Implications of proposals for future international climate policy after 2012 on Sweden

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1. INTRODUCTION

This report presents implications of future international climate policy after 2012 on Sweden. It was prepared by Ecofys for the Swedish Environmental Advisory Council.

The calculations in this report are based on the report “Factors underpinning future action” prepared by Ecofys for the Department for Environment Food and Rural Affairs (DEFRA), United Kingdom (Höhne et al. 2007).

The report first provides the assumptions used to quantify the approaches and then shows the results.

2. FUTURE GLOBAL APPROACHES FOR ALLOCATION OF EMISSION ALLOWANCES

This section presents emission allowances for seven possible future architectures consistent with emission pathways towards 450, 550 and 650 ppmv CO_2eq. for the years 2020 and 2050. This means that the calculation outcomes have to meet the global emissions reference points mentioned above. The following approaches are included in the calculation of emission allowances:

- Contraction and convergence by 2050
- Common but differentiated convergence
- Multistage
- Global Triptych
- Sectoral approach
- GHG intensity targets for all countries

For this comparison of future architectures the Evolution of Commitments tool (EVOC) is used. A detailed description of the EVOC model is included in Höhne et al. 2007.

2.1.1 Contraction and convergence by 2050

Under Contraction and convergence (C&C) (Meyer 2000; GCI 2005), all countries participate in the regime with quantified emission targets. As a first step, all countries agree on a path of future global emissions that leads to an agreed long-term stabilisation level for greenhouse gas concentrations (‘Contraction’). As a second step, the targets for individual countries are set in such a way that per capita emissions converge from the countries’ current levels to a level equal for all countries within a given period (‘Convergence’). The convergence level is calculated such that resulting global emissions follow the agreed global emission path. The resulting convergence levels for this report are given in Table 1. It might be more difficult for some countries to reduce emissions compared to others, e.g. due to climatic conditions or resource availability. Therefore, emission trading could be allowed to level off differences between allowances and actual emissions. However, C&C does not explicitly provide for emission trading.

As current per capita emissions differ greatly between countries some developing countries with very low per capita emissions, (e.g. India, Indonesia or the Philippines) could be allocated more emission allowances than necessary to cover their emissions (“hot air”). This would generate a flow of resources from developed to developing countries if these emission allowances are traded.

For a stabilisation at about 650 ppmv CO_2eq. a convergence at about 4 to 5 tCO_2eq. per capita in 2050 is necessary (see Table 1). In this case the average per capita emissions lie around 6 tCO_2eq. per capita in 2020. For a stabilisation at about 550 ppmv CO_2eq. in 2050 a convergence at about 3 tCO_2 per capita with average per capita emissions of about 5 tCO_2eq. in 2020 is required. To reach a stabilisation at about 450 ppmv CO_2eq. a convergence at about 2 tCO_2 per capita is necessary. In this case average per capita emissions in 2020 around 4 tCO_2 per capita are needed.

Table 1. Convergence level of per capita emissions in $tCO_2eq./cap$ for the considered SRES scenarios in 2050

Scenario	450 ppmv CO_2eq.	550 ppmv CO_2eq.	650 ppmv CO_2eq.
A1, B1	2.1	3.2	5.1
A2	1.6	2.5	4.0
B2	2.0	2.9	4.8

Under relatively strict long-term targets (e.g. 450 ppmv CO_2eq.) and convergence by, e.g., 2050, also several developing countries would have to reduce their emissions compared to the BAU; as the per capita emissions have to converge to a level below current average of developing countries, those developing countries above or close to the average (e.g. Argentina, Brazil, Venezuela, Mexico, South Africa, South Korea, Namibia, Thailand, China) will soon (e.g. 2020) be constrained and will not receive excess allowances. More excess allowances would be available under a higher concentration target, e.g. 550 ppmv CO_2, or under earlier convergence, e.g. by 2030. The later the convergence year, the higher is the contribution of developing countries because late convergence years require low emission levels. These would lead to a smooth convergence path for many developing countries. For convergence in earlier years higher, above developing country average conversion levels would be needed. This would allow more space for initially increasing, peaking and then declining emissions of developing countries.

2.1.2 Common but differentiated convergence

Common but differentiated convergence (CDC) is a new approach presented by Höhne et al. (Höhne et al. 2006). Annex I countries' per capita emission allowances converge within, e.g., 40 years (2010 to 2050) to an equal level for all countries. Individual non-Annex I countries' per capita emissions also converge within the same period to the same level but convergence starts from the date, when their per capita emissions reach a certain percentage threshold of the (gradually declining) global average. Non-Annex I countries that do not pass this percentage threshold do not have binding emission reduction requirements. Either they take part in the CDM or they voluntarily take on positively binding emission reduction targets. Under the latter, emission allowances may be sold if the target is overachieved, but no emission allowances have to be bought if the target is not reached.

The CDC approach, similarly to C&C, aims at equal per capita allowances in the long run (see Figure 1). In contrast to C&C it considers more the historical responsibility of countries. Annex I countries would have to reduce emissions similarly to C&C, but many non-Annex I countries are likely to have more time to develop until they need to reduce emissions. Non-Annex I country participation is conditional to Annex I action through the gradually declining world average threshold. No excess emission allowances ("hot air") would be granted to least developed countries.

