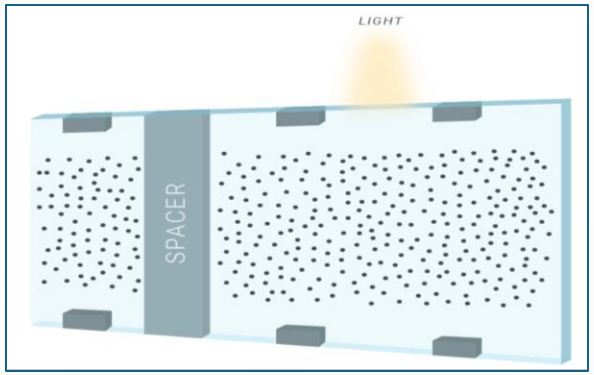
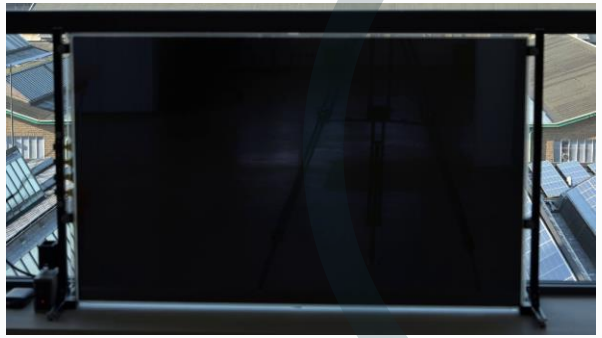
Energy efficiency of windows integrating Electrophoretic Light Modulators

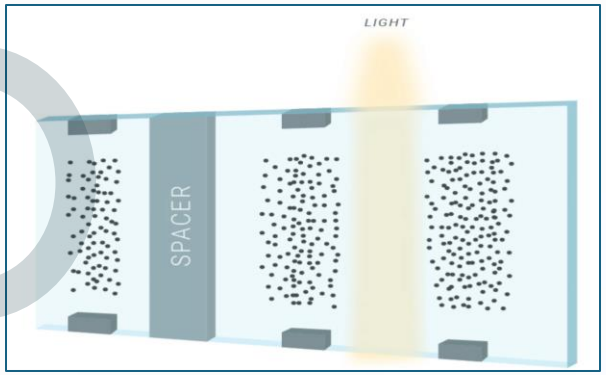
Romaric Massard[a], Carmelo Guido Galante[b], Luigi Giovannini[c], Matthew Tee[d]

a. eLstar Dynamics, The Netherlands, romaric.massard@elstar-dynamics.com
b. Eckersley O'Callaghan, UK, carmelo@eocengineers.com
c. Eckersley O'Callaghan, Italy, Luigi@eocengineers.com
d. Eckersley O'Callaghan, UK, Matthew@eocengineers.com

