Fighting to protect the climate - Evaluating the experience

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I. Historic background

Since the middle Bronze Age (approx. 1500 BC) Frankfurt's cathedral hill, has been inhabited. The first recorded mention of Frankfurt (Frankonofurd) was in 794 when Charlemagne called a meeting of the realm („Frankfurt Synode"). The royal court of the Franks develops into a palace and then into the residence of the east Franconian along with other sites in Aix-la-Chapelle and Ratisbon. In 1152 Staufer King Frederick Barbarossa is elected as Kaiser and Frankfurt finally is the city of royal elections.

The Römer has been a trademark for the prosperity and political power of the city since the time of the Late Middle Ages. In March 1944, the medieval old town of Frankfurt was demolished. While the Römer and Frankfurt's Dom were completely restored, the number of old traditional buildings was further reduced by disastrous reconstruction work. Whole areas of ruins as well as buildings that still stood were cleared out of downtown Frankfurt. Nowadays the image of Frankfurt is formed by office and high-rise bank buildings.

Figure I-I: Town hall (Römer)

II. Introduction

As one of the founders of "Climate Alliance", a group of municipalities in Europe formed to protect the climate, Frankfurt am Main decided in 1991 to set a global objective of cutting CO_2 by 50% by the year 2010. To organize the process of CO_2 reduction and to develop an energy concept, the "*Energiereferat*" was founded as a local energy agency in 1990.

The „*Energiereferat*" within the Environmental Department is responsible for all private customers (e.g. households, investors and industries), the Energy Section a part of the Building Department of the City of Frankfurt is dealing with energy saving measures in public buildings.

To achieve the ambitious goal on CO2-reduction , four lines of action are being followed:

- systematically developing combined heat and power (CHP) at big power stations and small or medium sized decentralized co-generation units
- designing low-energy homes with a heat consumption of less than 270 MJ/m^2 per year and laying down strict heat standards for the urban area
- saving electricity in housing, offices and industry
- promoting solar power and photovoltaic energy
- establish energy auditing and energy saving measures in public buildings.

III. CHP and decentralized co-generation

District heating from CHP plants is used since several years in Frankfurt, especially in the city-centre. The historical area at the Römer Hill was connected to the district heating network in 1953. The steam-based district heating system in the city-centre provides excellent conditions for heating as well as the use of heat-driven absorption cooling systems for the office and bank buildings. A total of 90,000 kW of absorption-chillers are installed. Therefore Frankfurt has the highest installed absorption-chilling capacity per capita in Germany.

The district heating system in the north of Frankfurt uses the heat from a waste incineration-plant, while the system in the southern part of the city gets its heat from natural gas and oil-fired boilers. In addition gases collected in a near-by waste disposal area are burned in the boilers. The total thermal generating capacity of the three district heating systems is 956 MW, the electric capacity is 391 MW.

In addition to the further extension of the district heating network, decentralized co-generation is one of the most effective measures to improve energy efficiency and to reduce CO_2-emissions. Starting in 1990 the *Energiereferat* has performed systematic studies on potential sites for decentralized co-generation systems. Up till now, more than 90 studies have been prepared. Beside these systematic search for potential co-generation sides the economic boundary conditions improved when the local utility started in 1992 to offer higher rates for electricity from co-generation plants feed back into the grid. At present the local utility and the regional government of Hesse promoting small scale co-generation units (< 30 kWel) by offering grants.

