Proposal for the Next Vintage of Long Run Scenarios in a Changing Scientific and Policy Context

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1 Objective: eliciting the development-climate Gordian Knot

The shared diagnosis underlying this proposal is that the development of economic scenarios under the IPCC impulsion should internalize, in addition to delivering GHGs emissions scenarios for climate modellers, the objective of better informing policy debates about how various visions of future long term development pathways affects the content, the efficacy and the social costs and benefits of adaptation and mitigation policies.

This paper provides a proposal for the production of new scenarios that stems from the following four policy-oriented concerns:

- To clarify ***catching – up (or differentiation) dynamics***, not only in terms of per capita GDP growth but also in terms of physical development patterns – this would allow to solve the difficulties of the PPP vs. MER controversy;

- To delineate ***the interplay between climate policies and sustainable development***, including energy security and poverty alleviation, in a context of long-term changes such as ageing, migrations, higher capital mobility and evolving world trade organization;

- To investigate ***the relative role of energy and non-energy parameters and policies*** in the achievement of high or low emission stabilization targets;

- To detect the ***long-standing implications of short term development options*** both for climate change and for overall development sustainability – this applies primarily to the dynamics of infrastructures and land-use, with a strong concern for technological and structural lock-in.

Progress in those directions will demand to address several methodological challenges, which were not equally underlined in the past four IPCC assessment reports, even if they have been mentioned earlier in the literature.

2 Methodological challenges

2.1 Scenarios meaningful for two scientific communities

A first difficulty comes from the fact that new scenarios catalyzed by the IPCC are expected first to be useful for mitigation and adaptation studies, second to be consistent with emissions scenarios used for next runs of heavy climate models. Indeed it would be increasingly blurring to disconnect the emissions scenarios from those used for analysing how to orient the world economy towards one of them. But policy analysis requires much more scenario variants than climate modelling itself, and it would be of no interest to try and feed climate models with all alternative scenarios developed for mitigation and adaptation assessment, since many of them indeed result in second order differences in terms of climate forcing.

Following the clear statement from the IPCC Working Group on New Emission Scenarios to limit the total number of new scenarios, we would suggest to concentrate on ***twelve basic scenarios*** which are meaningful both for climate simulations – because each of them will induce a different pace of climate forcing – and for economic analysis – because they can cover the range of economic mechanisms likely to impact on the efficacy of climate policies. Eventually, the following twelve scenarios should suffice in providing the information necessary to run climate models and provide various detailed climate change scenarios for detailed analysis and to be used in integrated mitigation and adaptation studies:

- A ***high*** no-policy emission scenarios in which the drivers of net GHGs emissions (including high carbon release from land cover changes) are set at their maximum plausible level, plus a ***low variant*** of this scenario for land cover changes[1];

- A ***medium*** no-policy emissions scenario in which these drivers are fixed at their average plausible value (including slowing down of carbon release from land cover change), plus a ***high variant*** of this scenario for land cover changes[1];

- ***Eight stabilisation*** scenarios, for 550 ppm and 450 ppm GHGs concentration targets, derived from an early policy action all over the world from each BAU emissions scenarios. This will allow to test the extent to which scenarios respecting identical stabilisation targets may lead to a different pace of global warming because of significant differences in emissions over the first part of the century. Obviously, how the *when and where* issue is likely to be resolved will generate a far more complex set of scenarios; they will simply be defined as variants of these eight scenarios which should be analysed only by economic modellers.

2.2 Short, medium and long run: linkages and path dependencies

The disconnection between very long run scenarios and scenarios examining short term policy issues should be reduced as far as possible and this for many strong reasons. First, negotiations will be conducted mostly on medium term objectives and the "passing points" between today and the end of the century are critical. Second the analysis of costs (or double-dividends) of early action cannot be separated from the impact of these decisions on the carbon content of growth over the medium and long run and of the differentiation and the sequencing of decarbonisation efforts amongst countries and sectors. Third, short and medium term emission trends will determine the pace of global warming and the magnitude of the environmental irreversibility effect.

The main challenge is the question of the path dependencies of development patterns and emissions trends, in particular those created by the building and transportation infrastructures in developing countries, the investments in electrical sector, the orientation of R&D, the dynamics of land uses.

