TU1403 – Adaptive Facades
STSM Adaptive facade for Med Area

Scientific Report Rosa Romano

Title STSM:	**Adaptive facades towards Med Area: the analysis of an innovative scientific approach.**	
Visitor:	- Name:	Rosa Romano
	- Affiliation:	University of Florence, Department of Architecture (DIDA)
	- Country:	Italy
	- ECI:	Yes
Host:	- Name:	Laura Aelenei
	- Affiliation:	LNEG
	- Country:	Portugal
Dates:	**From:**	**2016-07-17 To: 2016-07-22 and 2016-08-01 To: 2016-08-06**
	Nr. of days:	**15**
Budget:	**1875,00 Euro**	

1. SUMMARY OF STSM

The National Laboratory of Energy and Geology (LNEG), choice as host institution for my STSM, has a large research experience in energy in buildings, NZEB, façade elements and heat transfer, and it promotes façade design and engineering at a European level and beyond. In such context, the Energy Efficiency Unit develops in particular its activity in the energy efficiency field, acting in two particular sectors: the 'Building' (households, offices) and the 'Industry' sectors, with a particular focus on:

- Technologies, processes and products development, in close cooperation with the companies which are active in the Portuguese Economy;
- Advanced training and dissemination in specific fields;
- Energy efficiency in buildings by the integration of active and passive technologies in buildings, renewable energy systems, and prefabricated systems for building facades integration;
- New concepts: Net Zero Energy Buildings (NZEB) and Smart Cities;
- Audits in Building;
- EcoDesign and Design for Sustainability (products, processes) - The design of products that affect energy consumption, in a life cycle perspective, along with the communication to the market of its characteristics and functionalities;
- Etc…

Fig. 1. The Adaptive South façade of Edificio Solar XXI LNEG in Lisbon

The possibility to collaborate during my STSM programme of the Cost Action TU4013 with the team of international expert of National Laboratory of Energy and Geology (LNEG), coordinated by prof. Laura Aelenei, has allowed me to improve my knowledge in the field of the existing research about the evolution of smart façade systems in the area of design and industrial production and to start an interesting collaboration with the Working Group 1 of the COST ACTION that I hope continuing in the future.

