Task 56

Building Integrated Solar Envelope Systems for HVAC and lighting

Task Concept Paper

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This Concept paper was edited by Roberto Fedrizzi - EURAC, Fabian Ochs – University Innsbruck, Michaela Meir – AVENTA, Christoph Maurer – Fraunhofer-ISE

1. Scope of the Task

This Task will focus on the critical analysis, simulation, laboratory test and onsite monitoring of envelope systems entailing elements that use and/or control incident solar energy, having one or more of the following uses:

- To deliver renewable thermal or/and electric energy to the systems providing heating, cooling and ventilation to buildings
- To reduce heating and cooling demands of buildings, while controlling daylight

Technologies are considered that account for the specificity of the intervention on residential and tertiary buildings, both new-built and retrofitted.

Integration of Solar Envelope solutions into the building's HVAC and lighting systems through a systemic approach is central in this task.

Energy performance, indoor comfort and architectural integration are addressed all along the Task elaboration.

In the residential sector, solar thermal and PV systems are typically mounted on building roofs with limited attempt to incorporate them into the building envelope, creating aesthetic drawbacks and space availability problems. On the contrary, the use of facades is highly unexplored. Daylight control is delegated to the individuals' management of blinds and curtains, leading to high thermal loads both during midseasons and summertime.
In the tertiary segment (offices, schools, hospitals), the roof is again, most of the times, the only surface devoted to the installation of solar thermal and PV technologies. While daylight control nowadays is here state of the art in terms of shading effect, the utilization of shading devices to also redirect natural light into the room, improving visual comfort at the same time, has still to be deepened.
Moreover, when energy efficient technologies are installed together with traditional ones, frequently the first are just "added on top" of the main systems, thereby investment costs burst and performance are hardly optimised.

The Task will pose the attention on solutions looking at the mass market through an industrialised integration of active components into envelope elements. This is believed to provide the lowest cost-to-benefit ratio by:

- Optimising the installation and maintenance costs
- Entailing optimised control and continuous monitoring
- Providing reliable operation and predictable performance
- Eventually ensuring that more than one function is covered among the ones stated above (multifunctional systems)
- Substituting part of the backup system, instead of adding functionalities
- Reducing primary energy use by optimising the yearly solar energy utilization.

Despite the focus on industrialised solutions, best practices in terms of customised solutions will be also analysed in an attempt to assess their performance and potential adoption on the market.

The strategic objective of the Task is to coordinate the research and innovation effort taking place within the scientific community and the private sector, towards the utilization of envelope integrated technologies.

Specific objectives of the Tasks are:

- To gather relevant information on market available and "under-development" solar envelope systems both in terms of performance and costs
- To assess and develop test methods for the performance characterization of solar envelope elements (thermal, electric and daylighting performance characterization)
- To assess and develop simulation models for the performance characterization of solar envelope elements (thermal, electric and daylighting performance characterization)
- To develop design, manufacturing and installation guidelines for industrialised solar envelope systems, accounting for technological, architectural/aesthetical, economic, financing and customer acceptance viewpoints
- To assess and develop business models for solar envelope systems
- To enhance awareness of the public and private sector on the treated technologies.

Under this perspective, this Task perfectly matches the strategic plan of the SHC programme, in terms of Vision, Mission and Objectives.

IEA-SHC Vision

"Turning solar thermal into a major energy resource for heating and cooling by 2050 is an ambitious, but a realistic goal. It is achievable – provided that the right mix of research & development, industrial growth, consistent market deployment measures and adequate political framework conditions are applied."

This Task can play a major role in reaching this goal:

- by promoting the elaboration of simulation models and laboratory test methods, towards the entry into market of products with reliable, deemed performance
- by developing construction, installation, business and bankability models, towards the fast and reliable replication of best practice systems.
- by fostering awareness of the public and private sector towards a regulated market (standardization of the solutions and of the market).

IEA-SHC Mission

"The Solar Heating and Cooling Agreement's mission assumes a systematic approach to the application of solar technologies and designs to whole buildings, and industrial and agricultural process heat. (…). Through international collaborative activities, the Agreement will support market expansion by providing access to reliable information on solar system performance, design guidelines and tools, data and market approaches, and by developing and integrating advanced solar energy technologies and design strategies for the built environment, and for industrial and agricultural process heat applications."

