

Bergen SmartCity

Energy Efficiency



BERGEN KOMMUNE

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Bergen Næringsråd

Bergen
Smart
City

Smarter use of energy



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Summary

According to the International Energy Agency (IEA), energy efficiency is the most important factor in achieving the international goal of a mere two degrees increase in the average temperature by 2030. The 2007 Energy Efficiency report prepared by Bellona and Siemens demonstrated that Norway can save energy equivalent to 20 per cent of the country's electricity consumption by using modern, available technology. Last year, Bellona, Siemens and Trondheim Municipality dug deeper into the material, and found that Trondheim could save 22 per cent of the city's energy consumption by using available technology and solutions.

As Norway's second largest city, Bergen also has much to gain from energy efficiency. By adopting modern, energy efficient technology, Bergen could reduce the city's stationary energy consumption by 29 per cent – without affecting the inhabitants standard of living or comfort.

This is the overall conclusion of this report. It is based on analyses of the potential of energy efficiency in homes, commercial properties, industry, street lighting and the electrical grid in Bergen Municipality.

Most of the suggested measures will save inhabitants, companies and authorities billions of Norwegian kroner, as well as form a basis for sustainable development and a sustainable future.

Accordingly, this report focuses on what is possible to do right now, with today's tested and accessible technology. The report shows (with reasonable expectations as basis for analyses) that the energy consumption within Bergen Municipality's boundaries can be cut by over a quarter. It would take hospitals and health institutions in Bergen almost ten years to use an equivalent amount of energy. In other words, this report is about smarter use of energy – about thinking smart and acting smart – and this report shows that it is possible.

Bergen's potential for energy efficiency

By using modern, available technology, energy equivalent to 29 per cent of the city's stationary energy consumption can be saved within the following areas:

Housing	731 GWh
Commercial properties	496 GWh
Industry	45 GWh
Street lighting	14 GWh
Upgrading the electrical grid	53 GWh
Total	1339 GWh



About the report

This report examines how much energy can be saved in Bergen by using recognised methods and solutions. The calculations and suggestions for improving energy efficiency are based on tested solutions, i.e. all the technology that is necessary to reduce the energy consumption in the Municipality is already available on the market. In other words, there is no need to wait for the development of new technology – today's technology can do the job.

The report focuses on five main areas: Commercial properties, industrial activities, the distribution of electricity, housing and street lighting.

Bergen Municipality's inhabitants, politicians, and public and private sector businesses have already achieved a great deal in their work to make the city more climate friendly and energy efficient. Many measures have been implemented, and several have already had an effect. However, this report shows that the potential for further improvement of energy efficiency in the city is great.

The findings are based on a comprehensive survey, where central sources have included BKK, Bergen Municipality Council, Enova, Statistics Norway, Siemens and Osram. The analysis agency Perduco has contributed to the survey and the preparation of this report.

In the surveying of industrial activities, street lighting, space and energy consumption in Bergen Municipality, this report is based on the most recent data available. All other calculations are based on data from 2008.

Based on the survey of energy consumption, Siemens has carried out calculations to determine the energy efficiency potential. The suggested measures are based on experience from both Norway and abroad, which means that all the technology has been tested with good results.

The measures presented in this report are of course not exhaustive: There are many more measures that can be implemented and which would further improve Bergen's energy efficiency.

We hope that this report will provide inspiration for all those who want to work towards a more energy efficient Bergen, and – not least – other cities in Norway and abroad.

Energy terminology

1000 kWh (kilowatt hours) = 1 MWh (megawatt hour)
1000 MWh = 1 GWh (gigawatt hour)
1000 GWh = 1 TWh (terrawatt hour)

Bergen SmartCity

Among the smartest in the world

Many nations and cities across the globe are focused on environmental solutions that can contribute to reducing the energy burden on the environment. But even though much has already been done, the potential for further savings is significant. For example, the Energy Efficiency report prepared by Bellona and Siemens shows that Norway as a nation can save 20 per cent of its energy consumption through the use of modern technology. This is equivalent to the total energy consumption of half of Norway's households. The energy efficiency improvement potential in Bergen is also significant.

In 2007, for the first time in history, more people were resident in cities than outside of them. The energy consumption in cities is significantly higher than in areas outside them, and even though the world's cities cover just 0.4 per cent of the earth's

surface, they generate as much as 80 per cent of greenhouse gases and are responsible for 75 per cent of the world's energy consumption. In other words, it is crucial that comprehensive plans to ensure the smarter use of energy in cities are developed and implemented. A SmartCity is a city that thinks smart in terms of energy use. A city that has both calculated the potential of how much energy can be saved in various areas, and aims to achieve this potential.

