AMPERE Work Package 3 (WP3) model comparison study protocol

1. General information and guidelines:

Input harmonization: All scenarios should be run with harmonized GDP and population trajectories. Modeling teams are free to conduct the experiment with or without harmonized final energy demand. However, the choice of harmonization must not be changed between different parts of the experiment.

Long-term climate target specification: The study will focus on two long-term CO_2 equivalent concentration (= radiative forcing) targets: 450 ppm CO_2e (2.6 W/m^2) and 550 ppm CO_2e (3.7 W/m^2). The targets are converted into cumulative CO_2 budgets based on an extensive analysis of existing 450 ppm and 550 ppm CO_2e scenarios conducted by AMPERE Work Package 1. **Non-CO_2 Kyoto gases should be reduced at the greenhouse gas price implied by the CO_2 budget.** This formulation of the climate target was chosen to enhance comparability of model results (at the expense of some variation in ultimate forcing levels in the climate policy scenarios).

Policy targets vs. instruments: An emissions reductions target can be reached either by implementing an emissions constraint (quantity instrument, leading to a (shadow) price on GHG emissions) or an emissions price (price instrument, leading to a reduction of GHG emissions). If EU27 adopted a stringent climate policy and all other regions pursued only moderate action, carbon leakage may occur compared to the counterfactual situation where EU27 followed the rest of the world in pursuing a moderate climate policy. However, such carbon leakage can only be studied if the moderate climate policy in the rest of the world is implemented as a price instrument - even though the policy targets may be quantified as emissions (intensity) reduction commitments. We therefore require all modeling teams to implement the moderate climate policy scenario by means of a tax on GHG emissions (price instrument).

Treatment of climate policy revenues: CGE results will crucially depend on the details of who will receive the revenues from imposing a price on GHG emissions and how they will be recycled in the economy. We do not propose to fully harmonize these specifications between CGEs, but offer the following guidelines:

- In the following, we may call the climate policy price instrument a GHG tax. This terminology should not imply that revenues must necessarily accrue to the government (this is left to modelers' choice). However, the revenues should accrue to the region where the tax is imposed (even in the case of a globally harmonized GHG tax).
- Revenue recycling schemes should not change between the scenario runs from a single model – unless a clear rationale for such changes is given and the changes themselves are fully documented by the modeling team. Priority should be given to the comparability of mitigation strategies and costs across the sequence of scenarios.
- When deciding on the revenue recycling scheme, modelers should keep in mind that the 450 and 550 ppm CO_2e benchmark scenarios (either imposed on a no climate policy or moderate climate policy reference case) should reflect least cost mitigation strategies. This implies that efficient revenue recycling schemes should be adopted, i.e. efficiency should be prioritized over

simplicity if these two objectives are not aligned. It seems reasonable to adopt the same efficient revenue recycling scheme for the other scenarios as well (see preceding paragraph). Extra analysis exploring the impact of varying revenue recycling schemes in the study setting is encouraged but completely optional.

2. WP3 Scenario definition:

The WP3 scenarios are defined below. Common WP2 & WP3 scenarios that are also part of this exercise are defined in Appendix I. The first five scenarios are mandatory. Optional scenarios are prioritized (1st priority – blue color; 2nd priority – green color; 3rd priority – grey color).

All specifications refer to the time period after 2012. The model should only be allowed to respond to future climate policy (in any model variable) in the first model year following 2012.

Models should reproduce historic emissions until 2010/11. Modeling teams are free to use their default method of reproducing these emissions

