2004-05-10

Energy Aspects in Swedish Building Legislation of the 20th Century Concerning Dwellings

Johan Smeds

Division of Energy and Building Design
Lund Institute of Technology
Sweden

Historical Development

In a historical perspective it becomes clear that changes of the building legislation concerning energy issues result from experiencing some kind of energy crisis. One of the first energy crises that occurred in Sweden was as early as in 1760 when huge quantities of wood were needed to produce charcoal for the iron industry. Prices for wood increased dramatically and a solution had to be found. The prevailing heat source for houses of that time was open fireplaces or tile stoves. In 1766 Carl Johan Cronstedt and Fabian Wrede invented a new type of tile stove, where the flue gases went up and down through winding passages inside the stove. This invention increased the energy performance of the stove and reduced the amount of wood needed for heating. In 1767 a royal commission decided that all new tile stoves should be built like this. Better air tightness, insulation measures and interior windows were introduced. A consequence was that the first energy crisis could be solved.

In the beginning of the 20th century the fireplaces and tile stoves were often replaced by coal fired central heating systems, which made the energy system dependent on imported energy sources. Even though Sweden was not directly involved in any of the World Wars, the next crises came during and after WW I and II when Sweden, as well as all other European countries, experienced a shortage of materials and energy sources. After WW II oil gained importance in the 1950ies since it was more convenient to handle in comparison to coal.

The Suez crises in 1956 when Egypt took control over the Suez Canal had a short-term impact on energy prices, but it was still believed that oil would be the best energy source for the future. During the 1960ies oil prices dropped and the dependence on this fossil fuel increased even more. In the meantime nuclear power plants were slowly being developed.

Then oil prices increased again during the OPEC oil crisis that started in autumn 1973, when the OPEC states decided to reduce the oil supply. Due to the enormous dependency on oil the crisis caused severe inflation and increasing unemployment in many countries. It was now obvious that something had to be done to limit the energy use in general and most important to minimise the dependency on oil. The Swedish solution was to introduce stricter building regulations, to increase the use of district heating systems in urban areas and to build more nuclear power plants and make it possible for house owners to heat their houses with electricity.

Despite the Harrisburg nuclear accident in 1979 Sweden connected 12 new nuclear reactors to the grid in the early 1980ies. The second oil crisis in 1980 gave support to the new energy strategy. It was decided that the nuclear reactors should deliver electricity until 2010. The use of oil has in fact decreased since 1975, but instead the Swedish energy system has become very dependent on electricity from nuclear and hydro power plants. The nuclear meltdown of a reactor in Chernobyl in 1986 resulted in severe radioactive contamination of some regions in Sweden. This was a reminder of the hazardousness of nuclear power, which Sweden had now become so dependent on.

In 1995 it was decided that the electricity market should be deregulated. New power cables improved the connection of the Nordic grid with Germany and Poland, allowing electricity providers to trade electricity on an open market. The long-term consequence is expected to be that Swedish electricity prices will increase and adjust to an average European level.

Swedish Building Legislation

Swedish building legislation of the 20th century consists mainly of three parts: Building acts, building decrees and building regulations. Building acts contain laws ruling urban planning, land use and the control of planning procedures and the building system. Building decrees mainly rule the design of buildings and how the construction process is to be controlled. The building regulations contain mandatory provisions and general recommendations, which are meant to help architects and engineers to fulfil all requirements of the legislation. The first building decree was already introduced in 1876 and the first building act was introduced in 1907, followed by new versions in 1931, 1947 and 1987. Until 1945 there were mostly local building regulations for cities and regions of the country, which could differ a lot due to local building traditions. In 1946 the first national building regulation (BABS 1946) was introduced. The tables below give an overview of Swedish building acts, decrees and regulations of the 20th century.

Building Acts	
1907	Stadsplanelagen
1931	Stadsplanelagen
1947	Byggnadslagen, 1947:385
1987	Plan- och bygglagen, PBL, 1987:10

Building Decrees	
1876	Byggnadsstadgan för rikets städer
1915	Byggnadsstadgan för rikets städer
1917	Byggnadsstadgan för rikets städer
1920	Byggnadsstadgan för rikets städer
1921	Byggnadsstadgan för rikets städer
1931	Byggnadsstadgan, SFS 1931:364
1947	Byggnadsstadgan, SFS 1947:390
1959	Byggnadsstadgan, SFS 1959:612
1987	Plan- och byggförordningen, 1987:383