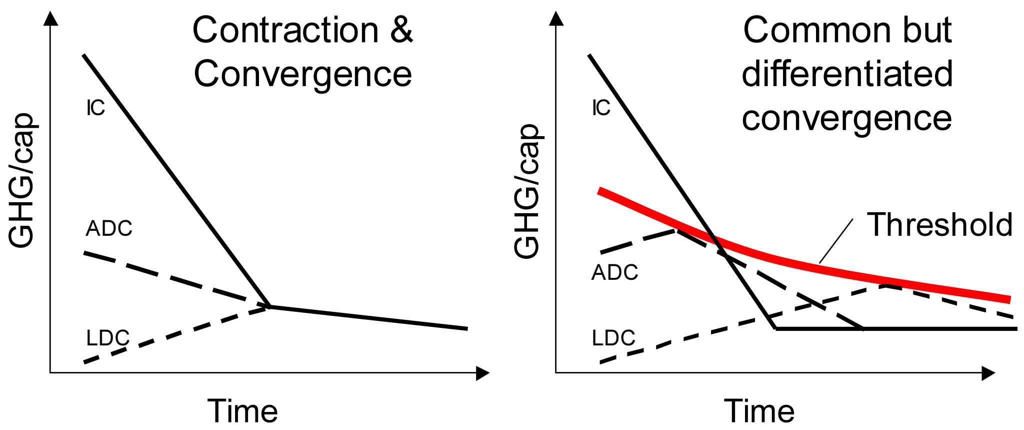

Figure 1. Schematic representation of GHG emissions per capita for three types of countries (an industrialized country (IC), an advanced developing country (ADC) and a least developed country (LDC)) under Contraction & Convergence (left) and under Common but Differentiated Convergence (right)

The parameters of the convergence time, the threshold for participation and the convergence level used in this report are provided in Table 2.

Table 2. Parameters used for the Common but Differentiated Convergence approach[1]

Parameter	Unit	450 ppmv CO_2eq.		550 ppmv CO_2eq.		650 ppmv CO_2eq.	
		2020	2050	2020	2050	2020	2050
Convergence time	Years	30	40	40	40	40	40
Threshold	% above or below world average	-55%	-30%	-10%	-5%	40%	23%
Convergence level	tCO_2eq./cap	1	1.8	2	2.6	8	4.5

2.1.3 Multistage

As the name suggests in a Multistage approach countries participate in several stages, with differentiated types and levels of commitments[2]. Each stage has stage-specific commitments with countries graduating to higher stages when they exceed certain thresholds (e.g. emissions per capita or GDP per capita). All countries agree to have commitments at a later point in time. For this analysis thresholds based on per capita emissions with four stages were applied as follows (e.g. Höhne et al. 2005):

- ***Stage 1 – No commitments:*** Countries with a low level of development do not have climate commitments. As a minimum all least developed countries (LDCs) would be in this stage. In the model countries in this stage follow their reference scenario as no emission reductions are required.
- ***Stage 2 – Enhanced sustainable development:*** At the next stage, countries commit in a clear way to sustainable development: The environmental objectives have to be built into the development policies. Such a first 'soft' stage would make it easier for new countries to join the regime. Requirements for such a sustainable pathway could be defined, e.g. inefficient equipment is phased out and requirements and certain standards are met for any new equipment, or there is a clear deviation from the current policies depending on the countries. This stage is implemented in the model by assuming countries reduce emissions by a percentage below their reference scenario within 10 years and then follow the reduced reference scenario.
- ***Stage 3 – Moderate absolute target:*** In this stage, countries commit to a moderate target on absolute emissions. The emission level may be higher than the starting year, but it should be below a reference scenario. The target could be positively binding, meaning that allowances can be sold if the target is exceeded but no allowances have to be bought if the target is not achieved. An incentive to accept such a target would be the possibility to participate in emissions trading. To model the group of countries in this stage, a percentage reduction below their reference scenario more stringent than in stage 2 is assumed.

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[1] It may not be possible to meet both reference points (for 2020 and 2050) per stabilisation level (450, 550 or 650 ppmv CO_2eq.) for one set of parameters. Different parameter configurations are necessary for each reference point. This means that the configurations e.g. for 2020 450 ppmv CO_2eq. are valid only until 2020. For long-term calculations (2050) other configurations are necessary which are valid only for 2050.

[2] E.g. Claussen and McNeilly 1998; Gupta 1998; Berk and den Elzen 2001; USEPA 2002; Blanchard et al. 2003; CAN 2003; Criqui et al. 2003; den Elzen et al. 2003; Gupta 2003; Höhne et al. 2003; Ott et al. 2004; Blok et al. 2005; den Elzen 2005; den Elzen et al. 2005; Höhne et al. 2005; Höhne and Ullrich 2005; Michaelowa et al. 2005; den Elzen et al. 2006

- ***Stage 4 – Absolute reduction target:*** Countries in stage 4 receive absolute emission reduction targets and have to reduce their absolute emissions substantially until they reach a low per capita level (essentially a fifth stage). The whole group of countries reduces its emissions as a certain percentage compared to 1990. The actual contribution of each country depends on its per capita emissions. Countries with high emissions per capita have to reduce more than countries with low emissions per capita. As time progresses, more and more countries enter stage 4.

The parameters for reductions and stage participation thresholds chosen for the calculations are given in Table 3. The choice of parameter values is subjective but should reflect a reasonable burden sharing of emission reductions among developed and developing countries. Several other options are possible. Lower stage-thresholds, for example, would require higher contributions of developing countries.

