Norwegian building energy statistics; specific energy consumption and consumption by category of use

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1. BACKGROUND

In 1996 the Norwegian Energy Administration (NVE) decided to establish (Enova SF in 2002) an operating apparatus which was given responsibility for the implementation of the Norwegian State's energy conservation programme. On the building side, NVE's Building Operator (who is now Enova's Building Operator) was given responsibility for developing a network of building owners whose reports of energy consumption would form the basis of a set of national statistics for building energy consumption by category of use.

In 2002, the total measured area of Norwegian buildings adds up to around 330 million square metres, of which about 120 million m^2 consist of commercial/industrial buildings. The remainder is housing, of which housing cooperatives account for some 30 million m^2.

Norwegian buildings consume a total of about 80 TWh of electricity a year, of which non-residential buildings use about 34 TWh. Figure 1.1 shows that about 32.5 TWh of electricity are used for heating purposes every year. The reason for this is that Norway has had easily available hydropower for many decades. Hydropower development has now come to an end, and with the continuing rapid growth in building energy consumption, in a typical year Norway now needs to import a considerable amount of electricity from its neighbours.

This is the main reason for the decision of the Storting in 2001 to set up a new state-owned company known as Enova, which has been given a ten-year mandate to restructure the national energy use in terms of conservation, conversion to other energy carriers and energy generation from new sources.
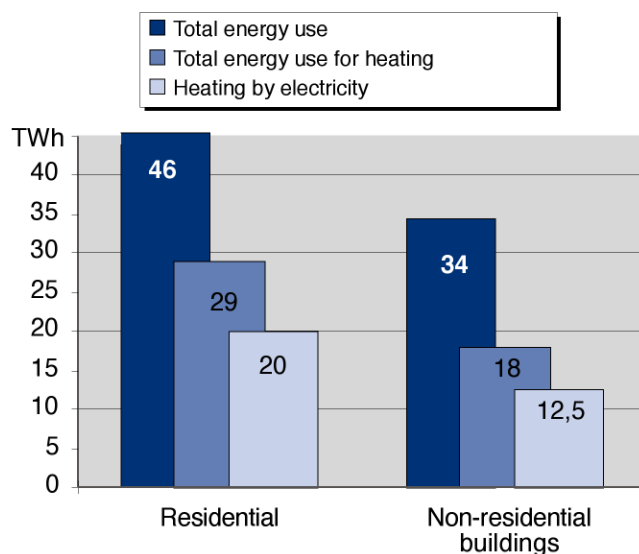

Figure 1.1   Energy consumption in Norwegian buildings in 2000

2. THE BUILDING NETWORK - CONTENT, SCOPE AND RESULTS

Since 1996, a network has been built up of building owners who must agree to reduce their energy consumption by supporting a range of activities in a network process. The network process lasts for between two and two-and-a-half years, and the building owners must commit themselves to cutting energy consumption by at least 10%. Financial support is not provided for investments, but for activities that raise awareness of energy consumption at all levels of the company. Typical activities include energy management, energy-use planning, energy follow-up and analyses, training and consumer information.

The Building Network currently consists of some 350 building owners who have supplied information on about 2000 buildings to the central database maintained by Statistics Norway.

About 80% of the buildings are in the public sector, while the remainder are privately owned. From 1996 until 1999 public-sector buildings were given funding priority.

Every year, about MNOK 18 has been distributed to network projects, which have produced annual savings of about 100 GWh, totalling about 600 GWh over the six years of the project so far. When the administrative costs of the Building Network are included, funding comes to around NOK 0.20 per kWh saved energy.

Since 2000, all buildings that join the Building Network have had their energy consumption measured before and after the network process. Starting in 2002, incentive agreements have been set up in order to relate the payment of support funds to the achievement of specific targets.

