Double-skin facade technology for energy-efficient commercial building refurbishment in Norway

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Introduction

annual rate	housing			commercial	
building activity	**mio. m²**	**percent**		**mio. m²**	**percent**
new built	2.91	1.33		2.46	1.94
refurbishment	3.28	1.5		1.91	1.5
energetic measures	4.37	2.0		2.54	2.0
demolition	1.31	0.6		1.52	1.2

- However, there exists very little work on exploring the possibility of energy efficient refurbishment by applying a ventilated double façade system to an existing building.

- Thus, it was interesting to investigate the impact of an additional ventilated glass facade can have on energy demand and thermal comfort of an office building with an existing box window facade.

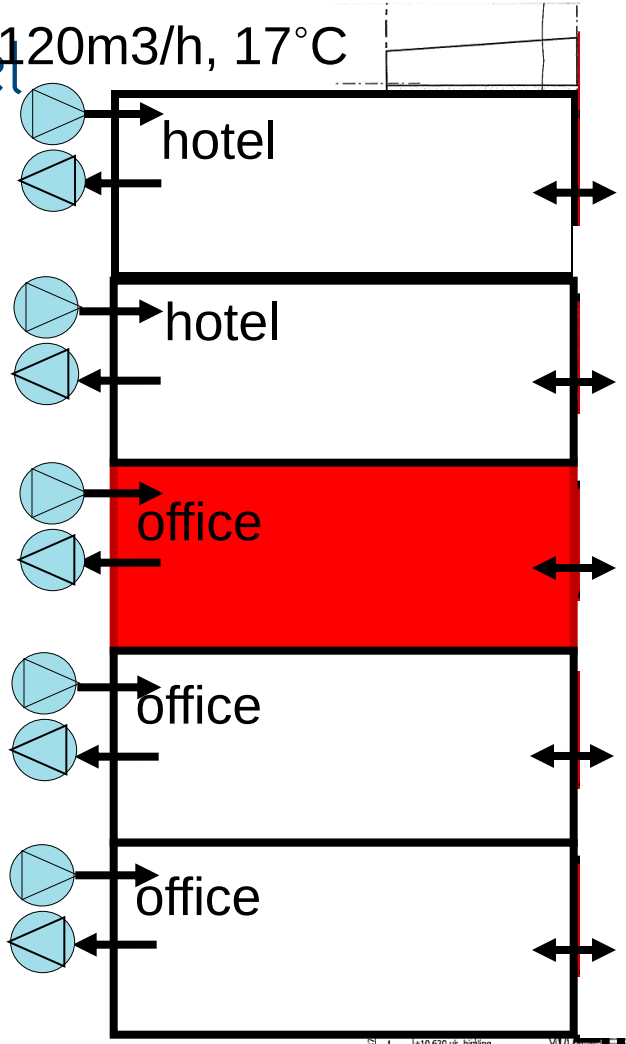
Credits: Lavenergiutvalget, Energieffektivisering, Juni 2009

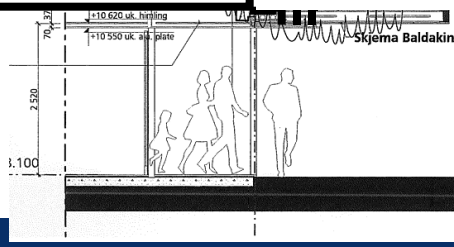

nova
Brende as
CATERPILLAR
Brende as
Utleie av
containere
18m³


OLAVS PUB OG SPISERI
OLAVS PUB OG
SPISERI

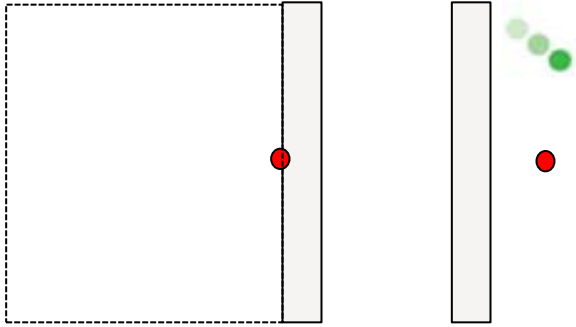
Combined thermal and airflow model

- Three different models were developed using TRNSYS and TRNFLOW:
  - base case model
  - ventilated double-skin façade with insulated glass (dsf (1))
  - ventilated double-skin façade with single laminated glass (dsf (2))
- Calculations for office room in the 3rd floor



