



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 Strømmand-Andersen, DTU & Henning Larsen Architects

Carlsberg: Henning Larsen Architects, Dorte Mandrup Arkitekter, Polyform & Signal Arkitekter

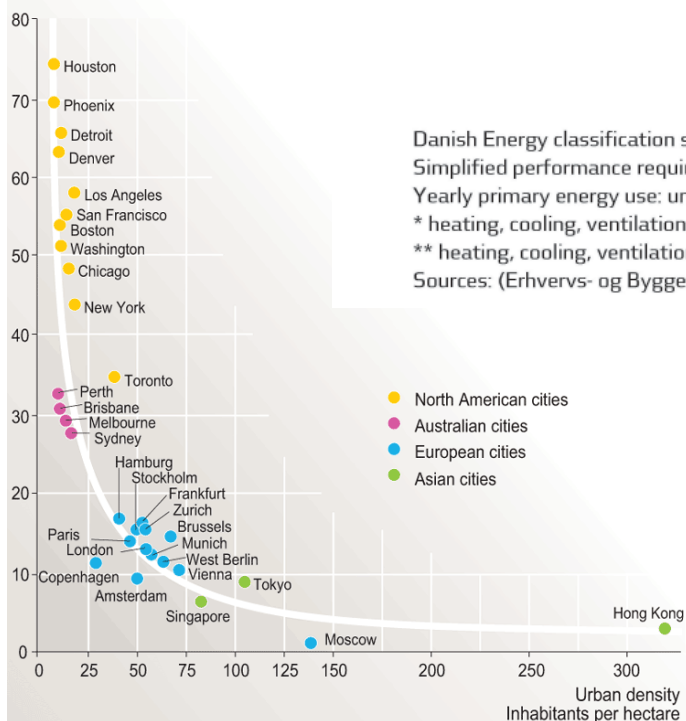
Design Guidelines: Henning Larsen Architects, Algreen Arkitekter, Peter Andreas Sattrup Arkitekt MAA. Sponsor: Realdania

Daylight and Sun in the Low-energy Cities of Tomorrow

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+ |

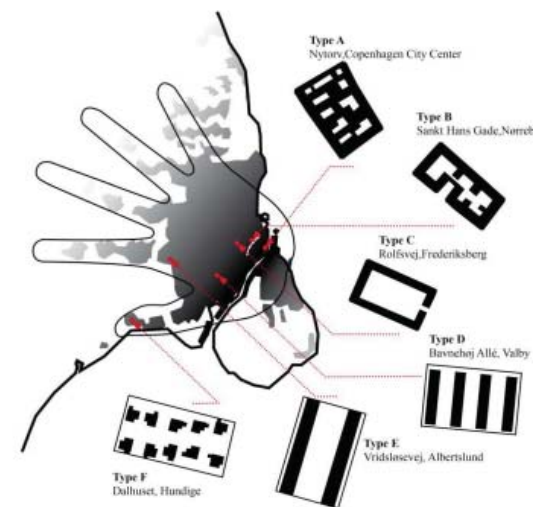
Transport-related energy consumption
Gigajoules per capita per year



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

Voluntary



Egnsplankontoret 1947, Sattrup & Strømmand-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

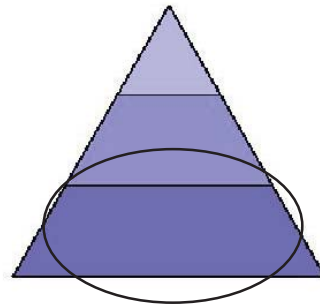
The form and materials of urban spaces create special urban microclimates.
The quality of the urban environments affect the indoor climate of buildings and their energy use.