Bergen is a SmartCity – one of the first SmartCities in the world. Other SmartCities include Trondheim in Norway, Ljubljana in Slovenia and Yekaterinburg in Russia. The report shows how much energy can be saved in Bergen, and where this potential is found. The next phase is to implement concrete measures to harvest these potential energy savings over the next two to three years. The project has received support from many key suppliers of knowledge, in addition to initiators, and BKK and the Bergen Chamber of Commerce and Industry in particular have contributed knowledge and factual information.

200.000 Norwegian kroner saved on heating and ventilation systems

An awareness of electricity consumption and the central operational control of heating and ventilation gave Gullstøltunet nursing home an estimated extra 200.000 Norwegian kroner to spend on its residents and employees. In 2005, Gullstøltunet installed a new central operational control unit (a system that controls heat and ventilation). It gave positive results: Consumption in 2006 was 240,000 kWh lower than the consumption for 2004. This is equivalent to the electricity consumption of ten self-contained homes.

Bergen



Smart cities make a difference

Who selects the city?

Bellona and Siemens nominated Bergen as Norway's second energy-smart city. The intention is to implement the SmartCity concept in as many cities as possible – both inside and outside of Norway. So far, other SmartCities include Trondheim in Norway, Ljubljana in Slovenia and Yekaterinburg in Russia.

City populations are increasing

Over the last 20 years, the Norwegian population has increased by 13 per cent to 4.8 million people. 86 per cent of this growth has occurred in and around the cities of Oslo, Bergen, Stavanger, Trondheim, Tromsø, Kristiansand, Moss and Drammen. While the populations of these large city regions increased by 24 per cent between 1990 and 2009, the population of the rest of the country has increased by just four per cent. If we include 15 more towns, the population growth in the rest of the country outside of towns and cities would be virtually zero. It is first

and foremost the Oslo region that receives the greatest domestic influx of people: Between 1994 and 2008, the net migration to the capital region was more than 48,000 people, which constitutes 56 per cent of the above mentioned eight city regions. Net migration into the Bergen region was more than 7,700 people in the same time period. This represents nine per cent of the net migration into the city regions.

When we know that the energy consumption in cities is significantly higher than outside of these areas, the importance of concentrating environmental efforts on cities becomes apparent. Smart cities can make a significant difference.

Norwegian cities of the future

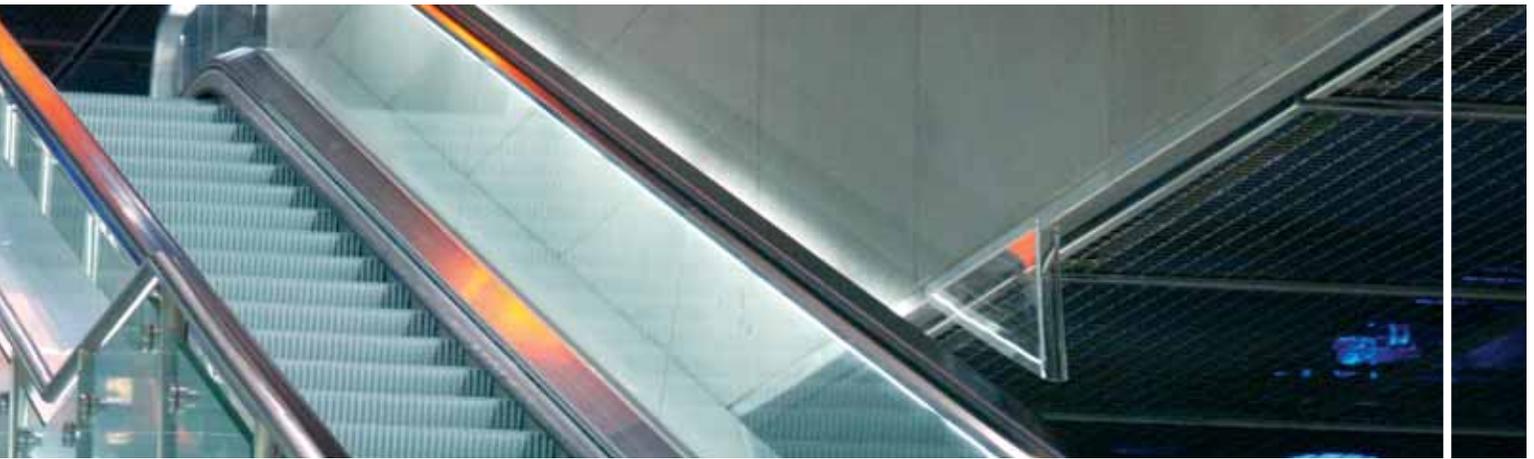
"Cities of the Future" is a collaboration between the Norwegian state and the 13 largest cities and towns in Norway to reduce greenhouse gas emissions – and make these cities and towns better places to live.