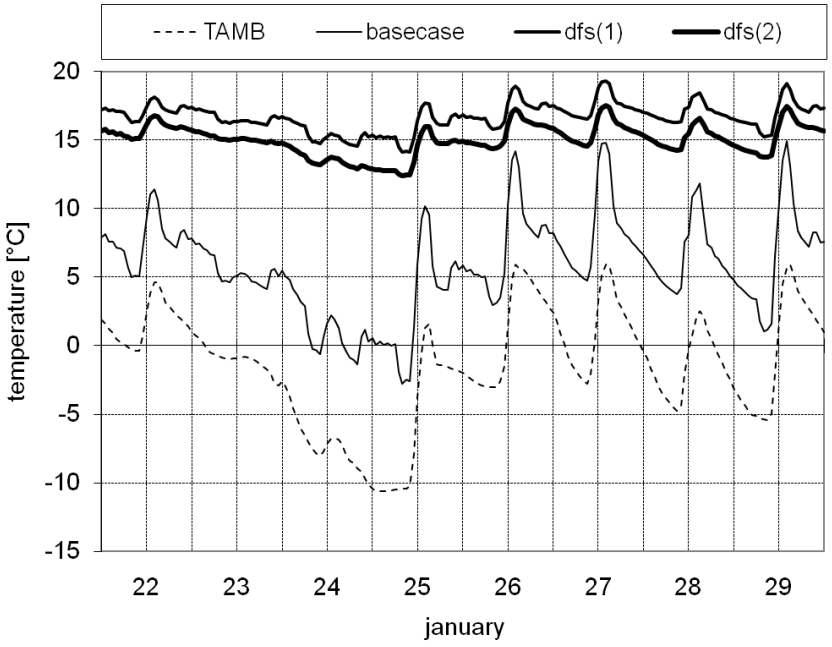


Results - Temperatures

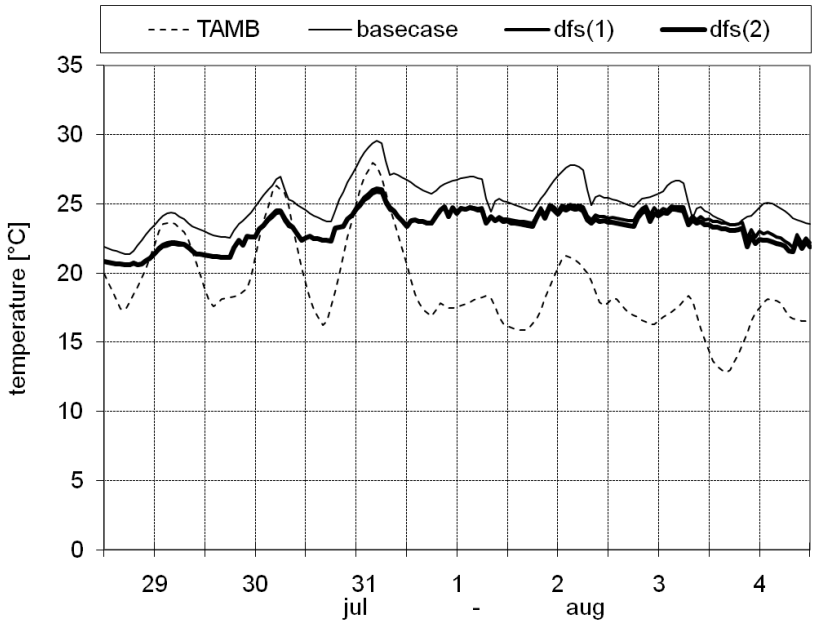


- Figure presents the temperatures of the window at the inside of the room for a typical winter week and a typical summer week.
  - It can be seen that window temperatures are higher for the dfs than the base case in the winter.
  - In the summer temperatures are lower than in the base case.

