NUTEK

Swedish Refrigerator Procurement

Profile #108

Executive Summary

The Swedish National Board for Industrial and Technical Development (commonly known as NUTEK) established the Swedish Technology Procurement Program (STPP) to exploit Sweden's potentials for energy efficiency and to counter increases in electricity use where this could be done cost effectively. NUTEK's goal for STPP is to reduce national demand for electricity by 10 TWh by the year 2000, thereby replacing 15% of the 60-70 TWh that Sweden currently generates using nuclear power. (In 1980, the public's concern about nuclear safety prompted the passage of a referendum to phase-out nuclear power.) To fulfill this target, STPP has completed procurement of energy-efficient computer monitors, lighting, washing machines, windows, heat pumps for single-family houses, industrial flow control systems, and refrigerator/freezers, the focus of this Profile. In each case the technology procurement has been devised and implemented to transform the market by encouraging manufacturers to produce more and more efficient equipment, rather than subsidizing purchases of efficient technology through rebates and other forms of direct incentives.

Exluding electric heating refrigerator/freezers consume 30% of residential appliance consumption. After determining that there was strong potential for greater efficiency in this end-use area, NUTEK assembled the "strong actors" who had the most interest in participating in the procurement process. Together they designed a request for proposals and formed a purchaser group to buy at least 500 refrigerator/freezers for rental properties. The group wanted the new units to be 40% more efficient than models available at the time and to reduce or eliminate the use of chlorofluorocarbons in both the insulation and cooling systems of the new units. NUTEK has followed up the procurement with the "Eloff" labeling campaign which requests that retailers add energy labels to appliances to help consumers make better choices.

The winning proposal of the technology procurement was submitted by Elextrolux AB, a Swedish company. Its prototype "TR 1066" was a 10.15 ft^3 unit that was 33% more efficient than the most efficient model already on the market, 44% more efficient than the most popular model, and 60% more efficient than the average model in use in homes in Sweden. The group's original order was for approximately 600 units. Since the program's inception in 1991, however, fully 3,350 Electrolux TR 1066s have been purchased, highlighting the immediate impact that the original purchase created. Furthermore, the market share for efficient refrigerator/freezers has increased from less than 1% to 5% in a matter of a few years, showing the leverage that incentives to a single manufacturer can cause. Cumulative savings through 1994 for the Electrolux model alone are more than 1 GWh and NUTEK estimates that annual savings from all of its market transformation initiatives will be 1 TWh by the year 2010, all at a cost to NUTEK of significantly less than half a million dollars.

NUTEK
SWEDISH REFRIGERATOR PROCUREMEMT

Sector:	*Residential*
Measures:	*Super efficient refrigerators*
Mechanism:	*Buyers group of rental property management companies presented RFP to manufacturers for 500 apartment sized refrigerators that consumed 40-50% less electricity than the most efficient model available at the time; Electrolux won the contract based on energy savings and reductions of CFCs*
History:	*632 Electrolux TR-1066 refrigerators delivered to the purchasers group in 1991; A slightly modified version became available to all consumers soon after*

1994 PROGRAM DATA

Energy savings:	*519.7 MWh*
Lifecycle energy savings:	*2,395 MWh*
Capacity savings:	*36.4 kW*
Cost:	*$95,540*

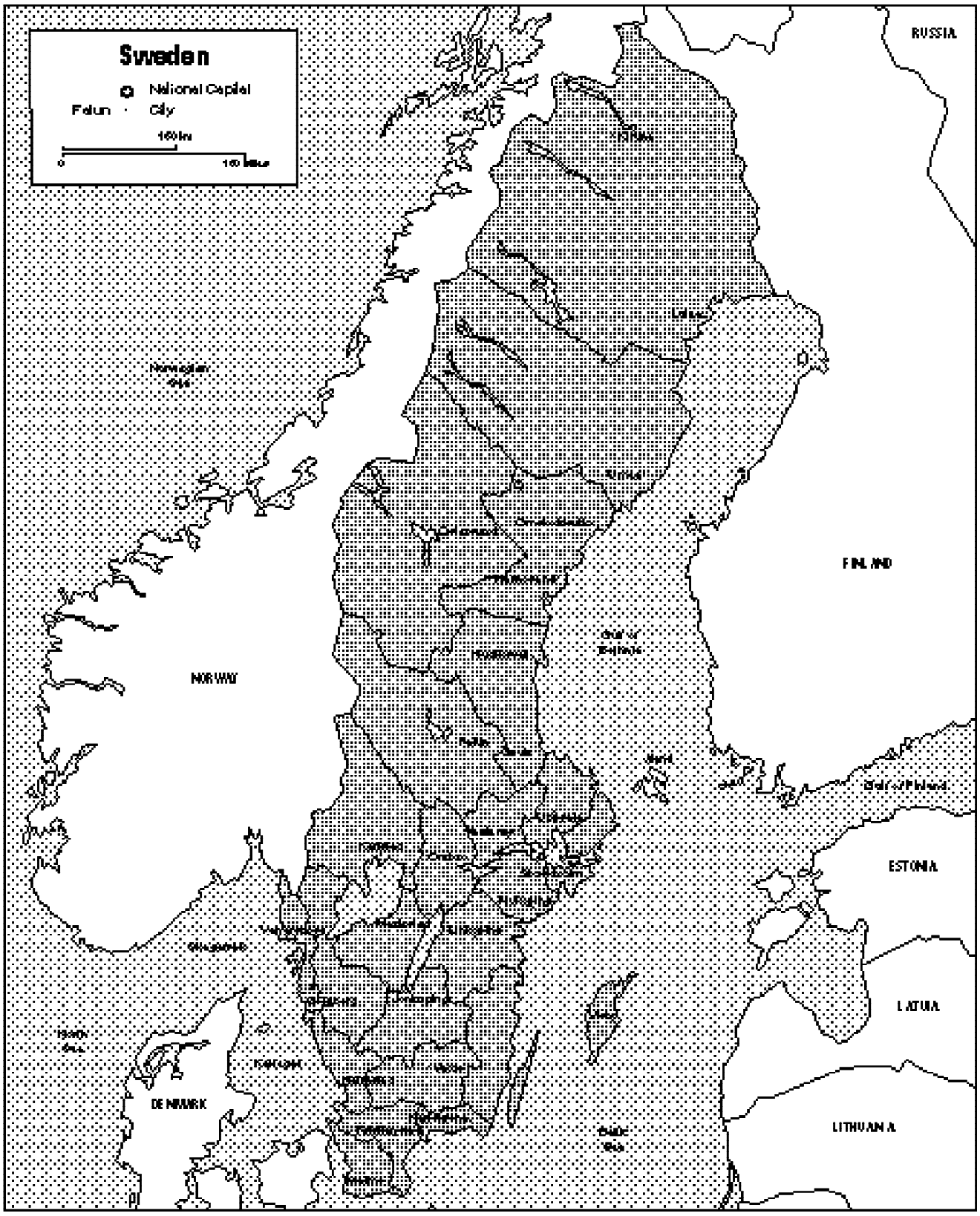
CUMULATIVE DATA

Energy savings:	*517.4 MWh*
Lifecycle energy savings:	*7,761 MWh*
Capacity savings:	*117.8 kw MW*
Costs:	*$311,020*

CONVENTIONS

For the entire 1994 profile series all dollar values have been adjusted to 1990 U.S. dollar levels unless otherwise specified. Inflation and exchange rates were derived from the U.S. Department of Labor's Consumer Price Index and the U.S. Federal Reserve's foreign exchange rates.

