

Joerie Alderweireldt (3E)

Energy efficient design of a passive school using thermal dynamic simulations

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DE VERDIEPING



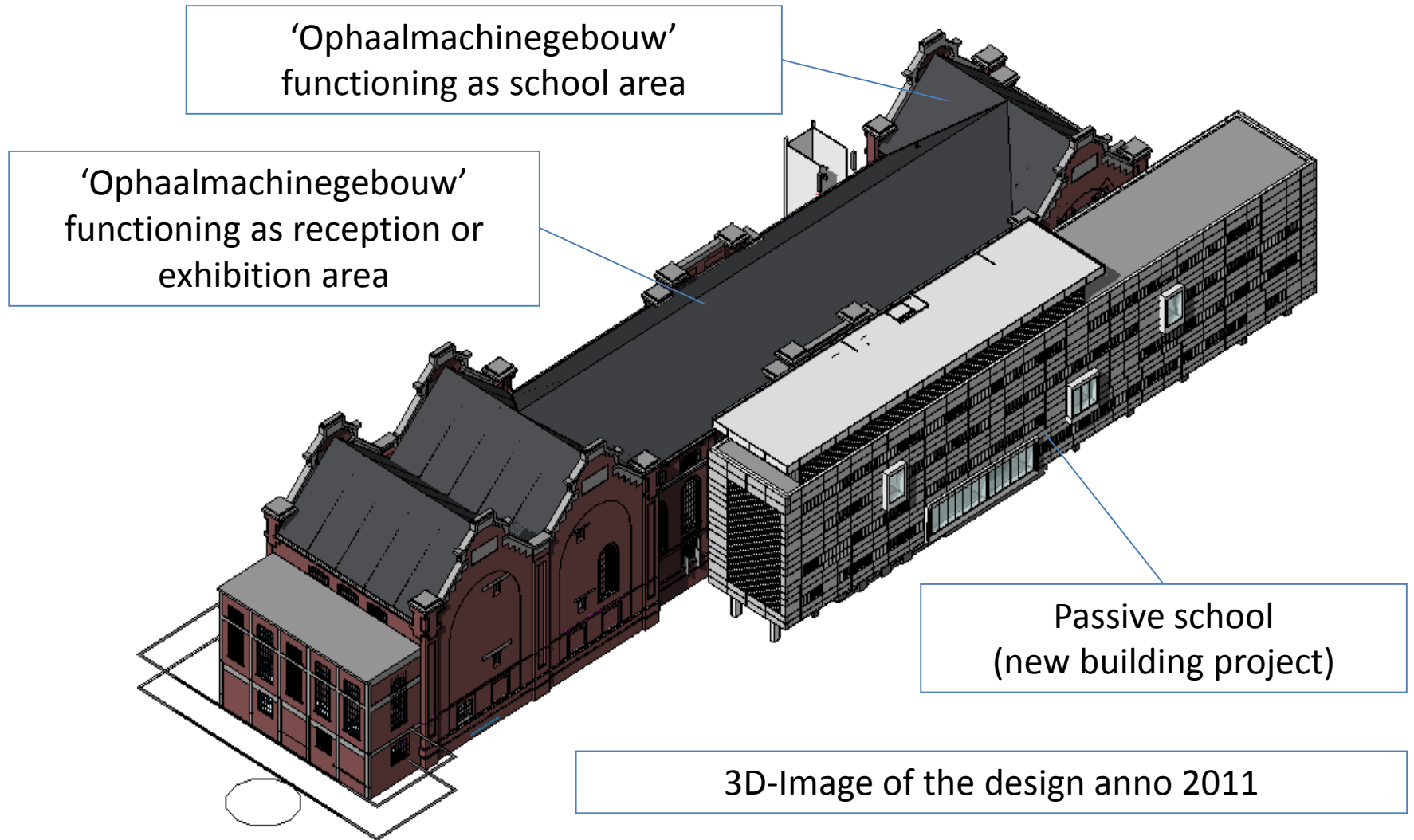
De restauratie en renovatie van het ophaalmachinegebouw
Inclusief de bouw van een passieve school van +/- 5000 m²