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SHEARING LAYERS

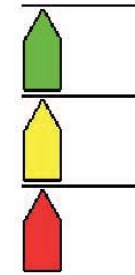
Energy systems
Building
City



DURABILITY

ENVIRONMENTAL MANAGEMENT

Energy
Comfort
Architecture

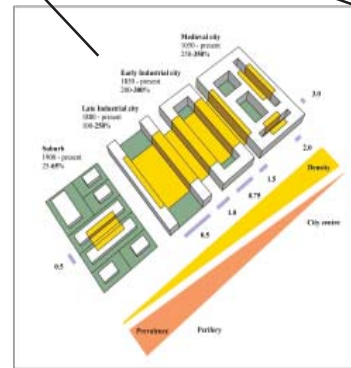


step 3
step 2
step 1

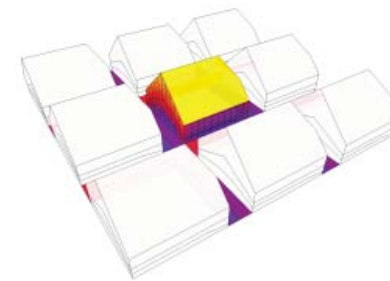
ENERGY PERFORMANCE



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



Building Typologies and Energy use
Sattrup & Strømman-Andersen 2011



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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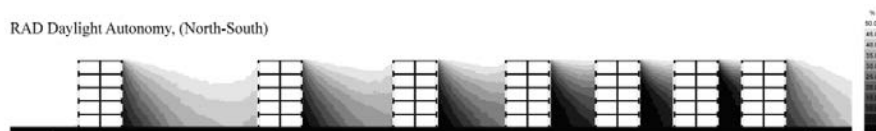
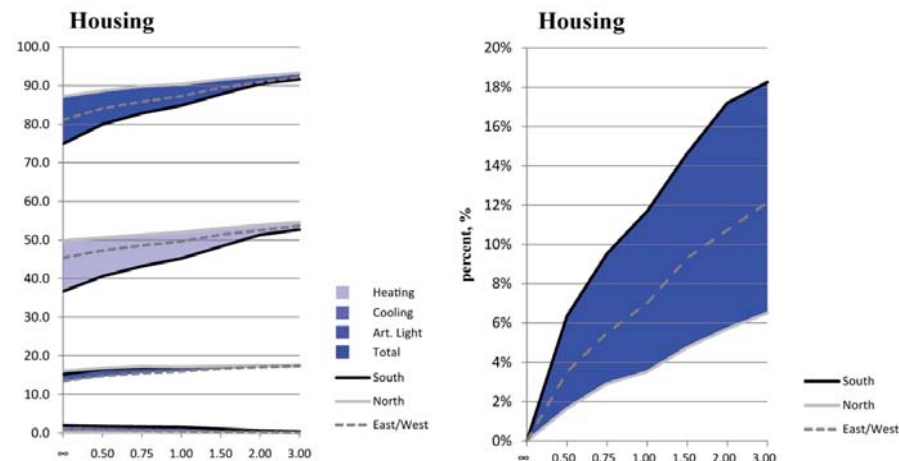
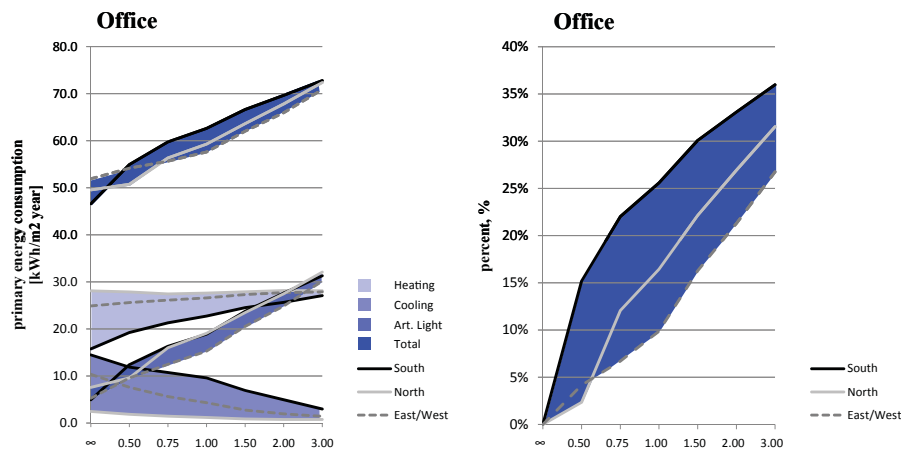


Figure: ##: Annual illuminance > 10.000 lux in street canyon. Performed in RADIANCE/DAYSIM (working hours 08-17, Contour range 0-50% in steps of 5%). Weather data., Copenhagen (*epw)

