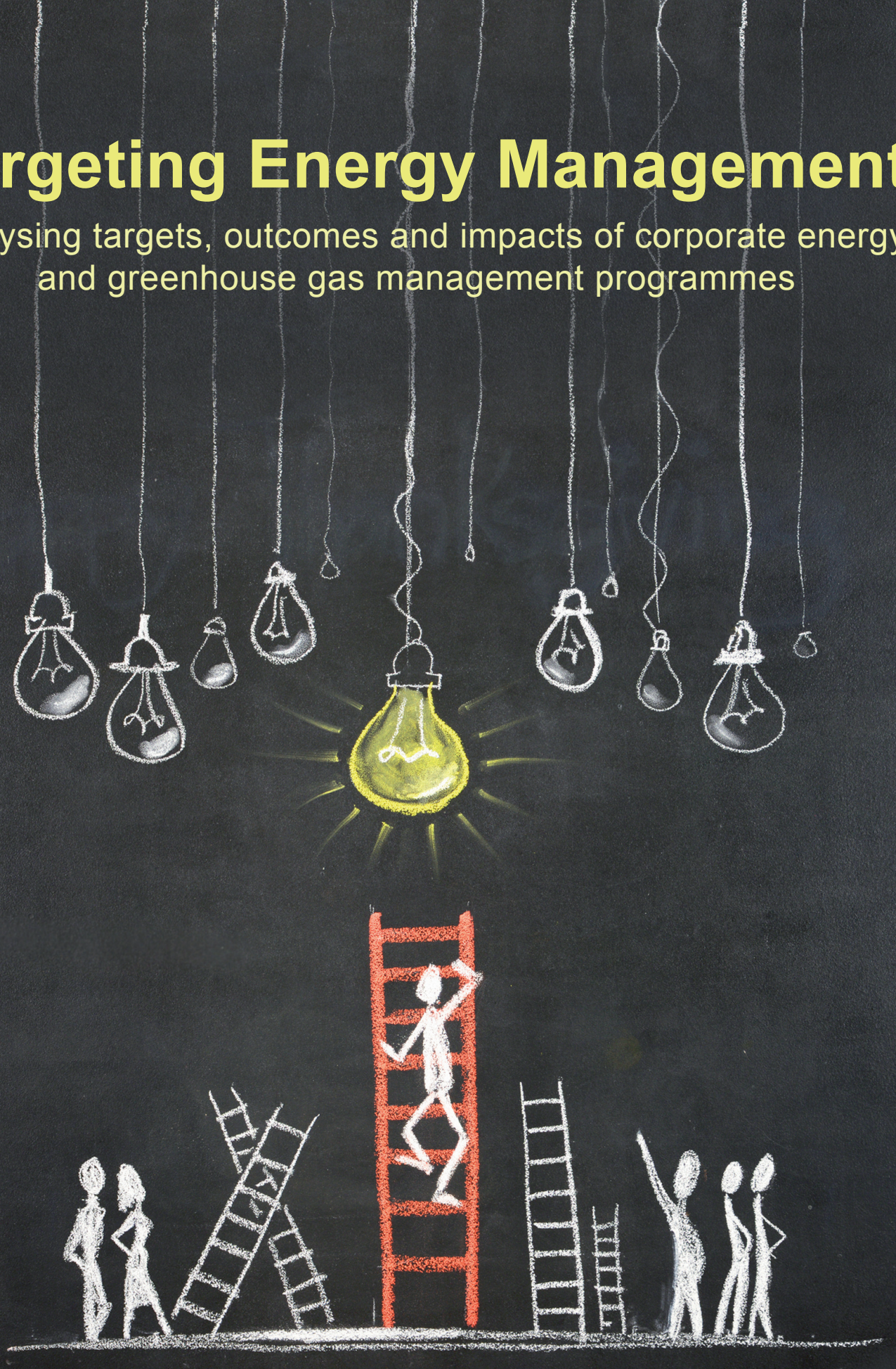
Targeting Energy Management

Analysing targets, outcomes and impacts of corporate energy and greenhouse gas management programmes



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Targeting Energy Management

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Targeting Energy Management - Analysing targets, outcomes and impacts of corporate energy and greenhouse gas management programmes

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The work presented in this thesis was supported by the HU University of Applied Sciences Utrecht

ISBN: 978-90-8672-064-4

Printing: Proefschriftmaken.nl || Uitgeverij BOXPress

Cover design: Lisa-Blue & Stein van der Zon

Targeting Energy Management

Analysing targets, outcomes and impacts of corporate energy and greenhouse gas management programmes

Energiebeheer gericht aanpakken

Het analyseren van doelstellingen, resultaten en impacts van energie- en broeikasgasbeheersprogramma's in bedrijven

(met een samenvatting in het Nederlands)

Proefschrift

ter verkrijging van de graad van doctor aan de Universiteit Utrecht
op gezag van de rector magnificus, prof. dr. G.J. van der Zwaan,
ingevolge het besluit van het college voor promoties
in het openbaar te verdedigen op
vrijdag 20 november 2015 des ochtends te 10.30 uur

door

Martijn Gerhard Rietbergen

geboren op 22 augustus 1972 te Nijmegen

Promotor: Prof. dr. K. Blok

Table of Contents

List of Figures

List of Tables

List of Abbreviations and Units

BaU:	Business-as-usual
CA:	Certification Agency
CMM:	Capability Maturity Model
CO_2PL:	CO_2 Performance Ladder
CR:	Certification Requirement
CSR:	Corporate Social Responsibility
EEI:	Energy Efficiency Index
EMAT:	Economically Most Advantageous Tender
ETS:	Emission Trading Scheme
EU:	European Union
FTE:	Full Time Equivalent
GHG:	Greenhouse Gas
GPP:	Green Public Procurement
kt:	Kilotonne
Mt:	Megatonne
PBP:	Payback period
PDCA:	Plan-Do-Check-Act
PJ:	Petajoule
SEC:	Specific Energy Consumption
SKAO:	Independent Foundation for Climate Friendly Procurement and Business
t:	Metric tonne
yr:	Year

Chapter 1

Introduction

1.1 Context

Global climate change is a major threat to sustainable development. This was internationally recognized in 1992 during the United Nations Conference on Environment and Development, also known as the 'Rio Conference'. This conference, amongst others, resulted in the United Nations Framework Convention on Climate Change (UNFCCC) - an intergovernmental treaty that aims at "stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UN, 1992). Later in 2010, parties to the UNFCCC agreed to commit to a maximum temperature rise of 2°C above pre-industrial levels in order to prevent the most severe impacts of climate change (UNFCCC, 2011). Therefore, the concentration of greenhouse gases in the atmosphere should stabilize to around 450 parts per million of CO_2-equivalent (IPCC, 2007).

The following strategies for curbing energy-related greenhouse gas emissions are often suggested: energy efficiency improvement, renewable energy, nuclear energy, and carbon capture and storage. Energy efficiency improvement will be the main strategy for reducing energy-related greenhouse gas emissions until at least 2030. It is projected that almost half of the necessary greenhouse gas emission reductions will be achieved by energy efficiency improvement (IEA, 2015).

Although there is a huge potential for energy efficiency improvement, a large part is not utilized yet (UNEP, 2011). This is caused by various investments barriers that prevent the implementation of energy efficiency measures, see e.g. Blok (2009): actors may not be aware of energy efficiency options (knowledge barrier), energy efficiency measures may not be economically attractive (economic barrier), there may be a lack of interest in energy efficiency, energy efficiency measures options may not be available yet (technical barrier), there is not a well-defined structure to decide upon and carry out energy efficiency investments (organizational barriers) or the actor carrying out energy saving investments may not be the actor who has the financial benefits (landlord-tenant barrier).

1.2 Stimulating the uptake of energy and greenhouse gas management

1.2.1 Energy and greenhouse gas management

Within companies energy management is frequently considered as a means to overcome several of these kinds of energy efficiency barriers (see, e.g. Ates & Durakbasa, 2012; Worrell, 2011; OECD, 2015). *Energy management* is defined as 'effectuating organizational, technical and behavioural actions in a structural and economically sound manner in order to minimize consumption of energy' (SenterNovem, 2004). It includes a wide range of *energy management practices*, such as: management responsibility (making commitment to continuous improvement, providing organizational support and resources), energy policy (setting targets, adopting procurement rules), energy planning (drawing up action plans, assess

opportunities), implementation (taking measures, monitoring emissions, training of employees, communicating results), checking (analysing and evaluating energy performance and progress) and reviewing (management review). The embedding of these energy management practices in company-wide management structures can be facilitated by using *Energy Management Systems.* The implementation of an energy management system must ultimately lead to the continuous improvement of energy efficiency (see, e.g. EPA, 2014; ISO, 2011). The exact requirements of an energy management system are specified by so-called *energy management standards*. The internationally acknowledged ISO-50001 (ISO, 2011) is probably the most well-known standard for energy management. Apart from the (inter)national standardization bodies other parties can formulate non-standardized specifications for energy management systems (Reinaud et al., 2012). Companies can seek certification of their energy management system through accredited agencies to ensure compliance with such energy management standards. Since energy use is often the main cause of CO_2 and greenhouse gas emissions for many companies, energy management is also considered the principle element of greenhouse gas management (Carbon Trust, 2010). Greenhouse gas management aims at minimizing greenhouse gas emission in a similar way as energy management.

1.2.2 Programmes for energy and greenhouse gas management

The uptake of energy management in firms can either be stimulated by government policies, NGO or private sector-led initiatives (IIP, 2013). In all cases energy and greenhouse gas management becomes part of a wider *programme for energy efficiency or greenhouse gas management*. These programmes are often a combination of several elements, e.g. energy management obligations; (ambitious) energy or greenhouse gas reduction target; the availability of incentive, support and compliance schemes, and 3) other obligations like public reporting, certification and verification (IEA/IIP, 2012). Due the complexity of such schemes, energy management programmes can come in many different forms, see e.g. overviews by Kahlenborn et al. (2010), Price et al. (2005), IEA/IIP (2012), IIP (2013). However, roughly such programmes can be divided in *mandatory* energy management programmes, *incentive-based* energy management programmes and *market-driven* certification programmes for energy management (Dahlgren, 2014). Mandatory energy management programmes, like the energy conservation law in Japan, enforce the adoption of energy management using a regulatory approach including measures for noncompliance (Kimura & Noda, 2014). Incentive-based energy management programmes, like the Swedish programme for improving energy efficiency in energy-intensive industries, promote the adoption of energy management by offering certain incentives, such as the exemption from regulatory policies or taxes, ease of access to information, and financial support (Stenqvist & Nilsson, 2012). Market-driven certification programmes for energy management, like the U.S. Superior Energy Performance programme, stimulate the adoption of energy management by promoting third-party certification of corporate energy management.

1.3 Setting targets for energy efficiency and greenhouse gas emission reduction

Setting targets for energy efficiency and greenhouse gas emission reduction is a key element in many programmes for energy and greenhouse gas management[1]. ISO (2011) defines energy targets as 'detailed and quantifiable energy performance requirements, applicable to the organization or parts thereof'. Meeting these targets will contribute to achieving the wider company's environmental quality objectives. Within energy or greenhouse gas management programmes targets are predominantly set for individual companies, but some programmes set targets for groups of companies (sector level) as well.

In general, when setting targets the following step-by-step approach is suggested: deciding about the organizational boundary (process, facility, business unit, entire company, group of companies, sector level); choosing the target type (absolute, relative, other); choosing the base year (rolling or fixed); defining the completion date (one year or multi-year commitment period); deciding upon the length of commitment period (long, medium or short); deciding about the use of offsets; and deciding about the target level (WBCSD/WRI, 2004; CDP, 2013; Carbon Trust, 2008).

One of the key issues in target-setting is choosing the target type. Many different target types for energy efficiency improvement or greenhouse emission reduction exist, that each have their pros and cons. In general, a broad distinction is made between absolute and relative targets. Absolute targets prescribe that a firm must limit its total energy demand or greenhouse gas emissions within the organisational boundary to a certain pre-defined level at a fixed point in the future. Relative targets aim at reducing the ratio between energy use or greenhouse gas emissions within the organisational boundary and a relevant performance metric (i.e. ton of product, number of employees or amount of turnover) to a certain pre-defined level over time (WBCSD/WRI, 2004).

