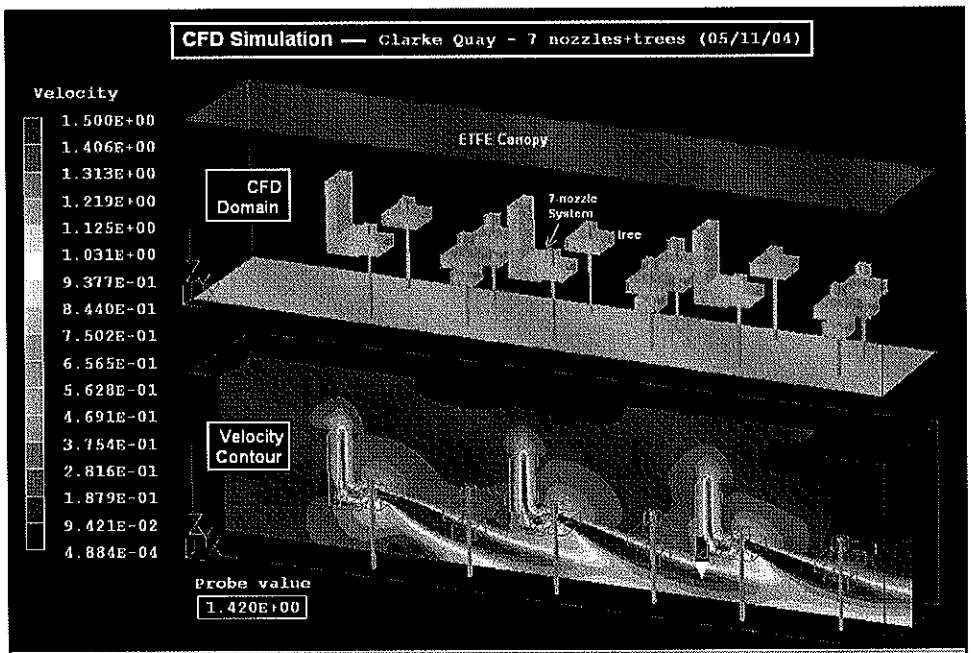

Open Plaza
Overall Shading Coefficient SC
LOW
High Shading
Best Balance
High Air Velocity
Tropical Comfort Index
ARUP


ARUP



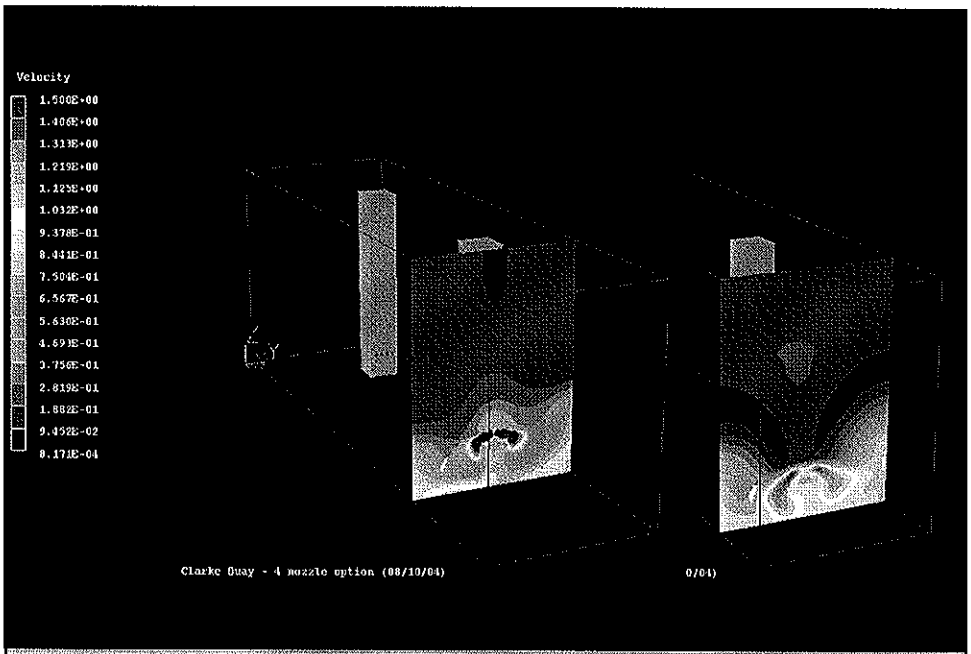
Nozzle Orientation

ARUP



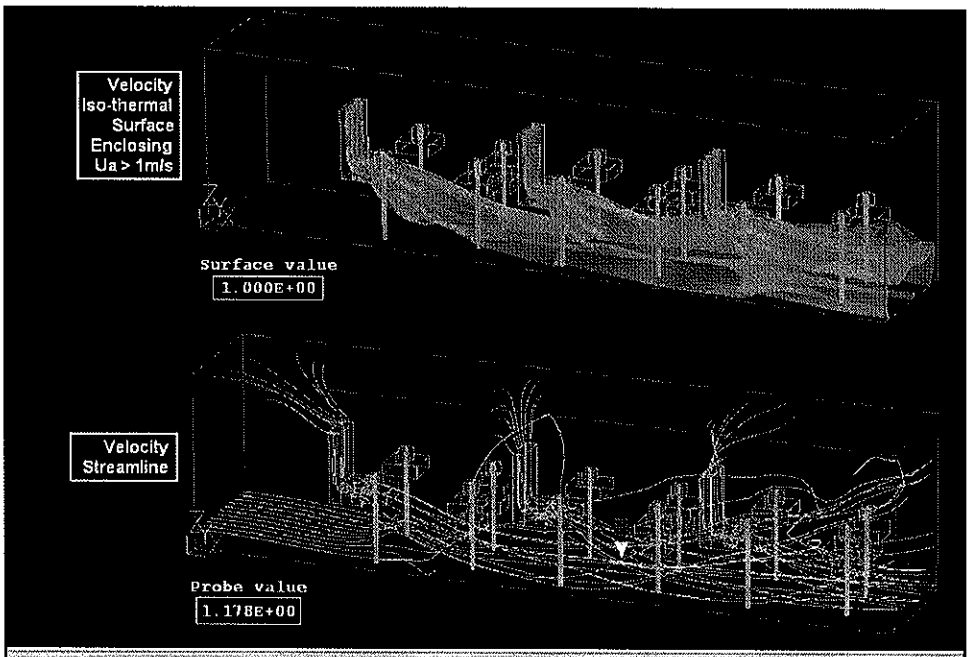
CFD

ARUP



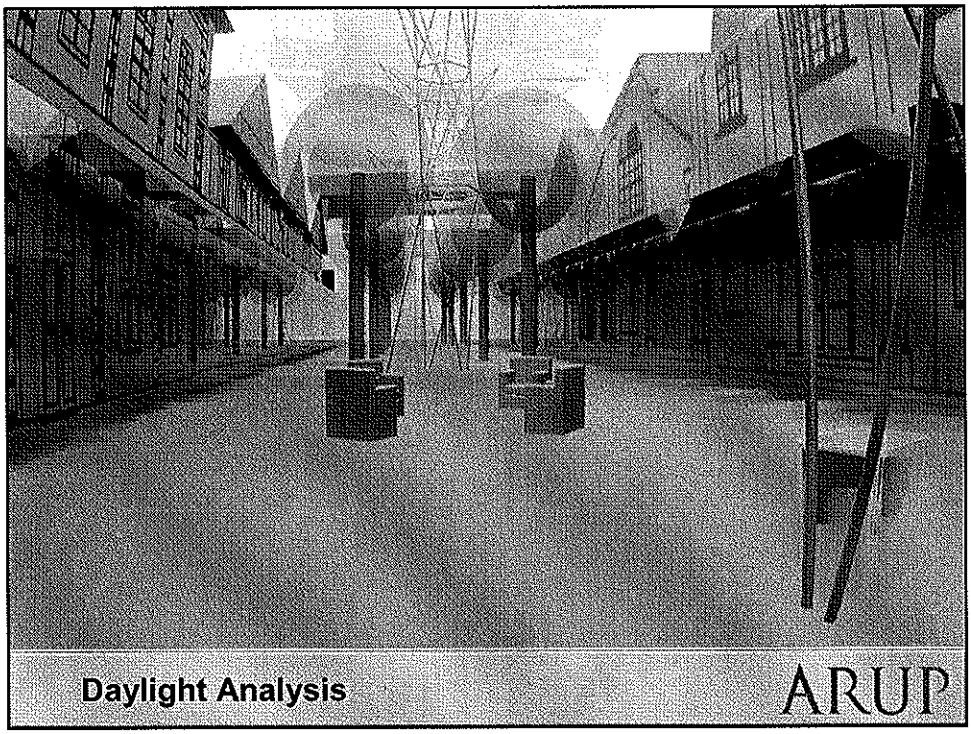
CFD

ARUP



CFD

ARUP



Daylight Analysis

ARUP



Mark Moody

... biography

Mark has responsibility within the Legrand Group for the continued evolution of the international market for low voltage and residential network systems, with a particular vision for convergence towards the "digital home".

Prior to this, he spent many years developing lighting control & VDI systems for major projects, in particular for Icon Commercial Buildings in the City of London.

As an active member of the IBG (Intelligent Building Group), Sustainable, Eco-friendly solutions for homes & buildings are at the center of his activity '.





Wired Infrastructure

... résumé

...value is being increased with the addition of ***individual*** applications that deliver excitement to different end-user communities, rather than one all encompassing "killer" application ...

...true ***convergence*** is gaining momentum, boundaries between mobile and fixed-line services; between voice, data and video; between computing and telecoms are becoming increasingly blurred ... However this convergence needs an underlying ***infrastructure*** to deliver and support it ...



Wired Infrastructure

... résumé



...***technology*** has profoundly changed the way we live, learn and work at home. However, are we preparing our homes adequately to fulfill this dream? Users need solutions adapted to this new "work" setting ...

... ***flexibility*** in everything. doing what we want, where we want, and when we want is key, The link between the home and office environment is increasingly less defined ...

...***individuality*** is no longer something reserved for expression away from the workplace Each home has unique needs, defined through time & by situation ...

...***responsibility*** toward the environment is driving the adoption of new processes, demonstrating appropriate use of resource, without compromising the home space ...

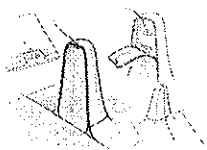


Wired Infrastructure

... résumé



Root ... (foundation infrastructure) the core or "backbone" delivers power, communication, entertainment & comfort, roots enable the interactivity throughout the home ...



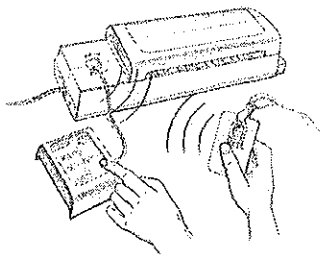
Trunk ... (local infrastructure) distribution from the root to an area of activity, where clusters of individual users can enjoy content & perform tasks, clusters can be share to others through the root ...

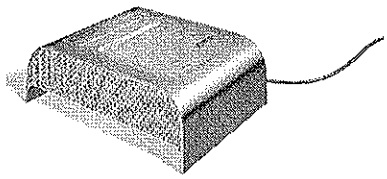


Branch ... (individual connectivity) distribution from the trunk to the individual, offering connectivity to trunk & root services, functionally and emotionally this is most important for the individual with most direct interaction ....











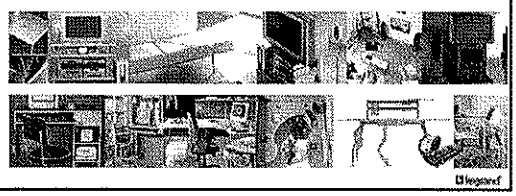
Wired Infrastructure

... Why the interest



schematic and technology

why the interest





Residential VDI

... today's applications



efficiency – pre & post build

type & method "off-site" construction

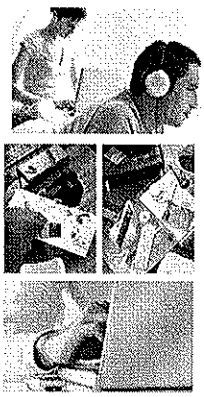
the service aggregator

content delivery



Residential VDI

... the near future



entertainment, the incentive to buy

flexibility for first, second, third generation owners

living and learning

cat6, better use of technology for all media

Multiple use buildings "one" infrastructure

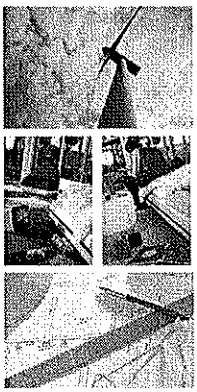


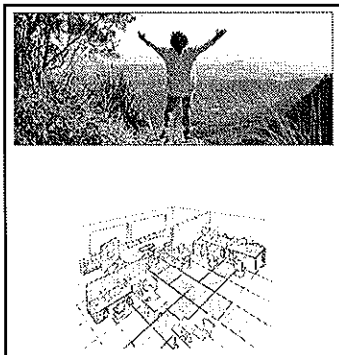
Residential VDI

... multiple & sustainable applications

sustainable technologies solar / wind generation

moving from disparate networks

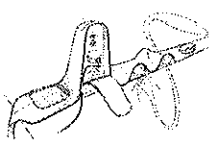




Residential VDI

... "Visioning" converged networks



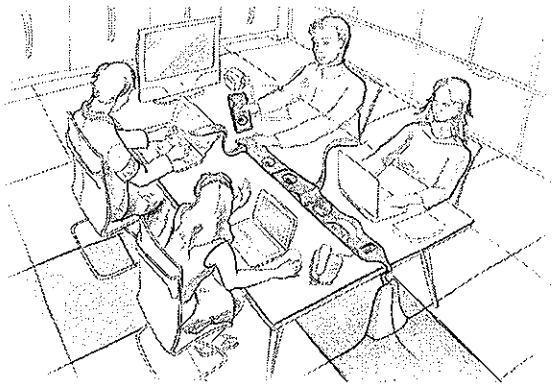


s: summary



Residential VDI

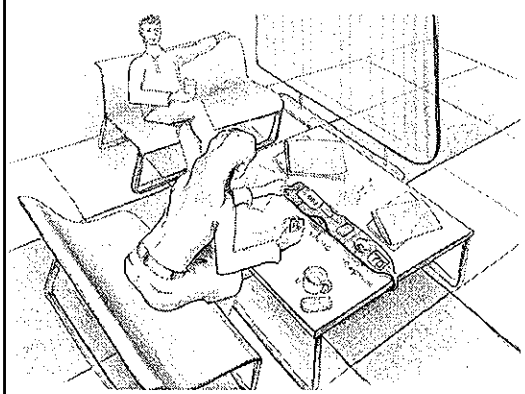
... "Visioning" converged networks





Residential VDI

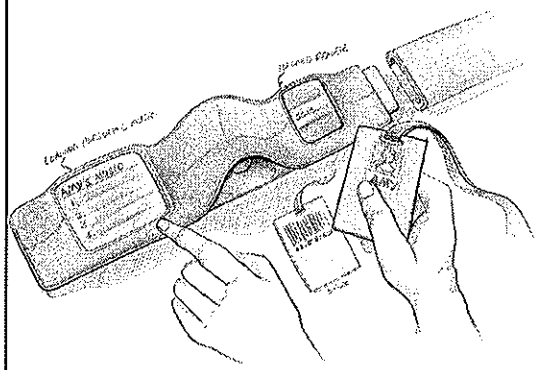
... "Visioning" converged networks





Residential VDI

... "Visioning" converged networks

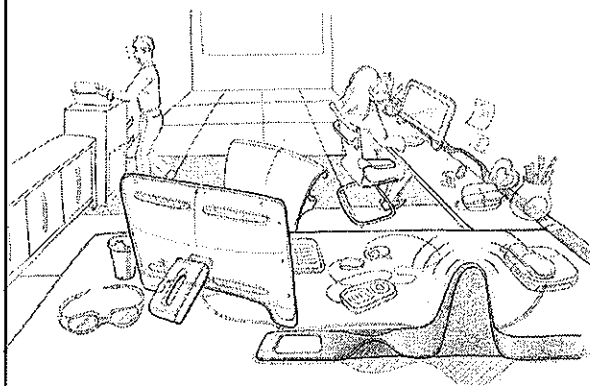


moss: branch: break time



Residential VDI

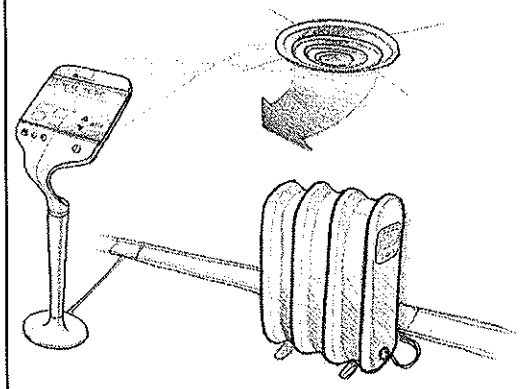
... "Visioning" converged networks





Residential VDI

... "Visioning" converged networks



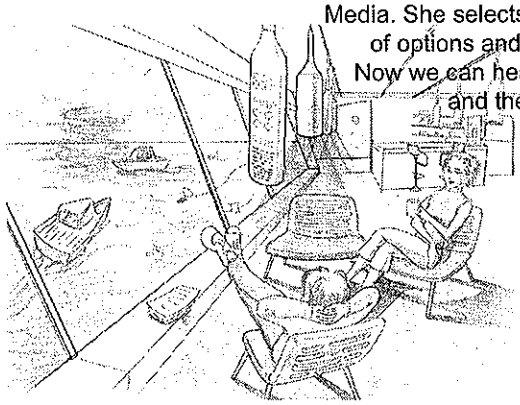
ivy: trunk: micro/macro climate control



Residential VDI

... "Visioning" converged networks

...from the panel, Goldthwaite selects "Environment" from a short list that includes Information, People and Media. She selects "Welcome Home" from the next list of options and the lights come on within the home. Now we can hear the sounds of mellow jazz playing and the whirring of window blinds adjusting themselves... Microsoft ...





Acknowledgements

... the roots of an "evolutive" building





Sustainability and the distributed workplace

Andrew Harrison
Director of Research
DEGW

DEGW

Introduction

- Buildings are typically under utilised - inefficient and unsustainable use of resources
- Globalisation and new mobile communications technologies call for new models of workplace, work processes and property management
- Traditional approaches to workspace will not serve the needs of global networked organisations



Impact of built environment on sustainability (USA)

- Americans spend 90% of their time in buildings
- Consume 1/3 total energy, 2/3 electricity
- Consume 1/4 harvested wood
- Consume 17% water
- Produce 33% of CO_2 and 40% landfill waste
  (GSA website)



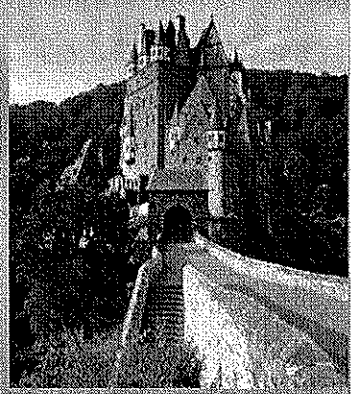
Impact of built environment on sustainability (UK)

- 50% of energy use is in the construction, operation, renovation and demotion of buildings
  (Inst. Of Civil Engineers)
- 98% of building stock remains unchanged from year to year
- Forecast that 6800 hectares of countryside will be urbanised each year over the next 20 years



Impact of built environment on sustainability (Germany)

- Daily increase in land use for settlement and traffic areas is 120 hectares
- If continuous 3% economic growth is achieved, 100% of country's surface covered by built environment in 157 years even with factor of 10 decoupling of relationship between GNP and land use (81 years without it) Federal Office of Statistics 1998



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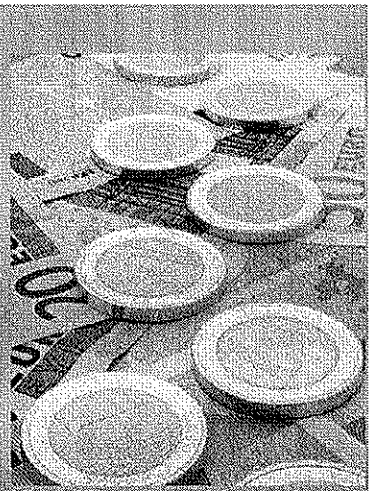
Eco-efficiency and Factor 10

- Eco efficiency aims at breaking the link (decoupling) between economic growth and environmental degradation
- Maximising the value added per unit of resource input
- Use of materials is a key element of environmental impact
- Factor 10 Club believes that within one generation nations can achieve a 10 fold increase in the efficiency with which they use resources
- *This will require radical change in how business is done*



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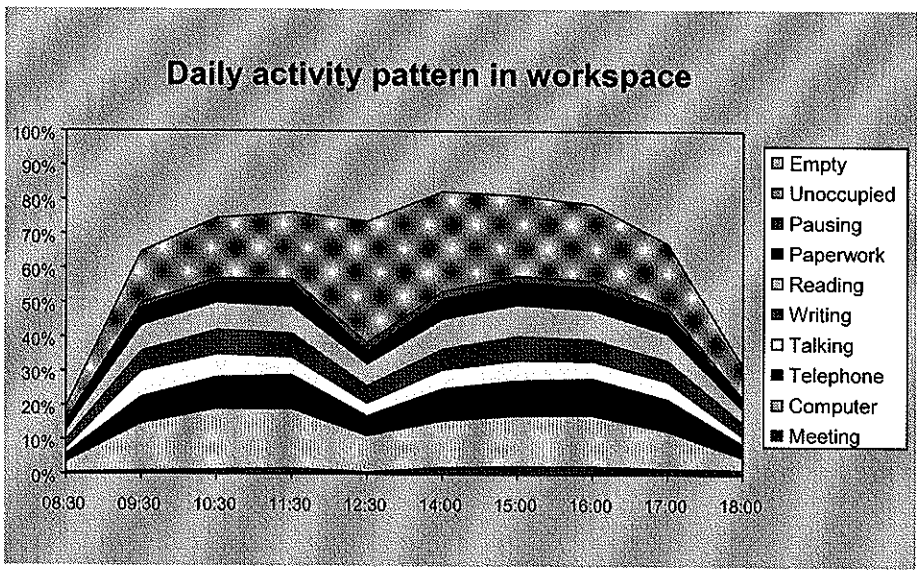
Time Utilisation Survey: poor utilization of most offices



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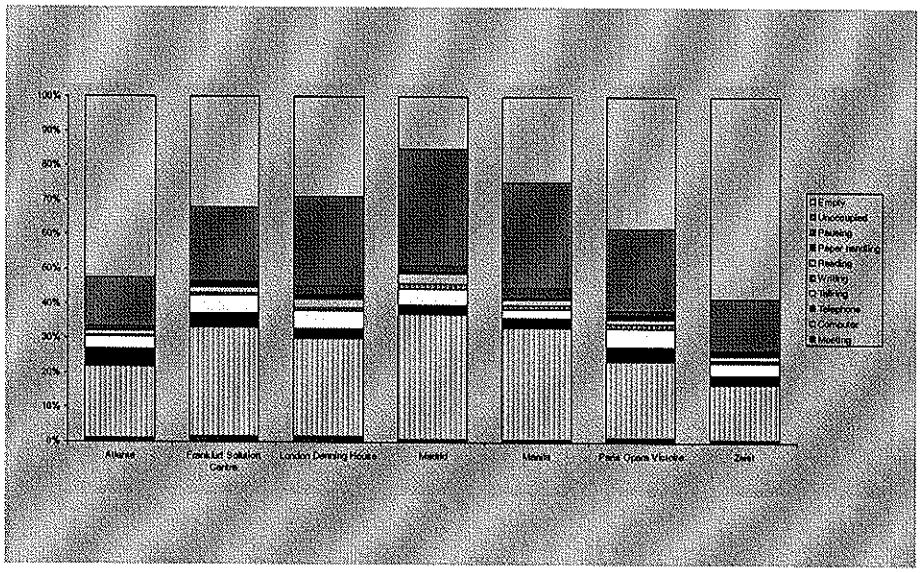
Time utilization studies: comparison of seven global locations



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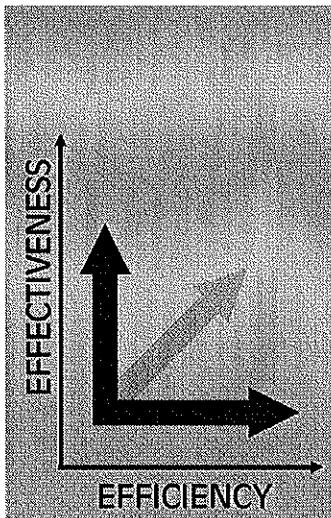
Balancing efficiency and effectiveness



•Increasing efficiency	•Increasing effectiveness
• Reducing cost • Space used to full capacity • Maximum levels of occupancy • Making the most of space	• Increasing value • Space used to full potential • The right range of worksettings • Making the most of people

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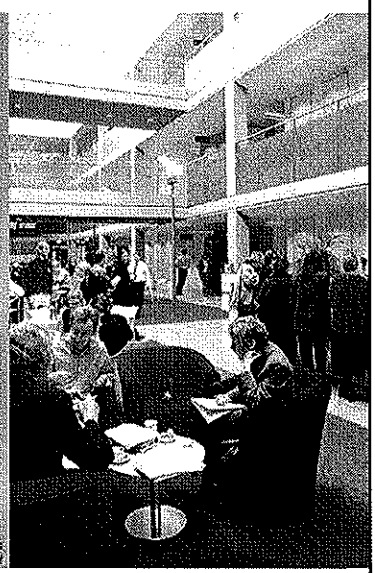
Work is Changing

- Shift from paper processing to knowledge brokering
- Open and non-hierarchical organisations
- Value in ideas not the manufacture of product
- Work when we like, where we like, how we like
- Organisation mixture of "core staff", "freelance staff" and "partners"



Boots Chemist Headquarters
DEGW Architects, Interior Change Management

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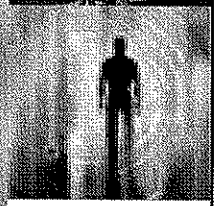
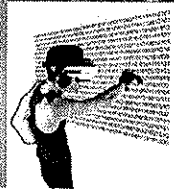
Shift from Physical to Hybrid Work Environments

- Physical working environments are increasingly equipped and formed through new technological features supporting mobile ways of working
- The combination of physical and the non-physical work environments creates new hybrid work spaces and environments
- How can these hybrid work environments be integrated into workplace strategies and the procurement process?