Cities of the Future is organised into four priority areas:

- Land use and transport
- Stationary energy use in buildings
- Consumption patterns and waste
- Adaptation to climate change

The 13 towns participating in the project are Oslo, Bærum, Drammen, Sarpsborg, Fredrikstad, Porsgrunn, Skien, Kristiansand, Sandnes, Stavanger, Bergen, Trondheim and Tromsø.

The programme started in 2008 and will run until 2014, assisting city Municipalities in sharing good ideas with each other and develop new arenas of collaboration with the business sector, their region and the State.



A climate neutral city

Bergen has the long-term goal of becoming a climate neutral city. Together with 12 other cities, the Municipality is participating in the collaboration “Cities of the future – cities with the lowest possible greenhouse gas emissions and good city environment”, initiated by the Government. Cities of the Future has four priority areas: land use and transport, stationary energy, consumption patterns and waste and adaptation to climate change. Bergen has a range of projects within all these areas. The projects will run for six years, from 2009 to 2014.

Bergen Municipality has set a goal of reducing greenhouse gas emissions from 700 of the Municipality’s own cars by 25 per cent within January 2011. By 2015, the goal is to have halved the total emissions.

Between 2003-2009, 194 municipal buildings were included in an energy management project, which achieved a six per cent reduction in energy consumption. The newly opened Bergen Light Rail system will be the backbone of Bergen’s future public transport

system. The railway will relieve the roads and runs on its own line as much as possible. The Bergen Light Railway is planned to be built from the city centre to Flesland. The first construction phase of the line runs from the city centre to Nesttun.

The private sector is also participating in the project. Sparebanken Vest has been among the initiators behind the Norwegian Climate Foundation. This is a non-profit foundation based on the internationally leading Norwegian knowledge and climate research environments. The foundation has received broad support from the business sector, professional environments and recognised organisations. The foundation’s purpose is to be a driving force behind the development and adoption of new forms of energy that can contribute to reducing energy consumption and greenhouse gas emissions.

Bergen is Norway’s second largest city with around 257,000 inhabitants divided between just over 120,000 households. The energy use per person in Bergen is eight per cent lower than the national average. The total energy consumption within the Municipality’s boundaries is approximately 6.7 TWh, which constitutes around three per cent of Norway’s total energy consumption. The energy consumption for purposes other than transport – the stationary energy consumption – is 4.6 TWh. Of this, the consumption of electricity constitutes 3.7 TWh per year. If the stationary energy use of households in Bergen is divided by the number of inhabitants, the consumption is 8,450 kWh per person (2008), compared to the national average of around 9,200 kWh (2008).

Bergen and energy

Total energy consumption	6.7 TWh
Of which stationary energy use	4.6 TWh
Of which use of electricity	3.7 TWh

Stationary energy use can be broken down as follows:

Just over 120,000 homes	2.1 TWh
6,600 commercial properties	1.7 TWh
500 industrial companies	0.8 TWh

Buildings

Buildings account for 40 per cent of Norway's – and the world's – energy consumption. An increased use of electronic products and higher comfort standards contribute to a steadily increasing level of energy consumption. If measures are not introduced, the International Energy Agency (IEA) estimates that buildings will be responsible for around half of the world's demand for energy by 2030.

Buildings are the largest consumers of energy, and will represent a long-term challenge if this issue is not addressed with strict energy regulations. Buildings have a long lifetime, and are inherited from one generation to the next. Adapting existing buildings with energy efficient technological solutions is an extremely good investment in terms of reducing future energy consumption. Siemens has experience from improving the energy efficiency of over 6,500 buildings across the world, and the majority of the efficiency improvement measures have been extremely profitable.

As we shall see below, the collective potential for improving the energy efficiency of housing and other private and public buildings in Bergen totals 1,227 GWh. This is as much energy as Bergen's hotels and restaurants use in 12 years (these use 103 GWh per year) – or as much as all educational buildings in Bergen will use over the next five years (these use 259 GWh per year).

We will first present the scope and energy consumption of commercial properties (public sector offices and private commercial buildings) before we look at other public buildings. Private housing is described on page 16.

Commercial properties in Bergen (public and private)

Bergen is a regional centre in the western part of Norway, with more employees who commute into the Municipality to work than those who travel to workplaces outside of it. There are estimated to be around 156,000 workplaces in the city. 35,000 people travel from outside of Bergen to work in the city, while 16,000 travel out of the Municipality. A workplace is most often linked to an office, store premises, warehouse or other industrial premises. Bergen has around 6,500 commercial properties and public buildings (all buildings excluding housing) with a total of 8.4 million square metres under their roofs. This means that the total area used for commercial properties is equivalent to 1,100 football pitches – greater than the total area used for apartments.