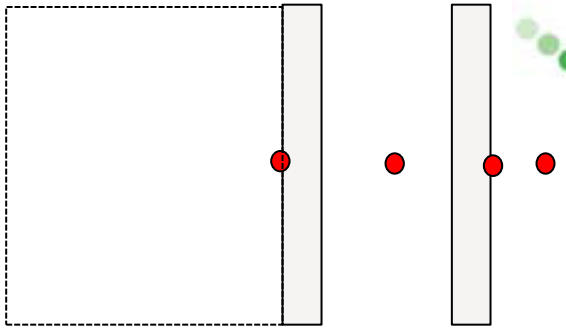
winter



summer

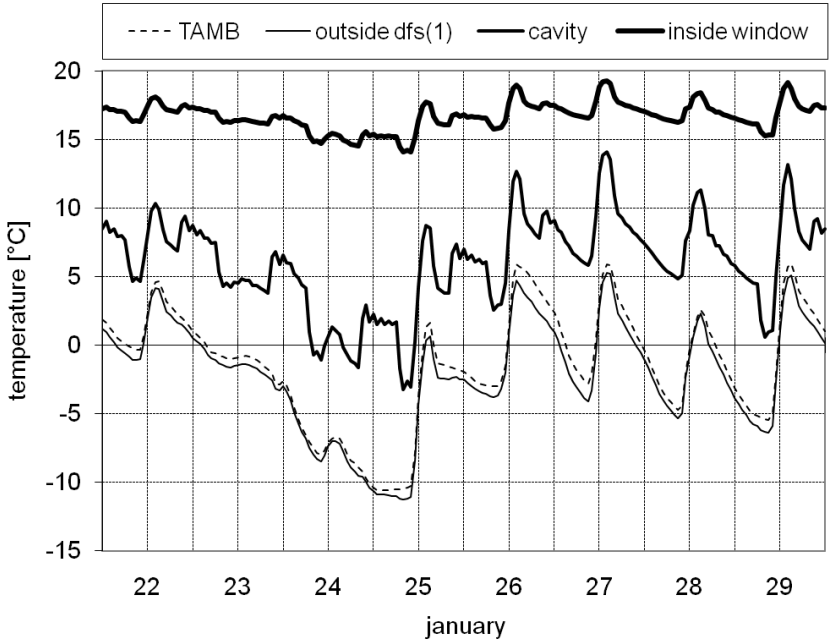


Results - Temperatures

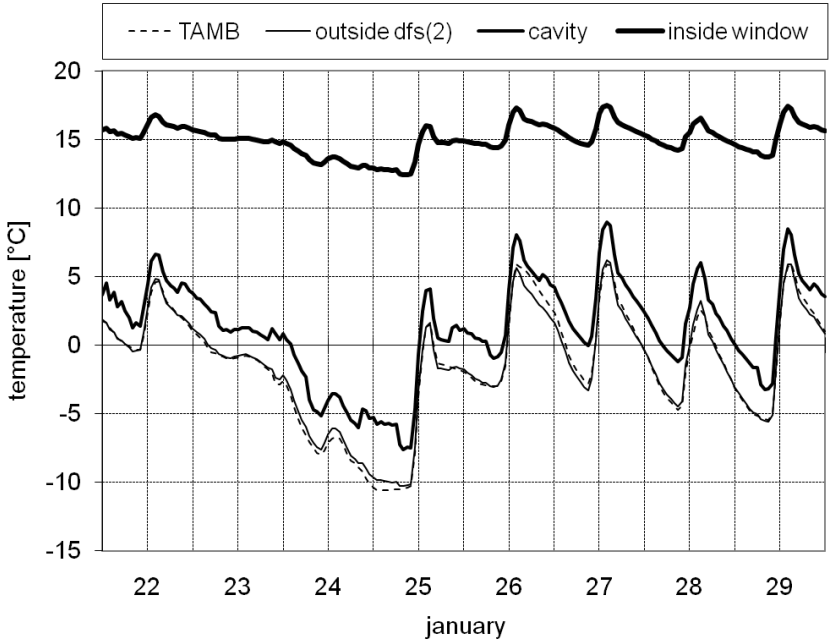


- Figure presents the temperatures of the window at the outside, in the cavity and inside of the room for dsf (1) and dsf (2).
  - Window temperatures are higher for the dfs than the base case
  - Cavity temperatures are higher for dsf (1) than for dsf (2)

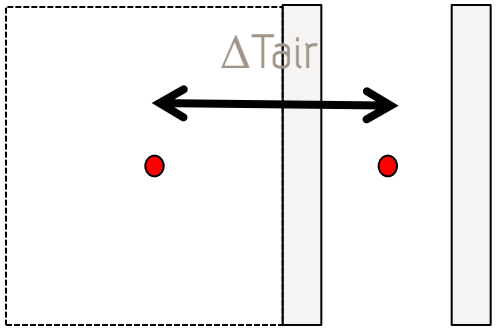
dsf (1)