Scenario Label	Scenario Name	Definition
RefPol – mandatory	Reference climate policy	**After 2012:** The climate policy for the year 2020 and beyond as defined in Appendix II should be implemented until the end of the time horizon of the model. Emissions and emissions intensity reduction targets until 2020 and after 2020 should be implemented by imposing a CO_2 (equivalent) tax that leads to the achievement of those targets. Capacity and renewable energy targets may be imposed directly as constraints. Modelers should make sure that they correct for "above baseline" emissions targets and "below baseline" improvement rates in the reference climate policy definition as explained in Appendix II. No trade of emissions allowances between regions should be allowed.
450 – mandatory	450 ppm CO_2e from reference case	The climate target should be implemented by imposing a cumulative CO_2 emissions budget onto the technology targets in the reference climate policy case (budgets are chosen to be identical to CF450 in Appendix I). The budget refers to total CO_2 emissions from all sectors, including land use. Models running until 2100 should impose a budget for the period 2000-2100: 1500 GtCO_2 Models running until 2050 should impose a budget for the period 2000-2050: 1400 GtCO_2 Models that do not include CO_2 emissions from land use should use the following CO_2 fossil fuel and industry emissions budgets (but only in this case!): Models running until 2100 should impose a budget for the period

		2000-2100: 1400 $GtCO_2$ Models running until 2050 should impose a budget for the period 2000-2100: 1300 $GtCO_2$ The historic CO_2 emissions from the year 2000 to the model base year should be subtracted from the CO_2 budget. *Global cooperation and harmonized action:* The global CO_2 emissions budget should be imposed on top of the technology measures that were implemented in the reference climate policy case. The carbon taxes to achieve emissions reductions targets in 2020 and emissions intensity improvements after 2020 are superseded by the global emissions constraint. A globally harmonized carbon price, ensuring full where flexibility of emissions reductions, should be established after 2012. Foresight models should be free to adopt the intertemporally optimal emissions reduction trajectory. This means that 2020 emissions reductions / carbon intensity might deviate from the 2020 emissions reductions / carbon intensity targets in the reference climate policy case. If the carbon price is established via a global emissions trading system, the allocation of emissions allowances should be chosen such that no emissions trading between regions, or banking and borrowing of allowances occurs (e.g. as it would be the case for a globally harmonised carbon tax without transfers between regions or across time). ***Non-CO_2 gases and other radiative forcing agents:*** Models which consider also non-CO_2 GHGs (N_2O, CH_4, SF_6, CF_4, and long-lived halocarbons) should use the resulting CO_2-price from the cumulative CO_2 budget constraint to price non-CO_2 gases. Emissions of all radiative forcing agents accounted for in the model should be reported.
550 - mandatory	550 ppm CO_2e from reference case	The climate target should be implemented by imposing a cumulative CO_2 emissions budget onto the technology targets in the reference climate policy case (budgets are chosen to be identical to CF550 in Appendix I). The budget refers to total CO_2 emissions from all sectors, including land use. Models running until 2100 should impose a budget for the period 2000-2100: 2400 $GtCO_2$ Models running until 2050 should impose a budget for the period 2000-2050: 1700 $GtCO_2$ Models that do not include CO_2 emissions from land use should use the following CO_2 fossil fuel and industry emissions budgets (but only in this case!): Models running until 2100 should impose a budget for the period

		2000-2100: 2400 $GtCO_2$ Models running until 2050 should impose a budget for the period 2000-2100: 1600 $GtCO_2$ All other specifications are identical to scenario 450 above.
RefP-EUback - mandatory (requires auxiliary scenario RefP-EU for perfect foresight models)	EU27 acting alone on stringent mitigation	***EU27*** unilaterally follows its climate policy roadmap by adopting ca. 25% (2020) and 80% (2050) Kyoto gas emissions reduction targets relative to 1990 emissions (including LULUCF; the original roadmap proposal as described in Appendix III excludes LULUCF, but we assume that LULUCF emissions are reduced in step with the other emissions in order to simplify the scenario setup). Note that the 2020 roadmap target implies a 20% emissions reduction relative to 2005. Kyoto gas emissions reductions targets between 2020 and 2050 can be derived by calculating percentage emissions reductions foreseen in the EU27 climate policy roadmap which is described in Appendix III (using linear interpolation of emissions for model years between 2020, 2030 and 2050). Models not representing the full basket of Kyoto gases should turn to Appendix III to determine the percentage reduction targets for the subset of gases they include. The emissions reductions targets should be imposed on top of the technology policy measures until 2020 that were implemented in the reference climate policy case for EU27. However, all carbon taxes from the reference policy are superseded by the emissions reduction targets. The roadmap is abandoned after 2030 due to lack of comparable action in other parts of the world. This should be implemented by relaxing the EU27 carbon price to the EU27 carbon price in the reference climate policy scenario RefPol over the period 2030-2050. ***Rest of world*** adopts the measures that were implemented in the reference climate policy case (RefPol; including the carbon taxes to reproduce emissions intensity improvements after 2020). The rest of world should be free to respond to the EU27 climate action, i.e. fixing emissions or any other variable trajectories to the RefPol reference should be avoided. No emissions trading between regions is allowed. Models should not anticipate the relaxation of EU27 carbon price after 2030. This requires perfect foresight models to run an auxiliary scenario where the EU27 roadmap is followed through 2050 and the EU27 carbon price and its trend are smoothly extrapolated over the period 2050-2100. Those models are requested to report the auxiliary scenario as RefP-EU. Model behavior for all world regions should be fixed to RefP-EU until 2030 when running the full scenario RefP-EUback.
450P-EU -	Rest of world	Model behavior for all regions should be fixed to the 2011-2030

