

Energy Saving Concept for 1,000 Buildings of the 'Landeshauptstadt München', Germany

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Synopsis

The Capital City of Munich spends more than 40 million Euros (~50 million US\$) annually for the supply of heat, electricity and water to its own buildings. This amount for energy consumption equals a production of carbon dioxide of approximately 110,000 tons per year. Due to the agreement to the „Bündnis zum Erhalt der Erdatmosphäre“ (alliance for the preservation of the earth's atmosphere), the city is obliged to reduce its CO₂-emission by 30 % until 2005 (on the basis of the year 1987). The municipal buildings' CO₂-emissions in conjunction with heating supply has been decreased by 20 % already from 1987 to 2000.

In a project unique of scale till now, 1,000 buildings – corresponding to about 50 % of the entire municipal building stock – have been examined closely and systematically within two years to identify potentials for energy savings.

The measures identified within this project lead to a **CO₂-reduction of 13%**, allows an **annual cost saving of 2.2 million €** and pays for itself within 4.5 years.

About the Authors

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Approach & Methodology

The Capital City of Munich spends more than 40 million Euros (~50 million US\$) annually for the supply of heat, electricity and water to its own buildings. This amount for energy consumption equals a production of carbon dioxide of approximately 110,000 tons per year. Due to the agreement to the „Bündnis zum Erhalt der Erdatmosphäre“ (alliance for the preservation of the earth's atmosphere), the city is obliged to reduce its CO₂-emission by 30 % until 2005 (on the basis of the year 1987). The municipal buildings' CO₂-emissions in conjunction with heating supply has been decreased by 20 % already from 1987 to 2000.

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The whole project has been subdivided methodically into three phases:

- Phase 1 – Energy Benchmarking:
The objective was a preliminary energy evaluation of every single property, based on measured and billed energy consumption.
- Phase 2 – Basic Concept:
The objective was the identification of measures to save heat, electricity, water, costs and emissions by means of on-site inspections and, subsequently, their qualitative description.
- Phase 3 – Detailed Concept:
The objective was the quantitative determination of energy savings and the necessary investments, what then led to a cost-benefit evaluation of every single measure.

