Equivalence of the alternative solution – Article 14 of the Energy Performance of Buildings Directive

For gas boilers
up to 100 kW

Progress report 2014

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Summary

The EU has introduced regular inspections of heating systems, to improve their efficiency, in Article 14 of the recast Energy Performance of Buildings Directive (2010/31/EU). The Netherlands has opted for an 'alternative solution' for mandatory inspections for gas-fired heating systems with a capacity of up to 100 kW, in accordance with the EU Directive. This requires a three-yearly report to the European Commission demonstrating its equivalence to the implementation described in the EPBD. For other heating systems, gas-fired with a capacity of 100 kW or more, and all heating systems operating on other fuels, as well as for air conditioning systems, the Netherlands has decided to implement mandatory boiler inspections, as described in the EPBD. Demonstrating equivalent impacts (with the approach described in the EPBD) for those systems is therefore not needed.

The Netherlands has an exceptionally efficient boiler and heating system stock, as a result of many years of government policy. The expected impacts of any additional measure are therefore small, regardless of the implementation selected. The 'HR107' boiler, a highly efficient gas-fired modulating condensing boiler, for example, has been the standard option in the Netherlands for many years (for new installations and replacements) and projections indicate that, within five years, virtually all installed boilers will be of this type. This will result in substantial further energy savings. This, however, also reduces the remaining potential for additional savings from other measures to improve heating system efficiency.

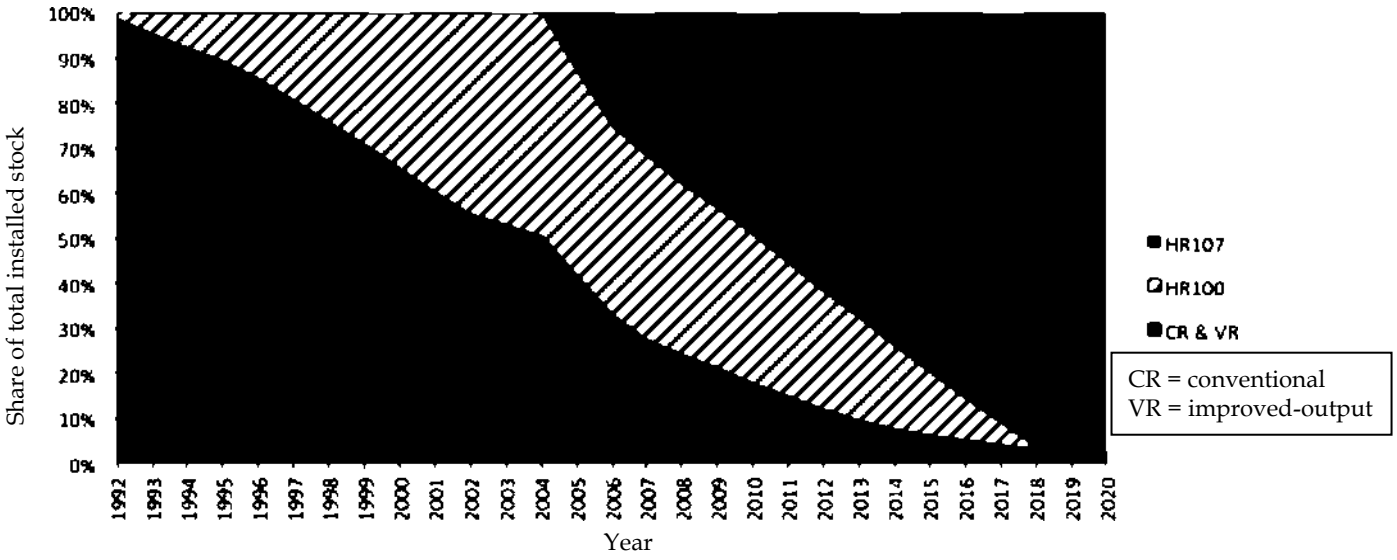


Figure 1. Ownership level of boiler types, as a share of the total installed stock (residential sector)

This report

This report presents an overview of existing policy for energy efficiency improvements of heating systems and a description and comparison of three scenarios:

- Baseline scenario, with no new policy
- Alternative solution scenario, with the alternative policy option as implemented by the Netherlands
- Mandatory inspections scenario, as described in the EPBD recast

In the baseline scenario, with no new policy, there will be no additional policy actions and no

additional efforts to improve the energy efficiency of heating systems in the Netherlands. Existing policies, including EPBD measures for building code requirements and the recently approved Ecodesign Directive for boilers, will continue to influence new and existing heating systems. Total energy demand, in this scenario, will amount to approximately 350 PJ in 2020. Related CO_2 emissions will amount to 19.6 Mt.

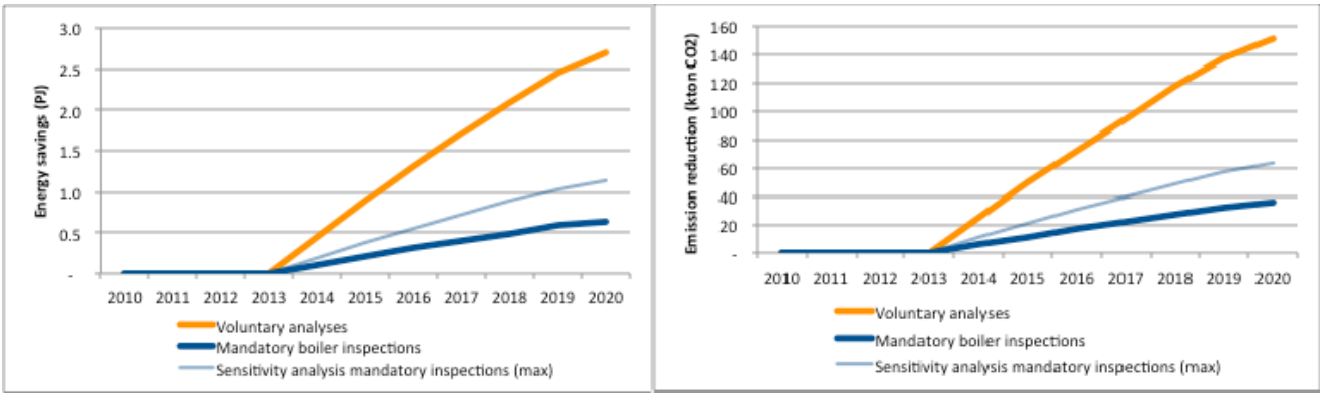
The **alternative solution** scenario includes, in addition to the policies in the baseline scenario, a voluntary analysis of the system performance of heating systems offered by market parties in collaboration with the Government. This voluntary analysis will be offered on top of the planned and ad-hoc maintenance of boilers and will include an analysis of the energy performance of the whole heating system, including the boiler, thermostat or temperature control, distribution and radiator system.