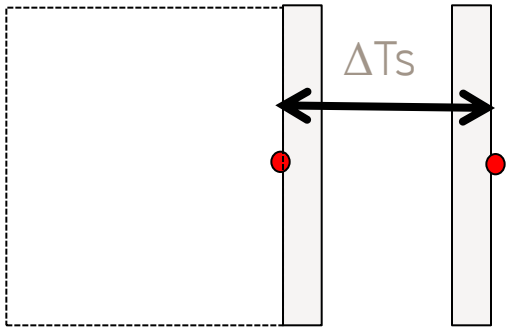


dsf (2)

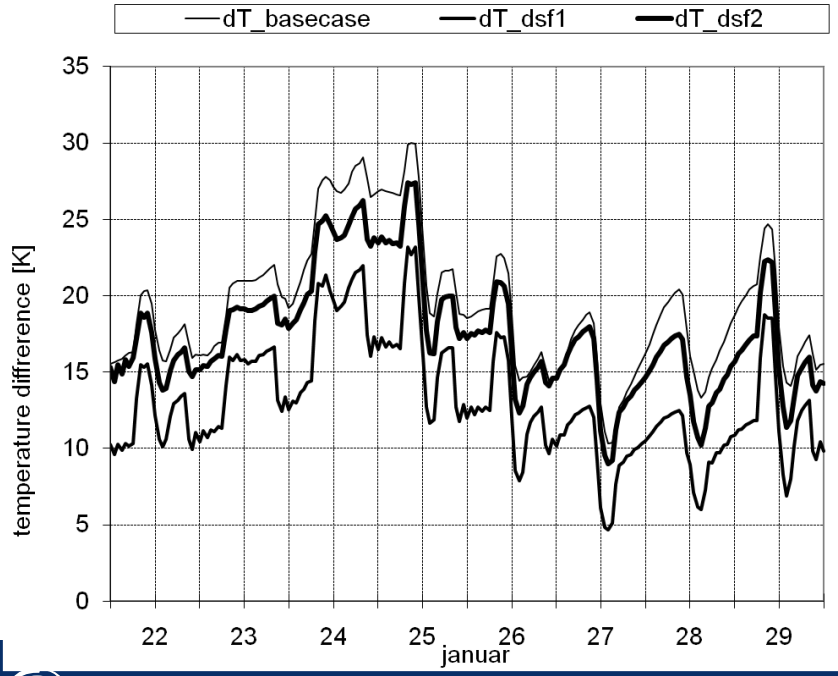


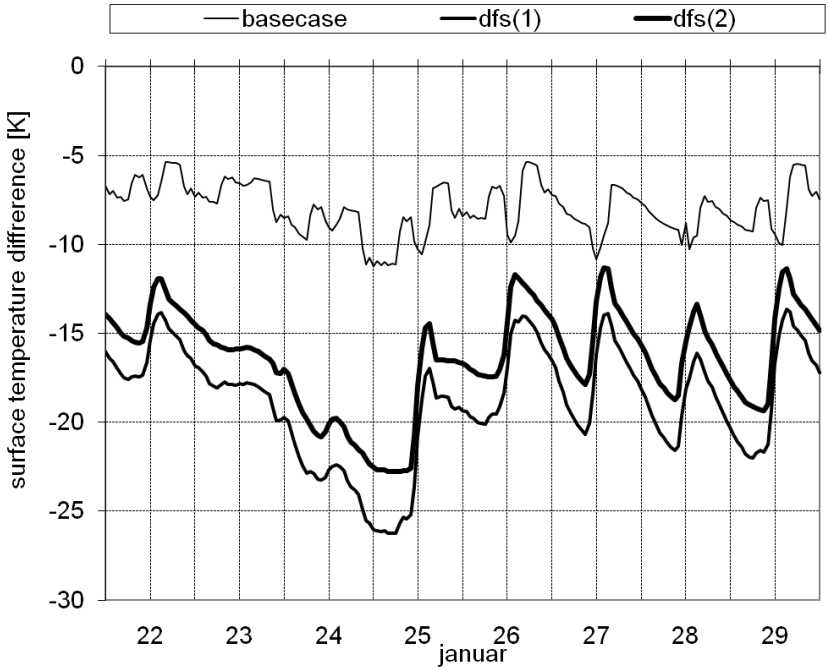
