Norway: Impact, compliance and control of EPBD legislation

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Fig.1

Fig.2: *Traditional buildings*

This paper explains how the EU Energy Performance of Buildings Directive (EPBD) has changed the national Energy Performance (EP) requirements and influenced building practices in Norway. Furthermore, it describes the national way of dealing with EPBD compliance and control and identifies interesting approaches and possible bottlenecks.

1 > IMPLEMENATION STATUS, 2010

Although Norway is not an EU Member State (MS), it is implementing the EPBD because Norway is part of the European Economic Area (EEA). The status of national implementation of the different elements of EBPD, are described below:

> ***EP calculation standard***: A revised national standard for building EP calculations was published, NS 3031:2007[1], with a minor revision due in 2010. It is based on ISO 13790. At the same time a new standard for building area & volume calculation was published, NS 3940:2007[2].

> ***Building regulations***: Revised EP regulations[3] for new buildings and major renovations were issued 2007-02-01 with a 2.5 year transition period. They will be further tightened in July 2010.

> ***Energy Act***: The revised national Energy Act[4], including energy labelling and inspection schemes, came into force 2010. Detailed regulations for certification & inspection are implemented.

> ***Certification***: The labelling scheme is already operative, but will not be obligatory for all buildings before July 2010. There are two different schemes for (a) houses, and (b) all other buildings. Scheme (a) permits self-assessment, whereas (b) is open for qualified users.

> ***Inspection***: The inspection scheme is operative and in full accordance with EPBD Article 8, extended to include ventilation systems. Existing buildings shall be inspected within 2 years.

2 > IMPLEMENTATION OF EPBD BUILDING REGULATIONS

2.1 EP calculation software

Improvements to the national EP calculation standard: In 2007, the national EP calculation method (NS 3031) was greatly improved by harmonizing it with ISO 13790. Whilst the previous version calculated only annual space heating demand, the revised version can calculate energy use at any stage in the energy supply chain (see Fig.3), i.e. net energy demand, delivered energy (bought energy), primary energy, or GHG emissions. You may use any software that conforms to NS 3031, or that is verified with EN 15265. This means that a lot of well-established software may still be used (e.g. ESP-r, EnergyPlus, VIP+) in addition to new home-grown user-friendly software that has been developed based on NS 3031,

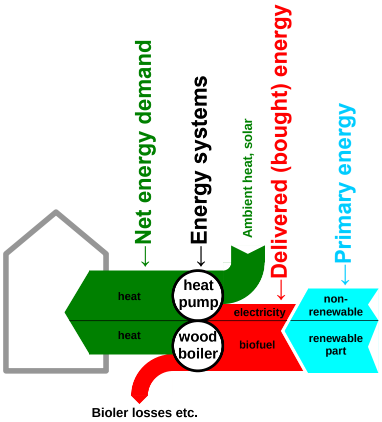

Fig.3: *Illustration of net & delivered energy, and primary energy type*

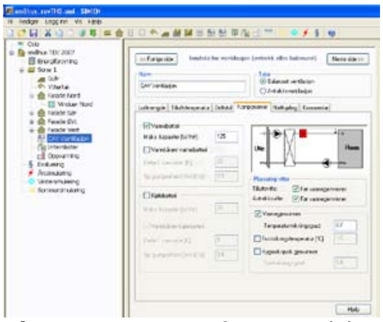

Fig.4: *'SIMIEN' software with dynamic hourly energy calculations according to NS 3031*

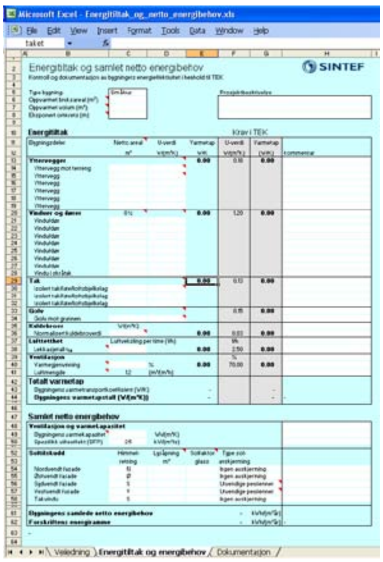

Fig.5: *Simple one-page spreadsheet from SINTEF according to NS 3031.*

most notably the free web-based Energy Certification software, and also some stand-alone applications (e.g. 'SIMIEN', or a spreadsheet by SINTEF).

Some special features of the revised EP calculation standard:

> The standard has general applicability, so can be used for building permit applications, energy labelling, indoor climate prediction, etc. The same input data can be used in calculations for both permits and labelling.

> For all buildings with AC-equipment, and all buildings of certain types (offices, retail, hospitals, universities) the EP calculation must be hourly dynamic instead of quasi-steady monthly.

> The new standard is published with a climate data file of hourly data from Oslo. This climate data must be used in EP calculations for building permits and energy labels throughout the country. This aids standardization of construction. However, future tightening of the building regulations will necessitate more climate zones. Naturally, the user is should use other hourly climate data in simulations of indoor climate, wherever the local climate differs from Oslo.

> In the case of EP calculations for building permits or labelling, some input data is 'fixed'. These are mostly parameters related to occupant behaviour: internal heat gains (equipment, people), hot water use, operating hours, and set-point temperatures for heating & cooling.

> Some other input data has 'default' values that the software user must use if they have no documentation. This includes for example: thermal bridges, lighting energy, minimum ventilation rates, and a long list of energy system efficiencies (e.g. boilers & heat pumps). The values can of course be changed if the user has specific documentation. The requirement for documentation is quite relaxed in practice.
Incidentally, if the building has automatic controls, the default lighting load may be reduced by 20 % *without* documentation of lighting performance. Similarly, in the case of DCV-VAV (demand-controlled ventilation with variable air volume), the design ventilation rates may be reduced by 20 % *without* documentation of true average flow rate.