3.   ENERGY STATISTICS FOR INDIVIDUAL BUILDING CATEGORIES

3.1   Energy statistics - basis, scope and utilisation
The establishment of the Building Network made it possible to develop a set of building energy statistics. Building owners who become members of the Building Network agree to report the energy consumption of a range of buildings for five years. Statistics Norway performs the statistical analyses and maintains the database of buildings. Statistics Norway's database contains basic data energy data on all the buildings, recorded on a standard template.

Since the sample of buildings is not random the figures that emerge from the statistics cannot simply be extrapolated to the total Norwegian building mass. For the categories that include the largest number of individual buildings the average figures are more representative than for the other categories.

In 2000, the statistics were based on data from 1039 buildings all over Norway, and in 2001 this figure had risen to about 1350 (the statistical report for 2001 will be published in June 2002).

As well as energy consumption, the report includes statistics on energy carriers, heating systems, ventilation systems and indices of use.

The statistics are based on the following criteria:
  • Energy consumption is measured as gross metered energy

- Area is measured as heated area according to Norwegian Standard (NS) 3940
- Building categories are defined according to NS 3457
- Climatic corrections are applied with respect to a normal year, but no corrections are applied for geographical location (climatic zones)

These statistics have become an essential tool for many actors in the building industry as well as for the authorities:
- Building owners use them in benchmarking their buildings vis-à-vis other building owners and buildings, and when estimating the energy consumption of new buildings
- Technical consultants use them in planning new buildings and conversions
- Energy companies use the statistics when making estimates of the power requirements of new installations, etc.
- For the authorities the statistics form part of the basis of the ongoing process of evaluation of the general energy situation.

In order to ensure that the statistics are as good as possible the Regional Energy Efficiency Centres network has been engaged to quality-assure the energy reports before these are sent over to Statistics Norway via the Internet.

The report, which is published and distributed throughout the sector, is processed by Enova's Building Operator. All the building owners who have submitted reports of energy consumption also receive data on their own buildings together with comparison data on other buildings of similar type, presented as shown in Figure 3.2.

3.2 Energy statistics - content and analyses

The statistics for 2000, which were published in mid-June 2001, referred to 1039 buildings with a total area of 5.8 mill m^2. Their total annual energy consumption was about 1.4 TWh, or 248 kWh/m^2.

Figure 3.1, the main diagram obtained from the statistics for 2000, shows energy consumption for individual building categories by energy bearer. We can see that commercial buildings have by far the highest energy consumption, while schools have the lowest consumption of non-domestic buildings. In 718 of these buildings, which had reported information in both 1999 and 2000, total temperature-corrected energy consumption fell by 3.8% from 1999 to 2000.

Figure 3.2 illustrates two examples of how energy consumption varies within a single building category. In 143 office buildings, energy consumption ranged from 90 to 520 kWh/m^2. Similar large variations were noted in school buildings. We can see that for schools with swimming pools, mean energy consumption increased from 191 to 254 kWh/m^2.

Since the type of heating system utilised was also registered as part of the basic data, it was possible to analyse how energy consumption varied according to type of heating system installed. Central heating systems were installed in 60% of the buildings, representing 77% of the total heated area.