[1] Indeed a 'upper bound' high growth scenario may include a deepening of current trends of converting forests into cattle breading areas or croplands; on the contrary upper-bound high non agricultural emissions can also be associated to a slowing down of deforestation, in case of high productivity growth in agriculture and/or slowing down of the increase of the meat content of diet. Symmetric options can be defined for the 'medium scenarios'.

2.3 Endogeneization of scenario variables, to avoid the combinatory trap

The determinants of GHG emissions can be grouped into three categories:

- The ***economic growth engine*** (demography, productivity growth and catch-up assumptions, savings, capital flows, fragmentation or integration of the world economy).

- The content of the ***development patterns*** (consumption patterns, technological styles, land cover and localization of activities, patterns of income distribution).

- The dynamics of the ***energy systems*** (energy efficiency, technological options on the supply and demand sides, fossil fuel resources) and the final price of fossil based energies.

Scenarios reported in the IPCC SAR showed the trap of combining the assumptions that can be made in each group of parameters as if they were totally independent. This practice resulted in an unrealistic large spectrum of emissions projections that the consideration of feedbacks mechanisms may narrow in the real world. For policy analysis, it did not help to understand the linkages between policies affecting the development patterns (in major part adopted for reasons independent from energy or climate) and climate centric policies.

Then a common ambition for energy-economy modellers should be to further endogenize the interdependences between these parameters, making for example GDP growth and structural change result from the interplay between the growth engine, the characteristics of development patterns and the energy markets (Figure 1). In particular this implies to consider a comprehensive endogenous growth engine – not only endogenous technical change, but also endogenous structural change and growth – when it is possible to get robust estimations of real mechanisms.

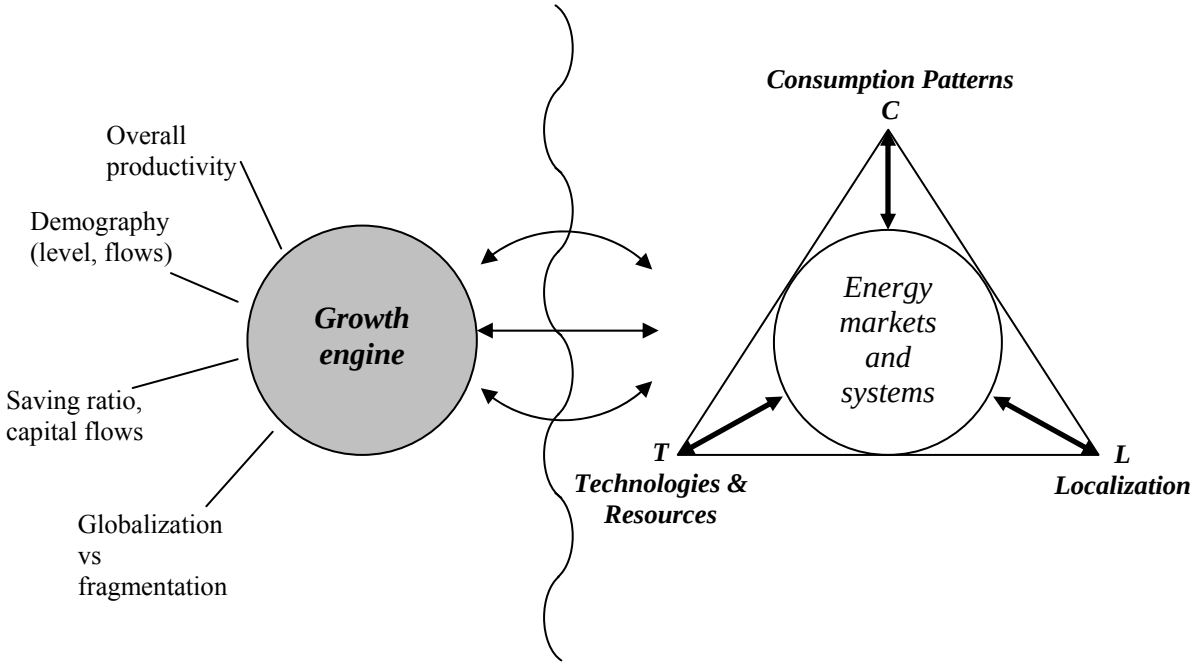

Figure 1: Interlinked mechanisms driving endogenous growth and structural dynamics

