Instruments to increase climate policy ambition before 2020 – economic and political implications in selected industry and emerging countries

Pre2020 climate policy ambition

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Authors

Sean Healy, Katja Schumacher
Öko-Institut

Thomas Day*, Niklas Höhne*, Karlien Wouters, Hanna Fekete*, Lidewij van den Brink
Ecofys

Vicki Duscha
Fraunhofer ISI

*: with Ecofys at the time of writing of the report

Project Lead Öko-Institut

Head Office Freiburg
Merzhauser Strasse 173
79100 Freiburg
Tel. +49 761 45295-0

Office Berlin
Schicklerstrasse 5-7
10179 Berlin
Tel. +49 30 405085-0

Office Darmstadt
Rheinstrasse 95
64295 Darmstadt
Tel. +49 6151 8191-0

info@oeko.de
www.oeko.de

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Abstract

Currently there exists a gap between the emissions projected in the Intended Nationally Determined Contributions (INDCs) submitted by countries to the UNFCCC and the emissions that are consistent with limiting global warming to below 2°C (Climate Action Tracker, 2015a; UNFCCC, 2015). Given that the INDCs only commit countries to mitigation actions beyond 2020, there is an opportunity to further reduce this projected emission gap in 2030 based upon more ambitious mitigation efforts prior to 2020. The aim of this research paper is to analyse the current mitigation of countries efforts, identify best practices and estimate the global impact on emission reductions in 2020 if applied globally. By estimating the extent to which mitigation potential may exist up until 2020 and by providing insights on how policy barriers may be overcome, this report aims to facilitate enhanced action by countries participating in the UNFCCC negotiations prior to 2020.

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Executive Summary

Introduction

The objective of the upcoming 21st Session of the Conference of the Parties (COP) in Paris to the United Nations Framework Convention on Climate Change (UNFCCC) is to reach a new international agreement on the climate, applicable to all countries, that prevents global warming exceeding 2°C. In preparation for COP 21 in Paris countries have already submitted their Intended Nationally Determined Contributions (INDCs), which outlines what post-2020 climate actions they intend to implement under a new international agreement. The aggregate impact of these INDCs will determine whether or not the international agreement negotiated at the COP 21 will be ambitious enough to prevent the occurrence of runaway climate change. However, a substantial gap currently exists between the 2025 and 2030 emissions projected in the INDCs that were submitted to the UNFCCC and the lower emission levels that are consistent with limiting global warming to below the 2°C threshold (Climate Action Tracker, 2015a; UNFCCC, 2015). Without increased levels of ambition, the projected emission levels associated with the existing INDCs will result in a 92 % chance that global warming exceeds 2°C and only a 'likely' 66 % chance of remaining below 3°C this century (Climate Action Tracker, 2015b).

Given that the INDCs only commit countries to mitigation actions beyond 2020, there is an opportunity to further reduce this projected emission gap in 2030 based upon more ambitious mitigation efforts prior to 2020. The aim of this research paper is to therefore analyse the current mitigation of countries efforts, identify best practices and estimate the global impact on emission reductions in 2020 if applied globally.

Methodology

The methodological approach involved three distinct steps. The **first step** was to generate an overview of the current status of activities in a selected sample of countries. The analysis is structured along indicators that support the screening of the countries, and a matrix containing two layers (reduction potential and the policy activities) was produced.

Based on this output, the **second step** identified a list of potential areas for greenhouse gas mitigation (hereon referred to as "thematic areas", e.g. fuel efficiency standards, low energy buildings). For each of these thematic areas, additional aspects were considered, such as the co-benefits or the role of the respective area in relevant forums to support discussions with and within BMUB and UBA. Based on this, a final set of thematic areas were selected for detailed analysis in the subsequent steps. The detailed methodology for the **screening of current activities** is described in section 2.1.

The **third step** consists of an in-depth evaluation of the selected thematic areas, including a qualitative assessment of the policy objectives, ambition, implementation barriers and co-benefits, and a quantitative assessment of the achieved and projected emission reductions of existing best practice policies. We then quantitatively estimated the global emission reduction potential of these policies by scaling these to a global level. Further methodological details for the qualitative and quantitative analysis are given in section 2.2.

Key findings

A first scan of policies in countries with high greenhouse gas (GHG) emissions and countries with remarkably ambitious climate change mitigation strategies (see Table 1) revealed that thematic areas with notable coverage in domestic climate policy are: general strategies and targets, renewable energy support schemes for electricity, product standards and codes for energy efficiency in buildings, and direct subsidies and fuel quotas for renewables in transport.

Table 1: Result of country policy analysis: most popular policy instruments and percentage coverage

	Changing Activity	Energy efficiency	Renewables	Low carbon (other than renewables)	Non-energy
General	Strategies and targets 69%				
Electricity		Performance standards 22%	Support schemes (e.g. feed-in tariff) 49%	Tax exemptions 6%	
	Carbon pricing schemes 25%				
Industry	Strategies 6%	Voluntary agreements 24%	Fuel quota 36%	CCS support schemes <3%	Regulation (Not evaluated)
	Carbon pricing schemes: 31%				
Buildings	Programmes 8%	Product standards and building codes 55%	Tax exemptions 40%	Not evaluated	
	Energy taxes: (Not evaluated)				
Transport	Modal shift programmes 14%	Vehicle standards 23%	Direct subsidies and fuel quota 50%	E-mobility programmes 14%	
	Energy taxes: (Not evaluated)				
AFOLU	Strategies 28%				Regulations/planning 39%

Scale: Minimum – Maximum

From this analysis, along with initial indications of mitigation potential, four areas were identified where ambition could be significantly enhanced by 2020.

Renewable Energy Support (RES)

Renewable energy support measures are becoming popular in many industrialised and developing countries across the world not only for their decarbonisation potential, but also for the multiple co-benefits that they entail, including increased rural electrification, improved energy security, decreased dependence on depleting resources and volatile fossil fuel markets, and improved local air quality and associated health benefits. Coverage of these policies is already above 50% globally.

This study has found that the most ambitious industrialised country policies may lead to a 2-3% annual reduction in national emissions intensity of the electricity production. Meanwhile, emissions intensity improvements might be even better in the short term for less developed countries, since the process of optimising the energy mix is still at an early stage; Morocco for example, has achieved 4% annual emission intensity reductions in recent years.

Targets for electricity generation from renewable energy are contributing significantly to the GHG emission reductions in the four considered countries in the quantitative analysis: Germany, the United Kingdom, China and Morocco. This study finds that the adoption of best practice policies in all other countries by 2020 has the potential to reduce emissions by 2.3 $GtCO_2$/a compared to a scenario without policies, or by 1.4 $GtCO_2$/a compared to a reference scenario that includes current policies. This maximum achievable potential is the upper bound as it assumes the full and expedited implementation of best practice policies by all countries; real implementation may be slower due to the large volume of upfront investment implied and the conflicting interests or other priority policy areas.

Analysis of best practice policies in this study showed that market instruments such as Feed-in Tariffs (FIT) and purchase guarantees are the most popular policy instruments in industrialised countries, whilst public sector investment remains the primary means of increasing renewable energy shares in many developing countries, owing to the weak penetration of markets and the lack of an attractive environment for private sector investment. This remains a key barrier for renewable energy development in developing countries. Other common barriers for countries worldwide include poor grid infrastructure, both in terms of its unsuitability and its insufficiency, and regulatory issues, particularly regarding the ability to obtain planning permission. The policy instruments in the best practice policies discussed, as well as the work of established and emerging International Cooperative Initiatives are focused on the mitigation of these barriers.

Light duty vehicle standards

Given the projected increase in car ownership in developing countries worldwide over the coming decades, it is of vital importance to implement emission standards to stop the growth in emissions or lead to an absolute reduction in emissions.

Improvements in the fuel efficiency and emissions intensity of light duty vehicles is promoted not only by national climate change mitigation ambition, but also by increasing consumer demand; through significant cost savings at the pump and local air quality improvements, consumers and urban dwellers may benefit greatly from development in this sector. Furthermore, net oil importing nations have an incentive to improve the fuel efficiency of their vehicle fleets in order to reduce their expenditure and dependency on volatile international oil markets.

With this in mind, the best practice policies featured in this study (EU, Japan, US and China) are forecast to result in fuel-efficiency improvements of 3-7% annually between 2015 and 2020. The most ambitious target for 2021 is the EU's target (originally expressed as gram CO_2 per km) of 24.6 km/l NEDC cycle[1] for the light duty vehicle fleet, which might rise to 34.4 km/l (NEDC cycle) in 2025. These targets are forecast to translate to a reversing total emissions trend for light duty transport in industrialised countries, of about -1% annually. The indications for emerging and developing nations are for continued, yet stunted, emissions growth, due to the anticipated boom of car ownership and kilometers driven in these countries; this study finds for example, a medium term emissions trend of +4% per year in China with full implementation of ambitious policies. Global coverage of policies in this area can be greatly enhanced, as currently only around a quarter of countries have such policies; whilst these countries tend to be those with the highest emissions from vehicles, light duty vehicle activity is forecast to increase significantly in the coming decades in regions with less policy coverage

This study finds that immediate adoption of the best practice policies of regional peers by all countries could initiate an emissions reduction of 0.6 $GtCO_2e$/a compared to a frozen technology scenario,

1 The NEDC cycle is the fuel economy cycle used for all cars in the European Union to test fuel economy under laboratory conditions. Real-world fuel economy is generally 20-30% higher than the fuel economy found using test cycles in laboratories. Every country is using different fuel economy standards expressed in their own national fuel economy cycle. In order to make inter comparison of legislation possible, this report shows all standards as if they were tested using the European NEDC cycle.

and 0.2 $GtCO_2e$/a below the current policies reference scenario by 2020. If all countries would adopt the European emission standards, the most ambitious of the countries analysed, this reduction could be 1.0 $GtCO_2$/a below the frozen technology pathway and 0.5 $GtCO_2$/a below the reference pathway. Importantly, the absolute net growth in global light duty vehicle emissions can be stopped and reversed, despite the significant increases in vehicle activity forecast for this time period.

Our analysis of best practice policies shows that standards are the most common policy instruments in this sector. From analysis of the four case studies, the outstanding factor that acts as a facilitator or barrier is the existence of significant incentives for both consumers and manufacturers. All of the standards in the best practice policies analysed include flexible compliance mechanisms that increase the incentives for manufacturers; the EU mechanism is particularly interesting as it creates a market amongst manufacturers for fuel-efficiency by allowing manufacturers to join together and pool their fleets for compliance purposes. Similarly, the Japanese system also focuses on natural market forces and competition within the industry through its Top-Runner programme which bases the standards on the best industry practices. Such market focused approaches demonstrate the potential to mitigate institutional bottlenecks and resistance from industry and associated stakeholders which is a considerable barrier in some countries. Addressing supporting policies, particularly fuel taxes and subsidies, is also important for providing consumer incentive and demand.

Developing countries face different challenges in setting policies for fuel economy of vehicles. One of the main barriers to set vehicle fuel economy standards in developing countries is that a high level of expertise is needed of the vehicles being sold, the costs, the benefits and the lead-time for a wide variety of vehicles. As an alternative to fuel economy standards, properly designed free bates (partial refunding of the paid price) for fuel efficient cars can be an effective and cheaper alternative. However, policies in developed countries also influence fuel economy of vehicles in developing countries via spill-over effects and imports of second-hand cars from developed countries. Finally, the road conditions, traffic congestion and car maintenance status could worsen the real-world fuel economy in developing countries compared to for instance European real-world fuel economies.

GHG emissions from flaring during oil and gas production

The policy to reduce flaring of associated petroleum gas (APG), a by-product in oil and gas production, to 5% in the analysed country Russia, can lead to a significant decrease in flaring emissions; if the target is meet, 2020 emissions in this area decrease by over 80% from the 2010 level according to our calculations. Implementation of similar policies and complete achievement of targets in the top-5 APG flaring countries could achieve maximum emission reductions by 2020 of approximately 0.16 $GtCO_2e$/a compared to a frozen technology scenario, and approximately 0.1 $GtCO_2e$/a compared to a current trend reference scenario that assumes a 52% reduction of flaring below the 2005 level in 2020. Global implementation of similar policies could result in an even bigger emission reduction. Realistically, the potential in this thematic area is somewhat limited by the complexity of ex-post compliance enforcement, particularly considering the political strength of the industrial sector in the countries referred to.

Analysis of best practice policies in Norway and Russia show the use of very similar policy instruments. In both cases, license requirements exist and a permit system and penalty system is in place. A major difference in the license requirements is the fact that in Norway companies were facing the requirements from the very beginning and were required to present a plan for gas utilisation in order to obtain a license to operate, while in Russia the law was only adopted a few years back, and threatens instead to revoke licenses, which proves much more difficult to enforce.

High technological and infrastructural investments in technology are necessary to utilise the associated gas due to the distance of production sites to locations of utilisation. This barrier was mitigated in Norway by requiring companies to deal with such investments prior to the provision of licenses, but such supporting policy is missing in Russia.

Electric appliances

Improvements in the fuel efficiency of electric appliances are of key importance to climate change mitigation objectives; consumer cost savings and improved household comfort. Many countries already adopt standards of this kind.

Global data on activity rates for appliance use, as well as energy efficiency gains, is critically low. The Ecodesign Directive in the EU is expected to result in savings of 458 TWh electricity or 0.3 $GtCO_2$/a by 2020 compared to a scenario without implementation of the Directive. In the situation that all countries were to immediately adopt best practice policy, this would result in emissions reductions of 1.5 $GtCO_2$/a compared to a reference scenario that includes most current policies in OECD countries and a small number of existing policies in non-OECD countries, and savings of 1815 TWh electricity or 2.2 $GtCO_2$/a by 2020 compared to a scenario without policies. This savings potential is divided equally over OECD and non-OECD countries.

The best practice policies in EU, Japan and South Korea primarily focus on addressing both the quality of products through the introduction of mandatory standards and improving the information available to consumers through labelling in order to promote the benefits of energy efficient appliances. The Japanese Top-Runner programme – as per the associated policy for light duty vehicles – drives industry competition and improvement through natural market forces, whilst South Korea uses a combination of labels, certifications and mandatory standards with stringent compliance laws. It was found in these cases that changing behaviour was a key barrier due to the relatively long payback periods for consumers, although this was partially mitigated in both Japan and South Korea by tax incentives for energy efficient appliances. International Cooperative Initiatives may play an important role in the dissemination of knowledge and best practices for appliance energy efficiency, whilst the global nature of the appliance market is also likely to ensure that energy efficiency gains in these best practice countries are also diffused elsewhere.

Conclusion

The quantitative analysis undertaken for each thematic area in this report demonstrates that efforts to globally replicate best practice policies could significantly contribute to a reduction in the projected emissions gap of 14 Gt in 2030 (UNEP, 2015b). Although the estimation of GHG mitigation potential based upon the replication of best practice policies globally is naturally subject to a high degree of uncertainty, the theoretical maximum potentials for GHG reductions by 2020 illustrate the important role of pre-2020 GHG mitigation efforts in lowering the emissions gap. The achievement of these GHG mitigation potentials will rely upon the use of a diverse mix of policy instruments (i.e. market instruments, mandatory standards) and also the use of complementary measures to overcome particular policy barriers that were documented within the qualitative analysis.

By estimating the extent to which mitigation potential may exist up until 2020 and by providing insights on how policy barriers may be overcome, this report aims to facilitate enhanced action by countries participating in the UNFCCC negotiations prior to 2020.

1 Introduction

The objective of the upcoming 21st Session of the Conference of the Parties (COP) in Paris to the United Nations Framework Convention on Climate Change (UNFCCC) is to reach a new international agreement on the climate, applicable to all countries, that prevents global warming exceeding 2°C. In preparation for COP 21 in Paris countries have already submitted their Intended Nationally Determined Contributions (INDCs), which outlines what post-2020 climate actions they intend to implement under a new international agreement. The aggregate impact of these INDCs will determine whether or not the international agreement negotiated at the COP 21 will be ambitious enough to prevent the occurrence of runaway climate change. However, a substantial gap currently exists between the 2025 and 2030 emissions projected in the INDCs that were submitted to the UNFCCC and the lower emission levels that are consistent with limiting global warming to below the 2°C threshold (Climate Action Tracker, 2015a[2]; UNFCCC, 2015[3]). Without increased levels of ambition, the projected emission levels associated with the existing INDCs will result in a 92 % chance that global warming exceeds 2°C and only a 'likely' 66 % chance of remaining below 3°C this century (Climate Action Tracker, 2015b).

Given that the INDCs only commit countries to mitigation actions beyond 2020, there is an opportunity to further reduce this projected emission gap in 2030 based upon more ambitious mitigation efforts prior to 2020. The aim of this research paper is to therefore analyse the current mitigation of countries efforts, identify best practices and estimate the global impact on emission reductions in 2020 if applied globally. The analysis focuses on firstly reviewing the policies of a selection of countries with either high greenhouse gas (GHG) emissions or very ambitious mitigation actions. Based upon the outcome of this review, along with an assessment of initial indications of mitigation potential, the following four thematic areas were selected where ambition could be significantly enhanced by 2020:

(1) Renewable energy support (RES);

(2) Light duty vehicle standards;

(3) Electrical appliances;

(4) GHG emissions from flaring during oil and gas production.

The best practices for each thematic area were firstly assessed in a qualitative manner to understand the development of these GHG mitigation policies – focusing in particular on necessary reforms and the introduction of complementary policies in order to overcome the barriers experienced during their implementation. The outcome of these best practices were then quantitatively analysed with the GHG reductions associated with these policies upscaled to a global level to provide an indication of the mitigation potential available. By estimating the mitigation potential up until 2020 for four thematic areas the report demonstrates how countries could contribute to reducing the existing emissions gap prior to 2020 if best practice policies were replicated globally. The implementation of such best practice measures up until 2020 will reduce the current emissions gap and ensure that the post-

[2] The Climate Action Tracker (2015a) estimates that the gap in emissions between their emission pledge pathway (including INDCs) and their 2°C pathway will be 11-13 $GtCO_2e$ in 2025 and 15-17 $GtCO_2e$ in 2030.

[3] 'Compared with the emission levels consistent with the least-cost 2°C scenarios, aggregate GHG emission levels resulting from the INDCs are expected to be higher by 8.7 (4.7–13.0) $GtCO_2$ eq in 2025 and by 15.1 (11.1–21.7) $GtCO_2$ eq in 2030' (UNFCCC, 2015).

2020 action specified by the INDCs will be more likely to follow an emissions pathway that does not exceed the 2°C limit.

2 Methodological approach

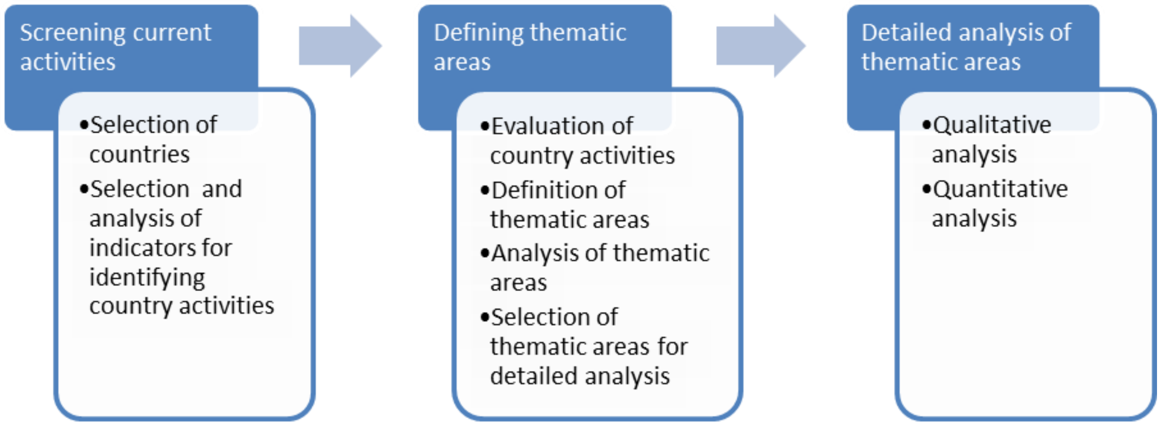
Our analysis includes three steps as illustrated in Figure 1.

The **first step** was to generate an overview of the current status of activities in a selected sample of countries. The analysis is structured along indicators that support the screening of the countries, and a matrix containing two layers (reduction potential and the policy activities) was produced.

Based on this output, the **second step** identified a list of potential areas for greenhouse gas mitigation (hereon referred to as “thematic areas”, e.g. fuel efficiency standards, low energy buildings). For each of these thematic areas, additional aspects were considered, such as the co-benefits or the role of the respective area in relevant forums to support discussions with and within BMUB and UBA. Based on this, a final set of thematic areas were selected for detailed analysis in the subsequent steps. The detailed methodology for the **screening of current activities** is described in section 2.1.

The **third step** consists of an in-depth evaluation of the selected thematic areas, including a qualitative assessment of the policy objectives, ambition, implementation barriers and co-benefits, and a quantitative assessment of the achieved and projected emission reductions of existing best practice policies. We then quantitatively estimated the global emission reduction potential of these policies by scaling these to a global level. Further methodological details for the qualitative and quantitative analysis are given in section 2.2.

Figure 1: General methodological steps



The approach applied in this paper uses elements of the “Climate Action Tracker country assessment”, which was developed to qualitatively and quantitatively evaluate country policies for their ability to induce a paradigm shift towards reaching a low carbon world by 2050 and to estimate emission reductions induced by these policies by 2020 and 2030 (Höhne et al. 2011). The indicators developed there form the basis for the first step of our methodological approach.

2.1 Screening of current activities

The first step covers the selection of countries as well as the definition and analysis of indicators for country activities, based on desk research and existing databases.

2.1.1 Selection of countries

The aim of this step is the selection of a representative sample of countries that will be part of the subsequent country screening. The countries, presented in full in the Appendix (see Table 20), were selected based on two main criteria:

- Countries with high greenhouse gas emissions in 2010: The top-30 emitters are of great significance to mitigation policy, and it is assumed that many of these countries will already have policies in place to reduce their emissions.
- Countries with ambitious domestic strategies or policies: In addition, Ethiopia, Costa Rica and the Maldives have been included for their highly ambitious carbon-neutral strategies, whilst Norway, Switzerland, Denmark, New Zealand and Chile are also of particular interest due to their comprehensive climate policy frameworks.

The EU is included as a single entity here, although a number of relevant individual member states are also included separately. In total a number of 38 countries were selected.

2.1.2 Indicators for policy evaluation

This step provides an overview of where mitigation action is happening. At this stage we focus on the presence of action and not its intensity. We developed a set of indicators to indicate the existence of a policy in each area (Table 2).

The approach builds on the methodology developed for the Climate Action Tracker country assessment (Höhne et al., 2011), and was adjusted to fit the context. The original Climate Action tracker methodology contains a set of indicators for combinations of policy area and sector (see Table 2) that are qualitatively described in the analysis for each country.

Table 2: Structure of indicators by policy area and sector

	1.Changing activity[4]	2.Energy Efficiency	3.Renewable Energy	4.Low Carbon	5.Other / Non Energy
1. Electricity					
2. Industry					
3. Buildings					
4. Transport					
5. AFOLU[5]					

Source: Own illustration adapted from Climate Action Tracker methodology. Greyed out boxes represent combinations that are not applicable, e.g. non-energy emissions in the transport sector are insignificant.

Policy and activity identification was achieved through the review of policy databases (see Appendix) and a country by country literature analysis and the existing expert knowledge within the team. The results of the country analysis were merged into a summary matrix highlighting the trends per policy area and sector. Each combination of sector and policy area was rated according to the prevalence of existing instruments in all countries.

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[4] Changing activity refers to: Incentives and barriers that indirectly reduce emission by changing behaviour or by introducing new technology concepts (see Appendix I, section 7.2.)

[5] Agriculture, Forestry and Other Land Use (AFOLU)

2.1.3 Selection of thematic areas and specific case studies for evaluation

The output of the country analysis - the summary matrix – was evaluated based on the sector reduction potential and the country activity coverage (i.e. occurrence of instruments). The aim of this analysis is twofold:

1. To identify areas that have a lot of action ongoing in a relatively large number countries, but for which a large reduction potential still exists in other countries. These actions have proven themselves to be working across different contexts and could therefore be relatively easily scaled up in others.
2. To identify areas where only limited action is happening but successful best practice policies exist that could also be implemented in other countries. These areas have not proven themselves across different contexts, put provide a high potential for scale-up.

Based on this analysis and our own expert knowledge we identified a number of distinct thematic areas for potential qualitative and quantitative evaluation. These thematic areas are not necessarily limited to the specific combinations of policy areas and sectors previously highlighted, but instead could cover multiple sectors and/or could cover a subsection of the policy area/sector combinations.

Within the selected thematic areas, policy case studies in specific countries were selected based on expert knowledge within the team on the following criteria:

- Success of policy implementation
- Different types of instrument
- Potential for, and relevance to, global coverage
- Data availability

2.2 Analysis of selected thematic areas

2.2.1 Qualitative Analysis

The detailed qualitative analysis of each selected thematic area aims to uncover the best policy practices supporting implementation of mitigation activities, and to discuss the barriers as well as the benefits of implementation.

A review of the literature, supplemented by interviews if deemed necessary, was conducted in order to describe the best practice policies implemented in the selected countries for each thematic area and to also establish the motivation for these policies and the effectiveness of their implementation. The following questions are addressed in the qualitative analysis:

- What are the best practice policies per thematic area in Annex I or Non-Annex I countries?
- What are the social, economic and environmental co-benefits of implementing best practice policies? What kind of support is required to implement supporting incentives on a global level?
- What are the existing and potential barriers for implementation and increased ambition, and how can they be removed?
- What is the status of the thematic area in the international climate policy environment?
- What is the future outlook for the best practice policies looking ahead at potential challenges that may need to be overcome in order to ensure continued effectiveness?

Specific methodological considerations for each thematic area are given within the corresponding sections.

2.2.2 Quantification of reductions

This section describes the approach to estimating potential emission reductions and scaling up best practice policies to a global level.

Our methodology consisted of two distinct steps. Firstly, the maximum impact of policies in the targeted thematic areas and countries was evaluated with respect to key performance indicators. Secondly, the evaluation of these key performance indicators from the selected countries is used to determine the potential impact of the policies on a regional or global level. The method of upscaling the policy impact to the regional or global level varies between thematic areas, and is covered under the *methodological considerations* section for each thematic area.

In order to estimate the reductions, a tool was designed to calculate and demonstrate differences between specific scenarios up to 2020. The specific scenarios used for each thematic areas are covered under the *methodological considerations* section for each thematic area:

- Frozen technology pathway – This pathway assumes that the technology will remain the same as the date of the most recent verified data, up until 2020; no further (autonomous) efficiency improvements will be achieved.
- Without policies pathway – This pathway projects the likely trajectory of emissions in the absence of policy in that area.
- Reference pathway (External scenarios, e.g. WEO) – The reference pathway assumes some autonomous efficiency improvements that are achieved through existing implemented policies as well as other effects. Since we will use an existing scenario, we cannot be sure what is included in the baseline and what is not included.
- With policies pathway – This pathway calculates the maximum potential impact of the adoption of the policies up until 2020.

Transparent assumptions and particular methodological considerations for each thematic area are given in the results section.

3 Results of screening of current activities

1,200 policies of 38 countries were screened to determine the rate of current policy activities in each thematic area. A summarised representation of the indicators that produce these results are given in Table 3, whilst the full list of indicators is presented in Table 22, Appendix I. The final aggregated results of the policy screening are provided in Table 4. The table provides the most popular policy instruments. The percentages indicate the coverage of all elements necessary to support one area and of all countries.

Table 3: Summary list of indicators for country policy analysis

Thematic area		Indicator	Weighting factor	No. of countries (/36)	Final indicator score
1 Electricity and heat	1.1 Cross-cutting	**1.1 Cross-cutting: Total**			**27.8%**
		Overarching incentives	1	10	27.8%
	1.2 Energy efficiency	**1.2 Energy efficiency: Total**			**21.5%**
		Incentives to increase efficiency of fossil fuel power plants	0.5	9	12.5%
		Support to increase the share of CHP	0.25	9	6.3%
		Policies to reduce distribution losses	0.25	4	2.8%
		Subsidies applicable in the electricity sector	-0.5	*	0.0%
	1.3 Renewables	**1.3 Renewables: Total**			**49.3%**
		Is effective support for RES-E?	0.75	23	47.9%
		Support to incentivise technology diffusion	0.25	2	1.4%
	1.4 Low carbon	**1.4 Low carbon: Total**			**5.6%**
		Policies that influence fuel switch	0.25	8	5.6%
		Incentives for biomass CCS	0.25	0	0.0%
		Incentives for coal or natural gas CCS	0.25	0	0.0%
		Active support for nuclear energy	0.25	*	0.0%
Industry	2.1 Cross-cutting	**2.1 Cross-cutting: Total**			**30.6%**
		Overarching incentives for industry sector	1	11	30.6%
	2.2 Changing activity	**2.2 Changing activity: Total**			**5.6%**
		Policies to support sustainable product redesign	1	2	5.6%
	2.3 Energy efficiency	**2.3 Energy efficiency: Total**			**23.6%**
		Schemes to improve energy efficiency in industry	0.5	12	16.7%
		R & D support policies	0.5	5	6.9%
		Subsidies/tax exemptions for conventional fuels in industry	-0.5	*	0.0%
	2.4 Renewables	**2.4 Renewables: Total**			**36.1%**
		Policies to increase use of RE in industry	1	13	36.1%
		Subsidies/tax exemptions for conventional fuels in energy intensive industry	-0.5	*	0.0%
	2.5 Low carbon	**2.5 Low carbon: Total**			**0.0%**
		Incentives for coal/gas CCS development	1	0	0.0%
		Incentives for biomass and process emission CCS	1	0	0.0%
	2.6 Non-energy	**2.6 Non-energy: Total**			**2.8%**
		Policies to reduce N2O emissions in industry	1	0	0.0%

Thematic area		Indicator	Weighting factor	No. of countries (/36)	Final indicator score
Buildings	3.1 Cross-cutting	**3.1 Cross-cutting: Total**			**5.6%**
		Overarching incentives	1	2	5.6%
	3.2 Changing activity	**3.2 Changing activity: Total**			**8.3%**
		Urbanisation policy for energy efficient development	1		8.3%
	3.3 Energy efficiency	**3.3 Energy efficiency: Total**			**54.9%**
		Incentives for efficient appliances	0.25	0	
		Subsidies/tax exemptions for electricity use	-0.5	*	0.0%
		Ambitious EE standards for new buildings	0.25	24	16.7%
		Incentive for high retrofit rates	0.25	26	18.1%
		Policies for efficiency improvements	0.25	0	0.0%
		Barriers (fuels)	-0.5	*	0.0%
	3.4 Renewables	**3.4 Renewables: Total**			**40.3%**
		Instruments for low-carbon heating/cooling in all buildings	0.5	29	40.3%
		Policies for renewables in cooking and hot water supply	0.5	0	0.0%
	3.5 Low carbon	**3.5 Low carbon: Total**			**0.0%**
		Support for fuel switch	1	0	0.0%
Transport	4.1 Cross-cutting	**4.1 Cross-cutting: Total**			**8.3%**
		Overarching incentives	1	3	8.3%
	4.2 Changing activity	**4.2 Changing activity: Total**			**13.9%**
		Strategies to avoid traffic and shift to non-motorised transport	1	1	2.8%
		Incentives that promote higher fuel use in transport	-0.5	*	0.0%
	4.3 Energy efficiency	**4.3 Energy efficiency: Total**			**22.9%**
		Incentive to reduce light vehicle emissions	0.33	11	10.1%
		Incentive to reduce heavy vehicle emissions	0.33	11	10.1%
		Taxes to incentivise reduction of fuel use	0.33	3	2.8%
	4.4 Renewables	**4.4 Renewables: Total**			**50.0%**
		Incentives to increase RE in transport	1	18	50.0%
	4.5 Low carbon	**4.5 Low carbon: Total**			**13.9%**
		Support for fuel switch: oil to low carbon tech	1	1	2.8%
AFOLU	5.1 Changing activity	**5.1 Changing activity: Total**			**27.8%**
		Incentives	1	10	27.8%
	5.2 Non-energy	**5.2 Non-energy: Total**			**38.9%**
		Incentives	1	14	38.9%

*: not comprehensively evaluated due to data gaps

Table 4: Result of country policy analysis: most popular policy instruments and percentage coverage

	Changing Activity	Energy efficiency	Renewables	Low carbon (other than renewables)	Non-energy
General	Strategies and targets 69%				
Electricity		Performance standards 22%	Support schemes (e.g. feed-in tariff) 49%	Tax exemptions 6%	
	Carbon pricing schemes 25%				
Industry	Strategies 6%	Voluntary agreements 24%	Fuel quota 36%	CCS support schemes <3%	Regulation (Not evaluated)
	Carbon pricing schemes: 31%				
Buildings	Programmes 8%	Product standards and building codes 55%	Tax exemptions 40%	Not evaluated	
	Energy taxes: (Not evaluated)				
Transport	Modal shift programmes 14%	Vehicle standards 23%	Direct subsidies and fuel quota 50%	E-mobility programmes 14%	
	Energy taxes: (Not evaluated)				
AFOLU	Strategies 28%				Regulations/planning 39%

Scale: Minimum … Maximum

The results from Table 3 and Table 4 illustrate that overarching climate policies exist in a lot of countries, while the picture for policies per thematic area is very mixed.