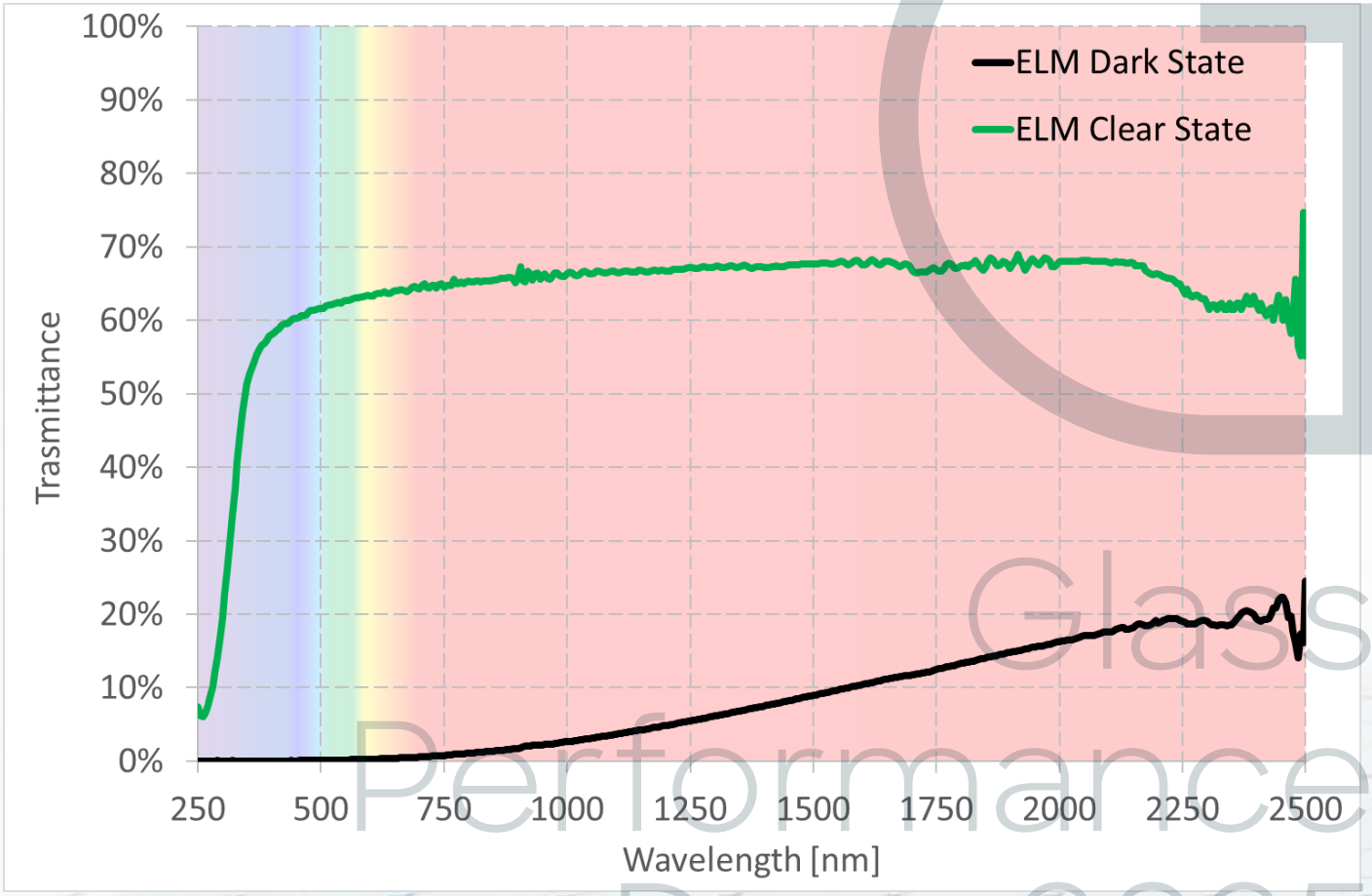
ELM technology







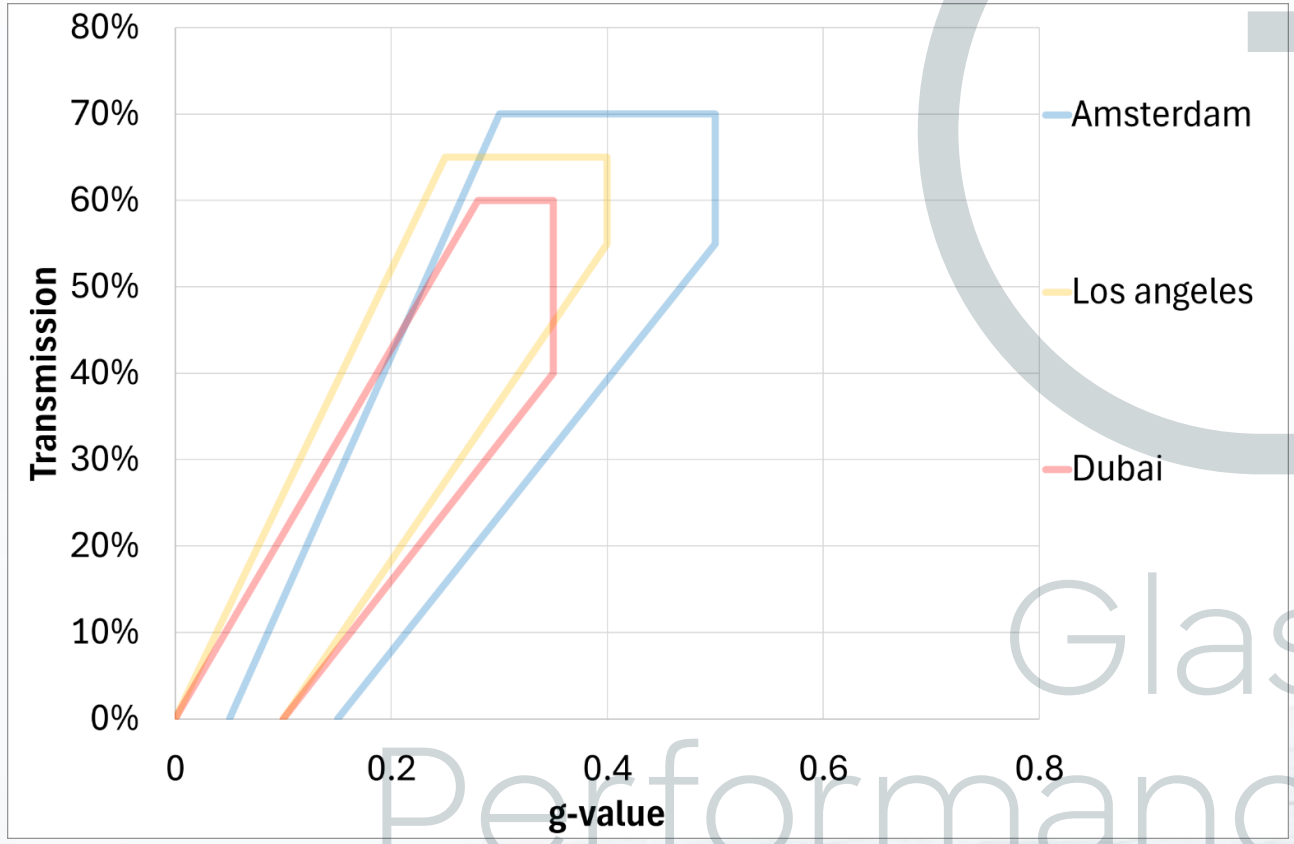
ELM technology performance



- Visible Transmission Range

