Low climate IMpact scenarios and the Implications of required Tight emission control Strategies

Reporting

Project Information

LIMITS

Grant agreement ID: 282846

Project website

Project closed

Start date
1 October 2011

End date
30 September 2014

Funded under
Specific Programme "Cooperation": Environment (including Climate Change)

Total cost
€ 4 462 878,50

EU contribution
€ 3 462 863,00

Coordinated by
FONDAZIONE ENI ENRICO MATTEI
Italy

Final Report Summary - LIMITS (Low climate IMpact scenarios and the Implications of required Tight emission control Strategies)

Executive Summary:
Climate change is one of the greatest challenges of our civilization. Its encompassing, long lasting and uncertain nature also make it one of the most difficult problems ever faced. Assessing the transition from

current emission trends to a long term target of carbon neutrality has occupied researchers and policy makers in the past several years. However, the transitional problem has been mostly characterized globally, without an explicit representation of what implementing stringent climate targets would actually mean in all the major emitting countries. This is the challenge at the core of the LIMITS project. For the first time, a series of models designed to study the interplay between the economy, the energy and land use sectors, and the climate –the so called integrated assessment models- has joined forces to investigate the implementation consequences of post 2020 climate agreements in all the major economies.
Supported by local experts in key emerging economies, these global models have worked out the consequences of future climate, environmental and energy legislation for the major economies. The research effort has significantly increased the understanding of the challenges and opportunities that different countries face when deciding to combat climate change. By comparing different policy scenarios, entailing different degrees of regional ambition, global cooperation and policy coverage, this project has provided the most comprehensive model based assessment of the regional implications of managing climate change.
In order to do so, a community based approach to research has been put into place. Different teams from different countries have simulated a variety of different policy outcomes, informing the scientific and policy debate. The project has led to an remarkably large number of publications (at the date of writing, 49), in the peer reviewed literature and in prestigious journals. Many of the papers produced in LIMITS have been cited in the IPCC 5th assessment report, with several researchers involved in both activities. The research outcome has helped inform the currently ongoing international climate negotiations, and has been disseminated in a number of stakeholder meetings and conferences around the world. The main research insights can be summarized as follows:

• Near-term policies can provide important impetus for long-term action
• The 2°C target calls for a peaking in emissions of all the major world regions within this or the next decade
• A limit of 2°C would require a significant reduction of carbon budgets in all major economies, to about half of what currently proposed in the negotiations
• The potential for mitigation options differs among regions
• Regional characteristics imply different mitigation patterns and costs: under the same carbon tax, developing countries would pay a higher cost
• Climate policies lead to major reductions in air pollution, with large near-term health benefits
• Climate policies would significantly improve energy security, but not viceversa
• Effects of climate policies on energy security vary among regions

Project Context and Objectives:
LIMITS is a 3-year research project that aims at advancing the understanding of the implementation of climate policies consistent with 2 degree Celsius. The main objective of the project is to provide an assessment of the emissions reductions strategies at the level of the world and the major global economies, and to assess their implementation in terms of:
• Defining emission reduction pathways according to different assumptions about technology availability, policy regimes, implementation obstacles, and evaluating the regional distribution of mitigation at the level of major economies;
• Assessing the investment requirements to implement these transformation pathways and the finance

mechanisms such that these resources can be best raised and allocated. Evaluating the national and international policies which are needed to ensure that the transition to a low carbon energy infrastructure is attained efficiently, given specific obstacles in the respective economies;
• Quantifying the changes in the energy infrastructure and land use which major economies need to implement to attain stringent climate policies;
• Evaluating the linkages of climate policies with other issues such as energy security, air pollution and economic development.

The LIMITS project assesses a series of critical questions which are especially relevant for climate policy making:
• What is the economic and technical feasibility of attaining stringent climate policies?
• What are the investment requirements to implement the necessary energy system transformations and how can countries foster the needed investments?
• What is the role of policies in promoting mitigation, recognizing the diversity of regional and national interests?
• Can mitigation policies help countries to attain co-benefits related to energy security and air quality?
LIMITS used results from multiple state-of-the-art integrated assessment models to gain insights into these questions.

