**Author: Dieter Seifried, Dipl.-Ing., Dipl. Volkswirt**

**Titel: Project „ECO-Watt-Project“ Building a Negawatt Power Plant in a School**

**Area „Energy efficiency markets & financing mechanisms (P5)**

**Affiliation: Büro Ö-quadrat**

## Abstract:

There is a remarkable energy-saving potential in public buildings. The author developed a concept for realizing the savings potential and to document that energy-saving and climate-protection measures can be economically profitable. The objective was to build a "negawatt power station" at a Freiburg public school with private capital. An organisation (ECO-Watt GmbH) was created in May 1998 to implement the project. Besides retrofitting the lighting system, efficiency improvements were undertaken for the ventilation and heating system. In addition, two solar plants (solar thermal and solar PV) were also installed. The total investment of the entire project amounted to 250.000 Euro.

To finance the investments, membership in the organisation was offered to interested investors. The ECO-Watt-Company pays interest on the capital according to the reduced energy costs resulting from the project. The capital will have been payed back to the investors after eight years, which is the term for the contract between ECO-Watt and the city of Freiburg. The interest rate will be between 3 and 6 %.

The cost savings for energy and water achieved through the „Negawatt-Plant“ are more than 65.000 Euro per year. Over 350 tonnes of CO2 will be reduced per year through this project.

The educational component of the project ensures that the pupils and teachers of the school are involved in the project and benefit from its financial success. An objective is to inform pupils and teachers about new efficiency technologies and sustainable energy resources and about the necessity to save limited natural resources.

Although the city of Freiburg financially benefits from the project, with a costs saving of approximately 1 million DM – it was very difficult to win the city's cooperation.

## 1. The idea of the project

Climate protection as an interesting investment field! Bringing ecology and economy together! These have been the basic ideas for the development of the ECO-Watt project. In the 90´s, serveral studies of the Oeko-Institute, Wuppertal Institute and other institutions showed, that energy saving measures are more cost-effectiv than buying electricity or gas. On the other hand the successes of the „Foerderverein energy and solar agency Regio Freiburg (FESA)“ as well as the successful wind-projects financed by privat investors devices courage. The FESA built seven large solar plants since 1994 for generation of electricity (Photovoltaik) with a power (load) of approximately 250 kW on Freiburger roofs and financed these investments over shares, which have been sold to 260 interested persons. Thus in principle each citizen could take part in a solar plant. If many citizens are willing to invest in a solar power plant – which under the conditions at that time was not profitable - then there should be people who want to invest their cash for the planned negawatt power station. Finally it was to be expected that such a negawatt power station can be operated profitable and under ecological criteria is to prefer all other technologies of the energy production or energy conversion.

The motivation for this project was situated on the part of the initiators fewer with the creation of a favorable investment, but was derived in particular from the target to open the available saving potentials in public buildings and to document economy of energy saving measures outward. What became for this purpose better are suitable, than a school, in the pupils and the teacher get the application of the efficiency technologies and solar energy to see to be able and descriptive demonstrated? There the Staudinger comprehensive school (to fig. 1 see appendix) for their engaged Lehrerkollegium admits was and with 1.200 pupils

There the Staudinger comprehensive school (to fig. 1 see appendix) for their engaged Lehrerkollegium admits was and with 1.200 pupils as well as energy and water costs at a value of approximately 500,000 DM per year (!) also an interesting size indicated, first the school line was inquired. The head master showed spontaneously interest, particularly since he had already longer detected the necessity for an energetic reorganization. After also the city administration gave its agreement for an investigation after some back and forth, the first step was done. 2. The conversion: First a feasibility concept for the project was created by the idea to the concept with own resources of the non-profit Oeko institute. The feasibility in principle according to the principle of the lying close and Energiesparcontracting could be shown thereby. However resulted a set of unresolved

