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Iddri's contribution to the Stern Review

Founded in 2001 as a research consortium, Iddri became a non-profit, nongovernmental, multi-stakeholders think-tank in 2003. Led by Laurence Tubiana, Iddri aims at developing policy dialogue and research on international governance, regulation matters and sustainability issues. Iddri provides forums and networks for creating common culture on sustainability issues among stakeholders, following 4 objectives:

- Contribute to building up a more equitable and effective global governance;
- Reduce controversies by initiating dialogues among stakeholders;
- Promote scientific research and multidisciplinary expertise on sustainability;
- Gathering timely information and knowledge to improve decisions-making

Iddri's focal areas are those requiring collective international action such as Climate change, Biodiversity or Agriculture and forests. Relevant cross-cutting issues related to above-mentioned topics are also explored, and in particular: Environmental and social responsibility, International trade, Global governance, Uncertainty and precaution.

During the last years, staff and results from Iddri's climate change program contributed to several policy dialogues at the French, European and International levels.

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Introduction: Ad hoc analytical framework for the assessment of climate change mitigation issues

Although reducing all greenhouse gases emissions balance is necessary, special attention should be paid to CO_2. Reducing anthropogenic emissions of carbon dioxide to the atmosphere is probably the most problematic issue to be addressed for preventing severe climate change, due to some of the very fundamental characteristics of CO_2 emissions:

- The direct links between economic growth and energy consumption, and therefore the causal relationship between economic growth and CO_2 emissions;
- The lack of foreseeable economically sound "end-of-pipe technology" for reducing CO_2 emissions in a mid-term future. The only credible prospective technological option, namely carbon capture and sequestration (CCS), despite being necessary – especially for reducing the impact of the projected mid-term growth of coal consumption, will only be relevant for a small share of future CO_2 emissions[1];

[1] More precisely CO_2 fluxes produced at a short distance from geological storage. The transportation constraint strongly reduce the foreseen potential of CCS in oil & gas reservoirs, in particular for potential

– The strong inertia of key drivers of both energy demand and energy production, resulting from their infrastructural nature. The capital turnover on the supply side range from 20 to 100 years. Except for road vehicles, the investments shaping the energy demand have similar life-times, contributing to the strong inertia of energy and CO_2 path.

Beyond their apparent simplicity, these observations provide the basic but necessary characteristics of any assessment of past, present or future emissions paths. In the context of climate change, emissions trends analysis will only be informative if they provide: (a) understanding of the structure of the global trends, and, (b), insights on the evolution of the different components of CO_2 emissions. The study of prospective emissions, identification of potential levers for change, or assessment of the impact or effectiveness of policies, should likewise be based on comprehensive analysis of the different factors shaping the emissions trajectories. Such framework has driven the Iddri working program on Climate Change, in which sectoral studies are providing informed practical recommendations for founding sound and consistent agenda for actions. 4 actions of the Iddri's climate change program are of interest for your review on the economic of climate change:

(A) Diagnosis on present trends of emissions and their implications for the future;

(B) Studies on mitigation technologies potential;

(C) Analysis of the implications of ambitious emissions reduction targets on the demand for industrial products (in collaboration with French industry);

(D) On-going research on the Chinese infrastructures policies for identifying levers that could favour less carbon-intensive systems.

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(A) Diagnosis on present emissions trends and their implications for the future

Greenhouse gas emissions have stabilise in Europe over the last decade. However, without understanding the factors contributing to the stabilisation, this observation is a guarantee neither of the European Union's ability to meet its emissions commitments under the Kyoto Protocol, neither of the existence of structural changes deemed necessary to attain emissions levels consistent with the UNFCCC long-term objectives. In order to avoid such pit-fall and understand the implications of past emissions trends for the future EU climate policy, Iddri conducted an analysis of sectoral changes in Europe[2]. This study identified the following tendencies:

- Emissions stabilisation and sectoral changes observed during the last decade are mostly due to events and policy developments unrelated to climate policy, and unlikely to be reproduced in other countries: Germany's reunification; substitution from coal to gas in

future major coal consumers such as China & India (CLIP n°17, 2005). Sequestration within saline aquifers or unusable coal beds might improve the perspective for CCS but are still conceptual options, facing poor knowledge of potential reservoirs and lack of understanding of their physical behaviors.