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Sustainable Accommodation for the New Economy (SANE)

- European Commission, €5.5 million, 5th Framework research project, Jan. 2001 - Dec. 2002
- Develop model and tools for the New European Workplace
- Objective: Enable space designers, technology developers and other workplace professionals to move from a location centric to location independent approach
- Creation of sustainable, collaborative workplaces for European knowledge workers, encompassing both virtual and physical spaces

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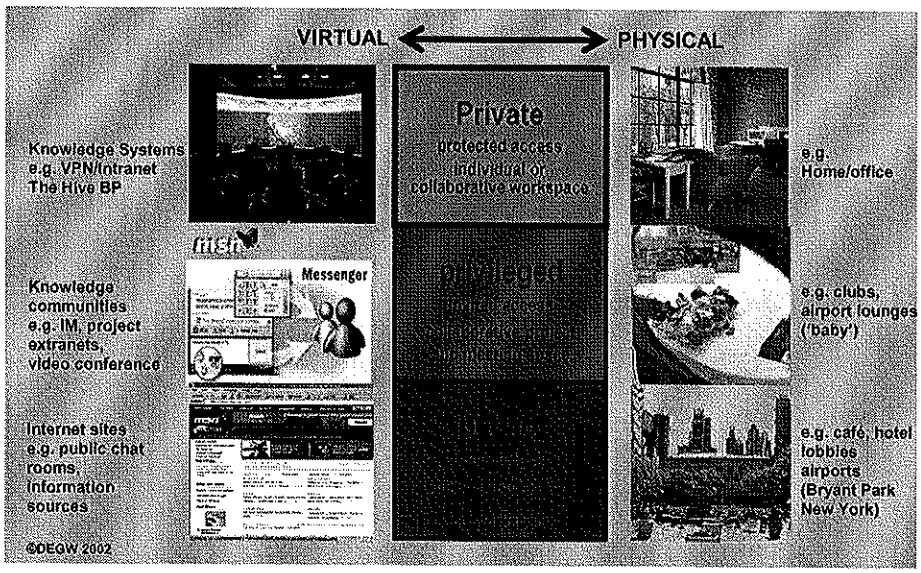
The 'SANE' Space Environment Model



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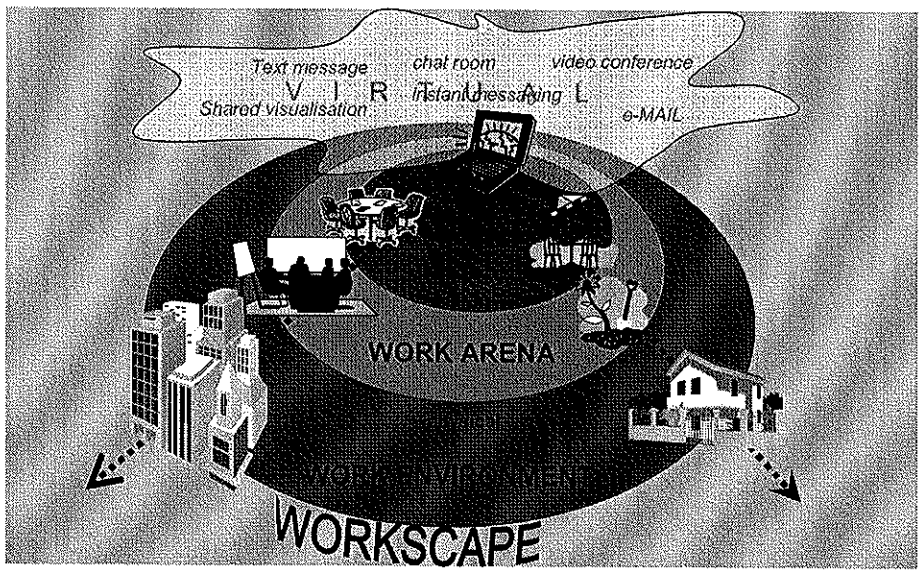
Thinking in Terms of a 'Workscape'



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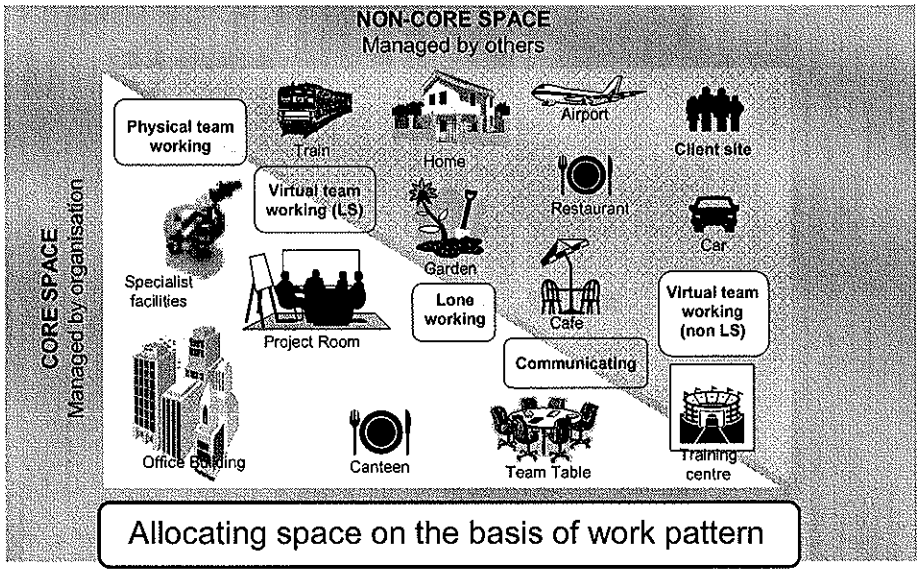
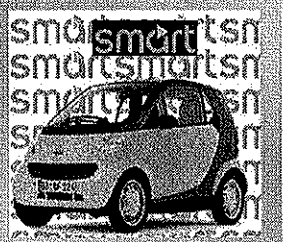
Hypothetical Distributed Real Estate Strategy



Choice Leading to New Paradigms of CRE Ownership





AVIS

Core Space
- Icon and image space
- long lease/freehold
- prime location
- highly serviced

Flexi Space
- shorter leases
- administrative or
- sales space
- conference/training space

Pay-As-You-Go
- licensed or pay for use
- shared/ borrowed from partners

"Company's assets are 'know how', not physical assets"

Benefits of a Distributed Workplace Strategy

- At the level of the individual
  - Blending living, working, moving
  - Optimising use of time
- At the level of the organization
  - Liberating capital
  - Freeing assets
  - Global networking
  - Innovation catalyst
- At the level of the city
  - Sustainability
  - Use of traditional/ cultural places as work locations
  - Reinventing the city



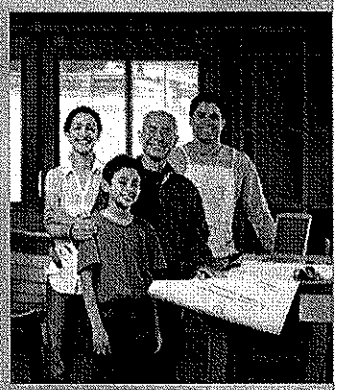
Risks and Challenges Related to Distributed Working

- Work-life issues: can people separate working and living?
- Maintenance of organizational culture in shared work environments
- Management of a distributed workforce
- Physical and information security
- Potential blandness of generic work environments
- Will the potential sustainability benefits be realised?



Future Challenges

- Impacts of the multi-generational workplace: four generations are currently in the workplace
  - Traditional workers (born 1928 – 1945)
  - Baby boomers (born 1946 – 1965)
  - Generation X (born 1966 – 1977)
  - Generation Y (born 1980 –)
- Impact of radical change in education on expectations of the workplace



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The Ageing Workforce

- By 2020, close to half the adult population of Europe will be over 50
- Increasing pressures for people to work longer
  - pension shortfalls
  - valuing of their expertise and knowledge
  - shortage of knowledge workers in growing economies
- Research by CROW suggests people are willing to work longer if there is more flexibility about how, when and where they work
- Impacts also on the physical and work environments – inclusive design – differing visual, auditory, work setting requirements
- Issues explored in *Capture IT*: RCA research project sponsored by DEGW, Steelcase and IDEO



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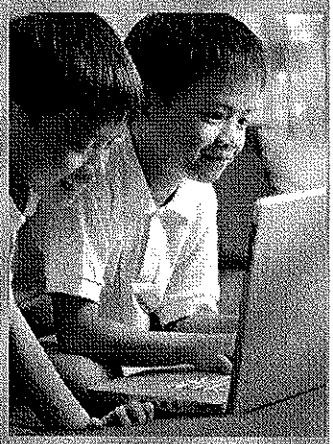
Educational Transformation

- Major changes in all levels of education: from primary schools through to universities
- Building Schools for the Future in the UK:
  - £70 billion investment in England over 15 years
  - £10 - £15 billion spend on IT
  - a new school every 3 days for 15 years
- Revolution not evolution in education practice



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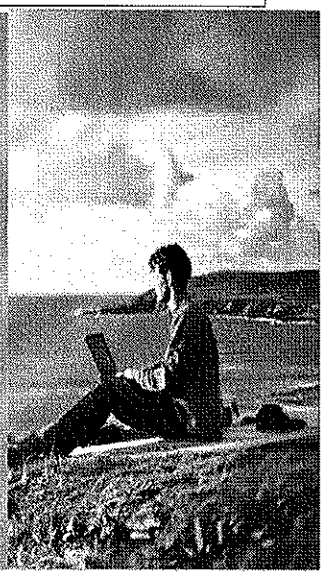
Implications for the Future Workplace

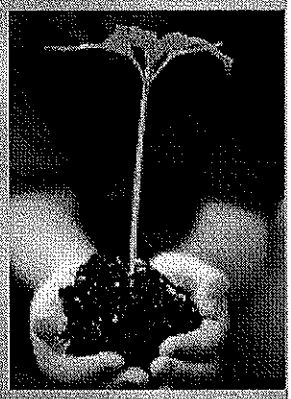
- Next generation of students entering the workforce will have very different expectations about where, how and when they work
- Multi-generation workplace will need to respond to diverse user requirements
- Increased blending of functions between work, leisure and learning
- New types of workplace providers, increased use of city spaces and facilities



DEGW Amsterdam – Bristol – Chicago – Glasgow – London – Madrid – Melbourne – Milan – Munich – New York – Paris – Rome - Sydney

Sustainable workplace questions

- What is a more sustainable way of working, of operating an economy?
- What is a sustainable working environment?
- Where should work take place?
- Where should these work environments be located?
- How can productivity and efficiency be increased and consumption decreased?
- What are appropriate urban and workplace indicators for sustainable development?



Towards a sustainable built environment
The UK perspective

Dongtan Eco City 东滩生态城市

Roger Wood
Associate Director Arup

November 1st 2006



ARUP

PRESENTATION CONTENTS

China's new direction in urban development

Why Dongtan?

Approach to master planning and integrated urbanism

The first phase master plan and the way forward.

Proposals for an R&D related to climate change and sustainability.

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Like much of the world, China is becoming more urban

"Urban population is to reach 1.12 billion by 2050 – this is a shift of more than 600 million people from rural to urban."

Guangming Daily

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Unsustainable urbanization is a threat to long term security

China's current development is ecologically unsustainable, and the damage will not be reversible once higher GDP has been achieved.

Zhenhua Xie, Minister of State Environmental Protection Agency

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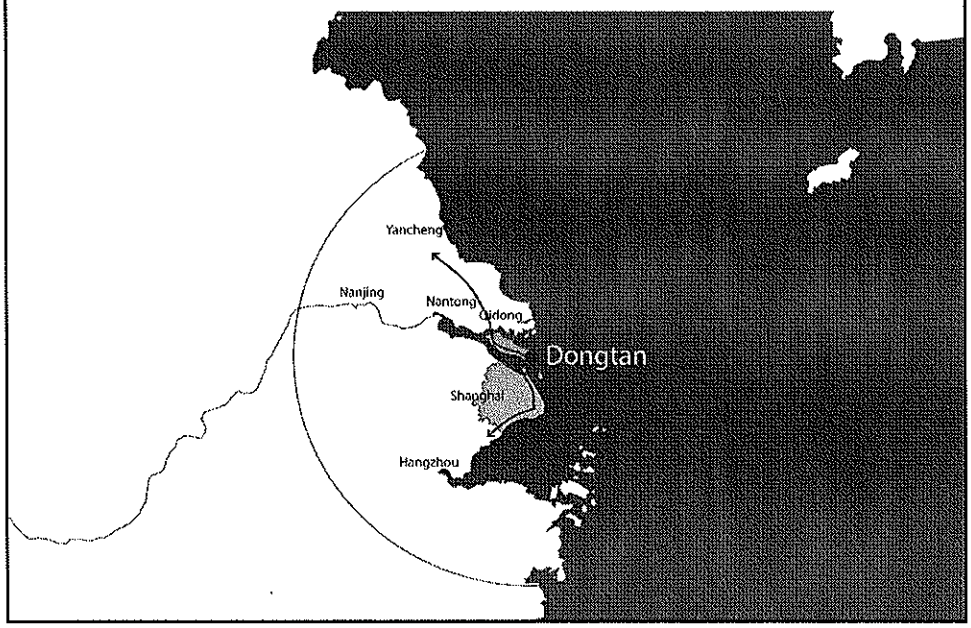
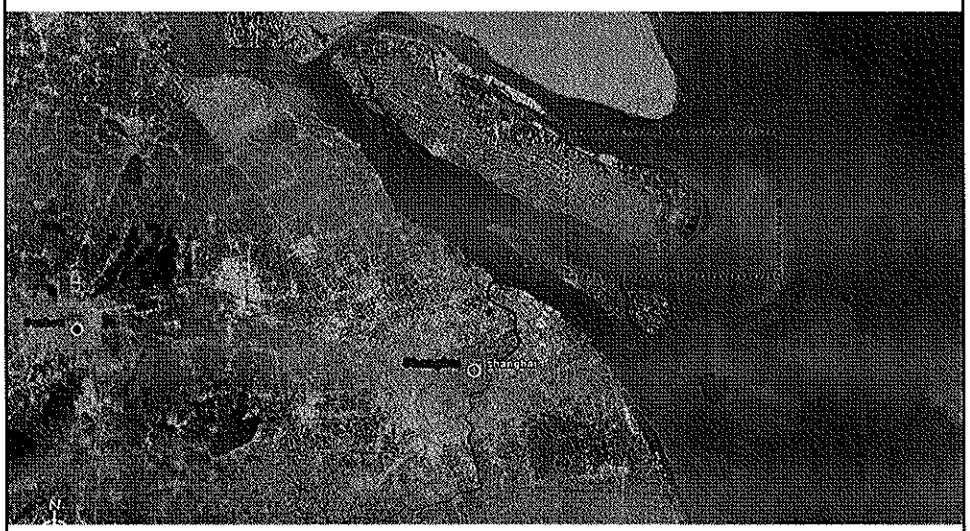


Towards a sustainable built environment – The UK perspective



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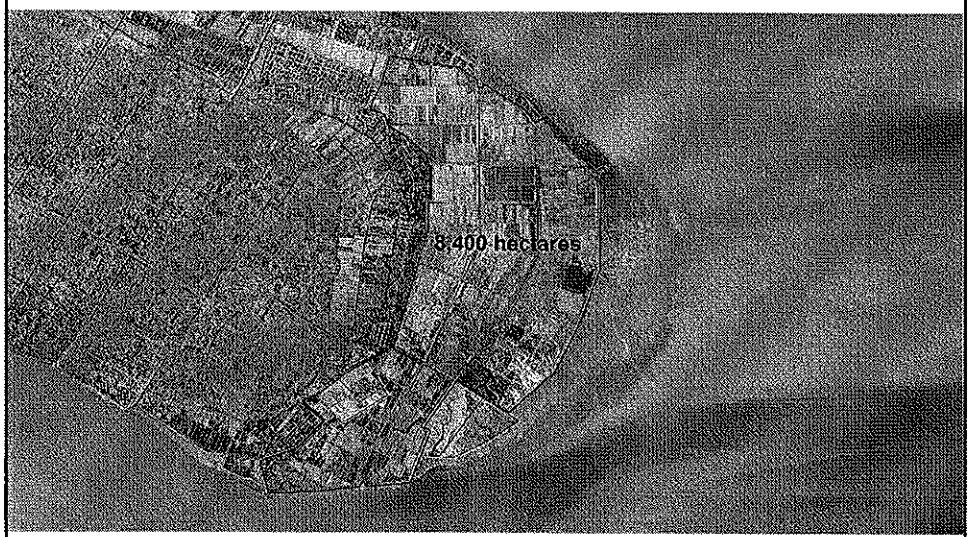

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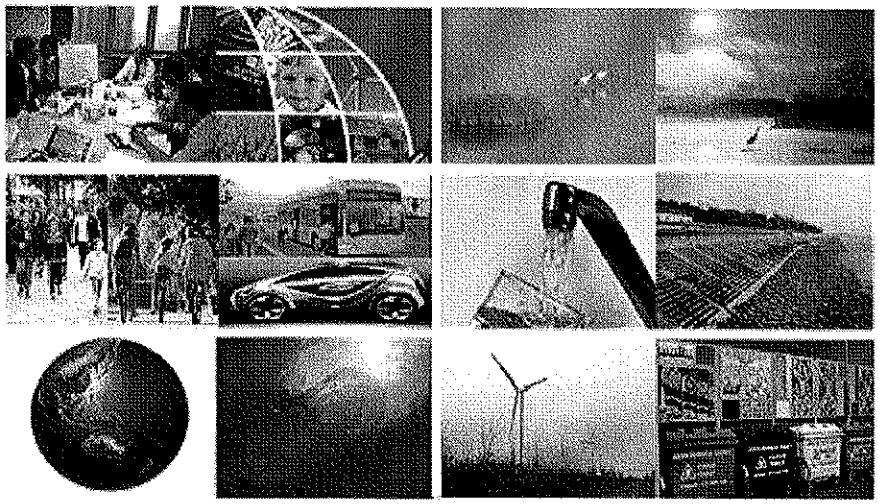
DONGTAN ECO CITY -THE SUSTAINABLE APPROACH
东滩生态城 – 可持续性发展



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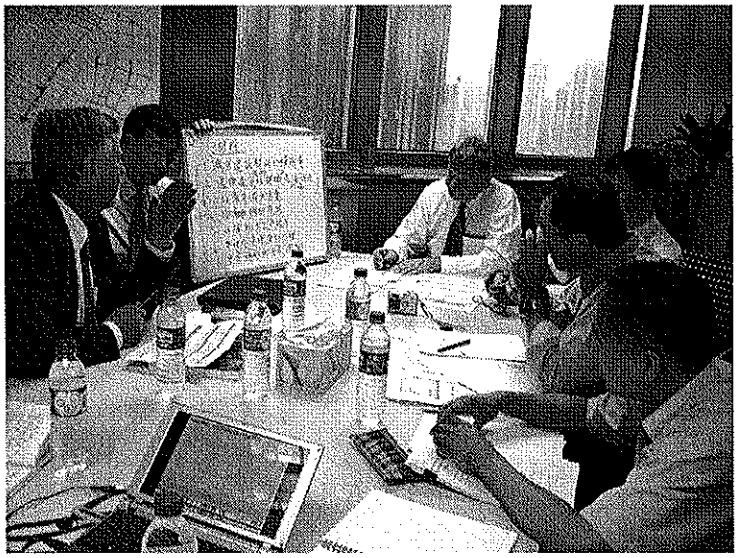
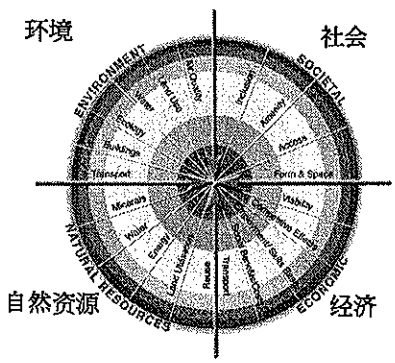
Towards a sustainable built environment – The UK perspective

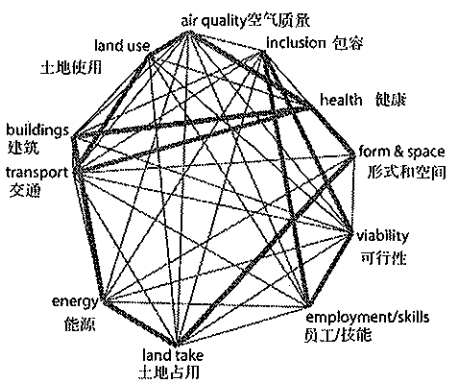


September 2005

ARUP

AN INTEGRATED APPROACH TO VALUE THROUGH BETTER DESIGN





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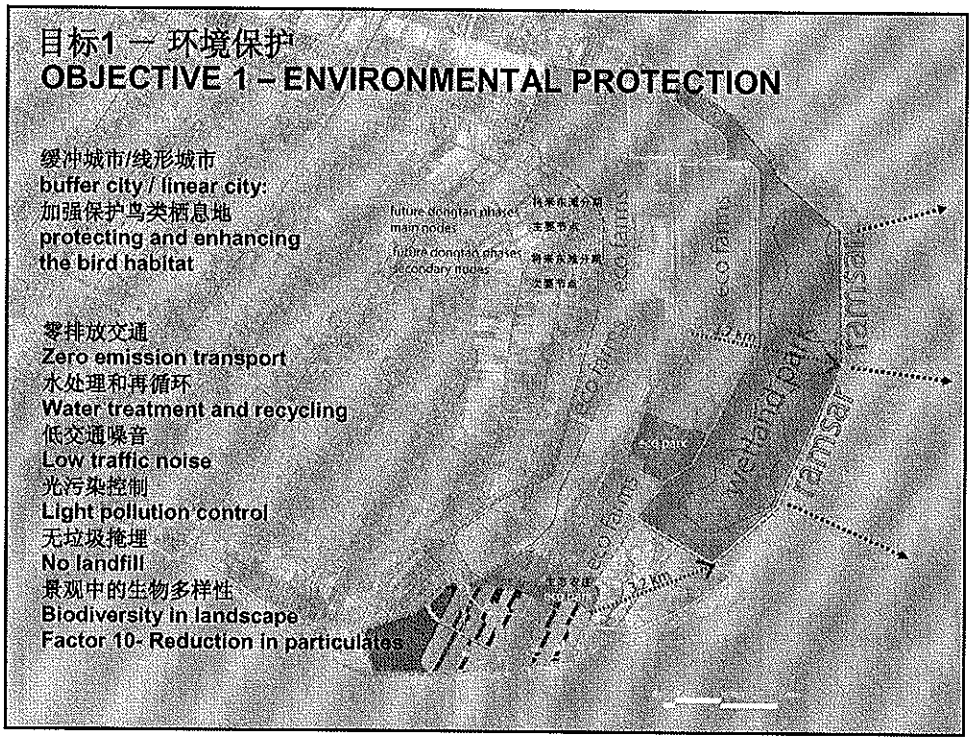
目标1 – 环境保护
OBJECTIVE 1 – ENVIRONMENTAL PROTECTION

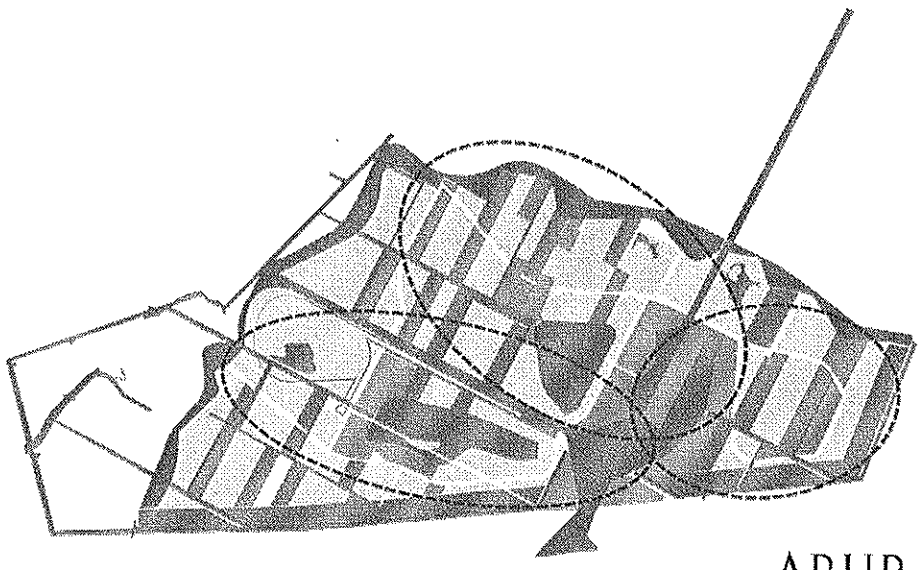
缓冲城市/线形城市
buffer city / linear city:
加强保护鸟类栖息地
protecting and enhancing the bird habitat

