PERMANENT REPRESENTATION OF DENMARK
to the European Union
Brussels

European Commission
Directorate-General for Energy
Directorate C
Renewables, Research and Innovation, Energy Efficiency
C.3 – Energy Efficiency

Rue d'Arlon 73
B-1040 Brussels, Belgium
Telephone +32 (2) 233 08 11
Fax +32 (2) 230 93 84
E-mail: brurep@um.dk
www.eurepraesentationen.um.dk

For the attention of: Paul Hodson

PAR PORTEUR

Annexes	File no	Office	
1	400.K.4-0		18 June 2014

Denmark's equivalence report on alternatives to the inspection scheme for oil and natural-gas boilers

Under the Directive on the energy performance of buildings (Directive 2010/31/EU of 19 May 2010), Member States must either establish an inspection scheme for oil and natural-gas boilers or introduce alternative measures with at least the same effect.

In the latter case, the effect of such alternatives must be proven to the EU by means of an equivalence report. This is such a report, which is enclosed in respect of Denmark. The report relates to the period from 30 June 2014 to 30 June 2017, and is an update to the previous report from the last three-year period.

Yours faithfully,

[signed]
Jakob Alvi
Representation Secretary

SRD/		DG: ENER		
A/				
ACTION:		DEADLINE:		
FILE CODE:				
200614				
A	B	C	D	E
DG	ASS	001	01	SIAC
DGA	DGA	DGA		
DBC	DCDE	DDE		

On 1 February 2011, Denmark opted to implement Article 14 of the Directive on the energy performance of buildings (Directive 2010/31/EU of 19 May 2010) using alternative measures as referred to in Article 14(4).

The present memorandum describes the impact of the alternative measures in comparison with the impact of a hypothetical inspection scheme over the period from 30 June 2014 to 30 June 2017.

A similar memorandum was produced in May 2013 in respect of the period from 30 June 2011 to 30 June 2014. The present memorandum is therefore a simple update to the 2013 memorandum, and much of the memorandum is repeated.

Summary

Under the Directive on the energy performance of buildings (2010/31/EU of 19 May 2010), Member States must introduce a scheme for inspecting boilers intended for the heating of buildings so as to help ensure that such boilers are energy-efficient. As an alternative to a mandatory inspection scheme, Member States may opt to implement other measures if the impact of such alternative measures is the same as the impact of an inspection scheme. Denmark has opted to implement alternative measures to a boiler-inspection scheme, and this report proves that alternative measures help to achieve greater energy savings than an inspection scheme could reasonably be expected to achieve.

It is a policy objective in Denmark for the heating of buildings to be based on renewable energy by 2035, and for oil firing to be phased out by 2030. The boilers that would be covered by a hypothetical boiler-inspection scheme are therefore expected to be phased out in 2030.

To be specific, a number of measures have been introduced that are to contribute to improving the efficiency of oil firing and natural-gas firing, or to phasing them out, and these measures aim for the same objectives as a boiler-inspection scheme.

The following are mentioned as alternative measures in this report:

- Advisory initiatives, including the Information Centre for Energy Savings in Buildings;
- A pool for phasing out oil firing;
- Subsidies for building renovations;
- Obligations for energy companies to make savings;
- Lower electricity tax for owners of heat pumps;
- A ban on the installation of oil firing in certain buildings, and efficiency requirements for boiler systems.

The effect of some of these alternative measures is calculated in terms of improvements to efficiency or the phasing-out of boilers, in the sense of the type of effect that an inspection could hypothetically have. Some of the alternative measures described are mentioned without any appraisal of their impact; this is due to excessively high uncertainty in assessing their effects.

The effect of a hypothetical boiler-inspection scheme depends on how many of the boilers in question there are in Denmark. It is estimated that there are 710 000 boilers, distributed as shown in Table A.

Table A. Boilers used for heating in Denmark

Type	Number
Oil	240 000
Natural gas	370 000
Solid fuel and biofuels	100 000
Total	710 000

The impact of a hypothetical inspection scheme and alternative measures respectively is shown in Table B. There is a considerable amount of uncertainty associated with the calculations. The impact of the hypothetical inspection scheme has been calculated both with and without regard to the fact that there are voluntary, market-based inspections of boilers. Mandatory inspections cannot be expected to have an impact on owners of buildings who have already agreed to have voluntary inspections conducted.

Table B. Impact of a hypothetical boiler inspection and alternative measures, TJ per annum in the first year of an initiative

Scheme		TJ
Hypothetical boiler-inspection scheme	Excluding voluntary schemes	9
	Including voluntary schemes	3
Alternatives	Obligations for energy companies to make savings	9
	Home/job scheme	86
	Changes to tax on electricity and security of supply	40
	Ban on oil firing in communal areas	1
	Boiler requirements	28
Total alternatives		164

Despite the uncertainty of the calculations, it appears that a boiler-inspection scheme would not have the same impact as the alternative measures would be expected to have.

Comparison with the previous equivalence report for the period from mid-2011 to mid-2014

As has been mentioned above, the present equivalence report is a simple update to the equivalence report for the period from mid-2011 to mid-2014, and much of the text, tables and calculations are repeated with updated data.

The same initiatives have formed the basis for this report as for the previous one. The most significant changes are:

- The ‘tax on security of supply’ has no longer been included, since it has not been adopted;
- The reduction in electricity tax for owners of heat pumps applies to the entire period in question;
- The ban on oil firing in new buildings applies to the entire period in question;

- The scheme of subsidies for home renovations, which is called the ‘Home/job scheme’, will only be in force for a short while during the relevant period, namely the second half of 2014, and thus only the first six months of the three-year period;

- The estimated impact of the obligation for energy companies to make savings has increased on the basis of the most recent data.

On the whole, these changes mean that the total impact of alternatives to boiler inspections has fallen (in relation to the previous report) from 181 TJ for each year that a measure is in force to 164 TJ per annum. The impact over the whole period has fallen from 839 TJ to 598 TJ.

The impact of a hypothetical inspection scheme has not changed. There has been a slight downward adjustment to the estimated number of boilers, but the adjustment is so small that it is of no practical significance for the calculations.

Finally, a new initiative called ‘Better Homes’ is described, although its impact has not been quantified.

Table of Contents

1 Introduction

Under Article 14 of the Directive on the energy performance of buildings (hereinafter *Buildings Directive*), Member States must implement either mandatory inspections of boiler systems over 20 kW or implement alternative measures that have the same effect that a mandatory inspection scheme would have had. It does not specify what alternative measures may include, but the Danish Energy Agency is of the view that a number of different initiatives could meet the challenge of inefficient boiler systems. The Danish Energy Agency therefore assumes that financial, legal and advisory measures must be treated as alternatives to mandatory inspections.

This 'equivalence report' proves that alternative measures yield greater energy savings than an inspection scheme would have done.