Building Regulations	
until 1946	Local building regulations, e.g. Malmö stads byggnadsstadga
1946	Byggnadsstyrelsens anvisningar till byggnadsstadgan, BABS 1946
1950	Byggnadsstyrelsens anvisningar till byggnadsstadgan, BABS 1950
1960	Byggnadsstyrelsens anvisningar till byggnadsstadgan, BABS 1960
1967	Svensk Byggnorm, SBN 67, PFS 1966:175
1975	Svensk Byggnorm, SBN 75, PFS 1978:1
1980	Svensk Byggnorm, SBN 80, PFS 1980:1
1988	Nybyggnadsregler, NR, BFS 1988:18
1994	Boverkets Byggregler, BBR 94, BFS 1993:57

Changes in the Building Legislation

The most important changes to the Swedish building code came after the oil crisis in 1973 with the introduction of SBN 75. In 1977 the supplement to SBN 75 on energy efficiency came into force. It is a component specific code giving lowest U-values for each building component. The most important changes to the Swedish building code concerning dwellings are listed and an example of U-values for houses in southern Sweden according to SBN 75 is shown below.

BABS, 1960

- Component specific U-values fulfilling comfort and economic requirements are used
- No insulation requirements are set for slabs on the ground
- Double pane windows are required in order to avoid cold draft

Svensk Byggnorm, SBN 75, 1975

- U-values for southern Sweden:

Component	U-Value (W/m^2K)
Wall towards ambient	0,30
Roof	0,20
Floor (slab)	0,30
Windows (frame + glass)	2,00

- Maximum air leakage (m^3/m^2h):

Component	Pressure difference (Pa)	Height of building (number of storeys)		
		1 – 2	3 - 8	> 8
Wall towards ambient	50	0,4	0,2	0,2
Window & door towards ambient	50	1,7	1,7	1,7
	300	5,6	5,6	5,6
	500	-	-	7,9
Roof towards ambient	50	0,2	0,1	0,1

- Lowest operative temperature: 18 ºC
- Accepted surface temperature on floor: 16-27 ºC
- Minimum ventilation: 0,35 l/sm^2 if mechanical ventilation is used
- Heat exchanger required if ventilation heat losses are higher than 50 MWh/a during the heating season
- Natural ventilation allowed
- Recirculation of air allowed
- Insulation of hot water piping and ventilation ducts require
- Maximum air leakage (ach/h) required from 1 July 1978:

Building type	Air change rate (ach/h) at 50 Pa
Detached single family house	3,0
Other dwellings, max 2 storeys	2,0
Dwelling with more than 3 storeys	1,0

Svensk Byggnorm, SBN 80, 1980

The piping system has to be prepared for installation of a domestic hot water meter for each apartment in a building, but there is no decision taken that a meter has to be used.

Elanvändningskommittén, ELAK, 1984

A special committee on energy use, elanvändningskommittén, was set up by the Swedish government in 1980. It came with a suggestion that stricter building codes should apply for dwellings heated only by direct electric resistance heating. Therefore U-values of 0,17 W/m^2K and mechanical ventilation with heat recovery were required for such buildings from 1984.

Nybyggnads Regler, NR, 1988

This building code has a new system approach instead of the component approach of the older building codes. This means that an average U-value for the whole building is calculated, allowing more freedom in designing the building envelope as long as a maximum U-value for the whole building is not exceeded. Solar gains are accounted for by adjusting the U-value of the windows by orientation dependent factors. This development in the building code requires exact, detailed and at times complicated calculations by the designer in order to show that the requirements of the building code are fulfilled.

The average U-value ($U_{m,krav}$) is calculated as follows, where A_f is the window area and A_{om} is the envelop area facing the interior:

$$U_{m,krav} = 0{,}18 + 0{,}95 \frac{A_f}{A_{om}}$$

Ventilation heat exchangers are now also required for buildings if the ventilation heat losses are higher than 2 MWh/a during the heating season. This means that not only large apartment buildings need heat exchangers, but also normal detached single-family houses. The lowest accepted thermal efficiency of the heat exchanger is 50%.

A limit is set to the temperature of hot water heating systems, which must not exceed 55 ºC.

Boverkets Byggregler, BBR 94, 1994

Changes in comparison to the building code of 1988 are rather small concerning energy issues.

Future Outlook and Discussion

A solution often used today seems to be to build more heat and power plants to supply an increasing energy demand. But it is doubtful if the investment costs in new infrastructure and energy utilities are lower than the costs for energy conservation measures. Until today the building legislation has always been a reactive measure to cope with an energy problem that was not expected on the supply side. Instead it could be a proactive measure limiting the energy use to avoid or at least limit problems in the future. Energy conservation measures by stricter building codes should therefore be seen as a risk management tool. In the end the best kWh is the one you do not use.