零排放交通
Zero emission transport
水处理和再循环
Water treatment and recycling
低交通噪音
Low traffic noise
光污染控制
Light pollution control
无垃圾掩埋
No landfill
景观中的生物多样性
Biodiversity in landscape
Factor 10- Reduction in particulates



由村落组成的城镇与自然相和谐
TOWN OF VILLAGES IN HARMONY WITH NATURE

Towards a sustainable built environment – The UK perspective



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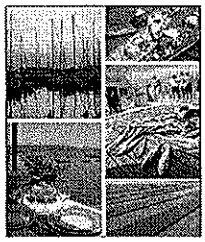
目标 2 — 社会与经济优势
OBJECTIVE 2 – SOCIAL AND ECONOMIC BENEFIT

可持续的生态城市 Sustainable Eco-city	80,000 residents 8万居民 15,000 visitors daily每天1万5千名游客	51,000个工作岗位 51,000 jobs
常规城市 Conventional Approach City	50,000 residents 5万居民	19,000个工作岗位 19,000 jobs





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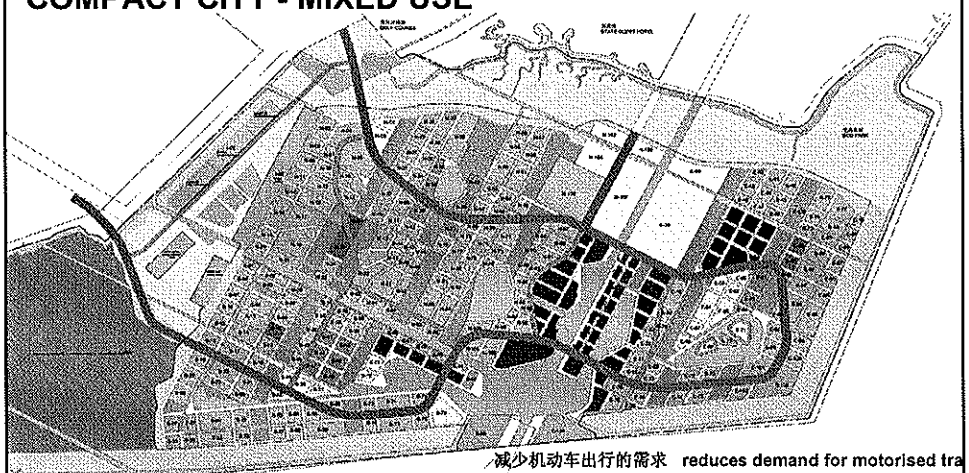
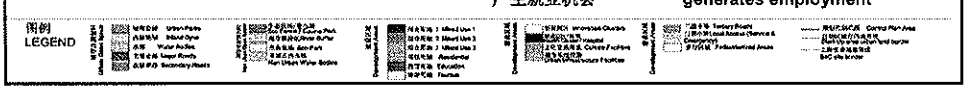
紧凑城市—混合用途
COMPACT CITY - MIXED USE



54 % 居住区域 / 46% 其他功能
54 % Residential / 46% other uses

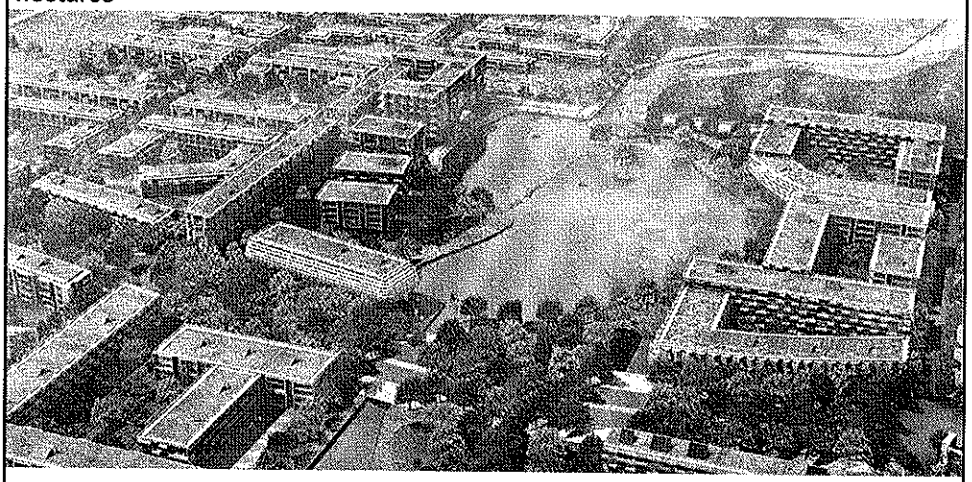
减少机动车出行的需求	reduces demand for motorised tra
通勤最少化	minimises commuting
提供本地化服务	provides services locally
产生就业机会	generates employment



紧凑的城市
COMPACT CITY

低层&高密度-3-8层/平均容积率　　1.45/每公顷平均75套住宅/8万人

low rise & high density – 3 to 8 storeys / 1.45 average plot ratio / 75 dwelling per hectares



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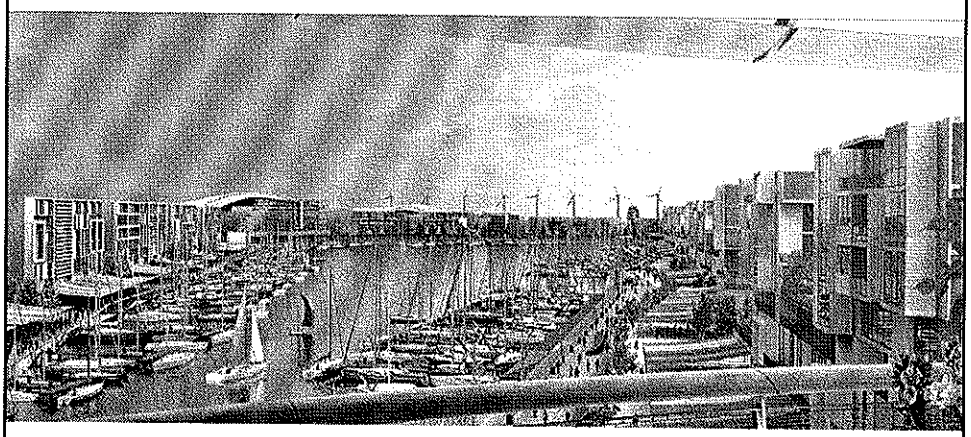
体量和形态
MASSING AND TYPOLOGIES

21'st century waterfront – Heart at the Harbour　　**二十一世纪的滨水地带-中心港口**

Dongtan's Urban Rooms are containers for peoples' interactions　**东滩城市空间是人们交流的容器**



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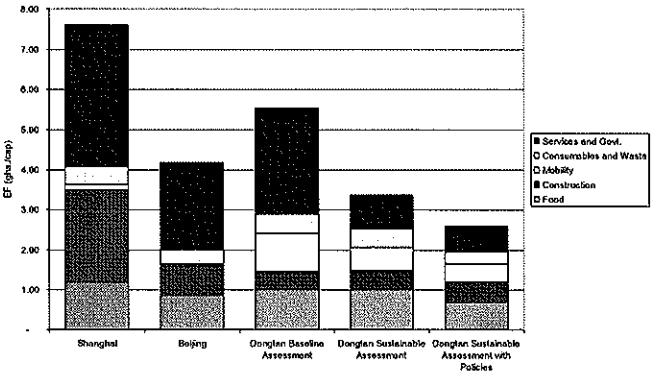
目标 3 — 低生态足迹
OBJECTIVE 3- LOW ECOLOGICAL FOOTPRINT

生态城市的足迹 2.6全球公顷/人　　Eco-City Footprint 2.6 gh/person

常规模式的生态足迹 5.8全球公顷/人　Conventional Approach City Footprint 5.8 gh/person

Factor 10- Reduction in energy footprint



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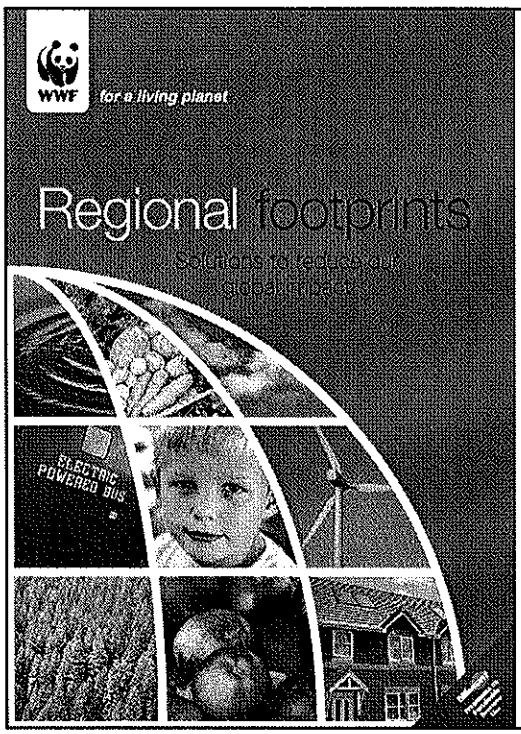

Towards a sustainable built environment – The UK perspective

Ecological footprinting

Using REAP for Dongtan

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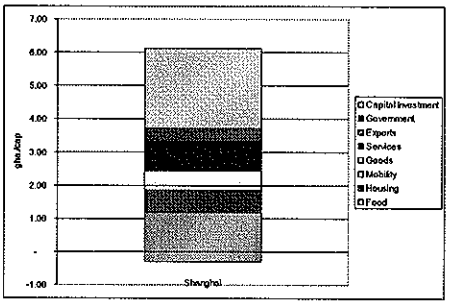
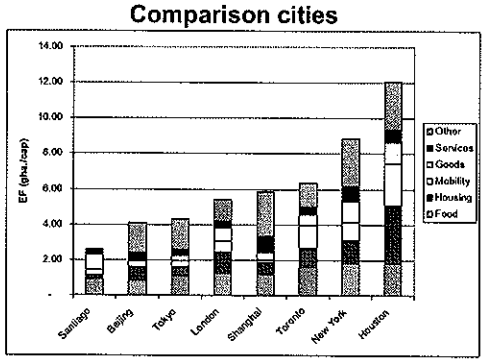
ECOLOGICAL FOOTPRINT-REFERENCE AND COMPARISON CITIES

Reference (Shanghai)



= 5.83 gha / capita

Comparison cities



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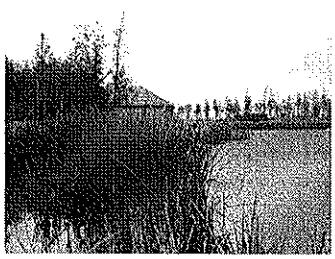
目标 4 — 水与防洪控制
OBJECTIVE 4 – WATER AND FLOOD MANAGEMENT

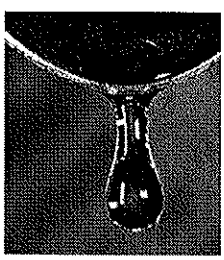
可持续的生态城市
Sustainable Eco-city

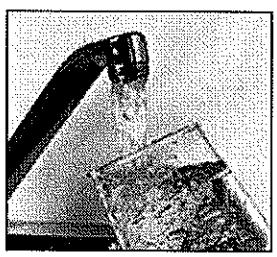
每日耗水16，500 吨/天
Water Consumption 16,500 T per Day
每日排水3,500 吨/天
Water Discharge 3.500 T per Day

常规城市
Conventional Approach City

每日耗水29，000 吨/天
Water Consumption 29,000 T per Day
每日排水29，000 吨/天
Water Discharge 29,000 T per Day
Factor 10 –Reduction in discharge







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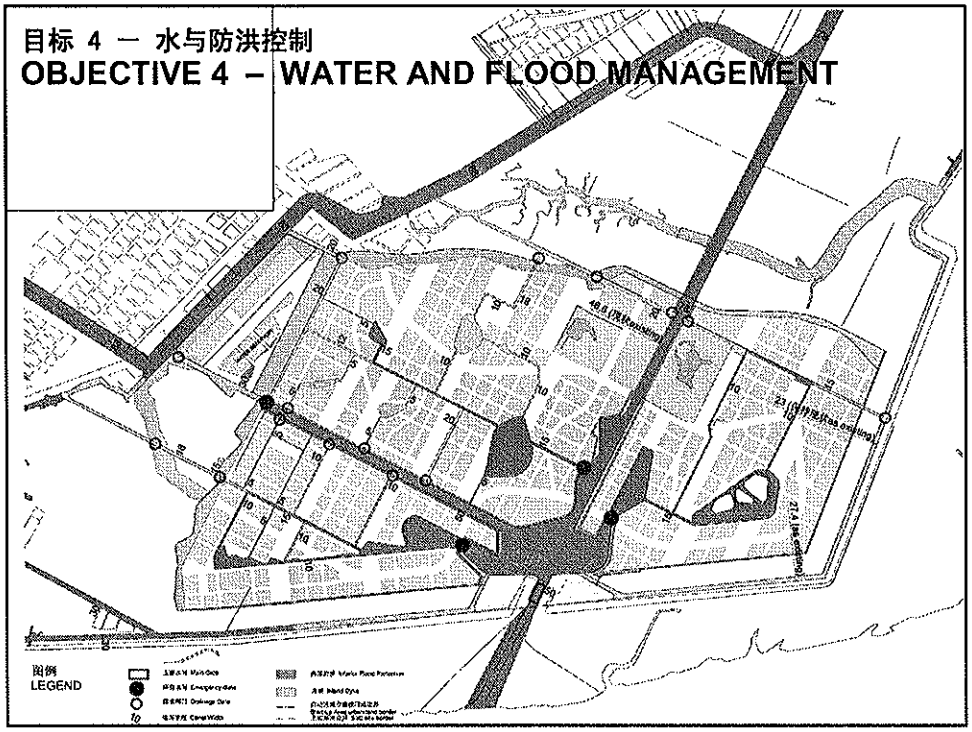
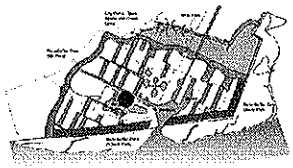
目标 4 — 水与防洪控制

OBJECTIVE 4 – WATER AND FLOOD MANAGEMENT



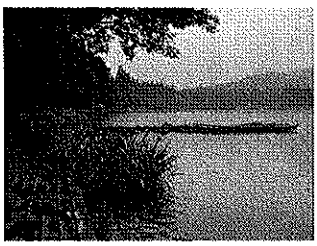
水体设计 – 意趣盎然的湖面

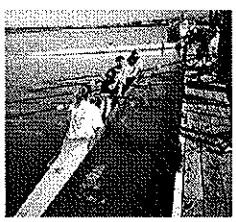
WORKING WITH WATER - RECREATION LAKE

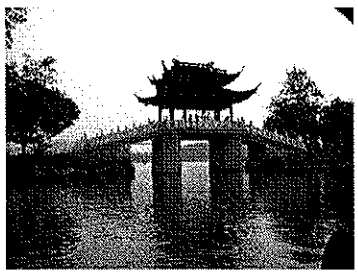












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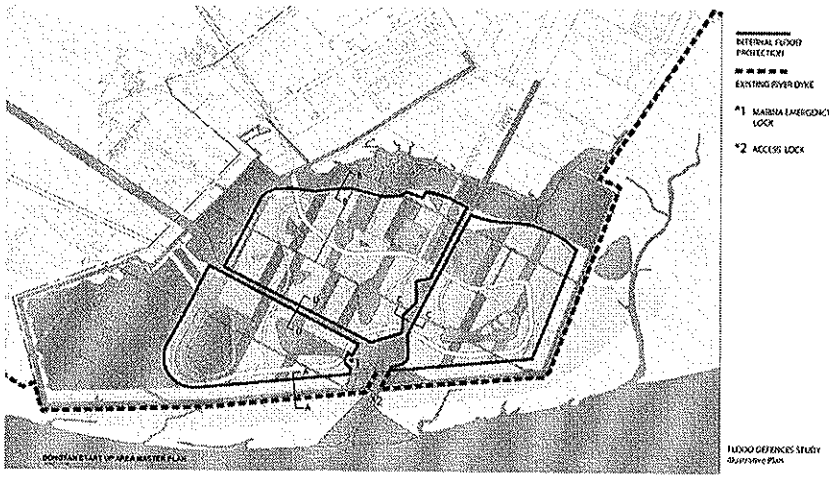
防洪策略
FLOODING APPROACH

Towards a sustainable built environment – The UK perspective

Self Sufficient Villages – Sustainable Flood Management Strategy [Plan]

自我防范的村庄-可持续性防洪管理策略[规划]



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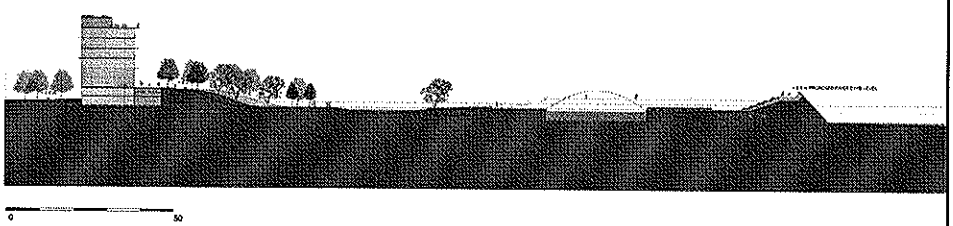
水之城-防洪控制
WATER CITY – FLOODING MANAGMENT

Towards a sustainable built environment – The UK perspective



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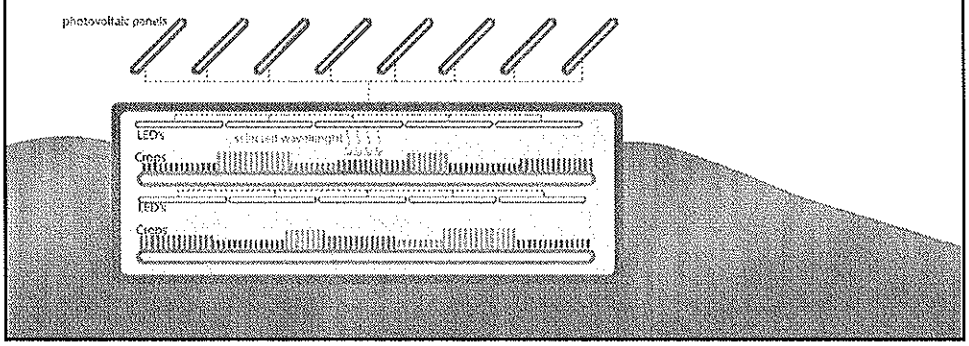
OBJECTIVE 5- AGRICULTURAL PRODUCTION

Sustainable Eco-City 8Ha of city factory, no loss of production

Conventional Approach City Loss of 1000 ha of productive land

Factor 10 –Improvement in agricultural productivity



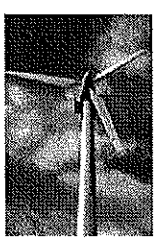
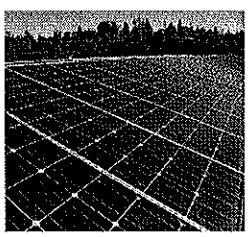
目标 6 — 能源产生、使用和减少排放
OBJECTIVE 6 – ENERGY PRODUCTION, USE AND EMISSION REDUCTION

可持续的生态城市
Sustainable Eco-city

能源需求 600兆瓦时/每年
Energy Demand 600 GWH/year
电能和热能不产生二氧化碳排放
No CO2 Emission from energy for power and heat

常规城市
Conventional Approach City

能源需求 1650兆瓦时/每年
Energy Demand 1650 GWH/year
每年产生350,000吨的二氧化碳排放
CO2 Emission of 350,000 tons per year
Factor 10- Reduction in carbon emissions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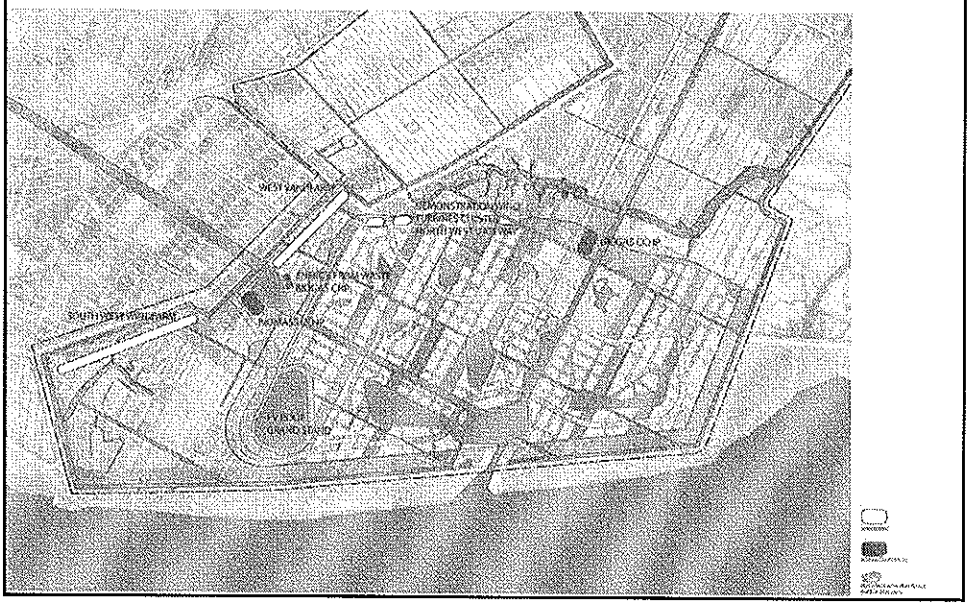
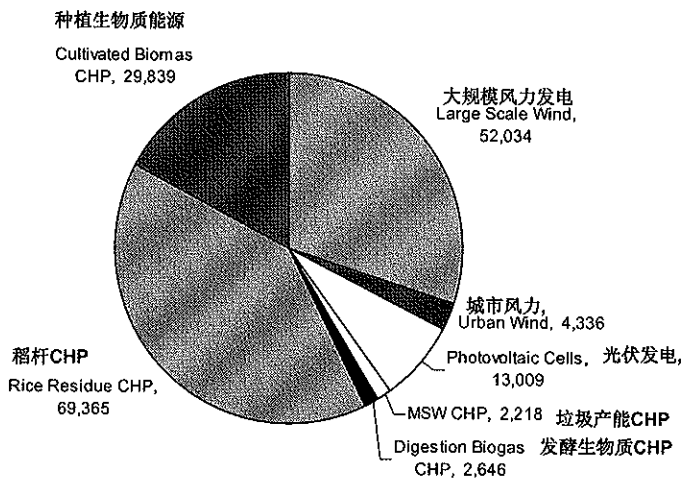
能量策略
ENERGY APPROACH



ECO DEMONSTRATOR –
SOURCES OF ELECTRICAL GENERATION (MWh per annum)



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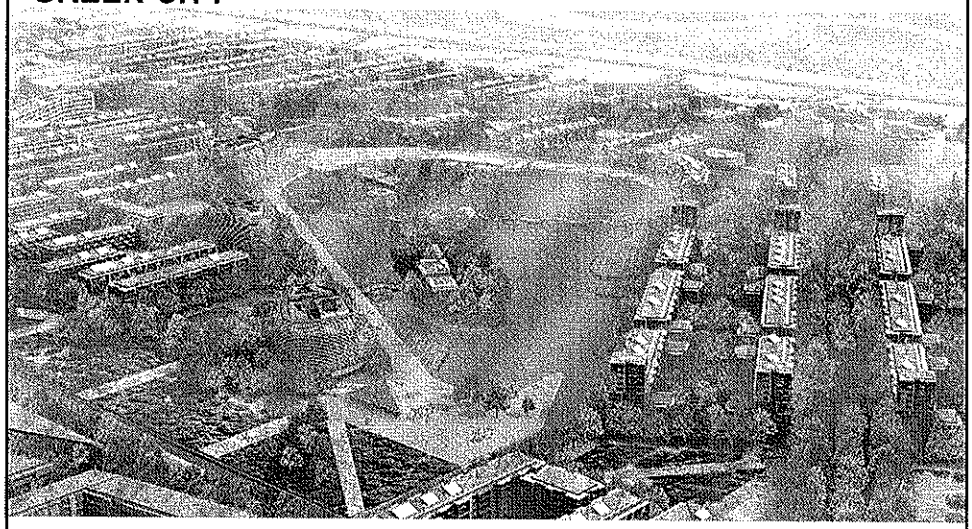
绿色的城市
GREEN CITY

