L'évaluation environnementale des bioraffineries

Journée Promotion Procédés Produits

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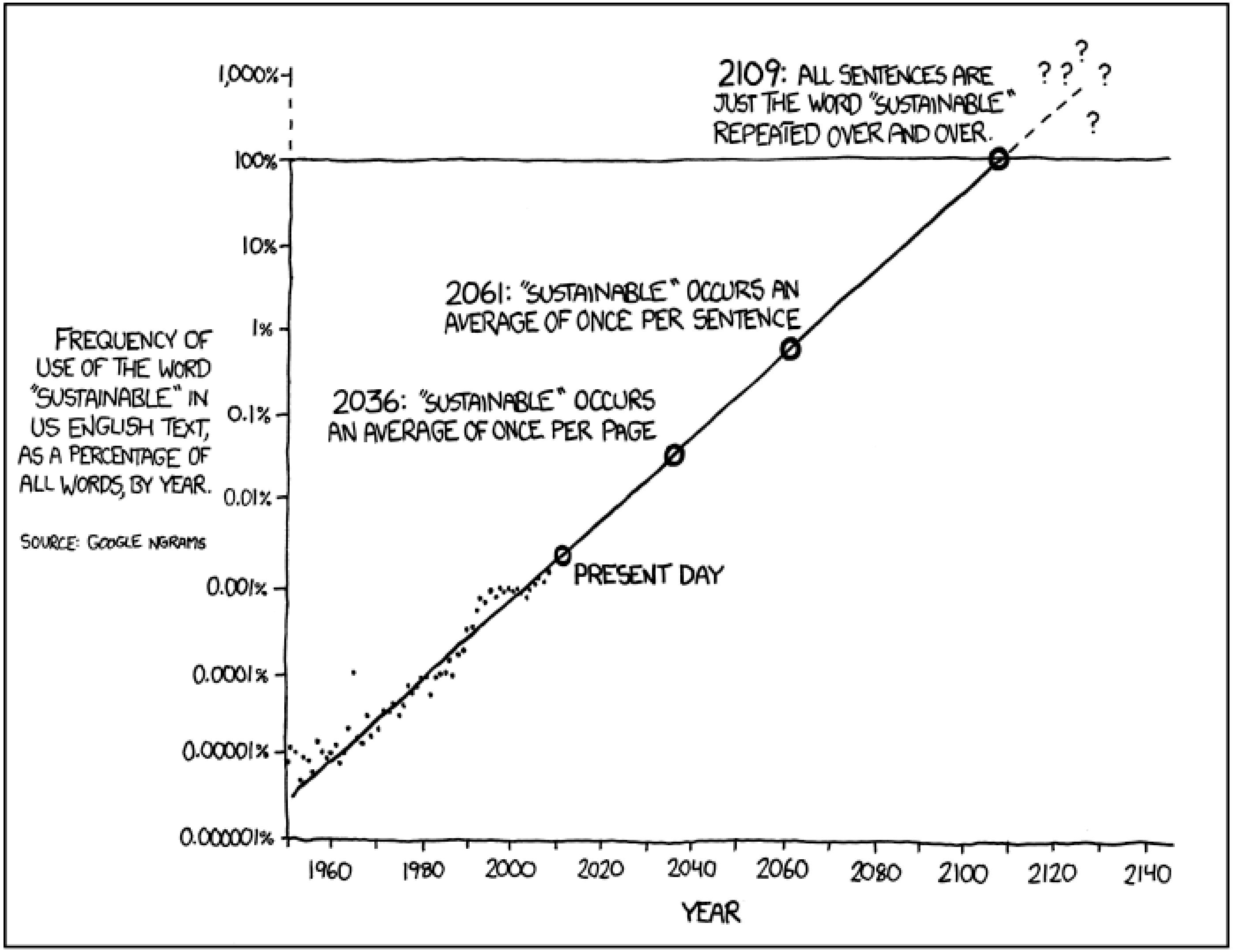
Plan de la présentation

- Une exigence de performance environnementale
- Quelles métriques pour la durabilité ?
- Application aux bioraffineries
- Conclusion

Du bon usage de la durabilité....



THE WORD "SUSTAINABLE" IS UNSUSTAINABLE.

La biomasse au carrefour de nombreux enjeux

Défi climatique : +2°C à +6°C en 2100 (GIEC 2007)

Défi énergétique : diminution des réserves fossiles

Carbone renouvelable

Défi alimentaire : compétition “food / non food”

Défi environnemental : impacts environnentaux (globaux et locaux)

Défis socio-économiques: développement des territoires, création de valeur ajoutée en Europe

Diapo: H. Boizard (INRA Laon-Mons)

Un faisceau croissant de contraintes

- Performance environnementale élevée
- Faibles impacts sur la biodiversité, les ressources en eau et en terre
- Pas d'interférences négatives (voire des synergies) avec la production de biens alimentaires
- Co-bénéfices (limiter l'érosion des sols, création d'emplois, revenus)
- Acceptabilité sociale
- Compétitivité avec les produits issus de ressources alternatives (fossiles)

Une expression dans les schémas de certification

- ✓**Mesures contraignantes**
  - ✓RE Directive au niveau Européen
  - ✓Renewable Fuel Standards 2 (USA)
  - ✓Mesures Nationales en Allemagne, GB, NL

- ✓**Initiatives volontaires**
  - ✓Roundtable on Sustainable Biofuels (RSB)
  - ✓Roundtable on Sustainable Palm Oil (RSPO)
  - ✓WWF International
  - ✓Forest Stewardship Council and Programme for the Endorsement of Forest Certification
  - ✓.....