Almost all countries gave overarching climate laws or strategies and/or overarching renewable and efficiency targets. With 69% this is the highest score for all areas analysed.

A number of thematic areas stand out thereby: renewable energy support schemes in the electricity sector, building and product standards in the building sector as well as subsidies and quotas in the transport sector already play an important role to date in many countries. All areas have a coverage of around 50%. For renewables in electricity generation, the policy instruments used are diverse, including feed in tariffs, quotas and tax exemptions. For energy efficiency in buildings the preferred instruments are product standards and building codes, which are very common. Many countries use fuel quota and subsidies to increase the use of biofuels in transport.

In addition, general carbon pricing mechanisms are emerging; they already now cover 25 to 30% of the countries. This includes emissions trading schemes and CO_2 taxes, both often applicable to electricity generation and industry.

Energy taxes in buildings and transport are likely to play an important role, but they were not surveyed in this study.

On the other hand some areas are still largely lacking in most countries. Examples are more structural measures (first column in Table 4) related to long lasting, recyclable products in industry, urban development programmes in buildings, and modal shift in transport. Dedicated support to low carbon energy other than renewables is also limited, with electromobility programmes emerging.

After evaluating the policy activity we also consider the mitigation potential per area, Table 5 provides an overview of the reduction potential of different thematic areas as provided by different studies.

Again certain thematic areas stand out somewhat regarding their potential. These include, most notably, renewable energy (in particular solar and wind energy), reducing deforestation but also fossil fuel subsidy reform. However it can also be concluded from the table that there are a lot of areas with very similar potentials. This implies that action will be necessary across a wide remit of thematic areas. For the analysis here, this implies that the mitigation potential is not such strong selection criteria as we originally envisioned it to be.

Table 5: Overview of mitigation potential by initiative

Topic		Wedging the gap	UNFCCC technical paper	IEA energy / climate map	Number of initiatives
Energy efficiency	Buildings heating and cooling	0.6	2	0.5	25
	Ban of incandescent lamps	0.5		0.5	
	Electric appliances	0.6			
	Industrial motor systems			0.4	
	Cars and trucks emission reductions	0.7		0.2	
Renewable energy	Boost solar photovoltaic energy	1.4	1 – 2.5		17
	Boost wind energy	1.2			
	Access energy through low emission options	0.4			
Limiting inefficient coal use in electricity generation				0.7	0
Methane and other climate pollutants	Methane from fossil fuel production	*	1.1	0.6	7
	Other methane and other climate pollutants				
	Efficient cook stoves	*			
Fluorinated greenhouse gases		0.3	0.5		3
Fossil fuel subsidy reform		0.9	1.5 – 2	0.4	1
International transport		0.2	0.3 – 0.5		4
Agriculture		0.8	1.3 – 4.2		1
Reduce deforestation		1.8	1.1 – 4.3		15
Waste			0.8		1
Companies	Top-1000 companies emission reduction	0.7			4
	Supply chain emission reductions	0.2			1
	Green financial institutions	0.4			1
	Voluntary offset companies	2.0			0
Voluntary offsets consumers		1.6			0
Major cities initiative		0.7			3
Sub-national governments		0.6			2
Total		9.7**	Not added	3.1	

Source: UNEP emissions gap report 2013

Based on the analysis of the policy activity (Table 4) and the mitigation potential (Table 5) we identified a number of thematic areas that were taken for closer consideration. These are summarised in Table 6. The highlighted thematic areas on the left part of the table fulfil the first criteria mentioned in section 2.1.3: they have a relatively large emission reduction potential and a lot of action ongoing that can be replicated in other countries or be improved in the countries where (weak) action already exists. The thematic area highlighted on the right side of the table satisfies the second criteria in section 2.1.3: There is only limited, however, relatively successful action ongoing but a relatively high mitigation potential exists.

Table 6: Extended list of possible thematic areas (indicative mitigation potential in brackets)

High current activity rate	Low current activity rate
Support schemes for electricity generation with renewable energy (up to 2.5 GtCO2e) *Electric appliances and lighting (up to 0.6 GtCO2e)* *Fuel efficiency standards for light duty vehicles (up to 0.7 GtCO2e)* Carbon pricing mechanism (n.a.) Reduce deforestation (up to 4.3 $GtCO_2e$)	*Methane from fossil fuel production (1.1 GtCO2e)* Limiting inefficient coal use in power (up to 0.7 $GtCO_2e$) Zero energy buildings Fossil fuel subsidy reform (up to 2 $GtCO_2e$) Increase efficiency (industrial motors) and use of renewables in Industry (up to 0.4 $GtCO_2e$) Waste (1 $GtCO_2e$) Fluorinated gases (0.5 $GtCO_2e$) E-Mobility (n.a.)

Four illustrative thematic areas with high mitigation potential that represent a balance between high, medium and low current activity rates were chosen for further analysis (Table 7). The table provides the rationale for the choice of each of these thematic areas.

Table 7: Selected thematic areas and their rational for selection

Selected thematic area	Rationale for selection
Support schemes for electricity generation from renewable energy	High activity rate (about half of the analysed countries have implemented a support scheme) High mitigation potential (UNEP gap report 2013: 2.5 $GtCO_2e$) Short term implementation still possible, with long term transformational effect
Electric appliances and lighting	High activity rate (about half of the analysed countries have implemented a support scheme) High mitigation potential (UNEP gap 2013: 0.6 $GtCO_2e$ in 2020) Often cost neutral in the long term; potential to increase ambition till 2020
Fuel efficiency standards for light duty vehicles	Medium activity rate (about a quarter of the analysed countries have implemented a support scheme) High mitigation potential (UNEP gap 2013: 0.7 $GtCO_2e$ in 2020) Often cost neutral in the long term; potential to increase ambition till 2020
Methane from fossil fuel production	Low activity rate (only few countries have measures implemented) High mitigation potential (UNEP gap 2013: 1.1 $GtCO_2e$ in 2020) Low cost option

We selected example countries (Table 8) for the evaluation based on the following criteria:

a) High level of ambition
b) Good data availability
c) Representative for the global situation

In parallel we identified an indicator for each thematic area that could then be used to estimate the global emission reduction potential. The indicator aims on the one hand to reflect the development in the thematic areas in the best way possible and on the other hand to allow for easy integration into a calculation tool for the calculation of the global impact. The indicator will then be used in the calculation of the global emission pathway.

Table 8: Overview of the countries selected per thematic area

Thematic area	Description of measures	Countries with best practice policies
Fuel efficiency standards for light duty vehicles	Reduce the specific fuel consumption of new vehicles entering the fleet	US, China, Japan, EU
Electric appliances and lighting	Reduce electricity use of new appliances	EU, South Korea, Japan
Emissions from flaring during oil and gas production	Reduce flaring of emissions; reduce leakage rate of pipelines	Russia, Norway
Support schemes for RES-E	Increase share of RES in the electricity supply	China, Germany, UK, Morocco (only quantitatively assessed), USA (only qualitatively described)

4 Results per thematic area

4.1 Renewable Energy Support (RES)

4.1.1 Germany: Feed in Tariff

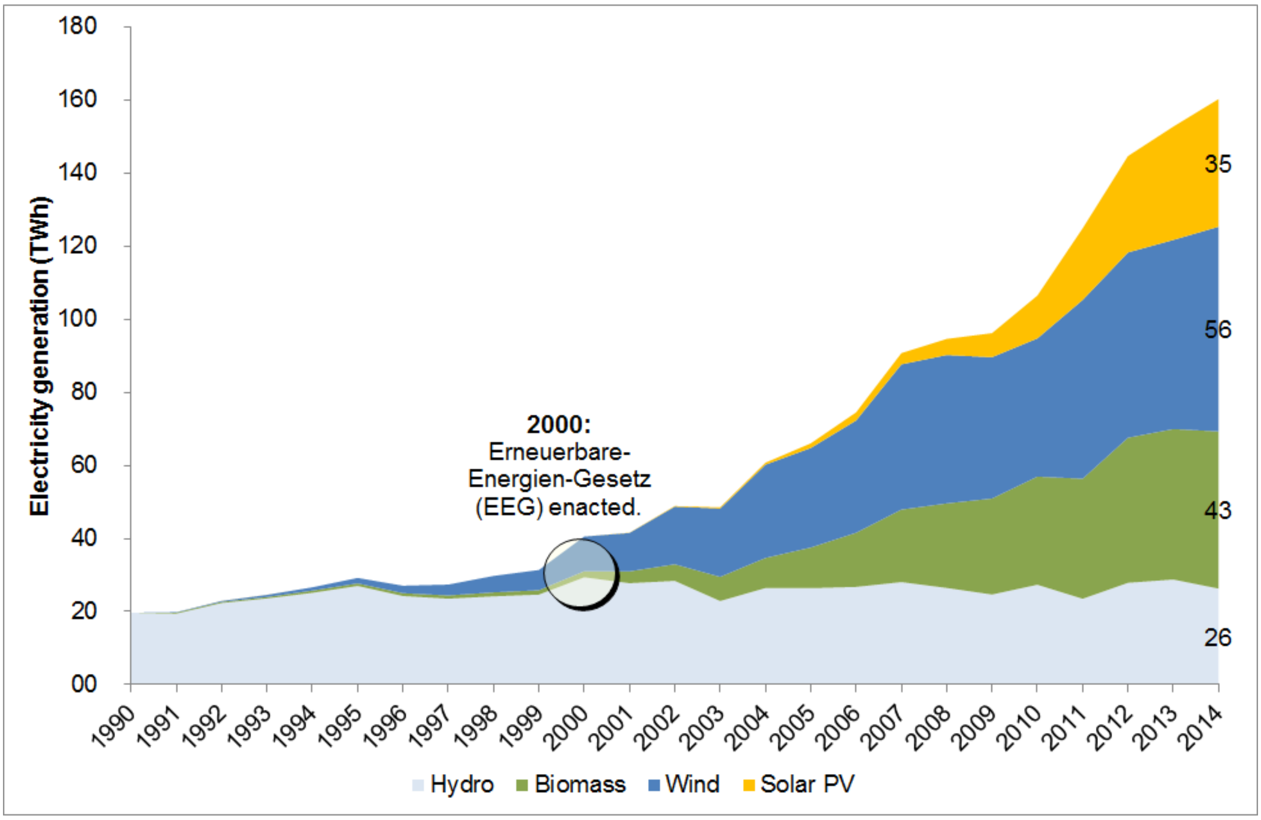
The German Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz – EEG), which was enacted in 2000 and subsequently amended in 2004, is the main policy instrument to promote renewables in the electricity sector. The EEG replaced electricity feed-in legislation (Stromeinspeisungsgesetz, StrEG) enacted in 1990 (IEA, 2007) and has been mainly responsible for the country's successful efforts to progress towards ambitious renewable energy (RE) targets (i.e. Germany expects to exceed the target set under the Directive 2009/28/EC of 18 % of gross final energy consumption originating from RE sources by 2020). It is also envisaged that at least 35 % of gross electricity production will come from RE sources by 2020 (BMU, 2013a).

The EEG provides that electricity from renewable power plants is preferentially fed into the grid and guarantees fixed feed-in tariffs to the producers using renewable energy. The differential costs between these guaranteed remuneration payments and the revenues received on the electricity market are transferred to the final customers. 'The relative differentiation of tariffs is based on equalisation of cost across all technologies; rates are set so that producers should make the same profit regardless of the cost of each technology, and therefore be indifferent towards investing in any particular technology' (IEA, 2007). The amount paid depends upon the year in which the installation was built, with rates guaranteed for a period between 15 and 30 years subject to the technology.[6] The EEG is widely considered to have had a significant impact on the development of renewable energy in Germany with growth experienced in several technologies since the introduction of the policy measure (Figure 2).

In 2014, RE shares of gross electricity generation in Germany reached 31 %, compared to only 4 % in 1990 (BMWi, 2015). The country is therefore making good progress towards its 2020 target of 35 % (BMU, 2013a). Figure 2 illustrates the considerable increase in electricity generation from wind (i.e. 56 TWh by 2014), solar PV (i.e. 35 TWh by 2014) and biomass (43 TWh by 2014) technologies that have been incentivised by the feed in tariff policy. Wind energy is the dominant source, accounting for 34.8 % of renewables based electricity generation in Germany in 2014, however the rate of increase in electricity generation from solar PV (i.e. accounting for 21.7 % of renewables based electricity generation in Germany in 2014) has also been considerable in recent years (BMUB, 2015) . The increased electricity generation from wind reflects the high levels of investment in the technology that accounted for 65 % of the total amount invested in the construction of renewable energy installations in Germany in 2014 (i.e. €18.8 billion). The construction of solar PV and biomass installations accounted for €2.3 billion and €1.3 billion of investment respectively in Germany in 2014 (BMUB, 2015).

[6] For example, all onshore wind developments receive the same FIT payment for the first five years, which was set in the 2012 EEG at 8.93 € cents/kWh. Following the initial payment, onshore wind projects with the strongest wind resources receive a lower payment (i.e. base payment) of 4.87 € cents/kWh for the remaining 15 years of the FIT contract. Onshore wind developments with less strong resources receive the initial payment for a longer period before this is eventually replaced by the base payment. However, the FIT payment for offshore wind developments was set at a higher rate in the 2012 EEG with an initial payment of 15.0 € cents/kWh and a basic payment of 3.5 € cents/kWh (BMU, 2013b)

Figure 2: Development of electricity generation from renewable energies in Germany



Source: BMWi (2015)

Although the feed in tariff policy has undoubtedly encouraged the development of RE in Germany, the debate over the cost effectiveness of the policy is ongoing in the country with some commentators arguing that the EEG surcharge[7] is imposing excessive costs on German households and businesses. Indeed, according to data recently published by BMUB (2015) the cost of EEG tariff payments have increased from €1.6 billion in 2001 to €21.9 billion in 2013. Several factors may have contributed to the increase observed in the EEG surcharge:

- The increase in renewable deployment incentivised by the EEG resulted in an increase in the EEG surcharge;
- The feed in tariff continued to stay more or less the same, despite a decline in wholesale power prices – which resulted in an increase of the EEG surcharge to cover the difference;
- The EEG allowed high energy intensive companies in Germany to apply for exemptions, which decreased the number of customers that the power prices were spread over therefore raising the EEG surcharge for remaining consumers.

Although it is undeniable that the EEG surcharge has increased over time, the counter argument suggests that the costs of the policy may have been over emphasised (BMU, 2009) and the co-benefits overlooked.[8] For example, the growing share of renewables sold on the electricity spot market is also

7 The differential costs between the guaranteed remuneration payments made to the plant operators and the revenues on electricity market are passed through to the so-called privileged and non-privileged power consumers based on different rates.

8 The policy measure is associated with many co-benefits that include job creation in the renewable energy sector, which has experienced an increase from 160,500 people employed in 2004 to 381,600 people in 2011 (BMU, 2013a). The

putting downward pressure on wholesale market prices when the production of solar and wind is high. It is also important to acknowledge that the cost of renewables continues to decline (especially photovoltaic technology) – partly as a consequence of higher levels of investment in research and development incentivised by the EEG. Nevertheless, in order to ensure that the policy remains cost effective in the long term several important reforms to the EEG were introduced in 2014:

- **Market premium:** Until 2017 the new EEG maintains a set level of remuneration per kilowatt-hour for renewable electricity, however for new installations a 'contract for difference' scheme has been introduced instead of a set feed-in payment that is automatically paid to the producers of renewables in Germany. The new EEG obligates producers to sell their electricity themselves and they will receive a 'market premium' for doing so which is calculated as the difference between the average monthly wholesale price and the set remuneration for electricity from different renewable sources stated in the law (Appunn, 2014).
- **Competitive bidding:** A competitive bidding model will be introduced in 2017 to replace feed in tariffs (which were previously adjusted downwards in the 2012 EEG) to only provide financial support to investors offering the lowest price for the electricity that their installation will produce (Appunn, 2014).
- **Growth corridors**: The new EEG sets annual targets for the addition of onshore wind (2,500 MW net), solar (2,500 MW gross) and biogas capacity (100 MW net), referred to as annual expansion 'corridors', with feed in remuneration adjusted depending on the amount of newly installed capacity. For example, if new installation achieve the target then the payment for renewables is reduced. It is envisaged that this will lead to better coordination of renewable development and an expansion of the grid (Appunn, 2014).

It is evident with these reforms that the EEG is evolving from a policy measure that primarily focused on scaling up domestic RE generation (i.e. 2000 to 2009) to subsequent phases of the policy where adjustments have been necessary in order to respond to the declining costs of renewables (i.e. 2009 to 2011) and the challenges of incorporating greater volumes of RE into the wholesale market (i.e. 2012 onwards). The policy has therefore, to a certain extent, removed some of the previous inflexible (and potentially expensive) guarantees for RE investment and is now gradually moving towards a model whereby there is more emphasis on market forces to promote the development of renewables. The viability of the policy may ultimately depend upon the future distribution of the EEG surcharge[9], and wider reforms to the electricity market to incorporate RE into the electricity grid.

4.1.2 China: Renewable Energy Law

In 2005 the Renewable Energy Law was passed by the Chinese government, which created a framework based upon four mechanisms to promote the growth of China's RE supply (Schuman, 2010):

- A national renewable energy target;

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shift to renewables is also associated with enhanced energy security with less dependence on fossil fuels that is equivalent to a saving of 322.5 TWh of primary energy from the use of renewables in 2012 (BMU, 2013a).

9 At present the EEG benefits industrial consumers who are sheltered from the full costs of the EEG surcharge and also benefit from the downward pressure on wholesale market prices due to increased renewables generating electricity.

- A mandatory connection and purchase policy;
- A feed in tariff system;
- A special fund for renewable energy development.

Following the introduction of the Renewable Energy Law, the State Council's energy department announced in 2007 mid and long term national targets for RE production with the aim of achieving 15 % of the country's primary energy consumption from non-fossil sources such as RE and nuclear power by 2020 (Schuman, 2010). In order to achieve this target, the Renewable Energy Law included provisions that required grid companies to both connect and purchase all of the RE power generated within their coverage area. The Law also directed the establishment of a set of feed in tariffs for different RE technologies, which guarantee an electricity price above the market rate that the grid company will pay the generator of RE.[10]

To ensure that the feed in tariffs provided an appropriately priced incentive that was cost effective, China firstly operated several feed in tariff programmes on a project by project basis through competitive bidding. Following this experience, a nationwide program was launched for the wind sector in 2009 with a comprehensive feed in tariff schedule that eliminated the need for further bidding on feed in tariffs. The tariff schedule is comprised of four tiers 'with the highest tariffs[11] available for projects in regions with the least abundant wind resources' (Schuman, 2010). A nationwide feed in tariff is also available for electricity generated from solar PV[12] and biomass-fired power plants[13] following similar learning phases through feed in tariff bidding.

The Renewable Energy Law also established in 2006 a Renewable Energy Development Special Fund (financed through a central government budget allocation for renewable energy), which would support the following activities (Schuman, 2010):

- Research in the science and technologies associated with developing and deploying RE, setting standards and demonstration projects;
- RE program for basic rural energy needs;
- Establishing stand-alone electricity projects in remote areas and islands;
- Exploration of RE resources, evaluation, and relevant information system;
- Encouraging the localization of production for equipment used in the deployment of RE.

China has experienced a rapid growth in the capacity of its wind and solar power between 2005 and 2014 (albeit from a low starting point) following the introduction of the Renewable Energy Law (Figure 3). The country is therefore making good progress towards reaching the ambitious targets recently set in its Energy Development Strategy Action Plan (2014-2020)[14], which aims to increase installed capacity of wind and solar power up to 200 GW and 100 GW respectively by 2020. The increase in renewable capacity also reflects the high levels of investment in the country, which is now

10 'The additional cost of the feed-in tariff over and above the cost of conventional power is paid by a national surcharge on end-users of electricity' (Schuman, 2010).

11 'The national feed-in tariff is divided into four tiers ranging between 0.51 to 0.61 RMB/kWh' (Schuman, 2010).

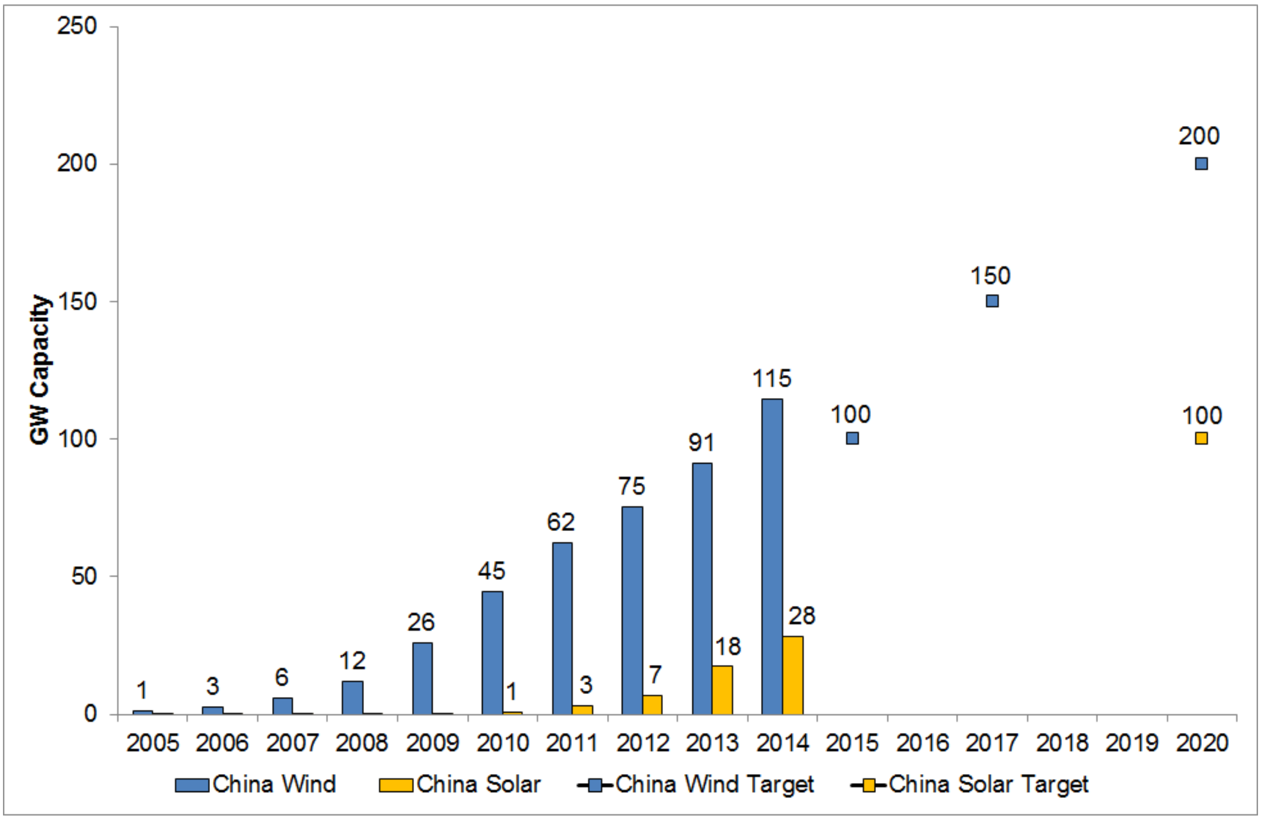
12 'The development of solar PV power generation projects nationwide divides solar projects into two categories: Projects approved prior to July 1, 2011, which have completed construction and have achieved commercial operation prior to December 31, 2011. These projects are entitled to a tariff of RMB 1.15 (approximately U.S. $0.177) per kWh. Projects approved after July 1, 2011 (or approved prior to that date but which cannot be completed before the end of 2011). These projects are entitled to a tariff of RMB 1 (approximately U.S. $0.154) per kWh' (Wigmore et al, 2011).

13 'China announced a national feed-in tariff for biomass-fired electricity in July 2010, set at 0.75 RMB ($0.11) per kilowatt hour' Finamore (2010)

14 http://www.nea.gov.cn/2014-12/03/c_133830458.htm

the world's leading investor in renewables investing $89.5 billion in 2014. This represents an increase of 32 % from the previous year and it was also nearly 73 % more than the US (Climate Group, 2015).

Figure 3: Cumulative development of wind and solar capacity between 2005 and 2014 compared to future targets



Source: BP Statistical Review of World Energy (2015)

Although the capacity of renewables continues to expand in China, progress towards the 2020 target of 15 % has been hindered in the past by a failure to fully implement on the ground the mandatory obligations placed on grid companies to connect all renewable projects and purchase the power produced. Long delays have been experienced with connecting renewable energy capacity in the country[15] due in part to the lack of resources and incentives to invest in the grid infrastructure necessary to facilitate the growth in renewables (Schuman, 2010). In order to improve the implementation of the RE support measures the following reforms were made to the 2009 amendments to the Renewable Energy Law:

- 'Adding measures intended to improve implementation of the mandatory connection and purchase policy, such as a quota system, a priority dispatch system, and technical standards for interconnection to the grid'(Schuman, 2010);
- 'Streamlining the RE fund that provides financial incentives for the deployment of renewable energy and importantly subsidises grid companies for the costs of integrating RE that they cannot recover from electricity sales to consumers'(Schuman, 2010);

15 'More than 30 % of China's wind capacity was not connected to the grid at the end of 2009' (Schuman, 2010).

- 'Increasing central government oversight of provincial and local renewable energy development planning to help with the co-ordination of transmission extensions' (Schuman, 2010).

China has made considerable progress in recent years to increase their RE capacity following the introduction of the Renewable Energy Law, although based on their experiences with implementing the various RE support policies it is evident that additional effort will be required in order to achieve the ambitious targets that the government has set and take advantage of the co-benefits of increasing renewables (i.e. air quality improvements, energy security). 'The amendments to the Renewable Energy Law demonstrate that China's central government is committed to overcoming some of the barriers that have stood in the way of achieving this goal' (Schuman, 2010). Indeed the most recent data on primary energy consumption indicates that progress is now being made on reaching the 2020 target with approximately 10.9 % of primary energy derived from non-fossil sources in 2014.[16] The future success of the policy will depend upon the ability of the transmission grid to incorporate increasing amounts of renewable energy into the electricity system that will require responsive policy design and strong enforcement.

4.1.3 USA: Production Tax Credit

In 1992 the Energy Policy Act introduced for the first time production tax credits (PTC), which provided a financial incentive in the form of a tax credit for each kilowatt-hour of electricity produced by a qualified project during the first ten years of operation for a range of RE technologies (Brown, 2012). Depending upon the RE technology, a corporate tax credit of either 1.1 cents/kWh (i.e. applicable for landfill gas, open-loop biomass, municipal solid waste resources, qualified hydropower and marine and hydrokinetic projects) or 2.2 cents/kWh (i.e. applicable for electricity from wind, closed-loop biomass and geothermal resources) is received by project developers in accordance with the PTC policy (EPA, 2013). The PTC, which is adjusted annually for inflation, has expired and been renewed on several occasions and most recently in January 2013 with the passage of the American Taxpayer Relief Act of 2012.

When the Energy Policy Act was signed in 1992, the motivation for introducing the PTC was primarily to lower the cost of RE technologies by encouraging more innovative designs and applications that would ultimately lead to an accelerated development of RE technologies to assist US states with the achievement of their renewable portfolio standards (RPS). These standards have been strengthened over time and have been complemented by a recent pledge in 2013 by the Obama administration to source 20 % of the electricity demand of all federal agencies from renewables by 2020. The wind industry in particular has benefitted from the introduction of the PTC policy with the cumulative total capacity reaching over 60 GW in 2012, which coincided with the largest annual addition of new capacity in wind power of 13 GW (Figure 4). The growth in electricity generation from wind power has been substantial in the United States between 1998 and 2014, due in part to improvements in the cost and performance of wind power technology that has been incentivised by the PTC policy (U.S. Department of Energy, 2013).

[16] Calculated based on data provided in the BP Statistical Review of World Energy 2015. The sum of non-fossil sources of primary energy (i.e. nuclear energy, hydroelectric and renewables) were divided by the total primary energy consumption in 2014.

Figure 4: Cumulative development of wind capacity in the USA between 1998 and 2014

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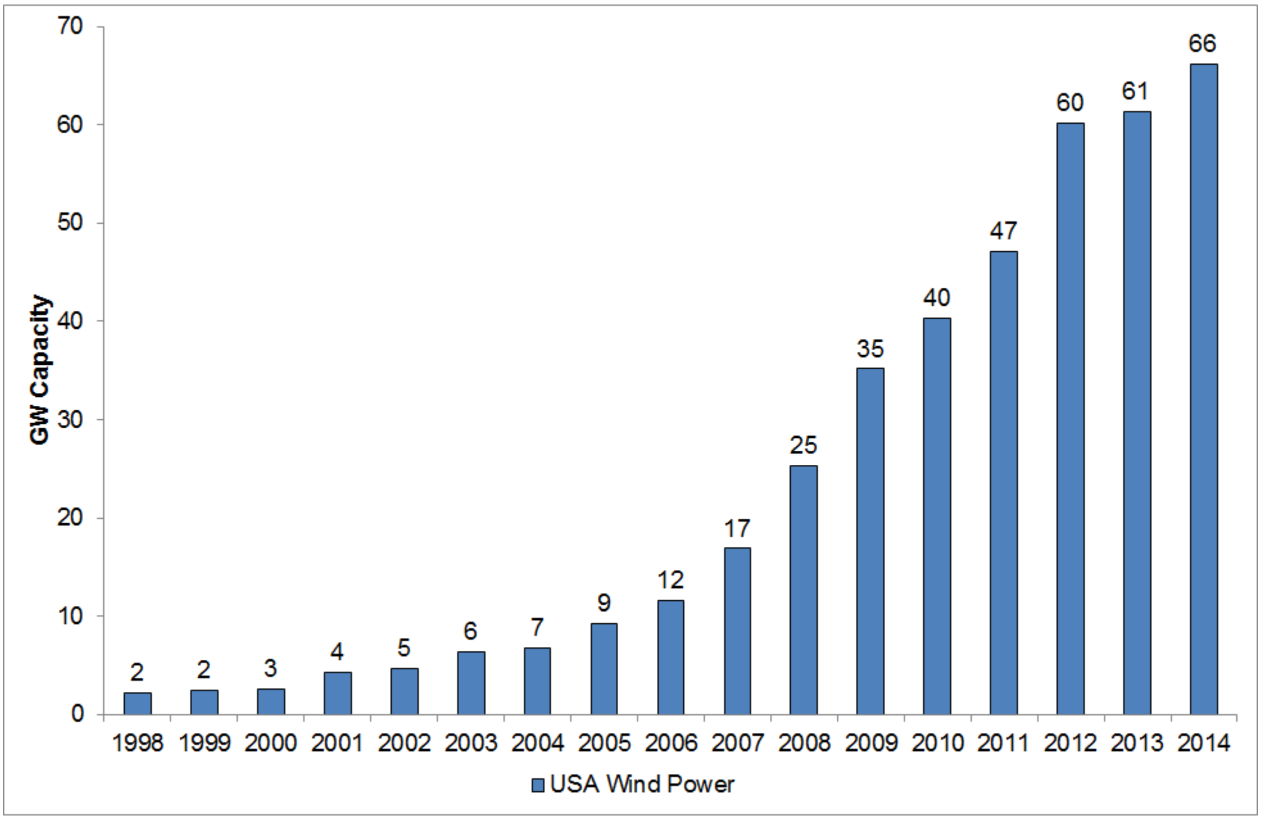


Source: BP Statistical Review of World Energy (2015)

Although the PTC policy has certainly encouraged the development of RE technologies over the last two decades the financial incentives for the long term investment in renewables has been insufficient due to the uncertainty that has arisen from the numerous occasions when the PTC policy has expired and then subsequently been renewed. For example, the American Wind Energy Association (AWEA) has previously argued that ‘the expiring nature of production tax credits has created a volatile U.S. wind market with new installations ramping up just before the credits expire[17], the following year having very little new wind development’ (Brown, 2012). However, it is also important to acknowledge other barriers to RE deployment in the USA such as the continued low natural gas prices, modest electricity demand growth and limited near-term renewable energy demand from state RPS[18] policies (US Department of Energy, 2013).

The PTC policy expired at the end of 2013 – however a provision within the American Tax Relief Act of 2012 allowed for qualified projects under construction before January 1st 2014 to also be eligible for financial support (KPMG, 2013). The provision represented a substantial change from the prior placed in services rule that applied to such projects and will allow for more RE projects to be financially supported in the absence of an extension to the PTC policy (Deloitte, 2013). At the time of writing, further attempts to extend the time period of the PTC have so far failed with the Senate recently voting down a PTC amendment (Juliano, 2015). Opposition to the extension of the PTC includes the

17 ‘The wind PTC has expired three times since 2000 (in 2000, 2002, and 2004), and the wind industry experienced precipitous drops in annual wind capacity installations in each of those years’ (Brown, 2012).