questions and problems, which had to be solved in the future, as for instance the security of the project in relation to price fluctuations, the selection of the company form or the participation of the school in the energy cost savings. On the basis of an analysis of the energy and water consumption specific saving measures were developed. The current page and the measures within the sanitary area were planned here by the Oeko institute in co-operation with the Freiburger engineer's office SGEU, the analyses on the heat page by the Fraunhofer institute for solar energy systems (Freiburg) were executed. Apart from the reorganization of the lighting, the heating pumps, which became ventilation and heating system also measures the water saving included into the concept. Beyond that the building was designated by two solar plants (a thermal system and a Photovoltaikanlage). Altogether an investment demand was determined by 555.000 DM. At least 115,000 DM at saved energy and water costs faced this investment demand on the income page with a careful calculation.

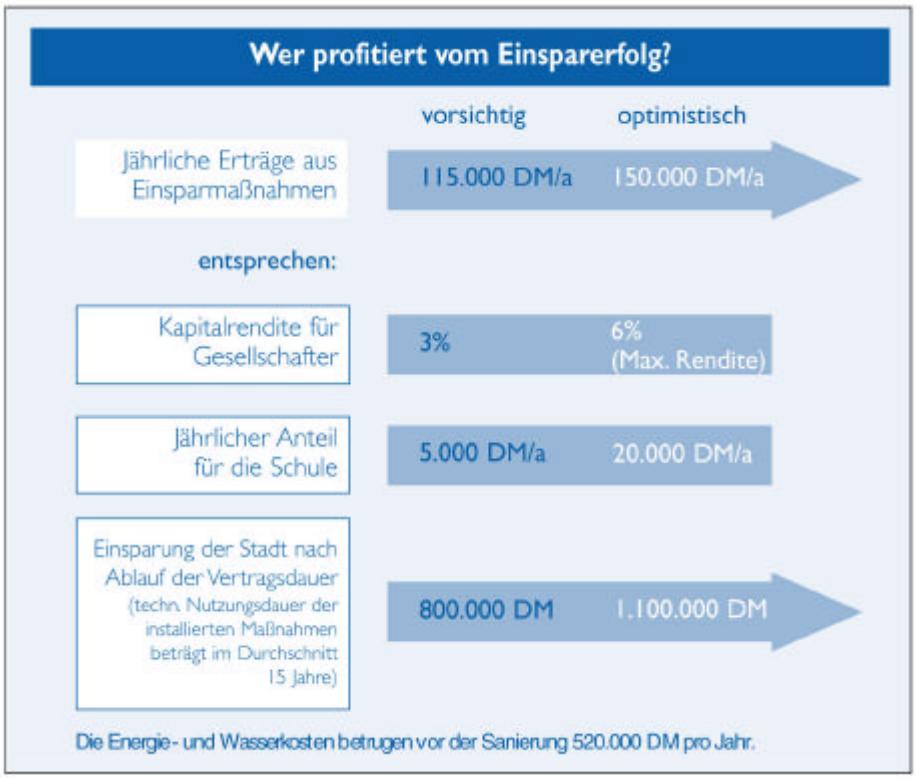
Enough thus, in order to pay interest on the necessary capital and to pay in one period back appropriately. Parallel to planning on the technical level the teachers and the parents adviser were included into the project. Finally it was the target of the project to lower not only by technical measures the energy consumption to interest but also by direct information and internal messages pupils and teachers in the topic climatic protection. Over the expected behavior modification we expected besides a security of technical saving success. Both the conference of total teacher and the parents adviser decided unique for the project and offered support at the time of execution. 3. By the concept for concrete conversion after all aspects seemed sufficiently clarified, became the conversion of the project decided. In addition three coworkers of the Oeko institute and two external persons created their own society, the ECO Watts of GmbH. For the project Staudinger comprehensive school was created a limited partnership, the ECO Watts of GmbH&CoKG, whereby the ECO Watts of GmbH as Komplementaerin with its capital of DM 50,000 adheres. The remaining capital comes from the limited partners, who had to be looked up in the future. In June 1998 the application of the project began. 400,000 DM should be in-recruited at least. The missing remainder should be financed over a credit with the Oeko bank. For application an information brochure was created, which brings up for discussion climatic protection as investment and which project describes. In three meetings the project was presented to parents and teachers at the Staudinger comprehensive school. So that as

much as possible parents and teachers could take part, the totaltotal total for this set on 1.000 became. - DM determined. In order to keep on the other hand the administration effort small, the mindestbeteiligung for external investors amounted to 5,000 DM. The acquisition of the means was made by the FESA and the ECO Watts of GmbH.

