

Summary

RECIPE

REPORT ON
ENERGY AND
CLIMATE
POLICY
IN EUROPE



The cost of
Decarbonization and
Recommendations
for Europe

...

RECIPE DEMONSTRATES THE NEED FOR CREDIBLE CLIMATE POLICIES. THESE ARE PARTICULARLY VITAL FOR INVESTMENT DECISIONS. INDUSTRIAL AS WELL AS FINANCIAL INVESTORS NEED ROBUST GUIDANCE ON TECHNOLOGY CHOICES, INVESTMENT VOLUMES AND REGULATORY STRUCTURES.



WWF *for a living planet®*



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THE RECIPE PROJECT WAS SUPPORTED BY

the Allianz / WWF-partnership on climate change.

Allianz is a leading global financial service provider,

WWF is a leading global environmental NGO.

In this brochure WWF and Allianz have drawn interpretations and formulated recommendations based on the RECIPE synthesis report and summarize it for a broader audience's understanding.

The interpretations, opinions and recommendations in this brochure are those of WWF and Allianz and should not be attributed to the scientific research institutions. An in-depth description of the underlying scientific results is available from the RECIPE synthesis report.

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INTRODUCTION

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RECIPE SHOWS THAT AMBITIOUS CLIMATE CHANGE MITIGATION TARGETS ARE FEASIBLE AT LOW COST – BUT ONLY IF DECISIVE POLITICAL AND ECONOMIC ACTION IS TAKEN WITHIN THE NEXT TEN YEARS. OTHERWISE WE WILL FAIL TO AVOID DANGEROUS CLIMATE CHANGE.

1.1

CLIMATE SCIENCE:
THE CALL FOR ACTION IS EVIDENT

...

The global economy's appetite for energy is big and it is growing: Developing countries are catching up economically and the de-linking of economic growth from carbon emissions growth is far from being achieved in the developed world either.

At the same time, the earth's ability to digest the waste products of our energy consumption is decreasing. Latest scientific evidence suggests that global warming is proceeding more rapidly than previously anticipated, with growth rates of greenhouse gas emissions increasing steadily. Between 2000 and 2006 the world emitted about 234 Gt CO₂, which is 25–30 percent of the total carbon budget that we can afford to emit until 2050 if we want to limit global warming with a probability of 75 percent to no more than 2°C above pre-industrial levels and thus avoid dangerous climate change. Solutions for mitigation are becoming more and more pressing.

RECIPE shows that ambitious climate change mitigation targets are feasible at low cost – but only if decisive political and economic action is taken within the next ten years. Otherwise we will fail to avoid dangerous climate change.

The report on energy and climate policy in Europe (RECIPE) analyses the costs of global decarbonization: It does not come for free, but at a very moderate cost compared to what would result if no action was taken.

The independent research project has been funded by the global insurer Allianz and the global environmental group WWF with the aim of adding to the understanding of policy options at hand to limit global warming. Allianz' intrinsic interest is to be able to continue providing insurance solutions against natural disasters. WWF aims at driving the essential economy-wide low carbon transformation required to ameliorate the risk of dramatic and irreversible changes to the earth's systems. Research undertaken as part of the RECIPE project should help to broaden the understanding for necessary action as well as identify options in the business sector. The report further calls for crucially important credible and clear policy frameworks and regulation.

On the following pages, Allianz and WWF summarize and interpret the scientists' findings from the RECIPE synthesis report for a broader audience's understanding in this brochure. As such, some of the interpretations of the scientific consortium's results and findings in the synthesis report here were made by WWF and Allianz alone. When referring to investors in this summary paper, both industrial investors and private financial investors are being addressed. Likewise, the general conclusions are relevant to both categories of investors, while it must be kept in mind that requirements, e.g. on Return on Investment (ROI) and amortization periods, might very well differ between the two groups.

1.2

OVERVIEW OF FINDINGS

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The most severe impacts of climate change can likely be averted at costs corresponding to a reduction of global consumption between 0.7% and 4%, the report says¹. RECIPE confirms the findings of the report on climate change mitigation costs by Nicholas Stern in 2006 and tests these against even more rigid requirements for decarbonizing the world.

¹
For a stabilization target of 410 ppm CO₂

RECIPE EXAMINES:

THE DISTRIBUTION OF REGIONALIZED COSTS OF CLIMATE CHANGE MITIGATION: What are the costs for the six different regions² if each region has its share based on GDP or if every citizen is given equal emission rights? Based on the RECIPE results, Allianz and WWF conclude that a per capita allocation that gives developing and emerging economies some headroom for development with a subsequent participation in the reduction efforts represents one possible compromise accommodating most of the negotiation asks on the table prior to Copenhagen.

²
Clustered in a climate policy context in accordance with the Kyoto Protocol (e.g.: India, China, EU, USA, Rest of Annex I, Rest of Non-Annex I)

THE COST OF DELAYING ACTION: What are the costs if politicians decide to postpone climate action to the latest possible date? RECIPE demonstrates that early action is much less costly than “waiting and seeing”. This is principally because early action prevents actors from investing in carbon-intensive infrastructure which is expensive to decarbonize or even decommission at a later date. RECIPE models compute³ the significant cost reductions to be greatest for the EU, assuming the EU takes advantage of this “first-mover” opportunity and takes unilateral early action compared to the case of a delay in action by all world regions until 2020. Similarly, the USA bears lower costs if it jointly with other Annex I countries adopts climate policy targets immediately. An early solution will also generally minimize the costs per region compared to delayed action. What is crystal clear is that the world needs to act soon and create globally relevant frameworks for costs to stay low and to avoid dangerous climate change.

³
For the long-term stabilisation target of 450 ppm CO₂; these findings result in a scenario where eventually all world regions join the effort to contain climate change to manageable levels.

THE COST OF TECHNOLOGY CHOICES: What are the costs if different technology options are not available? RECIPE finds that avoiding dangerous climate change will be much more costly without achieving mass scale availability of renewable energy forms such as wind and solar. Carbon capture and sequestration (CCS), if proven to work, does also represent a least cost option.

Based on these findings the authors of RECIPE develop a view on:

THE ROLE OF EUROPEAN POLICY-MAKERS: What action would Europe need to take in order to benefit from its first-mover advantage? On the international stage, the EU has a beneficial first-mover and leadership role to ensure a global agreement on emissions mitigation is concluded. RECIPE also suggests that Europe follows the UK example on a Climate Change Act as a transition framework to better guide and monitor progress of individual member states and comments on necessary amendments to the European trading scheme and the EU Renewables Directive.