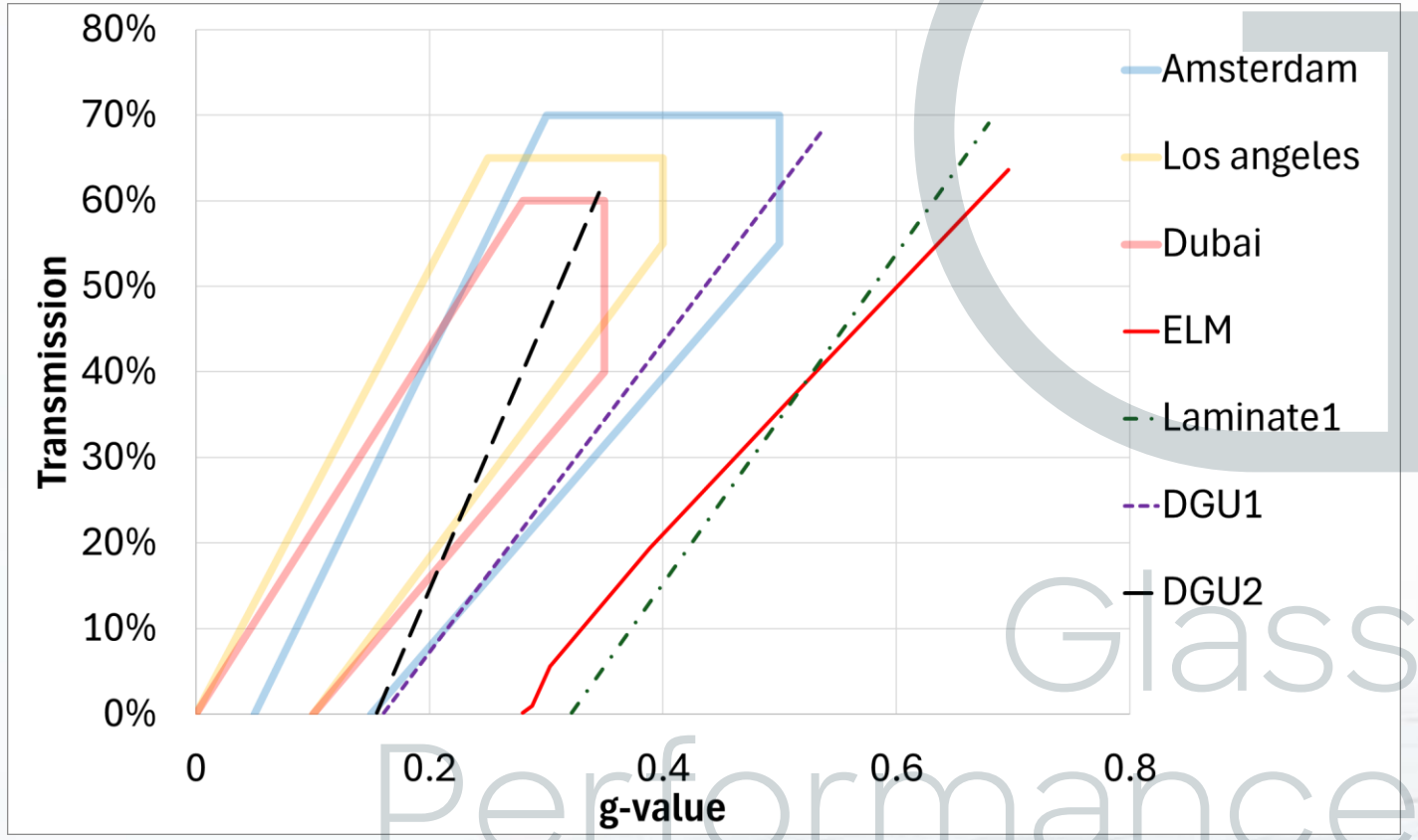
  0.2% - 70%
- Immediate response and full operations in minutes
- ELM power consumption <0.5W/m2
- Peak voltage 24V
- Operations: -20degC - 90degC