Figure 3.3 shows that for the sample as a whole, there was a difference of about 11% between buildings with direct electrical heating and those with central heating systems.
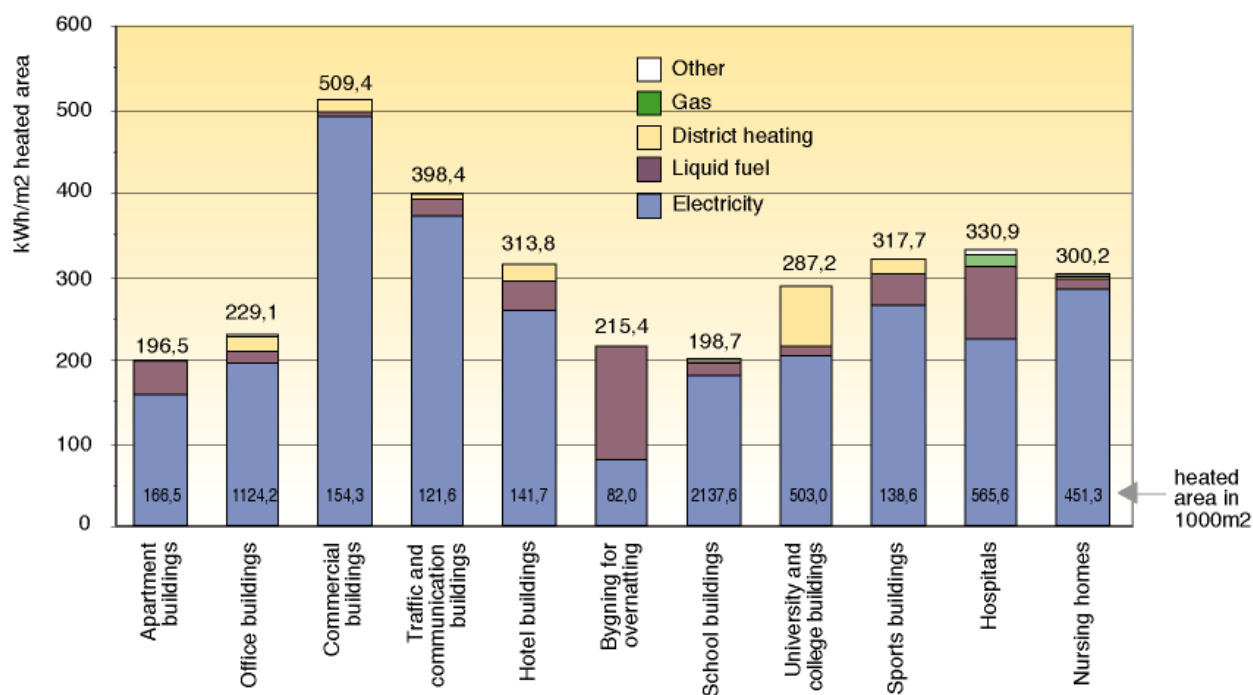
Figure 3.1:   Average specific temperature-corrected energy consumption in 2000 for major building categories
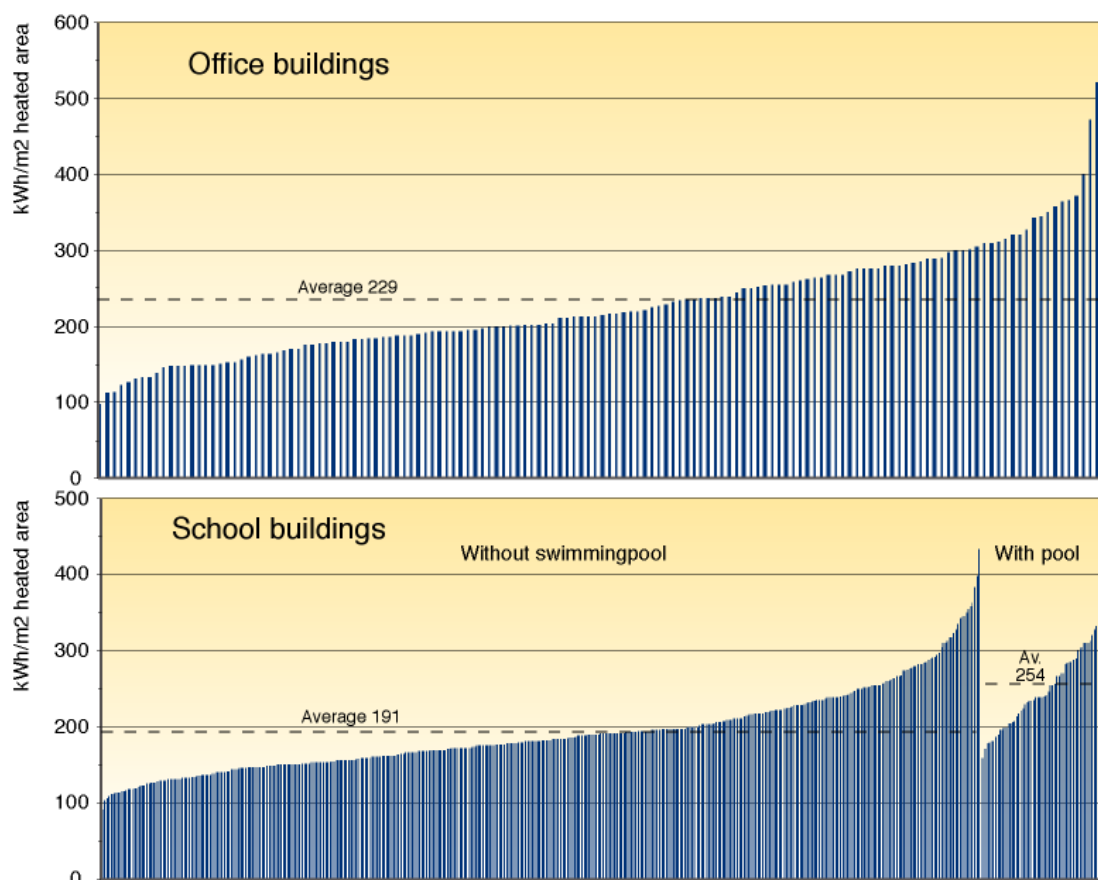

