Integrating GHG dynamics in biomass-based products LCA

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Introduction (1)

- Time dimension is a crucial element of the climate change challenge
  - Inertial phenomenon
  - GHG lifetimes, from years to centuries
- Influential conventions
  - GWP calculations: cut-off of GHG radiative effects after a given period of time
    - IPCC: 20, 100 or 500 yrs
  - CO_2 valuation methods
    - Marginal damage costs: discount rate
    - Marginal abatement costs: emissions reduction scenario

Introduction (2)

- LCAs deal with different timescales

Classical industrial products LCA

- *Production impact*

  Generally proportional to the FU

  Energy consumption, ..

- *Facilities impact*

  Equipments and buildings

- Facilities impact shared out over lifespans (usually 20 years), no discount rate
- Generally negligible

GHG fluxes implied by biomass production

- *Recurrent*

  Savings from fossil materials substitution

- *Occasional*

  Deforestation

- *Extended* (over decades)

  Carbon sequestration or emission from soils

- Same assumptions
- Negligible?

Introduction (3)

- Should we weight CO_2 emissions to handle such different timescales?
- Should we answer the question whether it is preferable to save 3 tCO_2 now or 5 tCO_2 in 10 years? or 50 years?..

We should try…

- Presentation outline
  - Definition of *dynamic* Global Warming Potentials
  - Application in two case studies

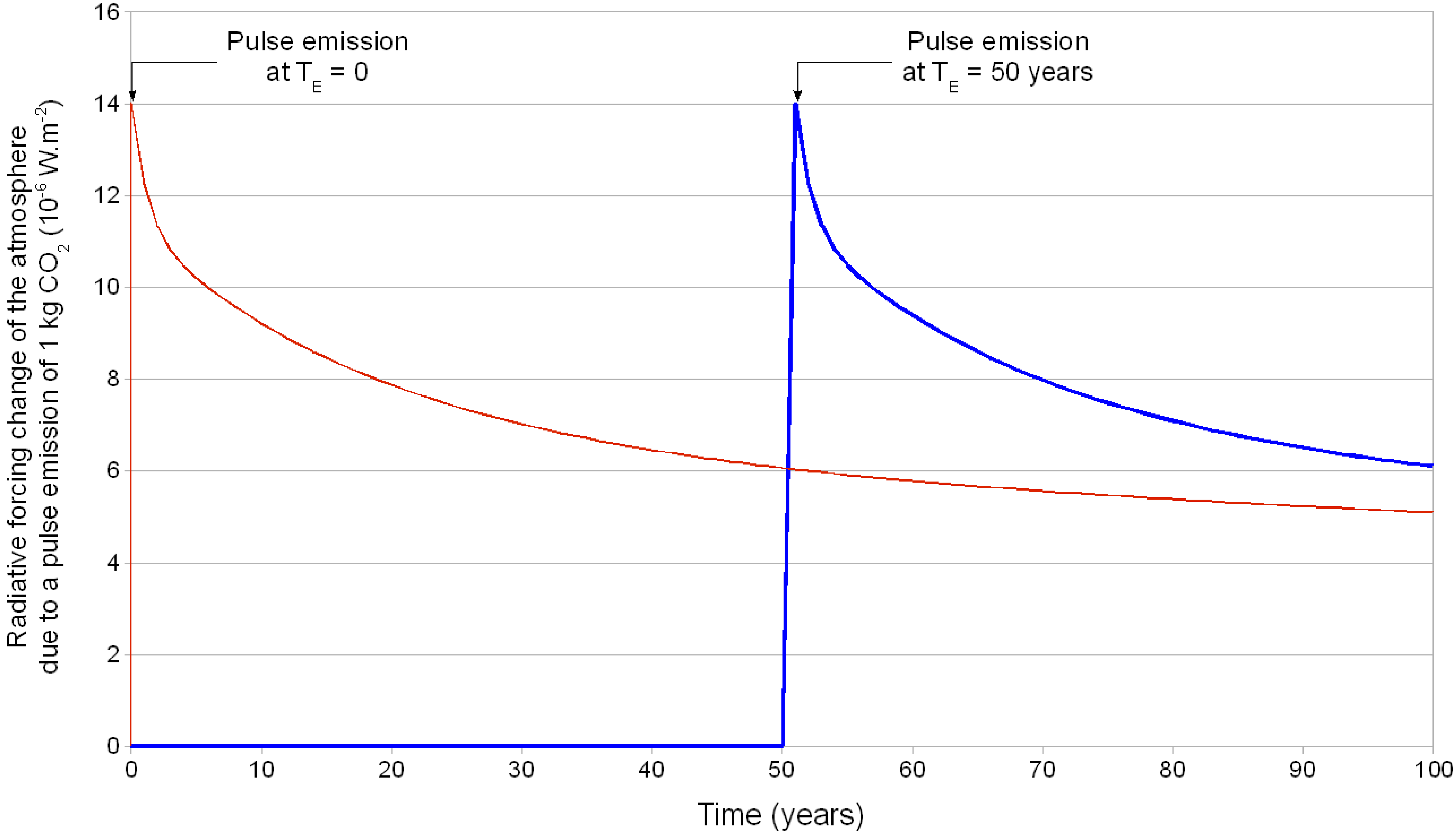
Standard GWP definition

- GWP definition from the IPCC:

