Article

ENERGY & ENVIRONMENT

Energy & Environment
0(0) 1–15

DOI: 10.1177/0958305X18765265
journals.sagepub.com/home/eae
SAGE

Voluntary agreements to achieve energy efficiency, a comparison between China and The Netherlands

Mingshun Zhang[1], Huanhuan Li[1], Wei Jin[2], Erik ter Avest[3] and Meine Pieter van Dijk[4]

Abstract

China has gained experience with voluntary agreements. In this paper the experiences in China will be analysed and compared to the factors contributing to the success of this model in the Netherlands. Are voluntary agreements an alternative for the Chinese command and control system? We distinguish different types of voluntary agreements and compare those in China and the Netherlands on a number of dimensions. The hypothesis is tested that voluntary agreements are more effective in achieving pollution control than the traditional command and control approach. It is found that indeed most voluntary agreements score good in China as well as in the Netherlands on a number of chosen indicators. Voluntary agreements are effective in achieving ambitious energy saving targets in a flexible and cost-effective way. Voluntary agreements have the function to mobilise support for energy saving, which is not easily mobilised through the traditional command-and-control approaches. There are however some important differences between the functioning of the system in China and in the Netherlands, where a more bottom-up approach is common. The Netherlands has a tradition of stakeholders' involvement and experience over a longer time of monitoring the effectiveness of the project and adjusting them if necessary.

[1]Beijing Climate Change Response Research and Education Centre, Beijing University of Civil Engineering and Architecture (BUCEA), Beijing, China
[2]Hebei University of Environmental Engineering, Beidaihe, China
[3]Dutch Enterprise Agency of the Ministry of Economic Affair (RVO.nl), Utrecht, the Netherlands
[4]International Institute of Social Studies (ISS), Erasmus University Rotterdam, The Hague, the Netherlands

Corresponding author:
Mingshun Zhang, Beijing University of Civil Engineering and Architecture, No. 1 Zhanlanguan Road, Beijing 100044, China.
Email: zhangmingshun@bucea.edu.cn

Keywords
Voluntary agreements, long-term agreement, energy policy, a comparison between China and the Netherlands, energy and environment

Introduction

Voluntary approaches appeared in Organisation for Economic Co-operation and Development (OECD) countries in the middle of 1960s and the early 1970s. The definition of VAs is broad and varied. Many arrangements can be encompassed in the scope of VAs, such as self-regulation, voluntary initiatives, voluntary agreements, long-term agreements (LTAs), negotiated environmental agreements, covenants, etc. A voluntary agreement is a voluntarily signed and binding public–private partnership between governmental and industrial parties that establishes a negotiated and mutually agreed upon target for energy-efficiency and environmental improvement over a long-term period including specified facilitation by supporting policies and instruments. It has a long-term outlook (typically 5–10 years) and governmental supporting policies assist companies in reaching targets. These agreements include an implementation plan for reaching the targets and annual monitoring and supervision of progress toward the targets. It is a participatory public–private partnership that combines sustainable development with innovation management and provides constructive dialogue and structured communication between public and private partners via industrial consultative groups and voluntary agreement platforms. It provides bottom-up feedback on required policy framing (mix of carrots and sticks) and suggestions for further actions and improvement options.

Voluntary agreements were introduced in the Netherlands as LTAs in 1992. The first phase 1 (LTA 1) was implemented during the period of 1992–2000, and phase 2 LTA2 was implemented during the period of 2001–2008. The Netherlands is now in the process of the LTA on energy efficiency (LEE) and in phase 3 (LTA3). The LEE covenant (introduced in 2009) is intended for large industrial companies for which participation in the European Emissions Trading System (ETS) is compulsory. LTA3 (introduced in 2008) is intended for non-ETS enterprises and LTA3 focuses on process efficiency, supply chain efficiency and renewable energy. The LEE relates primarily to process efficiency and supply chain efficiency.

China started VA activities in 2005, learning from European experiences, particularly from the Netherlands LTA experiences, and the VA has been implemented in three phases. Phase 1 (2005) is the execution of a comparative EU-China feasibility study reviewing policies and management instruments in energy saving and emission reduction including questionnaire surveys and development of China-specific covenant blueprint. Phase 2 (2008–2010) is the demonstration of VA business case for public and private partners by testing and improving blueprint for 14 large companies in Nanjing, Xian and Kelamayi.

Main supporting activities included benchmarking, negotiating targets, development of improvement plans, implementing projects, financial and organizational capacity building by advisory and supervision visits and training, performance evaluation, providing incentives and the publication of a manual for guiding implementation throughout China.

