SHORT TERM SCIENTIFIC MISSION (STSM)
SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

Action number: COST Action TU1403- Adaptive Facades Network
STSM title: An Integrated Vertical Greenery Systems (VGS) Assessment for the Development of a Classification Methodology
STSM start and end date: 20/03/2018 to 15/04/2018
Grantee name: Theoni Karlessi

PURPOSE OF THE STSM:

(max.200 words)
Vertical Greenery Systems (VGS) have gained increasing interest due to multiple benefits at building and city scale, also related to the upgrade of the quality of life regarding aesthetic, environmental, energy, societal and economy factors .
The present work aims to provide an analysis of vertical greenery through a holistic approach. The aspects investigated are:1. the engineering systems and techniques, 2. the appropriate plant selection and the plant characteristics related to the performance of the VGS, 3. climate factors and their influence to the efficiency of the VGS and 4. the VGS performance at building and microclimatic level, including the reduction of energy loads, the improvement of indoor environment (thermal and air quality) and also the alleviation of the Urban Heat Island Effect. Summarized results of different cases studies and existing experience are provided to set the basis of the investigation. Energy and environmental benefits are quantified to produce a solid synopsis in order to provide the main points of consideration for the most efficient solutions. The quantification refers to the external wall temperature reduction, and where available the temperature reduction of indoor air, outdoor air close to the VGS and energy reduction.
The prestigious case study of One Central Park building complex in Sydney is presented.
The interrelation of the parameters that determine the application and efficiency of vertical greenery require an overall research that will define the most appropriate solutions for the indoor and outdoor environment.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

(max.500 words)
The work has been divided in the following sections and the referred issues have been investigated and analysed:

1. Introduction: Current status of the urbanization trends are provided highlighting the need for Urban Green Infrastructure as an efficient and sustainable means of resolving issues of densely built urban centers.
2. Vertical Greenery Systems and Techniques: The categorization of VGS for buildings is provided in green façades (traditional and double skin) and living walls (continuous and modular). Their characteristics and the flora growing techniques are described
3. Type of plant species and selection criteria: The selection of the appropriate plant species determines the cost effectiveness and the energy efficiency of the VGS. Plant characteristics can be divided in four main groups: structural and radiative properties, plant traits and processes.

4. The influence of climate: The potential of VGS for buildings to serve as passive systems for energy savings is strongly influenced by the prevailing weather conditions. Climatic factors as temperature, humidity, rainfall, solar radiation, wind and the microclimate affect the growth characteristics of the plants (foliage density, plant height etc) as also their physiological responses (transpiration, position of leaves etc).The influence of each factor is analysed. Climate classification facilitates the analysis of performance of VGS and the comparison of the results. The most widely known and used system for the categorization of the world's climate, Köppen Climate Classification is also mentioned.
5. Benefits and critical issues of VGS for buildings: Benefits of vertical greening systems are multiple and strongly related with each other. Proved added value from the application of VGS can be recognized in aesthetic, environmental, social, energy and economic sectors. The incorporation of VGS acts positively both at building level and at city and community level. Benefits of each sector are summarized. The performance of VGS depends both on environmental and technical aspects that should be taken into consideration at the design and at the operational phase. A list of key issues that should be checked in order to ensure the system's efficiency is also provided
6. Quantification of the performance of VGS-Case studies: Existing research work that has been carried out mostly in the European and Asian region proves that VGS have a quantified effect on the thermal performance of the building and the microclimate of the surrounding area. The results of 23 studies are presented
7. The case study of One Central Park in Sydney: One Central Park in Sydney is a redeveloped site hosting the highest and one of the most prestigious green façade. Vertical greenery is the most dominant technology in this project providing energy and environmental efficiency in the indoor and surrounding spaces combined with other technical applications

DESCRIPTION OF THE MAIN RESULTS OBTAINED

Existing research work that has been carried out mostly in the European and Asian region proves that VGS have a positive and quantified effect on the thermal performance of the building and the microclimate of the surrounding area. Research shows significant reduction in the surface temperatures of the building facades and improvement of the indoor air environment. A synoptic presentation of the research data of 23 case studies on the performance of VGS including the following has been implemented:

- The publication of the scientific work
- The location
- The type of vertical greenery system
- The Koppen Climate Classification
- The period of study
- The main plant species used
- The orientation of the VGS
- The foliage thickness
- The external wall temperature reduction, and where available the temperature reduction of indoor air, outdoor air close to the VGS and energy reduction

One Central Park in Sydney is a redeveloped site hosting the highest (116m) and one of the most prestigious green façade. Vertical greenery is the most dominant technology in this project providing energy and environmental efficiency in the indoor and surrounding spaces combined with other technical applications. The integration of vertical gardens, on-site power and recycling plants and heliostats with Fresnel reflectors result in high energy efficiency, fulfillment of sustainability criteria and improved functionality of the building complex. OCP has been highly scored under the Green Star Rating System of the Green Building Council of Australia meeting the challenges of traditional high rise residential structures with poor energy performance. Hydroponics allows the irrigation through the recycled water circulation to the tower façade planters bringing vertical visibility to vegetation. The reduction of energy cooling load of interior spaces due to a 5 kilometer long system of linear slab edged planters that function as permanent shading shelves is about 20%. The shading from the plant foliage reduces the thermal impact by 20% additionally. Shadow effects and low light issues arising from the height of the buildings have been counterbalanced with 40 sun tracking heliostats which are used to redirect the sunlight to 320 reflectors beaming the light down to an atrium. At night the use of led lights on the reflector create an outstanding urban chandelier.

The effect of the vertical plantation foliage is multiple functioning as air cleaner and heat trap. Selected species are used to confine carbon dioxide and emit oxygen improving the environmental quality of the site's microclimate. The improvement of the thermal quality is also a key point as the façade temperature is reduced providing a cooler indoor environment and lower outdoor temperatures.

FUTURE COLLABORATIONS (if applicable)

The very well known, innovative and profound work of the University of Sydney in the field of engineering and adaptive technology for the built environment and the exchange of valuable experience with the visitor gave the opportunity to work on a challenging and innovative field of technology. As the University of Sydney is involved in many related projects, this STSM has set the basis for future collaboration.
.