AIR

Swegon Air Academy

Part B

Economic and social responsibility

DUNCAN:
THIS
CASTLE
HATH
A PLEASANT
SEAT;
THE
AIR
NIMBLY
AND
SWEETLY
RECOMMENDS
ITSELF
UNTO
OUR
GENTLE
SENSES

[William Shakespeare *Macbeth*]

CONTENTS

FOREWORD

Our need for fresh air, essential to our functioning as human beings, is not normally contested by anyone. This is because we have basic physiological needs - om brains and the cells in our bodies need oxygen so that they can develop and perform properly. However, the air we breathe contains more or less harmful substances and these cause more problems than most of us can probably imagine or understand. On their own, these substances might be troublesome - but collectively, they could be disastrous! Remember, that while we need about 0.75 kg of food and about 1.5 kg of liquid per day, we need at least 15 kg of air!

It is quite reasonable to compare an air handling system in a building to our own respiratory system with its airways and lungs, as both systems have enormous significance for our health and well-being. And, as the air is often used to supply or remove heat, this makes the importance of the air handling system even greater, as it significantly affects our comfort, well-being, productivity and efficiency. Buildings, too, need a continuous change of air to feel good.

LACK OF COMMON POINT OF VIEW

Bearing in mind all of the above, it is rather odd that those involved in lanning a building rarely see things from the same point of view. Short-term economic interests ~re often allowed to determine the choice of technical solutions and, when costs are not critical, buildings are all too often designed in such a way that they are neither pleasant to occupy nor energy-efficient. And, up to now, it has been rather difficult to acceptfeedback and learn from expensive mistakes, and thereby avoid repeating them.

PUBLIC HEALTH, ENERGY AND ENVIRONMENTAL ISSUES - AND ECONOMIC REALITIES

This book focuses on three main areas: Public health, energy and the environment. We are also convinced that economical aspects must be considered as well and this is a recurring topic throughout the book. No matter how efficient and health-promoting an investment might look, it would most probably never be carried out if it were not shown to be economically viable. Today, reliable research results show that there is a clear connection between poor indoor climate and ill-health. And ill-health costs a great deal of money. In other words, there is a real incentive for property owners to invest in good indoor climates now, as future tenants will almost certainly step up their demands.

CONTROL, REGULATION AND MONITORING - THE DECIDING FACTORS

In this electronic age, it is becoming increasingly obvious that control, regulation and monitoring will play a decisive role when it comes to maintaining good indoor climates and ensuring energy-efficient operation of buildings, with subsequent minimal impact on the outdoor environment. The importance of providing solutions that give the clientmaximum freedom of choice and flexibility is illustrated in Chapter 31/The intelligent building- a matter of choice, which discusses centralized building management systems, so-called BMS systems, for control, monitoring and management.

COMPLEX RELATIONSHIPS

- SIMPLE EXPLANATIONS

In this book, *Swegon Air Academy* has compiled ideas and points of view from a wide range of experts. The aim of the book is to put a spotlight on factors and circumstances that are important in the quest for pleasing - indoor environments and comfortable indoor climates, with due regard to energy issues and the outdoor environment. Our ambition has been to explain complex relationships in an intelligible way. It is our profound belief that it is possible to radically improve poorly functioning systems - if we can explain the whys and wherefores.

The passage of air through an air handling system is described, from the outdoor air intake, via an air-conditioned room and into our lungs, with a full account of what happens on the way. The physiological aspects, as well as the comfort, energy and environmental aspects, are examined. How different building designs affect the opportunities for creating good indoor climates is also discussed. Here, the effects that different factors have on each other are not always self-evident or discernable, nor are their specific effects on the indoor climate and total costs. We have, therefore, chosen to illustrate a number of them in greater detail and hope that this will contribute to future developments, for the benefit of all concerned.

TARGET GROUPS

This book is intended not only for clients, property owners and engin-eers, who can influence the design, layout and indoor climate of a build-ing, but also for everyone who would like to learn more about the air we breathe and how it affects us.

Increased insight will make it possible to avoid unnecessary costs, both in the investment stage and in the operational stage of a building project. Attractive premises are a must for survival on a competitive property market.

THE AUTHORS

This book blends theoretical knowledge from the academic world with practical market experience. Our ambition has been to portray the present-day situation and the opportunities in store in an objective and unprejudiced way, by engaging highly distinguished experts and writers from a representative cross-section of the industry.

Proceeds from the sales of this book will be reinvested in the activities run by *Swegon Air Academy*, i.e. in objective transfer of know-how and exchange of information via seminars, technical articles and publications. The contents of this book are available to schools and training programmes connected to the heating and ventilation industry at a subsidized rate.

Enjoy the book!

CONNY NILSSON
Director of the *Swegon Air Academy*

[AIR *Swegon Air Academy*]

PART A VENTILARE NECCESE EST...

PART B ECONOMIC AND SOCIAL RESPONSIBLITY

PART C THE ENERGY AND OUTDOOR ENVIRONMENT

PART D THE INDOOR ENVIRONMENT - IN A WIDER SENSE

PART E AIR TREATMENT AND INDOOR CLIMATE

AIR

Swegon Air Academy

Part B

Economic and social responsibility

B. ECONOMIC AND SOCIAL RESPONSIBILITY
CONNY NILSSON *Swegon Air Academy*

The work undertaken to create a comfortable, energy-efficient building with a good indoor climate involves numerous players. However, when it comes to the building services installations, focus is all too often on the initial price tag - despite the fact that it would be better to pay more attention to the operating costs. The reasons for this are reasonably straightforward: a developer finances the construction of a building but someone else is responsible for the future running costs. Unfortunately, suitable methods are seldom available for appraising the factors that influence life cycle costs, i.e. the costs that ought to be used as a basis for investment decisions. And this is a situation that is frequently seen, even in large companies and at national and municipal levels. Investment budgets and operating budgets are, in many instances, two quite separate entities. The person responsible for the investment budget is given a pat on the back at the end of the year, if there is still any money left, while the person in charge of the operating budget has to fight against unnecessarily high running costs, year after year, because of earlier, onesided focus on the investment costs.

If we take note of the ongoing debates in the media and, not least, the contents of this book, it is clear that we all have a joint responsibility when it comes to using no more energy than is absolutely necessary. It is not only a question of individual or company concern - it is a question of each and everyone's economic and social responsibility. It is hardly regarded as being progressive when more laws, standards and regulations are called for, but we have to ask ourselves whether changes in the right direction could come about in any other way.

For each company involved in the construction of a building, their own profitability is a strong driving force and this is quite understand-able. One way to tackle the issue - possibly utopian - would be to create a joint venture model based on the most reasonable solution, from an overall economic point of view, and then devise acceptable incentives for all involved to ensure strict adherence to the model.

In this part of the book, the need to regard contracts from a more holistic perspective is discussed, as well as whether laws, standards and established practice contribute to development - or stand in its way.

3. ECONOMIC CONSIDERATIONS IN NEW BUILDING AND RENOVATION PROJECTS

CONNY NILSSON *Swegon Air Academy*
Professor Emeritus ENNO ABEL
CIT Energy Management AB, Gothenburg

Although the discussion in this chapter is essentially applicable to complete projects, for either individual buildings or whole development schemes, it has been limited to issues arising around building services engineering – with special reference to air handling systems – as this is the primary topic in this book.

NEW BUILDINGS AND RENOVATION – BASIC DIFFERENCES

When new buildings and renovation projects are discussed it must be noted that there are vast differences in the conditions under which the work is carried out. When new buildings are planned and built it is assumed that they will be functional for a considerable period of time and at least 40 to 50 years. This would normally justify investments in high quality and good energy efficiency. On the other hand, a renovation project often entails upgrading a building to an acceptable standard, so that it can be used for a further number of years. It could even be a question of giving it a state-of-the-art standard, with the same technical and functional requirements as a new building. This difference in ambition will undoubtedly affect the extent to which new building services installations are considered acceptable.

ENERGY-EFFICIENT SOLUTIONS – NOT LEAST FOR THE SAKE OF THE ENVIRONMENT

It ought to be quite clear to most people today that priority must be given to energy-efficient solutions. The easily accessible and relatively cheap energy resources that we often take for granted will not be available in the future – and even if they were, we must still use them with the utmost care so that our outdoor environment is not subject to even more damage.

