USING INNOVATIVE PROCUREMENT MECHANISMS TO HELP COMMERCIALIZE NEW ENERGY-EFFICIENT LIGHTING AND VENTILATION PRODUCTS

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Abstract

Technology procurement is a useful process to develop and commercialize new technology. By definition, its purpose is to meet very specific and sometimes unique user requirements when no off-the-shelf solution to a problem is available on the market. Generally, a technology procurement process is based on active cooperation between one customer and one or more industrial contractors. Such processes, thus far, have predominantly been used as a means of satisfying specific needs in the defense, transportation, housing, power generation and heavy industry sectors.

When technology procurement is applied to diversified markets with many customers, it can be almost impossible to produce one single specification which all parties will accept. In a program for more efficient use of electricity, the Swedish National Board for Industrial and Technology Development has therefore introduced a number of innovative technology procurement processes.

The purpose of this paper is to demonstrate how innovative technology procurement has been applied to stimulate the efficient use of electricity in public and commercial buildings. Agreements have been signed with participants who control some 35 million square meters or almost 30 % of the total floor area of such buildings. The agreements specify program objectives and a bonus system. Within this given framework individual participants are responsible for priorities and detailed specifications. As a result of this, the participants purchase more energy-efficient lighting and ventilation products.

New efficiency standards--10 W/sq.m. for lighting and 1 kW/cu.m./sec. electric power for ventilation fans--have been introduced. 10 W/sq.m. for lighting is quite appropriate and possible to achieve. Without standards, this figure can be anything from 10 to 60 W/sq.m. in existing buildings, and 15-30 W/sq.m. in retrofit and in new construction. The new standard--1 kW/cu.m./sec.--for ventilation is rather extreme. Project results indicate that it is possible to achieve a level below 1.5 kW/cu.m./sec. Today we see values ranging from 0.5 to 10 kW/cu.m./sec. in existing buildings and from 2.5 to 4 kW/cu.m./sec. in retrofit and in new construction.

Several projects have been initiated, and some ten have been completed, according to the rules of the agreements. In new construction and retrofit of existing buildings, reductions in electricity use and power demand for lighting and ventilation are substantial, ranging from 40 to 70 percent.

In support of the agreements, certain components, such as HF electronic ballasts, refrigerator-freezers, windows, heat pumps etc, will be procured based on collective specifications. These components will be commercialized within said agreements, since a centralized procurement must not be allowed to disturb ordinary market relationships.

INTRODUCTION

The Swedish National Board for Industrial and Technology Development (NUTEK) is responsible for the implementation of a technology procurement program for the efficient use of electric energy. This program was initiated three years ago in close cooperation between NUTEK and the Swedish Council for Building Research (BFR).

The main objectives of the program are to stimulate the development of energy-efficient products, systems and processes, to demonstrate their function and to commercialize the results in residential and commercial buildings and in industry. If more efficient technology and methods are introduced on the market the result

will be better use of energy in the future. Thus far, the efficient use of electricity has been emphazised. Recently the scope of the program has been broadened to include all forms of energy, but still with a focus on electricity.

The purpose of this paper is to demonstrate how innovative technology procurement has been applied to stimulate the efficient use of electricity in public and commercial buildings. Somewhat modified the same method will be used for the development and commercialization of energy-efficient industrial processes.

Earlier energy conservation measures in Swedish public and commercial buildings have been very successful. But the goals for conservation of heating oil have been achieved by the successive introduction of new technologies that demand more and more electricity for their operation.

Early results from R&D projects sponsored by BFR suggest that the use of electricity has increased sharply in the building sector. Between 1975 and 1989 energy used for the heating of different kinds of premises as a mean for the total stock fell from almost 300 kWh/sq.m./yr to below 200 kWh/sq.m./yr. During the same period the use of electricity increased from 55 kWh/sq.m./yr to 100 kWh/sq.m./yr. When researchers study office buildings only they find that in the beginning of the 1970s the use of heat for a new building was around 200 kWh/sq.m./yr, while the electric energy use was some 50 kWh/sq.m./yr. New office building of the '90s use much less heat--around 50 kWh/sq.m./yr--while the electric energy use has increased to about 100 kWh/sq.m./yr. (Abel). We know many of the reasons for this, and we consider it important that the issue be addressed.

