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Federal Department of Economic Affairs FDEA
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LCA of agricultural biogas production – the effects of plant size

Martina Alig, ART

47th LCA Discussion Forum, 23 April 2012

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Background

- Switzerland: 72 Biogas plants (2010) of very different sizes: 50kW$_e$ - 1'000 kW$_e$
- Augmentation of capacity =
  - Better efficiency in conversion of organic matter
  - better energy efficiency
  - better utilization of infrastructure

  BUT: More substrate is needed → more transports
- What is the **ideal size of an agricultural biogas plants** regarding its environmental impacts?

⇒ Comparison of centralized and decentralized agricultural biogas plants of different sizes

⇒ Data collection on real farms with a questionnaire

⇒ Impacts analyzed: non-renewable energy demand, global warming potential, total environmental impact (UBP)

Project information

- Project title: **Life-cycle assessment of centralized vs. decentralized biogas production in agricultural facilities**

- Partners & Collaborators

ENERS Energy Concept	A. Dauriat
Agroscope Reckenholz (ART)	G. Gaillard, M. Alig, D. Scharfi
EREP	Y. Membrez, N. Bachmann
Ernst Basler + Partner (EBP)	R. Steiner
Agroscope Changins (ACW)	R. Charles

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Stations de recherche
Agroscope Reckenholz-Tänikon ART
Agroscope Changins-Wädenswil ACW

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Key questions and goals

- Evaluation of the ecological balance of agricultural biogas production as a function of output level (size of production facility), based on real biogas production facilities in Switzerland: “centralized vs. decentralized”

- Comparative analysis of the results and identification of the main determinants of environmental performance (non renewable primary energy use, greenhouse gas emissions, global ecological balance according to UBP method) of agricultural biogas production

- Elaboration of practical recommendations addressed to biogas producers, investors and/or political actors regarding the size of agricultural biogas production

- Update of ecoinvent inventories (v3) regarding agricultural biogas production (including cogeneration)

Project structure and organisation

Methodology (ENERS)
Definition of methodological basis
Elaboration of a questionnaire addressed to biogas producers

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Life cycle inventory (ENERS)
Implementation of life cycle inventories based on the answers to the questionnaire and on the structure of ecoinvent biogas inventories

→ **ecoinvent**
Resp.: ART

↓

Life cycle analysis (ENERS)
Environmental impact of centralized vs. decentralized agricultural biogas production
Identification of the main determinants of environmental performance
Sensitivity analysis