In many instances, a building is built with the aim of selling it as soon as it has been completed. In speculative building like this, it has all too often been seen that the building services have been chosen depending on their cost at the time of the initial investment. The client has quite simply chosen to do as little as possible and, in practice, placed all responsibility on the shoulders of the buyer or user. It has often been more profitable to spend money on an attractive entrance hall than on energy-efficient HVAC equipment. This is very alarming, as it is often extremely difficult to upgrade or replace an HVAC solution that is uneconomical from an energy use point of view. The EU directive on energy performance in buildings stipulates that all buildings that are built, renovated or sold must have an energy performance certificate. It has been reported from France that this has already had an effect on the price of buildings with poor building services solutions, while buildings with good and energy-efficient solutions are becoming more attractive and therefore increasing in value. Let us hope that this means that only good solutions will be used in the near future – even when building speculatively and in other countries in Europe.

When clients invest in new buildings for their own use it is often easier to convince them to choose high quality solutions with low energy demands – quite simply because they will have to pay for the running and maintenance costs themselves. Even here, however, there are instances when only semi-rational decisions are made. The budgets for investment and running costs are often two quite separate entities, which often leads to clients yielding to temptation and choosing cheaper solutions that could require more energy. The person responsible for investments will get a pat on the back and perhaps a bonus for not spending the entire budgeted amount. Keeping to the budget for running costs will, on the other hand, not be so easy, as the HVAC equipment will be inefficient and require far more energy than budgeted for. This means that it will be forced to operate at higher loads and will have a shorter operational life. How can progress and real differences then be made when it comes to the use of energy? Can this be achieved by any other means than intervention at government level, so that suboptimization can be avoided?

AIR HANDLING SYSTEMS GENERALLY REGARDED AS LOW STATUS

Having a heating system, functional lighting and domestic hot and cold water systems is so basic that no one today would even consider questioning them. However, when it comes to ventilation and air handling, opinions do, unfortunately, differ. This could be because air cannot be seen and is, perhaps, expected to be readily available without any special measures being taken. A number of the chapters in this book point out the importance of the indoor air with respect to health, well-being and productivity. The air handling system that is selected has a considerable effect on the cost of energy and, consequently, on the total economy of a building, and this is also illustrated in a number of the different chapters in the book. It is, therefore, hard to understand why this perhaps most important feature in a building has such low status. There are, of course, many clients who have very good insight into the matter and understand the significance of an air handling system. The choice of system and overall solution, however, have far greater effects on the economy of a building than many clients are, presumably, willing to admit.

The discussion below concerning economical aspects is mainly based on the chapter about energy efficiency in "Buildings and Energy – a systematic approach" [Abel and Elmroth, 2007].

RESOURCES VERSUS SAVINGS

If a decision has to be made about whether a future reduction in energy use can justify the resources used to achieve it, it must be possible to compare future energy savings with the consumption of materials, use of energy and work involved at the time of the investment.

From an environmental point of view, the most comprehensive way is to use the Life Cycle Assessment, LCA, method, which means that all environmental consequences are forecast and compared. Human work is not normally included, as this is not considered as something that, in itself, affects the environment.

The purpose of an LCA model is to provide a total picture of how the environment is affected by different processes. The production, use and demolition of a building are typical processes.

It is therefore possible, at least theoretically, to use the LCA method to study different alternatives and to choose the one with the least environmental impact. An analysis takes a great deal of time and it is not easy for someone who has not participated in the work to see what actually lies behind the results obtained. It is also difficult to avoid a certain degree of subjectiveness and this is why it is often difficult, in practice, to apply the method to a building.

A simpler method of assessment is to carry out an analysis based on one or two specific and environmentally harmful emissions. For example, the emission of carbon dioxide is often used when evaluating power generation and industrial processes. Here, the results are unequivocal and fully comparable. However, only one single aspect of the impact of the process on the environment is investigated.

RESPONSIBLE ECONOMIC DECISIONS

A practical way to determine the energy efficiency of solutions and measures applied to buildings is to use their economic values and recognized economic models. An economic evaluation is not a true environmental assessment. In practice, however, costs for resources and energy are connected to the environment, among other things via regulations and taxes that are motivated for environmental reasons. One of the differences between an environmentally based evaluation and an economic evaluation is, as mentioned above, that the environmental evaluations do not normally include human work, whereas economic evaluations do. An economic evaluation is simple and easy to follow and is related to the realities experienced by property managers. This type of evaluation is the one that is commonly relied on in practice and is therefore discussed in the following.

It is important to remember that an economic assessment means that only factors that can be expressed in economic terms are taken into consideration. If, for example, windows are to be replaced in an existing building, it is often just as much a question of comfort as of reducing energy costs. There could be good reasons for replacing the windows, even if it were not economical in a pure comparison of energy gains and cost of replacement. When looking at this from an economic point of view, the value of upgrading the comfort level should be estimated and added to the value of the energy gains, after which a comparison with the cost of changing the windows can be made.

An economic assessment is not always a sufficient basis for a wise decision about improvement measures. However, an economic assessment of a measure that is being taken solely for energy reasons is a great help when it comes to ensuring that the resources to reduce energy use are employed efficiently. It is therefore important to know what an economic assessment entails and the consequences that the different choices of input data have on the results obtained.

ECONOMIC EVALUATION

In order to decide whether an energy solution or an energy-saving measure is economically viable and realistic, the future energy savings are compared to the cost of the measures required to achieve them. This is a fundamental principle for all types of investments that lead to future savings. It is also necessary to determine whether the measures under investigation will have any indirect effects on the heating or cooling requirements in the building. For example, the installation of energy-saving light fittings will also affect the heat balance in the building, in addition to the direct use of electrical energy.

In the following, a number of important and especially useful methods for the economic assessment of measures taken towards improving energy efficiency are discussed.

A comparison between an investment made now and the subsequent future economic gain can be calculated in two different ways:

- The values of the future gains are recalculated so that they can be expressed as a single amount at the time of the investment. This present value is compared to the investment made.
- The investment is expressed in terms of future annual costs and compared to the expected annual gains.

The calculations are carried out using an assumed interest rate. The level of the rate is an expression of how future gains are valued when compared to having access to a capital sum today. If it did not matter whether a certain sum were available today or whether the sum were available, for instance, in ten years time, then the interest rate would be 0%. If, on the other hand, the availability of capital today is important compared to its availability in the future, then the interest rate should be high. A normal interest rate for the purpose of calculations could be the present loan rate plus an additional percentage that reflects the investor's financial situation in general.

If an amount b is saved every year for n years, then the accumulated value of all these amounts at the beginning of the first year, their present value B_0, is:

$$B_o = \left(\frac{1-(1+r/100)^{-n}}{r/100}\right) \cdot b = I(r,n) \cdot b \qquad (1)$$

where $I(r,n)$ is the present value factor for an annually recurring amount at an interest rate of r over a period of n years.

It is also possible to calculate the present value factor for a single amount saved in N years time, I_c (r,N)

$$I_c = (1+r)^{-N} \qquad (2)$$

If an amount A_0 is invested, then the yearly capital cost a during the next n years will be:

$$a = \left(\frac{r/100}{1-(1+r/100)^{-n}}\right) \cdot A_0 = P(r,n) \cdot A_0 \qquad (3)$$

where $P(r,n)$ is the annuity factor at an interest rate r over a period of n years.

Present value factors and annuity factors can be found in numerous books, in calculators and in computer programs for financial calculations. Figure 1 shows present value factors and annuity factors and how they vary with interest rates and time.

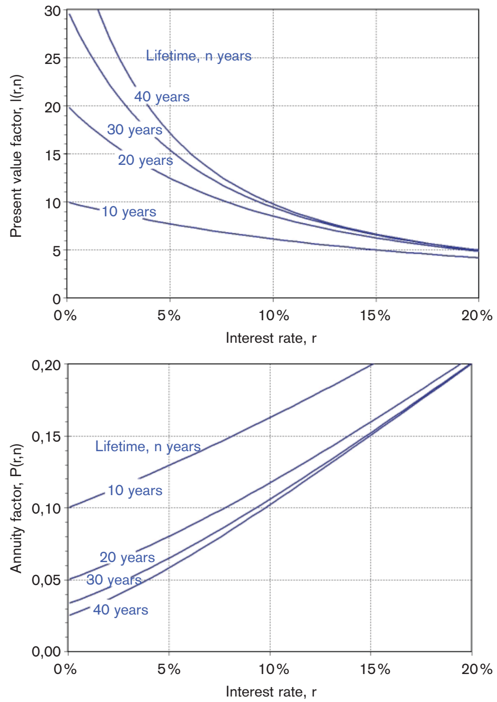

FIGURE 1. The variation of present value and annuity factors with interest rates and time.

