SHORT TERM SCIENTIFIC MISSION (STSM) FINAL REPORT

To whom it may concern,

Hereby I present the Scientific Report related to my Short Term Scientific Mission developed, as planned, between the 13th and 24th of March 2016 with the topic:

"**Review of the Adaptive Facade database, development of the educational pack draft plan and teaching material WG1**"

that I concluded within the COST action TU1403 Adaptive Facades.

The host institution was the Architecture Department of the University of the Basque Country UPV/EHU, the host responsible person was Prof. Arch. José Miguel Rico Martinez, professor and researcher at that University.

I took part in the COST Action 1403 in the framework of the objectives of WG1, and more specifically the mapping of different adaptive technologies, to provide an overview about their performance and to collect and analyse facades and technologies already adopted in practice towards a proper characterization and definition finding.
The main objective carried out in this STSM was to make progress in the tasks of the working group by developing the basis for the educational pack – critically reviewing the existing survey – individuating possible themes and strategies to deepen in the educational pack WG1, and setting up a draft of the teaching material.

I mainly focused on critically reviewing the existing survey on adaptive facades developed by WG1 by taking into account definitions of key concepts, case studies of adaptive components, materials, technologies and building/architectural integration methods towards adaptability. With the help of my host and the other members of the WG1, I re-organised and structured a final draft of the survey and developed a systematic output of the information gathered through the survey into detailed and summarized fact-sheets for each analysed example.
For further information, I attach a sample of the final survey and fact sheets which constitute the base of the further steps which will be taken by WG1 to assemble the teaching material for the WG1 Educational Pack and build up the Adaptive Facades Network database.

The exchange was very productive also because I was able to consistently give my contribution to the WG1's work by integrating into the classification and survey my knowledge concerning unpowered kinetic adaptivity in architecture, or auto-reactivity, which is the object of my Ph.D.
Also, I had the chance of benefiting from the expertise and of my host institution by getting to know their working methods, facilities and human resources, developing as well the relations between the *School of Architecture of the University of the Basque Country* and my home institutions *SAPIENZA Università di Roma Facoltà di Architettura*, and the *Technical University Munich, Faculty of Architecture.*

In the following table I describe to what extent I reached the prospected outcomes as defined in the STSM plan:
D.1.1. Report and database with current state-of-the-art adaptive façade materials, systems and new concepts.
D.1.4. Input and contributions to relevant parts of educational pack
D.1.5. Contribution to Industry Workshop

Prospected outcome	**Reached outcome**
D.1.1. Report and database with current state-of-the-art adaptive façade	Fully achieved. More specifically, the work carried out consisted of: - set, in agreement with the WG1 members, the basis of the overall structure of the survey, dividing the different aspects into parts ranging

materials, systems and new concepts.	from general to specific features; - develop each question in terms of main definition(s) and subsequent subcategories; - testing the validity of the survey by feeding the database with a few examples in each category; - suggest a systematic organization and output of the information gathered through the survey into detailed and summarized fact-sheets for each analysed example. The next steps for the WG1 will be to fill through this survey the database with case-studies and constitute the online Adaptive Facades Network database.	
D.1.4. Input and contributions to relevant parts of educational pack	Draft version a for the educational package WG1, according to the phases 1 – 4 of the edu-pack working structure	Partly achieved, still in progress. The outcome of the STSM defines the themes that could be addressed in the framework of a lecture cycle.
	Basic layout for teaching materials and presentations for all WG members to work in.	Not addressed during the STSM.
	Prepare teaching material and presentation for phase 1 (Data base with definitions)	Partly achieved, still in progress. The survey attached to this report presents the main definitions and a structured base to be further developed and implemented for the student workshops.
D.1.5. Contribution to Industry Workshop	Fully achieved. The attached material developed during the STSM will be a valuable input for an introduction and description of adaptive facades in educational packs and might as well be directly used in the workshops.	

Munich, the 17th of April 2016

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Survey: COST TU 1403 WG 1 Database Survey - V7

Page.1.- Survey content and introduction

This survey is created to feed an Adaptive Facade case-study database.This 9 pages survey is structured according to three levels of detail: basic level, building level and detailed level, which is further structured into the following sections:- Detailed description - Metrics- Characterization- Economical aspects- References, pictures and contact dataYou can leave the survey at anytime and continue later (upright button). This is a general form that serves all adaptive facade cases, including research projects still in a lab-phase, mockups, built solutions, products available in the market, etcWe use a three scale approach: Material - Component - Facade system. You can fill this unique survey for any case that fits any of the mentioned scales. For instance you could describe a phase change material, a shading device, a unitized curtain wall system, etc. You'll have to decide which questions are applicable to the case you are describing. If you can't give an answer, just skip the question. At the end you will be asked to enter links to pictures and drawings if available (you can also send them to j.rico@ehu.eus).We follow the definitions stated in "Design for façade adaptability – Towards a unified and systematic characterization"You can access the arcticle in the Cost Action site (http://tu1403.eu/) or by the following link: https://www.dropbox.com/s/4h6tu85sbdx3zfy/Design%20for%20facade%20adaptability%20%28characterization%29.pdf?dl=0

Page.2.- Basic level of information

Definition of adaptive façade product levels:Material: a material can be in different states of refinements such as raw, extruded or coated. Also materials which are inseparable combined, such as bi-metals, belong to his category. Examples: Polymer, Bi-metal, steel, wood, phase change material.Component: a component is an assembly of different set of elements. It forms a complete constructional or functional unit as part of a façade. For example an insulated glass unit but also a window frame including glazing or a sun shading device.Façade-system: a facade (or roof) system is composed of different transparent or opaque structural or technical components. It fulfils all basic technical façade functions such as insulation, rain and wind tightness.Building: the COST Action analyses adaptive facade cases and here information about the building level describes the context in which a facade is placed. In many cases, the performance of adaptive materials, component or facades can only be judged in the building context.

Quest.1.- Adaptive Facade (AF) study-case type:

(* This question is obligatory)
(* Tick only one option)

Material
Component
Facade system

Quest.2.- Case-study name (material/component/façade system), research project-title, building-name (max 26 characters):

(* This question is obligatory)

Respuesta: _____

Quest.3.- Building location (if applicable)

Location name: : _____

Latitude: : _____

Longitude: : _____

Quest.4.- Year of construction (for built solutions) or date of proposal/invention:

Respuesta: _____

Quest.5.- Main author / Group

Respuesta: _____

Quest.6.- Involved parties (more detailed information)

Designer / Inventor / Researcher : _____

Structural Engineer : _____

Services Engineer : _____

Facade consultant : _____

Manufacturer : _____

Contractor : _____

Building / project owner : _____

Other party involved : _____

Quest.7.- Keywords defining the case-study:

(* This question is obligatory)

1. : _____

2. : _____

3. : _____

4. : _____

5. : _____

Page.3.- Building level of information:

Questions in this page mainly focus in built solutions and therefore are not applicable in general to commercial components of wide application, research projects, lab. mockups, etc.

Quest.8.- Building floor area (if applicable):

(* Tick only one option)

0 - 50 sq.m.
50 - 500 sq.m.
500 - 5.000 sq.m.
5.000 and up sq. m.
Otro (Por favor especifique)_____

Quest.9.- Building use (if applicable):

Office
Education
Industry

Housing
Other (please specify)_____

Quest.10.- Building status (if applicable):

(* Tick only one option)

New built
Refurbished
Other (please specify)_____

Quest.11.- Is adaptivity part of the main architectural design concept of the building? (if applicable)

(* Tick only one option)

Yes
No
Other (please specify)_____

Quest.12.- Climate Type (Köppen Climate Classification System, see previous table).For case studies outside Europe, a world map is available at the following website http:// www.eoearth.org/view/article/162263/For cases not applied in specific buildings and locations: which climates do you see the biggest potential to apply this technology?

(* Tick only one option)

Not applicable
All of them
Af
Am
Aw
BWh
BWk
BSh
BSk
Csa
Csb
Cwa
Cwb
Cwc
Cfa
Cfb
Cfc
Dsa
Dsb
Dsc
Dsd
Dwa
Dwb
Dwc
Dwd
Dfa
Dfb
Dfc
Dfd
ET
EF

Quest.13.- Orientation of the facade system / component / material

N_
NE_
E_
SE_
S_

SW_
W_
NW_
All orientation
Not Applicable

Page.4.- Detailed level of information

Detailed information is structured into sections:4.1 Detailed description (purpose, classification, working principle).4.2 Metrics4.3 Characterization4.4 Economical aspects4.5 References, pictures and contact dataThe information given is not obligatory, but the databse would benefit a lot from every entry.

Page.5.- 4.1 Detailed description

Quest.14.- Please specify the Technology Readiness Level (applies to all the information submitted):

(* Tick only one option)

1 Basic principles observed and reported/ Idea
2 Technology concept formulated/Design Proposal
3 Technology validated in lab
4 Prototype demonstration
5 Commercial product/Existing building

Quest.15.- Function / goal / purpose

Thermal comfort_
Visual comfort_
Acoustic comfort_
Energy management (harvesting, storing, supply)_
Mass transfer control (e.g. condensation control)_
Indoor air quality_
Appearance (aesthetic quality)_
Structure performance (fire protection, earthquake)_
Energy generation_
Personal users' control_
Other (durability, accesibility, use of natural resources, etc). Please specify:_____

Quest.16.- Where does this technology fit in the following classification suggested by COST1403 WG2?

(* Tick only one option)

Standard Curtain Wall (StandCW)
Active Transparent Facades (ATF)
Switchable Glazing (SG)
Phase Change Materials (PCM)
Multifunctional Facade Modules (MFM)
Biomimetic Facades (BF)
Other (please specify)_____

Quest.17.- Select the type of facade system / component / material.