18 A Renewables Portfolio Standard (RPS) is ‘a policy that requires a certain percentage of electricity sold or generated within a defined geographical area be derived from qualified renewable energy resources’ (Brown, 2012).

advocate group, Americans for Prosperity (2014), which argues that 'American taxpayers and ratepayers have seen little return on this forced investment in wind energy over the past 20 years'. However, advocates of the PTC refer to the associated co-benefits of the policy, such as the creation of 30 000 jobs from the 470 facilities that support the increasing the share of RE in the utility generation mix (Brown, 2012). Further environmental benefits (i.e. health benefits from lower levels of air pollution) and enhanced energy security (due to less dependence on foreign fossil fuels) arising from the PTC are not quantified in the literature but are also important co-benefits to consider when evaluating the impact of the policy measure.

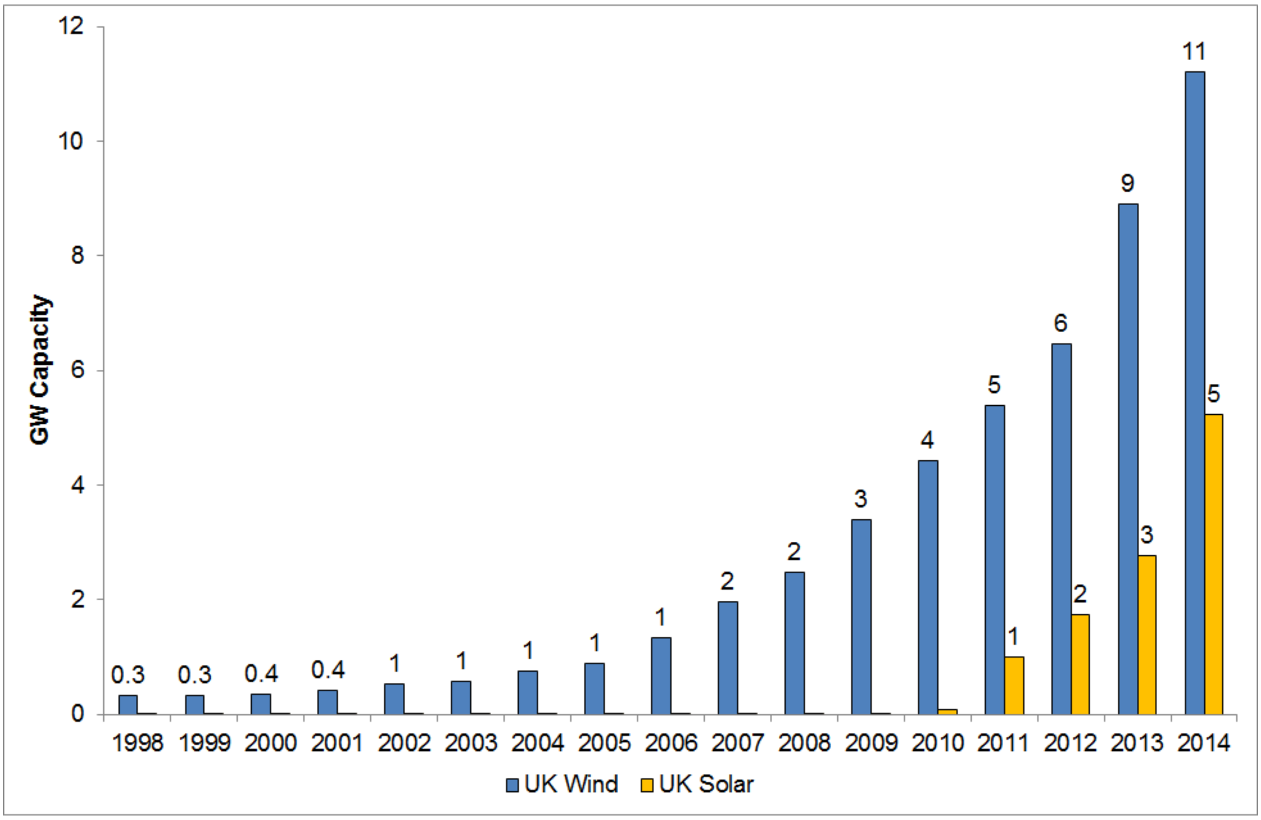
The future outlook of the policy remains very uncertain with current efforts to extend the PTC policy until 2015 currently only serving as a stop gap before a more fundamental reform of the policy measure takes place. In the future the PTC could be allowed to expire, be extended or phased out over time. According to Brown (2012) an argument for the expiration of the PTC could be that it would encourage wind developers to adopt certain behaviour (i.e. maximise turbine performance, minimise manufacturing costs) that will be necessary to improve the competitiveness of the industry on an unsubsidised basis. However, this option is not the preference of President Obama who recently announced in his 2016 federal budget proposal his intention to make the PTC permanent (Reuters, 2015) to overcome the political uncertainty that has previously hindered the implementation of the policy, although it remains to be seen if Obama's budget will be successfully passed by Congress.

4.1.4 United Kingdom: Renewables Obligation

The Renewables Obligation is the main policy measure of the UK government to encourage the growth of electricity generation from renewable sources. The policy measure, which came into effect in England, Wales and Scotland in 2002 and in Northern Ireland in 2005, places an obligation on licensed suppliers of electricity in the UK to ensure that a share of their supply to customers originates from eligible sources of renewable energy. Annually the obligation is set by the UK and the devolved administrations as a certain number of Renewables Obligation Certificates (ROCs) per MWh of electricity supplied to customers. Based upon the reported renewable generation, ROCs are issued to accredited generators by Ofgem (i.e. the National Regulatory Authority). In order to comply with the Renewables Obligation licensed suppliers are required to either present the ROCs acquired from generators, make a fixed 'buy out' payment per ROC or a combination of both (Ofgem, 2014).

The motivation for this policy measure is to adhere to the terms of the Renewables Directive (2009/28/EC), whereby the UK government has accepted a legally binding EU target of obtaining a 15 % share of energy from renewable sources in gross final consumption of energy by 2020. Given that only 1.3 % of the UK's gross final energy consumption originated from renewable sources in 2005, the target set in the Renewables Directive is very challenging and the UK government expects that approximately 30 % of electricity demand will need to be sourced from renewables in 2020 to meet the EU target (UK NREAP, 2009). As of 2013, the share of renewables in gross final energy consumption reached 5.1 % (Eurostat, 2015). Although the capacity of renewable technologies have increased up until 2014 (Figure 5) it is evident that further effort will be required if the UK is to fulfil its obligation under the Renewables Directive.

Figure 5: Cumulative development of wind and solar capacity in the UK between 1998 and 2014



Source: BP Statistical Review of World Energy (2015)

The implementation of the Renewables Obligation in the early phase was associated with slow progress - failing to meet any of the annual targets (i.e. obligation level) set between 2002 and 2009 (Woodman and Mitchell, 2011). Obtaining planning permission and access to networks are often cited as barriers to the deployment of renewable development in the UK, although it became evident through the implementation of the Renewables Obligation that limitations in the design of the policy may also have been responsible for the lower than expected growth rates. Design limitations of the policy included:

- Technology neutral: The UK government were initially reluctant to try and pick 'winners' and therefore adopted a neutral approach whereby all technologies received one ROC/MWh of electricity generated. However, this approach favoured more mature technologies (i.e. onshore wind) than other less mature technologies (i.e. wave, offshore wind) and left certain renewable options with insufficient incentives compared to the associated risk (Woodman and Mitchell, 2011).
- Uncertainty in ROC value: If suppliers approached the target for any year's obligation, the value of the ROC declined (i.e. due to the lower demand and this reflected greater compliance with the Renewables Obligation). If the target was met, the value of the ROC would reduce to zero as there would be no demand at all. The uncertainty with the ROC value was problematic for developers seeking funding for renewable energy projects (Woodman and Mitchell, 2011).

In order to address these limitations, the Renewables Obligation was reformed in 2009 to:

- Differentiate renewable technologies based upon a banding system, which results in less mature technologies such as offshore wind receiving more ROCs than more mature technologies and therefore more funding to encourage faster rates of deployment (Woodman and Mitchell, 2011).[19]
- Prevent a ROC price crash if the annual Renewable Obligation is met, by introducing the concept of 'headroom' i.e. setting the obligation for a period based upon the expected level of renewable generation plus a further proportion of ROCs expected to be issued in the relevant period (Woodman and Mitchell, 2011).[20]

Following these reforms to the Renewables Obligation, 11.2 % of the total electricity supplied in the UK was supplied by renewable technologies in 2012-13, equivalent to 35 TWh of renewable generation (Ofgem, 2014). The shift to renewable energy also has positive co-benefits with regards to both local air quality and energy security. It is evident that the Renewables Obligation has encouraged the increased deployment of renewables in the UK; however it is questionable whether or not an alternative policy measure would have been more successful and cost effective. Indeed the recent reforms to the Renewables Obligation have transformed the policy from a traditional quota obligation and tradable certificates scheme into a hybrid policy instrument with similarities to a feed in tariff (i.e. price certainty, differentiated by technology) demonstrating the need to address limitations with the original scheme. The UK government announced in the 2013 Energy Act that the Renewables Obligation will be phased out by 2017[21] and a new policy regime, Contract for Difference,[22] has been introduced from 2014 onwards. It is expected that the transition from the Renewables Obligation to a Contract for Difference regime will reduce subsidy levels over time as low carbon technologies mature and compete for funding.[23] It is also envisaged that the policy change will also provide longer term price certainty to encourage investments in low carbon plants at a lower cost of capital (DECC, 2015).

4.1.5 Quantitative assessment

4.1.5.1 Methodological considerations

Country-level quantification

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[19] The Government has reviewed the banding levels for appropriate incentives for the period 2013-2017. These bands include a reduction in the tariff for onshore wind to 0.9 ROCs/MWh and an increase for small wave and tidal stream projects, under 30 MW, to 5 ROCs/MWh

[20] Headroom works by providing a set margin between the predicted generation (supply of ROCs) and the level of the obligation (demand for ROCs). This helps reduce the possibility of supply exceeding the obligation in any given year and therefore reducing the market value of a ROC (DECC, 2014)

[21] New capacity installed before the expiration of the Renewables Obligation will still be eligible for financial support until 2037.

[22] A generator party to a Contract For Difference is paid the difference between the 'strike price' – a price for electricity reflecting the cost of investing in a particular low carbon technology – and the 'reference price'– a measure of the average market price for electricity in the GB market. It gives greater certainty and stability of revenues to electricity generators by reducing their exposure to volatile wholesale prices, whilst protecting consumers from paying for higher support costs when electricity prices are high (DECC, 2015a).

[23] In the first year of the regime, contracts were awarded in the UK to two offshore wind farms with strike prices varying between £114.39 and £119.89 per MWh. Contracts were also awarded to fifteen onshore wind farms will strike prices ranging from £79.23 and £82.50 per MWh and five Solar PV projects with strike prices ranging from £50.00 and £79.23 per MWh (DECC, 2015b).

To quantify the emission mitigation that will be achieved by renewable electricity targets, our approach follows these steps:

1. 2012 electricity generation per country by energy carrier (coal, natural gas, oil, nuclear, renewables) is taken from IEA Energy Balances (IEA, 2014c).
2. Total electricity generation in 2020 is based on 2012 generation and growth from the Current Policies Scenario of IEA World Energy Outlook 2014 by region (IEA, 2014b). Total electricity generation is taken to be identical in each pathway (i.e. reference, without policies, and with policies) .
3. The carrier mix in electricity generation in 2020 without target is determined for each pathway.
    i. Reference pathway: The share of each energy carrier is based on regional projections of the growth rate per carrier from the World Energy Outlook 2014 Current Policies Scenario (IEA, 2014b). This scenario already includes some existing policies affecting renewable electricity generation.
    ii. Frozen technology pathway: the total renewable power generation is frozen at the 2012 production level, while the remaining growth in electricity generation till 2020 is divided over the other carriers by their 2012 share.
    iii. Without policies pathway: This pathway is the average of the Reference pathway and the Frozen technology pathway.
4. As some countries have a generation target and others have a capacity target, the share of renewables in the with policies pathway is determined based on two different approaches:
    i. Generation target: The share of renewables in the carrier mix is based on the target.
    ii. Capacity target:
        - Regional load hours per technology and region are calculated from 2020 capacity and generation from the IEA (2014b).
        - Electricity generation in 2020 is calculated by multiplying the capacity target with the load hours for each technology. For renewable technologies for which no target is adopted, the installed capacity is assumed to stay at the 2012 level.

    If the share of renewables in the without policies pathway exceeds the share of renewable determined based on the generation or capacity target, this share is applied.
5. To determine the emission reduction due to additional electricity generation from renewable energy sources in 2020, the following steps are taken:
    a. Based on the IEA World Energy Outlook Current Policies Scenario (IEA, 2014b) the 2020 emissions factor for fossil carriers (coal, natural gas, oil) are calculated for each region. Total emissions per carrier are divided by the total generation of the respective carrier.
    b. The 2020 emission factor of fossil power generation is calculated by taking the weighted average of these emission factors (based on the shares of these carriers in the without policies and Reference pathways).
    c. The additional generation from renewable energy sources in the with policies pathway compared to the without policies and reference pathways is multiplied by these emission factors.

The steps indicated here imply the following assumptions:

1. Demand for electricity in 2020 is assumed to be the same in all pathways (i.e. support policies for renewable electricity do not influence total electricity production)
2. In absence of policy targets for a specific renewable energy source, the growth of renewable energy generation is assumed to be half of the growth projected in the World Energy Outlook 2014 Current Policies Scenario (IEA, 2014b).
3. The additional generation from renewable energy sources is assumed to be replacing generation by coal, natural gas and oil.

Global upscaling

The results of the country-level analysis are scaled up to the global level by applying the average annual %-point increase of the share of renewable energy carriers in the period 2012–2020 from the country-level analysis to the global level. From 2016 onwards it is assumed that all countries can increase their share of renewable energy carries by this average %-point each year. For the period 2012–2015, it is assumed that the share of renewable energy carriers has increased by half this rate, as many countries already have RES-E support policies implemented. The without policies and Reference reference pathways are determined for the global level using the same approach as described in the country-level analysis.

4.1.5.2 Results of quantitative assessment

Summary: Targets for electricity generation from renewable energy are contributing significantly to the increase of electricity generation from renewable sources in the four considered countries Germany, the United Kingdom, China and Morocco. If other countries follow their example, emissions in 2020 could be reduced by a further 1.4 GtCO₂/a below the reference pathway and 2.3 GtCO₂/a below the without policies pathway.

The results of RES-E support policies in Germany, the United Kingdom, China and Morocco are quantified. The input data for the quantification are shown in Table 9.

Table 9: Target input data for quantification of RES-E support

Country	2020 RES-E generation target	2020 capacity target (GW)	WEO region used for regional growth rates and load hours
Germany	35% (BMU, 2013a).	No target	European Union
UK	31% (UK NREAP, 2009)	No target	European Union
China	No target[24]	Wind (onshore): 200 Wind (offshore): 30 PV: 100 CSP: 3 Hydro: 350 Biomass: 30 (IRENA, 2014)	China
Morocco	No target[25]	Wind: 2 Solar: 2 Hydro: 2 (REN21, 2015)	Africa

[24] China has no renewable electricity generation target. However, there is a 15% renewable energy in primary energy consumption target for 2020 (http://climateactiontracker.org/countries/china)

[25] In some sources a 42% generation target is mentioned for morocco (e.g. IRENA, n.d.). However, this is incorrect as the 42% is in fact a capacity target.

The results of the quantitative analysis are shown in Figure 6 and Table 10. As can be seen from Figure 6 the RES-E support policies are projected to lead to a strong increase in the share of renewables in the electricity mix in all four countries, with shares of renewables ranging from 25% to 46% in 2020. The increase of the share of renewables over the period 2012–2020 is strongest in Morocco with an average 4.6 %-point increase. However, the total increase of renewable electricity generation is strongest in China with almost 900 TWh additional renewable electricity generation in 2020 compared to 2012, although the average increase of the share of renewable electricity generation is only 0.6 %-point per year in China. The emission reduction from RES-E support policies in 2020 in these four countries is estimated to be 0.58 Gt CO_2 compared to the without policies pathway and 0.14 Gt CO_2 compared to the reference pathway. The majority of these emission reductions occurs in China (see Table 10).

Figure 6: Share of renewables in electricity generation (country-level analysis)

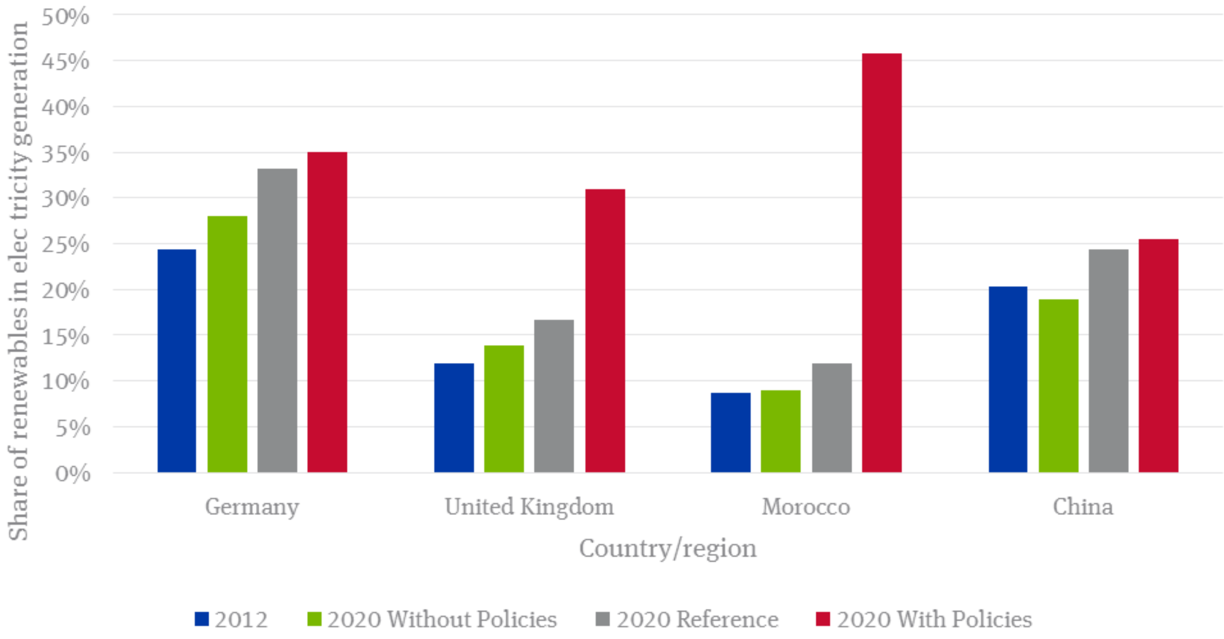


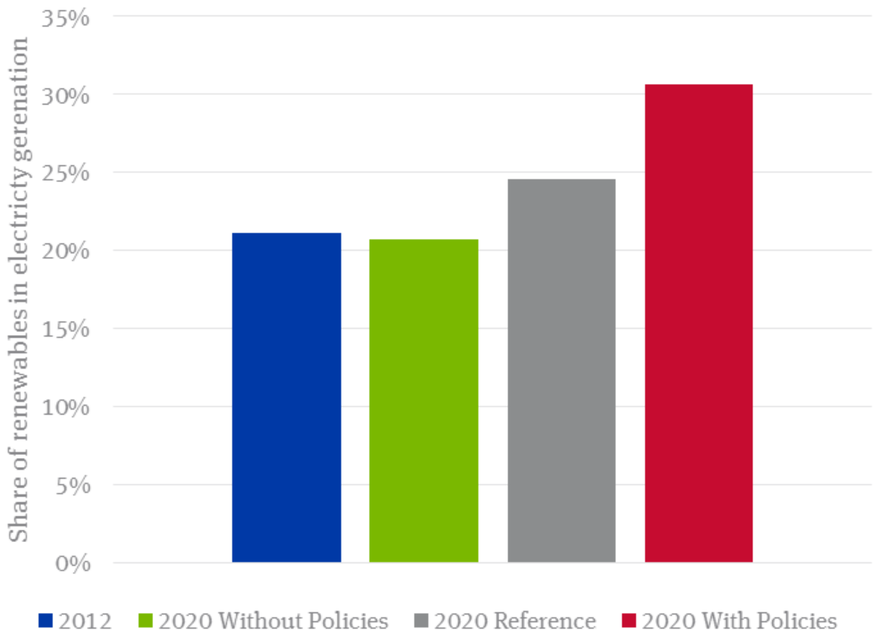
Table 10: Results country-level analyses RES-E support policies

	Pathway	Germany	United Kingdom	Morocco	China
Electricity generation (TWh)	2012	623	361	27	4985
	2020	662	383	38	7485
Share of renewables in electricity generation	2012	24%	12%	9%	20%
	2020 Without policies	28%	14%	9%	19%
	2020 Reference	33%	17%	12%	24%
	2020 With policies	35%	31%	46%	25%

	Pathway	Germany	United Kingdom	Morocco	China
Annual %-point increase of renewable share	2012–2020 With Policies	1.3	2.4	4.6	0.6
Emission reduction in 2020 (Mt CO_2/a)	Compared to without policies	41	50	11	481
	Compared to reference	11	41	10	81

For the global With policies pathways the average %-point increase of the share of renewables in Germany, China and the UK of 1.5%-point per year is applied to the global share of renewable electricity in 2012. For the period 2012-2015 half of this increase is applied. The %-point increase in Morocco is not taken into account in the average, since it's unlikely that the high growth rate needed to achieve the targets can be replicated in many other countries. Our upscaling approach suggests that the global share of renewables in the electricity mix could increase from 21% in 2012 to 31% in 2020 in if the policies adopted in the countries analysed will be adopted on a global level (see Figure 7). This is estimated to result in global emission savings of 2.3 Gt CO_2 below the without policies Pathway and 1.4 Gt CO_2 below the reference pathway in 2020.

Figure 7: Global upscaling result for RES-E support policies



This policy potential compares well to earlier estimates of technical mitigation potential from the power sector of 2.2-3.9 $GtCO_2e$ in 2020 (UNEP,2013).

4.1.6 International discussions in related forums

The increased adoption of renewable energy technologies is boosted not only by climate change mitigation ambition, but also by increased global energy security. Many countries see renewable technologies as a key means of increasing domestic energy security through reduced dependence on volatile oil and gas markets. Furthermore, small and medium scale renewable technologies provide potential for the electrification of rural areas in countries where centralised infrastructure is unable to reach large segments of the population, decreasing local dependence on dirty fuels and providing significant benefits for the social and economic development in disadvantaged areas. A further key motivation for the development of renewable energy shares, especially in emerging industrialising countries, is increasing concern over local air pollution and its effects on public health. These reasons, amongst others, make an increasingly attractive business case for the adoption of renewable energy technologies, before domestic pledges to climate change mitigation are even considered.

Given the suppressed demand demonstrated by the low electrification rates across the populations of most developing countries, international discussions are focused on maximising the rational business case for renewable energy, in order to avoid further adoption and path dependency on dirty technologies in emerging and developing countries. The need for decentralised and flexible infrastructure development is understood to be of key importance to the economic viability of small and medium sized energy generation facilities, and this is an area that international donors such as the World Bank, EBRD and EIB are keen to support, along with capacity building at the policy making level in order to support the conditions for renewable energy investment (Harrison et al., 2014).

Three key international cooperative initiatives promote the development of renewable energy supply worldwide:

- The Renewable Energy and Energy Efficiency Partnership (REEP) seeks to address barriers to the natural market development of renewables in order to build clean energy business models, and facilitates information sharing on best practice policies between countries.
- The International Renewable Energy Agency (IRENA) is a centre of excellence for knowledge in policy, finance and technology for renewable energy.
- The 300 GW/a initiative is an awareness raising platform for the future of PV, with a goal to inspire an industrial transformation to meet the goal of 300 GW installed PV capacity by 2025.

4.1.7 Summary and recommendations for RES

4.1.7.1 Summary and comparison of case studies

An overview of the RE support policies implemented in Germany, China, the USA and the UK is provided in Table 11.

Table 11: Summary of qualitative assessment

	Germany	China	USA	UK
Major policy	Renewable Energy Act (EEG)	Renewable Energy Law	Energy Policy Act	Renewables Obligation
Type	Feed in Tariff	Feed in Tariff	Production Tax Credit (PTC)	Renewables Obligation Scheme
RE Targets	RE share of 18 % in gross final energy consumption by 2020 (Directive 2009/EC/28). RE share of 35 %	RE share of 15 % of primary energy consumption by 2020 (Schuman, 2010). Energy Devel-	Renewable Portfolio Standards only implemented at state level. US government agencies to deliver a 20 % re-	RE share of 15% in gross final energy consumption by 2020 (Directive 2009/EC/28). RE share of 31 %

	Germany	China	USA	UK
	of electricity production by 2020.	opment Strategy Action Plan (2014-2020) aims to increase installed capacity of wind and solar power up to 200 GW and 100 GW respectively by 2020.	newable energy generation (electricity only) target by 2020.	of electricity production by 2020.
Key features	Guaranteed rate for electricity production based upon a feed in tariff schedule differentiated by RE technology, location and size. Reforms will improve the cost effectiveness of the policy moving away from a feed in tariff to a competitive bidding model with limits of funding based upon 'growth corridors' for renewable capacity.	Feed in tariffs for RE, which guarantee an electricity price above the market rate that the grid company will pay the generator.	Tax credit for each kWh of electricity produced by a qualified RE project during the first ten years of operation.	Obligation on licensed suppliers of electricity to ensure that a share of their supply to customers comes from RE sources. Reforms will move the policy towards a 'contract for difference' model of support for renewables from 2017 onwards.
Complementary Policies	Combined Heat and Power Act (KWKG) Renewable Energies Heat Act (EEWärmeG)	A mandatory connection and purchase policy A special fund for renewable energy development	Renewable Portfolio Standards (RPS) Mercury and Air Toxics Standards (MATS)	Renewable Heat Incentive (RHI) Renewable Transport Fuels Obligation (RFTO)
Barriers	Obtaining planning permission and access to networks. Public support for increased costs.	Lack of resources and incentives to invest in the grid infrastructure to support	Uncertainty in financial incentives from the renewal of the PTC.	Price uncertainty in ROCs. Obtaining planning permission and access to networks.

	Germany	China	USA	UK
		RE.		
Co benefits	Improvement in air quality and energy security			

In terms of overall ambition, Germany is a global leader in the promotion of RE and the country is making good progress towards the achievement of their ambitious RE target for 2020 (18 % share of renewables in final energy consumption). In comparison, the UK has a less ambitious RE target for 2020 (15 % share of renewables in final energy consumption). However, given the low starting point, considerable efforts will be required by the UK to achieve the challenging target. The lack of a national target for the USA, makes comparisons with other countries more difficult as Renewable Portfolio Standards are only implemented at state level. However, the Obama administration recently committed all US government agencies to deliver a 20 % renewable energy generation target by 2020. The Chinese target for non-fossil fuel use is also not directly comparable to the RE targets of Germany and the UK (the 15 % share of non-fossil fuels target in primary energy consumption in 2020 refers to both RE and nuclear power), nethertheless it is important to acknowledge the progress that has been made in a fast growing economy and the challenge that remains in order to achieve the 2020 target.

4.1.7.2 Barriers and mitigating policy features

The case studies primarily focus on addressing the market failure and economic barriers associated with the deployment of renewables via the introduction of financial incentives in the form of either a feed in tariff (i.e. China, Germany), renewables obligation scheme (i.e. the UK) or a production tax credit (i.e. the USA).

The production tax credit (PTC) in the USA demonstrated the importance of long term certainty in the provision of financial incentives, with changes in annual wind capacity directly related to the renewal or expiration of the PTC. The on-going uncertainty about the extension of the PTC in the USA remains a barrier to the deployment of renewables (refer to section **Fehler! Verweisquelle konnte nicht gefunden werden.**). Uncertainty in the value of ROCs in the UK's renewables obligation scheme was also initially problematic for developers seeking funding for renewable energy projects and led to policy reform (refer to section 4.1.4). In addition, obtaining planning permission added a further element of uncertainty to the deployment of renewables in the UK. Without the security of a long-term signal for investors in renewables, the effectiveness of both policies were, to a certain extent, undermined.

In contrast, the financial certainty provided by a feed in tariff schedule is an important factor to explain the success of both the Chinese and German policies. However both countries have experienced implementation barriers as a consequence of the rapid deployment of renewable technologies. For example, China's progress towards their RE target has been delayed due to a lack of capacity to connect renewable energy projects to the grid, , which has subsequently required the Chinese government to increase its oversight over development planning in order to co-ordinate the extension of transmission lines (refer to section 4.1.2). Whilst in Germany the social acceptability for supporting RE technology has been questioned in light of increasing electricity costs in the country, which has led to reforms to the feed in tariff policy to address concerns regarding its cost effectiveness (refer to section 4.1.1).

The case studies demonstrate the importance of reforming policies based upon the lessons learnt during implementation and how complementary policies are also necessary in order to address all of the barriers associated with RE deployment.

4.1.7.3 Co-benefits

It is evident from the case studies that the co-benefits associated with the deployment of renewable energy have been used to further justify RE support policies in all four countries. However, the promotion of certain co-benefits may be particularly emphasised in order to attain a political consensus for the policy measure. For example, the improvement in air quality has been a major driver for the promotion of clean energy technologies in China in order to overcome an environmental problem that has an increasingly detrimental effect on health. Indeed many commentators consider the smog that settled in January 2013 in Beijing, which had a concentration of particles with a diameter of 2.5 microns or less that was 40 times higher than the level considered safe by the World Health Organisation (The Economist, 2013), as a game changing moment leading to more ambitious environmental policies in the country. While in Germany the creation of employment opportunities was an important driver in the establishment of the German Renewable Energy Act and fast growing German RE industries have encouraged the government to maintain strong promotion policies to further support jobs in the renewable energy sector that have increased from 160,500 in 2004 to 381,600 in 2011 (BMU, 2013a).

4.1.7.4 Policy impacts and mitigation potential

Targets for electricity generation from renewable energy are contributing significantly to the GHG emission reductions in the four considered countries Germany, the United Kingdom, China and Morocco. If other countries follow their example, emissions in 2020 could be reduced by a further 2.3 $GtCO_2$/a below the without policies pathway or 1.4 $GtCO_2$/a below the reference with current polices.

4.2 Light Duty Vehicle Standards

4.2.1 U.S: Corporate Average Fuel Economy (CAFE) and GHG standards

In 2011, the United States had the world's second highest rate of car ownership, with 785 motor vehicles (of which 403 passenger cars) registered per 1,000 people (World Bank, 2014a) resulting in a fleet seize of 245 million motor vehicles, of which 126 million are passenger cars, in 2011 (World Bank, 2014a). Light duty vehicles represented a significant portion of U.S. greenhouse gases, accounting for approximately 16.2% of national emissions in 2013 (EPA, 2015). Furthermore, the U.S. is heavily dependent on oil imports; the transportation sector alone consumes approximately 14 million barrels of oil per day (American Energy Independence, 2013), of which approximately 27% was imported in 2014 (EIA, 2014).

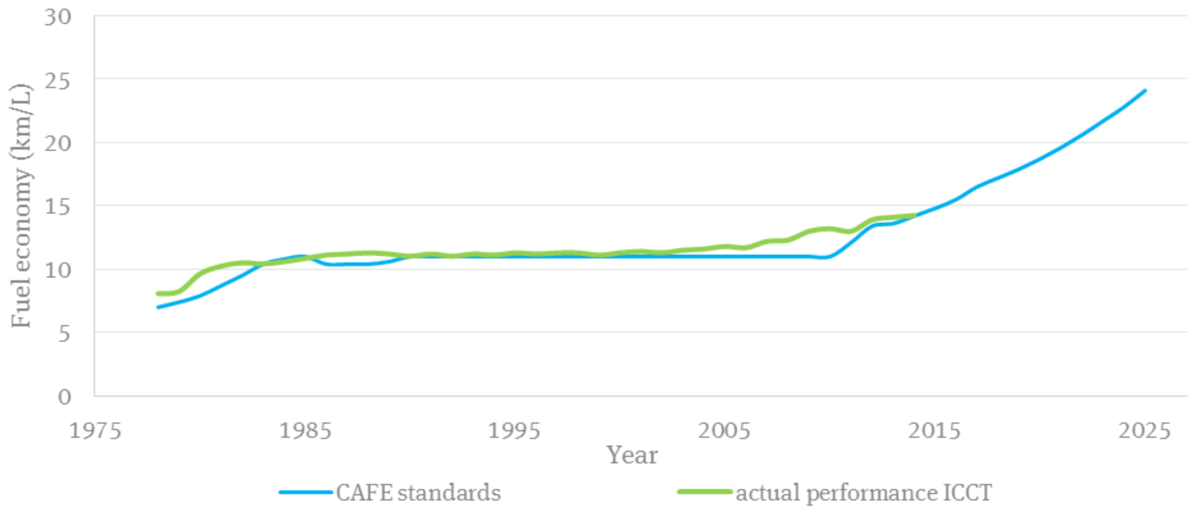
The United States has been regulating fuel economy of vehicles since 1975, with the Corporate Average Fuel Economy (CAFE) standards. However, despite an early start, Figure 8 shows that these standards were relatively static and unambitious during the 1980s and 1990s, and the US vehicle fleet at this time was one of the heaviest and least fuel efficient in the world (ICCT and Dieselnet, 2014). In 2009, the U.S. vehicle standards underwent considerable reform. Whilst the original standards had only been attached to fuel economy under the administration of the National Highway Traffic and Safety Administration (NHTSA), the new system saw the NHTSA combine with the Environmental Protection Agency (EPA) to include a greenhouse gas emissions standard; this was also a notable landmark for general climate change mitigation policy in the U.S., since it was also the first time that greenhouse gas emissions were regulated at the federal level (ICCT and Dieselnet, 2014). Following the successful implementation of the 2012-2016 phase, a second phase covering the years 2017-2025 was announced in 2012.