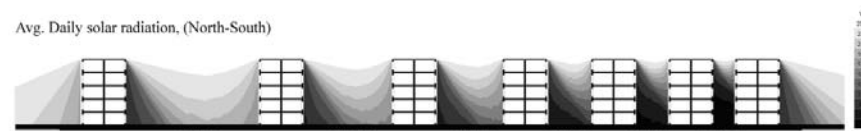
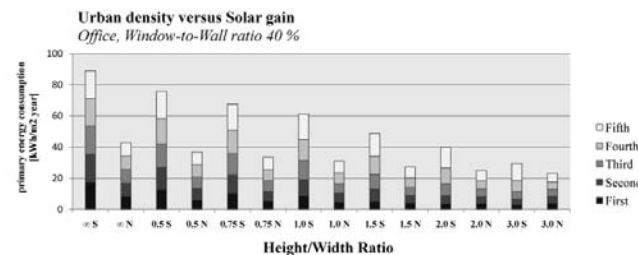
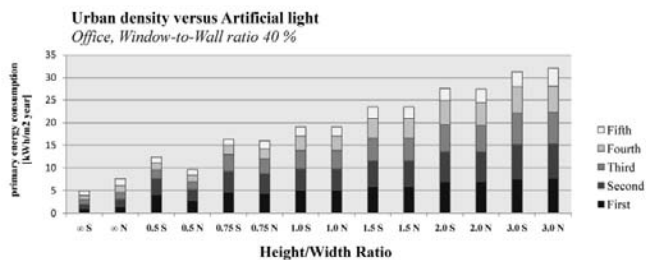


Figure: ##: Average daily solar radiation in street canyon. Performed in ECOTECH (working hours 08-17, Contour range 500-2500 Wh in steps of 200 Wh). Weather data., Copenhagen (*epw)



Urban Canyon and Building Energy use
Sattrup & Strømmand-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

Daylight and Sun in the Low-energy Cities of Tomorrow

RAD Daylight Autonomy

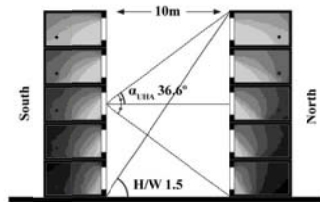


Figure: ##: Annual illuminance > 200 lux in street canyon with surface reflectance variables, Ground (Albedo) = 0.20 and External wall = 0.45 / Window = 0.15.

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

RAD Daylight Autonomy

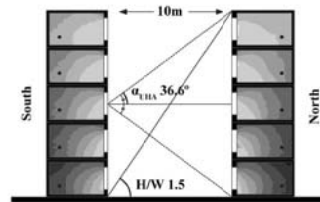
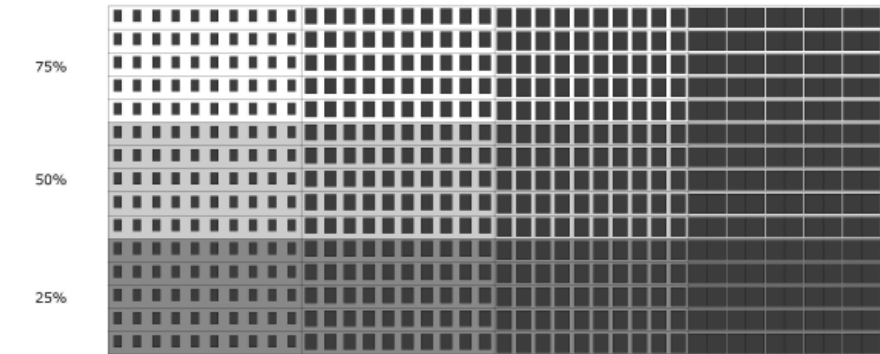


Figure: ##: Annual illuminance > 200 lux in street canyon with surface reflectance variables, Ground (Albedo) = 0.20 and External wall = 0.75 / Window = 0.15.