The alternative solution is expected to result in 24% of all buildings having undergone a voluntary analysis of their system energy performance (heating system) by 2020. In 70% of cases, these analyses are expected to result in system improvement measures being implemented. The total energy demand for the heating of buildings, in this case, will be approximately 0.77% (2.7 PJ) below the baseline scenario by 2020. Related CO_2 emission reductions are expected to amount to 151 kt.

The expected impacts of **mandatory boiler inspections** have also been assessed, for comparison. This would have consisted, on top of baseline scenario policies, of an extension of the requirement to regularly inspect gas-fired boilers with a capacity of 20 kW or more (instead of the current limit of 100 kW or more) included in the Environmental Management Act/Activities Decree. This inspection would also be included in the SCIOS (*Stichting Certificatie Inspectie en Onderhoud Stookinstallaties* – 'Foundation for Certification of the Inspection and Maintenance of Heating Installations') methodology. In addition, this requirement would be listed in the Decree on the energy performance of buildings.

The total energy demand for the heating of buildings, in this case, will be approximately 0.18% (0.6 PJ) below the baseline scenario by 2020. Related CO_2 emission reductions will amount to 36 kt. A sensitivity analysis was performed to test whether this result would change with other assumptions for input variables. The analysis shows that, when selecting the most optimal, though not most realistic, input variables for high energy savings, impacts would increase to 64 kt CO_2.

Impact of the scenarios: voluntary analyses and mandatory inspections



Conclusion

This analysis clearly demonstrates that the alternative solution, as being implemented by the Netherlands, will result in substantially higher energy savings than the mandatory boiler inspections, at lower cost. The better integration of inspections with scheduled maintenance, the

focus on improvements in the boiler and heat distribution system enabled by this alternative solution and alignment with natural moments for system improvements are the key explanations for this larger impact. This matches the findings presented in 2013.

The alternative solution as being implemented in the Netherlands thus comfortably meets the requirement of Article 14(4) of the EPBD recast for an alternative solution to meet or exceed the impacts of mandatory inspections as described in Article 14(1)-(3) of the EPBD recast.

1. Introduction

The EU has introduced regular inspections of heating systems, to improve their efficiency, in Article 14 of the recast Energy Performance of Buildings Directive (2010/31/EU). The Netherlands has opted for an 'alternative solution' for mandatory inspections for gas-fired heating systems with a capacity of up to 100 kW, in accordance with the EU Directive.

The Dutch Government has furthermore opted to use a combination of measures to implement Article 14 of the EPBD recast:

- Emission Limits (Medium-Sized Combustion Plants) Decree (inspection of gas boilers with a capacity >100 kW and boilers operating on other fuels with a capacity of 20 kW or more).
- Installation Performance Scan, to complement E&GO, MJA, DEN, and the Emission Limits (Medium-sized Combustion Plants) Decree/Activities Decree.
- Support campaigns to further increase the share of homes with a condensing boiler.

As a result of its decision to implement an alternative solution for some heating systems, the Netherlands is required to submit a report to the European Commission every three years, demonstrating that the alternative solution is at least equally as effective as the option described in the EPBD. For other heating systems, gas-fired with a capacity of 100 kW or more, and all heating systems operating on other fuels, as well as for air conditioning systems, the Netherlands has decided to implement mandatory boiler inspections, as described in the EPBD. Demonstrating equivalent impacts (with the approach described in the EPBD) for those systems is therefore not needed.

This second progress report describes the expected impact of the alternative approach adopted by the Netherlands, using the same reporting format and calculation method as used by the United Kingdom in its report to the European Commission. The report shows that this impact still meets the requirement set forth in the EPBD for the impact of an alternative solution to be equivalent to that of mandatory boiler inspections.

The report consists of the following sections:

- Introduction
- Description of scenarios for gas-fired boilers with an output of up to 100 kW
- Expected impact of the scenarios
- Comparison of options and conclusions

For further information on existing Dutch policy and for background information, please refer to the report 'Equivalence of the alternative solution – Article 14 of the Energy Performance of Buildings Directive', May 2013.

The Netherlands has already made considerable progress towards improving heating systems in comparison to other EU countries. Modulating condensing boilers are now used in virtually all new installations and boiler replacements in the Netherlands, and a significant share of the existing stock has similarly already been replaced with such boilers. This is due, in part, to years of policy-making and government support for development, training and marketing activities for boiler manufacturers and installers.

The result of this is that the energy efficiency of the average boiler in the Netherlands is already considerably higher than the European average and is close to the maximum that can be achieved

with gas-fired boilers[1]. On the other hand, this also means that there is limited potential to improve energy efficiency with further government policy and effort on the part of market parties, simply because the majority of the energy-saving potential has already been realised. In the case of the Netherlands, any further savings to be realised by implementing improved heating systems will, for the most part, have to be achieved by introducing new types of heating system. The alternative solution being implemented by the Netherlands in place of mandatory inspections helps to set this process in motion.

Summary of methodology

The methodology adopted in this report is consistent with that adopted in last year's report 'Equivalence of the alternative solution – Article 14 of the Energy Performance of Buildings Directive' and is based on the format and analysis methodology adopted by the United Kingdom in its report to the European Commission on the equivalence of alternative solutions for the implementation of Article 14 EPBD. For an exhaustive description, please refer to the 2013 report.