Unitized Curtain Wall_
Curtain wall (stick)_
Prefabricated Facade Module_
Double Skin Facade_
Ventilated facade_
-
External skin_
Window frame (e.g. automitically opening)_
Insulated glass unit_

Shading device (roller, louver, blind, shutter, etc)_
Insulation device(e.g. insulation layer, Vacuum Insulation Unit)_
Building services unit_
Energy harvesting device(e.g. photovoltaic element)_
Energy storage device (e.g. trombe wall)_
Air circulation device_
Natural ventilation device_
Solar tube_
Green envelope_
-
Liquid crystals_
Phase Change Materials_
Polymers_
Alloys_
Ceramics_
Wood_
Salthydrates_
Hydrocarbures_
Other (please specify)_____

Quest.18.- If you are describing a switchable glazing, specify:

(* Tick only one option)

Electro-chromic (EC), Liquid crystal, SPD
Photo-volta-chromic
Independently tunable NIR-VIS EC
Thermo- tropic / chromic
Photo-chromic
Fluidglass
Other (please specify)_____

Quest.19.- If you are describing a shading, please specify:

(* Tick only one option)

Screens / roller shades
Blinds with slat angle control
Bi-directional transmission control
Insulating shutters
Shading with dual-axis tracking
Other (please specify)_____

The following two questions are specially applicable to adaptive components or unitized facade-systems but also could be answered for materials produced in standard units:

Quest.20.- Area of the case-study (sq.m.):

Respuesta: _____

Quest.21.- Added weight (kg/sq.m.) of the case-study:

Respuesta: _____

The following three questions are specially applicable to adaptive materials but also could be answered for facade-systems or components including adaptive materials that play a key role in their function:

Quest.22.- Material effect - how does the material adapt?

Shape Memory Material_
Bi-material effect_
Electroactive material_
Superabsorbent material_
Phase Change
Other (please specify)_____

Quest.23.- Type of trigger (INPUT): - In the case of intrinsic operation: What triggers the smart material reaction? - In the case of extrinsic operation: What does the sensor detect in order to run an actuator?For instance, in the Institut du Monde Arabe facade, the trigger is optical.

(* Tick only one option)

Mechanical (e.g. wind load)
Thermal (e.g. outdoor air temperature)
Electromagnetic (e.g. solar radiation)
Optical (e.g. daylight level, glare)
Air quality (humidity, CO2 concentration, etc)
Building heating/cooling load
Occupant's presence
Other (please specify)_____

Quest.24.- Type of actuator (OUTPUT):For instance in the Institut du Monde Arabe facade the actuator output is Mechanical.

Mechanical
Pneumatical
Electromagnetic
Thermal
Chemical
Other (please specify)_____

Quest.25.- Explain the working principle of the case-study (short answer: max 500 characters):

(* This question is obligatory)

_____

_____

_____

_____

_____

Quest.26.- Detailed explanation of the working principle (unlimited number of characters). This text will not appear in the case study's summarized data sheet, but only in the detailed one:

_____

_____

_____

_____

_____

Page.6.- 4.2 Metrics and technical requirements

Quest.27.- Intro the value or value-range of the following metrics, if suitable to assess the adaptivity of your case-study:

UV Resistance : _____

Light transmittance (%) : _____

Solar transmittance (%) : _____

Total solar energy transmittance (%) : _____

Solar savings fraction (%) : _____

Weight/Density (g/cm2) : _____

Solar heat gain factor (%) : _____

U-Values (W/m2*K) : _____

Noise insulation : _____

Fire protection : _____

Colour : _____

Other : _____

Other : _____

Other : _____

Other : _____

Other : _____

Emissivity : _____

Quest.28.- Energy data based on:

Estimation
Detailed simulation
Measurement/testing
Long-term monitoring
Monitoring
Post occupancy evaluation
Soft landing
Other (please specify)_____

Quest.29.- Which simulation tools were used for the design?

DesignBuilder
Ecotect
eQuest
ESP-r
IES VE
IDA ICE
Radiance
TAS
TRNSYS
Own developed numerical model (give references if available in others section)
Trace 700

OpenStudio
Sefaira
IDF Editor
Simergy
Honeybee
AECOsim
SIMEB
HAP
Revit BPA / Green Building Studio
Others (please specify)_____

Page.7.- 4.3 Characterization:

As mentioned in the introduction we follow the definitions stated in "Design for façade adaptability – Towards a unified and systematic characterization". Refer to it in order to clarify concepts meaning.You can access the arcticle in the Cost Action site (http://tu1403.eu/) or by the following link: https://www.dropbox.com/s/4h6tu85sbdx3zfy/Design%20for%20facade%20adaptability%20%28characterization%29.pdf?dl=0

Quest.30.- Select the control/operation type:

(* Tick only one option)

Intrinsic (auto reactive)
Extrinsic (requires external controll)
Other (please specify)_____

Quest.31.- Explain the control/operation. Short answer (max 500 characters):

(* This question is obligatory)

_____

_____

_____

_____

_____

Quest.32.- Detailed explanation of the control/operation (unlimited number of characters). This text will not appear in the case study's data sheet, but only in the detailed sheet:

_____

_____

_____

_____

_____

Quest.33.- System response time (thick all that apply):

Seconds_
Minutes_
Hours_
Days_
Seasons_
Years_
Other (please specify)_____

Quest.34.- System degree of adaptivity:

(* Tick only one option)

on/off
gradual
Other (please specify)_____

Quest.35.- Degree of spatial adaptation (technology scale). In which scale does the technology trigger the adaptation? For an adaptive coating the scale is in nanometers, for a facade shutter the change occurs in a scale of centimeters/meters.

Nanometers_
Micrometers_
Millimeters_
Centimeters_
Meters_
Other (please specify)_____

Quest.36.- Level of AF visibility (Reijenga classification):

(* Tick only one option)

1 Not visible, no surface change (heat storage, phase change materials)
2 Visible, no surface change (smart glazing)
3 Visible, surface change (lamellas, rollers, blinds)
4 Visible, size or shape change (shutters, flaps, dynamic facade elements)
5 Visible, location or orientation change
Other (please specify)_____

Page.8.- 4.4 Economical aspects

Quest.37.- Is the system economically viable?

(* Tick only one option)

Yes
No
Other (please specify)_____

Quest.38.- Economic aspects

Cost/m2 : _____

Yearly cost of maintenance : _____

Quest.39.- Please estimate the cost of the case-study:

(* Tick only one option)

Low (traditional, residential, simple prefabricated, etc)
Medium (curtain walls, ventilated facades, etc)
High (double skin facades, high tech, etc)
Information not available

Quest.40.- System maintenance frequency

(* Tick only one option)

Daily
Weekly

Monthly
Yearly
Other (please specify)_____

Page.9.- References and additional information

Quest.41.- References (bibliography, web-sites, etc):

Reference 1: : _____

Reference 2: : _____

Reference 3: : _____

Reference 4: : _____

Reference 5: : _____

Quest.42.- Provide links to the study-case PICTURES/VIDEOS, their authors and types of license (or send them to j.rico@ehu.eus):

Link to picture/video 1 : _____

Caption, description : _____

Author : _____

CreativeCommonts/Copyleft/PublicDomain/Copyright) :
_____

Link to picture/video 2 : _____

Caption, description : _____

Author : _____

CreativeCommonts/Copyleft/PublicDomain/Copyright) :
_____

Link to picture/video 3 : _____

Caption, description : _____

Author : _____

CreativeCommonts/Copyleft/PublicDomain/Copyright) :
_____

Link to picture/video 4 : _____

Caption, description : _____

Author : _____

CreativeCommonts/Copyleft/PublicDomain/Copyright) :
_____

Link to picture/video 5 : _____

Caption, description : _____

Author : _____

CreativeCommonts/Copyleft/PublicDomain/Copyright) :
_____

Quest.43.- Provide a link to the study-case DRAWINGS, their authors and types of license (or send them to j.rico@ehu.eus):

Link to drawing 1 : _____

Caption, description : _____

Author : _____

CreativeCommonts/Copyleft/PublicDomain/Copyright) : _____

Link to drawing 2 : _____

Caption, description : _____

Author : _____

CreativeCommonts/Copyleft/PublicDomain/Copyright) : _____

Link to drawing 3 : _____

Caption, description : _____

Author : _____

CreativeCommonts/Copyleft/PublicDomain/Copyright) : _____

Link to drawing 4 : _____

Caption, description : _____

Author : _____

CreativeCommonts/Copyleft/PublicDomain/Copyright) : _____

Link to drawing 5 : _____

Caption, description : _____

Author : _____

CreativeCommonts/Copyleft/PublicDomain/Copyright) : _____

Quest.44.- Filling person info (this is optional information):

name: : _____

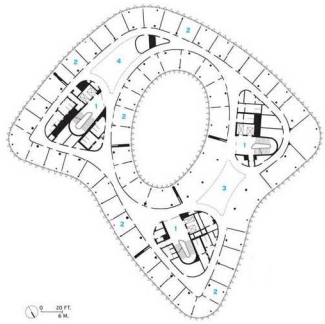
company/university: : _____

e-mail: : _____

WG affiliation (if applicable) : _____

Oval Cologne Offices

Sauerbruch Hutton Architekten 2010 Cologne

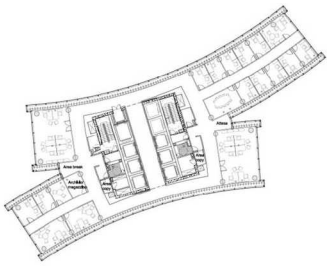


keywords	automatic vertical shutter; daylight regulation; irregular shape; oval; color in architecture	Adaptivity concept	Yes	Building use	Office
Type	Facade system	Building status	New built	Building floor area	500 - 5.000 sq.m.
T.R.L.	5 Commercial product/Existing building	working principle of the facade system / component / material			
Function / goal	Thermal comfort_Visual comfort_Appearance (aesthetic quality)_	The folding shutters are the sunscreens. They are made out of colored glass and automatically controlled.			
WG2 classification	automatic shutter system				
Type of system	Curtain wall (stick)_Shading device (roller, louver, blind, shutter, etc)_				
Area (m^2)					
Weight (kg/m^2)					
Effect		Operation principle of the facade system / component / material			
Trigger (input)	Optical (e.g. daylight level, glare)	The louvers are controlled externally by the system measuring the insolation.			
Actuator (output)	Mechanical				
Operation type	Extrinsic (requires external controll)				
Response time	Seconds_Minutes_				
Adaptivity	gradual				
Degree of adaptivity	Centimeters_	Level of AF visibility	4 Visible, size or shape change (shutters, flaps, dynamic facade elements)		
Cost/m2					
Maintenance cost/year					
Cost range	High (double skin facades, high tech, etc)				

