

# GLOBAL WARMING : THE SIGNIFICANCE OF METHANE

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## 1. CLIMATE CHANGE TARGETS

At its meeting on 30 October 2007, the EU Environment Council adopted the recommendation to avoid global warming of more than 2°C and recognised that "*stabilisation of the concentration of greenhouse gases in the atmosphere [...] to about 450 ppmv CO2 eq*" is required. The Environment Council underlined that "*this will require global greenhouse gas emissions to peak within the next 10 to 15 years, followed by substantial global emission reductions to at least 50% below 1990 levels by 2050*". Finally, the Council stresses that achieving this target, "*would require the group of developed countries collectively to reduce their emissions in a range of 25-40 % below 1990 levels by 2020*", noting that "*the EU's proposal for emission reduction commitments of the group of developed countries is consistent with this level of effort*".

In this text, the “concentration of 450 ppmv of CO2 equivalent” means the simultaneous presence of a set of greenhouse gases (CO2, CH4, N2O, etc) in the atmosphere in varying concentrations which do not have the same impact on global warming. However, their impact can be estimated as being equivalent to what the 450 ppmv concentration of CO2 alone would have caused.

There are several gases whose emissions are responsible for enhancing the greenhouse effect: CO2, CH4, N2O, CFC, etc. Each one of these “greenhouse gases” (GHGs) has its own particular properties in terms of infrared absorption and atmospheric lifetime after being emitted. In their simulation models, the experts who study climate change use data on emissions and concentrations of each of these GHGs in different scenarios in order to anticipate climate change.

The recommendation for stabilisation at “450 ppmv CO2 equivalent” is thus based on results of scenarios that anticipate emission reductions of the different GHGs needed at different time horizons in order to limit global warming to around 2°C at the beginning of the next century: for example, a factor two reduction of CO2 emissions, a 30% reduction of CH4 and N2O in 2050 compared to 2000 levels. It is obvious that if this simultaneous effort to reduce emissions of the different gases is not made, the CO2 reduction envisaged will not be enough alone to reach the 450 ppmv CO2 equivalent target and thus to limit global warming to 2°C.

However, in the same conclusions of the EU Environment Council of 30 October 2007 on reduction efforts needed, only CO2 emission reduction efforts are cited. Non CO2 GHGs (CH4, N2O, etc) are not specifically mentioned at all. Similarly, as part of the French national consultation to reform environmental policy (*Grenelle de l'Environnement*), conducted in 2007, after it was declared that the EU recommendations would be complied with, all the measures proposed focus on CO2 emission reductions. The final document does not once mention CH4.

## 2. TAKING METHANE EMISSIONS INTO ACCOUNT AND THE "GLOBAL WARMING POTENTIAL"

This lack of apparent interest for the other GHGs is probably linked to the use of highly simplified tools for assessing their role in reduction policies. Calculating emissions of the different GHGs in “tons of CO<sub>2</sub> equivalent”, which rapidly became the norm with policy-makers, has a very specific meaning but it is not suitable for all contexts and may, in certain cases, lead to an optical effect of distorting the issue at stake. In order to simplify the overall assessment of the impact of emissions of these different GHGs on climate change, it was decided to use rules of equivalence to make it possible to take into account emissions of non CO<sub>2</sub> GHGs within one single unit: the ton of CO<sub>2</sub> equivalent (t CO<sub>2</sub> eq). It is commonly defined on the basis of the relative impact of each gas on global warming compared to that of CO<sub>2</sub>, calculated over a determined period of time which follows the emission of each GHG, for example 100 years. This climate impact is determined as the cumulative radiative forcing linked to a given GHG over the period under consideration.

To achieve this, the IPCC<sup>1</sup> put forward the concept of Global Warming Potential (GWP). The GWP indicates the relative contribution to global warming over a given period (for example 100 years) of a pulse emission at the start of the period of 1 kg of a specific GHG in comparison to the contribution, over the same period, of an emission of 1 kg of CO<sub>2</sub>. The GWPs calculated for different time intervals take into account the differences in atmospheric lifetimes of the different GHGs.