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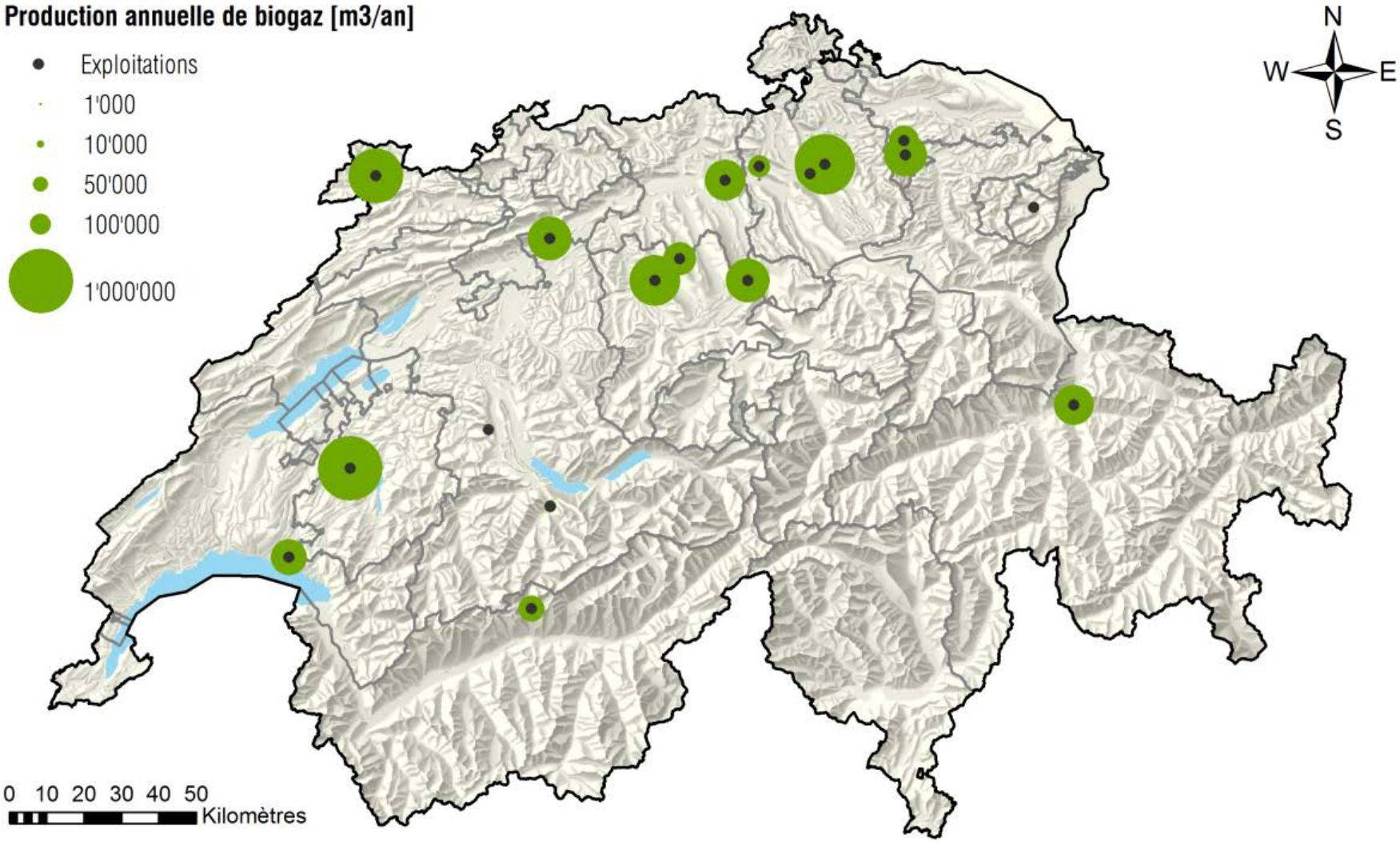
Case studies (ART)
More in-depth analysis
of selected biogas production facilities

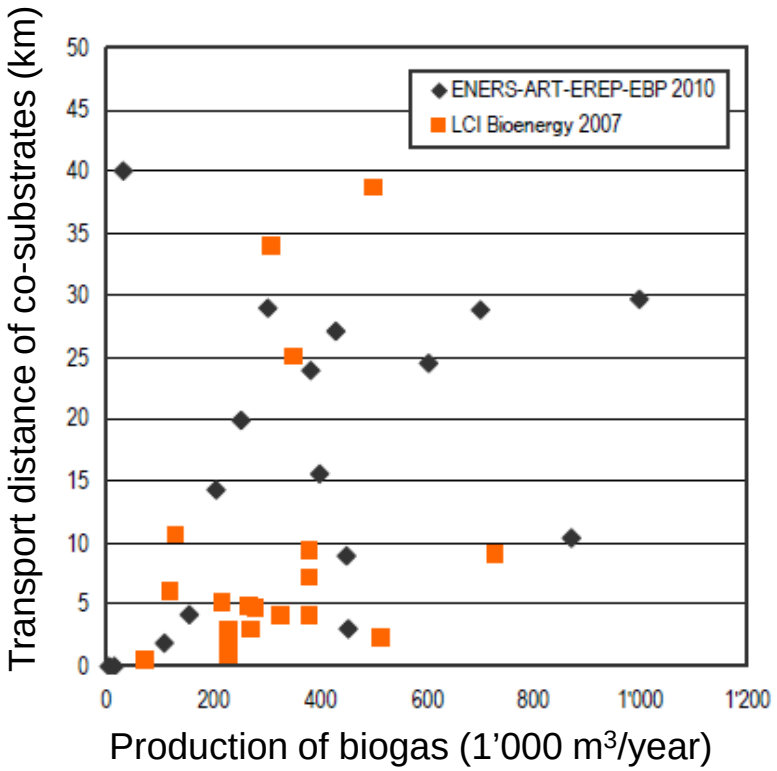
EREP, EBP: expert knowledge regarding biogas production, contact to biogas producer