The acquisition of the means was made by the FESA and the ECO Watts of GmbH. In November 1998 the Treuhaenderin FESA, which represents the interests of the investors, could close the checkout. The necessary capital had concerned collected, the participation total at 481.000 DM. But the signature of the city Freiburg under the contract was still missing. So all contracts had to be concluded between the ECO Watts and the quiet partners under the reservation that the contract between the city Freiburg comes and the ECO Watts of GmbH&CoKG before year end. Before this background regarded the acquisition phase very successfully ran. The saving contract could be closed in time to the year end with the city Freiburg. Over 8 years the ECO Watt society keeps the energy and water costs saved in relation to the reference consumption of the previous years recompensed and can with it the taken up capital back pay interest on and at the end of the 8 years to the financial sources pay. Now the way was free for the building of the saving power station. Still in February the advertisement of the work was executed, March the work was assigned to at the beginning of to local crafts enterprises. The Osterferien was used in order to renew in large sections of the building the lighting system. In summer holidays 1999 the last investment measures were transferred. Since October 1999 the saving power station runs in favor of the capital investors as well as in favor of the school: dependent on the success of saving the school receives an amount between 5.000 and 20.000 DM for the free order. After the currency of the contract of 8 years savings benefit the city. Over the service life of the technologies the city from this project will obtain a saving of over million DM.

4. The balance of economics and ecology a critical point at the time of the execution of energy saving projects is the allocation?Profits? (the economic advantage of saving measures) between the environment and the financial sources. Only if the most favorable saving measures are executed, then the saved energy quantity is small, the attainable profit however large. If fewer economic measures or even uneconomic measures are constricted into the massnahmenpaket with, then saving and thus the environmental discharge become larger - with net yield sinking at the same time related to the assigned capital. How now in the ECO Watt project was a balance between economics and ecology created? The

minimum interest charges desired of the participation should amount to 3 per cent per year, with a run time of 8 years. Energy cost savings, which go beyond planned minimum saving, lead to a higher net yield for the participation. In this case the additional savings between the school and the financial sources are divided, until for the quiet partners a net yield is achieved of 6 %. Over it going out energy cost savings are used at the Staudinger comprehensive school for further energy saving measures and to come thus directly the environment of benefit. An allocation of saving success is represented in figure 2. Figure 2 allocation of saving success with the ECO Watt project




5. Investments within the lighting area the investments into a new lighting system or for the controlling of the existing system was the largest single item with the investments. In this area approximately 200,000 DM were invested. The measures were enough from the light back-up (with approximately 500 lights) up to the daylight-dependent controlling of the lighting in the gymnasium and in a part of the corridors. The economy of the different measures lay apart thereby far. In figure 3 the lighting situation in a classroom before and

after the reorganization is represented. Fig. 3: Difference between old and new lighting system By substitution of the zweiflammigen prism tub light with conventional fluorescent lamp ballast and without verspiegeltem light soil by a einflammige light with electronic fluorescent lamp ballast and verspiegeltem light soil, the capacity can be reduced by approximately 60 %. The installed three-gang fluorescent lamp provides for a pleasant light and a high luminous efficiency related to the capacity. This form of the light back-up was made in a complete section in all classrooms. In the classrooms of the orientation level due to the higher robustness of the mirror raster light one preferred to the prism tub light. In the teacher rooms as well as in the library however einflammige mirror raster lights with T5-Leuchtstofflampen and electronic fluorescent lamp ballast were used. In the table 1 the economy of different measures is stated. The cost-benefit ratio was determined with consideration of the load effect of the measures. The calculations is the basis a interest on capital of 6 per cent. Further a writing-off for all measures was made over eight years (= contract run time). Planning costs were not considered in the calculation. Measures, the one cost-benefit ratio from over?eins? prove, must be transversesubsidized in the context of the project.

