Academic Report

adopted by vote
by the National Academy of Technologies of France (NATF)
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TECHNOLOGY AND CLIMATE CHANGE

SEVERAL SOLUTIONS TO MITIGATE THE EFFECTS AND TO ADAPT

EXECUTIVE SUMMARY

1. The National Academy of Technologies of France (hereinafter the Academy or NATF), fully conscious of the challenge of climate change and its effects, issues this Report which analyses and assesses technological potential that could be mobilized and/or developed. Indeed NATF deems that *"**inaction would have serious consequences**, unacceptable for France and for the planet Earth".*

2. **Climate geo-engineering**, given the state-of-the art knowledge available, **cannot constitute a viable, alternative solution**. Proposals to seed the atmosphere and/or the oceans will not prove efficient to either reducing greenhouse gas (GHG) emissions, or to mitigate their impact if the aim is to adapt to the prevailing situation.

3. This NATF Academic Report aims at identifying those conditions that should be encouraged globally and in the most contributive sectors, in order to decrease GHG emission levels and to advocate and encourage preventive adaptation measures. It is primordial that **a price be set for each tonne of equivalent emitted CO_2**.

4. When envisaging energy efficient measures, the cost of the investments needed must be lower than that for the energy saved, to which must be added – if the energy sources are not carbon-free – the value in tonnes of non-emitted CO_2. For all mitigation technologies, it is advisable that operators carry out **cost/benefit analyses** and ensure that the depreciation and later system management costs do not call for subsidies that would be disproportionate compared with the GHG emissions savings made.

5. Member States and the Europe have an important incentive role to play by preparing and drafting standards or EU Commission framework recommendations that could enable a price to be set for emitted carbon. Enterprises and public actors should, as of now, encourages business enterprises to set, as of now, an **'in-house price' for each tonne equivalent CO_2 in their calculations** for future investments measures. The actual price could be chosen in the price bracket proposed by the Euro-CASE Energy Platform.

6. The implication of 'main street' Society, the modifications of life-styles and behavioural patterns that have as their objective a carbon-lean Society will also play an important role enhancing GHG emission reductions. Better awareness campaigns are needed to make these evolutions realistic, accepted by all and easier to adopt. **Education and Training schemes** must integrate these factors.

7. **Developing nations** are often more vulnerable to the effects of climate change and merit special attention from public and private actors, to assess with the countries concerned the key factors for adaptation and the technologies available and/or which can be developed and to assure the mobilization of necessary funding.

8. In many areas, the highest degree of potential solutions for mitigation and preventive adaptation will stem from development of **new technologies,** applicable to:

   - **Agriculture, forests and soils**: increased carbon absorption in soils through better control of agricultural practice and the associate microbial layers; limiting emissions of N2O through more accurately dosed fertilizer programmes; prevention of deforestation and adapted forest management.
   - **Seas, oceans and coastlines**: risk prevention; development of *off-shore* installations; energy production using tidal forces and marine currents, or bio-mass; polder construction.
   - **Buildings, urbanism, mobility and transportation**: providing global solutions for tomorrow's cities; diversifying proximity services; removing regulatory hurdles (mutualizing energy consumption between buildings or multi-usage building management on a positive energy basis); using materials with a high carbon content (wood and timber); reducing emissions caused by transport systems.
   - **Energy**: progressively adopting more and more carbon-free energies; storage of electricity and flexibility of electric systems; continued R&D on carbon capture and sequestration. Changes in this field, notably through chnaged habits of consumption and utilization are very important factors if we wish to reduce GHG emissions.
   - **Information and communication technologies (ICTs)**: mutualizing infrastructures (including the physical networks for mobile phones) ; using low energy consumption data handling equipment or making use of recovered energy ; developing ICTs in industrial sectors and services to improve energy consumption efficiency-.
   - **Bio-economics:** should a price be set for emitted carbon then the processed attached to bio-economics will prove more attractive because of their excellent global emission balance. NATF would like to see the establishment and implementation of a road map for France.

In more general terms, NATF recommends that all sectors seen as high-level emitters of GHGs be encouraged to take action, making full use of new processes and organizations with costs that are compatible and proportionate to the energy saving economies made.