Table 3. Parameters used for the Multistage approach [3]

Parameter	Unit	450 ppmv CO_2eq.		550 ppmv CO_2eq.		650 ppmv CO_2eq.	
		2020	2050	2020	2050	2020	2050
Threshold to enter stage 2	tCO_2eq./cap	3.5	2.5	5.0	3.0	6.0	4.0
Threshold to enter stage 3	tCO_2eq./cap	4.5	3.5	6.5	5.0	7.5	5.5
Threshold to enter stage 4 in 2010	tCO_2eq./cap	6.0	4.0	7.5	6.0	9.0	6.5
Threshold to enter stage 4 in 2100	tCO_2eq./cap	5.0	1.5	6.5	4.0	7.5	5.5
Threshold for no further reduction in stage 4	tCO_2eq./cap	1.5	1.0	2.0	1.5	5.0	5.0
Stage 2 (enhanced sustainable development) reduction below reference scenario in 10 years	%	15	25	15	20	5	15
Stage 3 (Moderate absolute target) reduction below reference scenario in 10 years	%	30	30	25	30	10	20
Stage 4 (Absolute reduction) reduction per year*	%	5.0	9.0	3.0	6.0	0.7	3.0

*The reduction percentages per year are applied to the absolute emissions in the previous year and therefore lead to an exponential decline in absolute emissions. Other slopes (e.g. linear) are possible.

The parameters in the 650 ppmv CO_2eq. case could have a realistic chance of being acceptable to many countries: The second stage (pledge for sustainable development) would require 5 to 15% reduction below the reference scenario, the third stage (moderate reductions) would require emission to be 10 to 20% below reference. Participation in stage 4 (absolute reduction target) would be at 9 tonne carbon dioxide equivalent per capita (tCO_2eq./cap), which is between current Annex I and world average. The reduction obligations would still be ambitious with 0.7 to 3% reduction per year.

The parameters for the 550 ppmv case are much more stringent: The second stage (pledge for sustainable development) would already require emissions to be reduced by 15 to 20% below reference; the third stage (moderate reductions) would require reductions of 25 to 30% below reference. Participation in stage 4 (substantial reductions) would be at about current world average. The reduction obligations would be ambitious with a 3 to 6% reduction per year.

The parameters needed for the 450 ppmv CO_2eq. case stretch the approach to its limits: participation in stages 2 and 3 has to occur almost immediately for most developing countries. Already in stages 2 and 3 reductions of 15 to 25% and 30% respectively have to occur. Countries at stage 4 have to reduce emissions drastically by 5% to 9% per year.

[3] It may not be possible to meet both reference points (for 2020 and 2050) per stabilisation level (450, 550 or 650 ppmv CO_2eq.) for one set of parameters. Different parameter configurations are necessary for each reference point. This means that the configurations e.g. for 2020 450 ppmv CO_2eq. are valid only until 2020. For long-term calculations (2050) other configurations are necessary which are valid only for 2050.

2.1.4 Global Triptych

This approach was originally developed at the University of Utrecht (Blok et al. 1997) to share the emission allowances of the first commitment period within the European Union. It has been updated and revised subsequently (Phylipsen et al. 1998, Groenenberg 2002, den Elzen and Lucas 2003, Höhne et al. 2003, Phylipsen et al. 2004, Höhne et al. 2005, Höhne 2006).

Analogue to the first Triptych approach, the global Triptych approach is a method to allocate emission allowances among a group of countries based on several national indicators.[4] It takes into account main differences in national circumstances between countries that are relevant to emissions and emission reduction potentials. The Triptych approach as such does not define which countries should participate, but we have applied it here to all countries equally.

If the approach is applied globally, substantial reductions for the industrialised countries, especially those with carbon intensive industries (i.e. Eastern Europe and Russian Federation), are required. Substantial emission increases are allowed for most developing countries. But for lower concentration targets (e.g. 450 ppmv CO_2) these are rarely above BAU-emissions.

The Triptych methodology calculates emission allowances for the various sectors which are added to obtain a national target. Not individual sector targets but only the national targets are binding. This provides countries the flexibility to pursue any cost-effective emission reduction strategy.

The emissions of the sectors are treated differently: For ‘electricity production’ and ‘industrial production’, a growth in the physical production is assumed together with an improvement in production efficiency. This takes into account the need for economic development but constant improvement of efficiency. For the ‘domestic’ sectors, convergence of per capita emissions is assumed. This takes into account the converging living standard of the countries. For the remaining sectors, ‘fossil fuel production’, ‘agriculture’ and ‘waste’, similar reduction and convergence rules are applied.

Table 4 provides the parameters chosen for the calculation in this report. Details on the applied methodology can be found in Phylipsen et al. 2004. The choice of parameter values is subjective but should reflect a reasonable burden sharing of emission reductions. Several other options are possible. We intended the chosen parameters to be balanced in stringency over the sectors for the stabilisation levels of 450 and 650 ppmv CO_2eq. For 550 ppmv CO_2eq. the chosen parameter set is valid for both years, 2020 and 2050, but does not allocate emission reduction efforts evenly over all sectors. The parameters for the 650 ppmv case are relatively moderate: 40% to 50% share of renewable and emission-free electricity in 2050, 20% to 40% reduction in electricity generation based on coal and oil as well as convergence of all countries’ industrial energy efficiencies to a level that is 5% to 30% better than best available technology in 1995. The parameters for the 450 ppmv case stretch the methodology to the limit: 70% to 95% renewable and emission-free electricity in 2050, 70% to 95% reduction in electricity generation from coal and oil, convergence to an industrial energy efficiency that is 50% to 70% better than best available technology in 1995.

[4] Unlike e.g. the Multistage approach which is more a framework of stages that can be filled with different allocation methods for the several stages or C&C which is based only on per capita emissions.