Measures, the one cost-benefit ratio from over?eins? prove, must be transversesubsidized in the context of the project. This applies e.g. to the renewal of the lighting in the classrooms. Due to the relatively short period of use of 650 hours per year, the new lighting makes itself not paid within the eight-year old currency of the contract. However the light back-up in the library already amoritsiert itself after four years. Regarded over the service life of the technology (15 to 20 years), all measures present themselves in the context of the lighting reorganization as economical. The lighting control is particularly interesting in the gymnasium, which makes a control on the one hand regarding the daylight incident, on the other hand among other things is programmed. The morgentliche finery service keeps only one third of the lights de-energised, for the school sport to 300 lux or two thirds of the lighting is used and for matches and certain kinds of sport the entire lighting system de-energised.

Auswahl von realisierten Maßnahmen Beleuchtung ECO-Watt Projekt, Staudinger Gesamtschule
**Kapitalzins 6 %, keine Planungskosten, acht Jahre Vertragsdauer, Preisstand Strombezug 1998**
Alle Angaben in Netto-Preisen

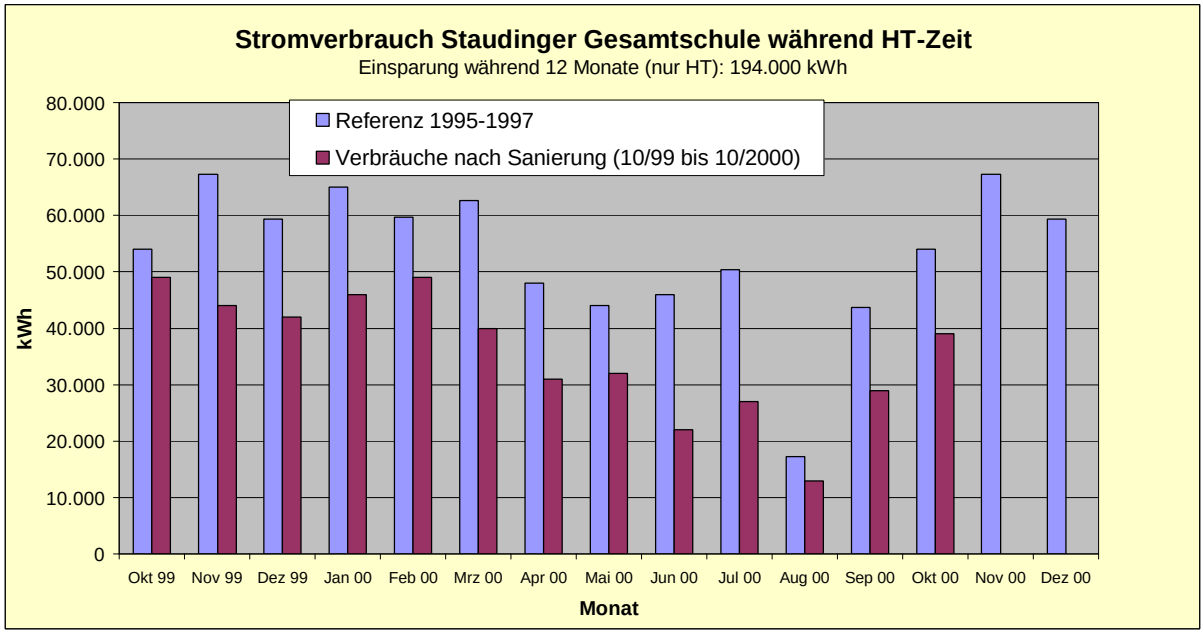
| **Teilbereich** | Maßnahme | Anzahl Leuchten vorher | Anzahl Leuchten nachher | Leistungsaufnahme vorher | Leistungsaufnahme nachher | Benutzungsstunden vorher | Benutzungsstunden nachher | Eingesparte Energie | Leistungsfaktor |