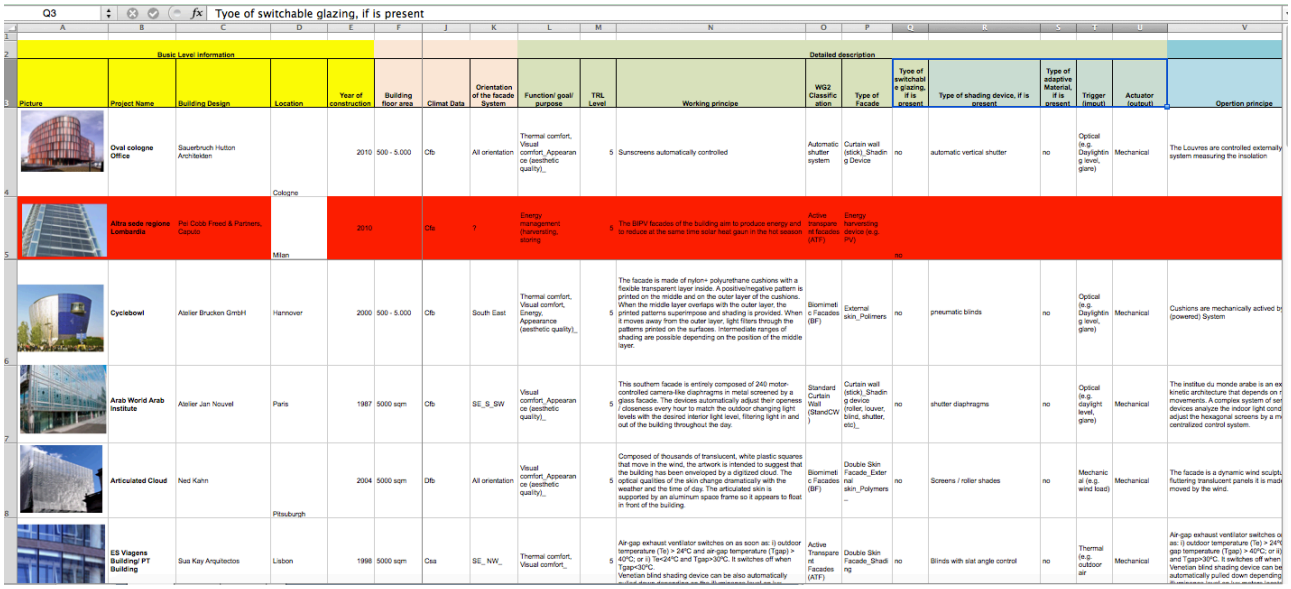
2. OBJECTIVES OF THE STSM

My STMS has been focused to know the research methodologies adopted in the research Group of LNEG in order to investigate the technological, functional and qualitative standards of dynamic façades and evaluate the energy performances of the building envelope as a dynamic system that interacts between indoor and outdoor environment.

The activities developed during my two weeks in Lisbon have been focused in particular to increase my knowledge in the frame of responsive/adaptive/interactive building envelopes working with the prof. L. Aelenei on the construction of an adaptive façade characterization matrix, based on: state of the art, database of different applications, projects developed in this area which could be a useful tool for developing new adaptive façade design and technologies.

The objectives of my STMS programme have been those following listed:

1. To analyse the state of art of the dynamic façade systems for the hot and temperate climate, contributing to map out these types of adaptive façades with the objective to increase the activity started in the WG1 with the creation of a supporting database.
2. To collect information from literature and case studies to build a new definition regarding adaptive facade that will be used for starting a new publication (already planned regarding specifically to the definitions).
3. To enhance the knowledge on novel materials, concepts and technologies and/or the new combinations of existing technologies for adaptive envelope, as indicated in the task 1.4 of WG1
4. To contribute to Annual Training School for dissemination of expertise to Early Stage Researchers



Picture	Project Name	Building Design	Location	Year of construction	Building floor area	Climat Data	Orientation of the facade System	Function/ goal/ purpose	TRL Level	Working principe	WG2 Classification	Type of Facade	Tyoe of switchable glazing, if is present	Type of shading device, if is present	Type of adaptive Material, if is present	Trigger (input)	Actuator (output)	Opertion principe
	Oval cologne Office	Sauerbruch Hutton Architekten	Cologne	2010	500 - 5.000	Cfb	All orientation	Thermal comfort, Visual comfort, Appearance (aesthetic quality)_	5	Sunscreens automatically controlled	Automatic shutter system	Curtain wall (stick)_Shading Device	no	automatic vertical shutter	no	Optical (e.g. Daylighting level, glare)	Mechanical	The Louvres are controlled externally system measuring the insolation