Altra Sede Regione Lombardia

Pei Cobb Freed & Partners, Caputo Partnership, SDPartners | 2010 | Milan



keywords	Building Integrated Photovoltaic; Photovoltaic glass; Curtain wall; Skyscraper; Renewable Energy	Adaptivity concept	No	Building use	Office
Type	Facade system	Building status	New built	Building floor area	
T.R.L.	5 Commercial product/Existing building	working principle of the facade system / component / material			
Function / goal	Energy management (harvesting, storing, supply)_Energy generation_Use of natural resource	The BIPV façades of the building aim to produce energy and to reduce at the same time solar heat gain in the hot season.			
WG2 classification	Active Transparent Facades (ATF)				
Type of system	Energy harvesting device(e.g. photovoltaic element)_				
Area (m^2)					
Weight (kg/m^2)					
Effect		Operation principle of the facade system / component / material			
Trigger (input)		-			
Actuator (output)					
Operation type					
Response time					
Adaptivity					
Degree of adaptivity		Level of AF visibility			
Cost/m2					
Maintenance cost/year					
Cost range	Medium (curtain walls, ventilated facades, etc)				

Regenerable PV with HEMN

Hyung-Jun Koo / material engineering

keywords	photosystem; regeneration ; dye infusion; biomimetic; photovoltaic	Adaptivity concept	Yes	Building use	Energy generation
Type	Material	Building status	New built	Building floor area	
T.R.L.	3 Technology validated in lab	working principle of the facade system / component / material			
Function / goal	Energy management (harvesting, storing, supply)_	Regenerable Photovoltaic Devices with Hydrogel-Embedded Microvascular Network (HEMN) is a material innovation for facades innovation surfaces with biomimetic microvascular network for dye infusion for regenerative photovoltaic performance. Photosensitive organic dye molecules (PoDM) reduce deterioration of long term energy operational outputs and enhance the performance of photovoltaic cells. This biomimetic network of dye infusion gives damage regerneration by chemical compounds of action and reaction have been undertaken by Hyung within self-heal photovoltaic. Vascular networks have been used as regenerative functions for hydrogel photovoltaic devices by photosensitive organic dye infusion, Fig. 1.				
WG2 classification	Biomimetic Facades (BF)				
Type of system	Energy harvesting device(e.g. photovoltaic element)_				
Area (m^2)	n/a				
Weight (kg/m^2)	n/a				
Effect	chemical infusion of organic dye	Operation principle of the facade system / component / material			
Trigger (input)	energy enhance performance function of PV	SOLAR HARVESTING DEVICE Optimization of regenerative functionality of a photovoltaic system by photosensitive organic dye molecules. Organic dyes are generally susceptible to light stress, high temperatures that reduce the long-term performance of photovoltaic cells. Embedded microfluidics within a network enables regenerative functionality by the infusion of chemical regenerative properties by transport of photoactive agents dye and electrolytes to create a microfluidic hydrogel solar cell of optimum performance for electricity generation.			
Actuator (output)	Chemical				
Operation type	photovoltaic of u-FGPV in a closed structure				
Response time	depending on dye infusion into network, changes response time of PoDM regeneration				
Adaptivity	gradual				
Degree of adaptivity	Nanometers_	Level of AF visibility	2 Visible, no surface change (smart glazing)		
Cost/m2	-				
Maintenance cost/year	-				
Cost range	High (double skin facades, high tech, etc)				

Hygroscope

Achim Menges Architect 2012 Centre Pompidou, Paris

keywords	Moisture sensitive; Parametric; Wood; Kinetic; Autoreactive	Adaptivity concept	Yes	Building use
Type	Component	Building status		Building floor area
T.R.L.	4 Prototype demonstration	working principle of the facade system / component / material		
Function / goal	Appearance (aesthetic quality)_	The thin wooden sheets curve (opening) and extend (closing) through a hygroscopic behavior (ability to take in moisture from the atmosphere when dry and yield moisture to the atmosphere when wet) in response to R.H. fluctuations which trigger the anisotropic characteristics of the materials.		
WG2 classification	Biomimetic Facades (BF)			
Type of system	External skin_Wood_			
Area (m^2)	2			
Weight (kg/m^2)				
Effect	Bi-material effect_	Operation principle of the facade system / component / material		
Trigger (input)	Air quality (humidity, CO2 concentration, etc)	The model opens and closes in response to climate changes with no need for any technical equipment or energy. Mere fluctuations in relative humidity trigger the silent changes of material-innate movement. The material structure itself is the machine.		
Actuator (output)	Mechanical			
Operation type	Intrinsic (auto reactive)			
Response time	Seconds_Minutes_			
Adaptivity	gradual			
Degree of adaptivity	Micrometers_Millimeters_	Level of AF visibility	4 Visible, size or shape change (shutters, flaps, dynamic facade elements)	
Cost/m2				
Maintenance cost/year				
Cost range	Information not available			

Cyclebowl

ATELIER BRÜCKNER GmbH 2000 Hannover Expo

keywords	Pneumatic; Sun shading; ETFE; Cushion; Pattern	Adaptivity concept	Yes	Building use	Exhibition pavillion
Type	Facade system	Building status	New built	Building floor area	
T.R.L.	5 Commercial product/Existing building	working principle of the facade system / component / material			
Function / goal	Thermal comfort_Visual comfort_Energy management (harvesting, storing, supply)_Mass transfer control (e.g. condensation control)_Appearance (aesthetic quality)_	The facade is made of nylon+ polyurethane cushions with a flexible transparent layer inside. A positive/negative pattern is printed on the middle and on the outer layer of the cushions. When the middle layer overlaps with the outer layer, the printed patterns superimpose and shading is provided. When it moves away from the outer layer, light filters through the patterns printed on the surfaces. Intermediate ranges of shading are possible depending on the position of the middle layer.			
WG2 classification	Biomimetic Facades (BF)				
Type of system	External skin_Polymers_				
Area (m^2)					
Weight (kg/m^2)					
Effect		Operation principle of the facade system / component / material			
Trigger (input)	Optical (e.g. daylight level, glare)	Cushions are mechanically activated by an exterior (powered) system.			
Actuator (output)	Mechanical				
Operation type	Extrinsic (requires external controll)				
Response time	Minutes_				
Adaptivity	gradual				
Degree of adaptivity	Centimeters_	Level of AF visibility	3 Visible, surface change (lamellas, rollers, blinds)		
Cost/m2					
Maintenance cost/year					
Cost range	Medium (curtain walls, ventilated facades, etc)				

Nitinol (NiTi)

keywords	Shape memory; Alloy; Kinetic; Temperature; Reactive	Adaptivity concept	Building use
Type	Material	Building status	Building floor area
T.R.L.	5 Commercial product/Existing building	working principle of the facade system / component / material	
Function / goal		Nitinol alloys exhibit shape memory effect (SME) and superelasticity (SE). Shape memory is the ability to undergo deformation at one temperature, and recover its original undeformed shape upon heating above its "transformation temperature". Superelasticity occurs at a narrow temperature range just above its transformation temperature; no heating is necessary to cause the undeformed shape to recover, and the material exhibits enormous elasticity, 10-30 times that of ordinary metal.	
WG2 classification			
Type of system	Alloys_Autoreactive material		
Area (m^2)			
Weight (kg/m^2)			
Effect	Shape Memory Material_	Operation principle of the facade system / component / material	
Trigger (input)	Thermal (e.g. outdoor air temperature)	Nitinol's unusual properties are derived from a reversible solid-state phase transformation known as a martensitic transformation, between two different martensite crystal phases. At high temperatures, nitinol assumes an interpenetrating simple cubic structure referred to as austenite (also known as the parent phase). At low temperatures, nitinol spontaneously transforms to a more complicated body-centered tetragonal crystal structure known as martensite (daughter phase).	
Actuator (output)	Mechanical		
Operation type	Intrinsic (auto reactive)		
Response time	Seconds_Minutes_		
Adaptivity	gradual		
Degree of adaptivity	Nanometers_	Level of AF visibility	4 Visible, size or shape change (shutters, flaps, dynamic facade elements)
Cost/m2			
Maintenance cost/year		Detail of NiTi wires	
Cost range			

Window antenna

Glafo 2014

keywords	Window antenna; Glass; Surface coating; Prototype; Mobile reception	Adaptivity concept	Building use
Type	Component	Building status	Building floor area
T.R.L.	4 Prototype demonstration	working principle of the facade system / component / material	
Function / goal	accesibility	The low-E coating on the glass normally Shields mobile signals. By using the electrical conductivity of the coating it's transformed into an antenna for mobile signals instead.	
WG2 classification	Active Transparent Facades (ATF)		
Type of system	Insulated glass unit_		
Area (m^2)			
Weight (kg/m^2)			
Effect		Operation principle of the facade system / component / material	
Trigger (input)		Always functions as an antenna	
Actuator (output)			
Operation type	Intrinsic (auto reactive)		
Response time	Seconds_		
Adaptivity			
Degree of adaptivity	Millimeters_	Level of AF visibility	2 Visible, no surface change (smart glazing)
Cost/m2			
Maintenance cost/year		Prototype development	
Cost range	Medium (curtain walls, ventilated facades, etc)		