> The EP calculation method prescribes the use of a very low set-point room temperature (22°C) if room cooling is to be installed. This artificially low set-point is meant to discourage installation of mechanical cooling by giving it a high energy penalty. However, there is a loophole in the case of central ventilation cooling, for which the set-point temperature is not limited by the EP calculation standard.

> Buildings that receive high solar gains must be zoned in the EP calculation. This ensures more accurate calculation of cooling demand and indoor climate.

2.2 Changes to the building regulations

The building regulations were tightened in 2007, and there will be slight changes in 2010 [3].

Simple yet flexible approach: Both the previous (1997) and new (2007/2010) regulations give two alternatives for checking compliance with the EP requirements for building permits, there are:

> **(a)** A simple checklist of prescriptive energy-efficiency measures, such as U-values. The benefit of this simple approach is that it does not involve any calculations, and is immediately understandable to laymen. To get a permit for a new building that does not comply with the whole checklist, one must have compensatory energy measures, and follow alternative (b):

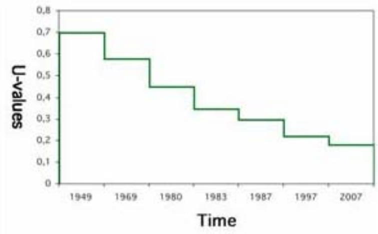

Fig.6: *Progressive tightening of wall U-value requirements in Norway since 1949. [source: NVE]*

Fig.7: *Holiday homes <150 m^2 and all log houses have more lenient U-value requirements, but are otherwise exempted from the EP requirements*

> (**b**) Conduct EP calculations using software that complies with standard NS 3031. Calculated energy consumption shall not exceed maximum limits [$(kWh/m^2)/yr$] defined for different building categories.

The two alternative approaches above are compatible, i.e. a building that complies exactly with checklist (a) will have approximately the same calculated energy use [$(kWh/m^2)/yr$] as the maximum limit set in alternative (b) for each building category. There is of course a deviation due to building geometry. There are also minimum requirements (e.g. maximum U-values and airtightness) that must be satisfied in all cases.

The U-values in the 2007/2010 regulations were chosen based on a technical & economic national study. They are incidentally the very close to the cost-optimum U-values estimated by Ecofsys for Oslo climate [5].

Changes to the checklist requirements, i.e. alternative (a):

Parameter	**1997†**	**2007/2010**
Wall U-value [W/m^2K]	0.22	0.18
Roof U-value [W/m^2K]	0.15	0.13
Floor U-value [W/m^2K]	0.30	0.15
Windows/doors [W/m^2K]	2.0 [1.6*]	1.20
Thermal bridges [$(W/K)/m^2_{floor}$]	†	0.06 [0.03*]
Airtightness, n_{50} [h^{-1}]		1.5 [2.5*]
Heat recovery [%]		80% [70%*]
Specific fan power [$kW/(m^3/s)$]		2/1‡ [2.5*]
Glazing area [% of floor]	20 %	20 %
Night-time setback [°C]		19 °C
Minimum requirements:		
Wall U-value [W/m^2K]		0.22 ▫
Roof/floor U-value [W/m^2K]		0.18 ▪
Windows/doors [W/m^2K]		1.60 ▪
Airtightness, n_{50} [h^{-1}]	1.5 [4*]	3.0 ▫
Solar shading / glazing system		g_t<0.1 if no A/C
RES % of heating demand		≥ 40%

* Special values for dwellings (single- or multifamily) in square brackets.
† Thermal bridges included in U-values in 1997 regulations.
‡ Daytime(occupied)/night-time(unoccupied) Specific Fan Power (SFP)
▫ No minimum requirements for log constructions.
▪ Stricter minimum requirements for log constructions over 150 m^2.

Changes to EP calculation requirements, i.e. alternative (b):
The 1997 EP calculations limited only space heating demand, while the 1997 'checklist' approach did not regulate ventilation heat loss at all, and thus posed a loophole to avoid for heat recovery.

This loophole was closed in the 2007 regulations, which have a much more complete 'checklist' including parameters that affect both space heating & cooling demand. Similarly, alternative (b) sets limits on the building's total net energy demand(1) [$(kWh/m^2)/yr$], and thus encompasses all heating & cooling energy. Primary energy use is limited by a simple requirement that ≥40 % of a building's heat demand shall be supplied by renewable energy carriers other than electricity or fossil fuels(2). This percentage will be increased in the near future. District heating originates mostly from refuse, which must be burnt anyway. There is still discussion on the choice of primary energy weighting factors in Norway, partly due to uncertainties about import/export of electricity, combined with local hydroelectricity, and on the 'renewableness' of district heating.

Energy labelling is based on calculated delivered energy (bought energy) and a secondary label for the fraction of primary energy that is

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[1] As defined in ISO 13790. Total net energy required for heating, cooling, ventilation, hot water, and all electrical equipment & lighting, taking account of solar & internal gains on the building's heat balance. Independent of energy delivery system efficiency (e.g. efficiency of boilers, heat pumps, solar collectors).
[2] Small buildings (<17000 kWh/yr) are exempted from this requirement.

from renewable sources. The certificate also declares the measured energy consumption [kWh/yr] and the expected calculated for the local climate. The table below summarizes parameters that have been added/tightened:

		Old regulations		EPBD implementation			
		1997 (**a**) Simple prescriptive	1997 (**b**) EP calculation	2007 / 2010 (**a**) Simple prescriptive	2007 / 2010 (**b**) EP calculation	2010 Energy labelling	2010 Inspections
Number of building categories		**1**	**7**	**1**	**13**	**13**	**-**
Heat loss	U-values	■	■	■*	■*	■	
	Thermal bridges	■	■	■*	■*	■	
	Infiltration		■	■*	■*	■	
	Heat recovery		■	■*†	■*	■	■
Energy use	Heat recovery defrost			■	■	■	
	Fan energy (SFP)			■	■	■	■
	Space heating		■	■	■	■	■
	Hot water (DHW)			■	■	■	■
	Pumps, lighting, eqpt.			■	■	■	
	Space cooling			■	■	■	■
	System efficiency					■	■
Minimum require-ments	U-values		■	■*	■*		
	Airtightness (n_{50})	■	■	■*	■*		
	Ventilation rates	■	■	■	■	●	■
	Thermal comfort	■	■	■	■	●	
	Window area (< %floor)	■		■†	■†		
	Glazing solar properties			■†	■†		
	% renewable energy			■	■	●	

* Indicates parameters from the last building regulations that were tightened in the new EPBD building regulations in 2007.
† Small revision of the building regulations in 2010, for non-residential buildings: Heat recovery and limiting window area and glazing solar gain factor (g-value).
● There is a secondary label for % renewable energy. Also the ventilation rate and indoor temperature set-point should comply with minimum values.

Fig.8

Ensuring long-term building quality: Two important features of the Norwegian approach to EPBD implementation are:

(1) the regulations limit *net* energy demand, thus ignoring the efficiency of energy delivery systems (e.g. boiler efficiency), and

(2) the EP calculation standard fixes input data related to occupant behaviour, including all heat gains (equipment, people, default lighting), hot water use, operating hours, set-point temperatures for heating & cooling, and minimum ventilation rates.

The combined effect of these two features has two benefits:

> ☺ It will ensure long-term and uniform quality of all building envelopes. It prevents misuse whereby a building designer could cut corners on thermal insulation by making overly optimistic assumptions about low-energy technical building services, building operation, and occupant behaviour. These can easily change/deteriorate over the lifetime of the building. Misuse has been further mitigated by placing limits on minimum U-values and airtightness. It seems sensible to that system efficiency affects the energy label but *not* building permit applications. Energy labels will be updated over the building's lifetime,

thus capturing any changes to the energy systems. Systems have a shorter life than the building, and are cheaper to upgrade.

- ☺ A building's energy label is calculated assuming fixed 'typical' user behaviour and internal heat gains. This is sensible because occupants might not have the same habits/activities as previous owners/tenants. User behaviour can have a significant impact on energy use.

And two downsides:

- ☹ The fixed input parameters in the EP calculation can pose a barrier to some innovative building services, especially ones that reduce internal heat gains (e.g. Energy Star equipment), hot water usage (e.g. water-saving showers), or that exploit adaptive thermal comfort. However, other innovative systems can in principle be accommodated in EP calculations with little problem (e.g. light dimming/ VAV/ efficient heating/cooling systems, insulated night shutters), given proper documentation and capable software.
- ☹ Another consequence is a distinction between air-to-air heat exchangers and air-to-air heat pumps in ventilation units. Unlike heat exchangers, heat pumps are considered an energy delivery system, and thus reduce bought energy but not *net* energy demand. This could affect the market for ventilation units with heat pumps. However, this effect might be mitigated by the energy labelling scheme, which is based on delivered energy.

Building categories: The number of building categories has been doubled from 7 to 13 (Fig.9). Multifunctional buildings should be subdivided into zones chosen from the 13 categories.

Vacation property (e.g. weekend cottages) was previously exempted from the regulations. Those above 50 m^2 are now included, because they are becoming increasingly luxurious, some with year-round heating. Small ones (<150 m^2) need only satisfy the minimum requirements. Also log cabins/homes need only meet minimum requirements, to uphold cultural heritage. Antiquarian buildings and cold storage buildings are also treated specially.

The regulations apply to new buildings and major renovations. 'Major renovations' is generally defined as over 50 % of the building area. The new regulations apply only to the affected areas/parts. Unfortunately, local authorities are very liberal in the case of renovation, often giving dispensation from EP requirements. This must be tightened in future.

Indoor climate: The minimum requirements for indoor climate and air quality remain largely unchanged since 1997, and are harmonized with EN 15251 Class II (7 ℓ/s·person + 0.7 ℓ/s·m^2 low polluting building). For dwellings, a mix of Class II & III presently suffices (0.5 ac/h, or 0.3 ac/h when unoccupied, and 7 ℓ/s·person in occupied bedrooms, and minimum extract flow rates from wet rooms & kitchen hoods).

Guidance notes to the regulations say that operative temperature in workspaces (non-residential) should be designed so as not to exceed 26 ºC more than 50 hours/year. Adaptive thermal comfort is not explicitly accommodated in the EP regulations.

There are also requirements related to air quality & radon, noise, daylight, and moisture damage prevention. None of these are changed as direct consequence of EPBD. The Health & Safety Inspectorate publish their own requirements for workspaces.