Project Execution

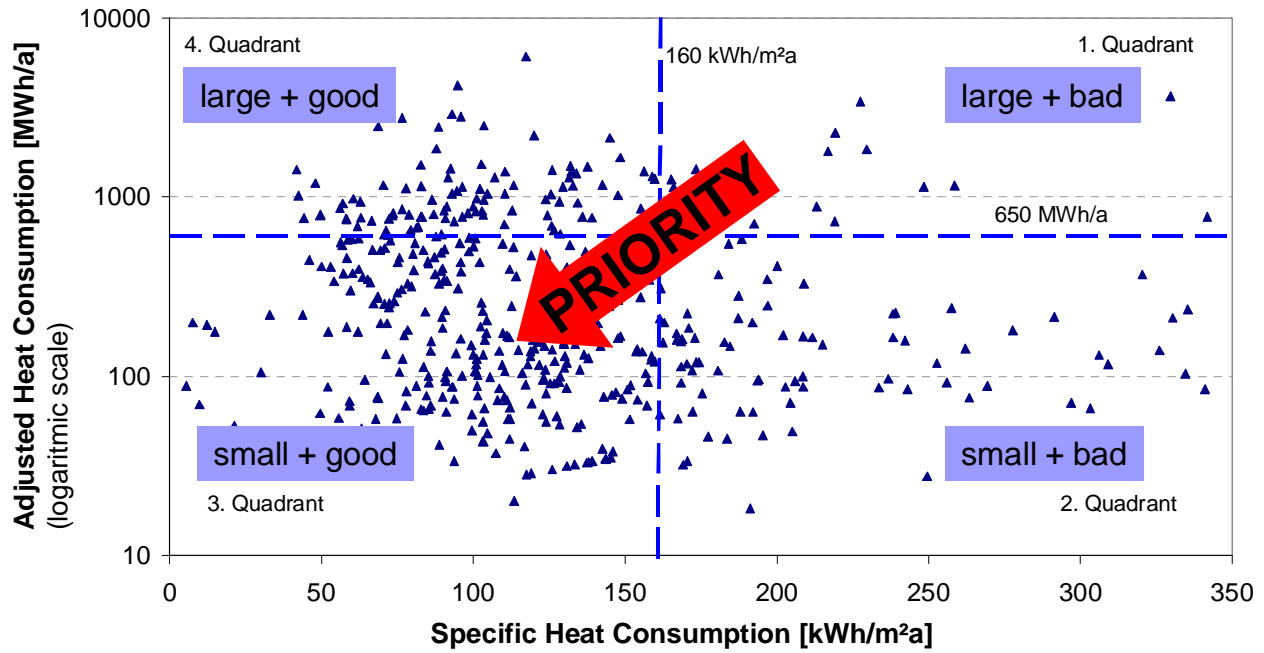
Phase 1 – Energy Benchmarking

In the analyzed buildings more than 50 % of the annual overall costs were spent for heating, more than 30 % for electricity and almost 20 % for water/sewage. Particularly, the building types „schools with indoor pool“ and „grammar schools“ caused about a quarter of the annual overall costs, despite their relative small number of buildings.

In order to compare the collected consumption data with adequate and sufficient external data (external benchmarking), the German guideline VDI 3807-2 /4/, as well as an extensive research report about energy consumption in buildings (ages Ltd.) /3/ was used. The latter contains data of energy and water consumption for more than 11,000 buildings in Germany, compiled from information out of 119 sources with more than 26,000 single values of consumption.

Weather-adjusted specific values for heat consumption were below the nationwide average for the majority of properties and for most types of buildings. This confirms the success of efforts, that have already made by the Capital City of Munich, towards an efficient use of energy in their own real estate /1/.

The precedent energy benchmarking supported purposive and efficient course of action in carrying out the subsequent project phases (see [Figure 1](#)).



[Figure 1](#): Absolute heat consumption [MWh/a] against specific heat consumption [kWh/m²a] for all analyzed properties.

Therefore those properties appearing as a triangle in the first quadrant, referred to as ‘large + bad’, should be examined with the highest priority. These buildings are assumed to reveal not only a high relative saving potential, but also – because of the high actual consumption at the same time – a high absolute saving potential. Less priority needs to be set on smaller and already ‘good’ buildings.

Phase 2 – Basic Concept

Between May 2000 and December 2001 all kinds of technical systems and equipment, building envelopes and utilization have been inspected and recorded on-site, in order to reveal saving potential for heat, electricity, and water. The proposals for measures have then been described and listed, photographically documented, and eventually provided with suggested priorities for realization.

In order to examine as many buildings as possible within a reasonable time and a justifiable effort, and then to implement the proposed measures efficiently, the main emphasis of the examination was put on saving measures showing payback periods of less than 10 years. Still, more than 3,000 single measures have been described.

The main focus was set on measures that require no investments (for example: adaptation of room temperature according to actual demand, correction of operation schedules, (re-)activation of nighttime set-back, adjustment of flow temperatures, examination of response times of ventilation installations, reduction of circulation time, pump operation with reduced power, etc.).

Focus was also set on the investigation of measures that require investment, as long as they pay back within the limit of 10 years. Typical measures here-under are installation/modernization of thermostatic valves, improving lighting fixtures (e.g. motion detectors and brightness sensors, energy-saving bulbs), use of controlled pumps, insulation of fittings and pipes, water saving fixtures, improving fan efficiency, roof insulation, etc.

In addition, further advice was given for upcoming renovation measures that have been discovered during the on-site inspections, but without further specification (e.g. replacement of windows and doors, renovation of roofs, replacement of water heaters, etc.).

The multitude of measures developed for each property has been ordered into a standardized structure from the very beginning of the project. In this process, similar measures that were described for different properties were assigned to common generic terms. Out of this superordinate catalogue a list of measures was created for each examined property, which contained those measures that were expected to ensure to pay for themselves within 10 years. Each measure was assigned to a priority of implementation between 1 and 3 (with 1 being the highest priority). Further-more, measures of renovation due to be dealt with in the long term were indicated briefly.

This methodology of categorizing measures facilitated the evaluation regarding different building types. Furthermore, the previously defined superordinate catalogue guaranteed a common standard for the identification and selection of saving measures. Additional reference to the particular object was given in form of verbal explanations and the photographic documentation, where extraordinary features of certain objects were explained (see Measure 1 – 9). This clear assignment between a proposed measure and the regarding technical or structural component of a particular building is of decisive importance for the subsequent implementation of measures.

The on-site inspections have been carried out by teams of two, usually consisting of an experienced engineer and a graduate student. In order to get the maximum results in a minimum time, repeating work steps have been rationalized as far as possible by the use of previously prepared forms and check lists, suitable technical aid like digital camera, laptop, and voice recorder, as well as the standardized utilization of measuring instruments like thermometer, illuminance sensor, etc.