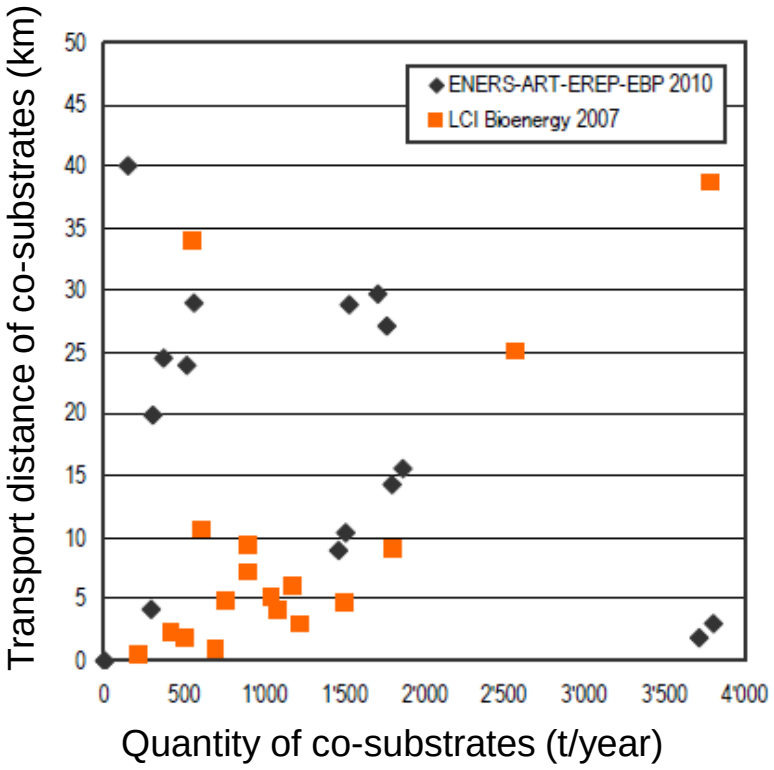
ACW: expert knowledge regarding soil fertility and use of digestate

Biogas plants analysed



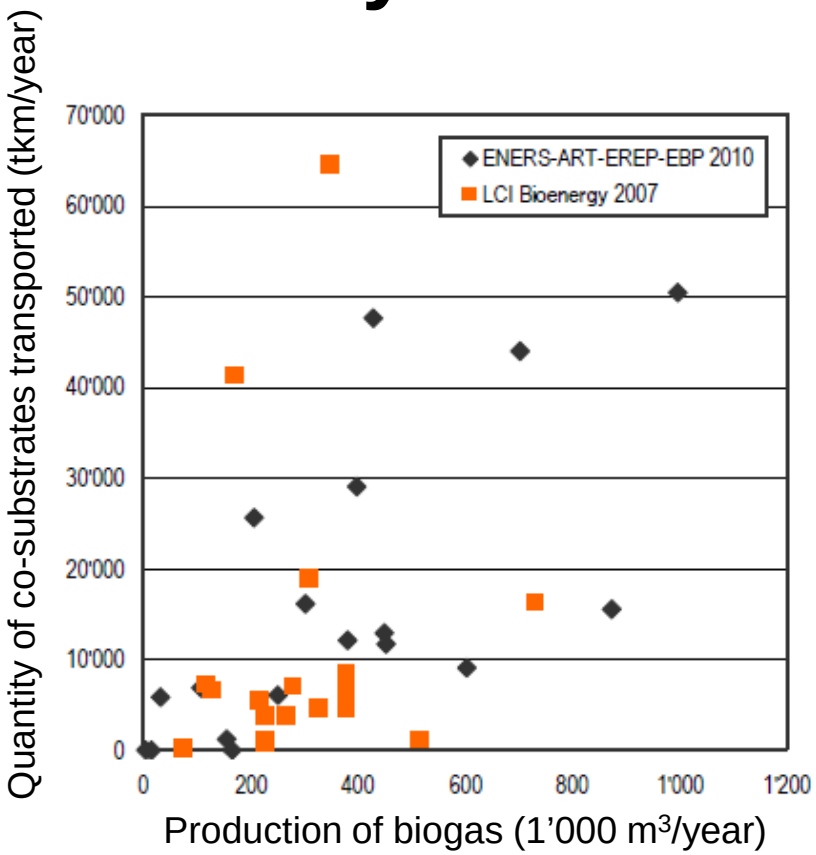
Analysis of the questionnaires (I)