Arab World Institute

Atelier Jean Nouvel 1987 Paris

keywords	Mechanic; Light regulating; Diaphragm; Moucharabieh; Polygon	Adaptivity concept	Yes	Building use	EducationMuseum
Type	Facade system	Building status	New built	Building floor area	5.000 and up sq. m.
T.R.L.	5 Commercial product/Existing building	working principle of the facade system / component / material			
Function / goal	Visual comfort_Appearance (aesthetic quality)_	This southern facade is entirely composed of 240 motor-controlled camera-like diaphragms in metal screened by a glass facade. The devices automatically adjust their openess / closeness every hour to match the outdoor changing light levels with the desired interior light level, filtering light in and out of the building throughout the day.			
WG2 classification	Standard Curtain Wall (StandCW)				
Type of system	Curtain wall (stick)_Shading device (roller, louver, blind, shutter, etc)_				
Area (m^2)					
Weight (kg/m^2)					
Effect		Operation principle of the facade system / component / material			
Trigger (input)	Optical (e.g. daylight level, glare)	The institue du monde arabe is an example for a kinetic architecture that depends on mechanicals movements. A complex system of sensor-brain devices analyze the indoor light conditions and adjust the hexagonal screens by a more or less centralized control system.			
Actuator (output)	Mechanical				
Operation type	Extrinsic (requires external controll)				
Response time	Seconds_Minutes_				
Adaptivity	gradual				
Degree of adaptivity	Millimeters_Centimeters_	Level of AF visibility	3 Visible, surface change (lamellas, rollers, blinds)		
Cost/m2					
Maintenance cost/year		Detail of the southern facade			
Cost range	High (double skin facades, high tech, etc)				

Tesselate

Hoberman Associates + Buro Happold

keywords	Perforated metal; Kinetic; Sunshading; Sliding; Panels	Adaptivity concept	Yes	Building use
Type	Component	Building status		Building floor area
T.R.L.	5 Commercial product/Existing building	working principle of the facade system / component / material		
Function / goal	Thermal comfort_Visual comfort_Energy management (harvesting, storing, supply)_Appearance (aesthetic quality)_	Tessellate is a modular framed and glazed screen system with perforated pattern shifting kinetically, with four metal perforated panels gliding past one another, regulating light and solar gain, airflow, and privacy.		
WG2 classification	Biomimetic Facades (BF)			
Type of system	Shading device (roller, louver, blind, shutter, etc)_			
Area (m^2)				
Weight (kg/m^2)				
Effect		Operation principle of the facade system / component / material		
Trigger (input)	Electromagnetic (e.g. solar radiation)	Each Tessellate module runs on a single motor. These modules are controlled by a single computer processor, which can be programmed for various purposes.		
Actuator (output)	Mechanical			
Operation type	Extrinsic (requires external controll)			
Response time	Seconds_Minutes_Hours_			
Adaptivity	gradual			
Degree of adaptivity	Millimeters_Centimeters_	Level of AF visibility	3 Visible, surface change (lamellas, rollers, blinds)	
Cost/m2				
Maintenance cost/year		Detail of three stages in a Tesselate screen		
Cost range	Medium (curtain walls, ventilated facades, etc)			

Articulated cloud

Ned Kahn 2004 Pittsburgh, USA

keywords	Kinetic; Screen; Plastic; Tiles; Art	Adaptivity concept		Building use	Museum
Type	Facade system	Building status	New built	Building floor area	5.000 and up sq. m.
T.R.L.	5 Commercial product/Existing building	working principle of the facade system / component / material			
Function / goal	Visual comfort_Appearance (aesthetic quality)_	Composed of thousands of translucent, white plastic squares that move in the wind, the artwork is intended to suggest that the building has been enveloped by a digitized cloud. The optical qualities of the skin change dramatically with the weather and the time of day. The articulated skin is supported by an aluminum space frame so it appears to float in front of the building.			
WG2 classification	Biomimetic Facades (BF)				
Type of system	Double Skin Facade_External skin_Polymers_				
Area (m^2)					
Weight (kg/m^2)					
Effect		Operation principle of the facade system / component / material			
Trigger (input)	Mechanical (e.g. wind load)	The facade is a dynamic wind sculpture. The fluttering translucent panels it is made of are moved by the wind.			
Actuator (output)	Mechanical				
Operation type	Intrinsic (auto reactive)				
Response time	Seconds_				
Adaptivity	gradual				
Degree of adaptivity	Millimeters_Centimeters_	Level of AF visibility	5 Visible, location or orientation change		
Cost/m2					
Maintenance cost/year		Facade of the museum			
Cost range	Medium (curtain walls, ventilated facades, etc)				

Oval Cologne Offices

Sauerbruch Hutton Architekten **2010** **Cologne**

Facade system

Latitude: 50°56'N
Longitude: 06°57'E

INVOLVED PARTIES

Designer / Inventor / Researcher

Structural Engineer
Agne-Wahlen-Daubenbüchel

Services Engineer
Transsolar Energietechnik

Facade consultant

Manufacturer

Contractor

Building / project owner

Other party involved

CASE STUDY INFORMATION

Keywords defining the case-study:
automatic vertical shutter; daylight regulation; irregular shape; oval; color in architecture

Building floor area (if applicable):
500 - 5.000 sq.m.

Building use (if applicable):
Office

Building status (if applicable):
New built

Is adaptivity part of the main architectural design concept of the building? (if applicable) **Yes**

Orientation of the facade system / component / material
All orientation

Climate type
Cfb

Please specify the Technology Readiness Level (applies to all the information submitted):
5 Commercial product/Existing building

Function / goal / purpose
Thermal comfort_Visual comfort_ Appearance (aesthetic quality)_

Where does this technology fit in the following classification suggested by COST1403 WG2?
automatic shutter system

Select the type of facade system / component / material.
Curtain wall (stick)_ Shading device (roller, louver, blind, shutter, etc)_

If you are describing a switchable glazing, specify:

If you are describing a shading, please specify:
Blinds with slat angle control

Area of the case-study (sq.m.):

Added weight (kg/sq.m.) of the case-study:

MATERIAL ADAPTATION AND WORKING EFFECTS

How does the material adapt?

Type of trigger (INPUT):
- In the case of intrinsic operation: What triggers the smart material reaction?
- In the case of extrinsic operation: What does the sensor detect in order to run an actuator?
For instance, in the Institut du Monde Arabe facade, the trigger is optical.
Optical (e.g. daylight level, glare)

Type of actuator (OUTPUT):
For instance in the Institut du Monde Arabe facade the actuator output is Mechanical.
Mechanical

Explain the working principle of the case-study (short answer: max 500 characters):
The folding shutters are the sunscreens. They are made out of colored glass and automatically controlled.

Detailed explanation of the working principle (unlimited number of characters). This text will not appear in the case study's summarized data sheet, but only in the detailed one:
The shutters are controlled externally by the system measuring the insolation.

METRICS

Intro the value or value-range of the following metrics, if suitable to assess the adaptivity of your case-study:

UV Resistance	Light transmittance (%)
Weight/Density (g/cm2)	Solar transmittance (%)

U-Values (W/m2*K)	Total solar energy transmittance (%)
Noise insulation	Solar savings fraction (%)
Fire protection	Solar heat gain factor (%)
Other	Emissivity
Other	Other
Other	Other

Energy data based on:

Which simulation tools were used for the design?

CONTROL / OPERATION OF THE SYSTEM

Extrinsic (requires external controll)

Explain the control/operation. Short answer (max 500 characters):
The louvers are controlled externally by the system measuring the insolation.

Detailed explanation of the control/operation (unlimited number of characters). This text will not appear in the case study's data sheet, but only in the detailed sheet:

System response time (thick all that apply):	**Seconds_Minutes_**
System degree of adaptivity:	**gradual**
Degree of spatial adaptation	**Centimeters_**
Level of AF visibility (Reijenga classification):	**4 Visible, size or shape change (shutters, flaps, dynamic facade elements)**

ECONOMIC ASPECTS

Is the system economically viable?	unknown
Cost/m2	
Yearly cost of maintenance	
System maintenance frequency	Monthly

REFERENCES (bibliography, web sites etc.)

Reference 1: **http://www.scientific.net/AST.77.124**

Reference 2: **R. Ruhmann, A. Seeboth, O. Muehling, D. Loetzsch, "Thermotropic Materials for Adaptive Solar Control", Advances in Science and Technology, Vol. 77, pp. 124-131, Sep. 2012**

Reference 3:

Reference 4:

Reference 5:

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AUTHOR OF THE SHEET INFO

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WG affiliation (if applicable)	WG1

Altra Sede Regione Lombardia

Pei Cobb Freed & Partners, Caputo Partnership, SDPartners **2010** **Milan**

Facade system

Latitude: 45°29'12.39"N
Longitude: 9°11'44.92"E

INVOLVED PARTIES

Designer / Inventor / Researcher

Structural Engineer

Services Engineer

Facade consultant

Manufacturer

Contractor

Building / project owner

Other party involved

CASE STUDY INFORMATION

Keywords defining the case-study:
Building Integrated Photovoltaic; Photovoltaic glass; Curtain wall; Skyscraper; Renewable Energy

Building floor area (if applicable):

Building use (if applicable):
Office

Building status (if applicable):
New built

Is adaptivity part of the main architectural design concept of the building? (if applicable) **No**

Orientation of the facade system / component / material

Climate type
Cfa

Please specify the Technology Readiness Level (applies to all the information submitted):
5 Commercial product/Existing building

Function / goal / purpose
Energy management (harvesting, storing, supply)_ Energy generation_ Use of natural resource

Where does this technology fit in the following classification suggested by COST1403 WG2?
Active Transparent Facades (ATF)

Select the type of facade system / component / material.
Energy harvesting device(e.g. photovoltaic element)_

If you are describing a switchable glazing, specify:

If you are describing a shading, please specify:

Area of the case-study (sq.m.):

Added weight (kg/sq.m.) of the case-study:

MATERIAL ADAPTATION AND WORKING EFFECTS

How does the material adapt?

Type of trigger (INPUT):
- In the case of intrinsic operation: What triggers the smart material reaction?
- In the case of extrinsic operation: What does the sensor detect in order to run an actuator?
For instance, in the Institut du Monde Arabe facade, the trigger is optical.

