Energy Savings Calculations for selected end use technologies and existing evaluation practices in Norway

A report produced for the IEA DSM Agreement, Task 21 Harmonisation of Energy Savings Calculations

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In the IEA DSM Agreement, Task 21 Harmonisation of Energy Savings Calculations, the following countries are participating:

France,
Republic of Korea
Netherlands
Norway
Spain
Switzerland
USA

Each country prepared a report on the Energy Savings Calculations for selected end use technologies and existing evaluation practices. These reports are available at
www.ieadsm.org

The report holds information on selected case applications. These cases are selected with a view to present information on the energy savings calculations that are or could be done for the selected end use technologies. The case applications are not selected as best practice examples, but are good examples for common practise.

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1. CASE APPLICATION

1.1   Introduction

The country experts discussed during the project how an overview could be created for the methods that are used for calculating or estimating (ex-post) energy savings. It was decided to use case applications in selected technology areas and energy end-users. For this project the selection of case applications is to illustrate what is or could be used for estimating energy savings from programme or project implementations. The case applications show the practise in a participating country, without suggesting that these are 'best practises'. They are a snapshot and sometimes also one of the applications that are in use in a country, but they clearly illustrate what key elements in the energy savings calculations are, how problems in data collections are handled and how default or standard values are used.

The case applications are selected for the following technologies and energy end-users:

a. Industry; Variable Speed Drive and High Efficient motor
b. Commercial Buildings; Heating system
c. Commercial Buildings; Integrated Air conditioning system
d. Households; Retrofit wall insulation
e. Households; Lighting

For Norway the following case applications are selected:
- electricity savings from heat pumps
- electricity savings from window retrofitting

These case applications are presented from section 1.2 onwards.

Each of the case applications presents the information in a common format, a template. There are four groups:

1. Summary of the program
2. Formula for calculation of annual energy savings
3. Input data and calculations of energy savings
4. Greenhouse gas savings

Additional information is provided in references, one or more annex and on definitions

The template was improved during the project, based on experiences to present the information for case applications and discussions during the experts meetings. A workshop was held in April 2011 in Korea to get feed back on the final draft of the template. During the workshop three different case applications were presented to illustrate the use of the template and to discuss future application.

In Annex A the final version of the template with instructions is enclosed.

Additional to the case application on energy savings, in Annex B one case application on the Demand Response programme "Remote Load Control" is included. The information on the Demand Response programmes is used to gain knowledge on the role energy savings play in such programs.

1.2 Electricity savings from heat pumps: The Norwegian Household Subsidy Programme

1 Summary of the program.

1.1 Short description of the program

1.1.1 Purpose or goal of the program

Energy use in Norway is characterized by an, in a European context, unusually high dependence on direct electrical heating. For households this translates into a situation where on average more than 60 % of the electricity consumption is for heating purposes. Many households have no real alternative to electrical heating, and in periods with cold weather and high electricity prices this implies high costs for the households. Also the supply situation (both power and energy) can be very challenging in these periods.

The purpose of the *Household Subsidy Programme* (HSP) is to stimulate the introduction of alternatives to direct electrical heating in households. Main technologies have been wood pellet based systems and air-to-air heat pumps. The latter turned out to be the most successful of these technologies in terms of market penetration, and is thus focused in this case description. In the first period of the programme, 2003, approx. 18.000 heat pumps were supported before the subsidy scheme was terminated. Subsequently the heat pump market has developed rapidly, and by 2010 more than 400.000 units have been installed in homes and buildings. In this case presentation we aim at describing how to calculate the energy savings resulting from this programme.

1.1.2 Type of instrument(s) used

The main instrument of the HSP was an investment subsidy, supported by various communication measures, such as media campaigns, a toll-free phone advice service, and a web based information and application portal.

The subsidy was 20 % of the total investment cost, or a maximum of NOK 5.000. (≈EUR 640, June 2011 exch. rate).

1.2 General and specific user category

The target group for the programme was private households. No segments of households were excluded, but it was recommended that the household had annual electricity consumption in excess of 20.000 kWh. This recommendation was to ensure a minimum level of profitability potential of the investment for the household.

1.3 Technologie(s) involved

Air-to-air heat pumps with the following technical characteristics were supported:
- Refrigerant: HFC or natural medium
- Inverter technology (variable compressor speed)
- CE-mark (officially tested) or Eurovent-classification

- Adapted to a Nordic climate to prevent ice build-up.

1.4 Status of the evaluation and energy savings calculations

There is no official national standard in Norway for the calculation of savings from heat pumps. The method described here is one that was underlined used in practice in an evaluation of the mentioned HSP (Bjørnstad et al., 2005). This study is probably the analysis that has had access to the highest quality metering data and other relevant data. Other studies use simpler savings calculation methods, typically limited by data availability and/or quality.

1.5 Relevant as a Demand Response measure

Electrically driven air-to-air heat pumps are not ideally suited as a demand response technology. If the heat pump replaces wood or oil based heating, the peak load potentially increases. Grid peaks in Norway correlate with low outdoor temperatures (high heating needs). Air-to-air heat pumps have their lowest efficiency (COP) when the heating need is the greatest. Although these heat pumps deliver substantial savings on an annual basis, their electricity peak load reduction potential is more limited.

It is possible that these heat pumps can be switched off during peak periods, thus reducing peak demand. In a well insulated house, this may reduce heating comfort only marginally. Since these pumps are not associated with thermal storage of any kind, their switching off periods will be of limited duration. In this respect the heat pumps may perform marginally better than the technology they were aimed to replace, namely electric panel heaters.

2 Formula for calculation of Annual Net Energy Savings

The aim of the calculation is to determine the annual net savings in kWh of electric energy per household of the households participating in the programme. Fundamental in this calculation is the measurement of the actual annual electricity consumption of the household before and after installation of the heat pump. The measured consumption data need to be normalised with regard to heating need, with either the base (ex-ante) year, the after (ex-post) year, or some normal year as reference. In addition data on the electricity end use distribution of the household is needed, in order to determine the share of electricity used for heating, which is the share that is to be normalised. The method applied calculates energy savings only between the measured base year and the measured reference year. By standardising the heating need, however, a normalised annual electricity savings number can be calculated. This number, which is calculated at an individual household level, represents an estimate of the annual electricity savings by the household.

2.1 Formula used for the calculation of annual energy savings

The normalised net savings formula in year t for household i is:

(1) $\qquad S_{t,i} = \left(CT_{-1,i} - CNH_{-1,i}\right) \cdot \dfrac{DDn_i}{DD_{-1,i}} - \left(CT_{t,i} - CNH_{t,i}\right) \cdot \dfrac{DDn_i}{DD_{t,i}}$

where

(2) $\qquad CNH_{t,i} = 8000 + 1000 \cdot m_{t,i}$

The aggregated net programme savings in year t become:

$$(3) \qquad PS_t = \sum_i S_{t,i}$$

Since it is only the heating part of electricity consumption that is subject to HDD variations (see section 2.5 Normalization), it is necessary to isolate the electric energy spent for space heating from other end uses such as lighting, washing, entertainment, refrigeration, etc.