mandatory	joins in 2030 (450 ppm action)	trajectory emerging in RefP-EUback. After 2030, all world regions start adopting the globally uniform carbon price from the 450 ppm CO_2e scenario 450 as carbon tax. World regions (including EU27) should linearly transform the tax from their regional 2030 carbon tax in RefP-EUback to the 450 scenario carbon price in 2050, and follow the carbon price trajectory thereafter. ***Non-CO_2 gases and other radiative forcing agents:*** Models, which consider also non-CO_2 GHGs (N_2O, CH_4, SF_6, CF_4, and long-lived halocarbons), should use the CO_2 price (differentiated by region before 2050) to price non-CO_2 gases. Emissions of all radiative forcing agents accounted for in the model should be reported.
RefP-CEback – optional (1st priority) (requires auxiliary scenario RefP-CE for perfect foresight models)	EU and China acting alone on stringent mitigation	***EU27 and China*** jointly follow the globally harmonized carbon price path from the 450 ppm CO_2e scenario as of the first model year after 2012. The carbon tax should be imposed on top of the technology policy measures until 2020 that were implemented in the reference climate policy case for EU27 and China. However, all carbon taxes from the reference policy are superseded by the emissions reduction targets. Treatment of emissions of non-CO_2 gases in EU27 and China as in 450. The 450 ppm CO_2e carbon pricing is abandoned by the EU and China after 2030 due to lack of comparable action in other parts of the world. This should be implemented by relaxing the carbon price to the EU27 and China carbon prices in the reference climate policy scenario RefPol over the period 2030-2050. ***Rest of world*** adopts the measures that were implemented in the reference climate policy case (RefPol; including the carbon taxes to reproduce emissions intensity improvements after 2020). The rest of world should be free to respond to the EU27 and China climate action, i.e. fixing emissions or any other variable trajectories to the RefPol reference should be avoided. No emissions trading between regions is allowed. Models should not anticipate the relaxation of the joint EU27 & China carbon price after 2030. This requires perfect foresight models to run an auxiliary scenario where the EU27 & China carbon price follow the 450 ppm CO_2e carbon price in scenario 450 until 2100. Those models are requested to report the auxiliary scenario as RefP-CE. Model behavior for all world regions should be fixed to RefP-CE until 2030 when running the full scenario RefP-CE.
450P-CE – optional (1st priority)	Rest of world joins EU and China in 2030	Model behavior for all regions should be fixed to the 2011-2030 trajectory emerging in RefP-CEback. After 2030, all world regions start adopting the globally uniform carbon price path from the 450 ppm CO_2e scenario 450 as carbon tax.