Phase 3 (2011–2015) is focusing on the scaling up of covenants throughout China, thereby contributing significantly to the global mitigation of climate change including widening agreements from large companies to small and medium enterprises (SME) sectors. Major activities include design of a SME blueprint, training of SME associations, strengthening the financial and institutional enabling environment, improving policy framing related to China's Five-Year Plan cycle outreach throughout China.

The main arguments from the practices of VA worldwide include the legal base of VAs (legally binding or not), VA's threat to competition, VA's environmental and economic effectiveness and the relation of VA and regulatory approaches. This paper is based on outputs of an EU funded three phases project on adoption of VA in China. It addresses the following issues with the aim of recommending China designing and implementing more effective VA policies.

1. A systematic comparison of Netherlands LTA and China VA.
2. Are VAs in China legally binding or legally not binding?
3. Are VAs in China a threat to fair competition?
4. Are VAs in China environmentally and economically effective, compared to business-as-usual?
5. What are the recommendations for China for upscaling VAs and improving effectiveness of VAs implementations?

Theoretical review

The theoretical advantages of VAs are flexibility and cost effectiveness, and allow for potential savings in administrative costs (Börkey,[1] p.6; Higley,[2] p.10). The opportunities for VAs to public authorities and branch associations or firms can be discussed as following. Firstly, the public authority can benefit from avoiding the challenges posed by the traditional instruments. As Higley and Lévêque[2] state 'the legal procedure of command-and-control instrument can be time consuming and expensive to implement in the event of non-compliance. The market based instrument can pose institutional challenges – typically requiring the involvement of fiscal and tax collection authorities in policy design and execution'. Negotiated agreements can benefit the governments, for instance, decreasing administration cost on avoiding putting new legislation or new tax, especially in the case of the target of agreements beyond the requirement of regulation.

Secondly as mentioned by Alberini and Segerson,[3] firms are profit-oriented, they will only undertake to invest in further pollution abatement if they expect a net gain for so doing. Five opportunities the firms might gain if participating in negotiated agreements.[2] Firstly, the participating firms gain the authority to determine the cost-effective measures to abate their pollutions. VAs shift the responsibility to firms to formulate their own environmental policy. As a result, they allow industry much more flexibility in formulating the means by which it will reduce pollution. VAs engage industry, and invest them with active role in determining the most effective and cost-efficient way to achieve environmental goals. As in the past, the responsibility for setting targets and outline methods has in the hand of environmental regulators.

The firms are believed knowing better than government on how to reduce their pollution. Secondly, VAs promote an open flow of information within industry association, particularly where agreements are made with an entire association. Such industry wide agreements

create a forum for the individual firms to communicate in the most efficient manner. Thirdly, a firm may benefit the opportunity of better use of, and access to inputs. It is due to the fact that the improvement of environmental performance can lead to an additional outcome in lower consumption costs and pollution abatement. Fourthly, VAs may produce input savings by enhancing the reputations of participating firms. The firms with good reputation on environment may contribute its relationship with stakeholders (clients, employees and government). The firms may benefit from, for instance, by attracting, recruiting and retaining employees and reducing the administrative cost of regulatory compliance. Finally, VAs may help firms by increasing sales because of the rising willingness of clients to buy green products. The green firm will be rewarded by the increase in market share of the environmental friendly products.

Some researchers argue that VAs have negative effects as well. One issue is that VAs may lead to regulatory capture by industry. Pollution firms have a clear incentive to obstruct the introduction of a more stringent environmental policy since the abatement of emissions is costly. The policy is said to have been 'captured' by industry when they do not pay additional expenses for the environment. The Wuppertal institute of Climate, Energy and Environment also argues that 'a voluntary approach will be considered as being captured by industry when the environmental target set is not more than the abatement associated with a business-as-usual (BaU) pattern'.[4] In other words 'the closer the target to BaU pattern, the higher degree of capture of a voluntary approach by industry interests'.[1] The consequences of regulatory capture may be poor environmental performance of the agreement.

The other issue is the occurrence of free riders. This issue occurs in negotiated agreements concluded between public authorities and a sector association with industry-wide targets. The regulation or tax can be avoided if industry-wide targets are complete. Then non-participating firms can benefit from the participation of other polluters. Each polluter has an incentive not to participate if it believes (or hopes) that the participation of other polluters will be sufficient to meet the target to prevent the costly new policy.

The third issue is VAs may influence competition. EU legislation prohibits the formation of any agreement that negatively affects free trade and competition in Europe. VAs have indirect effects on market structures, and can lead to strategic anticompetitive behaviour. There appears to be a trade-off between the goal of maintaining a competitive market and taking advantage of the flexibility and efficiency created by VAs.[2]

In the middle of 1990s, the European Commission (EC) produced a communication on the use of negotiated agreements as an instrument for the implementation of environmental policy in the Community.EEA[5], p.17). The EC concluded that 'negotiated agreements with industry have an important role to play within the mix of policy instrument. They can offer cost-effective solutions when implementing environmental objectives and can bring effective measures in advance of and in supplement to legislation. In order to be effective, it is essential, however to ensure their transparency and reliability'.