The reformed CAFE has the following design features:

- Emission caps are also set for non-CO_2 GHG emissions, including HFCs from air conditioning systems, N_2O and CH_4.
- Whilst the data above refers to averages for the entire vehicle fleet, the specific standards for each vehicle are set according to the vehicle's size, rather than its weight; the vehicle's footprint is determined as the product of the track width and the wheelbase. This has some advantages over a standard based on weight since it encourages the use of light materials in construction design, whereas a weight-based standard effectively penalises and discourages the use of light materials by applying a more stringent standard.
- Flexibility mechanisms are in place to make compliance cost-effective for manufacturers. For example, manufacturers obtain credits for achievement, which they can carry forwards or backwards for compliance in different manufacturing years (C2ES undated).

Figure 8 gives an overview of the development and stringency of the standard during this period.

Figure 8: CAFE standards and actual performance for light duty passenger vehicles - MY 1978-2025



Data relates to the average fuel economy of light duty passenger vehicle fleet manufactured in each year.
All standards and actual performances are converted to units of km/L NEDC cycle as proposed by ICC
Missing ICCT data was based on NHTSA data calibrated to ICCT values. This calibration was based on overlapping years.
Source: ICCT, Dieselnet, 2015d for years 2000-2013 and NHTSA, 2014 for other years.

Figure 8 shows that under the current standards, the average passenger car is expected to achieve at least 37.8 mpg (15.5 km/L NEDC cycle[26]) by 2016, rising to 56.2 mpg (24.1 km/L NEDC cycle) in 2025. (ICCT, Dieselnet, 2015d). The 2025 target were implemented by the White House in 2014, after they were proposed in 2011. (White House, 2014) The latter part of the standard remains however

[26] The NEDC cycle is the fuel economy cycle used for all cars in the European Union to test fuel economy under laboratory conditions. Real-world fuel economy is generally 20-30% higher than the fuel economy found using test cycles in laboratories. Every country is using different fuel economy standards expressed in their own national fuel economy cycle. In order to make inter comparison of legislation possible, this report shows all standards as if they were tested using the European NEDC cycle.

uncertain, since due to legislative restrictions on long term policies in the U.S., the latter years of the 2017–2025 CAFE phase must be reconfirmed during a mid-term policy review.

The data represented in Figure 8 show that implementation of the reformed CAFE has generally been successful, with average performance remaining slightly higher than the standard since the year 2000. However, the role of the standard in achieving the current performance level is debated; the chart suggests that the most recent performance indicators might be a result of natural improvements in the industry, since the fuel economy appears to have improved at a steady rate over the past ten-to-fifteen years, even before the CAFE was reformed. The graph also indicates that the proposed trajectory of standard stringency may not be much more ambitious than BAU industry development, as the gradient of the standard trajectory is only marginally steeper than the gradient of the actual performance during these years.

The ambition of the U.S. policy and the ease of its implementation may have been negatively affected by the following barriers:

- Lack of strong enforcement and penalisation for non-compliance: In 2010, manufacturers were liable for a fee of $2.33 for every 0.1 km/l under the target standard, times by the total number of vehicles manufactured that year (ICCT, 2014). This penalty has only increased 10% since 1983, whilst general inflation during the same period stands at 119% (United States Government Accountability Office, 2007). Therefore, a number of manufacturers choose to pay penalties rather than comply with the standards; in particular, major European and Asian manufacturers have consistently paid large penalties each year, whilst increasing their U.S. sales volumes, while domestic manufacturers have complied with the standards and seen their sales decrease over the previous two decades.
- The strength of industry and stakeholders: The reformed CAFE standards, including the latest phase covering 2017-2025, has received wide support from industry and other stakeholders. The EPA reports that 13 major manufacturers representing over 90% of U.S. sales announced their support for the scheme, in addition to the United Auto Workers and several significant consumer organisations and local governments (EPA, 2012a). However, the support of these stakeholders is key to the passing of legislation, and the widespread support is likely a reflection of the relatively low-ambition, and the reluctance of NHTSA to raise the penalties for non-compliance.
- Popularisation of SUVs (large passenger vehicles of 7-10 people): During the 1990s and 2000s, SUV sales boomed, with negative effects for fuel economy and its future prospects. These negative effects derived from the fact that SUVs were categorised in the existing CAFE architecture as light trucks, with very lenient fuel economy standards. Whilst the framework was revised with the CAFE reform, the historical performance of these vehicles was such that improvements to an ambitious standard would have required dramatic industry development and behavioural change (ICCT and Dieselnet, 2014).
- Low fuel taxes: Relative to other developed nations, fuel taxes are very low in the U.S. and unlikely to be raised significantly in the near future due to political unpopularity. Therefore, there is little economic incentive to the consumer for fuel efficient vehicles, and the CAFE is thus largely dependent on incentives for manufacturers' compliance.

Despite the barriers discussed, developments in vehicle fuel economy are supported by the following complementary policies (UNEP, 2010):

- Gas guzzler tax: Since 1980, passengers vehicles with an extremely low fuel economy (now set at 9.5 km/l) are liable for extra taxes of between USD $1,000 and $7,000. However, SUVs are exempt, despite widespread use as passenger vehicles.

- Cash for Clunkers law: Since 2009, buyers of new cars may receive between USD $3,500 and $4,500 toward the purchase of a new CAFE compliant car when they trade-in some older and less-efficient vehicles.
- Tax credits for purchase of hybrid electric cars: Until 2010, sales of hybrid electric cars were kick-started by making purchasers eligible for a federal income tax credit of up to $3,400.
- Priority lanes and parking: A number of states have launched initiatives giving priority to top-performing fuel efficient and electric vehicles on specific road lanes and free parking areas in the city.
- Labelling and public information: Manufacturers are required by federal law to label cars in the showroom with fuel economy information.

4.2.1.1 Motivation and co-benefits of U.S. CAFE

The EPA have quantified the co-benefits of the CAFE standards relating to consumer cost savings, energy security and health (EPA, 2012c):

- Through the decreased consumption of fuel, the revised CAFE standards are estimated to save consumers between USD $6,000 and $7,000 over the lifetime of the vehicle, despite an estimated increase in vehicle cost of approximately $900.
- The U.S. imported approximately 3.2 billion barrels of oil in 2011. The current CAFE standards will save an estimated 600 million barrels of oil by 2030, exceeding the total quantity of imports from Saudi Arabia. Total lifetime savings of cars manufactured in the 2017-2025 phase will be 4 billion barrels.
- Health benefits related to reduced volumes of PM2.5 during the 2017-2025 are estimated at USD $4.3 billion to $5.5 billion, whilst other health benefits in the scale of USD $3.1 billion to $9.2 billion are estimated. Figures are based on a discount rate between 3% and 7%.

This list is for indication purposes only, and is not an exhaustive overview of co-benefits. Further considerations of co-benefits for all countries are given in section 4.2.7.3.

4.2.2 EU: Reducing CO_2 emissions from passenger cars - Regulation 443/2009/EC

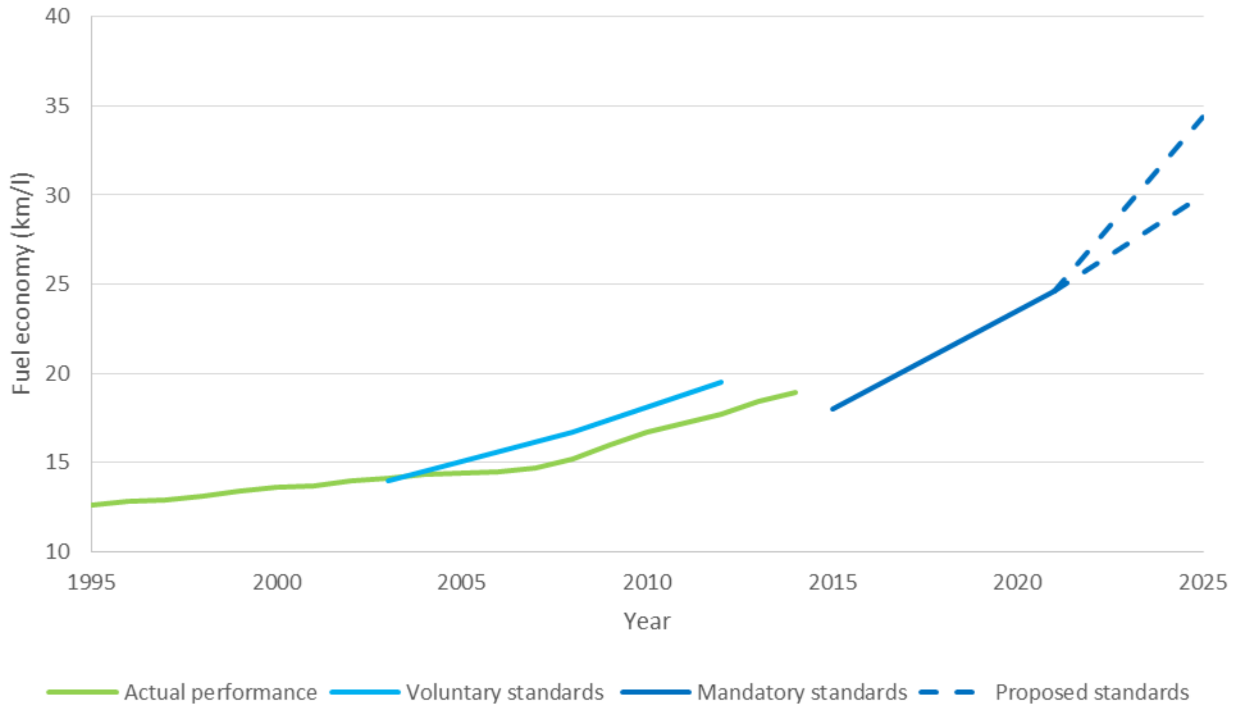
The EU is a major producer, exporter and importer of vehicles, and has one of the largest vehicle fleets in the world, with over 280 million motor vehicles cars (of which 242 million passenger cars) in 2011 (European Union, 2013). Car ownership reached in 2011 553 motor vehicles/1000 people of which 477 are personal cars (World Bank 2014a). European legislation is therefore highly influential for the practices of manufacturers, business leaders and policy makers worldwide. Furthermore, road traffic remains a thorn in the EU's greenhouse gas emission reduction plans; passenger cars alone accounted for 12% of EU-wide GHG emissions in 2010, and emissions from the sector increased by 26% between 1990 and 2010, despite the EU's overall emissions declining by approximately 7% (UNEP, 2010).

The EU began legislation efforts for passenger vehicle emissions with voluntary emission reduction agreements with car manufacturers in 1995 and 1998. As Figure 9 shows, the voluntary emissions were not entirely successful. Although the first interim target for 2003 was exceeded, subsequent targets were not reached, with only two manufacturers complying with the voluntary agreement (JATO, 2009).

In 2009, mandatory standards were introduced through Regulation 443/2009/EC. These standards are based on emissions (measured by gCO_2/km) and their translation into fuel economy targets is represented in Figure 9. Standards are set at five year intervals, and manufacturers are required to comply in a phased approach: for example, where the target for 2015 is 130 gCO_2/km (or 18.0 km/l NEDC cycle[27]), 65%, 75%, 85% and 100% of the manufacturers' fleet must meet this target by 2012, 2013, 2014 and 2015, respectively. The next target for 2021 (ICCT 2015) is 95 gCO2/km (24.6 km/l NEDC cycle), whilst the proposed range for a 2025 target is 68–78 gCO2/km (34.4–30 km/L NEDC cycle) (ICCT and Dieselnet, 2015c). The EU passenger car standards will therefore become the most stringent in the world by 2020 (ICCT, 2014).

The specific target of each vehicle is defined by a weight-based categorisation, although the European Parliament intends to review the possibility of phasing in a size-based vehicle footprint, similar to the U.S. model, from 2020 (ICCT, 2014).

Figure 9: EU standards and actual performance for light duty passenger vehicles - MY 1995-2025



Data relates to the average fuel economy of light duty passenger vehicle fleet manufactured in each year. All standards and actual performances are converted to units of km/L NEDC cycle as proposed by ICCT.Missing ICCT data was based on NHTSA data calibrated to ICCT values. This calibration was based on overlapping years. Source for performance: ICCT, Dieselnet, 2015c for years 2000-2013, ICCT, 2014c for 2013 and European Commission, 2015 for 201.
Source for standards: ICCT, Dieselnet, 2015c

[27] The NEDC cycle is the fuel economy cycle used for all cars in the European Union to test fuel economy under laboratory conditions. Real-world fuel economy is generally 20-30% higher than the fuel economy found using test cycles in laboratories. Every country is using different fuel economy standards expressed in their own national fuel economy cycle. In order to make inter comparison of legislation possible, this report shows all standards as if they were tested using the European NEDC cycle.

Figure 9 indicates that the EU was reached the 2015 standard already in 2013, a trend which continued in 2014. Thereon, the standard requires fuel economy improvements of 5.0% per year to reach the 2020 standards, making it the world's most ambitious policy in terms of both the level of attainment and the rate of improvement.

The EU standards include the following incentives and flexibilities for manufacturers:

- *Super-credits* for vehicles with emissions below 50 gCO_2/km. Each vehicle is counted as 3.5 cars for the manufacturers' yearly average in 2012 and 2013, in order to incentivise their production. Super credits are phased out by 2016.
- Manufacturers may choose to pool their fleets to jointly meet the targets, thereby providing flexibility and creating a market for emissions savings between manufacturers.
- Credits for eco-innovation: Manufacturers who develop innovative technologies in areas not tested, such as energy efficient lighting, may apply for credits against their emission standards.
- Stringent penalties: A primary incentive for compliance, the penalties from 2019 will be €120 for each g/km over the target, approximately ten times higher than the U.S. penalties for non-compliance.

The EU also has a comprehensive set of complementary incentives and policies in place:

- Import restrictions for vehicles not meeting EU criteria (EU Council Directive 92/53).
- High fuel taxes in most EU member states, relative to other regions.
- Buy back schemes for older, inefficient cars in some member states, including large programmes in France and Italy.
- Mandatory labelling of emissions and fuel economy on all car brochures and showrooms across the EU.
- The Green Car Initiative intends to mobilise €5 billion for R&D in the automotive sector.
- The European Commission encourages member states to adopt national taxation policies to promote the purchase of fuel efficient vehicles.

4.2.2.1 Motivation and co-benefits of E.U. vehicle emissions regulation

Whilst co-benefits for all countries are elaborated in section 4.2.7.3, Brannigan et al. (2012) have quantified some of these benefits for the EU standards:

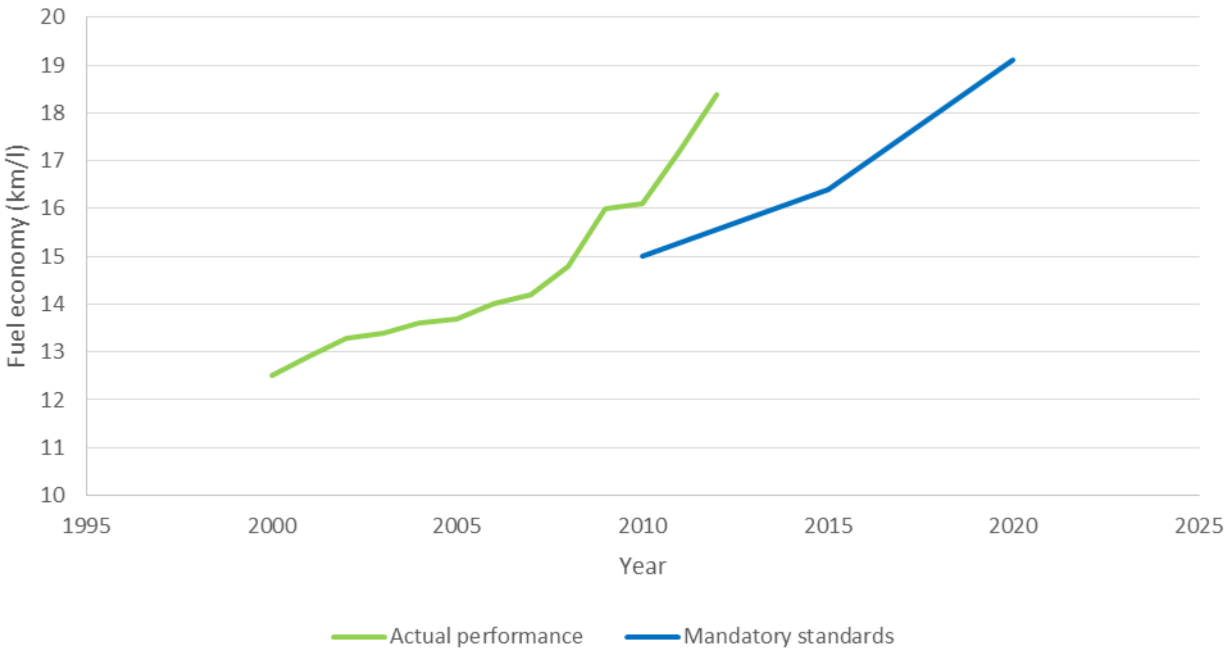
- Under business as usual, energy security is forecast to decrease (worsen) by 40%. This may be largely mitigated by stringent adoption of the vehicle standards, along with a package of other transport measures indicated in the report; this scenario is estimated to lead to only a 3% decrease in energy security. This relates to EUR 8 billion in energy security cost savings in 2050.
- Continued improvements to the standards stringency may lead to cost savings of up to EUR 45 billion in 2050, through decreased air pollution in cities. Furthermore, where standards lead to decreases in average vehicle weight, a lower frequency and severity of road traffic incidents is likely.

4.2.3 Japan: Top Runner Fuel Efficiency Standards for Light Duty Vehicles

Japan has historically been a global leader for fuel efficiency and emissions for light duty vehicles; Japan's new vehicle fleet has been the world's most fuel efficient since 2000, and was approximately 14% more fuel efficient than the EU in 2011 (ICCT, 2014). Car ownership is comparable to Europe with 587 motor vehicles/1000 people of which 454 are passenger cars (World Bank, 2014a). However, due to the size of Japan's existing vehicle fleet (75 million motor vehicles of which 58 million are passenger cars) (World Bank, 2014a), this remains a key area for mitigation action; in 2011, vehicle emissions accounted for 220 $MtCO_2$, or 18.5% of total national CO_2 emissions (IEA, 2013).

The Japanese standards for vehicle fuel efficiency are set based on best achieved industry practices within the country. Fifteen weight ranges between 800 kg and 2,500 kg are defined, and the most fuel efficient vehicle in production within each weight range is designated the top-runner. Thereon, the performance of the top-runner is defined as the new standard, and manufacturers must ensure that the average fuel economy of their production fleet in each weight category meets the new target within a defined time period. This process has resulted in the average fuel efficiency standards for 2010 of 15.1 km/L JC08 Cycle[28] (=15.0 km/L NEDC cycle[29]), a target of 16.8 km/L JC08 Cycle for 2015 (=16.4 km/L NEDC) and a target of 20.3 km/L JC08 cycle for 2020 (=19.1 km/L NEDC cycle).

Figure 10: Average standards and achieved performances of new production light duty passenger vehicles in Japan



Data relates to the average fuel economy of light duty passenger vehicle fleet manufactured in each year.
All standards and actual performances are converted to units of km/L NEDC cycle as proposed by ICCT
Source for performance: ICCT, Dieselnet, 2015b for years 2000-2012
Source for standards: ICCT, Dieselnet, 2015b

28 The JC08 cycle is the Japanese fuel economy testing procedure for cars under laboratory conditions as defined by legislation. Real-world fuel economy is generally 20-30% higher than the fuel economy found using test cycles in laboratories. Every country is using different fuel economy standards expressed in their own national fuel economy cycle.

29 The NEDC cycle is the fuel economy cycle used for all cars in the European Union to test fuel economy under laboratory conditions. Real-world fuel economy is generally 20-30% higher than the fuel economy found using test cycles in laboratories. Every country is using different fuel economy standards expressed in their own national fuel economy cycle. In order to make inter comparison of legislation possible, this report shows all standards as if they were tested using the European NEDC cycle.

Figure 10 indicates that the standards have, to date, been successfully implemented; the 2015 standard, set in 2007, was comfortably achieved and exceeded by 2010. The ease with which the industry is achieving these targets suggests that the top-runner programme may be made even more ambitious by shortening the time-frame given to achieve the targets defined. The following list gives an overview of some of the factors that have facilitated successful implementation of the standards, and the potential and existing barriers that have been mitigated:

Industry competition: The top-runner approach naturally rewards early-movers and therefore ensures progression through natural competitive market forces. Vehicles that exceed the fuel economy standards may be eligible for additional reductions in vehicle tax (ICCT, Dieselnet, 2015b). Therefore, potential political and capacity barriers are made less significant since achievement of the standards is partially driven by market forces and therefore less dependent on institutional frameworks.

- Flexible mechanism for compliance: Flexibility for compliance of manufacturers is given on two levels (ICCT, 2014). Firstly, only the average performance of the production fleet in each category must meet the standard, rather than every vehicle. Secondly, manufacturers may accumulate credits for over-compliance in some weight categories for use in other under-performing categories.
- Education and popularisation: The Japanese government has declared its intention to stimulate the production and consumption of next-generation vehicles through awareness and education campaigns for end-users and manufacturers (Automobile Evaluation Standard Subcommittee, 2011).

Complementary policies and incentives: Although Japan's fuel efficiency targets are mandatory; penalties to manufacturers for non-compliance are minimal. However, penalties are effectively transposed onto the customers purchasing non-compliant vehicles through tax incentives at the point of vehicle purchase and registration for lighter vehicles and those with smaller engines (UNEP, 2010), and a comparably high tax rate on fuel. In addition, a green-sticker labelling policy ensures easily accessible information for consumers (ICCT, 2014).

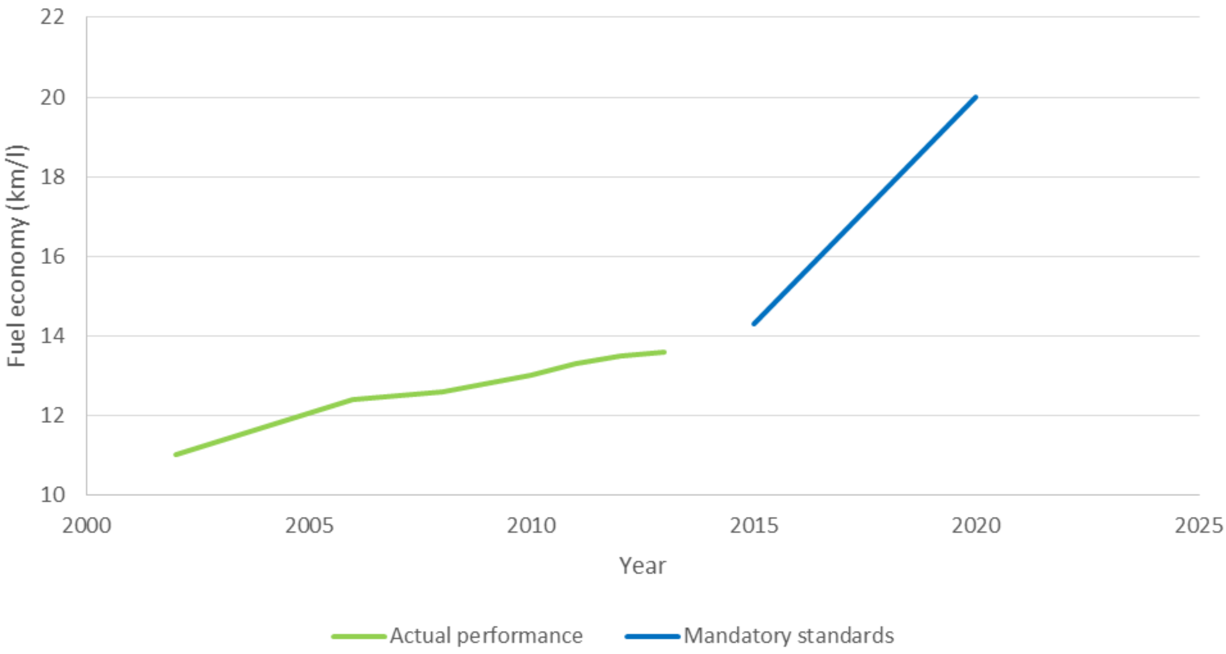
4.2.4 China – Corporate Average Fuel Consumption (CAFC)

China's light duty vehicle stock remained modest in 2011, compared to the U.S., the EU and Japan; China had only 68 motor vehicles per 1,000 people (of which 53 are passenger cars), and just 38% as many passengers cars as the U.S. in 2011 (World Bank, 2014a). In 2011, the total fleet has a size of 93 million motor vehicles of which are 72 million passenger cars (World Bank, 2014a). However, the significance of China's light duty vehicle fleet emissions is expected to soar; conservative estimates predict that annual sales may reach approximately 50 million units by 2020, which is comparable to total global vehicle sales in 2009 (UNEP, 2010). Since 2008, the total fleet grows with 21-27% each year (World Bank, 2014a). At such a rate of growth, China is expected to have more registered highway vehicles in 2035 than any other country, and the sector might emit 1.9-3.2 $GtCO_2$ per year by this time (UNEP, 2010), equivalent to approximately 6-9% of total global emissions across all sectors in 2010 (World Bank, 2013).

Fuel economy standards for light duty vehicles in China were introduced in 2004, with the first phase beginning in 2005. Until 2012, vehicles were given specific standards according to their weight category, and every single vehicle produced between 2005 and 2012 was required to meet the standard for its specific category. From 2012, in order to give manufacturers more flexibility whilst at the same time guaranteeing a specific final result for the fleet average, the Corporate Average Fuel Consumption (CAFC) standards were introduced, which combined individual category standards with an average fleet standard to be achieved by manufacturers. For 2015, a target was set at 6.9 L/100 km NEDC cycle[30] (=14.3 km/L NEDC cycle) while for 2020 the standard is 5.0 L/100km NEDC cycle (=20.0 km/L NEDC cycle).

The new CAFC standards should result in the fuel economy levels indicated in Figure 11.

Figure 11: Average standards and achieved performances of light duty passenger vehicles in China



Data relates to the average fuel economy of light duty passenger vehicle fleet manufactured in each year.
All standards and actual performances are converted to units of km/L NEDC cycle as proposed by ICCT.
Source for performance: ICCT, Dieselnet, 2015a for years 2002-2012
Source for standards: http://www.transportpolicy.net/index.php?title=China:_Light-duty:_Fuel_Consumption

As Figure 11 indicates, progress for the first decade after the introduction of the original standards in 2002 was slow. Manufacturers generally met the standards for all vehicle types, but the lack of a corporate average standard incentivised the production of heavier cars with less stringent standards. The CAFC standard facilitates much greater ambition, as demonstrated by the proposed average annual fuel economy improvement of 6.7% between 2015 and 2020.

Flexibility schemes for manufacturers are included in the new mechanism. Electric cars with a range of over 50km may be counted five times, and cars with a fuel economy of over 35km/l may be counted three times towards the corporate average, in order to incentivise the production of these vehicles. Another important compliance flexibility to manufacturers is the fuel consumption credit for adopting off-cycle fuel saving technologies (ICCT, Dieselnet, 2015a). Furthermore, manufacturers can accumulate credits for exceeding CAFE standards for use in a subsequent year. Credits have a three year validity.

[30] The NEDC cycle is the fuel economy cycle used for all cars in the European Union and China to test fuel economy under laboratory conditions. Real-world fuel economy is generally 20-30% higher than the fuel economy found using test cycles in laboratories. Every country is using different fuel economy standards expressed in their own national fuel economy cycle. In order to make inter comparison of legislation possible, this report shows all standards as if they were tested using the European (and Chinese) NEDC cycle.

In case standards are not met, China will:

- Publicly name the companies involved.
- A ban on production of new car models in the following year, who cannot meet their specific fuel economy standards for that particular year (the so-called weight-based Phase 3 standard targets. This is done by not processing the type-approval certificate application.
- Request an improvement plan from the company involved.
- Halt construction of a new plant or extension of an existing plant in case the newly produced cars do not meet the fuel economy targets of the manufacturer (ICCT, 2014b).

Despite the relative stringency of these standards, there are concerns that the forecast growth in the scale of China's vehicle fleet will far outweigh the improvements (UNEP, 2010). A further barrier is the relatively low fuel tax rate, which decreases the potential incentive for fuel efficiency savings for the consumer. However, China has a number of supporting policies in place, or being piloted, to provide incentives for manufacturers and consumers:

- City-led initiatives for curtailing GHG emissions from transport (e.g. Shanghai and Beijing both have a significant fleet of public transport vehicles and taxis running on alternative fuels).
- A subsidy scheme is in place in some pilot cities to offer approximately $500 USD to consumers for purchases of cars that exceed the fuel economy standards by at least 20%, and up to $7,000 USD for some plug-in hybrid cars (UNEP, 2010). The government will invest in the development of recharge facilities throughout the pilot cities.
- Taxes for manufacturers and purchasers have been revised to incentivise the purchase of vehicles with smaller engines. For example, in 2006 the tax rate on vehicles with 1-1.5 liter engines was reduced to 3%, whilst the tax rate for vehicles with engines larger than 4 liters was increased to 20% (UNEP, 2010).
- A fuel economy labelling programme is mandatory, and must be displayed in the car at all times.

4.2.5 Quantitative assessment

4.2.5.1 Methodological considerations

Country-level analysis

To quantify the effect of meeting the light-duty vehicle standards, our approach follows these steps:

1. The quantification is based on reference projections for vehicle activity and emissions in the period 2010–2020, taken from national studies or other literature sources. These reference emissions projections are used for the reference pathway.
    - Where data are not available for each separate year (e.g. data are reported in 5-year increments), data for the remaining years are interpolated.
2. Based on these projections the reference fleet's average emission intensity (gCO_2/km) are calculated for each year.
3. A frozen technology pathway, which reflects the effect of changes in vehicle activity, is determined using the following steps:
    i. Vehicle activity is taken from the reference projections.
    ii. Fleet average emission intensity is kept at a constant level from the specified base year (i.e. the most recent year for which historical data are available).

   iii. Emissions projections are calculated from the vehicle activity and fleet average emission intensity.

4. The policy pathway, in which the adopted car standards are met, is determined using the following steps:
   i. Vehicle activity is taken from the reference projections.
   ii. The old vehicle stock (i.e. the cars already in the vehicle stock in the base year) is decreased by a constant value each year (in terms of vehicle kilometers driven).
   iii. The emissions of the remaining old vehicle stock are calculated with the fleet average emission intensity from the base year and the vehicle kilometers driven in a given year.
   iv. The difference with total emissions as projected in the reference pathway are attributed to cars built in that year and used to calculate the reference emission intensities of new cars.
   v. In the with policies pathway these new car emission intensities are replaced by the emission intensities implied by the vehicle standards. These new cars stay in the car stock for a specified life time. It is taken into account that real-world (in-use) fuel economy is typically 20–25% higher than the fuel economies found in driving cycles under laboratory conditions and as set in fuel economy standards (White House, 2014) (GFEI, 2014).
   vi. The steps above are repeated for each year until 2020.

The steps indicated here require to take assumptions on different aspects:

1. In case projections are not available for each year, our method assumes a linear development of both emissions and vehicle activity.
2. Vehicle activity is assumed to be the same in all pathways (i.e. car standards do not influence vehicles kilometers driven).
3. The decrease of the existing car stock is estimated based on assumptions regarding the average car lifetime. The average car lifetime is assumed to be 15 years in all regions.
4. Regarding the new vehicle emission intensities assumed by the vehicle standards, the following assumptions are made in our approach:
   i. Before the first target year, new car emission intensity is assumed to be similar to reference new car emission intensity.
   ii. Between two target years a linear improvement of emission intensity is assumed.
   iii. After the last specified target year, emission intensity is assumed to stay at a constant level.
5. In cases where fuel efficiency targets (e.g km/L) are adopted, in contrast to emission intensity targets (e.g. gCO_2/km), the target is first converted to an emission intensity target. Other types of vehicles (e.g. electric) and fuels (e.g. biofuels, LNG) are not taken into account in our analysis.

