Project No 282846

LIMITS

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

FP7-Cooperation-ENV
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Small or medium-scale focused research project

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Policy Brief on policy analysis
1/2013

LIMITS

LOW
CLIMATE
IMPACT
SCENARIOS
AND THE
IMPLICATIONS
OF REQUIRED
TIGHT
EMISSION
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STRATEGIES

Policy Brief on policy analysis 1/2013

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1. Modeling Durban platform scenarios

International climate policymaking is increasingly focused on the negotiation process under the Durban platform for enhanced action. This platform provided an interesting opportunity for discussing post-2020 emission reduction commitments beyond the traditional divide of developed versus developing countries. A refocus on the major economies might help achieve more than expected, and calls for new analytical thinking about the best policy instruments which can be put into place to provide adequate incentives to join the coalition. Integrated assessment models are tools which are heavily used to assess the implications and the interactions of climate mitigation policies globally, and which play an increasingly important role in the scientific debate about climate change mitigation. Global coupled energy-economy-land use-climate models are thus needed to assess the feasibility and socio-economic implications of 2 degree pathways.

The LIMITS project has set this as a central objective, and has evaluated 2 degree scenarios that were tailored to represent a set of plausible outcomes of the Durban platform negotiations on a post 2020 climate treaty. To this end, seven leading IAMs have run 12 scenarios, outlined in Table 1. The scenario design has addressed the most important features of the 2C space: the long term climate objective of both 450 and 500 ppm-eq, which would yield reasonably high and even chances of achieving 2C respectively, the level of ambition in 2020, with a more lenient reference policy ('weak') reflecting the unconditional Copenhagen Pledges and a more stringent version ('stringent') based on conditional Copenhagen Pledges, the level of international cooperation till 2020 and 2030, and finally, the burden sharing scheme to be adopted once the international treaty is signed (no sharing, per capita convergence and equal effort).

Scenario Type	Near term Target / Fragmented Action	Fragmented Action until	Long-term Target	Burden Sharing
Baseline	None	N/A	None	None
Reference	Weak	2100	None	None
Reference	Stringent	2100	None	None
Benchmark	None	N/A	450 ppm CO2e	None
Benchmark	None	N/A	500 ppm CO2e	None
Climate Policy	Weak	2020	450 ppm CO2e	None
Climate Policy	Stringent	2020	450 ppm CO2e	None
Climate Policy	Weak	2020	500 ppm CO2e	None
Climate Policy	Stringent	2020	500 ppm CO2e	None
Climate Policy	Weak	2030	500 ppm CO2e	None
Climate Policy	Weak	2020	450 ppm CO2e	Per Capita Convergence
Climate Policy	Weak	2020	450 ppm CO2e	Equal Mitigation Effort

Table 1: Scenario design of the LIMITS study.

2. Implications of Durban scenarios for achieving 2C

The scenarios have helped to understand the feasibility of attaining 2C for the set of Durban Action policy frameworks considered (DP henceforth). As highlighted in Figure 1, both baseline scenarios as well as fragmented climate policies (weak and stringent) lead to average temperature increases at the end of the century which are way above 2C, and in the range of 3-4.5C. On the other hand, stringent stabilization as investigated by the DP scenarios peak in 2020 and lead to a complete or near-complete phase out of global emissions by 2100. Simulations with a climate models indicates that the probability of overshooting 2°C before 2100 ranges from 24-41% for 450 ppm to 36-59% for 500 ppm CO2e.

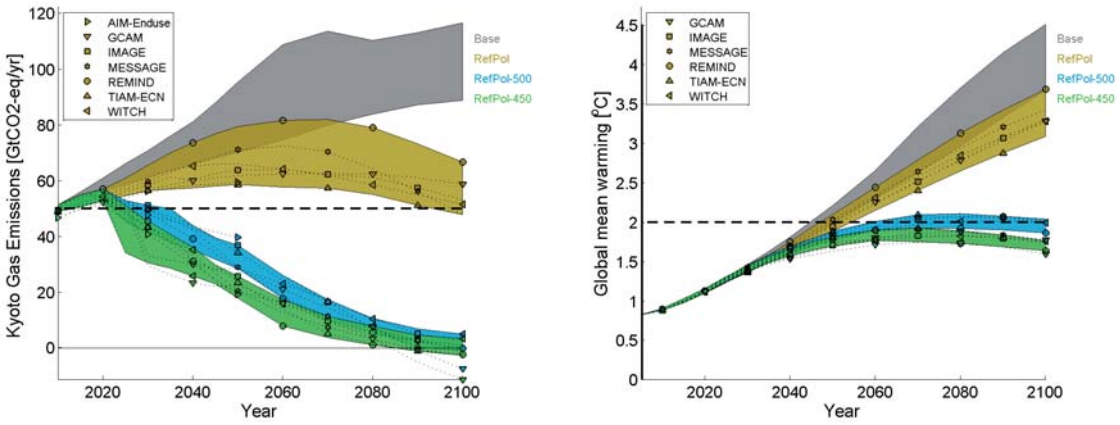


Figure 1: Emissions (left) and Temperature (right) pathways in the LIMITS scenarios

An important consideration for the feasibility of international climate negotiations will be the effort requires in terms of decarbonization rates and economic costs. Results indicate that the rate of action in the next one or of two decades will be crucial for determining the feasibility of achieving 2C: the larger the emission gap to cost effective scenarios, the higher will be the increase in the rate of emission reduction and of policy costs (Figure2). This indicates that emissions gaps above 10GtCO2e, corresponding to global delays to 2030 or to low effort in 2020, would jeopardize the chances of implementing 2C compatible policies, by increasing the decarbonization and economic effort above levels which would be already significant in the case of comprehensive and rapid global action.