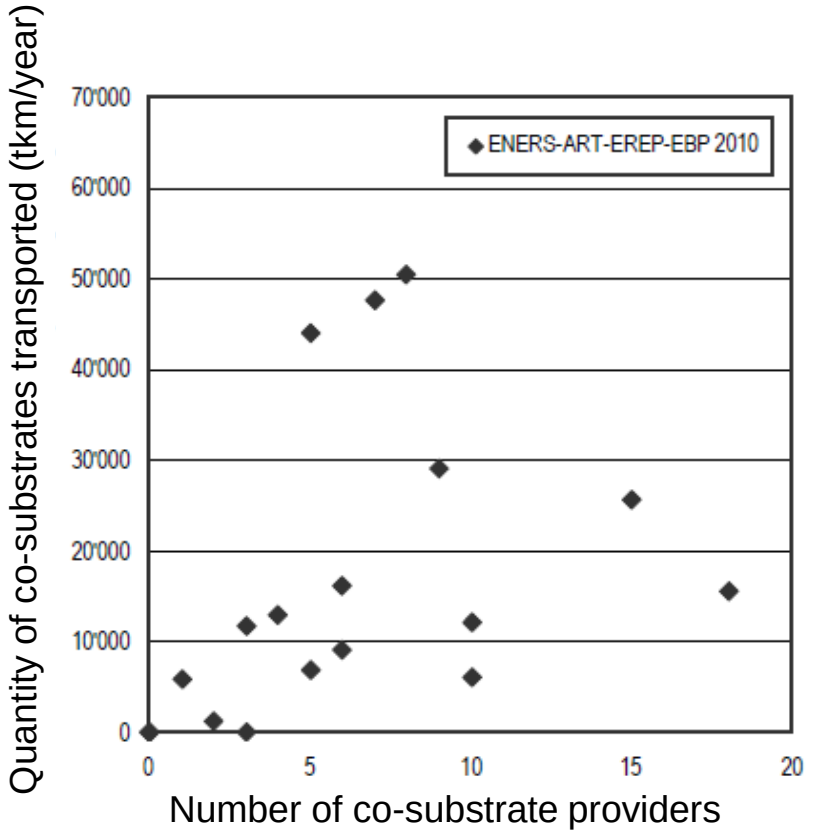




No relationship between production of biogas, quantity of co-substrates used, transport distance of co-substrates and number of co-substrates providers!

