Annex 49

Low Exergy Systems for High-Performance Buildings and Communities

A short description of the Annex 49 activities

more information can be found at:

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ECBCS Annex 49: *Low Exergy Systems for High-Performance in Buildings and Communities*

INTRODUCTION

There is a undisputable need for a more efficient energy use and the reduction in CO_2 emissions, so a huge effort must be made in the future to conserve high quality or primary energy resources. There will be a new dimension to this problem if countries with fast growing economies continue to increase their energy consumption of fossil energy sources in the same manner as they do now. Even though we still have considerable energy saving potential in the building stock, the results of the recently finished ECBCS Annex 37 - Low Exergy Systems for Heating and Cooling of Buildings - show that there is an equal or greater potential in exergy management. This implies working with the whole energy chain, taking into consideration the different quality levels involved, from generation to final use, in order to significantly reduce the fraction of primary or high-grade energy used and thereby minimise exergy consumption. New advanced technologies have to be implemented. At the same time, as the use of high quality energy for heating and cooling is reduced, there is more reason to apply an integral approach which includes all other processes where energy/exergy is used in buildings. In recent years we have made substantial progress in the development of new and integrated techniques for improving energy use, such as heat pumps, co-generation, thermally activated building components, and methods for harvesting renewable energy directly from solar radiation, from the ground or from various waste heat sources. Some of these issues and others have been dealt with in various annexes and task groups within the IEA.

The results obtained in Annex 37 were promising, and elucidated a huge potential for introducing new components, technologies and system solutions to create low exergy built environments. The exergy conversion (e.g. heat or electricity production) plays a crucial part in possible future activities in the overall system optimisation of the entire energy system within a building. The target should be to establish a holistic approach for an affordable, comfortable and healthy built environment, while obtaining a minimum input of exergy, and implementing a substantial amount of renewable energy sources into the energy supply of buildings.

THE EXERGY CONCEPT AND THE LOWEX APPROACH

Exergy is a concept which helps us distinguish between two parts of an energy flow: exergy and anergy. Only the exergy part of any energy flow can be converted into some kind of high-grade energy such as mechanical work or electricity. Anergy, on the other hand, refers to the part of the energy flow which cannot be converted into high-grade energy, e.g. low-grade waste heat from a power plant. Exergy can be regarded as the valuable part of energy, while anergy designates the low-value portion.

Unless a suitable use for it is found, e.g. waste-heat utilization in buildings, the low-value part of the original energy flow will eventually dissipate into the environment and be irreversibly lost. Such unalterable dissipation is designated as irreversibility. The exergy content of a given flow of energy depends on the attributes, e.g. the temperature, pressure, and chemical composition, of both the substance carrying the energy (energy carrier), and the surrounding environment. The more different the attributes of the energy carrier and the environment are, the higher the exergy content of the energy carrier is. For example, high-pressure steam required for electrical power generation has a higher exergy content than warm water needed by a dishwasher.

The Low Exergy (LowEx) approach entails matching the quality levels of exergy supply and demand, in order to streamline the utilisation of high-value energy resources and minimise the irreversible dissipation of low-value energy into the environment.

SCOPE AND OBJECTIVES OF THE ECBCS ANNEX 49

The scope of the proposed activity is to improve, on a community and building level, the design of energy use strategies which account for the different qualities of energy sources, from generation and distribution to consumption within in the built environment. In particular, the method of exergy analyses has been found to provide the most correct and insightful assessment of the thermodynamic features of any process and offers a clear, quantitative indication of both the irreversibilities and the degree of matching between the resources used and the end-use energy flows. The exergy content required to satisfy the demands for heating and cooling of buildings is very low, since a room temperature level of about 20°C is very close to the ambient conditions. Nevertheless, high quality energy sources like fossil fuels are commonly used to satisfy these small demands for exergy. From an economical point of view, exergy should mainly be used in industry to allow for the production of high quality products, see Figure 1.