[2] Climate change policies: Analysis of sectoral changes in Europe. C. Barbier, R. Baron *et al.*, 2004.

the United Kingdom driven by power market reform. We should not expect changes of such magnitude in the near future.

- Industry's direct and indirect emissions (trough electricity consumption) have been roughly stable since 1994. However, it is hard to predict whether efficiency gains to come will be enough to offset a recent increase in carbon-intensive materials demand such as cement, steel or glass.
- Power generation's CO_2 emissions have decreased slightly in spite of strong demand growth. However, as mentioned above, the carbon content of electricity has been markedly reduced for historical reasons in the UK and Germany. Coal to gas substitution potential remains important and could reduce EU's total emissions by 5 to 10%. However, these gains will be largely overcompensated by projected consumption growth that could reach 50% by 2030. Combined heat-and-power and renewable technologies will provide further emissions reductions, but ambitious policies on the demand-side will also be necessary.
- Despite efficiency gains in residential sector, increasing floor space and level of equipment, as well as reduction in households size observed all over Europe, resulted in growing energy consumption. Only large-scale measures to retrofit the existing residential stock can help curb emissions trends in this sector, but few countries have taken such measures to date.
- Similarly, energy efficiency improvements in tertiary/services sector do not compensate for growing floor space as well as increasing electricity consumption related to the diffusion of information technologies and air-conditioning. As these activities are increasingly contributing to the European economic growth, emissions trends in the sectoral should keep rising.
- Transport's growth, especially freight, has been significant in all countries. The highest rates of traffic growth per unit of gross domestic product are in Spain and Portugal, two countries where rail infrastructure is fairly limited. CO_2 emissions from transport grew by 18% in the EU between 1990 and 2000. The potential for energy efficiency improvements is important, but may be more than offset by traffic growth, increased engine displacement and new onboard equipment. Inverting emissions trends in this sector is the major challenge of EU's climate policy for decades to come.

Europe's primary energy demand continues to grow, especially in the residential-services and transport sectors. We do not observe any saturation of energy needs in EU-15 responsible for the bulk of GhG emissions. **In this context, incremental improvements of current policies may not be enough to achieve Europe's overall goal for 2008-2012, let alone to bring about more significant reductions in the future.** There is henceforth a risk of a major drift in greenhouse gas emissions once all one-off and least-cost measures have delivered their potential reductions. **It is therefore necessary to envisage real structural changes to ensure sustained emission reductions in the medium to long term.** Curbing electricity and transport demand, and the renovation of existing buildings ought to be priority fields of action for Europe and its Member states if they wish to reduce emissions markedly in the future. While countries and situations do differ in many aspects, the threat of climate change requires that EU countries set aside arguments related to their "national circumstances".

(B) Studies on mitigation technologies potential

Iddri is co-ordinating the activities of the *Club d'Ingénierie Prospective Energie*[3] (CLIP), a task-force founded in 1993, gathering more than 25 members coming from administrations and Ministries, research and technological institutes, and industrial members. CLIP activities aim at: (a) developing visions of potential spreading opportunities for energy technologies, and, (b) assessing the social and economic impacts and issues of these future technologies, especially on CO_2 emissions trends.

Follows are details on 6 CLIP studies of primarly interest for the "Stern Review".

i – Historical and prospective assessment of sustainability issues in buildings[4]

Detailed assessment of energy consumption in the housing and tertiary sector shows a decreasing share for heating, and a rapid growth of electricity consumption largely associated with the diffusion of both IT technologies and air conditioning. Traditional "building thermal performance standards" that provided the main regulation tools during the last decades should thus be replaced by a global energy assessment and target of buildings, comprising heating needs during winter period, summer comfort and overall energy consumption by electric devices.