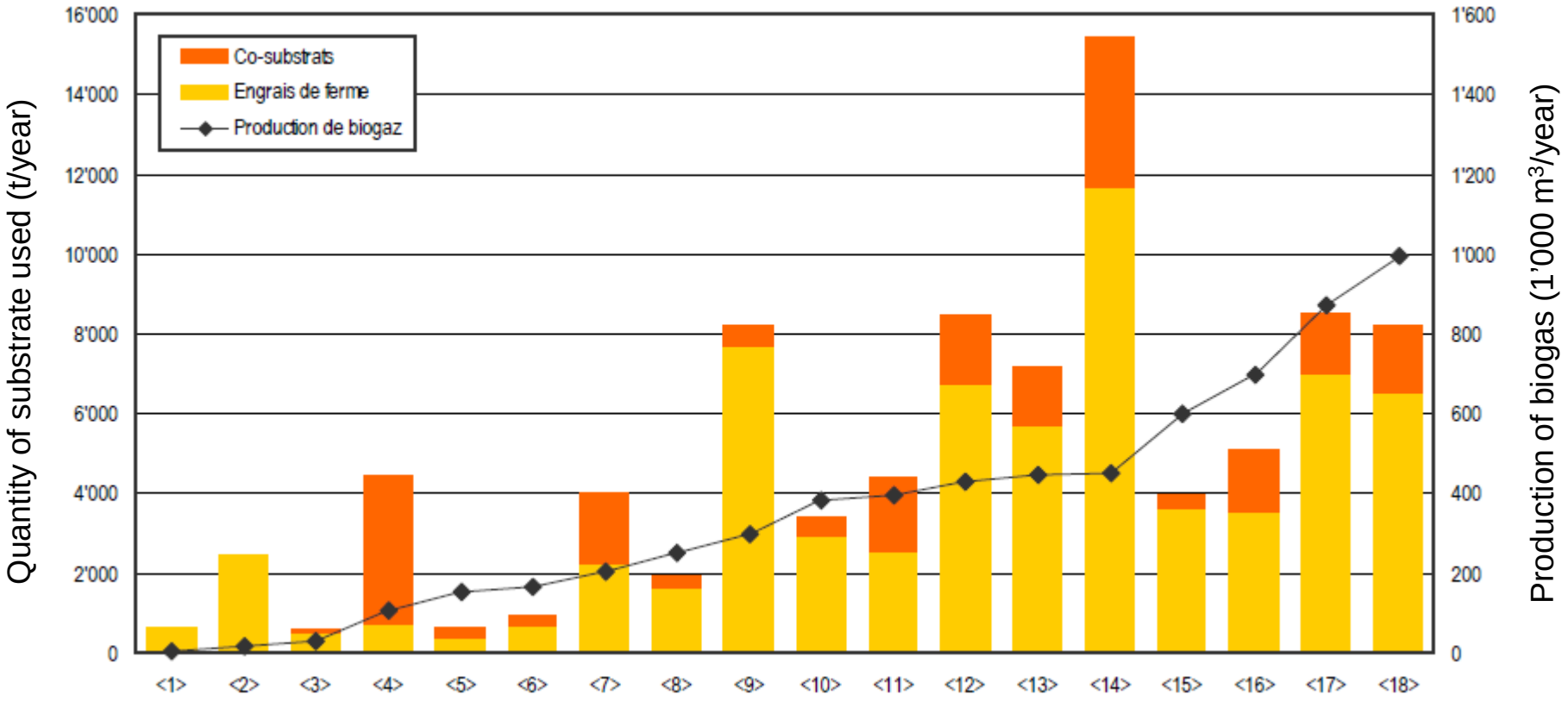
Analysis of the questionnaires (II)





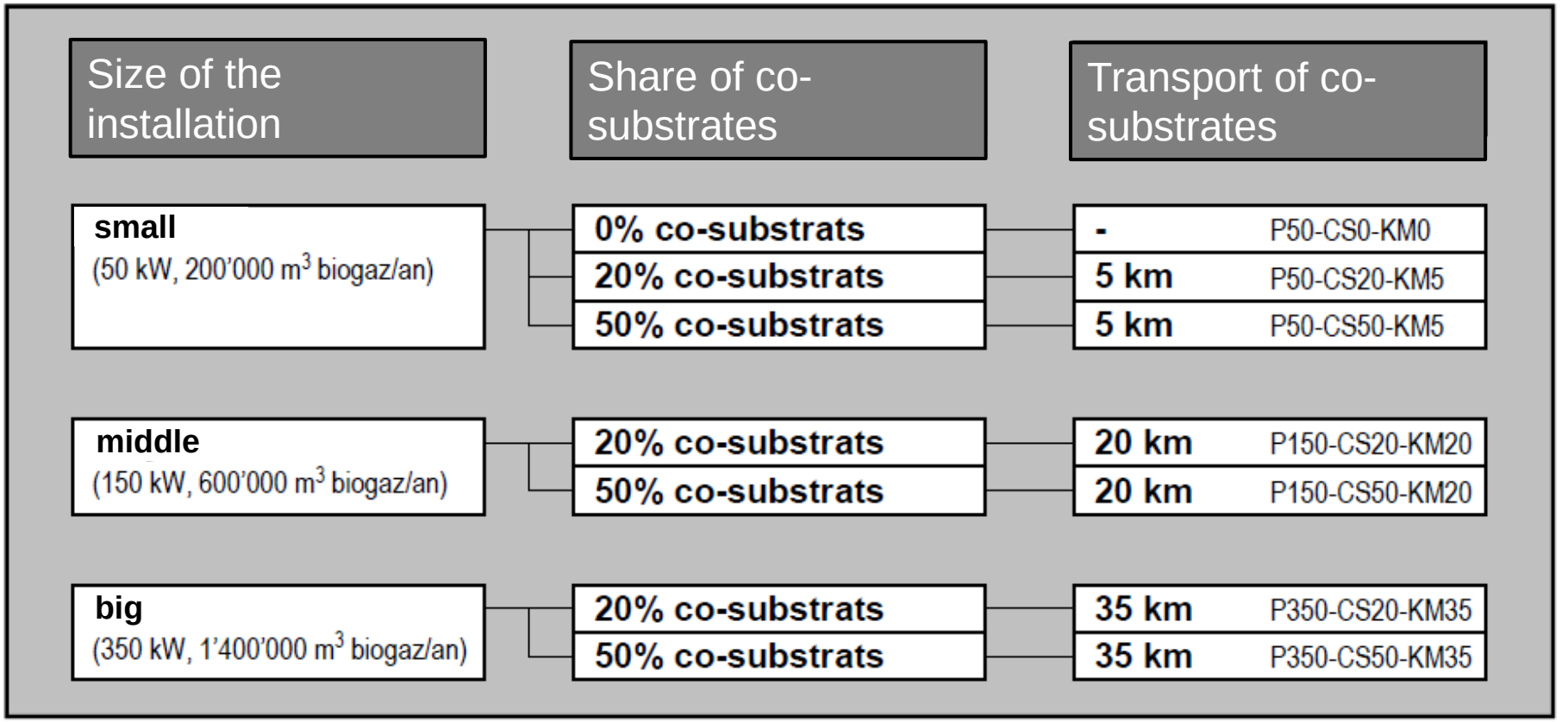
Only weak relationship between transported co-substrates multiplied by mean transport distance and production of biogas / number of co-substrate providers!