$$GWP_i = \frac{\int_0^{T_H} a_i \cdot C_i(t)\, dt}{\int_0^{T_H} a_{CO_2} \cdot C_{CO_2}(t)\, dt}$$

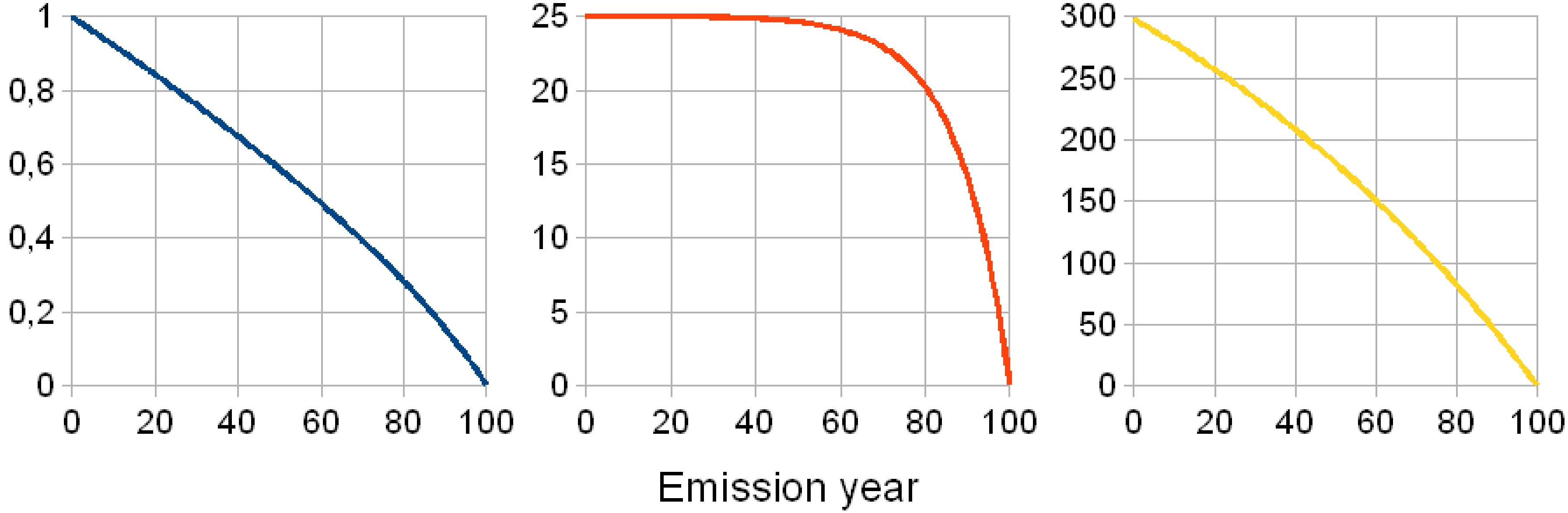
- With:
  - T_H, time horizon (usually 20, 100 or 500 years)
  - a_i, radiative efficiency of component i ($W/m^2/ppm$ or $W/m^2/ppb$)
  - $C_i(t)$, time-dependent abundance of component i in the atmosphere after a pulse emission
- Assumptions for dynamic GWP calculations: a_i as constants, $C_i(t)$ as independent of the emission year

Dynamic GWP (1)



Dynamic GWP (2)