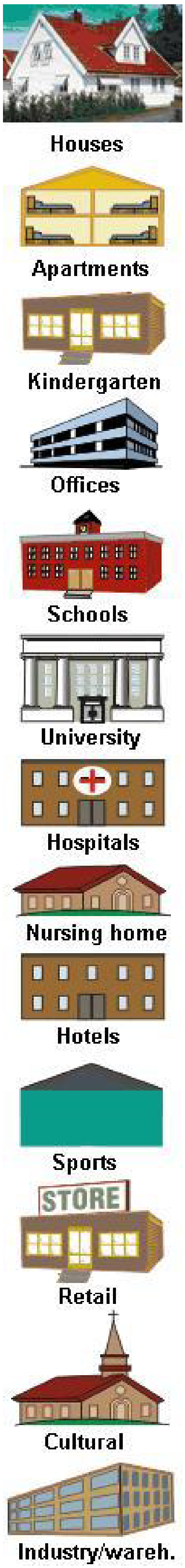
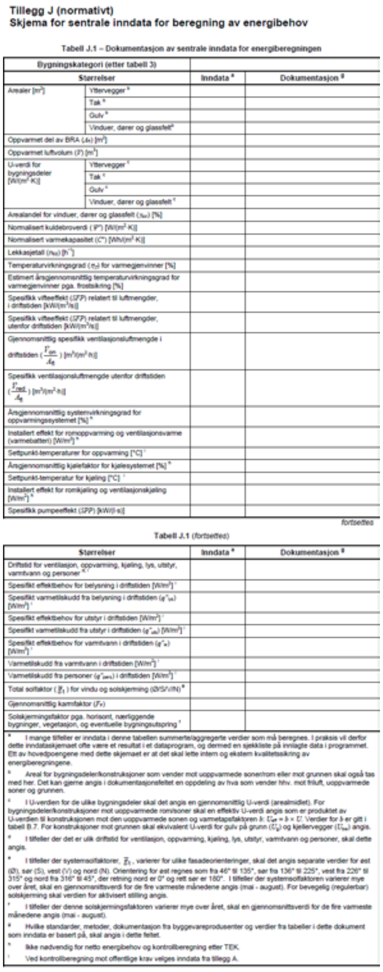


Fig.9 The 13 building categories

Fig.10



Tillegg J (normativt)
Skjema for sentrale inndata for beregning av energibehov

Tabell J.1 – Dokumentasjon av sentrale inndata for energiberegningen

Bygningskategori (etter tabell 3)			
Størrelser		Inndata [a]	Dokumentasjon [g]
Arealer [m²]	Yttervegger [b]		
	Tak [b]		
	Gulv [b]		
	Vinduer, dører og glassfelt [b]		
Oppvarmet del av BRA (A_{fl}) [m²]			
Oppvarmet luftvolum (V) [m³]			
U-verdi for bygningsdeler [W/(m²·K)]	Yttervegger [c]		
	Tak [c]		
	Gulv [c]		
	Vinduer, dører og glassfelt [c]		
Arealandel for vinduer, dører og glassfelt (γ_{fv}) [%]			
Normalisert kuldebroverdi (Ψ'') [W/(m²·K)]			
Normalisert varmekapasitet (C'') [Wh/(m²·K)]			
Lekkasjetall (n_{50}) [h⁻¹]			
Temperaturvirkningsgrad (η_t) for varmegjenvinner [%]			
Estimert årsgjennomsnittlig temperaturvirkningsgrad for varmegjenvinner pga. frostsikring [%]			
Spesifikk vifteeffekt (SFP) relatert til luftmengder, i driftstiden [kW/(m³/s)]			
Spesifikk vifteeffekt (SFP) relatert til luftmengder, utenfor driftstiden [kW/(m³/s)]			
Gjennomsnittlig spesifikk ventilasjonsluftmengde i driftstiden ($\frac{V_{on}}{A_{fl}}$) [m³/(m²·h)]			
Spesifikk ventilasjonsluftmengde utenfor driftstiden ($\frac{V_{red}}{A_{fl}}$) [m³/(m²·h)]			
Årsgjennomsnittlig systemvirkningsgrad for oppvarmingssystemet [%] [h]			
Installert effekt for romoppvarming og ventilasjonsvarme (varmebatteri) [W/m²] [h]			
Settpunkt-temperaturer for oppvarming [°C] [i]			
Årsgjennomsnittlig kjølefaktor for kjølesystemet [%] [h]			
Settpunkt-temperatur for kjøling [°C] [i]			
Installert effekt for romkjøling og ventilasjonskjøling [W/m²] [h]			
Spesifikk pumpeeffekt (SPP) [kW/(l/s)]			

fortsettes

Tabell J.1 (fortsettes)

Størrelser	Inndata [a]	Dokumentasjon [g]
Driftstid for ventilasjon, oppvarming, kjøling, lys, utstyr, varmtvann og personer [d, i]		
Spesifikt effektbehov for belysning i driftstiden [W/m²] [i]		
Spesifikt varmetilskudd fra belysning i driftstiden (φ''_{lys}) [W/m²] [i]		
Spesifikt effektbehov for utstyr i driftstiden [W/m²] [i]		
Spesifikt varmetilskudd fra utstyr i driftstiden (φ''_{utst}) [W/m²] [i]		
Spesifikt effektbehov for varmtvann i driftstiden (φ''_w) [W/m²] [i]		
Varmetilskudd fra varmtvann i driftstiden [W/m²] [i]		
Varmetilskudd fra personer (φ''_{pers}) i driftstiden [W/m²] [i]		
Total solfaktor ($\overline{g}_t$) for vindu og solskjerming (Ø/S/V/N) [e]		
Gjennomsnittlig karmfaktor (F_F)		
Solskjermingsfaktor pga. horisont, nærliggende bygninger, vegetasjon, og eventuelle bygningsutspring [f]		

[a] I mange tilfeller er inndata i denne tabellen summerte/aggregerte verdier som må beregnes. I praksis vil derfor dette inndataskjemaet ofte være et resultat i et dataprogram, og dermed en sjekkliste på innlagte data i programmet. Ett av hovedpoengene med dette skjemaet er at det skal lette intern og ekstern kvalitetssikring av energiberegningene.

[b] Areal for bygningsdeler/konstruksjoner som vender mot uoppvarmede soner/rom eller mot grunnen skal også tas med her. Det kan gjerne angis i dokumentasjonsfeltet en oppdeling av hva som vender hhv. mot friluft, uoppvarmede soner og grunnen.