	Altra sede regione Lombardia	Pei Cobb Freed & Partners, Caputo	Milan	2010		Cfa	?	Energy management (harvesting, storing	6	The BIPV facades of the building aim to produce energy and to reduce at the same time solar heat gaun in the hot season	Active transparent facades (ATF)	Energy harvesting device (e.g. PV)	no					
	Cyclebowl	Atelier Brucken GmbH	Hannover	2000	500 - 5.000	Cfb	South East	Thermal comfort, Visual comfort, Energy, Appearance (aesthetic quality)_	5	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.	Biomimetic Facades (BF)	External skin_Polimers	no	pneumatic blinds	no	Optical (e.g. Daylighting level, glare)	Mechanical	Cushions are mechanically actived b (powered) System
	Arab World Arab Institute	Atelier Jan Nouvel	Paris	1987	5000 sqm	Cfb	SE_S_SW	Visual comfort_Appearance (aesthetic quality)_	5	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.	Standard Curtain Wall (StandCW)	Curtain wall (stick)_Shading device (roller, louver, blind, shutter, etc)_	no	shutter diaphragms	no	Optical (e.g. daylight level, glare)	Mechanical	The institue du monde arabe is an ex kinetic architecture that depends on t movements. A complex system of sen devices analyze the indoor light cond adjust the hexagonal screens by a m centralized control system.
	Articulated Cloud	Ned Kahn	Pitsburgh	2004	5000 sqm	Dfb	All orientation	Visual comfort_Appearance (aesthetic quality)_	5	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.	Biomimetic Facades (BF)	Double Skin Facade_External skin_Polymers	no	Screens / roller shades	no	Mechanical (e.g. wind load)	Mechanical	The facade is a dynamic wind sculpt fluttering translucent panels it is made moved by the wind.
	ES Viagens Building/ PT Building	Sua Kay Arquitectos	Lisbon	1998	5000 sqm	Csa	SE_NW_	Thermal comfort, Visual comfort_	5	Air-gap exhaust ventilator switches on as soon as: i) outdoor temperature (Te) > 24°C and air-gap temperature (Tgap) > 40°C; or ii) Te<24°C and Tgap>30°C. It switches off when Tgap<30°C. Venetian blind shading device can be also automatically	Active Transparent Facades (ATF)	Double Skin Facade_Shading	no	Blinds with slat angle control	no	Thermal (e.g. outdoor air	Mechanical	Air-gap exhaust ventilator switches o as: i) outdoor temperature (Te) > 24°C gap temperature (Tgap) > 40°C; or ii) and Tgap<30°C. It switches off when Venetian blind shading device can be automatically pulled down depending