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THE PRECONDITIONS FOR EFFECTIVE CARBON PRICING: What are the mechanics that should govern a global carbon pricing scheme? RECIPE authors stress that the value of carbon prices will differ in different political regions for some time to come and suggest ways of merging those schemes – ultimately, active and effective carbon pricing is seen as crucial to initiating the transformation towards a low carbon economy. Policy instruments like emission standards, technology support policies, R&D funding etc. should be considered where they are most applicable and where markets are inefficient or malfunction. In the RECIPE modelling exercise these instruments are brought in complementary to carbon prices. The authors warn EU policy makers that free allocation of emission rights is disturbing the market and provides negative incentives to actually going green in investments – full auctioning should therefore be the allocation method of choice.

EU POLICY AND REGULATION OF DIFFERENT SECTORS IN EUROPE: When will the carbon-intensive sectors accounting for the lion's share of EU's emissions have to be carbon-free and what policy implications will have to follow? Decarbonizing the power sector is essential for staying within the calculated carbon budget for the century. This appears possible, the authors find, given that a range of low carbon technologies exists or seems in sight with targeted and extended investment support. In order to achieve the decarbonization of all sectors examined, policy-makers need to formulate credible mid- to long-term regulation to guide investments to flow into low-carbon technologies. The authors emphasize the critical role of the regulatory framework being clear and accepted by the investors for actual decarbonization to get underway. As an appropriate institutional design the authors suggest the adoption of climate change laws across Europe for setting such mid- to long-term targets and establish the required level of credibility. In the transport sector the ways to achieving the relevant decarbonization are significantly less clear and a wider mix of policies and technologies needs to be pursued. Industries such as cement and steel live on process-related emissions and accordingly have to master a major transformation in order to reduce CO₂ emissions. To trigger the decarbonization here the authors warn against exemptions for these sectors from the essential carbon price signal.

► RECOMMENDATIONS

for policy-makers and investors:

RECIPE lists a number of recommendations for both policy makers and investors. Both are strongly interlinked, as policy makers need to anticipate how investors would judge the credibility of any new regulation attempts and investors will need to believe that policy makers will formulate and apply stringent regulations eventually. Investment decisions directed one way or another determine technology development and deployment and thus ultimately the cost of mitigation against climate change.

1.3

THE RECIPE METHODOLOGY

• • •

Calculating economic growth over the century with and without climate change action: three models map out different mitigation scenarios. RECIPE's quantifications are based on comparison of models. Three structurally different energy-economy models (IMACLIM, WITCH, REMIND-R) represent different understandings of the world in its strategies to reach ambitious stabilisation targets. The models were developed by academic partners of the RECIPE research consortium⁴.

IMACLIM-R is a recursive-dynamic computable general equilibrium model, featuring high sectoral details. **REMIND-R** and **WITCH** are optimal growth models that simulate optimal development pathways for maximization of intertemporal welfare.

REMIND-R takes on a very technology-optimistic view – the “flexible tech world”. **WITCH** considers the world's energy system as rather inflexible – the “rigid energy and high efficiency world”, while **IMACLIM** models economic sectors in a different way, it gives the model actors only very limited foresight – the “short-sighted inertial world”.

4

The project assembles methodological knowledge from four academic project partners: Potsdam Institute for Climate Impact Research (Germany), CIRED (France), CMCC (Italy), and Climate Strategies (UK).

● EXPLANATION

The likelihood of 2°C:

Scientists (Meinshausen et al., Nature, April 2009) suggest that the “carbon budget” provides a solid indicator for staying below 2°C of global warming compared to pre-industrial levels. The carbon budget that remains for a robust (i.e. 75%) likelihood of staying below 2°C is around 1000 Gt CO₂ by 2050. According to this carbon budget until 2050, the modelled 450 ppm CO₂ scenario in RECIPE corresponds to a less than 50% likelihood of staying below 2°C, while the 410 ppm sensitivity assessment corresponds to a 57% likelihood of not exceeding 2°C. The models are based on carbon budgets of between 1360 and 1436 GtCO₂ by 2050. There is a clear need for further research on current energy economic modelling capabilities to look at stabilization at even lower emissions concentrations or even reduction levels.

	CUMULATED EMISSIONS (Gt CO ₂)			PROBABILITY OF EXCEEDING 2°C		
	BAU	450 ppm	410 ppm	BAU	450 ppm	410 ppm
IMACLIM-R	2404	1533	1366	97 %	58 %	45 %
REMIND-R	2650	1455	1436	100 %	51 %	50 %
WITCH	2235	1518	1360	94 %	57 %	43 %

RECIPE estimates the costs of mitigating climate change by looking at the cost differences between an assumed Business-As-Usual (BAU) scenario and the 450 ppm and 410 ppm CO₂ scenarios respectively. The BAU scenario applied in these models is based on the availability of cheap coal and an absence of meaningful climate policies. This will result in CO₂ concentrations of 730 ppm–840 ppm by 2100, inducing a global mean temperature increase of 3° to 7°C above pre-industrial levels.

The costs of mitigation RECIPE computes are calculated against the BAU growth in GDP, which does not take any account of costs resulting from accelerating climate change induced damages which are almost certain to occur at that level of temperature increase.

FINDINGS

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AN EQUAL PER CAPITA ALLOCATION OF THE CARBON BUDGET WITH HEADROOM FOR EMERGING AND DEVELOPING COUNTRIES SHOULD BE ONE WORKABLE SOLUTION, ALLIANZ AND WWF BELIEVE. YET THIS WOULD REQUIRE FINANCIAL SUPPORT FOR THE DEVELOPING AND EMERGING ECONOMIES TO ENSURE THEY PARTICIPATE IN SUCH AN AGREEMENT, THUS KEEPING AGGREGATED OVERALL COSTS LOW.

2.1 ECONOMIC COSTS OF DECARBONIZATION

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2.1.1 THE OVERALL COSTS OF DECARBONIZATION

The modelling results behind RECIPE confirm a moderate economic cost of decarbonization, calculating the costs at 0.7 % to 4 % of consumption losses (i. e. the fraction of economic output which can be consumed thus increasing welfare) when aiming for 410 ppm CO₂.

FOR EUROPE, THE MODELS PREDICT A 0.7 TO 3 % LOSS OF DISCOUNTED ANNUAL CONSUMPTION.

FOR THE WORLD, THE PREDICTED LOSSES RANGE FROM 0.7 TO 4 %, MEASURED IN DISCOUNTED CONSUMPTION LOSSES.