[c] I U-verdien for de ulike bygningsdeler skal det angis en gjennomsnittlig U-verdi (arealmidlet). For bygningsdeler/konstruksjoner mot uoppvarmede rom/soner skal en effektiv U-verdi angis som er produktet av U-verdien til konstruksjonen mot den uoppvarmede sonen og varmetapsfaktoren b: $U_{eff} = b \times U$. Verdier for b er gitt i tabell B.7. For konstruksjoner mot grunnen skal ekvivalent U-verdi for gulv på grunn (U_g) og kjellervegger (U_{bw}) angis.

[d] I tilfeller der det er ulik driftstid for ventilasjon, oppvarming, kjøling, lys, utstyr, varmtvann og personer, skal dette angis.

[e] I tilfeller der systemsolfaktorer, $\overline{g}_t$, varierer for ulike fasadeorienteringer, skal det angis separate verdier for øst (Ø), sør (S), vest (V) og nord (N). Orientering for øst regnes som fra 46° til 135°, sør fra 136° til 225°, vest fra 226° til 315° og nord fra 316° til 45°, der retning nord er 0° og rett sør er 180°. I tilfeller der systemsolfaktoren varierer mye over året, skal en gjennomsnittsverdi for de fire varmeste månedene angis (mai - august). For bevegelig (regulerbar) solskjerming skal verdien for aktivisert stilling angis.

[f] I tilfeller der denne solskjermingsfaktoren varierer mye over året, skal en gjennomsnittsverdi for de fire varmeste månedene angis (mai - august).

[g] Hvilke standarder, metoder, dokumentasjon fra byggevareprodusenter og verdier fra tabeller i dette dokument som inndata er basert på, skal angis i dette feltet.

[h] Ikke nødvendig for netto energibehov og kontrollberegning etter TEK.

[i] Ved kontrollberegning mot offentlige krav velges inndata fra tillegg A.

Fig.11: *Two-page EP calculation summary*

2.3 Building Regulations: Compliance and Control [3]

Construction errors are a significant problem in Norway. Approximately 10 % of the industry's costs are due to errors; half of which appear during the construction phase, and the remaining half are discovered after acquisition. Some appear only after many years (e.g. moisture damage). Insurance companies have a vested interest in improving construction quality. However, EP is rarely flagged as an issue.

Handling of building permit applications: Applications are generally submitted and administrated electronically (*http://byggsok.no/*). Output from the EP calculation is submitted together will any underlying product-documentation for non-default values in the calculation. Generally, a two-page summary will suffice (Fig.11). The format of this mandatory 2-page document is defined in NS 3031 Appendix J. It gives experts/clerks an instant overview of key data. Each data value has an associated comment field for referencing documentation. The clerk quickly sees whether the comment fields are used seriously to refer to appended documentation that proves the validity of the values taken forward.

Control of the regulations is the responsibility of the municipality where the building is located. This is mainly an administrative check that all QC forms and reports are completed & submitted. The local authorities do not necessarily have the resources or competence to check the underlying EP documentation, so in practice the system is largely based on trust. Builders will naturally wish to avoid mistakes that could result in sanctions or civil litigation by the building owner. Most noncompliance with the EP regulations is therefore probably done unawares, but there is probably a degree of deliberate noncompliance by hard-pressed builders who exploit the owner's incompetence and the superficiality of the authorities' control.

Some important parameters should strictly always be documented in a building permit, such as heat recovery efficiency or window U-values. However, in practice, the documentation can be very basic, such as declared product type, not necessarily manufacturer. This is reasonable, since the builder does not necessarily decide on specific building products until after receiving the building permit. Sadly, this practice can contribute to a gap between required and true performance of new buildings. Fortunately, energy labels can potentially reveal this.

The National Office of Building Technology and Administration administers a central national register for authorizing companies (designers, contractors and controllers) in the building trade.

A recent revision of the law has made the control system more stringent by enforcing third party on-site technical checks.

Sanctions and litigation: The Planning-&-Building Act lists sanctions that may be applied in case of law infringements. It is the responsibility of local municipalities to exercise control. The most common sanction is a fine together with enforced remedial work, and that the offending company can (partly or wholly) lose their authorization, but imprisonment is possible. If the planning-&-building authorities find that the offence is trifling, they usually refrain from subjecting it to any sanctions.

The authorities often do not have the capacity to uncover minor breaches of the building regulations, especially related to EP. This is confounded by socially accepted wisdom that buildings often use more energy than predicted, due in part to occupant behaviour. Often it is the building user (owner or tenant) who discovers infringements of the law, or deviations from contracted specifications. Therefore, in practice, most

[3] Compliance means the fulfilment of EP requirements and EP certification process, while control is the mechanism for checking compliance of individual buildings.

cases end up as disputes between, for example, the owner and builder, and can be solved by civil litigation.

Fig.12: *Norwegian certificate*

3 > IMPLEMENTATION OF ENERGY LABELLING

It has been decided that the energy-labelling scheme will be a free web-based service/database (EnergiMerkeSystemet, "EMS"). Its website (*http://www.energimerking.no/*) gives access to data acquisition, an EP calculation program, issuing of the certificates, and background information related to the scheme. Fig.13 illustrates the system.