Fig. 1. Screen shot of the Database case studies analysed to develop a new definition of "adaptive facades"

3. DESCRIPTION OF THE WORK CARRIED OUT DURING THE STSM (ACCORDING WITH THE DESCRIBED OBJECTIVES)

The goal of my STSM has been increasing my scientific experience through the exchange of knowledge within the working group of Prof. Laura Aelenei where a multidisciplinary team of architects and engineers work with specific expertise in the field of energy in buildings, architectural building integration of renewable energy systems and technology, developing interesting researches on the scientific area of building envelope.

The work that I have carried out at the host institution, during the two weeks of STSM, have been focused in particular on the following main specific activities:

3.1 ANALYSIS OF THE STATE OF ART OF THE ADAPTIVE FACADES (D1.1), contributing to map out these types of adaptive façades (available either on the market, or as prototypes or concepts) with the objective to increase the activity started in the WG1 with the creation of a supporting database of different technological solutions and applications of adaptive facades, characterized by a matrix of influencing parameters. In particular I worked to the design of a new datasheet to collect the information on the adaptive façades analysed in the first part of the research activities COST. Furthermore I have integrated the database with other case studies of adaptive envelopes located in the temperate climate.

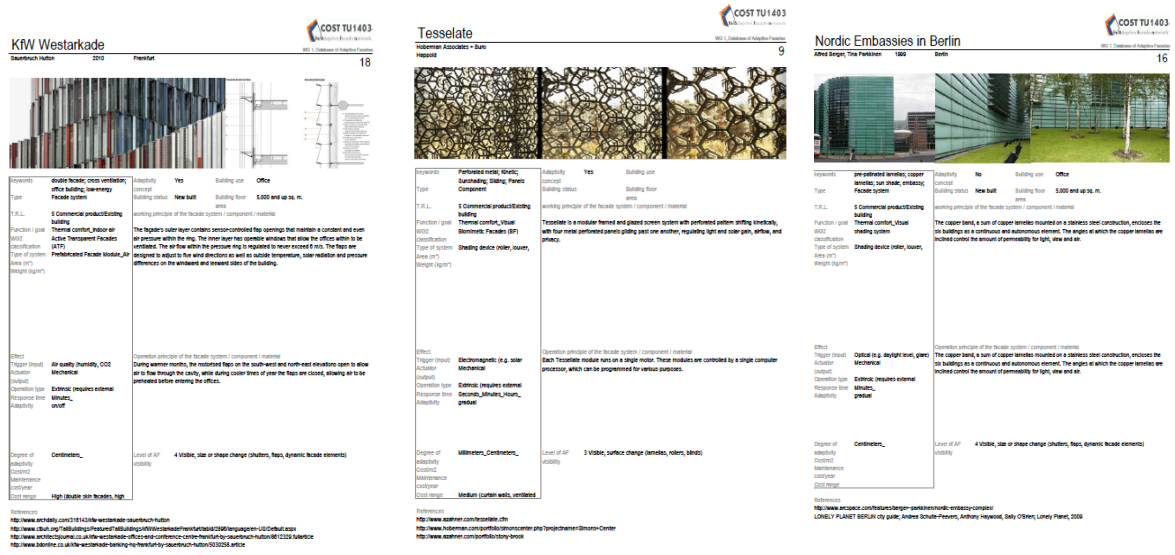


Fig. 3. A first draft of Datasheet developed for the COST database

3.2 STARTING DEVELOPMENT OF A NEW DEFINITIONS OF ADAPTIVE FACADE based on the state of the art and survey analysis that will be used for starting a new publication (already planned regarding specifically to the definitions). (D1.2)

Adaptive, in fact is only one designation for a concept that is described by a multitude of different terms. Even within the discipline of architecture, terms such as “smart”, “intelligent”, “interactive”, “adaptive” or “responsive” have been used loosely and interchangeably, creating confusion as to their specific meaning and their conceptual relationship to building performance and design. In response, during my STSM I have worked to build a provisional lexicon of descriptive, behavioural and methodological terms to assist researchers and designers in navigating the field of high-performance skins that incorporate materially innovative and feedback-based systems. It offers a brief overview of current advances in this nascent and rapidly evolving field and articulates a broader conceptual territory for the term “adaptive”; one that is able to interact with the environment and the user by reacting to external influences and adapting their behaviour and functionality accordingly: the building envelope insulates only when necessary, it produces energy when possible, it shades or ventilates when the indoor comfort so demands.

3.3 FIRST REVIEW OF MATERIAL PREPARED FOR ANNUAL TRAINING SCHOOL (D 1.6) for dissemination of expertise to Early Stage Researchers with a construction of an "Adaptive façade Syllabus" based on the state of the art and survey analysis to use during the working sessions in order to provide a systematic characterization of the adaptive façade for future trends of adaptive facades design, development of novel adaptive technologies.

Fig. 4. A second draft of Datasheet developed for the COST database

4. OTHER ACTIVITIES:

- To know the research activities of LNEG and in particular those dedicated to project, test and prototype innovative façade systems. During my two weeks of STMS, in fact, I could visit the LNEG Campus and its innovative buildings. In particular I worked inside the experimental Edificio Solar XXI, so to analyse the interesting technologies that have been adopted to reduce the energy consumptions for heating and cooling during all months of the year and to know the adaptive façade systems with the integration of an innovative PCM, that is tested in these months in the south façade of this building.
- To Acquire new skills on novel materials, technologies and new combinations of existing technologies for adaptive Facades in order to provide a selection of technologies applications already adopted in existing projects, identifying the strongest and weakest points, and to pursue new concepts and new products for adaptive façades;
- To develop new knowledge such as effective evaluation tools to analyse the energy performances of the multilayers and smart facades

5. OUTCOME

The outcome of my STSM have been:

a) The STSM has contributed to a deliverable described in the MoU of the Action

D.1.1. Report and database with current state-of-the-art adaptive façade materials, systems and new concepts

D.1.2. Report on real world case studies of adaptive façade applications.

D.1.3. Report on progress made in new adaptive technologies over the course of the Action.

D.1.6. Contribution to Annual Training School for dissemination of expertise to Early Stage Researchers

b) The STSM results in a joint journal/conference publication

As the min contribution is the structure of definitions regarding adaptive façade based on the state of the art and survey case studies analysis, the results of this STSM will be used also for starting a new publication (already planned regarding specifically to the definitions)

c) The STSM results in a joint research proposal

Opportunities for joint participation in H2020 proposal were analysed, in particular those relative to the calls regarding the adaptive envelopes (i.e. EE02 Energy-efficient Buildings; EE14 Construction skills; EE03 Standardised

installation packages integrating renewable and energy efficiency solutions for heating, cooling and/or hot water preparation, etc.).

