

Energy-efficient windows: Technology procurement helps manufacturers and market meet

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1. SYNOPSIS

This paper describes how innovative technology procurement can be used to help manufacturers and market to meet, to the benefit of both.

2. ABSTRACT

A major part of the energy losses of a building occur through its windows. NUTEK¹, whose working objectives include that of promoting and improving energy efficiency, saw this as an area of major potential improvement, suitable for the objective of an innovative technology procurement competition for windows. The end purpose of the work was to introduce windows of substantially improved performance to the market at competitive prices. NUTEK invited a number of interested parties to form a purchaser group, and drew up a performance specification for the new windows. The most important of these was a U-value not exceeding 0,9 W/m², K, with a target value of 0,8 W/m², K. The next step was to invite leading window manufacturers to submit tenders in accordance with the specification. Manufacturers who had not been specifically invited to tender were also welcome to do so. Sixteen entries had been received when the competition closed. They were carefully evaluated, and the actual windows themselves were tested by the Swedish National Testing and Research Institute (SP). After evaluation and testing, three entries remained that had passed all the tests and met the performance requirements. After negotiations with the purchaser group and the three finalist manufacturers, it was decided that the first prize should be awarded jointly, to one Swedish and one Norwegian window manufacturer. The winners were then given a further two months for further development of their entries, after which mass production of the new windows was started. This meant that highly energy-efficient windows had been brought on to the market in the remarkably short time of somewhat over a year from announcement of the competition.

3. INTRODUCTION

The Department of Energy Efficiency (DOEE) is the unit within the Swedish National Board for Industrial and Technical Development (NUTEK) that is responsible for public technology procurement for energy-efficient products. In addition, the Department is also concerned with demonstration and market introduction of energy-efficient products within the four sectors of domestic, commercial premises, industrial and transport applications.

This paper describes NUTEK's technology procurement project for energy-efficient windows that was carried out between May 1991 and January 1992, together with subsequent developments up to the end of 1992.

In its reviews of energy efficiency improvement measures for the domestic sector, NUTEK had decided that a project aimed at reducing energy losses through windows was urgently needed, as much of the energy lost by residential buildings occurs through windows. Even with present-day good building standards, energy losses through windows are ten times as high per m² as losses through a corresponding area of wall. The Swedish Building Code (SBN 1980) requires a U-value not higher than 2,0 W/m², K for windows, 0,25-0,30 W/m², K for walls and 0,17-0,20 W/m², K for roofs.

The Nordic climate can be very cold during the winter, although problems of severe climate during the

summer are very few. Nevertheless, the windows in which this project resulted can find markets in many other areas outside the Nordic countries, such as central Europe, the USA and Canada.

In addition to substantially lower energy losses, the windows also significantly reduce noise, providing a further market for them in areas of heavy traffic.

The windows are suitable for use in all types of buildings, although primarily intended for residential applications. At present, the supply situation for residential buildings in Sweden is relatively good, and production of new homes over the next few years will be low in proportion to the total volume of residential stock. It was for this reason that the windows project was aimed primarily at the refurbishment market.

The competition was announced in May 1991, and the finished product, in the form of energy-efficient windows, was available on the market in June 1992. This must be regarded as an extremely short lead time for product development and market introduction of a product such as this.

4. THE COMPETITION

4.1 The purchaser group

One of the first tasks of a technology procurement project is to set up a purchaser group : in fact, this is of fundamental importance for the project. The duty of the purchaser group is to represent the market, both by defining the requirements that it expects of the particular product concerned and by the subsequent purchasing potential that it represents.

The members of a purchaser group must be in a position to further development, and be interested in doing so. They ought also to be well placed to influence other purchasers in taking an interest in the new product. In addition, it is important to select the specialists and experts who will be associated with the purchaser group with the greatest care. Besides NUTEK's own representative and the project leader, the purchaser group for the window competition included representatives for four large potential purchasers (among the largest property owners and managers in Sweden), experts in the windows sector and the testing of building products and an expert on technology procurement.