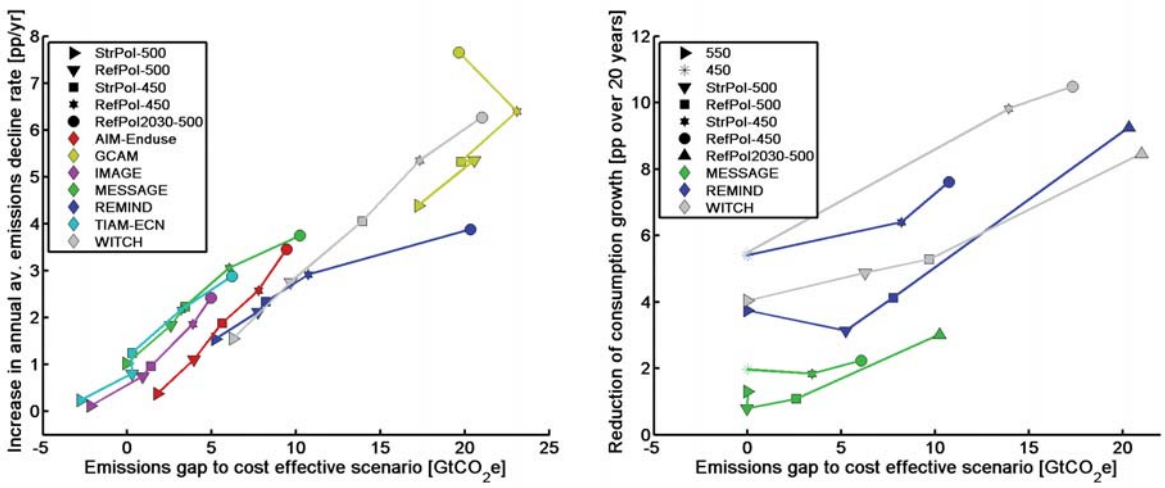


Figure 2: Decarbonization and economic effort of the climate policies in relation to the emission gap to idealized scenarios with full cooperation.

3. Investment needs and technological transition

Achieving stringent climate policies consistent with a 2°C climate change target would require a considerable upscaling of investments into low-carbon energy and energy efficiency, reaching approximately $45 trillion cumulative between 2010 and 2050, or about $1.1 trillion annually (see Figure 3). This represents an increase of some $30 trillion ($10-55 trillion), or $0.8 trillion per year, beyond what investments might otherwise be in a reference scenario that assumes the continuation of present and planned emissions-reducing policies throughout the world. In other words, a substantial "clean-energy investment gap" of some $800 billion/yr exists – notably on the same order of magnitude as present-day subsidies for fossil energy and electricity worldwide ($523 billion). Unless the gap is filled rather quickly, the 2°C target could potentially become out of reach.

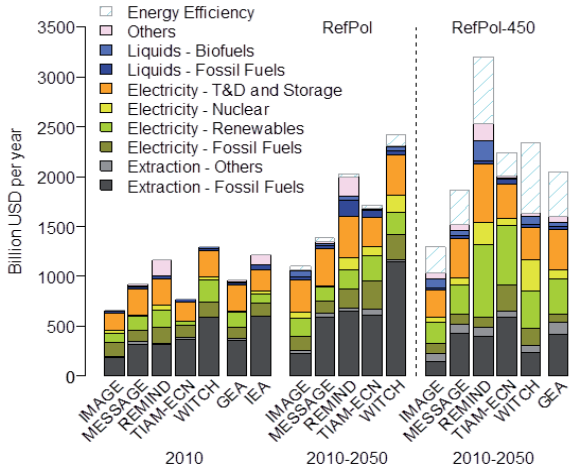


Figure 3. Global annual energy investments (both supply- and demand-side) across the various models in 2010 and average annual investments from 2010 to 2050 in the Reference and 450 scenarios. Also included estimates from the International Energy Agency and Global Energy Assessment.

A major decarbonization of the energy sector will be particularly needed (figure 4). Results indicate that average annual capacity additions for low-carbon energy technologies such as solar and wind power would need to be several times higher than the maximum average annual capacity additions rate observed in the recent past (i.e. for coal-based power plants, at a little over 50 GW/yr).