Type of actuator (OUTPUT):
For instance in the Institut du Monde Arabe facade the actuator output is Mechanical.

Explain the working principle of the case-study (short answer: max 500 characters):
The BIPV façades of the building aim to produce energy and to reduce at the same time solar heat gain in the hot season.

Detailed explanation of the working principle (unlimited number of characters). This text will not appear in the case study's summarized data sheet, but only in the detailed one:

METRICS

Intro the value or value-range of the following metrics, if suitable to assess the adaptivity of your case-study:

UV Resistance	Light transmittance (%)
Weight/Density (g/cm2)	Solar transmittance (%)

U-Values (W/m2*K)	Total solar energy transmittance (%)
Noise insulation	Solar savings fraction (%)
Fire protection	Solar heat gain factor (%)
Other	Emissivity
Other	Other
Other	Other

Energy data based on:

Which simulation tools were used for the design?

CONTROL / OPERATION OF THE SYSTEM

Explain the control/operation. Short answer (max 500 characters):

-

Detailed explanation of the control/operation (unlimited number of characters). This text will not appear in the case study's data sheet, but only in the detailed sheet:

System response time (thick all that apply):

System degree of adaptivity:

Degree of spatial adaptation

Level of AF visibility (Reijenga classification):

ECONOMIC ASPECTS

Is the system economically viable? Yes

Cost/m2

Yearly cost of maintenance

System maintenance frequency

REFERENCES (bibliography, web sites etc.)

Reference 1: **http://www.regione.lombardia.it/cs/Satellite?c=Page&childpagename=Regione%2FRegioneLayout&cid=1213349250902&p=1213349250902&pagename=RGNWrapper**

Reference 2:

Reference 3:

Reference 4:

Reference 5:

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AUTHOR OF THE SHEET INFO

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WG affiliation (if applicable)	WG1

Regenerable PV with HEMN

Hyung-Jun Koo / material engineering

Material

Latitude:
Longitude:

INVOLVED PARTIES

Designer / Inventor / Researcher
Hyung-Jun Koo, Orlin D Velev

Structural Engineer
-

Services Engineer
-

Facade consultant
-

Manufacturer
material technology innovation

Contractor
-

Building / project owner
-

Other party involved
-

CASE STUDY INFORMATION

Keywords defining the case-study:
photosystem; regeneration ; dye infusion; biomimetic; photovoltaic

Building floor area (if applicable):

Building use (if applicable):
Energy generation

Building status (if applicable):
New built

Is adaptivity part of the main architectural design concept of the building? (if applicable) **Yes**

Orientation of the facade system / component / material
S_

Climate type
All of them

Please specify the Technology Readiness Level (applies to all the information submitted):
3 Technology validated in lab

Function / goal / purpose
Energy management (harvesting, storing, supply)_

Where does this technology fit in the following classification suggested by COST1403 WG2?
Biomimetic Facades (BF)

Select the type of facade system / component / material.
Energy harvesting device(e.g. photovoltaic element)_

If you are describing a switchable glazing, specify:
aim: photoelectrochemical oxidation to reduce accelerated photo degradation for enhanced photovoltaic functionality

If you are describing a shading, please specify:
a material photosystem to reduce damage light stress by electrochemical regeneration

Area of the case-study (sq.m.): n/a

Added weight (kg/sq.m.) of the case-study: n/a

MATERIAL ADAPTATION AND WORKING EFFECTS

How does the material adapt? **chemical infusion of organic dye u-FGPV**

Type of trigger (INPUT):
- In the case of intrinsic operation: What triggers the smart material reaction?
- In the case of extrinsic operation: What does the sensor detect in order to run an actuator?
For instance, in the Institut du Monde Arabe facade, the trigger is optical.
energy enhance performance function of PV

Type of actuator (OUTPUT):
For instance in the Institut du Monde Arabe facade the actuator output is Mechanical.
Chemical

Explain the working principle of the case-study (short answer: max 500 characters):
Regenerable Photovoltaic Devices with Hydrogel-Embedded Microvascular Network (HEMN) is a material innovation for facades innovation surfaces with biomimetic microvascular network for dye infusion for regenerative photovoltaic performance. Photosensitive organic dye molecules (PoDM) reduce deterioration of long term energy operational outputs and enhance the performance of photovoltaic cells. This biomimetic network of dye infusion gives damage regerneration by chemical compounds of action and reaction have been undertaken by Hyung within self-heal photovoltaic. Vascular networks have been used as regenerative functions for hydrogel photovoltaic devices by photosensitive organic dye infusion, Fig. 1.

Detailed explanation of the working principle (unlimited number of characters). This text will not appear in the case study's summarized data sheet, but only in the detailed one:
For further information on this research paper:
Hyung-Jun K, Orlin DV (2013) Regenerable photovoltaic devices with a hydrogel-embedded microvascular network. Nat Sci Rep 3:2357. doi:10.1038/srep02357)

METRICS

Intro the value or value-range of the following metrics, if suitable to assess the adaptivity of your case-study:

UV Resistance	Light transmittance (%)
Weight/Density (g/cm2)	Solar transmittance (%)

U-Values (W/m2*K)		Total solar energy transmittance (%)	
Noise insulation		Solar savings fraction (%)	
Fire protection		Solar heat gain factor (%)	
Other	molecule engineering of dye to enhance hydrogel for 60% recovery of light stress in light damaged photosensitive molecules	Emissivity	
Other		Other	
Other		Other	

Energy data based on:

Monitoring

Which simulation tools were used for the design?

COMSOL Multiphysics package ver 3.5 setting domain and boundary conditions

CONTROL / OPERATION OF THE SYSTEM

photovoltaic of u-FGPV in a closed structure

Explain the control/operation. Short answer (max 500 characters):

SOLAR HARVESTING DEVICE

Optimization of regenerative functionality of a photovoltaic system by photosensitive organic dye molecules. Organic dyes are generally susceptible to light stress, high temperatures that reduce the long-term performance of photovoltaic cells. Embedded microfluidics within a network enables regenerative functionality by the infusion of chemical regenerative properties by transport of photoactive agents dye and electrolytes to create a microfluidic hydrogel solar cell of optimum performance for electricity generation.

Detailed explanation of the control/operation (unlimited number of characters). This text will not appear in the case study's data sheet, but only in the detailed sheet:

please refer to paper:

System response time (thick all that apply):	**depending on dye infusion into network, changes response time of PoDM regeneration**
System degree of adaptivity:	**gradual**
Degree of spatial adaptation	**Nanometers_**
Level of AF visibility (Reijenga classification):	**2 Visible, no surface change (smart glazing)**

ECONOMIC ASPECTS

Is the system economically viable?	lab testing at this moment - prototype under development
Cost/m2	-
Yearly cost of maintenance	-
System maintenance frequency	unknown at this moment

REFERENCES (bibliography, web sites etc.)

Reference 1: **Hyung-Jun K, Orlin DV (2013) Regenerable photovoltaic devices with a hydrogel-embedded microvascular network. Nat Sci Rep 3:2357. doi:10.1038/srep02357**

Reference 2:

Reference 3:

Reference 4:

Reference 5:

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AUTHOR OF THE SHEET INFO

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e-mail:	m.e.alston@salford.ac.uk
WG affiliation (if applicable)	WG1

Hygroscope

Achim Menges Architect **2012** **Centre Pompidou, Paris** 4

Component

Latitude: 48.8612
Longitude: 2.3533

INVOLVED PARTIES

Designer / Inventor / Researcher

Achim Menges Architect, Frankfurt Prof. Achim Menges, Steffen Reichert, Boyan Mihaylov (Project Development, Design Development)

Structural Engineer

Institute for Computational Design, University of Stuttgart Prof. Achim Menges, Steffen Reichert, Nicola Burggraf, Tobias Schwinn with Claudio Calandri, Nicola Haberbosch, Oliver Krieg, Marielle Neuser, Viktoriya Nikolova, Paul Schmidt (Design Development, Scientific Development, Robotic Fabrication, Assembly)

Services Engineer

Facade consultant

Manufacturer

Contractor

Building / project owner

Centre Pompidou Paris, permanent collection

Other party involved

Transsolar Climate Engineering, Stuttgart Thomas Auer, Daniel Pianka (Climate Engineering)

CASE STUDY INFORMATION

Keywords defining the case-study:

Moisture sensitive; Parametric; Wood; Kinetic; Autoreactive

Building floor area (if applicable):

Building use (if applicable):

Building status (if applicable):

Is adaptivity part of the main architectural design concept of the building? (if applicable) **Yes**

Orientation of the facade system / component / material

All orientation

Climate type

Please specify the Technology Readiness Level (applies to all the information submitted):
4 Prototype demonstration

Function / goal / purpose
Appearance (aesthetic quality)_

Where does this technology fit in the following classification suggested by COST1403 WG2?
Biomimetic Facades (BF)

Select the type of facade system / component / material.
External skin_ Wood_

If you are describing a switchable glazing, specify:

If you are describing a shading, please specify:

Area of the case-study (sq.m.): 2

Added weight (kg/sq.m.) of the case-study:

MATERIAL ADAPTATION AND WORKING EFFECTS

How does the material adapt? **Bi-material effect_**

Type of trigger (INPUT):
- In the case of intrinsic operation: What triggers the smart material reaction?
- In the case of extrinsic operation: What does the sensor detect in order to run an actuator?
For instance, in the Institut du Monde Arabe facade, the trigger is optical.
Air quality (humidity, CO2 concentration, etc)

Type of actuator (OUTPUT):
For instance in the Institut du Monde Arabe facade the actuator output is Mechanical.
Mechanical

Explain the working principle of the case-study (short answer: max 500 characters):
The thin wooden sheets curve (opening) and extend (closing) through a hygroscopic behavior (ability to take in moisture from the atmosphere when dry and yield moisture to the atmosphere when wet) in response to R.H. fluctuations which trigger the anisotropic characteristics of the materials.

