Sustainable Energy Supply in Social Housing

Rolf Katzenbach, Frithjof Clauss, Jie Zheng

***Abstract*—**The final energy use can be divided mainly in four sectors: commercial, industrial, residential, and transportation. The trend in final energy consumption by sector plays as a most straightforward way to provide a wide indication of progress for reducing energy consumption and associated environmental impacts by different end use sectors.The average share of end use energy for residential sector in the world was nearly 20% until 2011, in Germany a higher proportion is between 25% and 30%. However, it remains less studied than energy use in other three sectors as well its impacts on climate and environment. The reason for this involves a wide range of fields, including the diversity of residential construction like different housing building design and materials, living or energy using behavioral patterns, climatic condition and variation as well other social obstacles, market trend potential and financial support from government.

This paper presents an extensive and in-depth analysis of the manner by which projects researched and operated by authors in the fields of energy efficiency primarily from the perspectives of both technical potential and initiative energy saving consciousness in the residential sectors especially in social housing buildings.

***Keywords*—**Energy Efficiency, Renewable Energy, Retro-commissioning, Social Housing, Sustainability.

I. Introduction

In Europe energy consumption in the building sector (inclusive of residential, commercial, service and others.) has increased up to 41% of the total final energy consumption since recent years, which is the largest end-use sector, followed by transport (31,8%), industry (25,6%) and agriculture (2,1%). Final energy consumption of buildings has increased at EU level by around 1%/year since 1990. Until 2009 a share 27% of the final energy consumption in the EU was used in households and this number has risen up to 28,6% until 2012. However, the main final energy carriers are so far still oil products, different sorts of natural gas derivatives, electricity, biomass and a small proportion of other renewable energy sources.

Dipl.-Ing. Jie Zheng is scholar at the Excellence Graduate School of energy Science and engineering, Technische Universität Darmstadt, 64287 Darmstadt, Germany (phone: 0049-6151-75740; e-mail: zheng@energycenter.tu-darmstadt.de).

Dipl.-Ing. Frithjof Clauss is Executive Director of TU Darmstadt Energy Center, 64287 Darmstadt, Germany (e-mail: clauss@energycenter.tu-darmstadt.de).

Professor Dr.-Ing. Rolf Katzenbach is Director of the Institute and the Laboratory of Geotechnics and of TU Darmstadt Enregy Center of Technische Universität Darmstadt, 64287 Darmstadt, Germany (e-mail: katzenbach@geotechnik.tu-darmstadt.de).

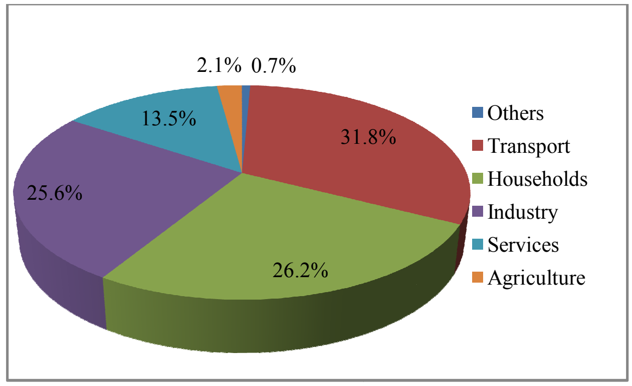

Fig. 1 Final energy consumption, EU-28, 2012 (% of total, based on tonnes of oil equivalent) [1]

Actually much more energy was proved to be consumed than necessary for living and production. As a result, not only the financial tension is mounting on the local government and household themselves, but also the contribution of housing to greenhouse gas (GHG) emission rises continuously and it has been observed to be one of major source of environmental pollution. How to bring more energy efficient technologies and awareness into people's daily life is focused by all the relevant professionals integrated in politics, economics, technics and education, because comparing to overdrives of generating and transmitting from power plants or overexploitation of energy sources, the improvement of energy efficiency costs much less and could be a most sustainable solution to cope with energy crisis and air and environmental pollution.