The vast majority of boiler systems in Denmark are fired by either oil or natural gas, and the basis for selecting alternative measures to mandatory inspections is that it has been a goal for a long time to phase out oil, and now also natural gas, for individual heating. Most recently, the Danish Government set targets for the energy sector in its policy document entitled 'Our Energy', which include all oil firing to be phased out by 2030 and all heating to be based on renewable energy by 2035. With such a relatively short conversion period, the Danish Government has chosen to focus its efforts firstly on conversion to renewable energy and secondly on improving heating efficiency.

The alternative measures discussed below have not been introduced as a direct consequence of the fact that a boiler-inspection scheme has not been adopted, but they aim for the same objectives as a boiler-inspection scheme. The impact of some of these alternative measures has been calculated in terms of improvements to the efficiency of boilers, or their phasing out. The measures may also have an impact on other things than improvements to the efficiency of boilers or their phasing out, but such effects have not been included.

By way of introduction, a description will be given below of how the boiler stock has been calculated for the various kinds of fuel, including the expected number of boiler systems over 20 kW. This will be followed by a description of the framework for mandatory inspections and the expected impact of a hypothetical inspection scheme. The alternative measures implemented by Denmark will then be described and their impact calculated. Finally, the impact of a hypothetical inspection scheme will be compared to the impact of the alternative measures.

2 Basic data on the boiler stock

According to the Buildings Directive, boiler systems with a rated output of more than 20 kW and designed to heat rooms are covered by the inspection requirement. On the other hand, boiler systems for purposes other than for heating rooms, such as for industrial or process applications, are not covered by the inspection requirement and will therefore not be included in the following calculation of boiler stock.

There are many sources that help to estimate the number of boiler systems. The primary source is the Buildings and Homes Register (BBR), which is a national register of data on all of the buildings and homes in the country. The register is continuously updated by local authorities, particularly through the processing of planning applications. Building owners are also required to report any changes to the BBR data manager, and utility companies supply the BBR with consumption data.

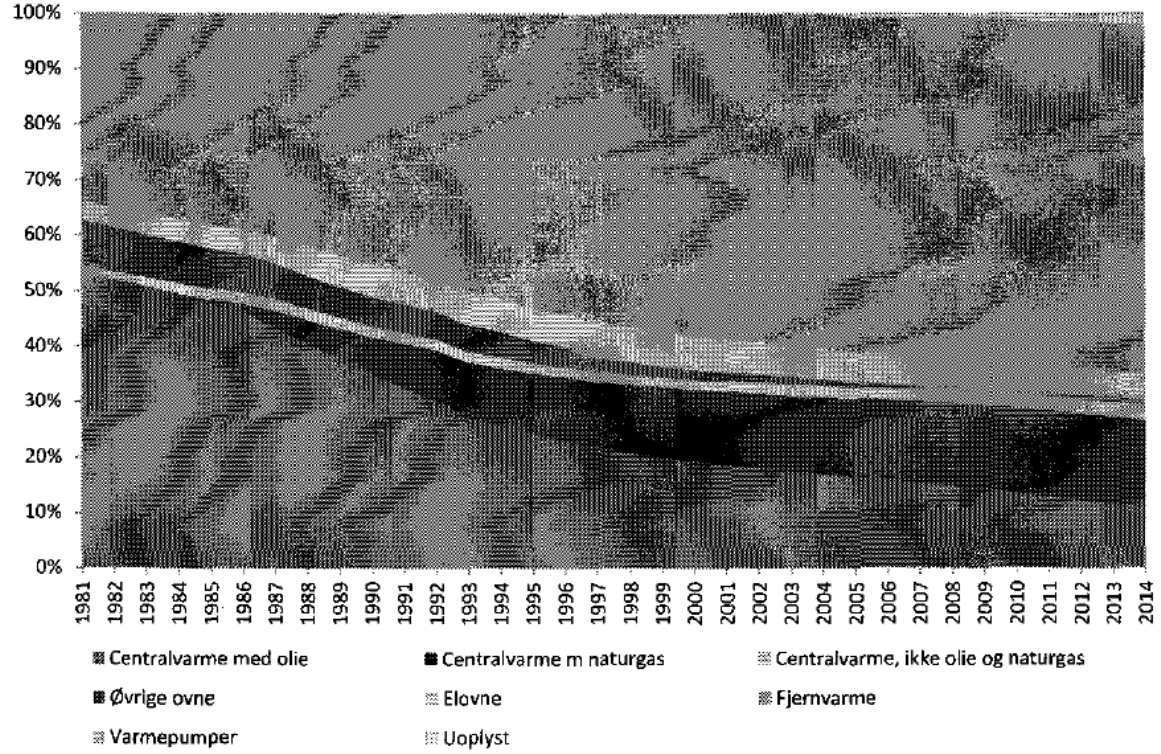
Not all building owners know that they are required to update the information in the register, and local authorities often update the register rather late, which reduces the register's validity. Some supplementary information is therefore also used below, particularly for oil firing and less commonly used types of system.

The historical trend in methods for heating homes may be shown by way of introduction. The proportion of homes heated by boilers, etc. (i.e. central heating with oil, natural gas, etc. or other stoves) has fallen dramatically over the last 30 years, while a relatively larger number of homes have come to be heated by district heating; please see Figure 1. The trend has been enabled by expansion of the district-heating network. Of the homes that have boilers, the proportion of oil-heated homes has fallen, while the proportion of boilers heated by natural gas has risen, and this too has been enabled by expansion of the communal natural-gas network.

The proportion of homes heated by heat pumps has been calculated separately for the last three years (heat pumps previously fell under 'electricity' or 'not stated'). In 2014, this proportion was 1.7 %, and it has risen considerably since 2010.

Figure 1. Homes by heating type, 1981-2014

Source: Statistics Denmark, StatBank, tables BOL1, BOL11 and BOL102.



Danish	English
Centralvarme med olie	Central heating with oil
Øvrige ovne	Other stoves
Varmepumper	Heat pumps
Centralvarme m naturgas	Central heating with natural gas
Elovne	Electric stoves
Uoplyst	Not stated
Centralvarme, ikke olie og naturgas	Central heating, not oil or natural gas
Fjernvarme	District heating

The number of oil-heated homes has fallen over the last five years, while the number of homes fired by natural gas has risen.

It is not clear how much the district-heating network will expand in the years ahead, but any expansion is far from likely to be as dramatic as it has been in previous decades. On the whole, however, it may be expected that oil firing will be phased out to a certain extent, albeit without any further measures.

The BBR contains data about heating systems, heating methods, supplementary heating methods, various details about oil tanks in particular, and information about supplies of oil, for example, to different addresses. This information relates to individual buildings or addresses. It is this kind of information that has been used below and, where no precise figures can be given for the number of boilers, it is because the information has not been updated in some cases. Finally, the information in the BBR is not quite as detailed as would be desirable. For instance, coal-fired systems cannot be separated from pellet firing.