Wished Thermal Performance for Dynamic Windows



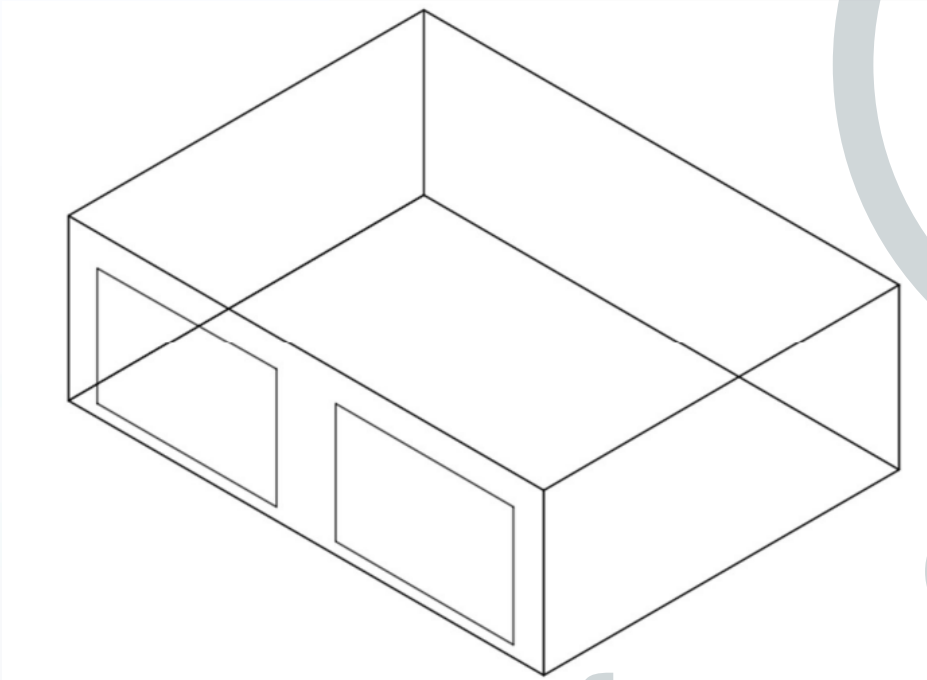
City	Dark state Light transmittance	Dark state g-value	Clear state Light transmittance	Clear state g-value
Amsterdam	0.1%	0.05 - 0.15	55%-70%	0.30 – 0.50
Los Angeles	0.1%	0.01 – 0.10	55% - 65%	0.25 – 0.40
Dubai	0.1%	0.01 – 0.10	40% - 60%	0.28 – 0.35

