Daylight and Sun in the Low-Energy Cities of Tomorrow

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Daylight and Sun in the Low-energy Cities of Tomorrow

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Work and cases developed as part of the Ph.D. dissertation

Sustainability - Energy Optimization - Daylight and Solar Gains
Royal Danish Academy of Fine Arts, School of Architecture 2012

Collaborations:
Scientific papers: Jakob Strømann-Andersen, DTU & Henning Larsen Architects
Carlsberg: Henning Larsen Architects, Dorte Mandrup Arkitekter, Polyform & Signal Arkitekter
Design Guidelines: Henning Larsen Architects, Algreen Arkitekter, Peter Andreas Sattrup Arkitekt MAA. Sponsor: Realdania

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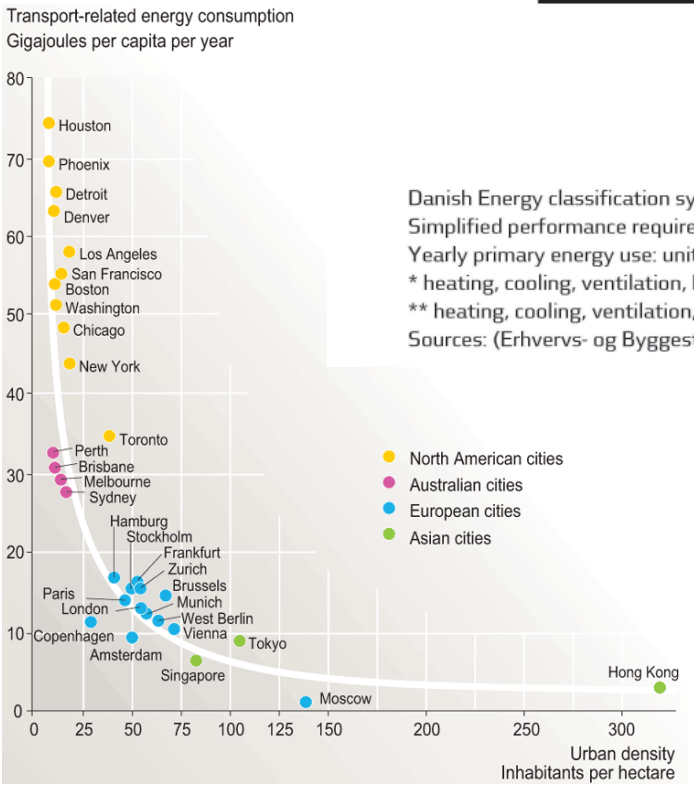
Regulatory

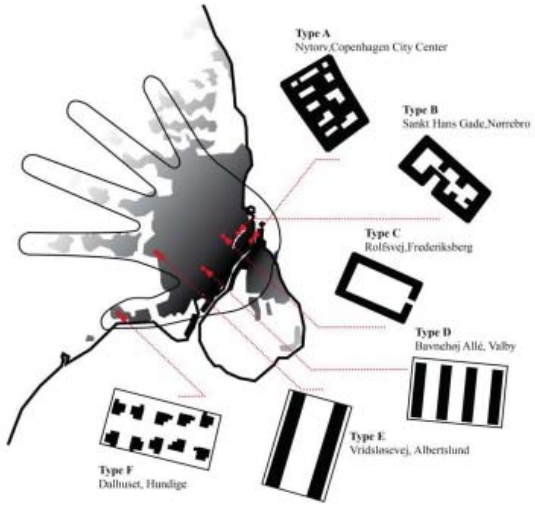
Year	housing*	workplace**	
2010	~50	~70	
2015	*~35*	*~50*	*low-energy 2015*
2020	*~20*	*~25*	**~ passivhaus**
	0	0	**zero energy**
	> 0	> 0	**active house / energy+**

Voluntary

Danish Energy classification systems: regulatory, proposed and voluntary
Simplified performance requirements.
Yearly primary energy use: unit kWh/msqyear gross area
* heating, cooling, ventilation, DHW
** heating, cooling, ventilation, DHW, artificial light
Sources: (Erhvervs- og Byggestyrelsen 2010)(Dansk Byggeri 2011)



Newman & Kenworthy 1989, AEdMD 2007



Egnsplankontoret 1947, Sattrup & Strømann-Andersen 2012

The challenge: Implementing future low-energy cities
Urban densification is a key strategy - but what is the balance between density, daylight and sun?