Table 1 divides the just under 3 million buildings in Denmark according to heating method and building use. The table is based on information provided by the local authorities/owners concerning the primary heating system and heating method and, on this basis, there is an indication that 356 699 buildings use oil for heating, and that 378 914 buildings are heated using natural gas. In addition to this, buildings that are heated using solid fuel also have a boiler that would have to be inspected under a hypothetical boiler-inspection scheme. There is an indication that 112 683 (= 100 276 + 12 407) buildings are heated using solid fuel. Most of them are presumed to use solid fuel or wood pellets; please see the special study below. Other heating methods have been included for the sake of completeness.

Table 1. Breakdown of buildings[1] by primary heating method and building use, number of buildings

Heating[2]	Houses	Other residential buildings	Production	Offices, etc.	Culture, institutions, etc.	Leisure	Total
District heating	656 033	80 461	13 375	37 990	22 372	7 834	818 065
Natural gas	331 357	10 394	13 335	13 950	7 573	2 305	378 914
Oil	272 069	8 223	34 948	15 733	5 398	20 328	356 699
Heat pumps	50 596	754	1 157	1 125	574	7 843	62 049
Electricity	104 941	3 731	7 705	10 264	5 152	202 337	334 130
Straw	7 855	205	4 065	162	68	52	12 407
Solid fuel	72 851	1 463	7 307	1 632	789	16 234	100 276
Other	8 268	495	2 987	1 316	560	4 348	17 974
Unknown	105 858	27 021	542 288	58 751	17 141	51 503	802 562
Total	1 609 828	132 747	627 167	140 923	59 627	312 784	2 883 076

Source: BBR, own calculations.
[1] Small buildings such as car ports, garages and outbuildings are not included.
[2] The classification is based on information about heating systems and methods.

As has been mentioned, this statement cannot be viewed in isolation as a statement of the relevant numbers of boilers. This is because the following factors, among others, are sources of uncertainty for the calculation:

- As is shown above, there is a trend towards phasing out oil firing, and not all building owners who have phased out oil firing have updated their information;
- Some buildings might not be heated (they might not be in use);
- Some buildings might use more than one boiler;
- Some buildings have supplementary boiler heating.

2.1 Oil-fired boiler systems

As is shown in Table 1, there were 356 699 buildings where the records of heating systems and methods indicated that the building was heated using oil. However, there was only information for 234 117 of these buildings indicating the presence of an oil tank. The Ministry of the Environment has carried out a comprehensive investigation to record the locations of the total number of active oil tanks in Denmark, and it may therefore be assumed that the BBR records of active oil tanks are of high data quality. Finally, supplies of oil have been recorded to addresses where there are a total of 273 847 buildings.

There are 8 088 buildings for which there is information suggesting the use of oil as a secondary heating method.

Table 2. Supplementary information about oil-fired buildings, number

	Number
Buildings where heating systems and methods indicate oil heating	356 699
... *of which*, buildings where there is also information indicating the presence of oil tanks that have not been removed	234 117
Number of buildings at addresses to which oil is supplied	273 847
Buildings for which there is information about oil for supplementary oil heating	8 088

Source: BBR, own calculations.

The Danish Energy Agency's main estimate for the number of oil-fired boilers is approximately 240 000.

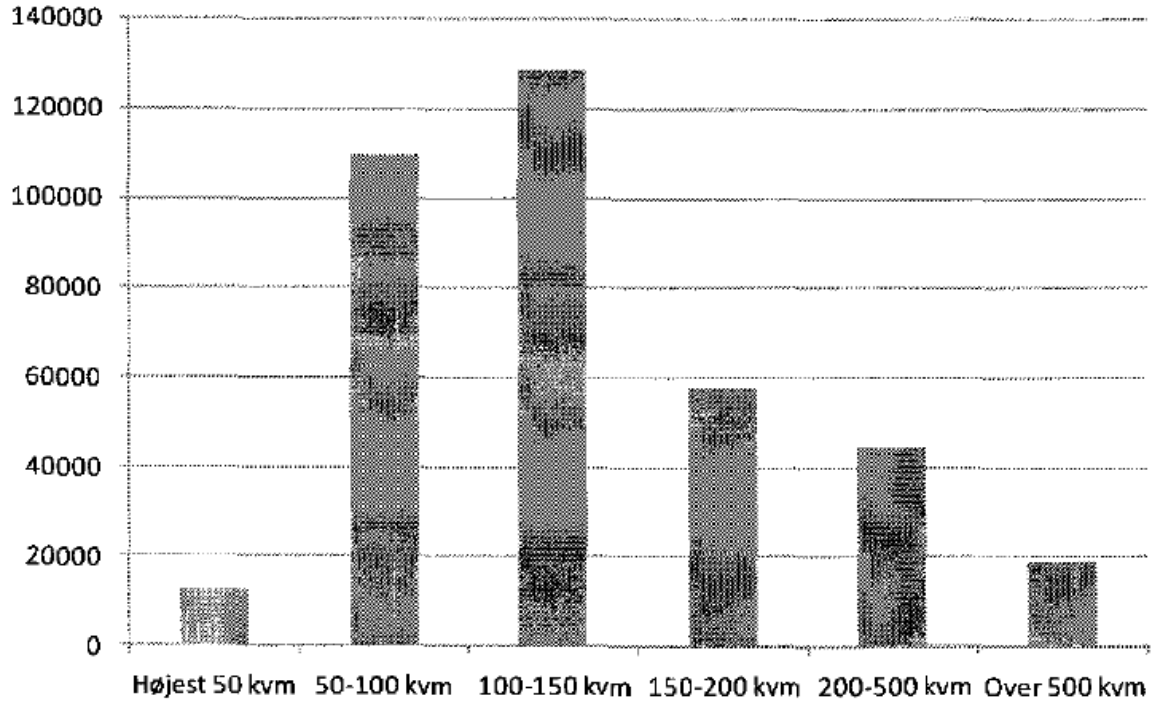
Since the BBR does not show the size of oil-fired boiler systems, their total number must be qualified further in order to find the number of oil-fired boiler systems subject to the inspection requirement under Article 14. How great a proportion of the stock has an effective rated output of more than 20 kW will be assessed on the basis of information from the boiler-inspection scheme.

Denmark had what was known as a *'boiler-inspection scheme'*, which consisted of annual *'energy measurements'*; please see Executive Order No 62 of 27 January 2011[1]. Following the entry into force of the scheme on 1 February 2011, all owners of oil-fired boiler systems were required to have energy measurements taken for their oil firing once a year. The measurements related to flue-gas losses and sooting numbers, and the type and age of the boiler were also recorded. The scheme did not, however, work as intended, presumably because the need for energy measurements had to a large extent been met by voluntary market-based schemes. At the same time, the central BBR developed to such an extent that it could be used to survey the boiler stock. This resulted in abolition of the requirement for annual energy measurements on 1 June 2013.