ELM Integrated DGU to Target Wished Thermal Performance



	Laminate 1	DGU 1 ELM + Low-E	DGU 2 ELM + HPC
#1	Float glass mid-iron 4mm	Float glass mid-iron 4mm	Float glass mid-iron 4mm
#2	PVB	PVB	PVB
#3	ELM	ELM	ELM
#4	PVB	PVB	PVB
#5	Float glass mid-iron 4mm	Float glass mid-iron 4mm	Float glass mid-iron 4mm
#6		Air/Argon 16mm	HPC
#7		Low-E	Air/Argon 16mm
#8		Float glass mid-iron 4mm	Float glass mid-iron 4mm
Transmission range	0.002 – 0.667	0.002 – 0.685	0.002 – 0.609
g-value range	0.322 – 0.679	0.161 – 0.538	0.155 – 0.345

Thermal Performance Evaluation: Model Build up



Shoe Box model using BESTEST Case 600 Low Mass Building and IDA ICE software

Conditions

- Room: 8x6x2.7m
- Window area: 12m^2
- Occupied hours: 8am-6pm weekdays
- No occupancy weekends or holidays
- Occupant density was 0.1 Ppl/m2
- Ventilation rate 2l/s/person (58l/s)
- Heating setpoint: 21^{0}C
- Heating setback temperature when unoccupied: 12^{0}C
- Cooling setpoint: 24^{0}C
- Cooling setback temperature when unoccupied: 50^{0}C
- Minimum internal natural day light: 300 lux for at least 50% of the annual occupied hours (8am-6pm)

Thermal Performance Evaluation: Model KPIs

- **Energy**
  Heating and Cooling Energy consumed in kWh

- **ASE**: Annual Solar Exposure, Daylight control
  % space too much direct sunlight
  (>1000 Lux for > 250 occupied Hours)
  Risk of glare and visual discomfort
  Max acceptable daylight level

- **sDA**: Spatial Daylight Autonomy, Daylight availability
  % floor area with > 300 lux & > 50% Occupied Hours
  Min acceptable daylight level

