Energy efficiency above fire safety?

How do you release the fire-energy from well insulated airtight buildings?

Ruud van Herpen MSc. FIFireE

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Where innovation starts

Outdoor fire

Fuel and fire:

NL:

Outdoor fires:
19,000 /yr

Casualties:
0 /yr

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Indoor fire

Fuel, building envelope and fire:

NL:

Indoor fires:
15,000 /yr

Casualties:
70 /yr

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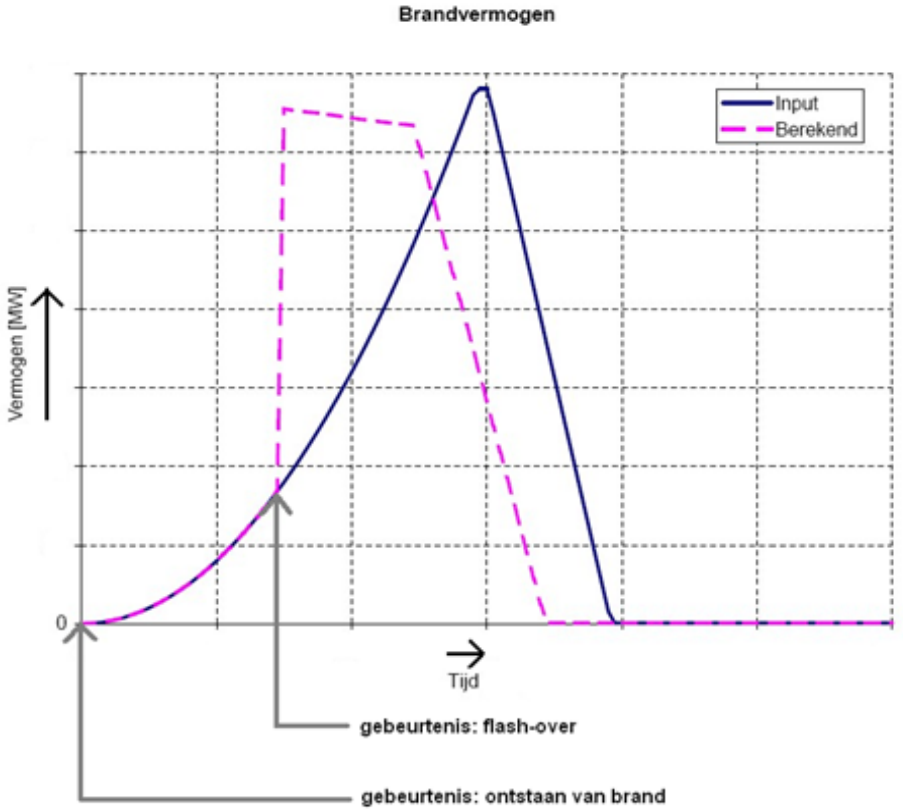
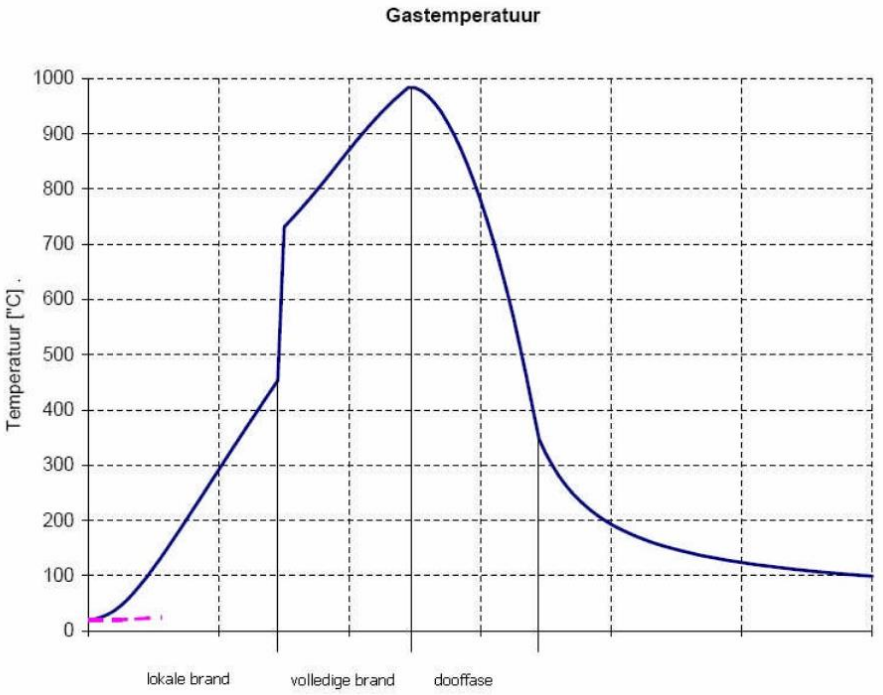
Fire ←→ Building interaction