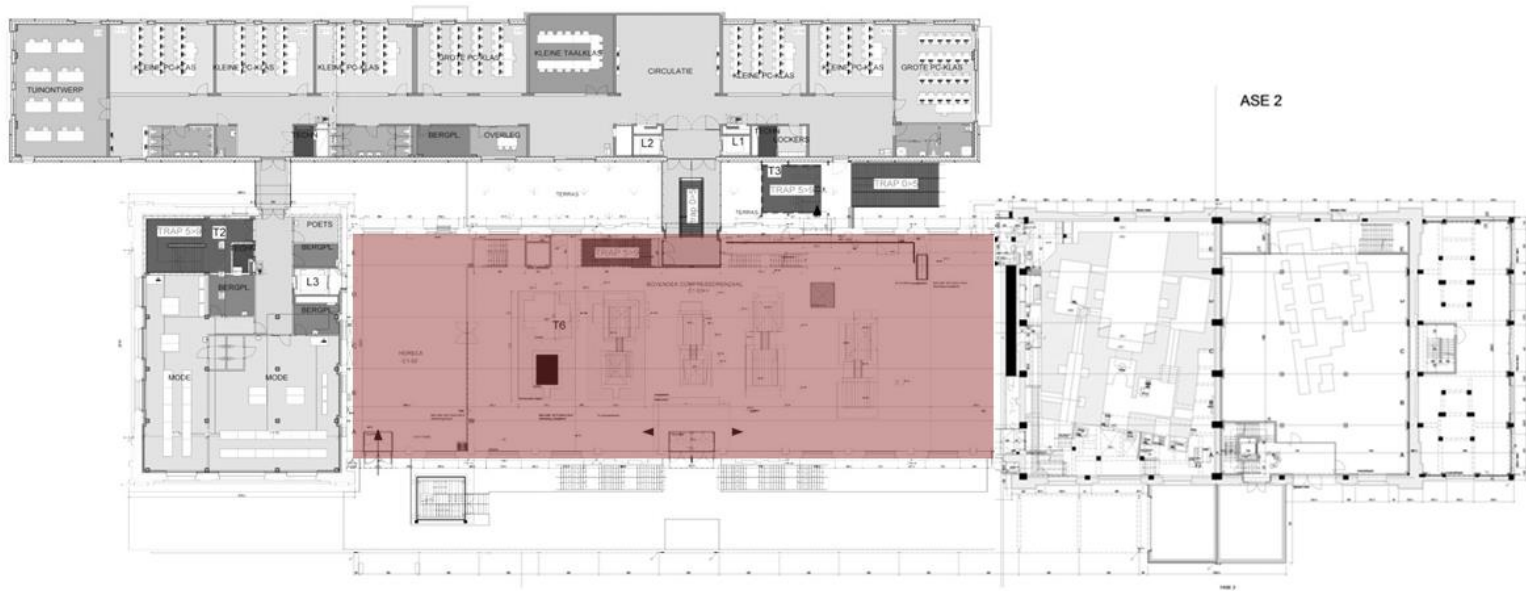
PassiveHouse Symposium
05 OKTOBER 2012

van het voormalig mijnterrein te Zolder
in het kader van Volwassenenonderwijs

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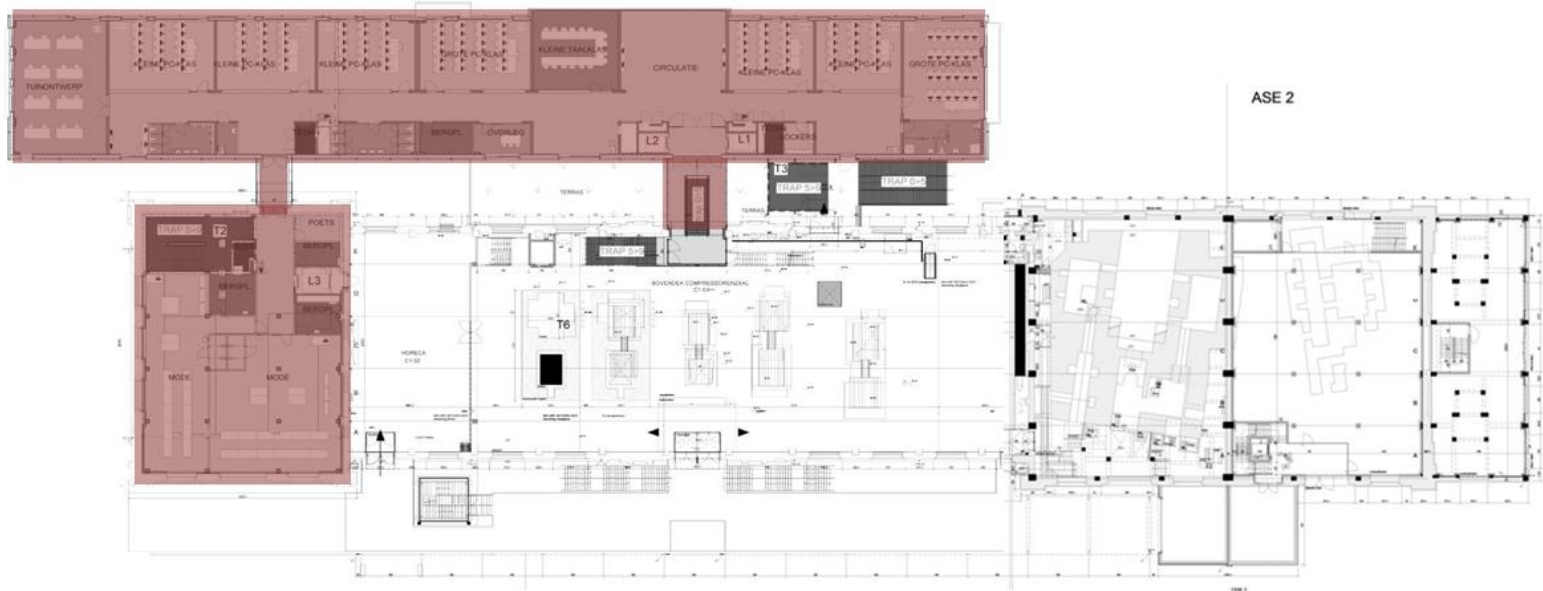
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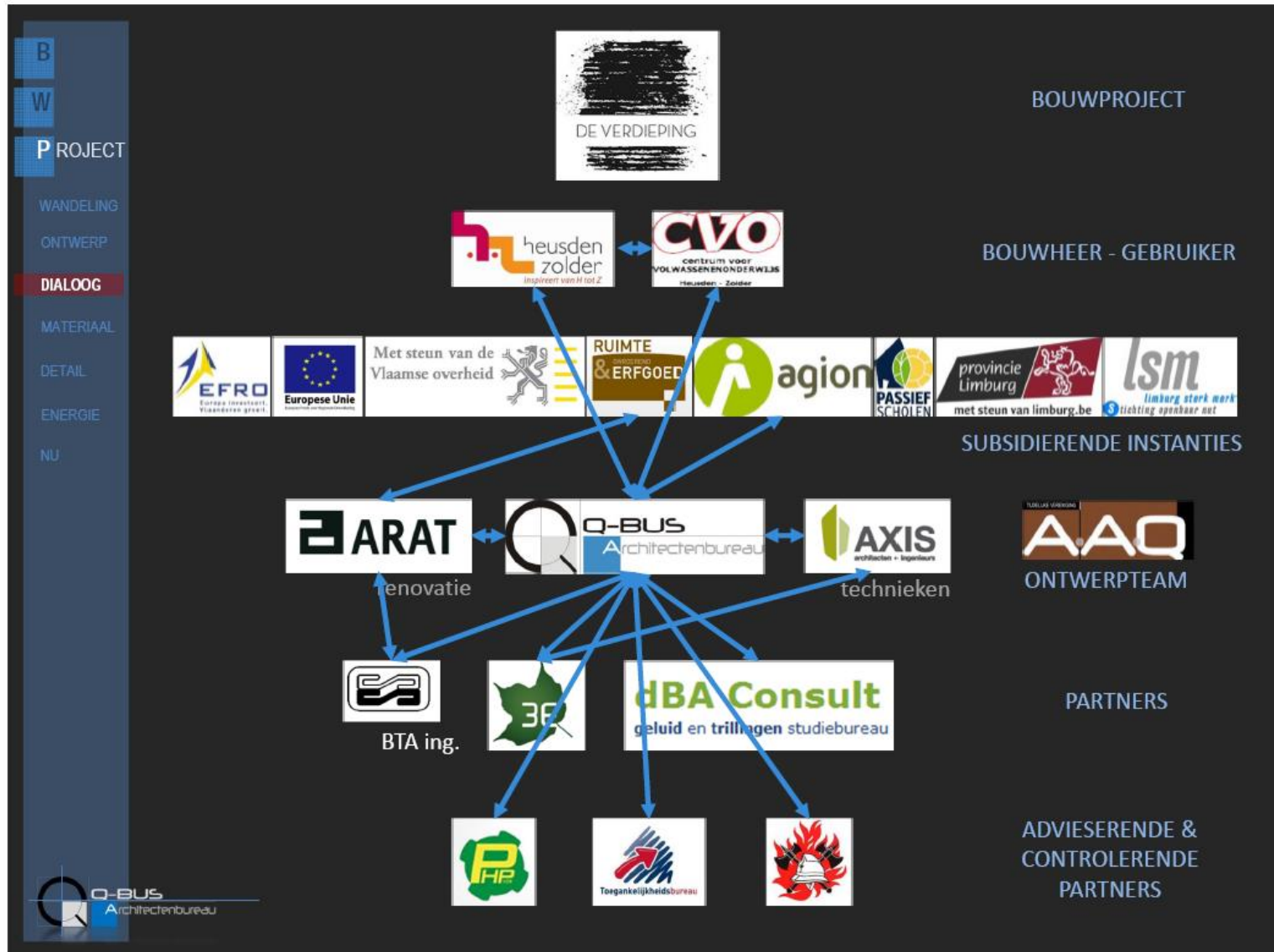
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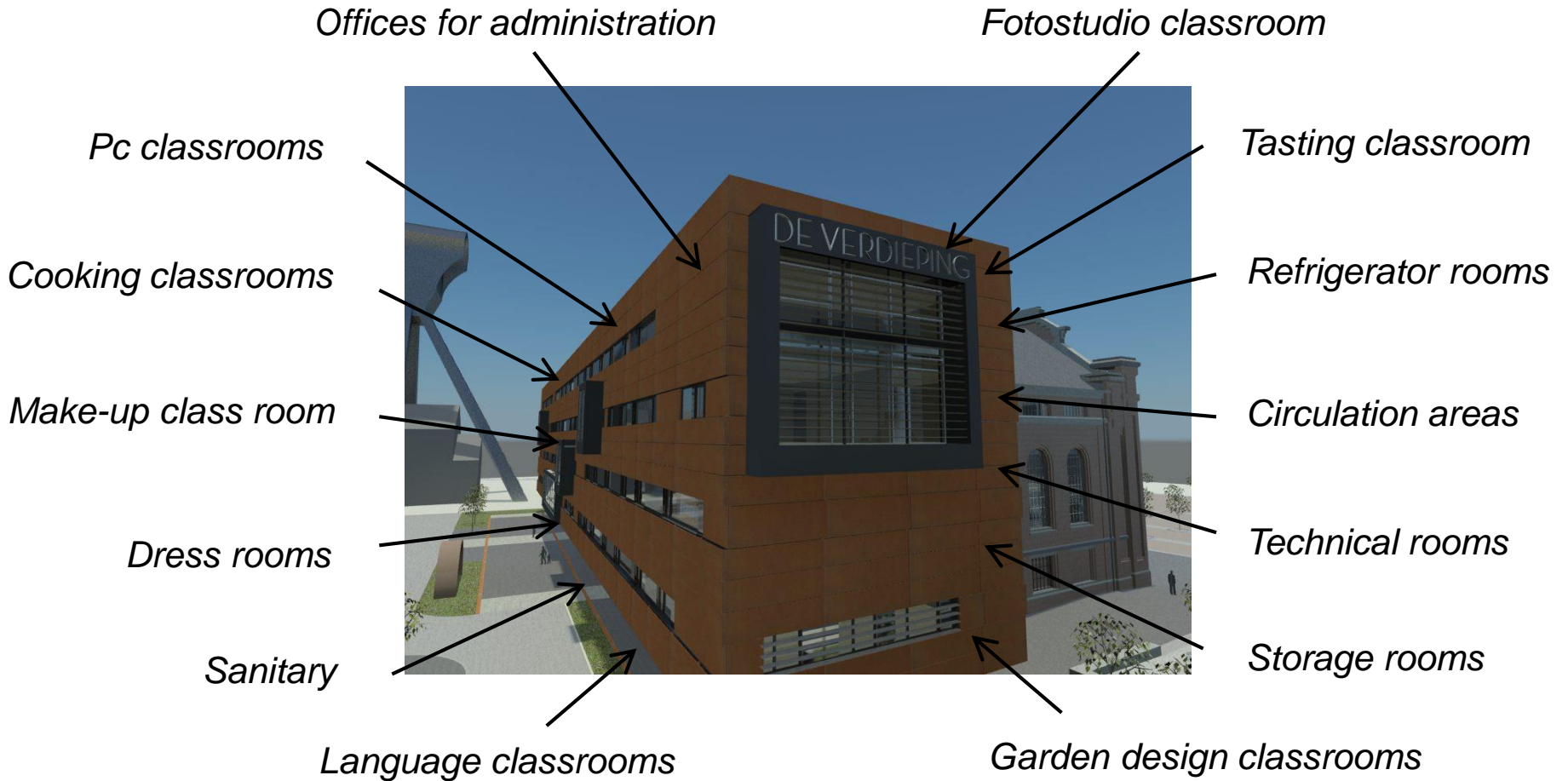