Many researchers stress that the proper design could contribute significantly for enhancing the transparency and reliability of VAs. Many suggestions were given for identifying possible safeguards against the main shortcomings of VAs. Generally speaking, they can be listed as below.

1. Create an open and transparent target setting process;
2. Ambitious target setting (more than business-as-usual);
3. Clearly quantitative target and timetable;

4. Communication between the parties;
5. Inclusion of monitoring and enforcement mechanisms;
6. An efficient burden sharing of targets among firms;
7. Third party participation;
8. Sanctions for non-compliance;
9. Legally binding with law; and
10. The threat of regulation.

The elements mentioned above are intended to serves as tools for the planning, designing, negotiation and performance of negotiated agreements, and also serve as guidance for this research to measuring the success and fail factors of the Dutch covenants towards their environmental effectiveness.

A systematic comparison of VA China and VA the Netherlands

The analytical framework for this research distinguishes the following nine elements of the system of achieving a voluntary agreement. The research approach chosen for this study is a systematic review of implementations of voluntary agreement (VA) in China and LTA in the Netherlands (Table 1).

Table 1 shows that there are important differences between VAs in China and LTAs in the Netherlands. The similarities are the objectives, incentives and penalties, monitoring and evaluation, sector concerned and the mechanism of reaching agreement. However, the major differences seem to be

1. The initiative in NL often comes from the sector and the negotiations are carried out by independent sector organizations. In China local government is more motivated at the earlier stage.
2. The motivations of industries adopting VA in China are the increasing environmental pressures and getting stricter of environmental regulations and standards. Motivations in the Netherlands are the reduction of production costs and increasing of resource efficiency. Thus the main difference between China and the Netherlands is that China's industries are adopting VA for reducing environmental impacts and complying more strictly environmental regulations and the Netherlands's industries are adopting VA more for reducing production costs and improving resource resources.
3. There seems to be more real stakeholder involvement in the NL, where also SME can be involved in the negotiations.
4. The difference in the governance structure for the LTAs in NL and VAs in China means that the traditional role of the government as independent regulator is somewhat undermined.
5. Both China and the Netherlands successfully involved small enterprises as well at a later stage.

The numbers of VA/LTA failures are three (out of the 52 big companies active). In particular 28 out of the 813 laundry SMEs, and 13 out of the 147 textile SMEs. The main reasons for this failure are the economic crisis starting in 2008. Other reasons mentioned are the changing of production, changing of company management and changing of key staff members. Numbers of LTA failures are very few in the Netherlands and the main

Table 1. A comparison of VAs in China and LTAs in the Netherlands.

Dimension	China	The Netherlands
Initiative, from the government or private sector	Very much from the government	An interaction
Motivation of industries adopting VA	Environmental pressures, increasing strict of environmental regulations and standards	Reducing production costs and increasing resource efficiency
Action level	Local	National
Legal status	Legally unbinding	Legally binding
Scale of VA implementation	52 big companies that will participate in national ETS, 813 laundry SMEs and 147 textile SMEs at the end of 2016. Numbers are still increasing and VA may be disseminated into more cities.Total energy consumption of VA companies in China is 950 PJ per year, which is less than 1% of total industrial energy consumption of China.	LEE: 100 big companies participating in EU ETS. LTA3: about 1000 companies. Both LEE and LTA3 companies consume 830 PJ of primary energy in a year, which makes up about 80% of the total industrial energy use.
Sectors concerned	Energy-intensive, both big companies and SMEs	Energy-intensive, both big companies and SMEs
Efficiency concerned	The existing VA is only concerning the process efficiency, and chain efficiency is not yet included. Future VA may also concern the chain efficiency.	Process efficiency, chain efficiency and renewable energy are concerned.
Period length	Excepting phase 1 (feasibility study, 2005) and phase 2 (demonstration, 2008–2010), phase 3 is well fitting with China national five-year plan (2011–2015). It is estimated that future VA in China will also fit into China's five-year plan system.	Long-term agreement, phase 1: 1992–2000, phase 2: 2001–2008 and phase 3: 2009–2020.
Monitoring & evaluation	Monitoring is done by companies. For big companies, verification by third party. For SMEs, verifications are done by public institutes authorized by local authorities.	Self-reporting and verified by third party.

reason is changing of production. There are no cases in the Netherlands that changing of company management and changing of key staff could result in failure of VA.