Ces schémas incluent une gamme de critères environmentaux, économiques et sociaux, et s'appliquent à une grande variétés de produits finis

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The GBEP criteria

PILLARS GBEP's work on sustainability indicators was developed under the following three pillars, noting interlinkages between them:		
Environmental	**Social**	**Economic**
THEMES GBEP considers the following themes relevant, and these guided the development of indicators under these pillars:		
Greenhouse gas emissions, Productive capacity of the land and ecosystems, Air quality, Water availability, use efficiency and quality, Biological diversity, Land-use change, including indirect effects.	Price and supply of a national food basket, Access to land, water and other natural resources, Labour conditions, Rural and social development, Access to energy, Human health and safety.	Resource availability and use efficiencies in bioenergy production, conversion, distribution and end-use, Economic development, Economic viability and competitiveness of bioenergy, Access to technology and technological capabilities, Energy security/Diversification of sources and supply, Energy security/Infrastructure and logistics for distribution and use.
INDICATORS		
1. Lifecycle GHG emissions	9. Allocation and tenure of land for new bioenergy production	17. Productivity
2. Soil quality	10. Price and supply of a national food basket	18. Net energy balance
3. Harvest levels of wood resources	11. Change in income	19. Gross value added
4. Emissions of non-GHG air pollutants, including air toxics	12. Jobs in the bioenergy sector	20. Change in consumption of fossil fuels and traditional use of biomass
5. Water use and efficiency	13. Change in unpaid time spent by women and children collecting biomass	21. Training and re-qualification of the workforce
6. Water quality	14. Bioenergy used to expand access to modern energy services	22. Energy diversity
7. Biological diversity in the landscape	15. Change in mortality and burden of disease attributable to indoor smoke	23. Infrastructure and logistics for distribution of bioenergy
8. Land use and land-use change related to bioenergy feedstock production	16. Incidence of occupational injury, illness and fatalities	24. Capacity and flexibility of use of bioenergy

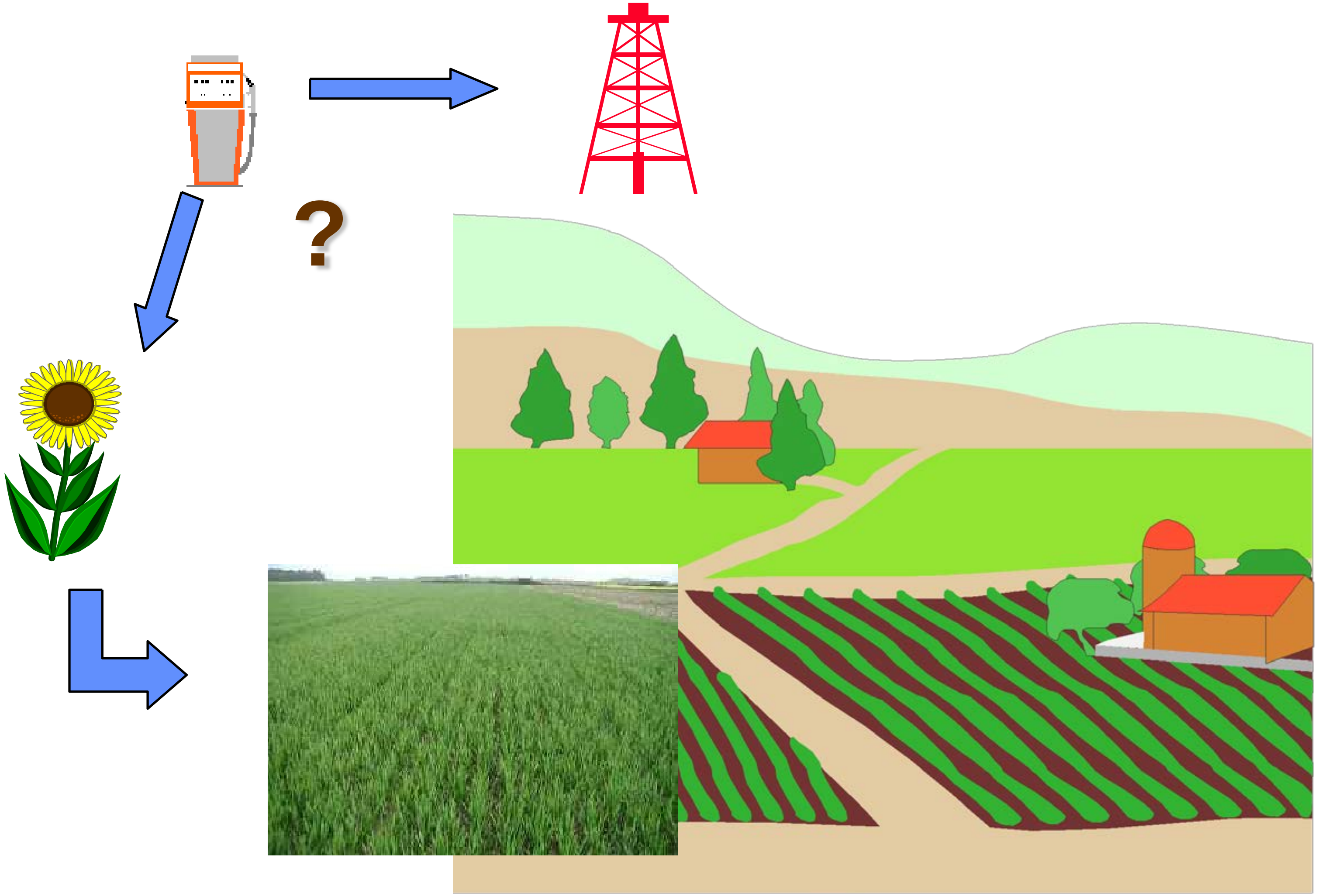
Themes and criteria put forward by the Global Bioenergy Partnership for sustainability assessment (GBEP, 2011).

