INFINITE
BUILDINGRENOVATION
Industrialised envelope solutions

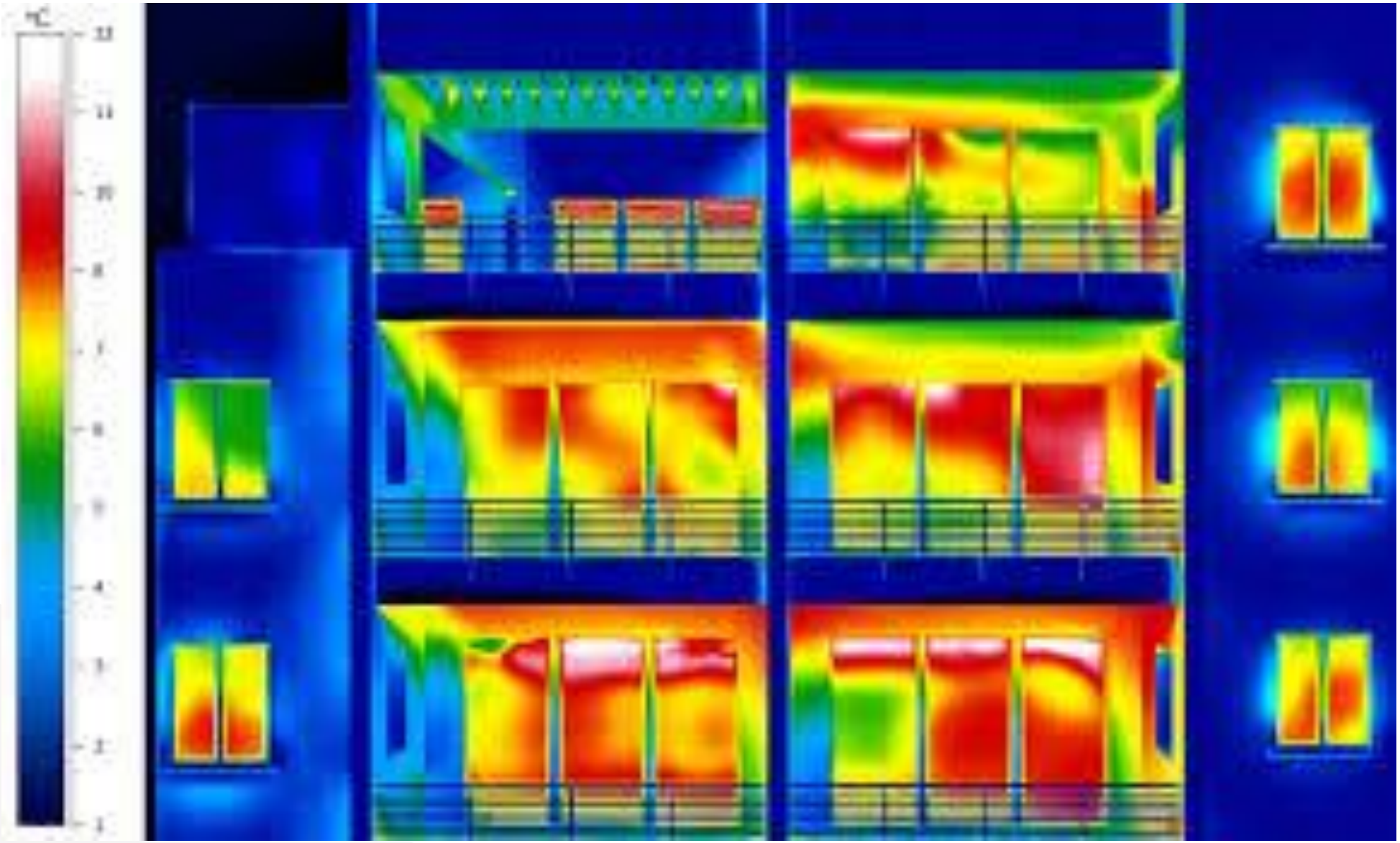
Smart Dynamic Glazing for Energy Efficient Building Envelopes

Michele Manca, LEITAT

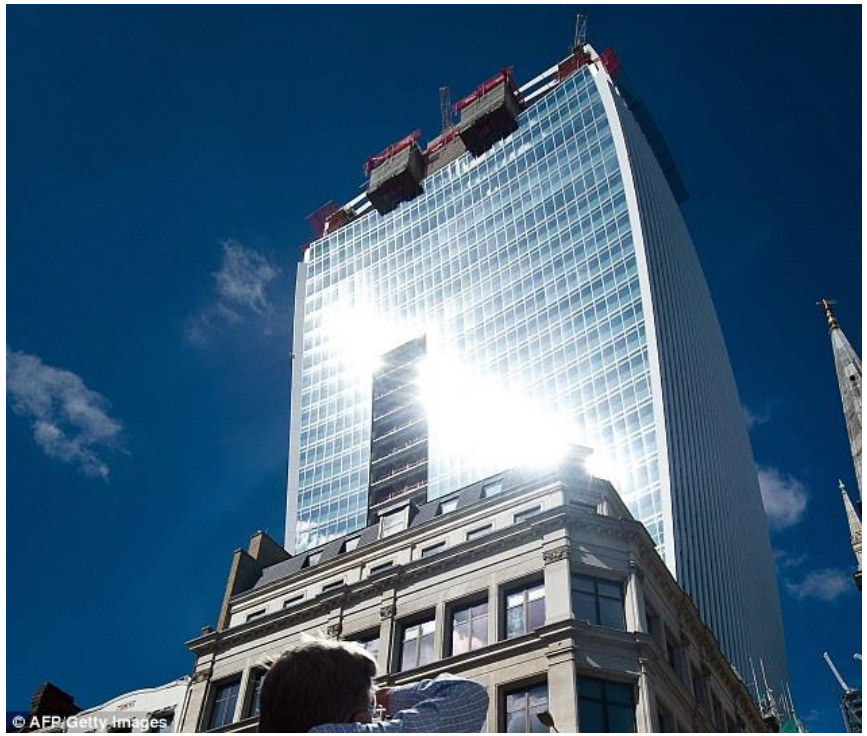
Sustainable Places 2023 - 15/06/23 - Madrid

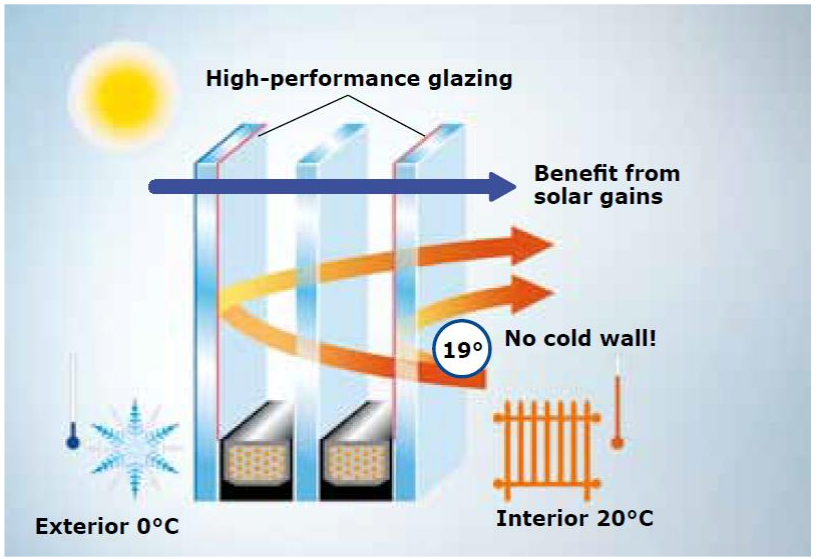
INFINITE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No **958397**

Which is the weakest building's energy component?

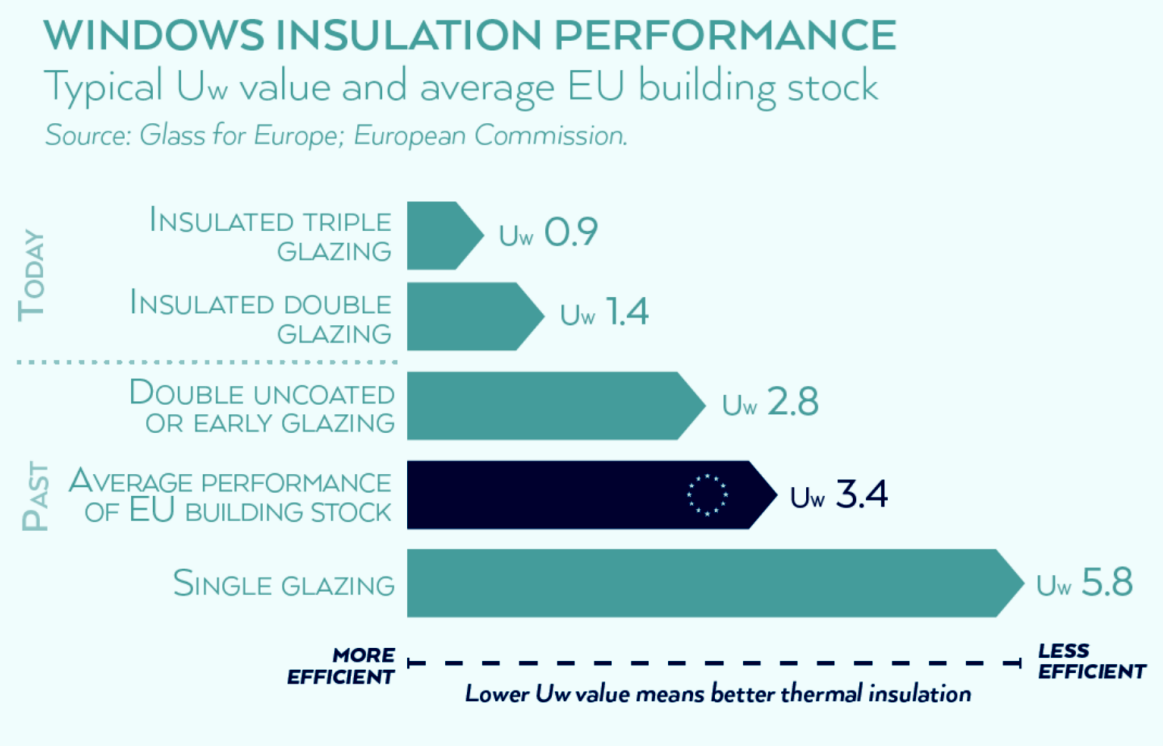


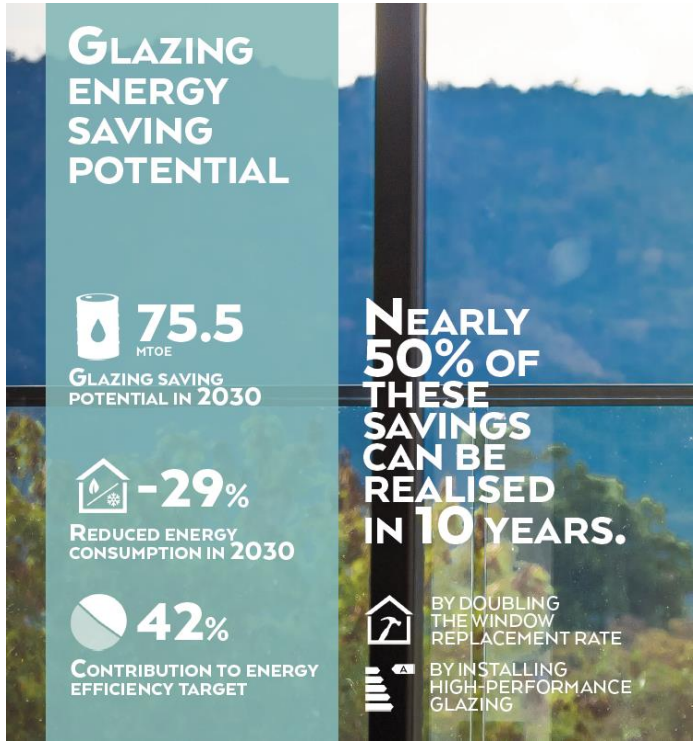
CAN WINDOWS MITIGATE THE NEED FOR AIR CONDITIONING IN BUILDINGS ?