Regional and global upscaling

The results of the country-level analysis for the best practice countries (China, USA, EU and Japan) are first scaled up to a regional level and subsequently scaled up to a global level. We assume that the other countries and regions adopt targets similar to the best practice countries. Therefore, the approach outlined for the country-level analysis is repeated. The only difference is that the targets applied are the targets of the selected best practice country instead of the national targets. These targets are applied from 2016 onwards.

Table 12 indicates which best practice countries are used as basis for which regional upscaling.

Table 12: Approach for upscaling quantitative analysis of vehicle standards

Best practice	Regions scaled up to	Reason
EU	Non-EU Europe Russia Australia Middle East	The EU has the most comprehensive and ambitious policy package which might reasonably be adopted by other industrialised countries.
China	India South Korea Africa Asia-Pacific-40	Second-hand imports from Asia represent the majority of the vehicle fleet in Africa. China is selected for upscaling since it is a non-Annex I country and since Japan's standard is considered too ambitious for unindustrialised countries.
US (& Mexico)	Canada Mexico Brazil Latin-America	The current U.S. standards may reasonably be scaled up to the Latin American region, since Mexico has already enacted a virtual copy of the U.S. CAFE standards (with a 1% goal reduction (ICCT and Dieselnet 2014)) and the Latin American vehicle fleet is largely based on U.S. imports. Since the U.S standards are also the least ambitious studied here, they may be realistic for application across the region despite the economic differences.
Japan	n.a.	n.a.

4.2.5.2 Results of quantitative assessment

Summary: Immediate adoption of the best practice policies of regional peers by all countries could initiate an emissions reduction of 0.6 GtCO$_2$e/a compared to a frozen technology pathway, and 0.2 GtCO$_2$e/a below the reference pathway by 2020. If all countries would adopt the European emission standards, the most ambitious of the countries analysed, this reduction could be 1.0 GtCO$_2$/a below the frozen technology pathway and 0.5 GtCO$_2$/a below the reference pathway.

Light-duty vehicle standard policies in the United States, the European Union, China and Japan are quantified. The input data for the quantification are shown in Table 13. Given that real-world (in-use) fuel economy is typically 20–25% higher than the fuel economies found in driving cycles under laboratory conditions and as set in fuel economy standards (White House, 2014) (GFEI, 2014), these target values are increased by 22.5% in the analysis.

Table 13: Input data for quantification of vehicle standards

Country/Region	Source for reference emissions and vehicle activity projections	Interpolation of data needed	Analysis base year (i.e. most recent available historic data)	Emission intensity or fuel efficiency target and test cycle	Emission intensity in NEDC test (g/km)
US	EIA Annual Energy Outlook (EIA, 2015)	No	2013	2016: 225 g/mile 2025: 143 g/mile CAFE-cycle (ICCT, 2014)	2016: 145 g/km 2025: 87 g/km

Country/Region	Source for reference emissions and vehicle activity projections	Interpolation of data needed	Analysis base year (i.e. most recent available historic data)	Emission intensity or fuel efficiency target and test cycle	Emission intensity in NEDC test (g/km)
EU	ICCT Global Transportation Roadmap Model (ICCT, 2012)	Yes	2010	2015: 130 g/km 2021: 95 g/km NEDC-cycle	2015: 130 g/km 2021: 95 g/km
China	ICCT Global Transportation Roadmap Model (ICCT, 2012)	Yes	2010	2015: 6.9 L/100km 2020: 5.0 L/100km NEDC-cycle	2015: 161 g/km 2020: 117 g/km
Japan	ICCT Global Transportation Roadmap Model (ICCT, 2012)	Yes	2010	2015: 16.8 km/L 2020: 20.3 km/L JC08-cycle	2015: 142 g/km 2020: 122 g/km

Figure 12 and Table 14 summarise the results of the quantification. From Figure 12, it can be seen that in all regions the vehicle activity is projected to increase until 2020 (e.g. the 2020 frozen technology pathway exceeds the 2010 emissions for all countries and regions In most cases meeting the adopted vehicle standards will lead to an emission reduction compared to both the reference pathway and the 2010 emissions. However, in the case of China the LDV emission trend remains upward compared to 2010 emissions even with the standards in place. This is due to the strong projected increase in the amount of vehicles in China. The emission intensity improvement cannot compensate for the strong increase in vehicle activity. In the case of Japan the fuel efficiency standards are already included in the reference pathway. Therefore, there is no reduction compared to the reference pathway. The policies in the European Union are the most ambitious and the resulting fleet average emissions in 2020 are projected to be the lowest of the four countries/regions analysed (see Table 14). Although the policies in the United States result in decreasing emission trend of 1.1% per year, 2020 emission intensity is projected to be significantly higher compared to the other countries/regions.

Figure 12: Results of country-level quantification for LDV vehicle standards

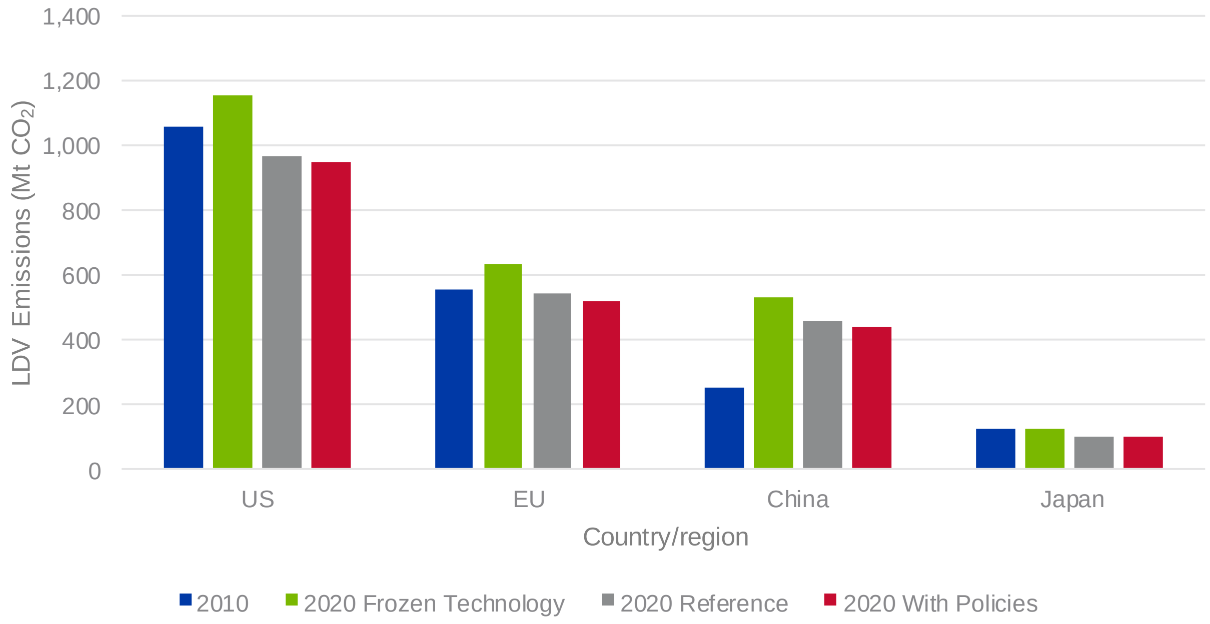
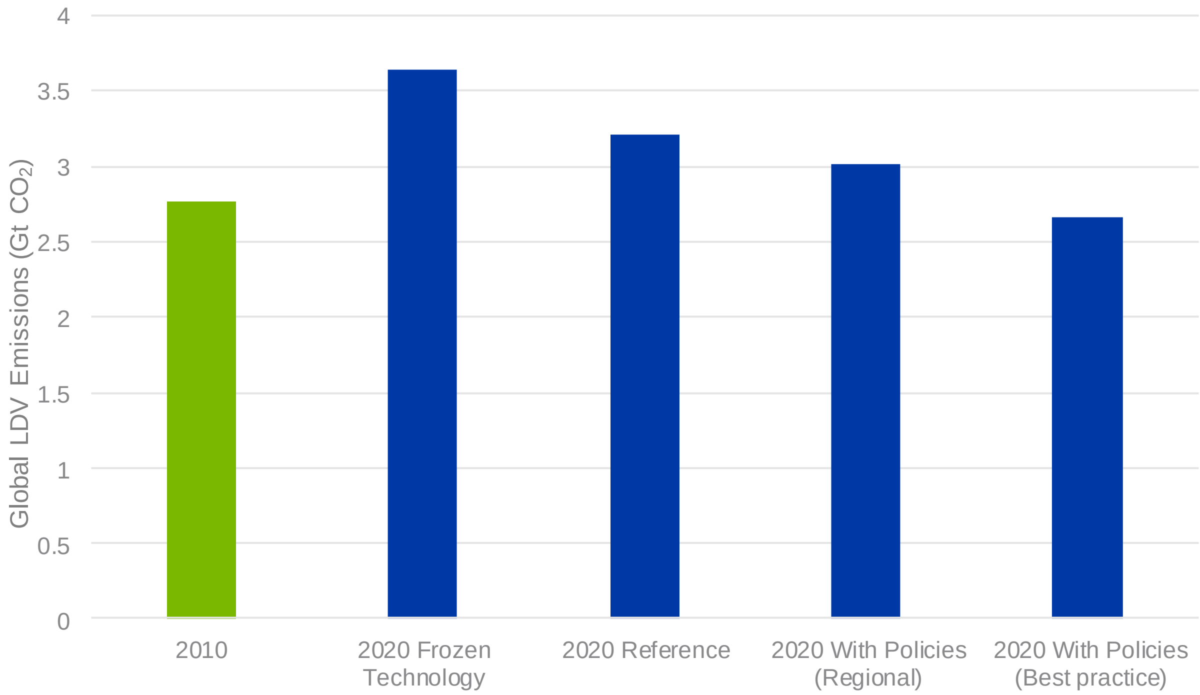


Table 14: Results of country-level quantification for LDV vehicle standards

	US	EU	China	Japan
Base year	2013	2010	2010	2010
Base year emissions ($GtCO_2$)	1.0	0.5	0.2	0.1
2020 emissions policies pathway ($GtCO_2$)	1.0	0.5	0.5	0.1
2020 reduction below reference pathway ($GtCO_2$)	0.02	0.02	0.02	0.00
2020 reduction below frozen technology pathway ($GtCO_2$)	0.20	0.11	0.09	0.02
2020 with policies fleet average emission intensity (gCO_2/km)	203	158	185	161

The 2020 vehicle activity projections from the ICCT Global Transportation Roadmap Model (ICCT, 2012) are used as a basis for the global upscaling of the quantification results. The emissions intensity and fuel economy targets shown in Table 13 are applied to the remaining countries and regions according to the outlined approach. The results are shown in Figure 13. The Frozen technology pathway is based on 2010 fleet average emissions and 2020 vehicle activity for each specific region from ICCT (2012). The reference pathway is based on the projections from ICCT (2012). Our upscaling approach suggests that absolute emissions from global light-duty vehicles in 2020 will be slightly higher compared to 2010 emissions if the polices adopted in the four countries/regions analysed will be adopted on a global level. Although global emissions are thus not expected to reduce due to these policies, a stabilization of global LDV emissions could be reached. This represents a reduction of 0.6 $GtCO_2$/a below the frozen technology pathway and a reduction of 0.2 $GtCO_2$/a below the reference pathway. If all countries would adopt the European emission standards, the most ambitious of the countries analysed, this reduction could be 1.0 $GtCO_2$/a below the frozen technology pathway and 0.5 $GtCO_2$/a below the reference pathway.

Figure 13: Global upscaling result for vehicle standards



This policy potential is about a quarter of the technical mitigation potential of 1.7–2.5 $GtCO_2$/a in 2020 for the entire transportation sector according to UNEP (2013). No estimates of technical mitigation potential for LDVs separately could be found for 2020. However, this policy potential for 2020 compares well with the mitigation potential due to energy efficiency options for light-duty vehicles of 0.7–0.8 $GtCO_2$/a in 2030 at costs below 100 US$ / tCO_2 reported by Ribeiro et al. (2007). McKinsey & Company (2009) estimates the technical mitigation potential for LDVs in 2030 to be 1.4–1.7 $GtCO_2$/a.

4.2.6 International discussions in related forums

Discussions in the international forums related to transport emissions appear to be leaning towards a focus on a consideration of the transport sector in the wider context of cities and urban planning. The vast majority of journeys (over 85%) for both light duty and heavy duty vehicles are made within cities or between cities with a journey distance of less than 150km (Harrison et al., 2014); this highlights the important role of urban planning and traffic flow management in reducing vehicle stoppages and associated fuel consumption. In this vein, significant emphasis was placed on transport in the ADP Work Stream 2's pre-COP19 workshops for sustainable cities, in which discussions leaned towards the concept of subnational policy making, at city or provincial level, for transport emissions and its supporting incentives. The Partnership on Sustainable Low Carbon Transport (SLoCAT) (REF) argues that transport is so dependent on the local subnational context that Transport Day and Cities Day should be combined at future COP meetings.

For a throughout assessment of global CO_2-emissions from personal vehicles, driving conditions during fuel economy tests should be representative of the real world. However, real-world (in-use) fuel economy is typically 20-25 percent higher than the fuel economies found in driving cycles under laboratory conditions and as set in fuel economy standards (White House, 2014) (GFEI, 2014). Therefore, the ICCT has undertaken a study to better understand the differences between in-use fuel economy and fuel economy under test conditions. In-use fuel economy is influenced by factors like traffic congestion, personal driving style and orography. Most strikingly, the differences between laboratory and real-world fuel economies has risen from below 10% higher in 2002 to around 25% higher in 2011 in developed countries. ICCT has thus identified the need to assess the real-world fuel-economy tendencies in today's U.S and European fleet of light-duty vehicles. Furthermore, in developing countries, the quality of roads, the pace of driving (often slower in case of bad roads), maintenance status of the car and local traffic congestion influence in-use fuel economy. (GFEI, 2014). Therefore, the differences between real-world fuel economy and laboratory test results could be even higher in developing countries.

Considering the gap between existing tests and the real-world, an initiative is proposed to develop a uniform fuel economy test for consumers. In recent years, the New Car Assignment Program has convinced car manufacturers to participate in independent testing, which allows a global standard of crashworthiness of a car. During an IEA workshop in April 2013, the idea was launched to develop a "Green Global NCAP" for fuel economy, noise, fuel upstream emissions and tailpipe emissions, which would set an independent definition of what a clean car is. GFEI will lead this initiative (GFEI, 2014).

International discussions also focus on spill-over effects of fuel economy policies implemented in major car-producing countries as EU, Japan and the USA on the fuel economy of personal vehicles in developing countries. Lessons learned indicate that manufacturers base their global technology introduction plans on the fuel economy regulations of these countries. This means that cars imported from the EU, Japan and USA (new ones and second-hand vehicles) generally are equipped with the same technologies, but lagging behind a couple of years. This spill-over effect does not apply entirely to cars produced within a developing country by major car manufacturers and local car manufacturers (GFEI, 2014).

In addition to national efforts, there are several global initiatives seeking to transform the high rate of greenhouse gas emissions from road-based transport:

- IRU 30 by 30 resolution: voluntary commitment of the road transport industry to reduce emissions by 30% by 2030 through various means.
- Global Fuel Economy Initiative (GFEI): partnership of six organisations that promotes research and knowledge on fuel economy and vehicle emissions.
- Partnership for Clean Fuels and Vehicles: global Initiative to promote cleaner fuels and vehicles in developing and transition economies; platform for exchange in developed and developing countries.
- International Council on Clean Transportation ICCT: independent not-for-profit; unbiased research and technical analysis for environmental regulators.
- Partnership on Sustainable Low Carbon Transport: SLoCAT promotes the integration on sustainable transport in global policies on sustainable development and climate change.

4.2.7 Summary and recommendations for light duty vehicle standards

4.2.7.1 Summary and comparison of case studies

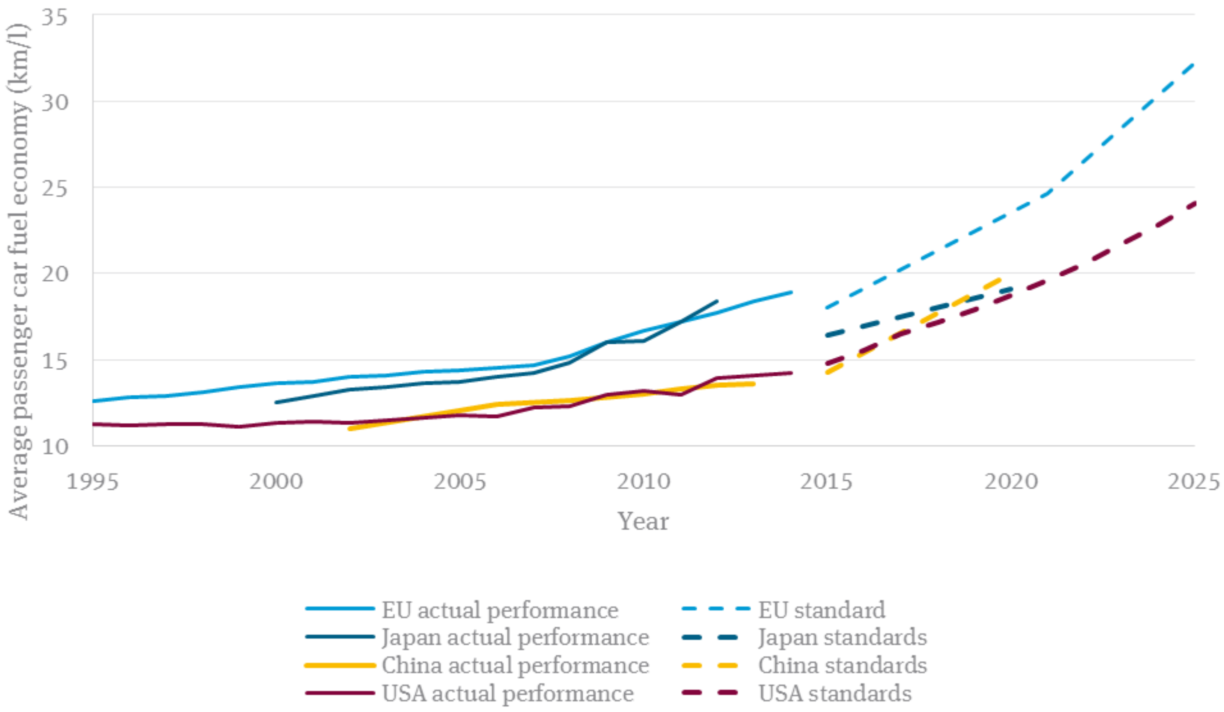
Table 15 and Figure 14 present a summary of the of the light duty vehicle policies in four best-practice case studies: EU, Japan, China and the US.

Table 15: Summary and comparison of vehicle standards in the EU, Japan, China and the US

	EU	Japan	China	US
Major policy	Regulation 443/2009/EC	Top Runner Fuel Efficiency Standards for Light Duty Vehicles	Corporate Average Fuel Consumption (CAFC)	Corporate Average Fuel Economy (CAFE) and GHG standards
Type	Emissions standard	Fuel economy standard	Fuel economy standard	Joint emissions (EPA) and fuel economy (NHTSA) standard
Standard (2020) (average new fleet passenger vehicles) in km/L in NEDC cycle	24.6 km/l 30.0-34.4 km/l by 2025 (subject to review)	19.1 km/l	20 km/l (subject to review)	18.7 km/l 24.1 km/l by 2025 (subject to review)
Ann. improvement (2015–2020)	5.34 (Actual annual improvement between 2014 and 2020 is 3.83%; 2015 standard exceeded in 2013)	3.10% (Actual annual improvement between 2010 2012 and 2020 is 0.47%; 2015 standard exceeded in 2010)	6.94%	4.79%
Key features	Flexible compliance mechanisms within and between manufacturers‘ fleets; stringent penalties; super-credits for innovative technologies.	Flexible compliance mechanisms; generation of industry competition to reach fuel efficiency.	Flexible compliance mechanisms between manufacturing years; super-credits for innovative technologies.	Combines fuel economy with emissions standards; standards set according to vehicle size, not weight; flexible compliance mechanisms between manufacturing years.
Complementary polices	High taxes on fuels; import restrictions for non-compliant vehicles; buy-back schemes; mandatory labelling; R&D.	Fuel tax and tax incentives for light vehicles (for end-users).	Tax incentives; city-led initiatives; subsidies in pilot cities; mandatory labelling.	Gas guzzler tax for very inefficient vehicles; buy-back scheme; priority lanes/parking for fuel economical vehicles; labelling schemes.

	EU	Japan	China	US
Barriers	-	Low penalties for manufacturers for non-compliance.	Major forecast growth in the fleet size; low fuel taxes.	Low penalties for non-compliance, regularly paid; little incentives for individual end-users; political strength of industry and stakeholders; low fuel taxes.
Co-benefits	Consumer cost savings; oil consumption/imports reduced; improved air quality; improved respiratory health; improved sales for the vehicle industry; employment opportunities in the vehicle industry.			

Figure 14: Comparison of achieved light duty vehicle fuel economy and proposed standards for EU, US, China and Japan, MY 1995-2025



Source: Summary representation of information contained in section 4.2. (See individual data for sources)

To compare the ambition between these cases directly, Figure 14 shows clearly that the EU is forecast to become the global leader in vehicle fuel economy standards, with its policies highly ambitious in both the level of its achievement and in the annual rate of improvement. Japan has historically produced one of the lightest and most fuel economical vehicle fleets in the world (after the EU), but considering its significant achievement to date, its standards for 2015 and 2020 are lacking in ambition; the 2015 standards were already met by 2010, and compliance with the 2020 standards would require an annual improvement of just 1.21% up until this date, significantly lower than EU and China's projected improvement rates of around 6.5% per year. However, Japan has a range of policies to support fuel economy and it remains to be seen whether performance continues to improve at a margin comfortably above the standards. Meanwhile, China is set to adopt the world's third most stringent standards if the 2020 target is approved this year, whilst the U.S. will diverge from the leaders who they continue to trail by a considerable margin.

4.2.7.2 Barriers and mitigating policy features

From analysis of the four case studies, the outstanding factor that acts as a facilitator or barrier is the existence of significant incentives for both consumers and manufacturers. Looking at the weakest case presented here, the U.S., penalties for manufacturers' non-compliance are so low that they are regularly paid, and fuel taxes remain critically below a level that might significantly shift consumer demand. In contrast, European Union members states have among the highest fuel taxes in the world, and the penalties for manufacturer compliance are approximately ten times higher than the U.S.. Insights from China and Japan suggest that incentives for consumers might hold even more importance than the stringency of enforcement for manufacturers; in Japan, for example, the minimal compliance penalties are offset by great consumer demand for light and fuel efficient vehicles due to the fuel taxes and the range of tax incentives for the purchase of lighter vehicles.

A considerable barrier that may prevent the tightening of incentives and the scaling up of ambition in the U.S. is the political strength of the industry and associated stakeholders. In, this aspect, Japan's system has the potential to mitigate institutional bottlenecks due to the nature of its top-runner approach, which bases the standards on the best industry practices and therefore promotes competition through natural market forces within the industry. However, the actual contribution of the top-runner programme to Japan's performance is debateable given the length of the compliance periods, and the subsequent ease with which they are met.

Looking to specific policies and supporting mechanisms, all four of these best-practice cases have implemented flexible mechanisms in one form or another; the EU version is particularly noteworthy for the generation of a market for fuel efficiency between manufacturers, due to the ability of manufacturers to meet standards by pooling their fleets with other manufacturers. All countries also have implemented mandatory fuel economy labelling at the point of purchase; this is a key instrument to overcome barriers associated with awareness, but the overall impact is dependent on consumer incentives to prefer fuel efficient vehicles in the first place.

One of the main barriers to set vehicle fuel economy standards in developing countries is that a high level of expertise is needed of the vehicles being sold, the costs, the benefits and the lead-time for a wide variety of vehicles. As an alternative to fuel economy standards, properly designed freebates (partial refunding of the paid price) for fuel efficient cars can be an effective and cheaper alternative (GFEI, 2014).

4.2.7.3 Co-benefits and motivation

Some quantified co-benefits have been included within the individual country case studies. A more general overview of potential co-benefits is given here:

- **Consumer cost savings:** Reduced expenditure at the pump is a clear co-benefit for consumers, and a significant motivation for improving fuel economy in most countries. This degree of relevance for this co-benefit (and consequently its potential to drive ambition) is dependent on policies in place to reward economical behaviour. Creating policy conditions that maximise the relevance of this co-benefit will in turn directly drive market innovation and public pressure for the ambition of fuel economy standards.

- **Reduced oil imports:** All of the countries featured in the case studies here are critically dependant on oil imports for transportation, creating a position of potential economic insecurity. Global price hikes or supply failures due to unforeseen circumstances can have devastating consequences for economies around the world. Policies to improve vehicle fuel economy may have a considerable impact on reducing oil imports and increasing energy security.
- **Air quality improvements:** Standards aimed at emissions and standards aimed at fuel economy may reduce local air pollution, with further positive effects for respiratory health. Of the countries reviewed here, this is particularly pertinent to China where urban air pollution poses a major health concern. This was the major motivation for progressive policy reform in Beijing ahead of the 2008 Olympic Games (UNEP, 2010).
- **Technological innovation:** Continued improvements in fuel economy and the use of alternative fuels required research and development that will be transferable to other sectors.

Shindell et al. (2011) find that applying the EU vehicle emission standards to developing countries worldwide would, in 2030, prevent 120,00 to 280,000 premature climate related deaths, save USD $600 billion to $2,400 billion in health costs, and save USD $1.1 billion to $4.3 billion in ozone related agricultural yield losses.

4.2.7.4Future outlook

Figure 14 suggests that the short term outlook for legislation of light duty vehicle fuel efficiency is generally positive; the rate of improvement between 2010 and 2025 is forecast to be significantly higher than during previous decades. This is a reflection of factors that are likely to increase motivation and capability also into the medium and long term:

- Governments will find fuel subsidies increasingly difficult to finance, both in view of increasing oil prices and pressure from international and (some) domestic forums to adopt economic policies that reflect environmental costs. This will increase motivation from two angles, as governments will want to reduce their oil imports and consumers who no longer benefit from the same rate of fuel subsidies will realise the economic gain of behavioural change.
- The increasing availability of more efficient and alternative technologies will improve the capabilities of countries to adopt more ambitious standards. Availability, understanding and technical capacity for biofuels is continuously improving its somewhat contentious potential; the IEA estimate that biofuels could provide up to 27% of transport fuel by 2050, offsetting approximately 2.1 GtCO_2 (OECD and IEA, 2011). Furthermore, advanced technologies such as integrated start generators and heat recovery are making their way into a number of new vehicles, whilst use of advanced lightweight material may reasonably increase fuel economy by up to 20% (UNEP, 2010).
- International pressure for enhanced action on climate change mitigation is increasing for all countries, and the transport sector remains a significant and relatively unexploited source of potential for sizeable emission reductions with great domestic co-benefits.

Given the forecast increase in activity within this thematic area worldwide over the coming decades, it is of vital importance that the above factors combine to motivate concerted and rapid progression. Within the next two decades, China will move from a position of having a light duty vehicle fleet just 10% the size of the U.S.‘s, to a position of consuming more vehicles each year than total global production in 2009 (UNEP, 2010). Similar patterns of mass car ownership are likely to unravel in other emerging economies, making the global vehicle fleet several scales larger than it is currently. Given the profound impact that this may have on worldwide GHG emissions, the development of low carbon options at an early stage is crucial; investments by developed countries in transferable low-carbon transport technologies now, may enable emerging economies to reasonably assume a greater share of mitigation responsibility later.

4.2.7.5 Policy impacts and mitigation potential

Emission standards for cars have a significant effect on the future growth of emissions in the analysed countries (United States, the European Union, China and Japan). For the developed countries the standards stop the growth in emissions and lead to an absolute reduction. The emission growth is slowed down for China. If all countries were to implement the best practice policies of peers in their region, 0.6 $GtCO_2$/a below the frozen technology pathway and a reduction of 0.2 $GtCO_2$/a below the reference pathway could be achieved. If all countries would adopt the European emission standards, the most ambitious of the countries analysed, this reduction could be 1.0 $GtCO_2$/a below the frozen technology pathway and 0.5 $GtCO_2$/a below the reference pathway. It could stop the growth in global emissions all together.

4.3 Emissions from flaring during oil and gas production

There are five main sources for fugitive emissions in oil and gas production (IPCC, 2000):

- Fugitive equipment leaks
- Process venting
- Evaporation losses
- Disposal of waste gas streams (e.g. by venting and flaring[31])
- Accidents and equipment failures (e.g. well blowouts, pipeline breaks, tanker accidents, tank explosions, gas migration to the surface around the outside of wells, surface-casing vent blows)

Further, three broad categories are differentiated:

- Oil and gas production
- Crude oil transportation and refining
- Natural gas processing, transportation and distribution

The following analysis of policies for reduction of emissions from oil and gas production focuses on the reduction of venting and flaring of waste gas streams.

4.3.1 Norway – the Petroleum Act and the Pollution Control Act

Crude oil production in Norway started in the 1970th. Today, Norway is among the 15 top producing countries of crude oil in the world (IEA 2015). While oil production started to decrease since 2000, gas production keeps increasing and accounted for 50% of overall petroleum production on the Norwegian continental shelf in 2014 (norskpetroleum.no website, 2015).

[31] Venting refers to the release of natural gas that is not processed for sale or use because of technical or economic reasons; Flaring refers to the burning of natural gas in the field as a means of disposal (Nurakhmet: Gas flaring and venting what can Kazakhstan learn from the Norwegian experience/ Handbook Petroleum Industry: Words and Phrases; Glossary of Canadian Association of Petroleum Producers (www.capp.ca)

Since the beginning of oil production in Norway, the government put policies in place to avoid wasting valuable energy[32], in particular natural gas associated with the oil production. Oil production is supervised by the Norwegian Petroleum Directorate (NPD) and the Norwegian Pollution Control Authority (SFT). Two particular laws regulate the handling of associated gas in petroleum production. In the Pollution Control Act[33], emission of gas or other substances into the air are prohibited in general. That applies for the venting of associated gas as well as the flaring of associated gas except for safety reasons. Under the Petroleum Act[34] each dwell is allowed a limited amount of gas flaring as required for safety reasons. The amount of flared gas is determined on a quarterly basis in case of regular operations, on a monthly basis for exploration of new fields. The amounts of gas venting and flaring need to be reported on an annual basis.

In addition, production licenses are provided under the Petroleum Act on a case-by-case assessment. The Petroleum Act requires a plan for development and operation of an oil or gas field (PDO) by the company applying for a production license. The PDO also needs to include an environmental impact assessment. To obtain a production license for a dwell, the company needs to take steps to utilize the associated gas. Mainly, three options are available for the associated gas development: (i) Electricity production via gas-fired turbine generators, (ii) gas conservation and (iii) re-injection into the dwell for improved oil-recovery. In the beginning of oil production in Norway, the production licenses had a limited duration of six month only, hence a regular review of production conditions took place. Today, licenses are valid for a number of years (starting with 4-6 years for exploration and 10-30 years for exploitation).

In 1990, the Norwegian Parliament in addition introduced a CO_2 tax for offshore petroleum activities[35]. Currently, for all gas burnt or discharged to the air, a tax of 1 NOK per standard cubic meter of gas (equivalent to 50€ per ton of CO_2) and 1 NOK per liter of oil or condensate needs to be paid (NPD).

In addition, Norway joined the EU ETS in 2008, putting further costs on the CO_2 emissions from flaring.

The strict regulation of venting and flaring resulted in a significant reduction of gas venting and flaring in Norway. Venting only accounted for 0.5Mt CO_2e in 2011 (see Figure 15). In 2012, flaring rates in Norway were between 0.3% and 0.4% of the total oil and gas production on the Norwegian shelf, compared with a global average of 1.1%. While oil and gas production almost doubled between 1990 and 2011 (Environment no website, 2014), gas flaring not only remained relatively stable, but also declined in a number of years. Today, only about 9% of CO_2 emissions from petroleum activities in Norway are from Flaring and Venting Gavenas, Rosendahl and Skjerpen, 2015), the major part (80%) coming from combustion activities providing the necessary electricity. In 2012, 0.015t CO_2e/Sm^3 crude oil were released by flaring, 0.0048t CO_2/Sm^3 crude oil by venting based on production figures by the Norwegian government and UNFCCC greenhouse gas emission inventories, adding up to 0.0206t CO_2e/Sm^3 crude oil.