Another important issue in the target-setting process is establishing the stringency of the target, i.e. the target level for energy efficiency or greenhouse gas emission reduction. This is especially important if targets are prescribed (fixed) by the programme initiator, or if targets are negotiated between firms and the programme initiator or a third-party, and to a lesser extent in the case where targets are self-imposed by the participating firm. In general, approaches for setting target levels may range from unilateral decisions by policy makers; collaborative approaches using feedback from the target group, consumers/third parties or experts; and a wide variety of modelling approaches (e.g. theoretical limits, past performance analysis, business-as-usual projections, benchmarking, cost-benefit and economic analysis), see e.g. Tonkonogy (2007), NCHRP (2010). In the end, a combination of these approaches is often used to establish target levels in energy and greenhouse gas management programmes.

1.4 Evaluating targets, outcomes and impact of energy and greenhouse gas management programmes

In contrast with the large amount of research on the relationship between environmental performance and implementing environmental management systems

[1] Target-setting for energy efficiency and greenhouse gas emission reduction has also been debated in various other energy, climate and environmental policy schemes, such as environmental management schemes (Honkasalo, 1998; Zobel, 2008), industrial energy or emission permits; and in internal and external cap and trade systems (Groenenberg & Blok, 2002; Victor & House, 2006).

(see e.g. the overviews by Heras-Saizarbitoria & Boiral, 2013; Nawrocka & Parker, 2009), the amount of empirical research evaluating the benefits, performance and impacts of introducing energy management systems, like ISO50001, is less extensive, amongst others due to its recent implementation (Bunse et al., 2011). However, there is a rich amount of literature on programmes for energy efficiency improvement and greenhouse gas emission reduction, like the numerous voluntary agreement schemes that also promote the uptake of energy management practices.

There are various *benefits* for firms to adopt energy management (programmes). The major benefits may include: reduced costs, increased environmental performance, public recognition, deferred legislation or other more stringent policies, and increased eligibility for using financial incentives or other competitive advantages, see e.g. Okereke (2007), Sullivan (2011), Rezessy & Bertoldi (2011). A smooth implementation of energy management practices is however not self-evident. Several *barriers* may inhibit the adoption of such energy management practices. These are for example the lack of commitment of top management; lack of priority given to energy issues; lack of financial resources; lack of organizational support; lack of information, lack of organizational culture of continuous improvement (see e.g. Reinaud et al., 2012; McKane et al., 2010; Rohdin & Thollander, 2006; Brown & Key, 2003). The importance of these barriers is confirmed by several studies examining the practice of energy management in particularly industrial sectors. In general, energy management practices have not been widely adopted, even not among energy-intensive firms. Though, especially well-organized, large and energy-intensive firms have been more successful, active and motivated in adopting energy management practices compared to other firms (Ates & Durakbasa, 2012; Thollander & Ottoson, 2010; Lee, 2012a; Backlund et al., 2012; Brunke et al., 2014; Christoffersen et al., 2006; Martin et al., 2012).

The uptake of energy management in firms can be stimulated by introducing programmes for energy efficiency and greenhouse gas emission reduction that include energy management obligations as well. On the one hand, several studies focusing on industrial sectors confirm the positive *impacts* of introducing such energy management programmes, on adopting new energy and greenhouse gas management practices (Backlund et al., 2012; Helby, 2002; Stenqvist et al., 2011; Krarup & Ramesohl, 2002; Price, 2005). These studies suggest that such programmes improve various energy management practices such as monitoring and reporting procedures, introducing energy efficiency procurement rules, raising awareness, increasing motivation etc. On the other hand, evaluations of voluntary agreements, as an important example of energy management programmes, also show that lenient targets, insufficient specific obligations, and deficiencies in reporting, monitoring and verification are often important threats of such programmes for delivering meaningful energy savings or greenhouse gas emission reductions (Rezessy & Bertoldi, 2011). It is often being suggested that these weaknesses can be addressed by involving independent third parties for verification and compliance assessments (Rezessy & Bertoldi, 2011). However, experience with conducting independent audits in the broader context of environmental management certification, shows that such audits are far from independent, rigorous and objective; that audits focus more on procedural conformity rather than on internalization of good environmental practices; and that a clear process for evaluating the continuous environmental performance improvement is lacking (see, Ammenberg et al., 2001, Boiral, 2007; Boiral & Gendron, 2011; Heras-Saizarbitoria et al., 2013)

At the time of research primarily studies were available investigating the outcomes of energy management programmes, see e.g. Farla & Blok (2002). Evaluations assessing the ex-post *impacts* of introducing energy management programmes on energy conservation in industrial sectors were almost non-existing. More recently, several studies have been carried out evaluating the impact of energy and greenhouse has management programmes. On the one hand some studies confirm the positive impact of such programmes on reducing energy use, see e.g. Cahill & Gallachóir (2012), Stenqvist & Nilsson (2012). On other hand, various studies claim that there is no consistent evidence about the (direct) relationship between implementing energy management (systems) and the firms' carbon performance, see Böttcher & Müller (2014), Lee (2012a) and Martin et al. (2012).

Market-driven (certification) programmes for energy and greenhouse gas management can play an important role in greening the supply chain. Buyers can encourage their suppliers to implement (certification) programmes for energy and greenhouse gas management, thereby contributing to energy efficiency and greenhouse gas emission reduction in the supply chain. In the broader context of green supply chain management a wide range of studies has been published that discuss the use of environmental criteria, tools and indicators in green supply management (e.g. Kovács, 2008; Lee, 2012b; Gonzáles et al., 2008; Nawrocka et al., 2009), that track progress towards green public procurement goals (e.g. Bouwer et al., 2006; PWC et al., 2009 and AEA, 2010); and that evaluate the enforcement of environmental requirements in green procurement contracts (Faith-Ell et al., 2006). Studies assessing the quantitative environmental impacts of such green supply chain initiatives are however rare, except for Ecofys (2012) and DHV (2009), that show the enormous potential for reducing energy use and greenhouse gas emission in the supply chain.

1.5 Why this thesis?

1.5.1 Scientific needs

This thesis fills several gaps in the scientific literature on energy and greenhouse gas management programmes. First, there is only limited scientific insight into the impact of introducing such programmes on improving internal energy management practices particularly in non-industrial sectors. Second, scientific studies about the quantitative impacts of implementing these programmes on energy conservation or greenhouse gas emissions within companies and their supply chain are rare. Third, limited empirical insight exists into the process of setting corporate energy or greenhouse gas emission reduction targets in programmes for energy and greenhouse gas management.

1.5.2 Societal needs for the thesis

There is also a clear public interest in this research. Participation in energy and greenhouse gas management programmes may provide participating firms certain financial benefits, serve as proof of compliance to governmental policies or provide public recognition. Therefore, it is in the public interest to investigate whether the eligibility for such competitive advantages is also based on genuine energy management practices. Furthermore, the design, implementation and monitoring of such programmes may require a lot of effort (in terms of time and money), from various societal stakeholders. Society therefore deserves to understand whether all these efforts put in mitigating climate change also do have an impact.

1.5.3 Relevance for practitioners

Also from a practitioner's point of view, this thesis will provide relevant insights. Practitioners, managing, implementing or accrediting energy efficiency or greenhouse gas emission reduction programmes need to understand how such programmes work in practice, need to have insight in the potential outcomes and impacts of these programmes, and need to understand how effectiveness of such programmes can be improved. More specifically, this thesis provides relevant insights for practitioners in the different types corporate targets for energy and greenhouse gas emission reduction, the pros and cons of using these different types, and how target for energy efficiency and greenhouse gas emission reduction can be established.

1.6 Introducing the energy and greenhouse gas management programmes observed in this study

Two rather distinctive programmes for energy and greenhouse gas management implemented in the Netherlands are being studied, i.e. the Long-term Agreements on Energy Efficiency and the CO_2 Performance Ladder.

1.6.1 The first generation Long-Term Agreements on Energy Efficiency

The Long-Term Agreements on Energy Efficiency were introduced in the Netherlands in 1992. The scheme has dictated energy conservation policies in the Netherlands for a long time, therefore making it an urgent object of research. These government-initiated incentive-based agreements are tailor-made negotiated agreements between the Ministry of Economic Affairs and industrial sectors. The voluntary, but binding agreements aimed at energy savings in the production process of primarily energy-intensive companies. The first generation of Long-Term Agreements did not follow a standardized approach for the continuous improvement of energy management. However, the agreements specified several energy management practices that companies needed to adopt, like regularly drawing up energy conservation plans, setting targets for energy efficiency improvement, implementation of economically feasible energy conservation measures, and annual monitoring and reporting of energy use. A wide range of supporting policy measures was available such as information and consultancy, investment subsidies, and energy audits. Energy efficiency improvement targets were negotiated at sector level, without a formal burden sharing approach among individual firms. In return for commitment to the agreements, the government promised not to impose supplementary national policy governing CO_2 reduction or energy conservation on these sectors. In 1998, the first generation of the Long-Term Agreements on Energy Efficiency were superseded by new covenants. The less energy-intensive companies continued their participation in the second (1999-2008) and third (2009-2020) generation of the Long-term Agreements on Energy Efficiency[2]. The more energy-intensive companies joined the Benchmarking Covenant on Energy Efficiency (1999-2009) that later continued into the Long-Term Agreement on Energy Efficiency (2009-2020) for companies participating in the European Union Emission Trading Scheme, see RVO (2014).

[2] The second and third generation of Long-Term Agreements on energy efficiency added energy savings throughout the entire product chain and renewable energy.

1.6.2 The CO_2 Performance Ladder

The CO_2 Performance Ladder is a more recent example of a programme for energy and greenhouse gas management, affecting companies in non-industrial sectors. Since these sectors have not been subject to specific energy and climate policies before, it is important to investigate whether such programmes can bring about impacts effectively. The NGO / private sector led programme was developed in 2009 by ProRail, the state-owned company responsible for the management of the Dutch railway network. Since 2011, the Independent Foundation for Climate Friendly Business and Procurement is the NGO responsible for the management of programme. The CO_2 Performance Ladder is characterized as a market-driven certification programme for energy and greenhouse gas management. Participation can give companies certain competitive benefits in the awarding of procurement contracts. Companies therefore need to get their energy and greenhouse gas management certified by an independent third party organization. The programme has its own energy management specifications, which are strongly linked to standardized approaches such ISO-50001 standard for energy management. Amongst a wide range of energy management specifications, such as commitment of the management board, drawing up energy conservation plans, monitoring of greenhouse gas emissions, annual publication of results, companies must individually establish greenhouse gas emission reduction targets (SKAO, 2014).

1.7 Evaluating impacts, outcome and implementation process

This study is rooted in the field of evaluation research. 'Evaluation' is defined as the systematic and objective assessment of an on-going or completed project, programme or policy particularly aimed to determining the needs, design, implementation process, outcome, impact, and efficiency (Rossi et al., 2004). This study focusses on the implementation process, outcomes and impacts of energy and greenhouse gas management programmes. Process evaluations assess how well a program is being operated, implemented and adopted. Outcome evaluations assess the extent to which a program achieves its intended objectives. Impact evaluations aim at determining what changes in the programme outcomes can be attributed to programme intervention, see EREE (2006). Programme impact is also known as programme effect, effectiveness, or actual outcome.