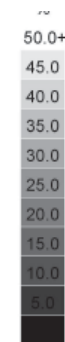
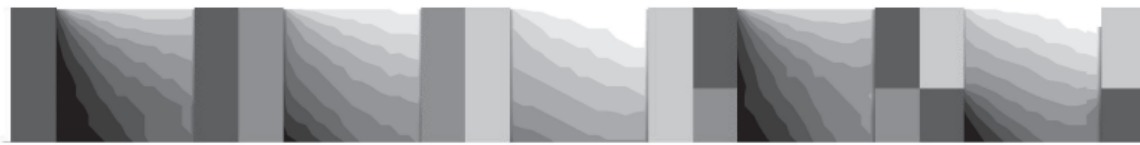
Performed in RADIANCE/DAYSIM, (working hours 08-17, Contour range 0-100% in steps of 10%). Weather data., Copenhagen (*epw)



wall reflectivity - window to wall ratio 20% 40% 60% 80%

Analysis Grid

Annual illuminance
Contour Range: 0.0 - 50.0 %
In Steps of: 5.0 %
© ECOTECT v5



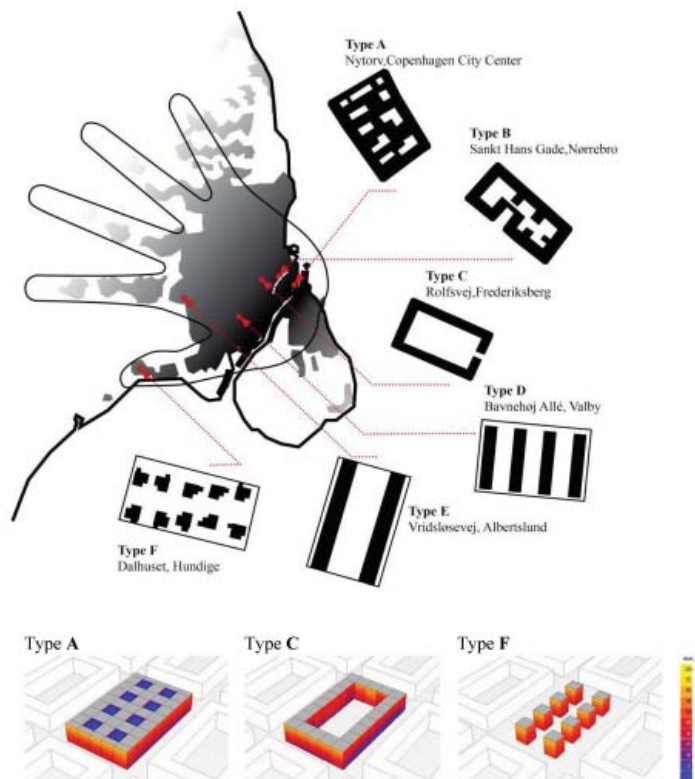
Annual illuminance > 10.000 lux in street canyon. Performed in RADIANCE/DAYSIM (working hours 08-17, Contour range 0-50% in steps of 5%). Weather data., Copenhagen (*DRY)

Glazing Ratios, Reflectivity and the Urban Daylight potential
Sattrup & Strømmand-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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Daylight Conditions

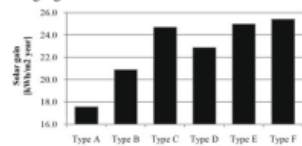


Table 5: Passive solar gain (kWh/m² year)