In order to explore these dimensions, LIMITS has involved ten partners from Europe, China, India, and collaborators from the US and Japan. The project brings together experts in several different domains which include integrated assessment modelling, energy system analysis, finance, economic development, land use and agriculture.
LIMITS can count on a very strong team, with 10 lead authors of the IPCC 5th assessment report WGIII participating in the project. Key integrated assessment models, including all the ones that generated the Representative Concentration Pathways, are involved in the generation of integrated low carbon scenarios.

The project is structured around 7 main work-packages and aims at carrying out and disseminating original research in the field of climate and energy policies. The first 4 work-packages contain the bulk of the research work to be carried out in the project. Specifically, WP1 is designed to establish a comprehensive set of “2°C scenarios” which can serve as a framework for more detailed investigations throughout the rest of the project. WP2 analyses the policy, institutional and financial requirements to implement 2°C policies in the major economies. WP3 looks into the feasibility of the rapid changes required in the energy infrastructure and land use patterns in major economies. Finally WP4, analyses how stringent climate mitigation policies impact and affect progress towards major national goals, in particular energy security and air pollution, as well as economic growth and development.

In addition to research, LIMITS aims at reaching out and disseminating the results to a large audience. To this ends, several project and stakeholders meeting have been held in Italy, Austria, Germany, the Netherlands, China and Belgium.

Project Results:
1. Regional mitigation pathways

Although challenging, it is still possible to achieve the 2°C target if emissions are reduced rapidly in the decades after 2020. Given that climate policies require national and regional action, the most important challenge of the Durban Platform is to ensure that stringent climate policies are implemented in large GHG-emitting countries and regions shortly after 2020.

1.1 National near-term climate policies are an important early step

1.1.1 Near-term policies can provide important impetus for long-term action
Despite their limitations, current near-term policies of limited geographical scope can provide very important bridges towards more comprehensive efforts. Although their contribution to the needed emission reductions may be relatively small, national near-term policies until 2020 can play a significant role by preparing economies for stronger action beyond 2020. Near-term emission reductions from national policies may bring the emissions trend closer to the required long-term trend, thus limiting the carbon lock-in and easing the transition to a pathway toward 2°C. Figure 1 compares the emission pathways associated with national policies in the reference case with no-policy pathways and 2°C pathways. In those regions where the reference case shows significantly lower near-term emissions than the no-policy case – above all in the EU – near-term policies are a significant early step toward more stringent policies that could achieve the 2°C target.

--> Figure 1

If countries fulfil their Copenhagen Pledges, the emissions intensity of the world economy will improve faster than the historical trend: by about 2% to 3% per year based on the LIMITS models compared to 1% per year in 2005-2010. For a cost-efficient pathway toward the 2°C target, global average emissions intensity improvements have to progress further: to about about 5% or more per year over the 2020s. The size of the gap between near-term emission trends and what is required in the medium term can be reduced by effective near-term climate policies.

1.1.2 The 2°C target calls for actions by all world regions within the coming decade
Without explicit mitigation policies, models project emissions to increase until very late in the century in essentially all regions. This result is based on the expectation of continued economic growth and availability of fossil fuels. The reference policies scenario would lead to earlier peak years in several major economies depending on the stringency of the commitments, but in other regions emissions would continue to grow well into the second half of the century (see Figure 2)..If on the other hand, the Durban Platform results in a global climate agreement to meet the 2°C target, emissions would have to peak and decline much sooner. The result show that for atmospheric GHG concentrations of 450 ppm CO2e, such a pathway requires emission reductions in the early 2020s in all world regions, in sharp contrast to the dispersed picture resulting from the no policies and weak pledges cases. A pathway to 500 ppm CO2e, would give the option of some leeway for an emissions beak by the 2030s in a few regions with the greatest economic difficulties to cut back emissions. It should be noted that Figure 2 only shows where emission reductions are achieved: the costs of these reductions may be shared via flexible instruments.