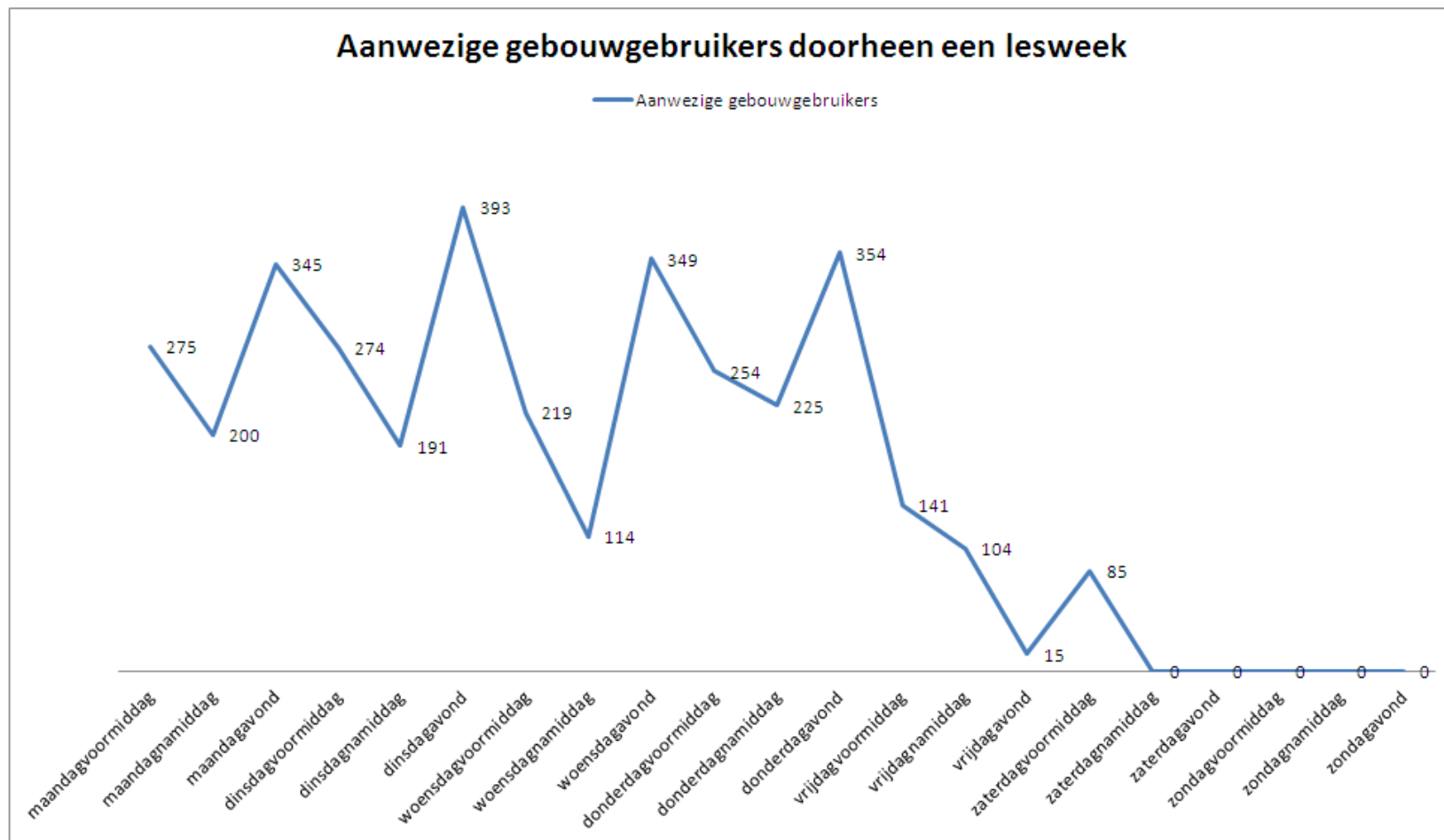
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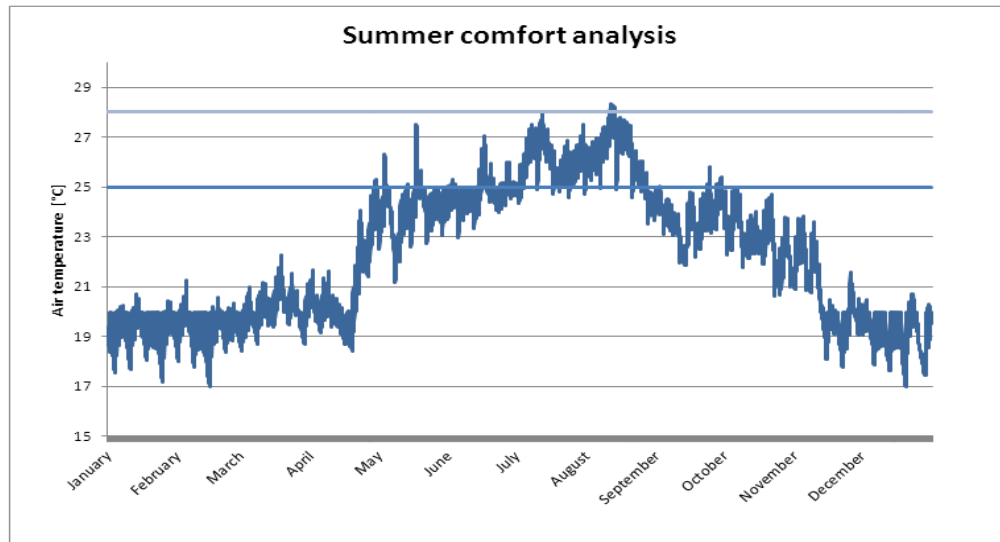
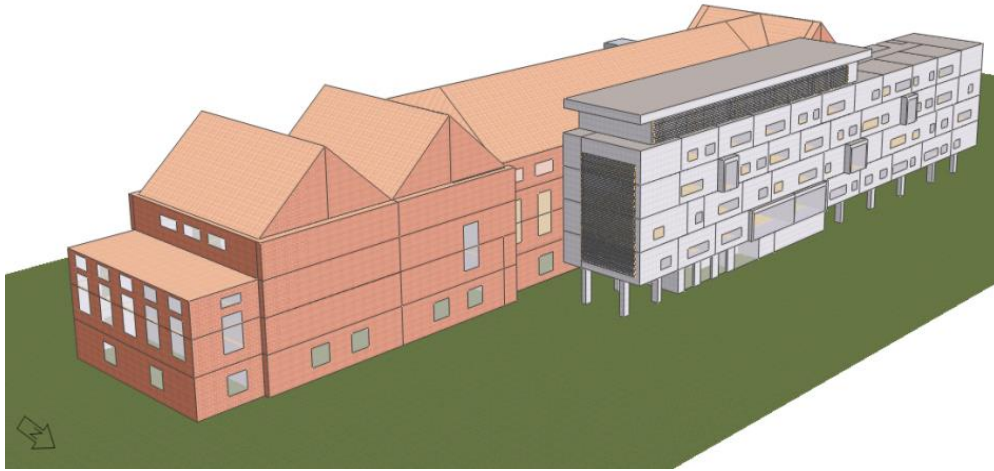
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Cloud of different room types in the school:





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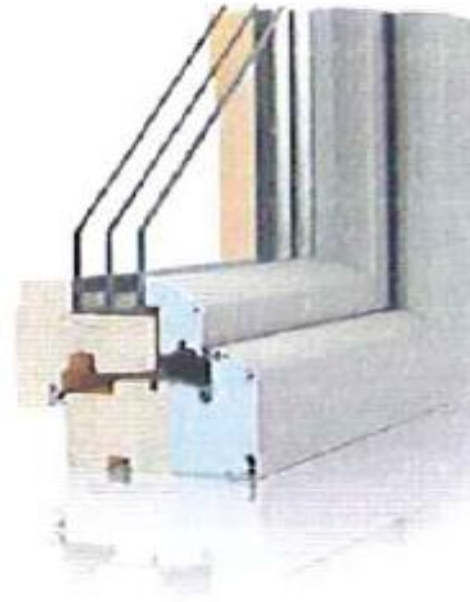
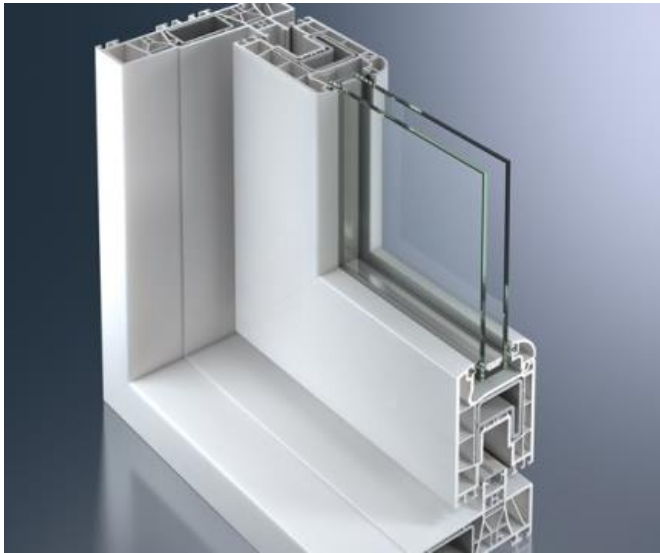
Summer comfort analysis	Hours > 25 °C	Maximum allowed
Administrative room	648 h	120 h
Language classroom (east orientation)	508 h	158 h
Language classroom (west orientation)	454 h	158 h
Language classroom (north orientation)	221 h	158 h
Language classroom (north orientation)	167 h	158 h

First decisions for the architectural and energy concept

- Provide active cooling in all classrooms as passive measures are kept limited
 - Inplantation of the building north of the existing building
 - Limit the weight of the structure by working with low weigth elements
 - Window-to-wall-ratio of 25% is preferred by the architects
 - Follow standard passive rules for the reference building
- Following these decisons several technical-economical optimisations are analysed by the use of dynamic simulations

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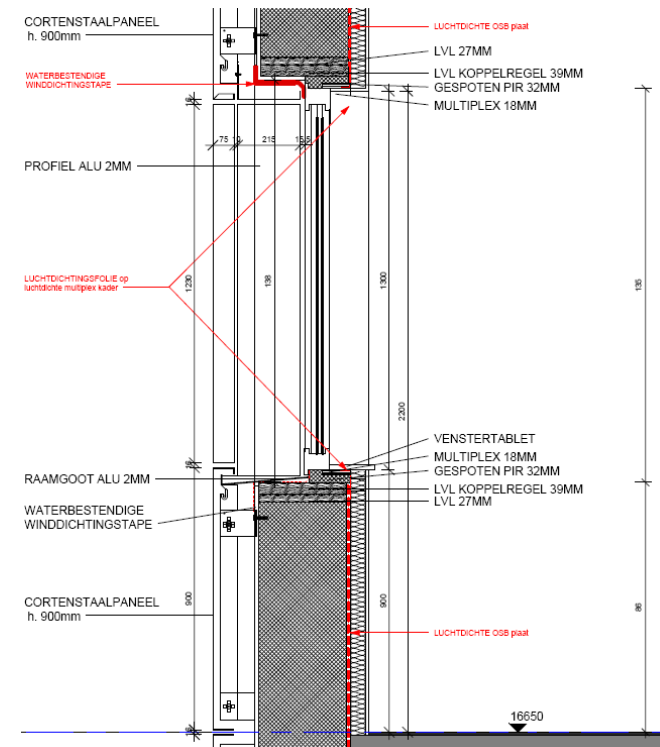
Optimisation 1 : Replacement of triple glazed windows by double glazed windows



Optimisation 1 : Replacement of triple glazed windows by double glazed windows

	$U_{\text{raam}}=0.65 \text{ W/m}^2\text{K}$	$U_{\text{raam}}=1.00 \text{ W/m}^2\text{K}$	$U_{\text{raam}}= 1.30 \text{ W/m}^2\text{K}$
Primaire energievraag (MWhp/jaar)	560.3	567.4	571.5
Primaire energievraag (kWhp/m ² .jaar)	995	100.8	101.5
Energiekost (€/jaar)	38 099	38 580	38 862
Energiekost (€/m ² .jaar)	6.8	6.9	6.9
Meerinvestering (€)	-	-72 618	-94 962

