

# Polymer-based Facades

Embodied, operational, and circular potentials

**Material**

Plastic/Polymers

**System**

Dynamic/Kinetic

Passive

Hybrid

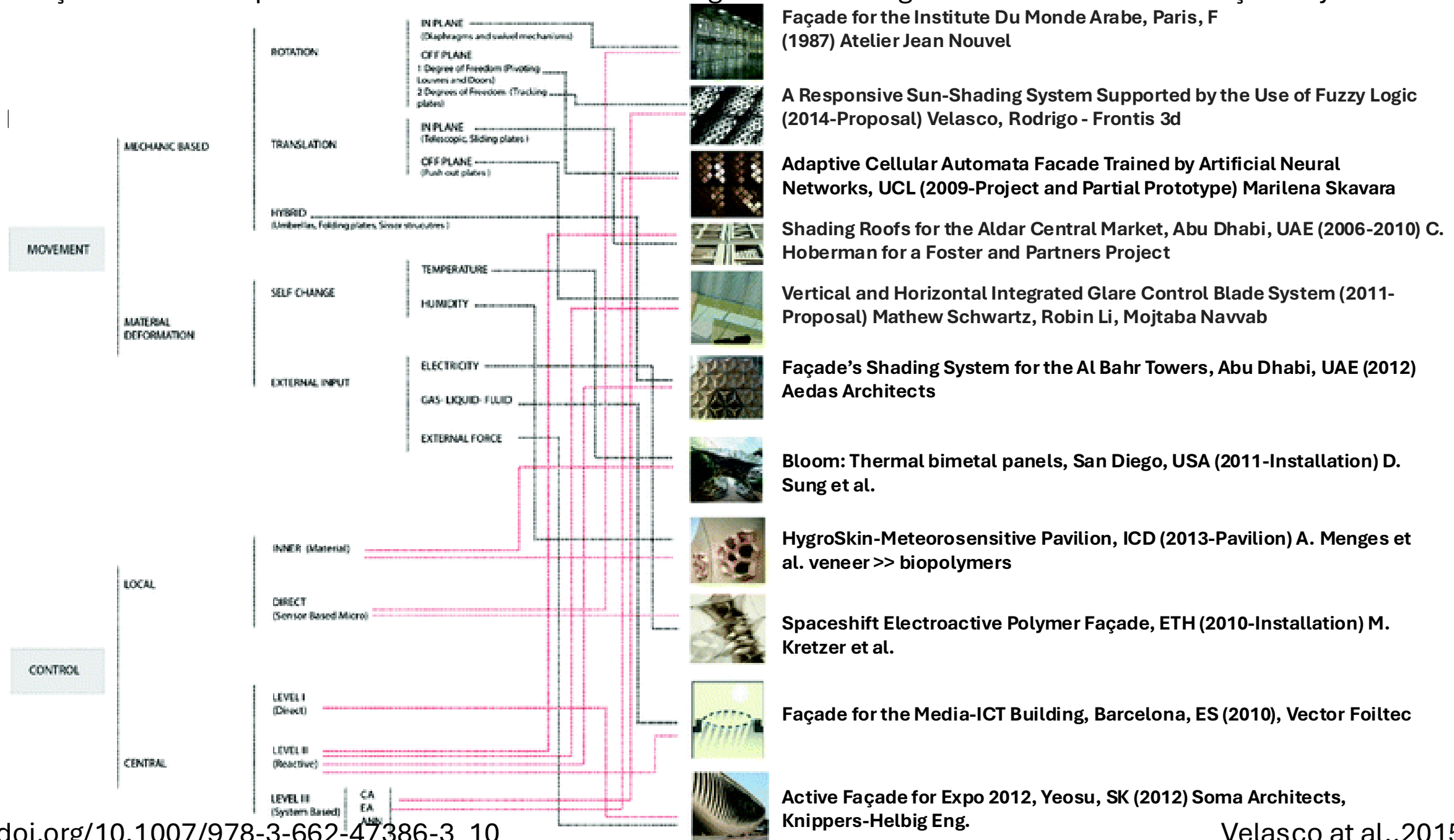
**Façade Performance**

Indoor comfort

Operational Emission

Embodied Emission

# Dynamic Façades and Computation: Towards an Inclusive Categorization of High