Results – Temperature differerences





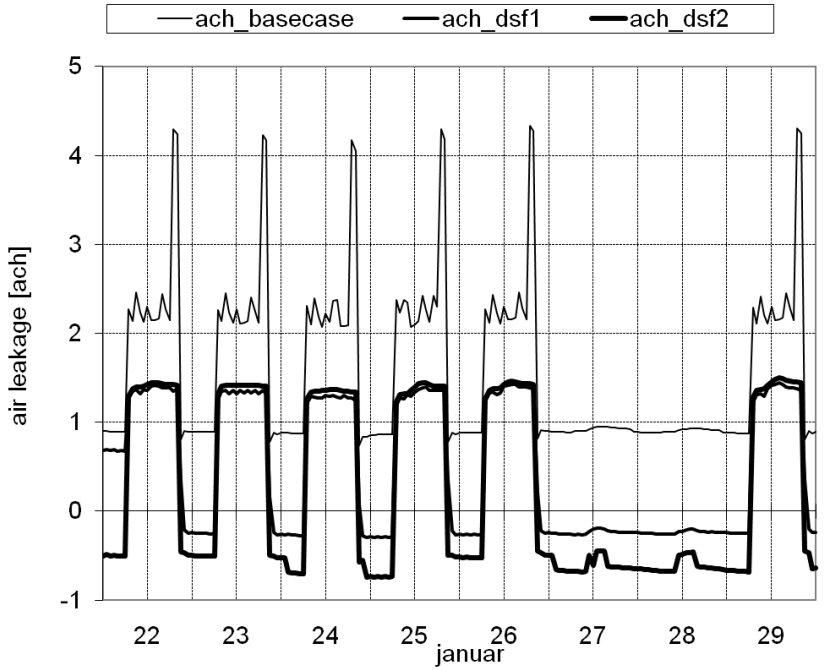
- less temperature difference for dsf (1)
- less surface temperatures for dsf (1)