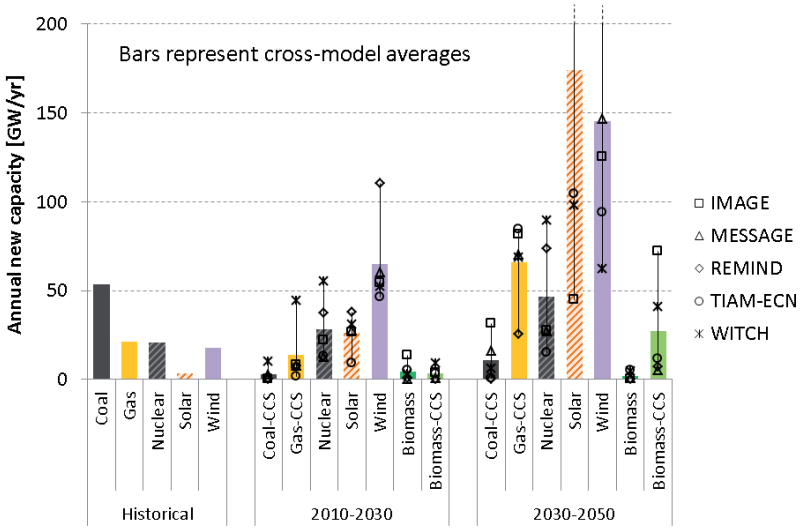


Figure 4. Average annual capacity additions (history and short to medium term future) for various fossil-based and low-carbon energy technologies in the RefPol-450 scenario.

4. Sharing the effort among the major economies

The aim of the LIMITS project –inspired by the new negotiation process in the Durban process- is to assess the implementation of 2C policies in the major economies. To this end, we have assessed the regional consequences of the Durban Action scenarios as designed in LIMITS. Regional issues are extremely important due to the differentiated distribution of costs and benefits of climate change policies.

Indeed, the distribution of the mitigation effort -measured in costs- of a carbon tax scenario is found to be quite unevenly distributed, as shown in Figure 5. The chart emphasizes a significant variation of costs across regions, and across models in some instances, but reveals a rather clear three-tier pattern. Advanced economies such as Europe, the US and Pacific OECD bear a cost which is lower than the global average. Fast-growing economies, including Latin America, Southeast Asia, India and Africa, pay a larger fraction of the cost. Finally, energy-exporting countries like Russia and the Middle East bear a policy cost which can be several times the global one.

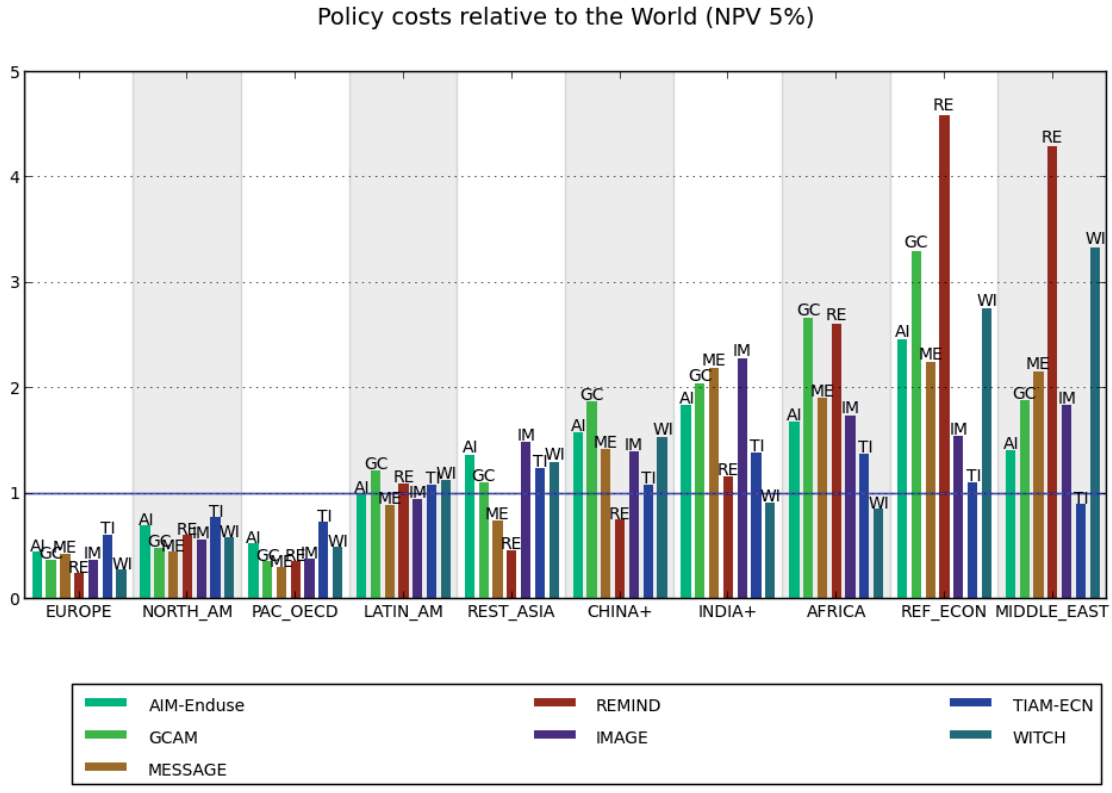


Figure 5: The distribution of regional policy costs. The chart shows regional policy costs across models in the 450 ppm scenario, relative to the global level (indicated by the blue line at 1).