Natural fire scenario: pre and post flashover situation





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Fire ←→ Building interaction

Project-specific approach

Fuel characteristics:

- Fire load density [MJ/m^2]
- Heat Release Rate [kW/m^2]
- Time constant for fire spread [s]

Building characteristics:

- Compartment geometry and dimensions
- Compartment envelope: heat-insulation and –accumulation
- Compartment envelope: openings and airtightness

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Boundary condition: fuel

Boundary condition: fuel

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Boundary condition: building envelope

Zutphen experiments:

Pre flashover fire reaches flashover by creating more openings in the building envelope

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Boundary condition: building envelope

Boundary condition: building envelope

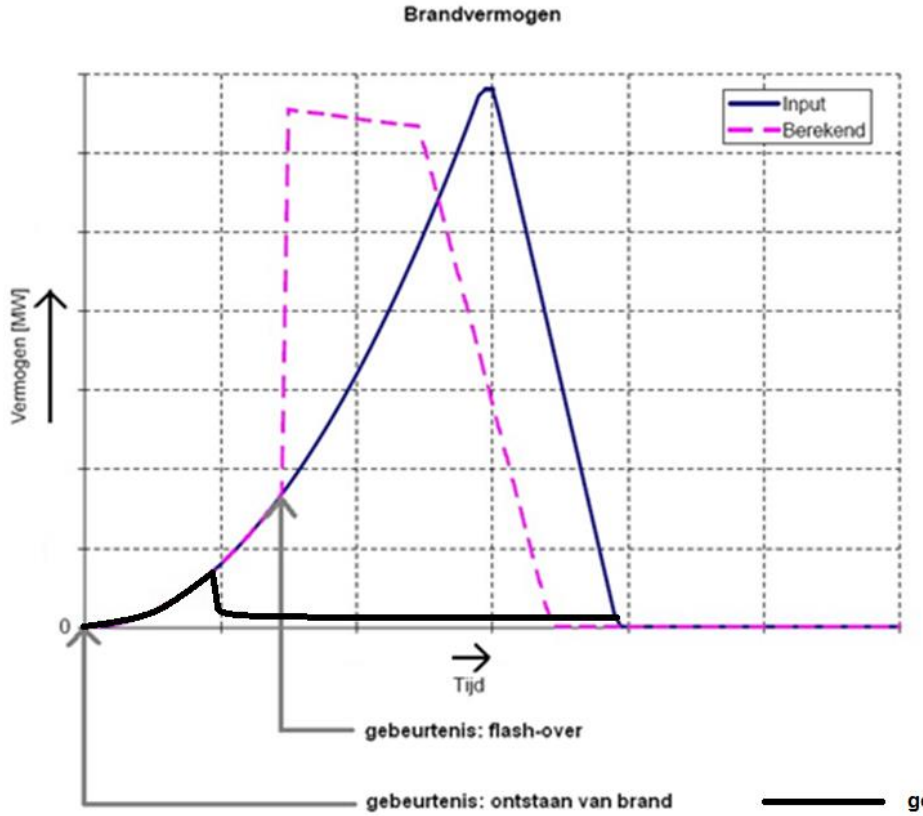
Insulation, accumulation, openings, airtightness