By concentrating on the built environment, the Task addresses all the mentioned support actions:

- providing access to reliable information on solar system performance
- delivering design guidelines and tools
- delivering data and market approaches
- developing and integrating advanced solar energy technologies and design strategies

2. Subtasks definition

Subtask A: Solar envelope systems classification and communication
An overview of products and solutions of solar envelope systems, which are presently available on the market, will be made available in Subtask A as a preparatory work for Subtask B and C. In particular, the conditions for the effective deployment of solar envelope systems will be analysed in this Subtask.
In addition, the communication of such factors and of the overall results will be tackled here.

A market analysis will be firstly carried out (Activity A.1) assessing existing solutions through a literature review and the advice of the experts participating. Moreover, standards, test methods and numerical tools will be categorised.
Different products and solutions will be evaluated through a SWOT analysis, accounting for technical and non-technical issues, which in the past have determined the success or the failure of solar envelope systems (Activity A.2).
A major activity of Subtask A will be then to attract and involve central actors, decision makers, planners, builders, architects, experts from research and industry. This will be achieved by the exchange of information generated in all Subtasks through local workshops, newsletters and an updated public website (Activity A.3).

Activities description
Activity A.1 - Market overview
The present activity will start with an overview of the current market of solar envelope components and systems. This state-of-the-art will include a review of existing solutions, their architectural integration, energy performance and costs, including the building (envelope) and integrated HVAC system. Focus will be given to industrialised solutions, even if fully customised solutions will be also addressed.
The figures will be extracted from actual market studies, finished R&D projects and Task deliverables (IEA-SHC Task 41, IEA-EBC Annex 50) as a starting point.
Non-technical issues will be also treated, such as aesthetic, architectural integration, economic, financing and customer acceptance.
Construction and rating standards, test methods and numerical tools will be finally categorised.
On the one hand, this should point out the needs, requirements and present barriers from a technical point of view and for the selected markets. On the other hand, this activity will be ended by identifying a common definition of "Building Integrated Solar Envelope System".

A two stage deliverable report (D A.1) is foreseen, entailing first only the market analysis performed and secondly also outcomes elaborated as part of Subtasks B and C.

Activity A.2 – SWOT analysis

It is expected that the state-of-the-art review will give answers on which systems are successful on the market and why, the actors involved, their responsibilities and strategies for market penetration. Specifically, the following actions will be pursued:

- Collect and classify the state-of-the-art of existing solar envelopes, the building and integrated HVAC system and accounting for installation, commissioning and maintenance issues, standards available and non-standardised test methods.
- Collect information on non-technical issues: economic aspects, market penetration, involved actors, responsibilities along the value chain, and ownership structures.
- SWOT analysis of systems assessed and "lessons learned" elaboration.

Activity A.3 – Dissemination
This activity has the aim to disseminate the results, which will be generated in all Subtasks to a targeted audience with the aim to make the Task outcomes known, and to attract stakeholders with key competence to join the Task (permanently or on a short term level).
In addition to the dissemination through the website (A.3.1), ongoing activities will be disseminated by two annual newsletters (A.3.2). Workshops for dissemination of results and collection of information are planned at selected Task meetings (A.3.3). This activity includes further the preparation of an online glossary of Task vocabulary that the public Task website (A.3.4) and the contact list for dissemination is regularly updated (A.3.5).
Activity A.3 will also coordinate the dissemination of the final deliverable of the Task. Dependent on the findings and the desired target group this will be realised in form of a printed handbook or an online free publications (A.3.6).