Of the boiler systems that had energy measurements taken from them under the boiler-inspection scheme, approximately 24 400 were greater than 20 kW, amounting to approximately 52.6 % of the total number of oil-fired boiler systems. Since all owners of boilers were subject to the requirement to have energy measurements taken, it is assumed below that the 45 652 energy measurements reflect the composition of the boiler stock throughout the country. It is, however, conceivable that there are more of the larger boiler systems that have had energy measurements taken from them, since it would give greater potential for energy savings if the boiler system were inefficient. Many boilers are under 20 kW, possibly more than half of them. This is indicated by the fact that the vast majority of oil-fired buildings are houses of less than 150 square metres (please see Table 1), and it may be expected that these buildings therefore include many that have boilers of no more than 20 kW.

[1] https://www.retsinformation.dk/Forms/R0710.aspx?id=l35641.

Figure 1. Distribution of buildings, indicating oil heating by building size, number



Danish	English
Højest 50 kvm	No more than 50 m^2
50-100 kvm	50-100 m^2
100-150 kvm	100-150 m^2
150-200 kvm	150-200 m^2
200-500 kvm	200-500 m^2
Over 500 kvm	Over 500 m^2

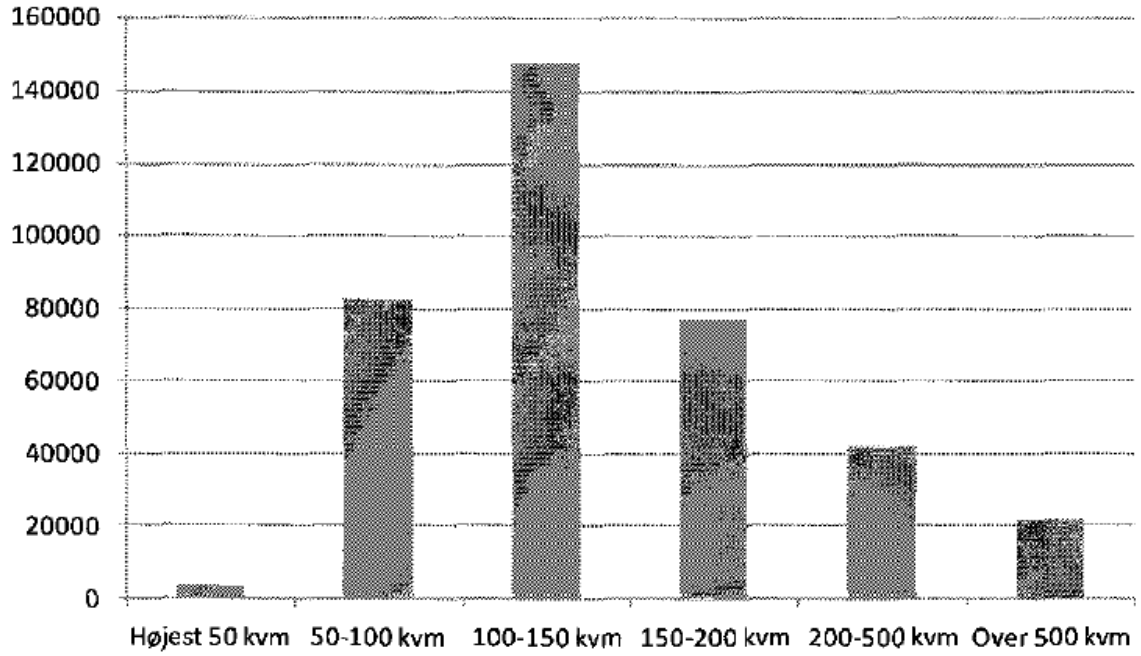
The starting point for the following calculations, however, is the recorded energy measurements, in that 52.6 % of all oil-fired boiler systems have a rated input of more than 20 kW, even if this proportion is greater than the Danish Energy Agency considers to be the case in reality. How great a proportion of boilers is over 100 kW is also relevant to the calculations below, because these boilers have to be inspected more frequently. The Danish Energy Agency is of the view that this only applies to a small number of boilers, and it is specifically assumed below that 5 % of boilers are of that size.

2.2 Boiler systems fired by natural gas

As is shown in Table 1, the information in the BBR indicates that the number of boiler systems fired by natural gas is 378 914, most of which are in houses, including terraced houses. The number of buildings at addresses to which natural gas is supplied may be estimated as 467 544.

The size of buildings where there are indications of natural gas is illustrated in Figure 2 and, as is the case for oil firing, the vast majority of buildings are less than 150 square metres.

Figure 2. Distribution of buildings, indicating natural-gas heating by building size, number



Danish	English
Højest 50 kvm	No more than 50 m^2
50-100 kvm	50-100 m^2
100-150 kvm	100-150 m^2
150-200 kvm	150-200 m^2
200-500 kvm	200-500 m^2
Over 500 kvm	Over 500 m^2

For homes heated by natural gas, it is assumed, as with oil-heated buildings, that 52.6 % of boilers have a capacity of at least 20 kW. As is the case with oil boilers, 5 % of boilers are assumed to be over 100 kW.

2.3 Coal and coke boilers

The Danish Energy Agency's *Energy Statistics* also show that household consumption of coal and coke amounted to 30 TJ/8333 MWh in 2011. If this was primary heating, this equates to 417 households, and if the energy consumed was used as a secondary heating source, it equates to 833 households.

The number of buildings heated by coal and coke cannot be estimated on the basis of the information in the BBR, since the BBR only indicates which buildings are heated by solid fuel, which also includes wood pellets, for example.

2.4 Biofuel boilers

Since the equivalence report of 24 June 2011, the Danish Energy Agency has had a report produced by FORCE Technology on the extent of biofuel boilers, which was published in November 2011. The report shows that approximately 88 000 boiler systems in Denmark are greater than 20 kW and fired by biofuels, including straw, firewood, woodchips, wood pellets, and biodiesel. The report estimates the total number of biofuel-fired boiler systems for heat production at approximately 136 000, of which approximately 88 000 are greater than 20 kW.

Fuel	Technology/ownership	Total consumption (TJ)	Under 20 kW	Between 20 and 100 kW	Over 100 kW	Total
Straw-fired boilers	Batch-fired systems in agriculture	3 915	0	0	5 400	5 400
	Automatically-fired systems in agriculture	435	0	300	300	600
Firewood-fired boilers	Private, agriculture, etc.	3 744	0	32 000	0	32 000
Woodchip-fired boilers	Forestry, agriculture, goods and private	108	0	200	40	240
	Larger buildings	146	0	0	35	35
Wood-pellet-fired boilers	Private, incl. agriculture	10 105	48 000	48 000	0	96 000
	Larger buildings	1 783	0	1 000	1 000	2 000
Biodiesel-fired boilers	Private, incl. agriculture	20	100	100	0	200
	Larger buildings	4	0	4	0	4

The total number of boilers in Table 3 and for coal and coke is fairly consistent with the number of buildings according to the BBR where there are indications of solid fuel or straw; please see Table 1. On the whole, the figures given in Table 3 include slightly more systems, but this may be due to the fact that supplementary heating systems have been included.