INTRODUCTION

Climatologists confirm that there has been a 1°C rise of the average temperature at the Earth's surface since the beginning of the industrial era. The primary case lies with carbon dioxide (CO_2) emissions, released by combustion of coal, oil and gas. Other gases with a shorter life span are also incriminated, such as methane (CH_4) or nitrous oxide (N_20)

The level of CO_2 concentration in the atmosphere was 285ppm[1] at the start of the industrial era, and at present stands at 400 ppm. What has been observed is that the planet Earth is no longer able to metabolize excess CO_2 emissions (and likewise for the other gases that contribute to the 'greenhouse' effects). This accumulation of GHGs in the atmosphere acts like plant forcing, *viz.,* induces a constant constraint that modifies the thermal balance of the Earth, with a rise in the average temperatures, a slow rise in ocean surface level and, quite probably, an increase in the frequency and amplitude of extreme climatic events: hot-spots and heat-waves, excess rainfall or intense droughts; the observed result is definitive: Mankind has become an actor vis-à-vis the climate. The complications of this "chronic fever" that we are forcing on our planet risks producing a boomerang effect if we decide not to change as of now our life-styles, or the 'trajectory' chosen for Progress, the tools that enable course correction and if we do not properly manage the impacts and consequences. The process is engaged and inasmuch as the phenomena and the systems are inertial, GHGs will remain at high levels for a very long time in the Earth's atmosphere.

When NATF chose as its motto *"Sharing reasoned, chosen Progress"* and adopted a visual logo with a human hand shaking a robotic hand, it was with the objective to underline the fact that as of its foundation (in 2000), the Academy in its Reports or Advice Notes would analyse, assess and take into account all the relationships between technologies and economic, social and environmental aspects appertaining to human activities.

The Academy was naturally led to keeping itself informed as to the evolution, year by year, of international negotiations in the 1992 Framework Agreement of the United Nations on Climate Change and to examine various aspects related to GHGs, notably in terms of energy investigations. It was felt that given the dynamics of the COP21, convened in Paris and which marked an important stage in the building of a global policy for climate issues - which did not constitute the end of a process that will unfold over several years – that it could offer a useful contribution in the form of a text that would reveal all its advantages during year 2016, when, and still under French Presidency, the ratified decisions of the COP21 will be implemented. This rather than proposing an overarching technological synthesis that would go unnoticed in the media turmoil in the following months.

The Academy considered that its contribution should concentrate on specific Recommendations that merit being implemented and monitored – downstream of the studies undertaken by the IPCC (Intergovernmental Panel on Climate Change) and depending on whether the scope is global, European or France. The Academic Report covers a very large scope from agriculture to forests, from drinking water supplies to the seas and oceans and coastlines, from buildings to mobility and transportation, from energy to bio-economics, from climate geo-engineering, to the skills and training programmes needed to control the climate. It has been the role of technological engineering that allows us to exploit fossil resources and to fertilize our fields to meet the growing demand of Mankind. In years to come, the same technology intensive engineering should be called on to help reduce the emissions of GHGs, to capture and store them and to better anticipate and manage the impacts of climate changes.

[1] 2 ppm = parts per million, 1 ppm represents 1 molecule de CO_2 for 106 molecules in the air.

Today, even if some uncertainties remain in regard to the precise values predicted by the IPCC modelling, in particular concerning the global average temperature as a function of CO_2 emission scenarios into the atmosphere for the rest of the 21st Century ahead, the decade-by-decade observations confirm the upwards trends. Consequently, the preventive and adaptation measures should be taken as of now. There are numerous paths here that cover – agriculture and forestry, energy, urbanism and transportation, industrial sectors, preservation of coastlines, access to drinking water, new forms of production and shared economies, lean management of Earth's resources and their utilizations … it is vital to see those actions already engaged intensified, to ensure constant financing, notably for the benefit of those populations who indeed are most vulnerable faced with the adverse effects of climate change, and for a large majority the least well-armed to cope with change, extreme events and possible disasters.

It will be through development of new technologies, that we shall see the highest potential for mitigation processes and protocols in a large number of areas.

Efficiency of developing these new technologies and deploying them on a large-scale will rely largely on commitment by tie State authorities, leading to the drafting and enforcement of new standards, creation of a carbon market, of tax incentives … Technology transfer to benefit the developing nations and the design processes for technologies adapted to the specific needs of these countries will depend on whether appropriate financial incentives are made available. Notwithstanding, new technologies, processes and protocols are only part of the solution - they must be 'tamed', adapted, disseminated and necessarily be seen as compatible with ongoing social and ethical dynamics if they are to contribute efficiently to mitigation of the adverse effects of climate change and to subsequent adaptation.