To address the tension between efficiency and equity, in LIMITS we have assessed two burden-sharing schemes, based on resource -and effort-sharing principles, respectively. Our results indicate that the asymmetric distribution of costs could be alleviated by endowing regions with emission permits and allowing free trade of such entitlements. As shown in the next figure, an allocation scheme based on the equalization of climate policy costs across regions would allocate OECD with emission reductions compatible with those enunciated by the Major Economies Forum and the European Commission. China would receive emissions allowances which peak before 2030, and which would return to today's levels by 2035 to 2045. Both China and India would be involved in limited transfer payments in this scenario.

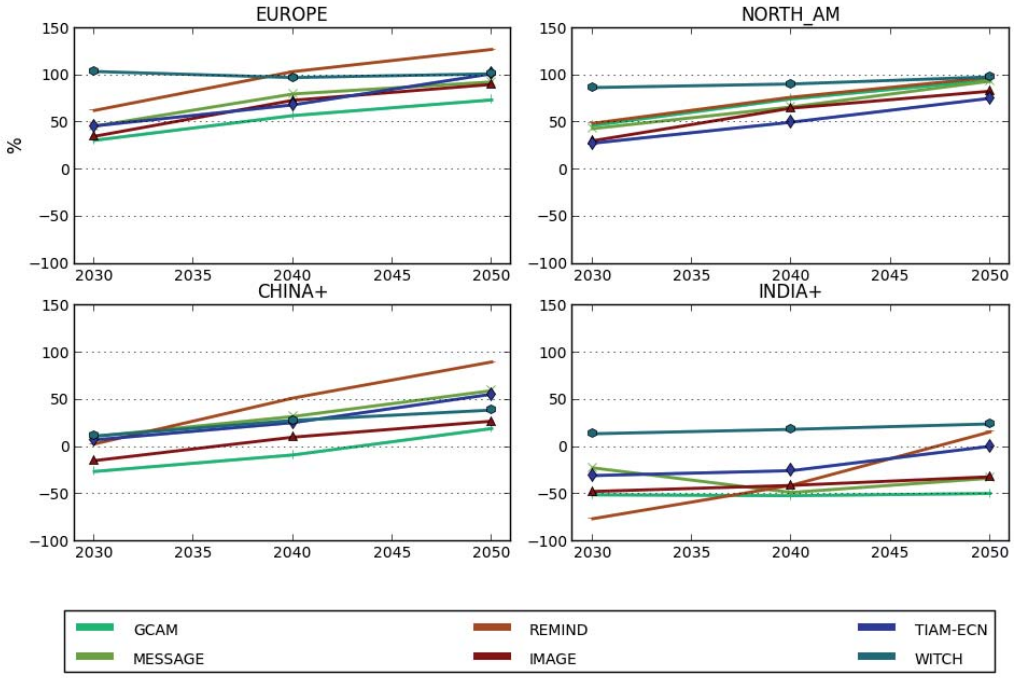


Figure 6: Emission allowances over time for the equal effort scenario, expressed in reductions from 2010 values.

However, finding an equitable solution in terms of cost balancing does not appear to be straightforward, especially when focusing on a resource-sharing rule of convergence to per capita endowments. Endowing regions with emissions permits would require a well-functioning market for emissions. Our results indicate that the size of the permit trade market would be significant in all the assessed regimes, and especially in the per capita convergence one. However, the main actors on the market for the two burden-sharing schemes would be different, with Africa and China being the major players in the per capita scheme, and the OECD and the energy exporting countries in the equal effort.

5. Policy recommendations

Several policy insights have emerged from the scenario analysis of the Durban Action scenarios. First, rapid and fast action is needed to achieve 2C with adequate probability; this would require a commitment to emissions peaking as early as 2020, with later dates leading to lower chances of attaining 2C and to significantly higher transitory decarbonization and economic efforts. In order to make the low carbon transition possible, large scale financing of the order of 1USD Trillion/yr will need to be redirected from fossil to low carbon sources. Another major challenge we have identified is the balancing of regional costs and benefits of climate policies. The distribution of policy costs appears to be quite uneven in the absence of compensatory mechanisms, due to different regional abatement potentials, and different economic structures. On the other hand, differentiating regional commitments would come at an expense in terms of additional policy costs, which we know we need to minimize if we want to achieve the big 2C challenge. Sharing mechanisms based on the establishment of carbon permits markets have the potential to alleviate this tension, but as shown in our project there appear to be no univocal solutions to the dual objective of efficiency and equity.

政策分析的摘要
1/2013

LIMITS

低环境影响情景分析及严格排放控制策略的实施

政策分析的摘要
1/2013

目录

The research leading to these results has received funding from the European Union Seventh Framework Programme FP7/2007-2013 under grant agreement n° 282846 (LIMITS).