Table 4. Parameter choices for 2020 and 2050 for the Triptych cases aiming at 450, 550 and 650 ppmv CO_2eq. concentration

Sector	Quantity	450 ppmv 2020	450 ppmv 2050	550 ppmv 2020 + 2050	650 ppmv 2020	650 ppmv 2050
Industry	Maximum deviation of total industrial production at country level in 2050	45%	45%	45%	45%	45%
	Maximum deviation of total industrial production at global level in 2050	10%	10%	10%	10%	10%
	Convergence of Energy Efficiency Indicator in 2050	0.3	0.5	0.6	0.95	0.7
	Structural change factor	0.2	0.35	0.45	0.95	0.6
Electricity	Maximum deviation of total power production at country level in 2050	45%	45%	45%	45%	45%
	Maximum deviation of total power production at global level in 2050	10%	10%	10%	10%	10%
	Share of renewables and emission free fossil in 2050	95%	70%	60%	50%	40%
	Share of CHP in 2050	5%	20%	20%	20%	30%
	Reduction of solid fuels in 2050 compared to base year	95%	70%	50%	40%	20%
	Reduction of liquid fuels in 2050 compared to base year	95%	60%	60%	50%	30%
	Amount of nuclear energy	Absolute unchanged				
	Amount of natural gas	Remainder				
	Total efficiency of CHP	90%	90%	90%	90%	90%
	Convergence of power generation efficiency of solid fuels in 2050	50%	50%	50%	50%	50%
	Convergence of power generation efficiency of liquids fuels in 2050	55%	55%	55%	50%	50%
	Convergence of power generation efficiency of gas in 2050	70%	70%	65%	65%	65%
Domestic Sector	Domestic convergence level – per capita emissions in tCO_2/cap/yr in 2050	0.5	0.7	1	2.6	1.7
Fossil fuel production	Fossil fuel emission level – % total emissions below base year in 2050	90%	90%	90%	90%	90%
Agriculture	Reduction below reference scenario emissions in 2050 – low GDP/cap	70%	70%	50%	20%	20%
	Reduction below reference scenario emissions in 2050 – high GDP/cap	90%	80%	70%	40%	40%
Waste	Waste convergence level – per capita emissions in 2050	0	0	0	0	0

2.1.5 GHG intensity targets for all countries

Various Authors have suggested that targets are expressed as dynamic variables – including as a function of the GDP ("intensity targets") or variables of physical production (e.g. emissions per tonne of steel produced)[5]. Dynamic targets aim at providing more flexibility to the countries, so that high costs are avoided, if the economic development and therefore emission development is different than expected at the time the target is set. In principle, they do not limit the economic growth of countries, but require that economic development takes place in a carbon-efficient way.

[5] E.g. Hargrave et al. 1998; Baumert et al. 1999; Lutter 2000; Müller et al. 2001; Bouille and Girardin 2002; Chan-Woo 2002; Lisowski 2002; OECD/IEA 2002; Ellerman and Wing 2003; Höhne et al. 2003; Müller and Müller-Fürstenberger 2003; Jotzo and Pezzey 2005; Pizer 2005; Kolstad 2006

For the illustrative case we have assigned intensity targets expressed as improvement of emissions/GDP at the same rate for all countries. This may be a less realistic case, but it may be instructive in understanding the dynamics of such an approach. The parameters used are included in Table 5.

Table 5. Parameters used for the GHG intensity target approach

Parameter	Unit	450 ppmv CO_2eq.		550 ppmv CO_2eq.		650 ppmv CO_2eq.	
		2020	2050	2020	2050	2020	2050
Equal reduction of GHG/GDP	%/year	5.6	5.3	4.0	4.4	2.6	3.2

3. FIGURES

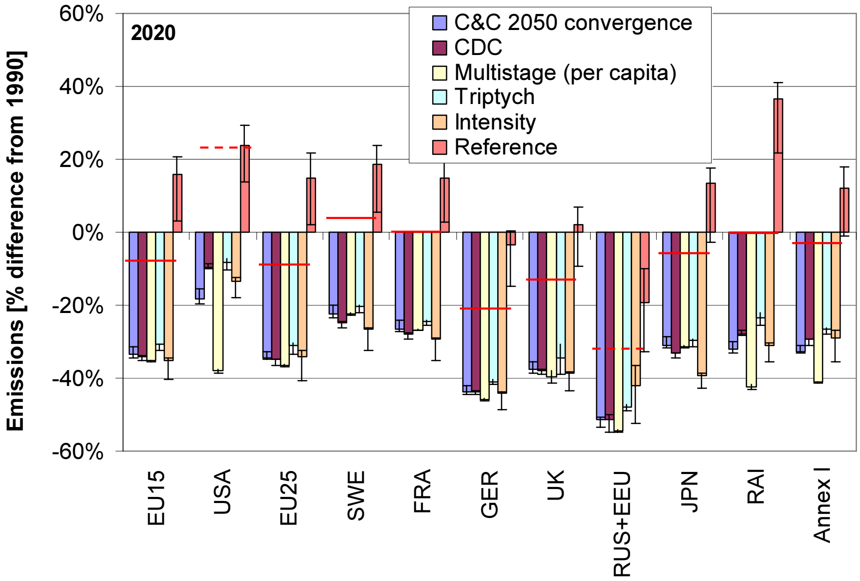
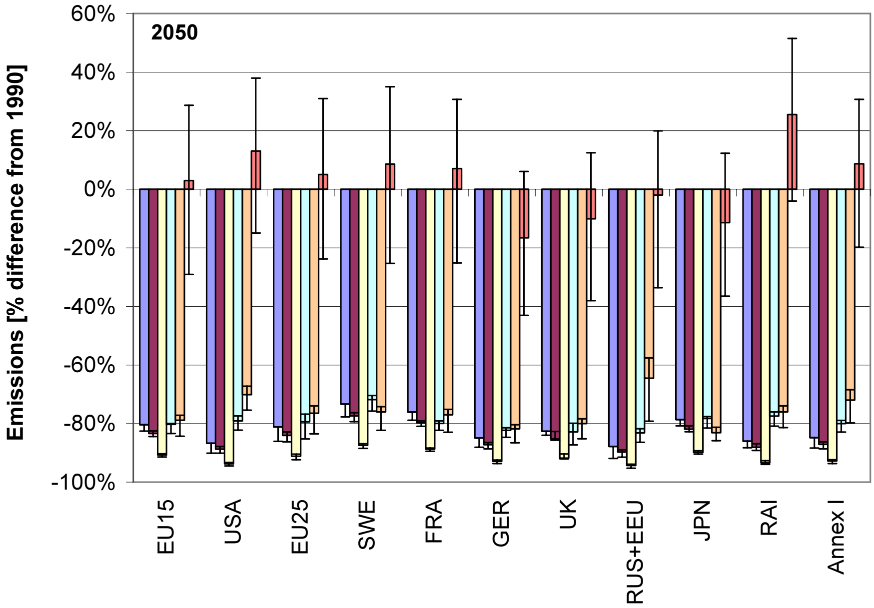