At an average annual growth rate of 3 %, each 1 % of consumption loss corresponds to a delay of global economic growth by 4 months. Thus, consumption losses of 3 % by 2050 indicate that it will take until 2051 to reach the welfare level that would otherwise have been reached in 2050.

Both calculations assume a stabilization target of 410 ppm CO₂. For stabilization at 450 ppm CO₂ in the atmosphere the global consumption losses would be at 0.1 and 1.4 respectively when compared to the Business-As-Usual scenario⁵.

⁵
These cost estimates and calculations do not consider possible costs of damages resulting from accelerated climate change, in which case mitigation becomes cheaper in comparison.

FIGURE A

CONSUMPTION LOSSES IN %

...

**A: AGGREGATED GLOBAL
CONSUMPTION LOSSES 2005-2100**

410 PPM
450 PPM

**B: AGGREGATED EUROPEAN
CONSUMPTION LOSSES 2005-2100**

EU 410 PPM
EU 450 PPM

WELFARE LOSSES
Global (A) and European (B) welfare losses as consumption differences relative to the baseline. Aggregated consumption losses discounted by 3%

5%

4%

3%

2%

1%

0%

CONSUMPTION LOSSES
Consumption is calculated as the fraction of economic output which can be consumed thus increasing welfare; consumption losses are best understood as a delay in time to achieve a certain level of welfare (each 1 % of consumption loss corresponds to a delay of global economic growth by 4 months assuming a growth rate of 3%, e.g. consumption losses of 3% by 2050 mean that it will take until 2051 to reach the welfare level otherwise reached in 2050)

IMACLIM REMIND-R WITCH

2.1.2

THE REGIONAL COSTS

...

● EXPLANATION

How should the global carbon budget be shared?

RECIPE examines four options for allocating carbon budgets, for example by GDP share or by converging in the long run towards an equal per capita allocation of CO₂ permits globally. One option calculated by RECIPE gives developing countries some headroom for development with a subsequent participation in the reduction efforts to allow them to catch up economically. On the 450 ppm basis of the RECIPE study, by 2050 per capita emissions globally converge to no more than 2t CO₂⁶, which implies immediate substantial reductions below Business-As-Usual in industrialized countries.

That “generic common but differentiated convergence allocation scheme” applied in the RECIPE scenarios is one representation of the questions on climate equity⁷. Per capita emissions levels in 2050 and beyond depend on the ultimate stabilization target and likely need to be much lower than 2t/capita in order to ensure a high probability to stay below 2°C warming.

■ FINDINGS

- All models agree that industrialized countries would benefit from a GDP share-based allocation while developing and emerging countries would be at a disadvantage (given their comparatively low GDP / capita today but significant future growth projections).
- The RECIPE models differ in their assessments of the regional distribution of costs for allocation rules that envisage a convergence of per capita CO₂ allowances by 2050, but they agree that for allocation schemes on an equal shares⁸ basis climate change action would result in acceptable levels of mitigation costs across regions. No region would face more than 5 % consumption losses.
- Financial transfers needed to enable low-carbon development particularly in emerging and developing countries have to be part of any future setting to keep global mitigation costs low.
- China’s recent and near-term economic growth is reflected in its increasingly carbon-intensive infrastructure. Concluding from RECIPE it would therefore result in higher costs if this recent infrastructure build-up was continued unaltered only to be decarbonized at a later stage.

⁶ The figure of two tonnes of CO₂ per capita as the available budget will also need to be revisited (probably significantly downwards) in the light of tightening climate caps and with a view to the likelihood of avoiding dangerous climate change.

⁷ WWF and Allianz are not promoting any particular approach to distribute the finite global greenhouse gas budget between 1990 and 2100 (GHG Development Rights, Common but differentiated Convergence, etc.)

⁸ A per capita allocation with headroom, common and differentiated convergence.

► RECOMMENDATIONS

World leaders struggle to agree on a climate deal and RECIPE’s findings provide some direction. A deal needs to reflect considerations of global climate equity between countries and generations, Allianz and WWF believe. An allocation scheme with Equal per capita allocation of the carbon budget with headroom for emerging and developing countries is one option on the table in current negotiations (e.g. the Greenhouse Gas Development Right Framework is another). Such a deal on climate change would require financial support for the developing and emerging economies to ensure they participate in such an agreement, thus keeping aggregated overall costs low.

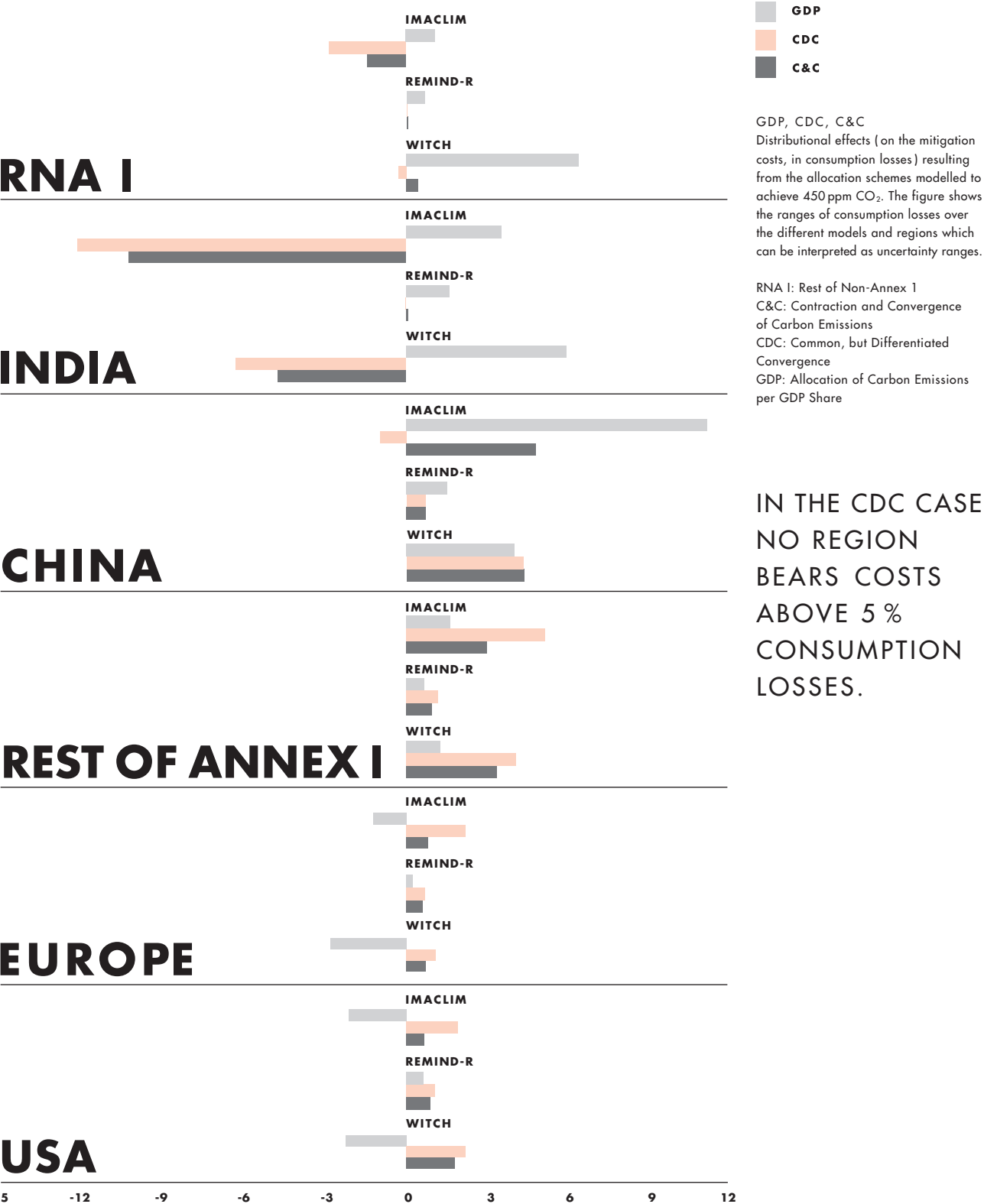
The authors of RECIPE also point out that investors will need to play their role in facilitating technology and finance transfers.