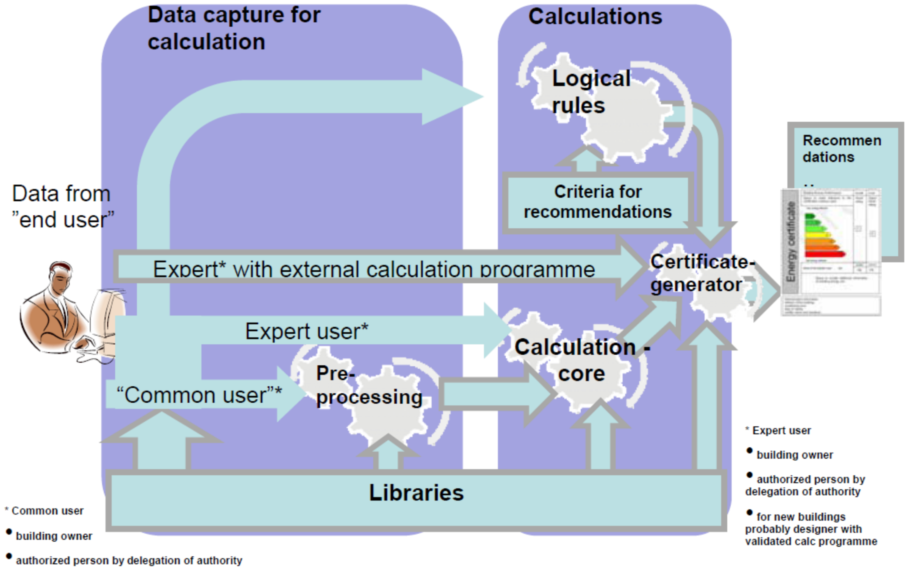


Fig.13: *Schematic showing information flow and processing in the Energy Marking System (EMS). [source: Rode & Isachsen, NVE]*

Which buildings?: Energy labelling will encompass generally all buildings over 50 m². Energy labelling will comply with EPBD Article 7. All buildings (not only public) over 1000 m² shall have the label on display at all times. This is wider than the scope of Article 7.3. However, listed buildings (cultural monuments), churches, agricultural work buildings, and industrial process premises will be exempted. Labels will last 10 years.

Fig.14
Who is qualified to label?

Who is qualified to label?: The website is available to all building owners to certify their own building. Owners can delegate the task to anybody who they deem more competent. All Norwegians have received a password card ('AltInn'/'MinID') for web access to some State services. There are two different categories of label:

Simple: For all residential buildings (single or multifamily housing), there will be no qualification requirements, and owners can cerfity the building themselves. This, and the lack of impartiality, has been strongly criticized by much of the building industry, and violates EBPD Article 10 that requires certification to be conducted by independent experts. However, the government has invested significant resources, relative to other countries, in developing the robust and user-friendly interface ('pre-processor' in Fig.13) and advanced automatic recommendation generator ('logical rules' in Fig.13). Moreover, it will be a cheap and unbureaucratic way of implementing the EPBD. This avoids an immediate bottleneck due to shortage of certified assessors.

Advanced: For all other buildings, there is a need for more detailed input to the software. The building owner can delegate the task of certifying to anyone they choose. However, certifiers must confirm that their qualifications are adequate against a predefined set of requirements. It is also be possible to upload calculations conducted on other validated EP calculation software.

Fig.15
Sanctions for noncompliance

Fig.16: *Control and spot checks. NVE acts as sheriff!* *[source: NVE]*

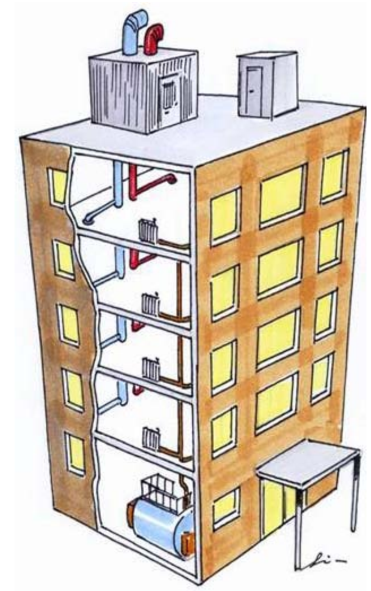
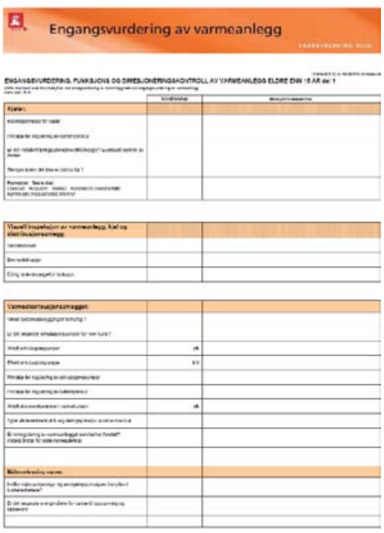


Fig.17: *Inspected systems [source: NVE]*



Engangsvurdering av varmeanlegg

Fig.18: *Heating system inspection form [source: NVE]*

Control and sanctions: Building owners are responsible for the quality of documentation that is stored in the national certification database (EMS). Potential buyers or tenants can check the documentation and decide whether the labelling has been done in a satisfactory manner. Any underlying documentation will also be available in the database. Most cases of missing or incorrect certificates will be a question that must be resolved by civil litigation between the buyer/tenant and seller, to settle claims for compensation. Such civil sanctions will of course not occur for breaches of the duty to display certificates in large buildings.

It is important for the credibility of the scheme that the authorities can impose sanctions for violations. The certification database is administered by the Norwegian Water Resources and Energy Directorate (*http://www.nve.no/*). Their control activities will include spot checks of the quality of energy labelling and inspection reports, and buildings that should have a visible certificate. This complies with EPBD article 17. The minor offence of missing or incorrect certification/inspection will incur an administrative fine.

4 > IMPLEMENTATION OF INSPECTION SCHEME

Inspection schemes: This will be an extension of already established voluntary inspection regimes by qualified service personnel, e.g. '*EO-ordningen*' for boilers and '*TELFO/KELF-ordningen*' for chillers/heat pumps, making them mandatory. Inspection reports are registered the same web-based central database as energy labels.
There will be three schemes; provisional details are given below:

> Regular (2-yearly for >100 kW, 4-yearly for >20 kW) inspection of fossil-fuel **boilers** irrespective of building type. Focus on energy.