		World regions should transform the tax from their 2030 carbon tax in RefP-CEback (EU and China acting alone) to the 450 scenario carbon price in 2050, and follow the global carbon price path thereafter. Treatment of non CO_2 gases and other forcing agents as in 450P-EU.
Base-EUback - optional (2nd priority) (requires auxiliary scenario Base-EU for perfect foresight models)	EU27 acting entirely alone	EU27 is constrained by domestic climate policy (EU27 roadmap) as in RefP-EUback. The roadmap is abandoned after 2030 due to lack of any action in other parts of the world. This should be implemented by relaxing the EU27 carbon price to zero over the period 2030-2050. Rest of world adopts no climate policy at all as in Base in Appendix I. The rest of world should be free to respond to the EU27 climate action, i.e. fixing emissions or any other variable trajectories to the Base baseline should be avoided. Models should not anticipate the removal of carbon pricing in the EU27 after 2030. This requires perfect foresight models to run an auxiliary scenario where the EU27 follows its roadmap through 2050 and the EU 27 carbon price and its trend are smoothly extrapolated over the period 2050-2100. Those models are requested to report the auxiliary scenario as Base-EU. Model behavior for all world regions should be fixed to Base-EU until 2030 when running the full scenario Base-EUback.
CF450P-EU - optional (2nd priority)	Cold start - Rest of world adopts climate policy in 2030	Model behavior for all regions should be fixed to the 2011-2030 trajectory emerging in Base-EUback. After 2030, all world regions start adopting the globally uniform carbon price path from the 450 ppm CO_2e scenario 450 as carbon tax. World regions (EU27) should linearly transform the tax from zero (its 2030 carbon tax in RefP-EUback) to the 450 scenario carbon price in 2050, and follow the global carbon price path thereafter.
550P-EU – optional (3rd priority)	Rest of world joins in 2030 (550 ppm action)	Model behavior for all regions should be fixed to the 2011-2030 trajectory emerging in RefP-EUback. After 2030, all world regions start adopting the globally uniform carbon price path from the 550 ppm CO_2e scenario 550 as carbon tax. World regions (including EU27) should linearly transform the tax from their 2030 carbon tax in RefP-EUback (unilateral EU27 action) to the 450 scenario carbon price in 2050, and follow the global carbon price path thereafter. Treatment of non-CO_2 gases and other forcing agents as in 450P-EU.

Appendix I: AMPERE Common Global Scenarios

The table below defines the three common global scenarios Base, CF450 and CF550. Those scenarios are mandatory for all models participating in WP3.

All specifications refer to the time period after 2012. The model should only be allowed to respond to future climate policy (in any model variable) in the first model year following 2012.

Models should reproduce historic emissions until 2010/11. Modeling teams are free to use their default method for reproducing historic emissions, including emissions constraints or carbon taxes (e.g. reflecting the 1st commitment period of the Kyoto protocol or domestic climate policies) if applicable.

Scenario Label	Scenario Name	Definition
Base	(No policy) baseline	**After 2012:** The carbon tax should be zero throughout the time horizon of the model, and all constraints leading to non-zero (shadow) prices of greenhouse gas emissions should be removed. Fossil fuel taxes and subsidies that are not related to climate change policy are not affected by these requirements.
CF450	450 ppm CO_2e from baseline (counterfactual climate policy benchmark)	The target should be imposed in terms of a cumulative CO_2 emissions budget onto the no policy baseline. The budget refers to total CO_2 emissions from all sectors, including land use. Models running until 2100 should impose a budget for the period 2000-2100: 1500 $GtCO_2$ Models running until 2050 should impose a budget for the period 2000-2050: 1400 $GtCO_2$ Models that do not include CO_2 emissions from land use should use the following CO_2 fossil fuel and industry emissions budgets (but only in this case!): Models running until 2100 should impose a budget for the period 2000-2100: 1400 $GtCO_2$ Models running until 2050 should impose a budget for the period 2000-2050: 1300 $GtCO_2$ The historic CO_2 emissions from the year 2000 to the model base year should be subtracted from the CO_2 budget. ***Global cooperation and harmonized action:*** The target is reached by imposing a globally harmonized carbon price ensuring full where flexibility of emissions reductions **after 2012**. Foresight models should be free to adopt the intertemporally optimal emissions reduction trajectory. If the carbon price is established via a global emissions trading system, the allocation of emissions allowances should be chosen such that no emissions trading between regions, or