Detailed explanation of the working principle (unlimited number of characters). This text will not appear in the case study's summarized data sheet, but only in the detailed one:

METRICS

Intro the value or value-range of the following metrics, if suitable to assess the adaptivity of your case-study:

UV Resistance	Light transmittance (%)
Weight/Density (g/cm2)	Solar transmittance (%)

U-Values (W/m2*K)	Total solar energy transmittance (%)
Noise insulation	Solar savings fraction (%)
Fire protection	Solar heat gain factor (%)
Other	Emissivity
Other	Other
Other	Other

Energy data based on:

Which simulation tools were used for the design?

CONTROL / OPERATION OF THE SYSTEM

Intrinsic (auto reactive)

Explain the control/operation. Short answer (max 500 characters):

The model opens and closes in response to climate changes with no need for any technical equipment or energy. Mere fluctuations in relative humidity trigger the silent changes of material-innate movement. The material structure itself is the machine.

Detailed explanation of the control/operation (unlimited number of characters). This text will not appear in the case study's data sheet, but only in the detailed sheet:

System response time (thick all that apply):	**Seconds_Minutes_**
System degree of adaptivity:	**gradual**
Degree of spatial adaptation	**Micrometers_Millimeters_**
Level of AF visibility (Reijenga classification):	**4 Visible, size or shape change (shutters, flaps, dynamic facade elements)**

ECONOMIC ASPECTS

Is the system economically viable?

Cost/m2

Yearly cost of maintenance

System maintenance frequency

REFERENCES (bibliography, web sites etc.)

Reference 1: **http://www.achimmenges.net/?p=5083**

Reference 2: **http://icd.uni-stuttgart.de/?p=7291**

Reference 3: **https://www.centrepompidou.fr/cpv/resource/c7GpBeA/rb964z**

Reference 4: **http://www.biomimetic-architecture.com/2012/hygroscope-centre-pompidou-paris/**

Reference 5:

Link to picture/video 1

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AUTHOR OF THE SHEET INFO

name:	Sandra Persiani
company/univer sity:	Technical University of Munich
e-mail:	sandra.persiani@tum.de
WG affiliation (if applicable)	in contact with WG1

Cyclebowl

ATELIER BRÜCKNER GmbH **2000** **Hannover Expo** 5

Facade system

Latitude: 52.3205837
Longitude: 9.8146405

INVOLVED PARTIES

Designer / Inventor / Researcher
ATELIER BRÜCKNER GmbH

Structural Engineer
Baustatik Relling, IPL Ingenieurplanung Leichtbau GmbH, TL ingenieure für tragwerk und leichtbau gmbh

Services Engineer
Arup Ingenieure

Facade consultant
Arup Ingenieure

Manufacturer
Foiltec GmbH

Contractor

Building / project owner
Duales System Deutschland AG

Other party involved

CASE STUDY INFORMATION

Keywords defining the case-study:
Pneumatic; Sun shading; ETFE; Cushion; Pattern

Building floor area (if applicable):

Building use (if applicable):
Exhibition pavillion

Building status (if applicable):
New built

Is adaptivity part of the main architectural design concept of the building? (if applicable) **Yes**

Orientation of the facade system / component / material
SE_S_SW_

Climate type
Cfb

Please specify the Technology Readiness Level (applies to all the information submitted):

5 Commercial product/Existing building

Function / goal / purpose

Thermal comfort_Visual comfort_ Energy management (harvesting, storing, supply)_Mass transfer control (e.g. condensation control)_ Appearance (aesthetic quality)_

Where does this technology fit in the following classification suggested by COST1403 WG2?

Biomimetic Facades (BF)

Select the type of facade system / component / material.

External skin_ Polymers_

If you are describing a switchable glazing, specify:

If you are describing a shading, please specify:

Screens / roller shades

Area of the case-study (sq.m.):

Added weight (kg/sq.m.) of the case-study:

MATERIAL ADAPTATION AND WORKING EFFECTS

How does the material adapt?

Type of trigger (INPUT):
- In the case of intrinsic operation: What triggers the smart material reaction?
- In the case of extrinsic operation: What does the sensor detect in order to run an actuator?

For instance, in the Institut du Monde Arabe facade, the trigger is optical.

Optical (e.g. daylight level, glare)

Type of actuator (OUTPUT):

For instance in the Institut du Monde Arabe facade the actuator output is Mechanical.

Mechanical

Explain the working principle of the case-study (short answer: max 500 characters):

The facade is made of nylon+ polyurethane cushions with a flexible transparent layer inside. A positive/negative pattern is printed on the middle and on the outer layer of the cushions. When the middle layer overlaps with the outer layer, the printed patterns superimpose and shading is provided. When it moves away from the outer layer, light filters through the patterns printed on the surfaces. Intermediate ranges of shading are possible depending on the position of the middle layer.

Detailed explanation of the working principle (unlimited number of characters). This text will not appear in the case study's summarized data sheet, but only in the detailed one:

METRICS

Intro the value or value-range of the following metrics, if suitable to assess the adaptivity of your case-study:

UV Resistance	Light transmittance (%)
Weight/Density (g/cm2)	Solar transmittance (%)

U-Values (W/m2*K)	Total solar energy transmittance (%)
Noise insulation	Solar savings fraction (%)
Fire protection	Solar heat gain factor (%)
Other	Emissivity
Other	Other
Other	Other

Energy data based on:

Which simulation tools were used for the design?

CONTROL / OPERATION OF THE SYSTEM

Extrinsic (requires external controll)

Explain the control/operation. Short answer (max 500 characters):
Cushions are mechanically activated by an exterior (powered) system.

Detailed explanation of the control/operation (unlimited number of characters). This text will not appear in the case study's data sheet, but only in the detailed sheet:

System response time (thick all that apply):	**Minutes_**
System degree of adaptivity:	**gradual**
Degree of spatial adaptation	**Centimeters_**
Level of AF visibility (Reijenga classification):	**3 Visible, surface change (lamellas, rollers, blinds)**

ECONOMIC ASPECTS

Is the system economically viable?	Yes
Cost/m2	
Yearly cost of maintenance	
System maintenance frequency	

REFERENCES (bibliography, web sites etc.)

Reference 1: **http://www.atelier-brueckner.de/en/projects/cyclebowl**

Reference 2: **http://www.architetturatessile.polimi.it/membrane_scocche/campi_mem/1B_edificio_tessile_t/2000_CycleBlowl_p/2000_CycleBlowl_P.htm**

Reference 3: **http://www.vector-foiltec.com/projects/duales-system-expo-2000-hannover/**

Reference 4:

Reference 5:

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AUTHOR OF THE SHEET INFO

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WG affiliation (if applicable)	in contact with WG1

Nitinol (NiTi)

Material

Latitude:
Longitude:

INVOLVED PARTIES

Designer / Inventor / Researcher

Structural Engineer

Services Engineer

Facade consultant

Manufacturer

Contractor

Building / project owner

Other party involved

CASE STUDY INFORMATION

Keywords defining the case-study:
Shape memory; Alloy; Kinetic; Temperature; Reactive

Building floor area (if applicable):

Building use (if applicable):

Building status (if applicable):

Is adaptivity part of the main architectural design concept of the building? (if applicable)

Orientation of the facade system / component / material

Climate type

Please specify the Technology Readiness Level (applies to all the information submitted):
5 Commercial product/Existing building

Function / goal / purpose

Where does this technology fit in the following classification suggested by COST1403 WG2?

Select the type of facade system / component / material.
Alloys_ Autoreactive material

If you are describing a switchable glazing, specify:

If you are describing a shading, please specify:

Area of the case-study (sq.m.):

Added weight (kg/sq.m.) of the case-study:

MATERIAL ADAPTATION AND WORKING EFFECTS

How does the material adapt? **Shape Memory Material_**

Type of trigger (INPUT):
- In the case of intrinsic operation: What triggers the smart material reaction?
- In the case of extrinsic operation: What does the sensor detect in order to run an actuator?
For instance, in the Institut du Monde Arabe facade, the trigger is optical.
Thermal (e.g. outdoor air temperature)

Type of actuator (OUTPUT):
For instance in the Institut du Monde Arabe facade the actuator output is Mechanical.
Mechanical

Explain the working principle of the case-study (short answer: max 500 characters):
Nitinol alloys exhibit shape memory effect (SME) and superelasticity (SE). Shape memory is the ability to undergo deformation at one temperature, and recover its original undeformed shape upon heating above its "transformation temperature". Superelasticity occurs at a narrow temperature range just above its transformation temperature; no heating is necessary to cause the undeformed shape to recover, and the material exhibits enormous elasticity, 10-30 times that of ordinary metal.

Detailed explanation of the working principle (unlimited number of characters). This text will not appear in the case study's summarized data sheet, but only in the detailed one:

METRICS

Intro the value or value-range of the following metrics, if suitable to assess the adaptivity of your case-study:

UV Resistance	Light transmittance (%)
Weight/Density (g/cm2)	Solar transmittance (%)

U-Values (W/m2*K)		Total solar energy transmittance (%)	
Noise insulation		Solar savings fraction (%)	
Fire protection		Solar heat gain factor (%)	
Other	Hysterese 30/40°C	Emissivity	
Other	Cycles >10 Millions	Other	
Other	Biocompatibility good	Other	

Energy data based on:
Measurement/testing

Which simulation tools were used for the design?

CONTROL / OPERATION OF THE SYSTEM

Intrinsic (auto reactive)

Explain the control/operation. Short answer (max 500 characters):
Nitinol's unusual properties are derived from a reversible solid-state phase transformation known as a martensitic transformation, between two different martensite crystal phases. At high temperatures, nitinol assumes an interpenetrating simple cubic structure referred to as austenite (also known as the parent phase). At low temperatures, nitinol spontaneously transforms to a more complicated body-centered tetragonal crystal structure known as martensite (daughter phase).