> One-off inspection of old (>15 year) **heating systems** with fossil-fuel boilers (>20 kW) irrespective of building type. Encompasses whole heating system, including distribution & sizing.

> Regular (probably 5-yearly) inspection of **refrigeration** and **ventilation** systems in buildings (>12 kW nominal cooling capacity). Encompasses AC-equipment, air handling units, and distribution. Focus on energy.

Who is qualified to conduct inspections?: It is provisionally intended that:

> >20 kW boilers will require relevant competence with 2 years of experience from inspection and operation.

> >100 kW boilers: As above but with 5 years of experience.

> One-off inspections of the rest of the heating system will require HVAC-related competence at engineer-level (bachelor) and 2 years of experience from building energy calculations.

> AC/ventilation installations will require HVAC-related competence at engineer-level (bachelor) and 2 years of experience from installing or evaluating such systems.

Control and sanctions will be the same as for the labelling scheme, with spot checks and administrative fines for missing reports. Professional misconduct of inspectors will may result in the loss of right to practice.

5 > OTHER NATIONAL INCENTIVES

There are many existing incentives for promoting energy efficiency. The energy labelling and inspection schemes will be coordinated with these:

> The Norwegian State Housing Bank gives higher loans for low energy housing. These loans have favourable interest rates.

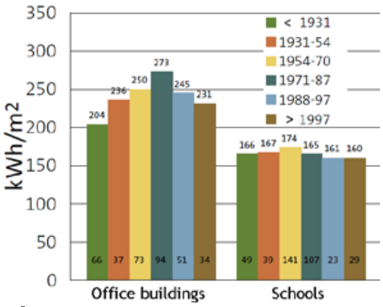


Fig.19: *Present energy consumption of offices & schools by construction year. Buildings from <1931 do not use more energy. Many older buildings in this sample have probably been rehabilitated. The picture for housing is the same. [source: ENOVA]*

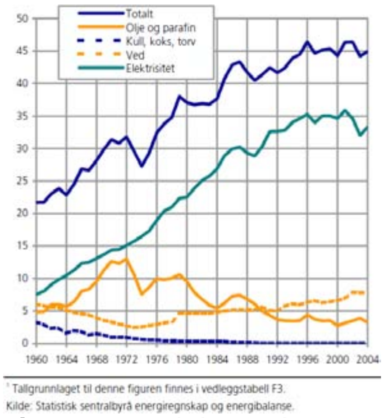


Fig.20: *Growth in total energy consumption of housing since 1960 [source: SSB]*

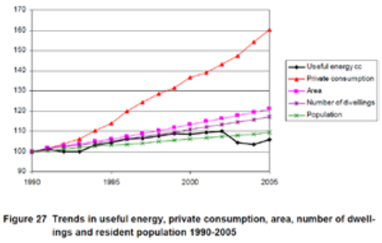


Fig.21: *Growth in wealth, built housing area, no. of dwellings and population since 1960 [source: IFE/ODYSSEE]*

Fig.22

> The national energy agency, Enova (*http://www.enova.no/*), provides financial support to new projects and energy retrofits.

> The municipality of Oslo has an energy-efficiency fund that can support energy-efficiency projects, usually retrofit.

> Regulation on informative billing, implemented 1999. High impact [7].

6 > IMPACT OF EPBD

It is difficult to analyse the impact of EBPD by isolating it from the other ongoing national measures. The building regulations were due for revision anyway in 2007. We might get a rough idea of the potential impact of EPBD by looking at the outcome of previous building regulations.

Impact of regulations on energy efficiency*:* The Norwegian building regulations have had requirements on thermal insulation since 1949 (Fig.6). Over the years, most recently 1987 & '97, the requirements have been both sharpened and extended to several other factors that affect energy use and indoor environment. There is strong historical evidence that tightening building regulations in 1987 & '97 influenced the energy efficiency of the building stock (Fig.19).

It is too early to say what impact EPBD has on the energy consumption of the building stock as a whole. However, the few new buildings that are being constructed after the new EPBD regulations are approx. 25 % more energy-efficient than buildings from 1997-2007.

Other historic influences: There was a longstanding trend of increasing energy consumption up to the mid 1990s (Fig.20). This was due to increasing wealth leading to growing dwelling size and energy-intensive use/in of dwellings, combined with the fact that the number of dwellings has increased as the population has grown and a larger fraction of people live alone (Fig.21). Since then, the degree-day-corrected energy consumption of the housing stock has stabilized (right-hand side of Fig.20), despite continued population growth and lower area-efficiency. It seems that housing standards have now plateaued, such that further increases in private wealth no longer result in increased energy use. Since the mid '90s, the energy consumption per m² has decreased, as well as consumption per dwelling and per capita. This improvement in energy-efficiency is due to a combination of factors, most notably higher energy costs, but also more focus on energy conservation (e.g. heat pumps), better insulation and more efficient equipment.

Summertime temperatures: Although the climate in Scandinavia is subarctic, tightening the thermal insulation requirements has worsened the problem of overheating in summer, most notably in apartment & office buildings. Another point to note is that the sun is lower in the sky at high latitudes, leading to more perpendicular solar radiation though windows in the East/South/West facades. Moreover, high latitudes experience more hours of daylight than Southern Europe during summer.

To reduce the risk of overheating, the new regulations are formulated to promote passive measures such as shading and limiting glazing area. Other beneficial changes to the calculation method thermal comfort are already described on pages 2-3 & 5. However, experience has shown us that the 2007 regulations are not strict enough on this topic. The building regulations will therefore be revised in 2010 to limit solar gain factor for non-residential buildings ($g_t \leq 0.1$) if cooling is installed. Another additional minimum requirement will be limiting window area ($\Sigma UA_{window}/A_{floor} \leq 0.24$), which should affect both cooling and heating load. These new requirements alone might not be sufficient, as it will still be possible to design wide office buildings with 100 % glazing.