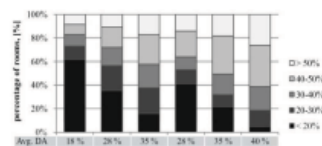
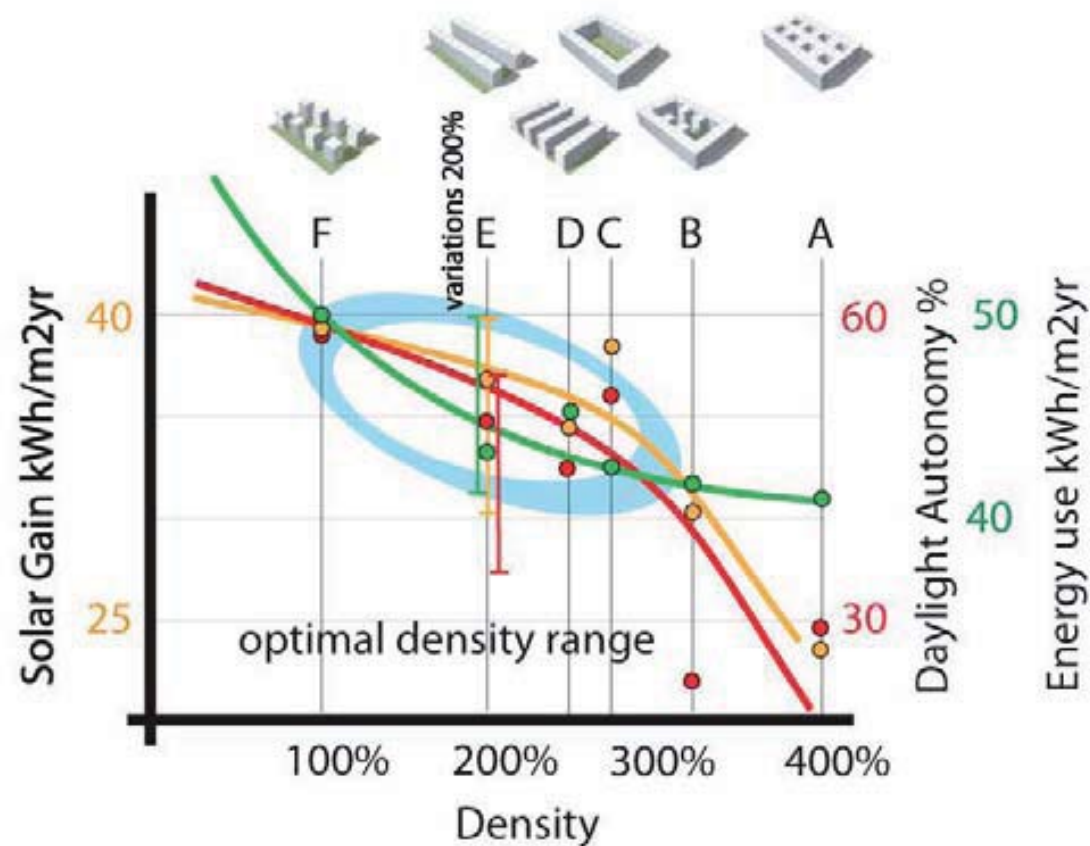


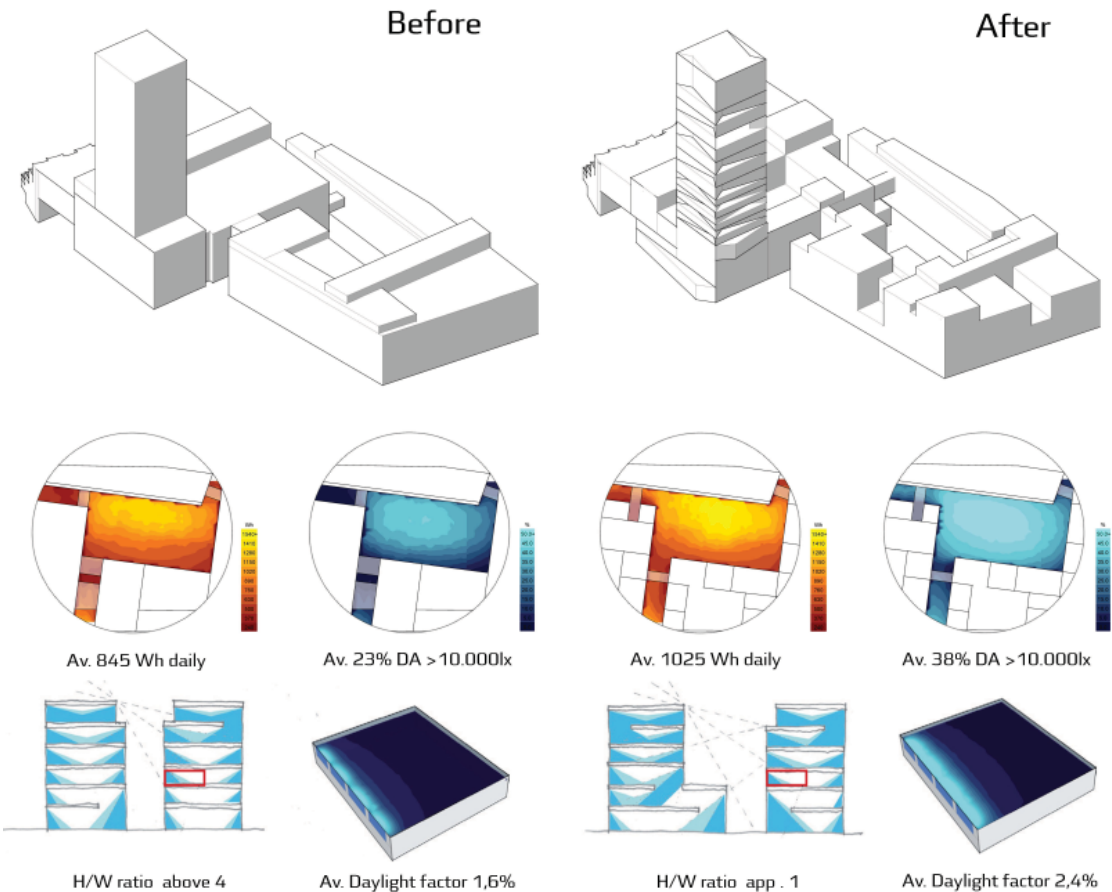
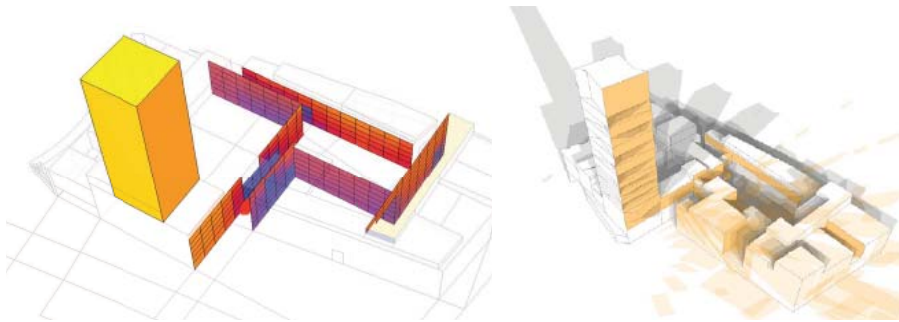
Table 6: Percentage of well-lit rooms as function of Daylight Autonomy (DA)