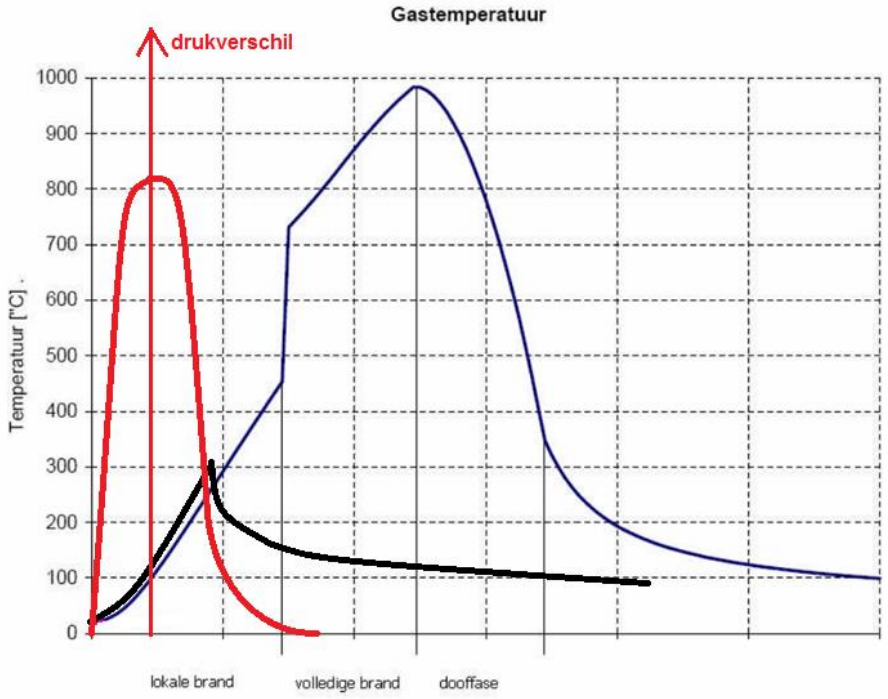
Boundary condition: building envelope

Insulation, accumulation, openings, airtightness

Boundary condition: building envelope

Insulation, accumulation, openings, airtightness





goed luchtdicht en goed geisoleerd

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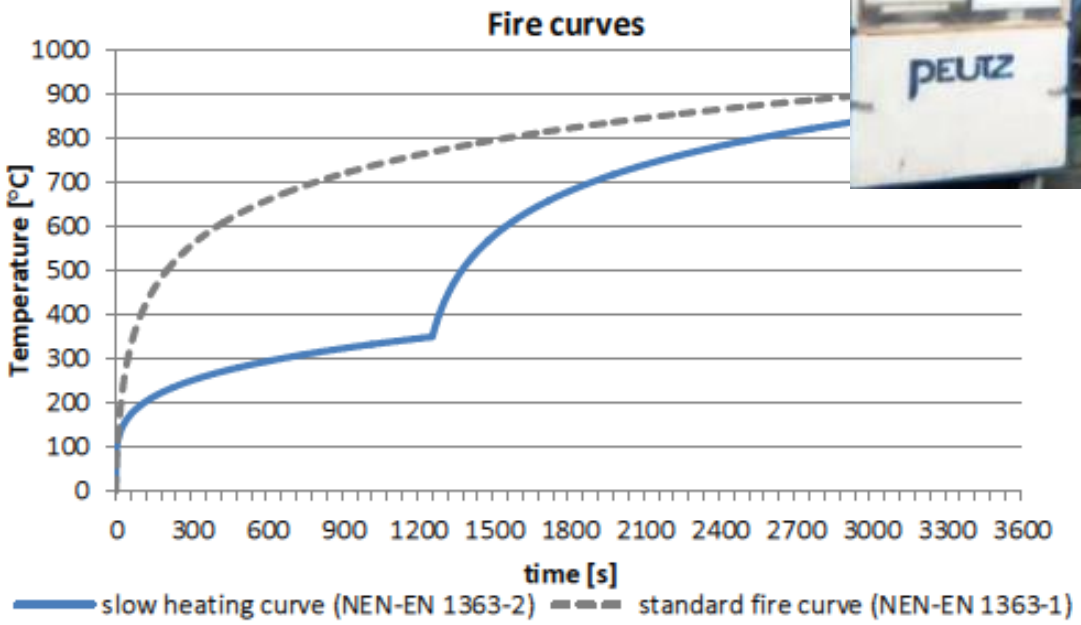
Boundary condition: building envelope