1. 德班平台情景的建模

国际间的气候政策制定越来越关注增强行动的德班平台的谈判进程。这个平台提供了一个很好的机会去讨论2020年后的减排承诺，不再划分发达国家和发展中国家。聚焦在主要经济体的方案可能有助于取得超出预期的成果，同时这需要新的分析思路来制定最佳的、行之有效的、足以吸引各方联合参与的政策措施。
综合评估模型是全球范围内用来评估减缓气候变化政策间相互影响的重要工具，并在减缓全球气候变化相关的科学讨论中起到越来越重要的作用。
因此，需要全球关联的能源- 经济-土地使用-气候循环模型，以评估2℃控温目标不同方案下的可行性及其社会经济影响。

LIMITS项目以此为目标，并对2℃控温目标的情景进行了研究。这些情景提出了代表德班平台谈判中关于2020后气候协议的各种可能结果。为此，七个主要的综合评估模型（Integrated Assessment Models, IAMs)已评估了12个情景，在表1中列出。情景的设计已经给出了实现2℃控温目标的最重要的因素：温室气体的浓度控制在450到500 ppm-eq的长期气候变化目标，前者可以较好的达到2℃控温目标，而后者则可以勉强达到；2020年需要达到的排放水平，考虑哥本哈根协议中无条件承诺而较为宽松的参考政策（“宽松”），以及基于有条件的承诺而较为严厉的参考政策（“严厉”）；到2020-2030年时的国际合作水平；最后 ，一旦国际气候条约签署后所采用的责任分担方案（责任不分担，人均趋同和共同行动） 。

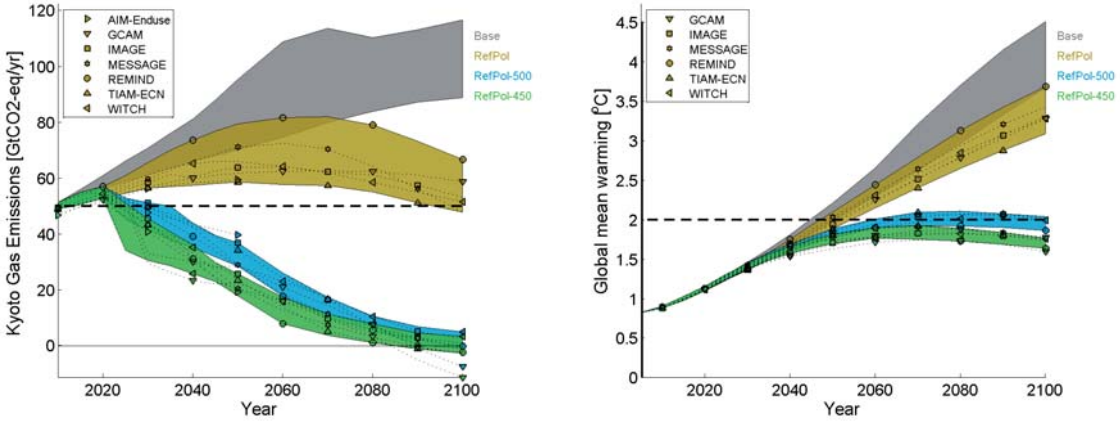
情景类别	近期目标 / 分散行动	分散行动至	长期目标	责任分担
基线	无	不适用	无	无
参照	宽松	2100	无	无
参照	严格	2100	无	无
标定	无	不适用	450 ppm CO2e	无
标定	无	不适用	500 ppm CO2e	无
气候政策	宽松	2020	450 ppm CO2e	无
气候政策	严格	2020	450 ppm CO2e	无
气候政策	宽松	2020	500 ppm CO2e	无
气候政策	严格	2020	500 ppm CO2e	无
气候政策	宽松	2030	500 ppm CO2e	无
气候政策	宽松	2020	450 ppm CO2e	人均趋同
气候政策	宽松	2020	450 ppm CO2e	减排努力行动均等

表1：LIMITS项目研究的情景设计

2. 德班平台情景中2℃控温目标的分析

该情景分析有助于理解德班行动政策框架（下文简称德班平台）下实现2℃控温目标的可行性。如在图一中显示，两个基线情景和分散的气候政策（“宽松”和“严厉”）一样会导致本世纪末平均温度升高远超2℃，升幅在3-4.5℃之间。另一方面，严格约束排放的情景，如德班平台情景，将会在2020年达到峰值，全球排放到2100年完全或近乎完全为零。气候模型分析表明，在2100年前升温超过2℃的概率在24-41%（以450ppm为目标）至36-59%（以500ppm为目标）之间。