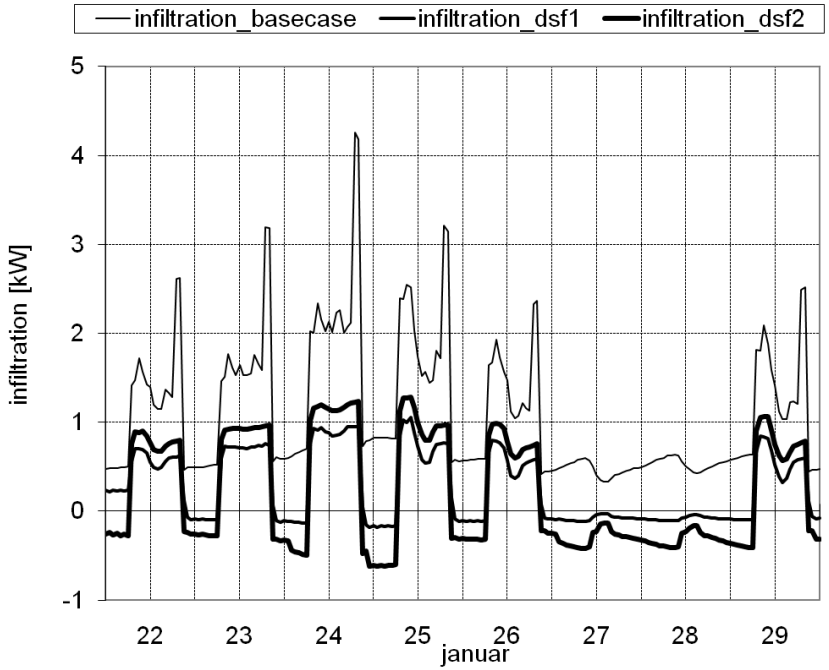




Results – Temperature differerences

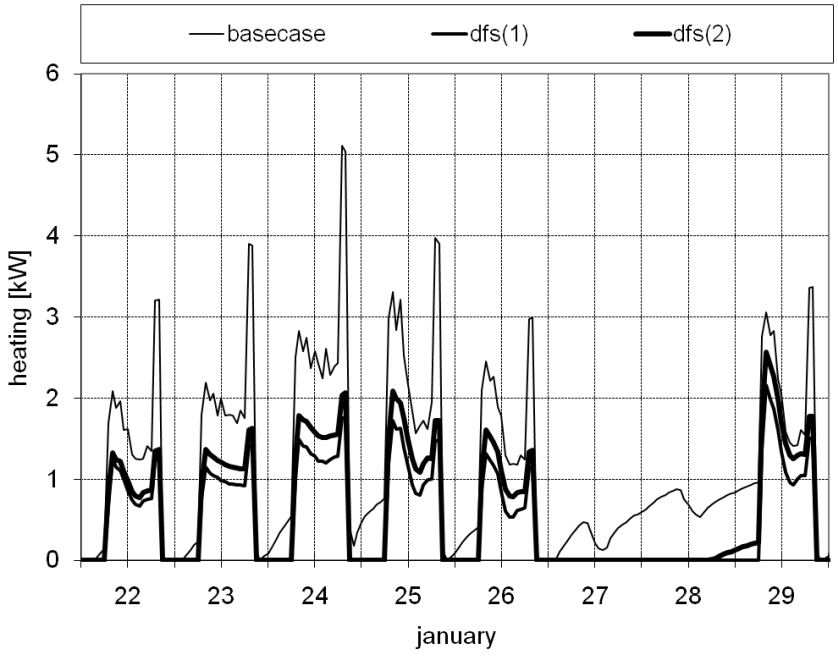
- Figures present air leakage n_{inf} (left) and resulting heat losses Q_{inf} due to infiltration (right) for dsf (1) and dsf (2).
  - less air leakage for both dsf compared with basecase
  - less infiltration accordingly with less infiltration for dsf (1) due lower temperature difference

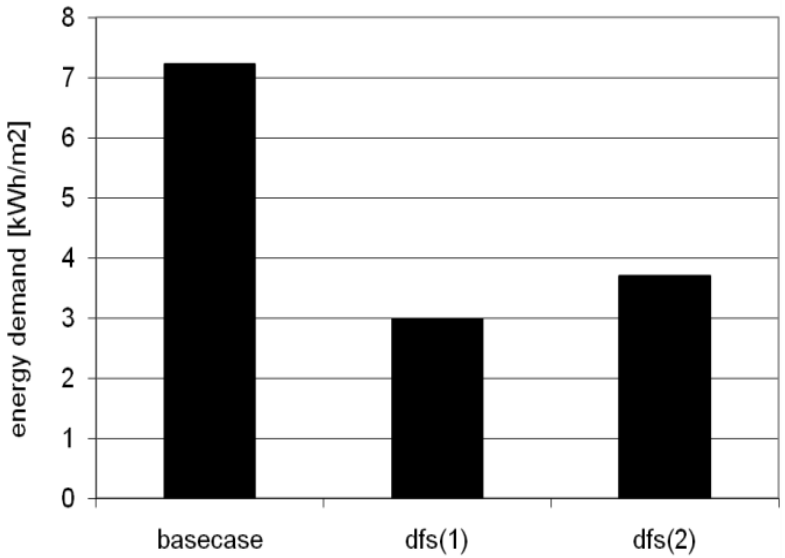




Results – Energy (power)