This report includes an update to the alternative solution impact analysis presented in 2013, incorporating more recent data on heating system stock and other relevant data. The description of the alternative solution adopted by the Netherlands and the two baseline scenarios (no new policy and mandatory boiler inspections as described in the EPBD) is reiterated here once again, along with a full description of the expected impact and a comparison of the scenarios. The impact has been calculated for the base year 2020, so that it can be compared with the impact of other European policy instruments.

[1] This is evidenced, for instance, in the '*Eindrapportage veldtesten, Energieprestaties van 5 warmtetechnieken bij woningen in de praktijk*' ('Final report on field tests: Real-world energy performance of 5 types of heating technology in the home'), Energy Matters, for the Netherlands Enterprise Agency, January 2014.

2. Description of scenarios for gas-fired boilers with an output of up to 100 kW

Baseline scenario: no new policy

This baseline scenario assumes that there will be no new policy actions and no additional efforts to improve the energy efficiency of heating systems in the Netherlands. Existing policies, including EPBD measures for building code requirements and the recently approved Ecodesign Directive for boilers, will continue to influence new and existing heating systems. This scenario serves as a basis against which to compare the impact of the policies adopted in the other scenarios.

The assumptions in the baseline scenario are as follows:

- Approximately 99% of newly purchased boilers are condensing boilers, almost exclusively of the HR107 type.
- The share of the existing stock made up of HR107 boilers is also increasing rapidly. Condensing boilers currently (2011 data) account for 86% of the stock, with HR107 boilers accounting for 56% and HR100 boilers 30%. HR107 boilers are expected to account for 97% of the existing stock by 2018. In other words, virtually all boilers that can be replaced with a condensing boiler are expected to be replaced with HR107 boilers within five years.
- HR107 boilers are all modulating, which means 'oversizing' has much less of an impact. Measures targeting smaller boilers that are better suited to the space heating demand of a building therefore also have a considerably smaller impact.
- In addition, almost all boilers in the Netherlands are combination boilers (combined heating and hot water). This means, at least in the case of new residential installations, that the output of the boiler is principally determined by the demand for hot water and not by the demand for heating. An analysis of the appropriate size of the boiler, as described in Article 14 EPBD, will therefore, in the case of the Netherlands, result in little or no improvement (geared to space heating demand) in the sizing of domestic boilers. It is possible that some benefit may be gained by improving the sizing of boilers in small, non-residential buildings. Larger, non-residential buildings are increasingly being fitted with what is known as a cascade system. Under normal conditions, oversizing the boiler in such systems has no effect on how the primary boiler is used and will therefore have no impact on the energy consumption.
- The majority of boilers (approx. 90%) are serviced regularly (= every 1 to 3 years).
- The average service life of a boiler is 12 years; the share of the existing stock that is made up of boilers over 15 years old which are in regular use is unknown, but is likely to be very low. It is estimated that such boilers are used as a primary heating source in approximately 3% of cases. In addition, there is likely to be a larger share of older boilers in use as non-primary boilers, as part of a cascade system in larger, non-residential buildings. Since these boilers are used infrequently and only during peak demand periods, the impact of such boilers on the performance of the heating system as a whole is minimal.
- Insulating existing buildings will yield a steady reduction in the heat demand. The installed boiler output will not decrease, however, because the hot water demand stays the same or increases.
- The European Commission recently announced the implementation of a Directive laying down minimum efficiency requirements for boilers and heating systems. These requirements appear to be lower than those of the HR107 label in force in the Netherlands, however, and so the Directive is expected to have a minimal impact on the Dutch market. On the other hand, all new installations (and boiler replacements) will have to meet the requirements detailed in the Directive, except where the installation of a condensing boiler

is not technically or economically feasible. This requirement has virtually no practical implications for the Netherlands, as HR107 boilers are already routinely used where possible during replacements.

The list below includes a summary of the assumptions made when calculating the expected energy impact of the baseline scenario. The assumptions are based on the impact of existing policy (including the announced Ecodesign Directive).

- The heat demand of buildings will experience a downward trend as a result of existing policy on the energy performance of buildings.
- The installed stock of gas-fired boilers in the Netherlands will be quickly replaced with new boilers, according to the schedule detailed below.
- Approximately 90% of gas-fired boilers are serviced regularly on a voluntary basis; this share remains constant. It is assumed that this percentage is the same for both condensing and non-condensing boilers.
- Boilers are typically replaced after approximately 12 years, when an older boiler exhibits too many problems and/or can no longer be repaired. Replacements solely for the purpose of improving energy efficiency do not occur.
- If a boiler is replaced, or large-scale changes are made to a heating system, the entire system must be assessed and must meet the minimum requirements in terms of system energy performance. As this assessment takes system components other than the boiler into account as well, a slight improvement might be expected in new and modified installations (as a result of improved design and improved thermostat/temperature controls).

Expected share of stock per boiler type, per year:

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
VR & CR	18%	16%	14%	12%	11%	9%	8%	6%	5%	3%
HR100	29%	25%	22%	17%	13%	9%	4%	0%	0%	0%
HR107	53%	59%	64%	70%	76%	82%	88%	94%	95%	97%

In this case, the total energy demand for the heating of buildings in 2020 will be approximately 350 PJ. Related CO_2 emissions will amount to 19.6 Mt.

Scenario 1: Alternative solution: voluntary analysis of system performance

It is assumed in this case that, in addition to the policies in the baseline scenario, market parties will collaborate with the Government to conduct a voluntary analysis of the system performance of heating systems and that they will issue guidance to owners based on the results of that analysis. The costs of the analysis, when combined with regular boiler servicing, are expected to amount to €30 (source: '*Keuring van verwarmingssystemen, Beleidsopties en lasten*' ('Inspection of Heating Systems: Policy Options and Costs'), Building Vision, January 2013). This voluntary analysis and guidance will be offered on top of regular maintenance and will include an analysis of the energy performance of the heating system as whole, including the boiler, the thermostat or temperature control and the distribution and radiator system, and guidance on how to improve the system and the way in which it is used. Further energy savings in the case of the Netherlands are expected to be achieved primarily by optimising distribution systems and heating systems as a whole, and by introducing new types of heating system. Additional savings are also expected to result from the guidance issued on the most energy-efficient way to use heating systems. This latter effect cannot be quantified yet and is thus not included in the calculations.