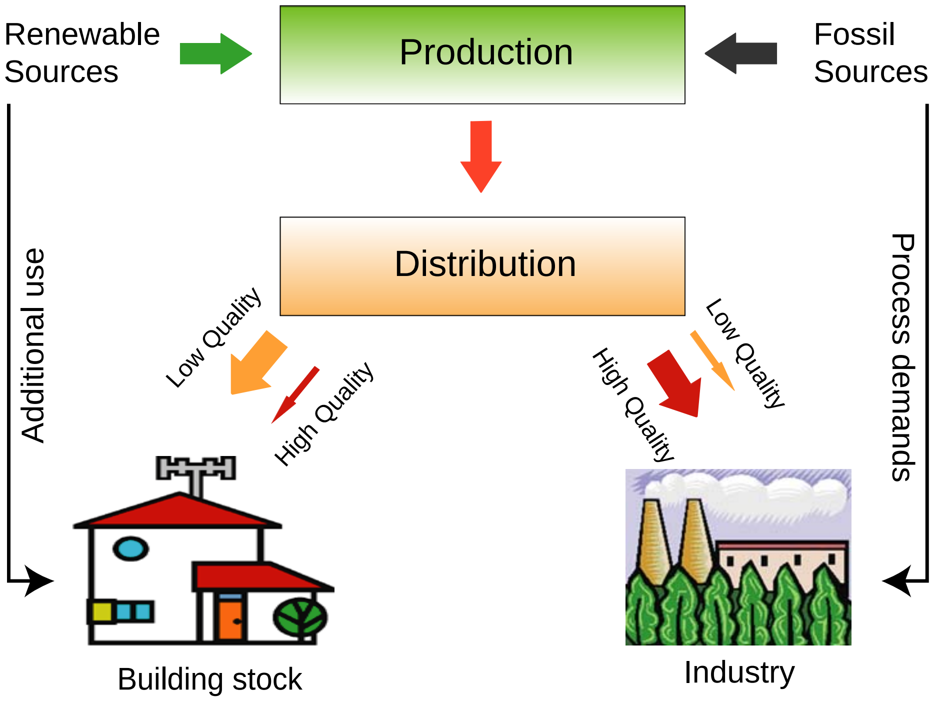

Fig. 1: Desirable energy/exergy flow to the building stock and industry.

It is known that the total energy use caused by buildings accounts for more than one third of the world's primary energy demand. There is however a substantial saving potential in the building stock. The implementation of exergy analyses paves the way for new potentials of increasing the overall energy chain efficiency. Exergy analysis can support the development and selection of new technologies and concepts with the potential for lowering exergy consumption for built environments. It can also quantify this potential. Up to now, a considerable effort has been made to reduce the energy demand of the building stock. The new approach is not necessarily focused on a further reduction of the energy flow through a building's envelope. When the demands for heating and cooling have already been minimised, the low-exergy approach aims at satisfying the remaining thermal energy demand using only low quality energy. This creates the potential for reducing the total amount of exergy needed by the energy supply-demand chain, and for providing a more customised distribution of exergy to consumers with different exergy requirements.

The major benefit of following low exergy design principles is the resulting decrease in the exergy demand in the built environment. By following the exergy concept, the total CO_2 emissions for the building stock will be substantially reduced as a result of the use of more efficient energy conversion processes. This new concept supports structures for setting up sustainable and secure energy systems for future building stock.

The strategies developed for a better and exergy optimised building design, aiming at a future of clean, clever and competitive energy use will help in pinpointing specific actions to reach this goal. Additionally, the exergy demand of buildings will be reduced due to new, enhanced heating and cooling systems.

The exergy concept applied to buildings leads to new research topics for building stock. The ECBCS Annex 49 is addressing the following research items :

- Combined exergy/energy analyses for community supply structures and buildings, especially those with changing ambient and boundary conditions. This will lead to the implementation of dynamic analyses for complex systems.
- Optimisation strategies for low exergy distribution and building technology system configurations.
- A mandatory holistic system approach to investigate the dependencies between energy production and the use of energy in buildings. This implies the feedback and the response of the building to the grid and energy production strategies.
- Integrated use of local renewable energy sources. Known and new, innovative techniques will be evaluated using new analysis tools. The results will indicate directions for new developments.
- Better control strategies for building service systems to reduce the overall exergy demand.
- Exergy as an indicator for sustainability and for long term, cost efficient solutions.
- Indoor comfort provided by placing the minimum possible exergy demand on building service systems.