		banking and borrowing of allowances occurs (e.g. as it would be the case for a globally harmonised carbon tax without transfers between regions or across time). ***Non-CO_2 gases and other radiative forcing agents:*** Models, which consider also non-CO_2 GHGs (N_2O, CH_4, SF_6, CF_4, and long-lived halocarbons), should use the resulting CO_2-price from the cumulative CO_2 budget constraint to price non-CO_2 gases. Emissions of all radiative forcing agents accounted for in the model should be reported.
CF550	550 ppm CO_2e from baseline (counterfactual climate policy benchmark)	The target should be imposed in terms of a cumulative CO_2 emissions budget onto the no policy baseline. The budget refers to total CO_2 emissions from all sectors, including land use. Models running until 2100 should impose a budget for the period 2000-2100: 2400 $GtCO_2$ Models running until 2050 should impose a budget for the period 2000-2050: 1700 $GtCO_2$ Models that do not include CO_2 emissions from land use should use the following CO_2 fossil fuel and industry emissions budgets (but only in this case!): Models running until 2100 should impose a budget for the period 2000-2100: 2400 $GtCO_2$ Models running until 2050 should impose a budget for the period 2000-2050: 1600 $GtCO_2$ ***Global cooperation and harmonized action:*** The same specifications on when and where flexibility as for CF450 (450 ppm CO_2e from baseline) apply. ***Non-CO_2 gases and other radiative forcing agents:*** The same specifications as for CF450 apply.

Appendix II: Reference climate policy reference scenario

The reference climate policy scenario RefPol is described as a collection of regional 2020 targets on emissions reductions, renewable portfolio standards and capacity targets. .

For some countries, the 2020 emissions (intensity) reductions targets represent the lower end of their Copenhagen pledges. For other countries, plausibility considerations lead to the specification of emissions reductions targets that are weaker than their Copenhagen pledges. In cases where Copenhagen pledges appeared to be ambitious (mostly developing country emissions reductions relative to baseline), the level of stringency was halved. For the US, the 2020 reduction target was taken from an assessment of the impact of existing US regulations[1]. Country targets were extrapolated to larger regions under the assumption that neighboring countries follow the example of regional leaders.

The stringency level of the regional emissions targets is extended beyond 2020 (until the end of the model time horizon) by using average GHG emissions intensity improvements per year as a proxy.

If, for a given region and period, the emissions (intensity) reduction target in 2020 and/or the emissions intensity improvement rates after 2020 as defined below are lower than projected by your model in the no policy baseline (Base), then the emissions (intensity improvement rates) in the no-policy baseline should be adopted for the reference policy scenario (for the regions and periods where they exceed the reference policy target). This requirement implies that no region can have higher than baseline emissions in the reference policy scenario.

The emissions reduction and carbon intensity targets for 2020 AND the emissions intensity improvements after 2020 should be imposed on the model by applying carbon (equivalent) taxes. They should NOT be imposed as emissions constraints on the model. This requirement allows regions in first mover scenarios to have higher emissions than in the reference policy and baseline scenarios.

[1] Source: N. Bianco, F. Litz, Reducing Greenhouse Gas Emissions in the United States Using Existing Federal Authorities and State Action, Report World Resources Institute, 2010.