2.5 Total number of boiler systems

Table 4 summarises the estimated number of boilers.

Table 4. Estimated number of boilers

Type	Number
Oil	240 000
Natural gas	370 000
Solid fuel and biofuels	100 000
Total	710 000

3 Impact of a hypothetical inspection scheme

There are several factors that can influence the impact of an inspection scheme. The content of a hypothetical inspection and the impact of such a scheme are discussed below. The estimate does not include administrative or financial conditions, even though these considerations would indubitably be of considerable importance if the implementation of an inspection scheme actually had to be decided upon.

3.1 Inspection content

According to Article 14(1), the elements of a mandatory inspection include *'the accessible parts of systems used for heating buildings, such as the heat generator, control system and circulation pump(s)... shall include an assessment of the boiler efficiency and the boiler sizing compared with the heating requirements of the building.'* The Directive does not specify in any detail how the inspection should evaluate the efficiency and sizing of the boiler compared with the heating requirements of the building.

The *efficiency* of the boiler can, for example, be investigated using measurements of the flue-gas temperature and sooting numbers. These parameters can show whether, for example, there is a need for the boiler to be cleaned, for the burner to be replaced, or for the nozzle to be adjusted. The *sizing* of the boiler must be assessed on the basis of the heating requirements of the building, so factors such as the size, use and insulation of the building and the condition of the windows must be involved. The sizing cannot be assessed, however, until the boiler system has been installed, and a sizing recommendation will therefore only be relevant in the context of replacing a boiler system with a new one.

3.2 Interval

Article 14(2) states that Member States may set different inspection frequencies depending on the type and effective rated output of the heating system whilst taking into account the costs of the inspection of the boiler system and the estimated energy cost savings that may result from the inspection. Larger systems with an effective rated output of more than 100 kW shall be inspected at least every two years, although this may be extended to four years for gas boilers; please see Article 14(3).

The Commission has announced that *'regular'* inspections mean at least one inspection during the boiler's life cycle. If a hypothetical inspection scheme were to be implemented in Denmark, a scheme with the fewest possible inspections required by law would presumably be chosen. Such a choice must be viewed in light of the fact that voluntary service agreements are already widespread, and it is therefore felt that there would not be a major energy saving to be gained from introducing coercive measures in the form of mandatory inspections.

Newer boilers generally have a shorter life cycle than old ones. For example, old cast-iron boilers have a very long life cycle if they are well maintained. An average age of 17 years will be assumed for all types of boiler system below, based on studies produced in conjunction with ECO-design[2].

With regard to establishing the interval for hypothetical inspections, the proportion of older boiler systems in the boiler stock will be disregarded below. This will result in a shorter average life cycle than may be expected for the actual boiler stock. As a result of the fact that the present report uses a shorter life cycle than the actual boiler stock might reflect, there will also be a shorter period between inspections than if the actual life cycle had been used.

The following assumes one inspection during the life cycle for boiler systems with a size of 20-100 kW, irrespective of fuel type, these being the vast majority of the boiler stock in Denmark. Inspections every two years are assumed for systems larger than 100 kW, with the exception of systems over 100 kW fired by natural gas, where inspections every four years are assumed. As has been mentioned above, it is assumed that 5 % of boilers are over 100 kW. There are thus assumed to be 25 000 inspections per annum; please see section 3.4.

3.3 Compliance and willingness to make improvements

Calculating the impact of a hypothetical inspection scheme must include considering the extent to which a hypothetical inspection scheme could be expected to be complied with, and whether a recommendation concerning improvements to energy efficiency would be implemented.

In some cases, the degree of compliance will depend on the quality of an inspection scheme and effective enforcement, although the degree of compliance may also be affected by other factors, such as the costs associated with an inspection. No studies have been carried out to examine what the typical compliance rate is for similar Danish schemes. The Danish Energy Agency estimates that the degree of compliance will usually be about 90 % for mandatory schemes of this kind. This factor will not, however, be included in assessing the impact of a mandatory inspection scheme, as a result of the uncertainty associated with the calculation.

There are also some widespread schemes in the Danish market for oil-fired services, and to some extent they do ensure that boiler systems operate efficiently; please see section 4.4 on voluntary service agreements. The growth in such agreements means that many owners of systems that are fired by oil or natural gas have already received the information that would be provided by a hypothetical inspection scheme, thus considerably reducing the impact of a hypothetical scheme.

[2] Please see the Base Case Study, Task 5 Report, Tables 2-6, page 11: http://ecoboiler.org/public/ecoboiler_task5_final.pdf and the Design Options Study, Task 6 Report, Table 1-1, page 2: http://ecoboiler.org/public/ecoboiler_task6_final.pdf.

3.4 Impact of a hypothetical inspection scheme

The aim of boiler inspections is to increase the energy efficiency of boilers and thus reduce fuel and energy consumption. Boiler inspections should work by ensuring that boiler owners implement some of the energy improvements proposed by the inspections. There are no studies that can be used directly to examine the impact of compulsory boiler inspections. There is, however, a study in Denmark regarding another kind of compulsory inspection that includes proposed energy improvements to be carried out voluntarily, namely the energy labelling of buildings.[3] The study points out that labelling reduces energy consumption by approximately 2 %. This effect may, however, be due to statistical chance, and the possibility therefore cannot be excluded that the energy-labelling scheme has not had any impact on energy consumption. The energy consumption of approximately 6 000 homes was measured, some of which had implemented energy labelling, while others had not. Consumption was measured several times over the 1999-2002 period, and it was therefore possible to investigate energy consumption before and after the labelled houses were energy-labelled and compare the consumption trend against that for non-labelled houses. Energy consumption was also checked with regard to the characteristics of the houses and their inhabitants.

The energy-labelling scheme and an inspection scheme for boilers do, as has been mentioned above, have the same fundamental characteristics, namely compulsory inspections combined with the willingness to implement proposals. On the other hand, there are some natural differences between the schemes, and it is therefore not certain that the impact of the energy-labelling scheme could be extrapolated directly to a hypothetical boiler-inspection scheme. Nevertheless, this will be done below.

As has been mentioned, the average impact on the total energy consumption of an energy-labelled house was a fall in energy consumption of approximately 2 %.