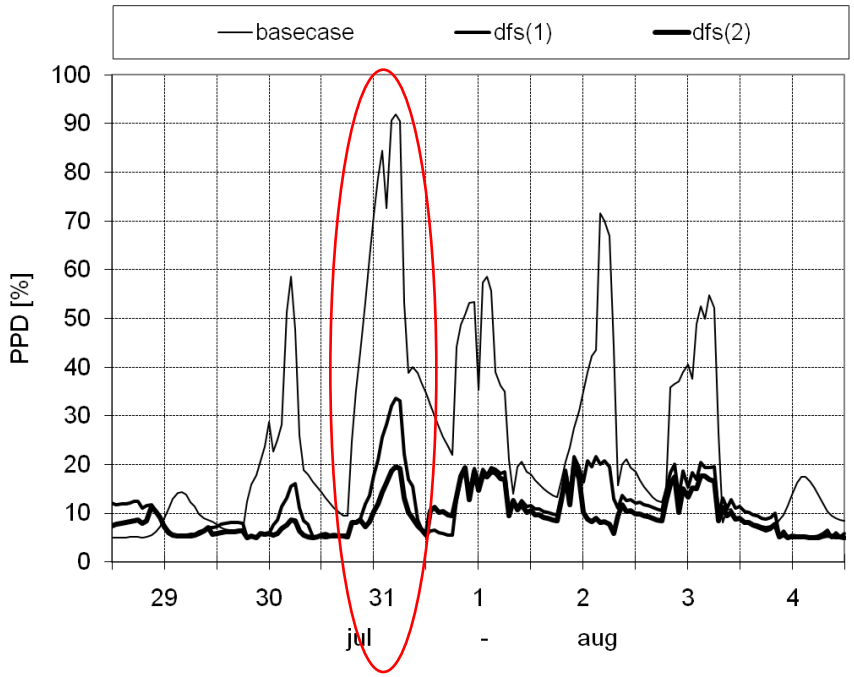
- Figure presents heating power needed for the office room for a typical winter week and heating energy demand for the whole year.
  - It can be seen that power distribution in the office (left) is reduced for both dfs types (1 and 2) with slightly more reduction for dfs (1).
  - Energy demand for heating in the office room is reduced by 59% (dfs(1)) and 49% (dfs(2)) respectively.

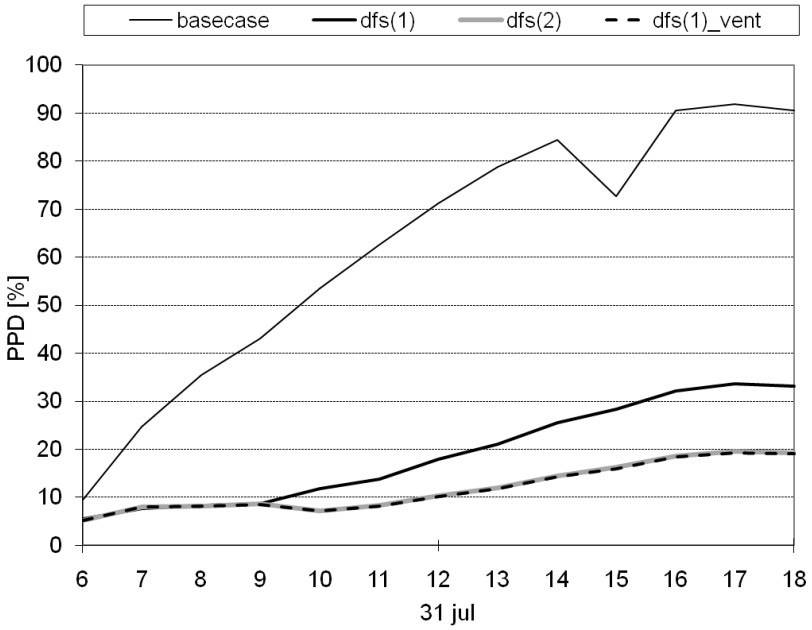




Results – Thermal comfort

- Figures present thermal comfort in percentage people dissatisfied (PPD) for a typical summer week and summer day (31 july).
  - PPD for dfs (1) and dfs (2) is much lower than basecase
  - dfs (2) performs better than dfs (1)





Conclusions

- The results show that energy efficient refurbishment of an existing façade with double façade system is possible.
- Temperatures on the inside of the windows as well as thermal comfort are improved with both types of dfs (1 and 2).
- Energy savings seem to range between 49% and 59% for the different rooms.