Region	Share of global Kyoto gas emissions in 2005[2]	Across the board GHG emissions reductions target in 2020 (ALL incl. LULUCF) [3]	GHG intensity reductions relative to 2005 (incl. LULUCF)[4]	Modern Renewable share in electricity production[5]	Minimum installed renewable energy capacity (target year in brackets)	Minimum installed nuclear power capacity (target year in brackets)	Average GHG emissions intensity improvements after 2020 (% / year)[6]
EU27	11.7%	-15% (2005)		20% of final energy (by 2020)			3%
CHN	17.3%		-40%	25% (by 2020)	Wind: 200 GW; Solar PV: 50GW (all by 2020)	41 GW by 2020	3.3%
IND	4.6%		-20%		Wind: 20 GW; Solar: 10 GW (all by 2020[7])	20 GW by 2020	3.3%
JPN	3.1%	-1% (2005)			Wind: 5 GW; Solar: 28 GW (all by 2020)		2.2%
USA	15.7%	-5% (2005)		13% (by 2020)			2.5%
RUS	5.7%	+27% (2005)		4.5% (by 2020)		34 GW by 2030	2.6%
AUNZ	1.6%	-13% (2005)		10% (by 2020)			3%
BRA	5.6%	-18% (BAU)					2.7%
MEX	1.3%	-15% (BAU)		17% (by 2020[8])			2.8%

[2] Based on: European Commission, Joint Research Centre (JRC)/PBL Netherlands Environmental Assessment Agency. Emission Database for Global Atmospheric Research (EDGAR), release version 4.2. http: //edgar.jrc.ec.europe.eu, 2011

[3] Relative to 2005 or no-policy baseline (BAU) as specified in brackets; use your model baseline in the latter case. If emissions in baseline are lower, adopt those emissions for the regions and periods concerned.

[4] If GHG intensity reduction in baseline is higher, adopt it for the regions and periods concerned.

[5] Reference quantity is *always* electricity production except for EU27 where it is final energy.

[6] Kyoto GHG equivalent emissions including LULUCF. Intensity improvements measured relative to fixed MER / PPP scenario. If improvement rates in baseline are higher, adopt those rates for the regions and periods concerned.

[7] Rounded, originally by the year 2022.

[8] Rounded, originally by the year 2024.

LAM	3.5%	-15% (BAU)					2.1%
CAS	1.3%						2.6%
KOR	1.2%	-15% (BAU)			Wind: 8 GW (by 2020[9])		3.3%
IDN	6.3%	-13% (BAU)		7.5% (by 2025[10])			2.1%
SSA	5.3%						2.3%
CAN	1.7%	-5% (2005)		13% (by 2020)			2.4%
EEU	1.5%						2.6%
EFTA	0.3%						3.5%
MEA	3.6%						1.5%
NAF	1.2%			20% (by 2020)			1.5%
PAK	0.7%						1.9%
SAF	1.0%	-17% (BAU)					2.8%
SAS	0.5%						2.9%
SEA	3.9%			15% (by 2020)			2.1%
TUR	0.8%				Wind: 20 GW (by 2020[11])		2.3%
TWN	0.6%						3.3%

Targets are specified for the set of regions on which the harmonization of GDP trajectories is based.

Models that only include CO_2 or GHG emissions from the fossil fuel and industry sector, or total CO_2 emissions, should apply above emissions (intensity) reduction targets in 2020 and emissions intensity improvement rates after 2020 to the basket of GHGs included in their model.

If models show infeasibilities due to the implementation of the technology targets, those targets should be relaxed until the infeasibility is removed.

When aggregating those targets for the "harmonization" regions (i.e. the 26 regions used for the GDP harmonization and listed above) onto model regions, the following should be observed:

- **Region to region mapping:** Identify a mapping of harmonization regions to model regions. If harmonization regions do not fully map, modeling teams should identify the next best mapping between the two region sets (possibly using subregions of EU27, if EU27 spreads over two

[9] Rounded, originally by the year 2022.
[10] If your model only covers 10 year steps round to the year 2030.
[11] Rounded, originally by the year 2023.

model regions; see below). In the following, we provide instructions on how to aggregate climate policy targets of several harmonization regions to a single target for their corresponding model region. The EU27 regions may be split across several model regions in some models. In this case, the EU27 subregion in each model region should be assigned the same emissions reductions target (in percent reduction from 2005) and emissions intensity improvement rates as EU27. The target on renewable energy share in final energy should be split onto subregions using the information in Appendix III.