The 2 % saving comes from many different kinds of energy improvement, and it is not known how much of the savings relate to boilers and may therefore be compared to initiatives of relevance for a hypothetical inspection scheme. It is, however, known from data relating to the obligations of energy companies to make savings that just under 30 % of savings in households relate to boilers. It is therefore assumed that a boiler inspection can reduce the energy consumption of a house by 30 % of 2 %, i.e. by 0.6 %. It must be mentioned that this 30 % is presumably a relatively large proportion, particularly since it also includes conversions from oil to heat pumps or district heating, which is not necessary the kind of advice that would emerge from a boiler inspection. The primary aim of a boiler inspection is simply to check whether boilers work to an acceptable level, and not to provide advice about alternatives, for example, if the boiler actually works. For this reason, the impact of a hypothetical inspection is overestimated somewhat.

Finally, it is assumed that the total number of relevant boilers is 710 000 (please see Table 2), that a boiler must be inspected every 17 years on average[4], and that 52.6 % of these boilers are over 20 kW. In other words, it is assumed that there are 25 000 inspections per annum.

[3] Vibeke Hansen Kjærbye (2008): 'Does Energy Labelling on Residential Housing Cause Energy Savings?', AKF working paper, http://www.akf.dk/udgivelser/2008/pdf/energy_labelling.pdf/.
[4] Please see the Base Case Study, Task 5 Report, Tables 2-6, page 11: http://ecoboiler.org/public/ecoboiler_task5_final.pdf and the Design Options Study, Task 6 Report, Table I-I, page 2: http://ecoboiler.org/public/ecoboiler_task6_final.pdf.

Many of these boilers will, however, have been inspected already under voluntary schemes. In all likelihood, boiler owners would receive the same advice regarding efficiency improvements or replacements under these schemes as they would under a hypothetical inspection scheme. In the case of boilers that are inspected voluntarily, therefore, the impact of a hypothetical inspection scheme cannot be anticipated, and since it has been estimated that ⅔ of all boilers have already undergone voluntary inspections, a hypothetical inspection will only work for a good 8 000 boilers per annum. Nevertheless, the impact of a hypothetical boiler-inspection scheme has been calculated in two ways, namely with and without a reduction owing to the voluntary schemes. On the basis of energy consumption in a standard house of 17 MWh per annum, the total annual energy saving from a hypothetical inspection scheme will be 3 TJ per annum if the impact of the market-based schemes is considered. If it is not, the effect is approximately 9 TJ per annum.

Please note that this is the impact over *one* year of inspections carried out *this* year. The impact of the other initiatives described below has been calculated in the same way. Since the impact is preserved in the building over the coming years, the impact of the inspections will accumulate. The accumulated impact is given in section 4.

4 Alternative measures

By way of introduction, it may be mentioned that the Danish Government's objective is for oil firing to be phased out by 2030, and for all heating to be based on renewable energy by 2035[5]. One of the goals is therefore to scrap many of the boilers that would be inspected under a boiler-inspection scheme.

Some of the measures have a limited impact. All of the calculated effects are very uncertain, but an attempt has been made to support them by working on the basis of the initiatives' fundamental characteristics, such as how many homeowners are expected to use the scheme and how great the energy saving is estimated to be for the individual investments (usually assessed on the basis of a standard house or typical size for a specific investment). An attempt has been made to assess how many of the investments to which the initiatives relate would have been made without the initiative (i.e. the initiative's impact has been estimated). This estimate is usually made based on studies of similar initiatives in the past.

Only the measures that are associated with improving the efficiency of boilers, or with replacing boilers, have been included. It has been estimated, for example, that a certain percentage of some subsidy schemes relates to boilers. the calculated effects may thus best be compared to the hypothetical inspection scheme.

[5] Please see 'Our Energy', at http://www.ens.dk/da-DK/Politik/Dansk-klima-og-energi-politik/regeringensklimaogenergipolitik/forhandlinger11/Documents/vores-energi-web.pdf.

4.1 Advice

4.1.1 Information Centre for Energy Savings in Buildings

The advice provided by the Information Centre for Energy Savings in Buildings is aimed at the craftsmen who have to implement energy-saving initiatives. The Information Centre gathers and disseminates information about specific, practical opportunities for reducing energy consumption in buildings, including the potential for savings by replacing boiler and heating systems. Among other things, the Information Centre is responsible for publications explaining the energy savings that can be made by replacing boilers, units and tanks.

The publications describe how and when various kinds of boiler must be replaced with an alternative or newer model. The various publications on initiatives to improve efficiency cover the following among other things:

- Recommendations and advantages of replacing heating boilers, hot-water tanks and district-heating units;
- Examples of energy savings from replacing heating boilers, hot-water tanks and district-heating units;
- A checklist for installing new sources of heating, with maintenance suggestions for every point;
- A guide on how to choose a heating supply for detached and semi-detached houses when an old firing system needs to be replaced;
- A guide on heat-flow systems to ensure optimum interaction between the boiler and radiators/floor heating;
- Product guides for selecting suitable boilers.

In addition to the focus on potential energy savings from initiatives to improve existing systems, the Information Centre has also explained the advantages of converting to another heat source. Its publications on this top include:

- Recommendations for selecting heat sources and an overview of their individual advantages;
- Examples of energy savings from converting to geothermal heating, gas heating, district heating or heat pumps;
- Checklists for installing various heat sources, with maintenance suggestions for every point;
- A description of the installation and maintenance of the various heating units.

The impact of this advisory initiatives on energy consumption has not been calculated.

4.1.2 Support for the phasing-out of oil and natural-gas firing

According to the energy agreement of 22 March 2012,[6] a pool of DKK 42 million (approximately EUR 5.6 million) was set aside to promote conversion to heating based on renewable energy (over the 2012-15 period).

The Danish Electricity Saving Trust and Good Energy provided independent advice to individuals from 1997 to 2012 concerning energy savings in buildings, etc. As part of the implementation of this DKK 42 million pool, an advisory unit was established in June 2013 to provide advice over the telephone and online to building owners wishing to convert from oil or natural gas to heat sources based on renewable energy. The unit is intended to provide advice about the technical, financial and comfort conditions associated with the various alternatives to oil and natural-gas firing.

In addition to providing advice to homeowners, the resources will also be used for projects that can explain how the conversion of oil and natural-gas firing to heat sources based on renewable energy could be made cheaper. Specifically, the pool must be implemented by supporting demonstration projects and new forms of collaboration among local craftsmen.

The impact on energy consumption of implementing this pool has not been calculated.

4.1.3 Better Homes

'Better Homes' is a scheme established by the public sector that is very small in scale when carried out in reality. Through this scheme, Better Homes advisers give homeowners a general overview of the opportunities for home improvements, and they can offer assistance throughout the entire project. For example, advisers can produce a plan that provides banks and mortgage lenders a better basis for issuing loans. The advisers must have taken certain courses, some of which are directly relevant to replacing or optimising oil or natural-gas firing.

Better Homes is part of a family of initiatives, together with other one-stop shop initiatives and ESCO Light initiatives. Better Homes may have a good impact, as a result of the official requirements for advisers and the plans that they produce.