Performance Kinetic Façade Systems

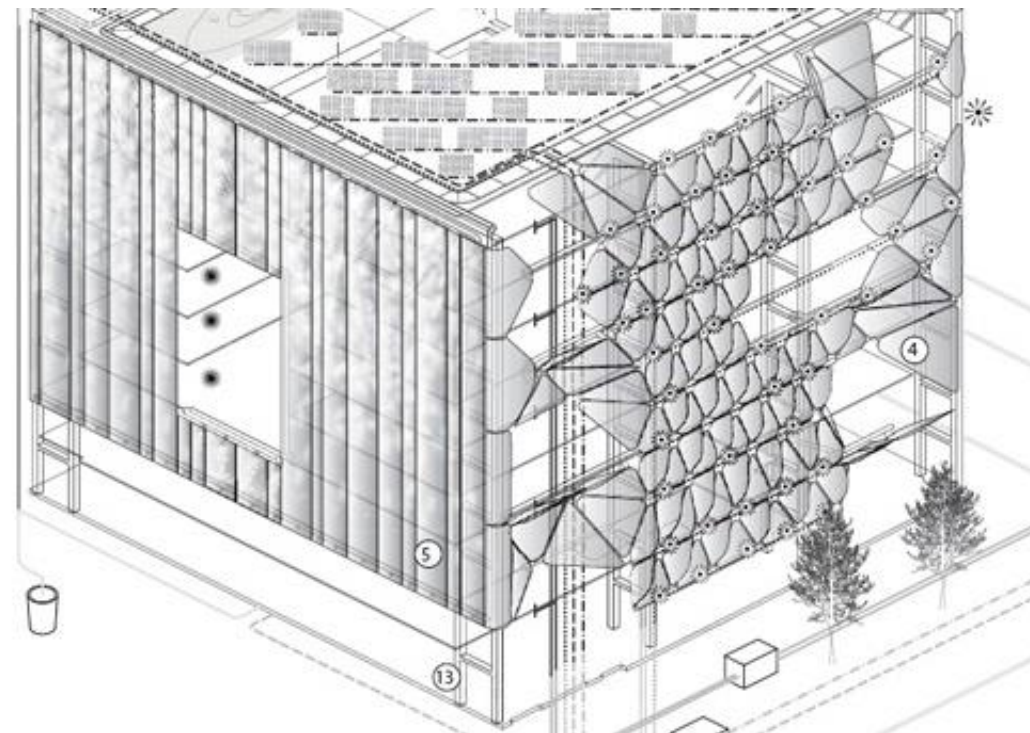


# Adaptive, multi-layer membrane façade; ETFE foil; double layer; Pneumatic Cushion

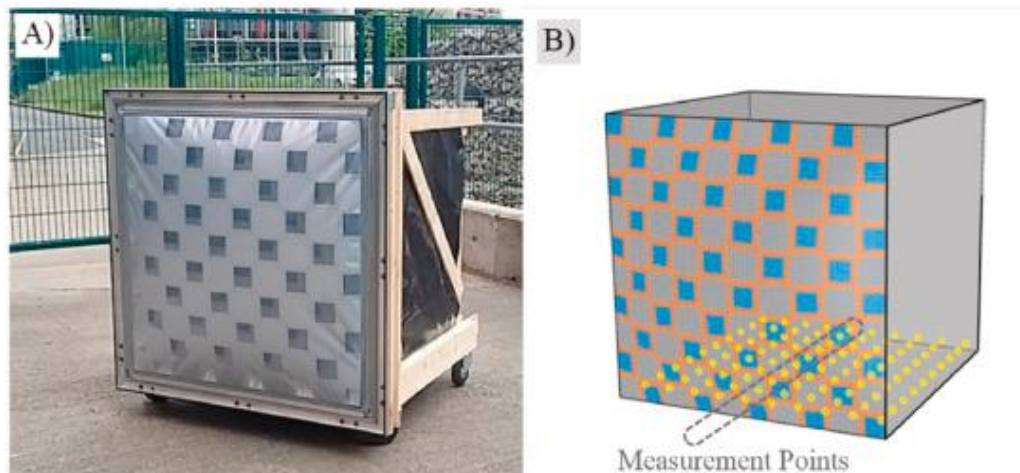
Movement  
Material Deformation  
External  
Gas/Air



Variable printing patterns and materials (PV) on ETFE membranes



Nitrogen fog (SW); air (SE)