In Sweden it is and has always been the full responsibility of the contractor that the requirements of the building code are fulfilled. In practical terms this means that a person without any expertise can be responsible for the quality of the building. The local housing committee only has a supervision function concerning the fulfilment of the technical requirements of the building code. A consequence of the system approach that was introduced in 1988 is that it is much harder for authorities to control if the calculation of the average U-value for a building is correct. Even if correct calculations are delivered to the local authorities, the control process is far too labour and cost intensive. It is hard to draw conclusions of a delivered calculation result since the amount of input makes it complicated to calculate backwards. There is a clear lack of competence in the local authorities to deal with such calculations. The use of computer programs has not changed anything concerning this problem. This has unfortunately led to a rather varying quality of the building stock and to increasing energy use in new buildings. A conclusion is that it would be better to reintroduce a component specific building code with fixed maximum U-values for all components of the building envelope.

The increase of energy use is also a result of the latest changes of the building code that allows ventilation systems without heat exchangers if renewable energy sources are used for heating. The problem is that the heating system might be replaced by a heating system using non-renewable energy sources in future. If the building is originally designed for using natural ventilation it is complicated to install a balanced ventilation system with heat recovery afterwards to save energy. The building can thereby not be considered as robust.

Unfortunately there is no requirement in today's building code to take heat bridges into account in the U-value calculations. It is of course a step in the calculation procedure that requires deep knowledge of construction details, but not taking heat bridges into account delivers optimistic results of the average U-value of a building. Furthermore there is no maximum limit given for the total energy consumption of a building. It is mentioned in the building code that electrical installations must be designed to limit the load and so that they are energy efficient, but it is not quantified in any way.

Individual measurement of space heating and domestic hot water consumption is still not mandatory in Sweden, despite of an EU-directive recommending European governments to include this in their legislations. If you don't know how much energy you use it is of course hard to achieve energy savings. Even if individual measurement doesn't technically decrease the energy demand, it will most likely improve the awareness of tenants on how much energy they use in their households and in the long term it will change the user behaviour.

In order to improve the energy performance of new buildings, voluntary alternatives to today's building codes and standards could be introduced for those contractors that want to build a more energy efficient house. An alternative building standard can work as a benchmark that gives an example of what can be achieved with modern technology. This system is already in use in countries like Switzerland where the Minergie standard was introduced and Germany where the Passivhaus standard is often used. It would then be possible to link financial incentives like lower interest rates for loans or other subsidies to alternative building standards. In Germany and Switzerland thousands of new dwellings have been built according to these alternative standards.

References

Nordisk Familjebok, http://runeberg.org/nfbm/0313.htm , 2004

Energiboken, T21:1995, Byggforskningsrådet, Stockholm, 1995

Elisabeth Kjellsson, *National analyses of existing instruments*, Draft working document, June 16 1998, Lund University, Sweden, 1998

Johan Nässén, John Holmberg, *Energy efficiency – a forgotten goal in the Swedish building sector?*, article in press, Energy Policy, 2004

Konsekvenserna av ett förbud mot direktverkande elvärme I nya byggnader, Rapport, Boverket, juni 2003

Program för energihushållning i befintlig bebyggelse, Betänkande av Energihushållningsdelegationen, Statens offentliga utredningar SOU 1980:43, Bostadsdepartementet, Stockholm 1980

Byggnadsordning för Malmö, 1935

Byggkommentarer, SVR:s Förlags AB, Stockholm, 1961

SBN 1975, *Svensk Byggnorm*, Statens Planverks Författningssamling, PFS 1978:1, Stockholm 1975

SBN 1980, *Svensk Byggnorm*, Statens Planverks Författningssamling, PFS 1980:1, Stockholm 1980

EL OCH OLJA, *Förslag från Elanvändningskommittén (ELAK) till restriktioner, användning och hushållning*, Ds I 1980:22, Industridepartementet

NR, *Nybyggnadsregler*, Boverkets Författningssamling, BFS 1988:18, Karlskrona 1988

BBR 94, *Boverkets Byggregler*, Boverkets Författningssamling, BFS 1993:57, Karlskrona 1994

Europaparlamentets och rådets direktiv 2002/91/EG av den 16 december 2002 om byggnaders energiprestanda, Europeiska gemenskapernas officiella tidning, 4 januari 2003