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Interuniversity Research Centre for the Life Cycle of Products, Processes and Services

A summary of modelling requirements to assess the climate change impacts of bioenergy systems

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IEA Bioenergy
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Impact of timing of GHG emissions
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POLYTECHNIQUE MONTRÉAL
WORLD-CLASS ENGINEERING

Modelling requirements to assess climate change impacts

1. Current situation
   - Carbon accounting
   - GWPs
   - The timing issue
2. Choosing a metric
   - The cause-effect chain
   - Physical and economic metrics
3. Additional considerations related to timing
   - Cumulative vs instantaneous metrics
   - Time horizon
   - Discount rate

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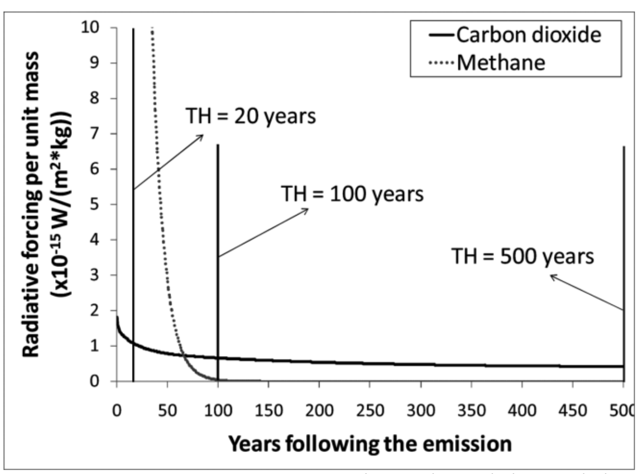
Traditional GHG accounting methodology

GHG	Inventory (kg)	
CO_2	X	
CH_4	Y	
N_2O	Z	
…	…	
TOTAL		

Global Warming Potentials



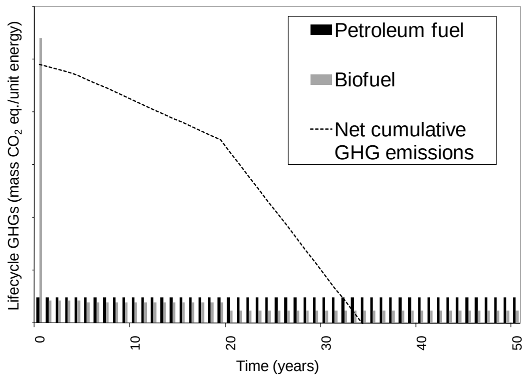
Levasseur et al. 2010 Environmental Science & Technology

$$GWP_i = \frac{\int_0^{TH} a_i[C_i(t)]dt}{\int_0^{TH} a_r[C_r(t)]dt}$$

	GWP20	GWP100	GWP500
CO_2	1	1	1
CH_4	72	25	44

The timing issue

- Land use change emissions and biofuels;
- Forestry (bioenergy, carbon mitigation projects);
- Temporary carbon storage …