The actual end use distribution of electricity in Norwegian households is an ongoing debate, and the answer to this problem is still uncertain. Top-down and bottom-up methods differ in results. Some attempts to measure the end-use distribution have been undertaken, but it is difficult to generalise from these findings. The most recent work in this respect is the Remodece-project (Grinden and Feilberg, 2008). The Norwegian part of this analysis shows a heating share in households at approximately 60 %. However, when a household invests in new heating technology, such as heat pump, one can not apply this "average percentage approach" to both ex-ante and ex-post distributions. An alternative method is to deduce the electricity used for non-heating purposes and define the residual as electricity for heating. Myhre (2004) suggests the following simple formula: Non-heating part = 8000 kWh + 1.000 kWh per household member.

The 60 % share is valid for the base-line only, since one major goal with the programme is to reduce the heating share of end use. The more robust method for obtaining the energy savings therefore is to estimate the non-heating consumption in the baseline, and use the same value as non-heating consumption also after the installation of the heat pump, provided that no changes in demographics or other variables that affect this consumption have taken place.

Annual consumption data have been calculated on the basis of semi-annual data on electricity sales before and after the installation of heat pump. Data for the individual households have been obtained from the respective grid owners. This should imply high reliability, provided that the households read and report data correctly.

2.2   Specification of the parameters in the calculation

The following parameters are used in the calculation formulas:

i =   household index, $i = 1...n$
t =   time index, specified as follows:
$t = -1$ =   The last full year before installation of heat pump (ex-ante year)
$t = 0$ =   The <u>point in time</u> of installation of the heat pump
$t > 0$ =   Any full year of operation after installation of the heat pump (ex-post year) (limited to the lifetime of the heat pump)
$m_{t,i}$ =   the number of members of household i in year t
$S_{t,i}$ =   Normalised net savings of electric energy in year t for household i
PS_t =   Total programme net savings in year t
$CT_{t,i}$ =   Observed (metered) annual <u>total</u> consumption of electricity (kWh) in year t for household i
$CNH_{t,i}$ =   Annual consumption for <u>non-heating purposes</u> of electricity in year t for household i (kWh). Can be metered or estimated.

DDn_i =   Normalised annual degree day sum for household i

$DD_{t,i}$ =   Observed (metered) degree day sum in year t for household i

2.3   Specification of the unit for the energy saving calculation

The energy savings in kWh electric energy per year are specified per household participating in the Household Subsidy Programme.

2.4   Baseline issues

The baseline consumption is estimated based on individual household meter readings. This is based on the meter values that were reported to the electricity supplier as a basis for billing. The baseline total electricity consumption is thus assumed to be fairly correct.

There are more uncertainties related to the split of the total consumption on heating and non-heating consumption. The simple formula in (2) is used to identify the non-heating consumption. This is the best approximation that can be obtained based on the available demographical data and with the desire to maintain a simplest possible calculation, but we know that variables other than household size affect this value. There is no reason, however, to assume that this formula introduces any systematic error or bias to the calculation.

The remaining heating part of the electricity consumption must be normalised with respect to heating degree days to correct for variations over time in outdoor temperatures.

The baseline is static.

2.5   Normalization

The heating part of electricity consumption is normalised for HDD variations. The use in Norway of the concept of "Heating Degree Days" is based on the idea that Norwegian homes do not require active heating when the outdoor temperature is 17 ˚C or higher. The heating need a given day is assumed to be proportional to the difference between 17 ˚C and the observed average outdoor temperature, if this average is below 17 ˚C.

Different methods are used to estimate the average daily temperature, depending on how frequent temperature observations are available on the location in question. Since there are significant regional variations in temperatures in Norway, local temperature observations are necessary to get a reliable value for the Heating Degree Days.

The Norwegian Meteorological Institute publishes normalised annual HDDs for different regions in Norway. Our measured data are normalised according to these values.

2.6   Gross to net corrections

By gross savings we mean the savings in electricity consumption for the individual households resulting from replacing the electric panel heater with an air-to-air heat pump. In other words, these are the savings that the household would have obtained if the heat pump had produced similar "heat services" as the electric panel heater, ceteris paribus. We observe

from survey data that an assumption of "all other factors unchanged" is not generally satisfied. Many households report that they have done one or several of the following changes in energy use between ex-ante and ex-post consumption metering:
- reduced use of fire wood
- reduced use of heating oil
- increased general indoor temperature
- changed (increased) heated floor area
- etc.
These changes in energy use imply that the changes in metered consumption are not only due to the installation of the heat pump, but also a result of the sum of effects from all these energy use changes. These energy use changes may be termed interaction effects, substitution effects, rebound effects, etc. By net savings we thus mean the savings that can be verified after all adjustments in energy use that are relevant in relation to the installation of the heat pump. The effects of the individual elements of energy use changes are not quantified.

In order to estimate the gross to net corrections, the following has been done. First, the average savings for all households in the sample is calculated, without respect to any of the mentioned changes in energy behaviour. This number is the average net savings for the household sample. Second, a sub sample of households is identified. This sub sample consists of all households that report that they have done no changes in energy use other than the heat pump installation. The measured average savings of the households in this sub sample thus represents an estimate of the gross savings of the households participating in the programme.

Free riders are not corrected for.

3 Input data and calculations

3.1 Parameter operationalisation

The parameters of the formula have been operationalised as follows:
-   Ex-ante and ex-post electricity consumption have been measured for each individual household based on self-reported meter readings.
-   Heating Degree Days data have been obtained from the Norwegian Meteorological Institute. Data for the meteorological station closest to the individual household in the relevant period (year) are used.
-   "Normal year" HDD data are used to normalise the observed consumption data
-   Demographical data on the individual households are used to estimate the non-heating proportion of the electricity consumption

A survey to a sample of households participating in the 2003 HSP is the main source of data for the calculations. The survey yielded 466 valid responses.

3.2 Calculation of net annual savings as applied

The mean total annual savings for the full sample (N=466) are 5.116 kWh. These are the net annual savings per household. Here the effects on savings due to technical interactions, rebound effects etc. are accounted for.

The calculated savings for the sub sample of households that did no ex-post adjustments in their energy use is 5.946 kWh/year. This is an estimate of the gross annual savings, i.e. savings directly related to the installation of the heating pump, without adjustments for the supplementary effects mentioned above.