Daylight openings:

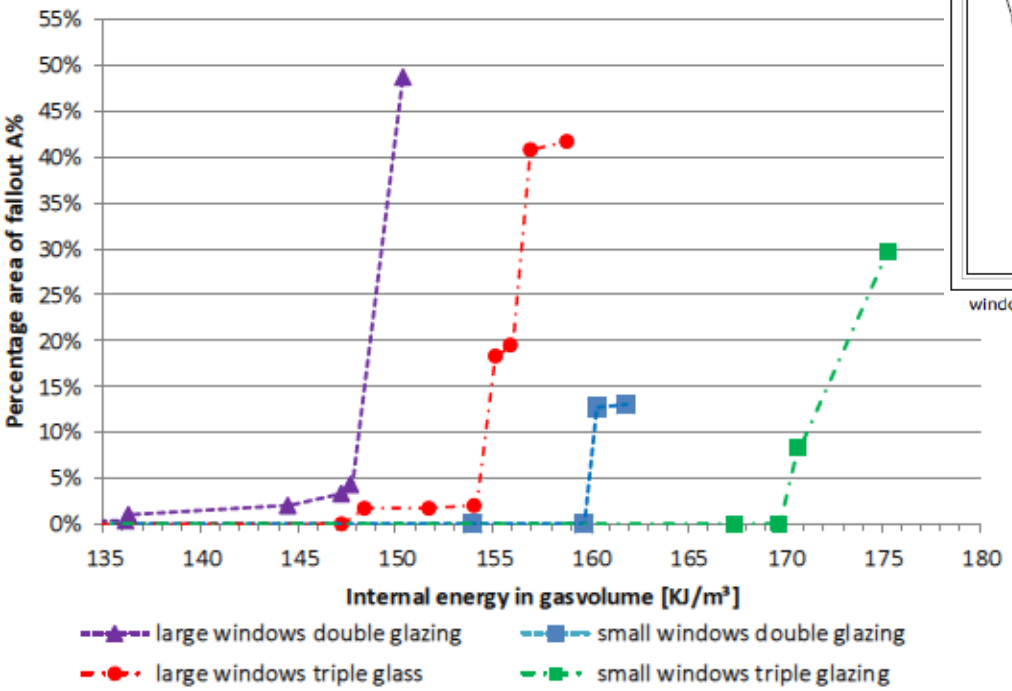
Experiments with double and triple glazing at Peutz Laboratory