Figure 3.2:   Differences in energy consumption in individual buildings in same category of use
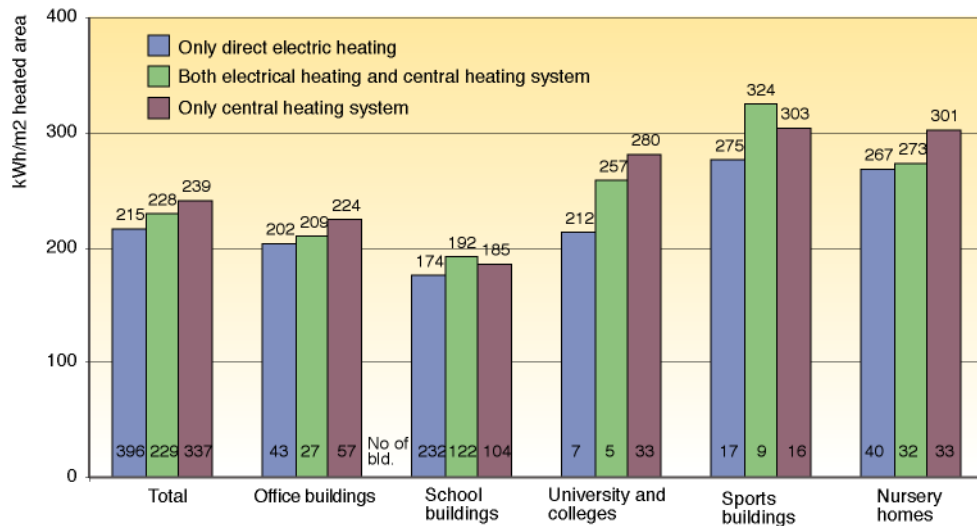
Figure 3.3:   Energy consumption in buildings with different types of heating system

82% of the buildings had balanced ventilation installed, 65% of these as the only system. 83% of this volume of air passes through a heat recovery unit. Comfort cooling is installed in 202 buildings; 37% of the total area.