Typologies, Building Patterns and Energy use
Sattrup & Strømman-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 achieved through design.

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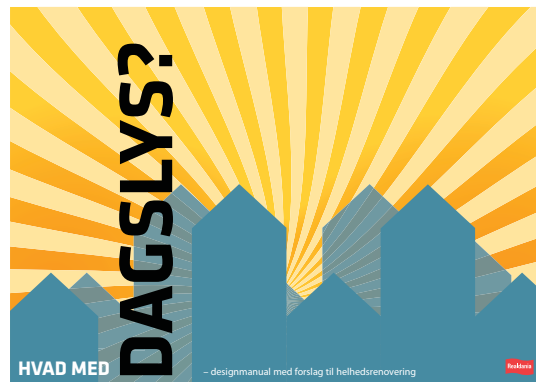
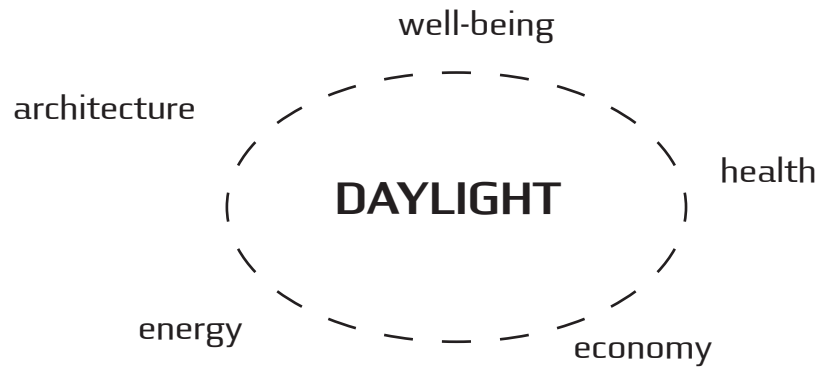


Carlsberg Urban design competition: Peter Andreas Sattrup with Jakob Strømmand-Andersen - Henning Larsen Architects, Dorte Mandrup Arkitekter, Polyform and Signal Arkitekter