1.8 Research objective, questions and thesis outline

The wider objective of this thesis is to contribute to improving the effectiveness of programmes for energy efficiency improvement and greenhouse gas emission reduction in companies by evaluating the target-setting process, the outcomes and impacts of such programmes. The main research question of this thesis is formulated as follows:

"What is the impact of energy and greenhouse gas management programmes on improving corporate energy management practices, accelerating energy efficiency and CO_2 *emission reduction?"*

This research question will be studied by means of two different cases of energy and greenhouse gas management programmes, i.e. the Long-Term Agreements on Energy Efficiency and the CO_2 Performance Ladder. The main research question is broken down in the following sub questions:

1. *How can ambitious targets for energy efficiency improvement and greenhouse gas emission reduction in programmes for energy and greenhouse gas management be established?*

This question will be addressed in chapters 2 and 3. *Chapter 2* will present a taxonomy for distinguishing various types of targets for limiting energy use and greenhouse gas emissions. A comprehensive overview is presented of past, current and proposed future policies worldwide using such targets for limiting industrial energy use or greenhouse gas emission reductions at sector or firm level. This overview includes approximately 50 different emission permit systems, voluntary or negotiated agreement schemes and emission trading systems. The various target types are compared with respect to the certainty of the environmental outcome and compliance costs, the targets' relevance for the public and for industry and their environmental integrity, as well as their complexity and potential for comparison. *Chapter 3* investigates the target-setting process in the CO_2 Performance Ladder. It is an example of an energy and carbon management programme that explicitly requires firms to set ambitious targets for greenhouse gas emission reduction. In this chapter we will investigate whether the current target-setting procedures in the CO_2 Performance Ladder does guarantee the establishing of such ambitious greenhouse gas emission reduction targets. The CO_2 Performance Ladder introduces a wide range of specific requirements for setting ambitious targets that will be introduced in this chapter. The interpretation of these requirements by various involved actors (scheme owner, firms, third party certification authorities, consultants) will be investigated. Next, the way companies establish ambitious greenhouse gas emission reduction targets will be studied. This will be followed by an evaluation of the ambition level of the greenhouse gas emission reduction targets. Finally the auditing practice of third party certification agencies responsible for assessing target levels will be analysed.

2. *What is the impact of energy and greenhouse gas management programmes on improving energy and greenhouse gas management in practice?*

This second research question will be addressed in *chapter 5*. Also in this chapter the CO_2 Performance Ladder is the object of research. In this chapter the following energy management practices are being studied: the organizational changes, the monitoring and analysis of energy use and CO_2 emission reduction, the functioning of the Plan-Do-Check-Act Cycle, the management involvement and target-setting for CO_2 emission reduction. Improved practices must lead to additional energy conservation and CO_2 emission reduction measures and ultimately CO_2 emission reduction. Therefore, this chapter investigates the impact of the CO_2 Performance Ladder on taking additional energy conservation and CO_2 emission reduction measures, analyses the CO_2 emission reductions since the introduction of the CO_2 Performance Ladder, and provides a preliminary assessment of the impact of the programme on CO_2 emission reduction. As the CO_2 Performance Ladder is probably not the only driver for changing energy management practices, the influence of other contextual drivers, such as corporate strategies, other governmental policies and market-based standards is studied as well.

3. What is the impact of energy and greenhouse gas management programmes on energy efficiency improvement and greenhouse gas emissions reduction?

This third research question will be addressed in both chapters 4, 5 and 6. *Chapter 4* evaluates the potential impact (ex-ante) of the CO_2 Performance Ladder on the reduction of CO_2 emissions in the Netherlands. An inventory is made of firms participating in the programme, their CO_2 footprints and CO_2 emission reduction targets. Business-as-usual scenarios are constructed forecasting CO_2 emissions, turnover and employment in the involved sectors. On the basis of these business-as-usual trends, CO_2 footprints and target levels for CO_2 emission reduction, the potential outcome of the programme is estimated. *Chapter 5* evaluates (ex-post) the achieved CO_2 emission reduction of companies participating in the CO_2 Performance Ladder. Moreover, it provides a preliminary assessment of the impact of the programme on CO_2 emission reduction. *Chapter 6* investigates the outcome and impact (ex-post) of the Long-Term Agreements on Energy Efficiency in the Netherlands. Two distinctive methods are explored to isolate the impact of these agreements on energy savings. The first method calculates the impact of the Long-Term Agreements on Energy Efficiency by estimating the additional investments (and related energy savings) made by the involved industries. The second method assesses the impact of the Long-Term Agreements on Energy Efficiency by comparing the monitored energy efficiency improvement with modelled energy efficiency improvements in the business-as-usual case. By applying these methods the energy savings that can be attributed to the Long-Term Agreements on Energy Efficiency will be calculated.

Chapter 7 will summarize the research objectives, the main research findings and conclusions of this thesis.

Chapter 7

Summary and conclusions

7.1 Introduction

Global greenhouse gas emissions must be reduced drastically to limit global increases in temperature to the relatively safe level of maximum 2 degrees Celsius. In the coming decades, energy efficiency improvement will be the main strategy for reducing energy-related greenhouse gas emissions. Although there is a huge potential for energy efficiency improvement, a large part is not utilized yet. This is caused by various investments barriers that prevent the implementation of energy efficiency measures. The introduction of energy management is frequently considered as a means to overcome several of these kinds of energy efficiency barriers.

The uptake of energy management in firms can be stimulated by introducing wider programmes for corporate energy and greenhouse gas management. These programmes are often a combination of several elements, e.g. energy management obligations; (ambitious) energy or greenhouse gas emission reduction targets; the availability of incentive, support and compliance schemes; and other obligations like public reporting, certification and verification. Up till now there is however limited insight in the process of setting ambitious energy efficiency or greenhouse gas emission reduction goals within these programmes, in the impact of introducing such programmes on improving energy management practices, and in the impact of these programmes on energy conservation or greenhouse gas emission reduction. The main research question of this thesis is formulated as follows:

"What is the impact of energy and greenhouse gas management programmes on improving corporate energy management practices, accelerating energy efficiency improvement and CO_2 emission reduction?".

In this thesis the first generation of Long-term Agreements on Energy Efficiency in the Netherlands and the CO_2 Performance Ladder are studied as two different cases of energy and greenhouse gas management programmes. The Long-Term Agreements on Energy Efficiency are tailor-made negotiated agreements between the Ministry of Economic Affairs and industrial sectors, aiming at energy savings in the production process of energy-intensive companies. The CO_2 Performance Ladder is a certification programme for energy and carbon management in the Netherlands, mainly adopted by non-industrial firms. Participation can give companies certain competitive benefits in the awarding of procurement contracts.

The remaining parts of this chapter summarize the thesis chapters one by one. The final section draws the general conclusions.

7.2 Setting SMART targets for industrial energy use and industrial energy efficiency

Target-setting is often a key element in industrial energy policies, including various energy and greenhouse gas management programmes. There is a range of characteristics that distinguishes targets from each other, such as the actors involved in the target-setting process, the binding character of the target (binding, semi-binding,

voluntary), the target boundary (scope and coverage), the length of the commitment period, the type of base year (fixed or rolling), the target category and type, etc.

The primary goal of Chapter 2 was to develop a taxonomy for categorizing various types of SMART industrial energy use or greenhouse gas emission reduction targets. The taxonomy includes: volume targets (also known as absolute targets); physical efficiency and economic intensity targets (both known as relative targets); and economic targets. Volume targets prescribe that a company or a sector must either limit its total energy use or greenhouse gas emissions to a certain prescribed level or reduce energy use or greenhouse gas emissions by a certain percentage relative to a base year. Physical energy or CO_2 efficiency targets prescribe that firms must either limit the amount of energy use (or greenhouse gas emissions) per unit physical output to a certain level or reduce the amount of energy use (or greenhouse gas emissions) per unit physical output with a certain percentage compared to a business-as-usual case or a base year. Economic energy or CO_2 intensity targets prescribe that firms must either limit the amount of energy use (or greenhouse gas emissions) per unit economic activity or reduce the amount of energy use (or greenhouse gas emissions) per unit economic activity with a certain percentage compared to a business-as-usual case or a base year. The economic activity can be expressed in terms of production value, value added, revenue or sales. Economic targets take into account costs and or revenues of energy saving investments, which help to define the financial burden for individual firms. We distinguish socio-economic targets, profitability targets and ability-to-pay targets.

Chapter 2 also provides a comprehensive overview of the use of targets for industrial energy use or greenhouse gas emission reductions at sector or firm level in past, current, and proposed future policies world-wide. This overview includes approximately 50 different emission permit systems, emission trading systems and voluntary or negotiated agreement schemes.

Finally, Chapter 2 includes an assessment of the various types of targets. The target types are compared with respect to the certainty of the environmental outcome and compliance costs, the targets' relevance for the public and for industry, and their environmental integrity, as well as their complexity and potential for comparison. Volume targets guarantee a (relatively) certain environmental outcome, have high public relevance and are not as complex as other types of targets. Physical efficiency targets lead to environmental improvements with a high level of integrity, allow for (international) comparison of the environmental performance among firms or sectors and have high relevance for industry. Economic targets combine various advantages such as a high level of environmental integrity, high certainty of compliance costs and high relevance for industry. Economic intensity targets do not have clear advantages compared to other type of targets.

7.3 The target-setting process in the CO_2 Performance Ladder

Energy and carbon management programmes, like the CO_2 Performance Ladder, have been increasingly adopted by firms as a response to climate change. These schemes often demand the setting of ambitious targets for the reduction of corporate greenhouse gas emissions. However, only limited empirical insight is available in the way ambitious target levels for corporate greenhouse gas emission reduction are being established. Chapter 3 therefore aims at answering the question 'To what extent does the current target-setting process in the CO_2 Performance Ladder lead to ambitious CO_2 emission reduction goals?'. An exploratory research design was used as the main research approach for this study. Data were collected through interviews

with relevant stakeholders, document reviews of the certification scheme, and monitoring reports.

First, the research findings indicated that several certification requirements for setting CO_2 emission reduction targets were not very well defined. As a result, there was no fully harmonised interpretation among the stakeholders (companies, third-party certification agencies, scheme owner, consultants) of the exact scheme's obligations. Second, the research results indicated that the targets were not very ambitious yet, e.g. because CO_2 emission reductions did not require considerable efforts from firms up till now, firms tend to avoid risks of underachievement, the concept of best available technologies was not used as a guiding principle in the process of setting ambitious targets, and some targets are likely going to be met anyway, even without the CO_2 Performance Ladder. Third, the research provided insight in the way independent certifying agencies evaluate the target levels for corporate greenhouse gas emission reduction. There appeared to be a semi-structured procedure among certifying agencies for evaluating the target-setting of greenhouse gas emission reduction goals, but the final assessment whether target levels are sufficiently ambitious was not well-defined. Thereby, external assessments were not always based on the full set of criteria explicitly mentioned in the scheme's requirements.

Overall, we can therefore conclude that the current target-setting process in the CO_2 Performance Ladder does not necessarily lead to the most ambitious corporate greenhouse gas emission reduction goals as yet. Other approaches for setting target levels, such as minimum performance levels, must be considered, to maintain the CO_2 Performance Ladder as a legitimate tool for green public procurement.

7.4 Assessing the potential impact of the CO_2 Performance Ladder on the reduction of carbon dioxide emissions in the Netherlands

The CO_2 Performance Ladder is a certifiable energy and carbon management programme that can also be used as a tool for green public procurement. Green public procurement is often recognized as an effective instrument for reducing energy use and CO_2 emissions in the supply chain of commissioning parties. The question is whether this type of green procurement scheme can contribute significantly to CO_2 emission reductions in the Netherlands. The research question addressed in chapter 4 is 'What is the potential impact of the CO_2 Performance Ladder on the reduction of carbon dioxide emissions in the Netherlands?'. The research was based on several methodologies for ex-ante impact assessments of energy and climate policies. Data were collected from document reviews, such as CO_2 footprints, energy management plans, progress reports and environmental statistics.