Detailed explanation of the control/operation (unlimited number of characters). This text will not appear in the case study's data sheet, but only in the detailed sheet:

System response time (thick all that apply):	**Seconds_Minutes_**
System degree of adaptivity:	**gradual**
Degree of spatial adaptation	**Nanometers_**
Level of AF visibility (Reijenga classification):	**4 Visible, size or shape change (shutters, flaps, dynamic facade elements)**

ECONOMIC ASPECTS

Is the system economically viable?

Cost/m2

Yearly cost of maintenance

System maintenance frequency

REFERENCES (bibliography, web sites etc.)

Reference 1: **https://nitinol.com**

Reference 2: **http://www.adaptronik.fraunhofer.de/**

Reference 3: **http://www.rtm-medizintechnik.de/**

Reference 4:

Reference 5:

Link to picture/video 1	http://www.g-rau.de/en/products/actuators-made-of-shape-memory-alloys.html
Caption, description	Detail of NiTi wires
Author	G.RAU GmbH & Co
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Caption, description	
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WG affiliation (if applicable)	in contact with WG1

Window antenna

Glafo **2014**

Component

Latitude:
Longitude:

INVOLVED PARTIES

Designer / Inventor / Researcher
Glafo

Structural Engineer

Services Engineer

Facade consultant

Manufacturer
Inwido

Contractor

Building / project owner

Other party involved

CASE STUDY INFORMATION

Keywords defining the case-study:
Window antenna; Glass; Surface coating; Prototype; Mobile reception

Building floor area (if applicable):

Building use (if applicable):

Building status (if applicable):

Is adaptivity part of the main architectural design concept of the building? (if applicable)

Orientation of the facade system / component / material
All orientation

Climate type
All of them

Please specify the Technology Readiness Level (applies to all the information submitted):
4 Prototype demonstration

Function / goal / purpose
accesibility

Where does this technology fit in the following classification suggested by COST1403 WG2?
Active Transparent Facades (ATF)

Select the type of facade system / component / material.
Insulated glass unit_

If you are describing a switchable glazing, specify:

If you are describing a shading, please specify:

Area of the case-study (sq.m.):

Added weight (kg/sq.m.) of the case-study:

MATERIAL ADAPTATION AND WORKING EFFECTS

How does the material adapt?

Type of trigger (INPUT):
- In the case of intrinsic operation: What triggers the smart material reaction?
- In the case of extrinsic operation: What does the sensor detect in order to run an actuator?
For instance, in the Institut du Monde Arabe facade, the trigger is optical.

Type of actuator (OUTPUT):
For instance in the Institut du Monde Arabe facade the actuator output is Mechanical.

Explain the working principle of the case-study (short answer: max 500 characters):
The low-E coating on the glass normally Shields mobile signals. By using the electrical conductivity of the coating it's transformed into an antenna for mobile signals instead.

Detailed explanation of the working principle (unlimited number of characters). This text will not appear in the case study's summarized data sheet, but only in the detailed one:

METRICS

Intro the value or value-range of the following metrics, if suitable to assess the adaptivity of your case-study:

UV Resistance	Light transmittance (%)
Weight/Density (g/cm2)	Solar transmittance (%)

U-Values (W/m2*K)	Total solar energy transmittance (%)
Noise insulation	Solar savings fraction (%)
Fire protection	Solar heat gain factor (%)
Other	Emissivity
Other	Other
Other	Other

Energy data based on:

Which simulation tools were used for the design?

CONTROL / OPERATION OF THE SYSTEM

Intrinsic (auto reactive)

Explain the control/operation. Short answer (max 500 characters):
Always functions as an antenna

Detailed explanation of the control/operation (unlimited number of characters). This text will not appear in the case study's data sheet, but only in the detailed sheet:

System response time (thick all that apply):	**Seconds_**
System degree of adaptivity:	
Degree of spatial adaptation	**Millimeters_**
Level of AF visibility (Reijenga classification):	**2 Visible, no surface change (smart glazing)**

ECONOMIC ASPECTS

Is the system economically viable?	
Cost/m2	
Yearly cost of maintenance	
System maintenance frequency	Yearly

REFERENCES (bibliography, web sites etc.)

Reference 1: **Adaptive facade network - Europe, page 63 (http://tu1403.eu/?page_id=209)**

Reference 2: **http://www.glafo.se/projektinformation/13-2/3P00015E2A.htm**

Reference 3:
Reference 4:

Reference 5:

Link to picture/video 1	http://www.glafo.se/projektinformation/13-2/3P00015S2A.htm
Caption, description	Prototype development
Author	Mikael Ludvigsson
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WG affiliation (if applicable)	WG1

Arab World Institute

Atelier Jean Nouvel **1987** **Paris** 8

Facade system

Latitude: 48.848926
Longitude: 2.357231

INVOLVED PARTIES

Designer / Inventor / Researcher
Jean NOUVEL, Gilbert LEZENES, Pierre SORIA, Architecture Studio

Structural Engineer

Services Engineer

Facade consultant

Manufacturer

Contractor

Building / project owner
Institut du monde arabe, Scarif (owner's representative)

Other party involved

CASE STUDY INFORMATION

Keywords defining the case-study:
Mechanic; Light regulating; Diaphragm; Moucharabieh; Polygon

Building floor area (if applicable):
5.000 and up sq. m.

Building use (if applicable):
Education Museum

Building status (if applicable):
New built

Is adaptivity part of the main architectural design concept of the building? (if applicable) **Yes**

Orientation of the facade system / component / material
SE_S_SW_

Climate type
Cfb

Please specify the Technology Readiness Level (applies to all the information submitted):
5 Commercial product/Existing building

Function / goal / purpose
Visual comfort_ Appearance (aesthetic quality)_

Where does this technology fit in the following classification suggested by COST1403 WG2?
Standard Curtain Wall (StandCW)

Select the type of facade system / component / material.
Curtain wall (stick)_ Shading device (roller, louver, blind, shutter, etc)_

If you are describing a switchable glazing, specify:

If you are describing a shading, please specify:
shutter diaphragms

Area of the case-study (sq.m.):

Added weight (kg/sq.m.) of the case-study:

MATERIAL ADAPTATION AND WORKING EFFECTS

How does the material adapt?

Type of trigger (INPUT):
- In the case of intrinsic operation: What triggers the smart material reaction?
- In the case of extrinsic operation: What does the sensor detect in order to run an actuator?
For instance, in the Institut du Monde Arabe facade, the trigger is optical.
Optical (e.g. daylight level, glare)

Type of actuator (OUTPUT):
For instance in the Institut du Monde Arabe facade the actuator output is Mechanical.
Mechanical

Explain the working principle of the case-study (short answer: max 500 characters):
This southern facade is entirely composed of 240 motor-controlled camera-like diaphragms in metal screened by a glass facade. The devices automatically adjust their openess / closeness every hour to match the outdoor changing light levels with the desired interior light level, filtering light in and out of the building throughout the day.

Detailed explanation of the working principle (unlimited number of characters). This text will not appear in the case study's summarized data sheet, but only in the detailed one:

METRICS

Intro the value or value-range of the following metrics, if suitable to assess the adaptivity of your case-study:

UV Resistance	Light transmittance (%)
Weight/Density (g/cm2)	Solar transmittance (%)

U-Values (W/m2*K)	Total solar energy transmittance (%)
Noise insulation	Solar savings fraction (%)
Fire protection	Solar heat gain factor (%)
Other	Emissivity
Other	Other
Other	Other

Energy data based on:

Which simulation tools were used for the design?

CONTROL / OPERATION OF THE SYSTEM

Extrinsic (requires external controll)

Explain the control/operation. Short answer (max 500 characters):

The institue du monde arabe is an example for a kinetic architecture that depends on mechanicals movements. A complex system of sensor-brain devices analyze the indoor light conditions and adjust the hexagonal screens by a more or less centralized control system.

Detailed explanation of the control/operation (unlimited number of characters). This text will not appear in the case study's data sheet, but only in the detailed sheet:

System response time (thick all that apply):	**Seconds_Minutes_**
System degree of adaptivity:	**gradual**
Degree of spatial adaptation	**Millimeters_Centimeters_**
Level of AF visibility (Reijenga classification):	**3 Visible, surface change (lamellas, rollers, blinds)**

ECONOMIC ASPECTS

Is the system economically viable?	No, it is known for its high building/maintenance costs and mechanical failure
Cost/m2	
Yearly cost of maintenance	
System maintenance frequency	Not available

REFERENCES (bibliography, web sites etc.)

Reference 1: **http://www.jeannouvel.com/en/desktop/home/#/en/desktop/projet/paris-france-arab-world-institut1**

Reference 2: **http://www.imarabe.org/architecture-institut-du-monde-arabe**

Reference 3: **http://www.akdn.org/publications/akaa/1989_138.pdf**

Reference 4: **Moloney, Jules. Designing Kinetics for Architectural Facades, State Change, Routledge, New York, 2011.**

Reference 5:	**Khoo, Chin Koi; Salim, Flora; Burry, Jane. Designing Architectural Morphing Skins with Elastic Modular Systems, RMIT University,Spatial Information Architecture Laboratory (SIAL), international journal of architectural computing, issue 04, volume 09, p. 397- 419.**
Link to picture/video 1	https://www.flickr.com/photos/joevare/3949286058/
Caption, description	Detail of the southern facade
Author	"joevare"
CreativeCommonts/Copyleft/PublicDomain/Copyright)	Free for sharing, even commercial use
Link to picture/video 2	https://www.flickr.com/photos/loran/3373246658/
Caption, description	Detail of the Moucharabieh
Author	"loran"
CreativeCommonts/Copyleft/PublicDomain/Copyright)	Free for sharing, even commercial use
Link to picture/video 3	https://www.flickr.com/photos/bluguia_pablo/2829138470/
Caption, description	Detail of the south facade with open and closed diaphragms
Author	"Pablo"
CreativeCommonts/Copyleft/PublicDomain/Copyright)	Free for sharing and adapting, even commercial use
Link to picture/video 4	https://www.flickr.com/photos/claveirole/7977235614/
Caption, description	Southern facade of the IMA.
Author	"Mon Œil"
CreativeCommonts/Copyleft/PublicDomain/Copyright)	Free for sharing and adapting, even commercial use
Link to picture/video 5	https://www.flickr.com/photos/sergemelki/3389136542/
Caption, description	Detail of the diaphragm's mechanisms
Author	Serge Melki
CreativeCommonts/Copyleft/PublicDomain/Copyright)	Free for sharing and adapting, even commercial use
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AUTHOR OF THE SHEET INFO