It can be seen that the assumed interest rate strongly affects both the present value factor and the annuity factor. The results of a comparison between an investment and future savings is completely dependent on the assumed interest rate. In practice, it is not possible to assess the profitability of an investment without knowing the exact interest rate that has been used for the calculations.

It can also be seen that the effect of the calculation period is less, the higher the interest rate becomes. A low interest rate promotes long-term investments, even if the gains are low. High interest rates promote investments with high profits, even if the calculation period is short.

If the rate of inflation is assumed to be the same for all items in an economic assessment, then it can be ignored. If, on the other hand, one of the items can be presumed to have a different cost trend than the average rate of inflation, this must be taken into account.

An assumption regarding future relative changes in energy costs in a profitability calculation can greatly influence the results. An assumption of future relative price rises has the same effect on the result as a reduction of the interest rate.

PROFITABILITY ANALYSIS

The aim of a profitability analysis is to determine whether an investment is reasonable, given specific economic conditions. The basic methods of determining profitability are:

- Annual cost method. The future annual investment costs are compared to the annual gains due to the investment.
- Present value method. The present value of future annual gains, due to an investment, is compared to the investment required.
- Internal interest method. The interest rates corresponding to future annual gains are compared to the assumed interest rate for the calculation.
- Pay-off method. How many years it takes to repay the investment using the annual gains, without taking into account any interest costs.

Profitability calculations are discussed in depth in literature dealing with business economics and investment calculations.

ECONOMIC DESIGN

Economic design is an aid towards achieving the lowest possible energy demands when using the resources made available for energy management. The material resources are expressed in terms of investment costs and the energy saved is expressed in terms of energy costs. This means that accepted economic models can be used to compare energy gains with the resources used to achieve them.

Designing for energy efficiency means designing structural elements, components and systems so that the energy demands will be as low as possible within the available financial framework.

Generally speaking, it is possible to achieve a lower energy demand by choosing a more expensive solution: heat losses are reduced when the thickness of wall insulation is increased; pressure drops in HVAC ducting are reduced if greater dimensions are chosen; heat recovery is more efficient if larger heat exchangers are chosen, etc. It should be noted, however, that the relative energy gain due to a specific measure is usually reduced for every additional increase in the size of the measure.

This can be illustrated by looking at the insulation in the external wall of a building. The thicker the insulation used, the smaller the heat loss through the wall. However, the relative increase in energy gain is reduced for every new layer added. The cost, on the other hand, increases linearly with thickness.

Three common methods are used for assessing economic design:

- Annual cost method: Design for the lowest yearly cost
- Marginal cost method: Design based on the marginal cost that gives the lowest annual cost
- LCC (Life Cycle Cost) method: Design to achieve the lowest total cost

These three methods will produce the same final results if the initial conditions are the same.

The total annual cost is the sum of the annual capital cost a and the running cost c. The running cost comprises the annual energy cost and the annual maintenance cost. If, for simplicity, it is assumed that the latter is independent of the size of the HVAC plant, it can suffice to examine the energy cost alone:

The total annual cost will be:

$$a+c = P(r,n) \cdot A_0 + c \qquad (4)$$

Annual cost method

In a diagram with the total annual cost $a+c$ as the y-axis and the investment cost A_0 as the x-axis, the minimum annual cost is given by the point on the curve where the slope of the tangent is 0, i.e. the tangent is horizontal, see Figure 2.

$$\frac{d(a+c)}{dA_0} = P(r,n) + \frac{d(c)}{dA_0} = 0 \qquad (5)$$

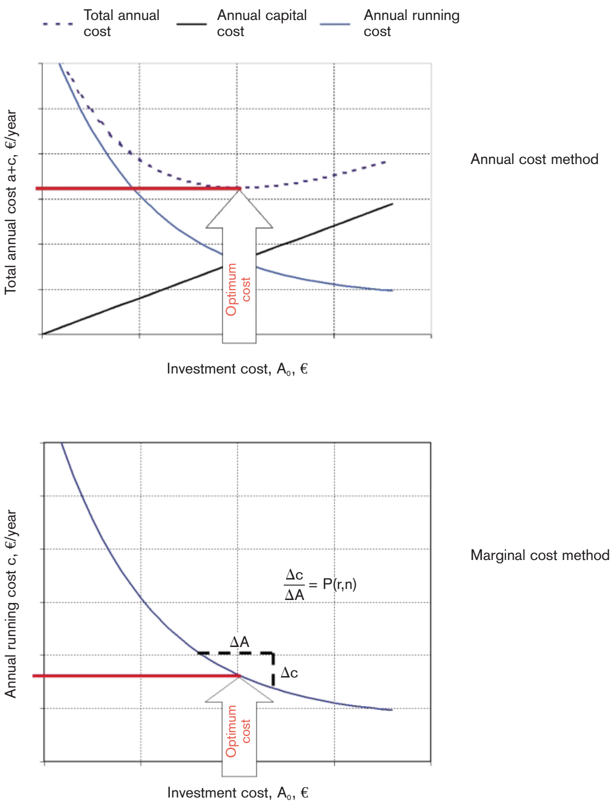

FIGURE 2. The principles behind economic design (determination of the optimum investment cost) when using the annual cost method and the marginal cost method.

The marginal cost method

In a diagram in which the energy cost c and the investment cost A_0 are the axes, the minimum annual cost is where the slope of the tangent is $-P(r,n)$. This is because the lowest annual cost after rewriting Equation (5) is also obtained when the following conditions have been fulfilled:

$$P(r,n) = -\frac{dc}{dA_0} \qquad (6)$$

At the point labelled Optimum cost in Figure 2, in the marginal cost method, the marginal cost of a greater investment will precisely balance the annual decrease in energy cost due to the investment.

To the left of this point, the reduction of the annual energy cost, i.e. the energy saving, is greater than the marginal cost of the investment. An increase in investment cost will mean a lower total annual cost. At points to the right of the Optimum cost point, any increase in investment cost will lead to a capital cost that exceeds the value of the energy savings, which means that the total annual cost will increase.

The annual cost method is probably the most often used for economic optimization. On the other hand, the marginal cost method can be easier to use and more illustrative when designing parts of a building or components that do not have side-effects on the energy demands in other parts of the building. For example, wall insulation, floor insulation, choice of glazing, extract air heat recovery systems, ventilation ducting etc.

Normally it is not possible to freely choose the thickness of the wall insulation or the cross-sectional area of the heat exchanger in a heat recovery system. These are determined by the design of the building and how the products are manufactured. In practice, this means that the size that is closest to the optimal size will have to be chosen.

The LCC method

The LCC method is used to minimize the total cost of a building, or a building services installation, over its lifetime. The present value C_0 of the total annual running costs during the lifetime of the building or the installation is given by:

$$C_0 = I(r,n) \cdot c \qquad (7)$$

If the annual costs for service and maintenance are assumed, analogously to previous assumptions, to be independent of the size of the HVAC plant, the life cycle cost will be given by:

$$LCC = A_0 + C_0 = A_0 + I(r,n) \cdot c \tag{8}$$

The minimum value is given by

$$\frac{d(LCC)}{dA_0} = \frac{d(A_0 + I(r,n) \cdot c)}{dA_0} = 1 + I(r,n)\,\frac{dc}{dA_0} = 0 \tag{9}$$

The economic design value, from a total cost point of view, is illustrated in Figure 3.

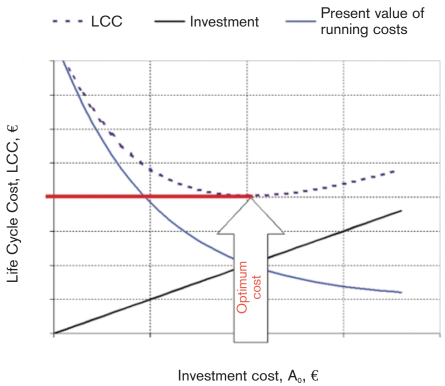

FIGURE 3. Determining the optimum economic design value using the LCC method.

The life cycle cost is much higher than the investment cost, as the present value of the running costs is also included.

An LCC calculation, as described above, is a somewhat impractical design tool, as the life cycle cost of an individual building or plant cannot be easily compared to that of another building. An annual cost is easier to understand and can be assessed to be reasonable or not by someone experienced in building processes. This is not the case when it comes to the life cycle cost. An analysis carried out according to the LCC method indicates how a certain system should be dimensioned or which of two systems should be chosen. Although it does not show whether the cost level itself is realistic or not, the LCC method is probably the most commonly used cost assessment method when designing new buildings.