- **GHG emissions reduction targets:** Weigh the fraction of residual emissions under the target (w.r.t. baseline or 2005 emissions; e.g. 85% for the EU27 2020 emissions target) with the emission shares of harmonized regions in the year 2005 to derive the fraction of residual emissions (w.r.t. baseline or 2005 emissions) that is allowed for the model regions. If emissions targets of harmonized regions associated with a model region are a mix of reductions relative to baseline, 2005 and/or emissions intensity reductions, convert everything to one metric, e.g. emissions reductions relative to baseline, prior to the aggregation. This will require making the assumptions that the emissions growth in the (unknown) baseline of the harmonized regions is identical to the emissions growth in the baseline of the associated model region.
- **Renewable energy shares:** Identify the largest harmonization region associated with the model region (largest in terms of GDP (PPP) in 2005), and adopt its renewable energy target for the entire model region (implying no target if the largest region does not have such a target). Please find the harmonized GDPs (2005) for all harmonized regions below.
- **Installed capacity targets** of a model region is derived by adding the capacity targets of associated harmonization regions.
- **Emissions intensity improvements after 2020:** Let i = 1,…, n enumerate the harmonization regions mapped to the model region. Let E(2020) be the emissions of the model region in 2020 and $Y_i(t)$ the GDP of Region i (in fixed MER or PPP terms). Let ΔE_i be the share of the emissions of the Region i in the model region in 2005. Let r_i be the GHG emissions intensity improvement rate in Region i as defined above. Then the emissions target E(t>2020) of the model region is determined by $E(t) = E(2020) * (\Sigma_i \ \Delta E_i \ * Y_i(t) / Y_i(2020) * (1-r_i)^{t-2020})$.

Region	GDP 2005 in PPP according to AMPERE harmonization (billion USD/yr)
EU27	13552
CHN	7020
IND	2789
JPN	3987
USA	12682
RUS	1764
AUNZ	888
BRA	1396
MEX	1271

LAM	1866
CAS	273
KOR	1095
IDN	789
SSA	798
CAN	1181
EEU	558
MEA	2012
NAF	751
SAF	331
SAS	271
SEA	1410
TUR	706
EFTA	517
TWN	613
PAK	378

Appendix III: EU27 climate policy

DECARBONISATION SCENARIO FOR THE EU27

EU-27 GHGs emissions in kt CO_2-eq					
	1990	2005	2020	2030	2050
Total	**5,532,268**	**5,129,571**	**4,113,960**	**3,277,438**	**1,112,535**
Energy related CO_2 emissions	4,030,620	3,946,574	3,187,857	2,431,249	587,419
Non-energy related CO_2 emissions	329,515	304,458	305,685	304,884	33,556
Industrial Processes CO_2 emissions	296,008	274,923	279,989	288,055	29,003
Other CO_2 emissions	33,507	29,536	25,697	16,829	4,552
Non-CO_2 GHGs emissions	1,172,133	878,539	620,417	541,305	491,560

	Cumulative emissions in $MtCO_2$-eq.	
	2010-2050	2020-2050
Total	**123,585**	**78,876**
Energy related CO_2 emissions	90,576	55,501
Non-energy related CO_2 emissions	9,767	6,825
Industrial Processes CO_2 emissions	9,075	6,405
Other CO_2 emissions	692	420
Non-CO_2 GHGs emissions	23,242	16,551

The EU27 GHG emissions roadmap does not include LULUCF emissions.

Renewable energy share in energy roadmap modeled with PRIMES.