Payback time

Based on emissions:
35 years

Based on cumulative radiative forcing:
48 years

Data from US EPA, 2009

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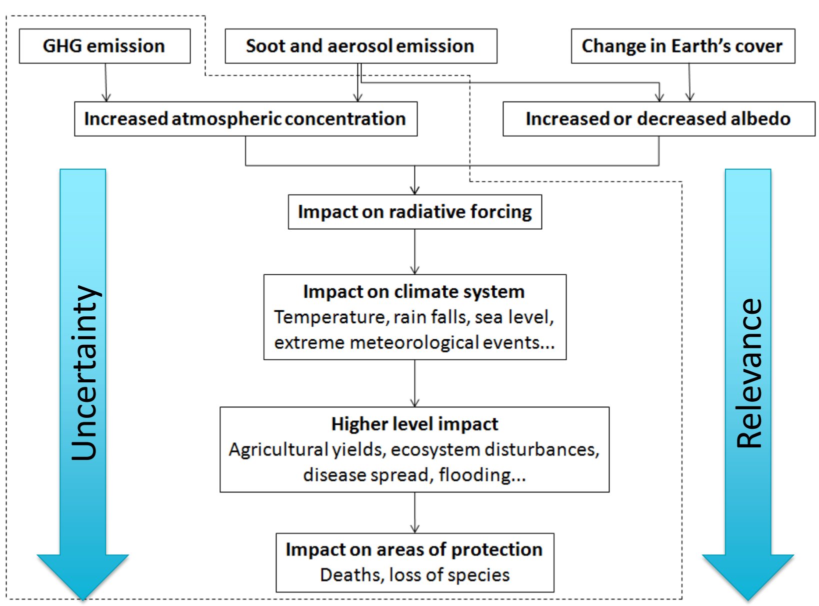
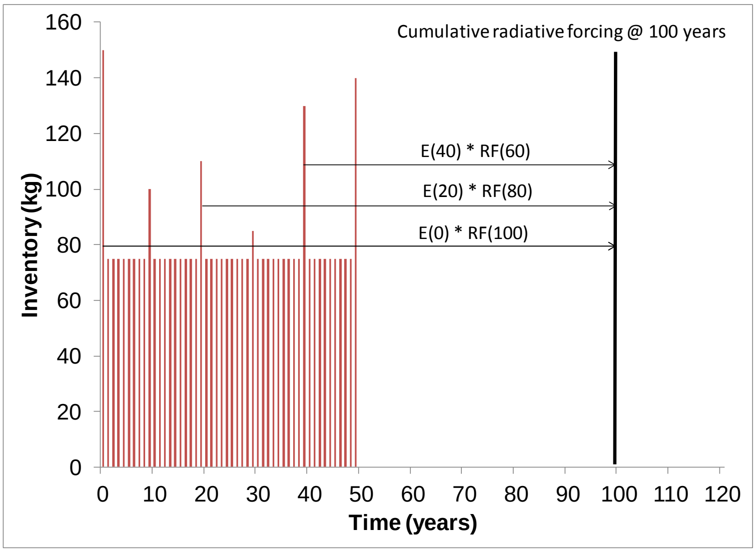
The cause-effect chain



Time-dependent radiative forcing



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Modelling radiative forcing

$$GWP_i = \frac{\int_0^{TH} a_i[C_i(t)]dt}{\int_0^{TH} a_r[C_r(t)]dt}$$

Parameters available in IPCC assessment reports

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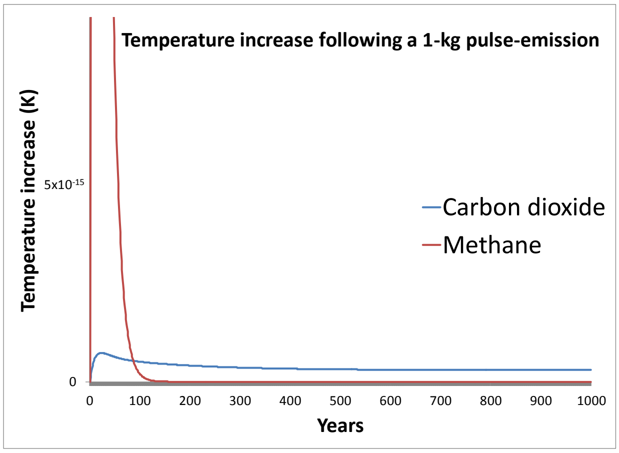
One step further: temperature



Calculated using the concept of GTP (Global Temperature Potential) (Shine et al. 2005)

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Modelling damages on human health

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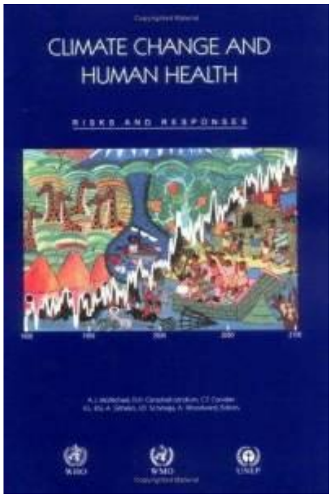
Damages on human health: the ReCiPe approach

World Health Organization



DF_{HH} [DALY/ºC.yr] =

Damages on ecosystems: the ReCiPe approach

Thomas et al. 2004

letters to nature

Extinction risk from climate change

Chris D. Thomas[1], Alison Cameron[1], Rhys E. Green[2], Michel Bakkenes[3], Linda J. Beaumont[4], Yvonne C. Collingham[5], Barend F. N. Erasmus[6], Marinez Ferreira de Siqueira[7], Alan Grainger[8], Lee Hannah[9], Lesley Hughes[4], Brian Huntley[5], Albert S. van Jaarsveld[10], Guy F. Midgley[11], Lera Miles[8]*, Miguel A. Ortega-Huerta[12], A. Townsend Peterson[13], Oliver L. Phillips[8] & Stephen E. Williams[14]

areas[7–12]. This 'climate envelope' represents the conditions under which populations of a species currently persist in the face of competitors and natural enemies. Future distributions are estimated by assuming that current envelopes are retained and can be projected for future climate scenarios[7–12]. We assume that a species either has no limits to dispersal such that its future distribution becomes the entire area projected by the climate envelope model or that it is incapable of dispersal, in which case the new distribution is the overlap between current and future potential distributions (for example, species with little dispersal or that inhabit fragmented