The GWP of CH<sub>4</sub> at the time horizon TH for emissions in the year 0 is the ratio of the integral 0 to TH of the function of the decline in CH<sub>4</sub> over time, multiplied by the radiative efficiency of CH<sub>4</sub>, to the integral 0 to TH of the function of the decline in CO<sub>2</sub> over the same period, multiplied by the radiative efficiency of CO<sub>2</sub>. The numerator of this ratio is the “absolute global warming potential” or AGWP for CH<sub>4</sub>, and the denominator the “absolute global warming potential” or AGWP, for CO<sub>2</sub>”

To say that the GWP of CH<sub>4</sub> over a 100-year period is 21, means that the emission of 1 unit of mass of CH<sub>4</sub> has a climate impact equivalent to that of the emission of 21 unit of mass of CO<sub>2</sub> over the 100 year period following these emissions.

The convenience of using the t CO<sub>2</sub> eq as a single unit has very quickly led to its widespread use, whether it be for past emissions that have been observed or future emissions anticipated (particularly in climate policy targets) as cumulated emissions over a specific (past or future) period. In most documents setting out climate change mitigation programmes, it appears as if there were only one GHG involved, the “CO<sub>2</sub> equivalent” whose emissions need to be reduced.

## 3. THE DANGERS OF USING GWP TOO DIRECTLY

Whereas the First Conference of the Parties (COP 1 1995) merely stated that “Parties may use global warming potentials to reflect their inventories and projections in carbon-dioxide-equivalent terms. In such cases, the 100-year time-horizon values provided by the Intergovernmental Panel on Climate Change in its 1994 Special Report should be used”, the use of GWPs over a 100-year period very quickly became the norm. The pulse emission of 1 t of CH<sub>4</sub> in 2000 is counted as 21 t CO<sub>2</sub> eq<sup>2</sup> on the basis of the cumulative effects respectively of CH<sub>4</sub> and CO<sub>2</sub> between 2000 and 2100, and the emission of 1 t of CH<sub>4</sub> in 2020 for example

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<sup>1</sup> Intergovernmental Panel On Climate Change.

<sup>2</sup> The coefficient 21 was adopted in particular by the Kyoto Protocol on the basis of the IPCC publications in 1995 and has been retained ever since.

is counted as 21 t CO<sub>2</sub> eq on the basis of the cumulative effects respectively of CH<sub>4</sub> and CO<sub>2</sub> between 2020 and 2120: the impacts of a CH<sub>4</sub> emission compared to those of an emission of the same volume of CO<sub>2</sub> are each year put back 100 years.

Adopting such a rule has significant consequences on the relative assessment of the role of the different GHGs. While the use of the concept of CO<sub>2</sub> equivalent, as previously shown, does not present any ambiguity to estimate concentrations, using it to estimate emissions necessarily implies that a reference is made to an integration period from when the emission is made<sup>3</sup>.

As the atmospheric lifetime of CH<sub>4</sub> is short compared to that of CO<sub>2</sub>, the GWP of CH<sub>4</sub> varies considerably depending on the period of time chosen.

With the rule of the equivalence coefficient being 21 (GWP over a 100-year period following the date of emission), it is therefore impossible to estimate the impact at a given time horizon (2020, 2050, 2100) of a CH<sub>4</sub> emission. To make this estimate, it is necessary to take into account the difference between the year of emission and the year of the time horizon since the equivalence coefficient (the GWP) rapidly varies depending on the time period chosen to measure the respective impacts of CO<sub>2</sub> and CH<sub>4</sub> on global warming.

Furthermore, it is vital to bear in mind the fact that the GWP concept applies to climate impacts of a pulse emission at a given point in time. To apply it without caution to measures which continue over time in order to estimate the impact at a given time horizon may thus lead to serious errors of assessment.

#### 4. CALCULATING THE GWP

The GWP calculation for CH<sub>4</sub> at different time horizons was made on the basis of the most recent IPCC indications<sup>4 & 5</sup>, by a three step method:

- a) by reconstituting the CO<sub>2</sub> and CH<sub>4</sub> decline curves in the period 0-500 years;
- b) from there, by calculating the AGWPs of CO<sub>2</sub> and CH<sub>4</sub> using values of the radiative efficiency of these two GHGs provided by the IPCC<sup>6</sup>;
- c) then calculating the GWP of CH<sub>4</sub> as the ratio of the AGWP for CH<sub>4</sub> to the AGWP for CO<sub>2</sub>, for the same unit of mass, for example 1 kg.

#### *The decrease of CO<sub>2</sub> and CH<sub>4</sub> in the atmosphere*

The decline curve for CH<sub>4</sub> emitted in the atmosphere is the exponential  $e^{-t/12}$ .

The decline curve of CO<sub>2</sub> emitted in the atmosphere is the sum of a constant and three exponential curves, one of which corresponds to a very rapid decline (less than two years' lifetime).