The suggested energy efficiency improvement measures will provide a total energy efficiency improvement potential of 496 GWh. The majority of the measures are also commercially profitable: With a calculation interest rate of six per cent and an energy price of 1 krone/kWh (excluding VAT), the suggested measures have a total repayment time of just nine years.

Private commercial properties

These buildings contain almost 9,200 private employees that house 65 per cent of the county's 113,000 workplaces in the private sector. The commercial properties cover a total of 5.8 million square metres, constitute around 23 per cent of all buildings in Bergen, and account for an equivalent share of the Municipality's energy consumption. We have excluded energy used for production processes from the calculations. The energy efficiency improvement potential in private commercial properties is 347 GWh.



Commercial properties have various potential for energy efficiency. While offices, warehouses, hotels and restaurants are at around 35 per cent, areas used for industry and production have a lower potential. This type of commercial property has an energy efficiency improvement potential of 106 GWh.

Public buildings

27 per cent of employment in Bergen is within the public sector. This is linked to, among others:

286 pre-schools

87 primary and secondary schools

12 upper secondary schools

42 retirement homes (public and privately owned)

Bergen Municipality

University of Bergen, Norges Handelshøyskole (NHH),

Høgskolen i Bergen

Haukeland University Hospital

Bergen contains 2.5 million square metres of buildings classified as schools, health institutions/hospitals, sports centres and cultural institutions. There is also building space linked to public offices, which are included under private commercial properties in the previous section. 43,000 public sector employees work in these buildings. Bergen Municipality owns municipal property totalling 900,000 square metres, including 286 pre-schools and 87 primary and secondary schools. Municipal activities have a total energy consumption of 267 GWh. Between 2003-2009, 194 municipal buildings were included in an energy management project, which achieved a six per cent reduction in energy consumption.

Health institutions, including care homes, is also a large group consisting of 637,000 square metres. Other public property is used in connection with County Council and State services and organisations,

for example, the University of Bergen and Haukeland University Hospital. The University of Bergen owns 95 buildings that constitute a total of 318,000 square metres, and rents a further 55,000 square metres.

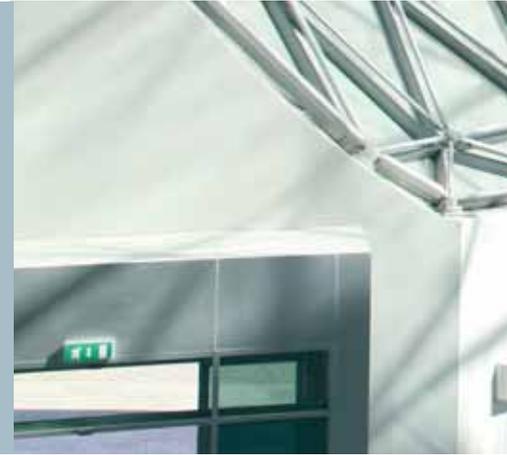
The public buildings have a total energy consumption of 627 GWh per year. The project has calculated that schools and health institutions/hospitals have an energy efficiency potential of 29 per cent, while cultural institutions and sports centres have a potential of 11 per cent. Their total energy efficiency improvement potential is 149 GWh. This is more than the total electricity consumption of all hotels and restaurants in Bergen.

Lighting

Lighting in Norwegian commercial properties is a combination of energy inefficient components up to thirty years old, and new, modern components with advanced control systems. Modern light sources with electronic connection equipment, motion sensors and daylight control can use over 80 per cent less electricity than older lighting types. A number of upgrades have already been carried out, and the total possible saving in commercial properties is therefore estimated to be 45 per cent.

Bergen's commercial properties consist of office buildings, warehouses, workshops, industrial buildings, factories, health institutions/hospitals, cultural institutions and sports centres, as well as other types of buildings. These buildings have different types of lighting, and therefore different proportions of their energy consumption is used for this purpose. Osram and Lyskultur estimate that on average, lighting accounts for 20 per cent of the electricity consumption in Norwegian commercial properties. Since Bergen has a broad spectrum of businesses, we will use 20

Buildings (cont.)



per cent as the basis for calculating the energy efficiency improvement potential within lighting.

If we presume that a fifth of the energy consumption of commercial properties is linked to lighting, this means that almost 273 GWh are needed to light Bergen's more than 6,600 commercial properties.

This is more than the total amount of electricity Bergen's pre-schools, schools, university and colleges use in an entire year. With a reduction of 45 per cent, 123 GWh can be saved. This is equivalent to the total energy use for more than 8,000 homes.