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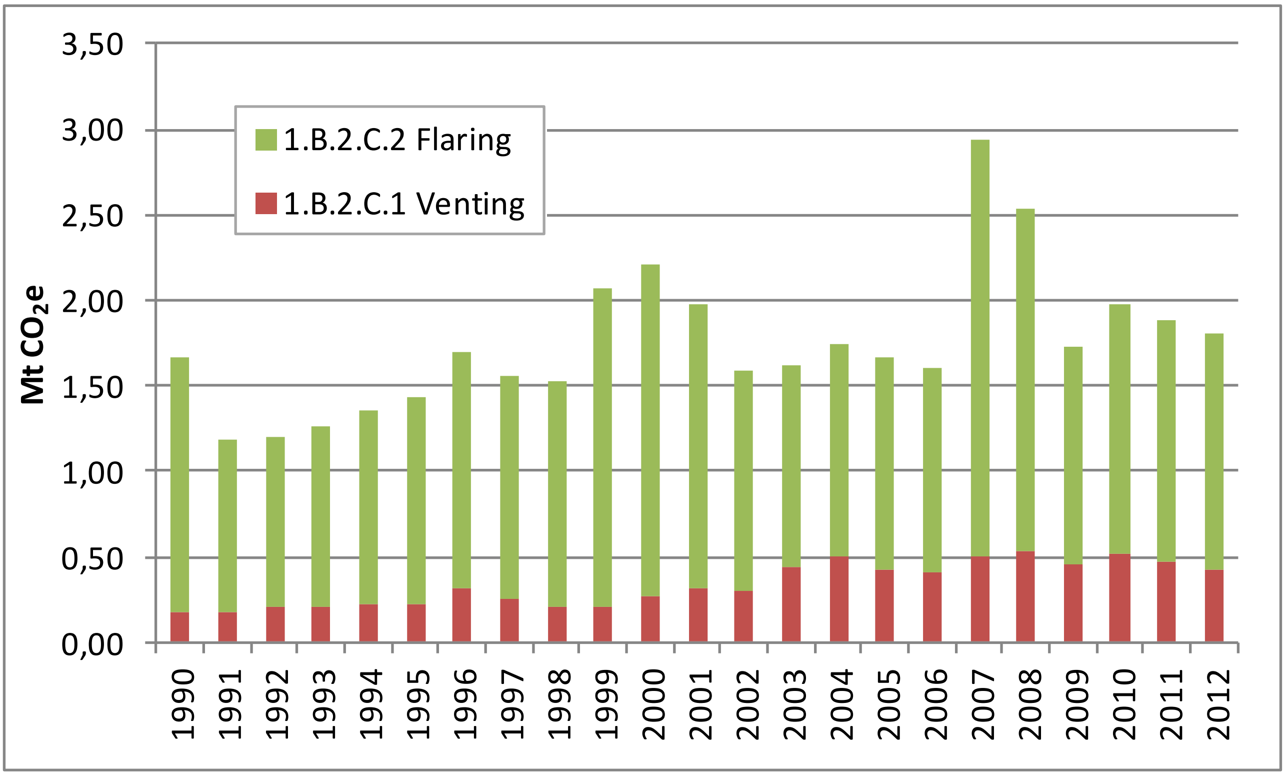
[32] The Norwegian Parliament produced '10 oil commandments' that are significant for the direction of Norwegian petroleum policy. The fifth commandment requires "Flaring of exploitable gas on the NCS must not be accepted except during brief periods of testing" (http://www.npd.no/en/Publications/Norwegian-Continental-Shelf/No2-2010/10-commanding-achievements/).

[33] Act of 13 March 1981 No 6 Concerning Protection Against Pollution and Concerning Waste

[34] Act 29 November 1996 No. 72 relating to petroleum activities

[35] Act 21 December 1990 no 72 relating to tax on discharge of CO_2 in the petroleum activities on the continental shelf

Figure 15: Emissions from venting and flaring in Norway



Source: UNFCCC data interface

As utilisation of associated gas in petroleum production has always been a requirement in Norway, the starting point for the implementation of such a policy was quite different compared to countries that might want to introduce the same policy subsequently. In particular:

- Companies and other stakeholders were involved in finding an appropriate regulatory approach from the beginning (GGFR, undated).
- As the application for production licenses requires all companies to provide a plan on the utilisation of the associated gas, no retrofitting was needed. Also, the requirements lead to investment in infrastructure for the transport of gas which allows for further processing and the sale of the associated gas. Today, gas makes up about 50% of total petroleum production in Norway (Environment no website, 2014).
- Measuring and reporting is an important part of a successful policy to reduce venting and flaring. In Norway, clear rules for reporting apply, a flaring and venting register is kept and regular audits define the correctness and accurateness of the data provided (Nurakhmet, undated).

A number of co-benefits occurred from the restrictive regulation on associated gas:

- Re-injection of associated gas results in improved oil recovery from a number of dwells.
- Utilisation of associated gas for selling and transport via a pipeline system opened up a new market for Norway.

Norway launched two initiatives to promote its flaring policies:

- Oil for development was launched in 2005 by the Norwegian government. It focuses on long-term capacity building and institutional cooperation with relevant governmental agencies within the areas of resource management, revenue management and environmental management.

- The World Bank's Global Gas Flaring Reduction Partnership was launched in 2002. It supports the efforts of oil producing countries and companies to increase the use of associated gas and reduce flaring and venting. It provides a standard framework for governments and companies to take collaborative actions and reduce barriers to associated gas utilisation. Major partners include Russia, Kazakhstan, Algeria, Angola as well as major oil producing companies.

In 2015, a new initiative was launched with the aim to end routine flaring at all oil production sides by 2030. Norway as well as the Norwegian Statoil endorse this initiative.

4.3.2 Russia – License requirements and the law "on environmental protection"

Russia is the third largest producer of crude oil and the second largest producer of natural gas (IEA, 2014a, 2015). At the same time, Russia is one of the top flaring countries (Carbon Limits, 2013), contributing about 25% to global flaring in 2012. Only about 76% of the associated petroleum gas (APG) is utilised (Carbon Limits, 2013).

In 2012, Russia introduced and strengthened regulations that require companies to reduce flaring and stop wasting associated gas. Two large regions (Khanty-Mansiysk and Yamalo-Nenets) demand the utilisation of a certain amount of associated gas. Otherwise the license for oil production at the subsoil can be withdrawn.

- In addition to the license requirements, the national law "on environmental protection" regulates payments for pollutants associated with flaring and venting of associated gas. Three groups can be differentiated and associated with differing payment rates: "within established emission limits", "within temporarily agreed emission limits" and "above-limit emissions". In case emissions exceed a threshold of 5% of the produced associated gas, government decree No. 1148 (2012) stipulates that payments are multiplied with a factor of 25 (a factor of 12 until 2014). If no acceptable measuring equipment is present at the well, a multiplier of 120 applies. No multipliers are applied if the threshold of 5% is not exceeded, if total annual production does not exceed 5 million cubic meters or if the associated gas contains less than 50% non-hydrocarbon components.

To incentivise investments in utilisation equipment, payments for gas pipelines, compressor stations, separation units, facilities for electricity and heat production or for re-injection of gas into the well can be subtracted from the fines under decree No. 1148. For efficiency, companies can aggregate production across all fields to reach the utilisation rate of 95%. If, however, the target is not met, fines are calculated per field.

Further regulations incentivising the utilisation of associated gas include:

- Additional economic incentives were provided in 2008 when the pricing of associated gas was liberalised increasing companies bargaining power with the associated gas processing, Gazprom-owned facilities.
- Associated gas is given priority access to free capacities in the gas transportation pipelines.
- Reduced mineral extraction tax rates apply for associated gas that is re-injected into the well for improved oil recovery.
- An amendment to the law "On electricity" from 2010 gives priority access to the national electricity grid for electricity from utilised associated gas and its derivatives.

Estimations of the World Bank indicate that the economic losses related to gas flaring in Russia are more than $5bn per year, part of which can be recovered if the amount of gas flaring is reduced. Yet, a number of barriers exist (World Bank 2013b):

- There is a large number of low pressure and low volume wells in remote areas with limited connectivity. Infrastructure systems for gas transportation require funding investments. Furthermore, local demand close to the wells is very limited.
- Gas impurities require further processing and cleaning before it can be sold.
- Re-injection of associated gas, though often used to improve oil production, can also result in damaging of oil production in a well depending on the geological circumstances. Proust (2006) estimates that the excess of gas in a well has a negative impact on oil production after 5-8 years of gas re-injection.
- In addition to the technical and infra-structure barriers, a further major barrier is the limited enforcement of the rules and regulations described above and the limited economic incentives from the fines that are applied. A recent report on the status of gas flaring in Russia states that so far no case is known in which a company actually lost its production license even though non-compliance with the utilisation of associated gas regulations is common. Furthermore, fines do not present the necessary economic incentive to invest in gas utilisation equipment (Carbon Limits, 2013). As long as oil production does not become less important for the Russian economy, chances are that political protection of the industry will remain high and continue to hinder introduction and enforcement of effective rules and regulations against gas flaring (WWF Russia, 2009).
- Comparisons of Russian statistics reveal that different estimation methods for the amount of gas flaring are used (Carbon Limits, 2013).

Since 2004, one of the major oil and gas producing districts in Russia, the Khanty-Mansiysk Autonomous Okrug-Ugra (KMAO) is a member of the Global Gas Flaring Reduction Partnership (GGFR) of the World Bank. In KMAO, the GGFR provided advisory services including (Hamso, 2013)

- Comparison of satellite and reported data on flared associated gas volumes
- On-site measurement of flare gas volumes
- Assessment of associated gas flare volume measurement procedures and regulation
- Technical and economic modelling of associated gas utilization options
- Analysis of potential associated gas projects and gas sources clustering in KMAO

As a result, a number of associated gas utilisation projects for power generation, municipal heating and improved oil recovery were implement within a government programme between 2007 and 2010. The projects increased the volume of efficiently used associated gas by 8%, resulting in an 86% utilisation rate in KMAO in 2011. The GGFR work on economic associated gas utilization projects also attracted oil companies, who invested almost $1 billion in such projects in 2012 (World Bank, 2013). Further collaboration between KMAO and the GGFR was formalized by the signing of a Reimbursable Advisory Services Agreement in December 2012 (GGFR, 2013).

However, the reductions in KMAO have been offset by new flares in other regions, as investments in new oil production capacity typically outpace investments in associated gas utilisation (Carbon Limits, 2013). Russia itself is not a member of the GGFR.

4.3.3 Quantitative assessment of policies

4.3.3.1 Methodological considerations

Although GHG emissions (mainly CO_2 and methane) occur at different stages of fossil fuel production, our quantification of policies focusses on flaring of associated petroleum gas (APG) associated with oil production only.

Country-level analysis

Our approach for quantifying the effect of policies to reduce associated natural gas flaring consists of the following steps:

1. Historical data for the amount of APG flared are taken from the National Oceanic and Atmospheric Administration (NOAA, 2011). This dataset is based on satellite data and contains the most consistent national and global estimates of gas flaring volumes from 1994 until 2010 (Ismail & Umukoro, 2012).
2. Historic crude oil production is taken from IEA (2014c).
3. APG production in 1994–2010 is estimated based on:
    i. Where possible, APG flared and estimates of the share of APG production flared are found in literature.
    ii. For the years, where no estimates are available in literature, the APG production is estimated based on the relationship between crude oil production and APG produced. This relationship is derived from the results of step 2 and 3i.
4. The share of APG flared in each year is calculated based on the APG produced and APG flared values.
5. APG produced in 2020 is estimated based on the 2010 value and regional growth projections for oil production taken from BP (2015b).
6. The amounts of APG flared in 2020 in the different pathways are calculated.
    i. Frozen technology pathway: the share of APG flared is kept constant at the 2010 value.
    ii. Reference pathway: The trend of the share in APG flared in recent years (2006–2010) is continued until 2020.
    iii. Policies pathway: The target set for APG flaring is met in 2020.
7. The greenhouse gas emissions related to this amount of flaring are calculated by multiplying with the emission factor of 2.7 MtCO2e / BCM flared (estimated based on Farina, 2010).

The steps indicated here require assumptions on different aspects:

1. The main assumption underlying this approach is that crude oil production can be used to estimate APG production. This assumption is made because available statistics do not differentiate between associated and non-associated natural gas production. Although APG production is related to oil production, the proportion of associated gas to oil can vary strongly between oil fields (Ismail & Umukoro, 2012). However, for Russia, for example, we found a strong correlation between APG flared and crude oil production.
2. The greenhouse gas emissions from flaring natural gas are estimated on the global figures for APG flared and the associated emissions from Farina (2010). It is thus assumed that emissions per amount of APG flared are constant worldwide. Due to the different compositions and local characteristics of APG flaring, this emission factor will in practice not be constant.

Regional and global upscaling

The mitigation potential of flaring reduction policies is only quantified for Russia. It was chosen not to scale up the results of this case study to the global level. Instead it is only scaled up to the top-5 APG flaring countries (Russia, Nigeria, Iran, Iraq, and Algeria). This approach was chosen because the flaring circumstances differ strongly between countries. In developed countries, APG utilization is between 97% and 99% (Ismail & Umukoro, 2012). Scaling up to the Russian target of 95% utilization (Farina, 2010) is thus not feasible. Furthermore, in case non-oil and gas producing countries would reduce flaring, effects on global emissions are insignificant. Therefore, it was chosen to only scale up the results to the top-5 flaring countries, in which utilisation rates are relatively low. These top-5 countries cover 57% of the global APG flaring (NOAA, 2011).

The approach taken for the upscaling consists of the following steps:

a) Historical data for the amount of APG flared data are taken from NOAA (2011).
b) Historic crude oil production is taken from IEA Energy Balances (2014c).
c) The ratio of APG flared over crude oil production is calculated.
d) Crude oil production in 2020 is estimated based on the 2010 value and regional growth projections for oil production taken from BP (2015b).
e) The amounts of APG flared in 2020 in the different pathways are calculated in different ways.
   i. Frozen technology pathway: the ratio of APG flared over crude oil production is kept constant at the 2010 value.
   ii. Reference pathway: The trend of the ratio of APG flared over crude oil production in recent years (2006–2010) is continued until 2020.
   iii. Policies pathway: The 2020 ratio of APG flared over crude oil production from the Policies pathway for Russia is applied to the 2020 crude oil production.
f) The greenhouse gas emissions related to this amount of flaring are calculated by multiplying with the emission factor of 2.7 $MtCO_2e$ / BCM flared (estimated based on Farina, 2010).

4.3.3.2 Results of quantitative assessment

Summary: The policy to reduce APG flaring to 5% in the analysed country Russia, can lead to a significant decrease in flaring emissions. If the target is met, 2020 emissions in this area decrease by over 80% from the 2010 level according to our calculations. If the top-5 APG flaring countries adopt similar policies, an emission reduction of about 0.1 $GtCO_2e$/a below the reference could be achieved in 2020.

The reduction of flaring from associated petroleum gas (APG) is quantified for Russia only. Russia has set a target of 95% utilisation of APG in 2014 (Farina, 2010). In the absence of a target beyond 2014, the same target is applied for 2020. Based on PFC Energy (2007), the APG flaring rate in the period 1994–2005 is taken to be on average 45%. As described in the methodology, the amount of APG production for other years is estimated based on crude oil production and literature value for the share of APG flared. As can be seen in Figure 16, the amount of APG flared and crude oil produced are strongly correlated in the period 1994–2005. After 2005, the amount of APG flared decreased compared to oil production. This decoupling coincides with the increasing awareness for the gas flaring issue in Russia (Farina, 2010). Based on this decoupling from 2006 onwards, the flaring trend from 2006–2010 is taken as the basis for the reference pathway.

Figure 16: Index of APG flared and crude oil production for Russia (1994 - 2010)

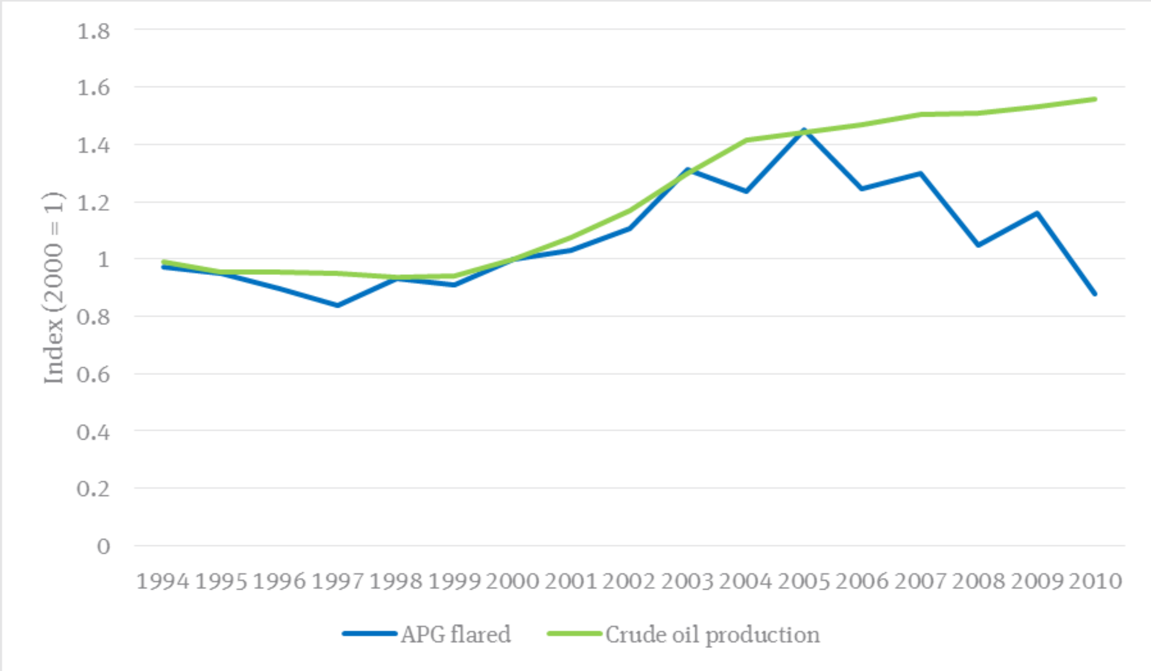


Figure 17 and Table 16 show the results of the quantification for Russia. Due to the projected decrease in oil production in the region (BP, 2015b), the emissions in the 2020 frozen technology pathway are below the 2010 level. A continuation of the recent trend of decreasing APG flaring would lead to a decrease in flaring emissions of 63% below the 2010 level. Achieving the 95% utilisation target would lead to decrease in flaring of 81% below the 2010 level. According to our calculations, this is a reduction of 18 $MtCO_2e$ below the reference pathway and 75 $MtCO_2e$ below the frozen technology pathway. However, one has to keep in mind that there is a high uncertainty concerning the amount of APG flared. Russians statistics report values are much lower than the NOAA (2011) satellite data. According to Russian statistics the amount of flared APG was in the range of 11–17 BCM in the period 2003–2010 (Carbon Limits, 2013), whereas NOAA reports values in the range of 35–58 BCM in the same period.

Figure 17: Results country-level quantification of flaring reduction policies

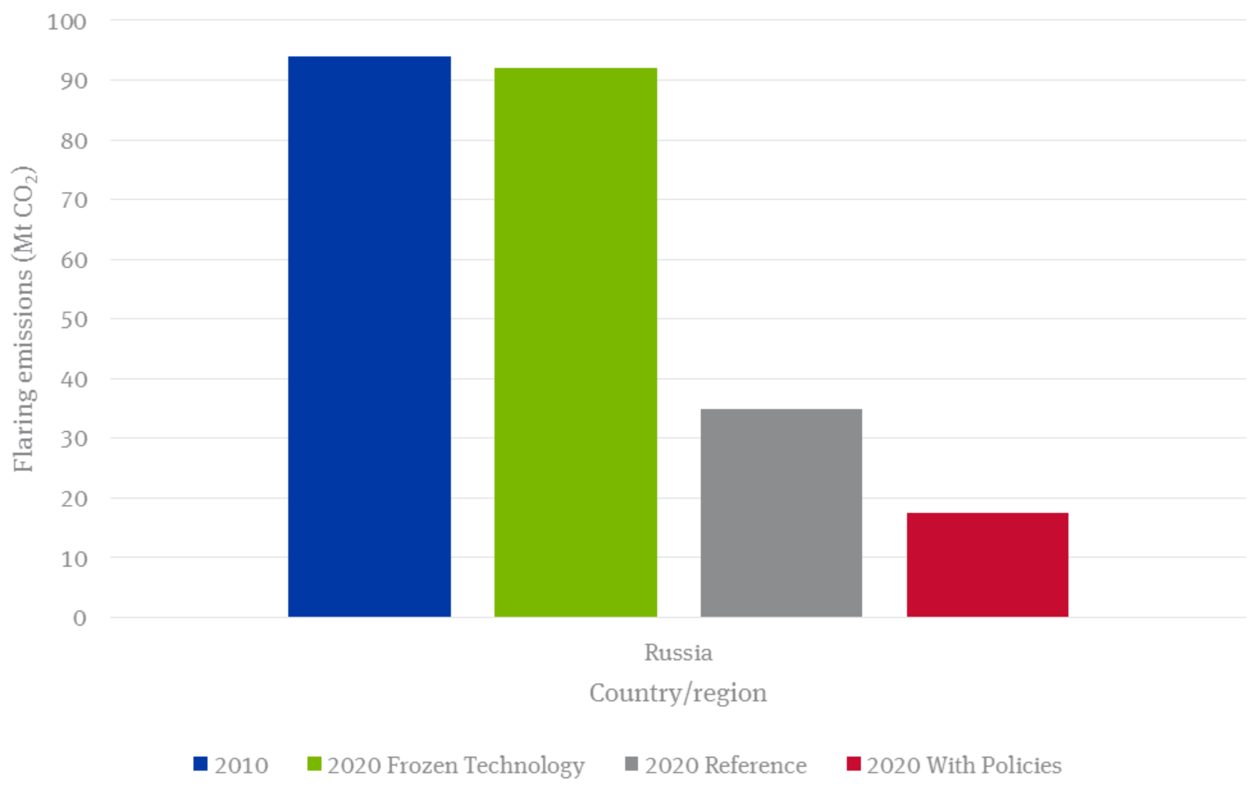
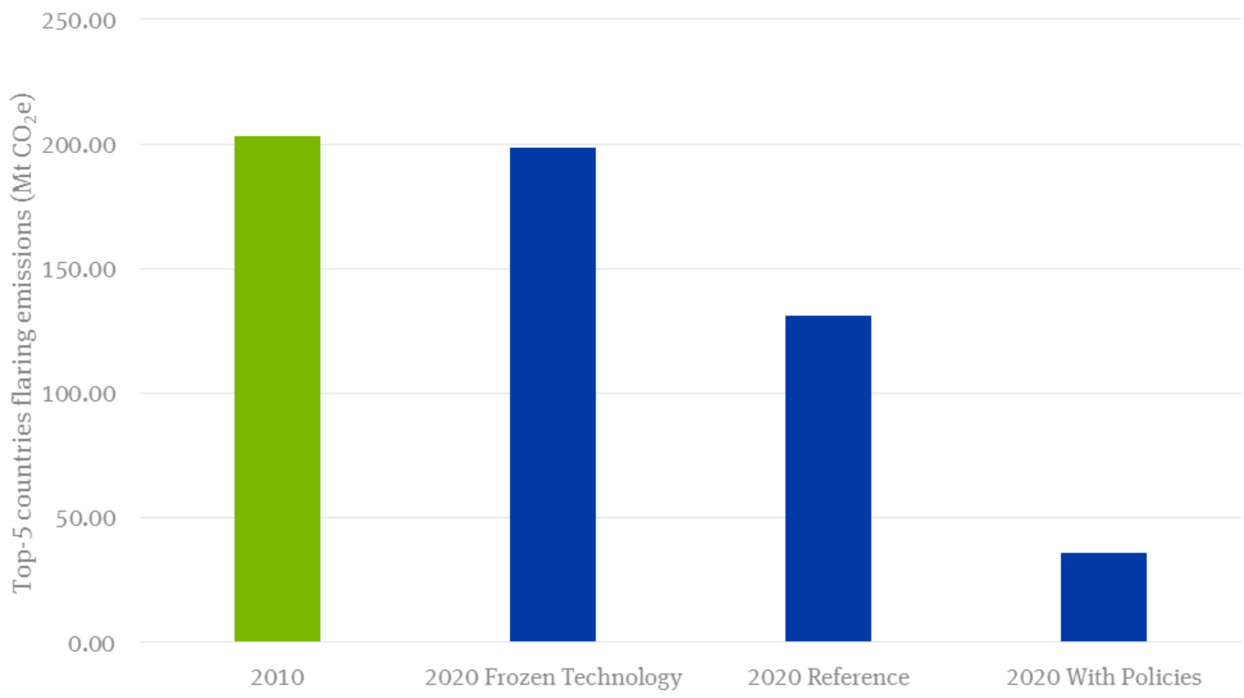


Table 16: Results country-level quantification of flaring reduction policies

	Russia (2012)	Russia (2020 with policy)
APG flaring rate	24%	5%
Flaring emissions $MtCO_2e$	94	17
BCM APG flared per mtoe crude oil production	7E-5	1E-5

Figure 18 shows the result of upscaling the approach for Russia to the top-5 flaring countries (Russia, Nigeria, Iran, Iraq and Algeria). Emissions in the frozen technology pathway are at the same level as the 2010 emissions, due to the comparable projected oil production. The reference pathway, in which the 2006–2010 trend continues, represents a reduction of 34% of emissions from the 2010 level. The policy potential pathway, in which the amount of APG flared per amount of crude oil production is set at Russian policy target level, represents a reduction of 82% below the 2010 level. This is an estimated reduction of about 0.1 $GtCO_2e$/a, equivalent to 73%, below the reference pathway in 2020. Since this upscaling only covers the top-5 flaring countries, the global policies potential will exceed this 0.1 Gt CO_2e/a. Considering that the top-5 flaring countries cover 57% of the flaring and that flaring rates in some countries are already below the 5% target, the global policy potential will be below 0.2 $GtCO_2e$/a.

Figure 18: Upscaling to top-5 flaring countries (only emissions from Russia, Nigeria, Iran, Iraq and Algeria are shown)



McKinsey & Company (2009) estimates the abatement potential from flaring reduction to be 70 $MtCO_2e/a$ in 2030 compared to their reference scenario, which includes a 72% reduction of flaring below the 2005 level. This estimate compares reasonably well with our estimate, taking into account that our reference pathway for the top-5 flaring countries represents a 52% reduction of flaring below the 2005 level in 2020.

4.3.4 International discussions in related forums

Progress on policy related to short-lived climate forcers (SLFCs) is promoted by its large potential for health improvements; in addition to the climate change mitigation potential, successful mitigation activities could prevent 24 million annual deaths from air pollution, and approximately 32 million tonnes of annual crop losses (Harrison et al., 2014).

Three key international cooperative initiatives focus on methane emissions from fossil fuel energy production:

- The Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants (CCAC) is a UNEP awareness raising initiative, seeking to enhance understanding and capacity to overcome barriers for this thematic area,
- The Global Methane Initiative (GMI) builds on the existing success of the Methane to Markets Partnership to promote the recovery and use of methane as a clean energy resource, for both the public and private sectors.
- The Global Gas Flaring Reduction Partnership (GGFR) of the World Bank promotes private-public partnerships and best practice guidelines for the reduction of flaring.

Importantly, technologies and knowledge for mitigation in this area are at a mature stage, and most countries are considered to be in a state of high-readiness to implement such measures. Countries participating in the CCAC have found development in this area to be a highly efficient means of enhancing domestic development and raising ambition for climate change mitigation. Given the high potential for mitigation and development in this area, a concerted effort currently exists to mainstream consideration of SLFCs in the work of global and regional development banks. In 2012, the World Bank was commissioned by the G8 to investigate ways in which it can better integrate SLFCs in its existing and future project portfolios.

4.3.5 Summary and recommendations for flaring during oil and gas production

4.3.5.1 Summary and comparison of case studies

The main features of the two case studies of Norway and Russia are provided in Table 17.

Table 17: Summary and comparison of methane policy in Norway and Russia

	Norway	Russia
Major policy	Petroleum Act and Pollution Control Act	License requirements and law on environmental protection
Type	License requirements; permit system	Permit system; license requirements
Key features	Production license requires plan on the utilisation of associated gas; Permit system for gas flaring	Limit requirements on gas flaring for production license; payments for gas flaring
Complementary polices	CO_2 tax for offshore petroleum activities applying to gas venting and flaring	Priority use of access transportation capacities for associated gas; liberalization of associated gas pricing; priority feed-in of electricity produced from associated gas into the national grid
Barriers	High infrastructure costs; Measuring and reporting	High infrastructure costs; Measuring and reporting; effective enforcement of policies
Co-benefits	Utilisation of associated gas e.g. for improved oil recovery, electricity production, heating or export	

A comparison of the two case studies shows that very similar policies are in place in Russia and Norway. In both cases, license requirements exist and a permit system and penalty system is in place. A major difference in the license requirements is the fact that in Norway companies were facing the requirements from the very beginning, while in Russia the law was only adopted a few years back. Hence, while in Norway companies are required to present a plan for the utilisation of associated gas to obtain a production license, the newly introduced Russian law allows for the revocation of the license. However, so far, Russian regulators have demonstrated little proactivity in the enforcement of these license requirements.

4.3.5.2 Barriers and mitigating policy features

In both case studies, distance of production sites to areas where the associated gas could be used presented one of the major barriers. As a result, high technological and infrastructural investments in technology are necessary to utilise the associated gas instead of flaring it. While in Norway, a strict requirement for the utilisation of associated gas required companies to deal with those investments, in Russia the effective enforcement of a similar policy is missing. So far, non-compliance does not result in a loss of production licence in Russia and fines do not present the necessary incentive to invest in associated gas utilization technology. The two cases show clearly that this lack of enforcement is a major barrier in Russia.

4.3.5.3 Co-benefits and motivation

The associated gas presents a valuable resource with three major application possibilities: (i) re-injection into the well for improved oil recovery, (ii) local use for heat or electricity generation or (iii) processing and resale/ export. In all cases, an economic value is provided.

4.3.5.4 Future outlook

The case study of Norway suggests that strict regulations can result in very low levels of gas flaring in the long run. With the Global Gas Flaring Reduction Partnership of the World Bank, Norway tries to help other oil producing countries and companies to utilize the associated gas instead of just burning it. In the long run, higher gas prices could help to increase the economic incentives for the utilization of associated gas.

4.3.5.5 Policy impact and mitigation potential

The policy to reduce APG flaring to 5% in the analysed country Russia, can lead to a significant decrease in flaring emissions. If the target is met, 2020 emissions in this area decrease by over 80% from the 2010 level according to our calculations. If the top-5 APG flaring countries adopt similar policies an emission reduction of about 0.1 GtCO_2e/a below the reference could be achieved in 2020. Global implementation of similar policies could result in an even bigger emission reduction.

4.4 Appliances

4.4.1 Japan: Top Runner programme

In 1998, the Top Runner Programme was adopted in a revision of the Energy Conservation Law, which introduced an efficiency standard programme requiring manufacturers to meet certain levels of efficiency for appliances based on the best performance of current technologies (Hamamoto, 2011). The Kyoto Protocol agreement in 1997 was a driving factor behind the introduction of the Top Runner Programme – with the policy aiming to lower GHG emissions in the residential sector via an increase in the energy efficiency of end-use products in order to contribute to the fulfilment of Japan’s Kyoto Protocol target (6% GHG reduction by 2008-2012 below 1990 levels). The scope of the Top Runner Programme is based on three criteria (Osamu, 2012):

- Products involving large domestic shipments;
- Products that consume a substantial amount of energy in the use phase;
- Products with considerable room to improve energy efficiency.

At the beginning of the Top Runner Programme energy efficiency targets were set for nine products (room air conditioners, fluorescent lighting, television sets, copying machines, computers, magnetic disk units, video cassette recorders, refrigerators, passenger vehicles and freight vehicles), which has risen to 31 in 2015.[36]

A multi-stakeholder consultation process decides upon the setting of standard levels and target years for the appliances selected,37 which are regularly revised, and based upon the 'top runners' (the most energy efficient product on the market during the standard setting process) whilst also taking into account technological potential for energy efficiency improvements.38 Importantly, the standards are also differentiated based on certain parameters (size, weight, and technology type) and producers are provided flexibility by only having to comply with a weighted average energy efficiency standard for the products that they sold in the target year. This means that the producer does not necessarily have to achieve every product target; however on average they must meet the energy efficiency standard. This flexibility allows producers to sell a wide range of products to meet consumer demand, whilst guiding the overall market to higher energy efficiency standards (Osamu, 2012).

The Top Runner programme is combined with labelling policies for manufacturers and retailers since 2006. Out of 31 products under the Top Runner program, 25 are covered by labelling for manufacturers and 5 for retailers. Moreover, consumer awareness for energy efficiency is promoted by awareness raising through promotion activities and collective memory of crises like the oil crisis (1970s) and the Great East Japan Earthquake (2011). Japan also supports other Asian government to implement energy efficiency policies. Finally, Japan has signed bilateral agreements with 10 Asian countries with the aim to facilitate diffusion of leading low carbon technologies under the framework of the JCM project. (METI, 2014)

The Ministry of Economy, Trade and Industry (METI) requires producers to submit a report in the target year that includes information on their sales and the energy efficiency of their products, which is the basis for an evaluation on their compliance with the Top Runner Programme. The main sanction for non-compliance with the policy follows the 'name and shame' approach whereby the recommendation from METI for a producer to improve their energy efficiency performance is publically announced if the producer subsequently fails to comply and is then ordered to meet the standard. Although there is no publically available documentation on rates of compliance, no producer has so far been announced as non-compliant. The successful compliance of producers may be due to the limited number of domestic producers in the Japanese appliance market and the fact that culturally criticism from the government acts as a serious penalty (Osamu, 2012). The implementation of the Top Runner Programme has therefore been very successful with all of the targets reached up to 2005 either being met or exceeded (Osamu, 2012). A more recent evaluation of achievements from 2015 by the Japanese government is shown in Table 18.