The Academy of Technologies of France (NATF) recommends:

- ***that the cost/benefit ratio for each solution be calculated and that reasoning be in terms of overall balance observations;***
- ***to set an agreed price for each tonne CO_2 equivalent saved.***

NATF is of the opinion that the measures it has investigated could call for an approach inspired, as far as possible, from the following orientation guide-lines:

- for any proposed, an assessment must be made to ascertain whether it is the most favourable solution for a given local authority compared with other possible measures envisaged. NATF recommends where possible to carry out a life cycle analysis;
- for the purpose of these assessments, it is advisable to reason in overall balance terms, costs and benefits, with the understanding that these balance calculations do not cover future costs and benefits, on the understanding that the balance calculations:
    - must include future costs and benefits and their distribution over time;
    - must integrate - over and above the estimated future economic data and prices – explicit calculated evolutions, social and environmental advantages and damage associated with each solution envisaged.
    - This approach obviously raises the question of the price to be set for each tonne equivalent CO_2 emitted.

If such a set price were to exist (as is the case for a barrel of oil, for a tonne of coal of a cubic metre of methane gas) many of the negative effects on world incomes levels of heterogeneous decisions taken to avoid GHG emissions –referring implicitly to value in the region of several hundred euros per tonne, down to several euros per tonne – would be avoided. Some people propose that the COP should agree to a price to be paid by all the significantly large carbon emitter states, the revenues from which taxes would be used to finance, notably, the poorer countries, helping them to undertake mitigation actions and local adaptation s to the effects of changing climatic phenomena. But this solution is currently out of reach. If a given developing country willingly accepts to pay its imported oil supplies at the going world price per barrel, it would assuredly refuse that each tonne of CO_2 it emits be as expensive as for a developed nation.

Consequently, this problem can only be examined step-by-step; there is the possibility, of course, to leave the politicians set prices by groups of countries and maybe indicate a price for an advised amount applicable on a world scale. This would go hand-in-hand with regional initiatives that could be oriented to levying a tax on each tonne CO_2 emitted, or to set up a coupon allocation system by auction, as is the case today within the European Union (EU.)

The EU did create such a market in 2008, progressively extended and improved since. Technically speaking this market has functioned normally, but the price for carbon depends on the quantity of coupons emitted and on demand which is a function of the economy at a given point in time. What has been patent, however, is that the sudden and steep drop of European Member state growth rates since2008 has had the consequence that there has been an excessively high number of carbon coupons auctioned and a collapse in the price per tonne CO_2, today somewhere in the area of 7 $US – and many consider this pricing to be too low to prove efficient.

This is a topic that does not explicitly lie within the remit of the Academy, but it its discussion could serve to enrich the analyses in two ways:

- on one hand, by participating and collaborating, with other bodies, to investigate and report on these questions;
- on the other hand, to determine whether the Academy itself - for the purpose of its studies - should not set a price for each saved tonne CO_2.

This would also provide the opportunity to recall that in energy consumption analyses, the cost of the investments must be lower than the value of the energy saved, plus the value of the tonnes of CO_2 not emitted if the energy source(s) used were not carbon-free.

Beyond the economic framework of the discussion, the Academy is also fully aware of the need to better understand and take into account the social factors that influence climate change issues.

Implementation of solutions to fight the adverse, negative effects of climate change depends on as much on State commitments and initiatives undertaken by non-governmental actors (enterprises, local authorities), as in the involvement of Society in its wider connotation. Indeed, modifications of life-styles and behavioural patterns that have as their objective a carbon-lean Society will also play an important role towards improved reductions of GHG emission.

Today, in France, some 80% of the population accept - and take seriously –the scientific consensus that exists in respect to climate change and two out of three French nationals assert that they are ready and willing to take daily actions to decrease GHG has emissions. Nonetheless, it cannot be excludes that the common interests of preservation of the planet Earth might fragment into set of individual vested interests and this would lead to general inaction.