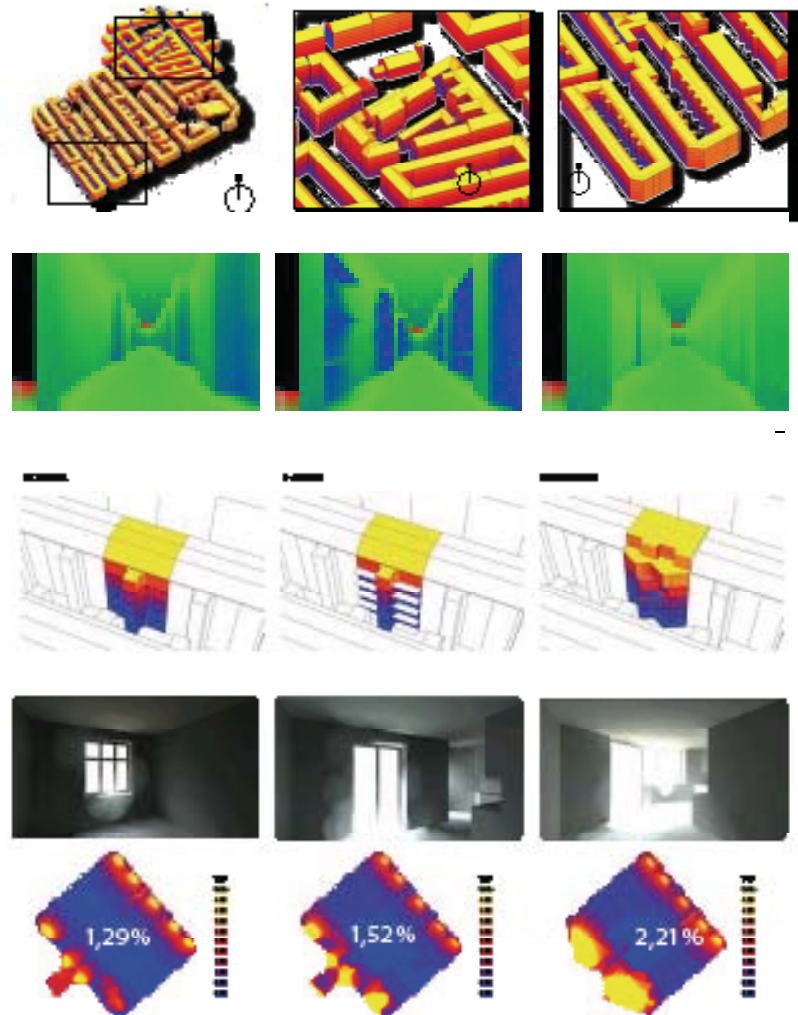
Urban design may have profound impacts on Daylight Availability.
In the Carlsberg case Daylight Availability was increased by >150% - through urban design

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Daylight and Sun in the Low-energy Cities of Tomorrow



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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Daylight and Sun in the Low-energy Cities of Tomorrow

STRATEGI 1: VINDLERER

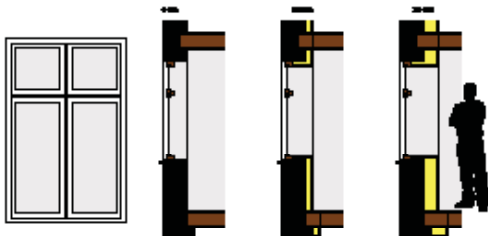
Denne strategi fokuserer på at maksimere dagslyset og solindstrømningen i rummet ved at optimere vindlerens placering og størrelse. Dette opnås ved at placere vindlerne højt og bredt, hvilket sikrer god lysindstrømning og solindstrømning i rummet.

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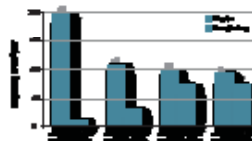
Vi undersøger:

- Dagslyset og solindstrømningen i rummet ved at optimere vindlerens placering og størrelse.
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KONKLUSION:

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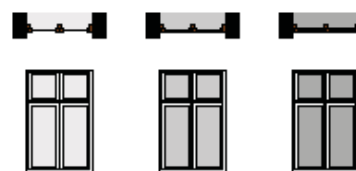
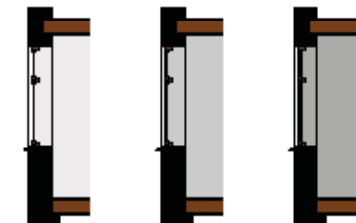


STRATEGI 2: VINDLER OG GLASTYPE

Denne strategi fokuserer på at maksimere dagslyset og solindstrømningen i rummet ved at optimere vindlerens placering og størrelse. Dette opnås ved at placere vindlerne højt og bredt, hvilket sikrer god lysindstrømning og solindstrømning i rummet.