2.4 Non optimal baselines

The common practice is to use compact macroeconomic models or multi sector computable general equilibrium models for projecting equilibrated growth pathways (often optimistic for reasons of political correctness) and to represent environment policies in the form of new constraints altering these trends. This constitutes an intellectual obstacle to detect the possible leverage effects between climate policies and development since real sustainability challenges come primarily from:

- ***imperfections in the economic machinery***, the hallmarks of which are the existence of incomplete and fragmented markets (multiple discount rates, unequal marginal costs across sectors & regions), weak policy regime, poor governance, under protected property rights and dual economy in perpetual reformation;

- ***fuzziness of economic signals and non economic information*** and delays in perceiving ultimate consequences of current decisions. This inhibits timely actions and trigger higher transition costs to adapt to changes of the economic context (energy shocks, sudden moves in capital flows, over or under estimation of long term demand in rigid sectors);

- ***feedbacks from climate change and degradation of local environments*** : it is indeed increasingly misleading to project baseline 'at constant natural environment' since the coupled feedbacks from changes in environment and climate will generate stresses on natural resources (e.g. water, ecosystems) and degradation of land and labor productivity.

In this project we aim at delineating real baselines that incorporate barriers to the achievement of the growth potential of each country or region. In other words, it means to develop scenarios with ***economic disequilibrium*** generated by the interplay between inertia of social and technical systems, imperfect foresights and 'routine' policy behaviors, in order to detect the many sources of sub-optimality (structural debt, unemployment, informal economy and unfulfilled basic needs, capacity shortages, missing markets). The sub-optimality involved in these scenarios is not likely to be determinant for giving inputs to climate modelers; it will be for costs assessments.

3 Scenario development: generic scenarios and variants

The generic scenarios that could be developed in a first step would assume smooth growth pathways due to the progressive resolution of market imperfections (for example debt extinguishment) and to the absence of surprises in energy markets. In a second step, variants of these scenarios could incorporate assumptions likely to alter the social cost of meeting the concentration targets (with a second order impact on the pace of climate forcing).

3.1 Generic scenarios: balanced growth and globalisation of world markets

Combining high and low assumptions about the three sets of determinants of reference scenarios would lead to 8 reference and 16 stabilisation pathways. This number can be reduced to twelve by selecting the high and low bounds of plausible values for each determinant. We should not try and define two 'more plausible' scenarios in order to avoid harsh controversies and the accusation of political arbitrariness. If we manage to endogenize enough feedback mechanisms (cf. 2.3), it will lead to prevent that combining the lowest bounds of plausible parameters values results in an implausible scenario.

3.1.1 KEY PARAMETERS OF THE POTENTIAL OF THE 'GROWTH ENGINE'

We propose to generate two alternative growth patterns (H and L) using two contrasted sets of assumptions:

- ***Labour productivity, income distribution and catch-up***: new scenarios will greatly be improved with the lessons from the PPP vs. MER debate[2], especially the need to carefully consider initial productivity gaps and partial vs. full catch-up at the sector level. Then equations driving this parameter should take into account the sum of cumulated investments in each sector in each region, so that the effective catch-up rate (high or low) would depend on endogenous economic growth (assuming that 'leader economies' will follow mean productivity growth rates between 1.6% and 2% per year). The high and low catch up rates could ultimately be combined with assumptions about the ***income distribution patterns*** and the level of ***informal economies*** prevailing in each growth pathways;

- ***Saving rates and ageing***: in all regions, the secular evolution of the saving rates is correlated with the pyramid of age and, especially in developing countries, with migration flows and money flows from migrants. Scenarios could benefit from an overlapping generation analysis, in which the evolution of regional saving rates hangs on assumptions about risk aversion, pure time preference and long run interest rates.

- ***Capital deepening*** trends have to be checked (around central values) to fit with realistic ICOR values.

In complement to these sets of assumptions about the very growth engine, the 'balanced' character of growth pathways will be secured by assuming a) explicit foresight of technological evolutions and of the efficiency of equipments b) no strategic behaviours regarding parameters such as oil prices or regional relative prices c) no protectionist policies to mitigate transitory costs of the economic globalisation.