In March 2007 the European Union (EU) has drawn up *the Climate and Energy Package 20-20-20* which entered into force in June 2009 [2]. Three key requirements were set to meet the ambitious climate and energy targets in Europe until 2020:

- A 20% reduction of greenhouse gas emissions from 1990 levels;
- A 20% increase of the share of energy consumption produced from renewable resources;
- A 20% improvement of energy.

The 20% objective translates into a saving of 368 million tons of oil equivalent (Mtoe) by 2020 compared to projected consumption in that year of 1842 Mtoe, that is to say 1474 Mtoe consumption in 2020, which needs to be achieved by the EU as a whole. But from the newest report by EU with taking into account measures implemented at national and European level up to the end of December 2009, the set goal has to be modified and is expected to be 1678 Mtoe, equivalent to only 8,9% energy saving relative to the previous projection [3]. The reasons caused the lowered progress consist in different aspects like lack of experience in technical improvement, failures of economic investment and unsuitability of laws and regulatory, market imperfection, which could be scarcely operationalized and replicable in European countries and regions because of their different development level as well. And yet the residential energy consumption (a share of 26,2%), as the most final energy use part of building sector, is in fact higher and the mainly potential reason ascribe a still low energy saving awareness, besides lower energy management efficiency and other potential problems. It is worth to be paid more attention on the energy efficiency especially in social housing building.

II. Situation Analysis

A. Social Housing in Europe

Social housing contributes to alleviate the pressure of housing demands for inhabitants with different income and educational levels and various family or age structure. An obvious higher the residential energy consumption (a share of 26,2%) has been observed, which shall not occur, however. Because of different political and economic situation there is significant diversity of the social housing development in all the European countries, but they also face similar pressures: from European energy regulation, from increased demands and aggravating financial burden and environmental pollution. Another in common is that most social housing generally is orienting towards the poor working families or even the middle classes while with very low income sources or social assistance grants. This is why it must be emphasized that the energy efficiency improvement in social housing shall be achieved with LOW INVESTMENT, at the same time with a precondition of keeping or enhancing current living qualities.

B. Social Housing Development in Germany

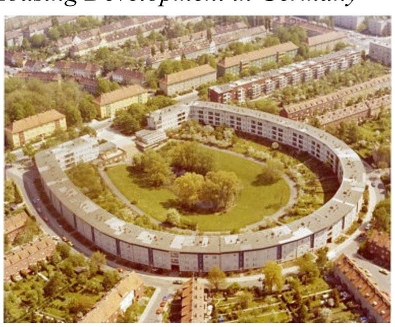

Fig. 2 Hufeisensiedlung in Berlin, built between 1925 to 1933 (one of the first social housing in Germany)

There is almost 100 years history of social housing in Germany since 1920s when new settlements were built to provide a healthy living environment for the low income people after the world-war I. Until 1987 there were more than 3,9 Mio. social housing stocks in Germany. With the market-based module the public sector or government provides subsidies to private firms to develop new social housing or rehabilitate the existing housing building. The housing remained "social" for a limited time – usually 30 or 40 years, after which it could turn into normal housing market [4].

The logistical regulation WoFG (*Wohnraumförderungs-gesetz*) was took effect since 1st September 2001 in Germany, which works for the social housing promotion. As a very important character the social housing in Germany is always strengthened the housing's consume attributes instead of its asset attribute.

III. Methodology for Improving Energy Efficiency in Social Housing

Improving energy efficiency in social housing is a great opportunity to optimize the current inefficient energy consumption situation in residential sector, as well is a significant contribution to promote economic progress, environmental and climate quality, living comfort and also social equality.

A. Beneficiaries

The objectives of improving energy efficiency in social housing are to meet and balance the benefits of all the relevant aspect:

- Tenants: energy cost saving and achieve so called "*saving heating for better eating and living*";
- Housing firms: building up a higher reputation and expand the market reach;
- Local government: reduce the financial burden to optimize the capital allocation in a comprehensive range and fields; contribution to environmental objectives like resource conservation and enhancement of energy security.

Approaches to improving energy efficiency in social housing are made different research and implementation in the existing housing building and the new building construction respectively.