6. BENEFITS OF THE STSM

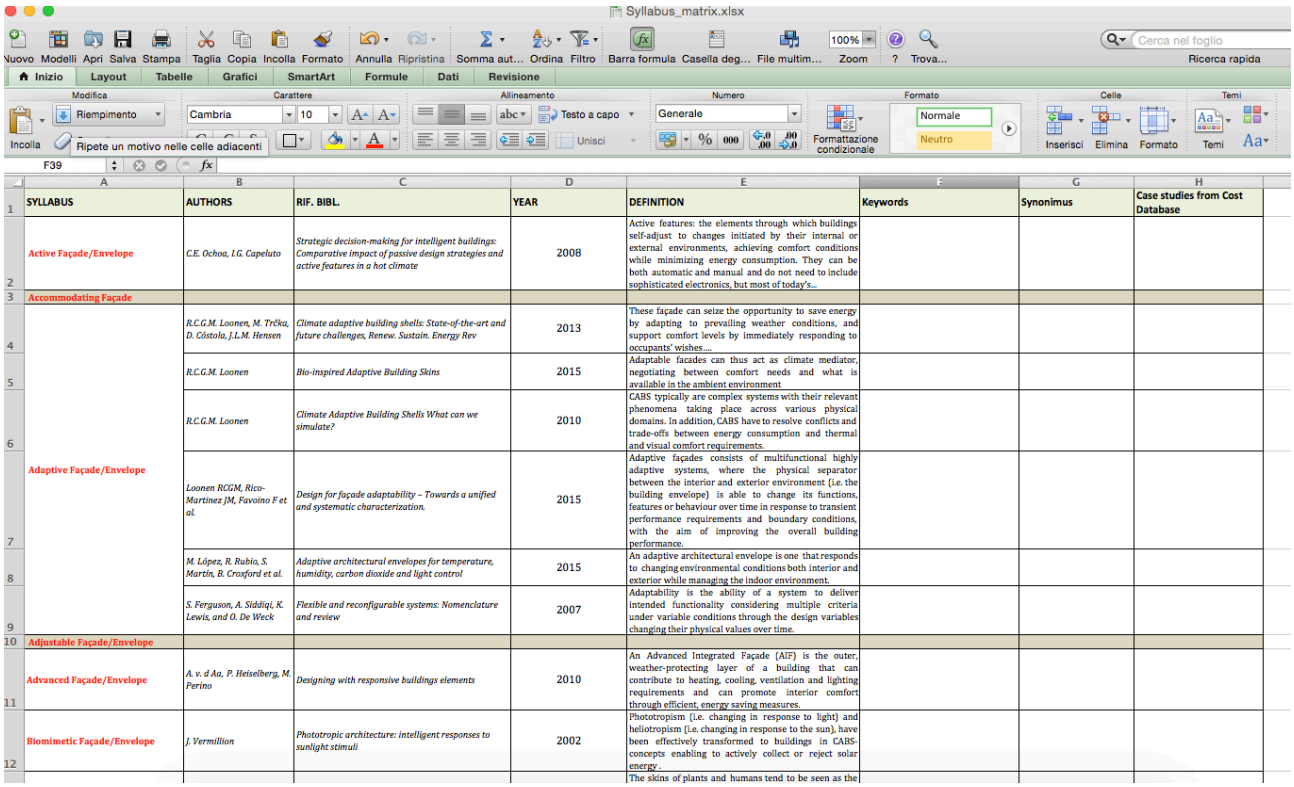
The relationships that I have developed during the STMS with other researchers employed in the field of design and test of adaptive envelopes allowed me to improve my knowledge and transferring this in my research and in the following activities developed into the COST Action TU1403:

- Editing of reports on: current adaptive facades modelling techniques; current state-of-the-art adaptive façade materials, systems and new concepts; real world case studies of adaptive façade applications; progress made in new adaptive technologies over the course of the Action; etc.