The impact of Better Homes has not been calculated.

[6] http://www.ens.dk/da-DK/Politik/Dansk-klima-og-energi-politik/politiskeaftaler/Sider/Marts2012Aftalefor20l2-2020.aspx.

4.2 Financial incentives

A number of various financial incentives are described below. The nature of the measures varies greatly, but the Danish Energy Agency is of the view that all of the initiatives affect the efficiency of the boiler stock or their phasing-out.

4.2.1 Energy company savings initiative

The energy company savings initiative means that electricity, natural-gas, district-heating and oil network and distribution companies must work together to achieve documented energy savings, amounting to a total of 10.7 Pi/year in 2013 and 2014 and 12.2 PJ/year in 2015-20. The energy companies themselves choose how to achieve these targets, and some of them offer subsidies for replacing firing systems in this context. Until the similar obligation under the Energy Efficiency Directive enters into force, the Danish Energy Agency feels that the impact of this may be included in the figures.

Impact

The energy companies have provided homeowners with support for converting from firing with oil or natural-gas to heat pumps and connecting to district heating. They have reported the extent to which this support has been provided, measured in terms of annual energy savings. Some of the savings would have been made without support from the energy companies, and it is assumed that 10 % of the savings would not. This percentage is relatively low, and it has also been set at a low/cautious level for examining the scheme's impact.

On this basis, the total saving is estimated to be 9 TJ per annum. The saving has been calculated as the oil (or natural gas) saved, minus 2.5 times the maximum electricity consumption for heat pumps. This is multiplied by 2.5 to calculate the consumption of fossil fuels necessary to produce electricity.

4.2.2 Tax changes

From 2013 onwards, tax on electricity consumption for private customers with consumption of more than 4 000 kWh/year has been reduced for the proportion of electricity consumption in excess of 4 000 kWh, which means a fall in consumer electricity prices of an estimated 18 %[7]. Building owners with heat pumps will usually take advantage of this tax reduction, and the financial incentive for converting from firing with oil or natural gas, for example, to heat pumps will be significantly greater, and it is expected that the tax changes will promote conversions of this kind.[8]

[7] The specific rates may be found on the Danish Tax Administration's website: http://www.skat.dk/SKAT.aspx?old=1982066&vld=0.

[8] It may be noted that a study of subsidies for converting from oil firing to heat pumps points out that subsidies promote conversions. Since subsidies and tax reductions have certain financial similarities, the study supports the assertion that tax reductions will have an impact.

Impact

As has been mentioned, the reduction in electricity tax means that the price of electricity will fall by approximately 18 % for owners of heat pumps. The change makes it more attractive to invest in heat pumps rather than a new oil-firing system for owners of oil-firing systems who are faced with replacing an old one.

It is not, however, known how great the impact of these tax changes is. Nevertheless, a study on a previous subsidy scheme has shown that a subsidy of DKK 20 000 for converting from oil firing to heat pumps resulted in approximately 3 300 conversions in one year. The impact of the subsidy scheme has therefore been used as a basis for assessing the impact of the tax changes. The subsidy scheme and tax changes have been compared by calculating how great an impact the subsidies and tax change have respectively had on profits over 10 years when investing in heat pumps rather than a new oil-firing system. These profits have been calculated as energy savings for the consumer in Danish kroner, minus the additional investment in heat pumps rather than an oil-firing system. The subsidy scheme naturally increases the gain by exactly the amount of the DKK 20 000 subsidy, while the tax change increases the gain by DKK 18 000 over 10 years. On this basis, the tax changes may be estimated to result in 18/20 x 3 300 = 2 970 conversions per annum. To make a cautious (low) calculation, however, an impact of 2 000 conversions per annum has been estimated.

This gives rise to an annual energy saving of 40 TJ.

The saving has been calculated as the oil saved, minus the increase in electricity consumption for heat pumps, multiplied by 2.5. This is multiplied by 2.5 to calculate the consumption of fossil fuels necessary for producing electricity.

4.2.3 The home/job scheme

This scheme[9] provides a taxable allowance of up to DKK 15 000 per annum, including VAT, for wages in respect of the servicing and maintaining buildings. Building owners can thus save approximately DKK 5 000 (EUR 670) in tax, for example by replacing an oil-firing system, which provides a financial incentive for individuals to make improvements to their homes, including improvements to save energy. This scheme will be in force until the end of 2014, which is therefore only six months out of the period studied in this memorandum.

Impact

It is expected that DKK 1.5 billion in subsidies will be paid out each year.

The impact of the annual energy saving when improving or replacing boilers as a result of the aid must be calculated. This requires four stages of estimates and assumptions:

[9] http://www.skat.dk/SKAT.aspx?old=1947018.

- The total amount of assisted investments is estimated.
  It is assumed that the total expenditure is four times greater than the subsidy.

- The proportion of investments that are made as a result of the aid is estimated.
  It is assumed that 30 % of assisted projects are carried out because of the subsidy (and therefore that 70 % of the projects would have been carried out in any case).

- The proportion of assisted projects that relates to energy savings in boilers must be estimated.
  It is assumed that 30 % of the assisted projects relate to boilers.

- The annual energy saving from the assisted energy projects must be estimated.
  It is assumed that the assisted projects are more or less profitable in terms of private finance, and have a repayment period of 15 years.

On this basis, the total annual energy saving may be calculated as 86 TJ.

4.3 Legal framework

4.3.1 Ban on the installation of oil and natural-gas firing in areas of communal heating

From 1 January 2013 onwards, a ban has been in place on installing oil firing and natural-gas firing in new buildings, and from 2016 oil firing may not be installed in existing buildings in areas of district heating or natural gas; please see Section 1(60) of Executive Order No 1314 of 12 December 2012[10]. A very large proportion of heated buildings (please see Figure 1) are found in these communal areas, so oil firing will gradually be phased out from these areas.

Impact

The impact of the ban on oil firing in new buildings is calculated according to energy consumption.

According to the BBR, a good 10 000 buildings (excluding outbuildings) were erected in 2012. Of these, some 169, or 1.6 %, were heated by oil.

For the period from 2011 to 2014, it is assumed that 10 000 buildings are erected every year, that 1.6 % of them would have been built with oil heating had the ban not been in place, and that these buildings will be heated using heat pumps. The saving per building from this is estimated to be 1.5 MWh (where electricity consumption per heat pump is weighted by a factor of 2.5). In total, the ban yields a reduction in energy consumption of just under 1 TJ per annum.

[10] https://www.retsinformation.dk/forms/R0710.aspx?id=144679.

4.3.2 Minimum requirements for boiler systems in the Building Code

The requirements for installing boiler systems are laid down in the Building Code; please see Executive Order No 810 of 28 June 2010, as amended[11]. This lays down the minimum requirements for the efficiency of boiler systems; please see section 8.5.1.4. The tradition in Denmark has been to have stringent requirements for the efficiency level for installing technical system; this has applied since 1977.