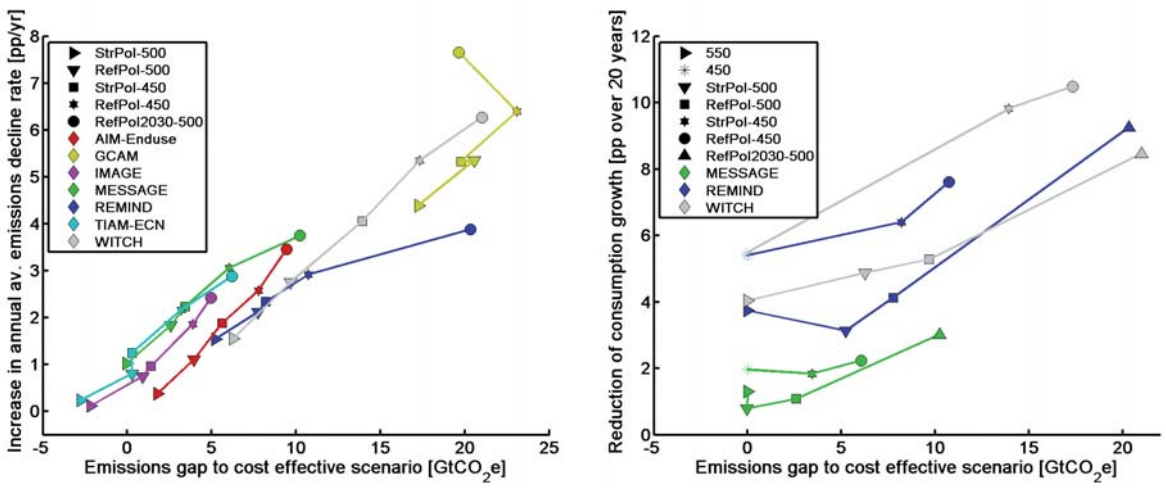
图中英文释义:
Kyoto Gas Emissions[GtCo2-eq/yr]
京都议定书气体减排[十亿吨二氧化碳当量/年]
Global mean warning[℃]
全球平均升温[摄氏度]
Base
基线情景
RefPol
参考政策
RefPol-500
参考政策（500pm）
RefPol-450
参考政策（450pm）



图一：LIMITS情景的排放量（左图）和温度变化（右图）

国际气候谈判中一个重要因素是考虑碳减排和经济成本下需要付出的行动。情景结果表明，接下来的一二十年减排行动的推进速度至关重要，关系到能否达到2℃控温目标：与成本有效情景的排放差距越大，需要的减排速率和政策成本就越大（图2）。这表明，二氧化碳排放量的差距超过100亿吨时，即全球排放峰值延迟至2030年，或仅实现了2020年较弱的行动，随之而来的脱碳压力和经济成本比现在还要增加，而现在已经到了需要全球迅速全面合作应对，因此这将危及实施实现2℃控温目标政策的机会。

图中英文释义:
Increase in annual av. emissions decline rate[pp/yr]
年均排放下降率的增长[%/年]
Reduction of consumption growth [pp over 20 years]
消费增长速度下降率[%/20年]
Emissions gap to cost effective scenario [GtCO2e]
与成本有效情景的排放差距[十亿吨二氧化碳当量]

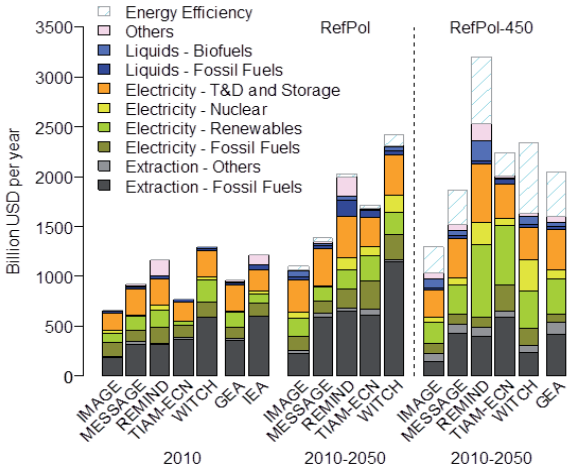


图二：气候政策的碳减排及经济成本与全面合作下理想情景相应的排放差距

3. 投资的需求和技术的转化

实现严厉的与2° C控温目标一致的气候政策，需要在低碳能源和提高能效领域进行一个大规模的投资，即在2010年和2050年期间累计达约45万亿美元，或每年约1.1万亿的规模（见图3）。这意味着增加了约30万亿美元（10-55万亿美元），或每年8000亿美元，超过了参照情景中设定的在全球范围内维持现有和所计划减排政策所需要的投资。换句话说，实际存在一个年均约8000亿美元的“清洁能源投资缺口”－ 看起来和目前各国对化石能源和电力补贴（5230亿美元）在同一数量级。除非投资缺口能尽快补上，否则控温2℃的目标可能会遥不可及。