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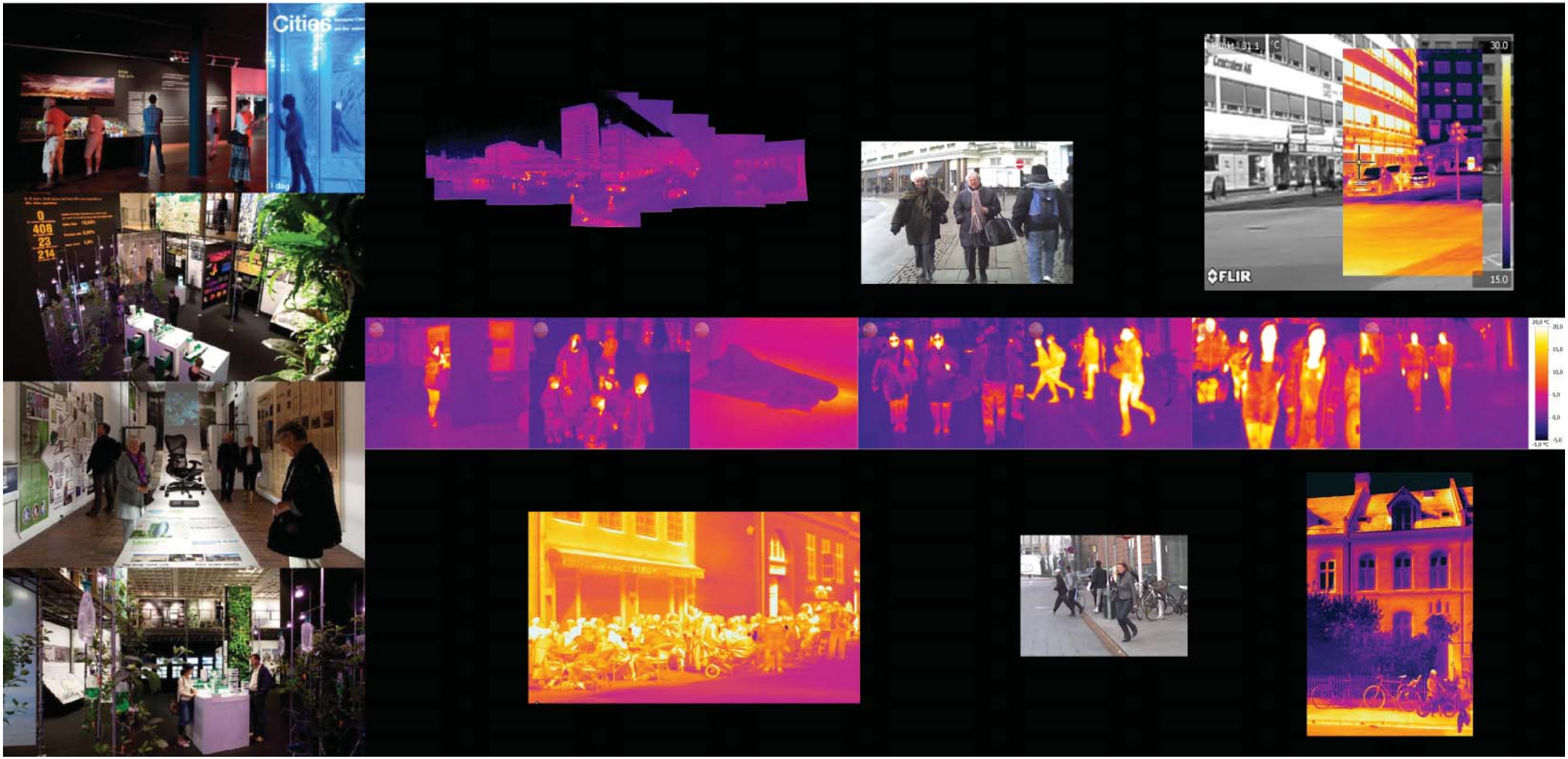

Louisiana - Green Architecture for the Future 2009

Copenhagen - Urban Microclimates, Peter Andreas Sattrup 2009

The form and materials of urban spaces create special urban microclimates.
The quality of the urban environments affect the indoor climate of buildings and their energy use.

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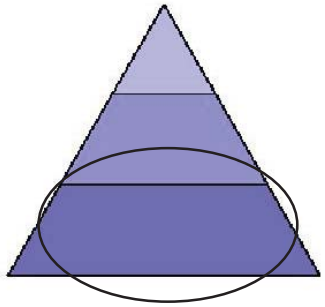
SHEARING LAYERS

Energy systems

Building

City

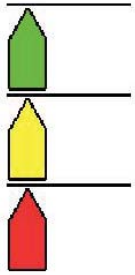


ENVIRONMENTAL MANAGEMENT

Energy — step 3

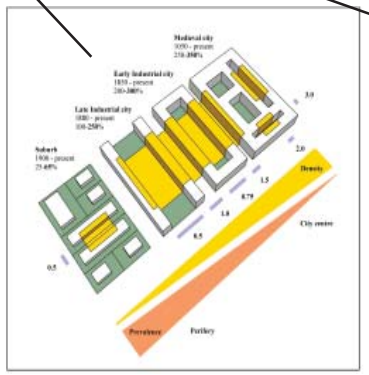
Comfort — step 2

Architecture — step 1



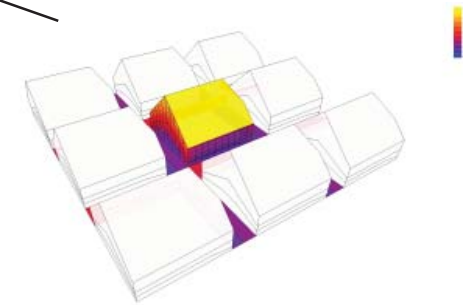
DURABILITY

Urban Canyon and Building Energy use
Sattrup & Strømann-Andersen 2011



Building Typologies and Energy use
Sattrup & Strømann-Andersen 2011

ENERGY PERFORMANCE



Solar Access design principles
Sattrup 2012

Environmental design and energy optimization starts at the level of the City.
What are the impacts of urban design on daylight, solar heat gains and building energy use?