Measure 1: Insulation of the crawl roof space.



Measure 4: Pump operation on a trial basis with reduced power.



Measure 2: Insulation of the floor slab against ambient air. Comfort problems in relevant rooms.



Measure 7 and 9: Ventilation installation computer room: Switch off ventilation completely if possible, windows are existing. (...) If fresh air operation necessary, stage 1 sufficient. Check ducts: supply air outlet barely perceptible, although air change of 3,600 m³/h is set.



Measure 3: Adjustment of heating times to utilization: Switch off Sa + Su, postpone start of heating-up operation Mo – Fr from 2, 3 and 4 o'clock respectively to approx. 5 to 6 o'clock.



Measure 8: Reduction of flow rate biology from present 2,800 m³/h to necessary personal air change.

Phase 3 – Detailed Concept

Based on the on-site inspections and the results of the energy benchmarking individual analyses for the municipal properties were developed.

The resulting saving potential for the overall pool of 1,000 buildings is displayed in the diagrams of Figure 2 and Figure 3, and summarized in Table 1.

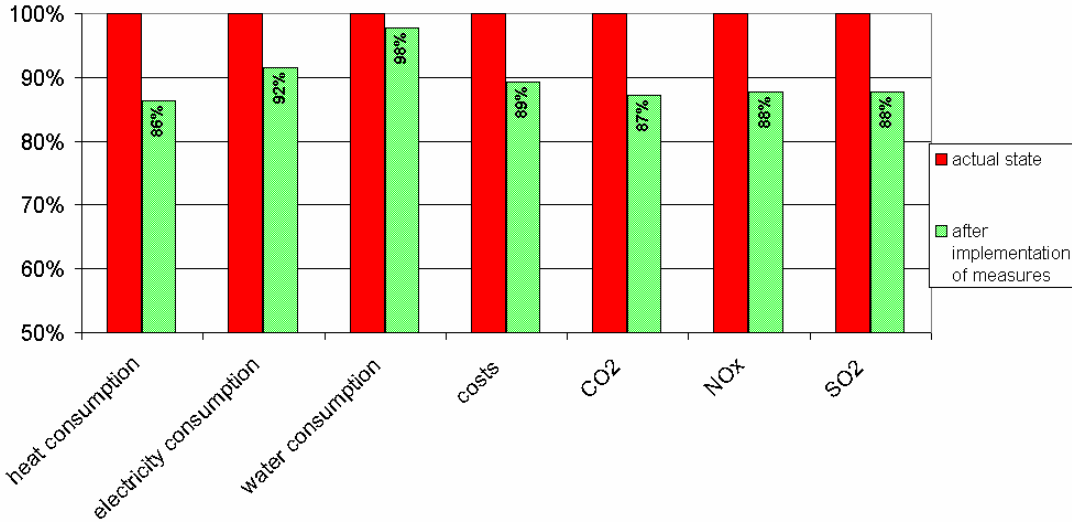


Figure 2: Comparison of actual state and future state after implementation of measures for the whole pool of buildings.