Un critère mais plusieurs procédures d'estimation

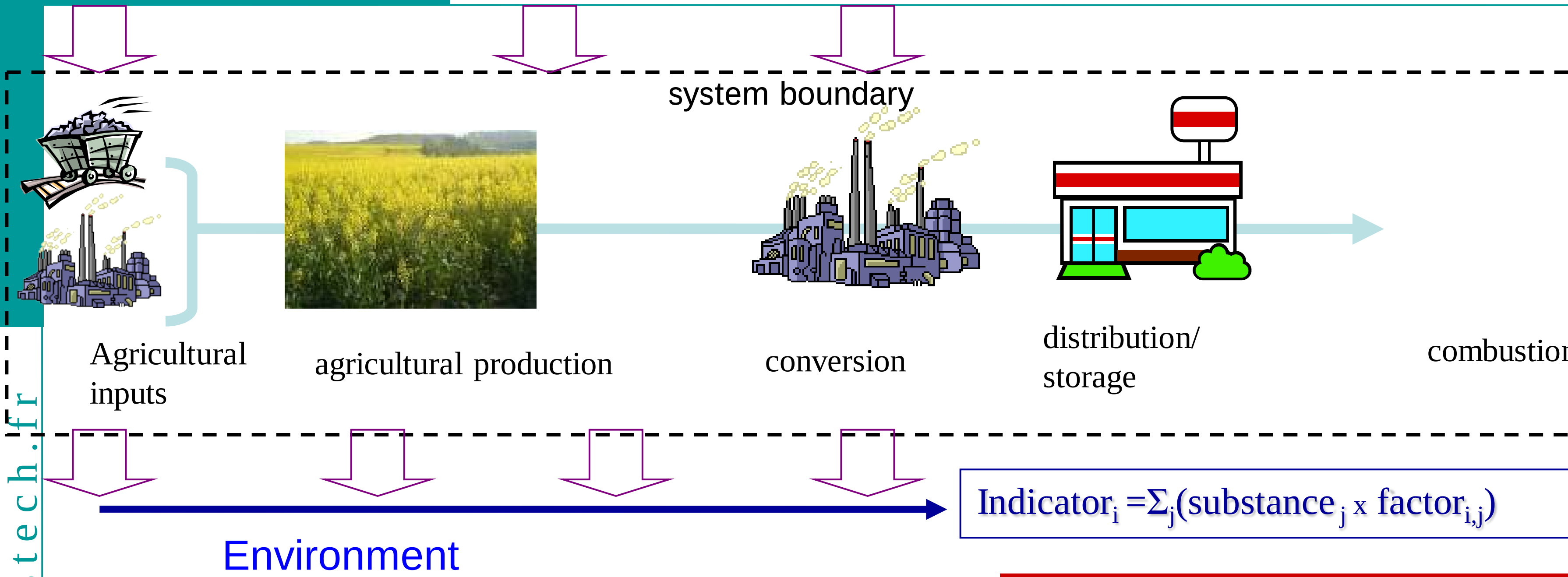
Source: ETTF, 2006

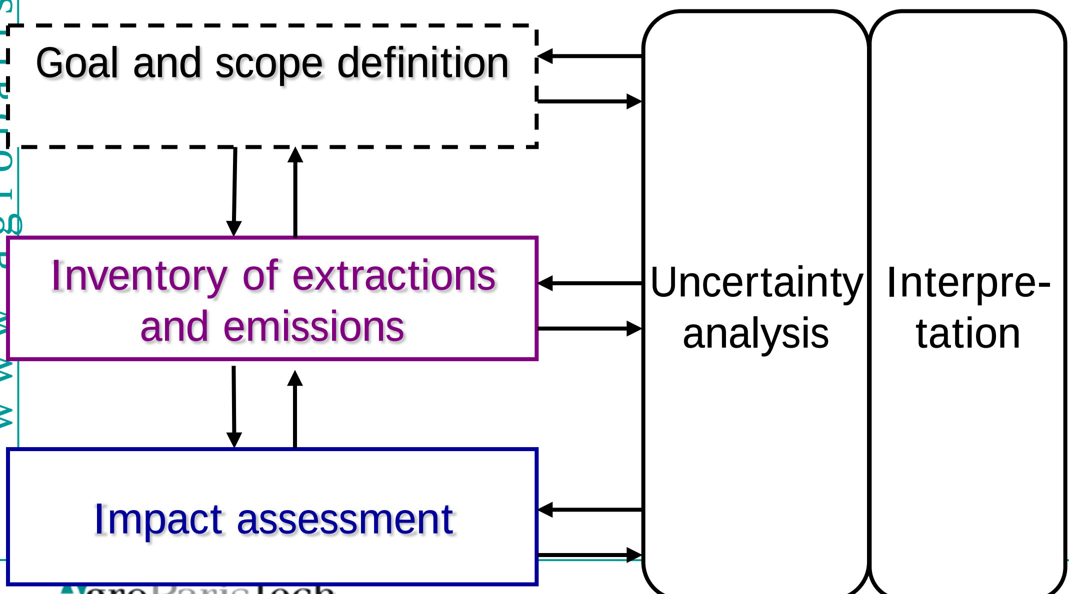
Criterion	Indicator / procedure
1. Greenhouse gas balance	
Net emission reduction compared with fossil reference, inclusive of application, is at least 50%. Here a strong differentiation of policy instruments is assumed, in which a better performance would lead to more financial support.	• Testing with the aid of calculation methods (Appendix 5). • Use of standard values for different steps in standard chains.
For all the themes below a dialogue with local and national stakeholders is required.	
2. Competition with food, local energy supply, medicines and building materials	
Availability of biomass for food, local energy supply, building materials or medicines must not decrease.	• Comply with minimum requirements testable by means of performance indicators. These are developed on the basis of obligatory reporting from the period 2007-2010.
3. Biodiversity	
No deterioration of protected areas or valuable ecosystems	• Comply with minimum requirements testable by means of performance indicators. These are developed on the basis of obligatory reporting from the period 2007-2010. • Further comply with the following requirement: • Plantations must not be located in or in the immediate vicinity of protected areas or valuable ecosystems. Reference year for ligneous feedstocks is 1994 [FSC 10.9], for palm oil 2005 [RSPO 7.3], and for other feedstocks 2006.
Insight into active protection of the local ecosystem	• Reporting obligation on a "management plan for active protection of the local ecosystem".