Figure 2. Change in emission allowances from 1990 to 2020 under the 450 ppmv CO_2eq. scenario. Data are included for EU15, USA, EU25, SWE (Sweden), FRA (France), GER (Germany), UK, RUS+EEU (Russia and the rest of Annex I countries from Eastern Europe), JPN (Japan), RAI (Rest of Annex I), and Annex I. The horizontal red lines for Annex I indicate the emission level in 2010 which are similar to the Kyoto targets except for the USA and RUS+EEU.



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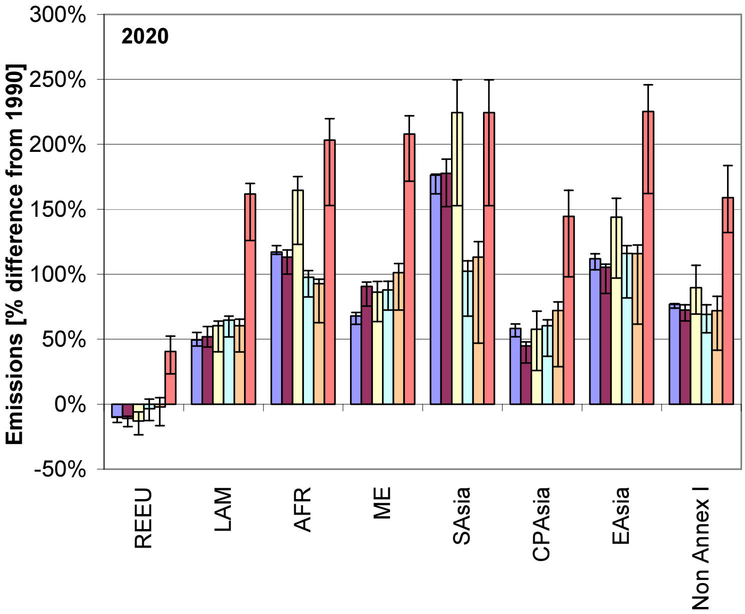

Figure 4. Change in emission allowances from 1990 to 2020 under the 450 ppmv CO_2eq. scenario. Data are included for REEU (Rest of Eastern Europe), LAM (Latin America), AFR (Africa), ME (Middle East), SAsia (South Asia, mainly India), CPAsia (Centrally planned Asia, mainly China), EAsia (East Asia) and non-Annex I.

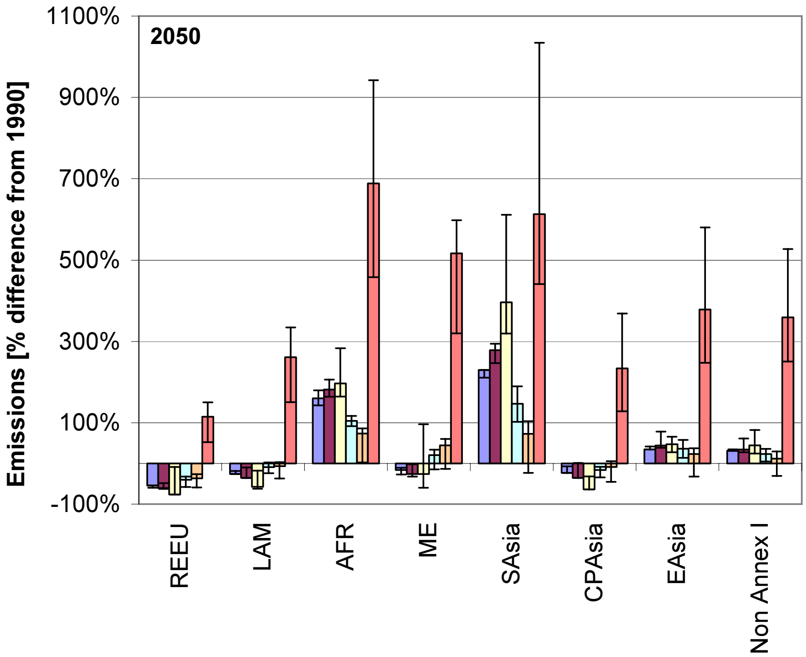

Figure 5. Change in emission allowances from 1990 to 2050 under the 450 ppmv CO_2eq. scenario. Data are included for REEU (Rest of Eastern Europe), LAM (Latin America), AFR (Africa), ME (Middle East), SAsia (South Asia, mainly India), CPAsia (Centrally planned Asia, mainly China), EAsia (East Asia) and non-Annex I.