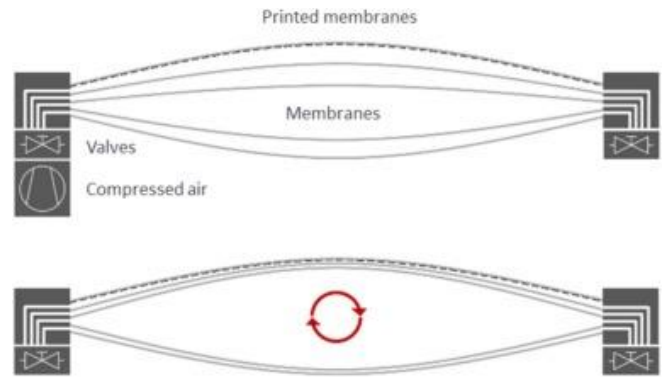


Indoor comfort testing



Multi-layer and LCA

# Ökobilanzierung adaptiver Hüllen und Strukturen



Parameter	Values
Foil material	Ethylene tetrafluoroethylene (ETFE); Polytetrafluoroethylene (PTFE); Polypropylene (PP); Polyethylene (PE); grammage 0.42 kg/m <sup>2</sup>
Foil end-of-life	Incineration; Recycling
Number of foil layers	1–6
Printing material	Aluminium, Titanium dioxide; Silver; Gold
Printed area	25–100 % for two layers (Interval: 25 %)
Contact welding length	1–4 m/m <sup>2</sup> (Interval: 1 m)
Filling substance	Argon; Air
Frame material	Polyoxymethylene (POM); Aluminium 100 % primary, Aluminium 80 % secondary, Aluminium 100 % secondary
Frame weight	Polyoxymethylene (POM): 13.6 kg/m <sup>2</sup> ; Aluminium: 4 kg/m <sup>2</sup>
Frame end-of-life	Disposal (metals); Incineration (plastics); Recycling
Operational strategy	Conductive; Insulating; Adaptive 1; Adaptive 2
Energy consumption (electricity)	120 to 595 kWh/a (simulation results)
Electricity mix (scenarios)	2020; 2030; 2040; 2050
Transport (by truck)	300; 1000; 2500 km



# Building Energy Rating

## - General Data

**Project:** Media tic

**Autonomous Community:** Catalonia

**Locality:** Barcelona

**Building type:** Offices

**Minimum solar DHW coverage:** 0.0

**CTE-HE 4 (%):** 0.0

**Annual renewable electrical energy:** 39,383.0 kWh/year

## - Summary of Annual Energy Indicators

Energy Indicator	Building Object	Reference Building	Index	Rating
Heating demand (kWh/m <sup>2</sup> year)	58.3	10.1	5.79	G
Cooling demand (kWh/m <sup>2</sup> year)	79.1	180.6	0.44	B
Climate emissions (kg CO <sub>2</sub> /m <sup>2</sup> )	62.9	140.6	0.45	B
DHW emissions (kg CO <sub>2</sub> /m <sup>2</sup> ) (domestic hot water)	0.0	0.0	-1.00	-
Lighting emissions (kg CO <sub>2</sub> /m <sup>2</sup> )	3.1	26.4	0.12	A
<b>Total emissions (kg CO<sub>2</sub>/m<sup>2</sup>)</b>	<b>66.1</b>	<b>167.0</b>	<b>0.40</b>	<b>A</b>

## - Total Value

**137.4 - 6.77 (l) - 17.43 (re)**

Concept	Building Object	Reference Building
Final Energy (kWh/m <sup>2</sup> year)	113.2	399.0
Emissions (kg CO <sub>2</sub> /m <sup>2</sup> year)	66.1	167.0

## - Reported Area (not in the report)

23000 sqm (7000+15000)

2500 sqm (ETFE)


The index is basically a ratio:

$$\text{Index} = \frac{\text{MediaTIC value}}{\text{Reference building value}}$$

So it shows how much better or worse MediaTIC performs compared with the calculated reference building.

For example, for total emissions:

$$\frac{66.1}{167.0} = 0.396$$

 Calificación Energética de Edificios	Proyecto	Media tic
	Comunidad Autónoma	Cataluña
	Localidad	Barcelona

## 1. DATOS GENERALES

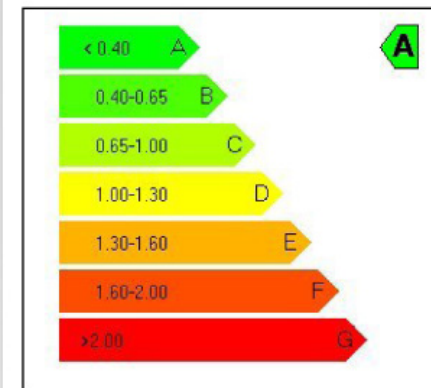
Nombre del Proyecto	Media tic	
Comunidad Autónoma	Cataluña	Localidad Barcelona
Dirección del Proyecto	--	
Autor del Proyecto	PGI engineering	
Autor de la Calificación	David Tuset i Truque	
E-mail de contacto	gm@pgigrup.com	Teléfono de contacto 972 222 823
Tipo de edificio	Oficinas	Cobertura solar mínima CTE-HE 4 (%) 0.0
		Energía eléct. con renovables (kWh/año) 39383.0