|---|---|---|---|---|---|---|---|---|---|
| | | | | kW | kW | h/a | h/a | kWh/a | |
| Bauabschnitt 2: alle Kassenzimmer | Ersatz zweiflammige Prismenwannen durch einflammige Prismenwannenleuchten mit EVK u. Dreibandenleuchten | 234 | 234 | 33,23 | 12,87 | 650 | 650 | 13.233 | 0 |
| Lehrerzimmer | Ersatz zweiflammige Prismenwannen durch einflammige Spiegelrasterleuchten mit EVK u. Dreibandenleuchten, T5-Technologie | 66 | 66 | 9,37 | 2,31 | 800 | 800 | 5.650 | |
| Sozialräume (Billiard u. Jugendtreff) | Benutzungsabhängige Lichtsteuerung | 26 | 26 | 1,85 | 1,85 | 1.500 | 500 | 1.846 | |
| WC | Leuchtenersatz und Steuerung in 13 WCs | 32 | 32 | 4,54 | 1,76 | 2.400 | 200 | 10.554 | |
| Flur Keller | Präsenzschalter für Flur | 7 | 7 | 0,50 | 0,50 | 2.400 | 100 | 1.143 | |
| Bibliothek BA 3 | Ersatz Glühlampen Strahler durch Leuchtstofflampen | 18 | 18 | 1,80 | 0,27 | 500 | 500 | 765 | |
| Bibliothek BA 3 | Ersatz zweiflammige Prismenwannen durch einflammige Spiegelrasterleuchten mit EVK u. Dreibandenleuchten | 88 | 88 | 12,50 | 3,08 | 1.200 | 1.200 | 11.299 | |
| Turnhalle groß | Beleuchtungssteuerung in Abhängigkeit von Anwesenheit und tageslichtabhängig; Training/Wettkampfschaltung | | | 21,00 | 21,00 | 2.500 | 1.700 | 16.800 | |
| **Summe Innenbeleuchtung** | **Auswahl von Maßnahmen** | | | **84,8** | **43,6** | | | **61.289,2** | |