The 2003 HSP was a one-shot programme, in that it was open for applications during only a few weeks. The net savings resulting from the programme are therefore limited to the 18.100 households that participated. However, the programme had a significant market effect, since the market for air-to-air heat pumps has developed strongly after the programme, as indicated in the introduction. These "spill over" effects are not included in the aggregated calculations.

18.100 households with average net annual savings at 5.116 kWh/year represent net programme savings close to 92.6 GWh/year.

3.3   Total savings over lifetime

Only annual savings are calculated in this programme.

3.3.1   Savings lifetime of heating commercial buildings

Although not relevant for the annual savings calculation, the technical lifetime for the heat pumps is assumed to be 12 years.

3.3.2   Lifetime savings calculation of heating commercial buildings

N.A.

4   **GHG savings**

There is no calculation of GHG savings

References

Bjørnstad, E. et al. (2005): Evaluering av tilskuddsordningen til varmepumper, pelletskaminer og styringssystemer. NTF-rapport 2005:2. Nord-Trøndelagsforskning, Steinkjer.

Grinden, B. and N. Feilberg (2008): Analysis of monitoring campaign in Norway. REMODECE report D-10.

Myhre, L. (2004): Energitiltak i eksisterende boliger. Presentasjon. Oslo: Norges byggforskningsinstitutt.

1.3 Electricity savings from window retrofitting: The "Enova Recommends" Program

1 Summary of the program.

1.1   Short description of the program

1.1.1   Purpose or goal of the program

Norwegian houses from the 1960s, -70s and -80s are built with an energy quality that is considerably lower than the quality prescribed by current building regulations. This lower quality is related to the windows, general air tightness and wall insulation, and manifests itself in a relatively high heat loss and thus high energy consumption for heating. Typically, 40 % of the heat loss through the building envelope is related to the windows of these houses, in a Nordic climate. The windows of such buildings thus represent a central component to address in order to achieve energy savings and increased comfort in the homes.

The purpose of the "Enova Recommends I" programme, which focuses on windows, is to stimulate the diffusion in the retrofit market of low-energy windows. By stimulating households to choose low-energy windows instead of standard windows in a retrofit process, additional energy savings can be achieved. The Enova Recommends commenced in 2008 and has been running since.

A simple monitoring scheme for the programme has been initiated. The following market data are collected on a quarterly basis:
i) Home retrofitting activities
A sample of 1.000 households answers a survey regarding their activities on home retrofitting. Among the questions are whether they have changed windows, the energy quality of the windows, the number of windows and their size.
ii) Market data
All (or at least a large majority of) window producers in Norway report each quarter on their sales, including the sales of low energy windows. This gives a good picture of the overall market development for low energy windows.

1.1.2   Type of instrument(s) used

"Enova Recommends" is based on several instruments:
1) A label
The products that are promoted in this programme are labelled "Enova Recommends". This label is used on the products and on relevant promotion materials used by the programme.

2) Technical specification of the "Enova Recommends window"
A quality specification sheet has been developed, that details which criteria that must be satisfied in order for a specific window to qualify for the label. The U-value of the window is one of those criteria.

3) Supply side participation

Windows producers that supply products according to the technical criteria of the programme may use the label and other promotions related to Enova Recommends. These activities are regulated in a contract between the producer and Enova.

4) Retailers knowledge and promotion
Windows retailers are addressed through courses and other awareness-rising activities to better promote the recommended products.

5) Household advertising
The programme is advertised through many channels with the aim of affecting the relevant decision making of the household.

6) On-line services
Enova's free phone answering service and web services are set up to facilitate the programme.

7) PR and general marketing of the programme

1.2   General and specific user category (economic sector and subgroups)

The primary target group for the programme is private households who live in houses built during the 1960 to 1980 period, and in particular those that are in a mode for major home retrofitting. These are the actors who must represent the demand side for the low-energy windows.

The supply side of the programme may also represent a barrier to success. At the onset of the programme, only a single producer was already producing window models that satisfied the technical criteria of the programme. As a result of the programme, more than 20 producers have expanded their product inventory to also include the Enova Recommends quality windows.

1.3   Technologie(s) involved

The technology of the Enova Recommends is a window which is in accord with three main criteria: i) Energy efficiency, ii) Quality/function and iii) Availability. In addition they must be approved by the Norsk Dør og Vinduskontroll (Norwegian Door and Window control), which is a (voluntary) control organization for (producers of) doors and windows.

Criterion i) refers to the U-value of the window, which should be equal to or less than 1.0. (The U-value of a standard window within the current building code can be in the range between 1.2 and 1.6. The average value is assumed to be closer to 1.6). This measurement is based on a standard size window (1.20 m x 1.20 m) and includes the whole constriction (sash and frame). This window is typically a triple pane window, of which two of the panes have an energy coating, and with an inert gas (e.g. argon) between the panes. Windows with muntins usually do not reach up this standard. Criterion ii), functionality, implies that the window must be suitable for its assumed purpose as a window without adaptation/reworking and be easy to operate and maintain. Criterion iii) means that the window should be available for purchase from outlets in most parts of Norway, and that service, spare parts and warranty assistance should be available at the same locations. Concretely this means that the producer should be able to supply the product in more than half the counties in the country.

1.4   Relevant as a Demand Response

No

2   Formula for calculation of Annual Net Energy Savings

The aim of the calculation is to determine the annual savings in kWh per household of the households reporting to have purchased the recommended windows. There are no energy consumption data available for estimation of savings. We need to base the savings calculation on an assumed heating need of the individual households, and on the energy quality of the windows (deemed savings).

2.1   Formula used for the calculation of annual net energy savings

The following notation is used:
i   =   individual household index, $i = 1 \ldots n$
ES_i =   energy saving household i, kWh per year
A_i =   area of windows retrofitted household i, m^2
ΔU_i =   change (abs. value of improvement) in U-value of windows household i, W per m^2 and K
$\overline{D}_i$ =   average (normal) heating degree days per year, household i
E_j =   heat conversion efficiency of heating system, household i

The savings formula becomes:

$$ES_i = A_i \cdot \Delta U_i \cdot \overline{D}_i \cdot \frac{1}{E_i} \cdot \frac{24}{1.000}$$

2.2   Specification of the parameters in the calculation

Norwegian homes in the target group are predominantly heated by direct electrical heating, often in combination with wood stoves. The conversion efficiency for electrical heating is close to 1, for wood stoves it is typically in the range from 50 % (old stoves) to 80 % (new efficient stoves).

An approximate normal degree days value is available for all locations in Norway. If individual household level data are not available, a weighted average value is used (weighted by population density).