STRUCTURE OF THE ACTIVITIES

To accomplish these objectives, participants will carry out research and work on developments within the general framework of the following four subtasks: The first subtask, A “Methodologies”, is aimed at development, assessment and analysis methodologies, including a tool development for design and performance analysis of the regarded systems. The second subtask, B “Exergy efficient community supply systems”, focuses on the development of exergy distribution, and generation and storage system concepts. A third subtask, C “Exergy efficient building technologies”, is based on the reduction of exergy demand for heating, cooling and ventilating of buildings. The last subtask, D “Knowledge transfer, dissemination”, concentrates on the collection and spreading of information on ongoing and finished work. Figure 2 shows the structure of the subtasks.

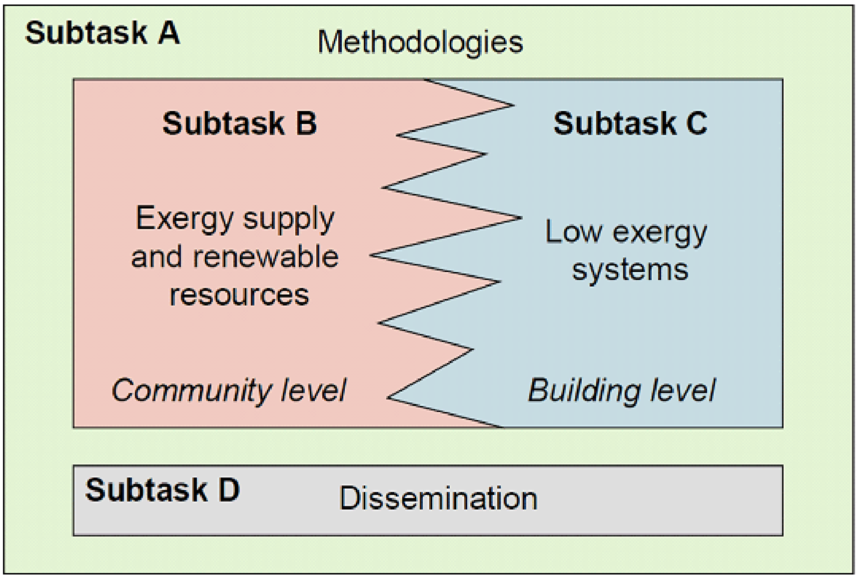

Figure 2: Subtask structure of the ECBCS Annex 49

The community[1] and the building level are directly connected by the final energy conversion process. Nonetheless, the distribution concept for exergy has to be fixed at the community level.

EXPECTED RESULTS

The primary presentation of the annex is expected to be an IT based guidebook on how to implement advanced LowEx technology at a community level in the built environment and how to optimise supply structures to ensure low exergy demand of the system solution, while providing good comfort to the occupants and users of the buildings. Furthermore, the work will focus on analysis concepts and design guidelines with regard to exergy metrics for performance and sustainability. This will include a possible classification of low-exergy forms of technology in terms of performance, improvement potential and innovation prospects. A collection of best-practice examples for new and retrofit buildings and techniques will show the potentials of the new approach. With this basis, recommendations for policy measures will be suggested and pre-normative work will be conducted.

The focus of the dissemination of documents and other information will be to transfer the research results to be used by practitioners. Methods of information dissemination will include conventional methods such as newsletters and articles, as well as new media; the Internet is to be used intensively to spread information. Workshops will be organised in different countries to show the latest project results and to provide an exchange platform for the target audience (notably, energy managers, designers, and energy service companies).

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[1] A community (e.g. a district) is defined as a group of buildings connected to one energy supply system.

PARTICIPATION

Participation in this annex requires a minimum effort of 12 person-months per country. Each participant's country is required to take part in at least one of the sub-tasks and it is recommended that all participants take part in Subtask D. Participation may partly involve funding allocated to a national activity, which falls substantially within the scope of work to be performed under this annex. Aside from providing the resources required for performing the work of the subtasks in which they are involved, all participants are required to provide the resources necessary for activities that are specifically collaborative in nature and are not meant to be part of a national program; for example, establishing common monitoring procedures, preparation for and participation in annex meetings, co-ordination with subtask participants, and contribution to documentation and information dissemination.

Until now the representatives from following nine countries declared interest in the cooperation activity Annex 49: Canada, Denmark, Finland, Germany, Italy, Japan, Poland, Sweden and The Netherlands.

CONTACT

For further information on the research activities mentioned before as well as to address any questions concerning or potential participation on the activities, please contact the proposed Operating Agent for Annex 49:

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