Tabelle1: Wirtschaftlichkeit verschiedener Maßnahmen bei der Beleuchtungssanierung

6. Energy conservation and regenerativ energy sources combine a lasting energy system must the available potentials of the rational energy use consistently open and the residual energy requirement to a large extent with regenerativ energy sources cover. From these considerations the saving measures were completed by the building of a thermal solar plant with a collector surface by 42 square meters. This covers the major part of the warm water heat requirement of the two gymnasia. Beyond that the building of a 2-kW solar plant was planned, which should be financed at least partly over conveyances and sponsor funds. Since these systems do not amortize within the currency of the contract of 8 years, concluded with the city Freiburg, these systems must be carried over energy cost savings with. The past results suggest that due to obtained savings, the proportion of the regenerativ power supply can be increased in the next years still clearly. Instead of the planned installation of a solar power station with 2 KW of performance already 4 KW were installed. Further plans are situated in the drawer.

7. The saving power station gets new generation: Energy foxes executed trained parallel to the investments a pupil/teacher working group in co-operation with the managing director of the ECO Watts of GmbH extensive school activities for the clearing-up of the pupils, teachers and parents. Project days and project weeks were executed to energy-specific topics and are brought up for discussion ever more frequently aspects of the climatic protection in connection with the energy use in instruction. In the meantime it is usual at the school that the pupils of the central level introduce and describe the again arriving pupils of the fifth class to the connections of the ECO Watt project, how the pupils can contribute through correct air and pressing of the light switch to the energy conservation. So that the energy-conscious behavior in all classes remembers, at the Staudinger comprehensive school saving competitions are executed, in which all classes can take part. After the saving power station had successfully started, did the formation of?Energiefuechsen become in co-operation with a teacher? begun. The pupils 6. Class (orientation level) it is trained in such a way that they could make and open independently at home saving potentials. The result could be able to be seen: Almost all energy foxes sought out saving possibilities in the own building. Many pupils discovered into their at home secret Stromfresser with television, printer, video device and halogenleuchten. The status by losses can be avoided mostly by adjustable plug sockets easily. Also with the lighting the pupils found frequently to modification requirement. In many households lamps are used still predominantly. For the termination of the energy fox formation was an attendance of the solar factory in Freiburg on the program (figure 4, see appendix).

With the guidance by the production plant the pupils appeared highly motivated and interest. School can make fun and obtain knowledge fuerx27s life! 8. After the first operational year after one year actual working time of the saving power station a first reliable trial balance can the results be drawn: The saving power station functions and throws off for environment and investor a pleasing yield. Within the first yearly over 200.000 kwh current were saved (see fig.5). Planned minimum saving was calculated in the planning phase with 130.000 kwh per year.




Die maximale Bezugsleistung von den Stadtwerken konnte um über 100 Kilowatt reduziert werden. Dieses gute Ergebnis konnte zum einen durch die Effizienzsteigerung bei der Beleuchtung sowie durch die Installation und Optimierung der neuen Lastmanagementanlage erzielt werden.

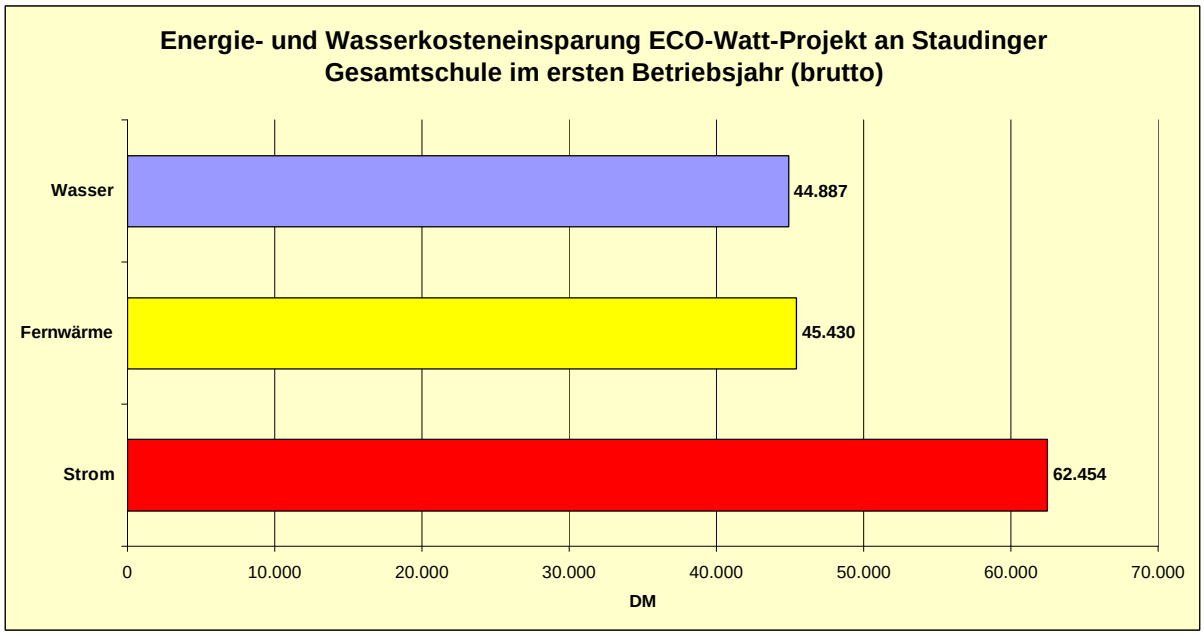
Auch im Wasserbereich liegt der Einsparerfolg deutlich über den Planungen. Rund 8,5 Mio. Liter Wasser werden durch die investiven Maßnahmen pro Jahr eingespart, das entspricht einer Einsparung von knapp 70 Prozent gegenüber dem Verbrauch in den vergangenen Jahren.