At the time of research, more than 190 companies participated in the scheme (halfway 2015 the number is over 650). The majority of these firms belonged to the construction or civil engineering industry. The scheme accounted for at least 1.7 Mt of aggregate CO_2 emissions, corresponding to nearly 1% of national greenhouse gas emissions in the Netherlands. The aggregate CO_2 emissions include direct CO_2 emissions, indirect CO_2 emissions of purchased electricity, heat and steam and indirect CO_2 emissions from private cars used for business travel. Companies participating in the scheme have set different types of CO_2 reduction targets with varying levels of ambition. The three major types of targets for CO_2 emission reduction used are volume targets for CO_2 emission reductions, economic intensity targets, measuring CO_2 emission reductions against turnover and relative targets measuring CO_2 emission reductions against full time equivalents (FTE), worked hours, or

productive hours. Very few companies have set physical CO_2 efficiency targets. Table 7.1 shows the average volume-weighted ambition levels for three major target types. Various business-as-usual scenarios were constructed forecasting the turnover and employment in the construction and civil engineering industry. On the basis of these projections, the net annual change in CO_2 emission was estimated under the assumption that companies would fully comply with the targets, see Table 7.1.

Table 7.1: Average weighted ambition level and projected net annual change in CO_2 emissions compared to emissions in the base year 2010 for three target types

Target type	Average weighted ambition level	Projected net annual change in CO_2 emissions		
		Average	High	Low
CO_2	-2.1%		-2.1%	
CO_2/FTE	-2.8%	-2.2%	-1.5%	-2.5%
CO_2/€ turnover	-2.0%	1.0%	2.2%	0.3%
Total		-1.3%	-0.8%	-1.5%

Overall, we conclude that the potential impact of the CO_2 Performance Ladder on reducing CO_2 emissions is in the range of 0.8%/yr to 1.5%/yr, with a most likely value of 1.3%/yr. The CO_2 Performance Ladder could therefore contribute significantly to achieving the annual CO_2 emission reduction rate necessary to remain below the Dutch emission ceiling for sectors not belonging to the European Union Emission Trading Scheme from 2010 until 2020 (-1.4%/yr). In absolute terms, the contribution of the CO_2 Performance Ladder to bridging the emission gap for sectors not belonging to the European Union Emission Trading Scheme is not yet significant because currently only a small portion of CO_2 emissions from these sectors is covered by the scheme.

7.5 The impact of the CO_2 Performance Ladder on improving energy and carbon management in construction and civil engineering firms

Energy and carbon management programmes, like the CO_2 Performance Ladder, are being implemented to facilitate continuous energy efficiency and carbon performance improvement in participating firms. Among the 500 participating companies (halfway 2015 the number is over 650), mainly from the construction and civil engineering sector, the CO_2 Performance Ladder is often considered as the major stimulant for energy efficiency improvement and CO_2 emission reduction. Chapter 5 addressed the question: 'What is the impact of the CO_2 Performance Ladder on improving energy and carbon management in construction and civil engineering firms'. The research was primarily based on interviews, descriptive analysis of energy efficiency and CO_2 emission reduction measures and quantitative analysis of CO_2 emission reductions.

Our study revealed that the CO_2 Performance Ladder stimulated a wide range of energy management practices such as stronger top management commitment; increased priority for energy issues'; improved Plan-Do-Check-Act cycles for energy management; improved insight in CO_2 emissions, performance and reduction options; and increased employee awareness. A wide range of potential energy efficiency barriers has therefore been tackled. Though, the CO_2 Performance Ladder has mainly improved energy management practices at administrative level, while implementation of energy management practices down-stream in the organization has just gradually started. Companies have implemented various CO_2 emission reduction measures that can be categorized as green mobility measures, green electricity, efficient (use of) machinery, more efficient production of materials, energy saving in buildings, renewables, and other measures. Companies have mainly adopted measures that affect the supporting business processes instead of the companies' core processes.

The CO_2 Performance Ladder has particularly stimulated green electricity purchasing and the adoption of various behavioural energy efficiency and CO_2 emission reduction measures. Over the past 4-5 years CO_2 emissions have decreased by 5.1%/yr, which is way beyond the projected impact of the CO_2 Performance Ladder on CO_2 emission reduction (0.8-1.5%/yr) calculated in chapter 3. The large difference was attributed to favourable long-term economic forecast used in Chapter 3 compared to the actual economic downturn in the past years. However, the CO_2 Performance Ladder still seems to have enhanced CO_2 emission reductions among the participating companies in addition to the steep CO_2 emission reductions due to the activity losses in the past years.

Overall, we conclude that, driven by the potential competitive advantage in contract awarding, the CO_2 Performance Ladder has been responsible for a strong shift towards more mature energy management among construction and civil engineering firms that otherwise would not have occurred.

7.6 Do agreements enhance energy efficiency improvement?

Negotiated energy agreement are commonly perceived as a promising and (cost)-effective alternative to traditional regulation. However, it is not yet known whether such agreements really enhance energy efficiency improvement. In Chapter 6 we therefore study the Long-Term Agreements on Energy Efficiency, that have been an important policy instrument for industrial energy conservation in the Netherlands for already several decades. We will address the question: 'What is the impact of the Long-term Agreements on accelerating energy efficiency improvement in the Netherlands?'. In this chapter, we specifically focus on the first generation of Long-Term Agreements in the period 1992-2000. These agreements were one of the first examples of energy covenants between government and industry in the world, making it an interesting topic of research. Other type of agreements on energy efficiency would prolong the first generation of Long-Term Agreements at a later stage. The research was based on several methodologies for impact assessment of energy and climate policies. Data were mainly collected from monitoring reports and interviews.

This chapter describes two approaches (bottom-up and top-down) developed to isolate the impact of the Long-Term Agreements on Energy Efficiency. The first bottom-up method isolates the impact of the Long-Term Agreements by making an estimate of the additional energy conservation investments and the associated energy savings. The energy conservation measures (and related savings) are first assigned to one of the following categories (in brackets the share in the total amount of energy saved): good housekeeping measures (9%), replacement investments (32%), energy efficiency and retrofit measures (18%), combined heat and power (22%) and other measures (22%). Subsequently, both experts and companies assessed to what extent different energy conservation investments categories have been encouraged by the Long-Term Agreements. For example, the Long-Term Agreements have 'strongly' encouraged retrofit measures, while replacement investments have been encouraged only 'slightly'. By assigning weights to the different 'degrees of stimulation', we could finally calculate the amount of stimulated energy savings for each category and hence the overall impact of the Long-Term Agreement on improving energy efficiency. The alternative top-down method isolates the impact of Long-Term Agreements by comparing the achieved energy efficiency improvement (-2.1%/yr in the period 1989-1998) with estimates of the energy efficiency improvement in the business-as-usual scenario (0.9%/yr - 1.6% /yr). The estimates of energy efficiency improvement in the business-as-usual scenario were based on model simulations.

The main conclusion is that between a quarter and a half of the energy savings in the Dutch manufacturing industry can be attributed to the agreements. In other words, the rate of energy efficiency improvement has increased by 33-100% compared to a situation in which there were no agreements.

7.7 Overall conclusions

The overall conclusions related to the three research questions in this thesis are the following:

1. *How can ambitious targets for energy efficiency improvement and greenhouse gas emission reduction in programmes for energy and greenhouse gas management be established?*

Establishing ambitious targets for improving corporate energy efficiency or reducing greenhouse gas emissions requires clearly specified guidelines. Target-setting approaches that lack well-defined concepts, requirements and clear assessment procedures for evaluating target levels, do not lead to the most ambitious corporate targets and must therefore be avoided. The target-setting process in the CO_2 Performance Ladder is in this respect a clear example of what not to do when aiming for ambitious target levels.

Energy and greenhouse gas management programmes must therefore use approaches for establishing target levels that are better aligned with suggested criteria for ambitious goals: targets should substantially go beyond business-as-usual projections, must be aligned with climate targets, must be based on the adoption of best available techniques, and must require considerable effort in economic or financial terms (WRI, 2013; Edvardsson-Björnberg, 2013). This implies that target levels should include obligations that for example require minimum performance levels (Scheihing et al., 2013), follow science based target-setting approaches (Krabbe et al., 2015), are based on benchmarking of energy efficiency measures (SKAO, 2015), or require the implementation of profitable energy saving measures (Agentschapnl, 2013). Though it must be acknowledged that also these approaches may have their drawbacks, e.g. with respect the enforceability, see e.g. CE et al. (2011).

A wide variety of quantitative targets for energy efficiency improvement and greenhouse gas emission reduction can be established, including absolute targets, relative targets and economic oriented targets. It is often suggested that in the case of relative targets uncertainties with respect to compliance costs of companies are reduced in comparison with absolute targets, which may lead to more ambitious targets (van Vuuren et al., 2002). In this study we found that this is true for CO_2 emission reduction targets measured against labour input. Contrary, CO_2 emission reduction targets measured against turnover, which is a more commonly used indicator for measuring activity, appeared to be less ambitious (i.e. have lower impacts) than volume targets.

2. *What is the impact of energy and greenhouse gas management programmes on improving energy and greenhouse gas management in practice?*

Programmes for energy and greenhouse gas management can considerably enhance energy management practices, such as top management commitment, increased priority for energy issues, enhanced co-ordinated actions, improved insight in CO_2 emissions, performance and reduction options, and target-setting. These programmes

are an extra impetus for energy and greenhouse gas management compared to existing energy and climate policy instruments, certification schemes and societal trends for sustainability.

In general our conclusions are in line with the existing literature on the impact of energy and greenhouse gas management programs, see e.g. Backlund et al. (2012), Krarup & Rahmesohl (2002), Stenqvist et al. (2011), Kimura & Noda (2014), Harrington et al. (2014). All these studies have addressed positive impacts to the introduction of such energy and greenhouse gas management programmes on improving energy management practices in primarily industrial sectors. Our study thus adds that such programmes can also for non-industrial firms have a serious impact on improving energy management.

However, a strong incentive, like the potential competitive advantage in contract awarding, is necessary as a driving force for continuously improving corporate energy management. These latter findings strongly confirm earlier observations from e.g. Krarup & Rahmesohl (2002), Rezessy & Bertoldi (2011) and Reinaud et al. (2012) on the need to embed energy management systems in wider governmental or sectoral energy management programmes (including voluntary agreement schemes) to be effective.

Furthermore, we have found that energy and greenhouse gas management programmes can stimulate the adoption of additional energy conservation measures in at least the short to medium long term. The magnitude of the additionality which is in the range of 25-50%, is confirmed by other studies, see e.g. Ericsson (2006), Cahill & Gallachóir (2012), Stenqvist & Nilsson (2012), Ecorys (2013). Particularly green electricity purchasing and the adoption of various behavioural energy efficiency and CO_2 emission reduction measures have been stimulated in the studied companies. Though, in general most of the implemented measures are relatively easy and low-cost energy savings measures that affect supporting business processes rather than more challenging energy saving measures in the core process. These results are difficult to compare with other studies, that did not use such a detailed breakdown of energy saving measures or covered other type of sectors.

In the longer term, it remains to be seen if energy management programmes can also further internalize energy management in the companies' organization that goes beyond the administrative level or whether the focus is mainly on procedural conformity as is often suggested in the context of environmental auditing, see e.g. Boiral (2007), Heras-Saizarbitoria et al. (2013). More intensive third party compliance audits are therefore needed that guarantee the implementation of genuine energy management practices. The alternative is that programme owners or regulatory authorities steer stronger on achieving energy efficiency improvement or CO_2 emission reduction targets.

3. What is the impact of energy and greenhouse gas management programmes on energy efficiency improvement and greenhouse gas emissions reduction?

Programmes for energy and greenhouse gas management can have an impact on improving energy efficiency and reducing greenhouse gas emissions. In the energy and greenhouse gas management programmes considered in this study we found that both energy efficiency and relative CO_2 emission reductions were enhanced within a range of 0.3%/yr - 1.0%/yr beyond autonomous improvements. Such programmes for energy and greenhouse gas management can therefore make an important contribution to achieving national energy and climate objectives. However, the values

for enhanced energy efficiency improvement are not sufficient to double the rate of energy efficiency improvement, which is necessary to limit global temperature rise to no more than 2 degrees (Rogelj et al., 2013). The estimated relative CO_2 emission reduction rate (1.3%/yr) is also far from sufficient to meet sector specific CO_2 intensity pathways for stabilizing greenhouse gas emissions in the atmosphere to around 450 ppm in 2050. The sector specific CO_2 intensity pathway for the category 'other industrial sectors', that also includes the construction and civil engineering sector, requires more than 5%/yr CO_2 intensity reduction from 2015 until 2050 (Krabbe et al., 2015). Therefore the impact of these programmes must be further reinforced, e.g. by aligning corporate greenhouse gas emission reduction targets with climate goals (Krabbe et al., 2015), by engaging the supply chain companies in reducing CO_2 emissions (Reinaud et al., 2012), and stronger regulatory threats in the case of non-compliance (Price, 2005; Rezessy & Bertoldi, 2011).