FIGURE B

CONSUMPTION LOSSES

IN % 2005–2100

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2.2

THE COST OF DELAYING ACTION: EUROPE HAS FIRST-MOVER ADVANTAGE

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● EXPLANATION

RECIPE estimates that wasting the next decade to take meaningful action on climate change results in an increase of mitigation costs of at least 46 % compared to early action. Such a delay would also require an overshooting of CO₂ concentrations beyond 450 ppm for a certain period of time before returning to 450 ppm territory which lowers the probability of staying within 2°C.

These costs⁹ result from delaying climate action and are estimated in scenarios for six regions.

Delaying action to combat climate change beyond the next decade, i. e. postponing real emissions reductions to take effect only in 2030, will make it infeasible to achieve a 450 ppm CO₂ scenario, thereby significantly increasing the risk of missing the 2°C threshold.

For an increased likelihood to staying below 2° warming Allianz and WWF consider stricter targets, i. e. 410 ppm and below, to be even more at risk from delaying action.

Four different delay scenarios are assessed, with the regions taking action at different points in time in different constellations.

THE WINDOW OF OPPORTUNITY IS QUICKLY GETTING SMALLER AND WILL EFFECTIVELY BE CLOSED AFTER 2020. AND EVEN THAT IS BASED ON THE MOST OPTIMISTIC ASSUMPTIONS AS MODEL RESULTS ASSUME THAT THE ACTORS INVOLVED BEHAVE IN OPTIMAL AND RATIONAL WAYS BUT “REAL NEGOTIATORS” ARE DRIVEN BY MANY INTERESTS.

■ FINDINGS

The world’s political leaders are trapped in a dilemma: Leaving the carbon-based world behind comes at costs the allocation of which is the contentious point. However, postponing action makes mitigation efforts more expensive – a first mover is required to break this deadlock.

- The EU can be such a first-mover as it would benefit economically from such an early move. It reduces the costs of mitigation to itself (and globally), even if the other regions do not participate at the same time.
- The US also benefits from mobilizing all Annex I countries of the Kyoto Protocol jointly with the EU to move early (as the Rest of Annex I is not modelled in detail no further regionalized conclusion can be drawn.).
- China benefits from moving early with Annex I.

9

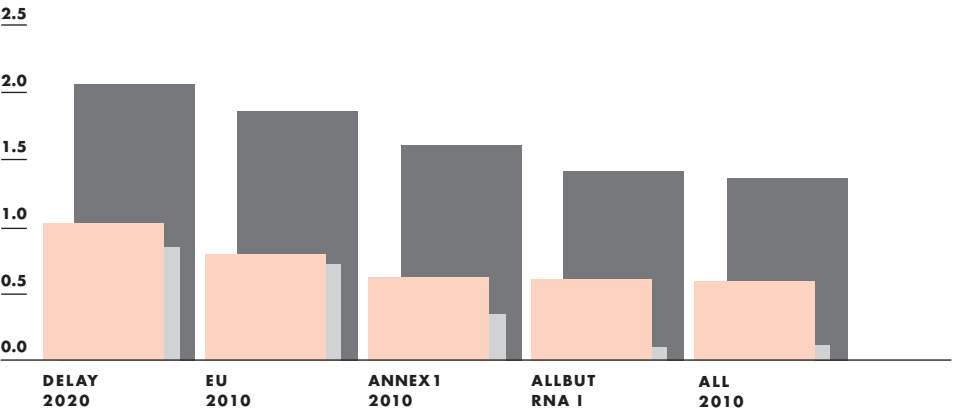
In figure C these costs are represented by the differences between the rightmost and leftmost bars per model result across the scenarios

FIGURE C

DELAYING CLIMATE ACTION

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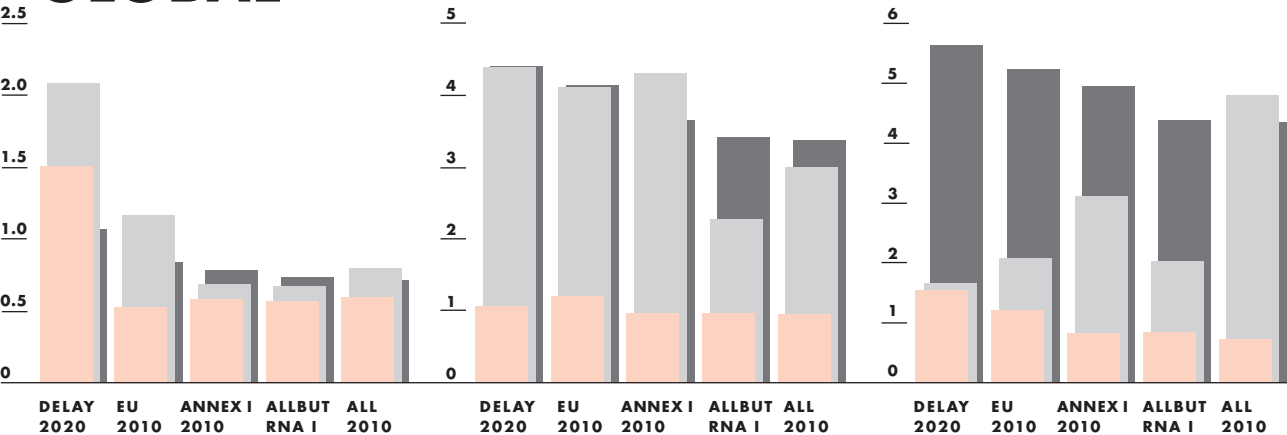
REMIND-R
IMACLIM
WITCH