If we replace an older light fitting (for example 2 x 36W fixtures with magnetic ballast and starter) with a new, modern fitting (for example 2 x 28W fixtures with electronic connection), calculations

from Osram show that the investment will be repaid within one to three years. If the new fitting is integrated with daylight and motion sensors, the investment's return will take longer, but provide a greater saving over the course of the equipment's lifetime.

More energy efficient lighting produces less heat and reduces the building's cooling needs. This energy saving is not included in the calculations.

EXPLANATION OF THE TABLE TO THE RIGHT:

The table suggests how a collective energy efficiency potential can be achieved. The efficiency potential and investments are shown for the entire Municipality of Bergen. The efficiency potential and investment costs are estimated by Siemens and Osram. Investment in Norwegian kroner per saved kWh gives an indication of how quickly the investment in the specific measure for energy efficiency shows a return. The lower the investment, the quicker the return. With a calculation interest rate of six per cent and an energy price of 1 krone/kWh, the measures have a total repayment period of nine years.



Commercial buildings Private/public	Efficiency improvement potential Measure (MWh)	Investment excl. VAT (Mill. NOK)	Investment in Norwegian kroner (excl. VAT) per saved kWh	Per centage share of area measures implemented in
Buildings	49 426	989	20	
Insulation, roof and/or walls	3 591	47	13	1
Insulating strips for windows and doors	15 697	63	4	10
Replacement of windows	22 604	659	29	2
Replacement of external doors	7 535	220	29	1
Sanitation	611	0	0	
Energy saving showers/fittings	611	0,2	0	50
Heating	54 209	245	5	
Insulation of pipes and valves	1 255	4,96	4	70
Shunting and external temperature compensation	2 114	13,53	6	30
Transition to quantity regulated heating system with speed regulated pump	50 4 933	28,19	6	50
Adjustment of heating system in combination with water purification	2 819	13,53	5	40
Heat pump	41 205	170	4	15
Thermostatic radiator valves	1 884	15	8	20
Cooling	23 546	471	20	
Automatic external sun shades	16 482	377	23	30
Transition to quantity regulated cooling system with speed regulated pump	7 064	94	13	13
Ventilation	65 143	773	12	
Better heat exchanger for ventilation	28 255	220	8	20
Change to direct drive fans	14 127	118	8	30
Frequency converters for fans	11 773	59	5	50
Demand controlled ventilation (DCV)	10 988	377	34	20
Lighting	123 000	410	3	
Control and regulation	180 015	448	2	
Central operational control unit with upgraded substations	23 546	141	6	15
Energy management/follow-up system (EMS)	31 394	126	4	40
Time-controlled ventilation	40 263	34	1	27
Precipitation control of snow melting system	39 243	63	2	5
Thermostat and time-controlled electric heating	15 383	62	4	28
Automatic time control of water-based heating	5 074	22,55	4	40
Reduced internal temperature	25 113	0	0	55
Total commercial properties	495 949	3 336	7	

Industry



Bergen has several hundred industrial companies. These account for almost half of the total energy consumption of the city's workplaces, but for less than every tenth job. There is much to be gained by introducing modern solutions to improve the energy efficiency within this sector. A calculation shows that the energy efficiency potential will give a total energy saving equivalent to 3,000 homes (these use 15,000 kWh per year).

A common feature of all industrial activity is the processing of raw materials and semi-processed goods using machines. In Norway, such machines are mostly powered by electric motors, but gas and other fuels are also used to produce the energy to drive the motors. Both the machines themselves and the organisation of the production processes affect how much energy is used.

Pressure to reduce

Industrial companies are being pressured to reduce their energy consumption from several sides: Stronger international competition in product markets means that lower energy costs have become a central part of an industrial company's competitiveness. An increasing number of environmentally conscious consumers are demanding products that leave the smallest possible carbon footprint, something that energy efficient processes throughout the entire value chain can contribute to.

Part of Bergen's industry falls under the so-called "quota obligated" sector, i.e. companies that must pay for greenhouse gas emissions from the use of

fuel oil and other fossil sources when they exceed given levels. Authorities set requirements regarding emissions reductions for greenhouse gases, and this is achieved by converting to renewable energy and energy efficiency in the form of energy management. In their climate treatment study for industry, the Climate and Pollution Agency calculated that through the use of energy management, 2.1 TWh of electricity and 0.9 TWh of fuel oil could be saved on a national level by 2020, compared with "business as usual".

Energy Optimisation

Siemens has analysed the potential energy savings in approximately 2,000 industrial companies across the world, and has developed the Energy Optimisation concept based on this. Experience shows that, independent of industry branch, the potential energy savings are between 10 and 15 per cent.