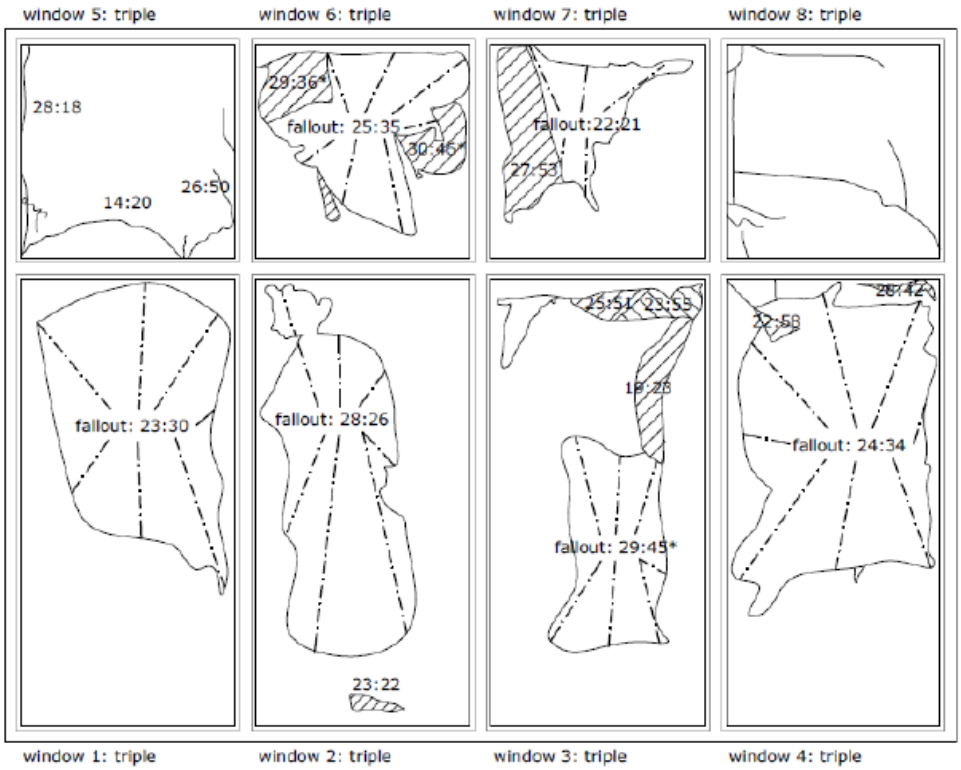


Boundary condition: building envelope

Daylight openings:

Percentage of glass fallout related to specific internal gasenergy [kJ/m³]





Conclusion:

Glass fallout after flashover

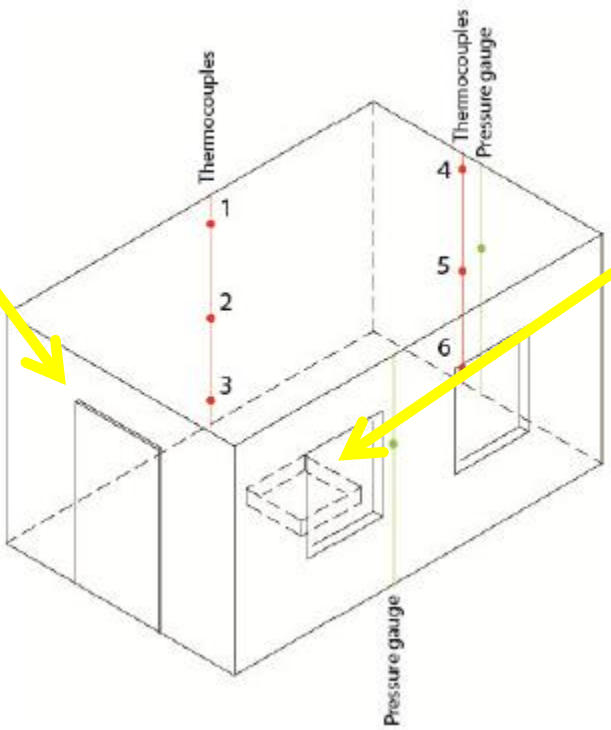
Boundary condition: building envelope

Airtightness:

Boundary condition: building envelope

Airtightness:

Adiabatic and airtight envelope without openings



Ethanol fuel with constant RHR

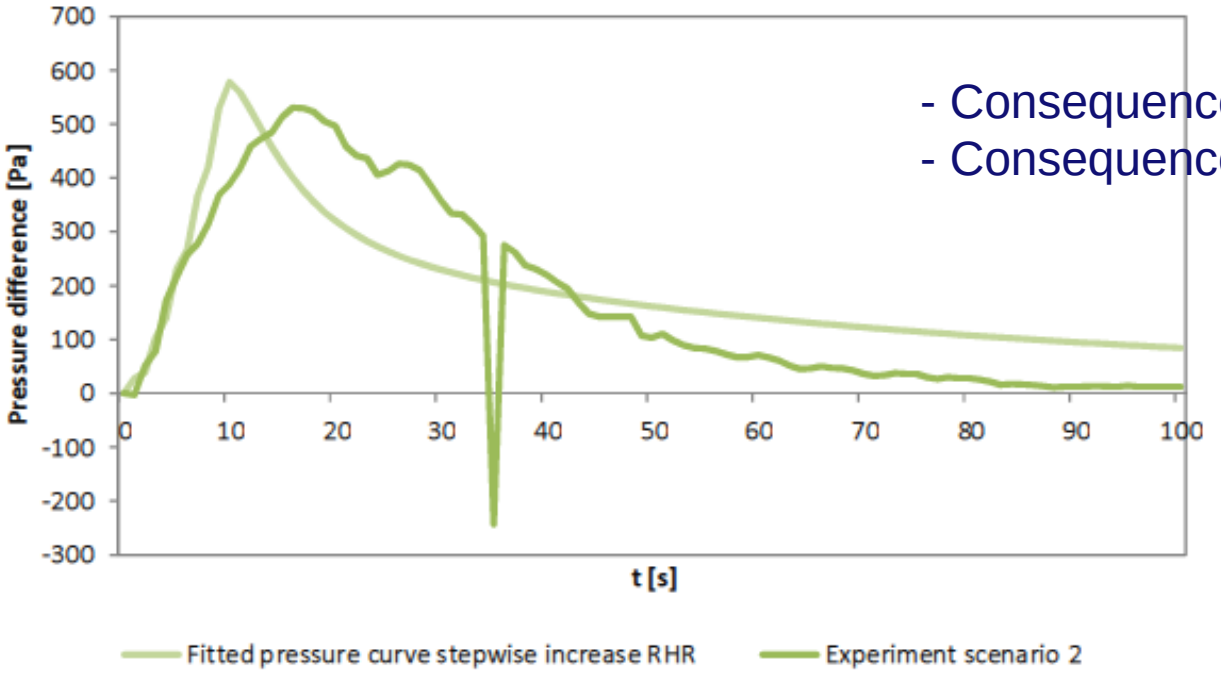
Boundary condition: building envelope

Airtightness:

$Q_{v,10}$ = 0.15 $dm^3/s.m^2$
RHR = 70 kW
A_{floor} = 8.64 m^2

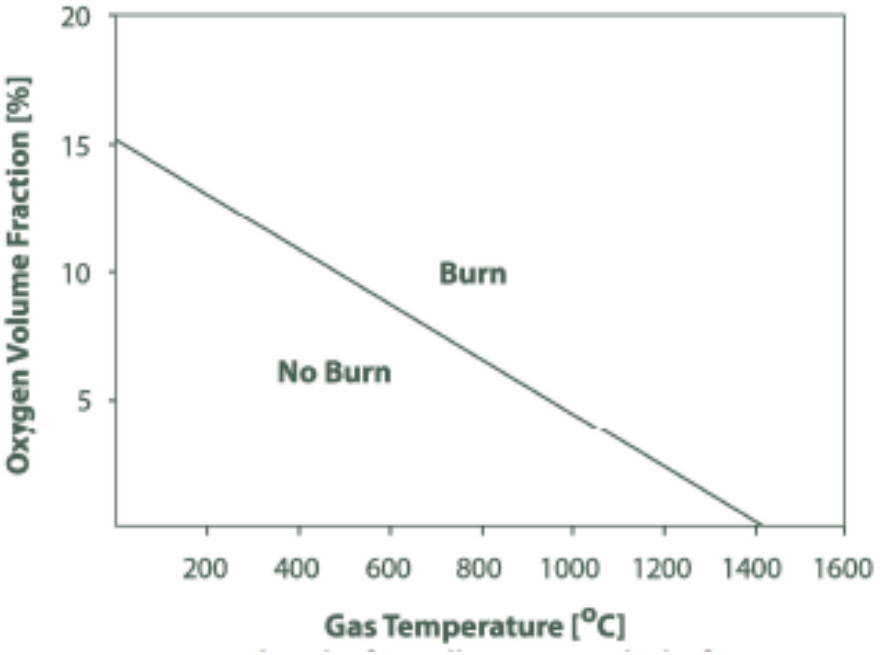
Conclusion:

Airtightness has no influence on RHR
Airtightness causes overpressure due to temperaturerise in compartment



- Consequences for building occupants?
- Consequences for glazing?