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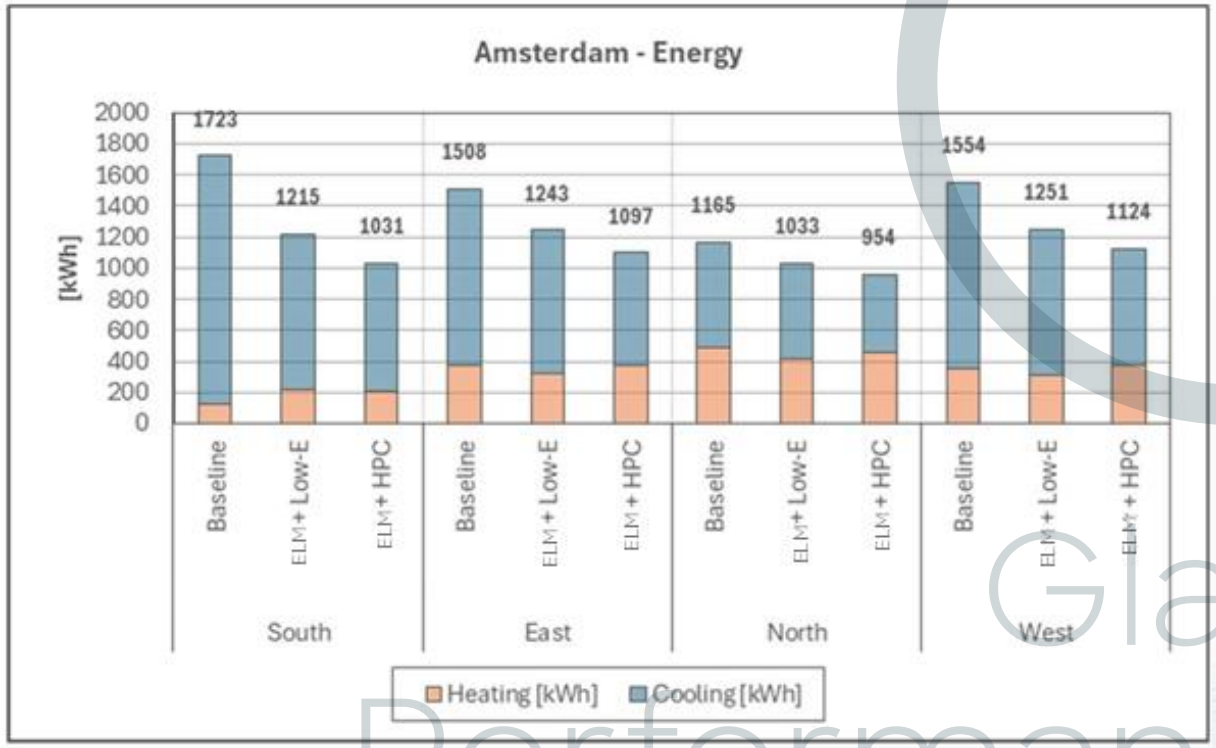
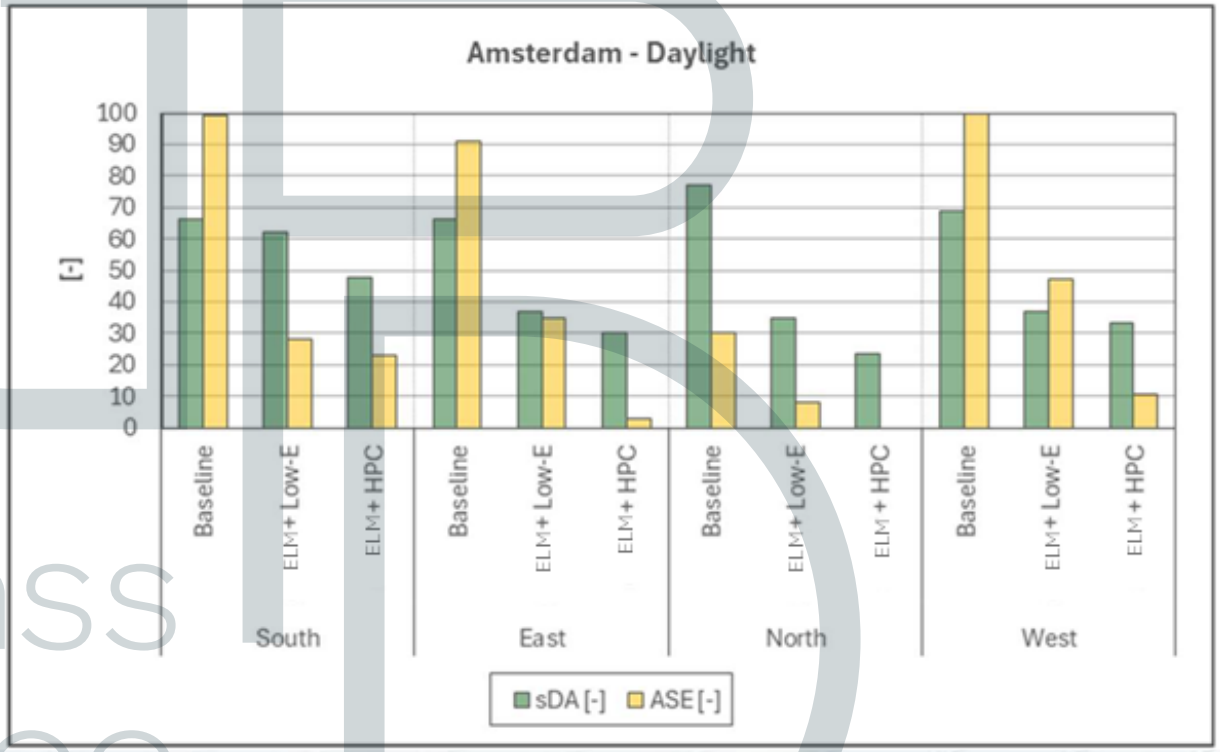
ELM integrated DGU Thermal Performance: Amsterdam





Conclusions

- Commercial based modeling with realistic conditions of minimum natural light conditions during occupied hours

- Significant energy savings via ELM integrated DGU with Amsterdam climate

  Beneficial on cooling but high heating required due to lower transmission compared to non dynamic windows.

- South facades show strongest energy savings