The Results Center uses three conventions for presenting program savings. ANNUAL SAVINGS refer to the annualized value of increments of energy and capacity installed in a given year, or what might be best described as the first full-year effect of the measures installed in a given year. CUMULATIVE SAVINGS represent the savings in a given year for all measures installed to date. LIFECYCLE SAVINGS are calculated by multiplying the annual savings by the assumed average measure lifetime. CAUTION: cumulative and lifecycle savings are theoretical values that usually represent only the technical measure lifetimes and are not adjusted for attrition unless specifically stated.



Sweden is a country of 9 million people located on the Scandinavian peninsula between Norway and Finland. It is the third largest country in Europe and was united with Norway until 1905 when Norway gained its independence. The close interdependence of Sweden and its neighbors involves trade, including energy, as well as environmental and security issues.[R#1,2]

Some 70% of Sweden is wooded and 15% of the country lies above the Arctic Circle. Traditional industry was based on forestry and mining and today its wealth of resources such as wood and iron ore have afforded Sweden an important position among the world's industrial nations. Its principal trading partners are Germany followed by the United States, United Kingdom, Denmark, Norway, and Finland. Its major exports are machinery, transport equipment, wood products and paper. Similarly, its principal imports are machinery, transport equipment, food, and other manufactured goods.

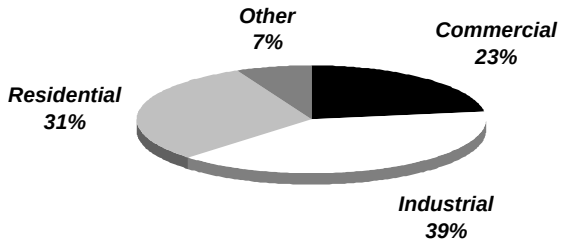
Sweden has been a neutral country since 1814. It has declined to participate in any wars or join into any international alliance (other than the United Nations), although it does maintain an impressive defense system. The standard of living in Sweden is one of the highest in the world. Until 1991 the country was a social democratic welfare state committed to 100% employment. During the late 1980s, however, this policy became increasingly difficult to maintain due to high inflation rates and increasing labor costs plus a wave of immigrants. For these reasons and in anticipation of the European Community's new market structure the Riksdag, Sweden's Parliament, approved a broad, austere economic program in 1991 which in many ways signaled the end of an era.

Efficiency programs, which began in the mid 1970s, were designed to reduce foreign oil consumption, as were Sweden's 12 nuclear plants built in the 1980s. By 1980 the public's concern about nuclear safety prompted a referendum to phase out nuclear power in Sweden when economically possible, and the Riksdag subsequently decided to begin the phase out in 2010 if possible. By 1991 it had become clear that there was not yet enough capacity from alternative sources to meet the country's demand and as part of its broader agenda, the Riksdag enacted an energy policy that postponed the phase-out.[R#5,15]

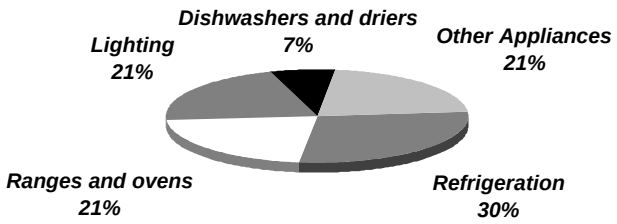
The industrial make-up of Sweden's economy as well as its location in a subarctic environment account for a high per capita energy use. Per capita electricity usage was approximately 14,644 kWh as compared to U.S. per capita electricity use in 1991 of 10,940 kWh. Swedish per capita oil consumption on the other hand was about half that of the U.S.'s in 1991.[R#6,7]

Sweden's total electricity consumption in 1994 was 137.8 TWh in 1994 of which 58.1 TWh (42%) was generated by hydroelectric plants, 70.1 TWh was from 12 units at 4 nuclear facilities (51%), and the remaining 9.6 TWh (7%) was from thermal plants many of which are combined heat and power plants and industrial cogenerators. There are approximately 4,000 MW of oil, gas, and diesel plants in Sweden which are used mainly for peaking and standby capacity. Two companies, Vattenfall (the Swedish State Power Board) and Sydkraft AB (Southern Swedish Power Supply) control over two-thirds of the capacity. The state-owned Svenska Kraftnät (Swedish National Grid) owns and operates the national grid. The are seven 400 kV lines, as well as some 200 kV lines, whose primary function is to shunt hydroelectricity from the north to the populated southern regions of the country. Sweden exchanges power with Denmark, Finland, Norway, and Iceland. In 1989 it imported 12.1 billion kWh while exporting 12.5 billion kWh.[R#3]

SWEDISH 1988 ELECTRICTY CONSUMPTION (131 TWh total)



1998 SWEDISH RESIDENTIAL APPLIANCE CONSUMPTION (14 TWh)



The Swedish National Board for Industrial and Technical Development (NUTEK), formed in 1991, has two primary responsibilities: to promote the growth and regeneration of Swedish industry and to promote long-term changes in the country's energy system.

NUTEK's guiding objective is to meet the government's and other clients' requirements for professional, customer-oriented analyses of a broad range of specialized fields. It is NUTEK's ambition to be at the forefront in assisting the Swedish business sector with policy and market studies and ensuring optimum use of natural resources for the purpose of stimulating profitable and environmentally sound strategies. Working with businesses, institutes of technology and universities, and by acting as a gateway to a wide network of contacts in Europe and the rest of the world, NUTEK strives to develop Sweden's technical status and competitiveness. The department analyzes and evaluates projects and information within its working areas in order to provide decision-makers and other interested parties with impartial, reliable information about those matters. Much of NUTEK's research and development work is carried out at colleges and universities.[R#8,9,10]

NUTEK ANALYSIS

NUTEK Analysis' studies are presented in national and international status reports, forecasts, expert reports, etc. NUTEK Analysis is staffed by approximately 40 analysts specialized in the areas of productivity, structural and regional development of industry, R & D systems, innovation processes, and energy systems and their relationship to the environment and the economy. NUTEK Analysis is divided into four specialized teams:

- Technology Team
- Regional Policy Analysis Team
- Structural Policy Team
- Energy Policy Team

TECHNICAL RESEARCH AND DEVELOPMENT

NUTEK Technical R & D contributes to the long-term renewal of business and energy systems by initiating and financing research and development. Activities are concentrated on long-term R & D that is regarded as having substantial innovation potential, on strategic R & D that would not otherwise be carried out, and on early phases of the innovation process. An important task is the encouragement of various parties in the R&D system to work together to address problem-orientated research and development and to interchange results. Other important areas are the support of international joint projects, particularly within the framework of the European Commission's research program and technology transfer to small and medium-sized companies. These activities are organized by four departments:

- Planning and Program Development coordinates long-term planning, systems research, technology transfer, international liaison, industrial research institutes and evaluation.
- Generic Technologies specializes in information technology, materials technology and biotechnology.
- Strategic Industrial Technologies' priority areas are biomedical technology, production technology, process technology and transport technology.
- Energy and Environmental Technology concentrates on air and water treatment methods, bioenergy, heat and power technology, combustion technology and energy technology in industry.