Sometimes the LCC method is quite simply regarded as the method that, already at the design stage, makes it possible to take into account future energy use. This consideration, however, applies to all economic design and is not unique to the LCC method described above and shown in Figure 4. If the same input data is used, the final result will always be the same, irrespective of whether the annual cost method, the marginal cost method or the LCC method is used.

The discussion of methods above focuses on energy use. To be completely correct, the economic assessment should also include future costs for new investments with shorter life spans than the building as a whole, such as HVAC plants. Future demolition and final disposal costs should also be included, though they often have limited economic effect. If, however, they are deemed to be economically significant, then they should be included.

For a more detailed study of the LCC concept, see [Johansson, 2005].

MAKING DECISIONS ABOUT ENERGY-SAVING MEASURES

A common principle that can be used when deciding on an energy-saving investment is to compare the annual capital cost of the proposed energy-saving measure to the value of the annual energy saving. The measure is carried out if the saving is deemed to be sufficiently large in relation to the annual cost of the investment. Each measure is assessed individually according to the current economic situation, for example, the financial options available and what they cost etc.

No matter which calculation method is used and no matter how the profitability criteria have been formulated, decisions must be made regarding the choice of interest rate, expected changes in energy price, and other relevant facts, for example, the expected lifetime of the building, so that they can be used in the calculations. The measures that fulfil stipulated criteria are then carried out.

The interest rate used in the calculations is determined by the management in the client's organization and depends on how much the company is prepared to spend on energy-saving measures, taking into consideration the company's overall financial situation.

The choice of the interest rate used in the calculations and other assumptions, such as increases in future energy costs, strongly affect the estimated profitability of a specific investment. When profitability calculations are used as a basis for investment decisions it must be quite clear what interest rate has been assumed and what increases in energy prices have been assumed.

Figure 4 shows how the choice of interest rate and assumptions regarding increases in energy costs affect profitability forecasts.

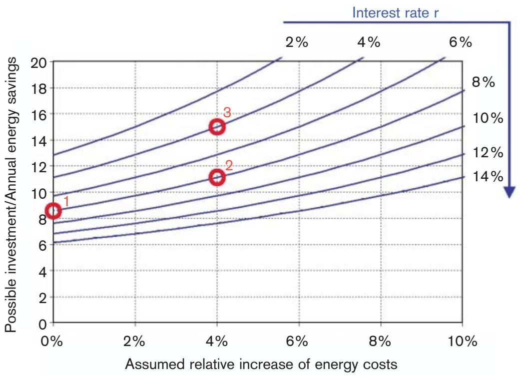

FIGURE 4. The effects of different interest rates and future energy costs on profitability forecasts over a life span of 15 years.

Any measure taken, for example, to reduce the use of energy, will result in an annual cost reduction. By investigating the relationship between a feasible investment and the annual cost reduction it is possible to determine a justifiable size of investment for the measure in question. The relative increase in energy cost shown in the diagram is the percentage increase above inflation.

The following examples are based on the curves in Figure 4:

An investment is estimated to save 20 000 € per year at the present level of energy costs.

1. If the interest rate were 8%, it would be profitable to invest up to 8.5 × 20 000 = 170 000 €.
2. If the interest rate remained at 8% but energy costs were expected to rise by 4% above inflation, it would be profitable to invest up to 11 × 20 000 = 220 000 €.
3. If the interest rate were 4 % and energy costs were assumed to increase by 4% above inflation, it would be profitable to invest up to 15 × 20 000 = 300 000 €.

A fundamental aspect of all energy-saving measures is that they must not impair the indoor climate for the occupants, living or working in the building, and thereby make it impossible to use the building as intended. This is clearly stipulated in the EU Energy Performance of Buildings Directive (EPBD), the so-called energy directive,

It is important to point out that, in the near future, we might be forced to think along completely new lines, beyond the economic reasoning discussed above. Due to national and international climate goals, we may be forced to take measures towards energy efficiency in both new and existing buildings that would not have otherwise been considered from a strict building economics perspective.

REFERENCES

Johansson, D. (2005): Modelling Life Cycle Cost for Indoor Climate Systems. Report TVBH-1014, Building Physics LTH, Lund.

Abel, E, and Elmroth, A. (2007): Buildings and Energy – a systematic approach. Formas, the Swedish Research Council for Environment, Agricultural Services and Spatial Planning.

4. SUB-OPTIMIZATION OR A HOLISTIC APPROACH

CONNY NILSSON *Swegon Air Academy*

Being able to see things from a bird's eye view could be another way of saying that you see the world about you in a positive, holistic way – a rare ability and, today, one that should be appreciated more than ever. In far too many contexts there is a tendency for people to watch out for themselves and subscribe to the motto "mind your own business and don't give a damn about anyone else". This is most probably the result of our quest for increased efficiency and is definitely something from which the building industry has not been spared. We have willingly rejected concepts such as foresight and helpfulness, unless they have actually benefited us personally. Why contribute to the common gain? It won't help me…

The indoor environment and the indoor climate also require holistic approaches. The design of our buildings, their uses and the demands made on indoor environments determine the design of a building's climate system and how much energy it uses. There are many different sides to the issue and this chapter throws some light on a number of them that are directly, or indirectly, connected to the operations of companies involved in indoor climate matters.

ENERGY, ENVIRONMENT AND CLIMATE ISSUES DEMAND OUR ATTENTION

Today, we find ourselves in a situation where something close to global consensus will be necessary to prevent – or at least postpone – a threatening energy, environment and climate crisis. This is why it is so important not only to identify the factors that are slowing down essential developments but also to bring to the fore ideas that can be used to eliminate these factors.

It is important that manufacturers and other players offering solutions towards a more economical use of energy are shown the opportunities that actually exist. There are many sides to the problem: The availability of cheap fossil fuels can no longer be taken for granted. The use of them is strongly questioned for environmental reasons and the increasingly visible climate changes are more or less a result of our lifestyles and our use of energy.

At the same time, demands are being made by people in, for example, India and China to be able to enjoy a standard of living that we, for years, have regarded as quite natural. This is a difficult equation to solve and we in the western world can hardly claim that people in other parts of the world must not be allowed similar opportunities.

Although energy, environment and climate issues have bearings on many different aspects of our society, our discussions will be limited to those concerned with indoor climate, air treatment and ventilation in buildings – quite simply because these form the basis of our business. In Sweden, the use of energy in buildings accounts for around 40 % of the total use of energy and this indicates that this is an area in which major investments could have significant effects in a national perspective. Similar situations exist in other European countries.

MEASURES IN EXISTING BUILDINGS REQUIRE KNOW-HOW

As the annual addition of new buildings only increases the existing stock by a few percent, it is obvious that, no matter how well new buildings are designed and built, a very large number of existing buildings will always account for a significant part of the energy used in this sector. New buildings will always mean an increase in the use of energy – unless a corresponding volume of old buildings is demolished. It is, therefore, imperative to implement energy-saving measures in the existing building stock. However, this requires a high degree of competency among those who design and implement the measures. Experience tells us that it is easy to go wrong – even if the intentions were good. We must not get caught in the same trap as in the 1970s, when saving energy became synonymous with sealed buildings and limited ventilation. Fortunately, we can remember what this led to and special attention has been given to these issues when formulating the EU directive on the energy efficiency of buildings. Here, it is clearly stated that energy-saving measures must not put the indoor climate at risk. Quite simply, it is a question of designing a building so that it requires as little energy as possible. On the other hand, fulfilling this ambition must not mean that it will be impossible to use the building in the way that was intended. The measures taken must not cause allergies or other forms of ill-health among the occupants. An absolute requirement ought be that energy-saving measures must not be allowed to impair the quality of the indoor air, unless they are the result of a deliberate choice to save energy at the cost of comfort. Nor should energy-saving measures lead to damage of the building itself.