Hours of use can be of great importance for energy consumption. Figure 3.5 shows the time of use for the most common types of building - i.e. the time that the building is generally in use. We can see from the figure that schools have the shortest average time at 10.2 hours per working day, while university building are in use for 12.8 hours a day. The long time of use for hotels and health sector buildings goes a long way to explaining their high specific energy consumption.
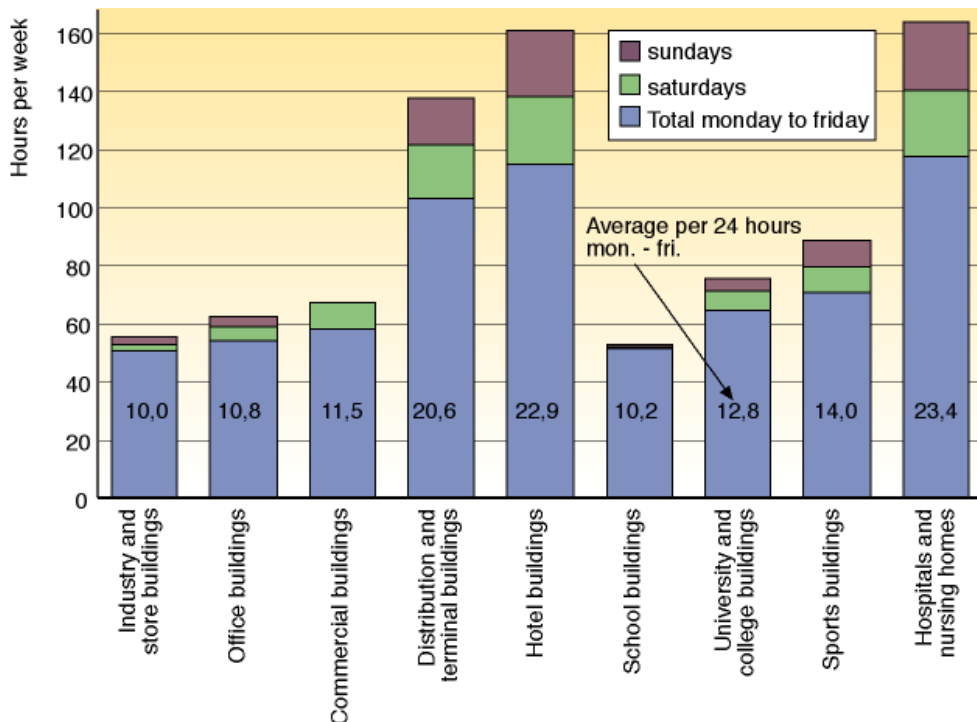

Figure 3.5:   Mean total hours in use per week for the most common types of building.

4. MODEL BUILDINGS - ENERGY CONSUMPTION BY CATEGORY OF USE IN 26 BUILDINGS

In order to obtain a better understanding of the energy consumption of buildings in terms of category of energy use, such as heating, ventilation, lighting, etc., Enova carried out a project entitled Model Building. Twenty-six buildings in four categories of use were instrumented according to a common plan. The measurement programme lasted for a year, from November 2000 until October 2001.

The types of energy use were defined in accordance with NS 3031:

1. Heating
2. Ventilation
3. Hot water
4. Fans/pumps
5. Lighting
6. Electrical equipment
7. Air conditioning

For the first time in Norway a systematic study and set of measurements have been made of how energy is used in such a large number of non-domestic buildings. Even though the sample was small (26 buildings) the analyses show a number of interesting features. The general impression was that the actual uses of energy are reasonably similar to those used by the most often used estimation programmes. However, wide variations from one building to another within the same building category were observed. This implies that standard normalised figures for energy consumption by category of use must be used with great caution. This may mean that operating conditions and user behaviour have more influence on energy consumption than we have believed.