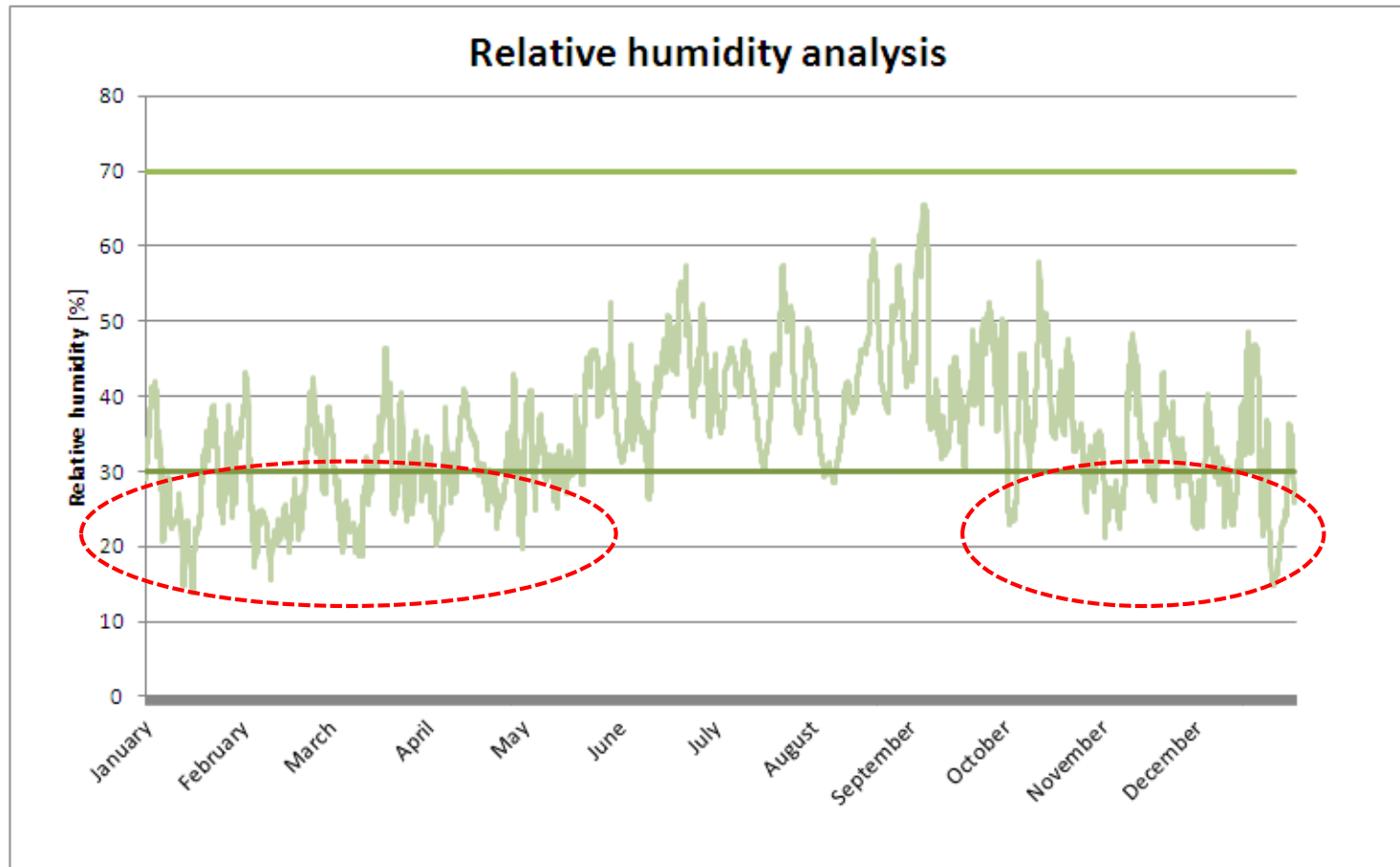
Optimisation 2 : Increase window-to-wall ratio



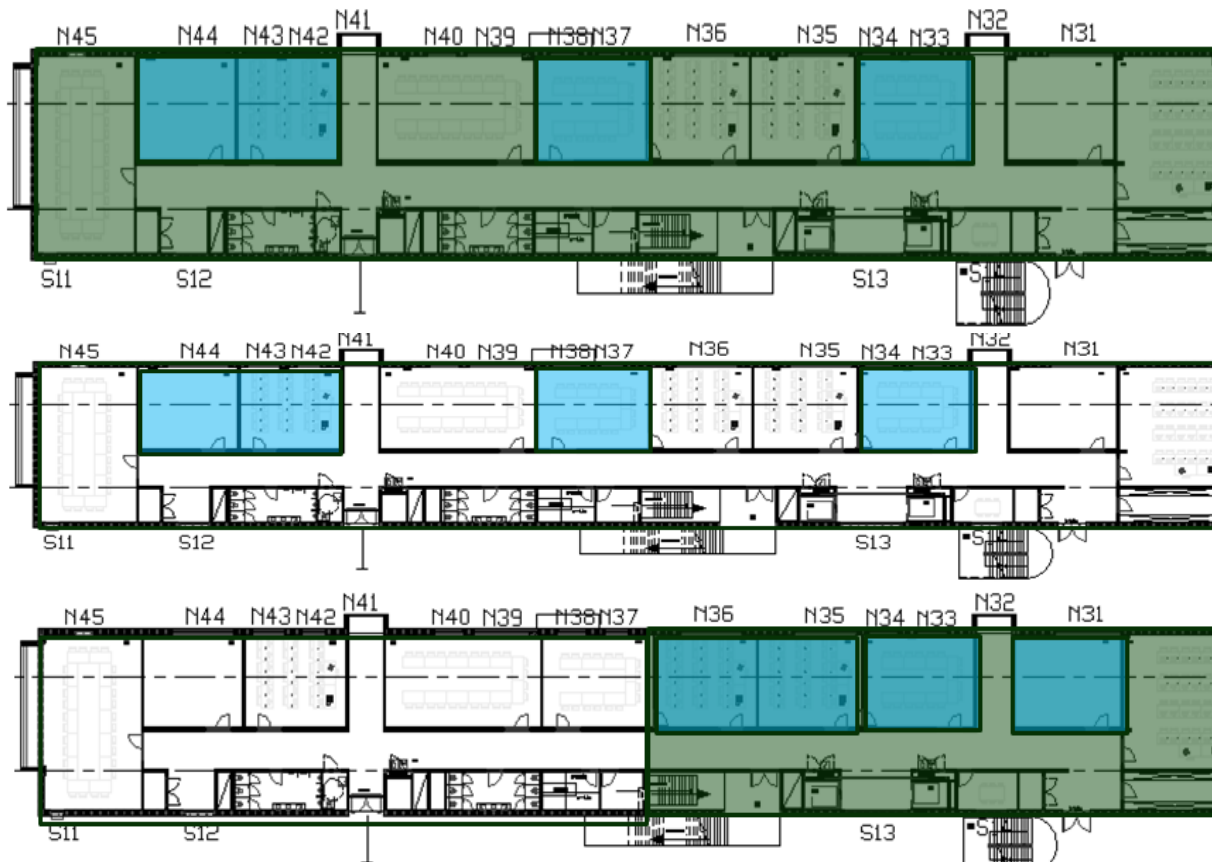
Optimisation 2 : Increase window-to-wall ratio

	Referentie	Verhoogd glaspercentage
Primaire energievraag (MWhp/jaar)	560.3	563.7
Primaire energievraag (kWhp/m ² .jaar)	99.5	100.1
Energiekost (€/jaar)	38 099	38 333
Energiekost (€/m ² .jaar)	6.8	6.8
Meerinvestering (€)	-	244 388