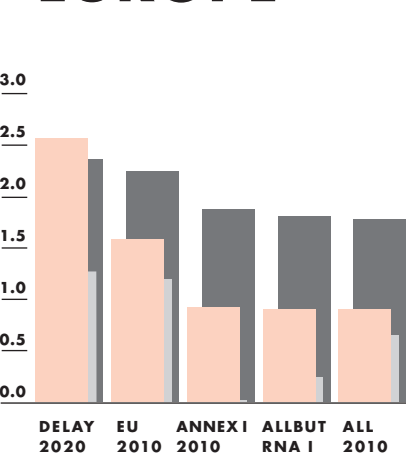
MITIGATION COSTS
(displayed as consumption losses and relative to baseline) for various scenarios with delayed participation in a global carbon market, and the benchmark case with global participation from 2010. Consumption losses are differentiated for all world regions modelled in the scenarios of fragmented action. (please note different scales)

SCENARIOS
DELAY 2020: All regions delay action until 2020
EU 2010: Only EU acts by 2010, others only by 2020
ANNEX 1: All Annex 1 parties act by 2010, others only by 2020
ALLBUT RNAI: All parties except the rest of the NON-ANNEX 1 act by 2010, others only by 2020

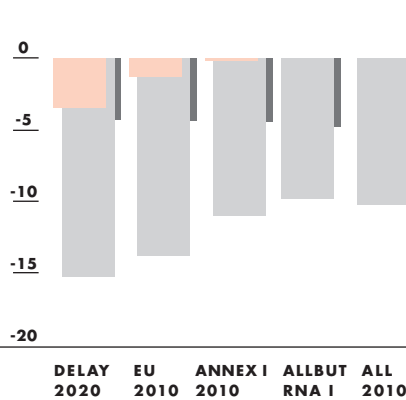
GLOBAL



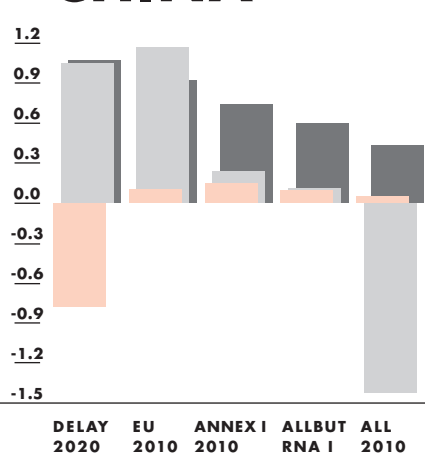
EUROPE



REST OF ANNEX I



CHINA



USA

INDIA

RNA I

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► RECOMMENDATIONS

Immediate climate change action pays off for Europe: By moving first in implementing ambitious carbon reduction targets, Europe's economy benefits as it foregoes investment into carbon-intensive infrastructure that otherwise would have to be dismantled well before the end of its economic life. Such policy actions had already been expressed at the 2008 EU Spring Council with the EU reduction pledge of 30% by 2020 in case of multilateral action. The IPCC in its findings from the fourth assessment report calls for up to 40% reduction by Annex I countries by 2020 which would constitute an adequate response by the EU to solving the climate crisis.

Emerging economies need to avoid further first-time build-up while the developed world must not revitalize or strengthen carbon intensive production modes. In an optimal world with a universal carbon price and easy access to investments every region would act accordingly. The real world requires real first-movers and RECIPE demonstrates that Europe has every reason to move first.

RECIPE demonstrates the need for credible regulation which is particularly relevant for investment decisions. Industrial as well as financial investors need robust guidance on technology choices, investment volumes and regulatory structures.

Investment decisions are a function of the credibility investors assign to future regulation and the direction and stringency they will bring – guiding expectations is fundamentally critical.

Allianz and WWF call for the EU to take on the first-mover role by strengthening its multilateral 30% in line with the IPCC request, i. e. to 40%. Moving first and mobilizing the Annex I group to join in the effort will benefit the EU further.

2.3

CARBON MARKETS – THE GLOBAL PRICE FOR CARBON

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● EXPLANATION

RECIPE identifies a global price for CO₂ as an essential instrument to internalize costs of climate impacts and to trigger technology innovation and efficiency improvements. Carbon markets are one option for establishing a global carbon price and as an instrument, cap and trade systems are increasingly being established in the OECD countries.

While in reality significant amounts of carbon certificates have been handed out for free in existing trading schemes, RECIPE identifies full auctioning of carbon allowances as essential for the carbon price signal to have the required effect. As carbon markets suffer from market failures, there needs to be supportive and additional policy action, RECIPE says. Complementary instruments need to be applied where carbon pricing alone is insufficient to induce the low-carbon transition, for example to foster the market introduction of renewables.

■ FINDINGS

The RECIPE authors recommend to link regionalized carbon trading schemes (within the OECD for instance) and the creation of a global market via linking, i. e. in a bottom-up manner¹⁰. To link developing countries into such a global carbon market, clear incentives for decarbonization and financial transfers not immediately based on binding reduction targets for developing countries need to be developed. The concept of National Appropriate Mitigation Actions (NAMAs) is set to facilitate the transition of specific sectors in developing countries to low-carbon growth paths. NAMAs need to be supported by capacity building, technology transfer, financial investments, and reporting requirements that help encourage mitigation efforts.

10

This is not to say that linking should substitute government trading. Different architecture options are feasible where one has coexistence of Kyoto-style trading and linking

► RECOMMENDATIONS

Policy makers:

Mid- and long-term targets and regulatory transparency need to be ensured to stabilize investors' expectations. Mechanisms need to be established that enable Non-Annex I countries to move ahead in their decarbonization and efficiency improvement efforts (no-lose targets, NAMAs, financial transfers).