EVERYTHING IS INTERRELATED

During the building process, most of the players involved can, to a certain extent, influence the use of energy in the building and are therefore responsible for contributing to its function from an energy point of view. This means that:

- The client largely determines, via the requirements specification, what will be required energy-wise. It is therefore essential that the requirements be formulated correctly. Even relatively small misjudgements can have dramatic effects on the final results.
- The architect has a great responsibility, as the design of the building, its location on the site and the choices of facade materials, windows and other components have far-reaching effects on the properties of the building.
- The building services consultants must be able to see the whole picture. Many factors, connected both to the building and its future use, influence the choice of technical solutions and use of energy. The work of the different consultants must be coordinated if all these factors are to be taken into account. For example, the size and quality of the windows, the sun shading measures, the indoor lighting and the use of the building, all affect the need for cooling – and this, in turn, has a direct bearing on the design and capacity of the ventilation plant and climate system.
- The builder's responsibility to construct the building according to the contract documents is indisputable. This cannot, however, be emphasized enough – especially when it comes to complying with airtightness requirements and avoiding, as far as possible, thermal bridges in the building envelope.
- The building services engineers also have a great responsibility when it comes to carrying out the installation work according to the contract documents. The implementation of any of their own ideas and initiatives regarding alternative solutions must be firmly established with the consultants concerned. Otherwise, there is a danger of changes being made that are regarded as reasonable from one point of view but disastrous from another.
- No chain is stronger than its weakest link and this link is often the running maintenance. The responsibility for this lies with the owner of the building. In this respect, there is often a great deal to be desired, which seems rather strange, as it should be in the owner's interest to have a profitable business. A properly maintained building will mean reduced energy use, fewer operational disturbances, happier tenants and a longer functional lifespan.

In general, it is reasonable to assume that if compromises or simplifications are made, then a higher price will have to be paid in some way. It might be in the form of higher noise levels or increased running and maintenance costs, or in a shorter operational life. But this does not mean that alternative solutions should not be questioned. On the contrary, alternatives should be weighed against each other and critically assessed. Any relevant consequences must be brought to light as early as possible. The important point is to see the situation from a holistic point of view and not just from one's own limited view of the project. This means, in turn, that an individual part of a project can, in certain circumstances, be allowed to be more expensive if it results in savings and benefits in other parts of the building.

FINANCE A KEY FACTOR

In most companies, the financial situation is often the overriding factor steering choices and decisions. When it comes to energy-saving measures, these will most probably never be carried out unless they can be financially motivated. Being able to see the whole energy picture, instead of focusing on details and parts of a project, should, therefore, also steer the client's actions.

New technology and new ways of thinking have, in recent years, provided new opportunities and not least in the most attractive areas of larger towns. Here, where rents have reached new record levels, solutions that increase the availability of rentable space are gaining new ground. Being able to offer functional, energy-saving solutions in situations like these is a challenge for all those who work in the field of building services engineering and building services technology. Decentralized solutions, that make it easier to control plant to meet actual needs, are gaining in popularity. And more demands are now often made for flexible installations that will allow future changes in the use of the building without extensive re-engineering.

THE LOWEST PRICE DOES NOT ALWAYS OFFER THE CHEAPEST SOLUTION

Contracts in the building industry are normally negotiated by submitting tenders and it is quite natural that low costs are important when a client chooses a particular engineering solution, supplier or contractor. This sometimes leads to a situation where contractors, after being awarded a contract, will try to introduce simplifications to make the project economically viable, especially as they might have under-bid purely for employment reasons. This is where large building companies, often in the role of general contractor, have a great responsibility. It is not uncommon for them to put undue pressure on the subcontractors, so that they themselves can still enjoy an economic gain. This is where someone with a holistic view is needed – most probably the building services consultant – who can assess the proposed simplifications and give approval before they are carried out. This means that the consultant will then be responsible for making sure that the function of the building and the energy-saving measures are not endangered. Working along these lines also means that the client will get what he has a right to expect. If it then turns out that the project will be more expensive than planned and the client then wants to consider other simpler solutions, the building services consultant is most probably the best person to present a consequence analysis to form a basis for new decisions.

VERIFIABLE TECHNICAL DATA AND THIRD PARTY CERTIFICATION

Historically, it has been relatively easy to install 'alternative equipment', quite simply by saying that it is similar to that prescribed by the consultant. This has often been risk-free, as it has been difficult, and sometimes practically impossible, to measure technical performance in the field to any acceptable degree of accuracy. This is precisely why third party certification has been introduced to show that products supplied actually fulfil the minimum specified requirements. An example of this is the voluntary certification program for a large number of product groups that has been established within Eurovent, the European ventilation industry organisation. By specifying that products certified by Eurovent must be used, the client is put in a much stronger position. An objection that used to be raised was that this led to limited competition but this is now a less valid argument, as a large number of suppliers of ventilation equipment have, in fact, chosen to certify their products through Eurovent.

Some properties can, of course, be measured in the field, for example, a fan's SFP, specific fan power, in the finished installation. Requirements for checks like these should be included in the original tender documents.

Testing and third party certification are two of the methods available to compel suppliers to take a more serious view of these matters. A supplier who has chosen to let a third party, for example Eurovent, certify its products has nothing to hide.

IT'S THE CLIENT WHO OFTEN SUFFERS

There are many examples of a client being offered alternative solutions with the same functions as those proposed by the consultant, but at a lower cost. That the client only enjoys a small part of the savings reaped by the contractor is quite normal but is, nonetheless, not fair play. The project, from the contractor's point of view is a financial success – in most cases at the client's cost, as a solution has been supplied that most probably uses more energy and requires more maintenance that the original solution suggested by the consultant. Other common consequences are higher noise levels and shorter life spans.

THE ENVIRONMENT SUFFERS

When the installation contractor or supplier offers a simpler solution, to win a contract thanks to low prices, the environment always suffers. By choosing smaller fans, pumps, air treatment units, air terminal devices or other components, or by installing narrower pipes and ducts, will, of course, lead to lower costs. The energy demand, on the other hand, will have to be greater to achieve the intended functions and the following increases in energy use will have a greater the impact on the environment. It is clear that new ways of thinking and new ideas are needed to ensure that the right solutions are chosen and that someone with the right competence and overall responsibility makes the final choices. This would be easiest to achieve by giving the consultant a more prominent role. Building services installations are, today, often very complicated and design engineers are required to have wide experience and knowledge. It is most probably among experts like these that people with the competence and ability to see the whole picture can be found.

THE ART OF MAKING THE RIGHT DEMANDS

No one can expect a client or a developer to be an expert in all the different fields of technology represented in the building process. This is why there are technical consultants. The client must always define what he expects of the building he wants to build and be precise when it comes to describing the intended use of the building. It is then the job of the consultant to convert the requirements specification into technical solutions and clearly explain the implications of different requirements and how they affect costs – initially and during operation. See Chapter 14/The client and the building process.

CAN THINGS BE DONE DIFFERENTLY?

In recent years, it has become increasingly common for the parties involved in a building project to cooperate in different ways, by so-called partnering, which quite simply means that they all work towards a common goal – a well-run building process, without allowing any departmental thinking or special interests to prevail. In some projects, different types of incentives have been included, whereby the money saved, thanks to the parties helping each other, is pooled. This is then divided up on completion of the project in a previously agreed way. It is, therefore, in the interests of all parties to help make the work run smoothly and to contribute that little bit extra towards a better final result, both from a collective and individual point of view.

A HOLISTIC APPROACH INSTEAD OF SUB-OPTIMIZATION

We are now in a situation where all forces of good have to cooperate with each other – partly to avoid a threatening energy, environment and climate crisis but also to achieve well-functioning buildings with indoor climates and physical environments that contribute to making us healthy, harmonic, productive and efficient individuals. As players in the different sectors of the building industry, we have an opportunity to actively influence developments. This will be a real challenge for all involved – clients, architects, builders, consultants, installation contractors, suppliers and operating staff. However, the most important thing that we can do is to stop being introverts, only looking to furthering our own interests. If we are to achieve a real change, then something new will be required: a paradigmatic shift. We must all start to pull in the same direction. To accomplish this, new ways of tendering for contracts will most probably be required. Only then will we see any significant results. Initially, the client and the environment will be the biggest winners but in the long run we will all stand to gain!

5. LEGISLATION, STANDARDS AND ESTABLISHED PRACTICE

Associate Professor **LARS E. EKBERG** Ph.D.
CIT Energy Management AB, Gothenburg

There are many critical factors that have to be dealt with correctly, both in new buildings or when making extensive alterations, if the buildings and building services installations are to have the right properties and qualities. In the first place, it has to be decided what the desired properties are. Secondly, the building and the services have to be designed so that requirements can be fulfilled. Thirdly, the building must be built properly and the services installed correctly. And, fourthly, the building and its services must be maintained, serviced and repaired, so that the functions of the systems giving the building its properties are those intended for the whole lifespan of the building.

If the results of the processes outlined above are to be successful, all those involved in the different stages must be aware of their responsibilities and act accordingly. One of the basic functions of the legislation that regulates building construction and the ways in which buildings are used is, in fact, concerned with where responsibility actually lies during the different stages in the building process. Another fundamental function of the legislation is to define the lowest quality level acceptable to society with regard to the different uses of buildings. Legislation also states the permissible impacts that buildings can exert on both the environment and society in terms of energy use.