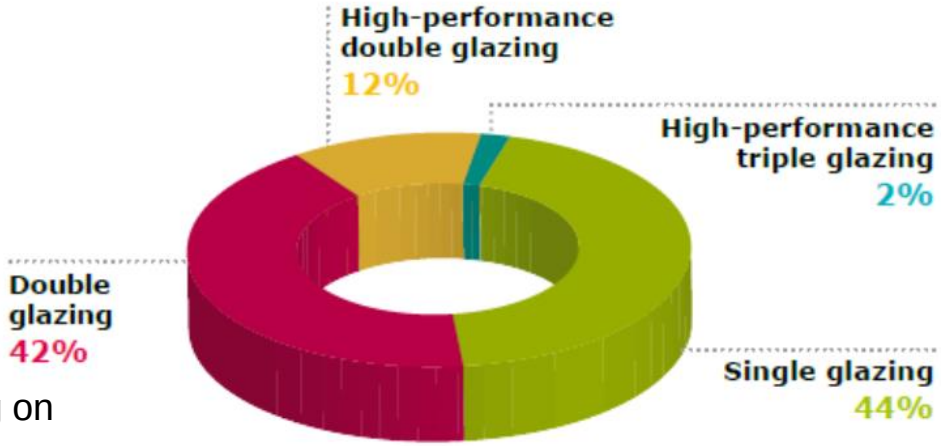


IMPACT OF WINDOWS THERMAL PERFORMANCES





If buildings were clad with high-performance double glazing, **90 million tons of CO_2 could be saved** every year in Europe, i.e. the equivalent emissions of **9.8 million Europeans** over one year.



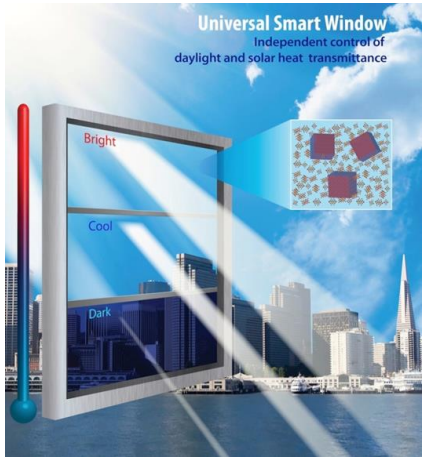
SOURCE: TNO 2019 R10442. Potential Impact of High Performance Glazing on Energy and CO_2 Savings in Europe

EVOLOUTION OF GLAZING TECHNOOGIES

- **1973: Typical Window:**
  - clear, single glazed,
  - double or storm window in north,
  - $U_{average}$ = 4.8 W/m²-K

- **2003: Typical Window:**
  - 95% double glazed
  - 50% have a low-E coating
  - 30-65% energy savings vs. 1973
  - $U_{average}$ = 2.5 W/m²-K

- **2030: Future Window:**
  - Zero net energy use (typical)
    - Net winter gain; 80% cooling savings
  - $U_{average}$ = .6 W/m²-K
  - Dynamic solar control

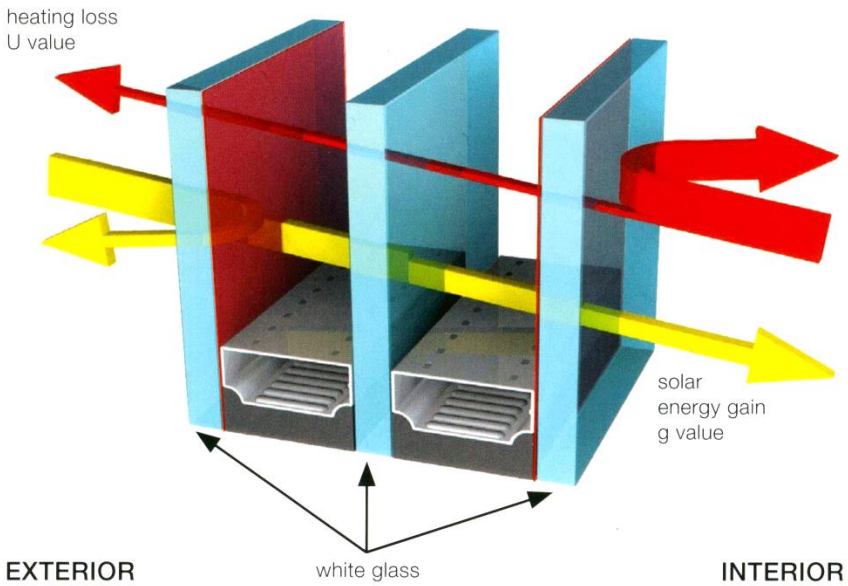


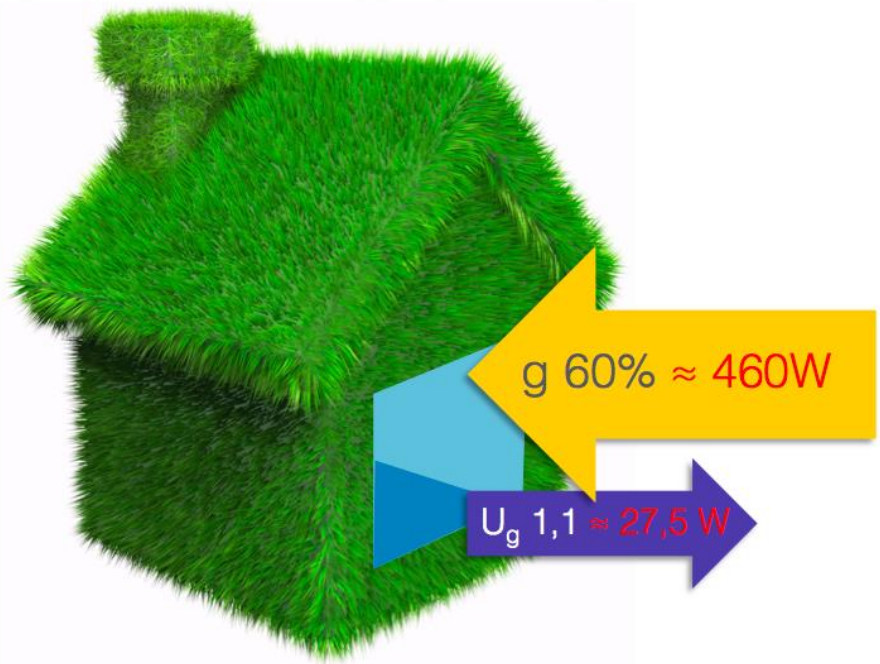
ASTM E971-11, EN 410, and ISO 9050 are the most commonly applied standards for energy performance calculation for glazed areas.

THE IMPORTANCE OF G-FACTOR

Winter: A double glass with a low-e coating has Ug value of 1.1 W/m^{2}K, if we have 20°C inside and -5°C outside the house, the heat flow generated by the Thermal Transmittance is 25°C x 1 m^2 x 1.1 , so 27,5W.

Summer: in the worst case during summer, the radiation on a vertical surface can get up to 765W/m^2. This means that if a double-glazed with low-e coating has a solar factor of 60% (or 0.60) the solar energy passing through that window will be around 60% of 765W, or about 460W.





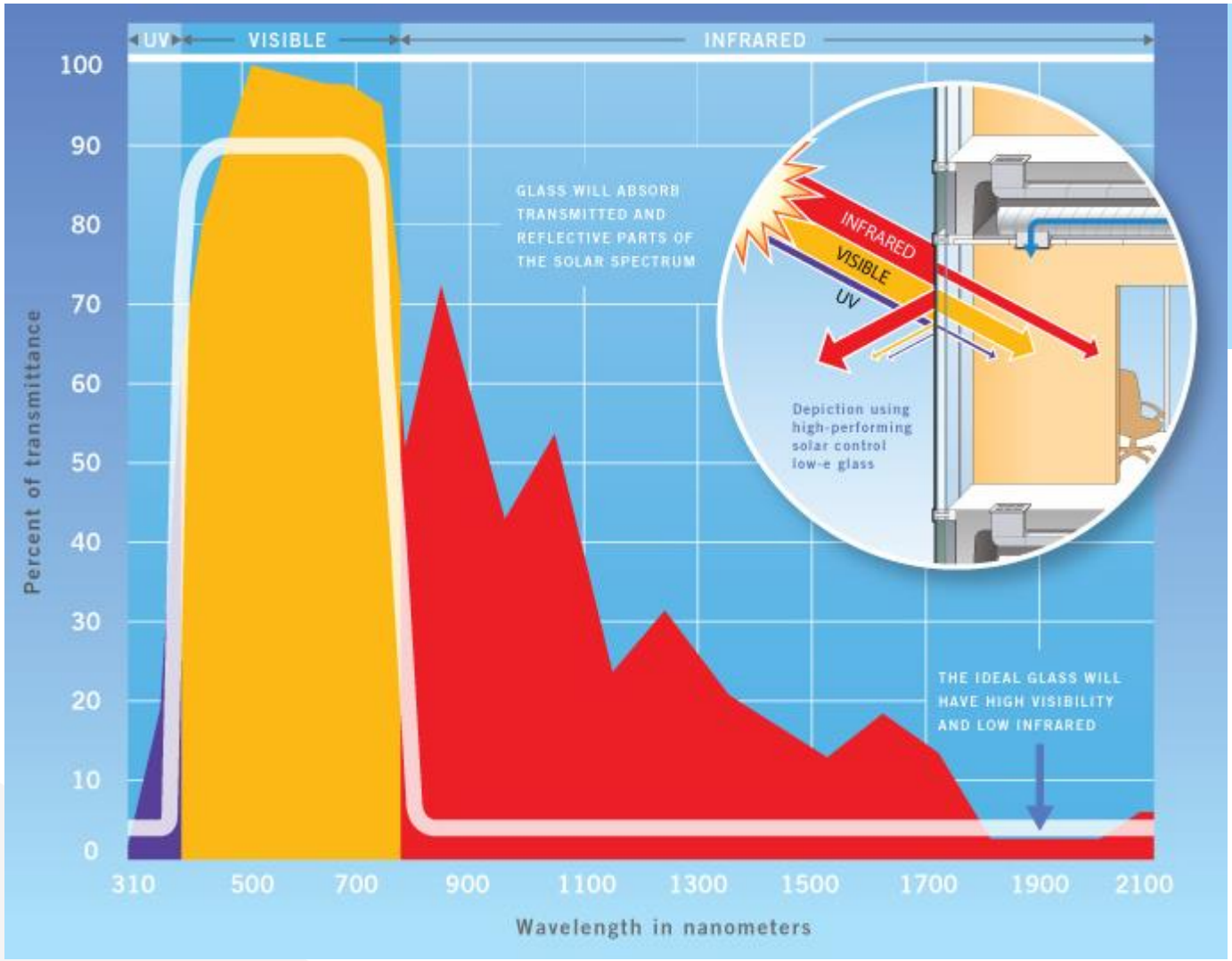
Source: GlassAdvisor® / quotes by Luca Papaiz

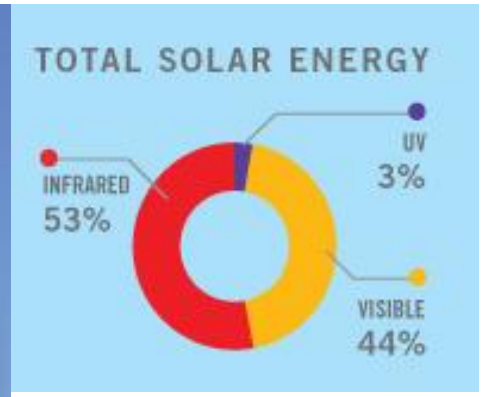
DYNAMIC CONTROL OF INCOMING THERMAL RADIATION

✓NIR RADIATION ENTERS the window when $T_{out} < T_{comfort}$ (winter sunny days /mid-seasons conditions)

