

SOLAR ENERGY BUILDINGS

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

Work Plan

Version 2.0; December 22, 2020

Note: This Version is based on the results of the results of the 88th IEA SHC Executive Committee Meeting and the ballot performed after this meeting

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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 CO₂ emissions¹. 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 thought, 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 grids 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 B: New and existing single buildings

Note: Buildings dealt with in this subtask are not connected to a thermal grid

Subtask C: New and existing building blocks / communities

Note: Buildings dealt with in this subtask are connected to a thermal grid

Subtask D: Current and future technologies and components

Note:

In the context of this Task the separation between (single) buildings and building blocks or communities is based on the aspect whether the buildings are connected to a thermal grid or not. This separation is based on the fact, 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.

4. Process

The Task starts on July 1, 2021 and ends on June 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 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) and
Jyotirmay Mathur, (MNIT, India)**

Note: tbc

Objectives

The main objective of Subtask A is to.....

will be completed after the Task preparation meeting

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	6,12,18,24,32,36
D.A6	SEB promotion document for investors	32
D.A7	Policy oriented document for the promotion of SEB	36

Subtask B: New and existing single buildings

Lead: N. N.

Objectives

The main objective of Subtask B is to.....

will be completed after the Task preparation meeting

Specific objectives of Subtask B are to:

- Elaborate on the economic and ecologic energy supply concepts with high solar fractions for new and existing buildings
- Define potential 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.). 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) and self-consumption levels. Consider available surface and the area-efficiency of individual technologies. Define integrated energy supply concepts for heat, cold, domestic electricity demand and e-mobility. Develop intelligent control concepts (data-based and predictive). Consider aspects of increased user involvement.
- Modeling, simulation, determination of levelised cost of energy, evaluation with technical, economic and environmental KPIs and optimization procedures.

Activities

Activity B1: Demonstration cases

- Demo cases summary (case studies)
- Guidelines for monitoring and reporting
- Reporting and sharing key findings
- Issues to consider: stakeholder viewpoints, different ambition levels
- Learning from the cases
- Best practices

Activity B2: 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 B3: Modelling, simulation and optimization tools

- Investigation and identification the tools for modelling a SEB (from demand to the energy balance calculation) that can be used for designing and operating a SEB
- Comparison between the different modelling and simulation tools such as POLYSUN or TRNSYS are used to investigate the optimal dimensioning and combination of different technologies that meets the desired renewable fractions of heat, cold and electricity., complexity, and scope/objective functions
- 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.B1	Summary of demonstration cases (case studies)	14
D.B2	Description of processes and tools currently used to design new Solar Energy Buildings	18
D.B3	Description of processes and tools currently used to convert existing buildings into Solar Energy Buildings	18
D.B4	Catalogue describing optimized solutions of Solar Energy Buildings	36

Subtask C: New and existing buildings blocks / communities

Lead: Elsabet Nielsen (DTU, Denmark), tbc

Objectives

The main objective of Subtask C is to.....

will be completed after the Task preparation meeting

Specific objectives of Subtask C are to:

- Elaborate on economic and ecologic energy supply concepts with high solar fractions for the existing building stock and for new building blocks or communities respectively
- Define potential 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.). 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 potentials (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. Develop intelligent control concepts (data-based and predictive). Consider aspects of increased user involvement.
- Modeling, simulation, determination of levelised cost of energy, evaluation with technical, economic and environmental KPIs and optimization procedures.

Activities

Activity C1: Demonstration cases

- Demo cases summary (case studies)
- Guidelines for monitoring and reporting
- Reporting and sharing key findings
- Issues to consider: stakeholder viewpoints, different ambition levels
- Learning from the cases
- Best practices

Activity C2: 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 C3: Modelling, simulation and optimization tools

- Investigation and identification the tools for modelling a SEB (from demand to the energy balance calculation) that can be used for designing and operating a SEB
- Comparison between the different modelling and simulation tools such as POLYSUN or TRNSYS are used to investigate the optimal dimensioning and combination of different technologies that meets the desired renewable fractions of heat, cold and electricity., complexity, and scope/objective functions
- 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.C1	Summary of demonstration cases (case studies)	14
D.C2	Description of processes and tools currently used to design new Solar Energy Buildings communities	18
D.C3	Description of processes and tools currently used to convert the existing building stock into Solar Energy Buildings communities	18
D.C4	Catalogue describing optimized solutions of Solar Energy Buildings communities	36

Subtask D: Current and future technologies and components

Lead: Thomas Ramschak (AEE INTEC, Austria), tbc

Objectives

The main objective of Subtask D is to.....

will be completed after the Task preparation meeting

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 or 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 solution 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.

Deliverables

No.	Deliverable	Month
D.D1	Description of available technology portfolio	9
D.D2	Description of promising future technologies	18
D.D3	Summary of new technologies and components developed within the Task	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 - : 2024 Breakdown by quarter	
		3	4	1	2	3	4	1	2	3	4	1	2
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 B: New and existing single buildings													
B.1.	Summary of demonstration cases (case studies)					D.B1							
B.2.	Description of processes and tools currently used to design new Solar Energy Buildings						D.B2						
B.3.	Description of processes + tools used to convert existing buildings into Solar Energy Buildings												D.B3
B.4.	Catalogue describing optimized solutions of Solar Energy Buildings												D.B4
Subtask C: New and existing building blocks / communities													
C.1.	Summary of demonstration cases (case studies)					D.C1							
C.2.	Description of processes and tools currently used to design new Solar Energy Buildings communities						D.C2						
C.3.	Description of processes + tools used to convert existing building stock into SEBcommunities						D.C3						
C.4.	Catalogue describing optimized solutions of Solar Energy Buildings communities												D.C4
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 developed within the Task												D.D3
Deliverable													

List of 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 (for discussion within the task)	9
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D.A7	Policy oriented document for the promotion of SEB	36
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D.B2	Description of processes and tools currently used to design new Solar Energy Buildings	18
D.B3	Description of processes and tools currently used to convert existing buildings into Solar Energy Buildings	18
D.B4	Catalogue describing optimized solutions of Solar Energy Buildings	36
D.C1	Summary of demonstration cases (case studies)	14
D.C2	Description of processes and tools currently used to design new Solar Energy Buildings communities	18
D.C3	Description of processes and tools currently used to convert the existing building stock into Solar Energy Buildings communities	18
D.C4	Catalogue describing optimized solutions of Solar Energy Buildings communities	36
D.D1	Description of available technology portfolio	9
D.D2	Description of promising future technologies	18
D.D3	Summary of new technologies and components developed within the Task	36