Monetization of climate change impacts

Impact = Emission (t CO_2) X Price of carbon (\$/t CO_2)

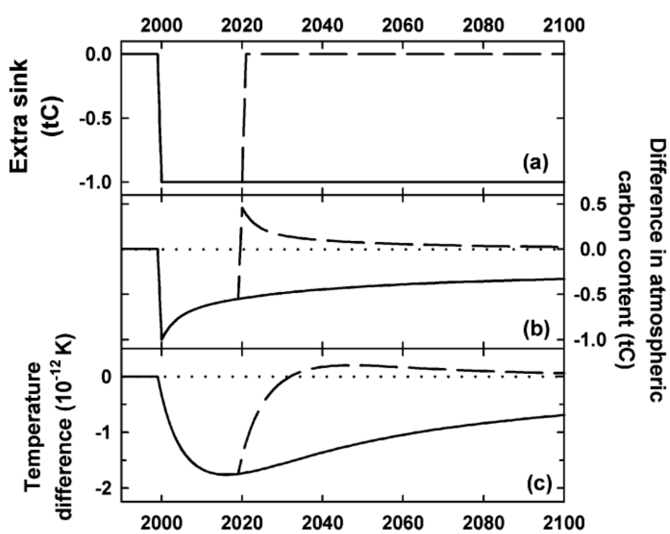
The price of carbon

- is fixed by subsidies, carbon taxes and/or emissions trading systems (policies);
- would be equal to the social cost of carbon in a perfect market.

Highly uncertain

(climate sensitivity, discount rate, valuation of economic and non-economic impacts, **increases over time**, etc.)

Cumulative vs instantaneous metrics



Kirschbaum, Mit. Adapt. Strat. Gl. Change, 2006

The choice of a time horizon

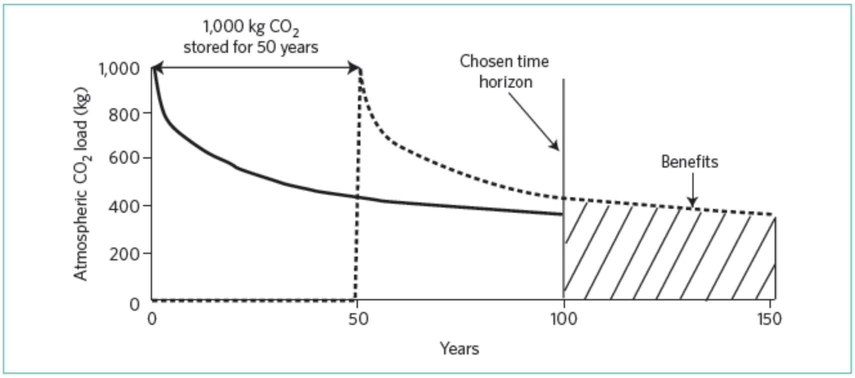


Table 1 | Benefits of storing 1,000 kg CO_2 over a period of 50 years calculated with the Lashof method[12] for different choices of time horizon.

Time horizon (years)	Benefits (kg CO_2e)
20	1,000
50	1,000
100	411
250	152
500	74
1,000	41

Levasseur et al., Nature Climate Change, 2012

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A subjective decision

There is certainly no conclusive scientific argument that can defend 100 years compared to other choices, and in the end the choice is a value-laden one.

K.P. Shine, Climatic Change, 2009

Short-term

• Climate change is an urgent issue, we have to make sure not to reach irreversible tipping points.
• Future is highly uncertain.
• Future generations will adapt.

Long-term

• Sustainability = intergenerational equity.
• Temporary mitigation activities should not be favoured compared to permanent actions.

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Discounting environmental impacts

$$Discounted\ value = \frac{Value}{(1+r)^t}$$

	0%
Year 1	1
Year 10	1
Year 50	1
Year 100	1

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A controversial issue

Some very intelligent people have argued that giving future generations less weight than the current generation is "ethically indefensible." Other equally intelligent people have argued that weighting generations equally leads to paradoxical and even nonsensical results.

W.D. Nordhaus in the New-York Times, following the publication of the Stern Review report

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Thank your for your attention