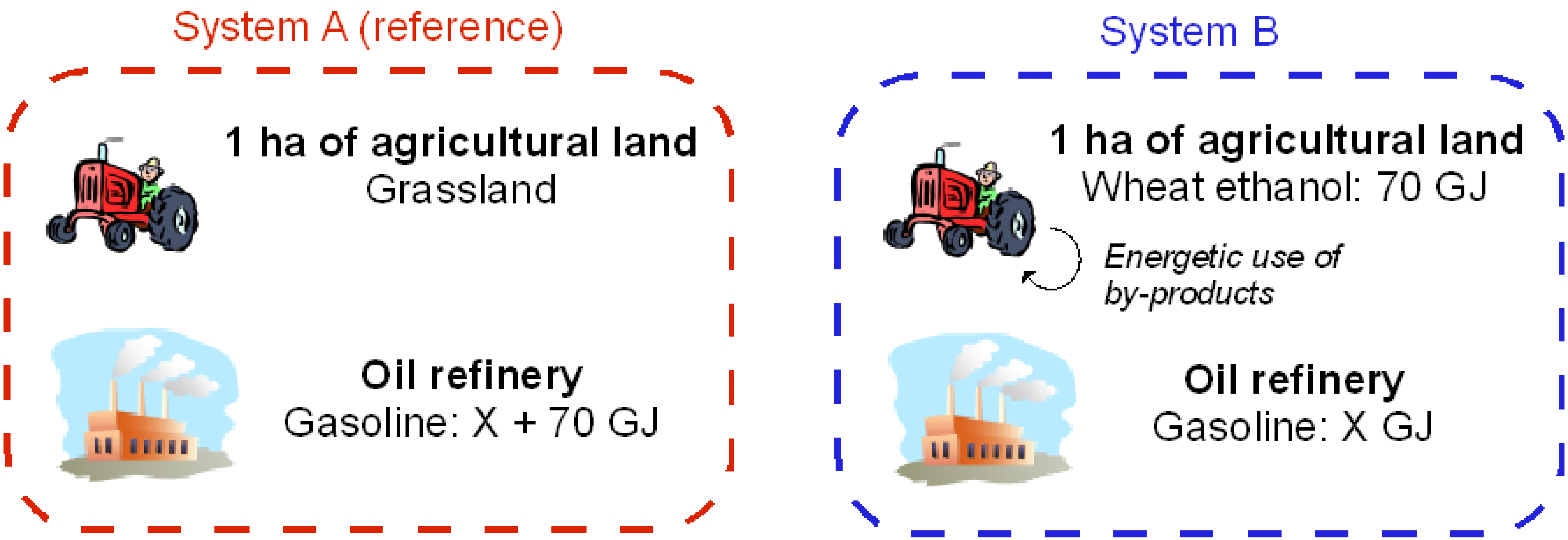
- Dynamic GWP ($kgCO_{2\text{-}eq}$ / kg_i), T_H = 100 yrs



- Is it preferable to save 3 tCO_2 now or 5 in 10 years? And what about 5 in 50 years?
  - 3 tCO_2 now are 3 x 1 = 3 $tCO_{2\text{-}eq}$
  - 5 tCO_2 in 10 years are 5 x 0.92 = 4.6 $tCO_{2\text{-}eq}$
  - 5 tCO_2 in 50 years are 5 x 0.59 = 2.9 $tCO_{2\text{-}eq}$

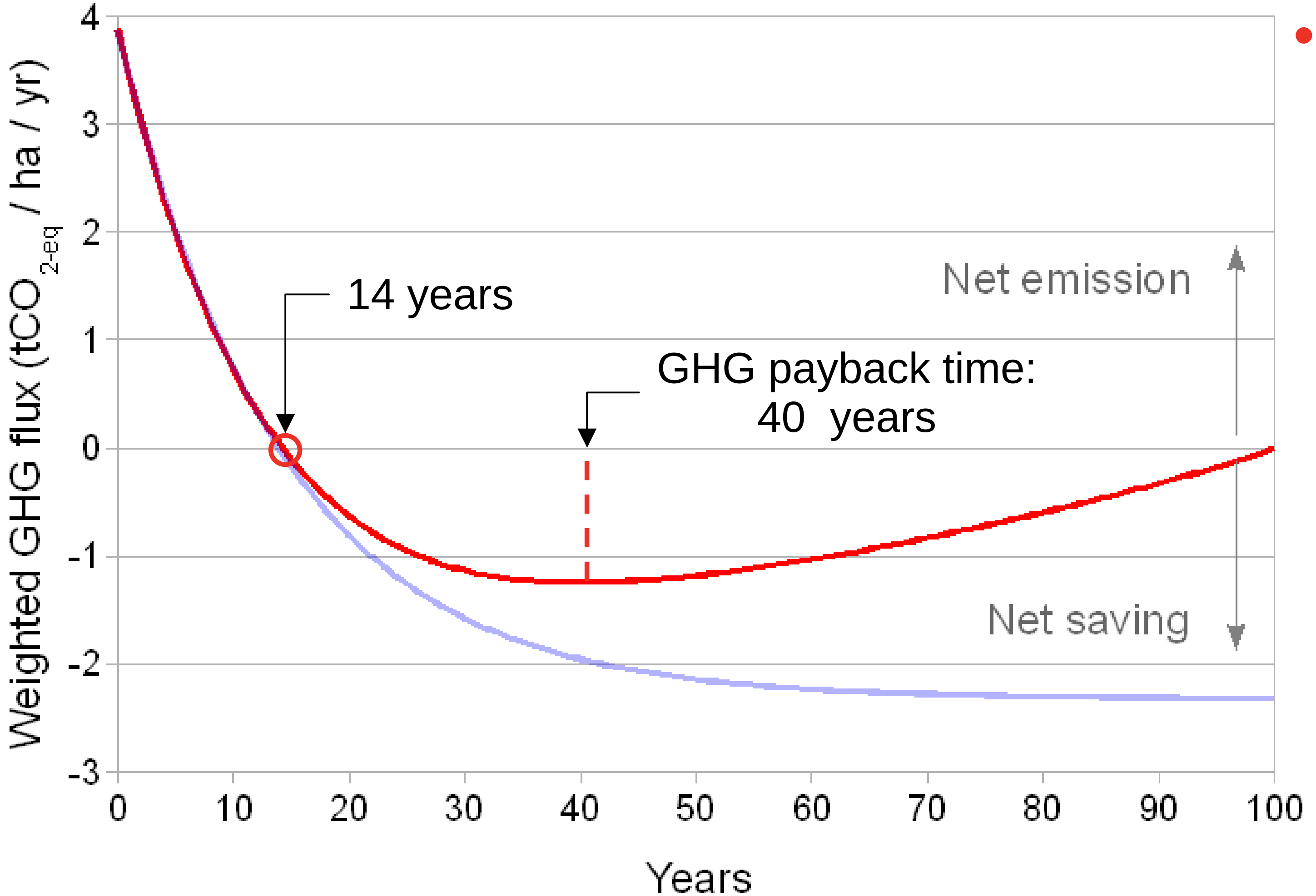
First case study (1)