It is established practice in the building industry to follow legislation, i.e. the mandatory requirements stipulated by the authorities, and that general, but non-mandatory, guidelines are often also followed. It is also common practice to make use of the guidelines found in the extensive range of building industry standards. These standards often comprise more far-reaching requirements and higher quality levels than those stipulated in official, mandatory regulations.

This chapter provides an overview of the way in which the building industry is regulated by laws, standards and established practice. There are, no doubt, quite large differences between different countries and it is not my ambition to provide a comprehensive and internationally valid picture of all current standpoints. Although the discussion does consider some international aspects, it is primarily concerned with the regulations in force in Sweden.

LEGISLATION

Society's minimum requirements placed on the building industry are stipulated in laws, ordinances and regulations. Laws and ordinances are based on political decisions and their application is governed by instructions formulated by public authorities. Building legislation stipulates how buildings are to be designed with respect to basic needs regarding durability, safety, health, comfort and energy management. This means that building regulations are concerned with requirements regarding a building's technical performance. There is also legislation that is directly concerned with the activities taking place in a building, for example, regarding the working environment.

There is a widespread feeling that the laws governing buildings and building construction are toothless and only suffice to provide a low minimum standard with respect to the indoor environment. Legislation might be regarded as being weak but this is, in fact, intentional. According to the European Convention on Human Rights and to the constitutions in many countries, people have a right to their own property. This means that the control exercised by a government with regard to the construction and use of buildings must not limit the owner's or user's right to their own property. A basic principle, where the scope of legislation is concerned and, by extension, the rights of the state authorities, is that the state must not regulate society in detail, unless there are pressing public interests. Pressing public interests in the building industry are, consequently, found in the fields of health and safety, sustainable outdoor environments and the use of energy.

Reasoning along these lines, it follows that it must be obvious or proven, perhaps in the form of scientific findings, that a certain law is necessary. Where the quality of indoor air is concerned, scientific proof of significant health risks only exists for a limited number of pollutants, at least regarding pollutants in homes, schools, offices and other non-industrial buildings. In buildings like these, there could easily be a large number of other potentially dangerous substances but at low concentrations. Only a few of these are regulated by legislation. PCB, asbestos and radon are a few examples.

Health risks are, however, quite well known for many substances at high concentration levels – levels that can occur in, for example, industrial processes. This is why there are hygienic limits that, above all, are applicable in industrial working environment contexts.

Research concerning environmental health medicine can lead to chemical substances, or other environmental factors, being pointed out as potential health risks but without sufficient proof so that mandatory regulations can be formulated. In cases like these, the authorities can stipulate that the so-called precautionary principle is to be applied. This approach has been adopted in Sweden, for instance, with respect to electromagnetic fields and electromagnetic radiation. The authorities can also formulate general recommendations that are more far-reaching than the mandatory requirements.

Within the European Union, proposals for national laws are often initiated when the Union draws up directives in different areas. A number of EU directives have been drawn up in the energy field, of which one is the directive on the energy performance of buildings [European Directive 2002/91/EC]. Another example that concerns the indoor climate and air quality in laboratories is the EU directive on good manufacturing practice in the food and pharmaceutical industries [Commission Directive 2003/94/EC].

BUILDING LAWS AND BUILDING REGULATIONS

Building laws are meant to regulate the actions of clients and property owners in connection with the construction of new buildings and extensions to existing ones. The applicable laws in Sweden, the Planning and Building Act (PBL) and the Law on Technical Qualities of Buildings (BVL), were passed by the Swedish Parliament. The more detailed regulations, the Planning and Building Decree (PBF) and the Decree on Technical Requirements for Construction Works (BFV), were issued by the government. The regulations issued by the government authority responsible for this area are in the form of the National Board of Housing, Building and Planning (Boverket) Building Regulations (BBR). The building regulations cover a wide spectrum of performance standards for buildings. They cover society's minimum requirements with regard to a building's design, accessibility, safety, load bearing capacity, fire safety, hygiene, health, environment and noise protection, as well as management of energy and other resources. Municipal building committees are responsible for making sure that the regulations are followed. Similar forms of legislation are in force in most other European countries.

At present, in Sweden, there are no official, mandatory requirements for alteration work carried out in buildings. Boverket does, however, provide guidelines in their General Recommendations for Alterations to Buildings (BÄR).

Air quality

To ensure an acceptable level of air hygiene, the building regulations only stipulate a highest pollution concentration level for a few substances, such as radon. In addition, a minimum outdoor air flow level is stipulated for ventilating rooms in a building. In the Swedish building regulations this level is, at present, 0.35 l/s per m^2 floor area. In many buildings, this level is far too low to keep the concentrations of pollutants, generated by the activities in the building, at acceptable levels. On the other hand, the flow rates could be sufficient to ventilate the pollutants emitted by the building itself (from floor coverings, paint, sealing compounds, etc). In other words, the building regulations have only been formulated with respect to the loads created by the building itself and not to the activities taking place in it. When planning a building it is therefore necessary to take into account other legislation, for example, concerning the working environment. In Sweden, the building regulations and working environment regulations complement each other and, to some extent, their contents have been coordinated.

The use of energy

The building regulations stipulate different types of requirements aimed at reducing the use of energy in buildings. They cover both the design of the building envelope, and associated demands for thermal insulation, and energy efficiency aspects of the building services. The present building regulations, in force since 2006, stipulate that the need for comfort cooling must be minimized by taking appropriate measures with regard to both the building itself and the building services. This means that window areas might have to be limited or effective exterior solar protection might have to be installed.

One way in which demands can be made on the energy efficiency of a ventilation system is to stipulate that heat recovery equipment with a minimum temperature efficiency rating must be used. In the current Swedish building regulations, a highest specific energy use expressed in kWh/m^2 floor area is stipulated for different types of buildings in different geographical locations. The stipulated values are for the sum of the heat energy and electrical energy used, excluding the electrical energy used for the activities in the building and the electrical energy used for domestic purposes.

Demands to limit the use of electricity can be formulated by stipulating that the ventilation system, the lighting system, pumps etc must be designed and chosen so that their power ratings are minimized and that electrical energy is used efficiently. Defining a sufficient power rating limit and what constitutes efficient use of energy might have to be decided by referring to established practice and current industrial guidelines. When it comes to fans the Swedish building regulations recommend a highest value of the SFP, specific fan power, expressed in kW_{el} per m^3/s. Here, a compromise is necessary and higher SFPs are allowed in systems that utilize heat recovered from the extract air for heating the supply air than in systems without heat recovery.

When demands are made for efficient building services it follows that they must be designed so that they can be balanced, tested, monitored and maintained. These aspects, which are connected to the running and management of a building, are given as recommendations in the Swedish building regulations.

COMPULSORY VENTILATION INSPECTION

Legislation in Sweden requires regular inspection of ventilation systems. These regulations have been formulated by Boverket, the same authority behind the building regulations. The requirements here state that the ventilation system must function, on the whole, in accordance with the requirements that were specified when the system was put into operation. The expression "on the whole" means that the old regulations need not be followed completely and that it is expected that reasonable judgement be exercised. This judgement might be affected by the remaining useful life of the system, the present use of the building and the latest findings with respect to the connection between ventilation and air quality.

WORKING ENVIRONMENT LEGISLATION

Working environment legislation is directed at employers and deals with a wide range of factors that can affect the working environment in general. Professions subject to special risks are dealt with in separate regulations, for example, regarding work in infectious environments, laboratories where chemicals are handled, working with hazardous waste, hairdressing work, working in harbours etc. With respect to all occupations,

the working environment legislation aims to ensure satisfactory levels of work safety in terms of protective devices, alarms, evacuation routines etc. In addition, legislation aims to provide acceptable conditions with regard to lighting, noise, acoustics, air quality, ventilation and indoor thermal climate. Property management, maintenance and cleaning are also areas covered by working environment legislation.

In Sweden, risks connected to exposure to chemical substances are dealt with in a separate set of regulations that contains a list of the highest acceptable concentrations of a wide range of substances, so-called hygienic limit values. This is generally applicable to work situations in which there could be dangerous concentrations of airborne particles, fumes and gases. The limit values are so high that, in practice, they are only applicable in industrial operations or work in laboratories with processes where specific chemical substances are used. In a similar way to the building regulations, the working environment legislation contains mandatory requirements as well as providing general recommendations. Further guidance is provided by referring to current standards and industrial guidelines.