4.2 The performance specification

When the purchaser group had been formed, work started on drawing up a performance specification , (NUTEK/DOEE, 1991) setting out the performance requirements that the purchaser group expects of the new product. In addition, other requirements include those relating to participation in the competition, submission of entries, test procedures, possible premiums, commercial negotiations and evaluation.

As far as the various detailed performance requirements are concerned, it is important that they are not mutually incompatible. It is also important that the performance specification is expressed in as general terms as possible, so that the entrants can allow their ideas to range as freely as possible.

Technology procurement of windows for the next millennia specified requirements relating to many characteristics. First and foremost, the windows should have a coefficient of thermal transmittance (a U-value) less than 0,9 W/m², K. An additional premium was offered to all submitted entries that had a U-value less than 0,8 W/m², K. Various technical performance requirements were also specified, relating to aspects such as raintightness and airtightness, resistance to wind load, strength and stiffness, manoeuvrability and resistance to condensation. All these requirements were in accordance with Swedish Standard SS 81 81 03.

In addition, at least 65% of the total area of the window must be glass, with the thickness of individual panes not exceeding 4 mm. Daylight transmittance and solar energy transmittance were both required to exceed 60%. No changes in subjective experience of colour, as seen from the inside, could be accepted,

and nor could any optical distortion.

Other requirements related to low weight, good noise reduction, a guarantee time of at least ten years and a life expectation of at least 30 years. The overall thickness of the window was also specified in the requirements to maximum 140 mm. Also, the window had to be openable and accessible for cleaning from the inside of the building. Finally, the window should be ready for immediate production once the competition was finished.

4.3 The invitation to tender

When the purchaser group had agreed on the performance specification, it was time for the window manufacturers to start work on producing their entries. NUTEK issued specific invitations to take part in the competition to 14 of the larger and medium-sized manufacturers of windows in the Nordic countries. The group included manufacturers of windows with wooden, metal and plastic frames. At the same time, an open invitation was also sent out to all window manufacturers by means of notices in the general and the specialised press. The competition was therefore open to all window manufacturers having sufficient competence and production capacity.

The above invitations and notices were issued in the middle of May, 1991. However, the fact that the competition was to be arranged had been announced earlier; one of the occasions being at a seminar on windows in January 1991. This seminar had been arranged by one of the largest glass manufacturers in Europe, and had been attended by representatives of most of the Nordic countries' larger window manufacturers.

Together with performance specification documents, participants in the competition received the FRAME computer program for calculation of the U-value of windows (Frame, 1991).

4.4 Premiums

All entries having a verified U-value less than $0,9 \text{ W/m}^2, \text{ K}$ were promised a premium of about ECU 8.600:- (SEK 75.000:-), which would be doubled if the U-value was less than $0,8 \text{ W/m}^2, \text{ K}$. (The verification was made by the Swedish National Testing and Research Institute (SP).) In addition, NUTEK guaranteed sales of 5.000 m^2 of the new windows to the winner of the competition, with an option for a further 5.000 m^2 . 10.000 m^2 corresponds to approximately 1,2% of the total Swedish sales of windows in 1992.

Purchasers who installed the new windows in their properties were promised a marginal cost subsidy by NUTEK of a maximum of about ECU 57:-/ m^2 (SEK 500:-/ m^2) for orders for the first 5.000 m^2 . ECU 57:-/ m^2 approximately corresponds to the marginal cost of the new windows, compared to modern standard Swedish windows.

4.5 Evaluation of the entries

16 entries had been received when the competition closed in October 1991. After initial evaluation, nine of them were regarded as being of sufficient interest to request prototypes for physical testing by the Swedish National Testing and Research Institute (SP). Measurement of daylight transmittance and calculation of solar energy transmittance were performed at the same time by the University of Uppsala.