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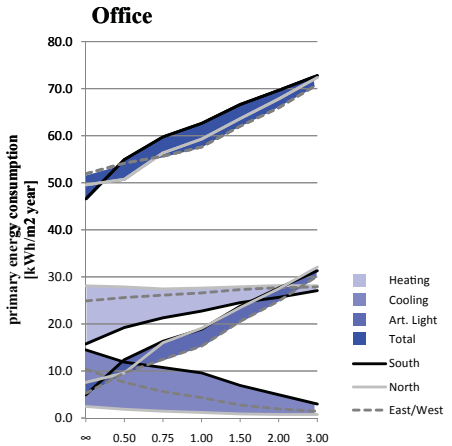
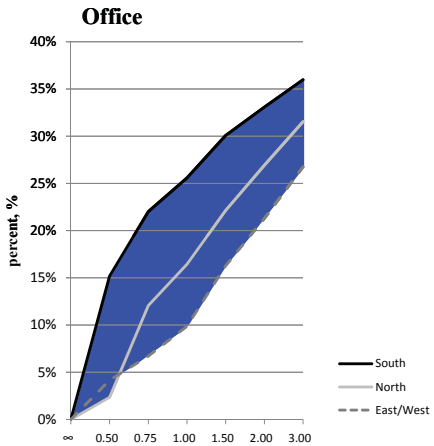
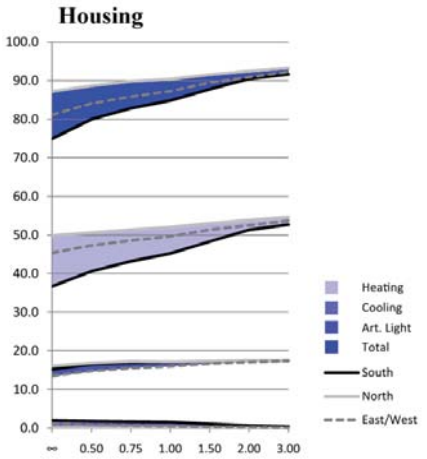
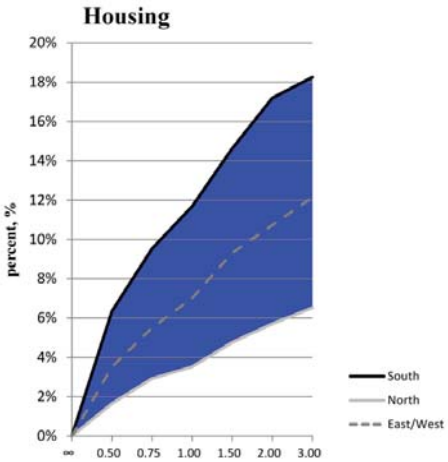








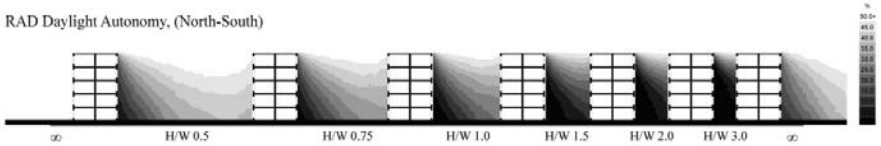


Figure: ##: Annual illuminance > 10.000 lux in street canyon. Performed in RADIANCE/DAYSIM (working hours 08-17, Contour range 0-50% in steps of 5%). Weather data., Copenhagen (*epw)

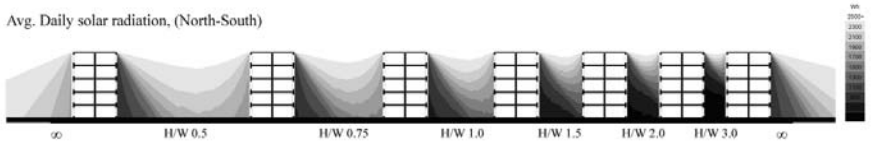
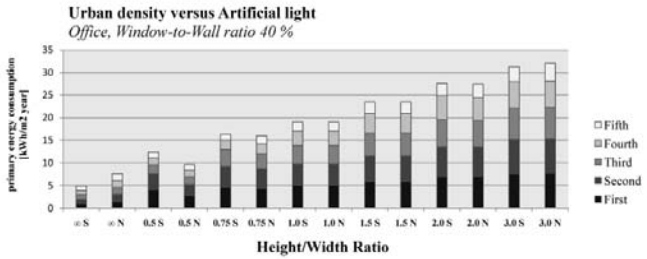
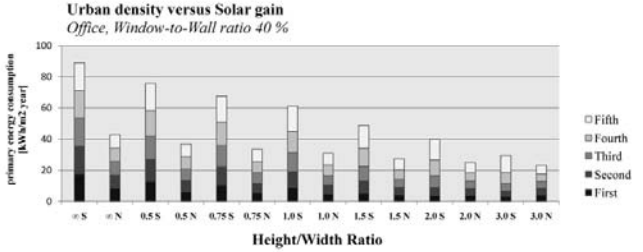