Although it remains to be seen how effective these measures are. Norway has at least taken a large step in the right direction, given that the previous building regulations (1997) did not limit energy for cooling.

Market effects: It is too early to say how energy labelling or inspection will affect the market value of buildings, and the trade of building products/services. However, it is expected to have an impact, aided by rising public concern for climate change.
We have already observed positive impacts of the new building regulations.

> Parts of the building industry were initially very concerned about the ability to economically adapt manufacturing & construction practices.
  For example, many SME window manufacturers were concerned about losing market shares because their windows did not have low U-values. However, this concern has ceased. Manufacturers have managed, with help, to upgrade and document their products.
  Another example was airtightness. The requirement for houses was tightened from $n_{50}\leq 4$ to 2.5. Builders have now discovered that simple changes in construction practice can easily achieve $n_{50}=1$(4) without increased construction costs. The requirement for larger buildings ($n_{50}\leq 1.5$) remained unchanged from the 1997 regulations, and has been proven to be achievable long ago.
> There is a general understanding that the increased building costs are profitable. The severity of the energy-efficiency measures in the new EPBD building regulations were based on an economic evaluation, with a payback period of 4.4~9.0 years depending on building type.
> The regulations have led to increased interest in building products for low U-value insulation, glazing, and airtightness. Leakage testing is expected to become more common, though it is not yet mandatory.
> Balanced ventilation with efficient heat recovery was already standard in large buildings before EPBD, and is now effectively standard for all. The 'checklist' heat exchanger efficiency will be increased to 80 % after 2010 (70 % for dwellings, and zones where recirculation must be avoided, e.g. isolation wards). The EP calculation standard properly calculates energy for defrosting heat exchangers(5).The software user must specify the type of heat exchanger (which decides the limiting exhaust temperature). The consequence of this is that regenerative heat exchangers (especially rotary) are predominant, as they generally do not experience icing. Plate heat exchangers, especially counter-flow devices, suffer a drop in efficiency due to defrosting in the subarctic climate. There is still potential for product development.

7 > SUGGESTED FUTURE IMPROVEMENTS

A government-appointed committee of experts has recently completed its report with national energy-conservation recommendations[6]. It suggests that it is possible to halve the building sector's energy use over 30 years. Such a halving can be achieved by tighter regulations for new buildings, considerable effort to make major rehabilitations energy-effective, and energy conservation measures in other buildings. Achieving these goals will require a long-term large-scale coordinated plan to change the market for energy-efficient solutions and empower the building trade to deliver the necessary solutions.

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4 Buildings with balanced ventilation do not have fresh air vents. Vents can increase n_{50} by at least 1 h^{-1}.
5 A further development of the method given in EN 15241. Defrost energy is best calculated using hourly weather data.

The following set of policy actions was recommended:

1 National action plan to improve energy-effectiveness of buildings
2 Large-scale competence plan for the building industry
3 Forewarned incremental tightening of the building regulations (Fig.23)
4 Stricter control of energy requirements for rehabilitation projects
5 Influential forerunner projects and demonstration buildings
6 Revised energy labelling scheme with 'energy plan' for existing buildings
7 Simplify, widen, and increase investment support from energy agency
8 State loan scheme for energy conservation/retrofit measures
9 White certificates for energy saving and tax incentives for energy efficient buildings
10 Special requirements for public buildings
11 Better information and advice to improve buyer competence

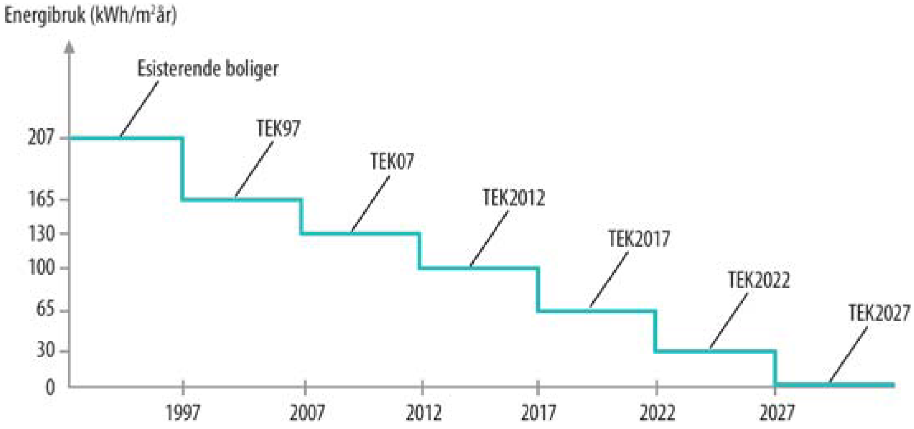

Fig.23: *Suggested plan for incremental tightening of building regulations, approaching Zero Energy standard by 2027 [6]*

8 > REFERENCES

[1] Norwegian Standard NS 3031:2007, 'Calculation of energy performance of buildings - Method and data', *http://www.standardnorge.no/*

[2] Norwegian Standard NS 3940:2007, 'Areas and volumes of buildings', *http://www.standardnorge.no/*

[3] National Office of Building Technology & Administration (Statens bygningstekniske etat), *http://www.be.no/*

[4] Act relating to the generation, conversion, transmission, trading distribution and use of energy etc. (The Energy Act).

[5] Booklet '*U-values for better energy performance of buildings*'. Brussels: Eurima (European Insulation Manufacturers Association)

[6] Report '*Lavenergiutvalget: Energieffektivisering*'. Oslo: Ministry of Petroleum & Energy (Olje- & energidepartementet)June 2009

[7] Regulation of 11 March 1999 concerning metering, settlement and coordination of electricity trading and invoicing of network services.

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