- Input and contributions to relevant parts of educational pack into WG1

- Teaching activity in Annual Training School, Education Pack and Industry Workshops, etc.

Moreover, the possibility to transfer knowledge between two research centres and to compare two different scientific approaches could accelerate the development of new international researches on innovative components and evaluation techniques, and their adoption and application in buildings located in South Europe.



SYLLABUS	AUTHORS	RIF. BIBL.	YEAR	DEFINITION	Keywords	Synonimus	Case studies from Cost Database
Active Façade/Envelope	C.E. Ochoa, I.G. Capeluto	*Strategic decision-making for intelligent buildings: Comparative impact of passive design strategies and active features in a hot climate*	2008	Active features: the elements through which buildings self-adjust to changes initiated by their internal or external environments, achieving comfort conditions while minimizing energy consumption. They can be both automatic and manual and do not need to include sophisticated electronics, but most of today's...			
Accommodating Façade							
	R.C.G.M. Loonen, M. Trčka, D. Cóstola, J.L.M. Hensen	*Climate adaptive building shells: State-of-the-art and future challenges, Renew. Sustain. Energy Rev*	2013	These façade can seize the opportunity to save energy by adapting to prevailing weather conditions, and support comfort levels by immediately responding to occupants' wishes....			
	R.C.G.M. Loonen	*Bio-inspired Adaptive Building Skins*	2015	Adaptable facades can thus act as climate mediator, negotiating between comfort needs and what is available in the ambient environment			
	R.C.G.M. Loonen	*Climate Adaptive Building Shells What can we simulate?*	2010	CABS typically are complex systems with their relevant phenomena taking place across various physical domains. In addition, CABS have to resolve conflicts and trade-offs between energy consumption and thermal and visual comfort requirements.			
Adaptive Façade/Envelope	Loonen RCGM, Rico-Martinez JM, Favoino F et al.	*Design for façade adaptability – Towards a unified and systematic characterization.*	2015	Adaptive façades consists of multifunctional highly adaptive systems, where the physical separator between the interior and exterior environment (i.e. the building envelope) is able to change its functions, features or behaviour over time in response to transient performance requirements and boundary conditions, with the aim of improving the overall building performance.			
	M. López, R. Rubio, S. Martín, B. Croxford et al.	*Adaptive architectural envelopes for temperature, humidity, carbon dioxide and light control*	2015	An adaptive architectural envelope is one that responds to changing environmental conditions both interior and exterior while managing the indoor environment.			
	S. Ferguson, A. Siddiqi, K. Lewis, and O. De Weck	*Flexible and reconfigurable systems: Nomenclature and review*	2007	Adaptability is the ability of a system to deliver intended functionality considering multiple criteria under variable conditions through the design variables changing their physical values over time.			
Adjustable Façade/Envelope							
Advanced Façade/Envelope	A. v. d Aa, P. Heiselberg, M. Perino	*Designing with responsive buildings elements*	2010	An Advanced Integrated Façade (AIF) is the outer, weather-protecting layer of a building that can contribute to heating, cooling, ventilation and lighting requirements and can promote interior comfort through efficient, energy saving measures.			
Biomimetic Façade/Envelope	J. Vermillion	*Phototropic architecture: intelligent responses to sunlight stimuli*	2002	Phototropism (i.e. changing in response to light) and heliotropism (i.e. changing in response to the sun), have been effectively transformed to buildings in CABS-concepts enabling to actively collect or reject solar energy.			
				The skins of plants and humans tend to be seen as the			

Fig. 2. Screen shot of the Syllabus matrix to use in the Summer School of September.

Florence 4 September 2016

The Visitor,

Arch. PhD Rosa Romano

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The Host,

Prof. Laura Aelenei

National Laboratory of Energy and Geology (LNEG)