✓NIR RADATION IS FILTERED OUT when $T_{out} > T_{comfort}$ (summer/ hot spring days)

SPECTRAL DISTRIBUTION OF SOLAR ENERGY





OUR SOLUTION

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

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(12) EUROPEAN PATENT APPLICATION

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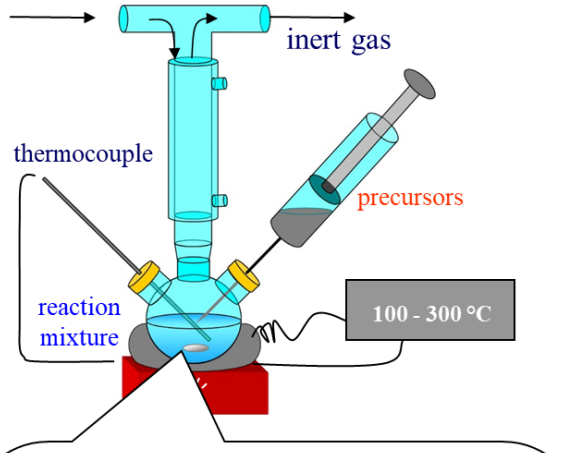
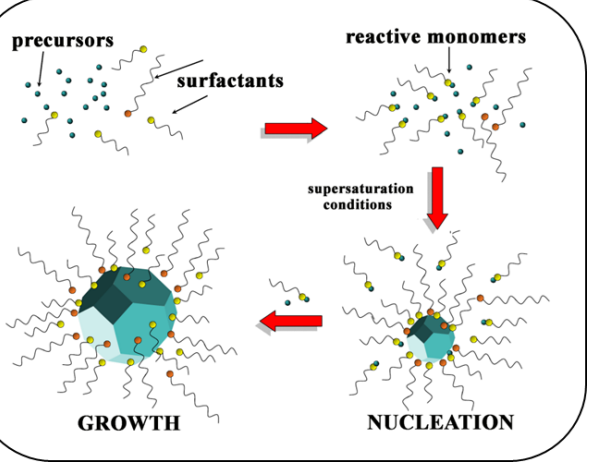
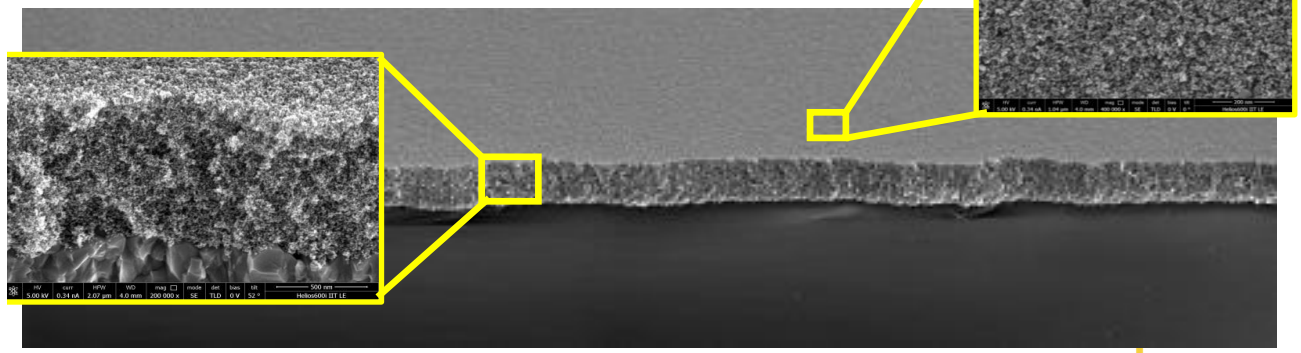
(54) **THERMO-RESPONSIVE DUAL BAND ELECTROCHROMIC DEVICE**

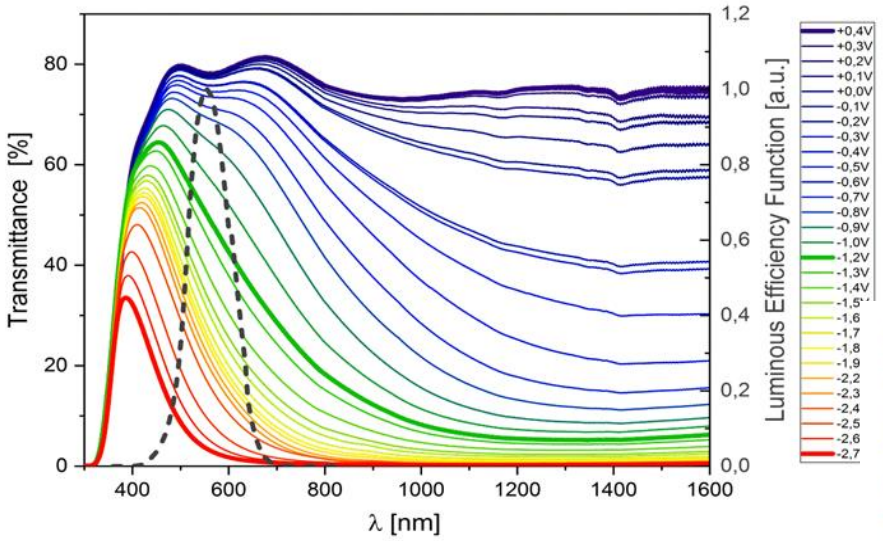
(57) It relates to a thermo-responsive dual band electrochromic device, which is capable of selectively controlling the amount of sunlight radiation transmitted in the visible and in the near-infrared regions by operating under four distinct optical regimes, namely: fully transparent, visible blocking, near-infrared blocking, and fully blocking. The device can be regulated either by an electric stimulus, namely by controlling the sign and the intensity of the applied bias voltage, or by a thermal stimulus. In the latter the attenuation of incoming thermal radiation results increased as temperature increases. The thermo-responsive dual band electrochromic device comprises a first electrode consisting of a first transparent conductive substrate (100) topped by a first electro-optically active layer (103) and a second electrode consisting of a second transparent conductive substrate (200) topped by a second electro-optically active layer (203) separated by a temperature-dependent ion conductive layer (301) consisting of a thermo-responsive polymer gel, an ion conductor and a plasticizer.

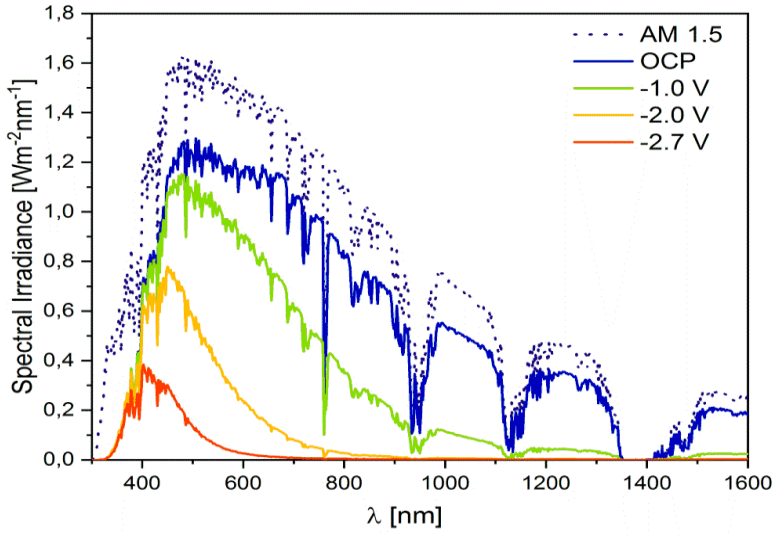




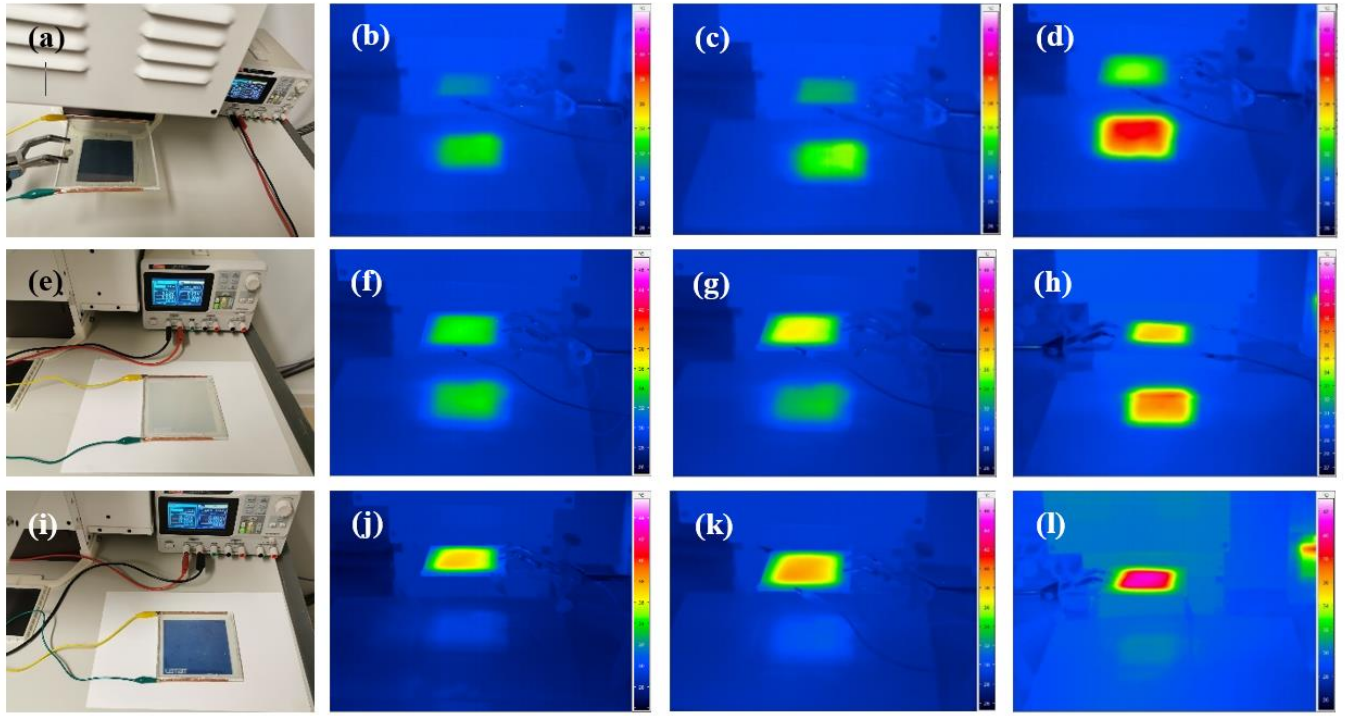


DYNAMIC CONTROL OF INCOMING THERMAL RADIATION





CLICK HERE TO WATCH THE VIDEO



Cots et al. *Energy Efficient Smart Plasmochromic Windows: Properties, Manufacturing and Integration in Insulating Glazing*, **Nano Energy**, 84 (2021) 105894