Scenario 1: alternative solution
The assumptions in scenario 1 are as follows:

- No changes are made to existing policy, as detailed in the baseline scenario.
- The Government and market parties jointly develop a system analysis tool. This tool is consistent with the tool developed for use in the inspection of new and modified heating systems as required under the Buildings Decree (implementation of Article 8 EPBD). The tool focuses on providing guidance (rather than a check of minimum performance requirements) and is an appropriate addition to regular maintenance activities.
- Installers and maintenance companies offer voluntary analyses during regular maintenance activities and when owners enquire about, or have issues with, heating system performance. Subsequent to conducting an analysis, an installer or maintenance company will, where applicable, offer to implement any measures that have been recommended. This increases the likelihood that guidance will be put into effect.
- The Government uses communication tools to draw attention to the energy efficiency of heating systems and encourages owners to have the energy performance of their technical building systems assessed at an appropriate time. The government draws attention in its communications to the benefits of optimising heating systems, e.g. lower energy bills, lower CO_2 emissions and improved comfort.
- Voluntary analyses are offered to owners in the residential and SME sectors. The estimated cost for domestic and small business systems is €30 per analysis; the cost for larger (i.e. commercial) systems will vary depending on the complexity of the system.
- Analyses are offered in particular if the owner complains about the performance of the system, if an older boiler (older than 12 years) is installed, and/or if an installer suspects that the heating system is not operating at maximum efficiency.
- Given the fact that analyses are offered during regular maintenance or when a boiler has a fault, i.e. when contact between the client and installer or maintenance company occurs as a matter of course, the costs of carrying out this analysis are kept to a relative minimum and predictions indicate a relatively high follow-up rate. Given the large number of systems that undergo regular maintenance, the voluntary tool is expected to reach a wide range of owners.
- Boilers are replaced when they are faulty; replacements solely for the purpose of improving energy performance do not occur at present or are rare. Following a system analysis, some owners will decide to upgrade early and replace (non-condensing) boilers that are over 12 years old with an HR107 boiler.
- Owners allow system improvements to be carried out if the analysis shows that the improvements will result in savings. System improvements included in this scenario are as follows:
    - Replacing the thermostat: replacement of on/off thermostats and old thermostats with programmable clocks with a modern modulating thermostat. In theory, this is expected to yield energy savings of up to 6% (source: Eco-design of Boilers, Task 4 Report, VHK, September 2007). For the purposes of this scenario, a conservative estimate has been assumed for the saving that would result from replacing old thermostats with a new, modulating thermostat, i.e. an energy saving of 3%.
    - Balancing the water distribution system ('radiator balancing'). The energy-saving impact of this is, in theory, difficult to calculate and, in practice, will depend greatly on the system configuration. Past experience shows that balancing the distribution system primarily results in energy savings in cases where the owner has complained about the performance of the heating system (source: '*Keuring van verwarmingssystemen, Beleidsopties en lasten*' ('Inspection of Heating Systems: Policy Options and Costs'), Building Vision, January 2013). For the purposes of this scenario, an average energy saving of 3% has been assumed.

- Changing radiators: The energy-saving impact of this measure depends to a great extent on the system configuration in the individual building. It is assumed for the purposes of this scenario that, in those cases where it is recommended, this measure will yield an average energy saving of approximately 5%.
- Early replacement of conventional (CR) and improved-output (VR) boilers. In an optimised system, this yields major energy savings. Predictions indicate that replacing a conventional boiler with an HR107 boiler will yield an average energy saving of approximately 20%, and replacing an improved-output boiler with an HR107 boiler will result in an average energy saving of approximately 10% This scenario assumes an average energy saving of 12% for those years leading up to when the boiler would have needed replacing for technical reasons.

Scenario 2: Mandatory inspections as described in Article 14 EPBD

This scenario has been produced so that the impact of the approach adopted by the Netherlands can be compared with the impact of the (fictional) introduction of mandatory inspections as described in the EPBD. It is assumed in this scenario that, on top of baseline scenario policies, the boiler inspection requirements detailed in the Environmental Management Act and the Activities Decree would be extended to include gas boilers with an output of 20 kW or more (instead of the current lower limit of 100 kW or more).

This inspection would also be included in the SCIOS (*Stichting Certificatie Inspectie en Onderhoud Stookinstallaties* – 'Foundation for Certification of the Inspection and Maintenance of Heating Installations') methodology and the requirement would be listed in the Decree on the energy performance of buildings.

The main points in scenario 2 (mandatory inspections) are as follows:

- All existing baseline scenario policies remain unchanged.
- Boilers with an output of 20 to 60 kW (primarily domestic boilers) are subject to mandatory inspections every 8 years.
- Boilers with an output of 60 to 100 kW (primarily SME sector buildings) are subject to mandatory inspections every 6 years.
- In the commercial sector, inspections are monitored and enforced via the system detailed in the Environmental Management Act.
- This instrument cannot be used in the residential sector (the Environmental Management Act does not apply to households). A requirement to that effect is incorporated into the Decree on the energy performance of buildings. The number of owners presenting their boiler for inspection is expected to be similar to the number that currently have their boiler serviced regularly (approximately 90%).
- All boilers in the SME sector are assumed to undergo regular maintenance.
- Boilers are replaced when they are faulty; replacements solely for the purpose of improving energy performance do not occur at present or are rare and are not anticipated in the coming years.

3. Expected impact of the scenarios

The scenarios have been modelled using a stock model of the installed boiler pool in the Netherlands, to allow for comparison of the impact in 2020, taking into account autonomous developments such as regular boiler replacement. Further to this, in compliance with the European Commission's request, a sensitivity analysis has been carried out for scenario 2 (mandatory inspections), as was the case in 2013. The results of this modelling are presented below, first for scenario 1 (alternative solution) and then for scenario 2 (mandatory inspections). The baseline scenario has also been modelled, as described in section 2, as a basis for comparing energy savings and CO_2 emission reduction.