Overall, it can be concluded that programmes for energy and greenhouse gas management can be an effective tool for improving energy management practices, stimulating adoption of additional energy conservation measures, and accelerating energy efficiency improvement or reducing greenhouse gas emission beyond business-as-usual in at least the short-to-medium long term. To guarantee higher impacts of such programmes in the longer term, it is necessary that these programmes are accompanied by clear procedures for setting ambitious targets for energy efficiency improvement or reducing greenhouse gas emissions; that strong incentive and supporting schemes are available; and that clear and effective compliance procedures for genuine energy management practices are in place.

7.8 Closing remarks

- From a methodological point of view this thesis contributed to the literature by developing a bottom-up methodology for assessing the impact of energy and greenhouse gas management programmes. Estimates of the programme impact are based on the rated additionality of individual energy conservation measures and their savings. Although such methodologies can also be debated, e.g. because the self-rated additionality may be biased, they are an important addition to existing assessment methodologies that use top-down approaches.
- In this study we evaluated the results and impacts of the first generation of Long-Term Agreements on Energy Efficiency in the Netherlands in the period 1992-1998. More recent progress reports from the newer Long-Term Agreements show that the rate of energy efficiency improvement in the production process in the same sectors investigated in this study remained at a similar level of 1.8%/yr in the period 1998-2007, but declined to 1.3%/yr in the period 2009-2013 (RVO, 2014, SenterNovem, 2008). More recently also the second and third generation of thesis Long-term agreements have been evaluated (Ecorys, 2013; Arentsen, 2004). According to Ecorys (2013) participants attributed 60% of the energy savings to the Long-Term Agreements. However, Ecorys (2013) also claims that this value is likely overestimated and that the impact is rather limited, amongst others because participants also agree that 60-80% of the investments would have been taken anyway also without the Long-Term Agreements. Arentsen (2004) concludes that the industrial Long-Term Agreements have had an additional impact of 1.4%/yr energy-efficiency improved compared to average domestic energy efficiency improvements in the period 1989-2002.

7.9 Recommendations for further research

Based on the research presented in this thesis we suggest the following routes for further research to improve the understanding of energy and greenhouse gas management programmes:

- The comparison of energy and greenhouse gas management programmes remains difficult due to differences in the design, target types and reporting requirements, see for example Rezessy & Bertoldi (2011) for an overview of results and impacts of several voluntary agreement programmes. Furthermore, research on the impact of energy and greenhouse gas management programmes did not always appear to be comparable, since different assessment methods, tools and indicators were used, ranging from simple questionnaires, in depth interviews (both used in our study), to more extended energy maturity matrixes and even questionnaires with over 100 questions (e.g. Backlund et al., 2012; Carbon Trust, 2011; Harrington et al., 2014). In this respect, very long questionnaires to measure impact are not very suitable for large-scale research requiring a high response rate. We could further learn from a cross-programme comparison, by using a more harmonized approach for assessing impacts of energy management programmes. We therefore recommend to develop such a standardized methodology and carry out comparative research on the impact of various energy management programmes on improving energy management practices, the successes and failures of such programmes and the cost-effectiveness.
- In this study we only considered the impacts of energy and greenhouse gas management programmes on improving internal energy and greenhouse gas management practices, energy efficiency and CO_2 emission reduction. However, the potential for energy efficiency improvement and CO_2 emission reduction in the supply chain is probably much larger. Up till now this has been a rather unexplored topic, except for studies like Ecofys (2012) and DHV (2009). We therefore recommend studying the use of energy management (systems) in reducing supply chain CO_2 emissions, thereby mainly focusing on the impacts in terms of CO_2 emission reductions versus the design features of such supply chain initiatives (see IIP/Ecofys (2012) for various supply chain initiatives promoting energy savings and greenhouse gas mitigation). The CO_2 Performance Ladder could serve here as a case study since it also explicitly sets requirements to managing supply chain CO_2 emissions.
- A question that also needs more attention in future research is how the impact of energy and greenhouse gas management can be sustained within companies. Therefor we suggest to further study the relationship between energy management and the barriers for energy efficiency improvement in more detail. Such a study might provide fruitful proposals for designing more effective energy management programmes.
- In relation to the previous point we also suggest to focus future research on the question how good energy management practices can be further internalized within the companies' organization. Most research up till now focused on analysing the rather administrative, organizational and technical aspects of energy management practices. However, energy management also includes behavioural actions necessary for the continuous improvement of energy performance. Future research should focus on the question how various levels of staff can effectively be engaged in energy management (systems) to reach

tangible impacts in the long term. It is suggested that in-depth case studies are carried out in companies, involving a wide range of different staff.

Hoofdstuk 7

Samenvatting en conclusies

7.1 Inleiding

De wereldwijde uitstoot van broeikasgassen moet drastisch worden teruggebracht om de mondiale stijging van de temperatuur tot het relatief veilige niveau van maximaal 2 graden Celsius te beperken. In de komende decennia zal de verbetering van de energie-efficiëntie de belangrijkste strategie zijn voor het verminderen van de energie-gerelateerde uitstoot van broeikasgassen. Hoewel er een enorm potentieel is voor verbetering van de energie-efficiëntie, wordt een groot deel daarvan nog niet benut. Dit wordt veroorzaakt door diverse investeringsbarrières die de invoering van maatregelen voor energie-efficiëntie verbetering verhinderen. De invoering van energiemanagement wordt vaak beschouwd als een manier om dergelijke barrières voor energiebesparing te overwinnen.

De invoering van energiemanagement in bedrijven kan worden gestimuleerd door de introductie van programma's voor energie-efficiëntie verbetering en vermindering van de uitstoot van broeikasgassen. Deze programma's zijn vaak een combinatie van verschillende elementen zoals verplichtingen voor energiemanagement; (ambitieuze) doelstellingen voor energiebesparing of beperking van de uitstoot van broeikasgassen; de beschikbaarheid van regelingen voor stimulering, ondersteuning en naleving; en andere verplichtingen, zoals openbare rapportages, certificering en verificatie. Tot nu toe is er echter beperkt inzicht in het proces van het formuleren van ambitieuze doelstellingen voor energie-efficiëntie verbetering of het terugdringen van de uitstoot van broeikasgassen binnen deze programma's, in de gevolgen van de invoering van dergelijke programma's op de verbetering van het energiemanagement, en in de impact van deze programma's op energiebesparing of de vermindering van de uitstoot van broeikasgassen. De centrale onderzoeksvraag van dit proefschrift is als volgt geformuleerd:

"Wat is de impact van energie- en broeikasgasmanagement programma's op het verbeteren van het energiemanagement in de praktijk, het versnellen van de energie-efficiëntie verbetering en het beperken van de uitstoot van broeikasgassen in bedrijven?".

In dit proefschrift worden de eerste generatie van de Meerjarenafspraken voor energie-efficiëntie verbetering in Nederland en de CO_2 Prestatieladder bestudeerd als twee verschillende casussen van programma's voor energie- en broeikasgasmanagement. De Meerjarenafspraken voor energie-efficiëntie verbetering zijn op maat gemaakte convenanten tussen het Ministerie van Economische Zaken en industriële sectoren, gericht op energiebesparing in het productieproces van energie-intensieve bedrijven. De CO_2 Prestatieladder is een certificeringsprogramma voor energie- en broeikasgasmanagement in Nederland, waar vooral niet-industriële bedrijven aan deelnemen. Deelname kan bedrijven bepaalde competitieve voordelen geven bij de aanbesteding van opdrachten.

De resterende delen van dit hoofdstuk vatten de hoofdstukken in dit proefschrift één voor één samen. In de laatste paragraaf worden de algemene conclusies getrokken.

7.2 SMART geformuleerde doelstellingen voor industrieel energiegebruik en industriële energie-efficiëntie

Het vastleggen van doelstellingen is vaak een belangrijk element in het industriële energiebeleid, met inbegrip van programma's voor energie- en broeikasgasmanagement. Een scala van kenmerken onderscheidt deze doelstellingen van elkaar, zoals de actoren die betrokken zijn bij het bepalen van de doelstelling, het bindende karakter van de doelstelling (bindend, semi-bindend, vrijwillig), de organisatorische grens (scope en dekking), de lengte van de verbintenisperiode, het type basisjaar (vast of rollend), de categorie en het type doelstelling, etc.

Het primaire doel van hoofdstuk 2 was het ontwikkelen van een taxonomie voor het categoriseren van verschillende soorten SMART geformuleerde doelstellingen voor het beperken van het industriële energiegebruik of de broeikasgasemissies. De taxonomie omvat: volume doelstellingen (ook bekend als absolute doelstellingen); doelstellingen voor de fysieke energie-efficiëntie en economische energie intensiteit (beide bekend als relatieve doelstellingen); en economische doelstellingen. Volume doelstellingen schrijven voor dat een bedrijf of een sector het totale energieverbruik of de uitstoot van broeikasgassen beperkt tot een vooraf bepaald niveau of dat het energiegebruik of de uitstoot van broeikasgassen wordt verminderd met een bepaald percentage ten opzichte van een basisjaar. Doelstellingen voor de fysieke energie- of broeikasgasefficiëntie schrijven voor dat bedrijven het energiegebruik (of de uitstoot van broeikasgassen) per eenheid fysieke productie beperken tot een vooraf bepaalde waarde of dat het energiegebruik (of de uitstoot van broeikasgassen) per eenheid fysieke productie met een bepaald percentage wordt verbeterd ten opzichte van business-as-usual of een basisjaar. Doelstellingen voor de economische energie- of broeikasgasintensiteit schrijven voor dat bedrijven het energiegebruik (of de uitstoot van broeikasgassen) per eenheid economische activiteit beperken tot vooraf bepaalde waarde of dat het energiegebruik (of de uitstoot van broeikasgassen) per eenheid economische activiteit met een bepaald percentage wordt verbeterd ten opzichte van business-as-usual of een basisjaar. De economische activiteit kan worden uitgedrukt in termen van de waarde van de productie, toegevoegde waarde, de omzet of de verkoop. Economische doelstellingen houden rekening met de kosten en baten van energiebesparende investeringen, en helpen daarmee de financiële lasten voor de bedrijven en de maatschappij te definiëren. We onderscheiden doelstellingen die rekening houden met de winstgevendheid van de investeringen, de specifieke kosten van de investering en de totale omvang van de investering.

Hoofdstuk 2 biedt ook een uitgebreid overzicht van het gebruik van doelstellingen voor industrieel energiebesparing of broeikasgasemissiereductie op sector- of bedrijfsniveau in voormalig, huidig, en toekomstig beleid. Dit overzicht bevat ongeveer 50 verschillende systemen voor milieuvergunningen, systemen voor emissiehandel, en programma's voor de beperking van het energieverbruik en of broeikasgasuitstoot (inclusief vrijwillige afspraken of convenanten).

Tenslotte bevat hoofdstuk 2 een evaluatie van de verschillende soorten doelstellingen. De doelstellingen worden daarbij vergeleken met betrekking tot de zekerheid van het milieuresultaat en de nalevingskosten, de relevantie van de doelstelling voor de maatschappij en voor de industrie, de milieu-integriteit, evenals de complexiteit en het potentieel voor onderlinge vergelijking. Volume doelstellingen staan garant voor een (relatief) zeker milieuresultaat, hebben hoge maatschappelijke relevantie en zijn niet zo complex als andere soorten doelstellingen. Doelstellingen voor fysieke energie-efficiëntie leiden tot verbetering van de milieu kwaliteit met een

hoge mate van integriteit, maken (internationale) vergelijking van de milieuprestaties tussen bedrijven of sectoren mogelijk en hebben een hoge relevantie voor de industrie. Economische doelstellingen combineren verschillende voordelen zoals een hoge mate van milieu-integriteit, een hoge zekerheid van de nalevingskosten en een hoge relevantie voor de industrie. Doelstellingen voor de economische energie intensiteit hebben geen duidelijke voordelen ten opzichte van andere type doelstellingen.