The two decline curves are presented in figure 1, for an emission of 1 unit of mass at year 0.

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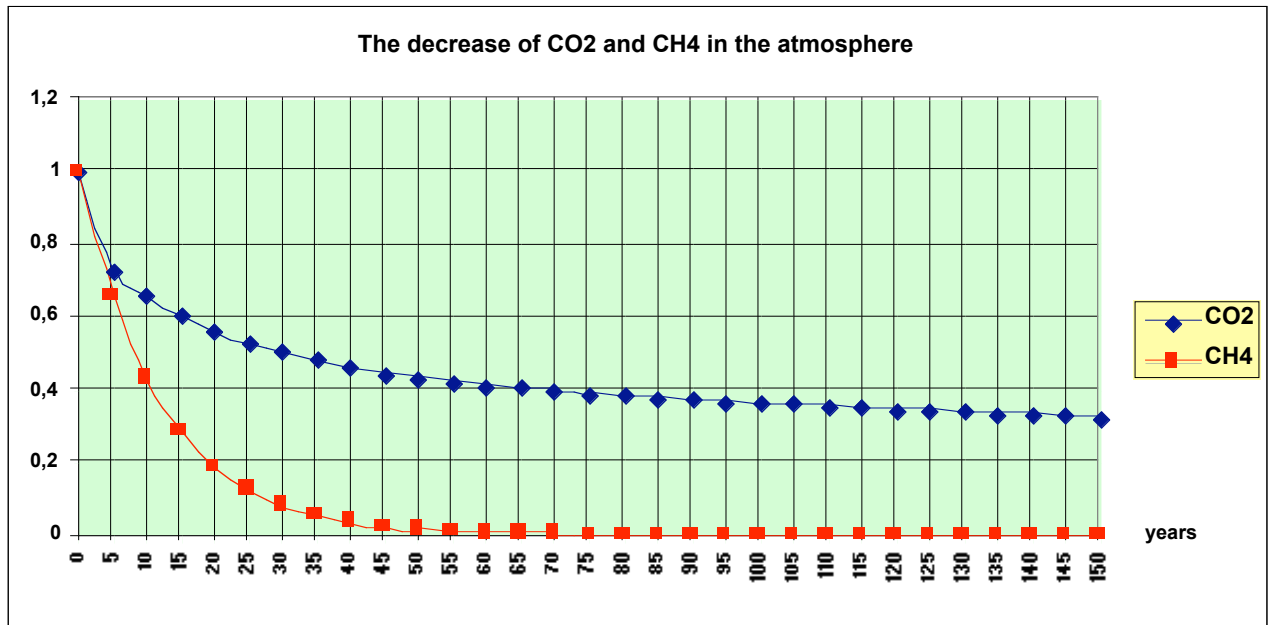
<sup>3</sup> The CO<sub>2</sub> equivalence for concentrations and the CO<sub>2</sub> equivalence for emissions are two different concepts.

<sup>4</sup> Reference : " Climate Change 2007 : Working Group I: The Scientific Basis".

<sup>5</sup> [ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter2.pdf](http://ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter2.pdf)

<sup>6</sup> For the same unit of mass present in the atmosphere, the radiative efficiency of CH<sub>4</sub> is equal to 73 times that of CO<sub>2</sub>.