After comprehensive testing and evaluation of the nine prototypes, it was clear that three of them fulfilled all the requirements of the performance specification. At an early stage of the work it had also become clear that a further factor, Esthetics, not capable of quantification, would have a considerable effect on the outcome of the competition. An architect was therefore coopted to the purchaser group at the start of the evaluation phase.

5. RESULTS

Unexpectedly few novel technical designs or advances were received among the entries. Instead, most of them concentrated on improvements of the various constituent parts of the windows, although some new ideas, such as the use of plastic films, were discussed. More time to work on the designs, and/or more help for the manufacturers, might have resulted in a greater number of entries with more special features, although this is not certain. More information on e.g. the new Canadian spacers might have given a different result. However, the entries that were received complied with the performance specification while allowing the manufacturers to use their existing production facilities, which must be seen as a sensible and correct choice by the manufacturers.

5.1 The winners of the competition

After the technical evaluation, NUTEK entered into negotiations with the three window manufacturers whose entries had fulfilled all the performance requirements. The result was a decision to award the first prize jointly to two of the manufacturers, with an honourable mention to the third finalist. The winners were respectively one of the Nordic countries' largest window manufacturers, a window manufacturing company from Norway, and a medium-sized manufacturer from Sweden. The prizes were awarded in January 1992.

Both of the winning entries were based on the principle of linked casements, with four panes in the form of a triple-glazed sealed unit on the inside and a single outer pane (see figure 1 and 2). In addition, both had wooden casements with external aluminium cladding. The Norwegian window incorporated thermal breaks in both the frame and the casement, while the Swedish design had a solid wood frame and casements. The coefficient of thermal transmittance of the Swedish window was $0,73 \text{ W/m}^2, \text{ K}$, while that of the Norwegian window was $0,88 \text{ W/m}^2, \text{ K}$.

In its report on the results, the purchaser group stated that the design of the Swedish window had been well thought out (NUTEK/DOEE, 1992). It was pointed out that the window met not only the required U-value, but also the more stringent target U-value, that it was based on a well-proven design and that the position of the thermal insulation did not present any risk in respect of mixing materials having different characteristics.

In the opinion of the purchaser group, the Norwegian design was elegant, with an interesting new detail design of the positioning of the thermal insulation in the frame and casement.

5.2 Further development of the windows

As this is essentially a market project, and not an experimental project, NUTEK and the purchaser group wanted further to investigate and develop some elements. These were to reduce weight, to increase daylight transmittance, to eliminate moisture risks and risks of external condensation and to perform additional tests of noise reduction. In order to do this, each of the winners received the following support from NUTEK:

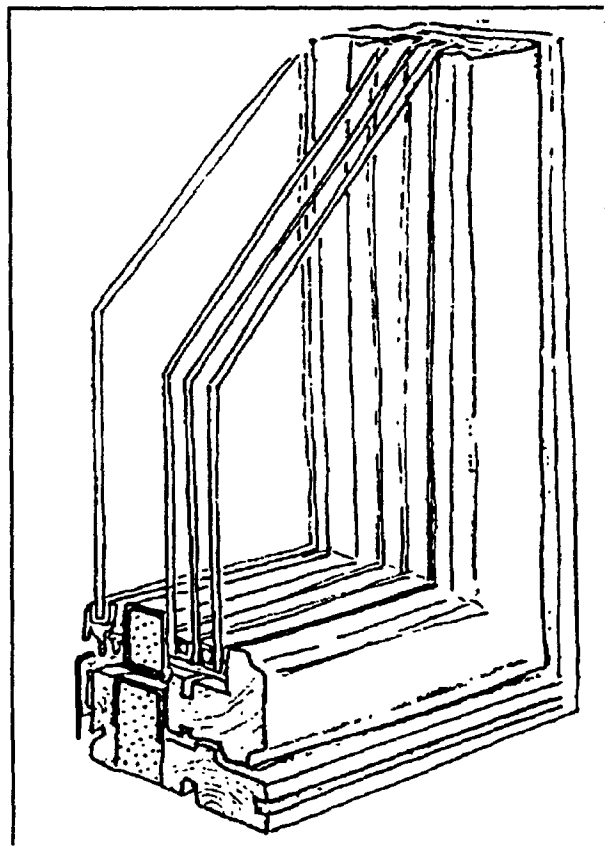


Figure 1. Perspective view of the winning Swedish window

- a development grant of about ECU 17.200:- (SEK 150.000:-)
- help with using the FRAME computer program to calculate U-values
- help with additional measurement of daylight transmittance
- ECU 57:- (SEK 500:-) per m² of window delivered, as a subsidy to the purchasers of the first 2.500 m².