Evaluer une filière ou un territoire ?



Life Cycle Assessment (LCA) for bio-based chains





Impact categories:

- **Global warming**
- **Consumption of non-renewable ressources**
- **Eutrophication of ecosystems**
- **Air quality (ozone)**
- **Toxicity, ecotoxicity**
- ....

(ISO standards 14040)

Potential pitfalls when applying LCA to biorefineries

On the methodological side:

- Definition of systems boundaries
- Handling of co-products
- Choice of impact metrics and characterization factors

Quality of input data: representativeness, accuracy, transparency

- Feedstock production and emissions (eg N_2O)
- Data related to logistics and industrial processing
- Context or scale issues (eg, power production: average mix or marginal)

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Des nouvelles questions....

Table 2. Categories and examples of recommended functional units (FU) for studying different research questions in LCA studies of biorefinery (BR) systems.

Category and example of FU	Examples of research questions
Use of feedstock	
1 hectare	What is the best use of land? What are the consequences for the environment of using land in different ways?
1 ton biomass	What technological pathway is best for conversion of this biomass? What are the environmental profiles of the different feedstock?
Waste treatment of 1 ton municipal household waste	What is the best waste treatment for this waste? What is the best use of biomass waste?
Single product	
1 kg product	What is the environmental impact of a BR product? What is the environmental impact of increased demand for a BR product? How is the environment affected by the use of a BR product?
1 MJ product	
Function of single product	
1 MJ electricity	
1 person-km	
Multifunctional	
1 biorefinery	What are the hotspots in the BR production system? What is the environmental impact of the BR? What is the environmental impact of building and running a new BR compared with business as usual? How is the environment affected by the use of different feedstocks for the BR?
Combination of output products	What is the environmental impact from these BR products? What is the optimal combination of output products for reducing environmental impact?
	What is the environmental impact of process integration (i.e. BR vs. stand-alone bioenergy production?

Source: Ahlgrene et al., Biofuels Bioprod. Bioref., 2013

Comment répartir la charge environnementale entre les co-produits ? (1/2)

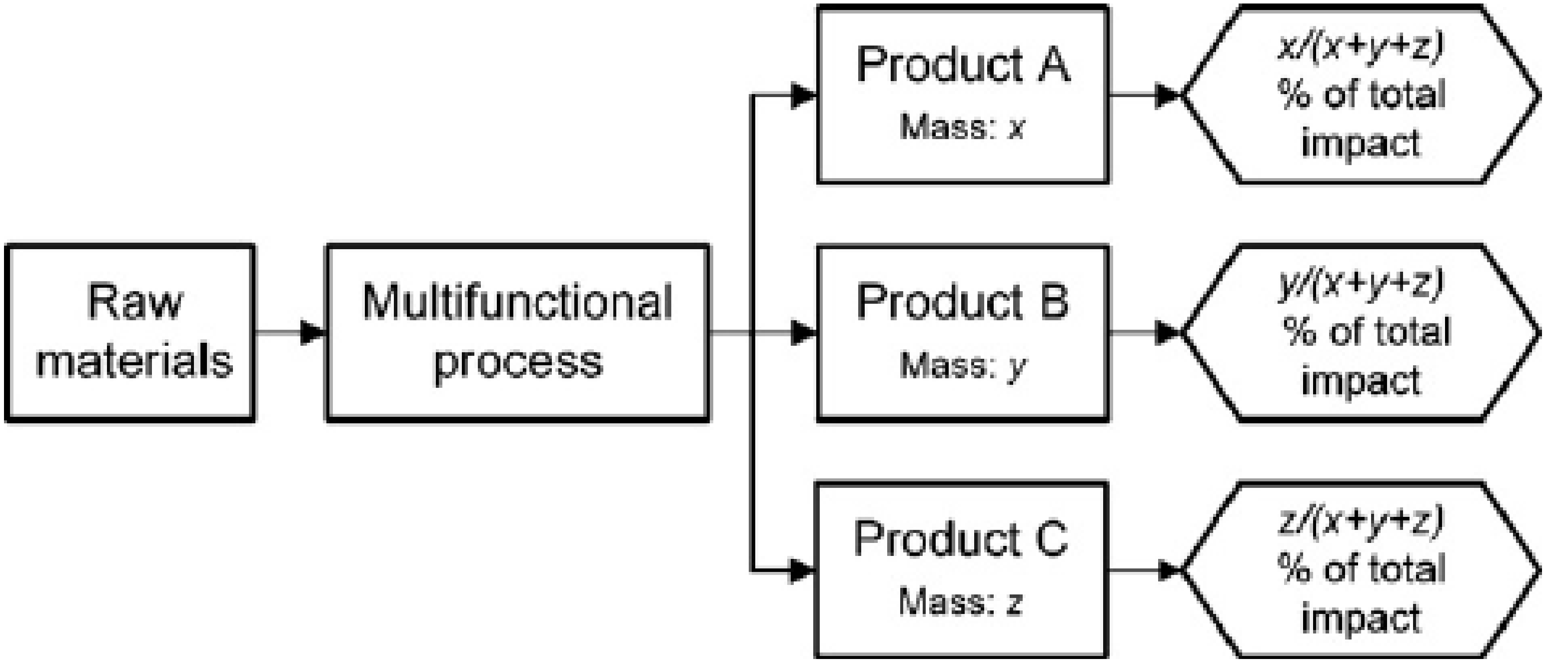


Fig. 1. Example of partitioning method: allocation of the environmental impacts according to the mass of the co-products.