Oxygen dependent combustion



Conclusion:

Oxygen controlled fire goes out below a temperature dependent minimum oxygen volume fraction

- Consequences for building occupants?
incomplete combustion → CO pollution

- Consequencesfor fire brigade?
stopped combustion → risk of re-ignition

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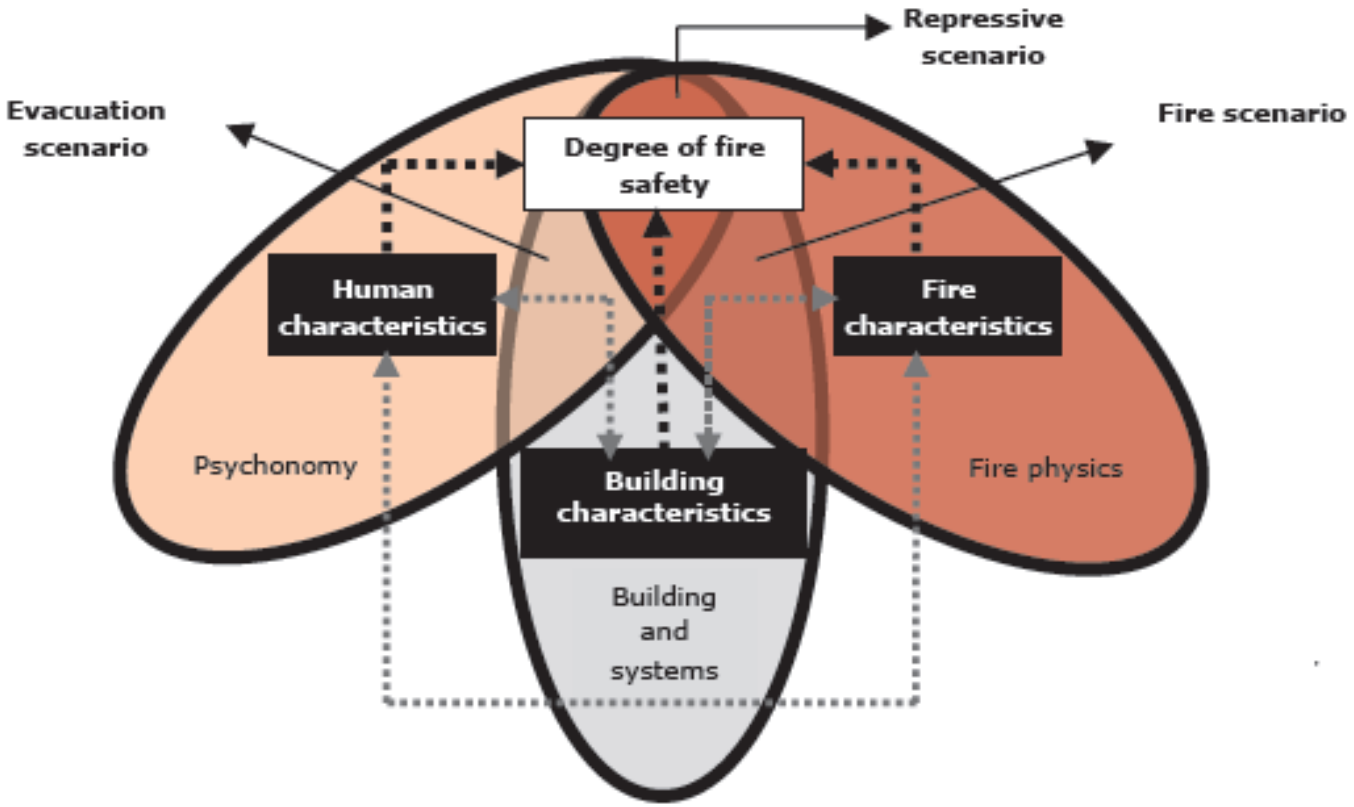
Safety of building occupants