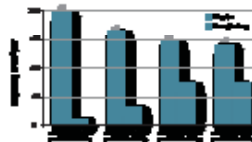
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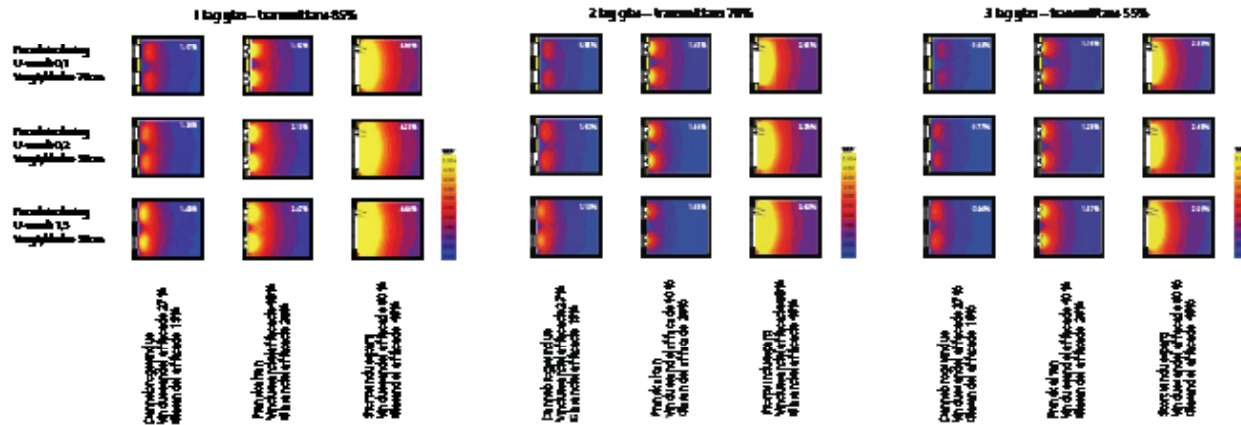
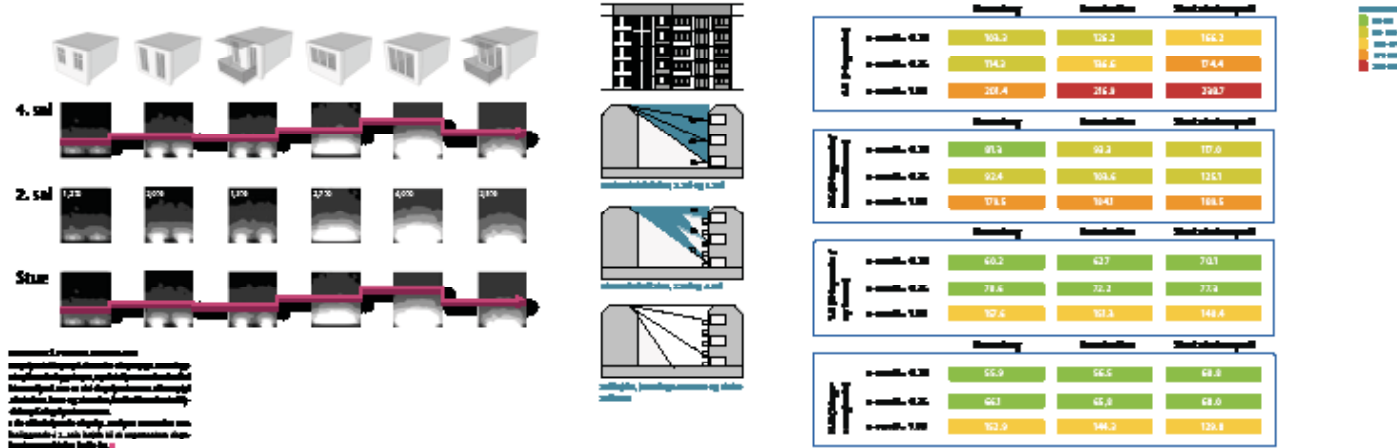
KONKLUSION:

- Dagslyset og solindstrømningen i rummet ved at optimere vindlerens placering og størrelse.
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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

Daylight and Sun in the Low-energy Cities of Tomorrow



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Daylight and Sun in the Low-energy Cities of Tomorrow

Some thoughts:

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

Environmental design and energy optimizations start 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