Source: Cherubini et al., Resour. Conservation & Recycling, 2011

Comment répartir la charge environnementale entre les co-produits ? (2/2)

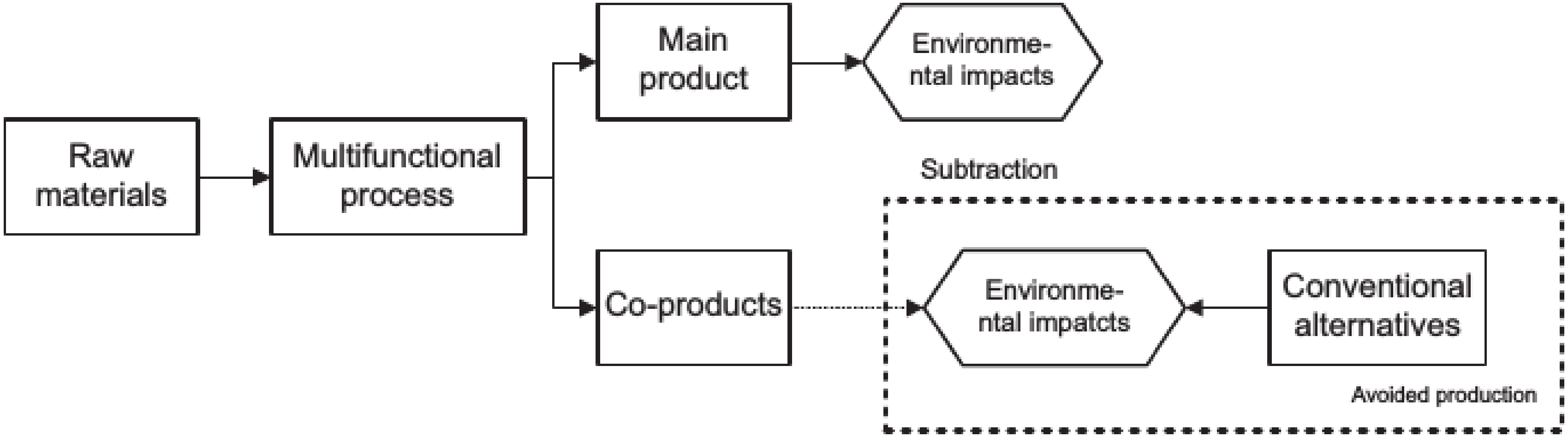


Fig. 2. System expansion or substitution method.

Source: Cherubini et al., Resour. Conservation & Recycling, 2011

Influence de la méthode de traitement des co-produits

Table 3
Total annual GHG emissions assigned to the biorefinery products using the selected allocation methods.

Product	GHG emissions kt CO_2-eq./a					
	Substitution method	Mass	Energy	Exergy	Economic	Hybrid method
Bioethanol	81.0	126	108	115	116	107
Heat	25.4	0	14.4	8.55	8.68	11.2
Electricity	16.1	0	3.68	3.63	2.49	7.08
Phenols	5.71	1.88	1.91	1.94	0.98	2.51
Total	128	128	128	129	128	128

Répartition des émissions de GES d'une bioraffinerie à base de pailles de blé en fonction des méthodes d'allocation.