Towards a sustainable built environment – The UK perspective



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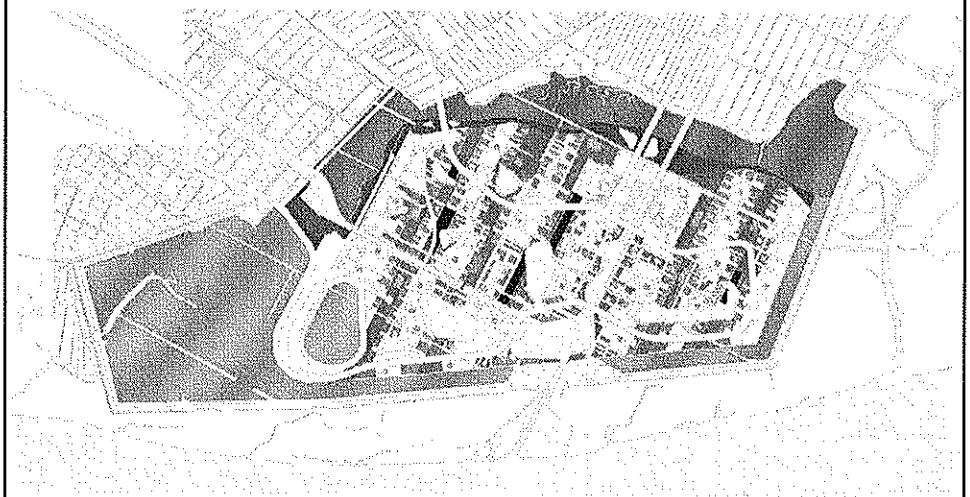
景观和开放空间
LANDSCAPE AND OPEN SPACE

Towards a sustainable built environment – The UK perspective

Open Space Character 开放空间特性



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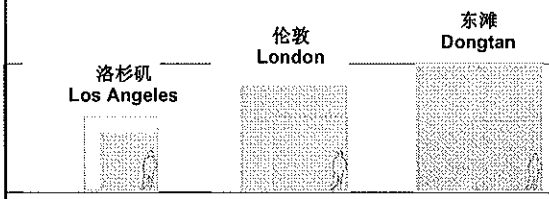
绿色城市—高标准
GREEN CITY – HIGH STANDARD

人均绿地面积: 世界健康组织(WHO)要求：8平方米 / 上海：10平方米
Green area per capita. WHO: 8 sqm / Shanghai: 10 sqm



6.6 sqm　20.5 sqm　27 sqm

总面积：215公顷
215 hectares / total
城市面积：73公顷
73 hectares / urban area
生态公园：142公顷
142 hectares / ecology park

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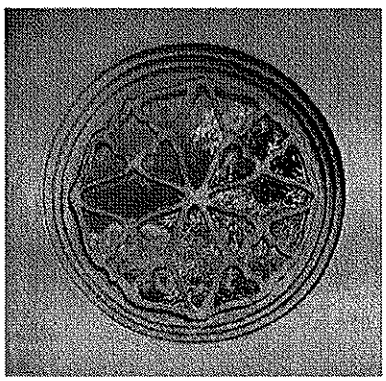
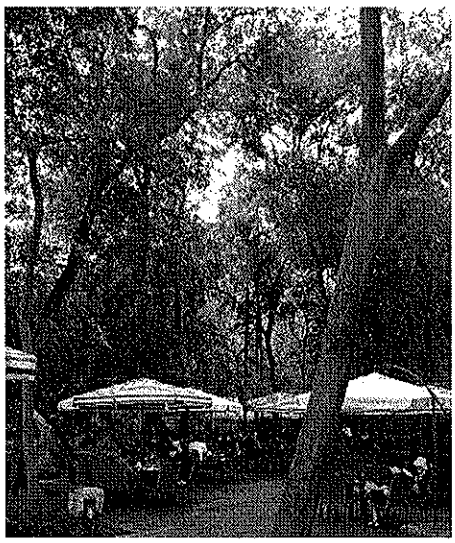
景观和开放空间
LANDSCAPE AND OPEN SPACE

In the heart of the City there will still be close contact with nature.
在城市中心也能贴近自然





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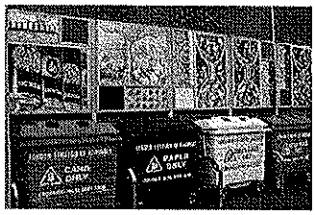
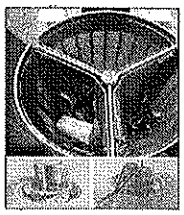
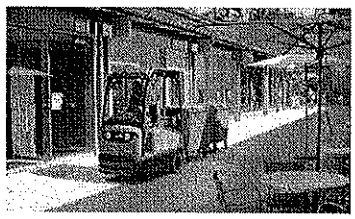
目标7 — 废弃物管理
OBJECTIVE 7- WASTE MANGEMENT

可持续性的生态城市
Sustainable Eco-city

100%的废弃物回收
100%WASTE COLLECTION
废弃物填埋量　5,000吨/年
5000 T/YEAR TO LANDFILL

常规城市
Conventional Approach City

80%的废弃物回收
80% WASTE COLLECTION
废弃物填埋量　30,000吨/年
30,000 T/YEAR TO LANDFILL
Factor 10-Reduction in landfill

ARUP

目标8 —可达性和交通
OBJECTIVE 8 — ACCESSIBILITY AND TRANSPORT

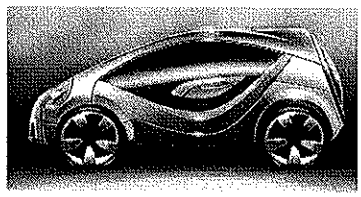
可持续性的生态城市
Sustainable Eco-city

每天的交通距离—420万公里
DAILY TRAVEL DISTANCE　4.2 million KM
零碳排放
ZERO CO2 EMISSIONS
平均交通距离 24公里
AVERAGE TRIP LENGTH 24 KM

常规城市
Conventional Approach City

每天的交通距离—600万公里
DAILY TRAVEL DISTANCE　6.0 million KM
每年二氧化碳的排放量 40万吨
400，000 TONNES CO2 EMISSIONS PER YEAR
平均交通距离 56公里
AVERAGE TRIP LENGTH 56 KM
Factor 10-Reduction in carbon emissions



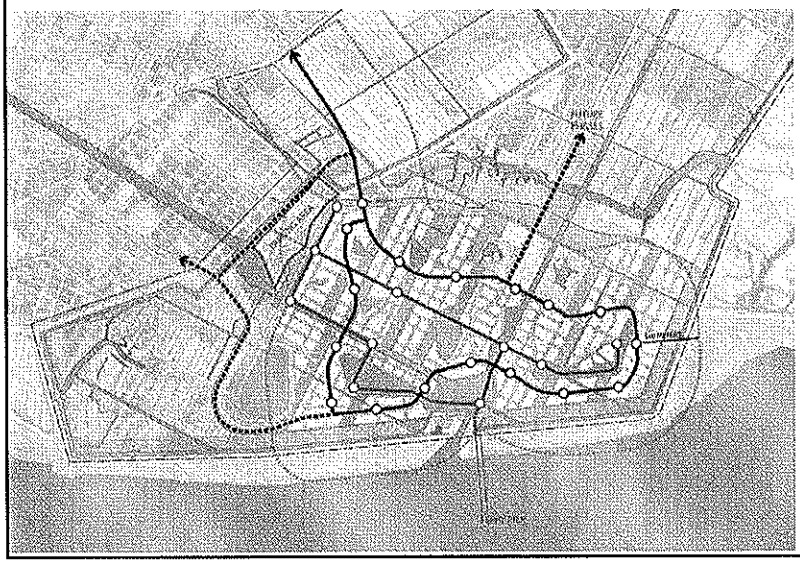


ARUP

可达性
ACCESSIBILITY

Delivering Public Transport – Road and Water, a complementary network

公共交通运输——公路和水路，作为一个补充的交通网络



P

通达的城市
ACCESSIBLE CITY

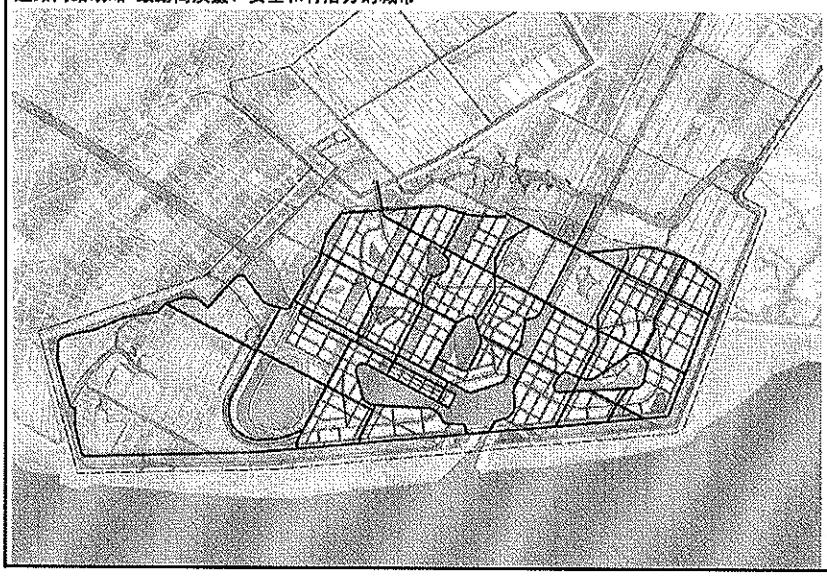


ARUP

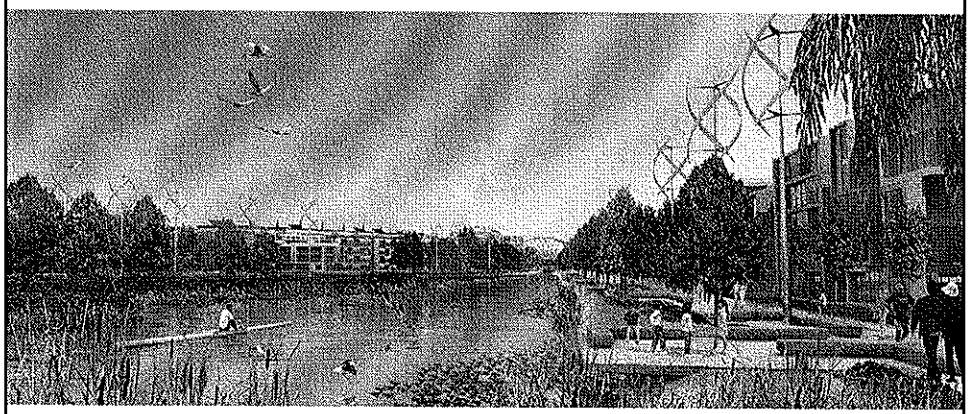
可达性
ACCESSIBILITY

Road Network Strategy – Encouraging a high quality, safe and active Town

道路网络战略-鼓励高质量、安全和有活力的城市



通达的城市
ACCESSIBLE CITY



ARUP

通达的城市
ACCESSIBLE CITY

人行道 — 自行车道：鼓励东滩成为高质量、安全和活跃的城市

Pedestrian – Cycle Routes : Encouraging a high quality, safe and active Town



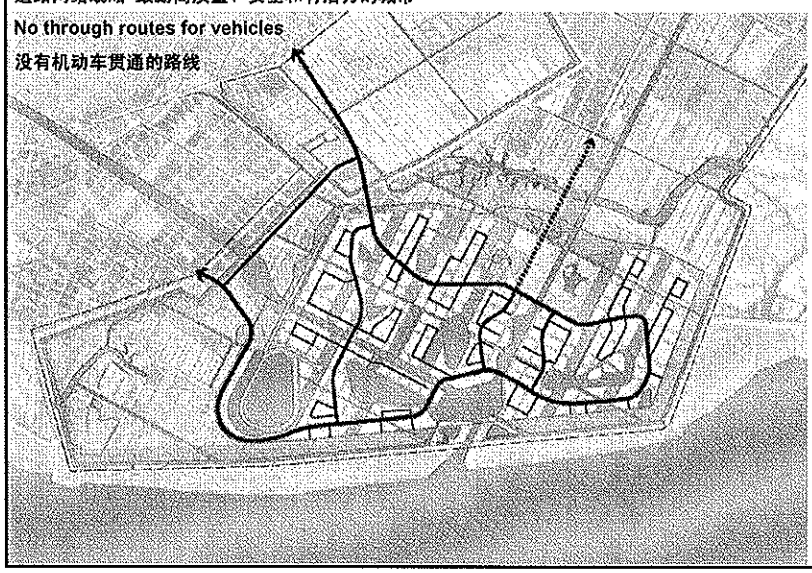
可达性
ACCESSIBILITY

Road Network Strategy – Encouraging a high quality, safe and active Town

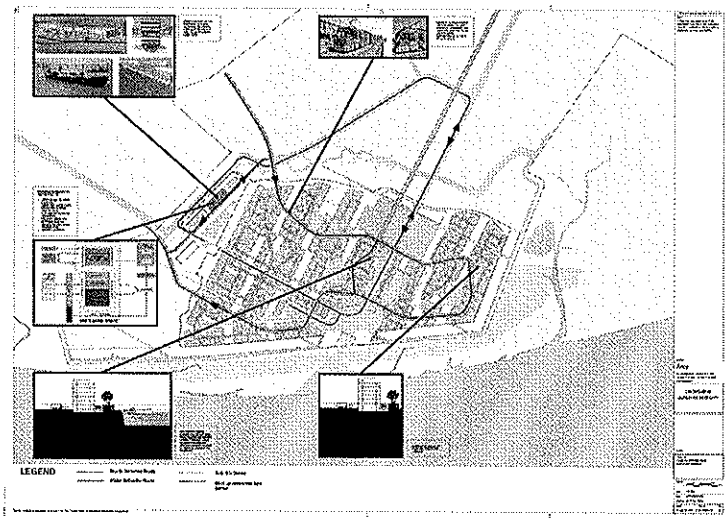
道路网络战略-鼓励高质量、安全和有活力的城市

No through routes for vehicles

没有机动车贯通的路线



Freight Logistics



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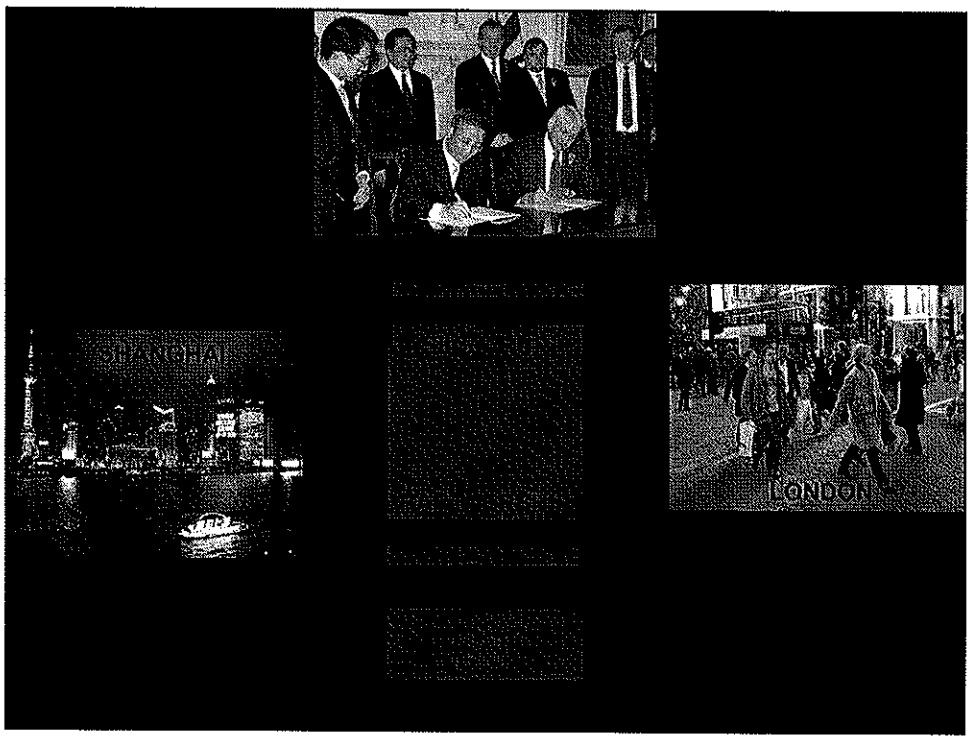

R&D Programme Progress overview

Steering Group meeting, Arup, London July 13 2006
- Leading UK academics
- UK government research funding body EPSRC
- 'Green paper' and 'Key Challenges papers produced

Meeting with Mr Zhiyong Jin, First Secretary, Science & Technology at Chinese Embassy London
- Contact identified: Department of Science and Technology of Shanghai - Mr Yuzheng Jiang to discuss funding in Shanghai

Research Workshop to take place at Arup offices in Hong Kong November 2 – 4
- Shanghai, Hong Kong, UK, Australian academic delegates
- UK public funding body present
- Arup facilitation and expert advisors

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Towards a sustainable built environment – The UK perspective

Outcomes of Steering Group meeting
Research challenges identified

Community engagement for sustainable society
Climate change
Biodiversity and ecology
Transport
Data capture and analysis
Infrastructure : waste, water & energy
Water – creation of a sustainable water environment
Low carbon/energy
Systems integration

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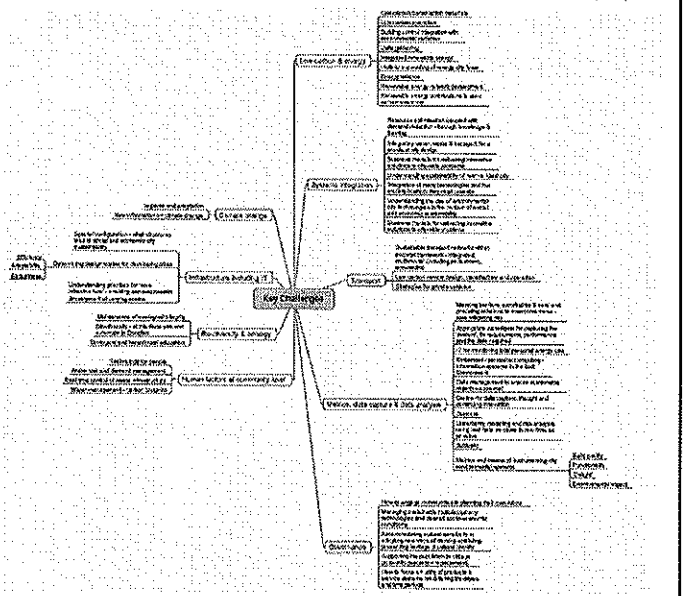
Outcomes of Steering Group meeting

Entailment diagram showing challenge headings and sub-headings

Key Challenges



ARUP

Research Workshop, Hong Kong 2 – 4/11/06

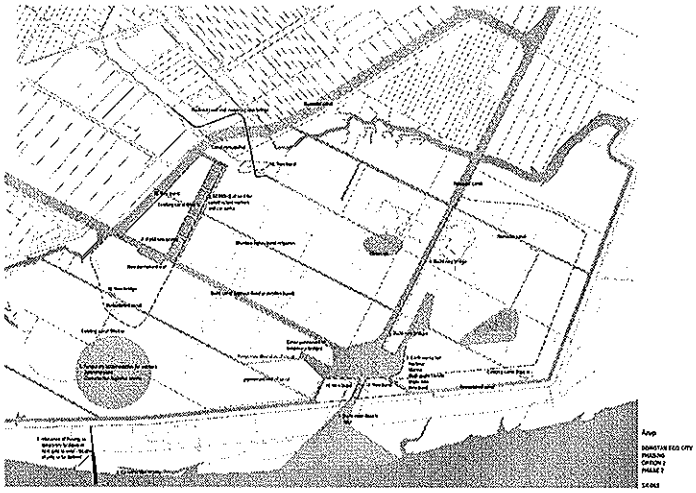
Attendees

Zheng Shiling (Tongji)	Chinese Academy of Sciences
Chen Yi (Tongji)	Architect
Long Weiding (Tongji)	Building Physical Services
Zhang Yalei (Tongji)	Environment
Lijun Sun (Tongji)	Transport & Road network
Arlen Min YE (HKU)	Architecture and Urban design
Peter Murphy (UNSW, Australia)	Built Environment
Alicia Greated (EPSRC)	Engineering
Peter Hedges (EPSRC)	Environment & Economy
Claire Tansley (EPSRC)	Built Environment
Patrick Godfrey (Bristol)	Systems
Phil Longhurst (Cranfield)	Environmental impact, waste management
Nicholas Leon (Imperial College)	Innovation
Bakr Bahaj (Southampton)	Sustainable Energy
Nick Tyler (UCL)	Civiil Engineering, Infrastructure
Alan Penn (UCL)	Architectural and Urban Computing
Andrew Chan (Arup)	CEO, Arup East Asia (for welcome session)
Roger Wood (Arup)	Dongtan project manager
Jeremy Watson (Arup)	Director, Global Research, Arup
Dr Jack Pappin (Arup)	Director & DTX leader East Asia
Dr Raymond Yau (Arup)	Director
Richard Hough (Arup Australia)	Structural Engineer & Multi-discipline expert
Yuan Yuan (Stephanie) Zhang (Arup)	Workshop administrator

ARUP

Dongtan 2006 –2010 The Way Forward

Enabling Works - 2007



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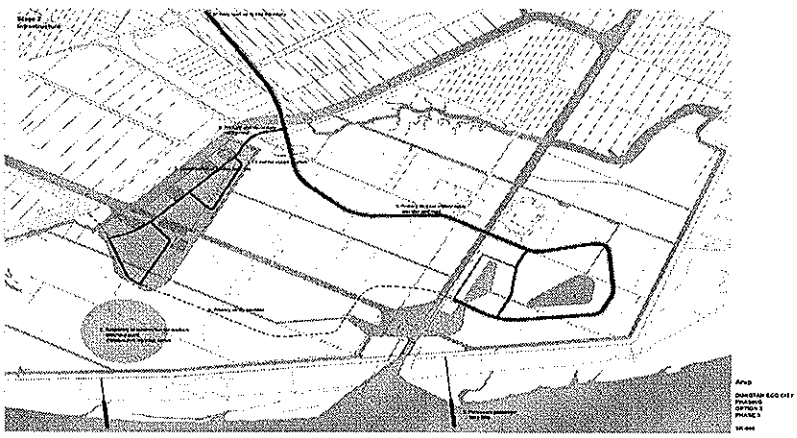
Towards a sustainable built environment – The UK perspective

Dongtan 2006 –2010 The Way Forward

Infrastructure – 2008/9



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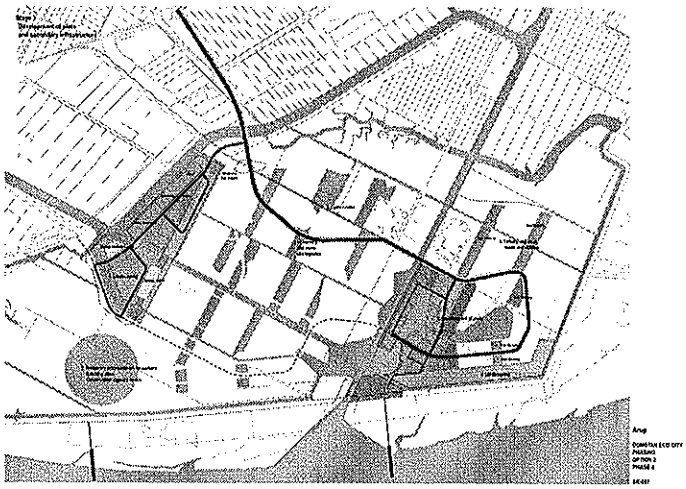
Dongtan 2006 –2010 The Way Forward

Phase 1 - 2010



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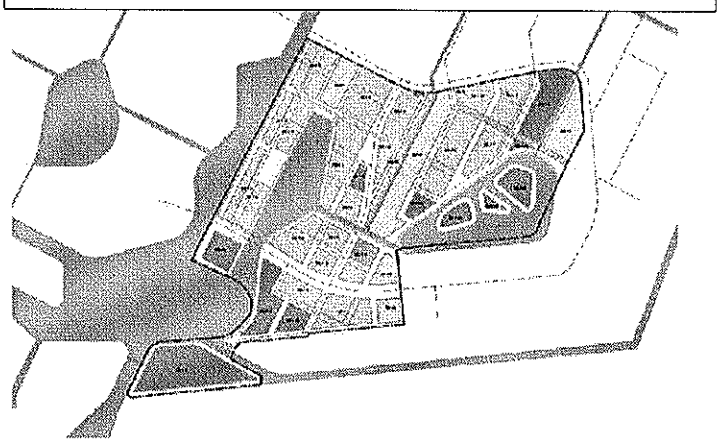
Towards a sustainable built environment – The UK perspective

Dongtan 2006 –2010 The Way Forward

District Development - 2010



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更好的城市，可持续发展的城市
BETTER CITY , SUSTAINABLE CITY



ARUP

Indoor Environmental Quality, energy efficiency and productivity

Bjarne W. Olesen
International Center for Indoor Environment and Energy, Technical University of Denmark

ABSTRACT

People spend in industrialized countries more than 90 % of there lives in an artificial indoor environment (home, transportation, work). This makes the indoor environment much more important for people health and comfort than the outdoor environment. In typical office buildings the cost of people is a factor 100 higher than energy costs, which make the performance of people at their work significantly more important than energy costs. The task is to optimize indoor environmental conditions for health, comfort and performance while conserving energy, since more than one third of current global energy consumption is used to maintain indoor environments. Detailed field investigations of the indoor environment in hundreds of large office buildings in many parts of the world have documented that the indoor environmental quality is typically rather mediocre, with many people dissatisfied and many suffering from sick-building syndrome symptoms.