Optimisation 3 : Amount and type of heat recovery units



Optimisation 3 : Amount and type of heat recovery units



1 air handling unit
for one floor

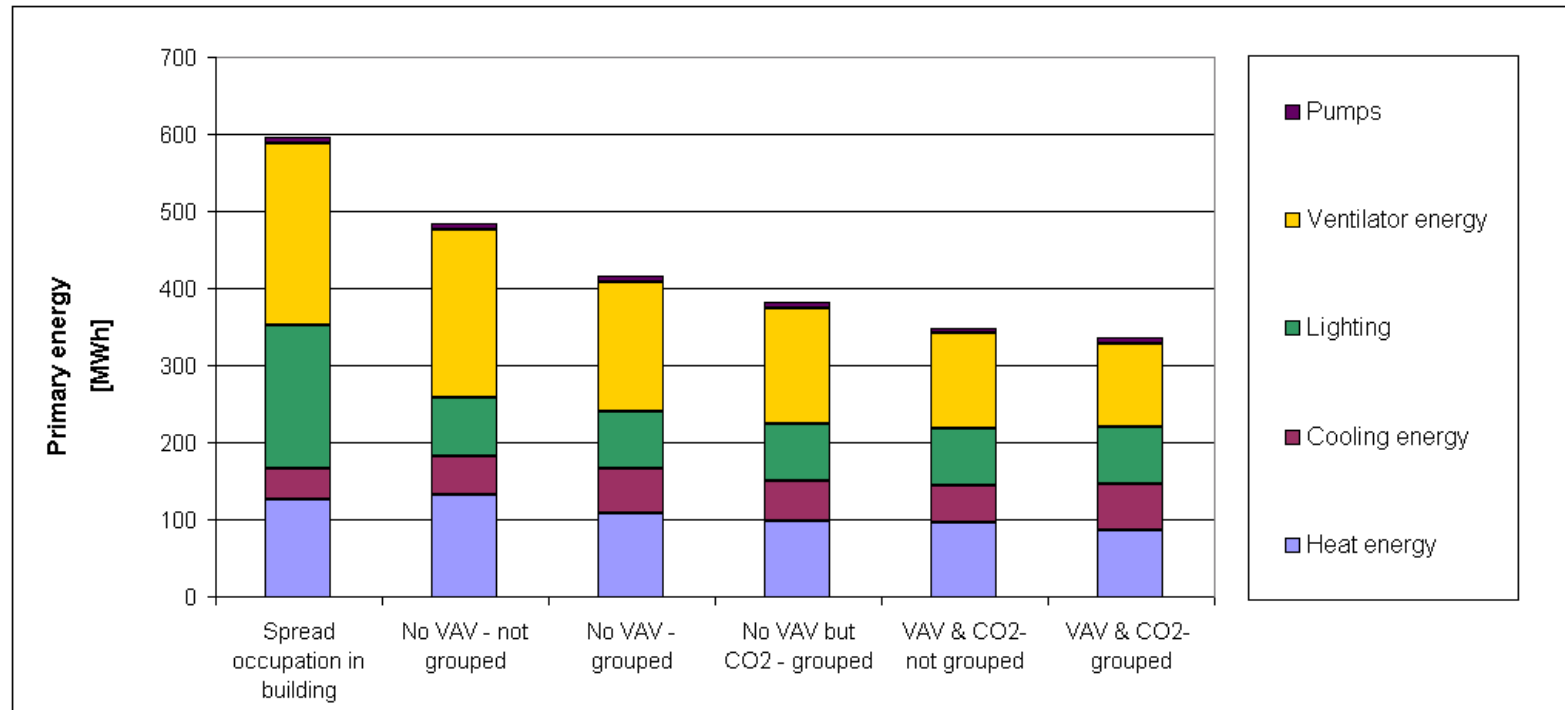
1 air handling unit for
every class room

2 air handlings units
for every floor

Optimisation 4 : Control of the ventilation systems

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
VAV	Neen	Neen	Neen	Ja	Ja
CO ₂ -gestuurd	Neen	Neen	Ja	Ja	Ja
Gegroepeerd	Neen	Ja	Ja	Neen	Ja
Bezettingsgraad	33%	33%	33%	33%	33%
Ventilatievolume	100%	50%	45%	44%	34%

Optimisation 4 : Control of the ventilation systems



Optimisation 4 : Control of the ventilation systems

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Jaarlijkse energiekost (k€/jaar)	33	28	26	24	23
Investering (k€)	0	0	9	82	82
Terugverdientijd (jaar)	-	-	1	5	5

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Jaarlijkse energiekost (k€/jaar)	-	-	26	24	23
Investering (k€)	-	-	9	82	82
Terugverdientijd (jaar)	-	-	-	33	33

Optimisation 4 : Control of the ventilation systems

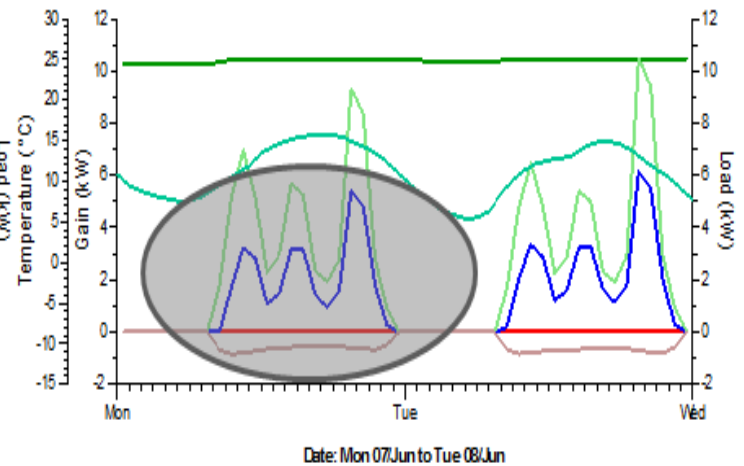
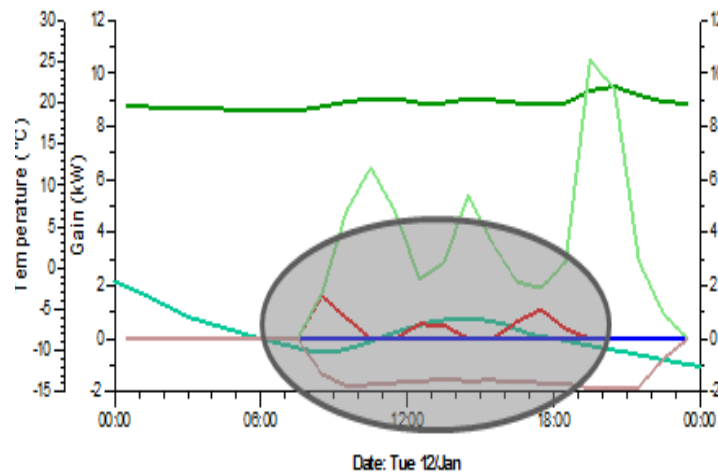
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VAV	Neen	Neen	Neen	Ja	Ja
CO ₂ -gestuurd	Neen	Neen	Ja	Ja	Ja
Gegroepeerd	Neen	Ja	Ja	Neen	Ja
Bezettingsgraad	33%	33%	33%	33%	33%
Ventilatievolume	100%	50%	45%	44%	34%