For instance the Swedish building code is very stringent when it comes to the heating of buildings. The use of electric heating has not been permitted unless the buildings are extremely energy-efficient and the systems flexible enough to allow for the substitution of electricity by other energy sources if need be. Today the code for extremely efficient buildings--the ELAK code--applies for all new buildings. The code regulates heating energy, not the use of electricity for other purposes. In fact there have not been any regulations or efficiency standards for other systems using electricity for their operation, such as lighting, ventilation and cooling systems.

Also, there has not been any need for new base-load power generation capacity for many years now. Inexpensive electricity has been in abundant supply. So conservation of electricity has not been encouraged at all. When there is a lot of cheap electricity around--and there are no standards for efficiency--many customers just purchase the cheapest equipment on the market without considering the future costs of operation. Even skilled professionals install inefficient equipment to cut investment costs.

When no one asks for efficient equipment, installations or buildings, manufacturers and builders have no incentives to introduce better solutions. The result is a continously rising demand for electricity. When the need for new power generation capacity occurs sometimes in the future, the price will be high. Even when the market signals become clear it will take long time to introduce new efficient technology, and the building stock will take ages to renew. In the meantime, the technology procurement program is a means of stimulating the market to develop and install more efficient equipment.

TECHNOLOGY PROCUREMENT

Technology procurement is a useful process to develop and commercialize new technology. By definition, its purpose is to meet very specific and sometimes unique user requirements when no off-the-shelf solution to a problem is available on the market. Generally a technology procurement process is based on active collaboration between one customer and one or more industrial contractors. Such processes, thus far, have predominantly been used as a means of satisfying specific needs in the defense, transportation, housing, power generation and heavy industry sectors.

Research and development of methods, products, systems and processes are often made key elements of technology procurement. The purchasing party--the customer--presents a specification based on their own needs. Thus, the technology procurement process becomes a way of producing new custom-made products, based on a market pull rather than a techology push strategy.

The development process, together with the delivery and evaluation of the first production run is normally based on a contractual relation between the customer and the contractor. Before delivery of the main production run it is usual that necessary modifications are made. With a successful result the contractor has both a good product and a satisfied customer to rely on when it is time for introduction on a broader market.

When technology procurement is applied to diversified markets with many customers, it is almost impossible to produce one single specification which all parties will accept. In the program for more efficient use of electricity, NUTEK has therefore introduced some innovative technology procurement processes.

INNOVATIVE PROCUREMENT

The technology procurement program differs a lot from earlier energy conservation programs. Before, almost any product or system resulting in energy--or rather oil--conservation, was entitled to some sort of general subsidy. Oil was expensive and had a very negative influence on the trade balance. Something had to be done quickly to curb consumption. In many cases oil was substituted by electricity.

Now we have quite another situation. Electricity will probably continue to be relatively inexpensive for many years to come. And if we want to reduce electricity consumption quickly, we should work on the end-users' attitudes. But there is no urgency. Prices are relatively low and supplies are plentiful.

Today it is more important to establish new design standards and to develop and commercialize more efficient technology adapted to the customers' needs. The most capable customers must lead the way and work in close cooperation with the contracting parties. In any case, it will take a long time to replace the installations of all existing buildings.

It is equally important not to overstimulate the market. Too much subsidy will encourage the participants to ask for equipment that will not be economically viable even with higher electricity prices in the future. No industrial contractor likes to develop products which have no market, when market stimulation disappears. Thus, we have to selectively find incentive levels reflecting the most probable price of electricity at the time when the results will be introduced on the general market. The problem we faced at the start of the program was: How can we get all this into terms that can be understood?

To begin with we invited some of the largest real estate management companies--together with some of the most prominent energy technology and systems experts--to discuss what can be done to achieve more efficient use of electricity in buildings. This included heating, cooling, ventilation, lighting and control systems, with emphasis on better indoor climate and working environment. Equally important was the question of adequate incentives.

As a result of this, we offered some of the largest real estate companies--who had been successful in earlier energy conservation efforts--to sign an agreement to participate in the technology procurement program. Those who were most active--and within their organizations had the quickest response to arrange for financing of their own portion of the costs--won the agreements. From earlier energy conservation programs we know that it is the enthusiasts who make results.