7.3 Het formuleren van CO_2 reductiedoelstellingen in de CO_2 Prestatieladder

Energie- en broeikasgasmanagement programma's, zoals de CO_2 Prestatieladder, worden in toenemende mate door de bedrijven geïmplementeerd als een antwoord op klimaatverandering. Deze programma's vragen vaak van bedrijven dat ambitieuze doelstellingen voor de vermindering van de uitstoot van broeikasgassen worden geformuleerd. Echter, er is slechts beperkt empirisch inzicht in de wijze waarop dit precies gebeurt. Hoofdstuk 3 beantwoordt daarom de vraag 'In hoeverre leidt de huidige manier waarop doelstellingen worden geformuleerd in de CO_2 Prestatieladder ook daadwerkelijk tot ambitieuze CO_2 emissiereductie doelstellingen?'. Een exploratief onderzoeksontwerp werd gebruikt als de belangrijkste aanpak voor deze studie. De gegevens zijn verzameld middels interviews met relevante belanghebbenden, documentonderzoek van het certificeringsschema en de monitoringrapporten voor broeikasgasemissies.

Als eerste laat het onderzoek zien dat een aantal certificatie-eisen voor het formuleren van CO_2 emissiereductiedoelstellingen niet erg goed zijn gedefinieerd. Als gevolg daarvan is er onder de diverse belanghebbenden (bedrijven, certificerende instanties, programma-eigenaar, en externe adviseurs) geen volledig geharmoniseerde interpretatie van de exacte verplichtingen in het programma. Vervolgens laat het onderzoek zien dat de doelstellingen voor CO_2 emissiereductie nog niet erg ambitieus zijn, bijvoorbeeld omdat de vermindering van de CO_2 uitstoot nog geen aanzienlijke inspanningen hebben gevraagd van bedrijven; omdat bedrijven de neiging hebben om risico's van onderpresteren te vermijden; omdat het concept van beste beschikbare technieken niet gebruikt wordt als leidraad voor het bepalen van ambitieuze doelstellingen; en omdat een aantal doelstellingen waarschijnlijk toch gehaald gaan worden, zelfs zonder de CO_2 Prestatieladder. Tenslotte geeft het onderzoek inzicht in de manier waarop doelstellingen voor CO_2 emissiereductie worden beoordeeld door onafhankelijk certificerende instanties. Er blijkt een semigestructureerde procedure te bestaan onder de certificerende instanties voor het evalueren van doelstellingen voor de beperking van de uitstoot van broeikasgassen. Echter, de uiteindelijke beoordeling of de doelstellingen voldoende ambitieus zijn, is niet goed gedefinieerd. De externe beoordeling van de doelstellingen bleek bovendien niet altijd gebaseerd op de volledige set van criteria die expliciet vermeld staan in de eisen van het programma.

Algemeen kunnen we daarom concluderen dat de huidige manier waarop doelstellingen in de CO_2 Prestatieladder worden geformuleerd en vastgesteld niet noodzakelijkerwijs leidt tot de meest ambitieuze doelen voor het terugdringen van broeikasgassen. Andere methoden voor het vaststellen van doelstellingen, zoals minimale prestatieniveaus, moet worden overwogen, om de CO_2 Prestatieladder te handhaven als een deugdelijk instrument voor duurzame aanbesteding.

7.4 Het beoordelen van de potentiële impact van de CO_2 Prestatieladder op de vermindering van de kooldioxide-uitstoot in Nederland

De CO_2 Prestatieladder is een certificeerbare norm voor energie- en broeikasgasmanagement die ook kan worden gebruikt als instrument voor duurzaam aanbesteden. Duurzame aanbesteding van projecten wordt vaak gezien als een effectief instrument voor het verminderen van het energiegebruik en de CO_2 uitstoot in de keten van de opdrachtgevers. De vraag is of dit soort instrumenten voor duurzame aanbesteding ook daadwerkelijk bij kunnen dragen aan de vermindering van CO_2 uitstoot in Nederland. De onderzoeksvraag in hoofdstuk 4 is daarom: 'Wat is de potentiële impact van de CO_2 Prestatieladder op de vermindering van de CO_2 uitstoot in Nederland?'. Het onderzoek gebruikt verschillende methoden en technieken voor de ex-ante effectbeoordeling van energie- en klimaatbeleid. De gegevens zijn afkomstig van documenten, zoals CO_2 voetafdrukken, energiemanagementplannen, voortgangsrapportages en milieu-statistieken.

Op het moment van het onderzoek namen meer dan 190 bedrijven deel aan de CO_2 Prestatieladder (halverwege 2015 zijn dat er meer dan 650). Het merendeel van deze bedrijven behoorden tot de bedrijfstak bouwnijverheid. De CO_2 uitstoot van deze bedrijven is tenminste 1,7 miljoen ton, wat overeenkomt met bijna 1% van de nationale emissies van broeikasgassen in Nederland. De CO_2 uitstoot omvat de directe CO_2 uitstoot, de indirecte CO_2 uitstoot van ingekochte elektriciteit, warmte en stoom en de indirecte CO_2 uitstoot van personenauto's gebruikt voor zakelijke reizen. Bedrijven die meedoen aan de CO_2 Prestatieladder hebben verschillende type CO_2 reductiedoelstellingen geformuleerd met uiteenlopende ambitieniveaus. De drie belangrijkste type doelstellingen voor vermindering van de CO_2 uitstoot zijn volume doelstellingen voor de reductie van CO_2 uitstoot, doelstellingen voor de economische energie intensiteit die CO_2 emissie afzetten tegen de omzet, en relatieve doelstellingen die CO_2 uitstoot afzetten tegen het aantal voltijd medewerkers (FTE), gewerkte uren of productieve uren. Doelstellingen voor de fysieke energie-efficiëntie worden door zeer weinig bedrijven gebruikt. Tabel 7.1 toont het gemiddeld gewogen ambitieniveau van de drie meest voorkomende type doelstellingen. Vervolgens zijn diverse business-as-usual scenario’s ontwikkeld die de omzet en de werkgelegenheid in de bouwnijverheid prognosticeren. Op basis van deze prognoses is een raming gemaakt van de netto jaarlijkse verandering van de CO_2 uitstoot in de veronderstelling dat bedrijven volledig voldoen aan de CO_2 reductiedoelstellingen, zie tabel 7.1.

Tabel 7.1: Gemiddeld gewogen ambitieniveau en geraamde netto jaarlijkse verandering in de CO_2 uitstoot in vergelijking met het basisjaar 2010 voor drie type doelstellingen

Type doelstelling	Gemiddeld gewogen ambitieniveau	Geraamde netto jaarlijkse verandering van de CO_2 uitstoot		
		Gemiddeld	Hoog	Laag
CO_2	-2,1%		-2,1%	
CO_2/FTE	-2,8%	-2,2%	-1,5%	-2,5%
CO_2/€ omzet	-2,0%	1,0%	2,2%	0,3%
Totaal		-1,3%	-0,8%	-1,5%

Het potentiële effect van de CO_2 Prestatieladder op het verminderen van de CO_2 uitstoot wordt geraamd tussen 0,8%/jaar en 1,5%/jaar, met een meest waarschijnlijke waarde van 1,3%/jaar. De CO_2 Prestatieladder kan daarom een belangrijke bijdrage leveren aan de jaarlijkse CO_2 emissiereductie (-1,4%/jaar in de periode 2010-2020) die nodig is om onder het Nederlands emissieplafond te blijven voor de sectoren die niet deel uit maken van het Europese CO_2 emissiehandelssysteem. In absolute termen is de potentiele bijdrage van de CO_2 Prestatieladder aan het behalen van de klimaatdoelstelling voor bedrijven die niet deel uit maken van het Europese CO_2

emissiehandelssysteem nog niet erg groot, omdat op dit moment slechts een klein deel van de CO_2 emissies van deze sectoren onder de CO_2 Prestatieladder valt.

7.5 De impact van de CO_2 Prestatieladder op verbetering van energie- en broeikasgasmanagement in bouwnijverheidsbedrijven

Energie- en broeikasgasmanagement programma's, zoals de CO_2 Prestatieladder, worden geïmplementeerd om de continue verbetering van energie-efficiëntie en broeikasgasprestatie in de bedrijven te faciliteren. Onder de 500 deelnemende bedrijven (halverwege 2015 zijn dat er meer dan 650), voornamelijk afkomstig uit de bouwnijverheid, wordt de CO_2 Prestatieladder vaak beschouwd als de belangrijkste stimulans voor verbetering van de energie-efficiëntie en CO_2 emissiereductie. Hoofdstuk 5 gaat in op de vraag: 'Wat is de impact van de CO_2 Prestatieladder op verbetering van energie- en broeikasgas management in bouwnijverheidsbedrijven'. Het onderzoek is voornamelijk gebaseerd op interviews, analyses van de energiebesparings- en CO_2 emissiereductie-maatregelen en kwantitatieve analyse van de vermindering van de CO_2 uitstoot.

Deze studie toont aan dat de CO_2 Prestatieladder het energiemanagement op een groot aantal vlakken heeft gestimuleerd, zoals een sterker commitment van het topmanagement, een verhoogde prioriteit voor energievraagstukken, een verbeterde Plan-Do-Check-Act cyclus voor energiebeheer, een verbeterd inzicht in de CO_2 uitstoot, prestaties en reductieopties, en een toegenomen energiebewustzijn onder de medewerkers. Diverse barrières voor energiebesparing zijn hiermee overwonnen. De CO_2 Prestatieladder heeft vooral het energiemanagement op administratief vlak verbeterd, terwijl de uitvoering van energiemanagement op lagere niveaus in de organisatie maar pas is begonnen. Bedrijven hebben verschillende CO_2 emissiereductiemaatregelen genomen die kunnen worden gecategoriseerd in maatregelen voor groene mobiliteit, groene stroom, energie-efficiënt (gebruik van) materieel, efficiëntere productie van materialen, energiebesparing in gebouwen, hernieuwbare energiebronnen en andere maatregelen. Bedrijven hebben vooral maatregelen genomen die de ondersteunende bedrijfsprocessen beïnvloeden in plaats van de kernprocessen van het bedrijf. De CO_2 Prestatieladder heeft vooral de inkoop van groene elektriciteit gestimuleerd en de invoering van verschillende gedragsmaatregelen voor energiebesparing en CO_2 emissiereductie. In de afgelopen 4-5 jaar is de CO_2 uitstoot gedaald met 5,1%/jaar. Dat is veel meer dan de verwachte impact van de CO_2 Prestatieladder op CO_2 emissiereductie (0,8-1,5%/jaar) berekend in hoofdstuk 3. Het grote verschil is toe te schrijven aan de gunstige economische vooruitzichten die zijn gebruikt in hoofdstuk 3 ten opzichte van de werkelijke economische teruggang in de afgelopen jaren. Echter, indien rekening wordt gehouden met CO_2 emissiereducties als gevolg van de economische teruggang in de afgelopen jaren, lijkt de CO_2 Prestatieladder nog steeds de CO_2 emissiereductie onder de deelnemende bedrijven te hebben versterkt.

Algemeen kunnen we concluderen dat, gedreven door de mogelijke voordelen in aanbestedingsprocedures, de CO_2 Prestatieladder verantwoordelijk is voor een sterke verschuiving naar een meer volwassen vorm van energiemanagement onder de bedrijven in de bouwnijverheid, die anders niet zou hebben plaatsgevonden.