BUSINESS & REGIONAL DEVELOPMENT

NUTEK Business is responsible for facilitating and encouraging the establishment of new businesses and supporting the growth of small and medium-sized companies by supplementing information, advisory services, and financing. This department is divided into three services: small companies' service, new companies' service, and the European Community (EC) small companies' program.

- Business Development involves financing and early assessment of projects, together with the provision of advisory services for individual innovators and small companies. Its objective is to regenerate business life by helping to ensure that technical product ideas with growth potential are developed to the market concept stage, making them attractive to the next financing source. The activity covers the areas of technology-based business development, innovation service and Eureka - a joint European product development scheme.

- NUTEK Regional promotes the progress of business by developing and disseminating information about matters benefitting regional business growth throughout Sweden. While most projects are dealt with by the county administra-

tive boards, NUTEK Regional is the main administrative body for the country's regional support system and it also makes decisions on larger projects. Through the financing of viable companies NUTEK also helps with the development of special grant areas that have been designated by regional aid policy.

Regional business development involves establishment of a knowledge base in conjunction with researchers, project activities together with county administrative boards and local authorities, dissemination of knowledge and experience and monitoring of international development. These activities are organized by three departments. One is responsible for regional planning development projects, women in business and EC matters, another department is responsible for Regional Business Support and a third for the handling of the Investment Fund and regional transportation support.

- The Electricity Market Department is responsible for transmission and distribution matters for electricity and gas as well as public energy planning and questions concerning tariffs for the grid operations and rules for the grid companies' accounting. NUTEK Electricity Market is in charge of the surveillance of the grid services and has to make sure that the consumers do not pay a higher price than is necessary and that the transmission tariffs, metering, and communications systems are designed so as to facilitate and promote competition. The activities have been organized into three departments: the Concessions Department, the Regulation and Appeal Department, and the Supervision and Review Department.[R#8,9]

- The Strategic Energy Supply Department is responsible for strategic planning to ensure Sweden's energy supplies in the event of war or energy crises. The Strategic Storage Department handles the Government's stocks of petroleum products.[R#9]

THE DEPARTMENT OF ENERGY EFFICIENCY

The Department of Energy Efficiency is responsible for technology procurement and demonstration of energy-efficient products for homes, offices, industries and urban transport. Nutek's Department of Energy Efficiency is also the authority responsible for implementing the Swedish Technology Procurement Program which was established by the Swedish Parliament in 1988 to improve energy efficiency particularly with regard to electricity. [NUTEK itself was formed in 1991 out of the merger of three government agencies, including the National Energy Administration which had been responsible for administering the Procurement Program.] The Department has run procurement projects with efficient home refrigerator/freezers, low-energy apartment laundry rooms, high-frequency lighting in offices and commercial spaces, energy-efficient windows, heat-pumps for single-family homes, industrial flow control systems, and power-down computer monitors which have become standard worldwide. This Profile focuses on the Department's technology procurement of combined refrigerator/freezers.[R#2]

In the mid-seventies most efficiency programs in Sweden were designed to reduce oil consumption and dependency on imported energy and fuels. In conjunction with these programs Sweden invested heavily in nuclear plants. As mentioned previously, a referendum in 1980 decided that Sweden's nuclear power should be abolished by the year 2010 for environmental reasons. Ironically, because of the nuclear program, dependence on foreign oil has to a large extent been eliminated but a surplus in capacity, partially due to a decline in the rate of demand for electricity, and resultant low prices have led to a reliance on electricity in both the industrial and heating sectors. Because of this reliance it seems less likely that it will be possible to abolish the nuclear program even though nuclear power is not considered environmentally safe and the demand for electricity is expected to grow at a significantly lower rate (1.5% per year) than in the eighties. In fact, the national forecasts indicate no need for new power production until the year 2000.[R#5]

TECHNOLOGY PROCUREMENT

Technology procurement is a process whereby a group of consumers forms a buyers group that seeks to influence manufacturers to develop and produce a new or improved product that meets the group's requirements, such as for energy consumption. The group offers to purchase a sizable amount of the new technology if it can in fact be manufactured according to the purchasing group's specifications.

In the United States, the "Golden Carrot" awarded by utilities through a design competition to a white goods manufacturer for the production and development of the Super Efficient Refrigerator is a good example of technology procurement. (See The Results Center Profile #106) Twenty-four utilities throughout the United States pooled together resources and jointly submitted an RFP for a new refrigerator, insisting that it be 25-50% more efficient than those currently available on the market. The Whirlpool Corporation won the "Golden Carrot" contest and agreed to distribute 250,000 super-efficient, CFC-free refrigerators in the utilities' service territories.

Technology procurement's greatest impacts tend to be indirectly related to the initial program. For instance, once a technology has been developed in response to the initial order by the purchaser group it becomes relatively easy for the manufacturer to make it available to subsequent consumers. In fact, eventually the new technology may become the standard for all manufacturers who find that they must adapt their own products to compete for market share. This is especially true for industries such as appliance manufacturers. In the United States other manufacturers such as Amana and Frigidaire will begin to offer their own versions of the CFC-free efficient models thanks to the initial design competition that they lost!

The ultimate goal of technology procurement therefore is to transform markets such that higher quality products become available and cost competitive with lesser quality products. NUTEK's market transformation programs are designed to strongly influence all manufacturers and suppliers to provide customers with more efficient technologies. Once the market has been transformed efficiency becomes transparent to consumers but remains a key factor for manufacturers' retention and expansion of market share.[R#5]

Fundamentally, technology procurement programs are based on cooperation between purchasers and manufacturers. Although no General Agreement has been used for NUTEK's refrigerator/freezer procurement, to support and strengthen the durability of savings from many of NUTEK's procurement programs purchasers are asked to sign a two-part General Agreement. NUTEK has General Agreements with owners of large office buildings, industrial companies, and some utilities, and they are not always signed in conjunction with a procurement effort but in the case that they are the purchaser first agrees to install and test the new product. In the second part the purchaser agrees that the accepted or revised specifications of the new product will become their organizations' standard for future purchases. This helps to ensure that subsequent purchases of similar equipment be of an equal or better standard and that savings are persistent.