Die **Wärmeeinsparung** betrug gegenüber dem Vorjahr rund 600 MWh und entsprach somit einer Verbrauchsreduktion von 24 Prozent (gradtagzahlbereinigt). Damit konnte der Planwert (30 Prozent) nicht ganz erreicht werden.

Gegenüber dem Referenzjahr konnten im ersten Vertragsjahr insgesamt knapp 80.000 Euro brutto (incl. MWSt) eingespart werden (Abbildung 6). Die Kapitalgeber können demnach mit einer Verzinsung ihres eingesetzten Kapitals von 5 Prozent rechnen. Die Schule wird mit über 7.500 Euro pro Jahr am Einsparerfolg beteiligt werden.

Neben den direkten Emissionsminderungen durch den verminderten Verbrauch von fossilen Energiequellen (rund 350 Tonnen $CO_2$ pro Jahr) sind mit dem Projekt weitere

Umweltwirkungen verbunden. So konnte z.B. durch den Einsatz effizienter Leuchten und Leuchtmittel der Quecksilbereinsatz in den Leuchtmitteln um über 90 Prozent reduziert werden. Darüber hinaus werden die Hausmeister beim Austausch defekter Leuchtstofflampen entlastet: Aufgrund der geringeren Anzahl von Lampen und der längeren Lebensdauer entfallen mehr als drei Viertel der bisherigen Auswechslungen.




The max. reference performance of public utilities could be reduced over over 100 kilowatts. This good result could be obtained on the one hand by the efficiency increase with the lighting as well as by the installation and optimization of the new load management system. Also within the water area saving success is situated clearly over planning. Approximately 8.5 millions litre water are saved by the capital measures per year, correspond to a saving of scarcely 70 per cent in relation to consumption in the passed years. Heat saving amounted to in relation to the previous year approximately 600 MWh and corresponded thus to a consumption reduction of 24 per cent (degree day-number-settles). Thus the budget value (30 per cent) could be achieved not completely. In relation to the basis year altogether scarcely 80,000 euro could be saved gross (inclusive MWSt) in the first contract year (figure 6). The financial sources can therefore count on interest charges of their assigned capital of 5 per cent. The school will also be taken part over 7.500 euro per year in saving success. Apart from the direct emission reductions by the reduced consumption of fossil energy sources (approximately 350 tons of CO2 per year) further environmental

effects are connected with the project. So the mercury application in the lighting up means could be reduced over over 90 per cent e.g. by the application of efficient lights and lighting up means. Beyond that the caretakers are relieved with the exchange of defective fluorescent lamps: Due to the smaller number of lamps and the longer life span more than three quarters of the past changing are omitted.

Obtained savings must be bought in no case with a renunciation of comfort. The opposite is the case: Pupils and teachers come into the benefit of a higher lighting comfort. Flickering the fluorescent lamps belongs to the past with the installation of electronic fluorescent lamp ballasts just like humming (with defective conventional fluorescent lamp ballasts). 9. The indirect effects of the project the effect of the project is not limited to the direct energy conservation. Over communication of the project and the results it is shown that climatic protection is not connected with high costs and missing. Rather one can finance with measures for energy efficiency increase on the one hand investments into the solar technique with and on the other hand still another yield on the assigned capital obtain. So are to be given to the city over this project Freiburg as well as other municipalities and participants an impact for imitation. The investment volume for the ECO Watt project amounts to over half million DM round half of the investment total is allotted to wages for the installation of the efficiency technologies, the other half on the purchase of the efficiency and solar technique. Since Freiburg over no relevant branches of industry orders (exception: Production of the Photovoltaik modules) affects itself this demand impulse approximately to the half in the region Freiburg and to the other half country widely. If one projects the investment volume in the context of this project over the energy consumption of the Staudinger comprehensive school on all public buildings of the city Freiburg, then alone Freiburg an investment total of over 12 million DM for the city, which could flow into economic efficiency technologies, is calculated. Such an amount of investment would cause for the city a long-term reduction of costs and for the region Freiburg a lasting impulse for ecological and socialcompatible technologies would mean.