**Moeilijk wanneer
lessen uitlopen**

**Grote afhankelijkheid
van groeperen**

**Hoge
flexibiliteit**

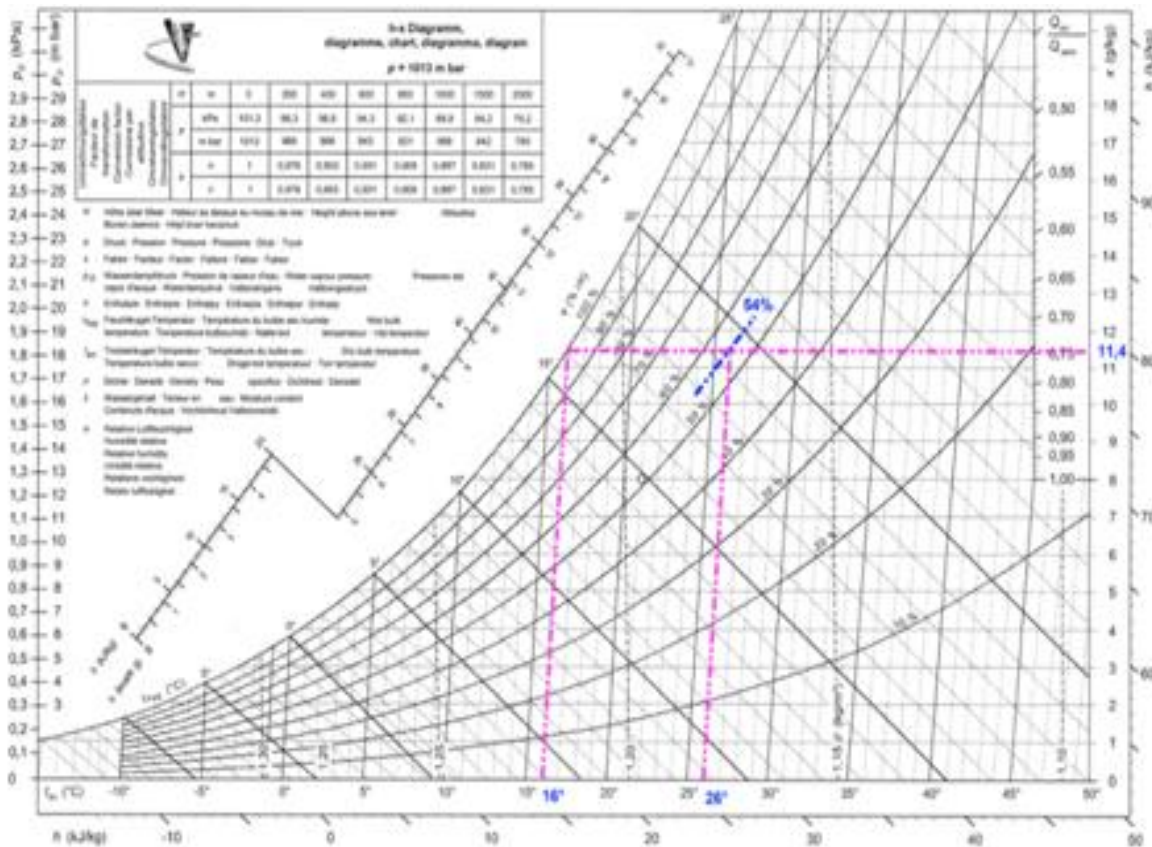
Optimisation 5 : Production, distribution and emission systems



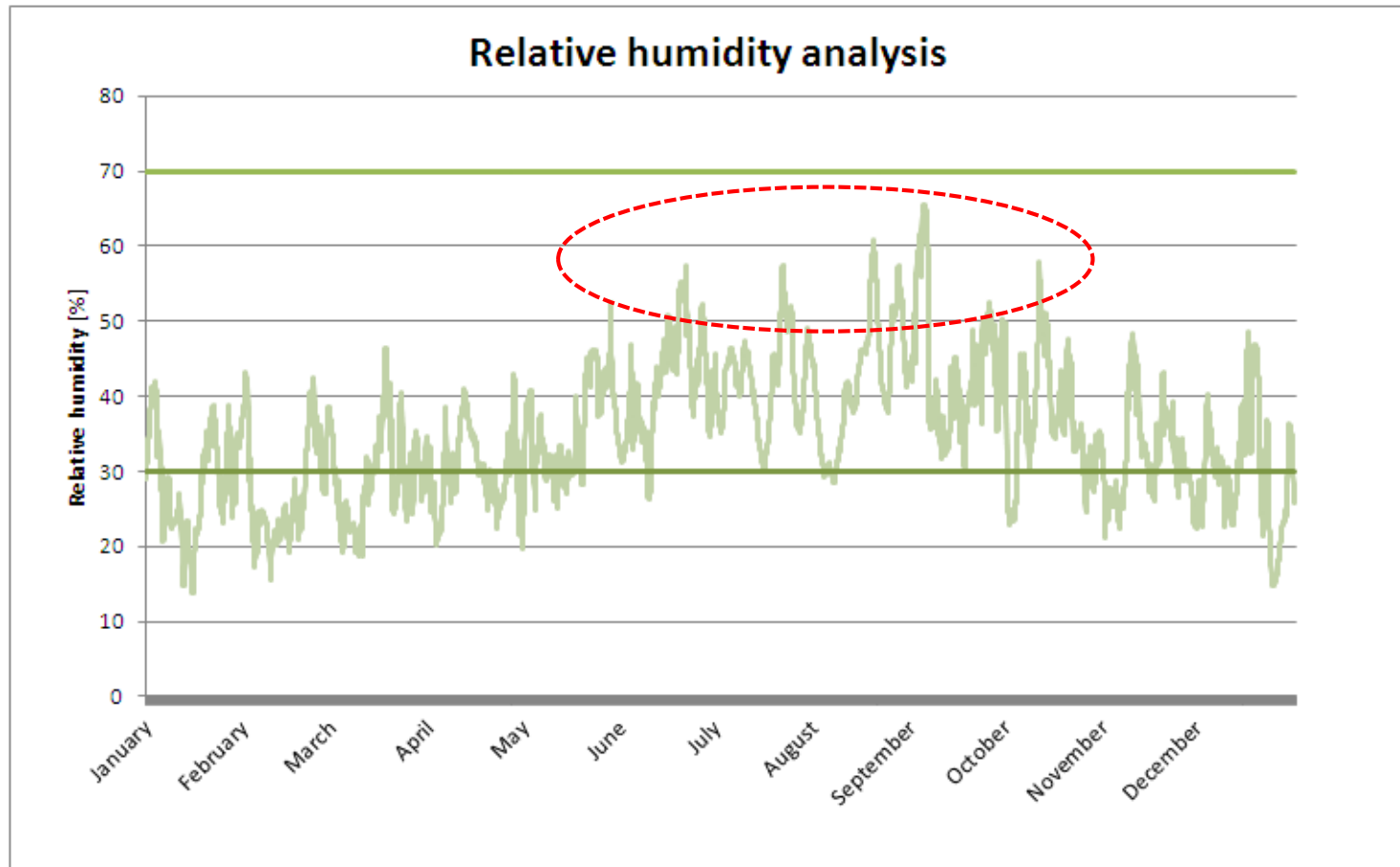
- Drybulb temperature: (Markhour.epw)
- Air temperature: N8_NEW_KEUKENI (passiveschool_version_15_withoutextraventilation.apj)
- Heating plant sensible load: N8_NEW_KEUKENI (passiveschool_version_15_withoutextraventilation.apj)
- Cooling plant sensible load: N8_NEW_KEUKENI (passiveschool_version_15_withoutextraventilation.apj)
- Internal gain: N8_NEW_KEUKENI (passiveschool_version_15_withoutextraventilation.apj)
- Aux vent gain: N8_NEW_KEUKENI (passiveschool_version_15_withoutextraventilation.apj)

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- Internal gain: N8_NEW_KEUKENI (passiveschool_version_15_withoutextraventilation.apj)
- Aux vent gain: N8_NEW_KEUKENI (passiveschool_version_15_withoutextraventilation.apj)
- Drybulb temperature: (Markhour.epw)