Table 18: Energy efficiency improvement of major products with Top Runner Standards

Product category	Energy efficiency improvement (result)	Energy efficiency improvement (initial expectation)

[36] The number of products included within the policy has been gradually expanded over time through a process of regular reviews and by 2013 energy efficiency standards and target years were set for 31 products Ministry of Economy, Trade and Industry Agency for Natural Resource and Energy, 2015).

[37] 'Energy efficiency standards are discussed and determined by the Ministry of Economy, Trade and Industry (METI) and its advisory committees comprising representatives from academia, industry, consumer groups, local governments and mass media' (Osamu, 2012)

[38] For example, 'the Top Runner Standards for room air conditioners (smaller than 4 kW) for 2010 were set for a 3-4 % improvement over the Top Runner products in 2005, because this level of technological improvement was assessed as feasible by stakeholders' discussions in the Air Conditioner Evaluation Standard Subcommittee' (Osamu, 2012).

Product category		Energy efficiency improvement (result)	Energy efficiency improvement (initial expectation)
Passenger vehicles		48.8% (FY 1995 → FY 2010	22.8%
Freight vehicles		13.2% (FY 1995 → FY 2010)	13.2%
Air conditioners	Non-ducted/wall mounted AC units 4kW or less	16.3% (FY 2005 → FY 2010)	22.4%
	Non-ducted/wall-mounted AC units, over 4 kW	15.6% (FY 2006→ FY 2010)	17.8%
	Other than non-ducted/wall-mounted AC units	15.9% (FY 2001 → FY 2012)	13.6%
Electric refrigerators (for residential use)		43.0% (FY 2005 → FY 2010)	21.0%
Electric freezers (for residential use)		24.9% (FY 2005 → FY 2010)	12.7%
Microwave ovens		10.5% (FY 2004 → FY 2008)	8.5%
Electric rice cookers		16.7% (FY 2003 → FY 2008)	11.1%
Lightning Equipment using only fluorescent lamp(s) as main light source	Lightning equipment for fluorescent lamp(s)	14.5% (FY 2006 → FY 2012)	7.7%
	Self-ballasted fluorescent lamps	6.6% (FY 2006 → FY 2012)	3.2%
Electric toilet seats		18.8% (FY 2006 → FY 2012)	9.7%
TV sets (Liquid crystal / plasma)		60.6% (FY 2008 → FY 2012)	37.0%
VCRs		73.6% (FY 1997 → FY 2003)	58.7%
Computers		85.0% (FY 2007 → FY 2011)	77.9%
Magnetic disk units		75.9% (FY 2007 → FY 2011)	75.8%
Copying machines		72.5% (FY 1997 → FY 2006)	30.9%
Space heaters (oil)		5.3% (FY 2000 → FY 2006)	3.8%
Gas Cooking appliances (oven area)		25.8% (FY 2002 → FY 2008)	20.3%

Product category	Energy efficiency improvement (result)	Energy efficiency improvement (initial expectation)
Gas water heaters (or gas space heaters with water heater)	7.9% (FY 2002 → FY 2008)	1.1%
Oil water heaters	4.0% (FY 2000 → FY 2006)	3.5%
Vending machines	48.8% (FY 2005 → FY 2012)	33.9%
DVD recorders (terrestrial digital broadcasting compatible)	45.2% (FY 2006 → FY 2010)	20.5%
Routers	40.9% (FY 2006 → FY 2010)	16.3%
Switching units	53.8% (FY 2006 → FY 2011)	37.7%
Transformers	13.1% (FY 1999 → FY 2006/2007)	30.3%

Source: METI, 2015
Note: * Estimated improvement of weighted average energy efficiency of all products within category group.

The contribution of the policy to energy efficiency improvements is not always easy to attribute with other factors potentially responsible (i.e. market demand for efficient products with low energy cost driving improvements or autonomous technological improvement). Nevertheless, the impact of the policy on the energy efficiency of certain products is noticeable. For example, the adoption of standards for room air conditioners altered the technological trajectory away from the ‘challenge of increasing heating capacity (to expand the market for heating) to one of improving energy efficiency’ (Osamu, 2012). The increase in energy efficiency rates following the introduction of the new standard in 1999 was significant and resulted in the 2004 target compared to 1997 levels being exceeded. Although the Top Runner Programme has experienced success in encouraging energy efficiency improvements, issues have arisen during its implementation:

- The consumer prices of products that belong to the listed categories could potentially be affected by the Top Runner Programme.
- Difficulties in determining the rate of technological improvement when target setting has also proved challenging for certain products (Osamu, 2012). For example, the target for fluorescent lighting was established just above the Top Runner products on the market due to very conservative estimates for the potential for further energy efficiency improvement. However, in reality unforeseen technological improvements meant that the target was easily achieved and demonstrates the practical problem of target setting and emphasises the need for regular revision of standards and the need for flexibility in the approach.
- The final energy consumption of Japan has continued to increase over the last few decades - revealing the more limited scope of the Top Runner Programme. After the Great East Japan Earthquake in 2011, it became more urgent to demand for quicker stabilization of energy supply and demand. To help to address this trend, it was decided that construction materials would also be added to Top Runner Standards (i.e. addition of three categories – insulation materials, sashes and multi-paned glazing) to improve the energy performance of the existing building stock (METI, 2015).

The Top Runner Programme in Japan has successfully encouraged the improved energy performance of a range of appliances through the introduction of efficiency standards that have been continually revised over time in consultation with a variety of stakeholders. The co-benefits of the policy include financial savings from lower energy consumption, which also has considerable benefits with regards to both energy security and lowering GHG emissions. A necessary pre-condition for the success of the policy was the market structure, which was dominated by a few domestic producers[39] that were willing to accept strict standards (Osamu, 2012). Furthermore, the technological potential for energy efficiency improvement existed. However the cost effective potential for efficiency of certain appliances is now becoming exhausted (air conditioner technologies). Decisions over future target setting and the addition of new appliances will be important to ensure the continued success of the policy.[40]

4.4.2 South Korea: Energy Efficiency Label and Standard Programme

Korea is the 10th largest energy consuming nation in the world and is particularly vulnerable to fluctuations in energy prices as the country imports 96% of its energy needs from overseas (KEMCO, undated). The need for greater energy security is therefore an important motivating factor in actively pursuing energy efficiency policies. Furthermore, given the increasing pressure on South Korea to become an Annex I country and to accept binding GHG reductions under the Kyoto Protocol – the impact of mandatory GHG reduction targets would be very negative without changing the energy intensive structure of their economy. In an effort to improve the energy efficiency standards of appliances, South Korea operates three major energy efficiency policies (KEMCO, undated):

- An energy-labelling programme;
- A high-efficiency equipment certification programme; and
- An energy stand-by programme

In 1992 the Energy Efficiency Label and Standard Programme was introduced, which required all energy-consuming products to have energy efficiency labels – with products graded from 1 (high efficiency) to 5 (low efficiency) and the production of products below the lowest energy efficiency standard is forbidden. The policy is mandatory and all manufacturers are required to comply with the Energy Efficiency Label and Standard Programme. The products included within the policy include household appliances, lighting equipment and passenger vehicles.

In 1996, the High-efficiency Appliance Certification Programme was set up to acknowledge products exceeding certain standards in energy efficiency with the issuance of a special certificate and covers a range of products including pumps, boilers and LED lighting equipment.

The e-Standby programme was established in 1999 to improve energy efficiency via the promotion of power saving appliances. Products that comply with the standby power reduction standards set by the government are recognised by the awarding of an Energy Boy label. In contrast, standby warning labels are applied to the remaining products on the market that fall below the government's standby power reduction standards. Household appliances and office equipment is included within the scope of the policy.

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[39] Theoretically the Top Runner standards may constitute improper trade restrictions and therefore could have been met with resistance from influential non-Japanese producers. However, given that the imported products make up marginal shares of regulated markets the possibility of conflict was considerably reduced (Nordqvist, 2006).

[40] Japan's Agency for Natural Resources and Energy announced on October 22, 2013 that two additional devices (i.e. electric motors and LED lamps) will be added to the list of products included in the Top Runner Programme (Japan for Sustainability Website, 2014).

The introduction of mandatory energy efficiency labels and standards has certainly encouraged positive developments in the energy performance of both refrigerator and air conditioner appliances. For example, energy consumption from refrigerators has declined by 59% between 1996 and 2010. During the same time period, the energy efficiency ratio of air conditioners has increased by 20 % (KEMCO, undated). Furthermore, the increased MEP standards introduced for 40W fluorescent lighting in 2004 (i.e. increasing from 60 to 80 lm/ W) transformed the market accelerating the switch towards 32W fluorescent lamps.

Voluntary schemes such as the high-efficiency equipment certification programme has encouraged consumers to purchase more energy efficient lighting with sales in the number of high-efficiency certified LED guide lights increasing rapidly from 40,000 in 2008 to 470,000 in 2010 (KEMCO, undated).[41] This has been further complimented by the South Korean government establishing the LED Deployment 18/30 Plan, which sets the objective to replace 30 % of all lamps with LED lighting by 2020 (IEA, 2012). The energy stand-by programme has also promoted the purchase of the 19 energy saving products covered by the scheme, with the market share of these high standby power reduction products increasing from 60% in 2008 to 98.6% in 2010 (KEMCO, undated).[42]

The policy measures introduced by the South Korean government have been effective in removing some of the barriers to energy efficiency improvements in appliances (i.e. lack of information). However, the IEA (2012) suggests that improvements in the energy performance of television products are still necessary. Indeed, TVs were the only exception to mandatory indication of energy efficiency grade (1 to 5) among the main energy consuming appliances in households (i.e. refrigerators, air conditioners, washing machines and TVs) – mainly due to the fact that the country is a world leader in the export of TV products (KEMCO, undated). In order to address this problem, from July 2012 mandatory standards and energy efficiency labelling will also be applied to TVs and it is expected that this will lead to rapid dissemination of LED TVs (which are more energy efficient that alternative products on the market).

In conclusion, it is evident that the energy efficiency policies that have been implemented by the South Korean government have been successful in improving the energy efficiency of various appliances over the last 20 years. In particular, the mandatory energy efficiency standards have driven energy efficiency improvements and it is expected that the recent inclusion of TV products in the programme will address a lack of coverage in the scheme and help to promote further improvements in energy efficiency. The additional co-benefits associated with improved energy efficiency in appliances (i.e. financial savings, energy security) further underlines the importance of energy efficiency in a country that is currently very dependent on energy imports. It is also envisaged that improved information via labelling will continue to allow consumers to be aware of the financial benefits of energy efficiency appliances.

[41] The rapid dissemination of the LED technology is also due to additional complementary policies such as tax exemptions and subsidies (KEMCO, undated).

[42] Although it is important to acknowledge that the market share of these 19 products designated as the standby warning label target products was only 1.4% (KEMCO, undated).

4.4.3 Quantitative assessment

4.4.3.1 Methodological considerations

Country-level analysis

Policies for energy efficient electrical appliances are only quantified for the EU. The reason for this is the lack of availability of data for other countries or regions. To quantify the effect of the Ecodesign Directive, our approach follows these steps:

1. Reference pathway historic (2010) and projected (2020) electricity consumption data for the residential & tertiary sector (which are analysed as one sector) and the industry sector in EU are taken from the European Commissions' reference scenario (EC, 2013).
2. The projected electricity savings from the implementation of energy efficiency regulations per product group are taken from Molenbroek et al. (2013).
3. These projected electricity savings are allocated to either the residential & tertiary or the industry sector.
4. For each product group, it is determined if the savings are already included in the reference scenario electricity consumption projections for 2020.
5. To estimate the electricity demand in 2020 without the policy implemented (without policy pathway), the savings already included in the reference scenario are added to the reference scenario electricity consumption.
6. To estimate the electricity demand in 2020 with the policy implemented (with policy pathway), the savings not yet included in the reference scenario are subtracted from the reference scenario electricity consumption.
7. Based on these data, the electricity savings in TWh are calculated compared to the without policies pathway and the reference pathway for each sector.
8. The emission factor ($MtCO_2/TWh$) of fossil power generation in the EU is calculated by:
    i. Determining the 2020 emission factors per fossil energy source (i.e. coal, oil and gas) by dividing the 2020 electricity generation by the 2020 emissions from fossil power generation by energy source (IEA, 2014b).
    ii. Taking the weighted average of these emission factors based on the shares of coal, oil and gas in the electricity mix in the reference scenario (EC, 2013) in 2020.
9. The emission savings resulting from the implementation of the Ecodesign Directive are calculated by multiplying the electricity savings by this emission factor.

Regional and global upscaling

For the upscaling of the appliances and lighting topic area, the following steps are taken.

a. The reference pathway is based on the electricity consumption in the buildings and industry sector from the WEO 2014 Current Policy Scenario (IEA, 2014b) for the OECD and non-OECD country groupings.
b. The electricity demand with and without policies similar to the Ecodesign Directive are calculated based on the following assumptions:
    i. **OECD countries:** Since many OECD countries have already adopted regulations for energy efficient appliances (e.g. Top-runner programme in Japan), it is assumed that OECD countries can achieve the same share of electricity reduction as can be achieved in the EU compared to the pathway without policies being implemented. Moreover, it is assumed

that 50% of this share of electricity reduction is already included in the WEO 2014 Current Policies Scenario (IEA, 2014b).

ii. **Non-OECD countries:** Some non-OECD countries (e.g. India and China) have implemented product policies. However, as many non-OECD countries have not yet implemented regulations for energy efficient appliances, it is assumed that these countries will not be able to achieve the same share of electricity reduction as the EU in 2020. Therefore, only 75% of this share of electricity reduction is applied to these countries. 20% of the savings potential is assumed to be already included in the WEO 2014 Current Policies Scenario (IEA, 2014b).

c. The savings compared to the electricity consumption without the policies implemented are multiplied by the emission factor for fossil power generation. This emission factor is calculated for the OECD and non-OECD country groupings based on 2020 electricity generation from fossil sources (coal, oil and gas) and emissions from fossil power generation from the WEO 2014 Current Policies Scenario (IEA, 2014b).

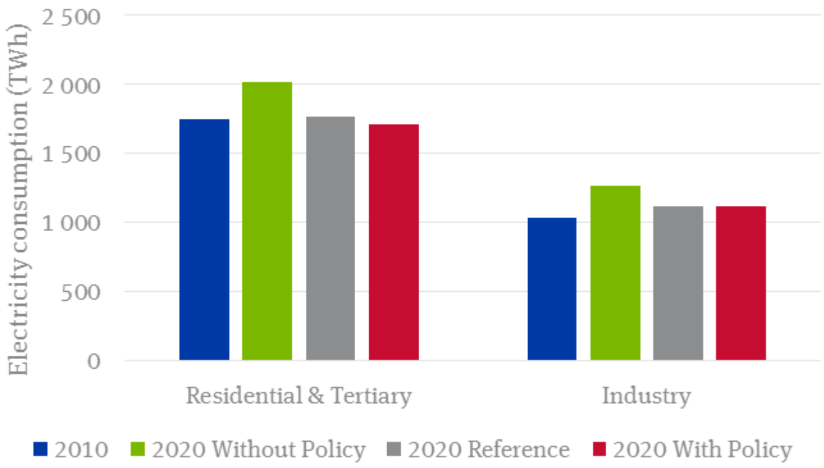
4.4.3.2 Results of quantitative assessment

Summary: The Ecodesign Directive in the EU are expected to result in savings of 458 TWh electricity or 0.3 Gt CO_2 by 2020 compared to the level without the Ecodesign being implemented. If all countries adopt the same policies, this is expected to result in savings of 2815 TWh electricity or 2.2 Gt CO_2 by 2020 compared to the without policies pathway.

Based on the European Commissions' reference scenario (EC, 2013) and projected electricity savings from the implementation of energy efficiency regulations per product group[43] from Molenbroek et al. (2013). The electricity consumption in the sectors using electrical appliances (i.e. residential, tertiary and industry sector)in the EU in 2020 is estimated (see Figure 19). In 2010 the electricity consumption in the residential & tertiary sector was 1746 TWh. Without the Ecodesign Directive implemented this is projected to increase to 2013 TWh in 2020. With the Ecodesign Directive implemented, the electricity consumption in 2020 can be reduced with 302 TWh or 15% to 1711 TWh compared to the level without policies. This 2020 level is slightly below the 2010 level. The electricity consumption in the industry sector was 1038 TWh in 2010. This is projected to increase to 1271 TWh in 2020 without the Ecodesign Directive implemented. With the Ecodesign Directive implemented, the industry 2020 level will be 1115 TWh. This is an increase from the 2010 level, but a reduction of 155 TWh or 12% compared the level without the Ecodesign Directive implemented. As can be seen from Figure 19, most of these electricity savings of both sectors are already included in the European Commission's reference scenario (EC, 2013). Additional electricity savings compared to this reference scenario are estimated to be 58 TWh in total.

[43] The following product groups are included in the analysis: electric motors, domestic lighting, televisions, tertiary lighting, standby and off-mode losses, ventilation fans, directional lighting, circulators in buildings, vacuum cleaners, imaging Equipment, PCs and servers, room air conditioning appliances, external power supplies, simple set-top boxes, complex set-top boxes, domestic refrigerators and freezers, laundry driers, electric pumps, domestic dishwashers, domestic washing machines.

Figure 19: Electricity consumption with and without Ecodesign Directive implemented



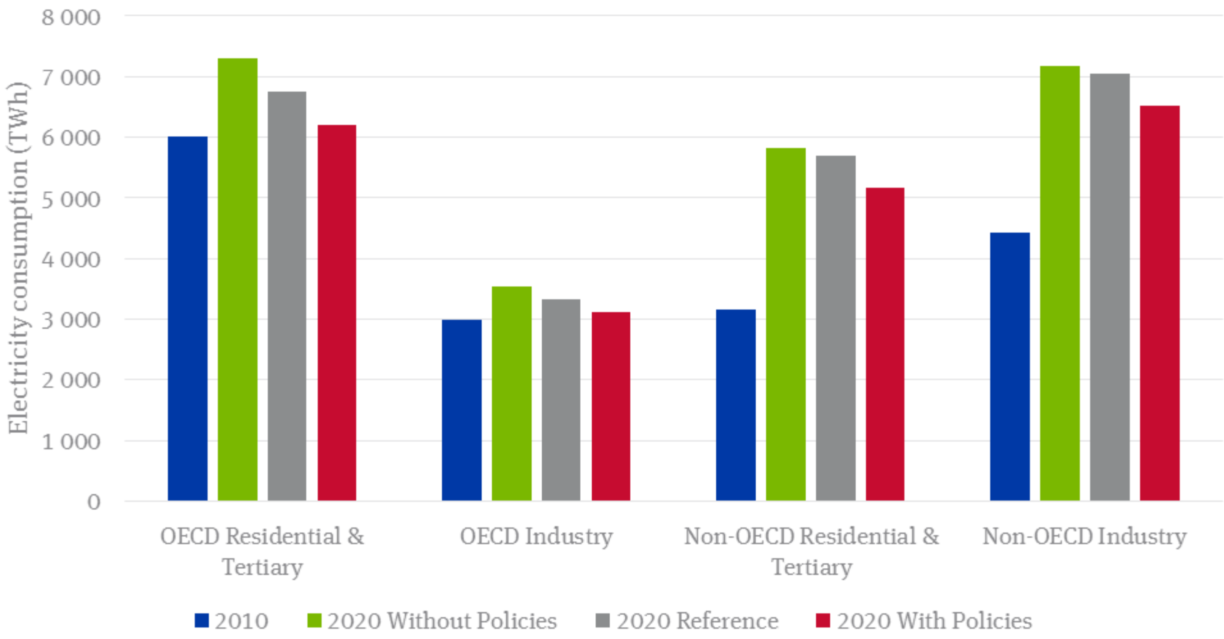
Applying an emission factor for fossil power generation of 734 g CO_2 / kWh to the total electricity savings of 458 TWh, the Ecodesign Directive saves 0.3 Gt CO_2 of emissions in 2020. Two thirds of this emission saving occurs in the residential & tertiary sector and one third occurs in the industry sector.

These results are scaled up to the OECD and non-OECD country groupings, assuming that in the OECD countries similar reductions of 15% in the residential & tertiary sector and 12% in the industry sector can be achieved. In the non-OECD countries it is assumed that 75% of this reduction can be achieved by 2020. Our results (see Figure 20) indicate that electricity consumption will increase compared to the 2010 level for each sector, even with policies similar to the Ecodesign Directive implemented on a global level. However, implementation of these policies causes an reduction of 2841 TWh (or 2.2 Gt CO_2[44]) or 12% below the level without policies. 1529 TWh can be saved in OECD countries and 1313 TWh in non-OECD countries. In the OECD countries over two thirds of the savings occur in the residential & tertiary sector, whereas in the non-OECD countries about half of the savings occur in the residential & tertiary sector. Compared to the reference pathway, savings of worldwide (partial) implementation of the Ecodesign Directive are estimated to be 1815 TWh (or 1.4 Gt CO_2[45]) in 2020. Half of this saving potential can be achieved in OECD countries and half in non OECD countries.

[44] Applying an emission factor for fossil power generation of 696 g CO_2 / kWh for OECD countries and 877 g CO_2 / kWh for non-OECD countries

[45] Applying an emission factor for fossil power generation of 696 g CO_2 / kWh for OECD countries and 877 g CO_2 / kWh for non-OECD countries

Figure 20: Global upscaling for appliances and lighting policies



Other studies have estimated the impact of global adoption of best practice policies for energy efficient electrical appliances in 2030. Although these results cannot be directly compared to our results because of the different time horizon, there results are presented here. McNeil et al. (2009) estimate the global electricity saving potential from seven product groups[46] to be 1301 TWh by 2030. When limiting our analysis to those product groups, we end up with a global saving potential of 932 TWh by 2020. According to Waide (2011) the annual saving potential in 2030 from the global adoption of world's best minimum energy performance regulation is around 4000 TWh of final electricity demand. This is substantially higher than our estimate of 2460 by 2020, reflecting the longer time horizon considered as well as the different approach. Waide (2011) selected the best practice policy for each product group, which is not in all cases the European Ecodesign Directive.

4.4.4 International discussions in related forums

Standards and labelling schemes are becoming increasing popular in countries around the world, due to both the significant mitigation potential and the potential for net savings in the medium to long term. Furthermore, the positive effects of the most ambitious domestic policies are somewhat diffused worldwide due to the global nature of the electric appliances market.

The development of the international dialogue on energy efficiency of electrical appliances is promoted by three key initiatives in particular: The Collaborative Labelling & Appliance Standards Program (CLASP) is an international organisation providing technical and policy support for governments looking to introduce energy efficiency measures. The Super-efficient Equipment and Appliance Deployment (SEAD) Initiative seeks to measure the potential for energy efficient appliance and to provide accurate information to public and private sector stakeholders in order to transform the global market for extra-high efficiency appliances. Since 2011, the International Partnership for En-

[46] These product groups are: residential lighting, refrigeration, residential air conditioning, standby, television, commercial lighting and commercial air conditioning.

ergy Efficiency Cooperation acts as the lead coordinating organization to carry out the G20 Energy Efficiency Action Plan and its Work Streams. It assists its member countries to identify and share proven, innovative practices and data on energy efficiency to better inform decision makers. (IPEEC 2015).

Next to these initiatives, one new initiative was launched in 2014. The Efficient Appliances and Equipment Global Partnership seeks to accelerate the transition to energy efficient appliances and equipment, building on the successful enlighten initiative which focuses on the global transition to efficient lighting. It belongs to the UN Global Partnership Programme and has the goal to accelerate the process of phasing out inefficient technologies. (Harrison et al., 2014) By the end of 2014, 14 southern African countries and 5 Latin American countries have joined the partnership (UNEP, 2014), while UNEP mentions almost 30 countries expressing interest to join.

CLASP notes that policy might be focused on three particular appliances in order to maximise the potential of energy savings, given the barriers faced by emerging and developing economies: ownership of air conditioning, hot water heaters and fridges is increasing at phenomenal rate, and the potential for energy savings and GHG emission reductions is very high when this suppressed demand is taken into consideration.

4.4.5 Summary and recommendations for appliances

4.4.5.1 Summary and comparison of case studies

An overview of the energy efficiency policies implemented in Japan and South Korea is provided below in Table 19.

Table 19: Summary of qualitative assessment for appliances

	Japan	South Korea
Major policy	Top Runner Programme	Energy Efficiency Label and Standard Programme
Type	Minimum Energy Performance Standards / Labelling	Minimum Energy Performance Standards / Labelling
EE target	Range of appliance specific targets set	Minimum standards for appliances covered by the mandatory scheme
Key features	Efficiency standard programme requiring manufacturers to meet certain levels of efficiency for appliances based on the best performance of current technologies	All energy-consuming products have energy efficiency labels – with products graded from 1 (high efficiency) to 5 (low efficiency) and the production of products below the lowest energy efficiency standard is forbidden.
Complementary policies	Tax incentives for energy efficient appliances	LED Deployment 18/30 Plan Tax incentives for energy efficient appliances
Barriers	The payback period of the capital cost of an energy efficient appliance is sometimes too long. Social behaviour difficult to change.	
Co-benefits	Financial savings from lower energy consumption – enhancing energy security.	

An international comparison of the energy efficiency performance of appliances of different countries is unfortunately not possible due to the lack of data available that is directly comparable. However, assessments undertaken by the IEA indicate that both Japan and South Korea should be considered as examples of best practice in promoting energy efficiency in appliances.

4.4.5.2 Barriers and mitigating policy features

The case studies primarily focus on addressing both the quality of products through the introduction of mandatory standards and improving the information available to consumers through labelling in order to promote the benefits of energy efficient appliances. The introduction of mandatory standards for energy efficiency in Japan has undoubtedly been very effective with the quality of the appliances within the scope of the policy improving considerably over time. However, given that the standards in the Top Runner Programme are set according to the most energy efficient product on the market – standards are often set with little consideration of the impacts on consumer costs (i.e. no requirements for a life cycle analysis or another type of cost analysis) (Osamu, 2012). If consumer costs rise too high as a consequence of the policy it will undermine its' objective as the financial viability of investing in energy efficient appliances will become difficult to justify. It is also evident, that in contrast to Japan (mainly domestic market for appliances) the price competitiveness of exports in South Korea may have been a factor leading to the initial exemption of TVs in the mandatory standards and energy efficiency labelling programme.

Additional barriers are identified in research papers and an UNFCCC report. National governments require specific expertise, since the key to successful program design and implementation is a thorough understanding of the market and identification of the most important local obstacles to the penetration of energy-efficient technologies (Stephane de la Rue du Can, 2014). Despite the economic feasibility of many investments in energy efficiency, further financial incentives are required to ensure the widespread diffusion of technologies: Payback periods of more than 5 years often require further incentives to be attractive to consumers like:

- Rebates for the purchase of efficient appliances
- Discounts for the purchase of efficient appliances
- Non-financial incentives such as technical assistance, training and information dissemination.

Other barriers mentioned are:

- High upfront capital costs
- Lack of affordable technologies suitable to local conditions
- Perceived capital risk
- Market organisation
- Price distortions
- Split incentives (e.g. the investor does not receive the financial benefits)
- Information barriers (UNFCCC, 2014)

4.4.5.3 Co-benefits and motivation

It is evident from the case studies that the co-benefits associated with increasing energy efficiency rates in appliances have been used to further justify the introduction of mandatory standards and labelling schemes in both Japan and South Korea. Improvements in energy efficiency are considered an important mitigation option to allow both countries to deliver future commitments to reduce their GHG emissions under the UNFCCC. However, the enhanced energy security that arises from increased energy efficiency is clearly a key objective influencing government decision making. It is also expected that enhanced energy security through improved energy efficiency will financially benefit consumers through the use of appliances that consume less energy. For example, KEMCO (undated) estimate that as a consequence of the total standby power declining between 2003 and 2011 this was equivalent to an annual financial saving of $ US 136 million KRW in 2011. However this co-benefit ultimately depends on designing a policy that prevents price increases in appliances and on behavioural changes associated with the rebound effect.

But the benefits of a switch to energy-efficient appliances go far beyond reducing GHG emissions and reducing expenditures of consumers on electricity. Lowering electricity consumption, especially during times of peak demand, reduces also the risk of blackouts. Moreover, large investments in new electricity generation capacity and grids can be avoided (Steiner, A. 2014).

4.4.5.4 Policy impact and mitigation potential

The Ecodesign Directive in the EU are expected to result in savings of 458 TWh electricity or 0.3 $GtCO_2$/a by 2020 compared to a scenario without implementation of the Directive. If all countries were to adopt best practice policy, this would result in emissions reductions of 1.5 $GtCO_2$/a compared to a reference scenario that includes most current policies in OECD countries and a small number of existing policies in non-OECD countries, and savings of 2,841 TWh electricity or 2.2 $GtCO_2$/a by 2020 compared to a scenario without policies. This savings potential is divided equally over OEC and non-OECD countries.

5 Conclusion

The quantitative analysis undertaken for each thematic area in this report demonstrates that efforts to globally replicate best practice policies could significantly contribute to a reduction in the projected emissions gap in 2030 (Climate Action Tracker, 2015a; UNFCCC, 2015). Although the estimation of GHG mitigation potential based upon the replication of best practice policies globally is naturally subject to a high degree of uncertainty, the theoretical maximum potentials for GHG reductions by 2020 (see bullet points below) illustrate transparently the important role of pre-2020 GHG mitigation efforts in lowering the emissions gap. The mitigation potential for GHG reductions by 2020 varied by thematic area and was further dependent upon the baseline applied.

- Renewable energy support (RES): 2.3 $GtCO_2$/a compared to a scenario without policies, or by 1.4 $GtCO_2$/a compared to a reference scenario that includes current policies;
- Light duty vehicle standards: 0.6 $GtCO_2e$/a compared to a frozen technology scenario, and 0.2 $GtCO_2e$/a below the current policies reference scenario by 2020. If all countries would adopt the European emission standards, the most ambitious of the countries analysed, this reduction could be 1.0 $GtCO_2e$/a below the frozen technology pathway and 0.5 $GtCO_2e$/a below the reference pathway;
- Electrical appliances: 2.2 $GtCO_2$/a compared to a scenario without policies, or by 1.5 $GtCO_2$/a compared to a reference scenario that includes current policies;
- GHG emissions from flaring during oil and gas production: 0.16 $GtCO_2e$/a compared to a frozen technology scenario, and approximately 0.1 $GtCO_2e$/a compared to a current trend reference scenario.

The achievement of these GHG mitigation potentials will rely upon the use of a diverse mix of policy instruments (i.e. market instruments, mandatory standards) and also the use of complementary measures to overcome particular policy barriers. The qualitative analysis in this report identified a range of policy barriers for each thematic area (see bullet points below), many of which were overcome in the best practice examples.

- Renewable energy support (RES): Financial support remains a key barrier, especially for developing countries that rely upon public money as opposed to the use of the market instruments increasingly adopted by developed countries. Common barriers for all countries also include poor grid infrastructure, both in terms of its unsuitability and its insufficiency, and regulatory issues, particularly regarding the ability to obtain planning permission.
- Light duty vehicle standards: The lack of significant incentives for both consumers and manufacturers remains the key barrier to improvements in light duty vehicle standards. All of the standards in the best practice policies analysed include flexible compliance mechanisms that increase the incentives for manufacturers. .
- Electrical appliances: Changing the behaviour of consumers is a key barrier due to the relatively long payback periods reducing the incentive to switch towards more energy efficient appliances.
- GHG emissions from flaring during oil and gas production: The high level of investments in technology to utilise the associated gas (due to the distance of production sites to locations of utilisation) is the key barrier to abate GHG emissions from flaring.

By both quantifying mitigation potentials up until 2020 for key thematic areas and identifying the key barriers associated with the uptake of abatement measures (and examples of how such barriers were overcome by the best practice examples), it is hoped that this report will facilitate enhanced levels of ambition prior to 2020 from all countries participating in the UNFCCC negotiations in order to start to close the emission gap now instead of further delaying efforts until after 2020.

6 List of References

American Energy Independence, 2013. American Fuels. http://www.americanenergyindependence.com/fuels.aspx.

Americans for Prosperity, 2014. Opposition letter to the PTC.

Appunn, 2014. Comparing old and new: Changes to Germany's Renewable Energy Act. Clean Energy Wire.

BMU, 2009. Electricity from Renewable Energy Sources: What does it cost?

BMU. 2013a. Renewable Energy Sources in Figures, National and International Development

BMU, 2013b. Tariffs, degression and sample calculations pursuant to the new Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz-EEG) of August 2011 ('EEG 2012')

BMUB, 2015. Development of renewable energy sources in Germany 2014. Charts and figures based on statistical data from the Working Group on Renewable Energy-Statistics (AGEE-Stat). February 2015.