Scenario 1: Alternative solution: voluntary analysis of system performance

Mandatory inspections are expected to have the following impact on the efficiency of heating systems in the Netherlands in relation to the baseline scenario:

- At least 60% of all installation and maintenance companies will offer voluntary analyses of heating system performance during regular maintenance, for an average price of €30.

- Analyses will be offered at intervals of 4 to 8 years, or at every third service.

- Approximately 40% of owners who are offered an analysis will agree to an analysis being carried out:
    - Approx. 10% because of complaints about the performance of the system;
    - Approx. 20% because their boiler is over 12 years old;
    - Approx. 10% because the installer suspects their boiler is not operating at maximum efficiency.

- An analysis is expected to indicate potential cost-effective system improvements in the majority of cases:
    - Approx. 40% of analyses are expected to indicate that the water distribution system is not operating at maximum efficiency and that the heating system performance can be improved by balancing the radiators;
    - Approx. 20% of analyses are expected to indicate that the positioning and/or size of the radiators is preventing the system from operating at maximum efficiency and that an improvement in system performance can be gained by replacing, changing or moving radiators;
    - Approx. 40% of analyses are expected to indicate that a thermostat control is preventing the system from operating at maximum efficiency and that the performance of the heating system can be improved by replacing the thermostat (with a modern, modulating thermostat);
    - Approx. 20% of the analyses carried out will point towards (cost-effective) early replacement of an old (conventional or improved-output) boiler with a modern HR107 boiler.
    - NB: different recommendations can arise independently of one another, as a result of which the total can amount to more than 100%.

- The anticipated response of owners to recommended system improvements is as follows:
    - Where radiator balancing is recommended, 80% will follow up on the recommendation;
    - Where changing the radiators is recommended, 40% will follow up on the recommendation;
    - Where replacing the thermostat is recommended, 50% will follow up on the

recommendation;
  - Where replacing the boiler is recommended, 50% will follow up on the recommendation.

- In view of the requirements set forth in the Buildings Decree (to obtain a minimum boiler efficiency when modifying heating systems), changes will only be made to radiators and thermostats if a condensing boiler is already installed, or is being installed at the same time. Balancing the distribution system is not regarded as a system improvement and is therefore not affected by the requirements of the Buildings Decree.

- The expected frequency and energy-saving rates of each of the measures resulting from voluntary system analyses are set out in the table below:

Installers who offer voluntary analyses		Consumers who have voluntary analyses carried out		Measures recommended		Measures implemented		Energy saving per measure		Energy saving expected by 2020 (as a % of total energy consumption)
60%	x	40%	x	Radiator balancing						
				40%	x	80%	x	3%		0.23%
				Changing radiators						
				20%	x	40%	x	5%		0.10%
				Replacing thermostat						
				40%	x	50%	x	3%		0.14%
				Replacing boiler earlier						
				20%	x	50%	x	12%		0.29%

The alternative solution is expected to result in 24% of all buildings having undergone a voluntary analysis of their system energy performance (heating system) by 2020. In 70% of cases, these analyses are expected to result in system improvement measures being implemented.

Scenario 2: Mandatory inspections as described in Article 14 EPBD

Scenario 2 (mandatory inspections) is expected to have the following impact on the efficiency of heating systems in the Netherlands in relation to the baseline scenario:

- There is a limited impact on the replacement of old (conventional and improved-output) boilers with new HR107 or HR107+ boilers in the 60-100 kW range. Inspections carried out after 12 years result in earlier replacement of some (around 20%) of the remaining boilers of that age (approx. 3% of the overall stock). Inspections conducted after six years are not expected to speed up boiler replacement. In view of the average service life of boilers, 18-yearly inspections are so rare that they are expected to have no impact.

- Nor is there any impact on boiler maintenance, which was already 90% of all installed boilers.

- As the replacement of boilers is already subject to system performance requirements, new and modified installations will become slightly more efficient (as a result of improved design and thermostats/temperature controls). Mandatory inspections will have no further effect.

- There is a limited impact on the replacement of old (conventional and improved-output) boilers with new HR107 or HR107+ boilers in the 20-60 kW range. Inspections carried out after 16 years result in earlier replacement of some (around 50%) of the remaining boilers of that age (approx. 3% of the overall stock). Inspections conducted after eight years are

not expected to speed up boiler replacement.

- Approx. 90% of boilers in this range are already regularly maintained. The only way to increase this figure would be by introducing a disproportionate enforcement system. The costs and benefits of such a system mean that it is undesirable, partly in view of the minimal increase in energy efficiency achieved by maintenance. The frequency of maintenance is accordingly not expected to increase either.

- As the replacement of boilers is already subject to system performance requirements, new and modified installations will become slightly more efficient (as a result of improved design and thermostats/temperature controls). In theory mandatory inspections of boilers after approx. eight years might temporarily increase this gain in efficiency. With this approach there will, after all, be a range of boilers whose system performance was not analysed on installation and which are to be inspected in the following eight years. It is, however, reckoned that in such situations, where there is at least an HR107 boiler which at the time is still in excellent working order, virtually no owners will replace their boiler merely because a slightly smaller model is slightly more energy-efficient, particularly because the hot water supply will be impaired as a result.

- The expected frequency and energy-saving rates of each of the measures resulting from voluntary system analyses are set out in the table below:

Installers who offer mandatory inspections		Consumers who have mandatory inspections carried out		Measures recommended		Measures implemented		Energy saving per measure		Energy saving expected by 2020 (as a % of total energy consumption)
100%	x	90%		Replacing boiler earlier						0.16%
				3%	x	50%	x	12%		

The alternative solution is expected to result in 90% of all buildings having undergone a voluntary analysis of their system energy performance (heating system) by 2020. In approximately 1.5% of cases, these analyses are expected to result in earlier replacement of boilers.

Sensitivity analysis – scenario 2

As well as being modelled on the most probable assumptions, scenario 2 has also been modelled and calculated using variables that constitute the limit of reasonable assumption.