This resulted in a number of minor adjustments to the designs, with final performance parameters as shown below.

Windows with these characteristics were introduced to the market in June 1992. This lead time, of just over one year, must be regarded as very short for a product development and market introduction such as this.

Development of the windows has not stopped, however. Both the Swedish and the Norwegian manufacturers have continued to develop their designs, and other window manufacturers are following in their footsteps. The new windows are now also available in a triple-glazed (2+1) version.

It may seem strange that the triple-glazed window has better noise reduction performance than the quadruple-glazed design, but this is due to the absence of resonance in the centre pane in the sealed triple-glaze in the quadruple-glazed design.

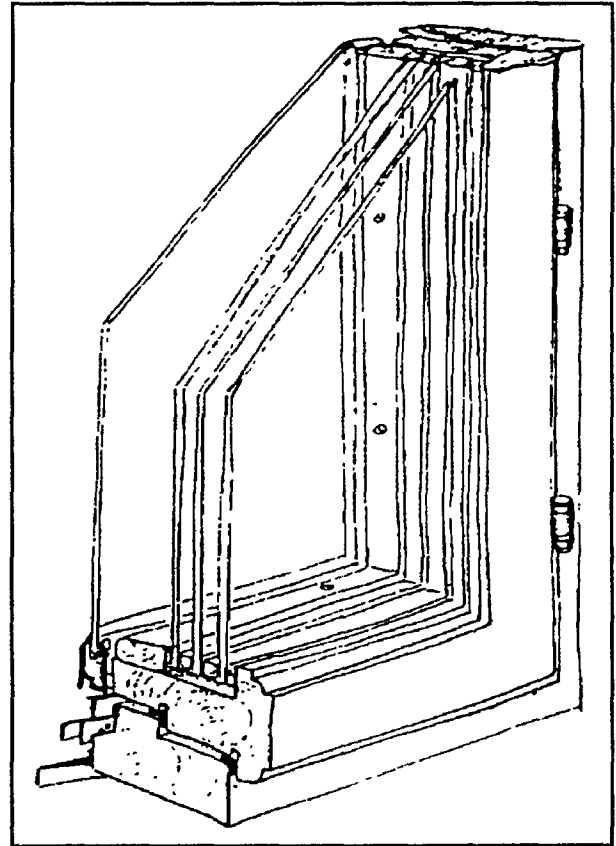


Figure 2. Perspective of the winning Norwegian window

5.3 Windows already installed

The new windows have already been installed in a number of developments in Sweden, both for new buildings and for retrofits. To date (January 1993), a total of about 7.000 m² of windows of this type has been installed. NUTEK's list of purchase option subsidies indicates the possible sales of at least a further 10.000 m² of windows have been indicated. Subsidies will be given to maximum 10.000 m² windows.

5.4 Difficulties in planning and implementing the project

A technology procurement project cannot be described as a linear function or as a straight-line process from A to B. The project develops and changes all the time as a result of new factors and new problems constantly occurring. In the window project, for example, it was suddenly found that the weight and daylight transmittance of the windows were critical, after which fire protection aspects had to be considered. Carrying out a project of this type requires a considerable degree of flexibility and a willingness to embrace new aspects. This in turn requires sound financial backing of the project and resilient project management.