The Participants

Up till now agreements have been signed with 13 of the largest real estate management companies and owners of public and commercial buildings. Together they control some 35 million square meters or almost 30 % of the total floor area of such buildings. They represent various kinds of typical Swedish real estate administrations, and they have in their stock all kinds of both residential and non-residential buildings. The categories which follow were included in the agreements:

(i) National Swedish Board of Public Building (KBS)--with its six regional administrations--has the responsibility for all state owned public buildings with a total area of more than 20 million sq.m. Typical examples are buildings for the different government administrations, the universities, the police force and so on.

(ii) Real estate management companies or administrations of four county governments, i.e. Skaraborg, Stockholm, Sörmland and Östergötland. They are responsible for all the buildings for medical services in their region, mainly hospitals and medicare centers.

(iii) Real estate management companies or administrations of four cities, i.e. Göteborg, Kalmar, Malmö and Stockholm, with responsibility for schools, day-care centers, etc. Since 1991 they have also been responsible for the buildings needed for the care of elderly people.

(iv) Real estate management companies of Sweden's four largest insurance companies. They hold a large stock of commercial buildings rented by other businesses for various purposes, including offices, shops and department stores.

We will also discuss similar agreements with some of the largest building construction contractors. They are equally important participants since they have very large in-house building management companies. They show interest in entering into agreements, but appear to prefer to wait for an upturn in building construction activity. Today many of their best projects are at a stand-still.

The Agreements

The main idea behind the agreements is that these very capable participants be given a framework of overall rules and monetary incentives. The rules set new minimum standards for energy-efficiency, which for the first time in Sweden include the use of electricity for other purposes than heating. The monetary support is in fact a budget additional to their own, which gives them incentives to procure somewhat more efficient products and systems than is motivated by their normal design specifications and economic criteria.

The work with the agreements in question has been guided by four principles:

(a) to encourage the establishment of new design and technology standards for the efficient use of electricity in non-residential buildings

(b) to introduce the comparison of different equipment on a life-cycle cost basis

(c) to encourage large customers to be innovative and to communicate market needs to manufacturers and contractors

(d) to moderately stimulate the participants to purchase more efficient equipment by offering them financial incentives

The agreements allow for individual participants to take the initiative. In this respect we did not give any detailed instructions on how to perform the task. They were able to choose totally on their own, between using the extra budget on new construction or for retrofitting of existing buildings. Each separate project can be small or large. The latter is very important since these kind of actors continously restore and change their buildings for different reasons. Our intention is that they always be alert on any upcoming possibilities to procure and install more energy-efficient equipment. By having so many different participants work according to their own plans and basic strategy, we have reason to believe the market will be diversified, and that they will use the incentives wisely.

Except for the standard preamble and formalities, the following clauses of the agreements are most notable since they govern the participants work:

(1) participants will procure electricity saving technologies in new construction and in retrofit of existing buildings alike

(2) participants will receive an investment bonus of SEK 1.50 for every kWh of electricity per year saved compared to conventional design, up to a ceiling of totally SEK 2.5 million. This incentive stimulates reductions in both power demand and in hours of operation.

(3) participants will try to meet the minimum efficiency standard of 10 W/sq.m. in new or retrofit lighting design

(4) participants will try to meet the minimum efficiency standard of 1 kW/cu.m./sec. for the operation of fans and auxiliaries in new or retrofit ventilation design

(5) if participants are successful and implement the new standards as recommendations throughout their whole organization, the ceiling can be lifted to twice as much, or SEK 5 million

(6) participants are requested to analyze and compare the discounted life-cycle cost of conventional design with those of energy-efficient designs for lighting and ventilation systems, as well as other appliancies, installations and equipment

(7) participants must form a project team and select a project manager

(8) the local distributor must be invited to participate in the project team

(9) measurements and verification of project results will be made

As the clauses above suggest, we make no distinction between design and equipment incentives. We pay bonus for less electric energy used without regard for how the participants accomplish these savings. The only requirement is that they satisfy the minimum efficiency standards. In this way, we stimulate the market for technology affecting both the power demand and the use of electicity in buildings. However, we do not stimulate reductions in either peak or reactive load, because that is mainly a concern for the distributors and their customers. We deliberately place the lighting standard first, because over-lighting creates numerous problems at modern VDU workplaces. It creates among other things over-heating of offices and related problems. Thus, the ventilation systems must be over-sized to take away excess heat. The result is larger electric loads for fans which in turn heats the air even more.