Recent studies under laboratory conditions and in the field have shown a significant influence of the indoor environment on peoples productivity. Also studies on people sick leaves show a very high loss of work time and performance, which have significant economical consequences for companies.

The paper present an update on to days requirement for a healthy and comfortable environment. The paper will mainly be dealing with the indoor thermal environment and air quality. Several standards and guidelines are specifying requirements related to comfort and to health; but the productivity of people is not taken into account. Recent studies showing that comfortable room temperatures, increased ventilation above normal recommendation, reduction of indoor pollution sources and more effective ventilation increases the performance of people. The results indicate increase of productivity of 5-10 %. Also based on the laboratory studies a 10 % increase in dissatisfaction decreases the productivity with around 1 %. The recommended requirements to the indoor environment will in the presentation be related to higher demands for energy efficiency of buildings.

INDOOR ENVIRONMENT- HEALTH-COMFORT AND PRODUCTIVITY

Bjarne W. Olesen
International Center for Indoor Environment and Energy, Technical University of Denmark
Gender: male
Paper reference code xxxs

ABSTRACT

Prepare People spend in industrialized countries more than 90 % of there lives in an artificial indoor environment (home, transportation, work). This makes the indoor environment much more important for people health and comfort than the outdoor environment. In typical office buildings the cost of people is a factor 100 higher than energy costs, which make the performance of people at their work significantly more important than energy costs. The task is to optimize indoor environmental conditions for health, comfort and performance while conserving energy, since more than one third of current global energy consumption is used to maintain indoor environments. Detailed field investigations of the indoor environment in hundreds of large office buildings in many parts of the world have documented that the indoor environmental quality is typically rather mediocre, with many people dissatisfied and many suffering from sick-building syndrome symptoms.
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paper.

KEYWORDS: health, comfort, productivity, indoor environment.

INTRODUCTION

Ambient (outdoor) air quality in cities in industrialized countries has improved greatly in recent decades. During this same period, indoor air quality has declined because of energy conservation, decreased ventilation and the introduction of many new materials and sources of indoor pollution. These developments and the fact that people in industrialized countries spend 90% of their lives indoors on average makes the quality of indoor air an important environmental issue with far-reaching implications for human health. The following three estimates are based on large worldwide field studies.

- In many industrialized countries, up to 50% of schoolchildren suffer from asthma and allergy, and this figure has doubled over the past 20 years. A new study by the Technical University of

Denmark documents for the first time associations with phthalates from plastic materials and with poor ventilation in homes.

- In offices, typically 20–60% of occupants suffer from symptoms associated with sick-building syndrome, which include headache, fatigue and irritation of mucous membranes. The Technical University of Denmark has shown that poor indoor air quality causes sick-building syndrome and that it reduces the productivity of office workers.
- In developing countries, 5000 people die daily from polluted indoor air according to the World Health Organization. The cause is indoor pollution from cooking without vents, using wood or manure as fuel.

When discussing problems with the indoor environment the focus is often on the requirements for ventilation. Increasing demand for lower energy consumption of buildings has resulted in decreasing heat losses due to transmission and tighter buildings. This may often result in too low ventilation rates. This fact and the introduction of many new building materials may often lead to un-acceptable indoor air quality and building damage like mould.
In the present paper will present new results regarding the influence of the indoor environment on the health, comfort and performance of the occupants. Also new knowledge related to indoor pollutant sources.

HEALTH

Based on the statement in the WHO constitution [1], health may be defined as a "state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". Likewise, healthy indoor air may be defined as the air that does not provide any risk of disease and that ensures comfort and well being for all occupants [2]. Although the right to health was recognized as early as in 1946 more than a half-century needed to acknowledge that every human being has the right to breathe healthy indoor air [3,4]. In order to meet this requirement it is the duty of building engineers and designers to adopt adequate techniques, which ensure the excellence of indoor air quality and minimize the occurrence of any possibly harmful compounds in the inhaled air in concentration and for duration that may cause unwanted health or comfort effects.
Exposures in indoor environments and health effects due to such exposures vary between regions of the world. In developing regions limited number of studies has been conducted regarding IAQ and health. The studies have dealt mainly with associations between indoor air pollution, due to un-vented burning of biomass, and health effects such as acute respiratory infections, chronic obstructive pulmonary disease and lung cancer. WHO has calculated that burning of solid fuel for cooking and heating in developing countries might be responsible for nearly 4% of the global burden of disease, i.e. approaching 2 million premature deaths per year [5]. This is one of the main environmental health issues of the world but so far little recognised.
Studies on exposures in indoor environments and health effects in developed countries have mainly been conducted in Europe and North America. The evidence is strong regarding an association between IAQ and lung cancer, allergies, other health and comfort effects including Building Related Illnesses (BRI), Sick Building Syndrome (SBS) and Multiple Chemical Sensitivity (MCS) [6,7].

Health in residential buildings

Allergic and asthmatic diseases have doubled in industrialized countries during the past two decades. They comprise one of the greatest current problems for public health, with enormous costs for medicine, treatment and absenteeism. In many industrialized countries, half the schoolchildren suffer from these allergic diseases, which are the main reason for absenteeism in schools.

The rapid increase of the incidence in allergy/asthma and other health effects (Figure 1, left) over the past few decades implies that it is due to changes in environmental exposures rather then genetic changes.

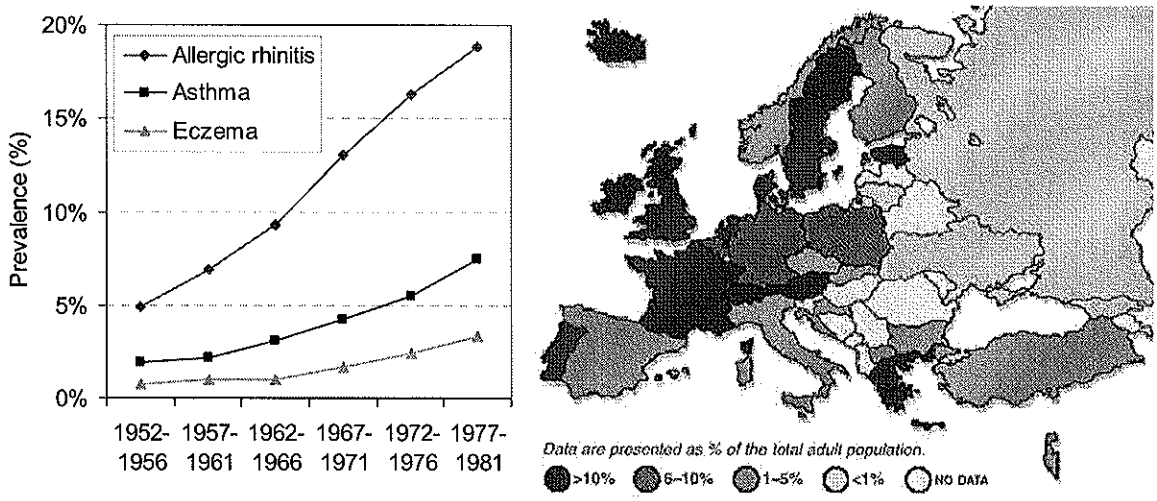

Figure 1. **Left:** Trends for allergic rhinitis, asthma and eczema among male conscripts (17-20 years age) in Sweden [8]. **Right:** Current data on prevalence of asthma in adults in Europe [9].

Surprisingly, very few people had asthma in the former communist countries in Eastern Europe before 1989 (Figure 1, right) despite high ambient air pollution in many cities. User charges for energy were often zero or very low, and the ventilation in leaky dwellings was typically much higher than in Western Europe.

Indoor air quality has declined partly because of comprehensive energy conservation campaigns and partly because high energy prices have motivated people to tighten their dwellings and reduce the rate of ventilation, so that the air change in many homes is at a historically low level. Other factors contributing to poor indoor air quality are the many new materials, especially polymers, and the numerous electronic devices that have been introduced indoors in recent decades, especially in children's rooms

The world's largest study [10,11,12,13] on the relationship between poor indoor air quality and asthma comprises 11,000 children, and detailed chemical, physical, biological and medical measurements have been performed in 200 homes with asthmatic children and 200 homes with healthy children. These homes were situated in areas with excellent outdoor air quality. The results show that low ventilation increases the risk of allergic symptoms significantly (Figure 2) and that the presence of phthalates emitted from polyvinyl chloride, including plasticizers in children's rooms, increases the risk of asthma dramatically (Figure 3). The global production of plasticizers has increased enormously since the 1950s and now comprises 3.5 million tons per year. These results may radically affect how indoor environments are designed to protect children from asthma and allergies.

Dampness

In a study of several residential buildings [14,15] with natural ventilation the humidity production was measured to 2,7 kg water per Person per Day. To limit the increase in the humidity in the indoor air from people (persons, cooking, etc.) to 4 g water per kg Air in relation to the outside air, a

ventilation rate of 7 l/s per person is required (16,17). In typical residential buildings this is equivalent to 0,35 l / s · m². This corresponds to 0.5 air changes per hour

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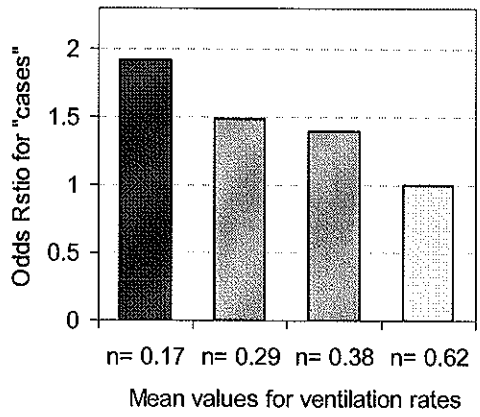

Figure 2. Odds ratio for being a "case", i.e. children with at least two symptoms of possible three (wheezing, rhinitis, eczema) as function of ventilation rates, in single family houses. [10,11,12]

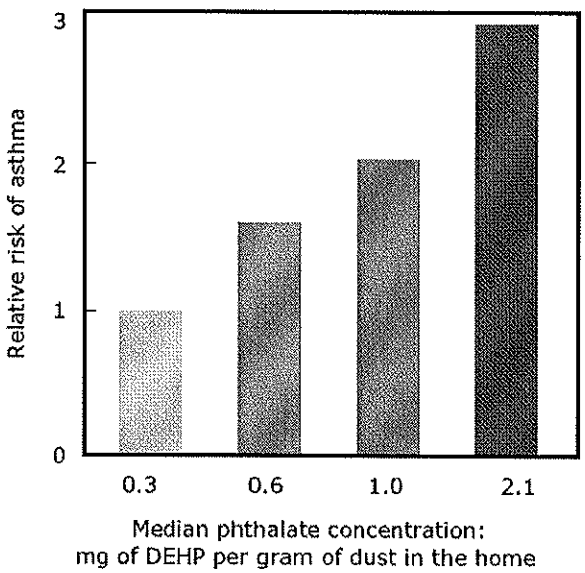

Figure 3: Plasticizers from polyvinyl chloride in dwellings increase the risk of asthma among children. Each column represents about 90 dwellings. DEHP: di(2-ethylhexyl) phthalate. [12,13]

In a large number of studies (including more than 100000 people) [10,18] an association has been found between living or working in "damp" building and health effects, such as cough, wheeze, allergies and asthma. However, there are indications that also other health effects, such as general

symptoms (e.g. tiredness, headache etc.), irritation and airway infections are associated with dampness. It should be noted that it is still not shown which dampness related exposures are responsible for the health effects observed [18,19,20,21]
The criteria used for classifying a building as damp may vary. Identified health-relevant moisture-problems included water damage (visible damp spots or detached/discoloured flooring materials) excess condensation of water on cold surfaces (e.g. on the inside of window panes) and signs of microbial growth (visible mould spots and bad odour). A distinction should however be made between the moisture in the building structure and humidity in indoor air. Moisture in the building construction (originating from outdoor or indoor sources) can degrade building materials, creating favourable conditions for microbial growth and chemical reactions that are often identified as sources of allergens, irritant substances and bad odour. Relative humidity in indoor air may cause condensation on cold interior surfaces or in the construction that also increases the risk of microbial growth and chemical processes. For example, the dew point corresponding to 23 °C with 50% RH of indoor air is 12 °C. Thus any indoor construction with a temperature approaching 12°C for this case is at high risk for condensation and thus ideal place for microbial activities, although the RH in the indoor air is still within acceptable limits. It is also well known that increased water content of indoor air will raise the risk of house dust mite (HDM) infestation (Figure 4, [22]). The infestation of HDM may be considered low (up to 1000 ng/g dust) if indoor absolute humidity remains below 7 g/kg air corresponding to relative humidity of 45% at 20-22°C.

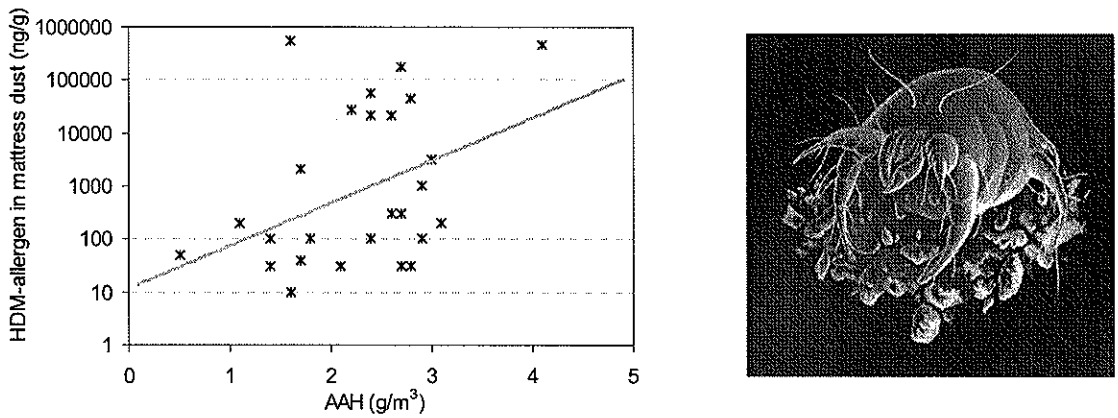

Figure 4. **Left:** HDM allergen in mattress dust as a function of adjusted additional humidity (AAH) in homes (difference between absolute humidity in air indoors and outdoors) [22]; **Right:** Close-up of adult dust-mite feeding within household bedding (http://www.jonathanlatimer.com/).

It is often assumed that dry indoor air, i.e. low air humidity could cause a drying out of the mucosa of the upper airways and skin due to increased evaporative power of dry air. A number of laboratory and field studies show that the perception of "dry air" is due more often to the air being polluted or too warm than being physically "dry". Since the sensation of dryness is strongly associated with the prevalence of SBS, it is therefore used as indicator of the health problems in buildings, but not to indicate that the air has low water content [23,24,25]

Ventilation
The scientific evidence, based on a recent European review, indicates that outdoor air supply rates below 25 L/s per person in commercial and institutional buildings are associated with an increased risk of SBS (Figure 5, [20]), increased short-term sick leave and reduced productivity.

Studies on the associations between health effects and ventilation rates and homes are rare. However the literature on "dampness" suggests that inadequate ventilation in homes constitute a major risk factor for health effects (cough, wheeze, asthma and airways infections) (Figure 5). A damp home is also associated with low ventilation rate and low ventilation rate (typically below 0.5 ach) is not only associated with increased house dust mites infestation, but also probably with increased concentration of many indoor-generated air pollutants. It should be noted that homes with higher ventilation rate (typically above 0.5 ach) may also present a risk for increased exposure to airborne pollutants if the bedroom, where people spend a substantial amount of time compared to the other locations of the dwelling, is not well ventilated [20, 26]. A simple indication of low ventilation in bedrooms was shown to be the amount of condensation on windows (Figure 6,

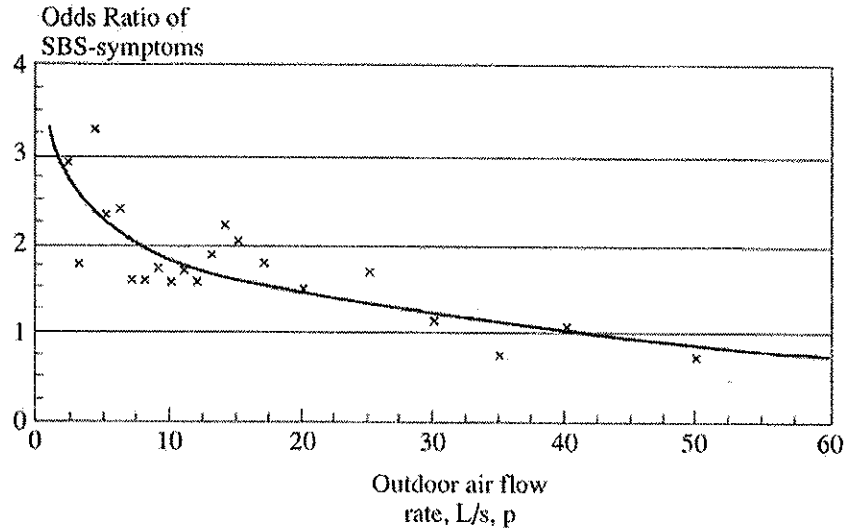

Figure 5. Adjusted odds ratio of SBS for low outdoor air flow rate in commercial buildings [20]

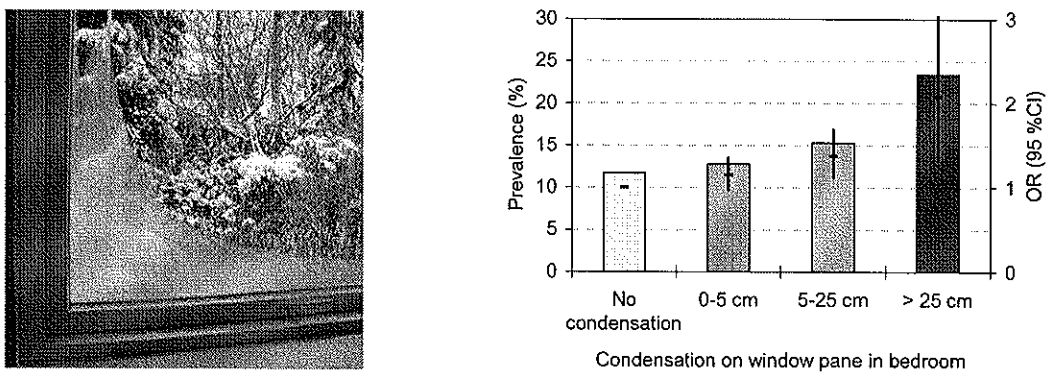

Figure 6: Window water condensation is often sign of poor ventilation in dwellings; Right: Prevalence and odds ratio for rhinitis among children versus condensation on windows pane in bedroom [11]

COMFORT

In most international standards and guidelines the recommended ventilation rates are based on comfort criteria.[27], which is related to the perceived air quality. In a new draft European standard prEN15251 [28] three categories are listed for recommended ventilation rates. This is similar to the existing European Guideline CR1752 [29]. Different parameters like %-Dissatisfied (Figure 7, right),

decipol [30,31] or CO_2-Concentration as an indicator of the bio effluents from people (Figure 7, left) and the required ventilation rate (Table 3). The CO_2 concentration above outdoor level corresponding to the three air quality categories is 460 ppm (category A), 660 ppm (category B) and 1190 ppm. Earlier most standard and guidelines for the required ventilation rates were given as ventilation per person. Both laboratory and field studies have, however shown that people and their activity (smoking, activity level), building and furnishing (floor covering, paint, furniture, cleaning, electronic equipment, etc.) and ventilation systems (filters, humidifiers, ducts etc.) may also contribute. Even the outside air may be a source to indoor air quality problems. It is, however difficult to compare the different type of sources. One possibility was introduced by using the Olf-Decipol units [31].

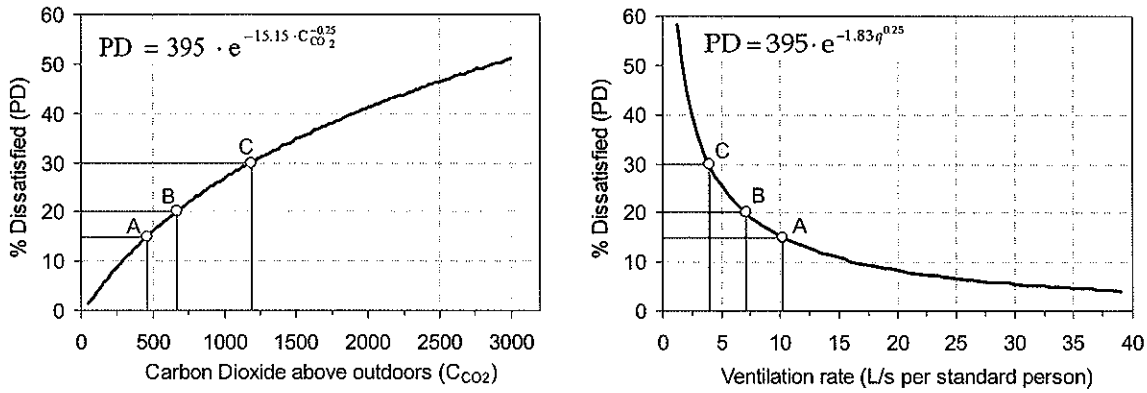

Figure7. **Left:** Carbon dioxide (CO_2) as indicator of human bio effluents [28,29]; Percentage of dissatisfied visitors as function of the CO_2 concentration above outdoor levels where sedentary occupants are the exclusive pollution sources. **Right:** Percentage of dissatisfied visitors as function of the ventilation rate per standard person (average sedentary office worker being thermally neutral, [29]). The pollution generated by such a standard person is called "olf"; the required minimum ventilation rate according to the three air quality categories A, B and C are 10 L/s.olf, 7 L/s.olf and 4L/s.olf, respectively.

Table 1 shows the emissions from people and their activity. The CO_2 emission is indicator for the bio effluents from people. The CO emission is used as indicator for smoking.
There is relative little information regarding the contribution of emission from building and furnishing on the perceived indoor air quality [31,32,33]. Some values are shown in Table 2. New studies [34] in non-smoking buildings show values around 0,08 – 0,13 olf/m². These values are in the range of low-polluting buildings (table 3). Even values down to 0,002 olf/m² floor have been measured [35]. Other studies [36] showed that also electronic equipment as PC's can be a significant source (Table 1). A new PC contributes to the pollution load equivalent to three persons. The monitor mainly causes it.
Like with several other indoor sources from the furnishing (furniture, paint, floor covering etc.) the emissions are highest when the product is new. Therefore a 3 year old monitor has almost no emission..

Table 1 Pollution load caused by occupants.

	Sensory pollution load olf/occupant	Carbon dioxide L/(h x occupant)	Carbon monoxide [a] L/(h x occupant)	Water vapour [b] g/(h x occupant)
Sedentary, 1-1.2 met				
0% smokers	1	19		50
20% smokers [c]	2	19	11×10^{-3}	50
40% smokers [c]	3	19	21×10^{-3}	50
Physical exercise				
low level, 3 met	4	50		200
medium level, 6 met	10	100		430
high level (athletes), 10 met	20	170		750
Children,				
kindergarten				
3-6 years old, 2.7 met	1.2	18		90
school				
14-16 years old, 1-1.2 met	1.3	19		50
Computer				
With CRT-Monitor, new	3			
With Flat screen Monitor	0			

a) From tobacco smoking
b) Applies to persons close to thermal neutrality
c) Average smoking rate 1.2 cigarettes/h per smoker, emission rate 44ml CO/cigarette

Table 2 Pollution load caused by the building, including furnishing, carpets and ventilation system.

	Sensory pollution load olf/(m^2 floor)	
	Mean	Range
Existing buildings[31,32,33]		
Offices [a]	0.3 [d]	0.02-0.95
Offices [b]	0.6 [c]	0-3
Schools, classrooms [a]	0.3	0.12-0.54
Kindergartens [a]	0.4	0.20-0.74
Assembly halls [a]	0.3 [d]	0.13-1.32
New buildings (no tobacco smoking)[34,35]		
Low-polluting buildings	0.1	
Non-low-polluting buildings	0.2	
Extremely low-polluting buildings	0.02	

a) Data based on more than 40 mechanically ventilated buildings in Denmark.
b) Data based on European Audit Project to optimise IAQ and Energy Consumption in Office Buildings, 1992-1995
c) Includes load caused by present and previous tobacco smoking.
d) Includes load caused by previous tobacco smoking.

Both people and building is taken into account in newer standards for the required ventilation rates in buildings. Table 3 show the required ventilation rates from recent standards like prEN15251 [28], ASHRAE 62.1 [37], and CR 1752 [29]. There is however quit big differences between the European recommendations and the ones listed by ASHRAE. One major reason is that ASHRAE requirements are minimum code requirements, where the basis for design is adapted people, whereas the European recommendations are based on un-adapted people.