eurac research

HUYGEN INSTALLATIE ADVISEURS

LEITAT managing technologies

RUBNER holzbau

one team

BOUYGUES CONSTRUCTION

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GRÜN STATT GRAU

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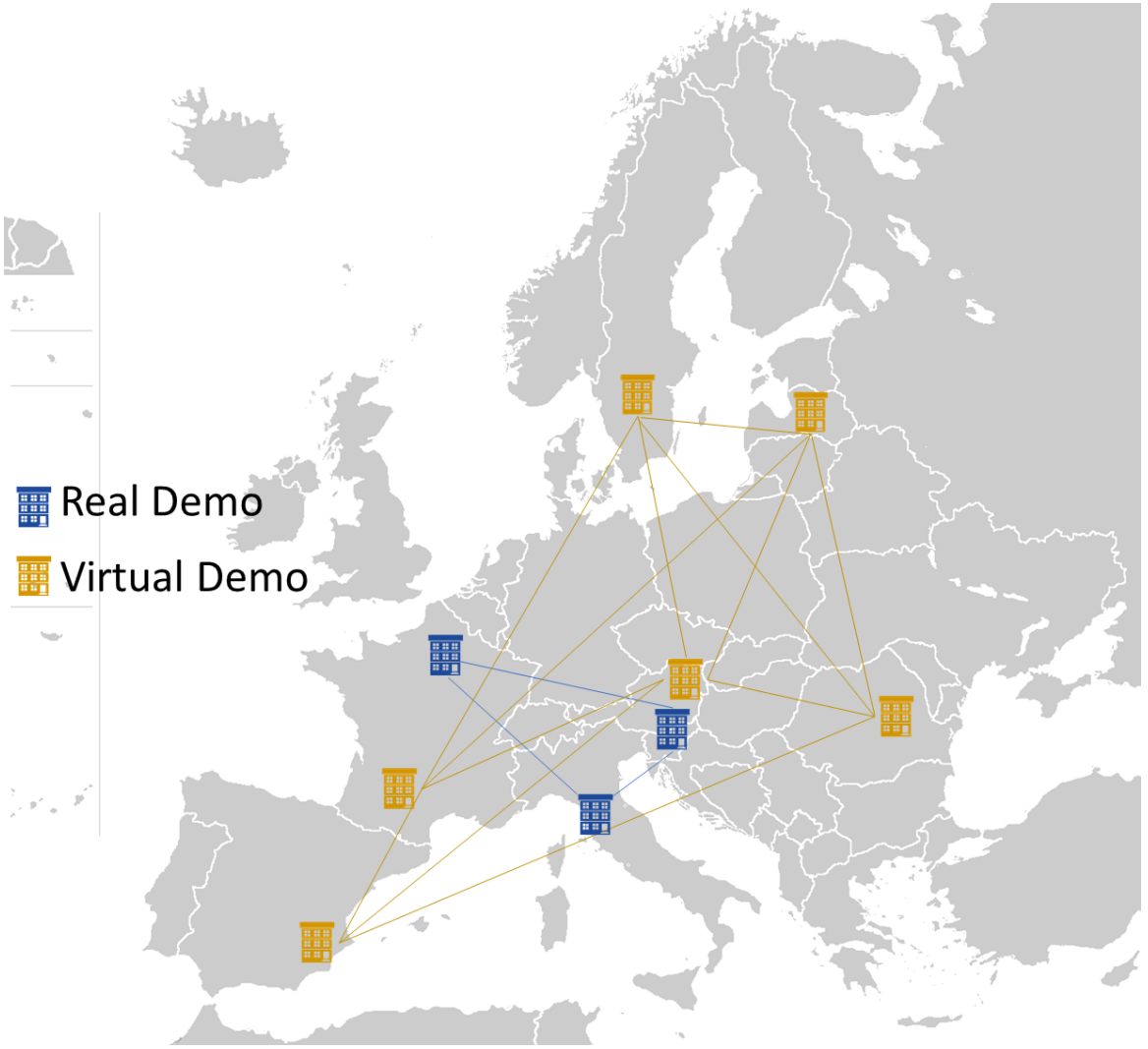
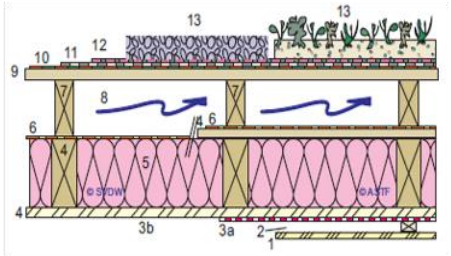


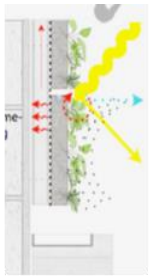
INFINITE BUILDINGRENOVATION

INFINITE/Industrialised durable building envelope retrofitting by all-in-one interconnected technology solutions project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958397

INFINITE PROJECT

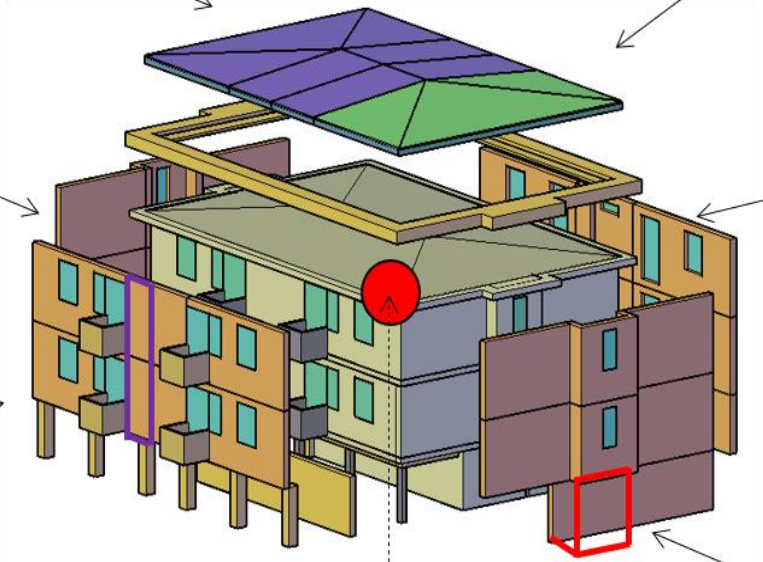
R2.4 ENERGY GENERATION BIPV KIT

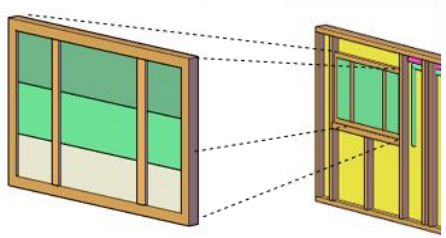




R2.1 PASSIVE ECO-COMPATIBLE & GREEN ENVELOPE

R2.5 ENERGY GENERATION BIST KIT

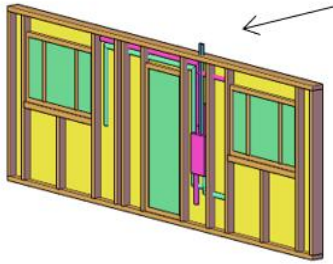




a flexible and robust window integration

R2.3 SMART WINDOW KIT

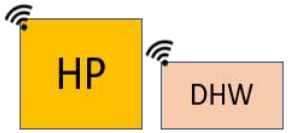
Sensing, autonomous and dynamic smart glazings



R2.2 ENERGY AND FRESH AIR DISTRIBUTION ENVELOPE KIT

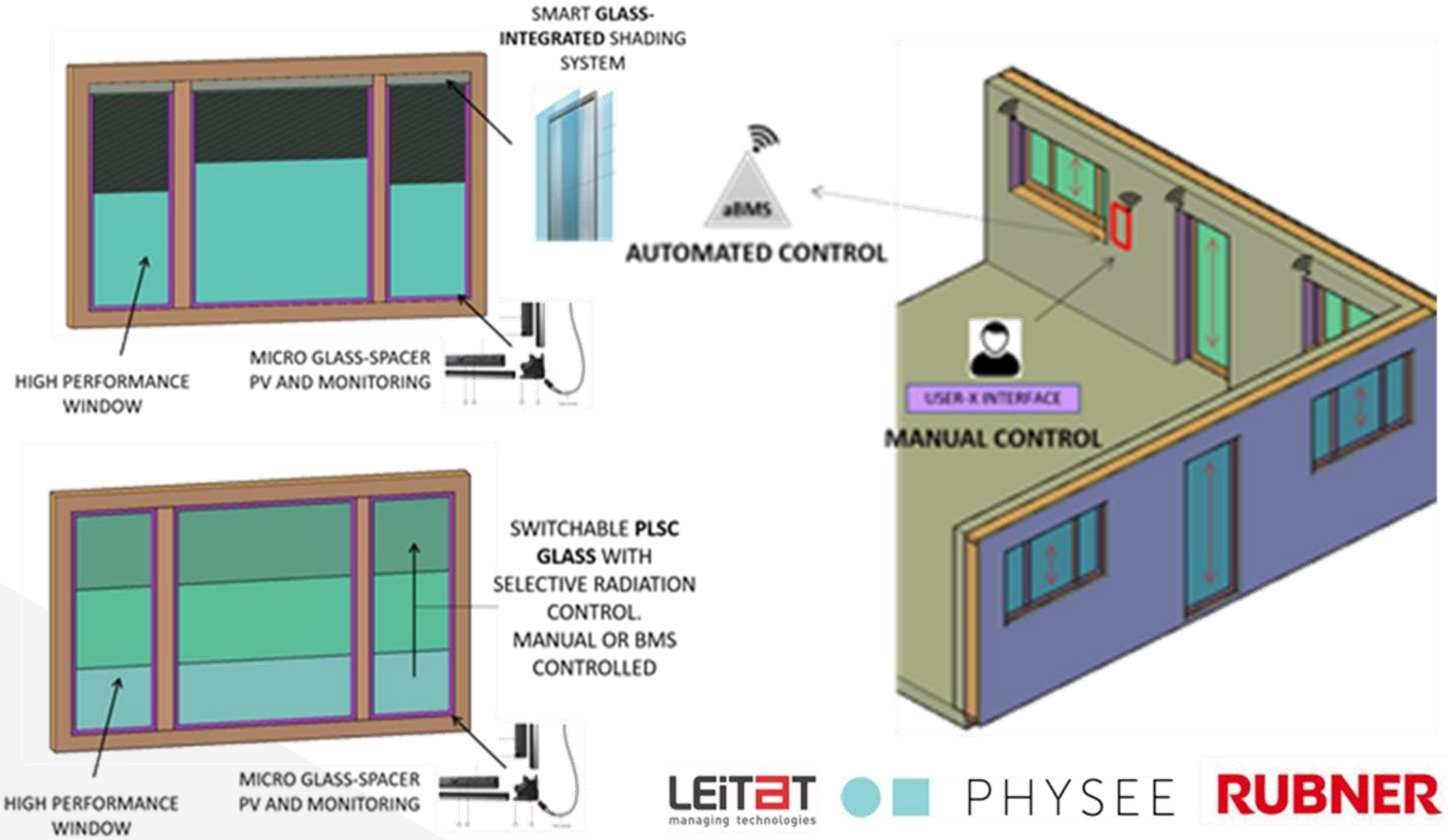
aBMS

R3 ADAPTABLE BMS AND OPTIMIZED CONTROL STRATEGIES



TRADITIONAL ENERGY SYSTEMS RENOVATION

INFINITE SMART WINDOWS KIT



LEITAT managing technologies PHYSEE RUBNER

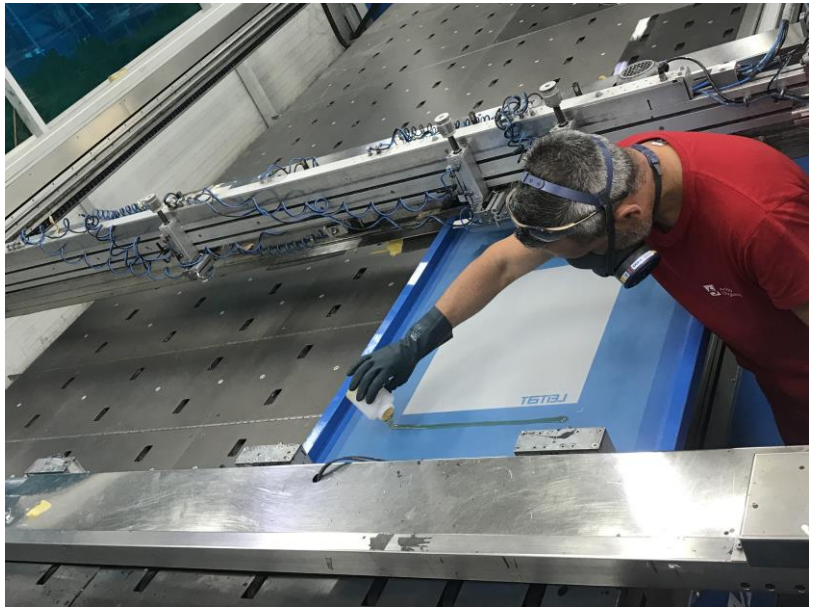
The kit as a whole proposes a unique combination of:

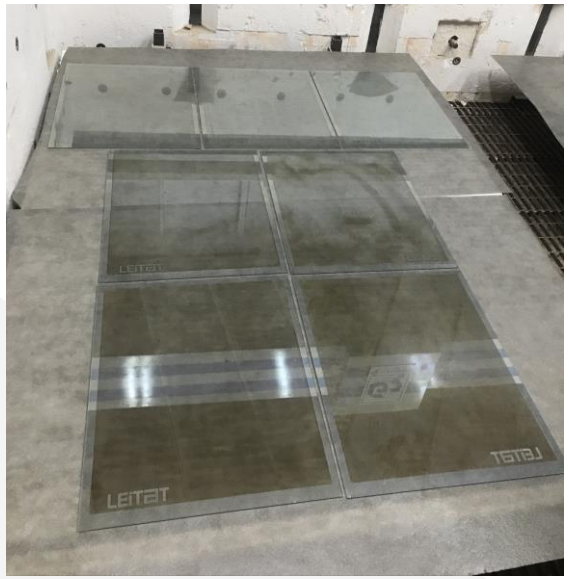
1. **easy retrofittable** glazing, with interoperable controllers for advanced shading systems
2. a **SMART DYNAMIC GLAZING** solution able to maximize the daylight and protect from the solar radiation
3. a **robust standardized interface** between the new and the existing window perimeter, assuring durable quality.

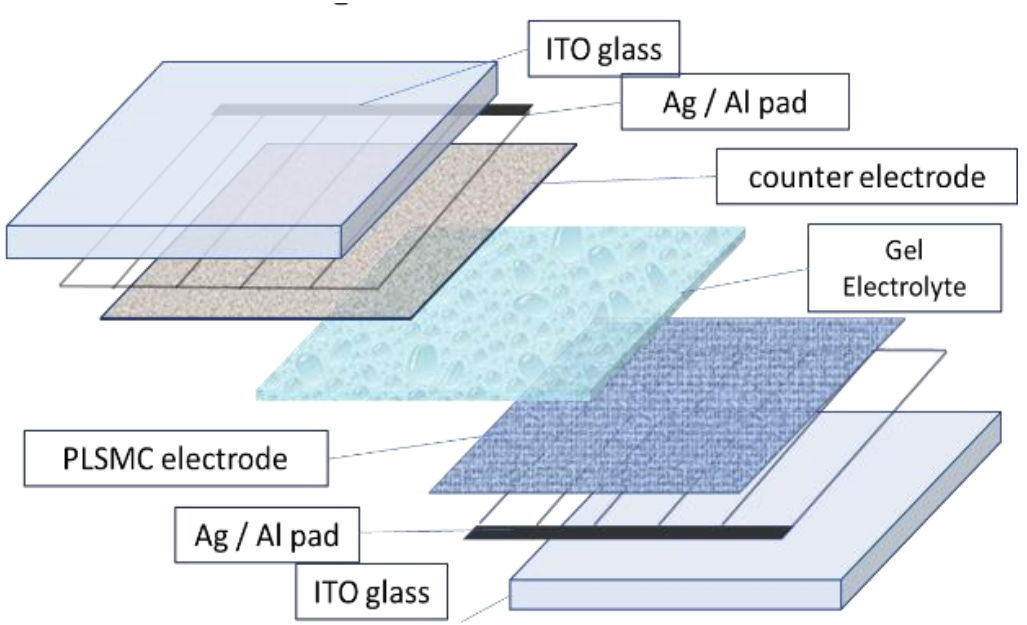
INFINITE BUILDINGRENOVATION

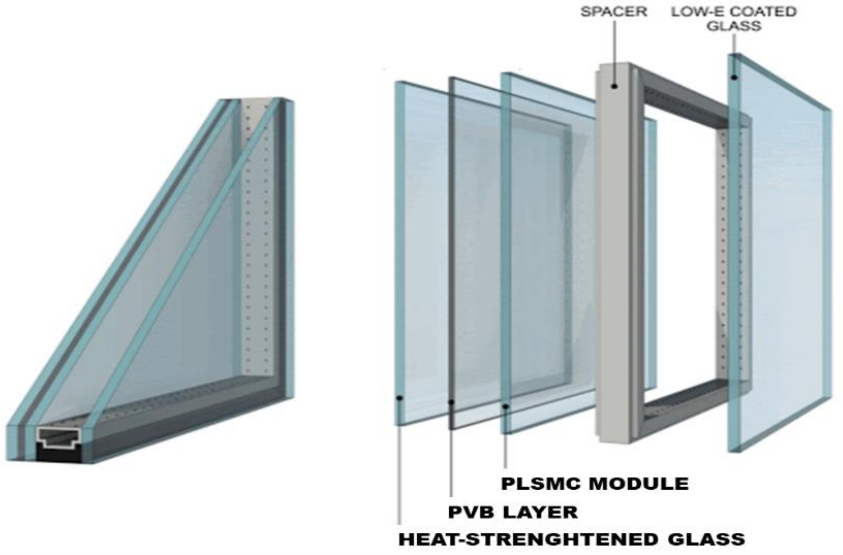
INFINITE/Industrialised durable building envelope retrofitting by all-in-one interconnected technology solutions project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958397

PLASMOCHROMIC MODULES MANUFACTURING & UPSCALING









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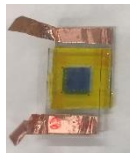
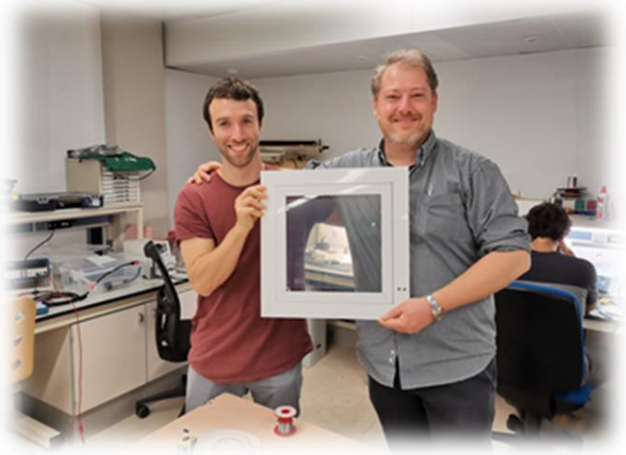
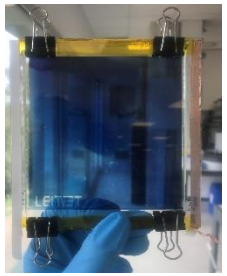