Simply assembling the purchaser group, as described in §4.1, is a demanding task. In addition to the points described above, a further three aspects affecting the purchaser group are of importance: 1) It is important to ensure that the purchaser group really does intend actually to order the new product; 2) It may be difficult to keep the purchaser group focused on the main purpose throughout the project, and 3) It is important that the experts in the group are up to date in respect of developments in the field concerned in other countries.

Table 1. Final performance parameters of the winning windows

	Glazing	Weight [kg]	U-value [W/m ² K]	Daylight transmittance [%]	Noise reduction [dB]
Swedish	3 + 1	56,5	0,88	60,6	37
Norwegian	3 + 1	54,0	0,86	60,0	37

As mentioned above in §4.2, it can be difficult to formulate the performance specification so that there are no mutually incompatible requirements, and also to specify the required performance without detailing how it is to be achieved. It is also difficult to foresee all the problems that can arise in connection with evaluation. For example, in this project it had not been realised how difficult evaluation of the Ésthetic aspect would be.

It is also important that there should be sound knowledge of measurement of quantifiable factors and experience of earlier product designs. This facilitates dealing with the unexpected during progress of the work.

In general, the window manufacturers had little experience of computer calculations. This resulted in some problems with the U-value calculation files using FRAME that had been called for from the manufacturers. Many of the entrants had far too often assumed stationary air in the designs when making their calculations.

5.5 Responses of various parties

5.5.1 NUTEK

It was not entirely clear for other parties involved why it was NUTEK that was the driving force behind this project. However, if a technology procurement project is to be operated, an impartial and financially sound party (or agent) is required. This party shows the other parties involved that there is a demand for the product as well as the necessary competence and capacity to carry out the project. NUTEK was a new participant in the windows sector, and new participants in any established situation are always regarded with caution.

5.5.2 The window manufacturers

On the basis of the results of the project, it seems to be important as to whether it is management or the technical development department of a window manufacturer that engages itself most strongly in the competition. The manufacturers where management were engaged put more effort in making a good result in the competition. It can also be noted that in no case did the shareholders involve themselves directly in the competition.

The window industry is, like the rest of the building sector, conservative in its ways. It was therefore not entirely surprising that, initially, the manufacturers seemed uninterested in the competition, claiming that there was no market demand for such windows. However, interest gradually increased as time went on, resulting in 16 entries by the time that the competition closed.

It could also be noted that, at first, it was the manufacturers of plastic windows who seemed to be more

interested in the competition than the manufacturers of traditional wooden windows. In addition, there also seemed to be a tendency among the Swedish manufacturers for the medium-sized companies to be more prepared to go in for this type of product development than are the larger companies.

5.5.3 Trade associations

Working with trade associations in projects of this type is not always the best way forward. It is possible that this is a Swedish peculiarity, although NUTEK has encountered similar problems with trade associations in the other technology procurement projects that have been operated. It is important not to regard the trade association as the primary partner, as it does not have the operative power. Instead, it is the manufacturers and purchasers who should be regarded as the most important.

5.5.4 The glass manufacturers

Of the larger glass manufacturers, it is primarily one which actively disseminates knowledge and attempts to interest window manufacturers in energy-efficient windows. This manufacturer has already previously attempted to persuade the window manufacturers to start producing high-performance windows with reduced energy losses, and some of the success of the competition must be ascribed to this groundwork.

The entries received incorporated the products of only two glass manufacturers. This is probably due to the fact that the market for glass is divided up among the larger glass manufacturers. For obvious reasons, the glass manufacturers are not exactly enthusiastic about the designs that incorporated intermediate films of plastic instead of glass.

It is also worth noting the reactions that occurred in the final stages of the project when the window manufacturers tried to obtain 3 mm glass with low-emission coatings. One of the glass manufacturers stated that it could not supply such a product as it was against company policy. However, the company

Table 2. Further development parameters of the winning windows

	Glazing	Weight kg	U-value [W/m ² K]	Daylight transmittance [%]	Noise reduction [dB]
Swedish	2 + 1	50	0,98	63,0	41
Norwegian	2 + 1	50	0,98	65,0	41

changed this later, saying that it could be supplied if a sufficiently large order was placed, but that the glass would be about 10% more expensive than the corresponding 4 mm glass. Another supplier stated that it supplied 3 mm coated glass at the same price as 4 mm coated glass, while a third glass manufacturer said that it willingly supplied 3 mm coated glass, at a price 10% less than its 4 mm coated glass.