Allocation of emission allowances in a linked-up system of several carbon markets has to be effective in inducing CO₂-reductions and establishing a robust price signal. Full auctioning serves this requirement. The level of exposure of industries to carbon leakage decreases with symmetric carbon prices, i. e. once the same carbon price applies globally in a growing global carbon market.

2.4

THE ROLE OF TECHNOLOGIES AND A CLOSER LOOK AT EU SECTORS

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● EXPLANATION

RECIPE is a comparison of models describing idealized scenarios. Additional to the policy scenarios, the project examines option values across the range of low carbon energy technologies. Furthermore, the scenario-world was given to sectoral experts across Europe to perform a “reality check” on four highly carbon relevant sectors in Europe, namely power and heat, industry (cement/steel), transport, and agriculture. These are amongst the sectors most impacted by the decarbonization of the world over the course of the century.

The models examined energy demand pathways by sector in line with the requested GHG emissions reductions. While RECIPE models the energy supply side explicitly, it assumes energy efficiency potentials to be taken up automatically when energy prices rise. In this world where energy demand grows significantly, avoiding dangerous climate change will be much more costly without achieving mass scale availability of renewables. Carbon capture and storage (CCS), if proven to work, also represents an economically important option. As shown here by RECIPE, the technology option value¹¹ of nuclear technology is comparatively low.¹²

The authors point out that reality does not see the certain mobilization of energy efficiency potentials even at negative costs. To reap those potentials, additional and robust regulatory efforts are required to ensure energy efficiency is increased significantly while ensuring that rebound effects¹³ do not eliminate these again.

The authors of RECIPE acknowledge that all technology options need to be assessed with full consideration of risks attached to them¹⁴.

IMACLIM, REMIND-R and WITCH model different levels of sector breakdown with IMALCIM having the highest level of differentiation between sectors. Figure E shows European CO₂ emissions by sector. The emissions abatement – the area between the 410 ppm path (dotted line) and the Business-As-Usual emissions (upper limit) can be attributed to the different sectors (brown colours). RECIPE demonstrates very clearly the transformational shifts required in energy end-use sectors, particularly electricity generation and, in the medium to long term, transport. Additionally, for sectors like steel, cement, and agriculture, which are characterized by inherent process-related CO₂ and other GHG emissions, the transformation will require some more fundamental rethinking of hitherto applied process structures.

11

Technology option value – a concept applied by RECIPE to assess how indispensable a technology option is. If the option value is high, the technology is crucial to meeting mitigation objectives at low cost. If the value is low the technology is not important and mitigation targets could be delivered without its use.

12

WWF and Allianz have their own views on individual energy sources, in particular with regard to nuclear energy. WWF position: WWF considers nuclear power an unacceptable balance of risk over benefit due to its very limited mitigation potential, costs, radiotoxic emissions, safety, and proliferation impacts, as it could cause major disruption to human populations as well as to the environment. WWF sees a system's conflict from nuclear hindering the required expansion of renewables. Allianz position: Allianz considers nuclear power as a transition type of energy source and as an insurer Allianz particularly weighs the risks associated with nuclear energy. Allianz respects the fact that governments and not the insurance industry have to decide on the employment of this technology.

13

The rebound effect refers to the fact that energy efficiency improvements have rarely proven to be permanent but that increased energy demand from other uses has tended to offset savings. An example would be the increased use of efficient appliances or services being offset by increases in size from previously smaller appliances etc.

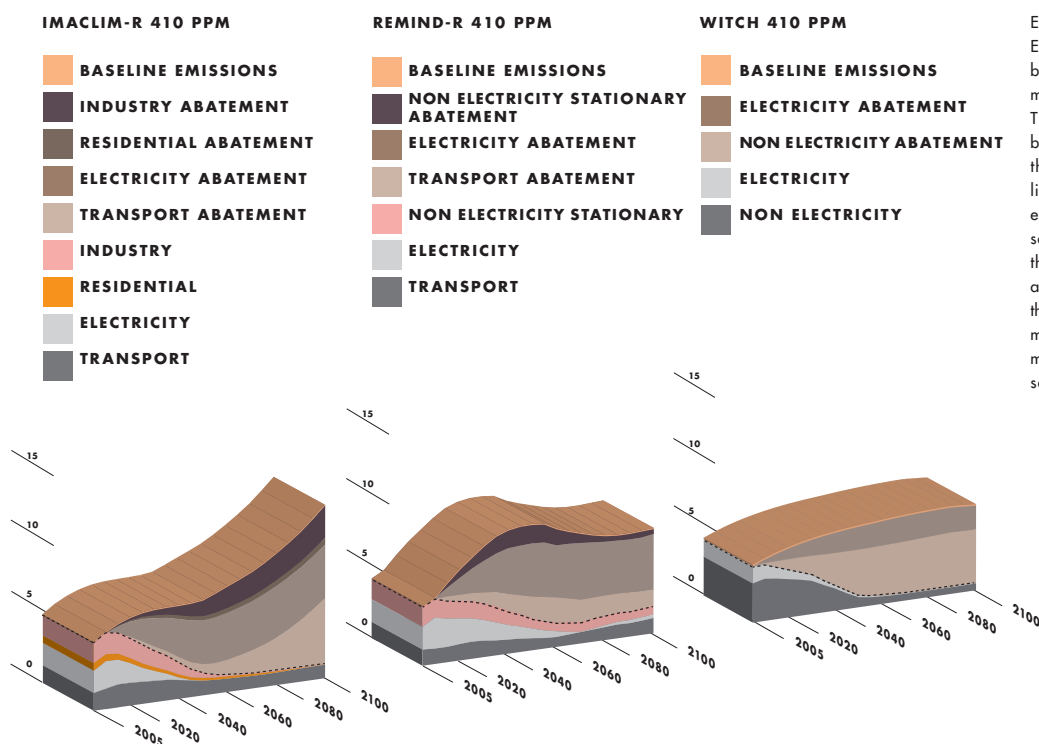
14

The modelling exercise did not cost all risks associated with technologies, but qualitatively described the associated risks of the respective technologies. Cost estimates applied in the models cover operational and capital expenditure.

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PRIMARY ENERGY SUPPLY
The figure demonstrates the composition of the primary energy supply for Europe in a 410ppm CO₂ scenario for the century. The use of fossil fuels w/o CCS will have to be drastically reduced.