A comparison of results achieved by VA China and LTA Netherlands

The Netherlands covenants are planned to run through to 2020. It is therefore worthwhile assessing the results over a longer period. Figures 1 and 2 show the results of the covenant from the start to 2014. These figures show that both covenants are achieving stable savings. As compared to 2009, the starting year of the covenant, LEE achieved an energy efficiency

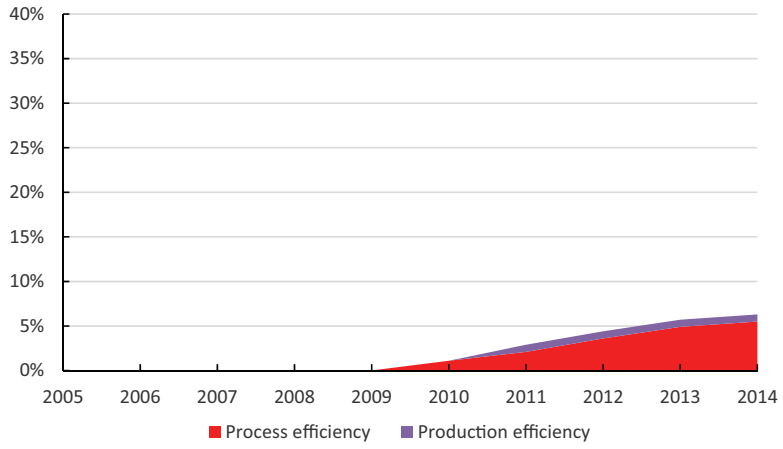

Figure 1. Saving LEE 2009–2014 (process efficiency + production chain domestic). (Data source: Netherlands Enterprise Agency, 2015.[6])

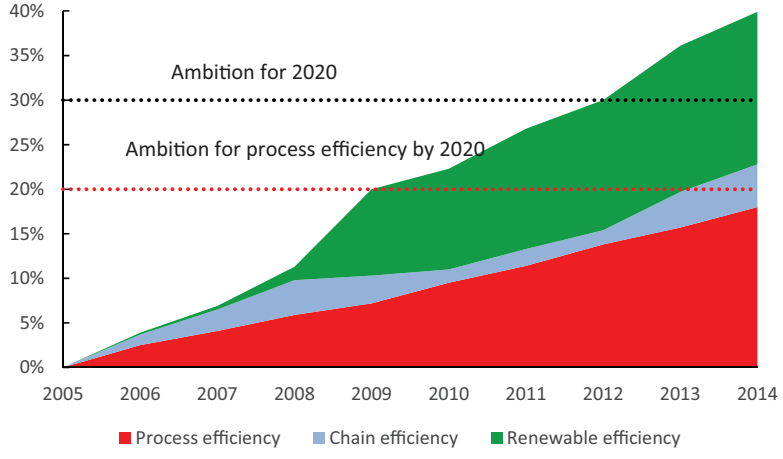

Figure 2. Saving LTA3 2005–2014 (process efficiency + chain efficiency + renewable energy). (Data source: Netherlands Enterprise Agency, 2015.[6])

improvement in, 2014 of 7.8%, or 1.6% per year (see Figure 1). The lion's share of this saving (6.5%) is due to process efficiency.

Between, 2005 and 2020, the participants in LTA3 have expressed the ambition of achieving an overall efficiency improvement of 30%. To 2014, an improvement of 21.2% has been achieved (on average 2.4% per year). Here, too, the majority (18.3%) relates to process efficiency (on average 2.0% per year) as compared to a 20% target for internal energy efficiency (see Figure 2). If chain efficiency in the production chain and chain efficiency achieved abroad as well as renewable energy are included, the total result amounts to 39.9%, of which roughly half consists of the purchase of renewable energy. In effect, this means that the 30% target for, 2020 has already been achieved. At an earlier stage, financial

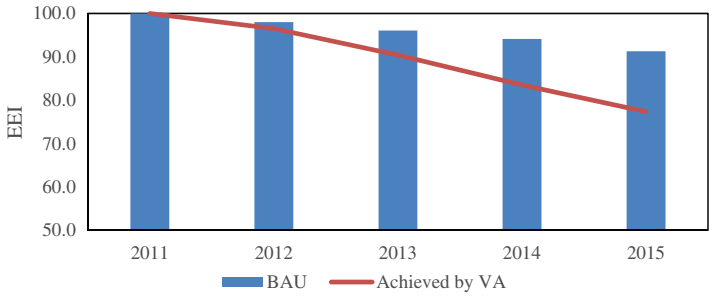

Figure 3. Result achieved by the 52 big companies (process efficiency). (Data source: Zhang et al.[7])
BAU: business-as-usual; EEI: energy efficiency index; VA: voluntary agreement.