Optimisation 5 : Production, distribution and emission systems



Optimisation 5 : Production, distribution and emission systems



Optimisation 5 : Production, distribution and emission systems

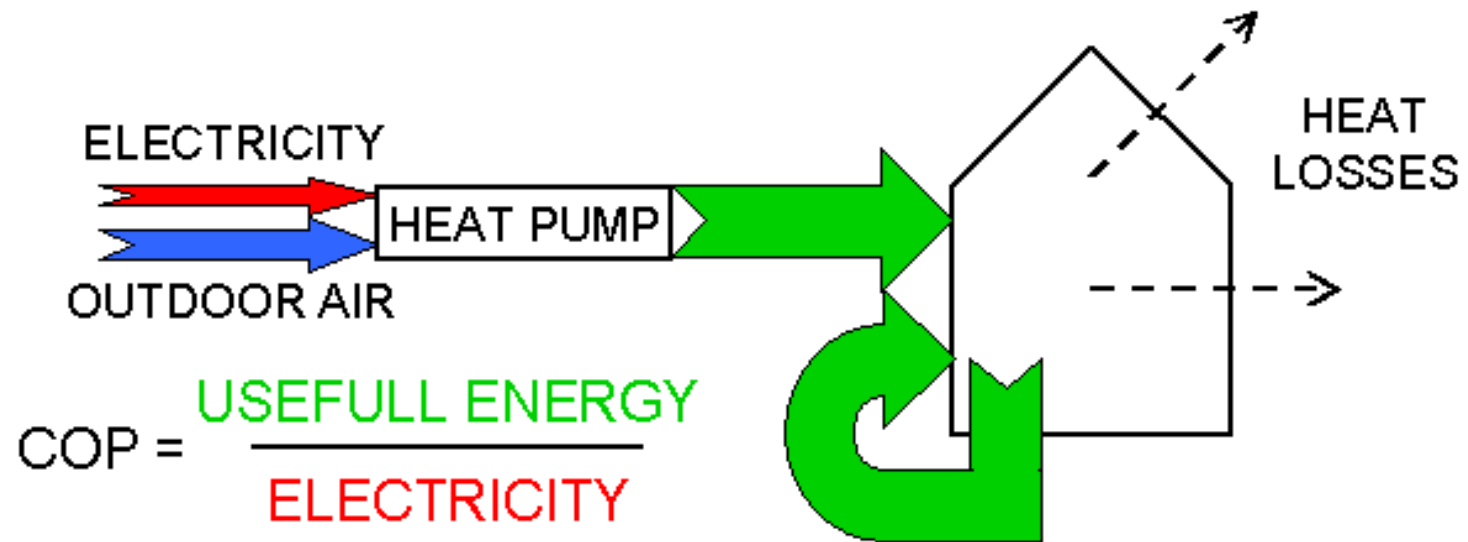
Analysis of emission systems

- Floor heating → Too slow system
- Radiating ceilings → Condensation can occur
- Hygienic ventilation → Too low temperature required
- Ventiloconvectors → No heat/cold recovery possible
- Ceiling units → Heat recovery possible

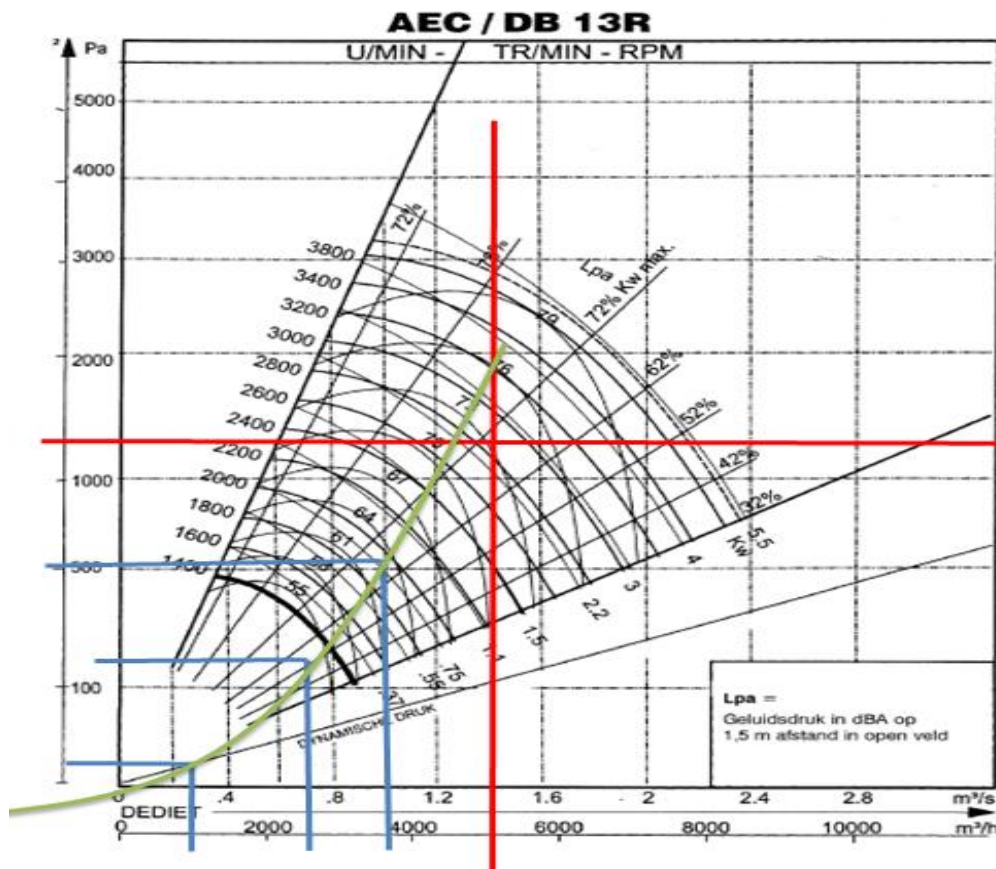
Optimisation 5 : Production, distribution and emission systems

	WP met WTW	VRV
Emissie	Warmte en koude	Warmte en koude
Koelmiddel	In klaslokaal en buitenunit	In klassen, leidingnetwerk en in buitenunit
Flexibiliteit	Hoog door water in leidingnetwerk	Laag door koelmiddel in leidingnetwerk
COP verwarming	3.9	3.5
COP koeling	5.0	5.5
COP warmterecuperatie	Tussen bovenstaande COP's en +/- 9	Tussen bovenstaande COP's en +/- 9
Potentieel andeel recuperatie	Zonder sanitair warm water en zonder koelcellen: 7.8% Zonder sanitair warm water en met koelcellen: 10.3% Met sanitair warm water en met koelcellen: 11.0%	
Akoestiek	Warmtepomp in klas dus extra geluidsbron	Geen warmtepomp in klas dus minder geluid

Optimisation 5 : Production, distribution and emission systems



Optimisation 6 : Night cooling versus active night cooling



Temperature difference of 8°C is required before night cooling is more efficient than active cooling

Temperature difference of 4°C is sufficient if night cooling is reduced below 75% of its total capacity

Optimisation 7 : Integration of photovoltaics on roof top

Heat demand kWh/m ² .y	17.4
Cooling demand kWh/m ² .y	7.0
Heat energy kWh/m ² .y	5.8
Cooling energy kWh/m ² .y	1.5
Lighting kWh/m ² .y	6.8
Ventilator energy kWh/m ² .y	15.2
Pumps kWh/m ² .y	0.4

Primary energy kWhpr/m ² .y	54.0
Energy cost €/m ² .y	6.5

RE kWhpr/m ² .y	19.4
RE %	35.9

The integration of photovoltaic panels allows the realisation of a Nearly Zero Energy Building