There may be any number of specific stipulations contained in General Agreements. One example of such a stipulation exists for participants who would be able to receive subsidies from NUTEK after the purchase of efficient office lighting equipment. The General Agreement might stipulate that as long as the electricity used by new office lighting did not exceed .93 watts/ft^2 the participant would be able to receive a subsidy from NUTEK toward the purchase of the new equipment. This arrangement would not absolutely ensure that future lighting equipment be as efficient as that which was purchased previously but NUTEK's experience has been that once participants are familiar with efficient technologies, it is rare that they will then purchase equipment below that standard.[R#5] ☞

THE SWEDISH TECHNOLOGY PROCUREMENT PROGRAM

The Swedish Technology Procurement Program (STPP) is one part of a broader program that was established in 1988 by several political parties both inside and outside the government to capitalize on the potential energy savings from efficiency in single-family homes and to counter increases in electricity use where this could be done cost effectively. Initially STPP focused solely on introducing new products for the efficient use of electricity but in a second step in 1991 the program was given a five-year budget and was extended to all types of energy. NUTEK's Department of Energy Efficiency received an initial five-year budget of $54 million (SEK 400 million) to administer the program. NUTEK has set a goal for the Swedish Technology Procurement Program to reduce the need for electricity by 10 TWh by the year 2000 and thereby replacing about 15% of Sweden's total 60-70 TWh of nuclear capacity. [R#5,15]

REFRIGERATOR PROCUREMENT

The market for refrigerator/freezers in Sweden is divided nearly in half between the managed rental properties and the private sector. The total number of installed refrigerators and freezers is somewhere between 1.5-2.0 million units. Currently the market for combined refrigerator/freezers in Sweden is around 100 to 150,000 units per year which includes both replacement and original equipment.[R#10]

NUTEK defines the energy consumption of refrigerator/freezers in terms of the number of kWh consumed per litre of adjusted volume per year, ie: 1.0 kWh/l/year. (Adjusted volume is defined as the volume of the refrigerator compartment plus two times the volume of the freezer compartment.) NUTEK analyses also report the total annual energy consumption per unit, ie: 679 kWh/year. For the convenience of our readers The Results Center has converted litres to cubic feet.

Since the mid-seventies the energy consumption of refrigerator/freezers has declined significantly in Sweden but because they nevertheless consume about 30% of household electricity (excluding electric heating) researchers had tried to determine if there might be strong potential for even greater efficiency in this area. The average electrical consumption of all brands of new refrigerator/freezers in Sweden is 40 kWh/ft^3/year (1.4 kWh/l/year) and of these the most efficient on the market before the procurement program used 34 kWh/ft3/year (1.2 kWh/l/year.) It is estimated that the average consumption of refrigerator/freezers already installed and operating in homes is more than 57 kWh/ft^3/year (2.0 kWh/l/year). STPP's eventual procurement obtained a new unit that was some 30% more efficient than the most efficient model available. [R#5,10]

A procurement organization, Husbyggnadsvaror (HBV), which purchases appliances for a large portion of the publicly-owned multi-family housing in Sweden, along with NUTEK project leader, Dr. Hans Westling, formed the purchaser group which included representatives from the energy supply authorities, Hyresgästernas Sparkasse och Byggnadsförening (HSB, the association of housing cooperatives), Skandia (an insurance and real estate company), the Swedish National Board for Consumer Policies, and the Swedish National Energy Administration. The group attended conferences on energy topics, held seminars, and made tours to research facilities. With the help of Dr. Westling and an independent expert on household equipment, the group set a goal to develop and purchase new refrigerator/freezers which would be 40-50% more efficient than models available at the time. The group determined that this could be accomplished through improved insulation, heat exchangers, and compressors. The group also wanted to reduce or eliminate the use of greenhouse gases in the new units and to add energy labelling on refrigerators to help educate consumers as to the efficiency benefits of the new units once they became available on the market.[R#4,5,10]

NUTEK's first steps in any procurement effort are to identify areas with good potential for energy savings as well as the "strong actors" or key constituents who will participate. (Strong actors are purchasers who have very good reasons to be involved in the purchase of new, efficient technologies.) Because keeping food cold consumes more household electricity than anything except heat and hot water there seemed to be good potential for energy savings in this end-use but, rather than subsidizing efficient technologies, the ultimate goal of STPP is to produce market transformations toward more energy-efficient technologies so that, in the future, customers will naturally purchase the new technologies without any incentives.

Technical potential is increased by technology procurement while market acceptance is enhanced with product demonstrations and energy labeling. New performance standards should constantly be set to keep up the pressure for improvement.[R#5,10]

After identifying the savings potential, NUTEK seeks to involve a purchasers group that is motivated to purchase the new, more efficient products. The purchasers group actually specifies the features and energy consumption of the new products. NUTEK realized that a convenient buyers group for refrigerators existed in the landlords and management companies that rent a large number of Sweden's fully equipped apartments. Fortunately NUTEK found that the management companies actually prefer to provide their tenants with modern and environmentally friendly equipment. Therefore, they exactly fit NUTEK's criteria for "strong actors." Another benefit to this potential buyers group from STPP's perspective was that only 3-5 organizations either make recommendations or purchase 80% of all the refrigerators the landlords and management companies eventually buy. This was clearly a consolidated group that not only purchased large numbers of refrigerator/freezers but also wanted the most modern environmentally friendly equipment since NUTEK had already identified good potential for energy savings through refrigerator/freezer procurement the next step was to develop and present an RFP to manufacturers.

The group realized that the largest growth in housing was in one and two person apartments so it decided to focus on smaller apartment sized refrigerators. An RFP was sent out to manufacturers for an apartment-sized refrigerator which consumed less than 28.6 kWh/ft^3 per year or, in other words, was 20% more efficient than the best on the market. Manufacturers whose completed proposals were accepted for consideration, met the required technical specifications of the purchaser group, but were not selected in the end, would be awarded 100,000 SEK ($13,500). The group agreed to purchase 500 units initially. Five manufacturers submitted proposals of which three were accepted for the evaluation which took place in June 1990. A Danish consortium, viz. Gram and Osby/AEG presented proposals that met the efficiency requirements of the RFP, but both companies were unable to improve on the environmental aspects of their current technologies.

The winning proposal for NUTEK's request for a highly efficient refrigerator was submitted by Electrolux, AB, a Swedish company. Electrolux had two proposals. One proposed model would consume 22 kWh/ft^3/year (0.79 kWh/liter/year) and another, which incorporated vacuum panels for insulation, consumed only 15 kWh/ft^3/year (0.53 kWh/liter/year). The purchaser group selected the first because it used more standard technology. By December of 1990 a prototype called the TR 1060-LE was available for testing; by September of 1991 was available on the market. The prototype unit, the TR 10 1060-LE, is a 10.15 ft^3 (290l) model that uses fairly conventional technology and that was 33% more efficient than the most efficient model available when it was first introduced, 44% more efficient than the most popular model, and fully 60% more efficient than the average model in use in homes in Sweden.

The Electrolux TR 1066 SLG sells for $1,240 (9,160 SEK), compared to the best seller on the market at the time of the competition which sold for $922 (6,850 SEK). The buyers group is assuming some element of risk due to their involvement in the procurement process in that they cannot be guaranteed that the new technology will be completely satisfactory. Therefore, as an added incentive to the original purchasers for their willingness to participate, NUTEK subsidized the cost of each new unit the buyers group purchased as part of the original procurement by $169 (1,250 SEK) which brought the per unit cost for the initial order down to $1,069 (7,910 SEK). In order to receive the added incentive, the buyers simply provided NUTEK with a receipt showing that they had in fact purchased one or more TR 1066s. The incentives were not available for purchases other than the initial procurement.