In certain areas and in certain types of buildings there are clear deviations from the norm:

- In university, college and office buildings fans and pumps are responsible for a larger proportion of energy use than was previously assumed (figure 4.1)
- In nursing homes more energy is used for lighting than previously assumed
- In most categories of building the proportion of energy that goes to ventilation and heating water is somewhat less than the estimation model suggests
- The part of energy consumption that is flexible (heating, domestic hot water supply, ventilation heat) varies more widely than expected, but for important categories such as office buildings and schools the average figures conform to expectations (figure 4.2)
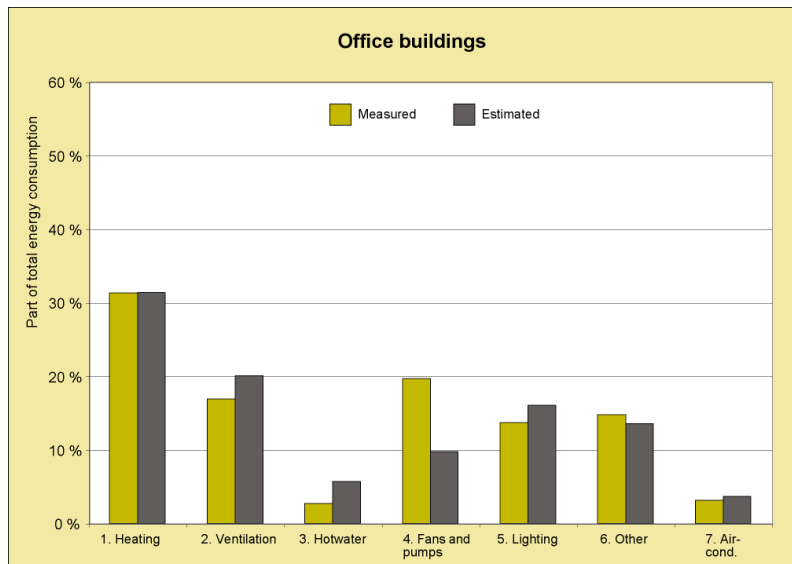
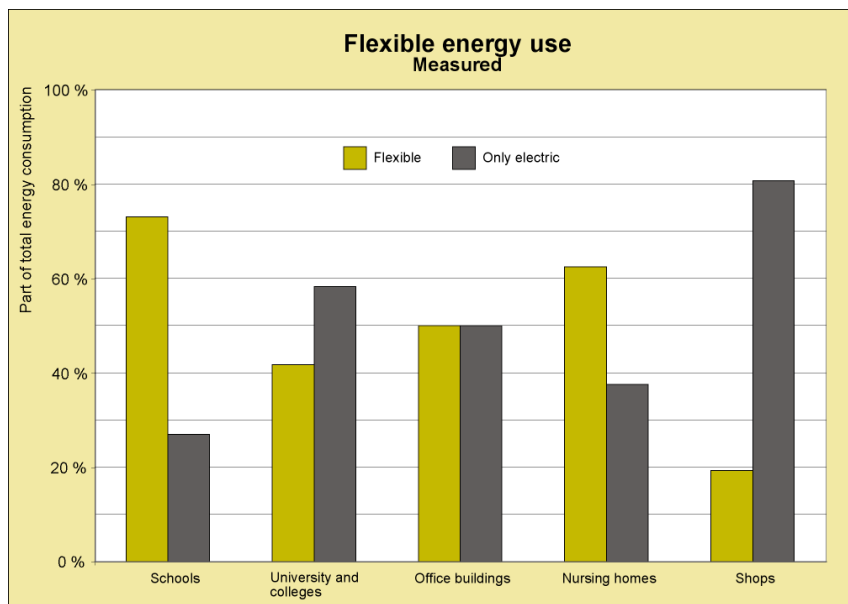Figure 4.1:   Measured and estimated figures for energy consumption in office buildings

Figure 4.2   Flexible and specific proportions of energy consumption for the five building categories represented in the study

REFERENCES

1.   Building Network's Energy Statistics for 2000. NVE's Building Operator (in Norwegian)

2.   Model Building project: measurement of energy consumption by category of use in 26 buildings. Enova's Building Operator (in Norwegian)