7.6 Versnellen Meerjarenafspraken energie-efficiëntie verbetering?

Energieconvenanten tussen overheid en industrie worden vaak gezien als een veelbelovend en (kosten)-effectief alternatief voor traditionele regelgeving. Het is echter nog niet bekend of dergelijke convenanten ook daadwerkelijk de energie-

efficiëntie verbeteren. In hoofdstuk 6 bestuderen we daarom de Meerjarenafspraken over energie-efficiëntie, die al decennialang een belangrijk beleidsinstrument voor energiebesparing in Nederland zijn. We gaan in op de vraag: 'Wat is de impact van de Meerjarenafspraken op de energie-efficiëntie verbetering in Nederland'. In dit hoofdstuk richten we ons specifiek op de eerste generatie van de Meerjarenafspraken over energie-efficiëntie in Nederland uit de periode 1992-2000. Deze Meerjarenafspraken waren een van de eerste voorbeelden van energieconvenanten tussen overheid en industrie in de wereld. De eerste generatie Meerjarenafspraken zou later nog worden gevolgd door nieuwe meerjarenafspraken over energiebesparing. Het onderzoek is gebaseerd op verschillende methodieken voor effectbeoordeling van energie- en klimaatbeleid. De gegevens werden voornamelijk verzameld uit de monitoringrapportages en interviews.

In dit hoofdstuk worden twee methoden (bottom-up en top-down) ontwikkeld om de impact van de Meerjarenafspraken over energie-efficiëntie te isoleren. De eerste bottom-up methode isoleert de impact van de Meerjarenafspraken door een inschatting te maken van de additionele energiebesparingsinvesteringen en de daarbij behorende energiebesparing. De energiebesparingsmaatregelen (en bijbehorende besparingen) worden daartoe eerst ingedeeld in één van de volgende categorieën (met tussen haakjes het aandeel in de totale energiebesparing): good housekeeping maatregelen (9%), vervangingsinvesteringen (32%), energie-efficiëntie of retrofit maatregelen (18%), warmtekrachtkoppeling (22%) en andere maatregelen (22%). Vervolgens is zowel door deskundigen als bedrijven beoordeeld in hoeverre verschillende categorieën energiebesparingsinvesteringen zijn gestimuleerd door de Meerjarenafspraken. Er is bijvoorbeeld beoordeeld dat retrofit maatregelen in ‘sterke mate’ zijn gestimuleerd door Meerjarenafspraken, terwijl vervangingsinvesteringen maar in ‘beperkte mate’ zijn aangemoedigd door de Meerjarenafspraken. Door weegfactoren toe te kennen aan de verschillende ‘mate van stimulering’ kon tenslotte de gestimuleerde energiebesparing per categorie worden berekend en daarmee de totale impact van de Meerjarenafspraken op de verbetering van de energie-efficiëntie. De alternatieve top-down methode isoleert de impact van de meerjarenafspraken door de bereikte energie-efficiëntie verbetering (-2,1%/yr in de periode 1989-1998) te vergelijken met de energie-efficiëntie verbetering in het business-as-usual scenario (0,9%/jaar – 1,6%/jaar). De energie-efficiëntie verbetering van in business-as-usual scenario is vastgesteld op basis van modelsimulaties.

De belangrijkste conclusie is dat tussen een kwart en de helft van de energiebesparing in de Nederlandse industrie kan worden toegeschreven aan de Meerjarenafspraken. Met andere woorden, de mate van verbetering van de energie-efficiëntie is toegenomen met 33-100% in vergelijking met een situatie waarin er geen Meerjarenafspraken zouden zijn geweest.

7.7 Algemene conclusies

De algemene conclusies met betrekking tot de drie onderzoeksvragen in dit proefschrift zijn de volgende:

1. *Hoe kunnen ambitieuze doelstellingen voor verbetering van de energie-efficiëntie en de beperking van de uitstoot van broeikasgassen in programma's voor energie- en broeikasgasmanagement worden vastgesteld?*

Het bepalen van uitdagende doelen voor het verbeteren van de energie-efficiëntie of het verminderen van de uitstoot van broeikasgassen vereist duidelijk omschreven

richtlijnen. Procedures voor het formuleren van doelstellingen waarbij goed gedefinieerde concepten, eisen en duidelijke beoordelingskaders voor het evalueren van het ambitieniveau ontbreken, leiden niet tot de meest ambitieuze doelstellingen en moeten daarom worden vermeden. De wijze waarop CO_2 reductiedoelstellingen in het kader van de CO_2 Prestatieladder worden vastgesteld is in dit opzicht een duidelijk voorbeeld van wat juist niet zou moeten worden gedaan als wordt gestreefd naar ambitieuze doelstellingen.

Energie- en broeikasgasmanagement programma's moeten daarom gebruik maken van methoden voor het vaststellen van doelstellingen die beter aansluiten bij de voorgestelde criteria voor 'ambitieuze doelstellingen': doelstellingen moeten aanzienlijk verder gaan dan business-as-usual projecties; moeten worden afgestemd op klimaatdoelstellingen; moeten gebaseerd zijn op het gebruik van de best beschikbare technieken; en moeten een aanzienlijke inspanning in economisch of financieel opzicht eisen (WRI, 2013; Edvardsson-Björnberg, 2013). Dit houdt in dat de doelstellingen bijvoorbeeld minimale prestatieniveaus zouden moeten bevatten (Scheihing et al., 2013), dat ze volgen uit een 'science-based' aanpak voor reductiedoelstellingen (Krabbe et al., 2015), of dat ze zijn gebaseerd op de benchmarking van energiebesparingsmaatregelen (SKAO, 2015), of dat de uitvoering van rendabele energiebesparende maatregelen wordt geëist (Agentschapnl, 2013). Echter, dit soort typen doelstellingen hebben natuurlijk ook nadelen, zoals bijvoorbeeld de handhaafbaarheid, zie CE et al. (2011).

Er is een grote verscheidenheid aan kwantitatieve doelstellingen voor de verbetering van de energie-efficiëntie en het terugdringen van de uitstoot van broeikasgassen, waaronder absolute doelstellingen, relatieve doelstellingen en economisch gerelateerde doelstellingen. Vaak wordt gesuggereerd dat bij relatieve doelstellingen de onzekerheid in de nalevingskosten voor de bedrijven wordt gereduceerd in vergelijking met absolute doelstellingen, wat weer kan leiden tot meer ambitieuze doelstellingen (van Vuuren et al., 2002). In deze studie vonden we dat dit geldt voor CO_2 emissiereductiedoelstellingen gerelateerd aan de input van arbeid. CO_2 emissiereductiedoelstellingen gerelateerd aan de omzet (die een meer algemeen gebruikte indicator is voor het meten van de bedrijfsactiviteit), blijken daarentegen minder ambitieus te zijn (dat wil zeggen: hebben een lagere impact) dan absolute doelstellingen.

2. Wat is de impact van energie- en broeikasgasmanagement programma's op het verbeteren van energie- en broeikasgasmanagement in de praktijk?

Programma's voor energie- en broeikasgasmanagement kunnen het energiemanagement in de praktijk aanzienlijk verbeteren, zoals sterker commitment van het top management, een verhoogde prioriteit voor energievraagstukken, verbeterde gecoördineerde acties, beter inzicht in de CO_2 uitstoot, prestaties en besparingsmogelijkheden, en het vaststellen van energie-efficiëntie en CO_2 emissiereductiedoelstellingen. Deze programma's zijn dus zeker een extra impuls voor energie-efficiëntie verbetering en broeikasgasemissiereductie ten opzichte van bestaande beleidsinstrumenten, milieucertificeringen of maatschappelijke aandacht voor energie en klimaat.

In het algemeen zijn de conclusies in overeenstemming met de bestaande literatuur over de effecten van energie- en broeikasgasmanagement programma's, zie bijvoorbeeld Backlund et al. (2012), Krarup en Rahmesohl (2002), Stenqvist et al. (2011), Kimura & Noda (2014), Harrington et al. (2014). Al deze studies rapporteren

positieve effecten van de invoering van dergelijke energie- en broeikasgasmanagement programma's op de verbetering van het energiemanagement in de praktijk in voornamelijk industriële sectoren. Onze studie voegt dus toe dat dergelijke programma's ook voor niet-industriële bedrijven een serieus effect kunnen hebben op de verbetering van het energiemanagement.

Echter, een sterke prikkel, zoals het potentiële voordeel bij aanbestedingen, is noodzakelijk als drijvende kracht voor een blijvende aandacht voor energiemanagement. Deze laatste bevindingen bevestigen eerdere observaties van bijvoorbeeld Krarup & Rahmesohl (2002), Rezessy & Bertoldi (2011) en Reinaud et al. (2012) over de noodzaak om energiemanagementsystemen in te bedden in bredere energiemanagement programma's (waaronder vrijwillige energieconvenanten) om effectief te zijn.

Verder hebben we gevonden dat energie- en broeikasgasmanagement programma's de invoering van aanvullende energiebesparende maatregelen op tenminste de korte tot middellange termijn kunnen stimuleren. De additionaliteit die wordt geschat op 25-50%, wordt bevestigd door andere studies, zie bijvoorbeeld Ericsson (2006), Cahill & Gallachóir (2012), Stenqvist & Nilsson (2012), Ecorys (2013). Met name de inkoop van groene elektriciteit en de invoering van verschillende gedragsmaatregelen voor energie-efficiëntie en CO_2 emissiereductie zijn gestimuleerd in de onderzochte bedrijven. In onze studie vonden we dat het merendeel van de uitgevoerde maatregelen relatief eenvoudige en goedkope energiebesparende maatregelen zijn die betrekking hebben op de ondersteunende bedrijfsprocessen in plaats van de meer uitdagende energiebesparende maatregelen in de kernprocessen van de bedrijven. Deze resultaten zijn moeilijk te vergelijken met andere studies, die niet zo'n gedetailleerde uitsplitsing van energiebesparende maatregelen hebben gebruikt of die betrekking hebben op andere sectoren.

Op de langere termijn, valt echter nog te bezien of energiemanagement programma's ook het energiemanagement dieper in de organisatie kan verinnerlijken, waarbij energiemanagement dus verder gaat dan het bestuurlijk niveau of dat de focus vooral ligt op procedurele conformiteit zoals vaak wordt gesuggereerd in het kader van de milieuaudits, zie bijvoorbeeld Boiral (2007), Heras-Saizarbitoria et al. (2013). Gerichte onafhankelijk controle audits zijn nodig om te garanderen dat het ingevoerde energiemanagement ook verder gaat dan het bestuurlijke en administratieve niveau van het bedrijf. Het alternatief is dat programma-eigenaren of regelgevende instantie sterker sturen op het bereiken van doelstellingen voor de verbetering van de energie-efficiëntie en CO_2 emissiereductie.

3. Wat is de impact van energie- en broeikasgasmanagement programma's op de verbetering van de energie-efficiëntie en de vermindering van de uitstoot van broeikasgassen?

Programma's voor energie- en broeikasgasmanagement kunnen een impact hebben op de verbetering van de energie-efficiëntie en het terugdringen van broeikasgassen. In de energie- en broeikasgasmanagement programma's die in deze studie zijn onderzocht vonden we dat zowel de energie-efficiëntie verbetering als de relatieve vermindering van de CO_2 uitstoot worden versneld met 0,3%/jaar - 1,0%/jaar bovenop autonome verbeteringen. Dergelijke programma's voor energie- en broeikasgasmanagement kunnen daarmee een belangrijke bijdrage leveren aan het bereiken van nationale energie- en klimaatdoelstellingen. Echter, deze waarden voor de verbetering van de energie-efficiëntie zijn niet voldoende om de energie-

efficiëntieverbetering te verdubbelen. Dat wordt namelijk nodig geacht om de wereldwijde temperatuurstijging te beperken tot niet meer dan 2 graden (Rogelj et al., 2013). De geschatte relatieve CO_2 emissiereductie (1,3%/jaar) is ook verre van voldoende om sectorspecifieke trajecten voor de beperking van de CO_2 intensiteit te volgen die nodig zijn voor het stabiliseren van de uitstoot van broeikasgassen in de atmosfeer tot ongeveer 450 ppm in 2050. Het sectorspecifiek CO_2 intensiteit traject voor de categorie 'andere industriële sectoren', dat ook de bouw en civiele sector bevat, vereist meer dan 5%/jaar vermindering van de CO_2 intensiteit in de periode 2015 tot 2050 (Krabbe et al., 2015). De impact van deze programma's zal daarom verder moeten worden versterkt, bijvoorbeeld door aanpassing van de CO_2 emissiereductiedoelstellingen aan wereldwijde klimaatdoelstellingen (Krabbe et al., 2015), door het betrekken van de bedrijven in de keten in het verminderen van de CO_2 uitstoot (Reinaud et al., 2012), en een sterkere regulerende dreiging wanneer doelstellingen niet worden nageleefd (Price, 2005; Rezessy & Bertoldi, 2011).