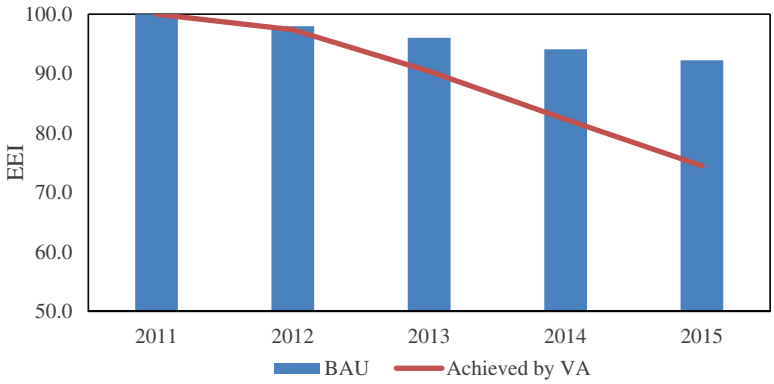

Figure 4. Result achieved by the 813 laundry SMEs in Nanjing (process efficiency). (Data source: Zhang et al.[7])
BAU: business-as-usual; EEI: energy efficiency index; VA: voluntary agreement.

incentives were available in the Netherlands and policy incentives are available for the whole period. In China both policy and financial incentives are available for the whole period. Financial incentives are mainly for companies conducting feasibility study, developing action plans and capacity building and networking. According to agreement, penalties include refunding of financial incentives, increasing of emission fee and bad images.

In China, 52 big energy intensive companies (petrochemical, cement, iron-steel, heat and electricity, paper-making and manufactures) from Nanjing, Changchun, Xian and Kelemayi, 813 SMEs in laundry sector of Nanjing and 147 SMEs in the textile sector of Jingzhou have participated in the VA implementation. China launched its national ETS at the end of, 2017 and some of these 52 big companies have participated in the ETS. For assessing the results achieved, China is applying energy efficiency index (EEI). EEI is defined as the ratio between the energy consumption of target year and specific energy consumption of reference year multiplied by the productivity (physical production amount) of target year. The main results achieved are presented in Figures 3 to 5.

Figure 3 shows that the energy efficiency (process efficiency) improvement of the participated 52 big companies is 23% in the period of 2011–2015. In the same period, the energy efficiency improvement of BAU (business-as-usual) is 9%, and thus the value-added of the

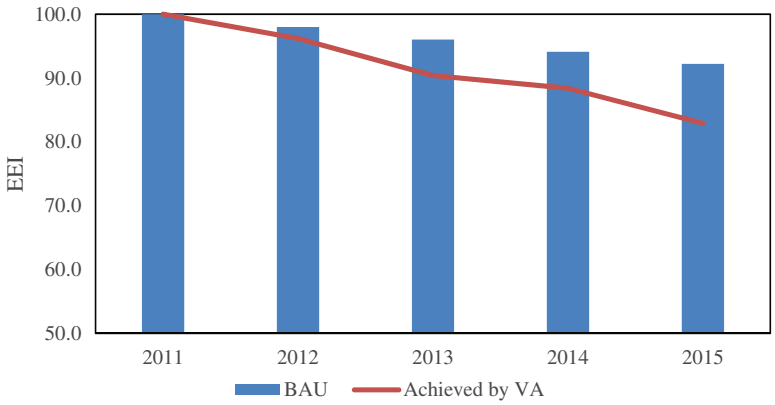

Figure 5. Result achieved by the 147 Textile SMEs in Jingzhou (process efficiency). (Data source: Zhang et al.[7]) BAU: business-as-usual; EEI: energy efficiency index; VA: voluntary agreement.

Table 2. Comparison of VA results in China and the Netherlands.[a]

For China and the Netherlands	Energy efficiency improvement	Energy savings in PJ
Netherlands LEE (100 big companies participating in EU ETS (2009–2014)	7.8%	7.3
China 52 big companies to be participated in China ETS (2011–2015)	14%	160.2
Netherlands LTA3 (about 1000 companies) (2005–2014)	21.2%	7.1
China VA (laundry and textile, 960 companies) (2011–2015)	14.5%	21.7

PJ: petajoule.
[a]1 PJ = 34,176 ton coal equivalent. (Data source: primary data.)

voluntary agreement is 14%. Figure 4 shows that the value added through energy efficiency resulted in an improvement of the 813 laundry SMEs of 18% for the period of 2011–2015. Figure 5 shows that VA value added energy efficiency improvement of the 147 textile SMEs is 11% for the period of 2011–2015. Table 2 shows the comparison of results achieved in China and Netherlands.