Deliverables
D A.1 State-of-the-art on existing solar envelope systems
D A.2 SWOT analysis based on the state-of-the-art information available
D A.3.1 Updated Task website (on-going)
D A.3.2 Two annual newsletters for the dissemination of on-going activities
D A.3.3 Annual workshops with targeted stakeholders
D A.3.4 Online glossary of Task vocabulary and definitions
D A.3.5 Database of contacts for dissemination activities
D A.3.6 Coordination and dissemination of final deliverable (printed handbook or free online publication)

Milestones
M A.1 A State-of-the-art of solar envelopes is available
M A.2 Lessons learned on solar envelopes are elaborated out of open available data
M A.3 Subtask results (reports) are disseminated
M A.4 Operative and updated public website
M A.5 Final Task deliverable available

Timescale / Deliverables and Milestones (semesters)

	year 1		year 2		year 3		year 4	
	1	2	3	4	5	6	7	8
A.1			D A.1, M A.1			D A.1		
A.2				D A.2, M A.2				
A.3.1	M A.4	D A.3.1		D A.3.1		D A.3.1		D A.3.1
A.3.2	D A.3.2	D A.3.2	D A.3.2	D A.3.2	D A.3.2	D A.3.2	D A.3.2	D A.3.2
A.3.3		D A.3.3		D A.3.3		D A.3.3		D A.3.3
A.3.4			D A.3.4			D A.3.4		
A.3.5		D A.3.5						
A.3.6				D A.3.6		D A.3.6		D A.3.6, M A.5

Subtask B: Performance characterisation of solar envelope elements

Subtask B aims to develop tools and strategies to foster the market penetration for industrialised solar envelope systems. In particular, it focuses on the solar envelope elements intended as the sub-systems, strictly incorporated in the building envelope.

Solar envelope elements need to be integrated in the construction process already at an early planning stage. To this purpose, planners need to be provided with the necessary information – i.e. integration parameters, performance measurements and modelling, etc. – when starting their task. The target of the subtask is finally a successful construction process including the transfer of knowledge and models e.g. between the component manufacturers and the planners of the building.
Key here is therefore the involvement of an industrial partnership from the very beginning of the program. The Activities reported next will be elaborated only with reference to the specific elements suggested by the manufacturers involved in the Task.

This Subtask will be built on three main Activities:

- development of strategies for the effective market penetration of solar envelope systems developed by the Task partners
- elaboration of simulation models for solar envelope elements, developed by the Task partners
- development of laboratory tests requirements for performance and functional assessment of solar envelope elements.

Activities description

Activity B.1 – Strategies for market penetration

Solar envelope systems shall offer attractive solutions with a good cost to benefit ratio, easy installation and maintenance, and architectural flexibility. In general, only a part of the innovative technologies reaches commercial success, while other technologies face barriers which they cannot overcome. This activity focuses on factors, decisions and strategies for economic success of innovative technologies. The success of innovative solar envelope systems depends on many technical, economical, but also

social and psychological factors, which are closely connected. Therefore, it needs to be discussed in a holistic way. New business models elaboration can be a part of this activity.

Since such technologies often have very specific advantages and challenges, several specific cases will be analysed to learn together more about specific challenges and solutions: a confidential feedback work will bring together a peer group of developers of solar envelopes (participating into the Task), in order to exchange experience and recommendations on their current solar envelope developments.
Based on this work, strategies for the development of solar envelope systems will be developed and published.

Activity B.2 – Simulation models of solar envelope elements
In addition to the discussion with the manufacturers involved into the Task, work is needed to characterise the solar envelope systems' performance. Simulation models are required to assess systems performance under different working boundary conditions (weather, building use, etc.). To this purpose, relevant KPIs will be first of all individuated and structured on the one hand, accounting for the envelope energy exchange, and considering indoor air quality, thermal and visual comfort. The work already done in IEA-SHC Task 44 and Task 50 will be used as a starting point.

On the other hand, simulation models of sub-systems (envelope elements) will be modelled by means of dynamic simulation software. In this activity, the envelope components will be addressed separately from the building and the results provided to Subtask C for the simulation in a number of climate conditions and building applications. Depending on the partners participating into this activity, 2 categories of solar envelope components will be analysed:

- market available solar envelopes by Task partners
- newly developed solar envelopes by Task partners

Activity B.3 – Laboratory tests of solar envelope elements
Moreover, test methods need to be developed that allow the envelope elements (sub-systems) characterisation. To date, a number of standards are available that can be used to calibrate simulation models, to rate the performance and safety of an envelope component. Moreover, non-standardised test methods have been developed (e.g. windows g-value characterisation) to cover standards' lacks. There is no coherence nor agreement within the scientific community and the industry on the tests that have to be performed to rate and compare envelope components. This activity, will address this complex issue by:

- Benchmarking/Analysing the available standards and non-regulated test methods (assessed in Subtask A), for envelope components entailing solar thermal, solar PV, day-lighting elements.
- Recommend the tests crucial to calibrate simulation models and/or to bring a solar envelope component on the market, i.e. thermal/electric performance assessment, fire safety and other building regulations compliancy, thermal bridges and humidity diffusion evaluation, etc.