## 2. RESUMEN INDICADORES ENERGÉTICOS ANUALES

Indicador Energético	Edif. Objeto	Edif. Referencia	Índice	Calificación
Demanda Calef. (kW-h/m <sup>2</sup> )	58.3	10.1	5.79	G
Demanda Refri. (kW-h/m <sup>2</sup> )	79.1	180.6	0.44	B

Emissiones Climat. (kg CO <sub>2</sub> /m <sup>2</sup> )	62.9	140.6	0.45	B
Emissiones ACS (kg CO <sub>2</sub> /m <sup>2</sup> )	0.0	0.0	-1.00	-
Emissiones Ilum. (kg CO <sub>2</sub> /m <sup>2</sup> )	3.1	26.4	0.12	A
<b>Emissiones Tot. (kg CO<sub>2</sub>/m<sup>2</sup>)</b>	<b>66.1</b>	<b>167.0</b>	<b>0.40</b>	<b>A</b>

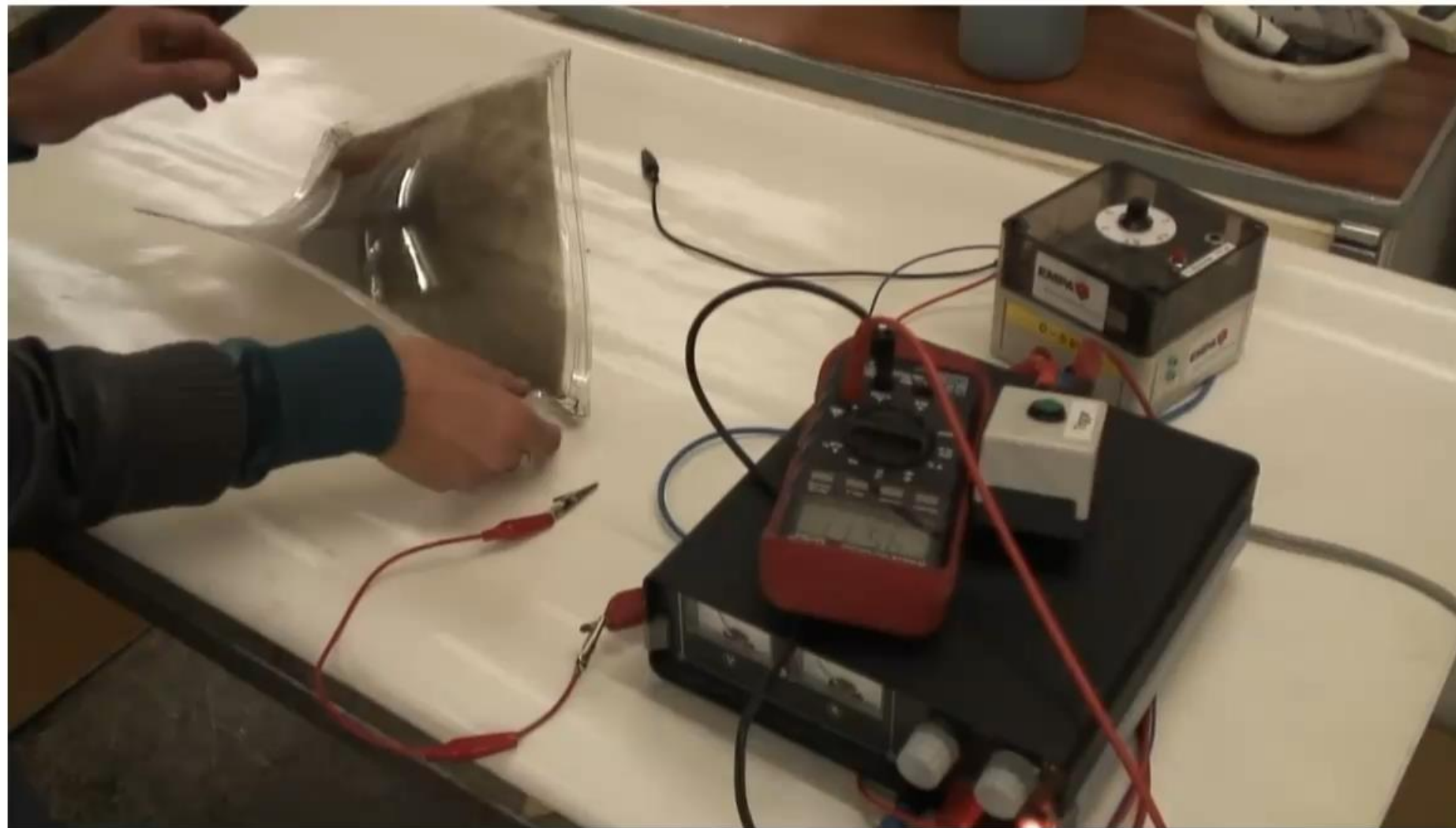
## 3. ETIQUETA Y VALORES TOTALES



Concepto	Edif. Obj.	Edif. Ref.
Energía Final (kWh/(m <sup>2</sup> año))	113.2	399.0
<b>Emissiones (kg CO<sub>2</sub>/m<sup>2</sup>año)</b>	<b>66.1</b>	<b>167.0</b>