The U-value for the new window is initially assumed to be 1.0. If statistics from the manufacturers indicate that the average "Enova Recommends" window is better than 1.0, then this value should be used. Assumptions with regard to the replaced window are discussed below under baseline issues.

In addition to reducing the convection heat losses, retrofitting large surfaces of windows will also have the effect of reducing the radiation heat losses of the inhabitants of the house. This implies an increase in the operational heat of the building. This could allow for a lowering of

the ambient air temperature without loss of comfort, thus increasing the savings even more. This effect is not accounted for in the formula.

2.3   Specification of the unit for the energy saving calculation

The energy savings is specified per household that has replaced one or more windows.

2.4   Baseline issues

Baseline issues relate primarily to the improvement of the U-value of the old and the new window, and they are not trivial. Viewing the problem from a micro-level bottom-up perspective, we find that there are two principally different baselines:

i) Enova Recommends triggers the retrofit
This is the situation where the household would not have replaced the window(s) in absence of the programme. In this situation it is correct to define the ΔU as the difference between the U-value of the old and new windows.

ii) Enova Recommends triggers an improved retrofit
This is the situation where the household has decided to replace their windows, but where Enova Recommends windows are chosen instead of a standard window due to the existence of the programme. Here it is the difference between the standard window (U=1.6) and the Enova Recommends window (U=1.0) that defines the ΔU.

The baseline window under baseline 2 will change over time as the average market window changes, and as the building code tightens. This information is obtained by monitoring the market for windows. This implies that we have a dynamic baseline.

Surveys must be undertaken in order to reveal which of the two baselines apply for the individual households. In lack of such information a conservative figure of U=1.6 is applied to the old/alternative window.

For the heating degree days value the weighted national average is used if no individual household location data are available.

2.5   Normalization

No normalization has been applied.

2.6   Energy savings corrections

There is no correction for double counting, free riders, technical interactions, and spill over effects or rebound effect.

3   Input data and calculations

Thus far the only data available to evaluate the effects of this programme are limited to a quarterly sample of 1.000 households recording:

- the number of households reporting having replaced windows
- the number of windows replaced and their size
- the number of panes in the new windows
- the age of the old windows

The weighted average number of degree days in Norway is also known (4.079).

Due to some uncertainties related to data quality, no concrete energy savings result from the "Enova Recommends I" has been calculated yet.

4 GHG savings

There is no calculation of GHG savings

References

Information on the "Enova Recommends" program is obtained from several internal working documents at Enova SF.

2. EVALUATION PRACTISE

2.1 Introduction

2.2 National Evaluation guidelines, guidances and selected reports on evaluations and energy savings calculations

2.2.1 List of guidelines

There is none.

2.2.2 List of guidance

There is none.

Norsk Enok & EnergyAS[1], Norway participated in the early 2000s the development of the European Ex-post Evaluation Guidebook for DSM and EE Service Programmes. But there are no examples of application of this guidance later on.

2.2.3 Selected reports

For the following, selected reports on evaluations, some key information are presented. The reports are only available in Norwegian.
- Energy efficiency in buildings. Efficient energy use
- Evaluation of the Household Subsidy Programme (HSP) for heat pumps, pellet stoves and steering systems
- Potentials for energy efficiency in the Norwegian on-shore industry
- Low-energy commission: Energy Efficiency
- IFE: Scenarios for stationary energy use in Norway

Additional there is a web based tool for energy labelling in buildings.

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[1] Liv Randi Lindseth, Norsk Enøk og Energi AS, Evaluation of the Energy Efficiency Check in Norway, proceedings ECEEE summer study 2001

Country:	Norway
Report title	Hanssen, S. O. et al (2007): Enøk i bygninger. Effektiv energibruk. (Energy efficiency in buildings. Efficient energy use). Gyldendal.
Year	1996, 2007
link	http://www.gyldendal.no/Etter-og-videreutdanning/Til-Fagskole/Bygg-og-anlegg/Enoek-i-bygninger
Highlights/summary	This is a >400 page reference book used in education and among practitioners. It provides a wide array of practical examples of energy efficiency improvements in building constructions and installations. It describes theories and formulas for energy need in these cases. It does not give explicit formulas for energy savings calculations.
Sector	Buildings
Technologies (max 15)	Insulation, windows, heating, cooling, heat pumps, ventilation, lighting, water heating, etc.
Baseline approach	N.A.
Default energy or savings values	No savings calculations
GHG emissions	N.A.
Comment	Available in Norwegian.

Country:	Norway
Report title	Evaluering av tilskuddsordningen til varmepumper, pelletskaminer og styringssystemer. Evaluation of the Household Subsidy Programme (HSP) for heat pumps, pellet stoves and steering systems.
Year	2005
link	North-Trøndelag Research Institute, report 2005:2 http://www.tfou.no/default.asp?publikasjon=38
Highlights/summary	The HSP was a once-off programme in operation in 2003. An approx. 20 % subsidy was given to 20000 households for investment in heat pumps, pellet stoves and steering systems. The evaluation documents obtained savings based on meter readings (pre-post), corrected for temperature and "behavioural" adjustments.
Sector	Households
Technologies (max 15)	Heat pumps (air-air, air-water), pellet stoves/burners and steering systems for direct electrical heating.
Baseline approach	Metered prior to installation
Default energy or savings values	Savings based on meter readings
GHG emissions	Not evaluated
Comment	Full report available in Norwegian.

Country:	Norway
Report title	Potensial for energieffektivisering i norsk landbasert industri. Potentials for energy efficiency in the Norwegian on-shore industry.
Year	2009
link	www.enova.no
Highlights/summary	Evaluates energy use in the main industrial sectors in Norway. Identifies significant potentials for energy efficiency, a large share of which associated with negative costs.
Sector	Industry
Technologies (max 15)	Focus on industrial processes: - utilisation of low temperature spill water (heating, el. production) - heat based electricity production - support systems (engines, steam systems, buildings) - management and control - industry-specific core processes
Baseline approach	"Business as usual", unchecked development
Default energy or savings values	Savings potentials from improved processes, BAT.
GHG emissions	Is evaluated in passing
Comment	Full report available in Norwegian. Reports large savings potentials.

Country:	Norway
Report title	Lavenergiutvalget: Energieffektivisering Low-energy commission: Energy Efficiency (main report)
Year	2009
link	www.regjeringen.no/upload/OED/Rapporter/OED_Energieffektivisering_Lavopp.pdf
Highlights/summary	Addresses all stationary energy use in Norway
Sector	Industry, buildings
Technologies (max 15)	Summarizes potentials in relevant sectors, thus most technologies are (implicitly) covered. Not a specific focus on technologies.
Baseline approach	"Business as usual"
Default energy or savings values	Savings potentials from theoretical improvements, deemed savings.
GHG emissions	Costs of reductions of emissions from different technologies discussed.
Comment	Full report available in Norwegian.

