SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

SOLAR ENERGY BUILDINGS

Integrated solar energy supply concepts for climate-neutral buildings and communities for the "City of the Future”

Work Plan

Version 3.0; November 9th, 2023

Note: This Version is based on the need for changes identified during the 4th, 5th and 6th meeting of Task 66 and was approved by the SHC Executive Committee at its 94th Meeting on Nov. 8th, 2023

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1. Background

On global level the operation of buildings accounts for around 40 % of the primary energy consumption and approximately 25% of the greenhouse gas emissions. In Europe buildings are responsible for 40% of energy consumption and 36% of CO_2 emissions[1]. Additionally, large amounts of energy are embodied in the building's construction materials.

A significant reduction of the non-renewable energy consumption of buildings is an important goal of many countries and regions. As a step towards this goal the European Parliament and the Council already on 16. December 2002 agreed on the energy performance of buildings directive (EPBD; Directive 2002/91/EU).

According to the latest version of the European Building Directive, only nearly zero energy buildings that meet specific energy requirements from renewable energy sources at the site or in the immediate vicinity may be erected from 2021 onwards. A completely renewable central energy supply for cities will in many cases not be possible due to a lack of space for renewable energy production inside the city. For this reason, decentralized solutions will also be needed in the city of the future that interact with existing grid infrastructures in the best possible way.

In order to characterize the impact of the building on the electrical and – if available thermal grid – in an appropriate way it is important to perform the calculations of the solar fractions based on short time intervals e.g. 15 minutes, and not on an energy balance over one complete year as it is e.g. the case for the definition of the German "Effizienzhaus-Plus". Using short time intervals to calculate the net energy balance is important, in order to reflect the fact that the electricity grid has no ability to store energy, so electricity fed into the grid is used immediately. As a result, electricity that is fed into the grid as excess photovoltaic energy in the summer, cannot be taken out of the grid again in the winter. Instead to cover electricity requirements in the winter, fossil fuel power stations have to be used. Calculating net values based on annual values therefore results in significantly lower equivalent carbon emission values than is actually the case.

This Task will build on the existing results of the following Task and will be coordinated with the ongoing ones within the framework of the Solar Heating and Cooling Programme (SHC):

- Task 63: Solar Neighborhood Planning
- Task 60: PVT Systems - Application of PVT Collectors and New Solutions in HVAC Systems
- Task 58: Material and Component Development for Thermal Energy Storage
- Task 56: Building Integrated Solar Envelope Systems for HVAC and Lighting

Additionally, the Task will seek to benefit from research results and collaboration with other IEA Technology Collaboration Programmes (TCP) such as the Energy in Buildings and Communities Programme (EBC) and especially with regard to

- Annex 67 (EBC): Energy Flexible Buildings

- Annex 83 (EBC): Positive Energy Districts
- Annex 82 (EBC): Energy Flexible Buildings Towards Resilient Low Carbon Energy Systems

Furthermore, the Task will account for the research results of the IEA TCP "Energy Conservation Through Energy Storage" (ECES) with a focus on the following annexes:

- Annex 34 (ECES): Comfort &Climate Box
- Annex 35 (ECES): Sector coupling
- Annex 36 (ECES): Carnot Batteries

2. Scope

The Task will focus on the development of economic and ecologic feasible solar energy supply concepts with high solar fractions for new and existing buildings and communities. The targeted solar thermal and solar electrical fractions depend significantly on the climate zone.

For central European climate conditions solar fractions:

- of at least 85% of the heat demand
- 100% of the cooling demand and
- at least 60% of the electricity requirements for households and e-mobility should be achieved.

The Task will address single-family buildings, multi-story residential buildings and building blocks or distinguished parts of a city, named communities, for both, new buildings and the comprehensive refurbishment of existing buildings.

In the context of this Task the separation between (single) buildings and building blocks or communities is based on the aspect if the buildings are connected to a thermal grid or not. This separation is based on the though, that in general all buildings will be connected to an electricity grid. Hence, with regard to the interexchange ability of energy between different buildings the only difference is the aspect if the buildings are connected to a thermal grid or not.