The prototype model has since been remodeled slightly. The currently available model, called the TR 1066 SLG, has a slightly smaller freezer compartment but contains the non-CFC coolant HFC-134a which is much more environmentally benign than CFCs. For environmentally concious consumers a more expensive model is available which uses butane for its coolant. Butane does not harm the ozone layer or contribute to global warming.[R#10]

In Europe environmentalists have tried to convince appliance manufacturers to avoid using HCFCs which, although far less damaging than CFCs, do harm the ozone layer and contribute

to global warming. Instead they favor using more "natural" gases: isobutane for the refrigerant and cyclopentane for the blowing agent. Both these agents are environmentally benign but they are also explosive so there are safety issues to consider in both the design and manufacture of products which contain these gases. For instance there can be no unsealed electrical switches in the interior of the units because tiny sparks inside the switches could cause explosions if there were gases escaping from the insulation material or a leak in the cooling system. Interior lights have to be tightly sealed for the same reason. Furthermore, European refrigerators of this kind do not have defrost heaters in them because the defroster's heater coils would pose similar problems for safety. Unfortunately, the blowing agent cyclopentane in refrigerator insulation is about 10% less efficient than HCFC-141b, and while butane and pentane are cheaper than the HCFCs and HFCs, the costs associated with safe design and manufacturing using these materials may actually cause the units to be more expensive in the end.[R#14]

In terms of the environmental significance of these coolants note that lifecycle analysis of refrigerators shows their contribution to global warming to be negligible compared to that caused by generating the energy to run them. It has been estimated that 98% of their global warming contribution comes from electricity generation while only 2% comes from releases of gases in manufacturing, usage, and disposal.[R#14]

When the competition/procurement was completed NUTEK had a press conference announcing the winner. Thereafter it was up to the Electrolux to promote its product. Nevertheless, NUTEK has continued to raise awareness of the program. To do so NUTEK uses informational brochures stuffed in utility bills, press releases for radio and other media, and has established a hotline that consumers can call to request information. Product labeling as stipulated by the procurement, however, is the primary mechanism NUTEK utilizes to educate consumers about the advantages of the energy efficient units.[R#5,12]

After the initial production of the TR 1066 LE and the purchase of 632 units by the purchaser group, STPP has been following up by distributing informational materials which are directed at appliance dealerships. All the suppliers in Sweden receive a newsletter from NUTEK and are occasionally invited to informational meetings as well. They also receive a booklet with all the energy-efficient household appliances listed as well as their energy efficiency labels. The "ELOFF" labels, which retailers can label their products with, draw consumers' attention to the most energy-efficient refrigerators, freezers, washing machines, dryers, and dishwashers. This aspect of NUTEK's efforts is aimed not at any large buyers' group but at the single-family consumers' market. NUTEK introduced the ELOFF labelling program on a voluntary basis following the refrigerator procurement. The label is only allowed on refrigerator/freezers that consume less energy than the most efficient model before the procurement.[R#15]

STAFFING REQUIREMENTS

At the inception of the refrigerator procurement program, two people worked as consultants for the purchaser group. After the group was formed three people at the Department of Energy Efficiency and one independent consultant became involved in designing and running the program. One person was involved in planning the project early on, making decisions about incentive levels and the feature requirements for the technology procurement. A second person, the head of the Energy Efficiency Department at NUTEK, also worked with the requirements, as well as promoting technology procurement. [R#4]

MONITORING

From 1991-1993, following the purchase of the 632 new TR 1066 refrigerators by the purchaser group, NUTEK diligently measured the refrigerators' energy consumption. A project called Hushallsel (HEL), which means household electricity, was implemented to evaluate the energy consumption of all appliances in 66 mid-size homes in four different areas in Sweden. (Some homes contained the new, efficient refrigerators, while others did not.) The resulting average consumption of the new efficient refrigerators was found to be 270 kWh/year, significantly lower than the estimated 310 kWh/year presented in the bid by Electrolux and in NUTEK's ELOFF booklet. In addition to its efforts with measuring the energy consumption of the refrigerators in homes, STPP is studying the progress of the market transformation by reviewing sales statistics every year. Of course for this analysis NUTEK is very interested in the sales of all brands and models of efficient refrigerators, not only the TR-1066.[R#12]

EVALUATION

The estimated results of the STPP are evaluated and verified annually and a report is prepared for the Ministry of Industry and Commerce. Consultants are often hired to help with this process. Actual energy savings data as well as an evaluation of the overall effect of the program's requirements are reported. [R#12]

A process evaluation of the STPP was completed in 1992 by Anders Lewald and Randal Bowie of NUTEK. Market transformation is not easy to measure and since it involves a relatively small, well-timed initial purchase it does not have a major immediate impact on most products sold. One way to measure market transformation is to look at the speed with which competing manufacturers adopt the new technologies in their products; another is to track sales for the newly developed product; and another is to measure consumers' interest in the energy and environmental features of the new products. NUTEK feels that it is difficult to isolate the effects of the program including free drivership (which is defined as the non-incented activity that results from the original program but is also its principal goal) from other trends such as the commercial development of new more efficient products. Furthermore, because the program was initiated by the Swedish government, which did not specify many needs and savings requirements, the evaluators did not have benchmarks or goals with which to compare the results of the program.[R#5,12]

NUTEK employs two computer models which were developed by the Electric Power Research Institute to estimate future savings that will result from STPP. These are the REEPS model for residential programs and the COMMEND model for commercial buildings. The REEPS model is designed to evaluate end-use and technological data for the residential sector. It provides a tool for developing long-term forecasts of energy-use patterns at the end-use level. NUTEK inputs sales statistics, types of residences, the number of inhabitants, and the technical specifications ("the energy factor") of the refrigerator to forecast energy efficiency options, technology options, and to determine the impact of price on a purchaser's decision making. NUTEK plans to use a third model for industrial monitoring in the future.

At this time no follow-up has been done to see how the purchasers have acted now that there are no longer incentives given for purchasing the efficient refrigerators, but this is something NUTEK plans do in the future. Nutek is also studying the consumers' interest in the energy and environmental aspects of products they purchase. A consumer survey in December, 1994 was used to determine their most important criteria for buying household appliances. Among those repondents who were aware of the Eloff labeling, fully 39% said that efficiency was an important criteria. Only 19% of those who had no knowledge of the Eloff labels saw efficiency as an important criteria for purchasing appliances. [R#10,12,13]

Program Savings

DATA ALERT: Program savings presented in the tables on the next page represent savings that have resulted from the development of a specific refrigerator, the TR 1066 which was developed for the initial procurement. While the program's "direct effect" was the purchase of 632 TR 1066 units, a total of 3,350 of these units were purchased between 1991 and 1994 and are thus accounted for in the savings presented. NUTEK, on the other hand, is counting on the savings from not only this model but all subsequently developed energy-efficient, R/F units to meet the program's savings goals.