ENVIRONMENT AND PERFORMANCE

The effects of indoor air quality on productivity became an issue only in the last decade, as a result of extensive research and an understanding of the strong connections between factors such as ventilation, air-conditioning, indoor pollutants and adverse effects on health and comfort. The complexity of a real environment makes it very difficult to evaluate the impact of a single parameter on human performance, mostly because many of them are present at the same time and as a consequence, act together on each individual. In addition, worker motivation affects the relationship between performance and environmental conditions (e.g. highly motivated workers are less likely to have reduced performance in an unfavourable environment; however they may become more tired that may also affect performance).
One way of evaluating the performance is the use of self-reported performance. This was used to study the self evaluation of the influence of environment, job satisfaction and job stress on performance [38]. The study was performed among 170 people in six offices. The self reported performance was made on a nine point scale. Based on the data the following equation for the self reported performance (WEP) could be established:

WEP = 6.739-0.419E-0.164JD-0.048JS (equation 1)
Where:
E = Dissatisfaction-Environment
JD = Job satisfaction
JS = Job stress

It is clear that the indoor environment was evaluated to have the biggest influence on performance. Much higher than job satisfaction and job stress.
A common approach, to evaluate the influence of climatic factors on human performance could be to measure the extent to which the SBS symptoms occur, as these symptoms are known to cause distraction from work or even short-term absenteeism. However, this link is not well established yet and must be better understood and recognized. A possible mechanism may be described as follows: (1) inadequate ventilation or superfluous emissions from different sources increase the concentration of pollutants, which negatively affect perceived air quality; (2) reduced air quality negatively affects the central nervous system, increasing SBS symptoms such as headache, difficulty in concentration, tiredness; (3) these symptoms will cause distraction from work and decreased work ability, i.e. productivity loss. Nevertheless, indoor pollution may also exacerbate the sensation of dryness and irritation of eyes. As a consequence, a higher blinking rate and watery eyes will negatively affect visual skills and decrease the performance of visually demanding work.
There is limited information in the literature showing a direct relationship between SBS symptoms and worker productivity. Analysing the data of British Office Environment Survey (BOES, [39]) Raw found that people reporting more than two symptoms on the SBS list are likely to have reduced performance ratings, and a linear relationship exists between SBS and self-estimated productivity.

Table 3 Smoking free spaces in commercial buildings according to ASHRAE 62.1[37], CR 1752 [29], prEN15251 [28]

Type of building/ space	Occupancy person/m²	Category CEN	Minimum ventilation rate, i.e. for occupants only l/s person		Additional ventilation for building (add only one) l/s·m²			Total l/s·m²	
			ASHRAE R_p	CEN	CEN low-polluting building[1)]	CEN *not* low-polluting building	ASHRAE R_a	CEN Low Pol.	ASHRAE
Single office (cellular office)	0,1	A	2,5	10	1,0	2,0	0,3	2	0,55
		B		7	0,7	1,4		1,4	
		C		4	0,4	0,8		0,8	
Land-scaped office	0,07	A	2,5	10	1,0	2,0	0,3	1,7	0,48
		B		7	0,7	1,4		1,2	
		C		4	0,4	0,8		0,7	
Conference room	0,5	A	2,5	10	1,0	2,0	0,3	6	1,55
		B		7	0,7	1,4		4,2	
		C		4	0,4	0,8		2,4	
Auditorium	1,5	A	3,8	10	1,0	2,0	0,3	16	6
		B		7	0,7	1,4		11,2	
		C		4	0,4	0,8		6,4	
Cafeteria/ Restaurant	0,7	A	3,8	10	1,0	2,0	0,9	8	1,17
		B		7	0,7	1,4		5,6	
		C		4	0,4	0,8		3,2	
Classroom	0,5	A	3,8	10	1,0	2,0	0,3	6	2,2
		B		7	0,7	1,4		4,2	
		C		4	0,4	0,8		2,4	
Kinder-garten	0,5	A	5,0	12	1,0	2,0	0,9	7	3,4
		B		8,4	0,7	1,4		4,9	
		C		4,8	0,4	0,8		2,8	
Department store	0,15	A	3,8	14,7	2,0	3,0	0,6	4,1	1,17
		B		10	1,4	2,1		2,9	
		C		6	0,8	1,2		1,7	

Based on his data, Fisk and Rosenfeld [40] estimated an average decrement in the self-reported productivity of 2%. Raw and his colleagues emphasized that the responses evaluated on a 9-grade subjective scale reflect the responder's belief, regardless of whether that belief is correct, and the actual productivity was not assessed. Mucous and work-related symptoms were also found to affect self-reported productivity [41], but no further validation on the accuracy of self-reports related to the actual productivity loss were made by other field investigations. Measured data in a field experiment [42] indicate a relationship between SBS symptoms and worker performance. As part of an SBS study of 3 weeks, in which the outdoor air supply was experimentally varied, 47 employees undertook two computerized neurobehavioral tests at their workplace. The workers presenting with more SBS symptoms were found to respond 7% longer in a continuous performance task and to have 30% higher error rate in a symbol-digit substitution test. As correlations were found also with temperature but not for the measured pollutants, it is more likely that the effects observed were not only due to air quality factors.

There is substantial evidence that poorly perceived indoor air quality is likely to have a negative effect on work performance. This effect was demonstrated first by Wargocki et al. [43] when he exposed impartial female subjects in a realistic office environment to the emissions from a carpet. The study showed that by improving perceived air quality, the SBS symptoms were reduced and performance of typical office tasks increased. These findings were later confirmed by several other independent investigations conducted in Denmark using different ventilation rates [44,45] and Sweden [46] using various types of pollution sources and different subjects. Based on these result an overall relation between ventilation rate per person and performance was established (Figure 8). The quantitative relationships were developed based on these results and show that for every 10% increment in % of dissatisfied in the range 15-68%, c.a. 1% decrement in performance of text-typing can be expected [45,47].

It is natural to ask whether such an improvement in the air quality level to obtain only a few percent increment on the productivity side will justify any investment to improve the indoor air quality, especially when there are no obvious complaints, and knowing that thermal conditions even within the

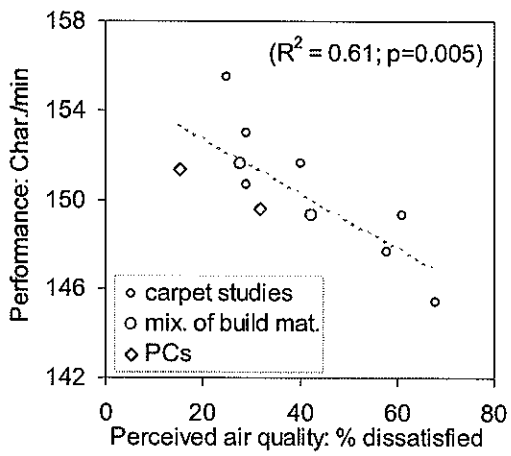

Figure 9. Performance of text-typing as function of PAQ expressed in % dissatisfied, based on the results of laboratory studies, using typical indoor pollution sources such as carpets, linoleum, books and papers on wooden bookshelves, sealant and personal computers [45,47]

thermal comfort zone according to Wyon [48] may reduce performance by 5-15%. Seppanen et al. [49] compiled the results from studies relating the indoor thermal temperature to performance (Figure 10).

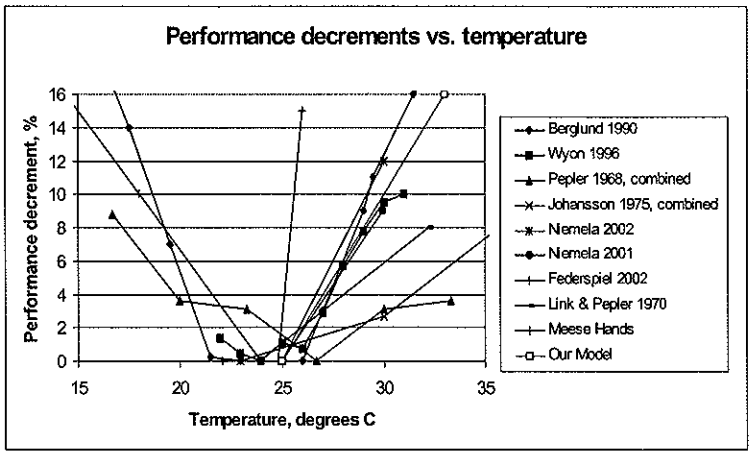

Figure 10. Relation between indoor room temperature and performance from several published studies [49]

Details about clothing and activity was not listed for all studies included in figure 10, so the temperatures cannot easily be related to the corresponding comfort zone. The authors conclude that the nature of this association is that productivity improves as thermal conditions approach a predicted thermal comfort zone.

The salaries of workers in typical office buildings exceed the building energy and maintenance cost by approximately a factor of 100. The same applies for the salaries and annual construction or rental costs [50,51]. Thus, even a 1% increase in productivity should be sufficient to cover any expenses related to doubling of energy or maintenance costs or other large investments involving construction costs or rent.

In view of the fact that a good IAQ also reduces the prevalence of SBS symptoms, Fisk et al. estimated that considerable gains and savings may result in health care costs, involving billions of dollars nation-wide in the US [40,52]. In another study Milton et al. [53] investigated the sick leaves for 3.270 employee in 40 buildings. For the employees in the offices the risk for short sick leaves was a factor 1,53 higher at a ventilation rate of 12 l/s · Person compared to a ventilation rate of 24 l/s · Person.

The effect of improving the indoor environment from Category C to B, or Category B to A was studied by Roelofsen [38]. The results are shown in table 4.

Table 4. Comparison of costs and improved performance by increasing the indoor environment from one category to a higher category [38]

Costs	Category C to B	Category B to A
Additional investments	~80 €/m²	~96 €/m²
Improved performance	~98 €/m² year	~55 €/m² year
Maintenance	~2,8 €/m² year	~1,1 €/m² year
Energy	~0,35 €/m² year	~1,00 €/m² year
Pay-back time	~0,8 year	~1,8 year

The review by Wyon [48] on the published literature showed that the payback time for general upgrading of currently unhealthy office buildings (representing 40% of the building stock) would be as low as 1.6 years if only a 0.5% increase in the overall productivity is achieved. Moreover, the cost-benefit simulation made by Djukanovic et al., [54] showed that the annual increase in productivity was worth at least 10 times as much as the increase in annual energy and maintenance costs, when improving the perceived air quality in office buildings, specifying a pay-back time of no more than 4 months due to the productivity gains achieved.
The results of recent studies [55,56,57] show that improving IAQ in real buildings has in fact larger effect on the actual performance of office work in the field (up to 9%) than would be predicted from the field laboratory experiments mentioned above. Based on the current knowledge regarding IAQ and performance of human work it seems that it is worth investing fundamental resources to improve the quality of indoor air, next to other environmental factors in real buildings, that will definitely lead to an improved work performance among the occupants, which is not necessarily measured in terms of characters typed or number of units added.

CONCLUSSIONS

The required ventilation rate in buildings must take into account both comfort and health.
People are not the only sources polluting the air (bio effluents, smoking, humidity). Also emissions from the building (building materials, paint, furnishing, electronic equipment like PC's and TV's) and HVAC systems must be taken into account.
Studies have shown that even if the ventilation rates meet existing standards there may still be a significant amount of people not finding the environment acceptable and in some cases result in health problems.
An increased ventilation rate will also increase the performance of the occupants. Limiting the pollution sources, improving air quality by air cleaning or increased ventilation rates may increase performance of the occupants by 5 to 10 %.
To reduce energy consumption by decreasing the quality of the indoor environment is a bad investment.

ACKNOWLEDGEMENTS

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Water for All
Conserve, Value, Enjoy
PUB



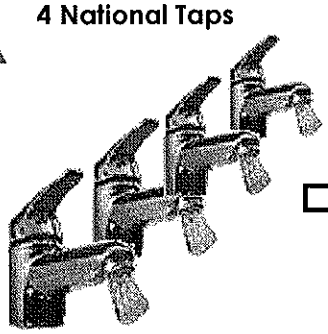
Water Efficient Buildings – A Singapore Perspective

Ramahad Singh – Deputy Director

Sustainable Water Management

"Water for All"

4 National Taps



"Conserve, Value, Enjoy"

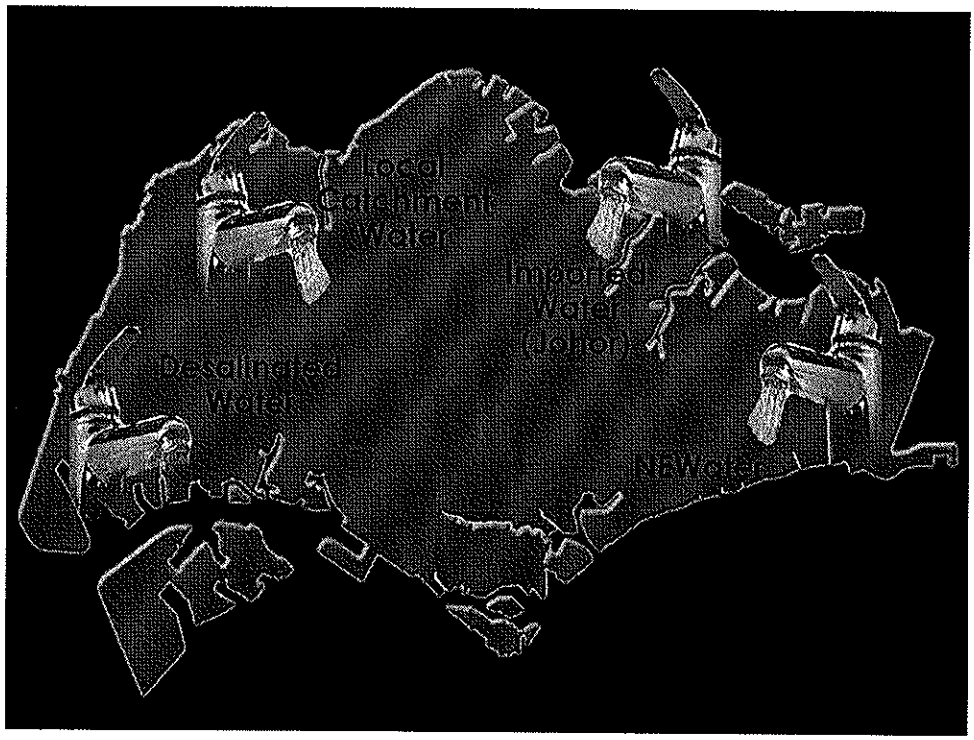
3P Approach



Supply

Demand

Water for All: Conserve, Value, Enjoy PUB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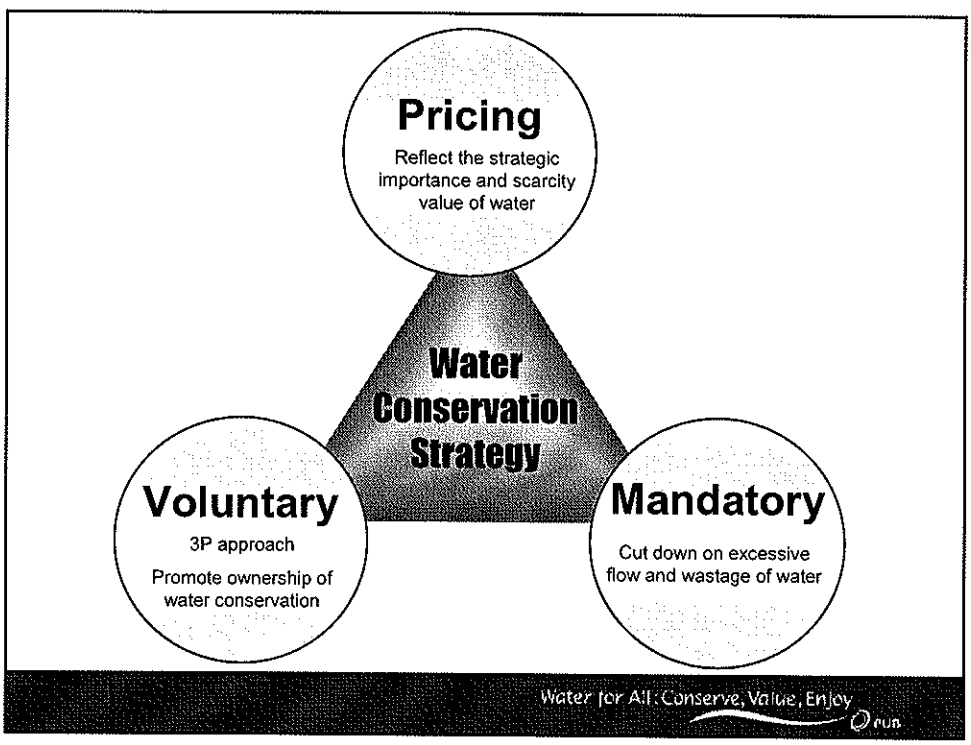

Pricing
Reflect the strategic importance and scarcity value of water
Water Conservation Strategy
Voluntary
3P approach
Promote ownership of water conservation
Mandatory
Cut down on excessive flow and wastage of water
Water for All: Conserve, Value, Enjoy

Pricing

Water Tariff Structure

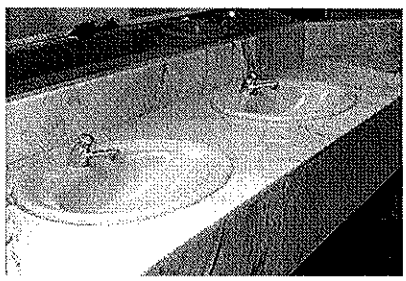
		W.e.f. 1 July 2000	
Tariff category	Consumption block (m^3 per mth)	Tariff (¢/m^3)	WCT (%)
Domestic	1 to 40	117	30
	Above 40	140	45
Non-domestic	All units	117	30

WCT : Water Conservation Tax - Broad-based Tax levied by the Government

Water for All: Conserve, Value, Enjoy

Mandatory

Installation of Water Saving Devices



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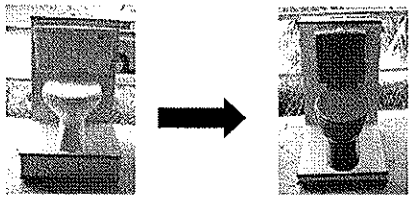
- Constant Flow Regulators

Since 1997

- Low Capacity Flushing Cistern



9 litre flushing cistern 4.5 litre flushing cistern

Water for All: Conserve, Value, Enjoy

Mandatory

Reduction of Max Allowable Flowrates

Area of Usage	Maximum Allowable Flowrate (litres/min)		Water Efficient Flow Rate (litres/min)
	Existing	New	
Basin Tap & Self Closing Delayed Action Basin Tap	8	6	2 (toilets) 4 (others)
Sink / Kitchen Tap and Wash Area	12	8	6
Shower Tap & Self-Closing Delayed Action Shower Tap	12	9*	7
Other Areas	12	8	6

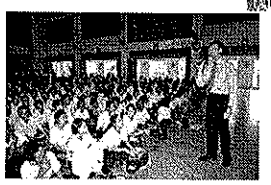
* Except for hotels remains at 12 litres / min

Water for All: Conserve, Value, Enjoy PUB

Public Education and Publicity Programme

- Educating Our Young
- Save Water Campaigns and Publicity Programmes
- Working with Grassroots/Institutions





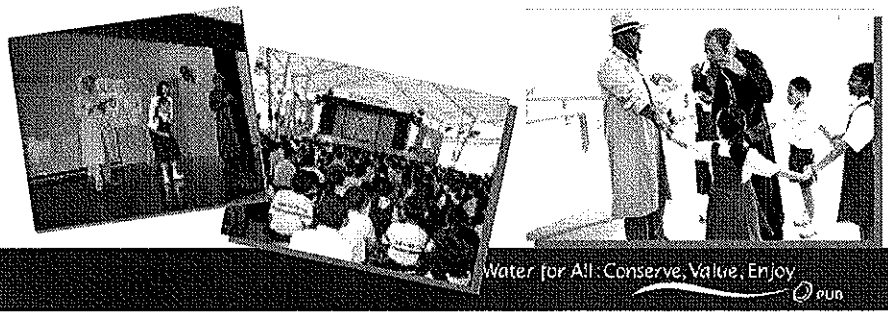




Water for All: Conserve, Value, Enjoy PUB

Water Detective Programme

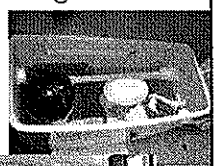
- Fun & interactive programme on reaching out to the young ones
- Target on primary school students from Primary 1-6
- Launch in Jul 2005



Water Efficient Homes Programme (WEH)



- 3Ps – community driven programme
  - Grassroots leaders distribute FOC Water Saving Kits
  - DIY and adopt good water saving habits (e.g. washing machines, shorter shower)
- Mobile exhibitions at grassroots events
- Door to door visit to assist in installation of WSDs
- Can save up to 5%
- Progress since launch in Feb 2003
- 82 constituencies launched
- More than 910,000 water saving kits distributed



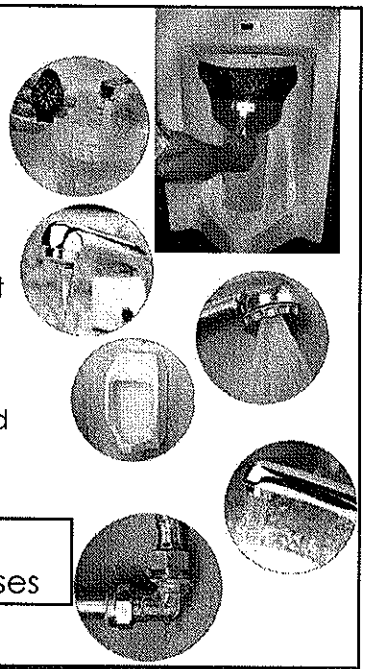


Water Efficient Buildings (WEB)

Encourage building owner / management agent to take ownership

- **Review** water usage pattern/habits
- **Reduce** water usage, keep to efficient flow rates/flush volume. Recycle/reuse where possible
- **Repair** leaking fittings promptly to avoid water wastage

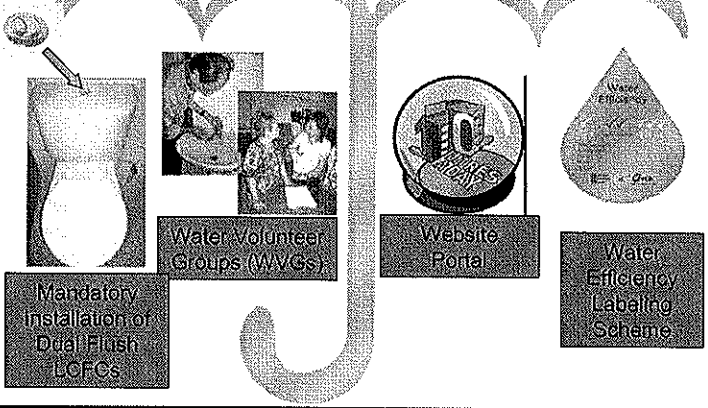
Results:
- Reach out to > 860 buildings/premises



Water for All: Conserve, Value, Enjoy

PUB

The 10-Litre Challenge



Water for All: Conserve, Value, Enjoy

PUB

Water Efficiency Labelling Scheme (WELS)

WATER EFFICIENCY LABELLING SCHEME (WELS)

- A voluntary labelling scheme dedicated to promoting Water Efficient Products
- Jointly administered by the Singapore Environment Council (SEC) & PUB

WATER EFFICIENCY LABELLING SCHEME (WELS)

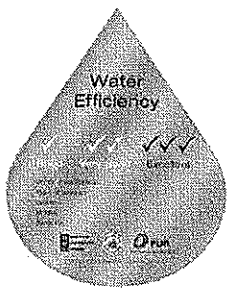
Objectives

- Facilitate consumer to make informed choice when purchasing products
- Increase public awareness on water conservation
- Encourage manufacturers/importers to bring in more water efficient products
- Promote water efficient building design
- Encourage innovation & R&D

WATER EFFICIENCY LABELLING SCHEME (WELS)

The Water Efficiency Label comprises:

- the title "Water Efficiency"
- ticks that indicate water efficiency of the labelled products (the more ticks, the more water efficient is the product)
- the water efficiency rating in words:
  - "Good" (for products with 1 tick)
  - "Very Good" (for products with 2 ticks)
  - "Excellent" (for products with 3 ticks)
- Water Consumption
- Type of Product
- Brand
- Model
- Serial No.