5.5.5 Other sub-contractors

Of the other sub-contractors, it was only the manufacturers of the sealed glazing units who had anything to say. They pointed out the increased risk of breakage of 3 mm glass.

5.5.6 The purchasers

The present economic recession makes it difficult to determine the true level of interest in the new windows. Many building projects have been halted at a relatively late stage as a result of the recession. Several builders, window manufacturers and others in the building sector have gone out of business or been forced to contract drastically over the last two years. As far as the window manufacturers are concerned, demand has fallen from 2,5 million m²/year to 800.000 m²/year during the same period.

Nevertheless, demand for the new windows is relatively substantial. The 5.000 m² of windows for which purchasers received a subsidy have long since been sold. With few exceptions, the purchasers at the large building companies are generally favourably disposed. Their interest is due largely to the fact that total production costs for new buildings are reduced, as the improved windows allow them to dispense with, or at any rate significantly reduce, radiator heating systems, combined with noise in busy areas becoming less of a problem.

One of the larger projects with the new windows that has already been completed is a conversion project in Västerås, involving installation of over 3.000 m² of windows. Together with other measures, this has cut energy use by half. Previously there were water radiators beneath each window, but after conversion there are only convector heaters in the halls and bathrooms of the apartments. The use of the new windows was a prerequisite for the new system to work. The new windows eliminate the problem of cold draughts and radiation draughts from the windows, thus allowing radiators to be dispensed with.

Another project in which the windows will be installed is for a larger Swedish hospital. In addition to the benefits of no draughts or radiation draughts, it is expected that the indoor climate will be greatly improved through elimination of the dust that normally collects on radiators. An additional benefit will be that cleaning will also be easier.

However, there are also purchasers who are not in favour of the new windows, one of whom is unfortunately a member of NUTEK's purchaser group. Despite the fact that the company's representatives helped to specify the windows, it has not been possible to get the company to commit itself to their use.

5.5.7 Architects

In general, architects have a weaker position in Sweden than in many other countries. Swedish architects are seldom involved in an entire building project right from the start until completion. Instead, their role can best be described as that of an *Êsthetic* designer of buildings, with the rest of the work being dealt with by the building and structural engineers and other parties.

Architects' interest in the new windows has changed as the project progressed. Initially, many architects reacted adversely and in a directly reactionary manner, as a result of fear of the new and of technically complicated designs. Others were simply disinterested. As time went on, tentative exploratory feelers were put out, and there is now considerable interest among architects in new knowledge of windows.

NUTEK invited a number of architects to produce proposals for how the new windows might best be used. In addition, NUTEK has also produced a guide that deals with technology, comfort, energy and cost considerations when deciding on the types of building services systems and energy-efficient windows. The guide is now spreading the message among architects and consultants (NUTEK/DOEE, 1992a).

5.5.8 Public authorities

The three major political parties in Sweden have a tripartite accord, the content of which ought to mean that it should be natural for other governmental parties and regulations to facilitate introduction of the new windows. Those most directly affected are the National Housing Board, the New Building Regulations and the mortgage regulations.

Mortgage regulations will in the future take account of the potentials of the new windows. This will be done by grading the amount of money that can be borrowed as a function of the U-values of windows,

down to a value of 1,0 W/m², K. However, as yet, the National Housing Board and the New Building Regulations (BFS 1988:18) have not adjusted their rules to suit, although this can perhaps be explained as natural lag.

5.5.9 The press

The press (both the daily press and the specialised press) has played an important part in NUTEK's technology procurement of windows. Information has constituted an active part of the marketing of the project, and NUTEK expended considerable effort in getting its message out via the press. The result was successful, and much was written about the project, both while it was in progress and after the awards. Radio and television have also covered the subject.