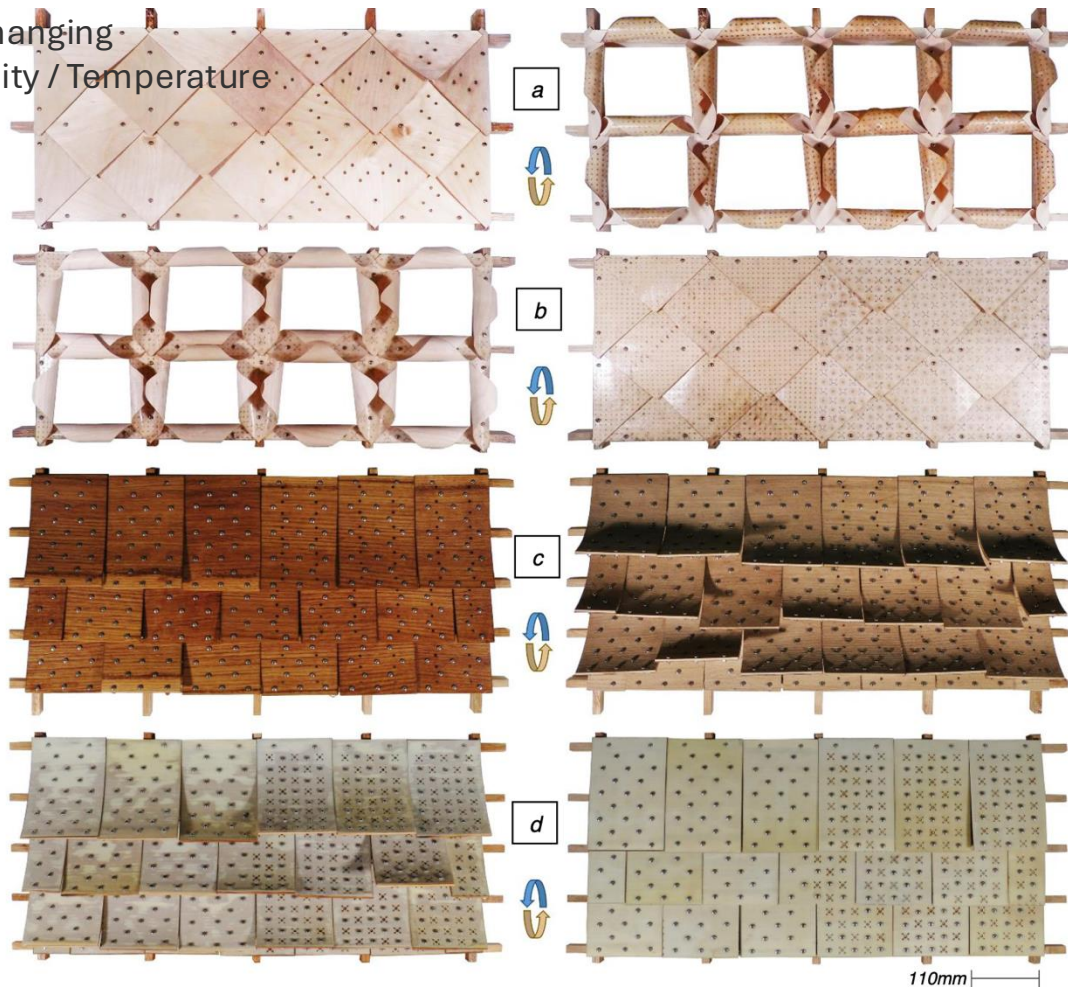
# Electroactive polymers

Movement  
Material Deformation  
External  
Electricity



# Self-responsive façades

Movement  
Material Deformation  
Self-changing  
Humidity / Temperature



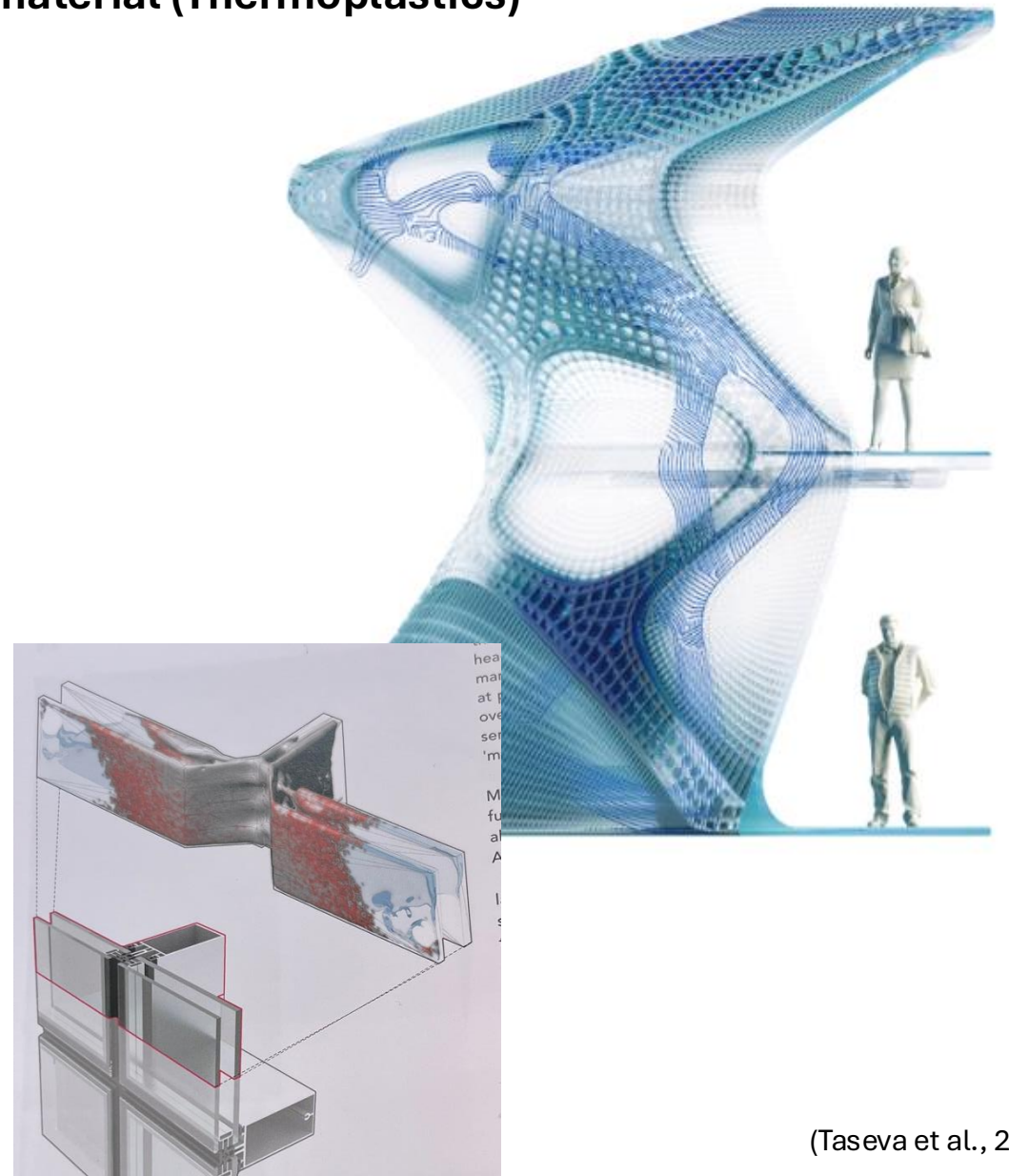
Veneer-based w adhesive layers; 4d printing w polymers

Figure 5: Prototypes of responsive cladding modules with different layer configurations and opposite pre-programming of panels in wet (left) and dry (right) conditions. The left and right sides of the prototypes consist of panels with standard and perforated active ('a' and 'c') and passive ('b' and 'd') layers respectively. The configuration of thin panels ('a' and 'b') is the same as glued composites in figure 3. Thick panels ('c' and 'd') comprise of 3.2mm thick quarter-cut English oak and 0.35mm epoxyglass layers.