An analysis carried out for a food manufacturer in Oslo showed that the potential for improved energy efficiency was around twice as high, approximately 27 per cent. One out of seven industrial companies in Bergen with at least ten employees lies within the food manufacturing industry, but to take account of possible variations, a conservative average potential improvement of 12 per cent has been used. For examples of the measures that result in such energy efficiency improvements, see the text box "The energy efficient industrial company".

Varying potential

Bergen has several large industrial companies where we have surveyed the energy consumption in the utilised production processes: Toro, Hansa Bryggerier, Tine, Kavli, Friele, Bir Avfallsenergi and RollsRoyce. These companies have worked with energy efficiency to varying degrees, and the potential for savings



within each company therefore varies. A review shows a total energy saving potential of ten per cent within production.

Almost 500 industrial companies

According to Statistics Norway's company register, almost 500 industrial companies are located within Bergen Municipality, and employ just over 12,000 employees. Just over 160 of the Municipality's industrial companies have over 10 employees, which we assume to be the smallest company size for industrial production of a certain size.

Opportunities for large profits

Bergen's industrial companies used 375 GWh of electricity in 2008, and energy totalling 775 GWh in their production processes. The electricity consumption of industrial companies is equivalent to 12 per cent of their total energy consumption, and 31 per cent of the stationary energy use linked to workplaces in the private and public sectors. For comparison, industrial companies account for just over eight per cent of Bergen's total employment. Improving the energy efficiency in industrial companies will therefore give relatively large profits for the Municipality's total energy consumption.

For simplicity, this report uses an estimated potential saving linked to electricity consumption. The reason for this is that district heating is included in the industry's total energy consumption of 775 GWh, where waste and gas are significant factor inputs, and this report has not analysed the potential for improved energy efficiency in district heating production. A 12 per cent reduction of 375 GWh will save 45 GWh. This is more electricity than that used by all of Bergen's building and construction companies in a year.

The energy efficient industrial company

Industrial companies are being pressured to reduce their energy consumption from several sides: Competitiveness in product markets means a focus on costs – and energy costs money. In addition, consumers and authorities are setting stricter requirements for production processes that leave a smaller carbon footprint than previously.

Today, an energy efficiency project is about much more than machines and automation. When an industrial company is to carry out an energy efficiency project, a range of areas within the company must be taken into account. The Energy Optimisation concept does just this.

The areas to focus on are:

- Cooling/heating
- Heat recovery – e.g. utilisation of waste heat
- Compressed air
- Electrics
- Processes
- Automation
- Water
- Energy efficient attitudes among all employees
- Available support schemes

Street lighting

The roads and streets in Bergen Municipality are lit by 41,300 street lights. These burn for 4,400 hours per year and have an annual electricity consumption of 26 GWh.

Street lighting has made a quantum leap in terms of energy efficiency improvement in recent decades. In addition, new regulations have been introduced, in regards to the poisonous substance content of lights. The street lights in Bergen are a combination of new and older technology. Ten per cent are of the older mercury type, 70 per cent are the slightly newer sodium type, and 20 per cent are of the newest technology type, metal halogen. The energy efficiency potential of changing the light sources in mercury lights from HQ to Sodium HCl/HQI would be around 1.4 GWh. In addition, there is great energy potential in the more extensive use of lighting management. Furthermore, if this is combined with the use of requirement controlled LED technology, the electricity consumption of street lighting can be reduced by 50 per cent. This amounts to an energy efficiency potential of 13 GWh. The total energy efficiency potential for street lighting is therefore 14.4 GWh. This potential does not include the possibility of using LED lighting to provide more precise lighting, less light pollution and therefore a need for fewer lights.

Earth Hour

On 27 March 2010, Bergen was one of the 162 Norwegian Municipalities that turned off their lights at eight thirty in the evening in connection with Earth Hour, an international movement supported by the World Wide Fund for Nature (WWF). The movement aims to highlight the problem of climate change by asking private persons, businesses, authorities and organisations to turn off electric lights for one hour. Many private companies in Bergen participated in the movement. A public survey carried out in Norway by Norstat showed that 46 per cent of those surveyed answered that they participated in Earth Hour this year.



Upgrading the grid

On the way from production to outlets in homes and companies, an average of ten per cent of produced electrical power is lost. This amounts to 12 TWh annually. In Bergen, the losses in the electrical grid are estimated to be below five per cent.

The most important cause of these losses is the low voltage level in the part of the electrical grid that leads from transforming stations out to end users. 50-60 per cent of the losses occur here. This part of the electrical grid is called the distribution grid, while the overlying grids are known as the regional grids and the national grid.