FIGURE E



EUROPEAN CO₂ EMISSIONS
European CO₂ emissions decomposed by different sectors for the different models in the 410 ppm scenario. The upper limit indicates the derived baseline emissions development for the business as usual case. The dashed line demonstrates the aggregated emissions pathway for the 410 ppm scenario – the brown colours is thus what is required in emissions abatement which can be attributed to the different sectors broken down by the models (this breakdown differs by model, IMACLIM delivers the most sectoral differentiation).

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■ FINDINGS

EU POWER AND HEAT SECTOR: DECARBONIZING THE SECTOR WELL BEFORE 2050

The RECIPE authors consider full decarbonization of the energy sector well before 2050 to be feasible if renewables and carbon sequestration and storage technology (CCS) are available at mass scale, given the underlying energy demand modelling. CCS, if proven to work large-scale, in combination with biomass is considered a technology option that can even generate negative emissions.

The authors observe that the capacities and capabilities of the electricity grid structure in Europe are insufficient. Smart grid structures would need to be established immediately. According to RECIPE this has to be accompanied by improved grid regulation.

Energy efficiency improvements will require additional measures since market failures prevent them from being driven by energy price increases. Efficiency improvements can create leeway for transforming the energy supply side, but rebound effects need to be prevented.

EU INDUSTRY (CEMENT/STEEL): FUNDAMENTAL RESTRUCTURING EXPECTED FROM 2020 ONWARDS

The European steel and cement industries need to fundamentally change their processes in a future carbon free world. From 2020 onwards the authors expect the next “natural” investment cycle in these industries in Europe; the models assume only limited potential for decarbonization before that time. Electrification is assumed to act as a major driver for short- to mid-term reductions as it means “shifting emissions” related with conventional processes to the electricity sector which is assumed to have the easiest and least costly decarbonization options.

Short-term reductions until 2020 are seen as very difficult to achieve at low cost looking at the economics and lifetimes of today’s installations. An undistorted carbon price signal is essential to guide industry players to decarbonization, says RECIPE and demands the full auctioning of emission certificates today in order to achieve this. Only a few industries are subject to leakage¹⁵, and where proven, compensation through efficiency improvement support is considered one option for easing those pressures. To guide current measures and give direction to the industry’s next investment cycle, once again credibility of future regulation is crucial.

EU TRANSPORT: DIVERSE POLICY MIX NEEDED TO MANAGE THE SHIFT TOWARDS LOW-CARBON TRANSPORT

Addressing the transport sector is crucial to decarbonizing Europe. Transport volumes are continuing to rise and no clear decarbonization option exists. Until now transport has not been a major policy focus. Technical options such as electrification and alternative fuels such as hydrogen and sustainable biofuels still require intensive research and development.

¹⁵

Carbon leakage describes the pressure from asymmetric carbon prices, i. e. carbon prices increasing production costs in one region but not applied elsewhere will make production less profitable given that only one competitor has to bear them. Only a few industries are subject to carbon leakage, and policy options need to be considered while asymmetric prices persist. The first-best solution would be to establish carbon prices universally.

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The abatement costs for transport will eventually become a determining factor for CO₂ prices and overall abatement costs in the future. IMACLIM suggests a mix of infrastructure policies, regulation on vehicle efficiency, etc.. As full electrification of the transport sector is not implemented in the models the role of policies to support a high penetration of a plug-in hybrid fleet etc. cannot be assessed fully.

WWF and Allianz interpret the findings that electrification seems required for containing the volume of liquid fuels in transport from 2016 onwards.

EU AGRICULTURE: MORE SINKS, LESS FERTILIZERS AND REDUCED METHANE EMISSIONS FROM “LIVESTOCK FARMING”

The emissions from agricultural production and related industries (e.g. production of fertilizers) are numerous. No single mitigation option will solve the problem. The most promising mitigation options are:

- Protection of existing but degraded and greenhouse gas emitting carbon sinks like bogs and grassland.
- Reduction of nitrogen emissions from fertilizers (mineral and manure) after application to the ground.
- Reduction of methane emissions from cattle through reduced meat and milk consumption.

Apart from the mitigation of greenhouse gases from agricultural production, the sequestration of CO₂ in soils and vegetation is crucial. The stored carbon is very vulnerable to later release, as effective storage highly depends on land use practices.

► **RECOMMENDATIONS**

for policy-makers (per sector)

POWER: CARBON EFFICIENCY STANDARDS OF POWER PLANTS TO BE CONSIDERED AS ADDITIONAL POLICY INSTRUMENTS

The models deployed by RECIPE calculate that there is de facto no room for new installations of conventional coal power production – investments into coal fired power plants without CCS have to be phased out immediately. Regulation would need to reflect this. In view of these findings, policy makers should consider carbon efficiency standards across Europe as a supplementary regulatory instrument to the emissions trading scheme.

Decreasing energy demand will open up more options for the power sector to be supplied with carbon free technologies. More flexibility¹⁶ and leeway to actually decarbonize the energy supply helps reducing the dependency on individual technologies.

Additional policies to ensure accelerated development of low carbon technologies are required. Feed-in schemes for renewables and publicly funded innovation programmes have proven effective. Technology selection in general needs to consider the entire

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'Flexible' shall be understood as for a wide number of co-existing or substitutable technologies

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risk profile of the respective technologies. RECIPE finds that nuclear has a low economic option value.

Despite Europe being less dependent on CCS technology, RECIPE finds that an EU-wide regulatory framework is needed to set the rules for intensive testing and trialling of that technology.

Energy research and development budgets and deployment of pilot plants need to be significantly increased and directed towards the renewables, energy-efficiency technologies, and CCS.

INDUSTRY (CEMENT AND STEEL):

Full auctioning of emission certificates is necessary.

The steel and cement sectors are most dependent on clear and credible signals of rigid climate policy. Therefore, mitigation efforts in these sectors would actually benefit in the long-term from full auctioning of carbon emission rights under the European Trading Scheme of CO₂ allowances, because this would constitute such a signal. Free allocation would actually reward carbon intensive production and send the wrong signal to the industry instead of incentivizing decarbonization.

TRANSPORT:

To date, no low-carbon transport technology has reached scalability. Policy options therefore need to focus on the following:

- Effective and long term efficiency regulation for all vehicle classes.
- Choices of technology options should be made considering the decarbonization options of the energy carrier. Today only electrification can tap low energy potential.
- Transport must receive a larger share of research and development funds to support low carbon technologies' large scale deployment.
- Infrastructure investments should be redirected to alternative fuels and electrification infrastructure as well as to freight rail.
- Technology policy alone is insufficient from today's view (IMACLIM model result). Strong additional regulatory and pricing policies to reduce transport demand and induce modal shift will have to be established in order to contain rebound effects of efficiency gains.