# Functional graded facades through material deposition or multi-material (Thermoplastics)



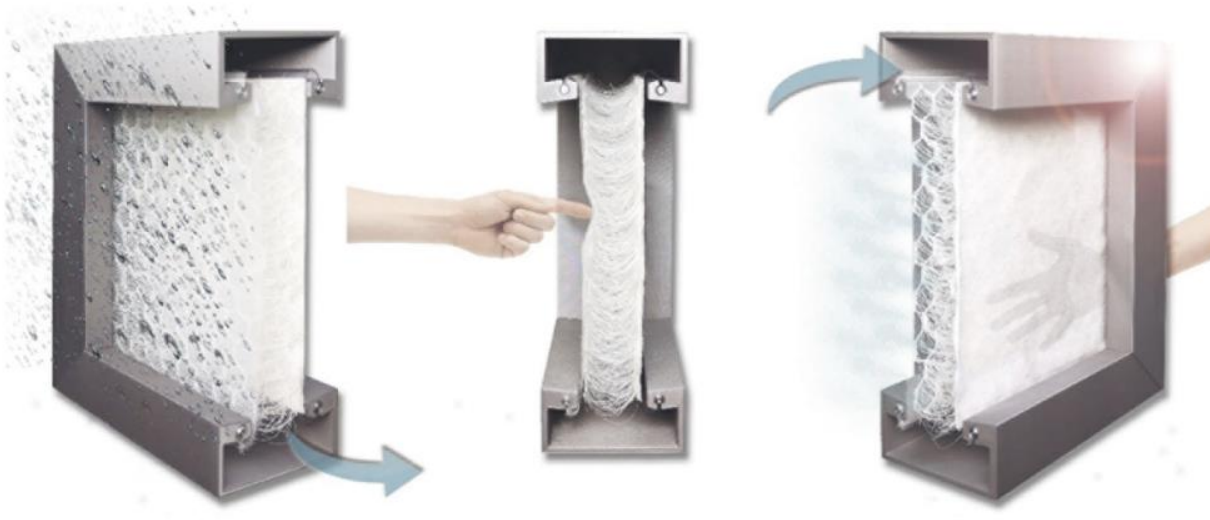
Figure 4. Investigated infill geometry types: circular gradient, truss-gradient, ShwartzP minimal surface gradient.



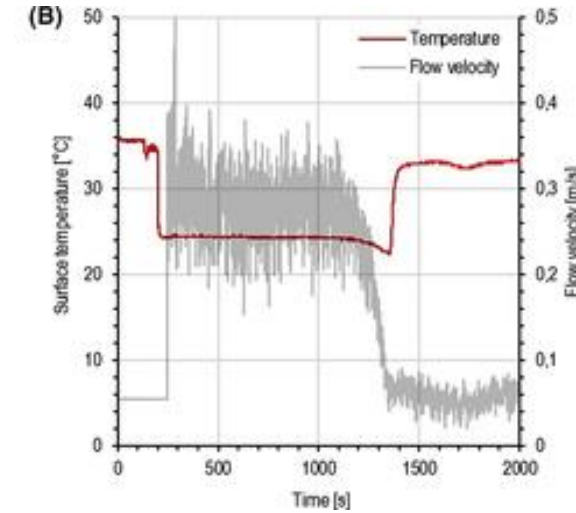
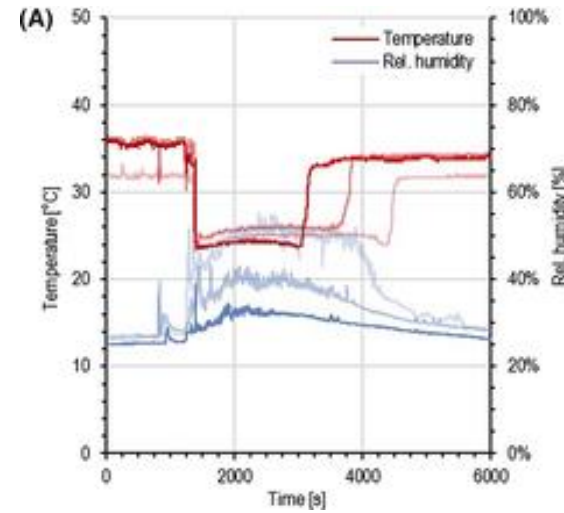
(Taseva et al., 2020)

# Potentials of hydroactive lightweight façades for urban climate resilience (*HydroSKIN*)

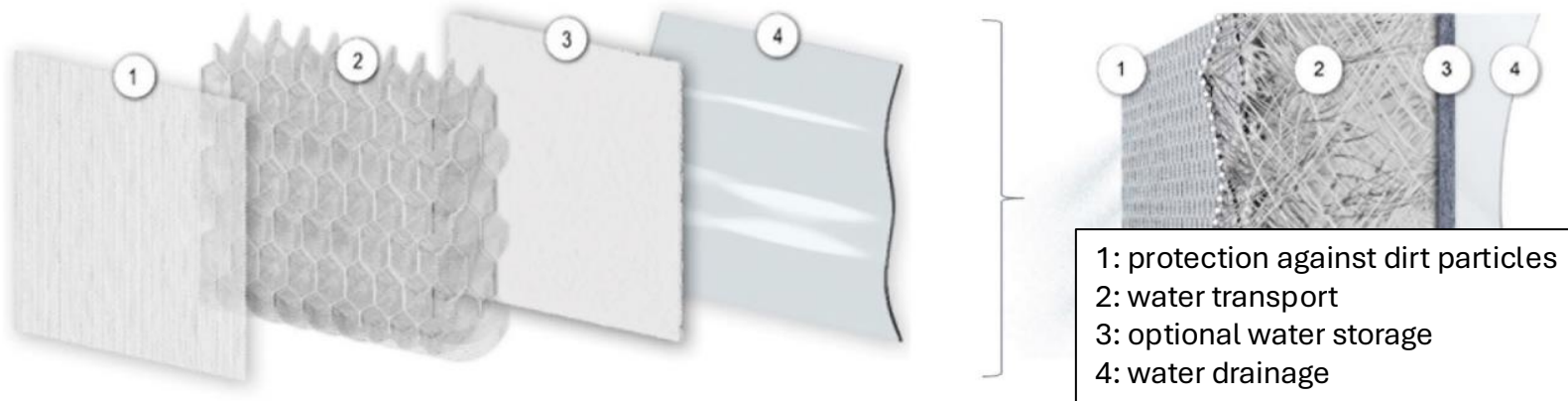
## Ökobilanzierung adaptiver Hüllen und Strukturen