Table 2 shows that China's VA is more effective than the Netherlands LTA for both big companies and SMEs in both energy efficiency improvement and energy savings. The fundamental reason is the huge difference of the baseline level of industrial energy performance of the Netherlands and China. China's industrial energy consumption per 10,000 Chinese Yuan gross domestic product (GDP) is, which is about two times the industrial energy consumption per GDP of the Netherlands (45,000 US$). Such huge industrial energy efficiency differences mean that China has a much bigger energy saving potentials than in the Netherlands. This explains why China's VAs achieve much more energy efficiency improvements and energy savings than the Netherlands' LTAs and LEE.

Table 3. Environmentally effectiveness of VAs' implementation, compared to BAU in China (2011–2015).[a]

	Energy saved in PJ	CO_2 reduction in million ton	SO_2 reduction in ton
52 big companies	160.2	14.8	21,898.6
813 laundry SMEs	2.7	0.2	34.7
147 textile SMEs	19.0	1.8	193.5
Total	181.9	16.8	22,126.8

PJ: petajoule.
[a]1 PJ = 34,176 ton coal e.q. CO_2 emission reduction is estimated by 1 ton coal e.q. = 2.7 tons of CO_2. SO_2 reduction is measured by local environmental departments. (Data source: primary data.)

Are China's VAs environmentally effective and economically efficient?

For assessing the environmental effectiveness, we use the data of 2011–2015 and apply the following analytical framework in Table 3.

Table 3 shows that VA China is quite effective for both big companies and SMEs in energy saving and resulted in CO_2 reduction, which is estimated by energy reduction. During the five years period, 1012 VA companies have achieved 181.9 PJ or 6.2 million ton coal e.q. energy saving, as compared to business-as-usual. According to the current energy price, value of the 6.2 million ton coal e.q. is about 13 billion Chinese Yuan or 1.7 billion euro. However reduction of pollutant SO_2 is not significant, as compared to energy saving. This may be explained in Figure 6, which shows the numbers of VA solutions planned and implemented.

Figure 6 shows that 97% of housekeeping solutions and 96% of energy saving solutions have been implemented, given to the fact that housekeeping solutions are no-investment or very low investment and mainly on capacity building and awareness raising, and energy saving solutions makes significant direct economic profits with short pay-back time (PBT). However only 61% of pollution control solutions have been implemented, since pollution control solutions hardly make direct economic profits and thus participating companies are not well motivated to take the actions. Thus we conclude that VA is very effective in achieving energy and climate target and it may not be effective in achieving environmental target of pollution control.

For assessing the economically efficient, we calculate the PBT of the measures that are taken by the participating companies, which is presented in Table 4.

Table 4 shows that payback time of good housekeeping solution for both energy saving and pollution control is less than one year. Payback time of improved process technology and equipment for energy saving for both big companies and SMEs is less than three years and for pollution control is more than five years. Payback time of replacement or new investment (R&D may be needed in this case) for energy saving is more than five years, and for pollution control is more than seven years. We therefore conclude that VA is high economically efficient for energy saving for both big companies and SMEs and may not be high economically efficient for pollution control. This can be explained that internationally VA or Netherlands LTA is mainly adopted for achieving energy saving target and climate targets.

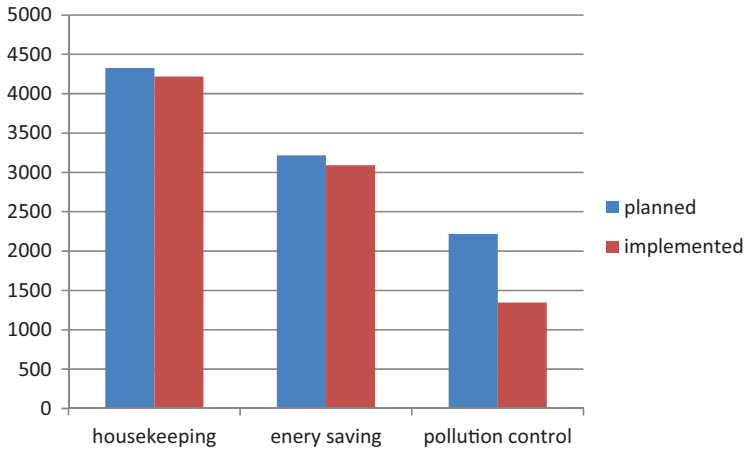

Figure 6. Numbers of solutions planned and implemented by VA. (Data source: primary data.)

Table 4. Assessment of economically efficient by PBT in China (2011–2015).[a]

	Measures	Average PBT in years
52 big companies	Good housekeeping measures (e.g. improved management and operating procedures)	≤1
	Improved process technology and equipment for energy saving	≤3.2
	Improved process technology and equipment for pollution control	≥5
	Replacement/new investments for energy saving	≥5
	Replacement/new investments for pollution control	≥7
813 laundry SMEs	Good housekeeping measures (e.g. improved management and operating procedures)	≤1
	Improved process technology and equipment for energy saving	≤2.0
	Improved process technology and equipment for pollution control	≥5
	Replacement/new investments for energy saving	≥3
	Replacement/new investments for pollution control	≥7
147 textile SMEs	Good housekeeping measures (e.g. improved management and operating procedures)	≤1
	Improved process technology and equipment for energy saving	≤2.6
	Improved process technology and equipment for pollution control	≥5
	Replacement/new investments for energy saving	≥4
	Replacement/new investments for pollution control	≥7

[a]Data source: primary data.