-->Figure 2

1.1.3 A limit of 2°C would require a significant reduction of carbon budgets in all major economies
Figure 3 provides estimates of regional cumulative emission budgets from 2010 to 2100 as well as the historical contribution to emissions of the major economies. It indicates that in the No Policies and Reference scenarios, the emissions of major economies like China or OECD countries would by themselves exhaust the entire global carbon budget compatible with 2°C. This attests to the crucial importance of a comprehensive climate agreement if the 2°C target is to be met. A limit of 2°C would require a significant reduction of carbon budgets in all major economies. The regional budgets for 2°C scenarios shown in 3 assume a cost-efficient distribution of global mitigation efforts. However, there is considerable uncertainty about the cost-effective regional split of emission budgets as it depends on, inter alia, baseline emissions, regional mitigation potentials, and terms of trade effects, all of which can vary substantially across models and regions.

--> Figure 3

Keeping cumulative global emissions within a 2°C carbon budget likely requires negative CO2 emissions in the second half of the century. The potential for negative emissions varies by region (see Figure 1 above), depending on trends in emission drivers, technological capabilities, and the availability of carbon storage sites.

1.2 The potential for mitigation options differs among regions

1.2.1 Regional characteristics imply different mitigation patterns
Many factors determine regional mitigation pathways, such as the differences in energy resource endowments, existing infrastructure, technological capabilities, and energy demand trends, as well as differences in national energy and climate policies. Progress toward a global climate policy regime may harmonize regional policies somewhat, but the other factors would remain.
Several deployment patterns can be extracted from the LIMITS models for four major economies (China, India, the European Union, and the United States) under the constraints of a 2°C scenario. In all regions, the electricity sector has the strongest abatement potential. Here, carbon neutrality can be achieved by mid-century with a variety of technology options. Figure 4 shows more specific regional deployment patterns in the electricity sector, both in the reference case and under 2°C constraints. Several observations can be made from the data shown in Figure 4 and from other LIMITS data:
• Although the configurations differ across models, in nearly all regions, the share of non-biomass renewable energy in electricity production increases two- to three-fold. The expansion of renewable energy is most dramatic in China, which becomes the largest user of non-biomass renewable energy by the late 2020s, overtaking the United States.
• Models differ in the relevance they assign to nuclear power. On average, nuclear energy use increases only moderately in all regions except China, where nuclear power grows most strongly as a response to climate policy.
• After 2030, the use of CCS is important in all regions as a decarbonization strategy for the remaining fossil fuel use and as an option for negative emissions through BECCS. In India and other emerging economies, CCS plays an important role in allowing continued use of coal in order to satisfy growing energy needs. BECCS is expected to find application predominantly in the USA, China and the EU due to

the combination of technological capabilities and access to biomass feedstock.

--> Figure 4

For the end-use sectors, significant reduction potential needs to become available in the industry sector, depicting potential in particular in emerging regions like China and India. In economically more advanced regions with higher motorization rates, such as the EU and US, abatement in the transportation sector becomes increasingly more important, especially once other mitigation options have been exploited. According to most LIMITS models, abatement in the buildings sector is not as strong as in the industry and transportation sectors, although it must be noted that the high and increasing share of electricity use in buildings means that a decarbonized electricity sector can minimize buildings-related emissions. Overall, energy efficiency in end-use sectors is an important abatement strategy in all regions. The reduction of emissions from land-use does not play a major role in China, India, the US, and Europe, but holds significant mitigation potential in Latin America, Africa, and some regions of Asia. The reduction of non-CO2 emissions can be considered a complementary response strategy that may contribute 10-20% to overall abatement.

1.2.2 China, India and Brazil may play important roles in achieving the 2°C target
Figure 3 showed the very significant role of non-Annex I regions (Asian countries, Latin America, Africa, and the Middle East) with regards to global emission reductions – simply based on the size of their expected future emissions in the absence of climate policy. In order to obtain further insight into the emission reductions in some of these regions, LIMITS partners compared the results from global models with those based on national models. These studies confirmed that the results from global and national models are largely consistent: Reducing emissions to a level that could keep a global temperature rise by 2100 under 2°C was not only found technologically feasible at the global level but also at the level of specific regions and countries. However, the studies also confirmed the large gap between current plans and the level of ambition that would be needed to follow a 2°C pathway.