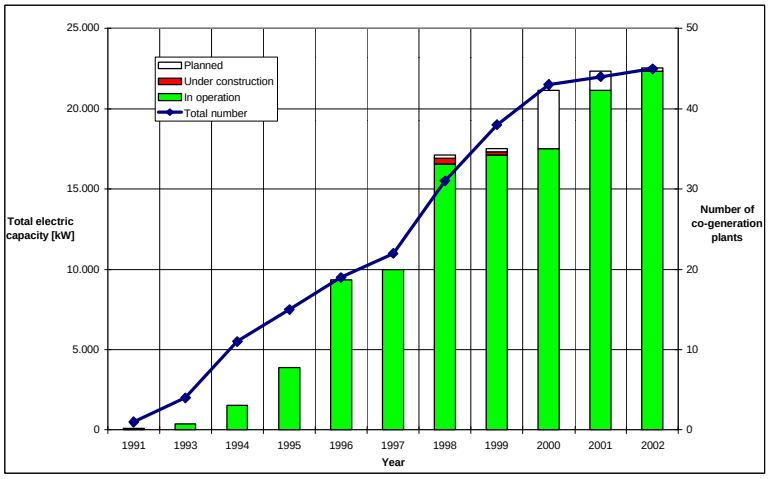


Figure III-I: Development of co-generation capacity

As a result of these combined efforts the co-generation generating capacity in small and medium units increased from 100 kWel (1991) to 17,000 kWel (1998). The 32 co-generation plants with electric capacity ranging from 5 kWel to 4,000 kWel includes units for hospitals, offices, schools, small residential district heating systems and private houses.

In 1998 a fuel-cell co-generation unit will be installed to provid the heat and electricity for a public swimming-pool. This project is subsidised from an energy saving fund provided by the utility (PREAG AG).

Till 2002 the number of co-generation units in Frankfurt will exceed 40 and the goal of the City Council is to reach a total generating capacity of 50,000 kW from decentralized co-generation by the year 2010. The rational use of energy in the co-generation units reduces the CO_2-emissions by almost 60,000 tons per year.

IV. Energy efficiency in public buildings

The energy section within the building department is responsible for all public buildings and continuously monitoring the energy and water consumption of these buildings and an yearly energy report is published. The energy efficiency in the public sector is continuously improved and at present a training program to improve the ability of school caretakers to implement energy saving measures is developed. All department were asked to name energy-agents for their premises. In addition a bonus scheme was introduced to give caretakers and energy-agents an incentive to improve the efficiency of energy usage and to reduce costs.

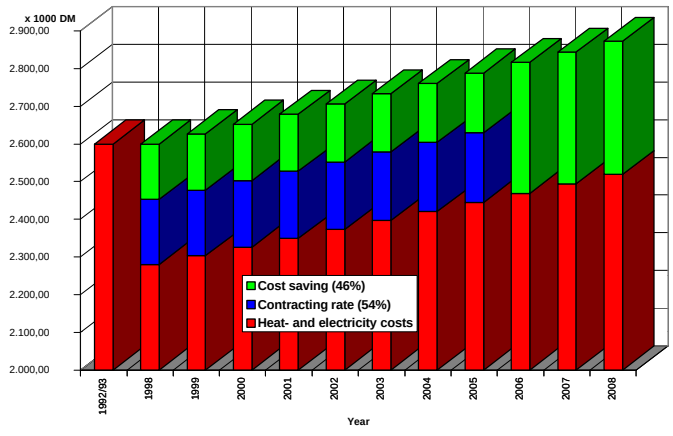
Due to financial restrictions it was necessary to find new way to realize energy saving measures in the public sector. One possibility is the use of external (or internal) contractors. With this way of financing the „Palmengarten“ (Frankfurts botanical garden) was equipped with new boilers and a co-generation plant.

Figure IV-I: Co-generation unit „Palmengarten“

Further samples of contracting projects are the installation of a 200 kWel fuel-cell in a public swimming-pool and the refurbishing of the complete heating system - including pipe-work and hot water storage tank- in a school. The design of the heating system for the school was done in close co-operation with a group of students. As a result of the economic and environmental comparisons performed by the students condensing boilers and co-generation unit are installed instead of standard gas-boilers.