Engineering estimates suggest that the Electrolux TR 1066 SLG refrigerator/freezer developed as a result of the refrigerator procurement program consumes 313 kWh/year. To determine average unit savings, this annual value was compared with the volume-adjusted annual energy usage of the Electrolux TR 1171, the most efficient model available before the procurement. The difference between these unit annual consumption values, represents savings, in this case 154 kWh/year. Based on the TR 1066's individual unit annual savings of 154 kWh, and the procurement's direct order of 632 refrigerators, the program's first-year annual savings was at least 97,328 kWh with lifecycle savings of 1.46 GWh. (NUTEK's field testing of the TR 1066 suggested an annual energy consumption of 270 kWh, indicating that the delta and program energy savings presented are conservative.)[R#10,11,12]

The initial procurement of 632 refrigerators has created subsequent sales of the new model that are clearly the result of the program. The 3,350 units sold between 1991 and 1994 have produced over 517.4 MWh in total annual energy savings, 1,034.7 MWh in cumulative energy savings, and lifecycle energy savings of 7,760.6 MWh based on an average measure lifetime of 15 years.

In terms of the 117.8 kW of capacity savings, The Results Center estimates that refrigerators run approximately 50% of the time. By dividing the annual energy consumption of the new unit by the number of hours that the units operates, the per unit capacity requirement was determined. A similar exercise was simulated for the most efficient unit prior to the program, and the difference between the two, multiplied by the total sales of 3,350 units provides an indication of the program capacity savings.

PARTICIPATION RATES

For the purpose of this Profile participation is defined as the number of Electrolux TR 1066 refrigerators sold. While the initial procurement was for only 632 units, by the end of 1994 3,350 TR 1066s had been sold. Note that ultimately the program will create a fundamental market transformation, whereby all manufacturers improve their products to compete with Electrolux, greatly expanding program participation and the program's effect.

FREE RIDERSHIP

Since there were no refrigerators of the type purchased under the STPP prior to the refrigerator procurement program, free ridership is nonexistent. However, as with all market transformation programs, the goal of STPP is market transformation whereby many more efficient refrigerators are intended to saturate the market than were sold as part of the initial order. The program influences the market, initially with the help of incentives, so that improved technology becomes readily available and customers eventually purchase those products without any incentives. The end result of the program is to turn all new customers into free drivers.

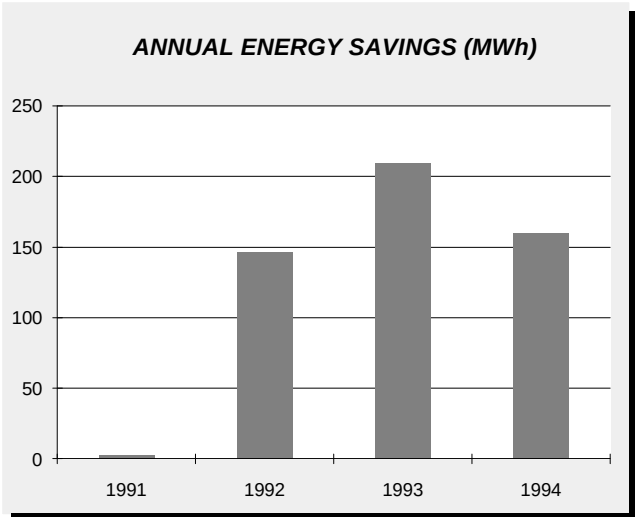
MEASURE LIFETIME

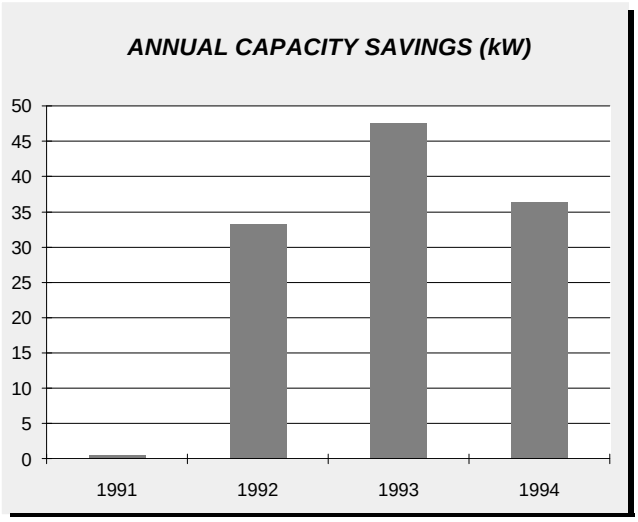
In order to estimate the lifetime of refrigerators NUTEK assumes that after 15 years just half of the refrigerators are still operating and after 21 years all will need to be replaced. Given this assumption the average measure lifetime for the refrigerator used by the STPP program is 15 years. The Results Center has used this number to calculate the lifecycle energy savings listed below and to calculate the program's cost of saved energy presented in the next section.[R#12]

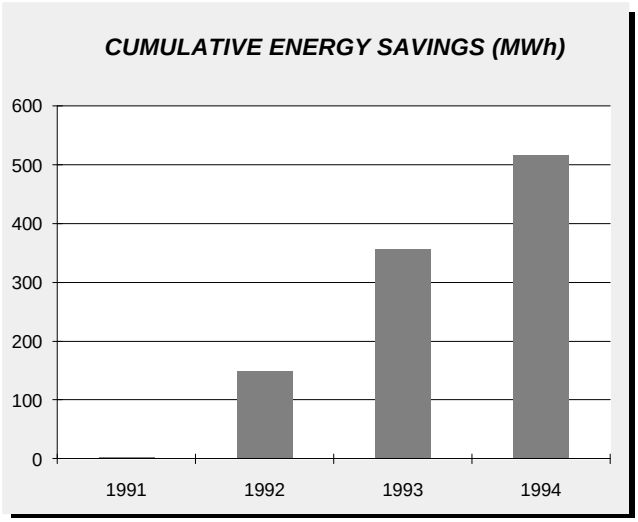
PROJECTED SAVINGS

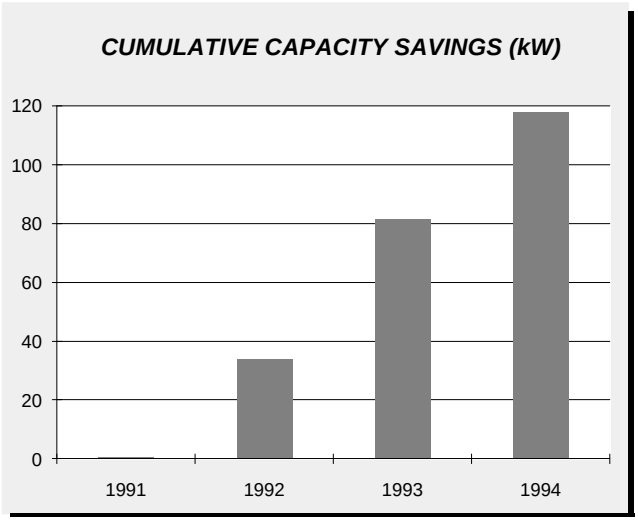
NUTEK estimates that the annual savings from refrigerator/freezer procurement by the year 2010 will be 1 TWh. This estimate is based on the annual energy savings in 2010 from all refrigerator/freezers, purchased through 2010, with efficiencies better than the most efficient model available just before the initial procurement. NUTEK uses this definition of savings in order to easily compare it with electricity production.[R#15]