B. Approaches for Optimization of Energy Efficiency in Existing Social Housing

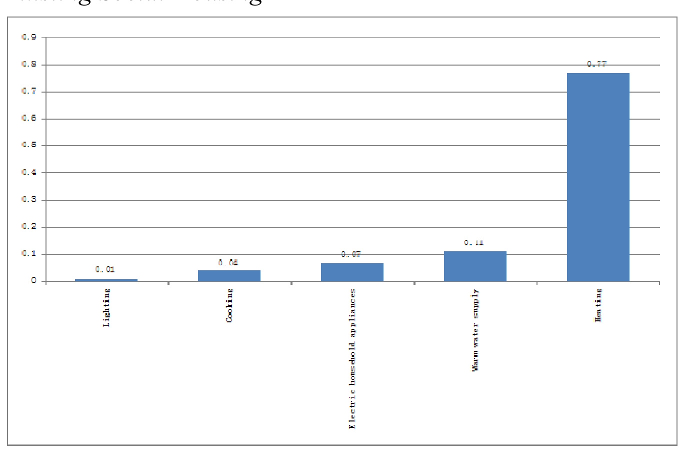

Fig. 3 Final energy consumption of household in Germany

For the existing social housing building it shall clarify the final energy use structure generally in household, firstly. During the daily life the energy is demanded mainly in heating and warm water supply and in cooking, lighting, washing and other electrical application in common. Fig. 3 illustrates the final energy consumption of household in Germany.

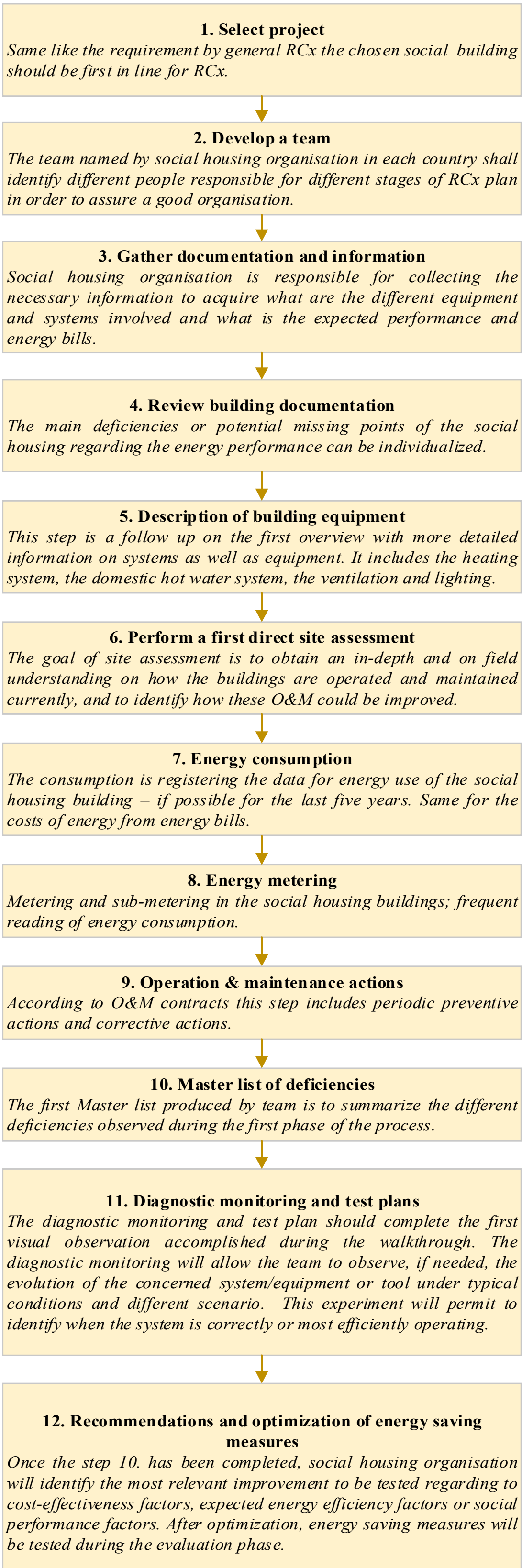

Fig. 4 Workflow of Retro-Commissioning in social housing buildings

Retro-commissioning (RCx) is defined as "a systematic investigation process for improving or optimizing an existing building's performance" [5], which can be achieved by identifying and implementing relatively low-cost operational and maintenance improvements and meet the efficiency expectations of owners, tenants and other stakeholders. In other words, retro-commissioning is supposed to assure building system functionality as a whole. Not only each part of equipment or systems can be optimized during the process of retro-commissioning, but also a successful co-function among all parts must be pursued and assured.