3. Objective and Organization

The main objective of Task 66 is the development of economical energy supply concepts for high solar fractions of single-family buildings, multi-story residential buildings and building blocks or distinguished parts of a city for both, new buildings and the comprehensive refurbishment of existing buildings. A central component of the energy supply concept development is the synergetic consideration of the interaction with grid infrastructures (electricity and heat) in the sense of bidirectional flexibility.

In recent years, numerous technological advances have been made in the field of solar energy (thermal and electrical), in the field of other renewable energy technologies as well as in the

field of building services. As a result, both at the technology level and at the energy-system level (e.g., through sector coupling), new approaches will be followed in this Task. These will then be further developed quantified and scalability and transferability will be assessed.

For the broad applicability in the "city of the future" holistic renewable energy supply concepts for residential buildings will be elaborated, which enable a high energy grid interaction and flexibility potential, high surface efficiency of the conversion of solar radiation into heat and power on site or nearby the building, a high economic competitiveness and high user acceptance.

Although the Task will not focus on large-scale community developments, the Task will study the interaction and integration of large numbers of SolarEnergyBuildings with the electric and thermal girds and community energy systems.

In addition to the use of solar energy and energy efficiency aspects this Task will pursue optimal integrated technical solutions that also provide good indoor climate for both heating and cooling situations with high solar fractions. The process followed within the Task recognizes the importance of optimizing the design for the functional requirement, reducing loads and designing energy systems that pave the way for seamless incorporation of renewable energy innovations that contribute to a significant increase in the cost effectiveness of solar heating and cooling technologies and designs through increased performance and reduced costs to increase their market competitiveness in heating and cooling applications.

The main objective of the Task is the development of economic and ecologic feasible solar energy supply concepts for heat and electricity with high solar fractions for new and existing buildings and communities.

Additional objectives are listed in the following:

Objective 1: To identify and map the relevant involved stakeholders (energy suppliers, housing developers, urban planning, industry, research, and governmental (local, regional, national) and their needs and roles as well as supporting and inhibiting (legal) framework conditions.

Objective 2: To give an overview on various technology options and the available technology portfolio, taking into account existing and emerging technologies with the potential to be successfully applied within the context of this Task. Furthermore, strategies will be elaborated how challenges in an economical context can be overcome.

Objective 3: To exploit the new degrees of freedom and possibilities by linking individual technologies from the technology portfolio and to optimize the interaction of local generation, storage, consumption at the building and district level enabling interactions with the grid capitalizing on new technological opportunities and unlocking new revenue streams

Objective 4: To develop and define optimized integrated and grid-interacting energy supply concepts for heat, cold, domestic electricity demand and e-mobility with intelligent control concepts and promoting user oriented approaches.

Objective 5: To give recommendations to policy makers and energy related companies on how they can influence the uptake of cost-effective solutions related to the planning and implementation of Solar Energy Buildings.

To achieve these objectives, the work is organized into the following Subtasks:

Subtask A: Boundary Conditions, KPIs, Definitions and Dissemination

Subtask BC: New and existing buildings and building blocks / communities

Subtask D: Current and future technologies and components

Note:
During performing the work of Subtask B originally dedicated to "Thermal stand-alone buildings and building blocks" and Subtask C originally dedicated to "Thermal grid connected buildings and building blocks" is became obvious that there are several similarities. Hence a lot of synergy effects could be generated by merging Subtask B and C. Furthermore, this helped to overcome the problem that the work of Subtask B was quite challenging to be performed due to the strong Covid 19 restrictions in China in the period between 2020 and 2022. Hence, a merge of Subtask B and C was proposed and accepted by the ExCo at its 92nd ExCo-meeting in December 2022.

4. Process

The Task starts on July 1, 2021 and ends on September 30, 2024.

The Operating Agent will organize two plenary Task meetings a year. Provided it is possible with regard to the Corona pandemic, the meetings will take place at varying locations, each time hosted by representatives of participating countries. In connection with the Task meetings, Subtask Leader meetings will be organized. If needed, the participants and Subtask Leaders of each Subtask may decide to organize separate meetings. In such cases, they shall inform the Operating Agent of the meeting and its results.

In case it is not possible or not appropriate to hold physical meetings, online meeting will be organized by the Operating Agent.