SAVINGS OVERVIEW	ENERGY SAVINGS (MWh)	CUMULATIVE ENERGY SAVINGS (MWh)	LIFECYCLE ENERGY SAVINGS (MWh)	CAPACITY SAVINGS (kW)	CUMULATIVE CAPACITY SAVINGS (kW)
1991	2.3	2.3	34.7	0.5	0.5
1992	146.1	148.4	2,191.5	33.3	33.8
1993	209.3	357.7	3,139.0	47.6	81.4
1994	159.7	517.4	2,395.4	36.4	117.8
Total	517.4	1,034.7	7,760.6	117.8	









Cost of the Program

COSTS OVERVIEW	CONSULTING (x1,000)	ADMIN. (x1,000)	INCENTIVES (x1,000)	EVALUATION (x1,000)	CONFERENCES (x1,000)	INFORMATIONAL MATERIALS (x1,000)	TOTAL COSTS (x1,000)	COST PER PARTICIPANT
1991	$0.9	$0.0	$0.8	$0.2	$0.1	$0.0	$2.0	$136.0
1992	$44.7	$1.5	$36.9	$11.2	$3.0	$0.7	$98.0	$103.6
1993	$52.7	$1.8	$43.5	$13.2	$3.5	$0.9	$115.5	$85.2
1994	$43.6	$1.5	$36.0	$10.9	$2.9	$0.7	$95.5	$92.4
Total	$141.9	$4.7	$117.1	$35.5	$9.5	$2.4	$311.0	

DATA ALERT: Total costs for this program have been distributed over four years according to the number of Electrolux TR 1066s sold in each of those years. Swedish Kroners were converted to U.S. dollars according to the exchange rates for each year and then U.S dollars were levelized to 1990 dollars per The Results Center's conventions. NUTEK had no actual costs of running the program after the original procurement and does not consider subsequent purchasers of these refrigerators to be "participants" in the program. The Results Center has distributed costs in this way simply to provide a better comparison of this program with others it has profiled.

The total cost of the STPP has been $311,020. Based on the number of units sold each year NUTEK's total costs for the refrigerator procurement program were $2,040 in 1991, $97,970 in 1992, $115,460 in 1993, and $95,540 in 1994.

COST EFFECTIVENESS

In order for a technology procurement program to be considered cost effective NUTEK requires that the total cost of the program not be more than the value of energy savings from the procurement. Total costs for the refrigerator/freezer program were $311,020. Lifecycle savings due to sales through 1994 of just Electrolux TR 1066s (7.7 GWh) have amounted to well over the 4.18 GWh required for the program to be cost effective under this definition. As of the end of 1994, 3,350 TR 1066s had been sold. Lifecycle savings from those sales is estimated at 7,760,610 kWh which is valued at $651,891 using a cost per kWh of $.084. To give readers an idea of the extent of STPP's market transformation, by the end of 1994, 5% of the 80,833 refrigerator/freezers sold were energy efficient as compared to 1.5% in 1992 and 0.02% in 1991.[R#5,10]

COST OF SAVED ENERGY AT VARIOUS DISCOUNT RATES (¢/kWh)	3%	4%	5%	6%	7%	8%	9%
1991	7.38	7.92	8.48	9.07	9.67	10.29	10.93
1992	5.62	6.03	6.46	6.90	7.36	7.83	8.32
1993	4.62	4.96	5.32	5.68	6.06	6.45	6.84
1994	5.01	5.38	5.76	6.16	6.57	6.99	7.42
Total	5.04	5.41	5.79	6.19	6.60	7.02	7.46

In order to determine STPP's cost of saved energy The Results Center has weighted NUTEK's program costs over the four years according to sales in those years of TR 1066s. The resulting weighted average cost of saved energy at a 5% real discount rate is 5.79¢/kWh.

COST PER PARTICIPANT

Similarly, The Results Center has calculated NUTEK's average cost per participant based on sales of TR 1066s for each year since 1991 and the total cost of running the program for each of those years. The average cost per participant was $104.29.

COST COMPONENTS

Of the $117,070 spent on incentives, two manufacturers who succeeded in meeting the RFP's technical requirements but did not produce the most efficient prototype received $11,707 each for a total of $23,414, and subsidies for each of 632 units purchased as part of the initial agreement with the manufacturer cost NUTEK $93,656. Approximately $141,910 was spent hiring a consultant to design and manage the initial phases of the STPP. An environmental impact evaluation cost $16,675. Metering of refrigerator/freezers in residences cost $18,804. Conferences and meetings cost $9,460. Administration by NUTEK staff cost approximately $4,730 and producing educational and informational materials about the program cost $2,370.[R#12]

Environmental Benefit Statement

AVOIDED EMISSIONS: Based on 1,034,700 kWh saved 1991 - 1994						
Marginal Power Plant	**Heat Rate BTU/kWh**	**% Sulfur in Fuel**	**CO2 (lbs)**	**SO2 (lbs)**	**NOx (lbs)**	**TSP* (lbs)**
Coal	***Uncontrolled Emissions***					
A	9,400	2.50%	2,231,000	53,000	11,000	1,000
B	10,000	1.20%	2,379,000	20,000	7,000	5,000
	Controlled Emissions					
A	9,400	2.50%	2,231,000	5,000	11,000	0
B	10,000	1.20%	2,379,000	2,000	7,000	0
C	10,000		2,379,000	14,000	7,000	0
	Atmospheric Fluidized Bed Combustion					
A	10,000	1.10%	2,379,000	6,000	3,000	2,000
B	9,400	2.50%	2,231,000	5,000	4,000	0
	Integrated Gasification Combined Cycle					
A	10,000	0.45%	2,379,000	4,000	1,000	2,000
B	9,010		2,140,000	2,000	1,000	0
Gas	***Steam***					
A	10,400		1,298,000	0	3,000	0
B	9,224		1,127,000	0	7,000	0
	Combined Cycle					
1. Existing	9,000		1,127,000	0	4,000	0
2. NSPS*	9,000		1,127,000	0	2,000	0
3. BACT*	9,000		1,127,000	0	0	0
Oil	***Steam--#6 Oil***					
A	9,840	2.00%	1,878,000	28,000	3,000	3,000
B	10,400	2.20%	1,992,000	28,000	4,000	2,000
C	10,400	1.00%	1,992,000	4,000	3,000	1,000
D	10,400	0.50%	1,992,000	12,000	4,000	1,000
	Combustion Turbine					
#2 Diesel	13,600	0.30%	2,493,000	5,000	8,000	0
Refuse Derived Fuel						
Conventional	15,000	0.20%	2,959,000	8,000	10,000	2,000

In addition to the traditional costs and benefits there are several hidden environmental costs of electricity use that are incurred when one considers the whole system of electrical generation from the mine-mouth to the wall outlet. These costs, which to date have been considered externalities, are real and have profound long term effects and are borne by society as a whole. Some environmental costs are beginning to be factored into utility resource planning. Because energy efficiency programs present the opportunity for utilities to avoid environmental damages, environmental considerations can be considered a benefit in addition to the direct dollar savings to customers from reduced electricity use.