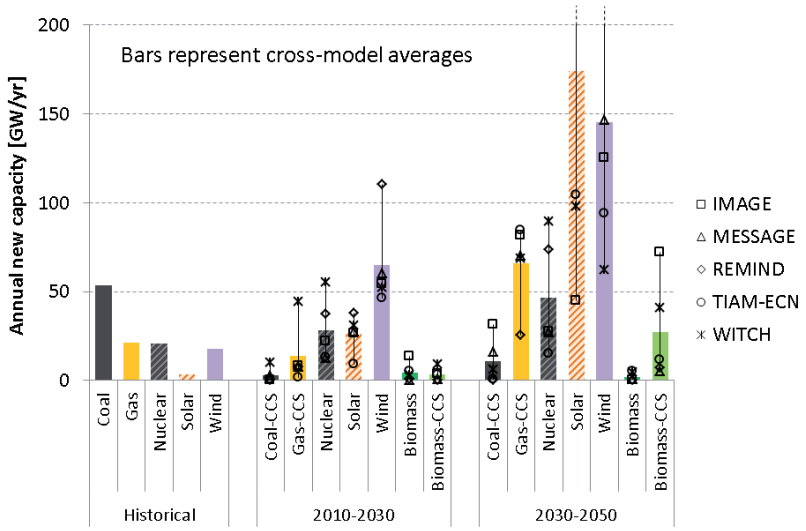
图中英文释义:
Billion USD per year
十亿美元/年
Energy Efficiency
能源效率
Others
其他能源
Liquids-Biofuels
液体的生物能源
Liquids-Fossil Fuels
液体的化石燃料
Electricity-T&D and Storage
电能的传输和储存
Electricity-Nuclear
核电
Electricity-Renewable
可再生电能
Electricity-Fossil Fuels
化石燃料电能
Extraction-Others
其他能源的开采
Extraction-Fossil Fuels
化石燃料的开采



图三，2010年不同模拟情景下每年全球在能源上（供给方和需求方）的投资以及参照情景和气候政策情景（以450ppm为目标）下在2010-2050间能源的年均投资。数据包含了国际能源署和全球能源评估的预估。

能源领域需要有一个大幅的碳减排行动（图四）。结果表明，每年平均新增的低碳能源技术的产能，如太阳能和风能发电，将会是过去年平均最大新增产能的几倍（如，煤电厂，略超过5000万千瓦/年）。

图中英文释义:
Annual new capacity[GW/yr]
每年新增产能[100万千瓦/年]
Bars represent cross-model average
柱体代表各个模型的平均值
Coal
煤炭
Gas
石油
Nuclear
核能
Solar
太阳能
Wind
风能
Biomass
生物燃料