1x1 cm^2

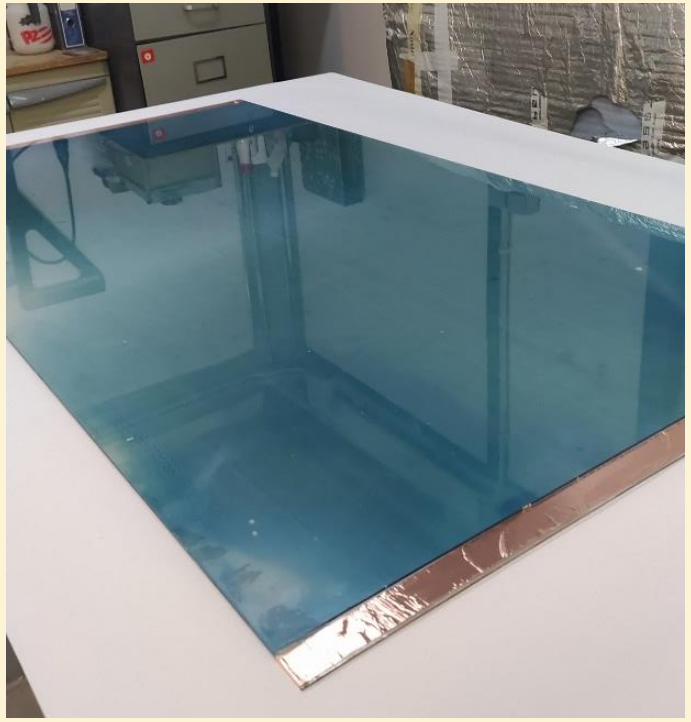




12x12 cm^2

30x30 cm^2

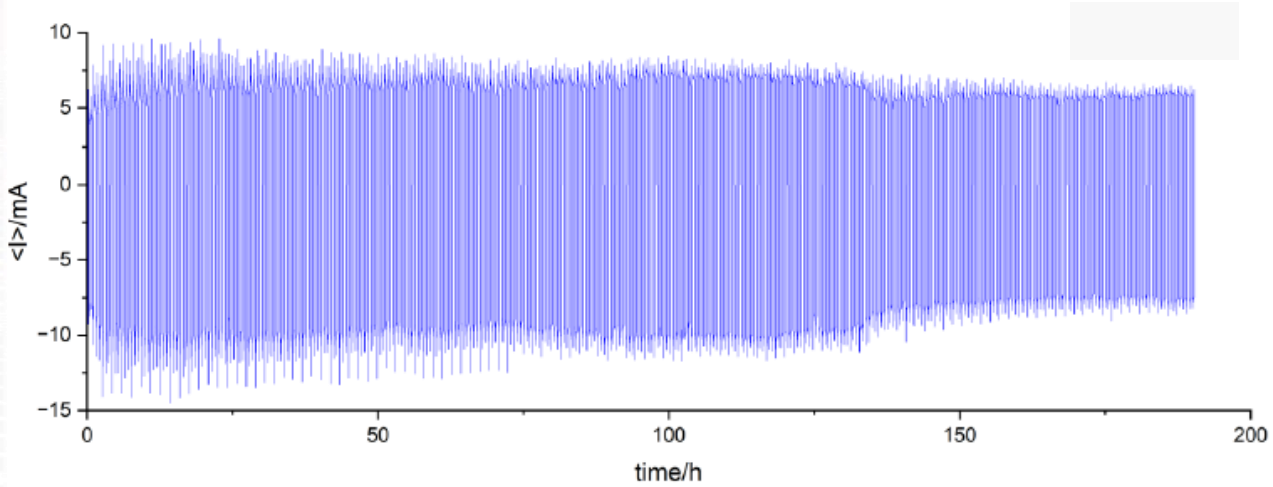
45x50 cm^2



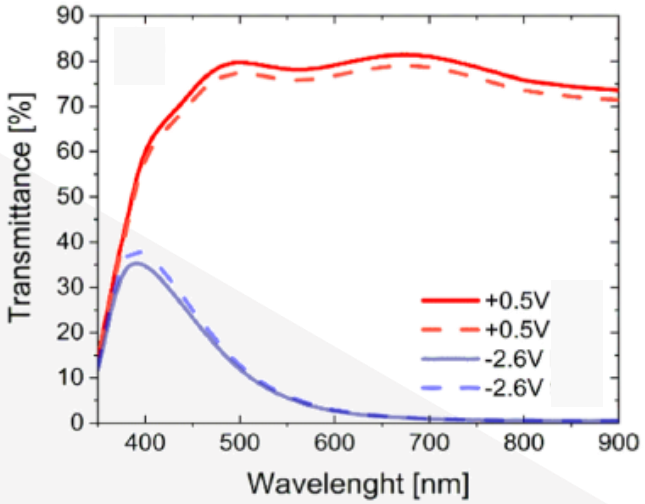
70x130 cm^2

INFINITE BUILDINGRENOVATION

INFINITE PLASMOCHROMIC MODULES @ M24



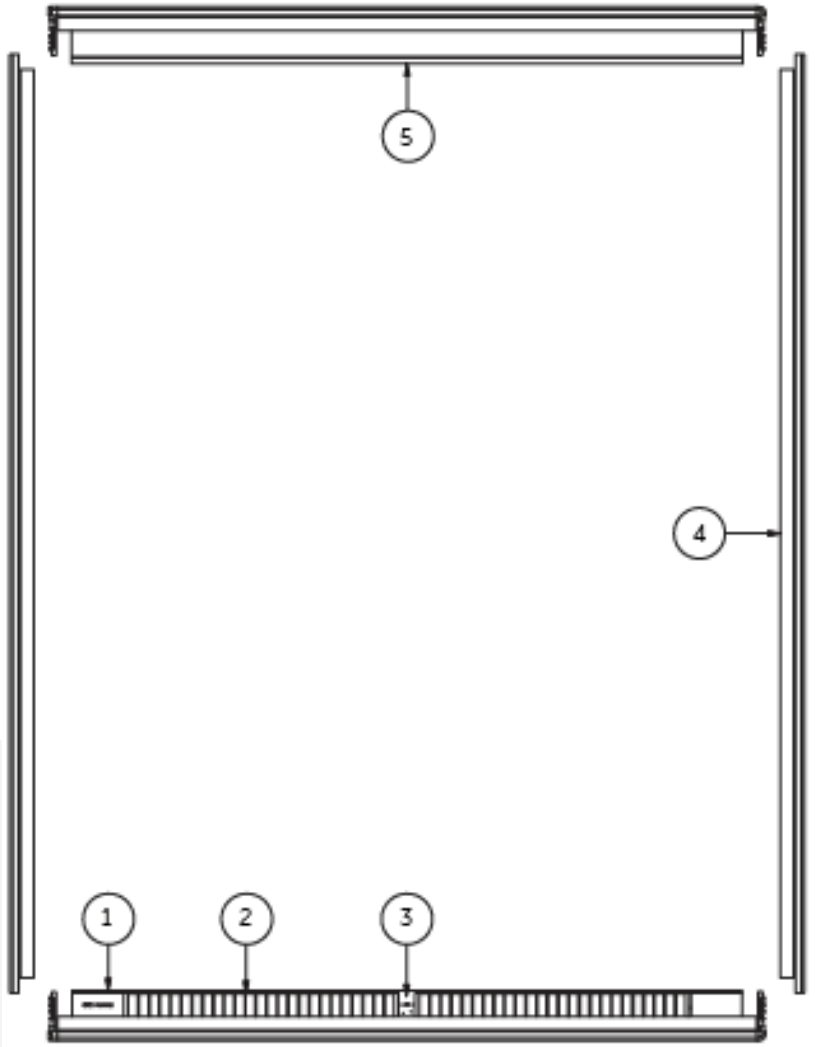
Charging/discharging ageing test carried out at 85ºC and 40 %RH.



Transmittance spectra recorded before (continuous line) and after (segmented line) ageing test.

LEITAT PLSMC MODULE	
Maximum Optical Modulation	0.1 % < T_{NIR} < 74 %
	5% < T_{LUM} < 72 % (EN 410)
Spectral Selectivity	T_{LUM} /T_{SOL} > 1.5 (in COOL MODE)
Switching Speed	$T_{col,600nm}$ < 3min $T_{bleach,600nm}$ <10min
	$T_{col,1500nm}$ < 1min $T_{bleach,1500nm}$ <15min
Abs. Power Density	< 500 mW / m^2
Electrochemical Stability	> 10000 col/bleach cycles at RT
Thermal Stability	> 500 cycles at 85ºC and 40 % RH

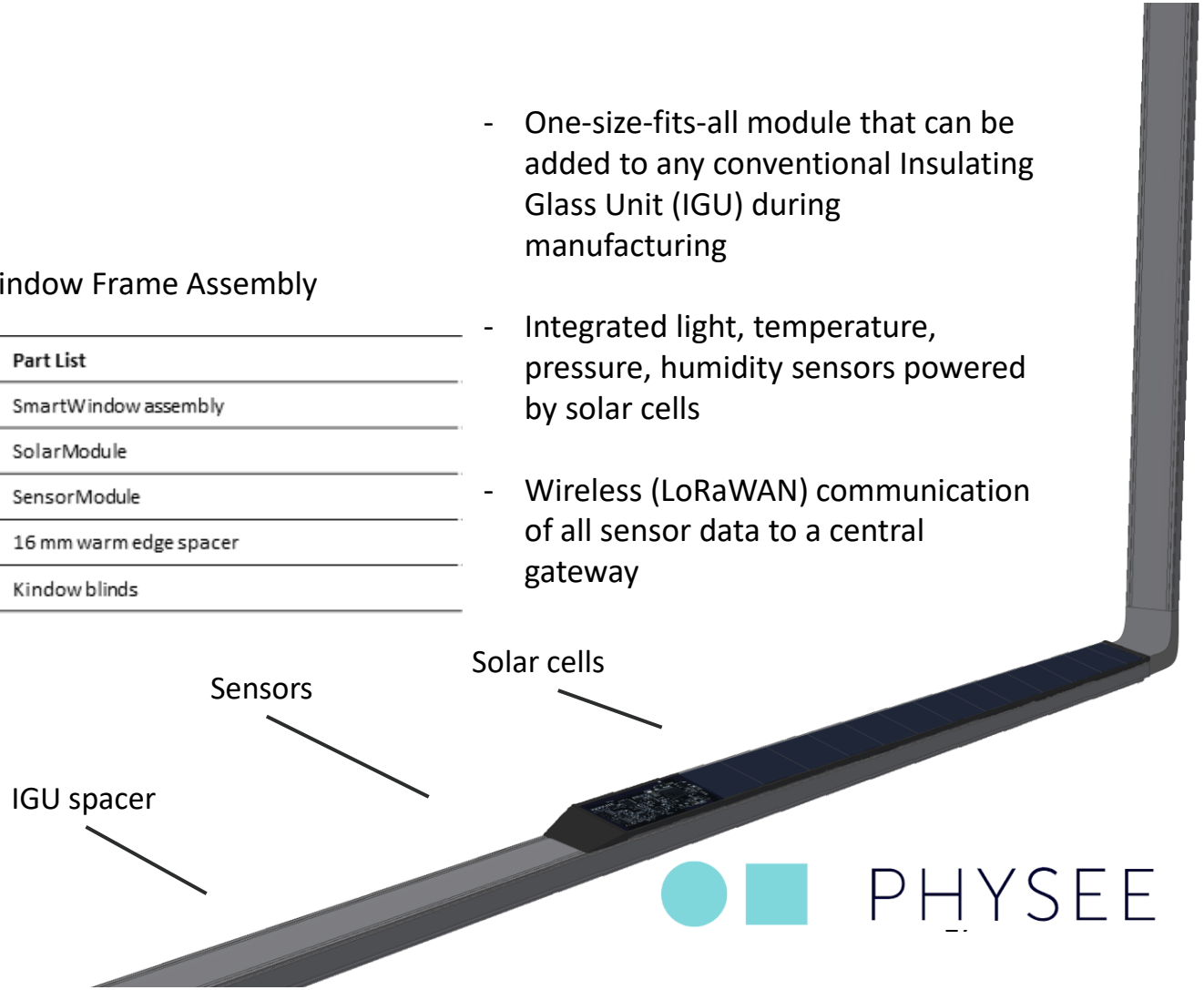
INFINITE SMART WINDOWS KIT



Smart Window Frame Assembly

item	Part List
1	SmartWindow assembly
2	SolarModule
3	SensorModule
4	16 mm warm edge spacer
5	Kindow blinds

- One-size-fits-all module that can be added to any conventional Insulating Glass Unit (IGU) during manufacturing
- Integrated light, temperature, pressure, humidity sensors powered by solar cells
- Wireless (LoRaWAN) communication of all sensor data to a central gateway