5. Subtasks

Subtask A: Boundary Conditions, KPIs, Definitions and Dissemination

Lead: Frank Späte, (OTH-AW, Germany)

Objectives

The main objective of Subtask A is to elaborate definitions required for the assessment and comparison of solar energy buildings and to disseminate the concept of solar energy buildings.

Specific objectives of Subtask A are to:

- Define the framework conditions and system boundaries as well as screening for legal framework conditions and definition of reference buildings (single and multi-family houses) or districts; Define the involved stakeholders (energy suppliers, housing developers, urban planning, etc.); Discuss and define different scenarios regarding overall energy system developments; Determination of specific KPIs;
- Address aspects of scalability and assignability, user and stakeholder engagement, business and statement models, financing;
- Summarize and prepare the results; disseminate measures;

Activities

Activity A1: Define performance assessment methodology for SEBs and all KPIs necessary and useful. Criteria to compare and evaluate different designs must be set up in this activity. They must be relevant to the market needs and must be quantifiable.

Activity A2: Use the methodology to assess SEB´s Subtask B and C, with a relevant reference as benchmark. Having derived a set of criteria in A1, this activity will use the set to evaluate the projects that Subtask B and C has provided. They will be assessed and compared if possible, at least qualified.

Activity A3: Prepare and manage industry workshops. Along the task duration, workshops will be organized where local stakeholders, planners, etc. will be invited to share experience and knowledge. This is a way to faster disseminate Task outcomes and to faster get feedback and problems detection from real practices.

Activity A4: Based on the results of the Task, guidelines will be prepared for policy makers, municipalities, and energy related companies on how to encourage the market take-up of cost-effective strategies combining energy efficiency measures and renewable energy measures for the transformation to SEB´s. The guidelines will also include aspects for a stakeholder dialogue. Furthermore, guidelines will be prepared for building owners and investors.

Deliverables

No.	Deliverable	Month
D.A1	Draft list of KPIs (for discussion within the task)	9
D.A2	Final list of KPIs	18
D.A3	Draft definition of reference buildings / cases (for discussion within the task)	9
D.A4	Final definition of reference buildings / cases	12
D.A5	Industry Workshops	9,12,18,24,32,38
D.A6	SEB promotion document for investors	32
D.A7	Policy oriented document for the promotion of SEB	36

Subtask BC: New and existing buildings and building blocks / communities

Lead: Elsabet Nielsen (DTU, Denmark)

Co-lead: Xinyu Zhang and Wenbo Cai (CABR, China)

Objectives

The main objective of Subtask BC is to give examples of solar energy buildings and an overview of methods and tools used to design, operate, and evaluate solar energy buildings.

Specific objectives of Subtask BC are to:

- Investigation of economic and ecologic energy supply concepts with high solar fractions for new and existing buildings and communities, based on the technologies determined in subtask D. If applicable, further develop individual technology elements.
- Exploit the new degrees of freedom and possibilities by linking individual technologies from the technology portfolio from a perspective that looks at the entire energy system, such as sector coupling, SRI indicators (Smart Readiness Indicator), self-consumption levels, and grid load rejection potential (overall grid infrastructures), etc. Consider available surface and the area- efficiency of individual technologies. Define integrated and grid-interacting energy supply concepts for heat, cold, domestic electricity demand, and e-mobility. Consider aspects of increased user involvement.
- Modeling, simulation, and determination of KPIs defined in subtask A and optimization procedures.

Activities

Activity BC1: Demonstration cases

- Demo cases summary (case studies)
- Guidelines for monitoring and reporting
- Reporting and sharing key findings

- Stakeholder viewpoints
- Learning from the cases
- Best practices

Activity BC2: Planning and implementation methodology

- Documenting processes and tools currently being used to design SEB´s and under development by participating countries
- Tools and methods for different phases: design, construction, operation and verification, maintenance, renovation, end of life, etc.
- Other issues to consider: mobility, storage, monitoring, etc., different contexts (climates, markets, urban, suburban, and rural, etc.)