- Eventually developing laboratory test methods for the characterisation of the envelope component as a whole.

Deliverables
D B.1 Report on workshops for the identification of barriers for new solar envelope systems
D B.2 Report on the development of strategies for market penetration
D B.3 Report on confidential feedback workshops
D B.4 Report on simulation models of solar envelope components
D B.5 Report on test methods and recommendations

Milestones
M B.1 First industry workshop delivered
M B.2 Second industry workshop delivered
M B.3 Third industry workshop delivered
M B.4 Simulation models assessed for solar envelope sub-systems
M B.5 Simulations of single envelope sub-systems developed
M B.6 Standards and available test methods analysed
M B.7 Recommendations for performance and functional test methods delivered

Timescale / Deliverables and Milestones (semesters)

	year 1		year 2		year 3		year 4	
	1	2	3	4	5	6	7	8
B.1		M B.1		D B.1, D B.2, M B.2		D B.3, M B.3		D B.2
B.2				M B.4		M B.5		D B.4
B.3			M B.6	D B.5		M B.7		D B.5

Subtask C: Assessment of solar envelope systems at building level
In Subtask C complete solar envelope systems are defined based on active and passive components and integrated into the HVAC system of reference buildings. This buildings are considered as virtual case studies, which the specific envelope elements proposed by the industrial partners are integrated into.

The task is performed into 2 parallel and interacting activities.

- At first, solutions that are technically and economically meaningful will be identified by means of building and HVAC simulations. A decision support instrument (pre-design tool) will be developed as part of this activity, allowing simplified calculations to be performed.
- Additionally, existing systems will be evaluated by monitoring demonstration systems installed.

The solutions will be evaluated based on reference conditions assessed in Subtask A,

and sub-systems and KPIs defined in Subtask B.

Activities description

Activity C.1 - Building models elaboration and systems definition

For the detailed technical analysis of building integrated solar envelope systems, building and system simulations are performed using reference buildings. Based on experience from previous (IEA SHC T44) and ongoing projects (EU FP7 iNSPiRe), reference buildings will be selected and classified based on following aspects:

- New Buildings and or buildings energy renovation (Building age)
- Electricity, heating/cooling and domestic hot water demands
- User patterns (occupation profiles) as well as IAQ as well as thermal and visual comfort requirements
- Climate boundary conditions and RES availability for the location.

In addition to this, system sizing and rules for system design will be highlighted and categorised: synergies and conflicts between different technologies will be identified. Measures will be suggested to avoid conflicts between competing technologies, considering prefabrication/industrialization, space restrictions, and rules for the appropriate dimensioning and coupling of different subsystems, required as input for C.2.

Activity C.2 – System simulations

Simulations will be carried out and results are expected to lead to the development and optimization of control strategies for coupled control of indoor air quality, thermal and visual comfort, pursuing optimal energy performance. The subsystems simulated will be:

- Heat Recovery and Ventilation Distribution
- Energy (heat/cold/electricity) generation and distribution
- Daylighting and artificial lighting systems

Activity C.3 – Technical, environmental and economic analysis of the simulation results

Detailed technical-economic analysis will be carried out in order to assess the impact of the integration of the solar envelope systems in different buildings and climates.
The simulation results will be analysed and information will be organized, in order to be suitable for building and HVAC designers, e.g. in form of a decision/design tool (see also C.5). Performance figures elaborated in Activity B.2 will provide information on:

- Occupants related aspects (indoor air quality, thermal and visual comfort)
- Energy and environmental related aspects (final energy, primary energy, LCA)
- Economic aspects (LCC/LCOE)

Activity C.4 – Analysis of monitoring results

Monitoring of building integrated systems in order to understand the actual performance in real operating conditions; Typical residential and or office buildings equipped with a solar envelope will be monitored for at least one year. For the analysis

and evaluation of the monitoring data the same approach as for the simulations will be applied; If applicable normalization of the results using simulations (developed in Activity C.2) i.e. extrapolation to standard weather conditions and users' behaviour.