Safety of building occupants

ASET (available safe egress time)

Acceptable conditions in compartment and thermal load on separation constructions and building structure:

- Fuel characteristics
- Building envelope characteristics

RSET (required safe egress time)

Amount of people and efficiency of evacuation:

- Building occupants characteristics

ASET > RSET :
Safety level depends on uncertainty in boundary conditions

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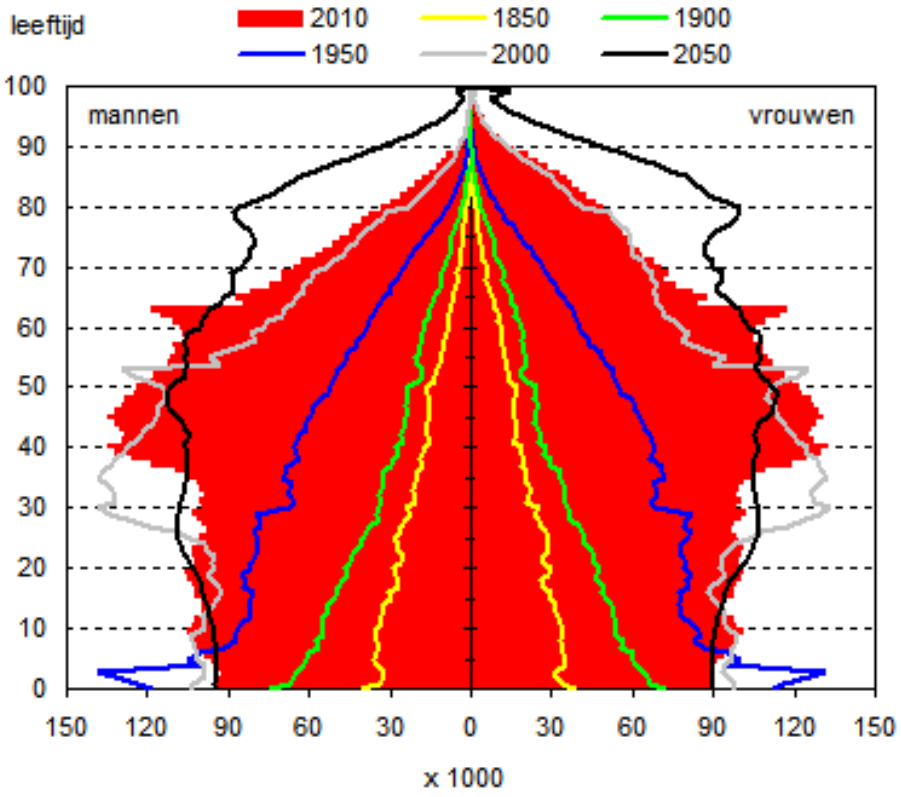
Boundary condition: building occupants



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Boundary condition: building occupants

Self-reliant….

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Recommendations

Extra firesafety measures in modern airtight, well insulated dwellings:

- Automatic optical detection and fire alarm in all rooms
- Automatic life-safety sprinkler
- Pressure valve near entrance door (> 50 Pa)

Remaining research questions:

- Performance of glass to thermal load of fire and mechanical load of high overpressure in fire compartment
- Reduction of overpressure by ventilation devices
- Uncertainty in natural fire scenario (fuel and building characteristics)
- Modeling oxygen dependent combustion

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Sources and backgrounds

Student's theses:

- Niek Spijkerboer (Saxion):
  Brandveilig wonen in een passiefhuis
- Ronald Huizinga (TU/e):
  Influence of the performance of double and triple glazing on the fire development in a dwelling
- Vincent van den Brink (TU/e):
  Fire safety and suppression in modern residential buildings – fire behaviour in airtight dwellings
- Ruben Burink (Saxion):
  Simulation of fire behaviour in multizone airtight dwellings

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