A well-planned and executed retro-commissioning project typically occurs in four distinct phases: Planning, Investigation, Implementation, and Hand-Off [6]. According to the practical experiences by authors concentrating efforts on energy efficiency in social housing projects in European countries, it is proposed to introduce the process of retro-commissioning in the affordable housing in twelve steps shown in Fig. 4. Because the common retro-commissioning methodologies have been created in a Northern American context for heating and cooling devices based on energy devices and using electricity as energy carrier, however, European heating systems are more prominently based on water warmed by different energy carriers.

Each stakeholder benefits from retro-commissioning. The operation cost of building owners is to be reduced, therefore increase the net profits. The living situation of tenants is getting more comfortable, safer and healthy with a reasonable energy costs, so that the tenants' complaint could be reduced or avoided, which contributes to improving the work efficiency of building and energy manager.

C. Approaches for Optimization of Energy Efficiency in New Construction

Commissioning in new housing building shall begin during design and continue through construction, occupancy and operation [7]. That is to say, energy and costs can be saved throughout the entire process for each stakeholder. It is worth mentioning that except the same benefits like by retro-commissioning in existing buildings, a remarkable character or advantage by commissioning in new housing is possible to introduce renewable energy in new construction instead of conventional energy sources such as gas and electricity or other fuel energy.

In the context of current energy situation and social structure in European countries especially in Germany, a multi-level passive house is designed to a more popular extent, which takes the living demands of different generations into account and aims to provide a harmonious, convenient life with affordable costs. The concept of low energy social housing building for the purpose of energy efficiency and cost saving should take consideration of the following factors from the authors' point of view that is based on practices:

- *Building Orientation*: define the target user groups and determine what local, utility and government resources are available. As a decisive assumption it needs to consider and evaluate all the possible effects before designing a new energy saving building especially for low-income population.

- *Configuration of Heating System*: as the main energy consumption in household it is suggested that all the energy production and system maintenance for heating shall be taken into full consideration and work in a most efficient matrix (e.g. optimization of heat pump, combined heat and power, renewable energy like geothermal energy, solar energy or biomass, auxiliary energy if needed or possible etc.).
- *Configuration of Ventilation System*: for example, try to maintain the double flux ventilation.
- *Building Construction*: strictly control the use of materials which are corresponding to the building elements like windows, walls, basement and roof, through the trial and error method, in order to assure the insulation in the whole system.
- *Practicability of Photovoltaics*: assess the profitability of photovoltaics for building owners and also its acceptable level in target population.
- *Efficient Operation*: equipment monitoring like continue controlling the entire system after coming into service, which depends not only on the technical optimization by owners or managers, but last not least the users or tenants' energy using behavior is a very noteworthy point.
- *Passive House*:an efficient green building model with a consideration of cost, environmental impact. It has been proved in a pilot project participated by authors that the energy consumption could be saved approx.18 to 20%.
- *Others Activities with Tenants*: Performance tracking like communication and information exchange between building owners / energy managers and tenants play a significant role to sustain and optimize the energy saving measures.

D.Other Initiatives of Energy Efficiency by Users and Providers

In order to strengthen the empowerment of final energy consumers as respects the detail information about their individual consumption by time quantum and spatial dimension (e.g. energy consumption in each room of housing), smart metering is an important and intelligent implementation for energy metering and recording, which on one hand helps energy providers to avoid peak consumption and optimize the timing of domestic energy consumption in line with supplier requirements and energy tariffs as well contribute to a sustainable development of energy markets with regards to the services and demand management, on the other hand provides a transparent and accurate consumption data or bills by heating, cooling and warm water supply, to customers or tenants.