Possible measures which might be recommended in these mandatory inspections are:

- Radiator balancing: our assumption is that this is recommended in fewer than 5% of inspections and that the recommendation is followed up in fewer than 10% of those cases, as radiator balancing is a measure typically taken when an installation is not working as well as it should. To assess the sensitivity of this assumption, we estimated the maximum extent to which such measures would be taken. Based on the timing of mandatory inspections and the anticipated market response, we expect that radiator balancing is recommended in fewer than 5% of cases and that the recommendation is implemented in fewer than 20% of those cases.

- Changing radiators: our assumption is that this is recommended in 0% of mandatory inspections. Radiator replacement is a drastic measure which, generally speaking, is offered only to owners who have themselves expressed an interest in improving their installation. Past experience of energy-saving programmes has shown that measures that

require major adjustments to a building are only ever implemented when the owner was already interested in measures designed to save energy and increase comfort prior to guidance being issued. This experience has been used to extrapolate data for changing radiators following a mandatory inspection (and also underlies the assumption that these measures will be implemented more frequently if a voluntary analysis is offered at an opportune moment). To assess the sensitivity of this assumption, we estimated the maximum extent to which such measures might be recommended and taken. We expect that radiator replacement might be recommended in a maximum of 5% of inspections and then implemented in no more than 10% of those cases.

- Replacing the thermostat: our assumption is that thermostat replacement is, generally speaking, not offered in mandatory inspections either. Provided that an installation is working well, owners will have little need to periodically replace components such as thermostats. Nevertheless, thermostat replacement might be recommended when a boiler may still be used for a number of years but the thermostat itself is fairly old. Based on experience gained from previous programmes, we also expect market acceptance of this recommendation in mandatory inspections to be low, although perhaps higher than for radiator replacement, as the measure is structurally less invasive. To assess the sensitivity of this assumption, we estimated the maximum extent to which such measures might be recommended and taken. We expect that thermostat replacement might be recommended in a maximum of 20% of inspections and then implemented in no more than 20% of those cases.

The expected frequency and energy-saving rates of all the measures following mandatory inspections is set out in the table below. The assumptions for scenario 2 are shown in normal font and those for the sensitivity analysis in italics.

Installers who offer mandatory inspections		Consumers who have mandatory inspections carried out		Measures recommended		Measures implemented		Energy saving per measure		Energy saving expected by 2020 (as a % of total energy consumption)
100%	x	90%	x	Radiator balancing					=	
				0%	x	0%	x	3%		0.00%
				5%		*20%*		*3%*		*0.03%*
				Changing radiators						
				0%	x	0%	x	5%		0.00%
				5%		*10%*		*5%*		*0.02%*
				Replacing thermostat						
				0%	x	0%	x	3%		0.00%
				20%		*20%*		*3%*		*0.11%*
				Replacing boiler earlier						
				3%	x	50%	x	12%		0.16%
				3%		*50%*		*12%*		*0.16%*

The alternative solution requires the system performance of some 90% of buildings to have been analysed by 2020. The analyses will result in approx. 1.5% of cases in earlier replacement of boilers and in 0% of cases in other system improvement measures.

4. Comparison of options and conclusions

The Netherlands has opted for an 'alternative solution' to mandatory inspections for gas-fired heating systems with a capacity of up to 100 kW, in accordance with the EU Directive.

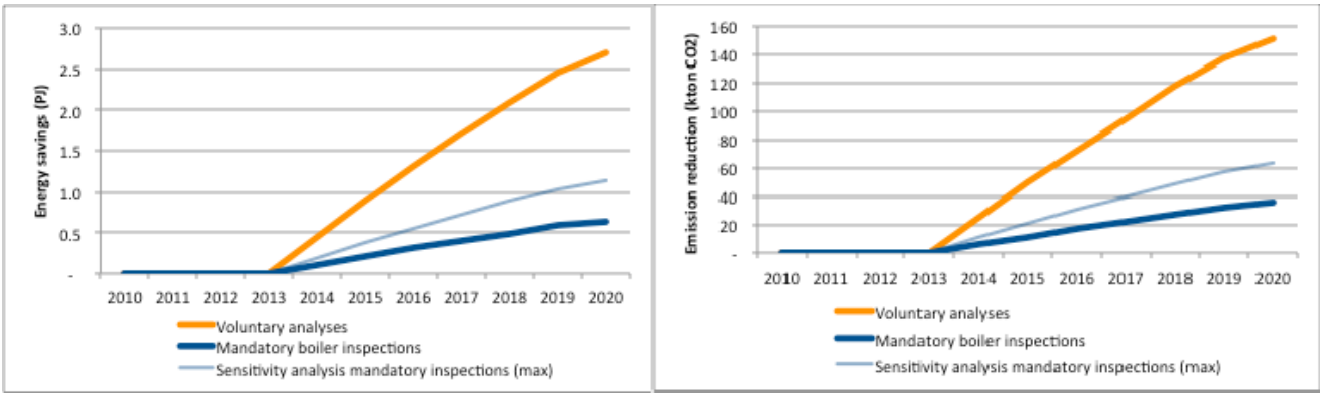
The **alternative solution** scenario includes, in addition to the policies in the baseline scenario, a voluntary analysis of the system performance of heating systems offered by market parties in collaboration with the Government. This voluntary analysis will be offered on top of the planned maintenance of boilers and will include an analysis of the energy performance of the whole heating system, including the boiler, thermostat or temperature control, distribution and radiator system. The alternative solution is expected to result in 24% of all buildings having undergone a voluntary analysis of their system energy performance (heating system) by 2020. In 70% of cases, these analyses are expected to result in system improvement measures being implemented.

The total energy demand for the heating of buildings, in this case, will be approximately 0.77% (2.7 PJ) below the baseline scenario by 2020. Related CO_2 emission reductions are expected to amount to 151 kt.