Activity C.5 – Predesign tool development
A tool (e.g. PHPP) will be (further) developed that enables detailed design both during the task and afterwards for energy planning and auditing. The tool should allow to evaluate the energy performance of a building equipped with a solar envelope system with respect to:

- Heat Recovery and Ventilation Distribution
- Energy (heat/cold/electricity) generation and distribution
- Daylighting and artificial lighting systems

Simplified algorithms will be developed with focus on cooling based on the results of the simulation models developed and validated in Subtask B and C.

Deliverables
D C.1 System Simulation Models
D C.2 System Simulation Results
D C.3 Design Guidelines
D C.4 Monitoring Results
D C.5 Decision/(pre-)design Tool

Milestones
M C.1 Reference Buildings and Boundary Conditions assessed
M C.2 Identification of meaningful solutions
M C.3 Assessment of the simulation results
M C.4 Assessment of the monitoring results
M C.5 Cross-sectional analysis and development of design support tool

Timescale / Deliverables and Milestones (semesters)

	year 1		year 2		year 3		year 4	
	1	2	3	4	5	6	7	8
C.1		D C.1, M C.1						
C.2			M C.2					
C.3				M C.3		D C.2		D C.3
C.4						M C.4		D C.4
C.5				M C.5				D C.5

3. Target groups and Collaborations

The Task targets three levels of stakeholders:

1. Solar technologies and envelope systems **manufacturers**, and the **H&C industry** sector, as providers of Solar Envelope Systems. In addition, **architects, engineering offices, construction companies and ESCO's** are also addressed as adopters of such technologies.
2. Public and private investors are targeted: **housing companies and building owners, banks and public bodies,** such as municipalities, playing the role of the adopters of the technologies analysed.
3. Finally, the **scientific community** is also tackled, being the first line of innovation support to industry and results' dissemination.

A number of past and ongoing SHC Tasks related will provide input to the one in object:

Past

- Task 21 Daylight in Buildings
- Task 27 Performance of Solar Facade Components
- Task 28 Solar Sustainable Housing
- Task 31 Daylighting Buildings in the 21st Century
- Task 41 Solar Energy and Architecture
- Task 44 Solar and Heat Pump Systems

Ongoing

- Task 50 Advanced Lighting Solutions for Retrofitting Buildings
- Task 53 New Generation Solar Cooling and Heating Systems

Interaction and collaboration will be also sought with the following Tasks and Annexes:

EBC - Annex 67 Energy Flexible Buildings. The aim of this Annex is to demonstrate how energy flexibility in buildings can provide generating capacity for energy grids, and to identify critical aspects and possible solutions to manage such flexibility.

PVPS - Task 15 – Building integrated PV. The main objective of this Task is to facilitate the acceleration of BIPV application in the built environment, by identifying and breaching the most important process and policy thresholds, in combination with the development of business and marketing strategies for BIPV application worldwide.

An overlap of activities is perceived with the **e-Cost action TU 1205**: Building integration of solar thermal systems. That entails a large scientific community, with researchers from around Europe, involved at different levels and in different ways to the design and analysis of BIST technologies. A strong collaboration with this Action will be sought from the very beginning, in order to profit of the results already obtained (avoiding replication) and optimising the effort.

A certain overlap is also encountered with the activities of the **e-Cost action TU 1403**: Adaptive Façades Network. Synergies will be verified.

4. Information Plan

Task information will be communicated through the following channels:

1. Task meetings

Task meetings will be held twice a year, preferably combined with an (international) event such as a conference to directly disseminate findings to one of the target audiences. Task meetings will preferably be in the different participating countries worldwide. Task meetings will preferably consist of both plenary sessions, subtask parallel sessions, and a seminar / workshop.