Electricity enters Bergen via 25 transforming stations, which transform electricity to the distribution voltage of 11kV. 90 per cent of the grid consists of underground cables, and ten per cent is overhead networks.

Increasing the voltage level in the distribution grid would reduce the losses. The improved energy efficiency would amount to an energy saving of 52,8 GWh, which also means a saving of 16.2 million Norwegian kroner during a normal year.

Another tool to reduce grid losses is the introduction of so-called two-way communication. Using two-way communication, network companies have the opportunity to reduce the load at individual end users in high load situations, thereby achieving a more even load profile throughout the day, week and year.

The measures are profitable within 30 years – the same time horizon that Enova uses as the basis for such infrastructure.





Bergen's homes use less energy than those in the rest of the county, but it is nevertheless possible to cut the energy consumption further. By adopting available technology, enough energy equivalent to the energy consumption of 49,000 households in Bergen can be saved.

Buildings are responsible for around 40 per cent of the world's energy consumption, and private homes constitute around 67 per cent of this. Private homes are therefore responsible for 29 per cent of the world's total energy consumption, and 21 per cent of greenhouse gas emissions.

The proportion is approximately the same in Norway, where households stand for 30 per cent of Norway's stationary energy use. Even though the energy consumption of households has been stable in recent years, there is significant potential to reduce it.

In densely populated cities, the figures are rather different: In Bergen Municipality, buildings account for 57 per cent of the energy consumption. Of the energy consumed by buildings, homes are responsible for around half, 55 per cent, compared with 30 per cent on a national basis.

The average city home is basically more energy efficient than homes in more sparsely populated areas. Almost every other home in Bergen is an apartment. The average energy consumption in apartment blocks is 12,600 kWh per year, less than half of that used by detached houses, which in 2006 used 26,700 kWh.

In 2007, households in Bergen had a total energy consumption of 2.1 TWh. Of this, electricity constituted 1.8 TWh. While every home in Norway uses just over 14,500 kWh per year on average, the average home in Bergen has an energy consumption of around 15,000

kWh. The degree of urbanisation in Bergen is probably the explanation for the energy consumption being below the level in the rest of the county – 15,800 kWh.

In this report, we have reviewed the energy efficiency potential in Bergen, where we have taken what is normal for Norwegian households as a starting point and adjusted this for particular distinctive features linked to urbanisation. By utilising existing products to improve energy efficiency, households in Bergen can save 23 per cent of their current energy consumption. This amounts to 474 GWh. If the potential improvement linked to lighting and household appliances is considered in addition, the total energy efficiency potential is 731 GWh. This is equivalent to 41 per cent of the electricity consumed by private households. See the table for specific measures.

Lighting

Osram and Lyskultur estimate that 15 per cent of the electricity consumption in Norwegian homes is used for lighting. This means that almost 270 GWh is needed to light Bergen's just over 120,000 homes.

Lighting in Norwegian homes is a mix of traditional, inefficient incandescent lamps, more effective halogen lamps (both with and without dimming), as well as more effective energy saving light bulbs. A class A light bulb uses 80 per cent less energy than a traditional incandescent light bulb. A reasonable estimate of the energy efficiency potential is to assume as a starting point that a little over half of the light bulbs in Bergen are of the inefficient, older type. We can therefore say that the energy consumption of lighting can be reduced by 50 per cent.

Under these assumptions, 130 GWh can be saved if all less effective light bulbs are replaced with energy saving light bulbs. This is equivalent to the total

Households

electricity consumption of more than 8,500 homes. Modern components, better placement of light sources, the correct use of fixtures, motion sensors and other management systems can provide an energy efficiency improvement of a further 15-20 per cent. This is however not included in the calculations.

As is evident in the overview of energy efficiency measures, replacing traditional incandescent lights with energy saving bulbs (70 per cent of replacements), halogen bulbs (29 per cent of replacements) and LED lights (one per cent of replacements) is among the measures with the lowest investment cost in relation to potential savings. The investment will be repaid within less than a year. If this is integrated with daylight and presence control, the repayment period increases, but the energy efficiency improvement over the equipment's lifetime will be higher.

Efficiency improvement potential of building types

	[GWh]	%
Offices	102	26 %
Health and social services	40	20 %
University and colleges	36	36 %
Schools and pre-schools	28	18 %
Warehouse/logistics	61	25 %
Hotels and restaurants	27	27 %
Sport and cultural buildings	5	3 %
Business premises	44	11 %
Light industry	30	10 %
Total commercial properties	373	18 %
Households	474	22 %
Total	847	20 %

Potentials linked to lighting and household are excluded. These represent a total energy efficiency potential of a further 380 GWh.

