Going low energy - full scale

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VELUX DAYLIGHT SYMPOSIUM 2011

GOING LOW ENERGY - FULL SCALE

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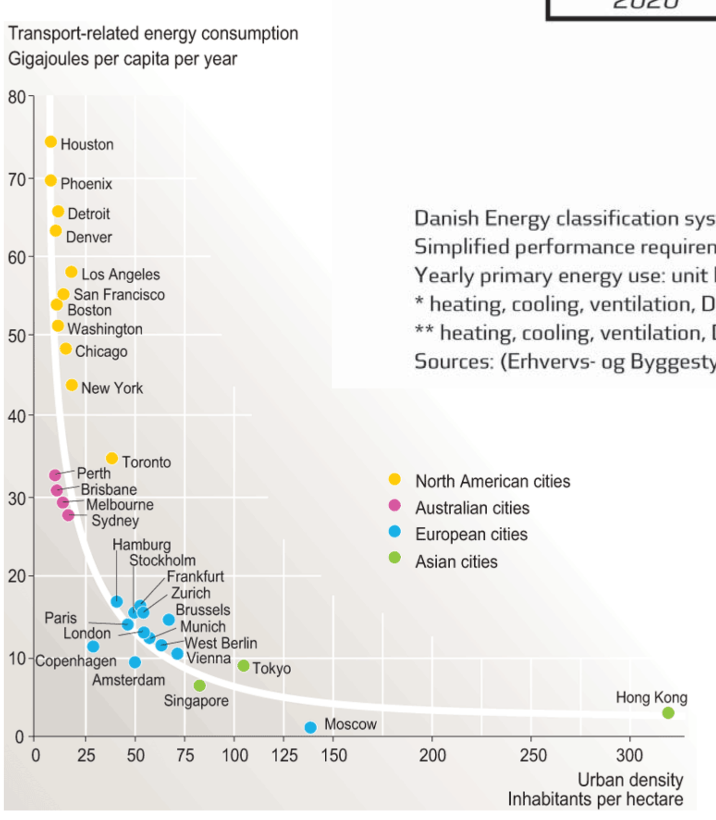
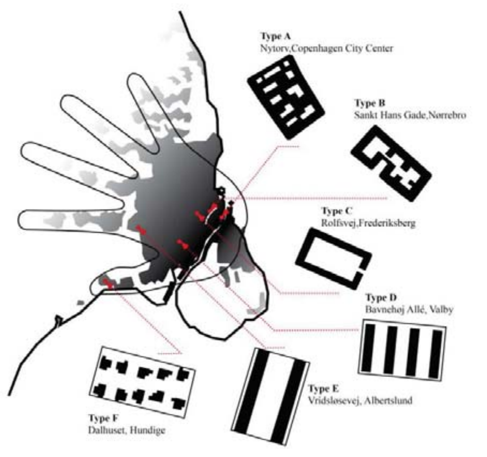
Regulatory

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)





Egnsplankontoret 1947, Sattrup & Strømann-Andersen 2011

Agenda:

As cities and buildings will need to change to a low-energy paradigm within the next decades to lessen fossil fuel dependency and mitigate climate change - what will be the consequences to architecture and planning of adopting low-energy building technology full scale?

Which design parameters have the greatest impacts on environmental performance and building energy use?

City sprawl and single family homes lead to high energy use. In current architecture and planning urban densification is seen as one of the key instruments to improve sustainability by reducing energy use for transport. In the future cities are likely to become more dense than now.

But how does densification affect building energy use?

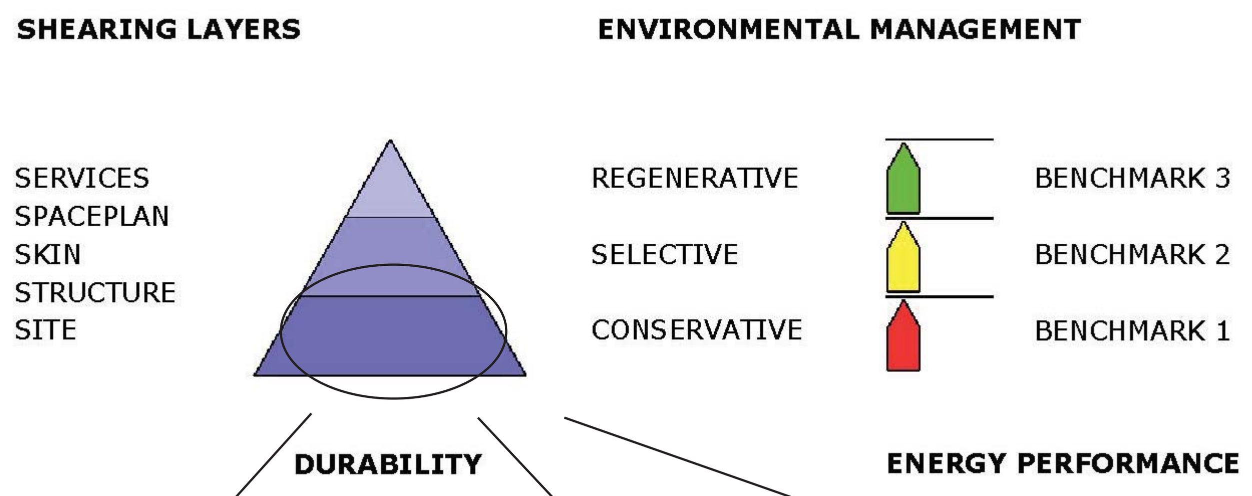
Hypothesis:

There is a hierarchical relationsship between environmental performance and architectural scale. Design decisions taken at the biggest scale have the greatest impact. (Sattrup - Foster, Eberle, Schuler 2009)

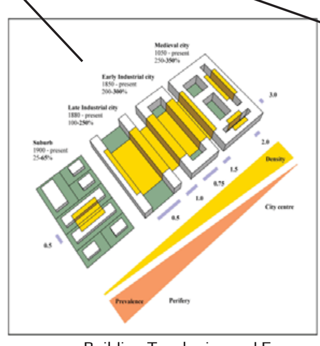
This idea potentially connects embodied and operational energy concerns while lending itself to an incremental level of definition progress in the design process.

Is it true? Can it be identified? How would it be expressed?

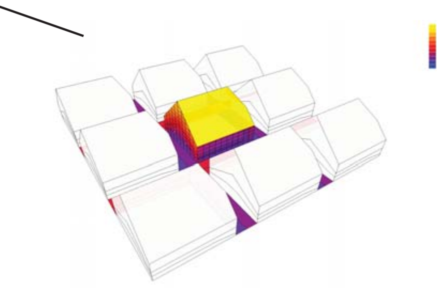
To answer these questions, the impact of urban geometry and facade transparency on building energy use is investigated focusing on daylight and passive solar gains in a cool temperate climate using Copenhagen as the case.



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



Building Typologies and Energy use
Sattrup & Strømann-Andersen 2011



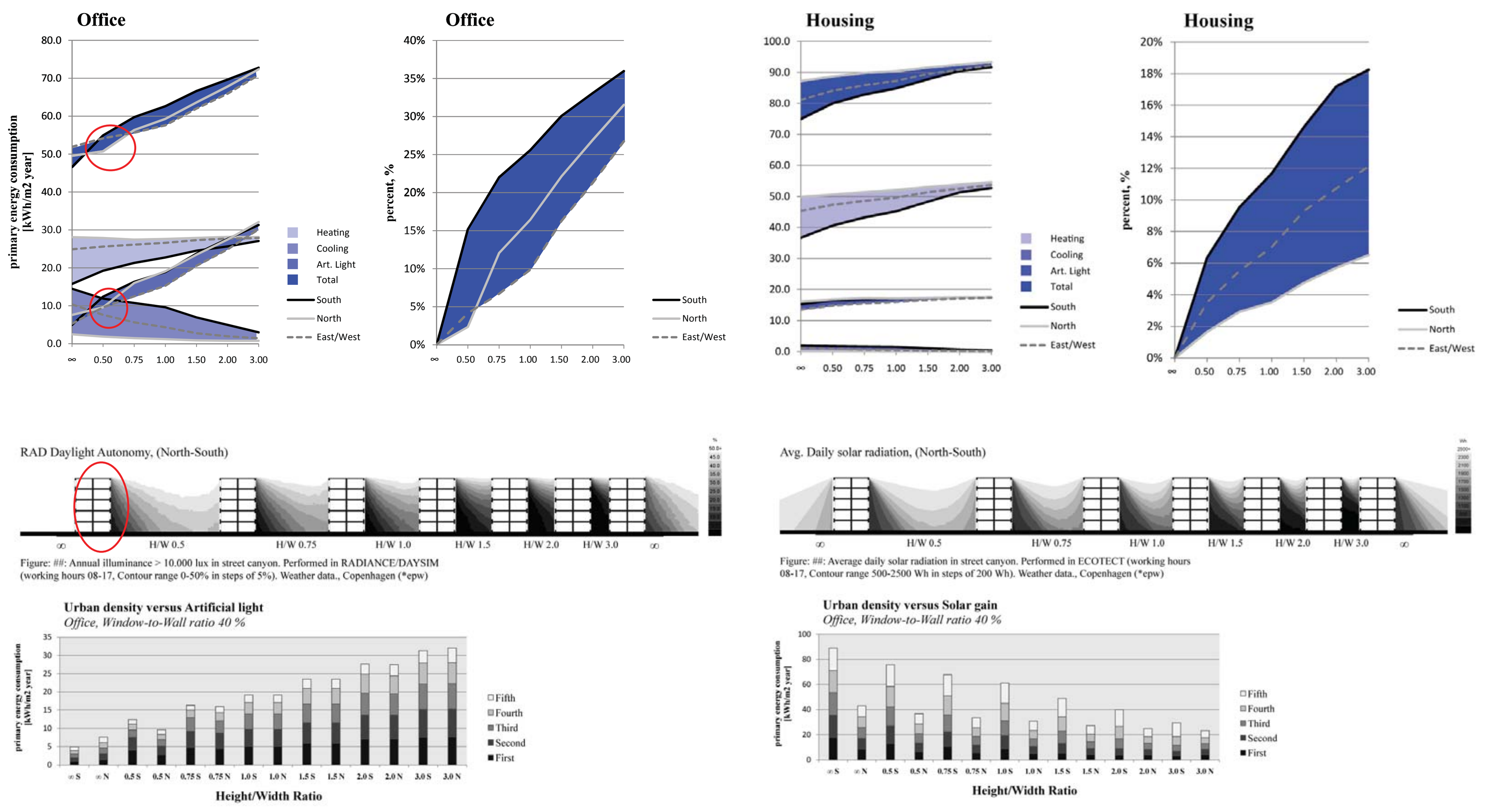
Solar envelopes and urban energy potential
Sattrup & Strømann-Andersen 2011