	PRIMES REFERENCE SCENARIO (2020)					PRIMES DECARBONISATION SCENARIO (2020)				
	RES share in gross power generation	RES-H&C (1)	RES-E (2)	RES-T (3)	Overall RES share (4)	RES share in gross power generation	RES-H&C (1)	RES-E (2)	RES-T (3)	Overall RES share (4)
EU-27	**33.75**	**20.37**	**33.62**	**9.98**	**20.08**	**34.31**	**20.80**	**34.19**	**10.94**	**20.57**
EU-15	**36.43**	**19.95**	**35.92**	**10.38**	**20.54**	**36.89**	**20.43**	**36.36**	**11.45**	**21.04**
New member states	**18.55**	**22.13**	**19.64**	**7.73**	**17.72**	**19.55**	**22.39**	**20.84**	**8.09**	**18.15**
Austria	78.11	28.74	80.17	11.84	34.07	77.87	29.59	80.00	14.23	34.95
Belgium	22.38	11.59	19.26	11.11	12.74	22.49	12.11	18.99	11.54	13.03
Bulgaria	16.35	20.01	20.85	6.06	16.24	18.01	20.36	23.15	6.34	17.05
Cyprus	17.83	21.44	17.69	3.91	13.27	19.35	21.27	19.33	5.11	13.76
Czech Republic	7.29	17.64	7.62	8.50	12.92	7.09	18.40	7.79	8.60	13.34
Denmark	56.21	33.38	53.38	10.11	29.67	56.93	33.86	54.13	12.01	30.30
Estonia	22.44	40.53	29.25	6.03	29.24	24.08	40.60	31.62	6.31	29.90
Finland	45.72	47.35	42.05	8.85	38.74	47.10	47.55	43.35	10.12	39.36
France	27.55	27.53	29.95	10.24	22.74	26.70	28.33	29.43	11.39	23.11
Germany	33.90	14.96	33.30	11.71	18.00	33.96	15.54	32.62	13.04	18.31
Greece	30.80	19.17	29.74	8.10	17.76	32.73	19.59	31.52	9.11	18.51
Hungary	18.19	16.66	17.39	7.44	14.27	19.03	17.29	18.17	7.87	14.81
Ireland	44.40	11.03	41.66	9.31	15.95	52.42	11.41	49.14	10.35	17.72
Italy	32.60	15.99	28.76	9.94	16.61	33.62	16.07	29.92	10.72	17.04
Latvia	69.97	53.41	68.03	6.76	40.33	71.15	54.53	69.09	7.57	41.14
Lithuania	24.19	34.04	25.29	6.98	22.97	24.65	34.18	25.77	7.27	23.14
Luxembourg	17.62	11.01	9.07	9.32	9.11	16.15	11.19	9.60	9.40	9.24
Malta	11.91	39.86	10.59	3.26	11.12	15.12	40.06	13.45	3.60	12.22
The Netherlands	29.19	10.55	29.21	8.68	13.80	29.78	10.79	29.83	9.59	14.19
Poland	11.69	21.94	12.13	8.59	16.13	13.06	21.93	13.49	8.83	16.42
Portugal	67.90	47.01	59.77	7.17	34.20	79.78	47.49	69.76	8.76	37.31
Romania	38.43	25.01	41.33	5.06	24.01	39.02	25.07	42.03	5.70	24.30
Slovakia	19.41	12.76	21.36	8.80	14.16	21.36	12.91	22.85	9.13	14.68
Slovenia	34.50	32.06	37.62	10.57	25.04	37.02	32.32	40.97	11.24	26.06
Spain	39.03	18.86	39.19	10.14	19.94	39.41	19.08	39.57	10.65	20.16
Sweden	67.11	74.84	71.64	11.63	56.22	69.33	75.46	74.08	13.98	57.70
United Kingdom	33.68	9.47	32.46	10.48	15.05	33.97	9.77	32.80	11.58	15.46

(1) Share of renewable energy in heating and cooling: gross final consumption of energy from renewable sources for heating and cooling (as defined in Articles 5(1)b) and 5(4) of Directive 2009/28/EC) divided by gross final consumption of energy for heating and cooling.

(2) Share of renewable energy in electricity: gross final consumption of electricity from renewable sources for electricity (as defined in Articles 5(1)(a) and 5(3) of Directive 2009/28/EC) divided by total gross final consumption of electricity.

(3) Share of renewable energy in transport: final energy from renewable sources consumed in transport (cf. Article 5(1)(c) and 5(5) of Directive 2009/28/EC) divided by the consumption in transport of 1) petrol; 2) diesel; 3) biofuels used in road and rail transport and 4) electricity in transport.

(4) Share of renewable energy in gross final energy consumption.