Figure: ##: Average daily solar radiation in street canyon. Performed in ECOTECT (working hours 08-17, Contour range 500-2500 Wh in steps of 200 Wh). Weather data., Copenhagen (*epw)





Urban Canyon and Building Energy use
Sattrup & Strømann-Andersen 2011

Environmental design and energy optimization starts at the level of the City.
Daylight becomes an increasingly important energy parameter in low-energy city cities

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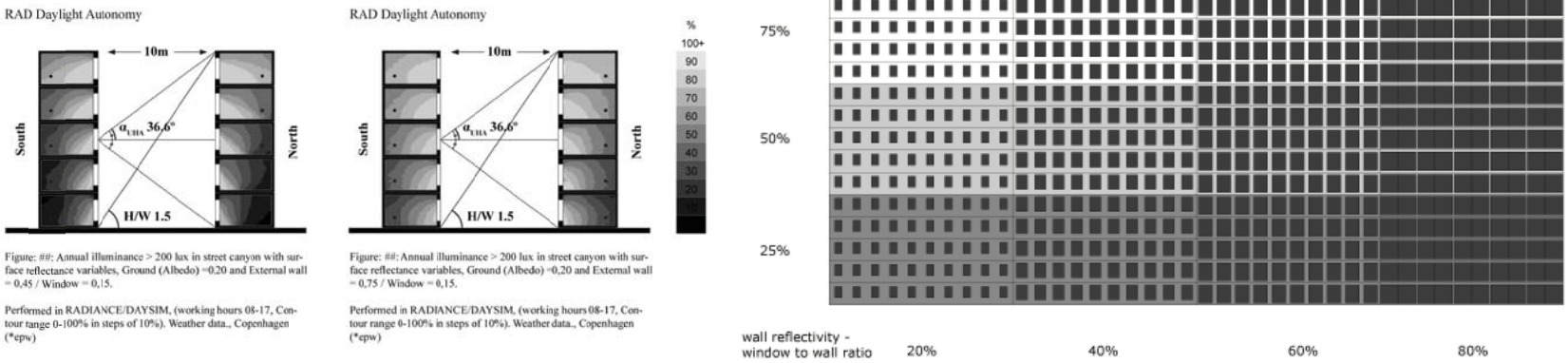
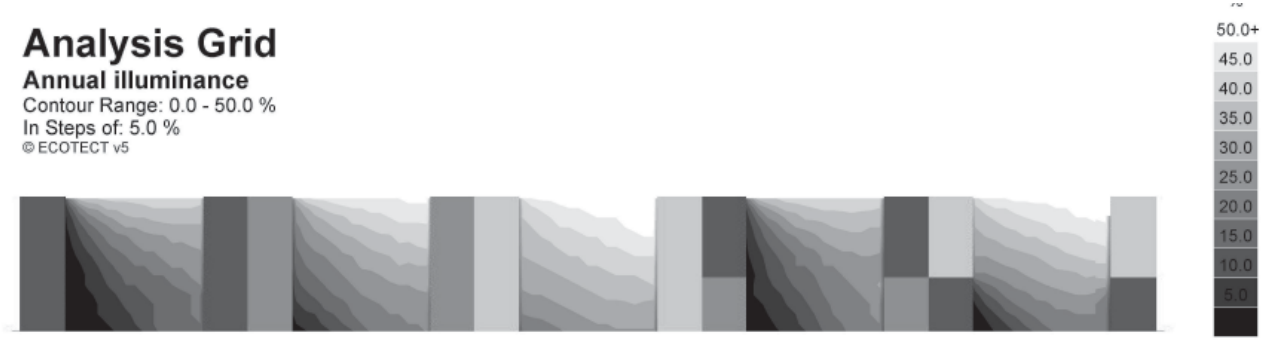


Figure: ##: Annual illuminance > 200 lux in street canyon with surface reflectance variables, Ground (Albedo) =0,20 and External wall = 0,45 / Window = 0,15.

Performed in RADIANCE/DAYSIM, (working hours 08-17, Contour range 0-100% in steps of 10%). Weather data., Copenhagen (*epw)

Figure: ##: Annual illuminance > 200 lux in street canyon with surface reflectance variables, Ground (Albedo) =0,20 and External wall = 0,75 / Window = 0,15.