BMWi, 2015. Zahlen und Fakten Energiedaten: Nationale und Internationale Entwicklung.

BP, 2015. BP Statistical Review of World Energy.

BP. 2015b. Energy Outlook 2035.

Brannigan, C., Gibson, G., Hill, N., Dittrich, M., Schroten, A., van Essen, H., van Grinsven, A., 2012. EU Transport GHG: Routes to 2020 II. Final Report Appendix 1: Development of a better understanding of the scale of co-benefits associated with transport sector GHG reduction policies. http://www.eutransportghg2050.eu/cms/assets/Uploads/Reports/EU-Transport-GHG-2050-II-Task-1-FINAL-12Jul12.pdf.

Brown. 2012. U.S. Renewable Electricity: How Does the Production Tax Credit (PTC) Impact Wind Markets?

Carbon Limits 2013: Associated Petroleum Gas Flaring Study for Russia, Kazakhstan, Turkmenistan and Azerbaijan. Final Report. http://www.ebrd.com/downloads/sector/sei/ap-gas-flaring-study-final-report.pdf

Climate Action Tracker, 2015a. CAT Emission Gaps. 1st October 2015 http://climateactiontracker.org/global/173/CAT-Emissions-Gaps.html

Climate Action Tracker, 2015b. Effect of current pledges and policies on global temperature http://climateactiontracker.org/global.html

C2ES, undated. Federal vehicle standards. http://www.c2es.org/federal/executive/vehicle-standards.

DECC, 2012. Renewables Obligation Banding Review for the period 1 April 2013 to 31 March 2017: Government Response to further consultations on solar PV support, biomass affordability and retaining the minimum calorific value requirement in the RO. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66516/7328-renewables-obligation-banding-review-for-the-perio.pdf

DECC, 2014. The Renewables Obligation (RO): Setting the obligation level. https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/the-renewables-obligation-ro

DECC, 2015a. Electricity Market Reform: Contracts for difference. Accessed on 7th September 2015 via https://www.gov.uk/government/collections/electricity-market-reform-contracts-for-difference.

DECC, 2015b, Contracts for Difference (CFD) Allocation Round One Outcome. Accessed on 7th September 2015 via https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/407059/Contracts_for_Difference_-_Auction_Results_-_Official_Statistics.pdf

Deloitte. 2013. Swerving from the cliff – Tax provisions in the American taxpayer Relief Act of 2012.

EC (2013). EU Energy, Transport and GHG Emissions Trends to 2050 Reference Scenario 2013. http://ec.europa.eu/energy/observatory/trends_2030/doc/trends_to_2050_update_2013.pdf

EIA. 2015. Annual Energy Outlook 2015. http://www.eia.gov/forecasts/aeo/

EIA, 2014. Frequently asked questions. How much petroleum does the United States import and from where? http://www.eia.gov/tools/faqs/faq.cfm?id=727&t=6 (4 October, 2015).

Environment.no website, 2014. http://www.environment.no/topics/marine-areas/oil-and-gas-activities/

EPA, 2012a. EPA and NHTSA Set Standards to Reduce Greenhouse Gases and Improve Fuel Economy for Model Years 2017-2025 Cars and Light Trucks. http://www.epa.gov/otaq/climate/documents/420f12051.pdf.

EPA, 2012b. Inventory of U.S. greenhouse gas emissions and sinks: 1990 – 2010. http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2012-Main-Text.pdf.

EPA, 2012c. Regulatory Impact Analysis: Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards. http://www.epa.gov/otaq/climate/documents/420r12016.pdf.

EPA. 2013. Department of Treasury. http://www.epa.gov/lmop/publications-tools/funding-guide/federal-resources/treasury.html

EPA. 2015. Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2013 http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Main-Text.pdf

European Commission, 2015, Reducing CO2 emissions from passenger cars, 06 October 2015, http://ec.europa.eu/clima/policies/transport/vehicles/cars/index_en.htm

European Union, 2013. EU Energy in Figures. Statistical Pocketbook 2013. http://ec.europa.eu/energy/publications/doc/2013_pocketbook.pdf.

Eurostat, 2015. Share of renewable energy in gross final energy consumption. t2020_31

Farina, 2010. Flare Gas Reduction: Recent global trends and policy considerations. http://www.genewscenter.com/Press-Releases/Five-Percent-of-World-s-Natural-Gas-Wasted-GE-Report-Says-2fb4.aspx

Finamore, 2010. China as the World's Number One Energy Consumer and World Leader in Clean Energy. Barbara Finamore's Blog http://switchboard.nrdc.org/blogs/bfinamore/china_as_the_worlds_number_one.html

Gavenas, Ekaterina, Rosendahl, Knut Einar and Skjerpen, Terje, 2015. CO2-emissions from Norwegian oil and gas extraction. Discussion Papers Statistics Norway Research department, No. 806, April 2015.

GGFR, 2013. The News Flare. Issue No. 14 September 2012 – June 2013. http://siteresources.worldbank.org/INTGGFR/Resources/GGFR_Gas_Flaring_Sep_2012_Jun_2013_FINAL.pdf

GGFR, undated. Comparison of Associated Gas Flaring Regulations: Alberta & Norway. http://siteresources.worldbank.org/EXTGGFR/Resources/5780681258067586081/Alberta_Norway_regulations_comparison.pdf

GFEI, 2014. Fuel Economy State of the World 2014, http://www.fiafoundation.org/media/46111/gfei-annual-report-2014-lr.pdf

Hamso, Bjorn, 2013. Global Gas Flaring Reduction Partnership (GGFR). Presentation at IPIECA Workshop, Rome, 09 October 2013. http://www.ipieca.org/system/files/eventmaterials/Weds_0910_Hamso_Global_gas_flaring_reduction_partnership.pdf

Hamamoto. 2011. Energy efficiency regulation and R&D activity: A study of the Top Runner Program in Japan." Low Carbon Economy 2:91-98.

Harrison et al. 2014. Enhancing Ambition Through International Cooperative Initiatives. http://www.ecofys.com/en/publication/enhancing-ambition-through-international-cooperative-initiatives/

Höhne et al. 2011. Climate Action Tracker- Country Assessment Methodology. http://climateactiontracker.org/assets/publications/publications/WP1_MethodologyCountryAssessment_website_2011.pdf

Huhne, Chris. 2014. The Guardian. "The Conservatives' onshore wind sums are all at sea".

ICCT. 2012, Global Transportation Roadmap Model, Version1-0.

ICCT, 2014. Global Passenger Vehicle Standards: Info and Tools. http://theicct.org/info-tools/global-passenger-vehicle-standards.

ICCT, 2014b CHINA PHASE 3 NEW PASSENGER CAR FUEL CONSUMPTION: PROPOSED IMPLEMENTATION RULE, http://www.theicct.org/sites/default/files/publications/ICCTupdate_China_CAFC_implementation_june2014.pdf (5 October 2014)

ICCT, 2014c, CO2 emissions from new passenger cars in the EU: Car manufacturers' performance in 2013, 13 Juni 2014, http://www.theicct.org/co2-emissions-new-passenger-cars-eu-car-manufacturers%E2%80%99-performance-2013

ICCT, Dieselnet, 2015a. Transport Policy website: China: Light-duty: Fuel Consumption. http://www.transportpolicy.net/index.php?title=China:_Light-duty:_Fuel_Consumption (4 October, 2015).

ICCT, Dieselnet, 2015b. Transport Policy website: Japan: Light-duty: Fuel Economy. http://www.transportpolicy.net/index.php?title=Japan:_Light-duty:_Fuel_Economy#cite_note-6 (4 October, 2015).

ICCT, Dieselnet, 2015c. Transport Policy website: EU: Light-duty: GHG. http://www.transportpolicy.net/index.php?title=EU:_Light-duty:_GHG (4 October, 2015).

ICCT, Dieselnet, 2015d. Transport Policy website: US: Light-duty: Fuel Economy and GHG. http://transportpolicy.net/index.php?title=US:_Light-duty:_Fuel_Economy_and_GHG (4 October, 2015).

IEA, 2007. Energy Policies of IEA Countries: Germany 2007 Reviewhttp://www.iea.org/publications/freepublications/publication/germany2007.pdf

IEA. 2012. The Energy Policies of IEA Countries – The Republic of Korea 2012 Review

IEA, 2013a. Key world energy statistics 2012. http://www.iea.org/publications/freepublications/publication/kwes.pdf (25 November, 2013).

IEA, 2014a. Natural Gas Information 2014.

IEA (2014b). *World Energy Outlook 2014*. OECD/IEA: Paris.

IEA (2014c). *Energy statistics and balances*. OECD/IEA: Paris.

IEA, 2014d. Statistics. China, People's Republic of: Renewables and Waste

IEA, 2015. Oil Information 2015

IPCC, 2000. Fugitive Emissions from Oil and natural gas activities, in: IPCC: Good Practice Guidance and Uncertainty Management in national Greenhouse Gas Inventories)

IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2. Energy.

IPEEC, 2015. http://www.ipeec.org/aboutipeec.html (11 October 2015)

IRENA, 2014. IRENA's Renewable Energy Roadmap (RE map 2030). http://www.irena.org/remap/IRENA_REmap_RE_targets_table_2014.pdf

Ismail, O. and Umukoro, G., 2012. Global Impact of Gas Flaring. Energy and Power Engineering, Vol. 4 No. 4, 2012, pp. 290-302. DOI: 10.4236/epe.2012.44039 .

Japan for Sustainability Website, 2014. Two Devices Added to 'Top Runner' List under Japan's Energy Saving Act. http://www.japanfs.org/en/news/archives/news_id034695.html

JATO, 2009. FIAT leads the volume brands on CO2 emissions for 2nd year running. http://www.jato.com/PressReleases/Geneva%202009%20C02%20Brands%20Release%20-%20REVISED%20-%20FINAL.pdf.

JRC/PBL (2012): Edgar Version 4.2 FT2010. Joint Research Centre of the European Commission/PBL Netherlands Environmental Assessment Agency. Online verfügbar unter http://edgar.jrc.ec.europa.eu/index.php, zuletzt geprüft am 30.01.2013.

Juliano, N. 2015: Renewable Energy: Senate votes down PTC amendment. Accessed on the 7th of September 2015 via http://www.eenews.net/stories/1060012507

KEMCO. undated. Korea's Energy Standards & Labelling – Market Transformation

KPMG. 2013. The American Taxpayer Relief Act of 2012.

KPMG. 2014. Tax provisions in Administration's FY 2015 Budget Proposals.

McNeil et al. (2009). Acting globally: potential carbon emissions mitigation impacts from an international standards and labelling program. http://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2009/Panel_4/4.416/paper

METI, 2014, Japan's Policy on Energy Conservation, https://unfccc.int/files/bodies/awg/application/pdf/2_japan.pdf (6 October 2015)

METI, 2015, Top Runner Program, developing the world's best energy efficient appliance and more, http://www.enecho.meti.go.jp/category/saving_and_new/saving/data/toprunner2015e.pdf (6 October 2015)

Molenbroek et al. (2013). Background report I: Literature review. Evaluation of the Energy Labelling Directive and specific aspects of the Ecodesign Directive. http://www.energylabelevaluation.eu/tmce/Background_document_I_-_Literature_report.pdf

NHTSA, 2014. CAFE - Fuel Economy. http://www.nhtsa.gov/fuel-economy (2014).

NOAA, 2011. Global Gas Flaring Estimates. http://ngdc.noaa.gov/eog/interest/gas_flares.html

Norwegian Ministry of Petroleum and Energy, 2014. Facts 2014: The Norwegian Petroleum Sector.

Nordqvist, 2006. Evaluation of Japan's Top Runner Programme: Within the framework of the AID-EE project. July 2006.

Nurakhmet, G., undated. Gas Flaring And Venting: What Can Kazakhstan Learn From The Norwegian Experience? http://www.dundee.ac.uk/cepmlp/gateway/?news=28103

Mason, Rowena. 2014. The Guardian. "Tories plan new attack on windfarms". http://www.theguardian.com/politics/2014/apr/01/tories-plan-attack-windfarms

McKinsey & Company, 2009. Pathways to a Low-Carbon Economy. Version 2 of the Global Greenhouse Gas Abatement Cost Curve. http://www.mckinsey.com/~/media/McKinsey/dotcom/client_service/Sustainability/cost%20curve%20PDFs/Pathways_lowcarbon_economy_Version2.ashx

Odyssee-Mure 2014, Energy Efficiency Key Indicators. Available from http://www.indicators.odyssee-mure.eu/online-indicators.html

OECD, IEA, 2011. Technology Roadmap. Biofuels for Transport. http://www.iea.org/publications/freepublications/publication/biofuels_roadmap.pdf (4 September, 2014).

Ofgem. 2014. Renewables Obligation – Annual Report 2012-13 https://www.ofgem.gov.uk/ofgem-publications/86392/roannualreport2012-13final.pdf

Osamu, K.. 2012. The Role of Standards: The Japanese Top Runner Program for End-Use Efficiency. Historical Case Studies of Energy Technology Innovation in: Chapter 24, The Global Energy Assessment. Grubler A., Aguayo, F., Gallagher, K.S., Hekkert, M., Jiang, K., Mytelka, L., Neij, L., Nemet, G. & C. Wilson. Cambridge University Press: Cambridge, UK.

PFC Energy, 2007. Using Russia's Associated Gas. http://siteresources.worldbank.org/INTGGFR/Resources/pfc_energy_report.pdf

Proust, E., 2006. Gas Re-injection. Total Experience. Presentation at the Global Forum: Flaring Reduction & Gas Utilisation, Paris, 13-15 December 2006. http://www.worldbank.org/html/fpd/ggfrforum06/howells/proust.ppt

REN21 (2015). Renewables 2015 Global Status Report. http://www.ren21.net/wp-content/uploads/2015/07/REN12-GSR2015_Onlinebook_low1.pdf

Reuters, 2012. Russia oil firms face heavy fines for gas flaring. http://www.reuters.com/article/2012/06/16/us-russia-oil-flaring-idUSBRE85F0DN20120616

Reuters, 2015. Obama 2016 budget urges states to cut emissions faster. Accessed on the 7th of September 2015 via http://www.reuters.com/article/2015/02/02/us-usa-budget-energy-idUSKBN0L60AF20150202

Schueneman, Tom. 2014. "Senate Finance Committee Approve Bill to Extend Renewable Energy Production Tax Credit". http://theenergycollective.com/globalwarmingisreal/366596/senate-finance-committee-approve-bill-extend-renewable-energy-production.

Schuman. 2010. Improving China's Existing Renewable Energy Legal Framework: Lessons from the International and Domestic Experience. NRDC White Paper

Shindell, D., Faluvegi, G., Walsh, M., Anenberg, S., van Dingenen, R., Muller, N., Austin, J., Koch, D., Milly, G., 2011. Climate, health, agricultural and economic impacts of tighter vehicle-emission standards. Nature Climate Change, 1, 59–66. http://www.nature.com/nclimate/journal/v1/n1/abs/nclimate1066.html.

Stephane de la Rue du Can (2014), Greg Leventis, Amol Phadke, Anand Gopal, Design of incentive programs for accelerating penetration of energy-efficient appliances, Energy Policy, Volume 72, September 2014, Pages 56-66, ISSN 0301-4215, http://dx.doi.org/10.1016/j.enpol.2014.04.035.
http://www.sciencedirect.com/science/article/pii/S0301421514002705

Steiner, A. 2014, High-Efficiency Appliances for a Low-Carbon Future, 23 September 2014, UNEP, http://climate-l.iisd.org/guest-articles/high-efficiency-appliances-for-a-low-carbon-future/ (7 October 2015)

The Economist. 2013. The East is Grey. http://www.economist.com/news/briefing/21583245-china-worlds-worst-polluter-largest-investor-green-energy-its-rise-will-have

UNEP, 2010. Global Fuel Economy Initiative.
http://www.unep.org/transport/gfei/autotool/case_studies/northamerica/cs_us_0.asp (4 September, 2014).

UNEP, 2013. The Emissions Gap Report 2013. http://www.unep.org/publications/ebooks/emissionsgapreport2013

UNEP, 2014, Annual Report 2014, http://www.unep.org/annualreport/2014/en/climate-change.html (11 October 2015)

UNEP, 2015a, website of Global Efficient Appliances and Equipment Partnership Programme
http://www.unep.org/energy/eae/index.html (11 October 2015)

UNEP, 2015b, UNEP Emissions Gap Report 2015 – Update on assessment of INDCs
http://www.unep.org/Pdf/UNEP%20Brief-INDC25Aug2015.pdf

UNFCCC, 2014. Updated compilation of information on mitigation benefits of actions, initiatives and options to enhance mitigation ambition, 2 June 2014, FCCC/TP/2014/3, http://unfccc.int/resource/docs/2014/tp/03.pdf (7 October 2015)

UNFCCC, 2015. Synthesis report on the aggregate effect of the intended nationally determined contributions

http://unfccc.int/resource/docs/2015/cop21/eng/07.pdf

United States Government Accountability Office, 2007. Vehicle Fuel Economy. Reforming Fuel Economy Standards Could Help Reduce Oil Consumption by Cars and Light Trucks, and Other Options Could Complement These Standards. http://www.gao.gov/new.items/d07921.pdf.

UK NREAP, 2009. National Renewable Energy Action Plan for the United Kingdom. Article 4 of the Renewable Energy Directive 2009/28/EC.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/47871/25-nat-ren-energy-action-plan.pdf

U.S. Department of Energy, 2013. 2012 Wind Technologies Market Report.
https://www1.eere.energy.gov/wind/pdfs/2012_wind_technologies_market_report.pdf

Waide, P. (2011). Opportunities for Success and CO2 Savings from Appliance Energy Efficiency Harmonisation. Navigant Consulting in Partnership with CLASP.

White House 2014, Improving the fuel efficiency of American Trucks, Washington, February 2014 https://www.whitehouse.gov/sites/default/files/docs/finaltrucksreport.pdf

Wigmore et al, 2011. China policy: shedding light on the recently enacted solar feed in tariff. US-China Quarterly Market Review, Fall 2011. http://www.acore.org/wp-content/uploads/2011/12/ACORE_QMR-fall2011_FNLhi.pdf

Woodman and Mitchell, 2011. Learning from experience? The development of the Renewables Obligation in England and Wales 2002-2010. Energy Policy.

World Bank, 2013a. World development indicators 2013. World Bank, Washington, D.C

Word Bank, 2013b. Igniting solutions to gas flaring in Russia. http://www.worldbank.org/en/news/feature/2013/11/12/igniting-solutions-to-gas-flaring-in-russia

World Bank, 2014a. World development indicators 2014. 14 April 2014, World Bank, Washington, D.C

WWF Russia, 2009. Russian Associated Gas Utilization: Problems and Prospects.

7 Appendix

7.1 Countries selected for the screening analysis

Table 20: List of countries that are selected for the screening analysis

Country	Emission in 2010 in $MtCO_2e$ JRC/PBL 2012. (Source	Rationale for inclusion
China	11,182	Top30 emitter
United States	6,715	Top30 emitter
EU	5,023	Top30 emitter
India	2,692	Top30 emitter
Russian Federation	2,510	Top30 emitter
Indonesia	1,946	Top30 emitter
Brazil	1,621	Top30 emitter
Japan	1,379	Top30 emitter
Germany	979	Top30 emitter
Canada	728	Top30 emitter
Mexico	661	Top30 emitter
Korea, Republic of	647	Top30 emitter
Australia	629	Top30 emitter
United Kingdom	620	Top30 emitter
France	538	Top30 emitter
South Africa	422	Top30 emitter
Turkey	420	Top30 emitter
Thailand	413	Top30 emitter
Ukraine	397	Top30 emitter
Malaysia	330	Top30 emitter
Kazakhstan	318	Top30 emitter
Argentina	315	Top30 emitter
Venezuela	310	Top30 emitter
Viet Nam	306	Top30 emitter
Colombia	187	Top30 emitter
Philippines	159	Top30 emitter
Belarus	150	Top30 emitter
Ethiopia	109	Ambitious goal for carbon neutral growth by 2025.
Chile	107	Low emission development plans
New Zealand	80	Ambitious policies on deforestation and agriculture
Norway	67	Comprehensive climate poli-

Country	Emission in 2010 in $MtCO_2e$ JRC/PBL 2012. (Source	Rationale for inclusion
		cies
Denmark	66	Comprehensive climate policies
Switzerland	57	Developed an interesting CO_2 levy
Costa Rica	11	Ambitious goal to become climate-neutral by 2021
Maldives	1	Ambitious goal to become climate-neutral by 2020

7.2 Appendix I – Indicators for selection of countries and thematic areas

Table 21: Structure of indicators by policy area and sector

	1.Changing activity47	2.Energy Efficiency	3.Renewable Energy	4.Low Carbon	5.Other / Non Energy
1. Electricity					
2. Industry					
3. Buildings					
4. Transport					
5. AFOLU48					

Source: Own illustration adapted from Climate Action Tracker methodology (ref). Greyed out boxes are non-applicable combinations.

The indicators cover policy incentives which have a direct or indirect impact on emission reduction in a country.

The **sector** defines the scope of the emission source that the policy is addressing:

- Electricity: Incentives and barriers relating to central electricity and heat production.
- Industry: Incentives and barriers relating to all industry sectors, including refineries, and the waste sector.
- Buildings: Incentives and barriers relating to energy consumed in residential, commercial and public buildings, including energy use, fuel and electricity
- Transport: Incentives and barriers relating to energy used in all modes of transport.
- Agriculture, Forestry and Other Land Use (AFOLU): Incentives and barriers relating to non-energy emissions from agriculture, forestry and other land use, which includes all land-based activities, e.g. non-CO_2 emissions from agriculture and CO_2 emissions from all forestry activities. The sector is further divided into the agriculture sector and land use, land use change and forestry (LULUCF) activities.

A **policy area** is a logical cluster of incentives and barriers. The following areas have been defined:

[47] Changing activity refers to transformations from one set of polluting activities to less polluting activities.

[48] Agriculture, Forestry and Other Land Use (AFOLU)

- **Changing activity**: Incentives and barriers that indirectly reduce emission by changing behaviour or by introducing new technology concepts.
- **Energy efficiency**: Incentives and measures to reduce energy consumption whilst maintaining activity.
- **Renewable energy**: Support for renewable energy sources across all relevant sectors.
- **Low carbon**: Policy support for direct CO_2 reduction. For the sectors involving energy use, policies may aim to influence the carbon intensity of the fuel mix except renewables, i.e. the shares of different emissions intensive fossil fuels, carbon capture and storage and nuclear power.
- **Non-energy**: Incentives and barriers relating to all emissions and removals from sources not directly linked to energy, especially emissions from processes in industry and from the land use sector. This category also includes all emissions from other gases, while the other areas mainly cover CO_2 emissions (except activity for AFOLU).

The specific indicators evaluated in each sector and policy area are given in Table 22.

Table 22: Data collection guideline for indicators

Thematic area		Indicator	Weighting factor	No. of countries (/36)	Indicator score
1 Electricity and heat	1.1 Cross-cutting	1.1 Cross-cutting: Total			27.8%
		Are there overarching incentives in place that apply to the entire electricity sector?	1	10	27.8%
		Emissions trading		9	25.0%
		CO2 and/or Energy taxes		3	8.3%
	1.2 Energy efficiency	1.2 Energy efficiency: Total			21.5%
		Are incentives to increase efficiency of fossil fuel power plants in place?	0.5	9	12.5%
		Direct subsidies		4	
		Performance standard or closure of inefficient plants		4	
		white certificates		2	
		Is there support to increase the share of CHP?	0.25	9	6.3%
		Are policies in place to reduce distribution losses?	0.25	4	2.8%
		Are there any subsidies applicable in the electricity sector, e.g. coal penny ?	-0.5	0	0.0%
	1.3 Renewables	1.3 Renewables: Total			49.3%
		Is effective support for RES-E?	0.75	23	47.9%
		Feed-in Tariffs/ premiums		13	
		Portfolio standards (RPS)/ RE Quota		3	

Thematic area		Indicator	Weighting factor	No. of countries (/36)	Indicator score
		Procurement rules		12	
		Green Certificates		5	
		Tax exemptions		5	
		Is there support that differentiates/ incentivises the diffusion of different technologies?	0.25	2	1.4%
		Is the administrative environment a major barrier to implementation?		0	
		Is preferential grid access and congestion management for renewable electricity in place?		0	
		Is an investment & implementation strategy for RE oriented grid structures in place		0	
	1.4 Low carbon	1.4 Low carbon: Total			5.6%
		Are policies in place that influence fuel choice and lead to a fuel switch?	0.25	8	5.6%
		Direct subsidies		4	
		Tax exemptions		5	
		emission performance standards		0	
		Are incentives for biomass CCS in place? Please specify in the comment field.	0.25	0	0.0%
		Are incentives for coal or natural gas CCS in place? Please specify in the comment field.	0.25	0	0.0%
		Is there active support for nuclear energy? Please specify in the comment field.	0.25	0	0.0%
Industry	2.1 Cross-cutting	2.1 Cross-cutting: Total			30.6%
		Are there overarching incentives in place that apply to the entire industry sector?	1	11	30.6%
		Emissions trading		11	
		CO2 and/or Energy taxes		3	
	2.2 Changing activity	2.2 Changing activity: Total			5.6%
		Are there policies in place that support the redesign of products to be less material intensive, long lasting, 100% recy-	1	2	5.6%

Thematic area		Indicator	Weighting factor	No. of countries (/36)	Indicator score
		cable?			
	2.3 Energy efficiency	2.3 Energy efficiency: Total			23.6%
		Are there schemes that lead to improvements over the baseline situation (additional) in energy efficiency in industry?	0.5	12	16.7%
		Direct subsidies		4	
		Tax exemptions		5	
		Voluntary agreements		3	
		White certificates		2	
		Do policies that support the demonstration of breakthrough technologies exist (R&D support)?	0.5	5	6.9%
		Are there subsidies, tax exemptions for energy intensive industry for conventional fuel supply and consumption (direct and indirect) in place?	-0.5	0	0.0%
	2.4 Renewables	2.4 Renewables: Total			36.1%
		Are policies in place that effectively lead to increasing the use of renewable energy in industry?	1	13	36.1%
		Direct subsidies		4	
		Tax exemptions		5	
		Green certificates		5	
		Renewable energy quota		0	
		Mandatory energy audits		0	
		Are subsidies, tax exemptions for energy intensive industry for conventional fuel supply and consumption (direct and indirect) that hinder the uptake of energy efficient technologies or renewables?	-0.5	0	0.0%
	2.5 Low carbon	2.5 Low carbon: Total			0.0%
		Are there incentives for coal / gas CCS development in industry?	1	0	0.0%
		Are there incentives for biomass and process emission	1	0	0.0%

Thematic area		Indicator	Weighting factor	No. of countries (/36)	Indicator score
		CCS development in industry?			
	2.6 Non-energy	2.6 Non-energy: Total			2.8%
		Are there policies to reduce N2O emissions in industry?	1	0	0.0%
		Are there incentives to reduce fugitive CH4 emissions from oil and gas production?		1	
		Are there incentives to decrease in landfill gas emissions, by either less landfilling or CH4 capture in place?		0	
		Are there policies to reduce F-gas emissions?		0	
Buildings	3.1 Cross-cutting	3.1 Cross-cutting: Total			5.6%
		Are there overarching incentives in place that apply to the entire electricity sector?	1	2	5.6%
		Emissions trading		0	0.0%
		CO2 and/or Energy taxes		2	5.6%
	3.2 Changing activity	3.2 Changing activity: Total			8.3%
		Is there an urbanisation policy in place that leads to energy efficient development?	1		8.3%
	3.3 Energy efficiency	3.3 Energy efficiency: Total			54.9%
		Are there incentive (regulation, support and information) for use of efficient appliances, including air conditioning?	0.25	0	
		White certificates		2	20.1%
		Product performance standards (e.g. top runner approach)		21	
		Direct subsidies		4	
		Information campaigns		19	
		Tax exemptions		5	
		Are there policies to remove subsidies, tax exemptions for electricity use in buildings (direct and indirect)?	-0.5	0	0.0%
		Incentives (fuels)		0	
		Are there (ambitious) efficiency standards for new buildings for all types of buildings in place?	0.25	24	16.7%

Thematic area		Indicator	Weighting factor	No. of countries (/36)	Indicator score
		Binding buildings performance standards		5	
		Direct subsidies		4	
		Credit schemes (e.g. KfW)		2	
		Information campaigns		19	
		Tax exemptions		5	
		Are there sufficient incentive for high retrofit rates for all types of existing buildings (for complete retrofit, i.e. full building envelope & upgrade supply system)?	0.25	26	18.1%
		Binding buildings performance standards for retrofitting		13	
		Direct subsidies		4	
		Credit schemes (e.g. KfW)		2	
		Information campaigns		19	
		Tax exemptions		5	
		Are there policies for efficiency improvement for other than heating fuel uses (i.e. cooking, hot water use)?	0.25	0	0.0%
		Barriers (fuels)	-0.5	0	0.0%
		Are there policies in place that remove detrimental subsidies, tax exemptions for fuel use in buildings (direct and indirect) in place?		0	
		If it exists, are there solutions to the landlord tenant problem in place? These could include regulation that allows costs for retrofitting of buildings to be included in the rent or be covered in contracting?		0	
		Are standards for new buildings properly implemented and enforced?		0	
	3.4 Renewables	3.4 Renewables: Total			40.3%
		Are there policy instrument on use of sustainable renewable heating/cooling in new buildings and existing buildings in	0.5	29	40.3%

Thematic area		Indicator	Weighting factor	No. of countries (/36)	Indicator score
		place for all types of buildings?			
		Tax exemptions		5	
		Binding buildings performance standards or obligations to use RE		2	
		Direct subsidies		4	
		Credit schemes (e.g. KfW)		2	
		Information campaigns		19	
		CO2 and/or Energy taxes		23	63.9%
		Are there policies supporting cooking and hot water supply with sustainable renewable fuels in place?	0.5	0	0.0%
	3.5 Low carbon	3.5 Low carbon: Total			0.0%
		Is there support for switching from oil/ coal to gas as heating/ cooking/ hot water use fuel in place?	1	0	0.0%
Transport	4.1 Cross-cutting	4.1 Cross-cutting: Total			8.3%
		Are there overarching incentives in place that apply to the entire electricity sector?	1	3	8.3%
		Emissions trading		0	0.0%
		CO2 and/or Energy taxes		3	8.3%
	4.2 Changing activity	4.2 Changing activity: Total			13.9%
		Are there strategies to avoid traffic and to move to non-motorised transport in place?	1	1	2.8%
		Are there strategies for modal shift to low carbon transport modes (public transport, freight rail, freight ships) in place?		4	
		Is there a fiscal or other incentives which promote higher fuel use in transport (buy more cars, bigger cars or drive/fly more) in place?	-0.5	0	0.0%
	4.3 Energy efficiency	4.3 Energy efficiency: Total			22.9%
		Is there an incentive to reduce light vehicle emissions (e.g. cars) per kilometre?	0.33	11	10.1%

Thematic area		Indicator	Weighting factor	No. of countries (/36)	Indicator score
		Vehicle fuel-economy or emission standards		6	
		Direct subsidies		4	
		Tax exemptions		5	
		Is there an incentive to reduce heavy vehicle emissions per kilometre?	0.33	11	10.1%
		Vehicle fuel-economy or emission standards		6	
		Direct subsidies		4	
		Tax exemptions		5	
		Are there energy or CO2 taxes in place that could incentivise reduction of fuel use in the transport?	0.33	3	2.8%
	4.4 Renewables	4.4 Renewables : Total			50.0%
		Are there incentives in place to increase renewable energy sources in transport (biofuels)?	1	18	50.0%
		RE quota		17	
		Tax reliefes		1	
		Direct subsidies		0	
	4.5 Low carbon	4.5 Low carbon: Total			13.9%
		Support for fuel switch from oil to natural gas or other low carbon technologies?	1	1	2.8%
		Are there incentives for electric mobility?		5	
AFOLU	5.1 Changing activity	5.1 Changing activity: Total			27.8%
		Incentives	1	10	27.8%
		Are there activities to promote sustainable consumption practices in place?		10	
		Does a consistent land use strategy exists (including a strategy for forest management planning), minimizing emissions from land use change (under the given national circumstances), promoting stabilization or increase of forest, wetland and protected areas that is supported by policy		0	

Thematic area		Indicator	Weighting factor	No. of countries (/36)	Indicator score
		tools to secure its implementation?			
	5.2 Non-energy	5.2 Non-energy: Total			38.9%
		Incentives	1	14	0.388888889
		Are there incentives to support emission reduction in agriculture for Livestock, CH4 and N2O emissions in place?		3	
		Are incentives in agriculture for cropland and organic/peaty soils, all non-CO2 emissions (including rice production) in place?		2	
		Are there incentives to reduce emissions from grassland in place?		3	
		Are there incentives to reducing deforestation, forest management, afforestation in place? Please specify further in the comment field		14	