Energy-management-system (EMS) Römer

In 1996 the City of Frankfurt (Building department) entered into a contract with a private company to install and operate an energy-management system for the city hall (Römer), Paulskirche and Museum „Schirn“. The goal of the project is to reduce the costs for energy- and water as well as the CO_2-emissions.



Based on the annual costs of 2.6 Million DM in 1992/1993 the potential cost reductions were estimated to be approximately 320,000 DM per year. To reach these cost savings an investment of 1 Million DM for control equipment was necessary. Repayment of the invested capital will be provided from the energy savings (54%) over a period of 8 years. The remaining 46% will reduce the operating costs for the buildings.

Figure IV-II: Energy management system - Cost saving

V. Improving thermal standards for housing

Figure V-I: One of the first improved energy-housing projects in Frankfurt (Specific heat demand: 300 MJ/m² a)

One of the „Energiereferat's" first initiatives in the 1990s was carried out jointly with the municipal housing department. As part of a project to build 1,500 new homes for people on low incomes, raising the thermal standards led to reductions of 20 to 50% in energy consumption compared to the initial project for an extra cost of 1 to 3%.

However, the Municipality of Frankfurt am Main thinks there is room for further improvement. Accordingly, at the start of major property projects, it offers investors the services of its team of experts free of charge to persuade them to build low-energy buildings.

The „Energiereferat" is mainly involved upstream of the planning permission stage, identifying future projects and developing relations with investors already persuaded of the usefulness of this approach. The agency's role has been backed up by Frankfurt's municipal electricity supply company. The local utility grants sizeable subsidies to households building a home that consumes under 235 MJ/m² per family. Till now more than 3,000 apartments with thermal standards superior to the national law have been constructed.

The results of several projects to date demonstrated that low energy houses with a specific heat demand of 200 MJ/m² a and below can be realized. The „Energiereferat" is continuously monitoring the projects and will soon compile a report on its findings.

Energy (round) table

As a part of an initiative by the German Environment Ministry, the municipality of Frankfurt am Main has called for an „Energy table". Participants include utilities, the chamber of heating fitters (Heizungsinnung), chimney sweepers, house owner and tenants' cooperatives, housing companies, environmental groups and political parties. The main topic was how to launch initiatives to speed up modernisation of old heating boilers. This is one of the fields where a large reduction in CO_2 production can be achieved quickly and easily. As a specific model, different alternatives for the heat supply in an old residential district had be worked out (single boilers - gas or oil, centralized supply with co-generation).

As a result of the „Energy table" high thermal insulation standards (specific heat demand below 235 MJ/m² a) are applied in rehabilitating the apartment blocks. The housing area comprises 450 apartments with a total net surface of approximately 27,000 m² has been heated by coal- are gas-fired ovens. Following the findings of the „Energy table" discussions the rehabilitated flats will be connected to a small scale district-heating system. In the first stage one co-generation unit with 30 kWel will be installed. As soon as all houses are connected a second co-generation unit with 50 kWel will be added.

One of the main findings is that it is vital to organize a discussion between the different parties (house owners and tenants) with the single aim of overcoming the usual obstacles.

VI. Energy efficient office buildings

How to construct a low energy office especially in high rise buildings has become a topical task. A lot of experience in this field has been gathered in a national energy saving campaign in Switzerland during the last 5 years. In the RAVEL "impulse" programme, a special emphasis was placed on electricity efficiency. Heat is often the smallest part of energy consumption in office buildings, with electricity for cooling, ventilation, lighting, pumping media and office equipment such as personal computers, copy machines etc. making up the greater part. Based on the Swiss experience a project was launched in Frankfurt with the aim to improve the energy efficiency in office buildings.

Energy forum for banks and offices

Figure VI-I: Skyline of modern Frankfurt showing Europe's highest office building

Within the climate protection program of the city of Frankfurt great importance has been attached to ensuring that new buildings have a low energy demand. Starting in the year 1992 there have been several plans for new high rise buildings. The Environment Department and the „*Energiereferat*" founded in January 1993 an "Energy forum for banks and offices", starting with an information meeting for investors, architects and planning consultants and the formation of a working group with the persons responsible for four projects.