Furthermore, the CLIP study identified two key drivers that will largely shape future CO_2 emissions paths related to buildings, and that should thus be considered as policy priorities:

- **The retrofitting rate.** During the 2000-2050 period, 80% of projected emissions reductions in buildings will come from upgrading existing buildings. In the contrary, alternative scenarios comparing different improvement rates for new constructions standards do not significantly affect CO_2 emissions by 2050.
- **The geographical structure of urban areas.** There are strong interrelations between individual energy budget and urban organisation. Beyond the well-known oppositions between personal car and public transportation or individual *versus* dense housing, this correlation raises questions on: (1) the investment capacity at both the individual and the public level, and, (2), the politics and measures priorities. In particular, the study suggest that an equilibrium point has to be find, beyond which further increasing constraints on buildings to offset less controlled transportation emissions will prove to be both technically and economically unreasonable.

ii – Potential development of electric cars in France by 2050[5]

This study assessed the impact of the potential diffusion of electric car technologies, namely:

- Electric car, with an effective autonomy of 300km/h and a reloading time of 1 hour;
- Hybrid cars, without needs of plugging;
- Pluggable hybrid cars;
- Fuel-cell cars, using methanol produced from natural gas;
- Fuel-cell cars, using liquefied hydrogen produced from natural gas.

The reference case scenario estimates that future technological progress of combustion engines will not compensate for the growth of both the number of vehicles per capita and

[3] Working Group on Future Studies for Energy

[4] CLIP n°13, 2001.

[5] CLIP n°13, 2001.

the mean annual use of these vehicles. In this "laissez-faire" scenario, 2050 CO2 emissions from cars will be 17% higher in 2050 than in 2000 (benefits of future incremental efficiency improvement included).

The CLIP study estimated that **hybrid technologies are the only electric options that will allow 2050 CO2 emissions from personal vehicles to be lower than 2000** (-12%). Until a technological breakthrough that might significantly increase the autonomy of "electric vehicles", the market share of this technology will remain limited due to the constraints on its daily use. Electric vehicles might however be developed on a urban niche, providing a reduction of both CO2 emissions and local air pollution. In the short term, electric vehicles is even one of the best technological option to reduce CO2 emissions, while demand saturation has not been reached. In the mid term (2020+), changes in French electricity mix may further reduce the interest of "pure-electric vehicles", and will contribute to the increase interest in hydrib technologies.

iii – Decentralised combined heat and power generation: potential impact on CO_2 emissions in France[6]

This study considered the potential impact of a large diffusion of decentralised cogeneration (DeCo), i.e. combined heat and power production. Different technologies have been considered for their energy potential, assuming that they become competitive by the year 2050. Considered technologies include: internal combustion units using natural gas, gas turbines and fuel cells. Decentralised co-generation provides "semi-base" energy: for economical reasons, installations are designed to respond to a medium consumption level and are thus unable to cover the peaks in energy demand. The potential of cogeneration diffusion thus depends on the energy consumption profile of considered sectors. Cogeneration is for example highly relevant for agriculture greenhouses, whereas less adapted to provide energy for school buildings.

Assuming the cost reduction hypothesis for these technologies, the study showed that **decentralised cogeneration has a huge potential, especially for housing and tertiary buildings and, in a smaller extent, for small industries.** Hotels, hospitals, Retirement houses and public pools should be the priority sectors for implementing these technologies. DeCo could provides up to 40% of the heat needs of considered sectors (20% of the national heat demand) covering in the same time 25% of their electrical consumption, or more with fuel cells under development. At the same time, **decentralised cogeneration provides significant CO2 emissions reduction**, even in France where the carbon content of electricity is very low compared to European standards.

With such a potential, DeCo will be in direct competition with traditional centralised power plants, providing an alternative for postponing part of the massive investment planned in the electricity sector, and an opportunity for reducing CO2 emissions in several sectors. This potential also raises questions on the management of the electrical network, notably in terms of stability, which need to be clarified before large scale use of decentralised cogeneration.