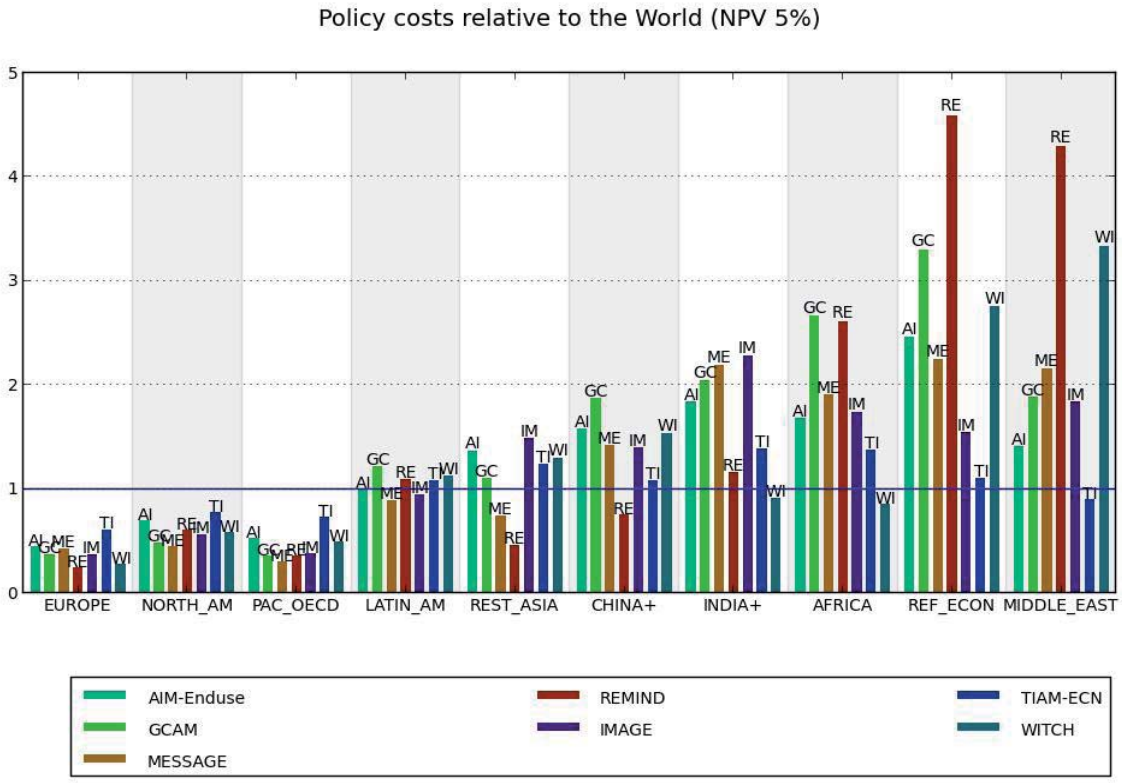


图四，参考政策（450ppm）情景下的各种石化能源和低碳能源技术年均产能增量（过去的和近期至未来中远期）

4. 主要经济体的共同努力

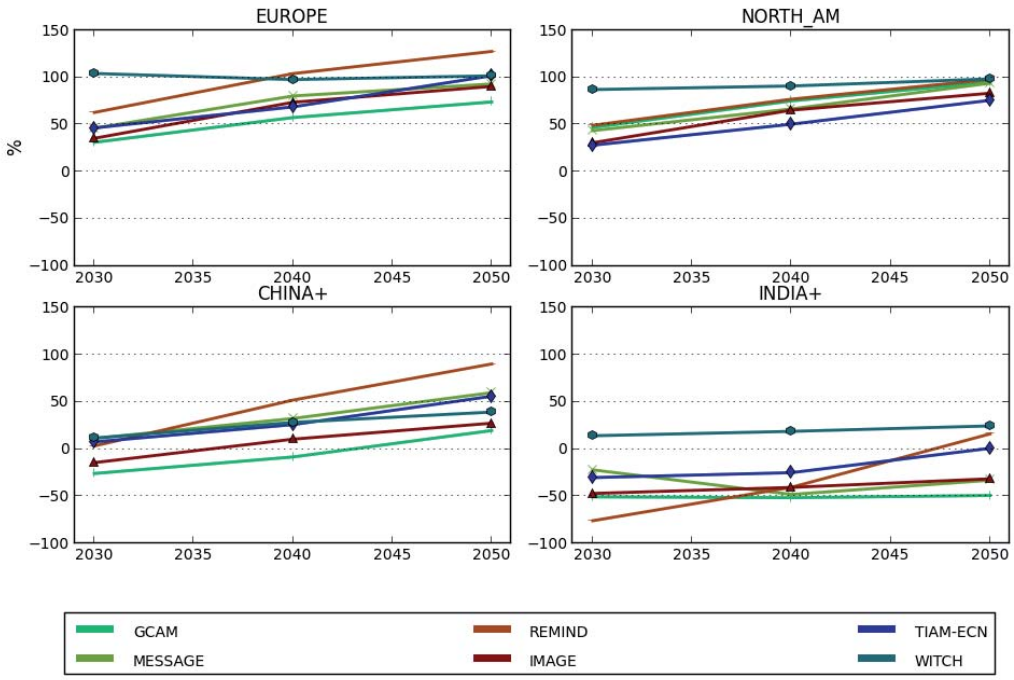
为支持于德班平台的谈判进程，LIMITS项目的目标是分析主要经济体的2℃控温政策。为此，我们已评估在本项目设计下的德班行动方案的区域影响。气候政策的成本和收益的不同分配方式使得地区问题极端重要。

确实，碳税情景模拟下的减排行动的分配----以成本计算，是相当不平均的，如图五所示 。该图表所强调，在不同区域，不同模型的某些情况下，成本的差异相当大，但还是展示了一个相当清晰的三层模式。发达经济体如欧洲，美国和太平洋经合组织所承受的费用，低于全球平均水平。快速增长的经济体，包括拉丁美洲，东南亚，印度和非洲，付出的成本的较大部分。最后，能源出口国如俄罗斯和中东承担高于全球平均水平的几倍的政策成本。



图五，地区气候成本的分布。图表给出了不同模型在450ppm情景下区域政策成本，与全球平均水平（图中蓝线）相对比。

为了解决效率与公平之间的紧张关系，在LIMITS项目内，我们评价了两个责任分担方案，分别基于资源共享和共同行动原则。我们的研究结果表明，成本的不对称分布可以通过赋予地区相应的排放配额，并允许其进行自由贸易而得到缓解。如下图，基于地区间政策成本均摊的分配方案将使得经合组织与主要经济体论坛及欧洲委员会一样承担减排。中国将获得排放配额并且在2030年之前达到峰值，到2035-2045年将会恢复到今天的水平。在这个情景模拟下，中国和印度将参与有限的转移支付。



图六，共同行动情景下排放配额，与2010年排放水平相比的减排量。

然而，寻找一个公平方案来平衡成本并非易事，尤其是在资源共享规则下实现人均趋同。赋予区域排放许可将需要一个运作良好的市场机制。我们的研究结果表明，在所有被评估分配制度中，排放许可贸易的市场规模将是巨大的，特别是在人均趋同的方案下。然而，市场中这两个责任分担制度的主要角色是不同的，非洲和中国是人均方案的主要角色，而在共同行动方案中经合组织和能源出口国则是主要角色。

5. 政策建议

从德班行动情景分析中可以得到一些政策。首先，需尽快采取行动，才有可能较好的达到2℃控温目标，这将需要保证在2020年之前到达排放峰值，因为越往后想要达到2℃控温目标越难，并且碳减排和经济的付出越大。为了能过渡到低碳阶段，将需要把1万亿美元/年的大规模投资从化石能源转向低碳能源。另外一个我们已经确认的挑战是区域性成本和气候政策利益的平衡。没有补偿机制的政策成本的分摊会很不平衡，因为不同地区的减排潜力和经济结构都不一样。在另一方面，差异化的区域承诺会造成额外的政策成本，而为了实现2℃控温目标恰恰需要尽可能减低这些政策成本。建立在碳排放许可市场之上的共享机制，有缓解这一紧张的潜力，但如我们研究显示，似乎没有单一的解决方案可以兼顾效率和公平的双重目标。