2. Workshops

Four industry workshops will be organised in the hosting country in combination with the Task meetings; relevant stakeholders will be invited to discuss on the relevant outcomes of the Task.

3. Website

The website will report on all the relevant information about the Task, and will be updated regularly. The website will as well be a linking portal to different SHC Tasks and other related programs of the EBC and PVPS Agreements.

4. Newsletters

Ongoing activities will be disseminated by means of six-monthly newsletters.

5. Guidelines

A number of guidelines will be disseminated as the result of all Subtasks' activities:
D A.3.4 Online glossary of Task vocabulary and definitions
D B.4 Report on simulation models of solar envelope components
D B.5 Report on test methods and recommendations
D C.3 Design Guidelines

6. Articles

Based on the scientific activities in the Task, articles will be presented and published both at conferences and in journals.

7. Predesign tool

The tool should allow architects and engineers to evaluate the energy performance of a building equipped with a solar envelope system. This will ensure easy access to complex information to relevant stakeholders of the HVAC and lighting sector.

5. List of participants and contributions **(to be updated at the kick-off meeting with specific contributions)**

Country	ID	Partner
Austria	1	University Innsbruck
Austria	2	Bartenbach
Austria	3	AEE-Intec
Canada	4	SolarWall
Denmark	5	DTU
Denmark	6	Solarcity
Denmark	7	Cenergia
Germany	8	Fraunhofer ISE
Germany	9	Fraunhofer IBP
Germany	10	HTF Stuttgart
Germany	11	Passiv Haus Institut
Germany	12	Facade-Lab
Germany	13	Gumpp & Maier
Germany	14	BASF
Germany	15	Ritter Solar
Italy	16	EURAC
Italy	18	University Palermo
Norway	19	AVENTA
Norway	20	NTNU
Qatar	21	GORD
Spain	22	University of Lleida
Spain	23	Tecnalia
Sweden	24	Lund University
Switzerland	25	SPF
Switzerland	26	Institut de Génie Thermique (IGT) - LESBAT
The Netherlands	27	Eindhoven University of Technology
United Kingdom	28	London south bank university
United Kingdom	29	University of Ulster

7. List of Deliverables

A.1 State-of–the-art on existing solar envelope systems
A.2 SWOT analysis based on the state-of-the –art information available
A.3.1 Updated Task website (on-going)
A.3.2 Two annual newsletters for the dissemination of on-going activities
A.3.3 Annual workshops with targeted stakeholders
A.3.4 Online glossary of Task vocabulary
A.3.5 Database of contacts for dissemination activities
A.3.6 Coordination and dissemination of final deliverable (printed handbook or free online publication)

B.1 Report on workshops for the identification of barriers for new solar envelope systems
B.2 Report on the development of strategies for market penetration
B.3 Report on confidential feedback workshop on current developments
B.4 Report on simulation models of solar envelope components
B.5 Report on test methods and recommendations

C.1 System Simulation Models
C.2 System Simulation Results
C.3 Design Guidelines
C.4 Monitoring Results
C.5 Decision/(pre-)design Tool

8. Gantt chart

	year 1		year 2		year 3		year 4	
	1	2	3	4	5	6	7	8
A.1			D A.1, M A.1			D A.1		
A.2				D A.2, M A.2				
A.3.1	M A.4	D A.3.1		D A.3.1		D A.3.1		D A.3.1
A.3.2	D A.3.2	D A.3.2	D A.3.2	D A.3.2	D A.3.2	D A.3.2	D A.3.2	D A.3.2
A.3.3		D A.3.3		D A.3.3		D A.3.3		D A.3.3
A.3.4			D A.3.4			D A.3.4		
A.3.5		D A.3.5						
A.3.6				D A.3.6		D A.3.6		D A.3.6, M A.5
B.1		M B.1		D B.1, D B.2, M B.2		D B.3, M B.3		D B.2
B.2				M B.4		M B.5		D B.4
B.3			M B.6	D B.5		M B.7		D B.5
C.1		D C.1, M C.1						
C.2			M C.2					
C.3				M C.3		D C.2		D C.3
C.4						M C.4		D C.4
C.5				M C.5				D C.5