[6] CLIP n°15, 2004.

iv – CO_2 emissions reduction potential by thermal-solar technologies in France[7]

This study assessed the potential contribution of thermal solar technologies for reducing GhG. A “Factor 4” reduction of total GhG emissions from buildings has been considered. The study pointed out (again) the importance of retrofitting existing building stock. In particular, the “Factor 4” target will not be achievable without thermal upgrading of 400,000 housing per year, during the next 30 years.

Taking into account the projected improvement in thermal performance of buildings (including passive thermal optimisation of buildings), **solar thermal heating does not prove to be competitive, whereas hot water production using solar energy proves to be highly efficient and promising.**

The CLIP study proved that a combination of :

- passive solar technologies applied to all new construction and implemented in existing building through ambitious upgrading programs;
- improved building construction standards & retrofitting programs;
- thermal solar hot water production;

will allow to reach 75%+ emissions reductions in the building sector.

v – Worldwide CO_2 emissions reductions potential by carbon capture storage (CCS)[8]

Power generation accounts for almost 40% of the world total energy related CO_2 emissions. This study focuses on geological carbon storage and its potential for capturing the CO_2 from electricity production. Carbon capture and storage (CCS) has been assessed taking into account the geographical distribution of potential reservoirs. Only oil and gas fields have been considered as potential reservoir. In the long-term future, saline aquifers and unusable coal mines may also be used for sequestrating carbon. However, theses options are still theoretical and have not been taken into account by the CLIP, which studies aim at studying the potential of “existing” technologies.

Prospective carbon capture has been estimated by detailing the annual new installed power capacity at the world level, assuming that CCS equipment will be installed on all plants build after 2020. Assumptions on the diffusion of technologies adapted to existing power plants (post-combustion) have also been considered. Under these optimistic assumptions and without taking into account the constraints on reservoirs storage capacities, CCS would sequester 66% of the CO2 emissions from electricity production by 2050, and 30% of the total emissions emitted from 2000 to 2050, taking into account the energetic cost of CCS.

These estimates of maximal capture have been confronted to the storage potential in oil and gas fields. A world-wide storage potential of 560 to 1170 Gt CO2 of has been estimated from a review of international literature and surveys. 60% of these reservoirs are located in the Middle East and Russia. **The comparison of available reservoirs and sequestration needs at the regional scale shows significant disparities.** Three groups of regions can be distinguished:

- Region with large surplus, for which the potential storage is at least 3 times larger than the total amount of captured CO2 (Middle East, former USSR, South America, North

[7] CLIP n°16, 2004.

[8] CLIP n°17, 2005.

and West Africa). These region only represent 17% of the carbon that might be sequestered up to 2050.

- Region with a surplus, where the reservoirs potential is larger than projected captured emissions (OECD Europe, Oceania, South East Asia and Central America). In these regions, 80% of the potential storage are located in offshore fields. Huge investments are thus needed to allow the full implementation of CCS technologies on all new fossil fuelled power plant builded after 2020
- Storage deficit regions, where the storage in oil and gas fields is not enough to absorb captured emissions (Eastern Europe, Canada, USA, South Asia of which India, Eastern Asia of which China, Japan, South Africa and Eastern Africa). Those regions represent 83% of the capture potential but only 9% of the storage potential. If a threshold of 1000 km is taken into account between the source of emissions and the storage location, the resulting potential for carbon capture and storage is significantly reduced. The countries representing 80% of the global carbon capture potential could only avoid 16% of the total CO2 emitted by the power sector between 2000 and 2050. Among those countries, China, India and USA, representing 53% of the world capture potential, could only avoid 14% of the emissions from power generation.

If carbon capture and storage will undoubtedly contribute to the mitigation of climate change, this study pointed out the fact that some of the countries that will rely the most on fossil fuelled power generation during the next 50 years have only access to a volume of reservoirs corresponding to a small share of projected emissions. Furthermore, this assessment has been made using optimistic hypotheses, i.e. overcoming several technical (and economical) difficulties before 2020, when full implementation of CCS is assumed. CCS potential might however be significantly improved if saline aquifers and unusable coal mines prove to be efficient reservoirs, but further R&D is necessary before large-scale use of these options can be envisaged.