Performed in RADIANCE/DAYSIM, (working hours 08-17, Contour range 0-100% in steps of 10%). Weather data., Copenhagen (*epw)



Annual illuminance > 10.000 lux in street canyon. Performed in RADIANCE/DAYSIM
(working hours 08-17, Contour range 0-50% in steps of 5%). Weather data., Copenhagen (*DRY)

Glazing Ratios, Reflectivity and the Urban Daylight potential
Sattrup & Strømann-Andersen 2011

Urban daylight distribution is strongly affected by the design of buildings.
Buildings may increase or decrease the daylight availability of neighbouring buildings.

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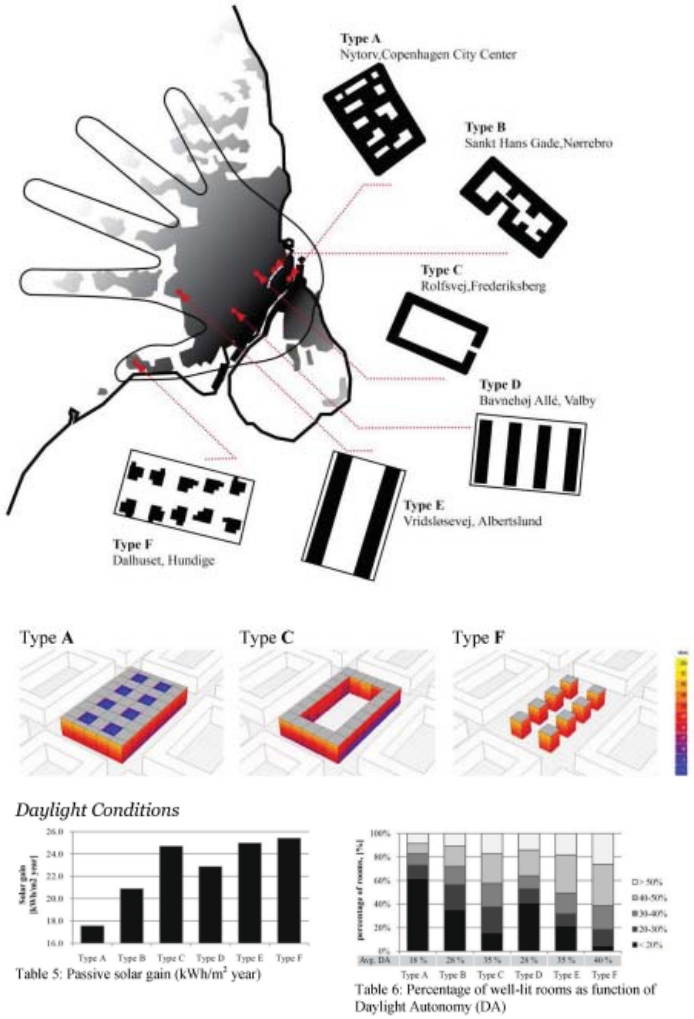
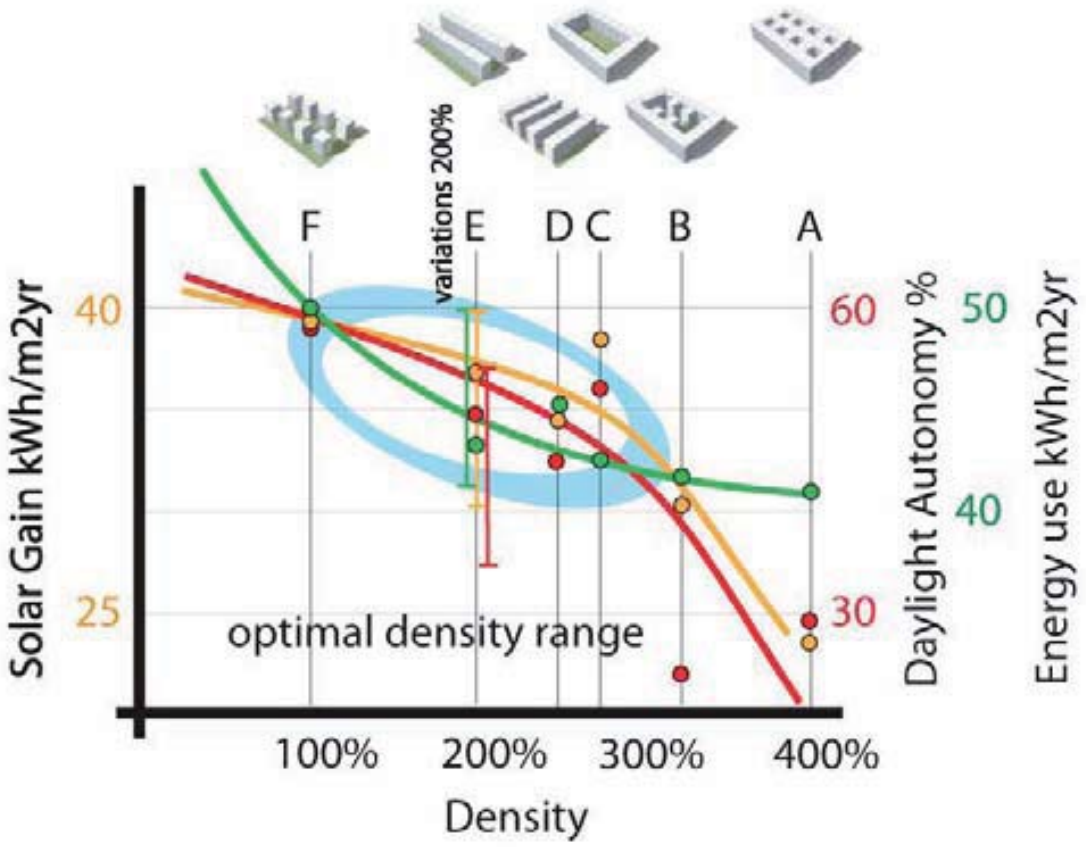