Is the VA China a threat to competition?

According to economic theory, voluntary approaches have indirect effects on market structure and competition whether they are principally aimed at improving the environmental reputation of the products sold by undertakers or at pre-empting policy interventions based on regulatory or economic instruments. Moreover, economic analysis provides support to the intuition that in a few cases voluntary approaches could be adopted with the strategic

objective to affect market structure and competition conditions (Moffet, 1998).[8–9] However, in general, a concentrated market structure has a positive effect on the environmental effectiveness of the actions undertaken within a voluntary initiative. This clearly raises a trade-off between the goal of maintaining competition in the market and the objective of exploiting the well-recognised flexibility that generally characterises voluntary approaches.

Chinese VA is legally unbinding, and there is no evidence that VA China have negative impact on competition in the market. However, China launched emission trading system (ETS) of CO_2 in 2017. Allocation of emission allowances can be an important mechanism for addressing competitiveness concerns over carbon pricing for trade-exposed industries and also to gain buy-in during the early stages of the implementation of the ETS. China is now allocating allowances mainly based on historic emissions ('grandfathering') and benchmarks play very limited role in allowance allocation. The emerging issue is how to deal with the VA participating companies who have already made more energy efficiency improvement before and those companies will receive relatively less allowances based on their historic emissions. Thus we concluded that the existing VA practices in China do have negative impacts on the competitiveness of the existing VA participating companies. In the future, VA may be an effective instrument for the ETS participating companies reducing their CO_2 emissions and thus VA may have positive impacts on competitiveness in China.

Conclusions and policy implication

China and the Netherlands are different countries in terms of scale, political and economic system. In the Netherlands there is a tradition of stakeholders' involvement and in the case of VAs the government is no longer considered the bad cop. However, the objectives and mechanisms used to come to a VA are largely the same and for that reason a comparison makes sense. The VAs are a more bottom-up and participatory approach, which means there is more ownership among the partners of the project to be achieved in the coming period, which in the end makes it more effective than the traditional command and control approach. Practices of VAs in China and in the Netherlands show that VA is effective in achieving ambitious energy saving targets in a flexible and cost-effective way. VA has potential function to mobilise the potentials of energy saving that are not easily mobilised by traditional command-and-control approaches.

The ambition has always been to formulate policy implications on the basis of this research. In particular we like to find out about voluntary restrictions in other sectors. Thinking in terms of the policy cycle theory, our research provides following recommendations to the policy makers of China how to improve the system of VAs.

1. It is very important that VA as a supplementary policy instrument should be integrated into a policy mix for achieving energy and climate change targets and VA alone can never play a role in realising targets. It is expecting that VA could play an important role in the moving of China's existing government to the coming governance.
2. It suggests that the existing VA practices at Chinese local level should be planned and implemented at national level and, learning by doing, VA could become an effective legal binding instrument for China dealing with the high pressures of energy efficiency and emission reduction.
3. It is crucial to recognise the efforts and progress that the VA participating companies have made before the allowance allocation in the China national ETS and to market sure

that the existing allowance allocation by grandfathering can never have negative impacts on the VA participating companies.
4. Adopting the VA in the energy-intensive sectors and sectors that have great potential for energy savings, given to the fact that cost-effective energy savings can make profits that are crucial for industries. VA may not be effective in terms of pollution control of reduction of pollutants, since reduction of pollutants may not make clear direct economic profits, as compared to energy saving.
5. For enlarging VA's impacts, it is suggested that not only process efficiency, but also chain efficiency and renewable energy should be taken into account in VA design and implementations for China.

Acknowledgements

This paper is based on a EU-China development cooperation project that was conducted in three phases (phase 1: 2005–2006 (Asia Pro Eco Project 19–2003), phase II: 2007–2010 (contract number: CN/ASIA PRO ECO II/08 (122287), phase III: 2012–2015 (DCI-ASIE/2011/262–880))). We would like to thank all experts and staff in the target areas of Nanjing, Jingzhou, Changchun, Xian and Kelamayi who kindly participated in this project for their valuable contributions and scientific advices. We also thank all target companies who are willing to share their energy and environmental data and contribute to the implementation of the project.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: total of about 4.5 million euro was funded by EC's three programmes of Asia Pro Eco, Asia Pro Eco II and Switch Asia.