3.1.2 DEVELOPMENT PATTERNS, TECHNICAL AND STRUCTURAL CHANGES

Assumptions about consumption styles, technology and localisation patterns may be combined into two contrasted visions of development over the 21th century:

(I) ***deepening and generalization of post-war II development patterns*** that basically continue on existing trends with a progressive convergence of all societies towards high levels of material

[2] e.g. Nakićenović et al., 2003 ; McKibbin et al., 2004; Dixon et Rimmer, 2005 ; Nordhaus, 2007.

consumption (with due adaptation to local conditions), standardization, economies of scale, 'just in time' stock management;

(II) ***re-switching and tunnelling towards an alternative pattern*** in which some of current trends are altered, for reasons unrelated with climate concerns, to achieve a less material intensive development ('service and information society'). In this hypothesis, developed countries progressively change their development styles whereas developing countries bypass the most material intensive phases of development.

These two visions will be declined for following three sets of assumptions:

- ***Consumption styles:*** the (I) and (II) patterns incorporate respectively high and low assumptions regarding a) saturation asymptotes for demands of energy consuming services such as housing space or electric devices b) preference for mobility (short and long distance);

- ***Technological patterns:*** the (I) and (II) patterns are separated by different assumptions about a) the material content coefficients b) the substitutability potential between metals, fossil based feedstocks and bioproducts (bioenergy, biomaterials) c) the infrastructure choices in construction and transportation d) the transport input in production,

- ***Localization patterns*:** the (I) and (II) patterns will be characterised by high and low levels of households mobility demand (in consistency with assumptions about individual preferences and infrastructure policies) and territorial distribution of populations and activities (strength of the ocean coastal drift). The latter distinction is critical to elaborate consistent land cover scenarios and their implications for the carbon cycle (deforestation)

Efforts will be undertaken to incorporate as far as possible medium and long run feedbacks of climate change on the economic systems, which is a relatively new methodological challenge in scenario generation, and would raise the opportunity to gather work from WG II and III of the IPCC.

3.1.3 ENERGY SYSTEMS – ENERGY MARKETS

On the demand-side, the (I) and (II) patterns would induce different demand profiles for energy services, first because of their differences in material intensity, second because of the resulting impact on the time profile of fossil fuel prices. These differences can be accentuated by assumptions about the efficiency of end-use equipments: pessimistic vs optimistic assumptions about the asymptotes of efficiency gains in end-use equipments.

On the supply-side, the (I) pattern would be associated with rather optimistic assumptions about fossil based energies and a slow relaxation of resistances to nuclear energy. The (II) pattern would be associated with more pessimistic assumptions on fossil energies, higher social acceptance of nuclear and more optimistic assumptions about bio-energies.

3.1.4 POLICY MIXES TO ACHIEVE GHGS STABILIZATION SCENARIOS

The emissions profiles retained for the stabilization scenarios can be adjusted to some exogenous cost-minimizing profiles (in aggregate GDP terms) for each region under a fully idealized when and where flexibility assumption with full participation of all countries to a climate regime beyond 2012.

Not to enter the complex issues involved in the precise definition of such a climate regime and since a fully-fledged emissions trading system amongst all economic agents is unrealistic given the asperities of the real world, stabilization scenarios could:

- assume the existence of a single world carbon price applied to all gases;
- interpret this price as resulting from a carbon trading system amongst Parties (in the Kyoto sense) to which emissions allowance have been given in such a way that no import or export is economical for none of the regions or countries,
- let governments convert this world price domestically at their convenience (carbon taxes, emissions quotas at the sector level, pricing differentiation in function of income levels etc …) to account for the specifics of their economies or any social constraints;
- assume that governments take any complementary measures helping to reach the final target at a minimal social cost (efficiency standards, modal choices in transportation, urban infrastructures)
- assume that countries experiencing more significant transitory or permanent GDP losses than others will remain in the system and that international community will assist them (loans, assistance to dedicated investments) in minimizing these net losses.

3.1.5 MULTI GAS DATA

To be useful to the climate modelers, emission scenarios have to include improved multigas output. This raise methodological issues concerning aggregation, since the source of multigas emissions are often at a less aggregated level then fossil fuel consumptions. The use of aggregated activity indicators as proxies of the multigas emissions may appear very rough in the future.

3.2 Variant scenarios: frictions, disequilibria, timetables

Variants of the ‘stable growth’ scenarios should be carried out not only in the form of sensitivity tests but also to bring additional material for policy analysis.