Following a market mechanism "*Needs must be supplied"* the demand response is a noticeable instrument for enhancing energy efficiency through its impact on the reduction or shift energy consumption by final customers. In other words the demand response reflects the users' sensitivity to energy prices and their energy saving awareness. It is particularly apparent in the tenants group of social housing buildings. Poor or lack of energy conservation consciousness is relatively common which is led to because of different kinds of reasons, such as educational background, the energy using behavior has no direct impact on their subsidies regularly received from government, lack of interaction between tenant and building owner as well energy supplier with the aim of energy saving. In view of these facts, how to strengthen the energy consumption awareness by tenants in social housing is a vital promotion for energy saving, which could be achieved with a complete resource consumption awareness system, which consists of various ways in communication and education, regular consumption data collection and comparison by users, possibility of access to energy consumption information at any time, and corresponding resource management system etc.

IV. CONCLUSION

Improvement energy efficiency aims to benefit the users and providers with a decreased amount of energy consumption, and as a result to reduce the environmental pollution, however it is not only an energy saving. In accordance with the new EU energy efficiency policies especially its 20-20-20 political package, it is expected to create more and sustainable business opportunities, widen and boost its competitiveness in energy markets especially the exploitation and development of renewable energy, as well enhance EU global leadership and reputation in energy saving fields. A chain effect by improving energy efficiency is illustrated in Fig. 5 below, which explains the necessity and importance to optimizing the current energy using model in European counties.

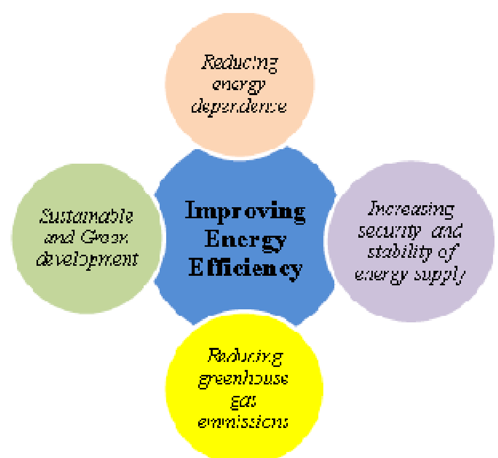

Fig. 5 Chain effect throughout improvement of energy efficiency

A sustainable energy supply results in a broad range of economic, political, social and environmental goods that in line with the missions of all the involved stakeholders. In the context of this interdependence it is also proved that the goals of energy efficiency in social housing is to provide a reliable and achievable possibility or opportunity to improve a long-term viability of affordable housing, generate economic activity, assure health and financial benefits to residents, and reduce GHG emissions [8].

REFERENCES

[1] Eurostat: http://ec.europa.eu/eurostat/statistics-explained/index.php/Consumption_of_energy
[2] The EU climate and Energy package: http://ec.europa.eu/clima/policies/package/index_en.htm.
[3] European Commission, "The Commission's new Energy Efficiency Plan", MEMO/11/149 08/03/2011.Brussels.
[4] K. Scanlon, C. Whitehead, "*Social Housing in Europe II – A review of policies and outcomes*," LSE, London: December 2008, pp. 12.
[5] Portland Energy Conservation, Inc. (PECI), "*Retrocommissioning Handbook for Facility Managers*", Oregon Office of Energy, March 2001, pp. 1.
[6] T. Haasl, K. Heinemeier, "*California Commissioning Guide: Existing Buildings*", California Commissioning Collaborative, 2006, pp. 31.
[7] T. Haasl, K. Heinemeier, "*California Commissioning Guide: New Buildings*", California Commissioning Collaborative, 2006, pp. 2.
[8] Deutsche Bank Americas Foundation – Living Cities, HRA – Analyze, Advise, Act, "*The Benefits of Energy Efficiency in Multifamily Affordable Housing – supporting the health & vitality of affordable housing, building residents & the greater economy*", Deutsche Bank Corporate Social Responsibility, January 2012, pp. 20.