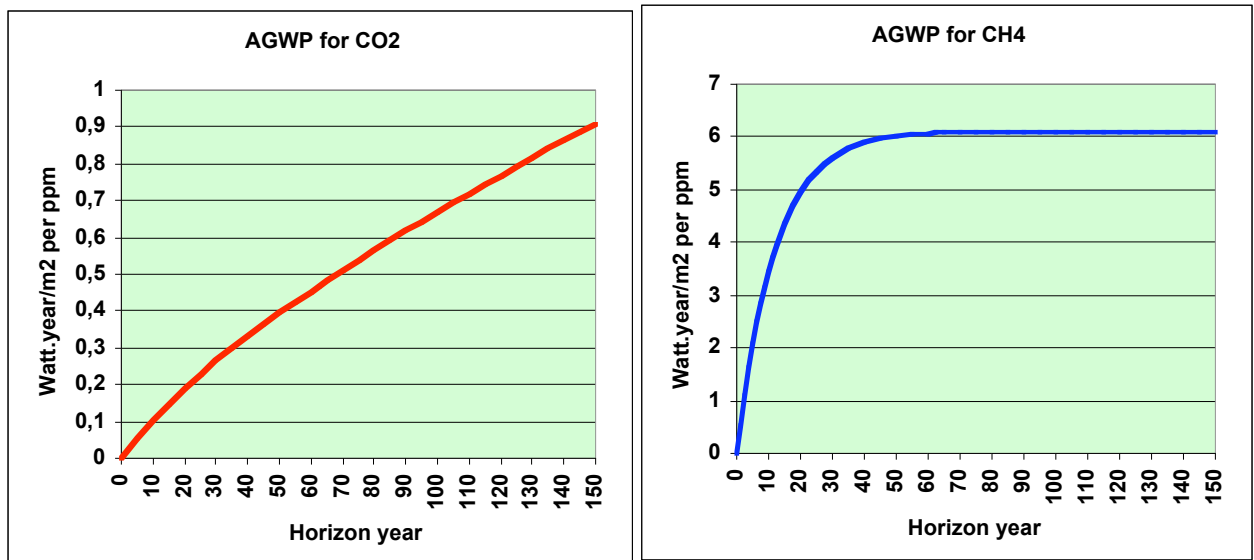
Figure 1<sup>7</sup>



**The AGWP of CO2 and CH4**

For the calculation of the AGWP for CH4, we take into account the indirect effect on global warming caused by the decline of CH4 in the atmosphere, on the basis of the 2007 IPCC report. The values of AGWP presented in figure 2 are given for 1 ppm<sup>8</sup>.

Figure 2



**The value of the GWP for CH4**

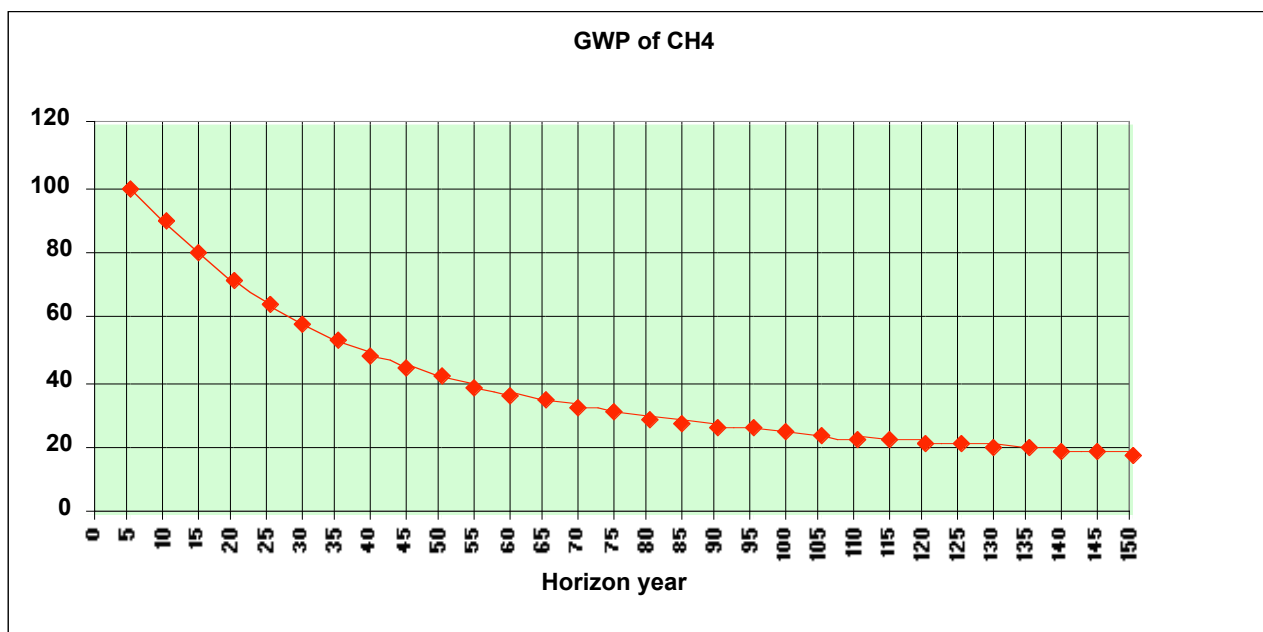
The GWP for CH4 is calculated as the ratio of the AGWP of CH4 to the AGWP of CO2, for an emission of 1 kg of each gas at year 0<sup>9</sup>.

<sup>7</sup> Source : IPCC 2007.

<sup>8</sup> The AGWPs for a 1 kg emission have also been calculated for each gas.

<sup>9</sup> The value of the GWP for CH4 and for an emission of 1 kg of both gases is equal to the ratio of the AGWPs per ppm (figure 2) multiplied by 44/16.