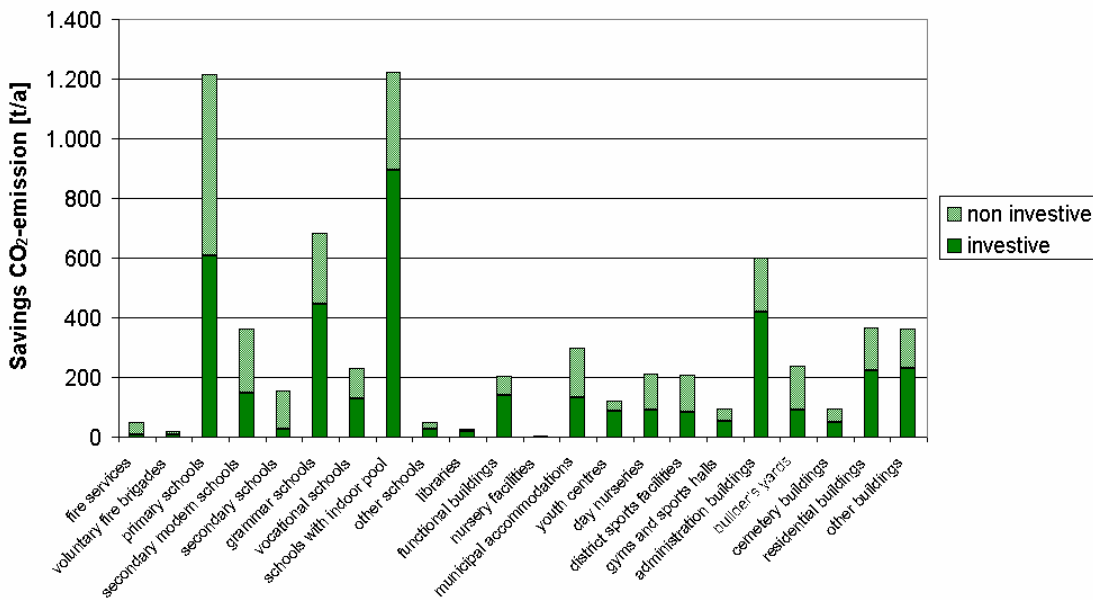


Figure 3: Absolute savings of carbon dioxide (CO₂).

<i>Savings</i>		
Heat	30.370 MWh/a	
Electricity	3.490 MWh/a	
Water	25.200 m ³ /a	
CO ₂ -emissions	6.810 t/a	
NO _x -emissions	5.030 kg/a	
SO ₂ -emissions	2.320 kg/a	
Costs	4,31 Mio. DM/a	2,20 Mio. €/a
of that:		
by non-investment measures	2,10 Mio. DM/a	1,07 Mio. €/a
by investment measures	2,21 Mio. DM/a	1,13 Mio. €/a
necessary <i>investment</i> for that	17,7 Mio. DM	9,0 Mio. €
mean <i>payback period</i> of entire package of measures		4,5 a

Table 1: Absolute savings, investments and mean payback period.

When evaluating these results it has to be taken into account that only economic saving potentials with payback periods less than 10 years were considered for the determination of the overall potential. For the calculation of payback periods, an ‘environmental bonus’ of 60 % was taken into account. With this bonus, the client wanted to consider the economic benefit of energy saving measures that result from the reduction of environmental damage due to combustion of oil, gas and coal /2/. (The proposed measures for the thermal use of solar energy represent a special case. They have always been included regardless of their payback period against the background of the „Solarbeschluss“ (“solar resolution”) of the Capital City of Munich /5/ /6/.)

The saving potential determined and disclosed within this project is not equal to the overall saving potential of all possible and technically and economically reasonable measures. Additional saving potential could be realized considering following:

- Saving measures with payback periods of more than 10 years.
- Extended potentials of combined heat and power (CHP) by expansion of the district heating net-work as well as by deployment of decentralized cogeneration units.
- Coupling of saving measures and renovation measures that have to be carried out anyway for the preservation of the structural substance and the systems engineering, respectively.

A change of fuel sources was not an objective for investigations within this project, as an almost area-wide supply of natural gas or district heating was existing, already. Consequently, measures

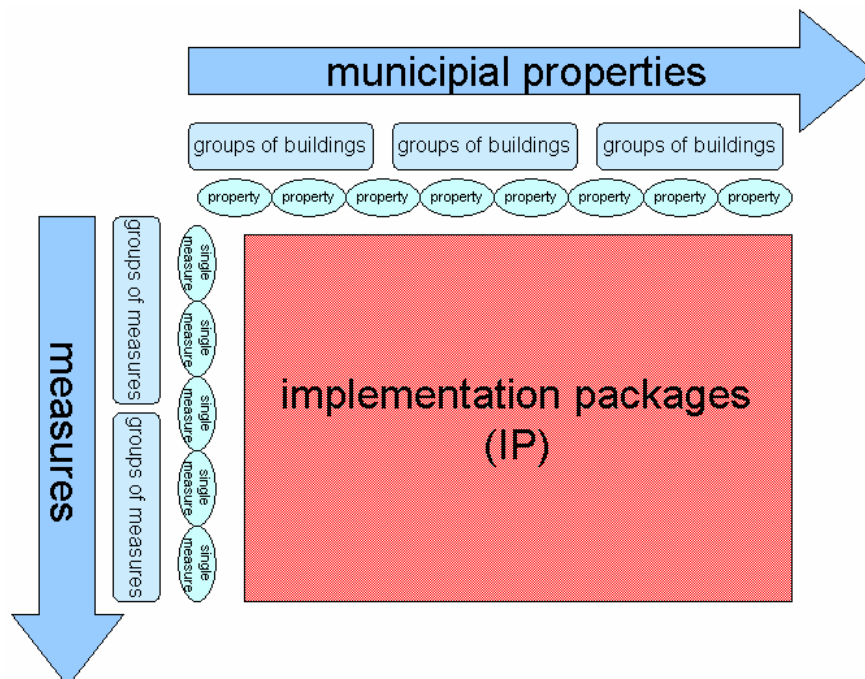
including for example the switch from coal firing to more low-emission and efficient fuel technologies are not to be effective in Munich.