The new minimum efficiency standards have been set after consultations with researchers, designers and manufacturers. We strongly believe the new lighting standard--10 W/sq.m.--is quite appropriate. It is well known that in existing buildings this figure can be anything from 10 to 60 W/sq.m. KBS and some other public building administrations have for years had a minimum efficiency design standard of some 15 W/sq.m. No doubt, 10 W/sq.m. is now feasible with the introduction of new advanced technology and design.

There is a strong need for research on how changes in lighting levels will affect people. In support of the technology procurement program, BFR has therefore initiated a lighting research program. The main objectives of this research program are to give better knowledge and education in lighting-related problems.

Regarding ventilation systems, the new standard--1 kW/cu.m./sec.--is rather extrem. Several authorities have suggested that this efficiency level might rather be 1.5 W/cu.m./sec. For example, ASHRAE recommendations suggest 1.7 kW/cu.m./sec. for constant air flow systems (CAV), and 2.6 kW/cu.m./sec. for variable air flow systems (VAV). But project results indicate that it is possible to achieve a level below 1.5 kW/cu.m./sec., independent of system selection. We therefore have not adjusted the standard yet, but in practice we agree to pay a bonus even up to the higher level--1.5 kW/cu.m./sec. Today we see values ranging from 0.5 to 10 kW/cu.m./sec. in existing buildings. There is no reason for such variations. Our objective is to identify a realistic minimum standard.

Implementation

We have experienced two major obstacles to implementation of the agreements. First, even with the help of monetary incentives, with the current prices of electricity, it is hard for the owners of buildings to justify more costly measures to conserve electricity. Last winter the former government--backed by the Liberal and Center Parties--proposed a long-awaited Swedish Energy Strategy built mainly around the status quo. Nuclear energy will continue to supply cheap electricity until the conclusion of the phase out in 2010 and as a result the power companies once again offer off-peak electricity at low prices. Nothing is wrong with that, under given circumstances, but the signals clearly effect the motivation to conserve energy. We hope our participants will not loose faith, but will instead continue to lead the way. It is possible that the additional funding of the technology program and the proposed new demonstration program for energy-efficiency will stimulate them. But it will certainly require more intervention by the government to stimulate ordinary people to conserve energy. We cannot rely entirely on market solutions.

To make matters worse, the agreements were signed just at the start of a downturn in the economy. The real estate bust--which followed--has led to a much weaker demand in the building industry as a whole. Several planned projects have come to a halt. Other more urgent projects still have major problems with funding. Some municipalities and cities have even sold property to raise money to finance operations. When the lenders´ windows are shut, new ways must be found to finance energy conservation activities. It is not impossible that NUTEK on a limited scale will have to be active in the lending or leasing business. If not, our faith in technology procurement as an important tool for development will likely end in frustration.

The second obstacle has been the total restructuring of the public sector, which has been going on for the last couple of years. In the wake of some failures in the planned part of our economy, every possible step towards a free market economy has also been taken in the public sector. The reorganization of public real estate administrations is one step which has kept our participants busy. Many of them have changed jobs

and the time for implementing existing agreements has been in short supply. This process probably is good for us all in the long run, but it certainly is a bit frustrating right now. We feel, however, that the organizations we work with are gathering momentum and will be very active in the years to come. Those who are working with the implementation of agreements will get more personal responsibility and greater reward from their jobs.

Nevertheless, there is a long planning process both in new construction and in the retrofit of existing buildings. Maybe we should be satisfied that as many as ten projects have been implemented within our agreements during the first year. The most frequent projects concern more efficient lighting and ventilation technology. The reductions in electricity use and demand are substantial in specific projects, ranging from 40 to 70 percent. However, we still have not seen any projects in such areas as daylighting or the cooling of buildings.

Electric energy saving technologies

The primary mechanisms for reduction of power demand and electric energy use for ventilation are the optimal design of fans and ducts and, of course, minimum operating time according to the circumstances. The electric energy conservation measures applied in most projects consist of larger high performance fan units which provide large air flow at low pressure. Better design of ducts--especially close to the fan unit--is also a very cost-effective measure that is easy to accomplish.