Table 5: Passive solar gain (kWh/m² year)

Table 6: Percentage of well-lit rooms as function of Daylight Autonomy (DA)



Typologies, Building Patterns and Energy use
Sattrup & Strømann-Andersen 2011

The optimal urban density range is quite higher than the suburban landscape of single family homes of today, but there are upper limits. Major improvements can be achived through design.

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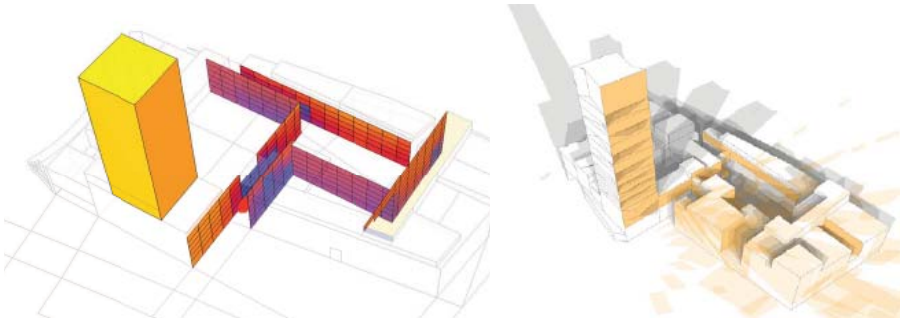

Carlsberg Urban design competition: Peter Andreas Sattrup withJakob Strømann-Andersen - Henning Larsen Architects, Dorte Mandrup Arkitekter, Polyform and Signal Arkitekter

Urban design may have profound impacts on Daylight Availability.
In the Carlsberg case Daylight Availability was increased by >150% - through urban design

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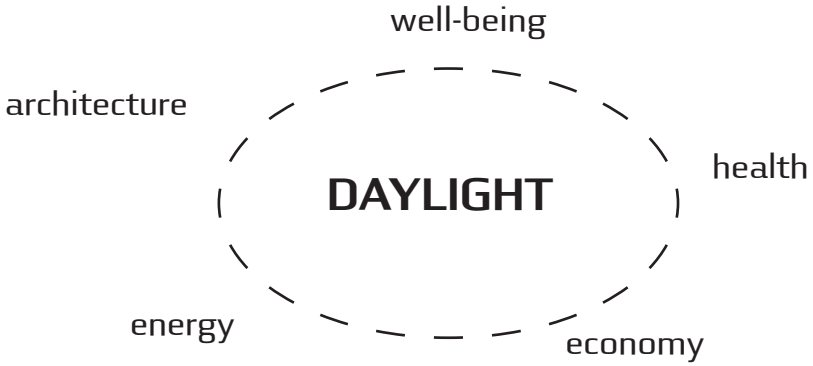