ENVIRONMENTAL LEGISLATION

Swedish environmental legislation is based on the Swedish Environmental Code, which aims to promote sustainable development and ensure a healthy environment for present and future generations. The Environmental Code is a comprehensive piece of legislation that covers all aspects of environmental impact. This means that the Code is very extensive and covers both the protection of people's health and of the outdoor environment. Valuable natural and cultural environments are to be protected and looked after; biological diversity must be maintained; land, water and other physical environments are to be used so that long-term resource management can be ensured.

The part of the Swedish environmental legislation that deals with the indoor environment is aimed at health protection and hygiene in dwellings and public buildings, for example, schools and nurseries. A central concept in this legislation concerns disturbances that are detrimental to human health. These are defined, as being "any disturbance that is liable to have adverse effects on health in medical or hygienic terms which are not minor or temporary". By law, an owner of a building or a tenant must take all necessary steps that can be reasonably demanded to prevent or eliminate any conditions deemed detrimental to human health.

The wording in the Act that concerns the indoor environment states that "In order to prevent adverse effects on human health, residential buildings must satisfy certain basic requirements". These include the provision of:

1. Adequate protection against heat, cold, draught, moisture, noise, radon, pollutants and similar disturbances
2. Satisfactory changes of air via equipment for ventilation or other means
3. Sufficient daylight
4. Sufficient heat
5. Facilities for maintaining an adequate standard of personal hygiene
6. A sufficient supply of water of acceptable quality for drinking, cooking, personal hygiene and other domestic purposes.

Swedish environmental legislation does not comprise any other compulsory ordinances with regard to the indoor environment. However, the official body responsible in this field, the National Board of Health and Welfare (Socialstyrelsen), does publish general recommendations and other guidelines concerning, for example, ventilation, cleaning, thermal indoor climate, noise, radon, moisture and microorganisms. The lack of mandatory ordinances has meant that the field has, to a certain extent, been regulated by case law and test cases.

OTHER LEGISLATION

In addition to the legislation mentioned above, there are numerous other laws that also apply to the building industry. Legislation is in force in the following areas, among others:

- Electrical safety
- Electromagnetic compatibility
- Fire protection
- Handling foodstuffs
- Manufacturing and handling pharmaceuticals

In most areas, there is a single authority that is responsible for the ordinances within each particular area. The supervisory authority, as in the case of building legislation, is often a municipality. Fire protection in Sweden is regulated by a number of laws and a number of authorities are, consequently, involved. Fire protection measures are regulated by building legislation, rescue service legislation and legislation concerning flammable and explosive substances.

STANDARDS

In general, standards comprise documented knowledge compiled by well-informed players in industry, commerce, research and other parts of society. There are standards for products and services as well as for environmental and quality management systems for businesses and organizations. The overriding aim of these standards is to increase safety, reduce costs and provide good working environments, as well as to provide environmental and consumer protection.

Standards are often written jointly by a number of the interested parties in a particular field and can therefore be seen as trade guidelines around which there ought to be wide consensus, both nationally and/or internationally. It is quite common for standards to be a joint product of business and research communities. New findings, for example, relating to the importance of the indoor environment for human comfort, can be expected to be put into practice via standards and trade guidelines, while they might never form the basis for mandatory legislation. Research observations, for example, suggesting that an airborne substance could cause ill-health, can reach the building industry via its own guidelines long before proof of health risks are so strong that mandatory legislation is deemed necessary.

International standards can be divided up into global standards and standards that are common to a certain part of the world or a continent. International standards are produced and published via the International Organization for Standardization, ISO, to which 140 countries are affiliated. A great deal of the standardization work in Europe is administrated by the European Committee for Standardization, CEN, with participation from 30 member states. In the electrotechnical area, standardization in Europe is managed by CENELEC (the European Committee for Electrotechnical Standardization) and in the field of telecommunications by ETSI (the European Telecommunications Standards Institute).

There are two main types of standards that are applicable to the building industry: those that deal with standardization from a product quality point of view and those that deal with working methods and documentation of important parts of the building process. An example of the former is the EN 779 standard, the purpose of which is to ensure the quality of air filters for ventilation purposes. This standard is thus applicable in connection with the choice of filters during the management phase of a building. An example of the latter type is the ISO 7730 standard, which provides guidelines for definitions of good thermal indoor climate. This standard is applicable during the initial stages of the planning process when the requirements specification for the indoor climate has to be formulated. In many countries, European and international standards are adopted as national standards.

There are a number of standardization institutes around the world. Three of the more well-known are:
- The American National Standards Institute (ANSI)
- The British Standards Institution (BSI)
- The German Institute for Standardization (DIN)

One of the advantages of working according to a prescribed standard is that the same method is used every time, which ought to mean that the work is carried out efficiently. Another advantage is that the method prescribed by the standard is, most probably, widely recognized. On the other hand, the use of standards is not always completely risk-free, as shown below. It is important that the person who stipulates that a certain standard be followed must also understand the implications of referring to the standard. It must be considered whether the standard actually represents the level of quality being aimed for and that it does not lead to consequences that, in the final result, prove to be unacceptable.

A new European standard for indoor climate and energy performance of buildings, EN 15251:2007, provides recommendations for the hygienic levels of different air flow rates. The required size of the outdoor air flow, according to the standard, depends, to a great extent, on how intense the indoor generation of pollutants is expected to be and the intended quality level of the indoor climate. This means that it is not sufficient to stipulate the use of this standard alone; the actual conditions created in the building in question must also be taken into consideration. This will most probably entail the implementation of a quality assurance system to ensure that any generation of pollutants in the building is kept as low as possible. Otherwise, according to the standard, there is a risk that an air flow rate of 30 l/s per person will be required, far higher than is demanded by established practice in most countries. A consequence here would be that the energy used by the air handling equipment would increase considerably. In addition, there would be an increased risk of draughts and noise. These are perhaps acceptable consequences, if the high air flow rate is really needed to ensure good indoor air quality. The person who has to make decisions in this matter should be well aware that required rates, according to the standard, are not necessarily based on scientific proof.

The following illustrates another example, in which a certain amount of insight is needed if a standard is to be used effectively. In the latest version of the European standard for classifying air filters for ventilation purposes, EN 779:2002, a test has been included to clarify whether a filter can be expected to have a sufficiently high degree of particle retention during the whole of its lifetime. This is because it has been shown that if the function of the filter depends on the filtering medium being electrostatically charged, the degree of retention rapidly falls as the electrostatic charge, all too often, quickly disappears when the filter has been put into use. The standard is formulated so that a filter can be approved even if the test shows that the degree of retention will most probably fall to an unacceptable level during actual use. In order to ensure that filters purchased maintain good quality, it is not sufficient to require them to have been approved according to EN 779. The details of the standard must be known and extra demands must be made with respect to the above-mentioned electrostatic effect.

OTHER GUIDELINES

When planning a building, guidelines are needed for both the specification of the indoor climate requirements and for the planning work. In Sweden, these are provided by the Swedish Society of Heating and Air Conditioning Engineers and similar organizations are to be found in many other countries, for example, ASHRAE (The American Society of Heating, Refrigerating and Air-Conditioning Engineers) and VDI (Verein Deutscher Ingenieure) in Germany. Both of these are national organizations whose publications are widely spread internationally and have probably had a great influence on international standardization work.

When it comes to spreading knowledge about the effects of indoor environment factors on human health and comfort it is important to mention ISIAQ (International Society of Indoor Air Quality and Climate). Among its members are both practicing engineers and researchers from all the different disciplines engaged in indoor environment issues: building technology, building services engineering, chemistry, medicine, psychology etc. The organization, well and truly an interdisciplinary body, has published a range of documents that provide guidance for drawing up requirements specifications for indoor climates and for investigating indoor environment problems.

Measurements are often required to verify that functional requirements have been fulfilled in finished buildings. Nordtest, the Nordic organization, has published a large number of method descriptions that can be used to carry out verification measurements in the building industry and in HVAC applications. For example, there are Nordtest methods for verifying that air movements in a room are acceptable and for measuring outdoor air flows. Nordtest methods are also available for a number of other areas, such as building materials and building structures, acoustics, vibrations and fire protection.

Eurovent is a European organization for manufacturers of components and systems for ventilation, heating and comfort cooling. The organization aims to keep its members up to date about current EU legislation and to develop certification programmes for products used in the HVAC industry. Eurovent participates in international and European standardization work and also publishes its own manuals and handbooks.