The environmental benefits of energy efficiency programs can include avoided pollution of the air, the land, and the water. Because of immediate concerns about urban air quality, acid deposition, and global warming, the first step in calculating the environmental benefit of a particular DSM program focuses on avoided air pollution. Within this domain we have limited our presentation to the emission of carbon dioxide, sulfur dioxide, nitrous oxides, and particulates. (Dollar values for environmental benefits are not presented given the variety of values currently being used in various states.)

HOW TO USE THE TABLE

1. The purpose of the accomanying page is to allow any user of this profile to apply NUTEK's level of avoided emissions saved through its Refrigerator Procurement to a particular situation. Simply move down the left-hand column to your marginal power plant type, and then read across the page to determine the values for avoided emissions that you will accrue should you implement this DSM program. Note that several generic power plants (labelled A, B, C,...) are presented which reflect differences in heat rate and fuel sulfur content.

2. All of the values for avoided emissions presented in both tables include a 10% credit for DSM savings to reflect the avoided transmission and distribution losses associated with supply-side resources.

3. Various forms of power generation create specific pollutants. Coal-fired generation, for example, creates bottom ash (a solid waste issue) and methane, while garbage-burning plants release toxic airborne emissions including dioxin and furans and solid wastes which contain an array of heavy metals. We recommend that when calculating the environmental benefit for a particular program that credit is taken for the air pollutants listed below, plus air pollutants unique to a form of marginal generation, plus key land and water pollutants for a particular form of marginal power generation.

4. All the values presented represent approximations and were drawn largely from "The Environmental Costs of Electricity" (Ottinger et al, Oceana Publications, 1990). The coefficients used in the formulas that determine the values in the tables presented are drawn from a variety of government and independent sources.

*** Acronyms used in the table**

TSP = Total Suspended Particulates
NSPS = New Source Performance Standards
BACT = Best Available Control Technology

LESSONS LEARNED

It takes many years for the savings significance of the STPP to be fully realized: In order to effectively improve efficiency at the national level by replacing outdated expired refrigerator/freezers with highly efficient new technology, one has to work with the market for ten to fifteen years before any significant results can be demonstrated. NUTEK believes that the timing for their procurement was good but that it will take much more time before the full savings potential is realized. Even if Sweden doesn't go through with the phase out of nuclear power the program has shown how one can avoid building new capacity.[R#5]

Involvement of both large experienced buyers and consumer advocates smoothed the STPP process: The long experience of the HBV, which is the largest buyer of refrigerator/freezers in Sweden, and other large multi-family organizations has been of great importance to the program. Also access to The Swedish National Board of Consumer Policies' information and testing experience meant a lot.[R#4]

Participants for procurement efforts, what NUTEK calls "strong actors" can be found among both purchasers and producers but the secret to activating them lies in their common interest in energy as well as other issues: Many potential participants are interested in testing new processes. Their interest can be strengthened by giving them the opportunity to address other questions such as environmental issues. Both manufacturers and purchasers have mentioned that their children insist that they work at reducing the environmental impacts of their activities.[R#5]

It is important not to ask too much of the program participants: The participants in one procurement program may well be active participants in another. Because purchasers tend to be busy people and participating in a procurement program usually becomes a highly publicized ordeal, it is important not to involve a participant in more than one project at a time. This may mean that it will take considerably longer to realize all the potential savings from various procurements.[R#5]

It is rare for new ideas to be initiated by inventors: NUTEK has found that small modifications to existing technologies and combinations of existing technologies are more likely avenues toward advancement than totally new ideas presented by inventors.[R#5]

It is essential to make it easier for the consumer to make a choice: The Eloff labeling has helped in this regard and NUTEK expects the effects of this effort will also become clear after some time, say in the next 10 to 15 years.[R#15]

TRANSFERABILITY

NUTEK has been promoting the same technology procurement used for refrigerator/freezers in other areas such as, windows, high efficiency lighting, home washing machines, computer monitors, heat pumps for single family homes, industrial flow control systems, small solar appliances, electric vehicles, and high frequency lighting.

In the United States the Super Efficient Refrigerator Program (SERP) has had much success with transforming the market toward more efficient and CFC-free refrigerator/freezers. (See The Results Center Profile #106) In SERP's case there are two separate "buyers" groups: a group of 24 utilities committed to a $30,000,000 award to incent the manufacturer which won the RFP and the consumers in the service territories of those supporting utilities who are entitled to buy the efficient CFC-free refrigerators for roughly the same price as comparable models. With SERP, the manufacturer is incented on a per unit basis

and energy labeling has also been employed. The scale of SERP is much larger in that the winning manufacturer is committed to delivering 250,000 units by 1997, while with STPP, the winning manufacturer had an order from the buyer's group of roughly 600 units. In both cases the programs have clearly advanced technology and transformed the market, but it seems that perhaps the American manufacturers required a much larger incentive to become involved in the program, while in Sweden, manufacturers were interested in improving efficiency without large orders or incentives. In both cases the manufacturer assumed a certain risk in developing prototypes and new products but they also saw the opportunity to be at the leading edge of the new market if they were successful.

The Consortium for Energy Efficiency (CEE) located in Boston, Massachusetts, was deeply involved with the development of SERP and is now promoting similar programs for other technologies such as horizontal axis washing machines. CEE is now working with the U.S. Department of Housing and Urban Development, the New York Power Authority (NYPA), and the New York City Housing Authority (NYCHA) on a procurement effort whereby NYPA will purchase 20,000 efficient R/Fs for NYCHA each year for four years. The RFP calls for 14 ft^3 R/Fs with energy consumptions of 500 kWh or less in the first year down to 355 kWh per year in the fourth year. HUD, which pays NYCHA's energy bills, will reward NYCHA with money saved from verified energy savings from the R/Fs. NYPA is paying the total cost of the R/Fs other than the 6% financing charges. It is hoped that money from energy savings will be enough to cover NYPA's 6% financing charge. If that is possible, NYCHA will receive the R/Fs for free. CEE is working with utilities, to try to get them more involved in the program either through rebates or financing for customers, and it is working with other housing authorities, universities, and developers to try to solicit orders of 100 or more units to "piggy-back" onto NYCHA's order. Through this "piggy-backing" effort, CEE hopes to be able to bring the annual order for RFs up to 40 or 50,000.

There are clearly other opportunities for technology procurement, especially for government purchases, larger manufacturing ventures, in fact anywhere that a buyers group can be identified. (The Urban Consortium used a similar strategy to bulk purchase long distance telephone service for its large municipal members.) In order for procurements to be successful, the advantages of the new products must be clearly identified and verified. Even manufacturers who don't win the contract with the buyers group can benefit from the program's support and efforts at establishing a market for, and consumer confidence in, the new technologies.

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