India: Both the global and regional models in the Indian study showed that coal will remain the mainstay of the Indian energy system under the no-policy scenario even by the end of the century. Coal is the most important domestic resource and is available at rather low costs. Future coal use, however, is expected to be much cleaner than now. Results from all modelling teams indicate that Indian CO2 emissions will not peak until 2100 under the no-policy scenario. To achieve peaking of Indian emissions by 2030, a minimum carbon tax of US$150 per tonne would need to be imposed. To achieve an emissions peak by 2020, an immediate minimum carbon tax of US$200 per ton CO2e is needed, along with expedited phasing-out of at least a third of coal-based energy infrastructure in the next ten years. The high level of investments in India also implies that ensuring the right infrastructure plays a key role here. For transport, this requires an integrated mobility plan with low-carbon transport at its core.

China: The study on China looked into a very stringent emission reduction strategy with emissions peaking in 2025 and declining by 70% until 2050. Such stringent policies could build upon the experience already obtained through current Chinese policies. For instance, China is already implementing caps on energy demand, together with targets for non-fossil fuel energy by 2020. China is also making significant progress in the implementation of provincial emission trading schemes.

Brazil: There is general agreement between the global and the regional models regarding the projected emission trends. Under current policies, energy-related CO2 emissions are projected to increase 1.5-3.0% per year in Brazil and the whole Latin American region. In the 2°C 450 ppm scenario, CO2 emission reductions in Brazil of 55%-87% below the Reference scenario are achieved by 2050. The implementation of CCS in combination with fossil fuels and bioenergy, as well as hydro, biomass and wind energy are identified as the most promising low-carbon options for the region, if technical, economic, environmental and social challenges can be overcome. Brazil is the first country in Latin America to adopt a national voluntary climate change mitigation goal by law. However, the assessment of the effectiveness of this goal is difficult due to the law's vague targets.
Further initiatives also exist in other countries. While at least half of global energy investments still flow into conventional fossil fuel energy infrastructure, a growing share of investment goes to renewable energy and energy efficiency –largely as a result of policy support. Such policies are not limited to industrialized countries. For instance, more than 40% of renewable energy investments in 2012 and 2013 were located in developing countries. Most of this investment occurred in the large emerging economies of China, India, and Brazil, with a significant share of the capital sourced domestically.

2. Near-term co-benefits of climate change mitigation

One of the key challenges in implementing ambitious climate policies is that mitigation requires short-term investments, whereas the benefits of avoided climate impacts only occur in the long term. Moreover, while these investments need to be made at the national level, the benefits will possibly occur in other global regions. On the other hand, mitigation policies could bring additional benefits including reduced air pollution emissions and improved energy security that could occur both in the short-term and locally. This section discusses how climate policies interact with air pollution and energy security objectives that might be an additional incentive for societies to invest in zero-carbon technologies.

2.1 Air pollution and climate policies

2.1.1 Climate policies lead to major reductions in air pollution

Climate policies lead to strong co-benefits for air pollution control. The LIMITS models show that without additional air pollution or climate policies, air quality will decline for all major pollutants. Currently-planned air pollution policies will be effective in reducing air pollution through end-of-pipe measures but reductions will be limited by rising energy demand and continued use of fossil fuels. The addition of climate stabilization policies consistent with the 2°C target could further reduce emissions of major pollutants by more than 50% globally due to improvements in energy efficiency and reductions in fossil fuel use. Most of the co-benefits from climate policy are found in Asia and Africa where climate policy is effective in offsetting the large increases in air pollution that occurs even with the implementation of planned air quality legislations. At the same time, the distribution of co-benefits is heterogeneous across pollutants and sectors.

--> Figure 5

2.1.2 Climate policies have large near-term health benefits

Climate change policies are beneficial for human health in the near-term, reducing in 2030 the number of global premature mortalities resulting from exposure to air pollution by almost 700 thousand lives. Over 80% of such benefits are realized in Asia with almost half a million lives saved in India and China combined. Globally, climate policies could reduce premature mortalities by more than half of what stringent end-of-pipe air quality controls could achieve in the absence of climate policy. This co-benefit can be as high as approximately 55% in China or close to 70% in North America. This indicates that the effective application of climate mitigation policies could substantially reduce the cost of air quality controls. A combination of climate policies with stringent end-of-pipe air quality controls could potentially reduce global premature mortalities from air pollution by 1.7 million cases.