Household appliances

Replacing older, inefficient household appliances with new ones of a high energy class gives great environmental benefits. The amount of energy needed to produce the products is small – just 5-10 per cent the energy that is used during the appliance's lifetime.

Figures from Elektronikkbransjen (lifetime) and Bosch Siemens (energy efficiency of individual and comparable products) provide the following data for white goods:

Product	Lifetime	Improvement in energy
Ovens	15 years	50%
Dishwashers	12 years	40%
Fridges	15 years	60%
Freezers	17 years	60%
Combination fridge/freezers	15 years	74%
Washing machines	12 years	50%
Tumble driers	12 years	60%

On average, the above mentioned Bosch Siemens household appliances use half as much energy today as they did 15 years ago, and there is reason to believe that the products of other manufacturers are also significantly more energy efficient today than previously. Enova estimates that the average household uses 4,200 kWh in the use of electrical appliances each year.

If we presume that the electric appliances in Bergen's homes consist of a combination of older and newer models, it is estimated that the energy consumption of electrical appliances can be cut by 25 per cent, or 1,050 kWh per household. For the entire city, this will amount to an estimated 127 GWh – the equivalent to the total energy consumption of almost 8,500 homes.

Households (cont.)

Measure	Efficiency improvement potential (MWh)	Investment inc. VAT (Mill. NOK)	Investment in Norwegian kroner (inc. VAT) per saved kWh	Per centage share of area measures implemented in
Buildings	185 562	4 617	25	
Insulation, roof and/or walls	59 399	974	16	10
Insulating strips for windows and doors	30 401	152	5	10
Replacement of windows	58 370	2 128	36	2
Replacement of external doors	37 392	1 363	36	2
Sanitation	33 900	65	2	
Energy saving showers/fittings	19 565	7	0	40
New water heater	14 335	58	4	10
Heating	58 605	324	6	
Insulation of pipes and valves	1 192	6	5	20
Shunting and external temperature compensation	1 950	16	8	20
Transition to quantity regulated heating system with speed regulated pump	2 730	19	7	20
Adjustment of heating system in combination with water purification	975	6	6	10
Heat pump	49 418	254	5	15
Thermostatic radiator valves	2 340	23	10	30
Ventilation	46 361	353	8	
Better heat exchanger for ventilation	27 361	266	10	10
Change to direct drive fans	15 200	76	5	10
Frequency converters for fans	3 800	11	3	5
Lighting and household appliances	257 000	130	1	
Lighting	130 000	130	1	
Household appliances	127 000		0	
Management and regulation	149 206	495	3	
Time-controlled ventilation	17 328		0	6
Thermostat and time-controlled electric heating	68 402	342	5	45
Automatic time control of water-based heating	7 020	39	6	40
Individual measurement of heating and hot water	13 680	114	8	5
Reduced internal temperature	42 775	0	0	50
Total	730 634	5 985	8	

Household appliances are not included in the total investment in millions of Norwegian kroner or total investment per kWh.

Method and sources

The energy efficiency potential calculations in this report are based on the the total energy consumption in Bergen being linked to space and applications. Figures from BKK, Statistics Norway and Norsk Petroleumsinstitutt have been used as the basis for the survey of the total energy consumption.

Figures for space in buildings are mainly based on figures from the Agency for planning and geological data in Bergen Municipality, but they have also been coordinated with figures from Statistics Norway. Information about industrial companies in Bergen was provided by Statistics Norway and Dun & Bradstreet. Figures for traffic counts and total street lights are also provided by Bergen Municipality. Data regarding the electrical grid in Bergen Municipality is from BKK Nett.

Unless otherwise stated, all data was provided by Statistics Norway. All included figures are the most recent available. These are mainly from 2008.

Bergen Municipality and BKK have contributed information regarding energy consumption, space

and applications. Based on material from Enova, Siemens and Osram have carried out analyses and calculations of energy efficiency potentials, and the figures have been quality assured by Bellona. These kinds of calculations necessarily depend upon simplifications of reality. However, each individual measure and energy efficiency potential percentage is based upon concrete experience from Norway and abroad.

The analysis agency Perduco has contributed to collecting and compiling information regarding the energy efficiency potential in the various areas covered by this report.

◀ ◀ EXPLANATION OF THE TABLE TO THE LEFT:

The table suggests how a collective energy efficiency potential can be achieved. The efficiency potential and investments are shown for the entire Municipality. The investment in Norwegian kroner per saved kWh gives an indication of how quickly the investment in the specific measure for improved energy efficiency shows a return. The lower the investment, the quicker the return. The efficiency potential and investment costs are estimated by Siemens.

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