5.6 The expected energy and economic impact of the programme

It is difficult to calculate the total potential of a project such as this. As mentioned above, the market for windows has contracted by two-thirds in two years, from 2,5 million m² per year to 800.000 m² per year. The proportion of new building has fallen, while the proportion of rebuilding and refurbishment has increased. Sweden faces an extensive programme of refurbishment, as the Million New Homes² that were built in the 1950s and 1960s are in significant need of refurbishment. In the long term, NUTEK expected a potential market for the new windows of half the refurbishment projects, i.e. amounting to some hundreds of thousands of square metres per year.

In financial terms, the new windows result in lower total building costs for new production and for extensive refurbishment, despite the fact that they are approximately 25% more expensive than standard windows.

In terms of an individual window, the energy saving amounts to 60% in comparison with the performance of a window with a good new building standard (U-value of 1.8 W/m², K). In the Västerås refurbishment project mentioned above, total energy use was halved, although some of this was due to other energy conservation measures (The Västerås Project, 1992).

It is important to emphasise that technology procurement and market introduction of new products is not a self-powered process. It is necessary to link development and marketing very closely.

5.7 Financial aspects

NUTEK's total commitment to the project was about ECU 345.000:- (SEK 3 million). Of this, about ECU 230.000:- (SEK 2 million) were used for the technology procurement itself, and about ECU 115.000:- (SEK 1 million) for implementing and developing the project on the system side.

It should be pointed out that most of the emphasis has been on coordinating, organising and planning the project, and not on distributing ECU 57:-/m² (SEK 500:-/m²) for high-performance windows. An interesting comparison can be drawn with the technology procurement project for auto power-down computer monitors that NUTEK has also carried out. This project would have been able to carry out without any financial inducements for the end product, only planning and coordination was required.

5.8 Market prospects

NUTEK expects that when the recession finally turns, there can be a potential market for the triple-glazed variant of the new windows amounting to some hundreds of thousands of square metres per year. During the next few years, the main market will probably be for refurbishment in the Million New Homes². This potential has been estimated on the basis of NUTEK being able to reach and influence important parties in the form of the large housing companies, which should provide favourable conditions for a successful outcome.

Many Swedish local authorities already have local building regulations governing noise reduction, permitting indoor noise levels of not more than 35 dB. In addition, the Government is also preparing a bill concerning noise reduction. This will also be a factor in favour of the new windows. Their good noise reduction performance must also be a useful sales argument in other countries.

As a result of the substantial fall in demand, there is now a tendency among the window manufacturers to compete with cheap and simple windows. This has also been affected by changes in the mortgage and grants regulations, so that it is now no longer so attractive for property-owners to carry out long-term rebuilding measures.

An evaluation performed by an independent marketing consultant noted that NUTEK's technology procurement had effected a breakthrough, in that the two winners are now no longer alone with their products. Four or five window manufacturers will be exhibiting high-performance windows at a fair to be held in Gothenburg in January 1993.

6. CONCLUSIONS

NUTEK's window technology procurement project must be regarded as successful, with the result that high-performance windows are now available on the market, with U-values of $< 0,9 \text{ W/m}^2, \text{ K}$ for quadruple-glazed versions and $< 1,0 \text{ W/m}^2, \text{ K}$ for triple-glazed versions. The new windows have already been installed in a number of buildings.

The new windows result in lower total building costs, despite the fact that the windows are more expensive than similar windows of good new building standard. This is because the heating system in the building can be substantially simplified, as no radiators are needed beneath the windows to eliminate cold draughts or radiation draughts.

From a methodological viewpoint, the project management team in the windows project benefited from the experience being obtained from NUTEK's high-performance refrigerator/freezer project, that was running somewhat ahead of the windows project.

Bearing in mind the present depressed state of the economy, the demand for the new windows must be regarded as good, and can be assumed to improve when building again picks up in Sweden.