The aim has been to reduce the resultant additional energy demand. One of the biggest German banks has set up the goal of an energy saving and ecological building as well. It became clear that the main ecological issue in office buildings is the energy demand. In the final outcome, it turned out that the highest office building in Europe has been designed with an energy demand 30% less than in the first planning stage, which is less than 50% of the energy demand of other office buildings constructed in this decade. The following figure shows the effect on energy consumption and cost for different lighting installations. It demonstrates that lower energy demand can be reached with lower investment cost having a immediate pay back.

Objekt	Ground surface *m²*	Intensity of light *lux*	Total installed electric power *kW*	Specific power *W/m²*	Specific power *W/m²*100lux*
COBA	42600	500	639	15	3,0
HELABA	37652	300	527	14	4,6
MESSE	598	350	6,6	11	3,1
FAG	892	500	12,7	14	2,8

(4,6-3,0)*W/m²*100lux* * 3 *100lux* * 37.652 m² = **181 kW**

181 kW * 1200 h/a * 0,3 DM/kWh = **65.160 DM/a**

Figure VI-II: Cost and energy saving due to improved lighting installation

Based on the experience from the „Energy Forum" the *Energiereferat* has designed a list of benchmarks towards energy efficient office buildings. The reference values on specific energy consumption for different usage (lighting, air-conditioning, cooling) can be used to evaluate the energy efficiency of a new or an existing building.

In Frankfurt, these values are handed over to potential investors. With integral planning of new office buildings energy demand can be reduced in a significant way and these methods may be applied to existing buildings as well. Cutting the energy demand and the CO_2 emissions of office buildings, we are on the path towards a new generation of low-energy office buildings.

VII. Summary : Evaluation of the experience

Since the *Energiereferat* started its work, some interesting results have been achieved:

- approximately 3,000 new dwellings have been constructed as low energy houses, with specific heat consumption between 180 and 280 MJ per square meter and year,
- more than 500 appartments in existing housing schemes will be renovated and fitted with improved thermal insulation reducing specific heat consumption by almost 65 %,
- co-generation capacity in small and medium size units has been increased from 100 kWel (1991) to 17,000 kWel (1998),
- the local utility pays 0,07 ECU/kWh for electricity fed into the grid from co-generation and 0,65 ECU/kWh from photovoltaics,
- 160 solar heating systems with a total surface of more than 2,000 m² have been installed,
- CO_2 emissions rose from 7.6 million tonnes in 1987 to 7.85 million tonnes in 1992, falling to 7.3 million tonnes in 1995 (not including traffic).

The energy report 1996 published in summer 1997 provides a detailed analysis of the development of the energy consumption and the emissions according to the different consumption sectors. The report has been made using the GEMIS software.

Apart from the CO_2 reduction by 550 000 t/a from 1991 on, the *Energiereferat* has also gained experience which is not quantifiable:

- The work done by an energy agency is successful if it cares for the management and the co-ordination of activities acting like a kind of "nerve centre" of the whole business. Therefore, one of the main tasks of a local energy agency consists in making actors with different interests co-operate without being itself dominated by one single group.
- The experience has shown as well that due to existing structural obstacles and due to a lack of motivation and training it is often necessary to discuss always again the same basic questions when starting a project. For this reason an energy agency should be based on a long-term activity and a long-lasting existence. Only a continuous engagement for a special project can guarantee its success.
- The activities undertaken by the agency can only be successful if all partners co-operating within a project can benefit at least of some advantages.
- The agency should not begrudge successful actors the success of their activities even if sometimes the agency has contributed to this success in a very decisive way. In this way, positive initiatives will automatically become known by others. Assistance provided by the energy agency will thus become more and more superfluous at least in some fields in the long-term.