Water Efficiency Labelling Scheme

3-tier Rating System

✓✓✓ Excellent

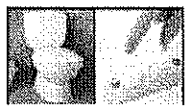
✓✓ Very Good

✓ Good

Products



Shower Head



Dual Flush Cistern



Washing Machine



Basin/ Sink Tap

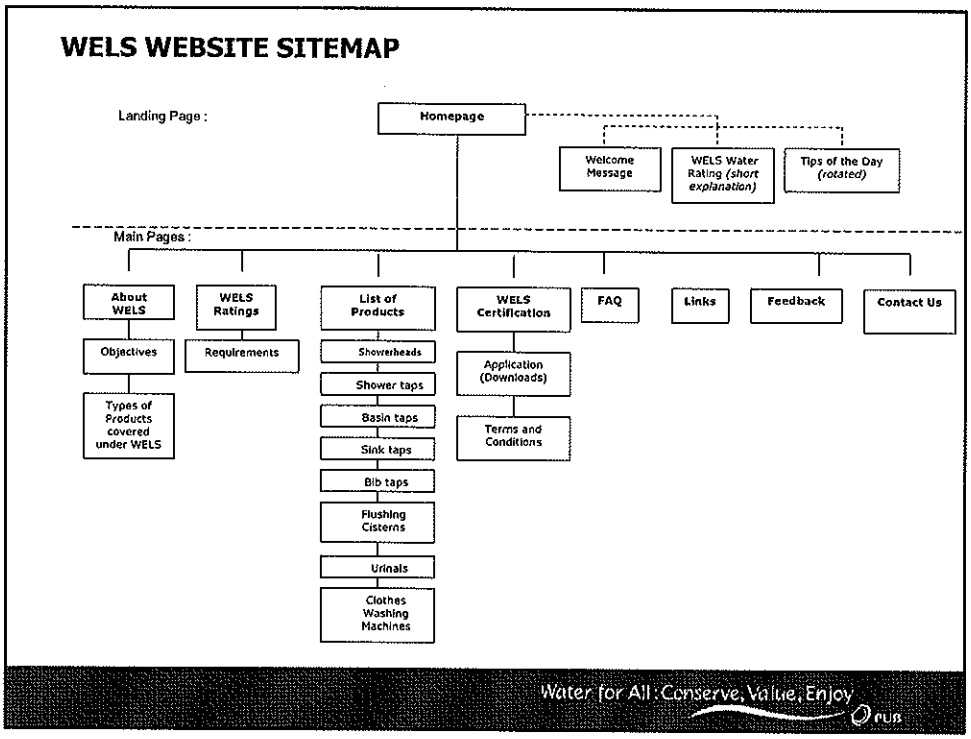
Criteria For Water Efficiency Labelling Scheme (WELS)

FITTINGS	MAXIMUM ALLOWABLE	✓ GOOD RATING	✓✓ VERY GOOD RATING	✓✓✓ EXCELLENT RATING
Shower Taps, Mixers & Showerheads (L/min)	9	>7 to 9	>5 to 7	5 or less
Basin Taps & Mixers (L/min)	6	>4 to 6	>2 to 4	2 or less
Sink/Bib Taps (L/min)	8	>6 to 8	>4 to 6	4 or less
Flushing Cisterns – Dual Flush Type (L/flush)	4.5 (full flush) 3.0 (low flush)	>4.0 - 4.5 (full flush) > 2.5 -3.0 (low flush)	>3.5 to 4.0 (full flush) > 2.5 – 3.0 (low flush)	3.5 or less (1) (full flush) 2.5 or less (low flush)
Urinals & Urinal Flush Valve (L/flush)	1.5	> 1.0 to 1.5	> 0.5 to 1.0	0.5 or less (2) Or waterless urinals
Washing Machine (L/Kg)	15	> 12 -15	> 9 -12	9 or less

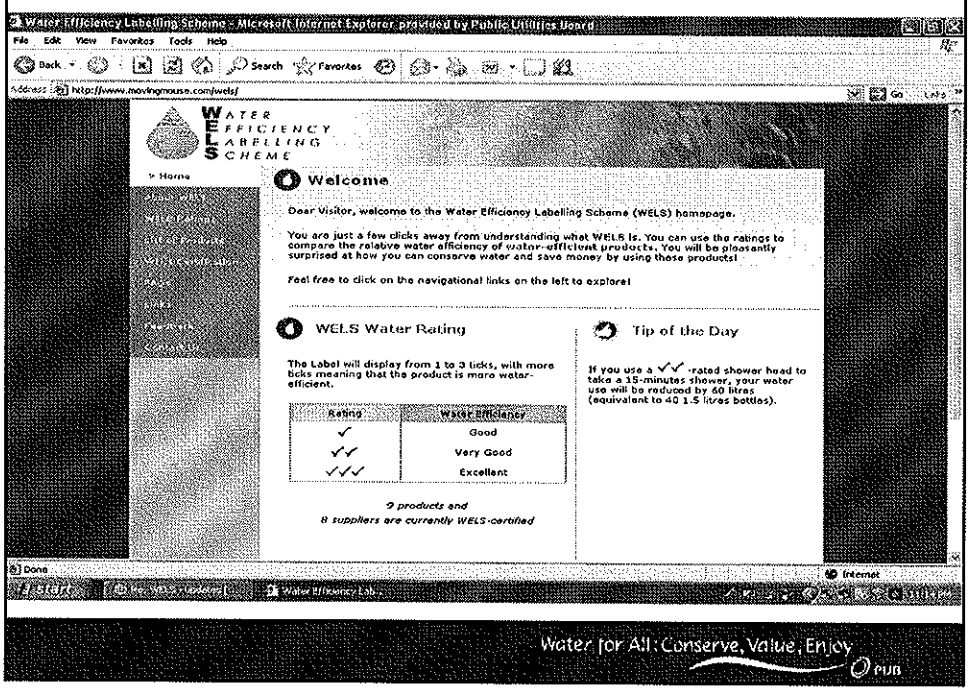
(1) To pass laboratory simulation test on waste transportation efficiency in pipe.

(2) To pass dilution test

WELS WEBSITE SITEMAP



WELS WEBSITE



INCORPORATE WELS IN BUILDINGS

WELS will be incorporated under BCA's Green Mark criteria for new buildings

Encourage developers, govt agencies as well as professionals to incorporate this scheme in their developments/buildings design specification

Water Efficient Practices

How to Conserve Water.....

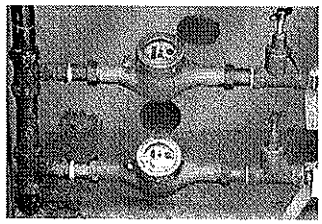
(1) Management commitment
(2) Monitor water usage
(3) Conduct water audit
(4) Install Water Saving Devices/ use of Water Efficient Labelled Products
(5) Water Substitution / Recycling

(1) Management Commitment

- Include water conservation in organisation's environmental mission statement
- Appoint a water controller
- Promote water conservation at workplace
  - Water conservation part of employee orientation & training programmes
  - Seek employee suggestions for water use efficiency eg. locate suggestion boxes in prominent areas
  - Conduct contests for employees eg.posters, slogans, efficiency ideas, etc.

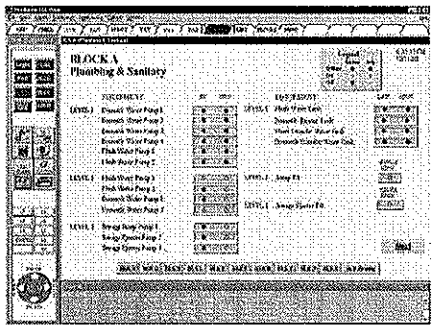
(2) Monitor Water Usage

- Key element
- Sub-meters should be installed
- Installation of submeters/private meters on all major water systems, such as cooling tower, irrigation, hot water devices, etc.\
  - Know how water is used
  - Identification of leak areas quickly



- Take water meter readings regularly (daily/weekly/fortnightly)
  - Monitor the water consumption on a plotted graph
  - Any sudden increase may indicate a leak in the system
  - Investigate immediately
  - Take prompt action to repair leaks, if any

- main and sub-meters should be linked to a building management system (BMS)
  - water usage trends can be recorded
  - Alarm activated if there is a sudden increase in water consumption or a new trend in water consumption as this will indicate the possibility of a water leakage



- Conduct regular meter test
  - During off peak period when there is no consumption or consumption is negligible
  - Ensure that all the tanks are isolated/fully filled
  - Watch the water meter to see if the counter moves
  - A movement on the counter means that there is a leak somewhere
  - Further investigation to locate possible leak

(3) Conduct Water Audit

Water Audit : identify potential water efficiency opportunities

- Identify all water usage areas from the source
- Know the breakdown of water usage at the different areas eg. guest rooms, public amenities, kitchen, cooling tower, laundry, outdoor areas, etc.
- Walk through survey
  - identify all water consuming equipment
  - check water flowrates at water fittings
  - review current water saving measures
  - note all water losses, excessive water pressure and leaks.
- Judge current water use efficiency & determine potential for water savings

Water for All: Conserve, Value, Enjoy

(4) Water Saving Devices/ Use of Water Efficient Labelled products

- Install modern water efficiency fittings without compromising comfort

»Showers : Low flow shower head

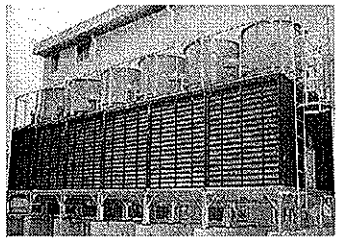
»Basin Taps : thimbles or CFRs

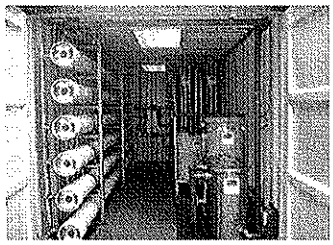
»Flushing cistern : use dual flush low capacity flushing cistern
: cistern water saving bags for 9 litre flushing cistern

Water for All: Conserve, Value, Enjoy

(5) Water Substitution/Recycling

- All application for water supply are submitted to PUB for approval
- Encourage substitution with NEWater and Seawater
- Encourage recycling of process water

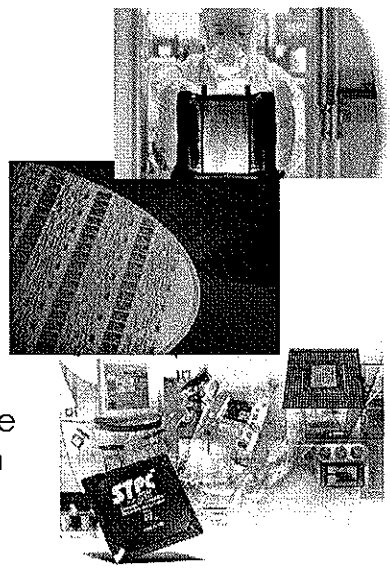




Water for All: Conserve, Value, Enjoy

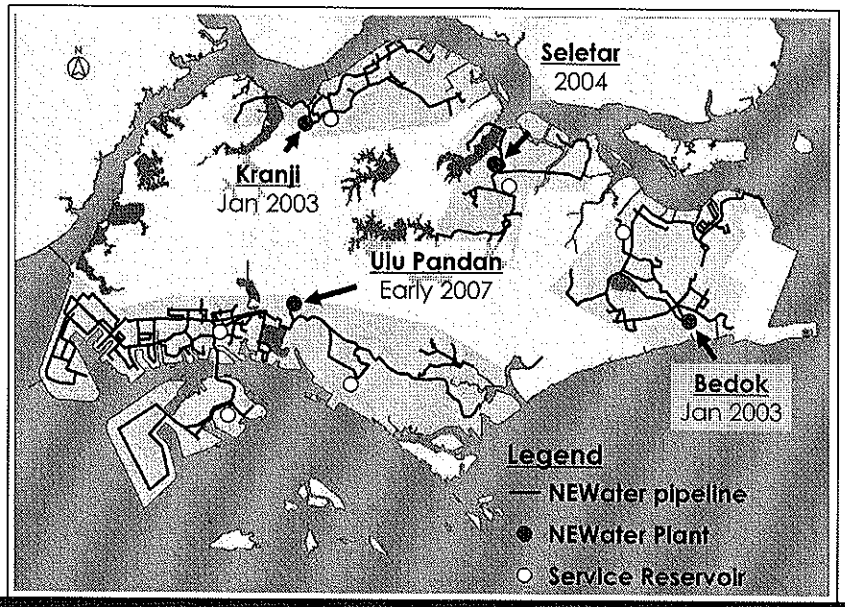
NEWater for Non Potable Use

- Supply through a secondary reticulation system
- Purer water quality
  - for process use, boilers, laundry
  - air-con cooling towers
  - further treated to produce Ultra-Pure Water for use in high-end electronic companies



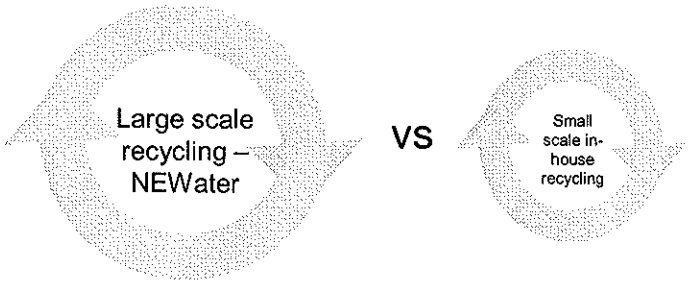
Water for All: Conserve, Value, Enjoy

Water Substitution (NEWater)



Water for All: Conserve, Value, Enjoy PUB

Water Substitution / Recycling

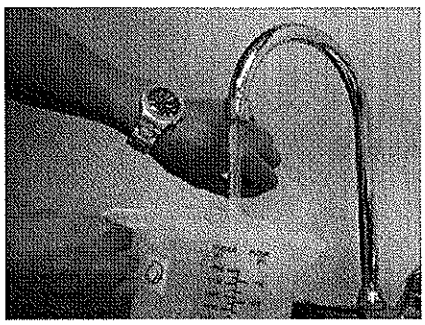


- Biggest incentive ⟹ Price of NEWater < Price of Potable Water
- Customers can further recycle their used water if it is economically viable and wish to do so

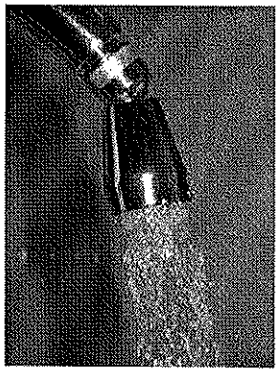
Water for All: Conserve, Value, Enjoy PUB

Thank You

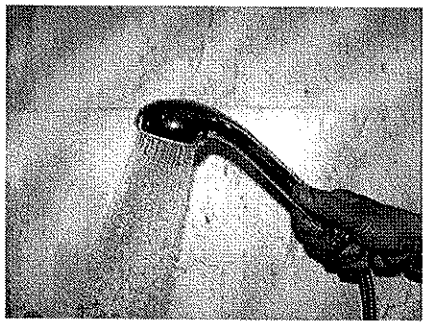
How to measure flow rate



Low Flow showerheads



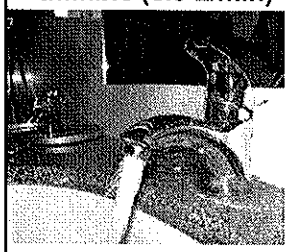
5 L/min

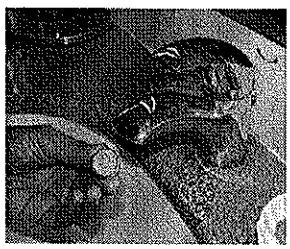


5.5 to 6 L/min

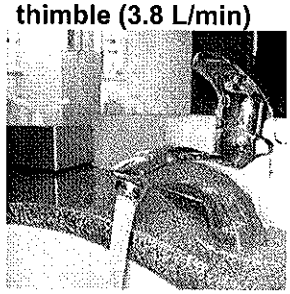
Water for All: Conserve, Value, Enjoy

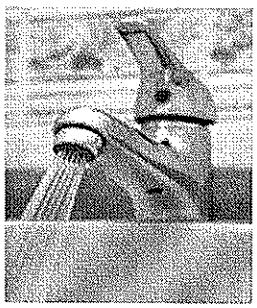
Before installation of thimble (6.5 L/min)





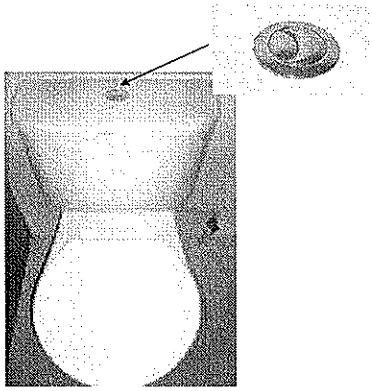
After installation of thimble (3.8 L/min)



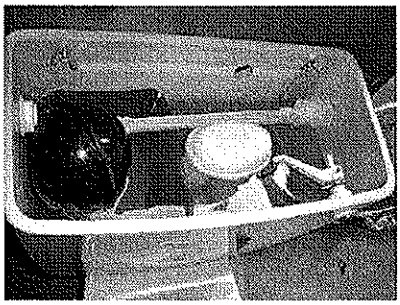


Installation of CFR (2 L/min)

Water for All: Conserve, Value, Enjoy



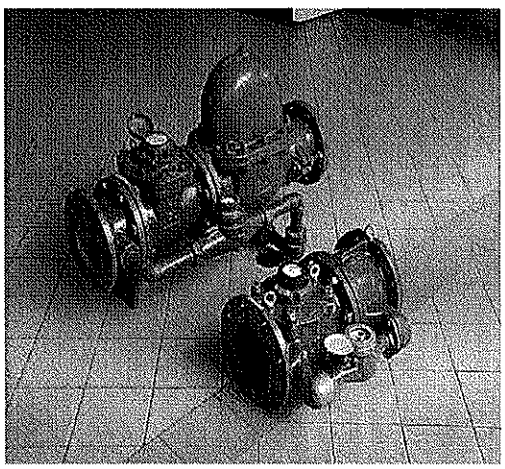
Dual Flush Low Capacity Flushing Cistern

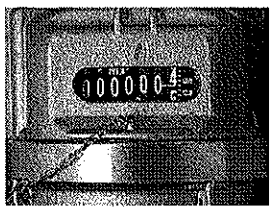


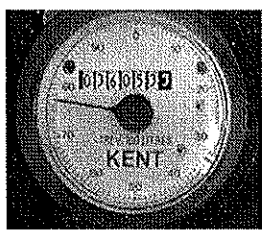
Cistern Water Saving Bag for 9 litre Flushing cistern

Water for All: Conserve, Value, Enjoy

Take Water Meter Readings Regularly

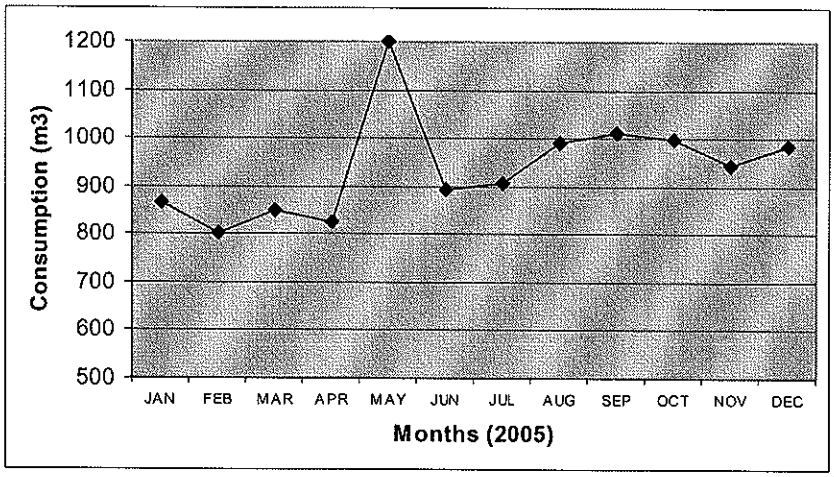






Water for All: Conserve, Value, Enjoy

2005 Monthly Water Consumption



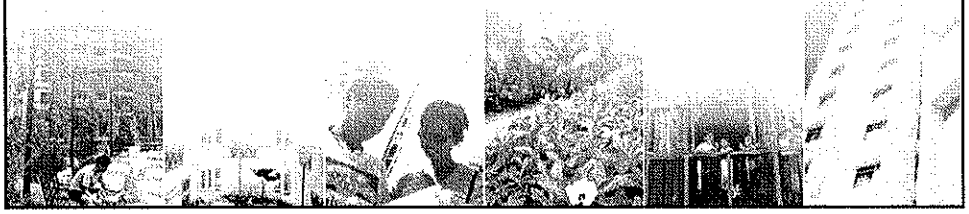
Water for All: Conserve, Value, Enjoy

HOUSING & DEVELOPMENT BOARD



Creating Sustainable Living Environment in Public Housing Development - HDB's Experience

Presented by
Dr Johnny Wong Liang Heng
Building Technology Department
Housing & Development Board





CONTENT

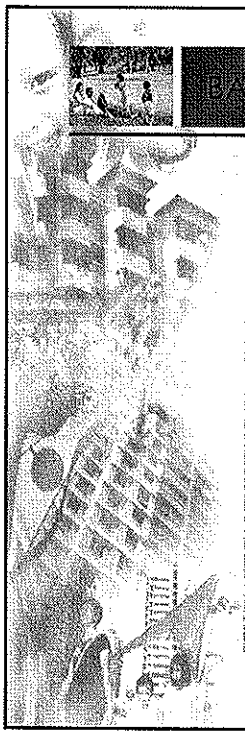
- BACKGROUND
- ENVIRONMENTAL SUSTAINANABILTY
- HDB GREEN BUILDING TECHNOLOGIES
- GREEN BUILDINGS FOR THE TROPICS

HOUSING & DEVELOPMENT BOARD



BACKGROUND





BACKGROUND

HOUSING & DEVELOPMENT BOARD

FORMED IN: 1960

VISION

Affordable Homes,

Vibrant Towns,

Cohesive Communities



BACKGROUND

WORLD CLASS PUBLIC HOUSING



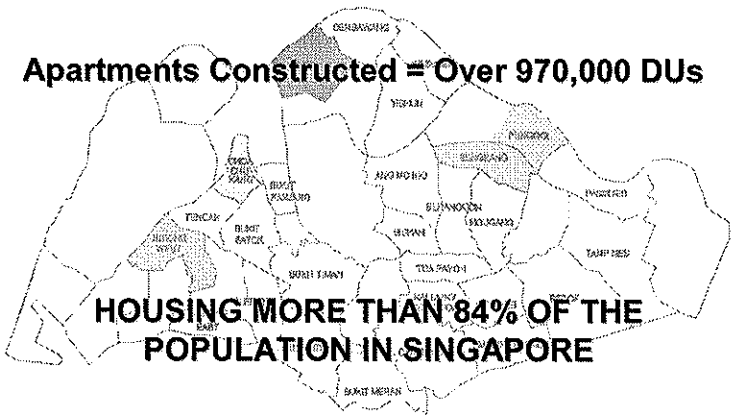
40 OVER YEARS OF TRACK RECORD



BACKGROUND

TRACK RECORD

Apartments Constructed = Over 970,000 DUs



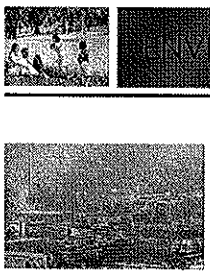
HOUSING MORE THAN 84% OF THE POPULATION IN SINGAPORE

HOUSING & DEVELOPMENT BOARD

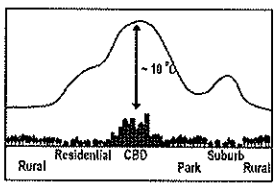


ENVIRONMENTAL SUSTAINABILITY









- Urbanization is a global phenomenon
- Increases building intensity and sealed surfaces
- Temperatures are higher in urban areas
  - lower wind velocities
  - increased exposure to radiation
  - Urban Heat Island Effects



ENVIRONMENTAL SUSTAINABILITY

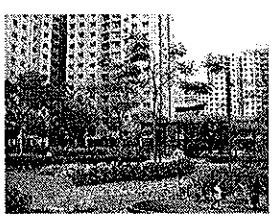
The concept of sustainability as described by UNCED (United Nations Commission on Environment and Development), Bruntland Report, 1987,

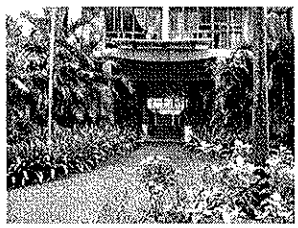
"Development which meets the needs of the present without compromising the the ability of future generations to meet their own needs"

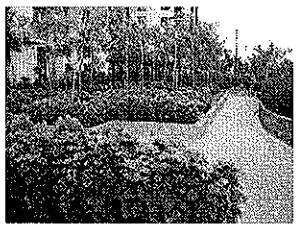


ENVIRONMENTAL SUSTAINABILITY

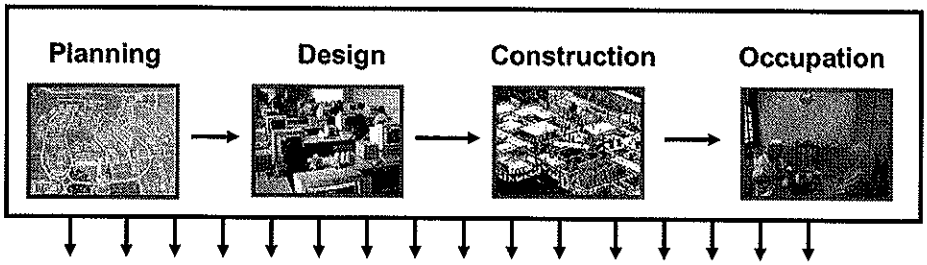
As the largest developer in Singapore, we recognize our role and responsibilities in leading the industry towards environmentally sustainable development