AGRICULTURE:

- In the future, the EU Common Agricultural Policy's funding instruments also need to be based on the greenhouse gas emissions (GHG) intensity of practices they support¹⁷. Rewarding low GHG-intensive practices etc. may lead to reductions of greenhouse gas emissions from agriculture.
- Biomass use for energy production has a certain potential to mitigate CO₂ emissions by substituting fossil fuels. The introduction of sustainability standards for bioenergy crops and biofuels is crucial to avoid environmentally and socially misguided developments.

¹⁷
e.g. input or surplus amounts of
nitrogen fertilizers

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► RECOMMENDATIONS

to Investors (by sector):

The shift to a low-carbon economy is a transformation process that requires significant investment volumes. RECIPE projects investments in low-carbon technologies to amount to about 0.2 % to 1 % of world GDP (over 21st century), while investments in conventional fossil fuel based sources of energy generation would fall by US\$ 300 to 500 bn. A significant part of these investments needs to be raised by private investors.

POWER & HEAT:

- Investments into coal fired power plants without CCS have to be phased out immediately in order to limit global warming below 2°C – or the likelihood of those to be rendered stranded investments from 2020 onwards will increase significantly.
- Technology choices need to be made in considering the full and comprehensive overview of risks attached to the technology – current assessments partly miss out on pricing all risk components – investors need to take a holistic approach. The key investment areas for the private sector in power and heat production and diffusion will be in renewable energies, storage systems and grid development. Additional Investments in low carbon technologies in the range of 0.2 % to 1 % of world GDP over the course of the 21st century are required.

INDUSTRY:

- The decarbonization of Europe's steel and cement industries as described in the RECIPE scenarios proceeds in partly overlapping stages:
- Efficiency improvements are foreseen as the only economical option by 2020 given existing installations.
- With an expected major new investment cycle in the industry, electrification of processes to reduce emissions from direct fuel use and the development of new, less carbon intensive processes or technologies follow from 2020.
- Carbon constraints will cause significant transformation in the industry. The potential impacts will have to be integrated into assessing value at risk or opportunities for investors.

TRANSPORT:

- Investments need to be considered with a time horizon to and beyond 2015/20 when transport will become the focus of carbon regulation. Growth in fossil and other high-carbon fuel use is not acceptable when aiming to avoid dangerous climate change.
- Electric vehicle infrastructure and electric fleets are priorities and key fields for investments to create market dynamics while RECIPE points to the uncertainties for how to decarbonise the transport sector in total.
- Location of production facilities and structure of supply chains for transport intensive industries will play a more crucial role as transport moves to the centre of carbon regulation and international transport is at the focus of an international climate regime.
- Biomass can only be accepted if it is sustainably produced and all (indirect) carbon emissions implications from land use changes are captured.

RESEARCH BASED FINDINGS FOR THE EU – SUMMARY FROM RECIPE SYNTHESIS REPORT

BY PIK, CMCC, CIRED, UNIVERSITY CAMBRIDGE EPRG:

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The RECIPE authors lay out a low carbon transition framework for Europe from a scientific perspective:

A LOW-CARBON TRANSITION FRAMEWORK FOR EUROPE

The Directives under the EU Climate and Energy Package provide for 20 % emission reduction by 2020 relative to 1990. The effort increases to 30 % in case of comparable efforts by other major emitters. Moreover, they set a binding target for renewable energy generation of 20 % of primary energy consumption to be reached by 2020. Europe's next step should be to launch a societal deliberation for developing a long-term trajectory for the transition towards a low-carbon economy by 2050, comprising for example legally binding reduction targets. Redirecting current investment flows is of paramount importance for the size of the final mitigation bill. Regulators should therefore provide:

- 1 AN INSTITUTIONAL FRAMEWORK** that regularly monitors progress of individual Member States against the transition path into a decarbonized economy. The UK's Climate Change Act could serve as a blueprint for Europe's transition framework.
- 2 A STRENGTHENED EU ETS**, that (i) expands its temporal reach along a trajectory consistent with the EU's fair share of reaching the 2°C target and extends coverage post 2020 to additional sectors where this enhances long-term predictability to low-carbon investors, (ii) clearly defines opportunities for low-carbon investments in Europe by limiting CDM use as EU emission reduction target is increased to 30 % as part of international deal, and (iii) reduces investment uncertainty and perverse incentives from free allocation by exploring international cooperation and other options to address leakage concerns in sectors considered at risk of leakage.
- 3 A RAPID AND ROBUST IMPLEMENTATION OF THE EU RENEWABLES DIRECTIVE.** RECIPE indicates that renewables will play a central role in any future low-carbon energy mix. The Renewables Directive allocates national objectives and the guidance on reporting expects Member States to characterize technology mix and complementing policies. Effective use of renewable power from intermittent sources will require flexible power market design integrating energy, transmission and balancing markets and the demand side, tailored network expansion, and financial mechanisms like feed-in tariffs that address policy risk. The Commission has to negotiate stringent compliance mechanisms so as to enhance the credibility of the national targets.
- 4 UP-SCALED RD&D FUNDING**, in particular for transportation and power generation technologies that are compatible with full-scale decarbonization of EU's energy system. Regulators should expand research grants and support demonstration projects for immature technologies. In this light, the EU CCS Directive is a laudable starting point but innovative renewable energy technologies deserve more attention.

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5 NON-MARKET BASED POLICIES as a complement to carbon pricing preventing a further build-up of emission intensive capital. RECIPE shows that conventional coal-fired capacities without CCS are phased out prior to 2020 under a cost-efficient stabilization path. In presence of inertia in utility investment behaviour, regulators should evaluate additional policies which limit the use of coal without CCS.

6 SUPPORT FOR DEVELOPING COUNTRIES in their transition to low-carbon growth. This requires technical assistance and capacity building, technology cooperation and public finance to contribute to incremental costs at a scale suitable for the challenge, including dedicated auction revenue from the EU ETS and from carbon pricing in international aviation and shipping.

Domestic regulations of this kind would enhance Europe's credibility in international climate negotiations while also lowering future cost of climate stabilization. RECIPE indicates that even if the introduction of climate policy is delayed in other parts of the world, Europe will enjoy a first mover advantage when unilaterally implementing stringent mitigation measures. The window of opportunity to prevent dangerous climate change at bearable cost is narrow and closing. Without a Europe that goes ahead by demonstrating the feasibility of effective climate governance, the global community is likely to miss this window of opportunity.

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