- Biofuel LCA involving a land-use change



- LCI data
  - Biofuel emissions: 32 gCO_2, 0.07 gCH_4 and 0.06 gN_2O / MJ
  - Gasoline emissions: 83.9 gCO_2 / MJ *(JRC, 2007)*
  - Land-use change, in French conditions: 92 ± 12 $tCO_{2\text{-eq}}$ / ha in 50-60 years *(INRA, 2002)*

First case study (2)



- Weighted approach over 100 yrs:
  - Saving of 6.5 $gCO_{2\text{-eq}}$ / MJ

- Classical approaches:
  - LUC impact not integrated into LCA result
    - Saving of 33.2 $gCO_{2\text{-eq}}$ / MJ but GHG payback time of 39 yrs
  - LUC impact shared out over:
    - 20 yrs: emission of -32.3 $gCO_{2\text{-eq}}$ / MJ
    - 50 yrs: saving of 7.0 $gCO_{2\text{-eq}}$ / MJ
    - 100 yrs: saving of 20.1 $gCO_{2\text{-eq}}$ / MJ

Second case study (1)

- Carbon sequestration credit of wood-based materials
- Issues about wood as a building material
  - Generally lower GHG emissions due to production *(PRESCO, 2005)*
    - 0.22 - 0.32 $kgCO_{2\text{-eq}}$ / kg of brick
    - 0.08 - 0.13 $kgCO_{2\text{-eq}}$ / kg of concrete
    - < 0.15 $kgCO_{2\text{-eq}}$ / kg of wood
  - Poorer thermal characteristics
  - Sequestration effect due to carbon storage?
- Assumptions:
  - CO_2 uptake by cellulose due to photosynthesis: 1.85 $kgCO_2$ / kg
  - Embodied CO_2 is released to the atmosphere at the end of the material lifespan

Second case study (2)

- Results

Material lifespan (years)	*10*	*20*	*30*	*40*	*50*	*60*	*70*	*80*	*90*	*100 and more*
Carbon sequestration credit ($kgCO_{2\text{-}eq}$ / kg)	0.14	0.29	0.44	0.60	0.76	0.93	1.12	1.32	1.56	1.85

Conclusion

- Dynamic GWP applications
  - Relevant assessments of emissions scenarios
  - First case study: biofuel LCA involving a land-use change
    - To be integrated in prospective works comparing different scenarios
  - Second case study: carbon sequestration credit of wood-based materials
    - Credit figures usable to complete existing LCI databases
- Slow or delayed emissions from biomass must be taken into account for relevant sustainability assessments
- GHG emissions weighting is helpful to consider GHG dynamics
  - Soil carbon changes, sequestration effect of carbon sinks
  - But also technical improvements, learning curves, resources scarcity, …
- Suggested weighting method in line with IPCC calculations
  - Preliminary results improvable with IPCC emissions scenarios data

Thank you for your attention!

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