The expected impacts of **mandatory boiler inspections** have also been assessed, for comparison. This would have consisted, on top of baseline scenario policies, of an extension of the requirement to regularly inspect gas-fired boilers with a capacity of 20 kW or more (instead of the current limit of 100 kW or more) included in the Environmental Management Act/Activities Decree. This inspection would also be included in the SCIOS methodology. In addition, this requirement would be listed in the Buildings Decree. The total energy demand for the heating of buildings, in this case, will be approximately 0.18% (0.6 PJ) below the baseline scenario by 2020. Related CO_2 emission reductions are expected to amount to 36 kt.

A sensitivity analysis was performed to test whether this result would change with other assumptions for input variables. The analysis shows that, when selecting the most optimal, though not most realistic, input variables for high energy savings, impacts would increase to 64 kt CO_2.

Impact of the scenarios: voluntary analyses and mandatory inspections



Measures implemented in the scenarios

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Voluntary analyses											
Radiator balancing					1.1%	2.3%	3.4%	4.6%	5.7%	6.9%	8.0%
Changing radiators					0.3%	0.6%	0.9%	1.1%	1.4%	1.7%	2.0%
Replacing thermostat					0.7%	1.4%	2.1%	2.9%	3.6%	4.3%	5.0%
Replacing boiler earlier					0.4%	0.7%	1.1%	1.4%	1.8%	2.1%	2.5%
Mandatory inspections											
Replacing boiler earlier					0.2%	0.4%	0.7%	0.9%	1.1%	1.3%	1.6%

This analysis clearly demonstrates that the alternative solution, as being implemented by the Netherlands, will result in substantially higher energy savings than the mandatory boiler inspections, at lower cost. The better integration of inspections with scheduled maintenance, the focus on improvements in the boiler and heat distribution system enabled by this alternative solution and alignment with natural moments for system improvements are the key explanations for this larger impact.

The alternative solution as being implemented in the Netherlands thus comfortably meets the requirement of Article 14(4) of the EPBD recast for an alternative solution to meet or exceed the impacts of mandatory inspections as described in Article 14(1)-(3) of the EPBD recast.

Expected impact of the scenarios

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Voluntary analyses											
Energy saving (PJ)					0.4	0.9	1.3	1.7	2.1	2.5	2.7
Emission reduction (kt CO_2)					25	50	73	95	117	137	151
Mandatory inspections											
Energy saving (PJ)					0.1	0.2	0.3	0.4	0.5	0.6	0.6
Emission reduction (kt CO_2)					6	12	17	23	28	33	36
Sensitivity analysis, mandatory inspections											
Energy saving (PJ)					*0.2*	*0.4*	*0.5*	*0.7*	*0.9*	*1.0*	*1.1*
Emission reduction (kt CO_2)					*11*	*21*	*31*	*40*	*49*	*58*	*64*

Annex: Methodology and assumptions

The methodology adopted in this report for the purpose of measuring the impact of the various scenarios is based on a model of building stock (residential and non-residential sector) in the Netherlands. The model is tailored to the questions raised in this report and is intended to assist with calculating the energy-saving impact of additional policies. The model contains no independent analysis of autonomous developments in the energy demand of buildings; for this purpose, the model adopts data reported by the Energy Research Centre of the Netherlands (ECN) (Reference Projection Energy and Emissions 2010-2020 Built Environment background report, ECN-E--10-108, November 2010). Since the report has such a solid basis, a high level of integration is similarly achieved with other data reported on building stock in the Netherlands.

The baseline scenario follows the autonomous development of the energy demand, as described by the ECN, and the development of the heating system stock as described in this report. The other scenarios are based on this baseline scenario, with an adjustment of the energy efficiency of the heat-generating process where appropriate, according to the additional energy-saving measures that are employed. Since the model is not required to include an independent analysis of the autonomous development of the energy demand, it has been possible to keep this report simple and accessible. Data is available for all input variables for the years 2010 and 2020. In the case of some variables, data is available for the intervening years as well, whilst for others, data has been interpolated.

The main assumptions in the model are as follows:

Factor	Values used	Justification
Number of buildings	As in [ECN, 2010]	Consistent with generally accepted projections of future building stock
Heat demand of buildings	As in [ECN, 2010]	Consistent with generally accepted projections of future energy consumption
Type and number of new heating systems	Based on [Sijbring and Overman, 2012] and data provided by the VfK (Dutch Association of Central Heating Boiler Manufacturers)	Consistent with the best evidence available from market reports
Type and number of heating systems in stock	Projection, based on ECN 2010, ECN 2012, Sijbring and Overman, 2012, and the VfK, 2014	Adopted from *Energiebesparing: Een samenspel van woning en bewoner – Analyse van de module Energie WoON 2012* ('Saving energy: A combination of home and occupant – An analysis of the Energy module of the National Housing Survey 2012'), ECN-E--13-037, August 2012
Energy content and CO_2 content of fuel	1 m^3 natural gas = 31.65 MJ 1 GJ natural gas = 56.1 kg CO_2	Source: The Netherlands: list of fuels and standard CO_2 emission factors, SenterNovem, December 2004

Energy saving from radiator balancing	Saving of 3% compared with baseline scenario	Sources (cited in this report) indicate various energy-saving rates for 'radiator balancing', ranging from 0% to more than 10%. The sources furthermore indicate that savings are on average higher when the owner has complaints about the heating system or when the system is faulty, as is assumed in the situations in the 'alternative solution' scenario. In view of the uncertainty surrounding the energy-saving rate, a conservative estimate has been adopted, well below the average reported savings.
Energy saving from changing radiators	Saving of 5% compared with baseline scenario	No working data is available for this measure. It is assumed that this measure will be used, as in the 'alternative solution' scenario, to improve heating system performance at lower water temperatures. This will ensure that a boiler is able to distribute heat as efficiently as possible and, in the case of condensing boilers, that the boiler is able to work in condensing mode for the majority of the time. The maximum energy saving in this instance would be above 10%. In view of the uncertainty surrounding the energy-saving rate, a conservative estimate has been made of the savings that will be generated.
Energy saving from replacing thermostat	Saving of 3% compared with baseline scenario	The European Eco-design study for boilers (cited in this report) reports that a maximum saving rate of 6% can be achieved by replacing a conventional thermostat with a modulating thermostat. In view of the fact that working experience of this measure is limited, a conservative estimate has been made of the savings that this will yield.
Energy saving from replacing boilers early	Saving of 15% compared with baseline scenario	The expected energy saving when replacing an improved-output boiler with an HR107 boiler is approximately 10%. The expected saving when replacing a conventional boiler with an HR107 boiler is approximately 20%. Given the mix of (non-condensing) boilers installed in the Netherlands' building stock and the expectation that the oldest (conventional) boilers will be the first to be considered for early replacement, an average saving rate of 12% has been assumed. A conservative estimate has been adopted in this case too, owing to the lack of information regarding the age of conventional and improved-output boilers in the installed stock.
Extent to which measures are applied	As indicated in the various scenarios	Justification for the level of application is included in the scenarios.