Urban Density and Building Energy use:

When low-energy building components are used, Daylight becomes a dominant energy theme, particularly in buildings that are occupied in the daytime.

Daylight is the design parameter most dynamically affected by increased urban density, and as the thermal performance of facade components is improved, energy used for artificial lighting may even become the single most important factor influencing primary energy use in high density cities.

Understanding the variations in energy use requires a holistic understanding of the socio-spatio-temporal relations between climate, building use, form, material and technology. Climate based simulation modelling is an essential tool in understanding these relations better.



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Urban Daylight Potential, Facade Transparency and Reflectivity

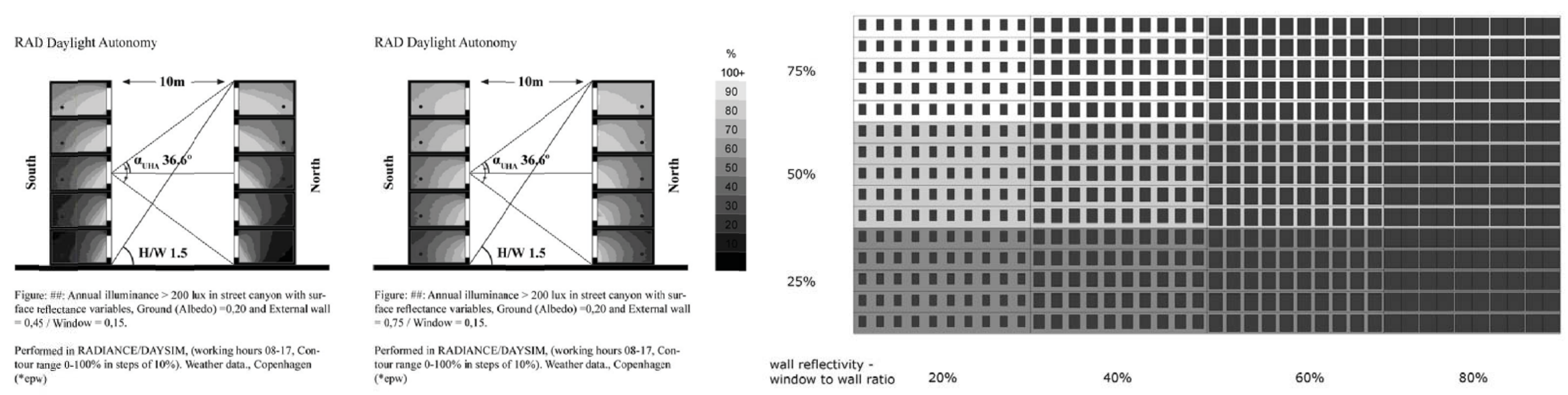
Analyzing the results above, an interesting detail can be noticed: The north side of an office building facing a wide urban space has less energy use for artificial lighting than its south facing equivalent. This effect is caused by direct sunlight reflected off the opposite facade and is related to the low sun of the cold season.