Conclusions

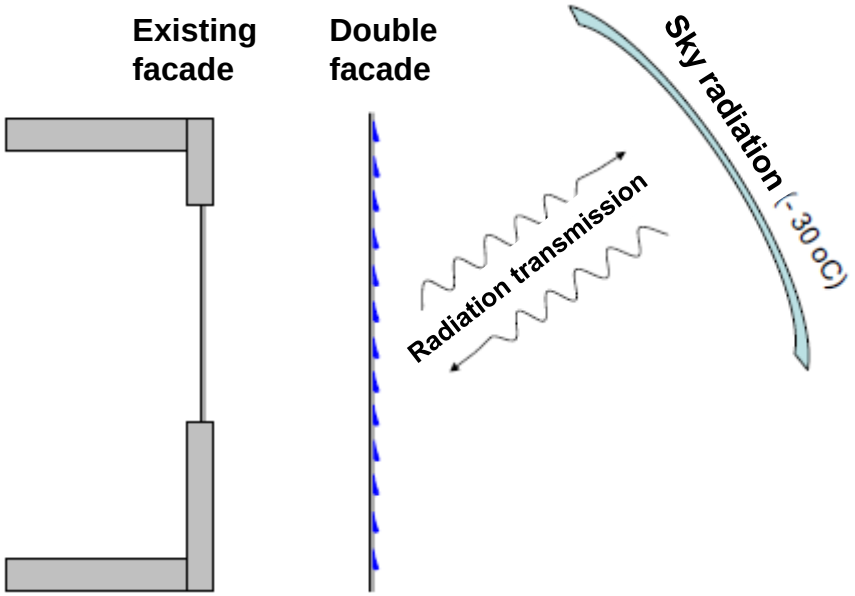
- The possibility of increasing airflow (more openings) in the dfs during warm periods provides advantages in thermal comfort and should therefore be further evaluated.
- More work is needed in order to optimize the construction of a ventilated dfs in respect to operational energy savings.
- One possibility could be to reduce air leakages in the existing façade.

Condensation

- Exterior condensation
  - Practical experiments
  - Previous calculations
  - Calculations using TRNSYS
- Internal condensation
- Shading as a measure against the outside condensing

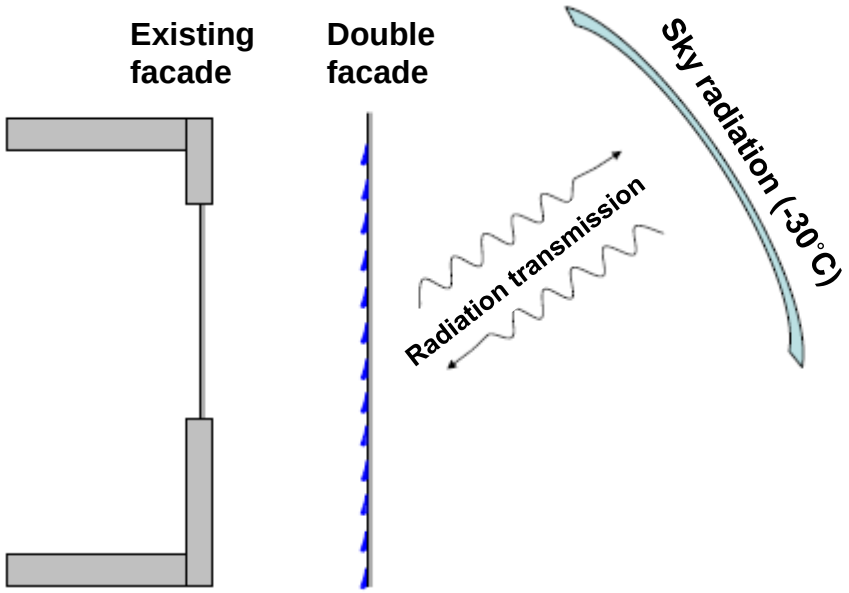
Condensation

Exterior condensation



Condensation

Internal condensation



Summary

Exterior condensation

- The calculations show that the likelihood of exterior condensation is great, both when we count the number of hours and condensed amount, when using double glazing.
- With one-layer glass the calculations show that the exterior condensation is nearly completely absent.

Summary

Internal condensation

- By using 2-layer glass the calculations show that the probability of internal condensation is large in terms of hours, but not in quantity.
- Using one-layer glass calculations show that internal condensation is very likely in terms of both number of hours and quantity. Ventilation of the cavity will improve the situation significantly but the consequences are huge energy consumption.

Summary

Shelter from the sky radiation

- If the building had mounted external shading / overhang (depth 2 m), this would have a major impact on the extrior condensation of double layered glass.
- Simulations show that the condensation is reduced to near zero.
- The measure is recommended.

Discussion

- Based on the simulations we have conducted, we recommend that it be used double layer glass U-value equal to 1.1 W/(m2 K). Moreover, we recommend that low emission coating facing outwards on the outer glass should be used.
- This solution is combined with horizontal shading / overhang (depth 2 m) located at the cornice of the top floor.
- Elements of applying a DF that are not considered in this report:
  - Can result in reduced light levels in the room due to several layers of glass and overhangs.
  - Can provide greater sound transmission between adjacent rooms (also vertically)
  - Can provide greater danger of fire and smoke spreading

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