Source: Cherubini et al., Resour. Conservation & Recycling, 2011

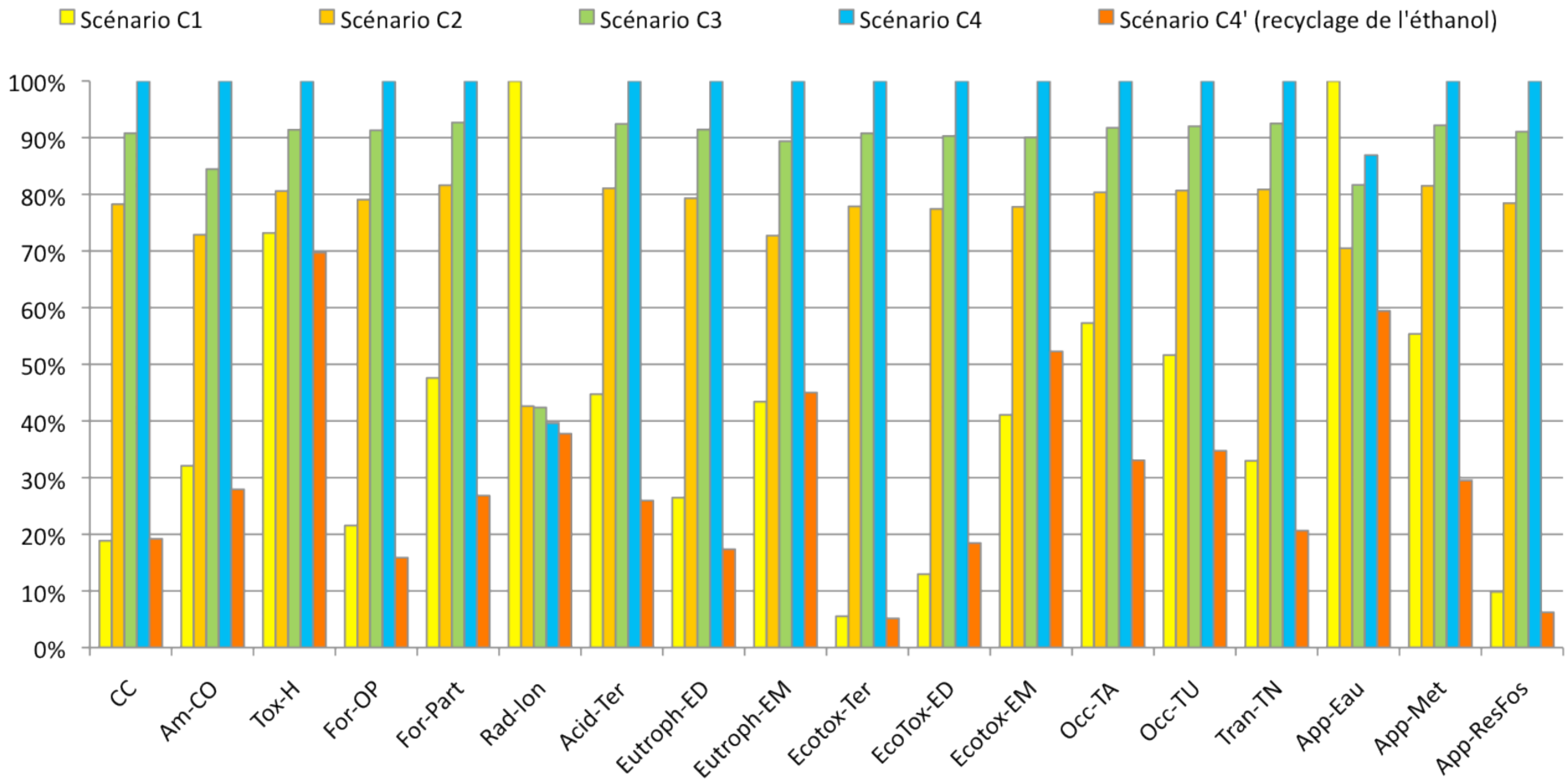
Du cycle de vie au procédé

Source: Gabrielle et Pontalier, 2013

Exemple de procédé

Etude du recyclage de l'éthanol
Couplage avec PROSIM

Comparaison des 5 scénarios

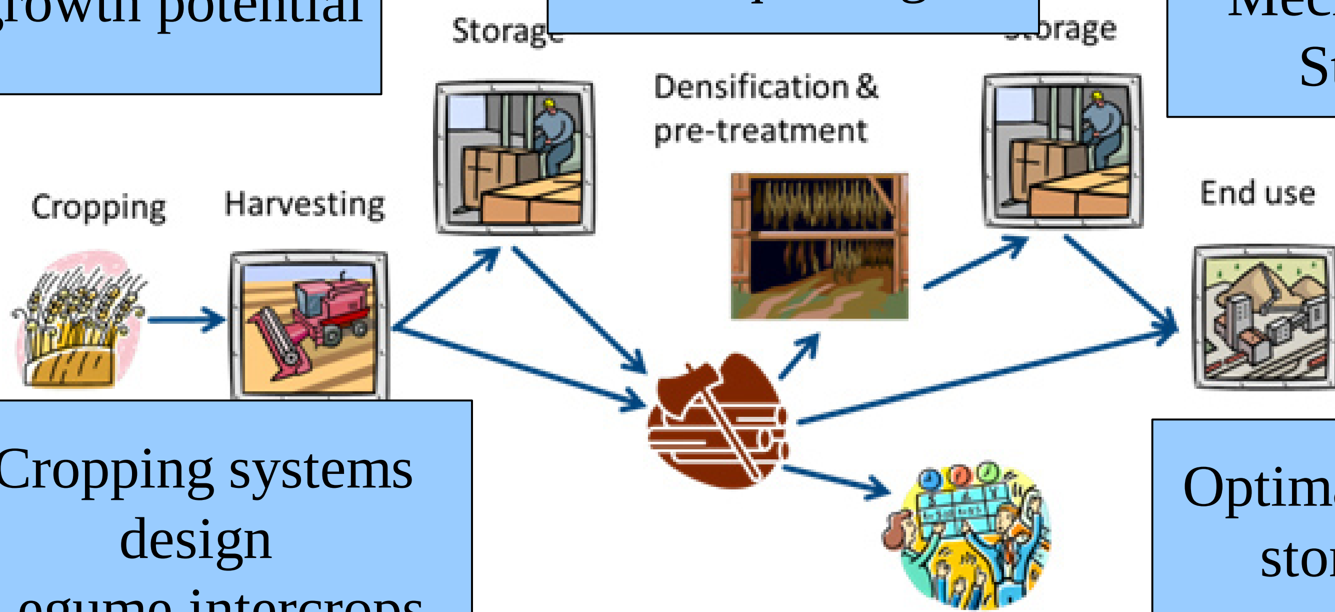


Evaluer pour progresser… sur la logistique

Benchmarking
Year-round supply
Decreased losses
Re-growth potential

Torrefaction
(wet or dry)
Pelletization
Briquetting

Whole rods vs chips
Indoor vs outdoor