Country:	Norway
Report title	IFE: Framskrivinger
	IFE: Scenarios for stationary energy use in Norway
Year	2009
link	www.enova.no
Highlights/summary	Addresses likely development of stationary energy use in Norway towards 2050.
Sector	Industry, buildings
Technologies (max 15)	Identifies drivers for energy demand, calculates a least cost technology mix to satisfy that demand. Not a specific focus on technologies.
Baseline approach	"Business as usual"
Default energy or savings values	Savings potentials from theoretical improvements
GHG emissions	Not evaluated
Comment	Full report available in Norwegian.

Country:	Norway
Report title	Energy labelling for buildings – **web based tool**
Year	2010
link	www.energimerking.no
Highlights/summary	From 2010 all new buildings and buildings marketed shall have an energy label (A-F). The label is calculated by entering key data of the building in the calculator. Multi-tier: data can be given as default building-type values to detailed building-specific data. Heating system affects the label.
Sector	Buildings
Technologies (max 15)	Wall/floor/ceiling insulation, windows, heating system
Baseline approach	Existing building
Default energy or savings values	Savings potentials from theoretical improvements
GHG emissions	Not evaluated
Comment	See webpage (in Norwegian)

2.3 Use of international guidelines and guidance

2.3.1 List of guidelines

There is none.

2.3.2 List of guidance

There is none.

2.3.3 Selected reports

There is none.

3. STANDARDS RELATED TO ENERGY SAVINGS CALCULATIONS

3.1 Introduction

Norway holds standards on several aspects of energy (e.g. Energy performance of buildings, Energy management systems).
There is no specific Norwegian standard on energy savings.

3.2 National standards

Report title	Norsk Standard NS 3031:2007. Beregning av bygningers energiytelse. Metode og data. Norwegian Standard NS 3031:2007. Calculation of energy performance of buildings. Method and data.
Year	2007
link	www.standard.no. Download must be purchased.
Highlights/summary	This document presents the official terminology, definitions and symbols used in energy-related calculations in the Norwegian buildings sector. It covers net energy demand, the needed supply of energy and CO_2-emissions. It does not explicitly cover energy *savings*.
Sector	Buildings
Technologies (max 15)	All of relevance for buildings: Heating, cooling, hot water, fans and pumps, lighting, technical equipment, frost avoidance, heat recovery.
Baseline approach	N.A.
Default energy or savings values	No savings calculations
GHG emissions	Calculated on the basis of primary energy need.
Comment	Available in Norwegian.

Report title	NS-EN 15603:2008 Energy performance of buildings - Overall energy use and definition of energy ratings
Year	2008
link	www.standard.no. Download must be purchased.
Highlights/summary	This standard defines the energy services to be taken into account for setting energy performance ratings for planned and existing buildings It does not explicitly cover energy *savings*. The purpose of the standard is to: a) collate results from other standards that calculate energy use for specific services within a building; b) account for energy generated in the building, some of which may be exported for use elsewhere; c) present a summary of the overall energy use of the building in tabular form; d) provide energy ratings based on primary energy, carbon dioxide emission or other parameters defined by national energy policy; e) establish general principles for the calculation of primary energy factors and carbon emission coefficients.
Sector	Buildings
Technologies (max 15)	All of relevance for buildings: Heating, cooling, hot water, fans and pumps, lighting, technical equipment, frost avoidance, heat recovery.
Baseline approach	N.A.
Default energy or savings values	No savings calculations
GHG emissions	Calculated on the basis of primary energy need
Comment	Available in English.

Report title	NS-3700:2010 Criteria for passive houses and low energy houses – residential buildings NS 3701:2012 Criteria for passive houses and low energy houses – commercial buildings
Year	2010, 2012
link	www.standard.no. Download must be purchased.
Highlights/summary	These standards define criteria for residential and commercial buildings that can be defined as passive or low energy buildings in a Norwegian climate. It builds on energy calculations according to NS 3031. The standards specify definitions, and criteria for heat loss, heating needs, cooling needs, energy need for lighting, energy supply and minimum standards for some building components. In addition, criteria for air tightness, testing procedures, measurement methods and reporting of energy performance are given.
Sector	Buildings
Technologies (max 15)	General building systems and technologies.
Baseline approach	N.A.
Default energy or savings values	No savings calculations
GHG emissions	N.A.
Comment	Available in Norwegian.

3.3 Developments on standards

3.3.1 Ongoing and expected developments

There are no major ongoing or expected developments in this area.

3.3.2 Comments on (draft) international standards

Norway does not participate actively in the European and international standardisation work related to energy savings; the CEN TaskForce 190 "Energy Efficiency and saving calculations" and the ISO Task Committee 257 "Rules for determination of energy saving".

3.4 Relevant organisations

Standards Norway is the national member of the International Organization for Standardization (ISO) and the European Committee for Standardization (CEN). Standards Norway holds a seat on the boards of these organisations

ANNEX A: Template energy savings calculation, with instructions, for case examples in IEA-DSM Task XXI

Frontpage:
Case application: [Name, including technology and user category]
Country: [Name]
Author(s): [Name]
Date and version: [day month year] [only full numbers of version]

Page 1
1 Summary of the program

1.1   Short description of the program
1.1.1   Purpose or goal of the program
[Also include the period the program was running or when it started.]

1.1.2   Type of instrument(s) used
[Please indicate the type of instrument used. E.g. financial support, subsidize, label and standard, agreements, tax reduction]

1.2   General and specific user category

[Please by a specific as possible. Make a clear distinction between households, industry, services (commercial and non-commercial. If more users are targeted, please give some specification, especially if formulas would be different for different user categories.]