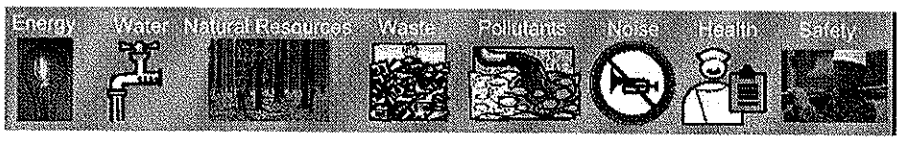




ENVIRONMENTAL SUSTAINABILITY



Impact on Environment, Health & Safety

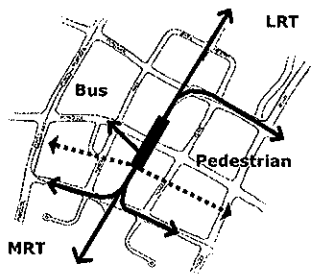


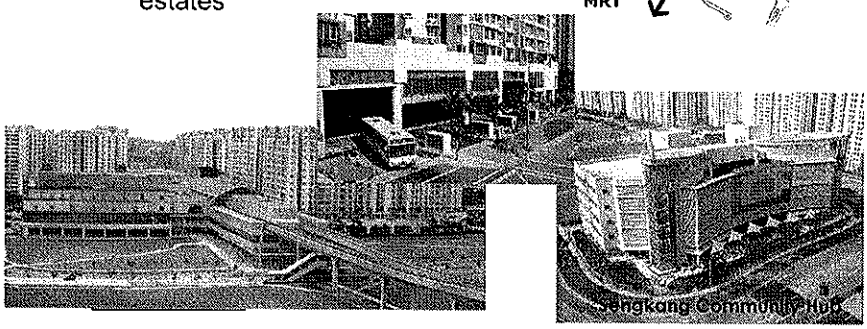
ENVIRONMENTAL SUSTAINABILITY

Planning

Accessibility

- Transport
- Enhancing accessibility in estates





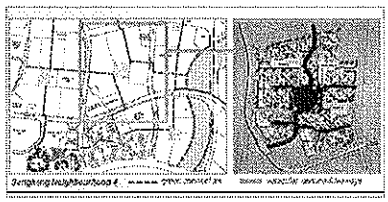


ENVIRONMENTAL SUSTAINABILITY

Planning

Connectivity

- Sheltered Linkways
- Green Connectors
- Landscaping











ENVIRONMENTAL SUSTAINABILITY

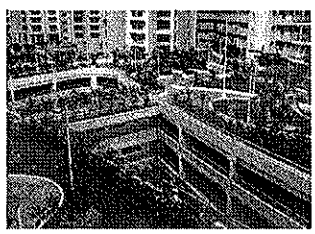
DESIGN

Green Spaces

- Regional and Neighborhood parks
- Better landscaping
- MSCP Gardens







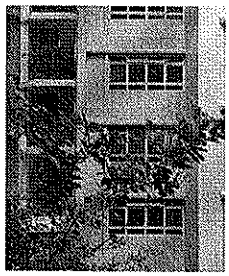


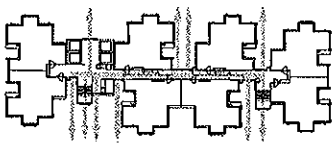
ENVIRONMENTAL SUSTAINABILITY

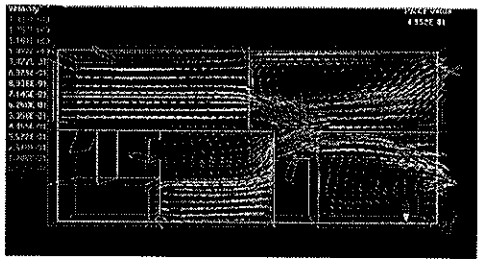
DESIGN

Thermal Comfort

- Orientation of buildings
- Natural Ventilation
- Cross Ventilation







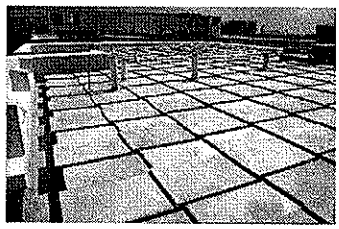


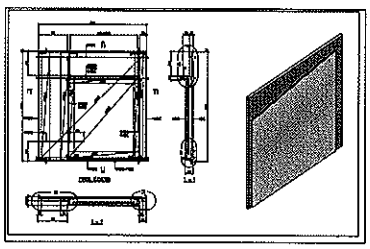
ENVIRONMENTAL SUSTAINABILITY

DESIGN

Thermal Comfort

- Gable end walls
- Secondary roofing system
- Sun-shading devices
- Void Decks









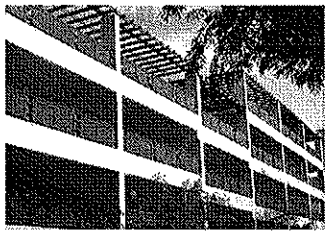
ENVIRONMENTAL SUSTAINABILITY

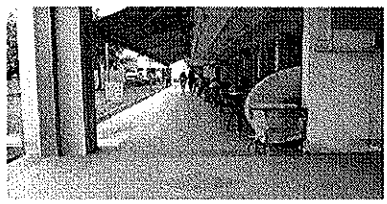
DESIGN



Lighting

1. Capitalize Natural Lighting
2. Common corridors
3. Open concept at MSCP

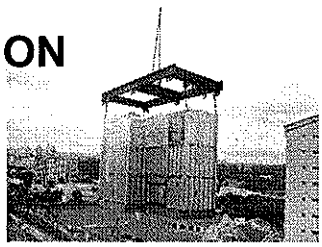






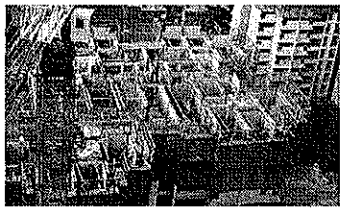
ENVIRONMENTAL SUSTAINABILITY

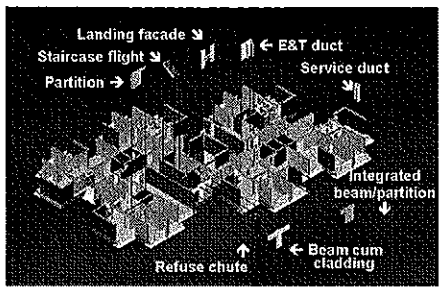
CONSTRUCTION



Prefabrication

- Reduce noise
- Reduce air pollution
- Less traffic congestion
- Less wastage

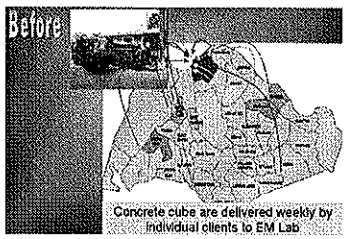


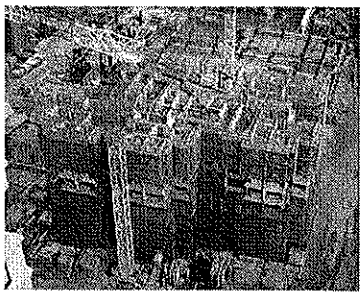


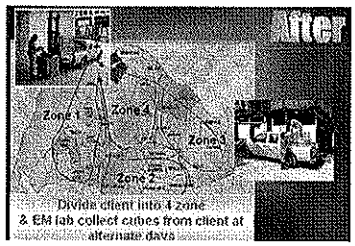
ENVIRONMENTAL SUSTAINABILITY

CONSTRUCTION

- Reusable metalforms
- Speed Cube for central collection
- Good site housekeeping



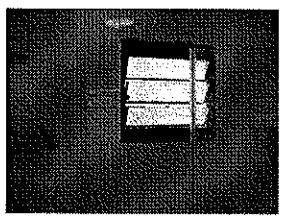




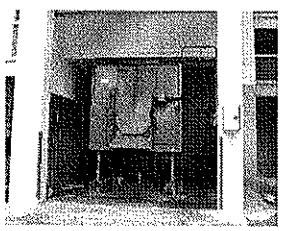
ENVIRONMENTAL SUSTAINABILITY

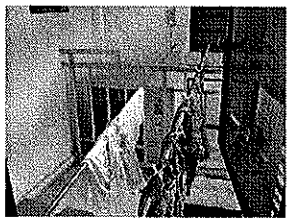
OCCUPATION

- Centralized Refuse Chute
- Clothes drying racks
- Naturally ventilated toilets
- Anti-fungal external paint
- Optional Components Scheme









HOUSING & DEVELOPMENT BOARD



RESEARCH & DEVELOPMENT





RESEARCH & DEVELOPMENT

RESEARCH & DEVELOPMENT

Technology that targets the need to reduce environmental burden without compromising long term safety, comfort and function

Objectives :

- Cost effective, high value
- Low maintenance cost, sound design
- Low complains , high satisfaction



RESEARCH & DEVELOPMENT

Committee on Environmental Sustainability

- Formed in 2004
- To provide strategic direction on creating environmentally sustainable towns and estates
- Represented by NEA, SemCorb, EM Services, BCA, NUS, Academia, etc.

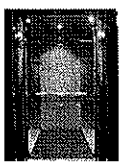


HDB GREEN BUILDING TECHNOLOGIES

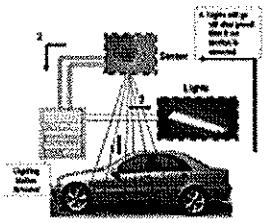
ENERGY EFFICIENCY

- Energy saving lamps and ballasts for public lighting
- Motion sensors to control lighting in MSCPs
- Variable Voltage Variable Frequency motor drive for lifts
- Solar Lighting for landscape lighting
- LED Lighting







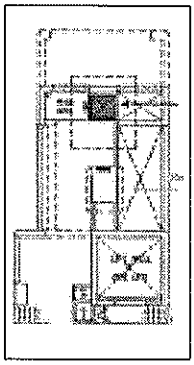






HDB GREEN BUILDING TECHNOLOGIES

ENCOURAGING RECYCLING



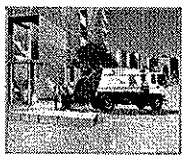
Recyclable Intermediate Chute System (RICH)

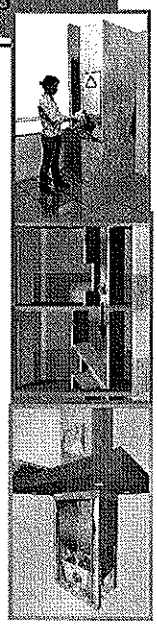
To provide a convenient mode for HDB dwellers to recycle

- Present door to door collection method is labour intensive
- Collaborated with SembEnviro on RICH







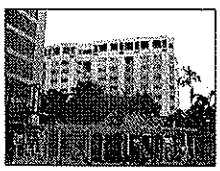


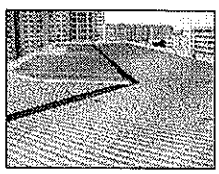


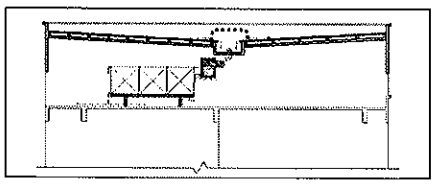
HDB GREEN BUILDING TECHNOLOGIES

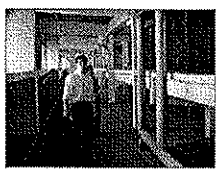
STORMWATER HARVESTING

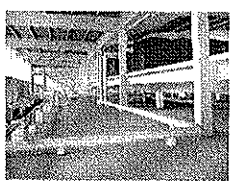
Harvesting rainwater for common area washing

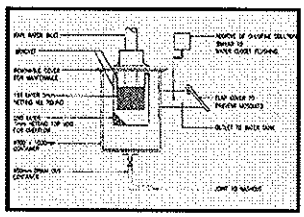




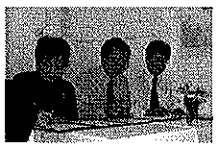






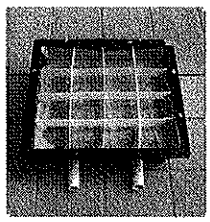


ENHANCING GREEN

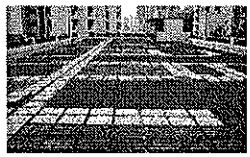


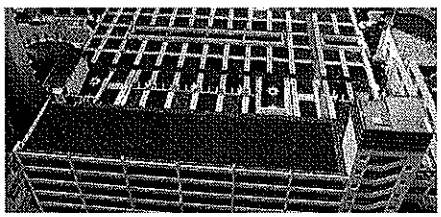
SIGNING OF MOU - 15 DEC 2004

HDB, NParks & United PREMAS

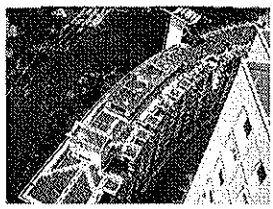








Blk 141A, Toa Payoh



Blk 157, Toa Payoh

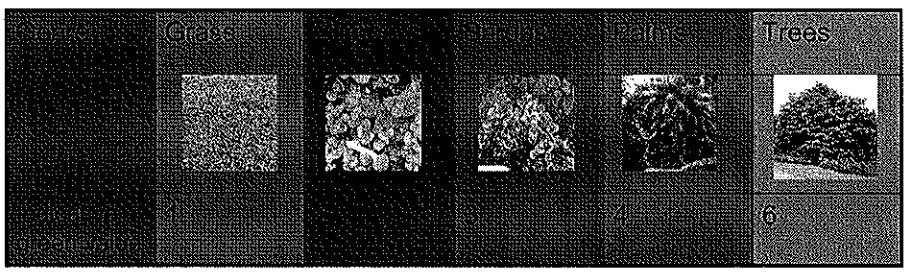
GREEN PLOT RATIO

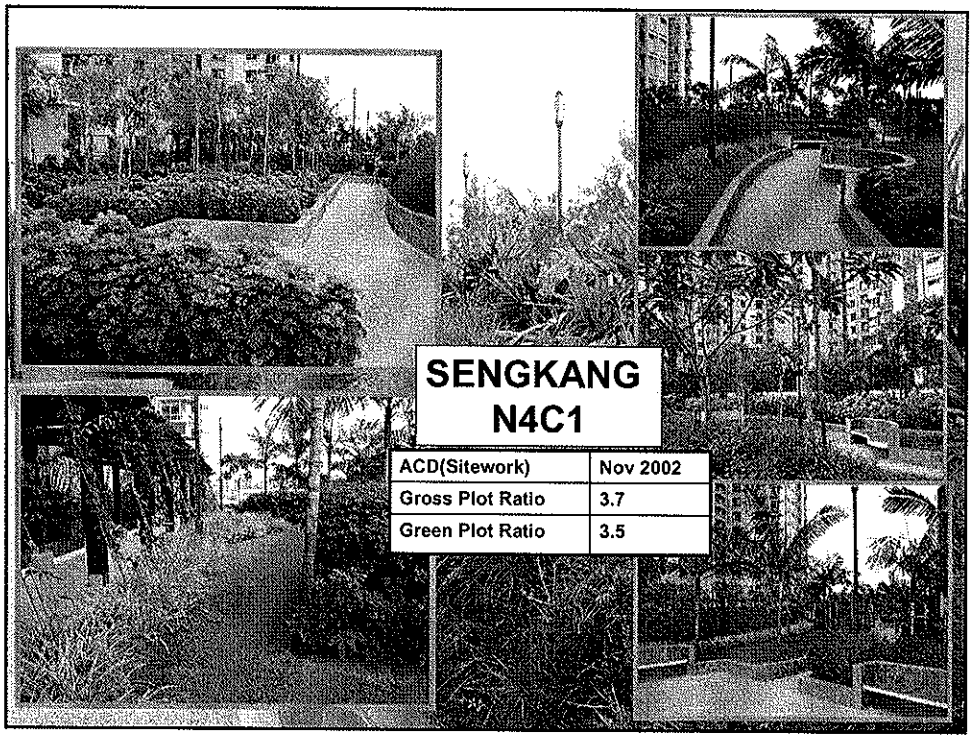
Objective

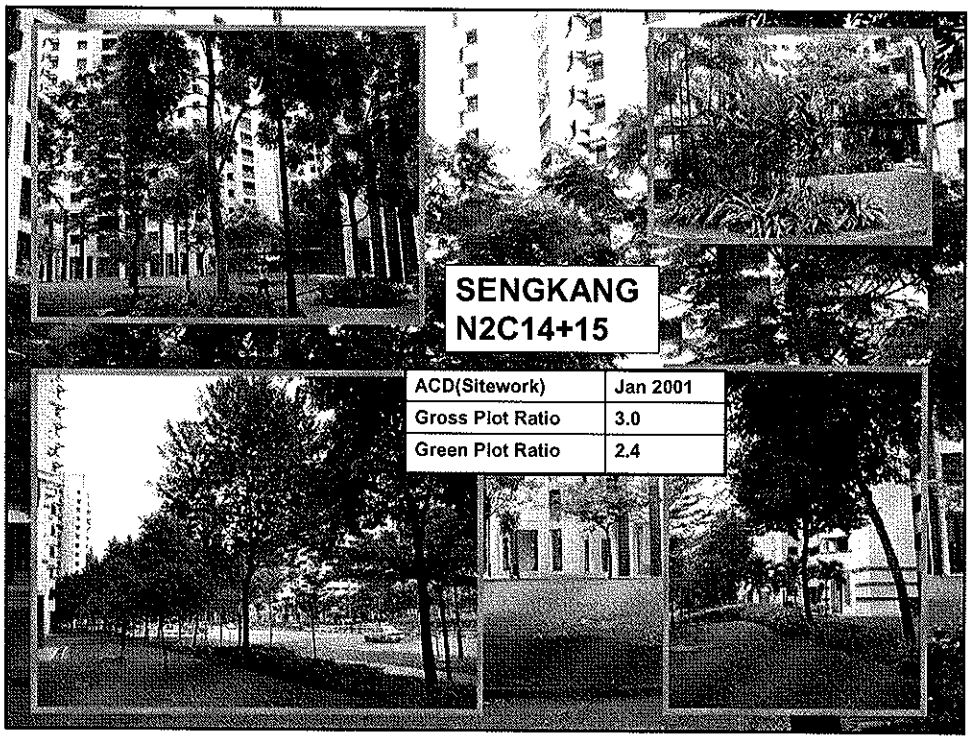
A design tool to balance the amount of 'green' vs 'grey'

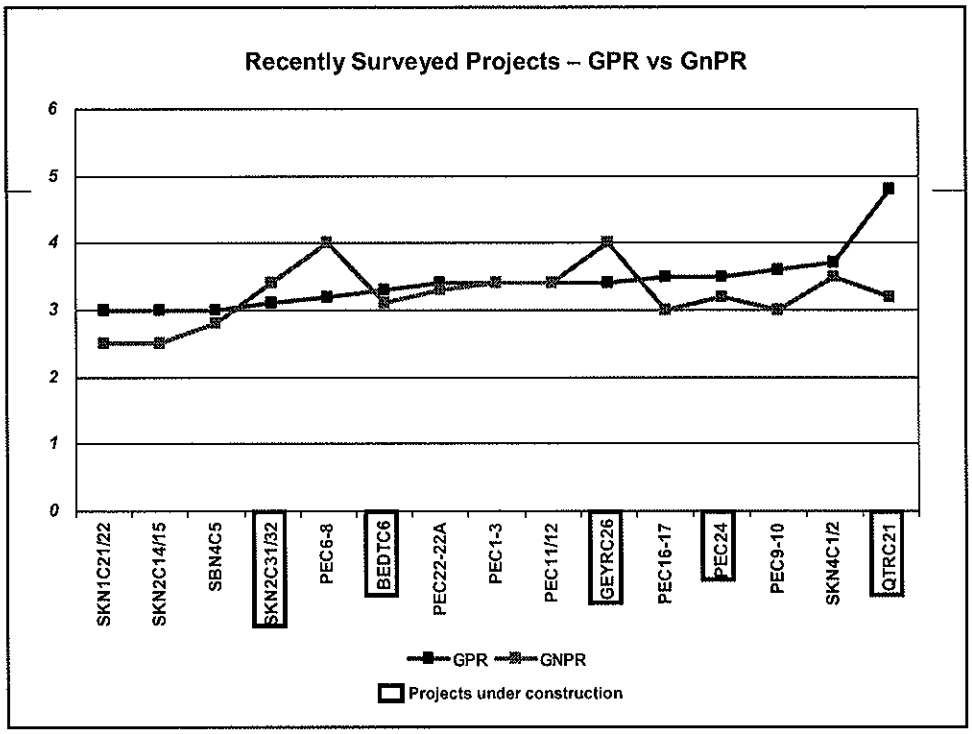
Benefits

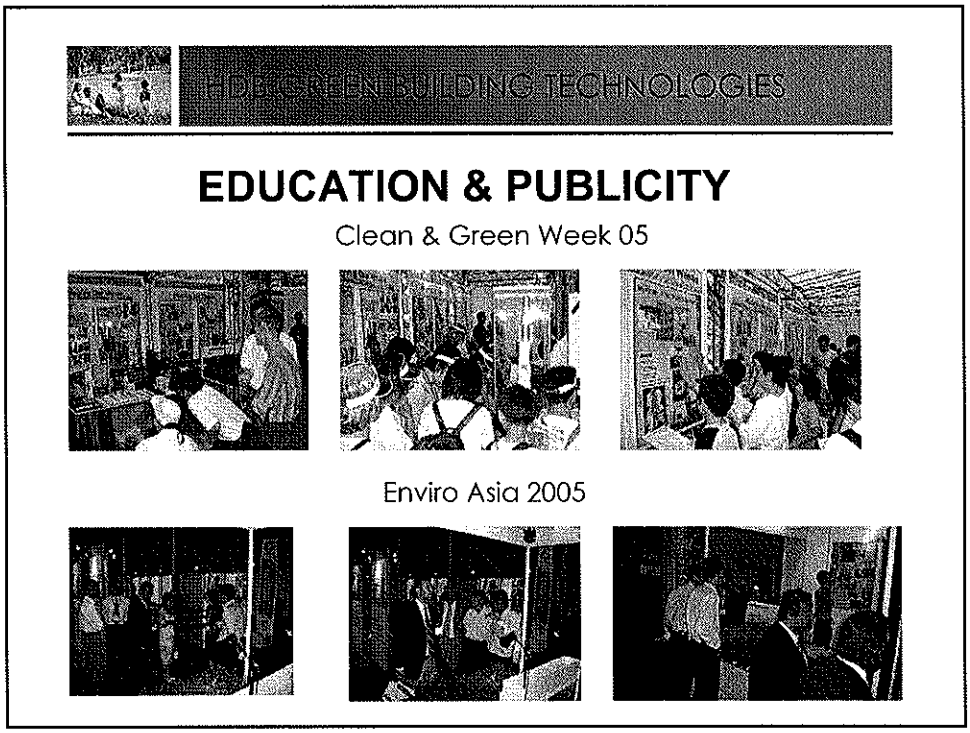
• Ensure natural environment lost can be recovered and protected




SENGKANG
N4C1
ACD(Sitework) Nov 2002
Gross Plot Ratio 3.7
Green Plot Ratio 3.5


SENGKANG
N2C14+15
ACD(Sitework) Jan 2001
Gross Plot Ratio 3.0
Green Plot Ratio 2.4


Recently Surveyed Projects – GPR vs GnPR
6
5
4
3
2
1
0
SKN1C21/22
SKN2C14/15
SBN4C5
SKN2C31/32
PEC6-8
BEDTC6
PEC22-22A
PEC1-3
PEC11/12
GEYRC26
PEC16-17
PEC24
PEC9-10
SKN4C1/2
QTRC21
GPR
GNPR
Projects under construction

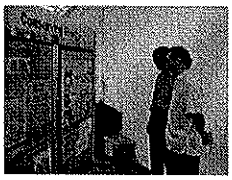

HDB GREEN BUILDING TECHNOLOGIES
EDUCATION & PUBLICITY
Clean & Green Week 05
Enviro Asia 2005



HDB GREEN BUILDING TECHNOLOGIES

EDUCATION & PUBLICITY

Nanyang CSSP Carnival 2005 (20 Nov 05)





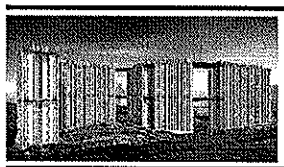
Promoting Community Gardening







HOUSING & DEVELOPMENT BOARD



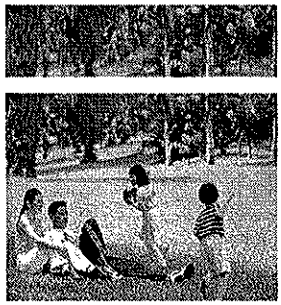
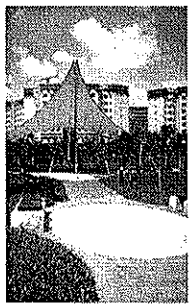
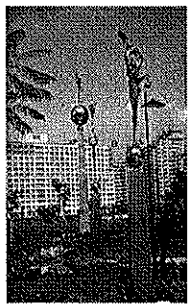
GREEN BUILDINGS FOR THE TROPICS



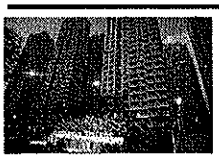


GREEN BUILDINGS FOR THE TROPICS

HDB does not build buildings …

We create a Sustainable Living Environment!



Thank You