PHYSEE

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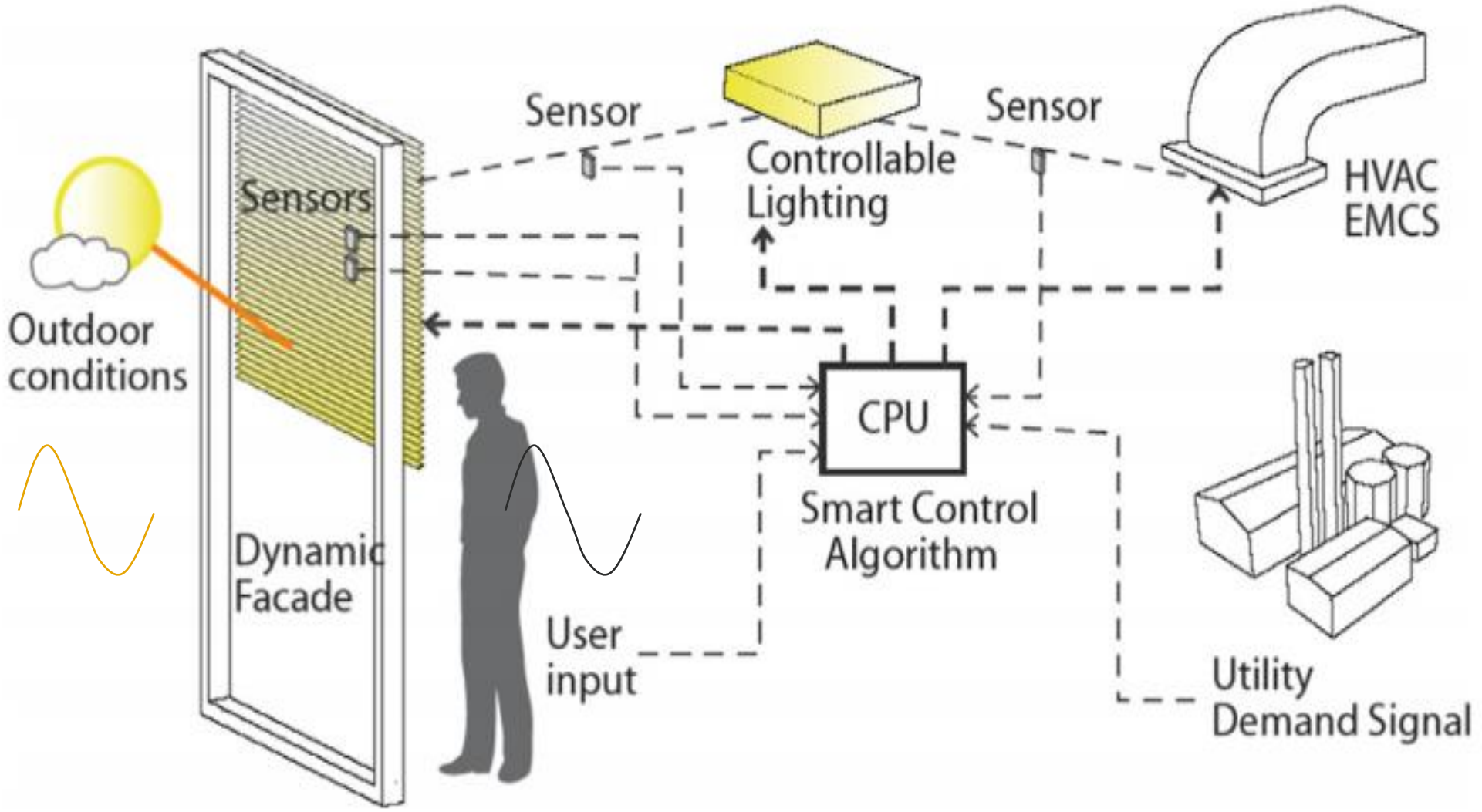
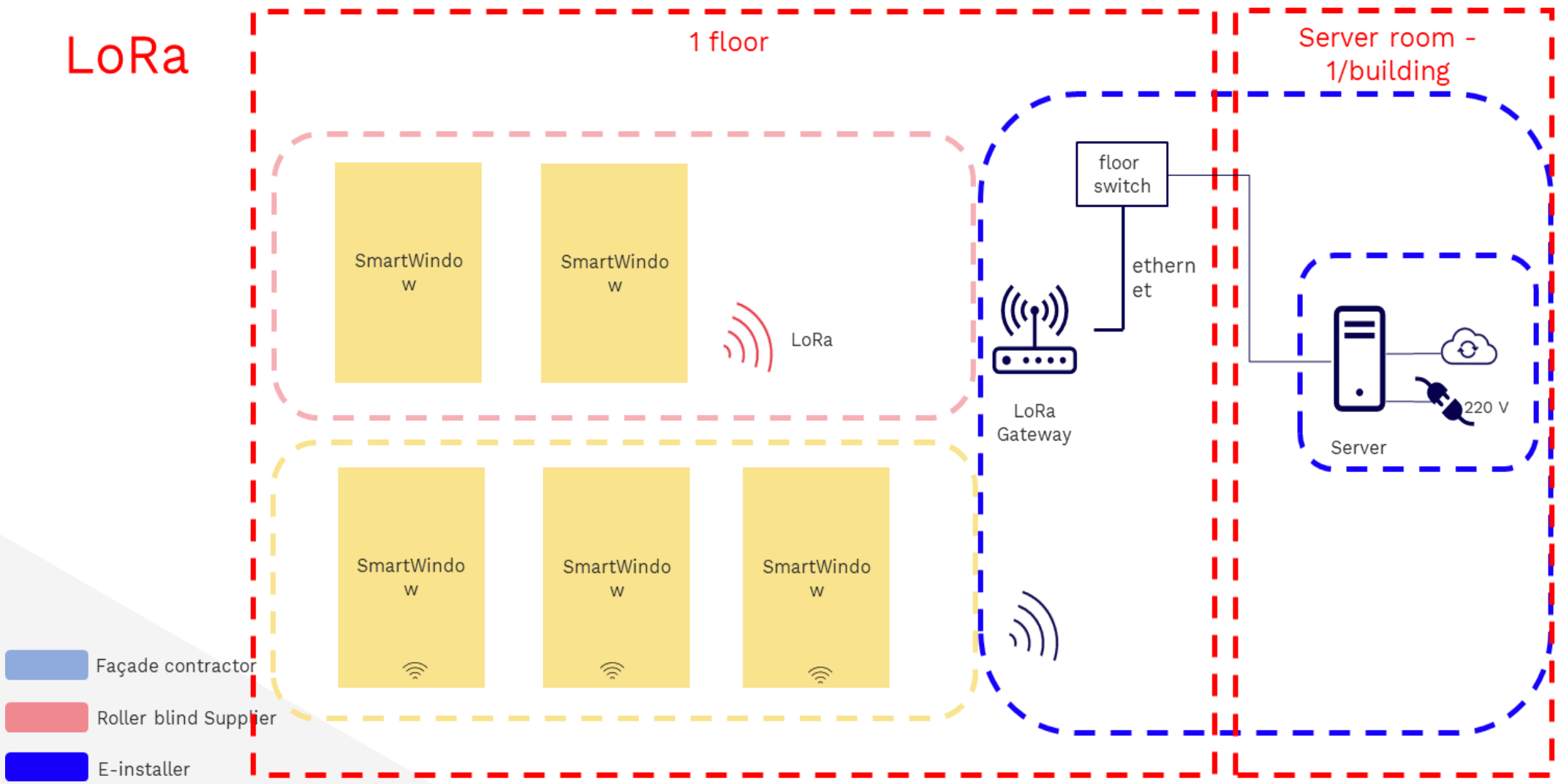
TOWARDS IOT-DRIVEN ACTIVE CONTROL OF SOLAR RADIATION



M. Konstantoglou, A. Tsangrassoulis, Dynamic operation of daylighting and shading systems: A literature review, *Renewable and Sustainable Energy Reviews*, **2016**, 60, 268-283.

WINDOW'S CONTROL UNIT INTERFACE WITH BMS: FUNTIONAL SCHEME



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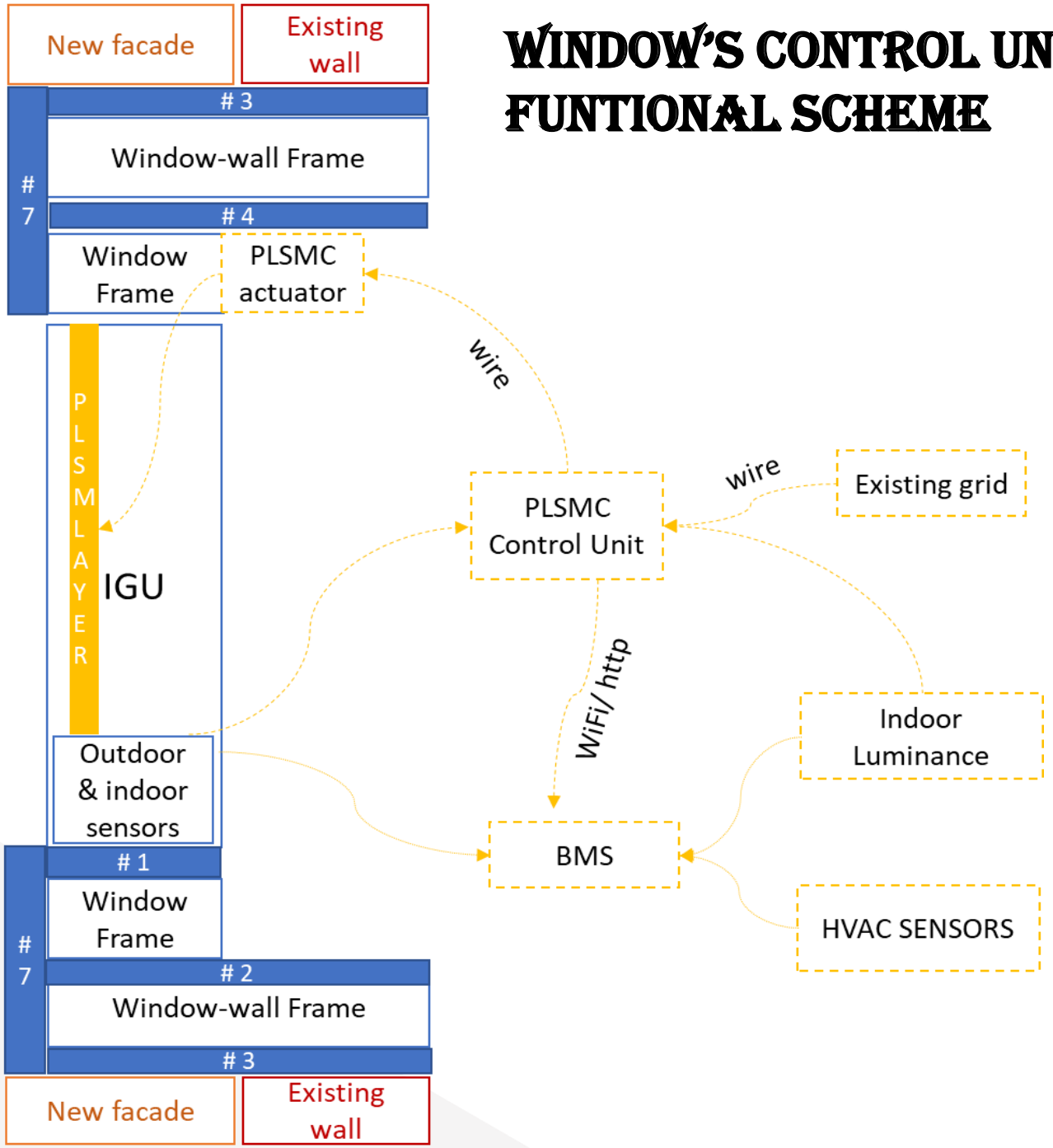
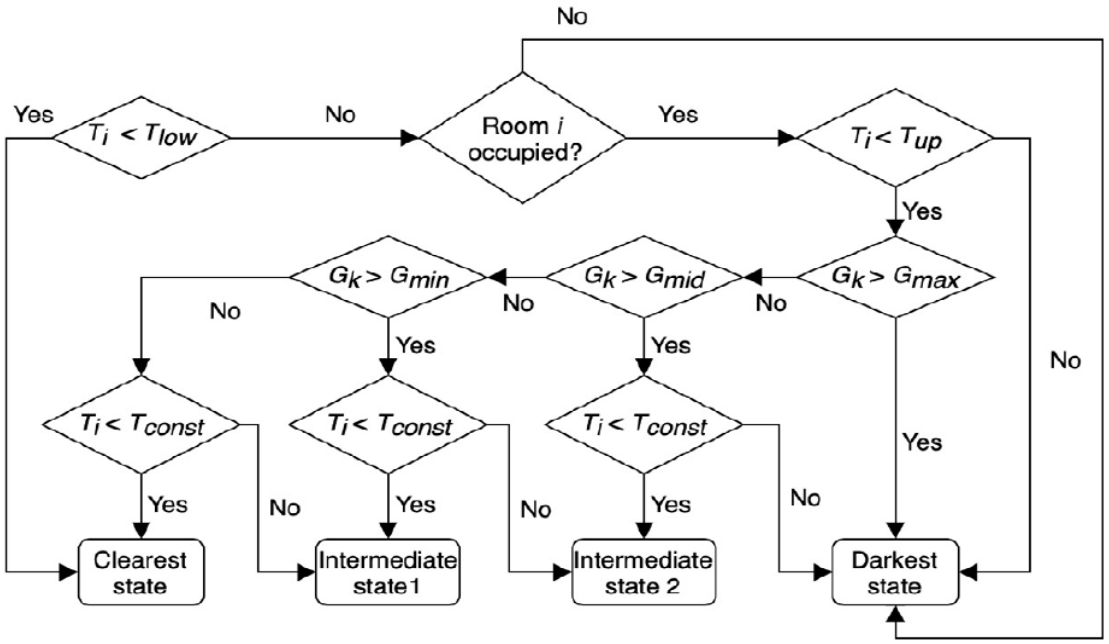