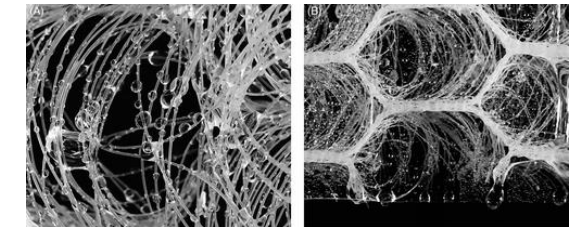
Quelle: ILEK



**Bild 11** Konzept hydroaktiver textiler Hüllen zur pluvialen Retention und evaporativen Kühlung von Gebäuden und urbaner Umgebung  
 Concept of hydroactive textile envelopes for pluvial retention and evaporative cooling of buildings and urban environments



**Bild 12** Konzept einer mehrlagigen textilen Hülle zur Aufnahme von windgetriebenem Schlagregen sowie zur Verdunstungskühlung  
 Concept of a multi-layer textile envelope for the absorption of wind-driven rain and for evaporative cooling



Rainwater harvest  
 Evaporative cooling  
 -  
 Low EC  
 Reduce OC

<https://doi.org/10.1002/cend.202200003>  
<https://doi.org/10.1002%2Fbate.202200067>

Eisenbarth et al., 2022;  
 Borschewski et al, 2022

# Thermal wall and active cooling through printed channel (Thermoplastics)



a



b

FIG. 8 The final full-size prototype: side view of the bottom part (a) and the full, freestanding prototype (b)

DESIGN	1	2	3	4
Nozzle size mm	0.4	0.4	0.4	0.4
Wall thickness	1.2mm	0.8 mm	1.2mm	1.2mm
Material	PETG colour	PETG transparent	PETG transparent	PETG transparent
Mass kg	0.533	0.286	0.417	0.693
Volume ratio solid /gas	0.2	0.08	0.23	0.23
thermal conductivity $\lambda$	0.101W/mK	0.094W/mK	0.104W/mK	0.109W/mK

TABLE 1 Different configurations that were tested for thermal conductivity

$\lambda : 0.1 \text{ W}/(\text{m}\cdot\text{K}),$   
 $U : 0.30\text{W}/(\text{m}^2\cdot\text{K}) (33\text{cm}) = R: 3.33\text{m}^2\text{K}/\text{W}$

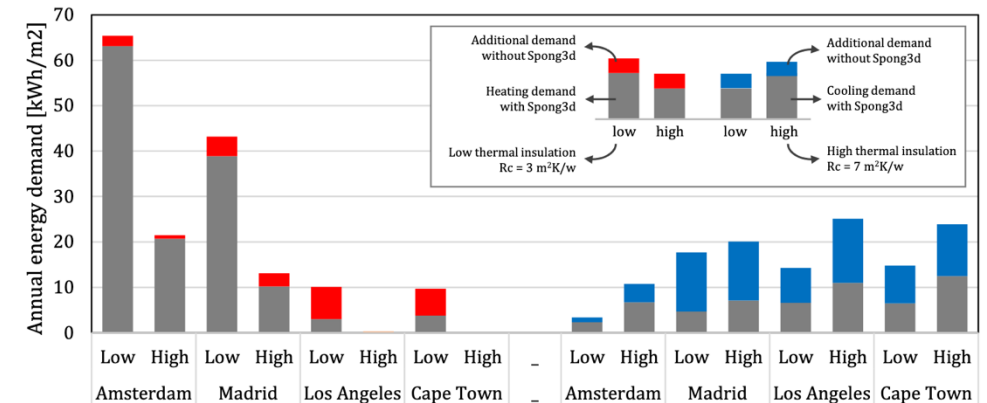


FIG. 6 Predicted energy demand for a reference office space in four different cities.