6.1 Lessons learned, and recommendations for assimilation of the work in other countries

It must be pointed out that a technology procurement project cannot be described as a linear function or as a straight-line process from A to B. The project develops and changes all the time as a result of new factors and new problems constantly occurring. Carrying out a project of this type requires a considerable degree of flexibility and a willingness to tackle new problems. This in turn requires sound financial backing of the project and resilient project management.

In addition, it is important to bear in mind that a technology procurement project is essentially a marketing project, and not an experimental development project. The objective is to result in the development of good-quality marketable products.

It is important for the results of a project of this kind that there are established methods of testing, and that the tests are carried out by an impartial testing laboratory. In addition, knowledge of other measurements and tests that might be needed is required. Long-term experience, too, of earlier product designs is an important asset for the work.

Measures are needed for the stimulation of demand and to get the manufacturers to believe in the demand. It is important to establish mutual trust between manufacturers and purchasers. It is also important for the purchasers to realize that they really can influence the end product through a project of this type, and that

they thereby bear some of the responsibility towards the manufacturers.

It takes time to build up demand for a new product. A successful technology procurement project requires persistence.

Competitions of this type should not be limited only to companies in the host country. Instead, they should be brought to the notice of companies throughout the world. There are two important reasons for this: 1) helping to prevent the establishment of cartels, and 2) providing fast-track access for fresh ideas to the country's own manufacturing base.

Spend time finding out what is being done in the field concerned in other countries. As far as windows are concerned, several projects are under way in countries such as Switzerland, Canada and the USA. NUTEK's Department of Energy Efficiency is always willing to work with other organisations on new projects, whether in the field of windows or in other areas.

Always work directly with those having the decision-making power, on both the manufacturers' and the purchasers' sides. Avoid representative associations as far as possible.

A technology procurement project needs a live-wire and involved project manager if the best is to be obtained from it.

On the whole, window manufacturers seem to be poor at marketing, which may possibly be due to the conservatism of the sector. In Sweden, the medium-sized manufacturers seem to have a more flexible organisation than the larger manufacturers, and are therefore more inclined to consider new products.

There is a fundamental difference in approach between technology procurement and supporting a particular project, a particular company or an individual research worker. This second approach seldom results in any breakthrough for the project, and so it can be seriously questioned if there is any point at all in working in this way. Technology procurement generally results in a significant step forward, as well as being financially more effective, and is therefore to be preferred as a working method.

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END NOTES

1. NUTEK - the Swedish National Board for Industrial and Technical Development. (Department of Energy Efficiency, DOEE.)
2. The Million New Homes programme. In the 1950s, the Swedish government decided to tackle the country's serious housing shortage (particularly in the major urban areas) by building a million new homes in ten years.
3. Conclusions and reasoning in this paper are those of the author.
4. An exchange rate of SEK 8:74 = ECU 1:00 (the six-monthly rate as of 1993-01-15) has been used.

REFERENCES

FRAME. 1991. "FRAME computer programme for calculation of the U-value of windows." Canada, 1991.

NUTEK/DOEE. 1991. "The low-energy noise-reducing window: innovative technology procurement -the window for the 21st century." Invitation to tender, May 1991. NUTEK/DOEE, Sweden.

NUTEK/DOEE. 1992. "Technology procurement of high-performance windows." NUTEK/DOEE, Sweden, May 1992. (In Swedish.)

NUTEK/DOEE. 1992a. "New potentials for building services systems and energy-efficient windows: a guide to technology, comfort, energy and costs when deciding on building services systems and energy-efficient windows." The Apartment Building Theme: NUTEK/DOEE, Sweden, 1992-12-23. (In Swedish.)

The Swedish Building Code, SBN 1980, 2nd edition, PFS 1983:2. Sweden. (In Swedish, summary in English.)

The Västerås project. 1992. "From The Million New Homes programme to an Environmental programme. Sweden" (Pamphlet, in Swedish.)