Activity BC3: Modelling, simulation and optimization tools

- Investigation and identification of the tools for modelling a SEB (from demand to the energy balance calculation) that are used for designing and operating a SEB
- Running simulation and optimization cases for validation and producing data on viability of different SEB concepts with different technology combinations under different operating and weather conditions

Deliverables

No.	Deliverable	Month
D.BC1	Summary of demonstration cases (case studies)	36
D.BC2	Description of processes and tools currently used to design new or convert existing building stock into new Solar Energy Building communities	32
D.BC3	Catalogue describing optimized solutions of Solar Energy Buildings	36

Subtask D: Current and future technologies and components

Lead: Michael Gumhalter and Thomas Ramschak (AEE INTEC, Austria)

Objectives

The main objective of Subtask D is to provide a summary of new technologies and components for solar energy buidligns.

Specific objectives of Subtask D are to:

- Define current and future technologies in a technology portfolio, such as solar thermal (conventional collector technologies, medium temperature collectors, charge boost sorption collectors, other specific new developments), PVT hybrid collectors, PV, micro heat pumps, different thermal and electrical energy storage technologies (e.g. activation of thermal masses, water storage with vacuum insulation, sorption storage, ice storage, stationary and mobile battery storage, etc.), heat and cold supply systems, water heaters and other technologies for heat, cold and power generation (biomass, green gas, cogeneration, etc.).
- Initiate the development of new of significantly improved technical solutions.
- Conduct techno-economic assessment of newly developed solutions.

Activities

Activity D1: Documenting and analyzing current and future technologies applied in SEB´s. Sources such as demo case studies (Subtask B and C), other IEA Tasks and Annexes, will be revised to create an inventory of the different technologies applied in a SEB or buildings approaching SEB status.

Activity D2: From the revision and analysis of the different technologies, the technologies will be classified into different topics/areas (heating, cooling, electricity, storage) and scope (building, district, city). In each segment the technologies can be compared and evaluated (using KPIs from subtask A) in terms of technical and economic aspects among others.

Activity D3: Developing SEB information sets and guidelines with respect to building types and climate and to document design options. This includes in particular information on their efficiency, cost elements such as investment costs and operational costs taking into account economies of scale. The interdependencies, obstacles and success factors for combining the technology options are also described. The information is made available in short fact sheets for certain technologies.

Deliverables

No.	Deliverable	Month
D.D1	Description of available technology portfolio	24
D.D2	Description of promising future technologies	30
D.D3	Summary of new technologies and components identified within the Task in the form of a Fact Sheet collection	36

6. Activity and Time Table Summary

IEA SHC Task - Solar Energy Buildings		Year 0,5 : 2021 Breakdown by quarter		Year 0,5 - 1,5 : 2022 Breakdown by quarter				Year 1,5 - 2,5 : 2023 Breakdown by quarter				Year 2,5 - 3,25 : 2024 Breakdown by quarter		
		3	4	1	2	3	4	1	2	3	4	1	2	3
Project Management														
Subtask A: Boundary Conditions, KPIs, Definitions and Dissemination														
A.1	Draft list of KPIs (for discussion within the task)			D.A1										
A.2	Final list of KPIs						D.A2							
A.3	Draft definition of reference buildings (for discussion within the task)			D.A3										
A.4	Final definition of reference buildings				D.A4									
A.5	Industry Workshops			D.A5		D.A5		D.A5			D.A5	D.A5		D.A5
A.6	SEB promotion document for investors											D.A6		
A.7	Policy oriented document for the promotion of SEB												D.A7	
Subtask BC: New and existing buildings and building blocks / communities														
BC.1	Summary of demonstration cases (case studies)												D.BC1	
BC.2	Description of processes and tools currently used to design new or convert existing building stock into new SEB communities											D.BC2		
BC.3	Catalogue describing optimized solutions of Solar Energy Buildings												D.B4	
Subtask D: Current and future technologies and components														
D.1	Description of available technology portfolio							D.D1						
D.2	Description of promising future technologies										D.D2			
D.3	Summary of new technologies and components identified within the Task in the form of a Fact Sheet collection												D.D3	
	Deliverable													

List of Deliverables

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D.D3	Summary of new technologies and components identified within the Task in the form of a Fact Sheet collection	36