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e-mail:	sandra.persiani@tum.de
WG affiliation (if applicable)	in contact with WG1

Tesselate

Hoberman Associates + Buro Happold

Component

Latitude:
Longitude:

INVOLVED PARTIES

Designer / Inventor / Researcher
Hoberman Associates + Buro Happold

Structural Engineer

Services Engineer

Facade consultant

Manufacturer
Zahner + Adaptive Building Initiative (ABI)

Contractor

Building / project owner
Zahner + Adaptive Building Initiative (ABI)

Other party involved

CASE STUDY INFORMATION

Keywords defining the case-study:
Perforated metal; Kinetic; Sunshading; Sliding; Panels

Building floor area (if applicable):

Building use (if applicable):

Building status (if applicable):

Is adaptivity part of the main architectural design concept of the building? (if applicable) **Yes**

Orientation of the facade system / component / material
E_SE_S_SW_W_

Climate type

Please specify the Technology Readiness Level (applies to all the information submitted):
5 Commercial product/Existing building

Function / goal / purpose
Thermal comfort_Visual comfort_ Energy management (harvesting, storing, supply)_ Appearance (aesthetic quality)_

Where does this technology fit in the following classification suggested by COST1403 WG2?
Biomimetic Facades (BF)

Select the type of facade system / component / material.
Shading device (roller, louver, blind, shutter, etc)_

If you are describing a switchable glazing, specify:

If you are describing a shading, please specify:
Screens / roller shades

Area of the case-study (sq.m.):

Added weight (kg/sq.m.) of the case-study:

MATERIAL ADAPTATION AND WORKING EFFECTS

How does the material adapt?

Type of trigger (INPUT):
- In the case of intrinsic operation: What triggers the smart material reaction?
- In the case of extrinsic operation: What does the sensor detect in order to run an actuator?
For instance, in the Institut du Monde Arabe facade, the trigger is optical.
Electromagnetic (e.g. solar radiation)

Type of actuator (OUTPUT):
For instance in the Institut du Monde Arabe facade the actuator output is Mechanical.
Mechanical

Explain the working principle of the case-study (short answer: max 500 characters):
Tessellate is a modular framed and glazed screen system with perforated pattern shifting kinetically, with four metal perforated panels gliding past one another, regulating light and solar gain, airflow, and privacy.

Detailed explanation of the working principle (unlimited number of characters). This text will not appear in the case study's summarized data sheet, but only in the detailed one:

METRICS

Intro the value or value-range of the following metrics, if suitable to assess the adaptivity of your case-study:

UV Resistance	Light transmittance (%)
Weight/Density (g/cm2)	Solar transmittance (%)

U-Values (W/m2*K)	Total solar energy transmittance (%)
Noise insulation	Solar savings fraction (%)
Fire protection	Solar heat gain factor (%)
Other	Emissivity
Other	Other
Other	Other

Energy data based on:

Which simulation tools were used for the design?

CONTROL / OPERATION OF THE SYSTEM

Extrinsic (requires external controll)

Explain the control/operation. Short answer (max 500 characters):

Each Tessellate module runs on a single motor. These modules are controlled by a single computer processor, which can be programmed for various purposes.

Detailed explanation of the control/operation (unlimited number of characters). This text will not appear in the case study's data sheet, but only in the detailed sheet:

System response time (thick all that apply):	**Seconds_Minutes_Hours_**
System degree of adaptivity:	**gradual**
Degree of spatial adaptation	**Millimeters_Centimeters_**
Level of AF visibility (Reijenga classification):	**3 Visible, surface change (lamellas, rollers, blinds)**

ECONOMIC ASPECTS

Is the system economically viable?	Yes
Cost/m2	
Yearly cost of maintenance	
System maintenance frequency	

REFERENCES (bibliography, web sites etc.)

Reference 1: **http://www.azahner.com/tessellate.cfm**

Reference 2: **http://www.hoberman.com/portfolio/simonscenter.php?projectname=Simons+Center**

Reference 3: **http://www.azahner.com/portfolio/stony-brook**

Reference 4:

Reference 5:

Link to picture/video 1	http://www.azahner.com/images/tessellate-unveiling.jpg
Caption, description	Detail of three stages in a Tesselate screen
Author	Zahner
CreativeCommonts/Copyleft/PublicDomain/Copyright)	
Link to picture/video 2	
Caption, description	
Author	
CreativeCommonts/Copyleft/PublicDomain/Copyright)	
Link to picture/video 3	
Caption, description	
Author	
CreativeCommonts/Copyleft/PublicDomain/Copyright)	
Link to picture/video 4	
Caption, description	
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Link to picture/video 5	
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Articulated cloud

Ned Kahn **2004** **Pittsburgh, USA** 10

Facade system

Latitude: 40.7683987
Longitude: -80.0070042

INVOLVED PARTIES

Designer / Inventor / Researcher
Ned Kahn + Koning Eizenberg Architecture

Structural Engineer

Services Engineer

Facade consultant

Manufacturer

Contractor

Building / project owner
Childrens' museum Pittsburgh

Other party involved

CASE STUDY INFORMATION

Keywords defining the case-study:
Kinetic; Screen; Plastic; Tiles; Art

Building floor area (if applicable):
5.000 and up sq. m.

Building use (if applicable):
Museum

Building status (if applicable):
New built

Is adaptivity part of the main architectural design concept of the building? (if applicable)

Orientation of the facade system / component / material
All orientation

Climate type
Dfb

Please specify the Technology Readiness Level (applies to all the information submitted):
5 Commercial product/Existing building

Function / goal / purpose
Visual comfort_ Appearance (aesthetic quality)_

Where does this technology fit in the following classification suggested by COST1403 WG2?
Biomimetic Facades (BF)

Select the type of facade system / component / material.
Double Skin Facade_ External skin_ Polymers_

If you are describing a switchable glazing, specify:

If you are describing a shading, please specify:
Screens / roller shades

Area of the case-study (sq.m.):

Added weight (kg/sq.m.) of the case-study:

MATERIAL ADAPTATION AND WORKING EFFECTS

How does the material adapt?

Type of trigger (INPUT):
- In the case of intrinsic operation: What triggers the smart material reaction?
- In the case of extrinsic operation: What does the sensor detect in order to run an actuator?
For instance, in the Institut du Monde Arabe facade, the trigger is optical.
Mechanical (e.g. wind load)

Type of actuator (OUTPUT):
For instance in the Institut du Monde Arabe facade the actuator output is Mechanical.
Mechanical

Explain the working principle of the case-study (short answer: max 500 characters):
Composed of thousands of translucent, white plastic squares that move in the wind, the artwork is intended to suggest that the building has been enveloped by a digitized cloud. The optical qualities of the skin change dramatically with the weather and the time of day. The articulated skin is supported by an aluminum space frame so it appears to float in front of the building.

Detailed explanation of the working principle (unlimited number of characters). This text will not appear in the case study's summarized data sheet, but only in the detailed one:

METRICS

Intro the value or value-range of the following metrics, if suitable to assess the adaptivity of your case-study:

UV Resistance	Light transmittance (%)
Weight/Density (g/cm2)	Solar transmittance (%)

U-Values (W/m2*K)	Total solar energy transmittance (%)
Noise insulation	Solar savings fraction (%)
Fire protection	Solar heat gain factor (%)
Other	Emissivity
Other	Other
Other	Other

Energy data based on:

Which simulation tools were used for the design?

CONTROL / OPERATION OF THE SYSTEM

Intrinsic (auto reactive)

Explain the control/operation. Short answer (max 500 characters):

The facade is a dynamic wind sculpture. The fluttering translucent panels it is made of are moved by the wind.

Detailed explanation of the control/operation (unlimited number of characters). This text will not appear in the case study's data sheet, but only in the detailed sheet:

System response time (thick all that apply):	**Seconds_**
System degree of adaptivity:	**gradual**
Degree of spatial adaptation	**Millimeters_Centimeters_**
Level of AF visibility (Reijenga classification):	**5 Visible, location or orientation change**

ECONOMIC ASPECTS

Is the system economically viable?	Yes
Cost/m2	
Yearly cost of maintenance	
System maintenance frequency	

REFERENCES (bibliography, web sites etc.)

Reference 1: **http://nedkahn.com/portfolio/articulated-cloud/**

Reference 2: **http://www.kearch.com/work/childrens-museum-of-pittsburgh/**

Reference 3: **http://architizer.com/projects/childrens-museum-of-pittsburgh/**

Reference 4: **https://www.youtube.com/watch?v=nvkNdlKVP2Y**

Reference 5:

Link to picture/video 1	http://architizer.com/projects/childrens-museum-of-pittsburgh/media/175114/
Caption, description	Facade of the museum
Author	Architizer
CreativeCommonts/Copyleft/PublicDomain/Copyright)	

Link to picture/video 2	https://www.flickr.com/photos/archidose/113136244/
Caption, description	Facade of the museum
Author	John Hill
CreativeCommonts/Copyleft/PublicDomain/Copyright)	All rights reserved

Link to picture/video 3	http://architizer.com/projects/childrens-museum-of-pittsburgh/media/171128/
Caption, description	Detail of the facade
Author	Architizer
CreativeCommonts/Copyleft/PublicDomain/Copyright)	

Link to picture/video 4	
Caption, description	
Author	
CreativeCommonts/Copyleft/PublicDomain/Copyright)	

Link to picture/video 5	
Caption, description	
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Link to drawing 5

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