--> Figure 6

2.2 Energy security and climate policies

2.2.1 Climate policies would significantly improve energy security

The LIMITS models show that climate policies lead to an overall improvement in energy security with lower energy trade, a decrease in resource depletion and an increase in the diversity of energy options. Without dedicated policies, the main contemporary energy security concern – the over-reliance of the transport sector on limited and unequally distributed oil reserves – would become worse. Additionally, coal trade would rise, potentially surpassing the current oil trade by mid-century. In contrast, under the 2°C scenario, the global energy trade by mid-century would be up to four times lower than in the no policies case. In addition, climate policies would lead to lower resource extraction, which would reduce perceptions of scarcity and associated price volatility, especially for oil. Climate policies would also lead to a higher diversity of energy options and thus higher resilience, the capacity of energy systems to respond to and recover from disruptions.

--> Figure 7

2.2.2 Energy independence policies would not protect the climate

While climate policies lead to lower energy imports, energy independence policies on their own do not significantly lower greenhouse gas emissions. We found that if all regions were to limit their energy imports, the global GHG emissions would decrease only slightly: cumulatively 3-17% over the 21st century compared to about 70% in the 2°C scenarios. This decrease occurs because the major 21st century energy importers (Africa, China, India, and the rest of Asia) would use less coal to fulfill their energy independence targets. Constraining oil imports would have no discernible impact on GHG emissions as oil could be substituted by other fossils. Additionally, we found that limiting energy imports is consistently ten times cheaper than stabilizing the climate stabilization and that energy exporters would bear a greater portion of the costs, as is also the case of climate policies.

--> Figure 8

2.2.3 Effects of climate policies on energy security vary among regions

Effects of climate policies on energy security vary among regions. In the EU, climate policies would

improve energy security by reducing imports, avoiding resource depletion and increasing diversity of energy options as compared to the no-policies case.
Similarly, in China and India, the pressures associated with growing energy imports, resource depletion and low or declining diversity would be all eased under climate stabilization policies.
In contrast, in the United States, a tension may emerge between energy security and climate policies. Without any new energy policies, the US is likely to become self-sufficient and could become a major energy exporter in the 21st century. In 2°C scenarios, the US would not be able to fully use its fossil fuel reserves and to generate as large energy export revenues as in no-policy case.
In summary, there is an asymmetric relationship between climate and energy security policies. Climate policies generally improve energy security though they may reduce potential energy export revenues in some regions. On the other hand, the most commonly pursued energy security policies (energy independence) would not result in significant GHG emission reductions even if applied consistently by all regions and over the long-term. Moreover, the costs of achieving reasonable energy independence are on the order of magnitude less than the costs of stabilizing the climate.

Potential Impact:
The main contribution of the project has been to advance the scientific understanding of climate change mitigation policies in the major economies. This is testified by the large number of publications, including highly ranked journals such as Nature Climate Change. In addition to peer reviewed articles, the project has generated public knowledge by providing open access to all the key results of the scenarios.
Moreover three policy briefs have been prepared and circulated, respectively on Policy Analysis, on Regional Analysis and on Limiting Global Warming to 2°C: Policy findings from Durban Platform scenario analyses. The first two documents have been drafted both in English and in Chinese.
LIMITS has also contributed outside the strict sphere of science. A series of 3 stakeholder meetings and a final conference has been held in Europe and China. LIMITS has sponsored two editions of the International Energy Workshop, one of the best known international fora for energy topics. The outcome of LIMITS has informed the international climate negotiations, with a side event in the UNFCCC conference of parties meeting in Warsaw, and a briefing to the EU delegation before the 2014 COP meeting in Lima.
The project has facilitated the policy conversation between different stakeholders in different countries, most notably between Europe and China, where the currently proposed 2030 target of emission peaking has been analysed and put forward by researchers involved in the LIMITS consortium.

List of Websites:

- Project website address: http://www.feem-project.net/limits/

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Last update: 12 May 2015

Permalink: https://cordis.europa.eu/project/id/282846/reporting