Figure 3



The GWP values thus obtained are equal to the values provided by the IPCC for 20, 100 and 500 years (respectively 72, 25 and 7.6)<sup>10</sup>. They are presented in Table 1 and Figure 3.

**Table 1 : The value of the GWP of CH4 depending on the time horizon (year of emission : 0)**

<b>Year</b>	<b>5</b>	<b>10</b>	<b>15</b>	<b>20</b>	<b>25</b>	<b>30</b>	<b>35</b>	<b>40</b>	<b>45</b>	<b>50</b>
<b>PRG</b>	101	90	80	72	64	58	53	49	45	42
<b>Year</b>	<b>55</b>	<b>60</b>	<b>65</b>	<b>70</b>	<b>75</b>	<b>80</b>	<b>85</b>	<b>90</b>	<b>95</b>	<b>100</b>
<b>PRG</b>	39	37	35	33	31	30	28	27	26	25
<b>Year</b>	<b>105</b>	<b>110</b>	<b>115</b>	<b>120</b>	<b>125</b>	<b>130</b>	<b>135</b>	<b>140</b>	<b>145</b>	<b>150</b>
<b>PRG</b>	24	23	23	22	21	21	20	19	19	18

This shows that the effect on global warming due to the emission of 1 kg of CH4 in year 0 is the same, over a period of 100 years, as the effect of the emission of 25 kg of CO2 in year 0; over a period of 20 years, of the emission of 72 kg of CO2 in year 0; and over a period of 50 years of the emission of 42 kg of CO2 in year 0.

## 5. COMPARISON OF TWO MEASURES TO REDUCE CH4 AND CO2 EMISSIONS

The example given below shows the order of magnitude of the assessment errors that are likely to be made by using “the 100 years equivalence”.

We consider two measures to reduce CH4 and CO2 emissions:

- firstly, in the year 0, putting a permanent end to the source of an annual emission of 1 kg of CH4 (which would continue if this measure were not implemented), ie 21 kg CO2 eq according to current methodology). We call this “CH4 measure”: from year 1, the CH4 emission avoided is thus 1 kg each year.
- secondly, in the same year 0, putting a permanent end to the source of an annual emission of 1 kg of CO2 (which would be permanent if this measure were not implemented). We call this “CO2 measure”: from year 1, the CO2 emission avoided is thus 1 kg each year.

<sup>10</sup> The same verification was conducted for N2O.

We calculate the compared impacts on global warming of each measure at different time horizons starting from the horizon year 1.

The respective cumulative effects of each emission avoided during the whole of the period between the year in which the measure was implemented and the horizon year is obtained by adding together the “absolute” GWPs of CH4 and CO2.

The ratio of the cumulative effects allows us to draw a comparison between a permanent CH4 emission reduction measure and a permanent CO2 emission reduction measure.

Figure 4 shows the results obtained, for each horizon year between 0 and 500 years, in five-year stages, for putting a permanent end to an emission of 1 kg of CH4 (21 kg CO2 eq according to current methodology) in the year 0.