1.3   Technologie(s) involved

[Present the technology or technologies; please clarify in case a not well-known technology is used]

1.4   Status of the evaluation and energy savings calculations

[Provide information whether the energy savings calculations are used in an evaluation report. Include references and source in the Annex]

[Provide information whether the energy savings calculations itself have been evaluated. Include references and source in the Annex]

[Use one of the following options to qualify the status: 1. Legal; 2. Official stamped; 3. Semi official; 4. Use in practice; 5. Under development; 6. Under research)

1.5   Relevant as a Demand Response measure

[Indicate when the case is relevant for DR; if so refer to the separate DR case application description]

2 Formula for calculation of Annual Energy Savings

2.1   Formula used for the calculation of annual energy savings

[Short introduction and provide information on the origin of the formula; please use one of the three options:
-    an existing formula (give reference; also in reference list in Annex the traceable source), or
-    an adapted version of an existing formula; please describe adaptations in short and give reference for the original formula (also in reference list in Annex the traceable source), or
-    self developed (short description; present additional documentation in Annex)]

[Present the formula]

2.2   Specification of the parameters in the calculation

[Provide information on the parameters and the reasoning of selecting those parameters]

2.3   Specification of the unit for the calculation

[The most common units are: an object of assessment; an action or an energy end-user]

2.4   Baseline issues

[Brief description which type of baseline is used in the energy savings calculations. The most commonly used types are:
    a.   before situation; evaluate the measure against the technique used before
    b.   stock average; evaluate the measure against the average stock technique
    c.   market average; evaluate the measure against the average technique on the market
    d.   common practice; evaluate the measure against the most commonly used technique]

[Describe whether a static or a dynamic baseline is used.
The before situation is always a static baseline. The other methods can be either static (using the values of a base-year or base period) or dynamic (changing over time, for example reflecting the change in most commonly used techniques)]
[Specify if a combination of approaches is used]

[Describe the important assumptions and the reasoning of the choice]

2.5   Normalization

[Normalization is a way to adjust the data in line with a normal situation; most common this is normalization for degree heating or cooling days.]
[Please describe briefly and give sources / references for the normal situation].

2.6   Energy savings corrections

2.6.1   Gross-net corrections

[Specify which (gross to net) corrections have been applied and how these are calculated. Please be clear in the corrections taken into consideration and used to correct.
[The most common categories are: a) double counting; b) free riders; c) technical interactions; d) spill over effects and e) rebound effect]

2.6.2 Corrections due to data collection problem

[Specify which corrections have been applied to handle imperfect data collections e.g. using sales data as a proxy for installation data, using a secondary data source for a bigger region than the region a programme is implemented]

3 Input data and calculations

3.1 Parameter operationalisation

[Describe how the calculation parameters are obtained; both for actual and reference situation.]

[Please also clearly indicate what type of values is used:
   a) deemed (rough approximations, expert opinions, etc.)
   b) calculated (for example using survey data)
   c) measured (for example real measurements taken, billing information, etc.)
   d) combination]

3.2 Calculation of the annual savings as applied

[Present the calculation with the values used. Please provide the data is several steps as this improves transparency and understanding]

3.3 Total savings over lifetime
3.3.1 Savings lifetime of the measure or technique selected

[Present information on the lifetime used. Also indicated whether this is an economical lifetime or not.]
[Present the number of years and the source for this value; include the reference in the Annex]

3.3.2 Lifetime savings calculation of the measure or technique

[Present the formula and the conducted calculation. In most cases this will be the outcome of 3.3.1 multiplied with the lifetime years. Please clarify if the energy savings calculated are not the same in all years. Explain if this is the case.]

4 GHG savings

4.1 Annual GHG-savings
4.1.1 Emission factor for energy source

[Present the emission factor used and give reference; included the source in the appendix.]
[Please specify what GHG emissions are included in the calculation: CO2; CH4 or N2O]

4.1.2   Annual GHG-savings calculation as applied

[Present the formula as well as the calculation]

4.2   GHG lifetime savings
4.2.1   Emission factor

[Present the emission factors used when not the same factor is used for the lifetime, and give reference; included the source in the appendix. Otherwise include: The same GHG emission factor(s) are used for the lifetime.]

4.2.2   GHG lifetime savings as applied

[Present the formula as well as the calculation]
[The lifetime should be the same as for the energy savings; if not please clarify]

References

[Please use: Report title, Author, year and if applicable the website]

Annex

[Present in the Annex additional information on methods, data sources etc. to elaborate the data, formulas etc]
[If no or no clear energy savings calculations is used in the case application, but a method could be used, please describe this in an Annex]

Definitions

[Provide definitions used for the target group, unit of saving etc.]

ANNEX B: Case application of Demand Response: Remote Load Control

Introduction

Demand response (DR) refers to the reduction of customer energy usage at times of peak usage in order to help address system reliability, reflect market conditions and pricing, and support infrastructure optimization or deferral. Demand response programs may include dynamic pricing/tariffs, price-responsive demand bidding, contractually obligated and voluntary curtailment, and direct load control/cycling.

The information on Demand Response products is collected to relating impacts of DR projects to those for energy savings. For this reason the information is organised as following. We start with general information on the DR project and relations with other DR initiatives (section 1 and 2). Then we present information to be related to energy savings calculations: input data, baseline definition and key parameters considered, and savings calculations (section 3-5). Next is information on changes in the load shape and benefits in sections 6-8. We end with sources and documentation.

1. The DR initiative "Remote load control (RLC)"

This Demand Response programme carried out in Norway is related to load shifting or peak load reduction and was conducted in the period 2005-2008 as part of the Market based Demand Response project.

The programme took 41 residential households, advised to buy energy with an hourly spot price contract, they got a time-of-day (TOD) network tariff which stimulated to load shifting, and RLC was offered as an "aid" to reduce load and costs in the peak hours.
The key element on this program is variable price of energy, especially for predetermined peak load hours. The TOD tariff - a tariff element which was activated only during predetermined peak load hours - was considered as the best price signal that would give small customers benefit from changes in their consumption pattern for electricity. A tariff with predefined peak periods will train the customers to reduce their consumption in periods when shortage of power is expected. The tariff is combined with a visual reminder the "El-button" (see right top of figure 3), a small watch-like magnetic token that should be placed on the most power-consuming appliances, indicating the peak periods. This was to stimulate the customer to avoid usage in the peak periods, in other words a voluntary load control/shifting.

The Remote Load Control allows the DSO to switch off/on loads at the customer premises via the AMR system. In this pilot RLC is applied to the electric water heaters in the homes. Water heaters have a typical load of 2-3 kW (tap water). Water heaters connected to a hedonically space heating system have a capacity in the 12-15 kW range. The latter system represents about 10% of all homes in the pilot. The total DR in this pilot thus is the combined effect of the RLC and voluntary load shifts.

2. Related DR initiatives

Related to this demand response initiative, there are others conducted within the framework of the market based Demand Response project. These are:

- Fixed price contract with return option; targeted to reduction of energy in shortage periods for a pilot with 2500 households;
- Automatic Demand Response (ADR); testing an automatic scheme disconnecting selected low prioritised appliances;
- Smart house and ToD tariff; advanced load control in 24 flats of a housing cooperative;
- Load shifting for commercial customers.

3. Input data

The expected peak load for the DSO determines the times for the energy peak payment. The (hourly) peak load periods and levels are predicted based on historical data, and reflects season, weekday, outdoor temperature, and other variables known to affect load level. The expected peak periods are reflected in the hourly prices in the spot market for electricity.

The TOD tariff consisted of traditional components such as fixed and a variable loss payment. Additionally, a new component representing the energy peak payment was included in this pilot programme.