Taking into account the slow development as well as the uncertainties of this technology, carbon capture and storage may only be a partial solution in the long term. Other policies are needed, such as electricity demand control and the use of alternative power generation (renewable energy use, cogeneration).

vi – Worldwide CO_2 emissions reductions potential by biological sequestration[9]

This study assessed potential CO_2 reductions provided by new forest plantations on agricultural land which may become available worldwide from now to 2050. Emissions reduction have been calculated taking into account the potential changes in carbon stocks on afforested land (both in biomass and soil), as well as the substitution of biomass to fossil fuel and material such as steel, aluminium or concrete. Four types of plantations have been considered, including: (1) short rotation plantations to meet local energy needs; (2) short rotation plantations producing wood only for material; (3) conventional plantations, with long rotations; (4) "sequestration only" plantations which are never harvested. The last kind of plantation is taking place whenever agricultural land becomes available whereas other plantations are made on free land, following the increase in wood demand for energy or for material. Wood demand has been calculated assuming a maximum penetration ranging from 15% to 25%, depending on the sector.

[9] CLIP n°17, 2005.

Agricultural land availability where projected new plantations will take place depends on the future development paths. Two contrasted scenarios have been considered, based on the IPCC SRES A2 and B1 scenarios, implemented using the IMAGE model[10]. Compared to A2, B1 scenario envision lower population growth, and faster technological improvements including energy and land use efficiencies. By 2050, B1 benefits from higher crop yields and lower livestock requirement to satisfy human nutrition needs; leading to a greater agricultural land availability (6 times higher compared to A2), mainly located in South America, Africa and China.

Despite having the best CO_2 emissions reductions potential[11], use of woods for energy or material purposes is limited by the demand for these products, significantly lower than the production potential. Taking into account demand constraint, projected biological carbon sequestration range from 1% (A2) to 5% (B1) of cumulated emissions until 2050. These figures might significantly improve if "Biomass-to-Liquid" technologies would become technically and economically feasible before 2050.

If biological sequestration can undoubtedly contribute to climate change mitigation, this study puts in light two significant limits to its potential:

- SRES scenarios describe world development path without GhG emissions reductions policies. Study results show that **biological sequestration can only offset a marginal share of the projected growing emissions**. Biological sequestration will thus only be relevant in addition to an ambitious reduction of GhG release in the atmosphere.
- **CO2 emission reductions from afforested agricultural land will only become significant after the year 2030, or even at a later stage if long rotations plantation are favoured. Forest plantations should be considered a long term option, and can therefore not as a temporary "buffer", allowing to postpone effective reductions of greenhouse gases**

(C) Analysis of the implications of ambitious emissions reduction targets on the demand for industrial products (in collaboration with French industry)

Technical assessment such as those detailed above provide images on what a future low carbon society might look like. However, even if it is possible to propose a Vision for 2050, it is still hard to comprehend how economies could evolve towards such carbon-less path. Except for projections about future energy systems, our perception of the industrial implications of these large-scale transformations remains limited. The important changes in production and consumption patterns and infrastructures needed to achieve these low-carbon societies will have nevertheless significant implications for a whole range of industrial activities, much beyond the energy sector. Recognising that whatever measures are taken to curb GhG emissions, any reduction goal compatible with climate stabilisation

[10] IMAGE is developed by the Dutch RIVM

[11] It should also be mentioned that almost 80% of emissions reductions through substitution of fossil fuel with wood for energy will remain permanent, whatever will be the usage of new forest plantation in the long term, which is not the case "sequestration only plantations"

will have considerable effects on economic activities, markets and behaviours, Iddri and its partners have set up a project to explore this particular aspect of climate policy.

The main goal of this still on-going study is to bring together industry experts and economists to assess, as a group, the consequences of such a future carbon constraint and how it will apply to various sectors in industry and to its markets, while trying to maintain the coherence between sectoral evolutions, to the extent possible. Ultimately, this should help defining what could be appropriate and realistic policies and measures that could bring such reductions at least economic and industrial cost. This project is conducted with a two-pronged approach.