**Figure 4**

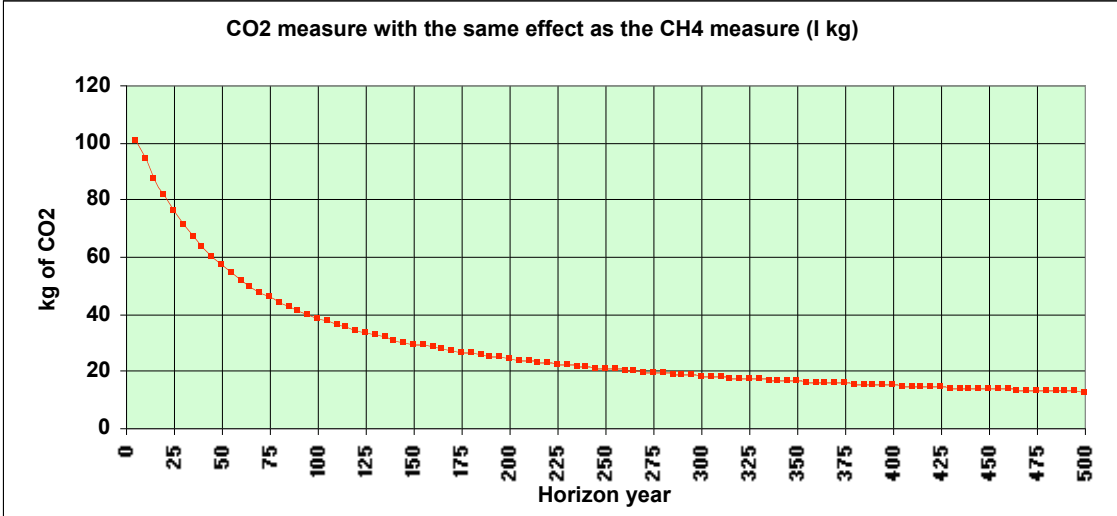


Table 2 indicates for the significant horizon years the values in kg CO2 of permanently avoided CO2 emissions in the year 0 which has the same impact on global warming at the time horizon as putting a permanent end to the emission of 1 kg of CH4 in the year 0.

**Table 2: Value of the CO2 measure with the same effect as the CH4 measure at different time horizons**

Horizon year	20	50	100	250	500
kg CO2	81	57	39	21	13

At 20 and 50 year time horizons, the underestimated impacts of using the GWP of 21 is thus highly significant (respectively a factor of 3.9 and 2.7). It is still a factor of 1.9 at a horizon of 100 years and does not reach the value of 1 until 250 years have elapsed.

**6. COMPARISON OF EMISSION REDUCTION POLICIES**

The same calculation may be made for different years in which the measure to put an end to a CH4 and a CO2 emission is implemented. These years may be different for each GHG and be spread over different periods. It is also possible to examine stopping emissions permanently or over a limited period of time.

For each year or period that the CH4 measure is implemented and for each horizon year, comparing the impacts results in a quantity of CO2 whose emission that stopped permanently in the same year or in the same period the measure was implemented (CO2 measure) would have the same effect on global warming in the same horizon year as the CH4 measure to

permanently reduce the emission of 1 kg CH<sub>4</sub> for this period in which the measure was implemented.

This method thus enables comparisons to be drawn between CH<sub>4</sub> and CO<sub>2</sub> emission reduction policies, for reductions that are permanent or limited in time.

## **7. WHAT ARE THE CONCLUSIONS OF THIS DEMONSTRATION?**

Firstly, it is important to be fully aware that using the "100-year GWP" to measure non CO<sub>2</sub> GHG emissions is not well suited to the case of permanent or long lifetime measures whose effectiveness is to be assessed at a given time horizon. In this context, it contributes to significantly playing down the importance of reducing emissions of GHGs with short atmospheric lifetimes. Thus, for example, methane which is not emitted over the period 2020-2100 as a result of a landfill site being closed in 2020 will have an impact (as opposed to if the site remained in operation) that would be far greater towards 2100 compared to a CO<sub>2</sub> emission source that has also been stopped permanently and whose climate impact is measured in an equivalent manner.

Using the GWP is only appropriate if applied year after year to time horizons considered to be of concern or decisive by climate studies, thus in particular 2050, 2100 and 2150. This is all the more significant as climate experts' current concerns lead them not only to advocate long-term stabilisation of GHG concentrations but also to avoid as far as possible intermediate exceedances of these concentrations over the coming century.

Finally, it is noted that CH<sub>4</sub> prevention policies implemented in the short term may continue to have a long-term impact greater than merely taking into account the current GWP would imply. To more or less ignore the impact of CH<sub>4</sub> as it is unsuitable for accounting purposes affects the exclusive character of the link that may exist between the issue of GHGs and that of energy. Furthermore, if the increase in atmospheric concentrations of CH<sub>4</sub> which was significant following the onset of the industrial revolution, has slowed down in the last few years for reasons that are still being debated, a renewed sharp increase in the event of the Arctic region melting, for example, remains quite possible.

It is thus important, now that the most recent IPCC report points to the consequences of climate change in the medium term, that GHG emission reduction policies be defined individually for each GHG : both CH<sub>4</sub> and N<sub>2</sub>O, on the basis of their real emissions, consistent with the scenarios used by climate experts and depending on the concentration levels they recommend be achieved at given time horizons. Purely economic and financial considerations linked to the emissions trading markets must not mask the importance of robust policies aimed at non CO<sub>2</sub> GHGs. Specifically, in addition to the vital CO<sub>2</sub> emissions reduction effort, greater attention must be paid to short-term reductions of CH<sub>4</sub> emissions whose impacts are significant at a time horizon of a few decades. Climate experts and policy-makers should make the most of the two-year negotiating period on the post 2012 regime, officially launched at the recent Bali Climate Conference, to give thought to this issue.