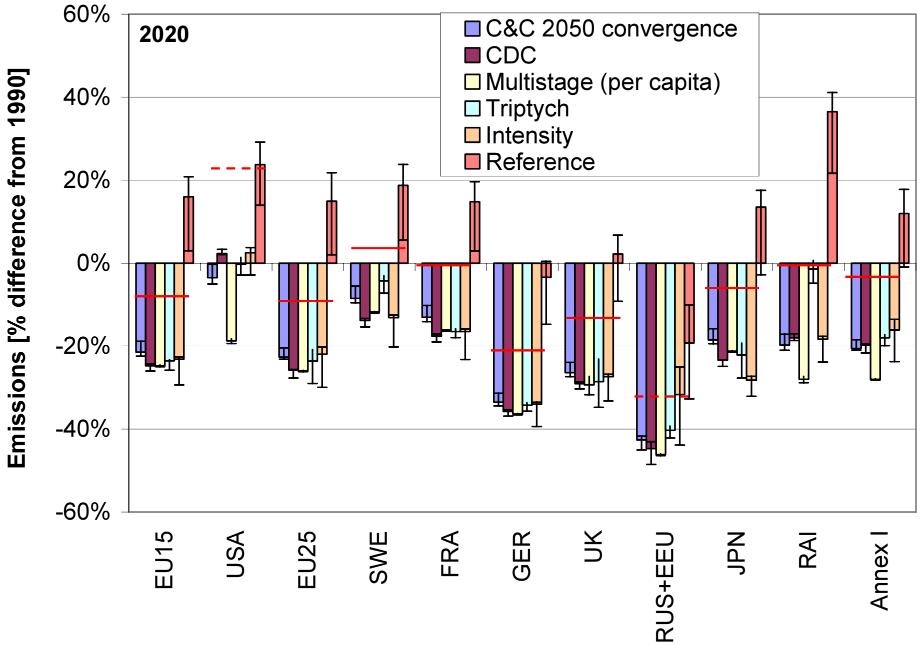

Figure 6. Change in emission allowances from 1990 to 2020 under the 550 ppmv CO_2eq. scenario. Data are included for EU15, USA, EU25, SWE (Sweden), FRA (France), GER (Germany), UK, RUS+EEU (Russia and the rest of Annex I countries from Eastern Europe), JPN (Japan), RAI (Rest of Annex I), and Annex I. The horizontal red lines for Annex I indicate the emission level in 2010 which are similar to the Kyoto targets except for the USA and RUS+EEU.

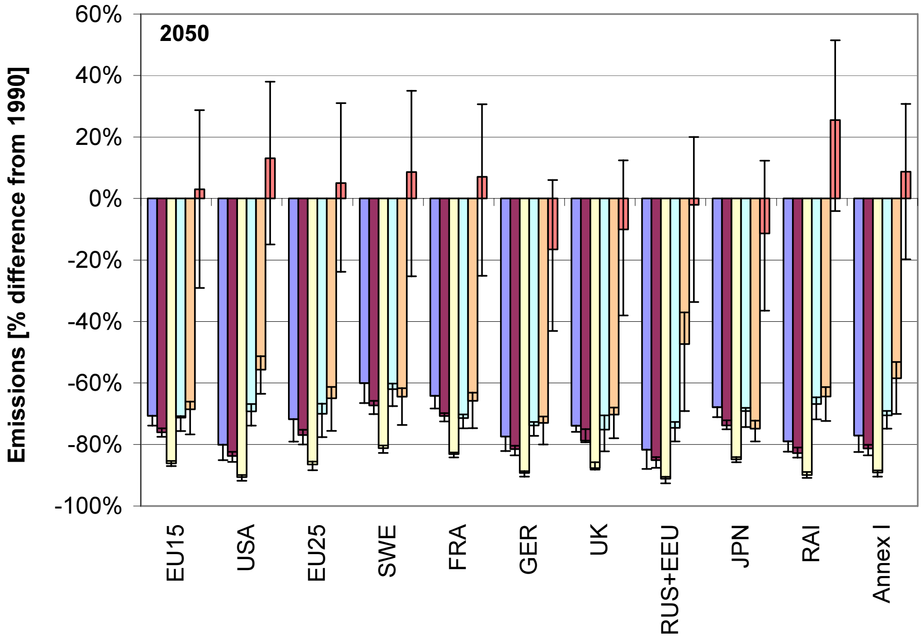

Figure 7. Change in emission allowances from 1990 to 2050 under the 550 ppmv CO_2eq. scenario. Data are included for EU15, USA, EU25, SWE (Sweden), FRA (France), GER (Germany), UK, RUS+EEU (Russia and the rest of Annex I countries from Eastern Europe), JPN (Japan), RAI (Rest of Annex I), and Annex I. The horizontal red lines for Annex I indicate the emission level in 2010 which are similar to the Kyoto targets except for the USA and RUS+EEU.