1) Industry participants provide input regarding current production processes and expected evolution (including possible technological breakthroughs), capital stock turnover, costs as well as key markets for industrial demand. Sectors covered include aluminium, cement, electricity, gas, glass, iron and steel, refining. The demand side (in particular buildings and transportation) is taken into account, with an eye to their materials content when significant reduction levels are envisioned.

2) This information is combined under different policy scenarios that depart from the assumption that a single policy instrument (tax or quota) can drive alone future changes towards a low-GHG economy. A key starting point of the project is that other policies and measures are already, and will continue to be, introduced to tackle emissions driven by transport and buildings, among others. The scenarios are evaluated from energy and economy viewpoints, seeking to evaluate constraints (capital stock turnover, investment cycles, technology development) and opportunities (new demand for materials, new sources of value added), along the path to 2050.

Preliminary results of this study show that envisioned infrastructural change necessary to attain ambitious emissions reduction targets (such as "Factor 4") will create a increased demand for the materials concerned with these works. Such an increase on the demand side will create a growing pressure on industrial GhG emissions. However, this growing demand also provides significant opportunities for the industry that can facilitate their commitment for actively contributing to ambitious climate policies.

(D) On-going research on the Chinese infrastructures policies to identify levers favouring less carbon-intensive systems.

This on-going project tries to bridge the gap between national development policies of emerging countries and international negotiations on climate change. While historically the preponderance of greenhouse gas emissions has been in the developed countries, expected and needed economic growth in developing countries results in a rapid growth in emissions. China, India and Brazil are already responsible for a significant share of global GhG emissions. However, since the establishment of the UN Framework Convention on Climate Change in 1992, North-South co-operation on climate change has not developed adequately. Worse, the discussion on how to address climate change in the longer term has become polarised, a situation repeated during the COP/MOP1 meeting at Montréal for the negotiation under the article 3.9 of the Kyoto Protocol. One reason for this lack of progress may be that industrialised countries did not make an effort to broaden the debate to sustainable development issues. Another reason is that climate change in developing countries is not a politically important focus of economic or development policy and is only recently being considered among national environmental policy objectives in some of these countries. Climate change remains marginal to the pressing issues of poverty, natural resource management, food security, energy needs and access, urban transport and land use that focus the attention of leading actors.

Current co-operation efforts and analyses of climate change policy have been driven mostly by concerns about climate change. This approach has had limited success in driving global action. However, re-framing global environmental policies as deriving from development priorities will not make climate change easier to solve. Rather, it suggests changes for the global collaboration framework on climate change that should be approached on multiple levels through local and national development programmes. During the COP/MOP1, developing countries such as South Africa elaborated diverse proposals based on similar approaches ; and concept such as "non-binding targets" or "sectoral targets" have been widely discussed.

Acknowledging the need of a new and effective framework for having emerging countries contributing to climate change mitigation, our project explores the idea that building climate policy upon development priorities of vital importance for developing countries will facilitate their international co-operation on climate change mitigation. Iddri plans to conduct detailed sectoral case studies aiming at identifying true and effective levers to curb prospective emissions paths. The first (on-going) case study address the building sector in China, in collaboration with a major Chinese city.

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Research detailed above have been conceived (and their results mobilised) to provide a foundation for effective and pragmatic propositions that might facilitate the necessary international co-operation for climate change mitigation. Our approach is therefore to take into account developing countries development priorities or other stakeholders priorities for increasing climate policy acceptance and relevance. Further efforts should be dedicated to:

- exploring policies that both met sustainability priorities of stakeholders and effectively address climate change;
- identifying promising policy options and projects that provide signals and guidance for the transition to long-term sustainable development and decarbonisation of the society.
- understanding the policy options informally discussed (sectoral agreements, allocation of rights / policy measures…) and the pragmatic political, economical and institutional constraints of their implementation. An analysis of their compatibility / exclusiveness would be useful.

These are the main objectives of Iddri's work program.

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