References

1. Börkey PM and Lévêque GF. *Voluntary approaches for environmental policy in OECD countries: an assessment*. CERNA, 2000.
2. Higley CJF and Lévêque GF. *Environmental voluntary approaches: research insights for policy-makers*. CERNA, 2001.
3. Alberini A and Segerson K. Assessing voluntary programs to improve environmental quality. *Environ Resour Econ* 2002; 22: 157–184.
4. Dalkmann H, Bongardt Rottman DK and Hutfilter S. *Review of voluntary approaches in the European Union*. Wuppertal Institute for Climate, Environment and Energy, Germany, 2004.
5. European Environmental Agency (EEA). *Environmental agreements – environmental effectiveness*. Environmental issues series No 3. Vol. 1 and 2, Copenhagen, 1997.
6. Netherlands Enterprise Agency. Covenants results brochure: Long-term Agreements in energy efficiency, Publication number: RVO-070-1501/BR-DUZA, October 2015.
7. Zhang M, Cui Y, ter Avest E, et al. Adoption of voluntary approach:Can voluntary approach generate collective impacts for China achieving ambitious energy efficiency targets? *Energy & Environment* 2018; 29: 281–299.
8. Moffet J and Francois B. 'The Implications of Voluntary Codes of Conduct for Competition and Competitiveness,' CAVA Working Paper 1998, CERNA, Paris.

9. Bailey P. Environmental agreements and compliance with the treaty: issues of free trade, competition and state aid. CAVA Working Paper No. 2000/2/12, 2000.

Mingshun Zhang holds PhD in environmental policy and urban sustainability from Erasmus University Rotterdamthe Netherlands. He is a professor at Beijing Climate Change Response Research and Educational Centre of BeijingUniversity of Civil Engineering and Architecture. Professor Zhang has 30 years working experience (6 years in The Netherlands and 24 years in China) in the field of environmental policy, environmental planning and management. Hehas conducted many researches on EU-China comparative studies on environmental policies and management. Since2002, Professor Zhang has made more than 20 scientifically research publications and 40 Peer-reviewed journal articlesin the fields of sustainability, environmental policies and management and low-carbon development.

Huanhuan Li is a student who is doing master programme at the Beijing Climate Change Response Research and Educational Centre of Beijing University of Civil Engineering and Architecture. She is now doing a master thesis on energy saving and emission reduction by adopting voluntary approaches and her master programme is supervised by Professor Mingshun Zhang.

Wei Jin holds a Master degree in environmental engineering from UNESCO-IHE, the Netherlands. She is now a senior lecturer in Hebei University of Environmental Engineering. She has 10 years working experience in policy of industrial energy saving and environmental governance. She has coordinated several projects on industrial energy saving and emission reduction in China. She has published more than 10 articles on industrial energy efficiency and environmental governance.

Erik ter Avest holds a Master's degree in chemical engineering from University of Twente. For eight years, he worked with Shell in various refinery and international head office positions. In 1994, he joined the predecessors of Netherlands Enterprise Agency RVO.nl that falls under the Dutch Ministry of Economic Affairs. He was program manager for five Dutch Long-Term Agreements on industrial energy-efficiency improvement and he has implemented a wide range of programs and policies for Dutch ministries and international governments. He has coordinated various international sustainable development projects with a strong focus on turning policy into reality by arranging chemistry between organizations and people within these organizations. In period 2012-2015, he managed a € 2 million EC SWITCH-Asia Chinese climate project that has largely exceeded energy saving target of 100 PJ/a and CO2 emission reduction target of 10 Mton/a by applying Collective Impact approach.

Meine Pieter van Dijk is economist, em. professor of Water Services Management at UNESCO-IHE Institute for Water Education, professor of entrepreneurship at Maastricht School of Management, visiting professor at the Beijing University for Civil Engineering and architecture, and em. professor of Urban management at the Institute of Social Studies (ISS) and the Institute of Housing and Urban development Studies (IHS) of Erasmus University. He participates in the Graduate schools of TU Delft and Erasmus University and is member of the research schools CERES and SENSE and worked on and in developing countries since 1973 as a consultant for NGOs, the Asian

Development Bank, the Inter-American Development Bank, the World Bank, different bilateral donors and UN agencies. His recent publications are *Urban governance in the realm of complexity*, *Water issues in Palestine: an overview, Benchmarking for the delivery of water and sanitation services to the urban poor*, *Achieving the SDGs: public good with private money*? *The contribution of economics to water and sanitation problems, From urban systems to sustainable competitive metropolitan regions*, *Shifts in urban Water governance paradigms, Cities as engines of growth and transformation in Ethiopia*, *Global value chains, linking local producers from developing countries to international markets*, *The new presence of China in Africa*, and *Managing cities in developing countries*.