Mechanical drying
Storage time



Cropping systems design
Legume intercrops
Recycling of process residues

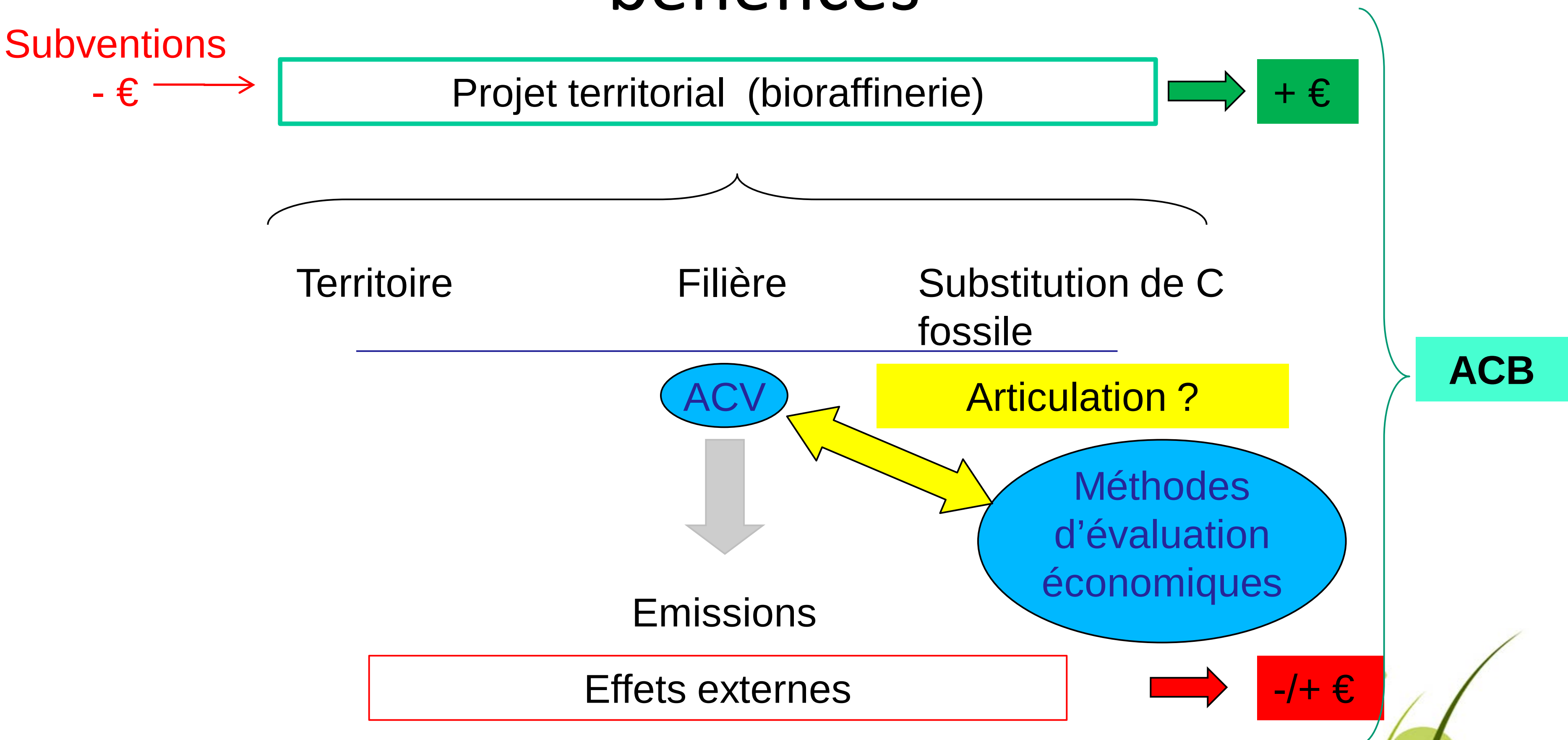
Optimal collection & storage points,
transportation routes
Resource planning

Deux cas d'étude pour approcher la durabilité

Miajadas power station, Spain (capacity: 16 MW) and Bourgogne Pellets, France

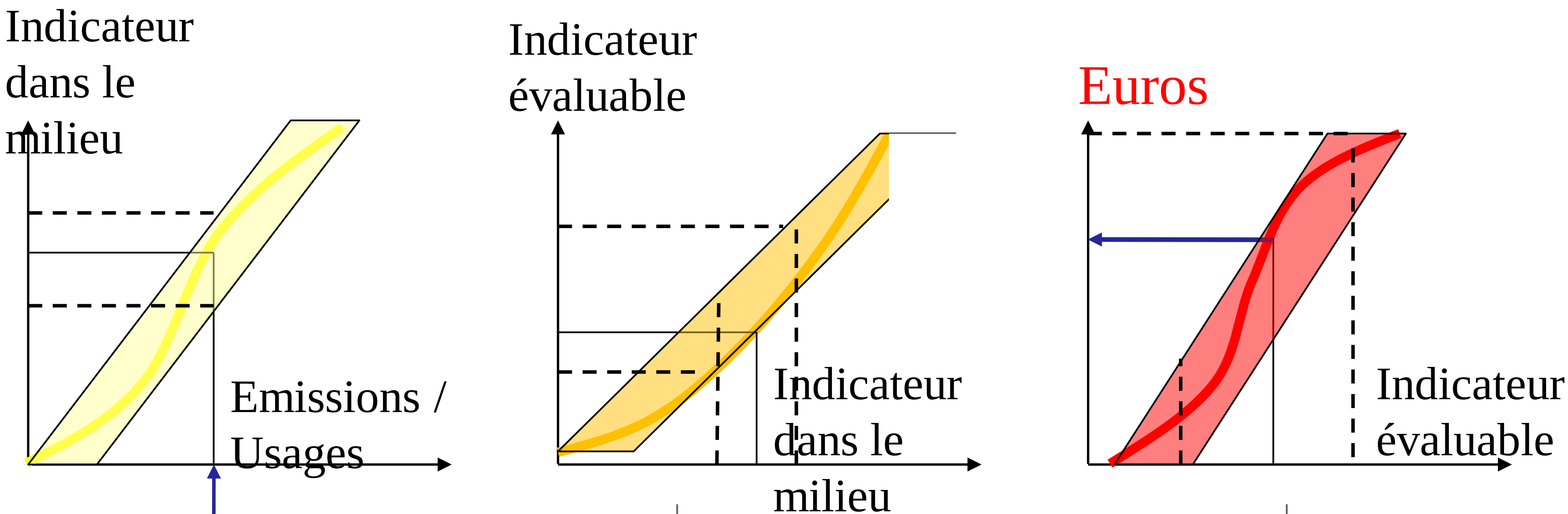
www.logistec-project.eu

Comment agréger les critères de durabilité? L'exemple de l'analyse coûts-bénéfices



Slide: V.Martinet, INRA.