- Three types of variants of ***baseline scenarios*** could be conducted:
  (i) Test of the impact of technical, economical and political ***frictions*** slowing down the pace of penetration *of* ***alternative techniques to conventional oil and gas*** (nuclear, coal to liquids, biofuels);
  (ii) Check how the baselines are altered by ***non energy-related parameters*** such as capital flows, a fragmentation of world markets, stickiness of the terms of trade, domestic wage policies;

(iii) Introduce endogenous or exogenous ***chocks*** triggered by sudden changes in oil prices or in exchange rates.

- The variants of ***stabilization scenarios*** could basically concentrate on three dimensions (in addition to sensitivity tests on the influence of frictions on the deployment of certain techniques):
  (i) Make explicit ***economic signals that may swamp carbon price signals*** as a major component of climate policies – this concerns in particular the prices of land and real estates, wage adjustments, the heterogeneity of capital costs (risk premium included) amongst countries and sectors;
  (ii) Capture the impact of ***regulatory uncertainty*** and ***price volatility*** on the efficacy of deployment of climate policies and alternative technologies, in view of examining what combination of policy tools would minimize the perverse effects of these parameters and enhance the incentive to innovate on both the demand and supply side.
  (iii) Examine the ***time tables of policies*** (binding emissions targets, carbon markets and/or carbon taxes, other pricing policies, non price measures, compensating transfers) capable to minimize the transition costs towards a stabilized fully-fledged climate regime governed by a single carbon price

The basic assumptions behind these policy variants is that, even though the assumption of a unique world carbon price applied from now on and without complementary policies is a very useful benchmark for policy analysis, it does not correspond to an optimal policy in a 'second best' economy with sharp political constraints. Variant scenarios should thus relax this assumption, accept the ***transitory existence of disparities in levels of carbon pricing*** and examine the following policy issues:

- *Timing of various forms of commitments* and pledges by countries for a fragmented and progressively converging regime;

- Content and timing of policies *on non-CO2 gases and carbon sequestration*;

- Content and timing of *infrastructure policies*;

- *Differentiation of policy signals* across sectors (energy, industry, land transports, aviation and shipping, agriculture);

- Design and timing of policy tools to alleviate transitory tensions generated by the emergence of a carbon price: international transfers to mitigate *the adverse effects on low income populations* and/or to launch early policy signals to reorient investments in infrastructure sectors, sectoral approaches for exposed energy intensive industry)

4 Some perspectives for scenario development with Imaclim

The four teams signatories of this proposal co-develop the Imaclim-R framework which is designed to meet at least part of the above challenges. This framework is an hybrid model which a) organizes in a consistent way technological and economical expertise b) extend the endogenous technical change assumption to consumption, localization patterns and structural change c) describes an economic

growth engine which allows for transitory disequilibrium d) allows for imperfect foresight and market imperfections which determine the duration of various disequilibria including those related to labor market, capital and trade balances).

The four teams have been and will be jointly embarked in various projects for example for the World Bank and for the World Energy Outlook of the International Energy Agency. They are prepared to build on this experience to develop jointly scenarios in the new IPCC context in harmony with the guidelines which will emerge from IPCC Expert Meeting "Toward New Emission Scenarios for Analysis of Greenhouse Gas Emissions Climate Change, Impacts and Response Strategies" of WG III, 19-21 September 2007, at Noordwijkerhout, The Netherlands.

Their specific priority will be on line with the above analysis, to generate scenarios (baselines and variants) helping to explore more in depth the relations between climate change and development - *sustainability* (preservation of' separate or aggregate values of capital stocks like manufactured, human, social and natural capital; dematerialization and its implications for growth). They will more specifically emphasize issues related to *irreversibility* (social costs of lock-ins and values of lost options), *discontinuity* (extreme events, oil shocks, abrupt changes in capital flows), *uncertainty* ' (including regulatory uncertainty due to global agreements and national policies), *equity* (intra and international).

Our scenario development work will not be exclusive or limited by the interactions among the four teams. We plan to gain benefits from the interfaces different partners have with several prominent global modeling teams such as MiniCAM and SGM at Pacific Northwest National Laboratory (USA), Asia Pacific Integrated Model (AIM) team at National Institute of Environment Studies (Japan) and MESSAGE model team at IIASA (Austria). We are obviously open to collaboration with any other teams pursuing the same priorities. Such interactions, we expect, would enhance our scenarios in specialized areas like forestry and land-use, the viability of various technology strategies (biofuels, nuclear) and multi-gas assessment; It would also allow for a better understanding of differences in results between Imaclim and their own modeling approaches.

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