4. Baseline definition and key parameters considered

The baseline profile for the individual customer can be understood as the load profile that would have been expected in absence of the DR measures, a "typical load profile". Such profiles are calculated on the basis of historical load profiles for similar customers. The baseline can be specified down to hourly periods. Figure 1 presents the average load for working days and the weekend.

Figure 1: Average 24 hour profile of households in the programme
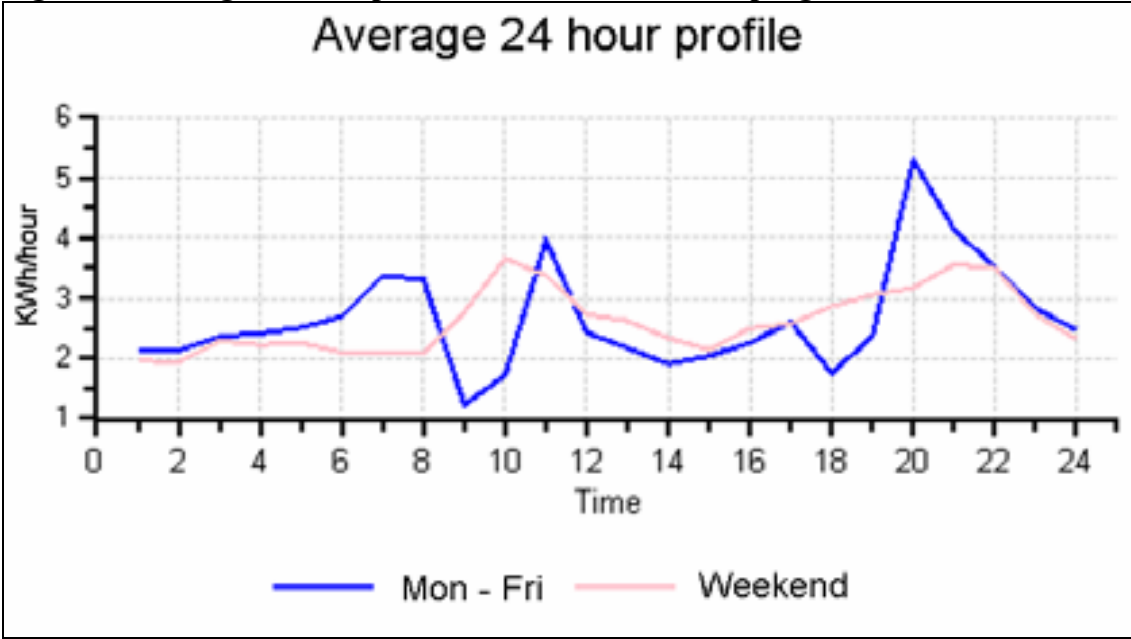
5. Savings calculation

There is no input data used for estimating energy savings.

The demand response ("savings") is defined as the difference between the projected load (baseline) and the actual metered load during the peak hours.
Average response in the pilot is energy savings[2] of 1 kWh/h for customers with standard electrical water heaters, and 2.5 kWh/h for customers with water space heating systems with electrical boilers.

The consumption for the household customers with both ToU Energy tariff and hourly spot price is presented in Figure 2. The figure shows considerable reduction of the consumption during the two peak load periods (marked sections). The maximum reduction is 35% during the morning and 31% during the afternoon.

6. Load shape impact

The effect in this pilot on the load shape is significant. RLC clearly shifts the customers' load peak from peak periods to non-peak periods.
The effect is most striking for households with a high load demand (electric water based heating systems). This can be measured and documented at the level of the individual customer.

Figure 2: Hourly spot price and ToU energy tariff

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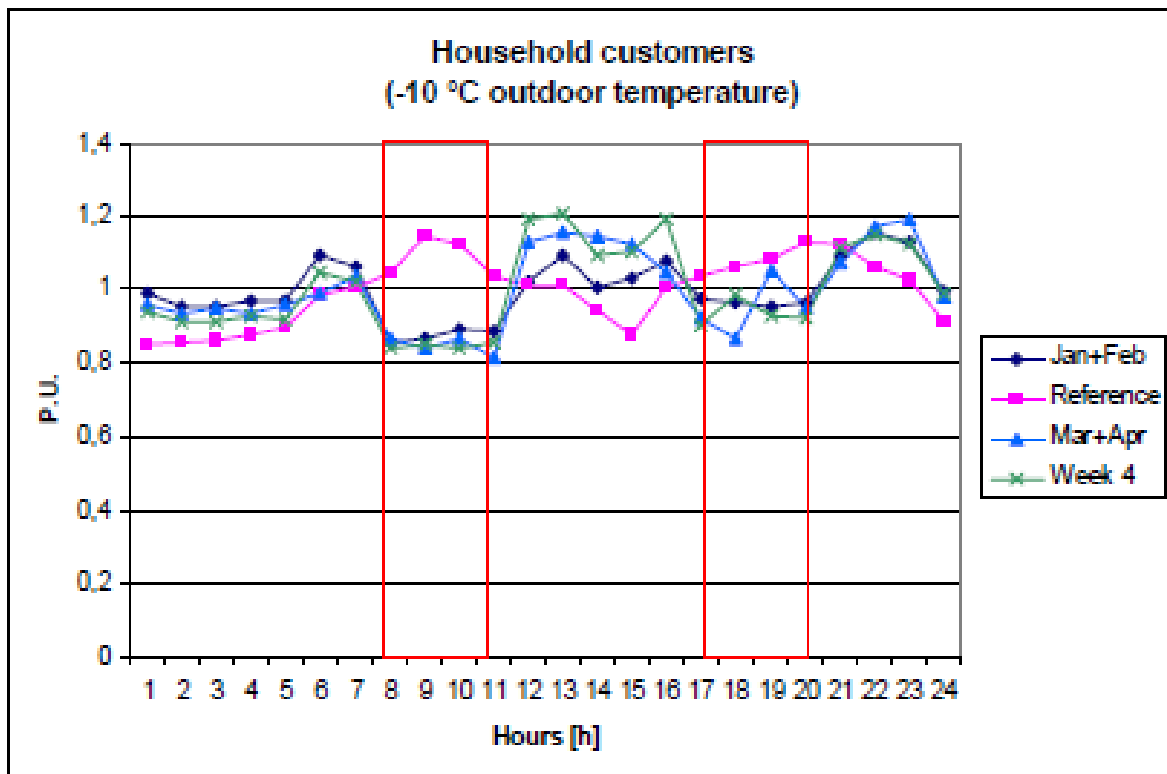
[2]Energy savings are expressed in the original report in kWh/h, intended as the amount of energy (kWh) saved in an hour (h)

Aggregating the energy savings results for the pilot program to the total Norwegian residential sector, the measured demand response could represent 4,2% of the peak load observed in the Norwegian system (1000 MWh/h).