THE IMPORTANCE OF CONTROL: EXAMPLE OF PREDICTIVE ALGORITHM



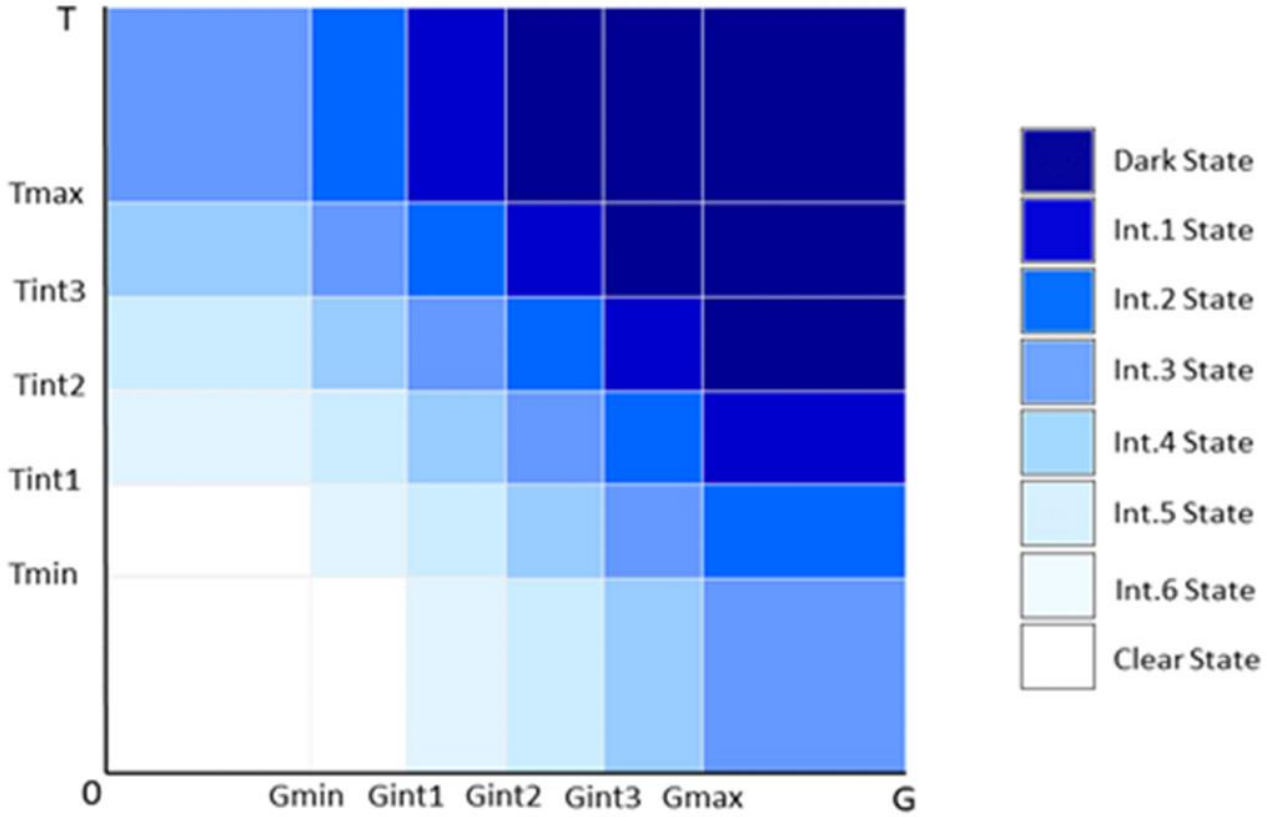
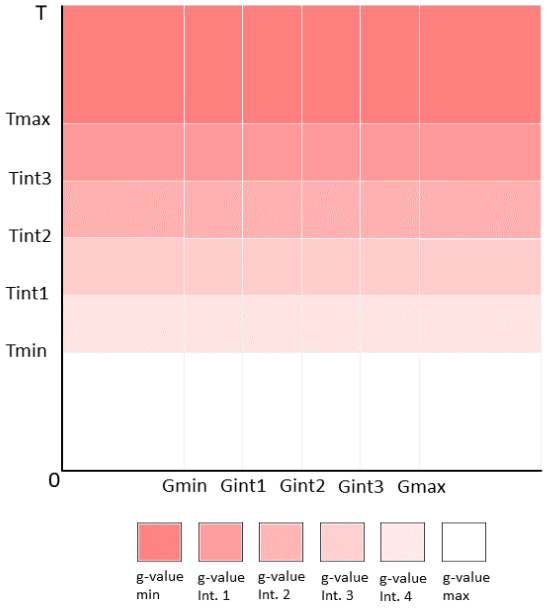
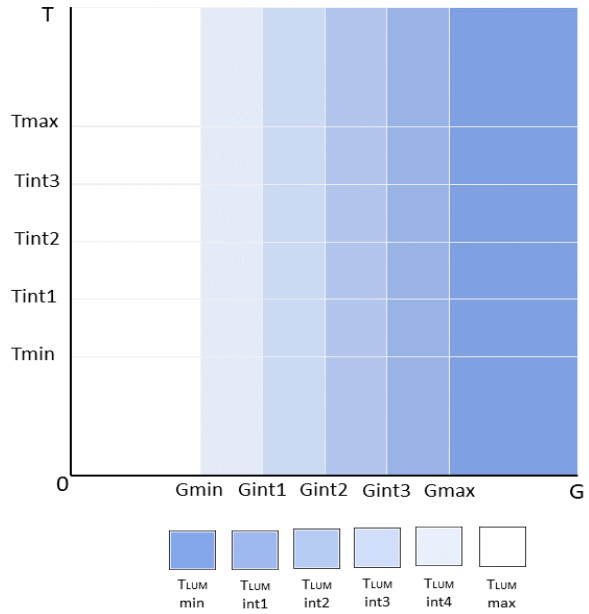


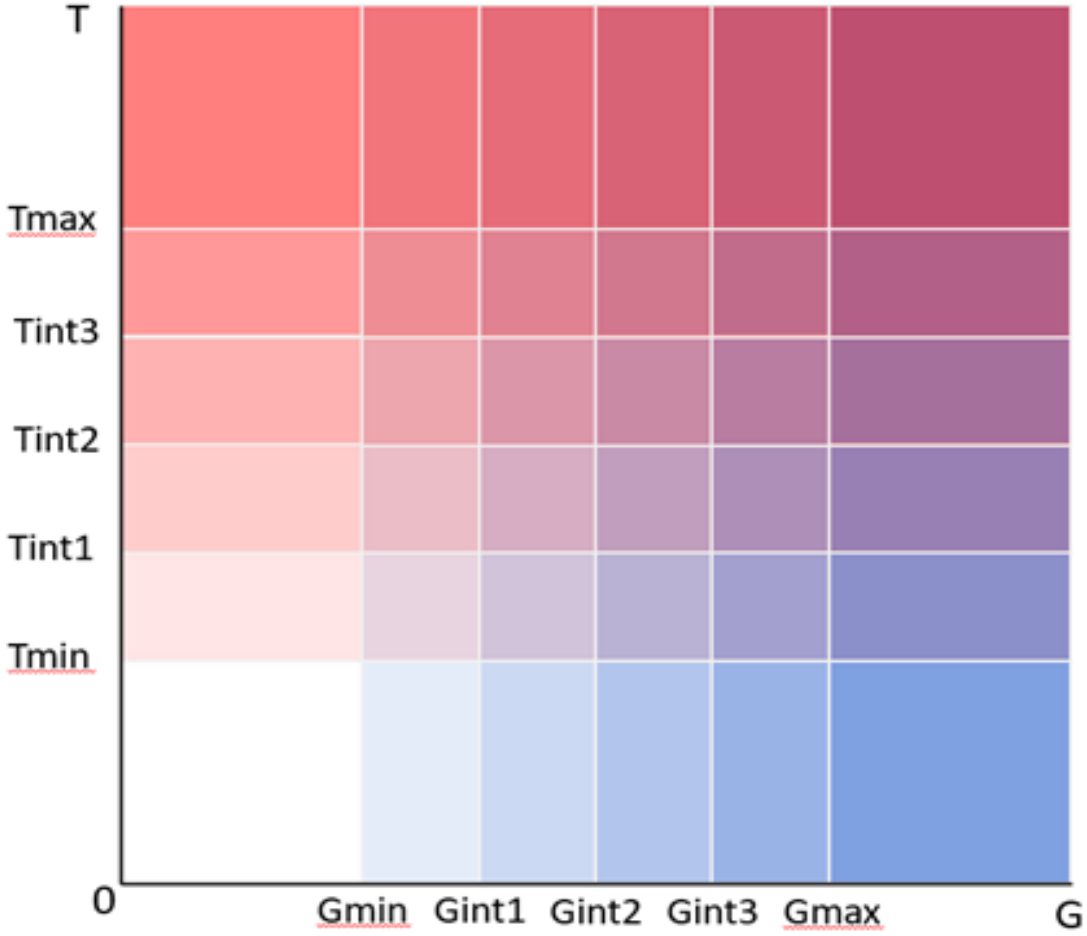
Table 10
Summary of control parameters.

Parameter
External temperature threshold
Lower temperature threshold, T_{low}
Upper temperature threshold, T_{up}
Minimum irradiance threshold, G_{min}
Occupancy
Maximum irradiance threshold, G_{max}

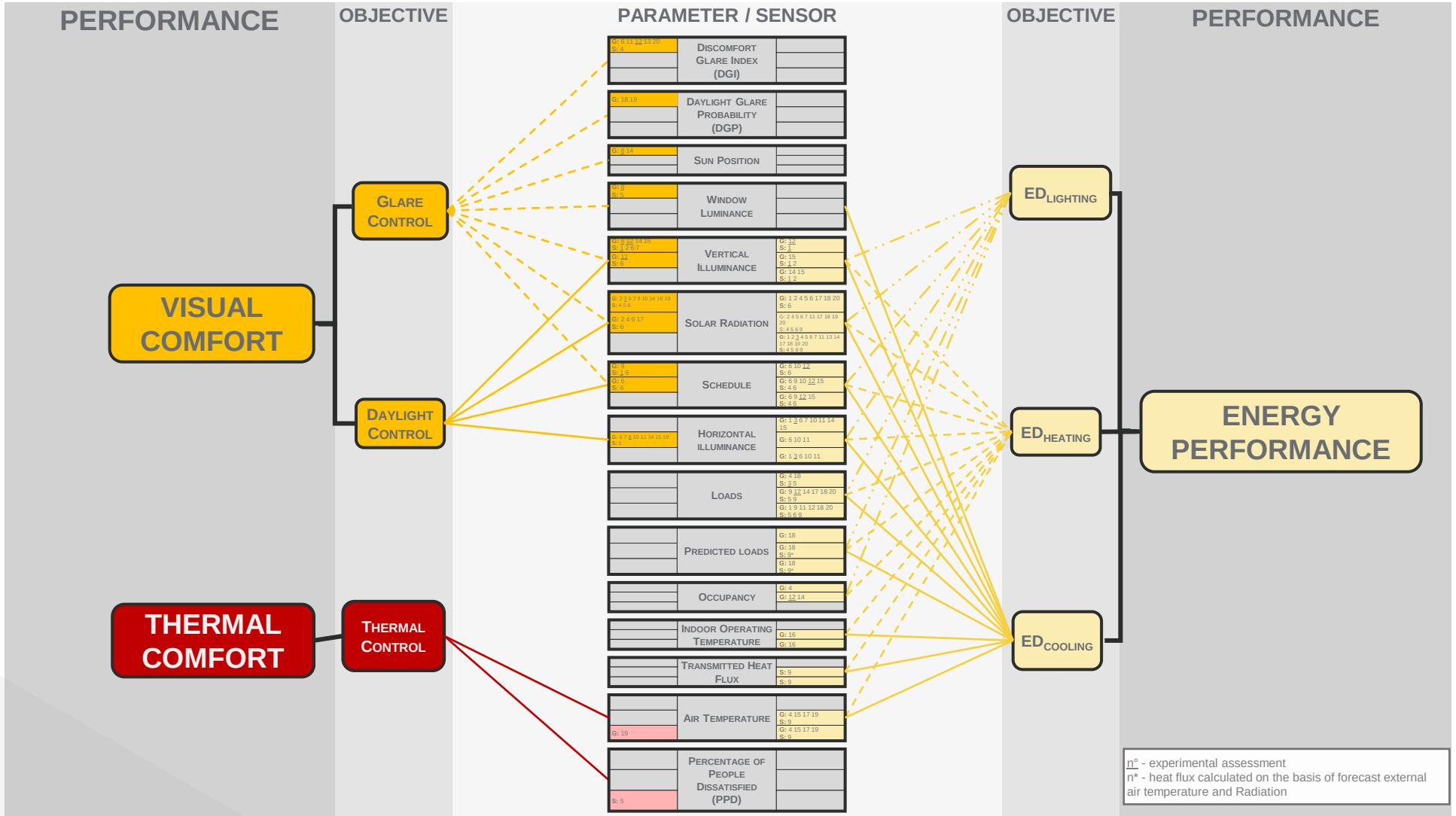
THE IMPORTANCE OF CONTROL: EXAMPLE OF PREDICTIVE ALGORITHM







TOWRADS AN INTELLIGENT SELF-RESPONDING BUILDING SKIN



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INFINITE
BUILDINGRENOVATION

Thank you

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