I would like to give you the facts and figures on costs and energy consumption in some projects before and after steps were taken. The technologies employed are familiar, i.e. improved luminaires, high efficiency fluorescent lamps, HF electronic fluorescent ballasts, occupancy and daylighting sensors, etc. Table 1 shows the facts and figures from some typical projects. These are preliminary figures. Measurements and verification of the results will be made in certain projects after several years of operation.

Table 1: Some examples of energy-efficient lighting projects realized within the agreements. All three examples result in 10 W/sq.m. of power demand.

Project/Description	Electric energy (kWh/yr)			Costs (SEK)	
	Before	After	Difference	Total	Bonus
Stockholm University Retrofit of the lighting installation. Less wattage HF-ballasts.	78,300	32,400	45,900	704,000	69,000
Government building Retrofit of the lighting installation. Less wattage HF-ballasts.	225,700	62,200	165,500	2 583,000	248,300
Hospital Retrofit of the lighting installation. Less wattage HF-ballasts.	100,000	50,500	49,500	216,500	74,200

NEW HF ELECTRONIC BALLASTS FOR FLUORESCENT TUBES

It has been shown that our minimum efficiency standard--10 W/sq.m.--for lighting is quite appropiate for most occasions, when efficient luminaires with high frequency electronic ballasts are utilized. Still there is some uncertainty about the durability of the new electronic ballasts, and in most cases improved luminaires with these ballasts are too expensive. Part of the cost problem relates to complicated installations and control systems.

In an attempt to overcome these problems, an invitation for tenders has been sent out to the major manufacturers of HF electronic ballasts. The technical specifications are based on the latest experience from the installation and operation of some new lighting systems with electronic ballasts and control systems in demonstration projects. An expert panel has made the specification of requirements after consultations with both manufacturers and customers, as well as other specialists in the lighting community. This is our way of identifying the market needs and of helping manufacturers offer products which will comply with them. The aim is low installation costs for the completed system including control devices.

From the successful bidder we will order at least 20,000+6,000 ballasts intended for 36 and 58 W fluorescent tubes respectively. The products will be delivered directly to the manufacturers of luminaire fixtures identified by some of the real estate management companies which have signed agreements with us. We have had discussions with authorities in other countries--i.e. Denmark, Norway and France--about cooperation on this matter. Thus, the total order might be much larger if the offered products are advanced enough and have the right price.

For some large building projects planned for completion in 1992, the signee of the agreements will purchase fixtures directly from the manufacturers and request that these electronic ballasts be installed in them. They will then provide complete fixtures with ballasts to the individual building contractors working on specific projects. The contractors will then install the complete fixtures, following the installation instructions from the fixture manufacturer.

This is obviously a chance for the lighting industry and the lighting design community to present new cost-efficient lighting products and systems, which will have a large market potential.

CONCLUSIONS

Technology procurement is a useful process to develop and commercialize new energy-efficient technologies. In such processes it is important to activate the markets' own forces, by letting capable large purchasers formulate detailed specifications according to their own needs and present them to the manufacturers and contractors.

To fullfil the objectives of a national program for the efficient use of energy, overall minimum efficiency standards together with well-designed monetary incentives, can be set as a framework for several purchasers' activities. Agreements between the administration responsible for the implementation of the program and some large purchasers, are a means of communicating the objectives to the market.

We believe a technology procurement program is of great interest to the purchasers as well as to the contractors. The purchasers can meet somewhat more stringent energy-efficiency standards than what their ordinary economic criteria allow for. Thus they can introduce and test new advanced technologies earlier than otherwise. The contractors and manufacturers get information on the markets' future needs, and they receive orders by well-known customers.

Equally important is the formation of well-functioning networks of purchasers, researchers, designers and other specialists in a suitable mix. Such networks can provide valuable support to the different participants.

The implementation of new design standards, advanced technologies, the analysis of life-cycle costs, and the like within large real estate management companies and administrations is a complicated process. From our own experience we know it takes a couple of years to get going. There is a long lead time in the planning and the design stages of a building project, but when the construction work finally starts the time is very short. Any changes in the construction phase are very costly and normally unacceptable. Everybody responsible for the implementation of the agreements, therefore has to be on the alert and take advantage of every opportunity they can find to introduce energy-efficient technologies.