Approximately 50 million DM of energy cost saving within the next 20 years would face the investments. Finally such projects have an important function also for the handicraft. The operations make practical experiences with modern efficiency and control technologies. Thus again a modification of the consultation and the supply of these operations is

connected opposite their future customers. These direct and indirect effects lead to the fact that current and oil imported goods from other regions and countries are replaced by innovative technologies and worker. This leads to additional occupation as well as to a stabilization of the purchasing power and the regional economic circulations. 10. The advancement of the beginning the ECO Watt project is from its structure a Energiespar Contracting project with a special financing form, the citizens' participation. Like many other Energiespar Contracting project this project in its planning phase encountered substantial resistance in the administration and in the policy. While it gives course in the industry and is that individual branches of production or services?outgesourct? become, the public hand does heavily to be able to be saved other more?fuer?. Many doubts and arguments are brought out, a Energiespar Contracting lets which appear unattractive or impossible. The Land of the Federal Republic north Rhine Westphalia started at the beginning of the yearly a new initiative and over the national initiative future energies a trend-setting project on the way brought. Under the title?100.000 Watt solar initiative NRW? are modern energy savings techniques and solar energy to be used, in order to make schools futurable.

What is behind the program title? At as much as possible larger schools in NRW a solar plant (Photovoltaik) with an output is to be installed of 50 Watts per pupil. Further at least 50 Watts of performance saving are to be implemented over a more efficient lighting and other saving measures per pupil. For this the existing lighting of the schools in large sections is to be replaced. Thus a current saving of over 60 per cent can be obtained within the lighting area. By the combination of the use of the solar radiation with the economic measures of the energy conservation, a reorganization and an investment model economical in itself can be obtained under utilization of the existing Foerderbedingungen for the regenerativ energy sources. As pilot project the Aggertal High School in angel churches was selected. For the school with approximately 800 pupils of Wuppertal institute the following concept was compiled: A Photovoltaikanlage on the roof of the main building is to produce electric current. The performance of the system will be with approximately 45 KW. From this an annual current production of 34.000 kwh leads itself off? The lighting system in the classrooms, the corridors, the gymnasium as well as the aula are to be modernized. The performance can be reduced by more efficient lights, electronic fluorescent lamp ballasts and daylight-dependent lighting control by approximately 50 KW. Annual current saving is calculated with 40.000 kwh? A gas-claimant blockheizkraftwerk will produce current and warmth for the school at the same time. This small power station will possess a performance of approximately 60 KW. The building and the financing of the

blockheizkraftwerkes are taken over by the current supply Aggertal. The current supply Aggertal supplies the current from the BHKW to the school or the city on the same conditions as so far. Likewise is the warmth produced in the BHKW evaluated at the same prices as the gas referred so far?

Further smaller measures to current -, warming and water saving are to reduce consumption of the school additionally. Altogether the current reference by the saving measures and the solar generation of current will reduce from so far 120,00 kwh to approximately 40,000 kwh. With the pilot study the entire planning, handling and implementation of the project from Wuppertal institute in co-operation with the current supply Aggertal are carried and co-ordinated with the project partners involved as well as the municipality angel churches. In the context of the pilot study all bases are to be compiled, which will enable it, the project to other schools to transfer. Internet addresses to the topic:

www.eco-watt.de

www.uba.de

www.oe2.de

Anlage

Abb.1.: Staudinger Gesamtschule

Abb.4: Energiefüchse beim Besuch der Solarfabrik