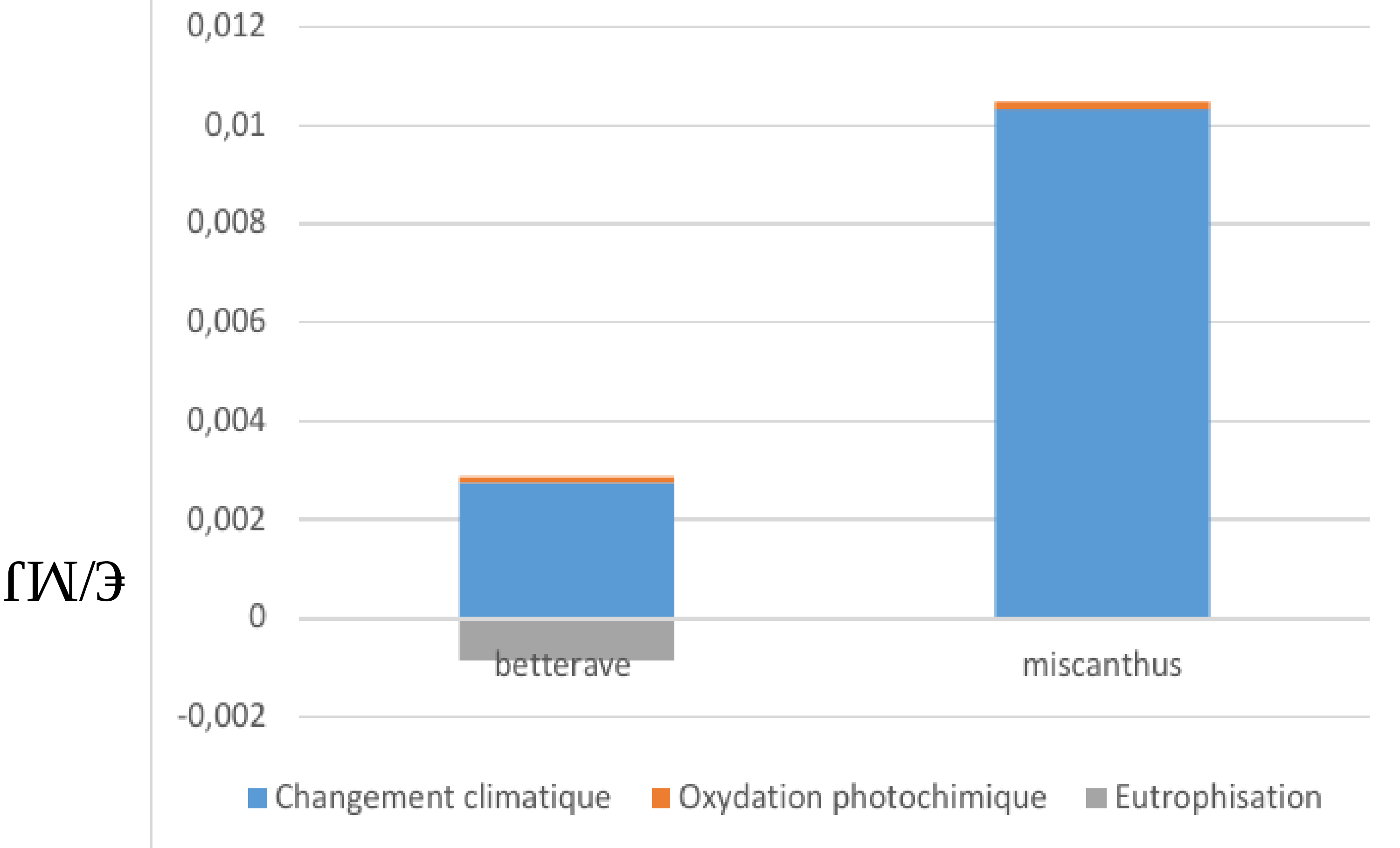
Chaîne causale: Localisation – Traduction - Monétarisation



Emissions de nutriments	Concentrations Phosphates	Clarté de l'eau
Emissions de polluants atmosphériques	Concentration en ozone	Hospitalisation
Surfaces de terres utilisées	Qualité de l'habitat écologique	Espèce emblématique

Slide: V.Martinet, INRA.

Monétarisation des externalités environnementales



Evaluation monétaire des externalités liées à une substitution de l'essence par de l'éthanol 1ère ou 2ème génération, en Picardie (Zhu, 2013).

Conclusion

- Les productions de biomasse et de bio-produits sont contraintes par de nombreux facteurs physiques et économiques (ressource en terres), et par les critères de durabilité (économies de GES, biodiversité, acceptabilité sociale).

- L'évaluation des projets de bioénergie se généralise et un certain nombre de lignes directrices sont disponibles (par exemple la directive RED) – elles s'appliquent aux bioraffineries.

- Les choix méthodologiques sont importants (et génèrent une incertitude).

- Il reste un certain nombre d'inconnues en termes d'externalités positives ou négatives (biodiversité, eau, changements d'usage des sols directs et indirects).

- Le bassin d'approvisionnement est l'échelle-clé pour améliorer les évaluations environnementales et la performance des projets, de même qu'un couplage avec le génie des procédés.

- La co-construction entre les opérateurs économiques et les parties prenantes de ces bassins est souhaitable pour le succès (et la durabilité) des projets bioraffinerie.

Merci pour votre attention

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