So the question arises – how are we supposed to go about encouraging people to become committed to the fight against the adverse effects of climate change? What we must recognize is that economic incentives may not necessarily produce the results as expected (in essence, a ‘rebound’, whereby there is an increased consumption, due to a reduction of the limits of a given technology). For this reason,

other forms of incentive ought to be envisaged. On one hand, we can identify so-called "libertarian paternalism" which consists of encouraging people to take decisions that are in the general interest, with no pressure, by law or by vested interests, but rather using a choice of architecture that encourages this choice. In this field, numerous paths still remain to be explored, for example, round the issues off energy consumption where citizens are not always fully conscious of the stakes. Moreover, efforts can be made to develop participative or deliberative democracy where private individual are party to the decisions often taken 'on their behalf'. Nevertheless, we still are missing a form of social engineering that, notably, would enable correct representation, avoid group polarization or the steering of collective convergence to situations fraught with cognitive bias. This approach can therefore only be used with discretion, inasmuch as there is a danger of seeing general interests quashed and superseded by private interests.

Again, we must not forget or neglect the influence that collective representation can have on individual commitments, on choice made to act or not. In recent popular imagery, the issues of climate change are tied to apocalyptic disaster scenarios in which Mankind will simply disappear from the face of the Earth because of his deleterious technological applications and their negative impact on the environment. This way of thinking leads to adopting a fundamentally flawed logic: we simply cannot predict whether a given new technological discovery will produce beneficial or adverse effects; when we blindly interrupt a technological arborescence, we run the risk of depriving future generations of benefits that could help improve their wellbeing and the future of Mankind. Thus, the so-called Precautionary Principle - which today focuses on the supposed benefits of action, could be reframed to reflect and include the consequences of inaction.

The Academy of Technologies of France (NATF) recommends furthermore:

-that the Precautionary Principle be reframed to reflect and include consequences of inaction.

The foregoing remarks serve to present the overarching framework in which several Academic Recommendations appertaining to analysing the issues raised by Climate Change phenomena on the basis of the decisions taken at the COP21.

The question is not about how "to save the Planet" but rather to limit the threats that face life on Earth (population management, living communities and their diversity), to avoid degraded drinking water and soil resources and other environmental or economic damage caused by extreme climatic events and near-future population migrations with the risk of conflicts through the necessary search for a land and/or for food. The fight to mitigate the effects of climate change is also a challenging question for our civilizations, on a par with the quest for peace on Earth.

Those efforts and commitments made first stabilize, then reverse, current GHG emission levels will be paramount.

Inasmuch as it is convinced that anticipation and taking action are important, the Academy – calling on the internal skills of its Fellows and/or by organizing hearings with external professional experts has been studying those sectors that emit the most GHGs or those most affected by climate changes.

In this perspective, it carried out in-depth investigations into various technologies that could conserve the potential for carbon storage of forests and agricultural lands, technologies that could introduce a good level of resilience for those productions that are most sensitive, *e.g.,* vineyards and wine production. The Academy also studied the role of ocean water masses in thermal regulation processes and those technologies that would enable better management of hydrologic systems and better preservation of coastal areas. It examined the relationships between building trades, urbanism,

mobility and transportation, their evolutions in connection to climate change. The Academy approached and sought advice from energy experts to identify those actions seen as most efficient for a reasonable cost. It examined the economic and/or legal contexts in which potential mitigation of GHGs could be deployed in industrial sectors and underline the importance of the special roles of tools such as life cycle analysis, or the advantages that could accrue from development of bio-economics. It pursued its earlier investigations of the impact of ICTs to optimize energy consumption and expenditures, albeit they themselves consume energy. The search for the best balance, in terms of GHGs, is at the centre of the debate, knowing that these technologies have also become essential to other sectors, notably for system and product modelling, as aids for innovation and design of new artefacts, processes and services.

Beyond the scope of these sectorial questions, the Academy lays emphasis on the economic and social conditions conducive to a transition to more favourable models, as well as the training conditions seen as suitable to encouraging creation of job openings associated with the transitions.

For each of these subjects, the Academy has chosen to issue what it deems as the key Recommendations involving technological changes, taken is their wide acceptation. These operations will be succinctly detailed in the following Chapter of this Report.

However, certain of these thematics will call for complementary studies during year 2016; the results will be integrated in yet another Academic report, before the end of the French Presidency of the Conference of Parties (COP), in November 2016.