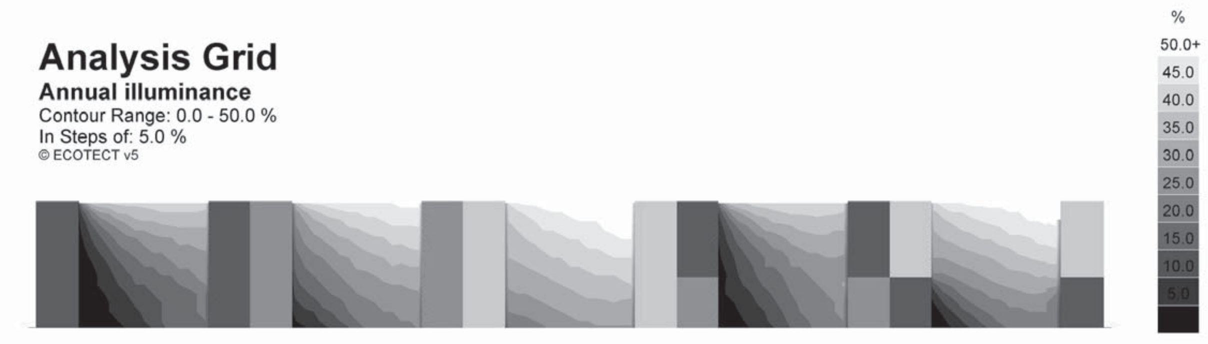
The reflectivity of the facade depends mainly on the colour and transparency of the materials and the glazing ratio. While glass may seem bright from below as it reflects the sky, its reflectivity is quite low.

As a result highly glazed facades are dark and reduce the urban daylight potential by 'privatizing' (Carpenter 2010) the daylight resource, leaving less for neighbouring buildings.

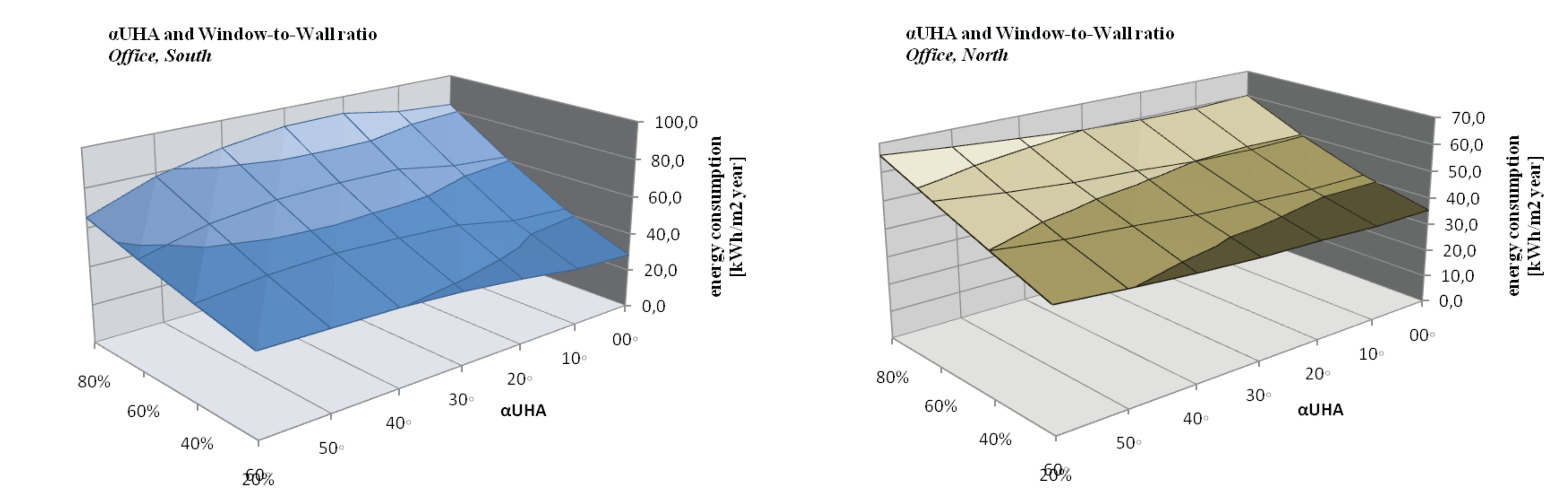
Bright facades can improve daylight autonomy considerably at the deepest levels of the urban canyon, decreasing the dependency on artificial lighting.

Facade mounted PV systems should also be considered in terms of their effect on the urban daylight potential.





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, Urban Density and Building Energy use:

Cross-referencing building energy use as a function of canyon height/width ratio and facade glazing, ratio it can be noted that while primary energy use increases with density up to 38% relative to unobstructed buildings, varying the glazing ratio is an alltogether more powerful design parameter with variations up to 300%. It should be noted that in these studies energy use is a direct expression of the parameter variations as there is no dynamic shading systems in the model.

Returning to the initial question of whether a hierarchy of scale is present it cana be seen that concerning operational energy, the building facade is the most influential scale. The interaction between design parameters is however highly dynamic affecting heating, cooling and daylighting. Highly glazed facades have the highest energy use and affect the urban daylight potential negatively.

The results suggest that there are limits to urban density, that the solar and daylight potential should be considered or indeed protected as a common resource.