Since 2010, the minimum requirements have been a CE-marked efficiency of at least 93 % at full load and 98 % at partial load for oil-fired boiler systems[12], a CE-marked efficiency of at least 96 % at full load and 105 % at 30 % partial load for gas-fired boiler systems,[13] while boiler systems for firing with coal, coke, biofuel and biomass must as a minimum comply with boiler class 3 in standard DS/EN 303-5, Central-heating boilers, in terms of combustion quality, effectiveness and safety.

Impact

The requirements of the Directive on efficiency requirements (92/42/EEC), which date from 1992, are very lenient, and it is estimated that they correspond to an efficiency requirement of 84 % for a typical oil or gas boiler, i.e. 14 percentage points below the 98 % requirement of the Building Code (which is the most relevant one). It is unrealistic, however, to assume that many oil-firing systems would usually be installed in Denmark if there were no requirement in the Building Code. It is therefore assumed that boilers with average efficiency of 96 % would be installed in the absence of a requirement in the Building Code.

There are estimated to be 23 000 conversions of gas and oil boilers per annum. Based on the energy consumption of a typical oil-heated or gas-heated house, the total annual saving has been calculated as 28 TJ per annum.

Please note that the most recent review of the boiler requirements in the Building Code took place in 2010, i.e. before the EU requirement for an inspection scheme.

4.3.3 Boiler-inspection scheme

During the period from 1 February 2011 to 1 June 2013, all owners of oil-fired boiler systems were required to have annual energy measurements taken; please see Executive Order No 62 of 27 January 2011 and section 2.1 above for further details. The scheme covered all oil-fired boiler systems, regardless of size, but ended on 1 June 2013, since the scheme had not worked as intended.

The aim of the scheme, in addition to taking annual measurements of the energy-efficiency of all boiler systems, was that only inefficient boiler systems should undergo a comprehensive

[11] http://bygningsreglementet.dk/forside/0/2.
[12] Efficiency is measured at 70° C at full load, and at 30° C, 40° C or 50° C at partial load, depending on the boiler type. This provision involves the use of condenser boilers.
[13] Efficiency is measured at 70° C at full load, and at 30° C at partial load. This provision involves the use of condenser gas boilers.

inspection, whereby the owner of the boiler was given advice about energy-efficient, profitable alternatives. The second stage of the scheme, which involved these comprehensive inspections, was never implemented.

4.4 Voluntary servicing schemes

The Danish Energy Industry Association has estimated that approximately ⅔ of all oil-fired boiler systems are covered by voluntary servicing subscriptions, where the service frequency is usually once a year. The aim of the voluntary servicing schemes is to ensure that oil firing works efficiently. The focus of servicing an oil-fired boiler system is the burner itself and the need for cleaning the boiler. The service check must thus ensure that the boiler system works as efficiently as possible.

It is also true of natural-gas boilers, that ⅔ of them are covered by a servicing subscription. These subscriptions may vary in scope and have an interval of 1-3 years, although the majority of servicing subscriptions have a check on the boiler system every two years. Such a service check examines whether the system is working properly, with the boiler, automatic mechanisms, pumps, flues and hot-water tank being inspected. The Danish Energy Industry Association is of the opinion that the service technician will also say if the boiler is so old that it would be profitable to replace the boiler system.

The Danish Energy Agency is of the opinion that the broad support for voluntary servicing schemes is one of the most important reasons for the failure of the boiler-inspection scheme. Owners of boiler systems want, to a large extent, to be kept informed of the boiler system's efficiency level as a result of the voluntary servicing schemes. The aim of Article 14, namely to ensure that information about efficient boiler systems is provided, is thus partly fulfilled by these voluntary agreements with the servicing industry. The voluntary schemes are therefore not an alternative to the hypothetical inspection scheme in the same way as the other measures are, but rather they are a measure that reduces the impact of the hypothetical scheme.

4.5 Overall impact of alternative measures

Table 5 summarises the impact of the hypothetical inspection scheme and alternative measures. As has been mentioned, the calculated effects are very uncertain. An attempt has been made to assess the impact of a hypothetical inspection scheme at a relatively high level, whilst assessing the impact of alternative measures at a relatively cautious (low) level.

The alternative measures do not only relate to the type of initiative that would result from the boiler inspection. The impact of these schemes on improving the efficiency of boilers, or on replacing boilers, has therefore been estimated.

Table 5. Impact of a hypothetical boiler inspection and alternative measures, TJ per annum in the first year of an initiative

Scheme		TJ
Hypothetical boiler-inspection scheme	Excluding voluntary schemes	9
	Including voluntary schemes	3
Alternatives	Energy companies' saving obligations	9
	Home/job scheme	86
	Changes to tax on electricity and security of supply	40
	Ban on oil firing in communal areas	1
	Boiler requirements	28
Total, alternatives		164

As has been mentioned, Table 5 shows the impact of initiatives over one year of implementing the initiative. For example, the hypothetical inspection scheme implemented in 2015 will result in an energy reduction of 3 TJ in 2015, but also in 2016 (and in the last six months of 2014 and the first six months of 2017), since the energy improvements have a long life cycle. Throughout the entire period for which the inspections should apply (i.e. mid-2014 to mid-2017), the inspection scheme will have resulted in an energy reduction of six times the annual impact (6 times 3-4 TJ)[14]. None of the individual alternative measures can be reckoned on for the whole period. Table 6 shows the impact of the initiatives over the whole period.

Table 6. Impact of a hypothetical boiler inspection and alternative measures, TJ accumulated over a three-year period from mid-2014 to mid-2017.

Scheme		Weighting[15]	TJ
Hypothetical boiler-inspection scheme	Excluding voluntary schemes	6	55
	Including voluntary schemes	6	18
Alternatives	Energy companies' saving obligations	6	54
	Home/job scheme	1.5	130
	Changes to tax on electricity	6	240
	Ban on oil firing in communal areas	6	5
	Boiler requirements	6	169
Total, alternatives			598

[1] The weighting reflects the extent to which the measures may be included throughout the whole period from mid-2014 to mid-2017; please see the body of the text.

5 Conclusion

On the basis of the above review of the impact of the alternative measures, the Danish Energy Agency is of the view that greater energy savings will be achieved in the boiler-system stock in Denmark by implementing alternative measures than if a mandatory inspection scheme were implemented. The impact of an inspection scheme and of the alternative measures has been calculated with some uncertainty, owing to the nature of the initiatives. Despite this

[14] The annual impact of inspections in the first year will make a contribution for three years, the annual impact of inspections in the second year will make a contribution for two years, and the annual impact of inspections in the third year will make a contribution for one year.

uncertainty, it is clear from the calculation that a boiler-inspection scheme would not have nearly the same impact as the alternative measures may be expected to have.