Over het geheel genomen kan worden geconcludeerd dat op de korte tot middellange termijn programma's voor energie- en broeikasgasmanagement een effectief instrument kunnen zijn voor de verbetering van energiemanagement in de praktijk, het stimuleren van het nemen van extra besparingsmaatregelen, en het versnellen van energie-efficiëntie verbetering en het terugdringen van de uitstoot van broeikasgassen. Om een grotere impact van dit soort programma's op langere termijn te kunnen garanderen is het noodzakelijk dat deze programma's vergezeld gaan met duidelijke procedures voor het bepalen van ambitieuze doelstellingen voor de verbetering van de energie-efficiëntie of de vermindering van de uitstoot van broeikasgassen; dat uitdagende prikkels en ondersteunende maatregelen aanwezig zijn; en dat controle procedures voor de naleving van energiemanagement helder en effectief zijn.

7.8 Slotopmerkingen

- Vanuit methodisch oogpunt heeft dit proefschrift bijgedragen aan de literatuur door de ontwikkeling van een bottom-up methode voor de evaluatie van de impact van energie- en broeikasgasmanagement programma's. Beoordelingen van het programma effect zijn gebaseerd op de geschatte additionaliteit van individuele energiebesparingsmaatregelen en hun energiebesparing. Hoewel dergelijke methoden ook kunnen worden bediscussieerd, bijvoorbeeld omdat de ingeschatte additionaliteit bevooroordeeld kan zijn, zijn deze methoden toch een belangrijke aanvulling op de bestaande top-down evaluatie methoden.
- In deze studie zijn de resultaten en effecten van de eerste generatie van de Meerjarenafspraken over energie-efficiëntie in Nederland in de periode 1992-1998 geëvalueerd. Meer recente voortgangsrapportage van de nieuwere Meerjarenafspraken laten zien dat de verbetering van de energie-efficiëntie in het productieproces in dezelfde sectoren als onderzocht in deze studie op een vergelijkbaar niveau bleef van 1,8%/jaar in de periode 1998-2007, maar daalde tot 1,3%/jaar in de periode 2009-2013 (RVO, 2014, SenterNovem, 2008). Meer recent zijn ook de tweede en derde generatie van de Meerjarenafspraken over energie-efficiëntie geëvalueerd (Ecorys, 2013; Arentsen, 2004). Volgens Ecorys (2013) schrijven deelnemers aan de Meerjarenafspraken 60% van de energiebesparing toe aan het convenant. Echter, volgens Ecorys (2013) is deze bijdrage overschat omdat volgens de deelnemers 60-80% van de maatregelen ook zouden zijn genomen zonder de Meerjarenafspraken. Arentsen (2004)

concludeert dat de Meerjarenafspraken een additionele effect hebben van 1.4%/jaar aan energiebesparing wanneer energie-efficientie verbetering van de deelnemende sectoren wordt vergeleken met de binnenlandse energie-efficientie verbetering in de periode 1989-2002.

7.9 Aanbevelingen voor verder onderzoek

Op basis van de resultaten in dit proefschrift bevelen we de volgende routes aan voor verder onderzoek om het begrip van energie- en broeikasgasmanagement programma's nog verder te verbeteren:

- De vergelijking van energie- en broeikasgasmanagement programma's blijft lastig vanwege verschillen in het ontwerp, verschillende type doelstellingen en rapportage-eisen, zie bijvoorbeeld Rezessy & Bertoldi (2011) voor een overzicht van de resultaten en effecten van verschillende vrijwillige energiebesparingsconvenanten. Onderzoek naar de impact van energie- en broeikasgasmanagement programma's blijkt ook niet altijd vergelijkbaar te zijn omdat verschillende evaluatiemethoden, instrumenten en indicatoren werden gebruikt, variërend van eenvoudige vragenlijsten, diepte-interviews (beiden gebruikt in onze studie), tot meer uitgebreide 'energy maturity' matrices en zelfs vragenlijsten met meer dan 100 items (zie bijvoorbeeld Backlund et al., 2012; Carbon Trust, 2011; Harrington et al., 2014). Zeer lange vragenlijsten om de impact te meten zijn in dit opzicht niet erg geschikt voor grootschalig onderzoek die een hoge respons eisen. We kunnen verder leren van een onderlinge vergelijking van programma's, met behulp van een meer geharmoniseerde onderzoeksaanpak voor het evalueren van de effecten van energiemanagement programma's. Wij adviseren daarom een dergelijk gestandaardiseerde methode te ontwikkelen en een vergelijkend onderzoek uit te voeren naar de impact van verschillende energiemanagement programma's op de verbetering van het energiemanagement in de praktijk, de succes- en faalfactoren van dergelijke programma's en de kosteneffectiviteit.
- In deze studie hebben we alleen gekeken naar de effecten van energie- en broeikasgasmanagement programma's op het verbeteren van het interne energiemanagement, de energie-efficiëntie en CO_2 emissiereductie. Echter, het potentieel voor verbetering van de energie-efficiëntie en CO_2 emissiereductie in de keten is waarschijnlijk veel groter. Tot nu toe dit is een vrij onontgonnen onderwerp, met uitzondering van studies zoals Ecofys (2012) en DHV (2009). Wij adviseren daarom het gebruik van energiemanagement (systemen) om de CO_2 uitstoot in de keten te verminderen verder te bestuderen, waarbij vooral de nadruk zou moeten liggen op het effect in termen van CO_2 emissiereductie ten opzichte van het ontwerp van deze keteninitiatieven (zie IIP/Ecofys (2012) voor diverse keteninitiatieven ter bevordering van energiebesparing en broeikasgasemissiereductie). De CO_2 Prestatieladder zou hier kunnen dienen als een case study, omdat de CO_2 Prestatieladder ook expliciet eisen stelt aan ketensamenwerking.
- Een vraag die ook meer aandacht behoeft in toekomstig onderzoek is hoe de impact van energie- en broeikasgasmanagement binnen bedrijven kan worden gecontinueerd. Daarom stellen wij voor om de relatie tussen energiemanagement en de barrières voor verbetering van de energie-efficiëntie in meer detail te bestuderen. Een dergelijke studie zou met vruchtbare

voorstellen kunnen komen om meer effectieve energiemanagement programma's te ontwerpen.

- In relatie tot de vorige aanbeveling stellen we ook voor om toekomstig onderzoek te richten op de vraag hoe goed energiemanagement verder kan worden geinternaliseerd binnen de bedrijfsorganisatie. Het meeste onderzoek was tot nu toe gericht op het analyseren van vooral administratieve, organisatorische en technische aspecten van energiemanagement. Echter, energiemanagement betreft ook gedragsverandering die nodig is voor de continue verbetering van de energieprestaties van het bedrijf. Toekomstig onderzoek moet zich richten op de vraag hoe medewerkers op verschillende niveaus in het bedrijf effectief kunnen worden betrokken bij energiemanagement (systemen) om tastbare resultaten op de lange termijn te bereiken. Diepgaande case studies zouden bijvoorbeeld kunnen worden uitgevoerd bij bedrijven, waarbij een breed scala van verschillende actoren wordt betrokken.

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Acknowledgements

It took a while, but now it's finally done. It has been hard work over a long period of time, but nevertheless it has been a satisfactorily job. Although writing this thesis has predominantly been an individual effort, it would not have possible without the inputs of other people. First and far most important, I would like to thank my promotor Kornelis Blok. Kornelis, you have undoubtedly played a key role in the development of my academic career. Thank you for putting confidence in me from the beginning until the end when writing this thesis; for all the things I learned from you; and for reviewing earlier versions of my thesis chapters. Ivo, you joined later as the supervising 'Hogeschool Professor', but despite that many thanks for your critical inputs.

I am also grateful to SKAO, in particular Gijs Termeer, for giving me the opportunity to investigate 'their' CO_2 Performance Ladder. Without their close co-operation it would have been rather difficult to get all stakeholders closely involved in the research. But even then, without the willingness of numerous interviewees, large parts of this thesis would not have been possible to investigate. So therefor, I am indebted to all interviewees for their co-operation.

Over the past years I have had so many colleagues at the Utrecht University and the Hogeschool Utrecht, so it is practically impossible to thank them all in person. Therefor: a generally addressed, but sincere 'thank-you' for your (administrative) support, scientific inputs (incl. co-authoring), and providing the right working atmosphere. Erlijn, a special 'thank you' for involving me in such inspiring projects at the Hogeschool Utrecht, that, I must admit, distracted me from writing this thesis sometimes.

During the past years I also got the challenging opportunity to develop my professional teaching skills. I therefore would to thank students from MEM EPCEM, MSc. Energy Science, MSc. Sustainable Development - Energy & Resources, B.Eng Algemene Operationele Techniek, for the inspiring time in education. Thereby, I especially would like to thank all students that contributed to the content of this thesis.

And then there are a few friends that I want to thank in person for their support, without neglecting the role of others. Rob, thank you for all your concerns, mental support and inexhaustible positive mood. You know how to do it, so guide me there! Arjan, thank you for your scientific inputs, especially on the statistical research work, that really strengthened the quality of this thesis. Ivan, after your PhD, we both raised families far away from each other, but bonds remained strong. The many holidays that we had with our families were a real necessity to recuperate from the research work. Ferry, thanks for all the thousands of running kilometres in the Amelisweerd forests; it has been the perfect way to relax, blow off steam and discuss all other important things in life. There is just a few more steps to take and we will do that together. Noel, thank you for igniting my interest in interdisciplinary environmental policy research ("the Vistula is on my mind"), but moreover for all other thrilling experiences in the past decades.

Finally, I would like thank my parents for their life-long support, and papa … I know you would be proud. Florus & Otto, my two beautiful, brave and beloved kids, please remember that there is no such thing as a free lunch in life! Wendy, thank you for all your endless love, priceless patience, and unconditional support during this long journey. Let's move on!

Curriculum Vitae

Martijn Rietbergen was born in Nijmegen (1972), the Netherlands. In 1996 he obtained a MSc. Degree in Environmental Science at the Radboud University Nijmegen. He started his academic career as a junior researcher at the department of Science, Technology and Society, Utrecht University. Until 2001 he worked amongst other on the EU funded VAIE project (Voluntary Agreements – Implementation and Efficiency) and the NOP project on Policy Instrument for Energy Efficiency Improvement of which the results are included in this thesis. In the period 2001-2004 he worked at the Leiden University as the co-ordinator for the European Postgraduate Course in Environmental Management. In 2003 he returned to the Utrecht University to work as the programme manager for the MSc. Energy Science at the Copernicus Institute for Sustainable Development and Innovation. Since 2008 Martijn has been employed at the University of Applied Science Utrecht, where he held several positions such as lecturer in sustainable energy systems in various BEng. Programmes, as project leader for the Institute Engineering & Design and as researcher at the Research Centre Technology & Innovation. In 2012 he was awarded a research voucher from the University of Applied Science Utrecht to continue his PhD research. He received his PhD degree from the Utrecht University in 2015.

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- Rietbergen, M.G., A. van Rheede, K. Blok (2015). The target-setting process in the CO_2 Performance Ladder: Does it lead to ambitious goals for carbon dioxide emission reduction?, Journal of Cleaner Production (103), p. 549-561. DOI: 10.1016/j.jclepro.2014.09.046
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