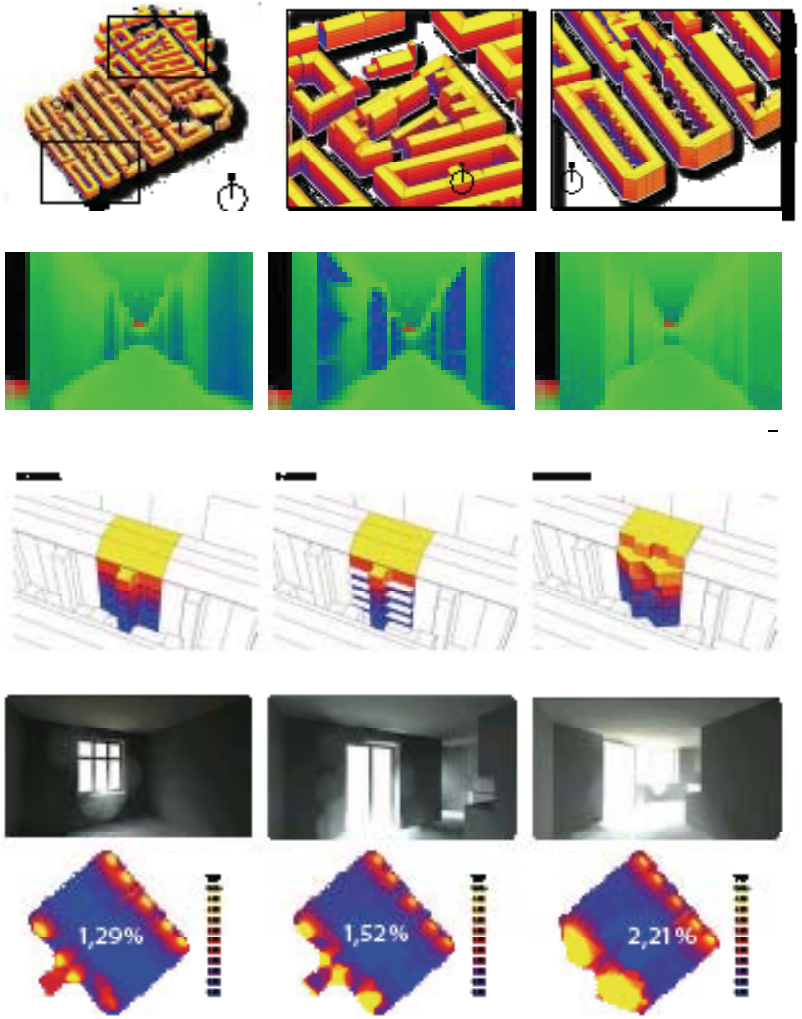

Collaboration with Henning Larsen Architects & Algreen Arkitekter
Research sponsored by Realdania

Case: Developing urban design guidelines for transformation of existing cities in Denmark
Focussing on daylight rather than technical optimization alone creates value on all parameters

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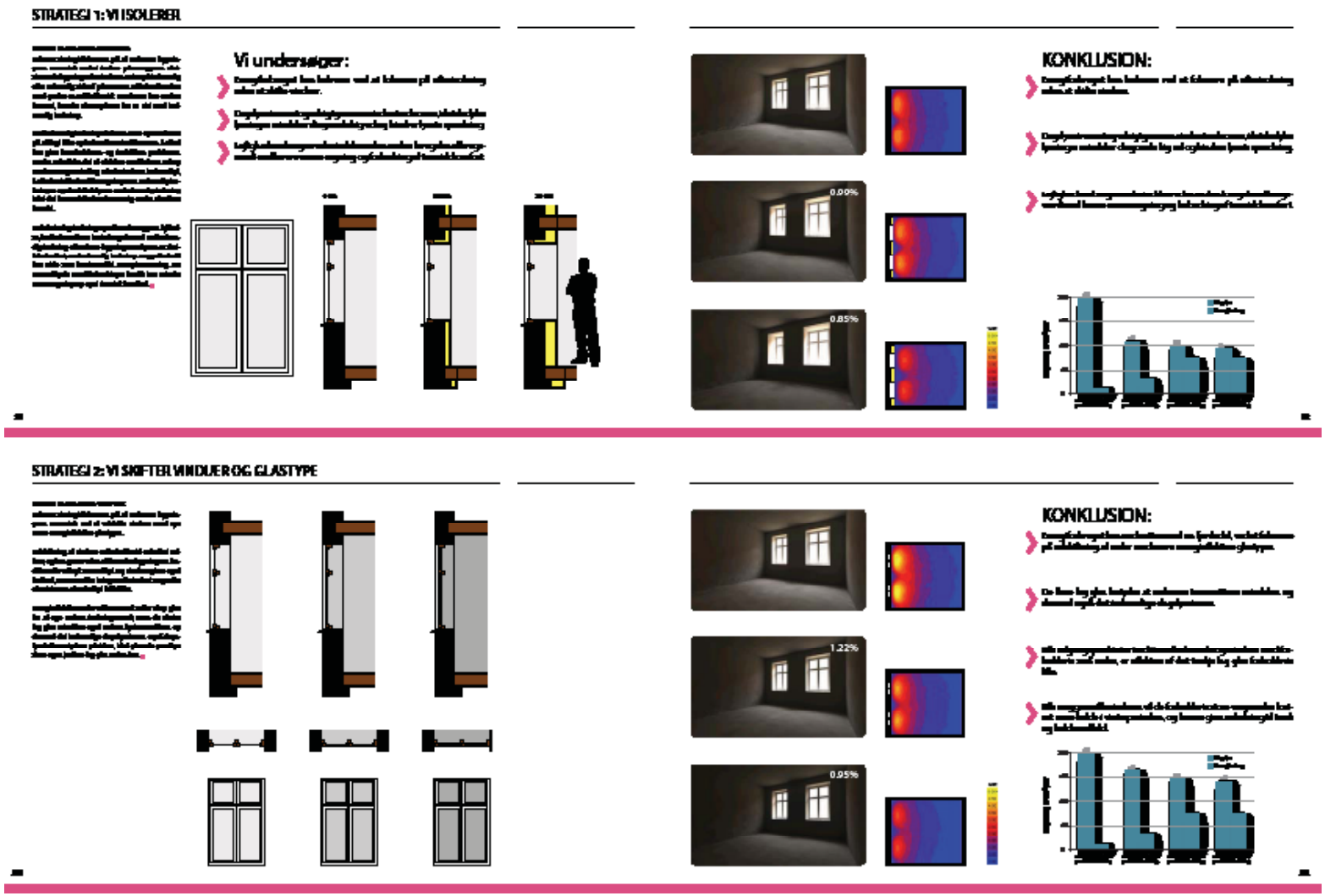