With regard to the contribution to climate protection, specific costs of 89 €/t CO₂ arise for the avoidance of CO₂ referring to capital expenditure (with an approach of 15 years for the average lifespan of the deployed technical components). A broader consideration including achieved cost savings (within the framework of a full cost examination) leads to specific costs of -186 €/t CO₂ for avoided CO₂ emissions. Since the average payback period is much lower than the expected average lifespan of the deployed technical components, the reduction of the CO₂ emissions is facing no medium-term extra costs but actually credit.

Project Implementation

The identified measures are about to be implemented by 2006 under directive of the Capital City of Munich. The energy saving concept led to a strategy of implementation that shows which measures are to be carried out by whom and in which chronological order. The basic idea of the concept of implementation was to bundle the approx. 3,000 proposed saving measures into groups to achieve an efficient and effective procedure for the implementation (see [Figure 4](#)).

In a general overview all saving measures identified in the basic concepts were arranged regarding groups of similar buildings as well as into categories of measures (no investment, low investment, investment). The resulting catalogue of measures can be used for future investigations of existing buildings (see [Figure 5](#)).



[Figure 4](#): Formation of implementation packages subject to groups of properties and measures.

Zustandigkeit: ✓ umsetzen er. realisieren		Kindergärten		Liste von 28 Kindergärten																												
Baujahr	Hochbau	Sanitär	Heizung	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	
Nicht-investive Maßnahmen																																
✓	✓	✓	✓																													
Heizung:																																
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Figure 5: Overview of saving measures (by the example kindergartens).

A remarkable result of this study was the considerable amount of saving potential that can be achieved by non-investment measures, only. This saving potential was pursued with the highest priority and has been realized consistently since fall 2000 by the municipal planning department (“Baureferat”).

Subsequently, the optimization during operation – independent from regular inspection, maintenance and repair – has been taken as a central task of the operation management within the technical facility management /7/ and was performed systematically and continuously by the regular operation personnel or additional specialized staff. This included in particular the adjustment and tuning of the control systems with regard to the actual utilization requirements. The operation optimization of the existing building services installations was then understood as a continuous process of improvement.

The development of property-comprehensive control technology which was already used for consumption measurement, supported the strategy of a continuous improvement process. Herein, the gradual implementation of the basic functions switching and turning was important: Optimization measures can be carried out by specialized engineers from a central computer without any staff on-site.

Concerning the financing of the implementation of the measures internal contracting ('intracting') will obtain special importance. In regard to both, the capital expenditure and the average payback period, the project corresponds to the benchmark data of the intracting-concept of the Capital City of Munich /1/.

The basic idea of internal contracting is to resolve the administration-immanent conflict between user and investor, that reveals when the implementation of saving measures on the one hand and financial use of this measure on the other hand are distributed among different municipal departments. In the case of the Capital City of Munich the intracting-concept intends that the Division of Energy Management of the Municipal Planning Department ("Baureferat") carries out saving measures in municipal buildings and participates in the resulting savings until the refinancing of the investment is completed.

Conclusions

The measures identified within this project lead to a **CO₂-reduction of 13%**, allows an **annual cost saving of 2.2 million €** and pays for itself within 4.5 years.

Furthermore, the project itself met and even surpassed all primary expectations: (1) It made a considerable and very economic contribution to the saving of re-sources and to climate protection in the Capital City's own real estate. (2) At the same time, it credits to the municipal budget of the City of Munich. (3) From the point of view of the users' departments the results of the project supported the aims of administrative reforms and budgeting. (4) The realization of the measures contributed essentially to reach the aim of CO₂-reduction of the Capital City of 30%, effective by 2005. (5) Last but not least, the project paid for itself with the implementation of 'quick-win' measures, only, within less than 10 months.

Also, a general methodology for large scale energy concepts was developed and used successfully in this project. Regardless of the type of building, utilization and persons involved in the project, it is suitable for large pools of buildings and features following bene-fits:

- Quick survey of large stocks of buildings
- Rapid collection and documentation of saving possibilities
- Determination of investments and saving potentials
- Identification of priorities for the implementation of measures

With this project, the Capital City of Munich made an essential contribution to the success of the Agenda 21, having as a motto „Think globally – act locally“.

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