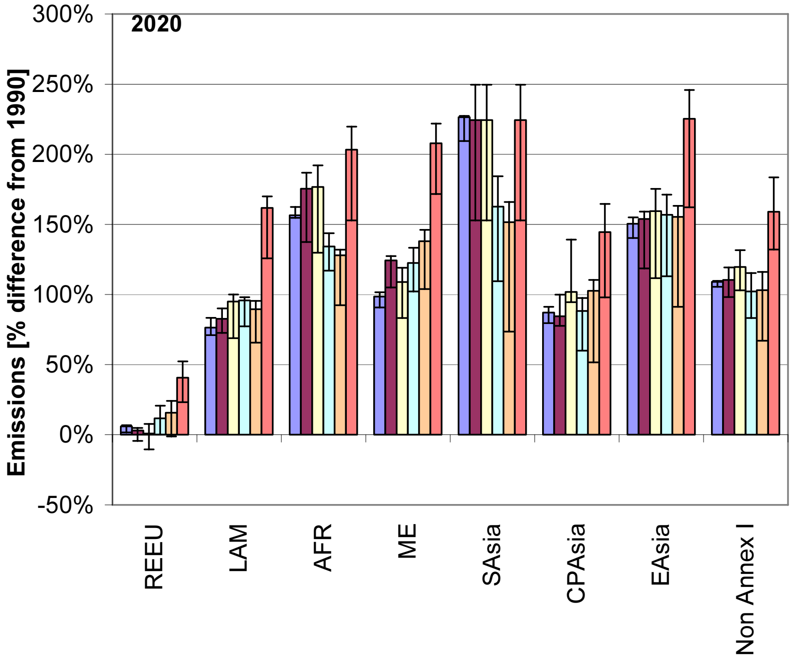

Figure 8. Change in emission allowances from 1990 to 2020 under the 550 ppmv CO_2eq. scenario. Data are included for REEU (Rest of Eastern Europe), LAM (Latin America), AFR (Africa), ME (Middle East), SAsia (South Asia, mainly India), CPAsia (Centrally planned Asia, mainly China), EAsia (East Asia) and non-Annex I.

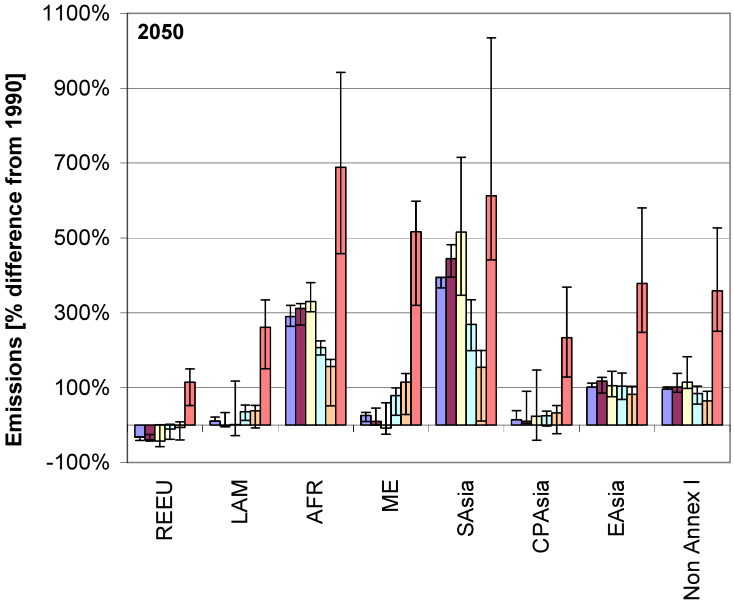

Figure 9. Change in emission allowances from 1990 to 2050 under the 550 ppmv CO_2eq. scenario. Data are included for REEU (Rest of Eastern Europe), LAM (Latin America), AFR (Africa), ME (Middle East), SAsia (South Asia, mainly India), CPAsia (Centrally planned Asia, mainly China), EAsia (East Asia) and non-Annex I.

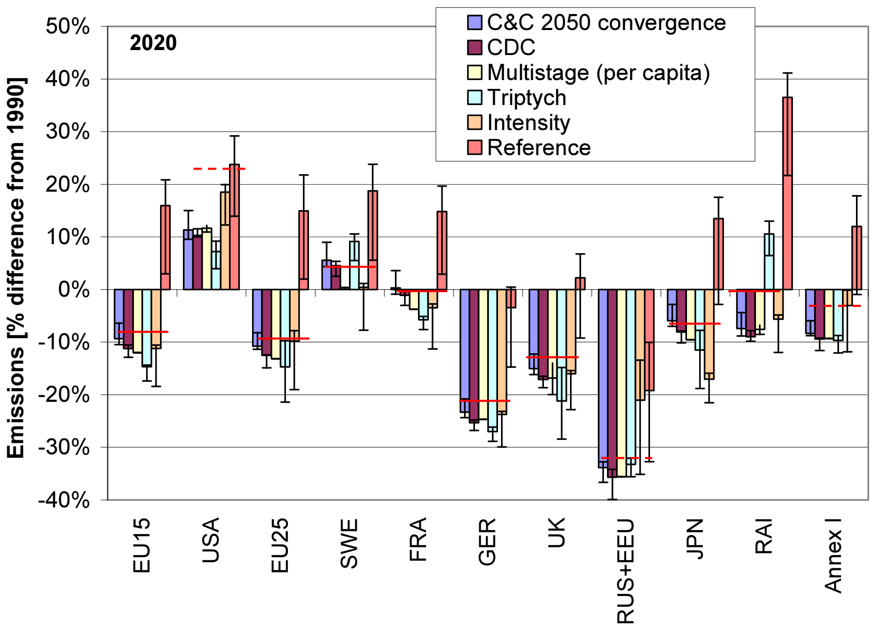

Figure 10. Change in emission allowances from 1990 to 2020 under the 650 ppmv CO_2eq. scenario. Data are included for EU15, USA, EU25, SWE (Sweden), FRA (France), GER (Germany), UK, RUS+EEU (Russia and the rest of Annex I countries from Eastern Europe), JPN (Japan), RAI (Rest of Annex I), and Annex I. The horizontal red lines for Annex I indicate the emission level in 2010 which are similar to the Kyoto targets except for the USA and RUS+EEU.