Sources used to determine the anticipated market response and the energy-saving impact of the various measures are described in the report 'Equivalence of the alternative solution – Article 14 of the Energy Performance of Buildings Directive', May 2013.

The most important data in the calculation model are as follows:

Table B.1. Number of residences

(x 1 000)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
New housing stock (max. 5 years old)	387	379	371	364	356	348	340	332	325	317	309
Existing housing stock	6 781	6 839	6 897	6 955	7 013	7 071	7 128	7 186	7 244	7 302	7 360
Non-residential stock	222	222	222	222	222	222	222	222	222	222	222

Table B.2. Gas consumption for heating purposes

(m^3 natural gas p.a.)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
New housing stock (max. 5 years old)	384	381	378	375	372	370	367	364	361	358	355
Existing housing stock	1 053	1 038	1 022	1 007	991	976	961	945	930	914	899
Non-residential stock	28 497	27 713	26 929	26 146	25 362	24 578	23 795	23 011	22 227	21 444	20 660

Table B.3. Boiler stock in residential sector (baseline scenario)

(x 1 000)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
New housing stock (built in 2010 or later)											
CR & VR	0	0	0	0	0	0	0	0	0	0	0
HR100	0	0	0	0	0	0	0	0	0	0	0
HR107	9	52	95	137	178	217	257	295	332	368	456
Existing housing stock											
CR & VR	1 248	1 095	942	848	755	661	568	474	381	287	194
HR100	1 851	1 690	1 515	1 296	1 056	816	551	276	0	0	0
HR107	2 768	3 090	3 426	3 743	4 082	4 422	4 788	5 164	5 543	5 646	5 698

Table B.4a. Energy demand for heating buildings in the baseline scenario

(PJ)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
New housing stock (built in 2010 or later)	0.9	4.6	4.4	4.3	4.2	4.1	3.9	3.8	3.7	3.6	8.6
Existing housing stock	236	225	223	222	220	218	217	215	213	211	196
Non-residential stock	200	194.5	189	183.5	178	172.5	167	161.5	156	150.5	145

The most important results of the calculation model are as follows:

Table B.4b. Emissions from heating buildings in the baseline scenario

(Mt CO_2)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
New housing stock (built in 2010 or later)	0.05	0.26	0.25	0.24	0.24	0.23	0.22	0.21	0.21	0.20	0.48
Existing housing stock	13.3	12.6	12.5	12.4	12.3	12.3	12.2	12.1	12.0	11.9	11.0
Non-residential stock	11.2	10.9	10.6	10.3	10.0	9.7	9.4	9.1	8.8	8.4	8.1

Table B.5a. Energy demand for heating buildings in the 'alternative solution' scenario

(PJ)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
New housing stock (built in 2010 or later)	0.9	4.6	4.4	4.3	4.2	4.1	3.9	3.8	3.7	3.6	8.6
Existing housing stock	236	225	223	222	220	218	216	214	212	210	195
Non-residential stock	200	195	189	184	178	172	166	161	155	149	144

Table B.5b. Emissions from heating buildings in the 'alternative solution' scenario

(Mt CO_2)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
New housing stock (built in 2010 or later)	0.05	0.26	0.25	0.24	0.24	0.23	0.22	0.21	0.21	0.20	0.48
Existing housing stock	13.3	12.6	12.5	12.4	12.3	12.2	12.1	12.0	11.9	11.8	10.9
Non-residential stock	11.2	10.9	10.6	10.3	10.0	9.7	9.3	9.0	8.7	8.4	8.1

Table B.6a. Energy demand for heating buildings in the 'mandatory inspections' scenario

(PJ)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
New housing stock (built in 2010 or later)	0.9	4.6	4.4	4.3	4.2	4.1	3.9	3.8	3.7	3.6	8.6
Existing housing stock	236	225	223	222	220	218	217	215	213	211	196
Non-residential stock	200	195	189	184	178	172	167	161	156	150	145

Table B.6b. Emissions from heating buildings in the 'mandatory inspections' scenario

(Mt CO_2)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
New housing stock (built in 2010 or later)	0.05	0.26	0.25	0.24	0.24	0.23	0.22	0.21	0.21	0.20	0.48
Existing housing stock	13.3	12.6	12.5	12.4	12.3	12.2	12.1	12.0	11.9	11.8	11.0
Non-residential stock	11.2	10.9	10.6	10.3	10.0	9.7	9.4	9.1	8.7	8.4	8.1

Table B.7a. Energy demand for heating buildings in the 'mandatory inspections' scenario sensitivity analysis

(PJ)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
New housing stock (built in 2010 or later)	0.9	4.6	4.4	4.3	4.2	4.1	3.9	3.8	3.7	3.6	8.6
Existing housing stock	236	225	223	222	220	218	216	215	213	211	196
Non-residential stock	200	195	189	184	178	172	167	161	156	150	145

Table B.7b. Emissions from heating buildings in the 'mandatory inspections' scenario sensitivity analysis

(Mt CO_2)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
New housing stock (built in 2010 or later)	0.05	0.26	0.25	0.24	0.24	0.23	0.22	0.21	0.21	0.20	0.48
Existing housing stock	13.3	12.6	12.5	12.4	12.3	12.2	12.1	12.0	11.9	11.8	11.0
Non-residential stock	11.2	10.9	10.6	10.3	10.0	9.7	9.4	9.0	8.7	8.4	8.1