In the Swedish building construction industry, it is almost compulsory practice to follow the generally accepted specifications that are given in the AMA (General Material and Workmanship Specifications) series of publications. AMA publications specify the demands placed on materials and workmanship in building, civil engineering and building services projects. The publications are used as guidelines when tendering for and carrying out contracts.

For HVAC purposes, a special AMA publication is used as a reference document when drawing up specifications and when carrying out HVAC contracts. The so-called 'HVAC' AMA contains regulations regarding HVAC systems, control and monitoring systems and components for these systems, thermal insulation of building services installations, fittings and equipment in large-scale kitchens, testing and technical documentation.

In Sweden, there is even a special system for negotiating contracts for property management, known as the AFF (Agreement for Property Management) system. With the help of the system guidelines, derived from the relevant industrial sectors, services can be defined and property management assignments can be described. An important element provided here is the use of clear definitions, which reduces the risk of terminological misunderstandings.

The final responsibility for fulfilling the requirements stipulated in the Swedish building regulations lies with the client, i.e. the person actually carrying out the building works or for whom they are carried out. Even environmental legislation places responsibility on the client, who must make sure that the planning of a building and its building services installations are carried out in such a way that a good working environment is ensured in the finished building. The client is obliged to choose project engineers who have the correct competencies and to ensure that all planning work is coordinated. One of the cornerstones in the building process is the quality assurance work, which comprises both checks and tests. It is the client's responsibility to make sure that this work is carried out to a satisfactory extent.

Furthermore, working environment legislation stipulates that each and everyone participating in the planning of a building must take the steps that are necessary to create a satisfactory result by cooperating with the other project engineers. An example of this is the cooperation between the architect and the building services consultant to ensure that there is sufficient space for installation work, service and repairs. Another example is the cooperation between the building services consultant and the design engineer who, together, must ensure that the transmission of noise from fan units can be minimized.

On a building site, the employer is responsible for planning, following up, assessing health and accident risks and, when necessary, remedying any shortcomings in the working environment. This is why the employer must ensure that regular checks are made, for instance, with regard to lighting, air quality, ventilation and noise as well as operation and maintenance. The employer, therefore, has a responsibility towards its employees. Furthermore, the property owner has a responsibility towards a tenant who uses a building as a place of work, for example, an employer who rents business premises. According to the Occupational Safety and Health Act, a property owner is not allowed to rent out substandard premises. A building must be maintained so that the technical performance standards stipulated in the building regulations are continuously met. Additionally, the functions of devices that are intended to fulfil the technical performance standards must be ensured. There are special regulations, for example, for lifts and automatic doors as well as for ventilation systems, as noted above in the section on compulsory ventilation inspection.

CONCLUDING REMARKS

According to the constitutions in numerous countries, their governments are not allowed to regulate society so that the rights of citizens to decide about their houses and homes are in any way restricted – as long as there are no issues of vital general interest, such as keeping the environment free from serious health risks. This constitutional principle means that powers of authorities are intentionally restricted, so that mandatory requirements, for example, regarding the indoor climate in buildings, do not stipulate a higher quality level than the lowest acceptable level. This means that there is wide freedom of choice for people to find their own ways of arriving at really good solutions. In order to do this, previously gained experience, knowledge and insights must be exploited. Here, the state takes its share of responsibility via the relevant authorities that, alongside mandatory requirements, provide advice not only with respect to how the basic requirements can be met but also to how an even higher quality level can be reached. For a system like this to work, the players in the different industrial sectors must know how the rules and regulations have been set up and be able to distinguish between mandatory requirements and non-mandatory advice.

The following is an example of what could otherwise go wrong:

The Swedish building regulations, prior to 2006, contained general recommendations regarding hygienic air flow rates in a number of different types of spaces, such as habitable rooms, kitchens, shop premises and assembly halls. The recommended air flows were considerably higher than the requirements stipulated in the regulations. In the revised version of the building regulations published in 2006, this recommendation had been deleted. The National Board of Housing, Building and Planning justified this by saying that the recommendations were often interpreted as being law and that they had a restraining effect on "creative solutions". It seems as though the Board yielded to a common misunderstanding, as the general recommendations are not at all mandatory. In actual fact, recommendations provided in the regulations issued by different authorities are, in general, based on many years of sound experience.

If a project planning group intends to deviate from recommendations like these, any decisions should be based on a thorough risk analysis and the reasons for stipulating any less stringent requirements clearly stated.

The example above shows that recommendations given by authorities are not always sufficient to ensure good indoor environments. This is why the industry needs standards and other guidelines to provide access to previously gained experience and knowledge. The use of standards and guidelines like these is fundamentally voluntary. In an individual project, it is quite reasonable to make a certain standard compulsory by stipulating in the building documents that it must be fulfilled. It is important that the person who stipulates such a requirement is well acquainted with the implications of the standard in question and can assess whether it actually provides the quality aimed for and that it also ensures that it does not lead to consequences that, in the final result, would prove to be unacceptable. In general, most standards can be said to make recommendations that are well founded – but there is no one-hundred-percent certainty.

COMMENT

If we want to find out whether a solution for increased energy efficiency is economically reasonable, i.e. whether the resources made available to reduce the use of energy are employed efficiently, we can compare the future energy savings with the investments required to achieve them. This type of economic evaluation is simple to carry out and to follow up, and relates to the property owner's experience and ongoing situation. Legislation and industrial standards specify the highest acceptable levels of energy use and codes of practice have been produced to facilitate compliance. The final responsibility, however, lies with each individual involved in the building process, who must see beyond their own financial gains. New and better tendering procedures, with incentives for the individual to contribute that little bit extra, will be required, if this is to become a reality.

EPILOGUE

The *Swegon Air Academy* hopes that this book will, to some extent, contribute towards an increased understanding of how a good indoor climate can help to make a building comfortable, efficient and profitable. We also hope that this book will increase understanding between the different players in the building industry and pave the way for an even better dialogue between property owners, architects, builders, consultants and installation contractors.

The chapters that discuss the present energy situation and how we ourselves affect the outdoor climate will, hopefully, cause us to reflect on these issues and stimulate active engagement. We can hardly prevent climate changes but we can join together to try and reduce them.

We would like to take this opportunity to thank all those who have made this book possible. In addition to all the contributing authors, we would like to thank Dr. Per-Erik Nilsson and his colleagues at CIT Energy Management for their valuable advice and especially Dr. Lars E. Ekberg, both for contributing three chapters and for his careful scrutiny of the other author's contributions.

Many thanks also to Lennart Nilsson, the project manager, at No Stress Advertising and to Torbjorn Lenskog for his attractive design work. With the exception of the Chapters 1 and 2, all contributions were originally written in Swedish. I would therefore like to thank John Bitton, who was responsible for translating the majority of the remaining chapters, and Mark Wilcox for their excellent work. I would also like to give special
thanks to the management at Swegon, for daring to invest in the project and especially to Area Manager Magnus Lind, who offered

numerous ideas and suggestions, as well as a good dose of encouragement when I was almost ready to give up.

With your help and that of the authors, the result has not been a dry textbook but a timeless publication with a soul of its own. You don't have to read it from cover to cover in one go: read it as you please - just pick out a suitable chapter and satisfy your curiosity!

CONNY NILSSON

Director of the *Swegon Air Academy*

COLOPHON

Publisher: Conny Nilsson, Swegon Air Academy, Box 300,
535 23 Kvanum, Sweden
Phone: +46 (0)512 322 00
Website: www.swegonairacademy.com

Technical Editor: Lars E. Ekberg, CIT Energy Management,
Gothenburg, Sweden

Project Manager: Lennart Nilsson, No Stress Advertising, Hjo, Sweden
Graphic Design and Art Director: Torbjorn Lenskog, Kungsor, Sweden
Picture Editor: Irene Berggren, Stockholm, Sweden
Translation: John Bitton, Helsingborg and Mark Wilcox, Hoganas,
Sweden
Artwork and Reprographics: Reijs & Co, Stockholm, Sweden

Sweden, 2008

ISBN: 978-91-984905-5-8

The *Swegon Air Academy* is a forum for objective and company-neutral sharing of knowledge and experiences related to air handling and indoor climate issues.

One of our primary goals is to explain complex relationships in an intelligible way, so that those who are interested in a subject can understand it at a deeper level.

Via seminars, newspaper articles and literature, the *Swegon Air Academy* contributes to a greater awareness of the importance of indoor air quality for health and well-being, to an increased understanding of the energy issue and to a higher level of involvement in matters concerning the outdoor environment.

The *Swegon Air Academy* provides information and educational activities all over Europe and co-operates with well-known experts in relevant fields.

Swegon Air Academy