The Design guidelines offer a 'tool box' to planners, administrators, designers and clients
The tool box allow them to navigate the consequences of different optimization strategies

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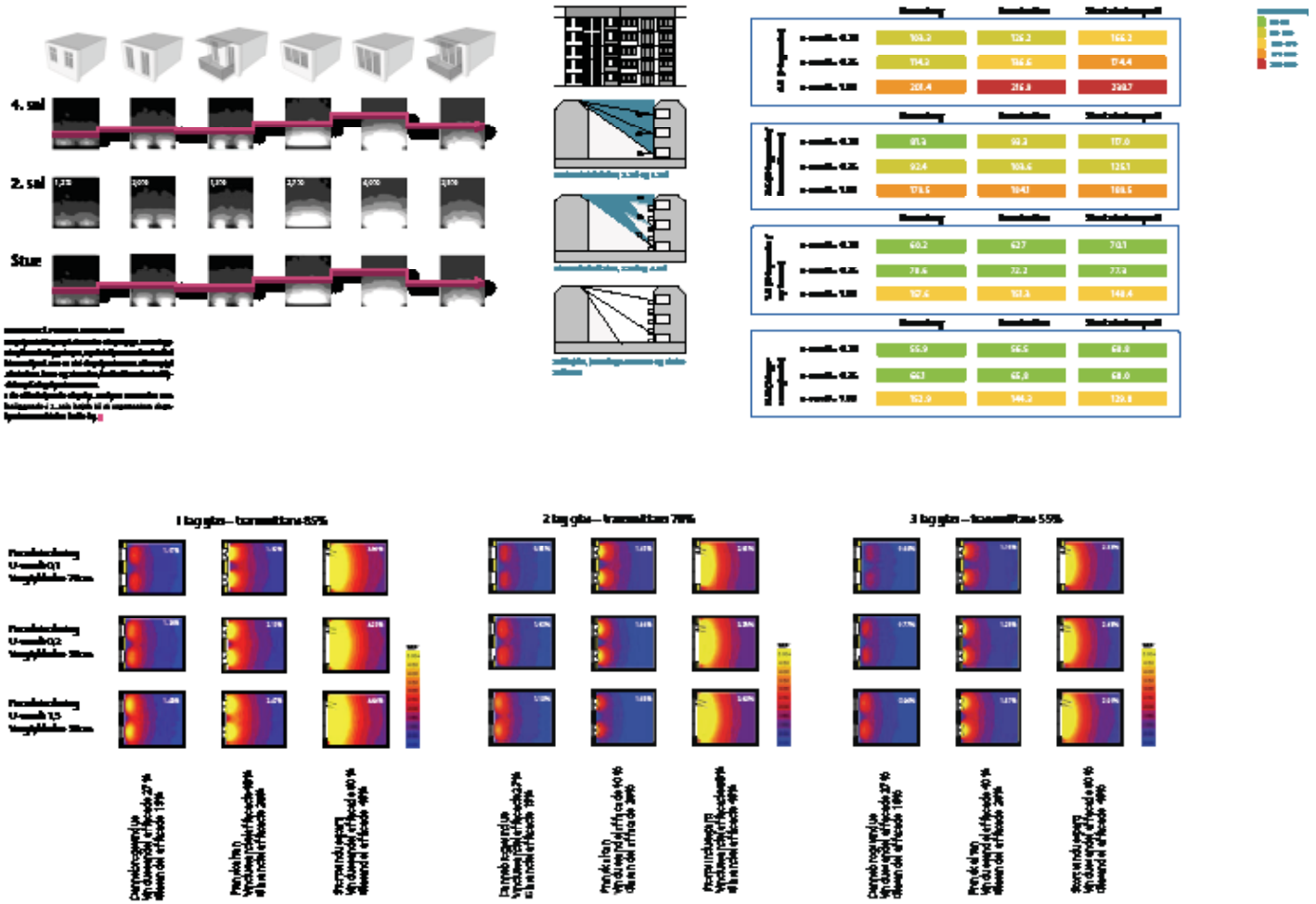

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Some thoughts:

Daylight and solar acces are important resources in the future quality of urban environments and energy efficiency of cities.

Environmental design and energy optimizations starts at the level of urban design.

We need more knowledge - but first of all we need to disseminate the existing knowledge in practice

Design guidelines may be an important instrument in this process

Thank you!

Peter Andreas Sattrup - pans@byg.dtu.dk