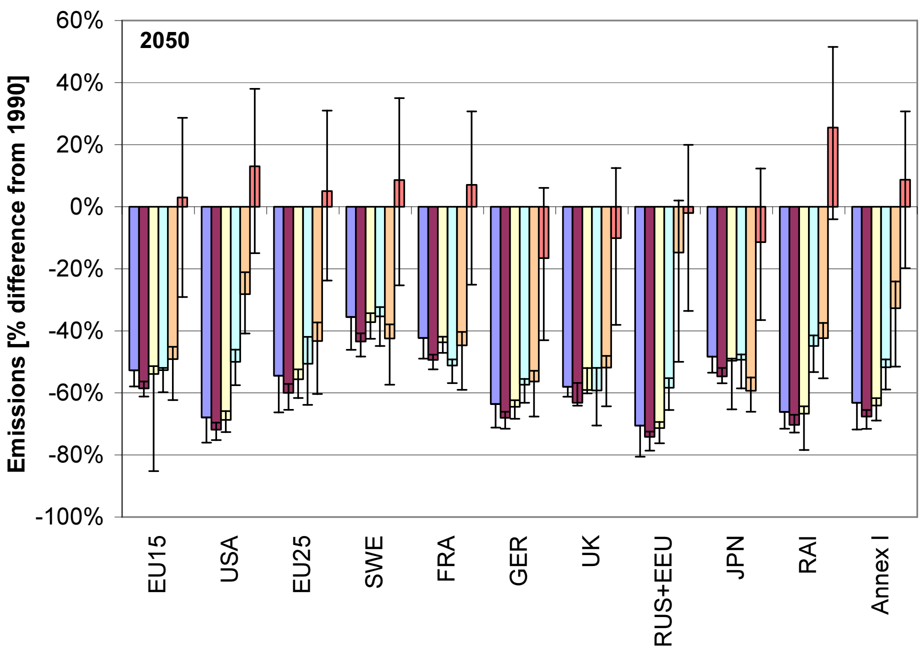

Figure 11. Change in emission allowances from 1990 to 2050 under the 650 ppmv CO_2eq. scenario. Data are included for EU15, USA, EU25, SWE (Sweden), FRA (France), GER (Germany), UK, RUS+EEU (Russia and the rest of Annex I countries from Eastern Europe), JPN (Japan), RAI (Rest of Annex I), and Annex I. The horizontal red lines for Annex I indicate the emission level in 2010 which are similar to the Kyoto targets except for the USA and RUS+EEU.

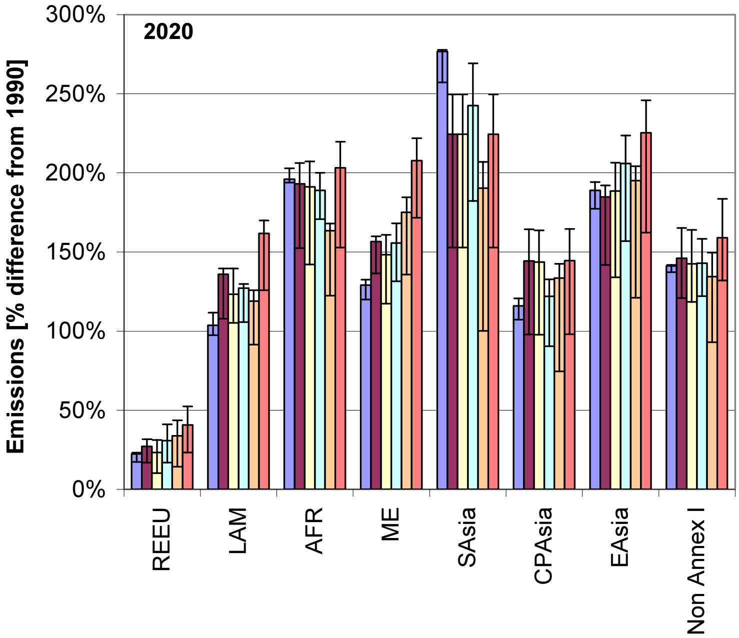

Figure 12. Change in emission allowances from 1990 to 2020 under the 650 ppmv CO_2eq. scenario. Data are included for REEU (Rest of Eastern Europe), LAM (Latin America), AFR (Africa), ME (Middle East), SAsia (South Asia, mainly India), CPAsia (Centrally planned Asia, mainly China), EAsia (East Asia) and non-Annex I.

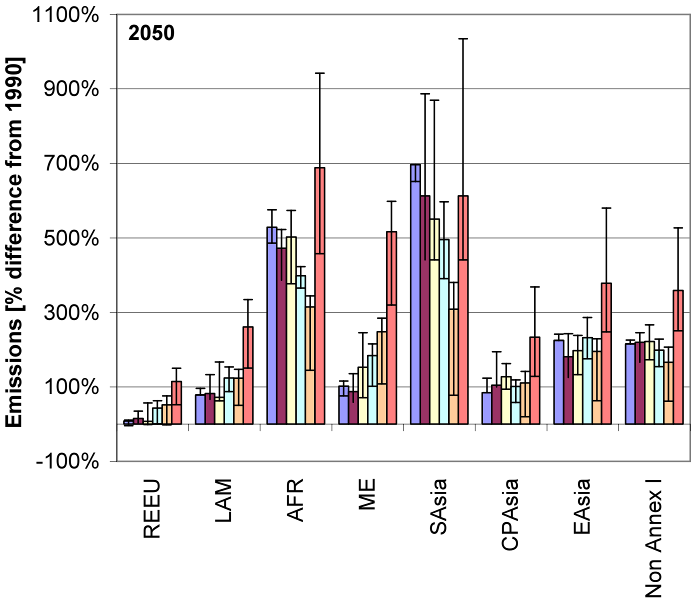

Figure 13. Change in emission allowances from 1990 to 2050 under the 650 ppmv CO_2eq. scenario. Data are included for REEU (Rest of Eastern Europe), LAM (Latin America), AFR (Africa), ME (Middle East), SAsia (South Asia, mainly India), CPAsia (Centrally planned Asia, mainly China), EAsia (East Asia) and non-Annex I.

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