In this scheme, some electric high demand sources (heating) can be replaced for other non-electric (gas, petrol, etc.). In this case, real electricity savings can be achieved, on the other hand, continuing with electric devices if only electric loads are shifted, it is hard to estimate electricity savings (for example using heat accumulators, which only shift electric loads but do not save energy).

7. Benefits to participants

With a standard grid tariff structure, benefits to customers from load shifting are economic savings due to avoidance of peak spot prices. In a normal situation these benefits will be modest.

An important key to this system is therefore to find a tariff structure that transfers some of the system benefits to the customer, thus creating the necessary incentives for the desired behaviour. In this case this is achieved by the energy peak rate of the tariff.

For customers with power contracts with hourly spot price, the benefits from load shifting are dependent on the price difference during the day. The daily price variations during the winter 2003-2004 was only 0,0025-0,00625 €/kWh. This gives the customer a minimal incentive to changes in consumption in a normal year. However, a combination of spot price and the intraday ToU tariff as used in the test project gave the most eager customers a cost reduction of ~25 €/month. In a dry and cold winter with high spot price level this amount could rise to ~35 € /month.

8.Other benefits

The most important benefits from a well-functioning DR scheme are related to grid costs. Transmission losses at high loads and avoided system expansions, thus a more efficient use of the grid, are the most important benefits. These benefits are primarily realized by the DSO.

In this case, GHG are not considered, but could be calculated multiplying the emission factor for Norway with the amount of energy savings achieved.

Figure 3: Load profile and load control
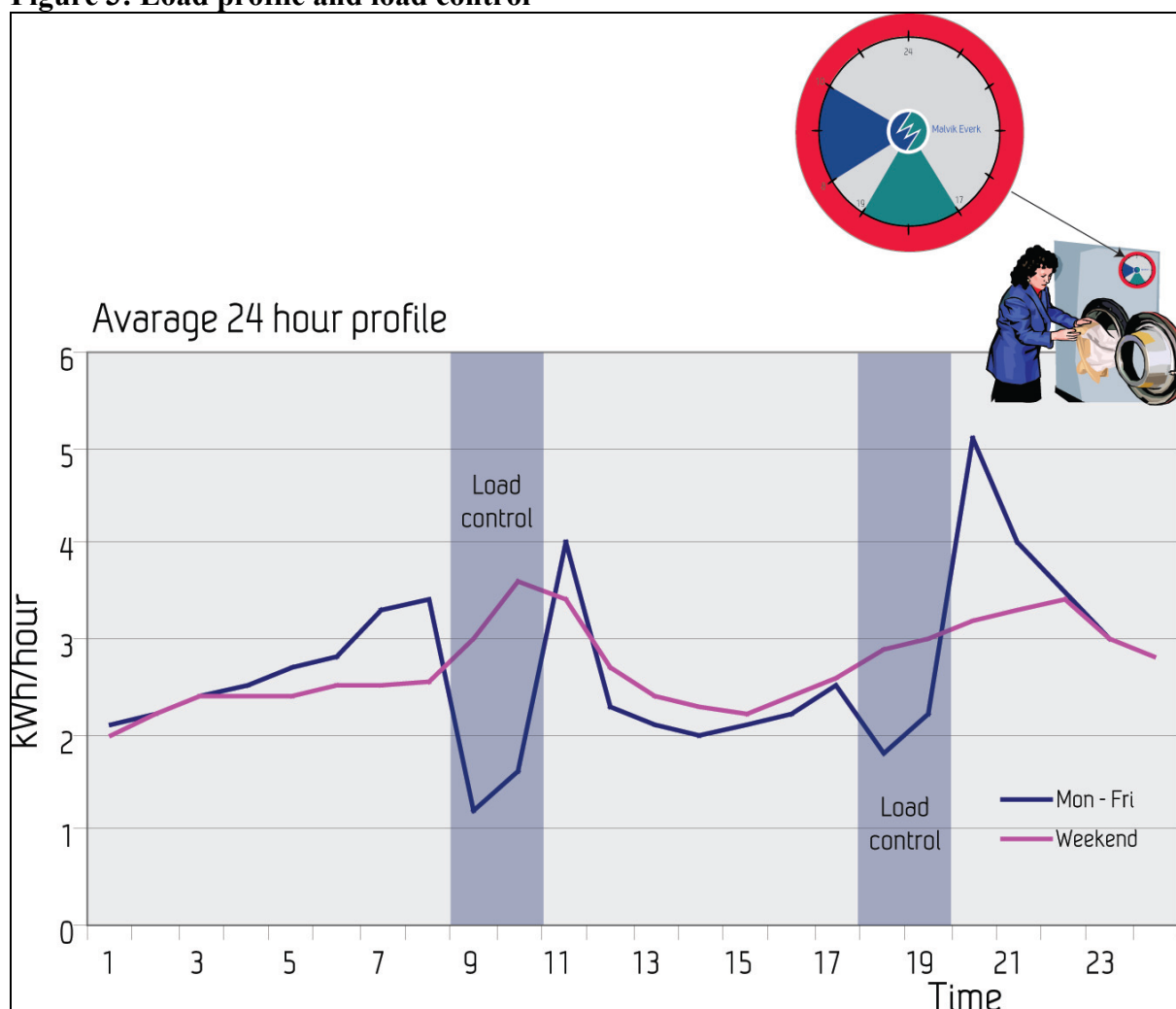
9. Sources and documentation

Ove S. Grande, *Market Based demand Response Results from Norwegian Research Projects,* IAE/DSM workshop, Trondheim 18 April 2012
http://www.ieadsm.org/Files/Exco%20File%20Library/Workshop%20Trondheim,%20Norway,%20April%202012/Market%20Based%20DR-%20results%20from%20Norwegian%20research%20projects.pdf

Ove S. Grande, Hanne Saele, Ingeborg Graabak, *Market Based Demand Response Research Project summary* (TR A6775), SINTEF Energy Research, 2008
http://www.energy.sintef.no/publ/rapport/08/tr6775.htm

Ove S. Grande, Ingeborg Graabak, Inge H. Vognild, Audun H. Wilberg, Market based Demand Response. End user Involvement and experiences from Norwegian pilots, Paper 0620, International Conference on Electricity Distribution Vienna, 2007
http://www.cired.be/CIRED07/pdfs/CIRED2007_0620_paper.pdf

Ove S. Grande, Hanne Saele, *Market based solutions for increased flexibility in electricity consumption*, SINTEF Energy Research, 2005
http://www.marketdesign.se/images/uploads/2005/cp_070607_9._Saele.pdf