Analysis of the questionnaires (III)

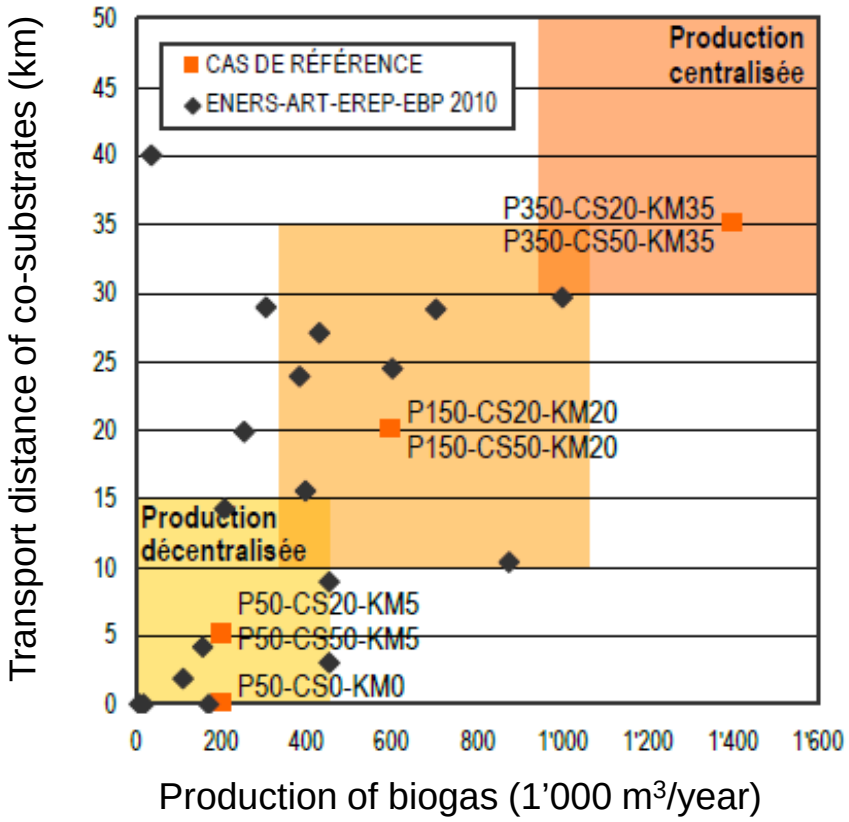


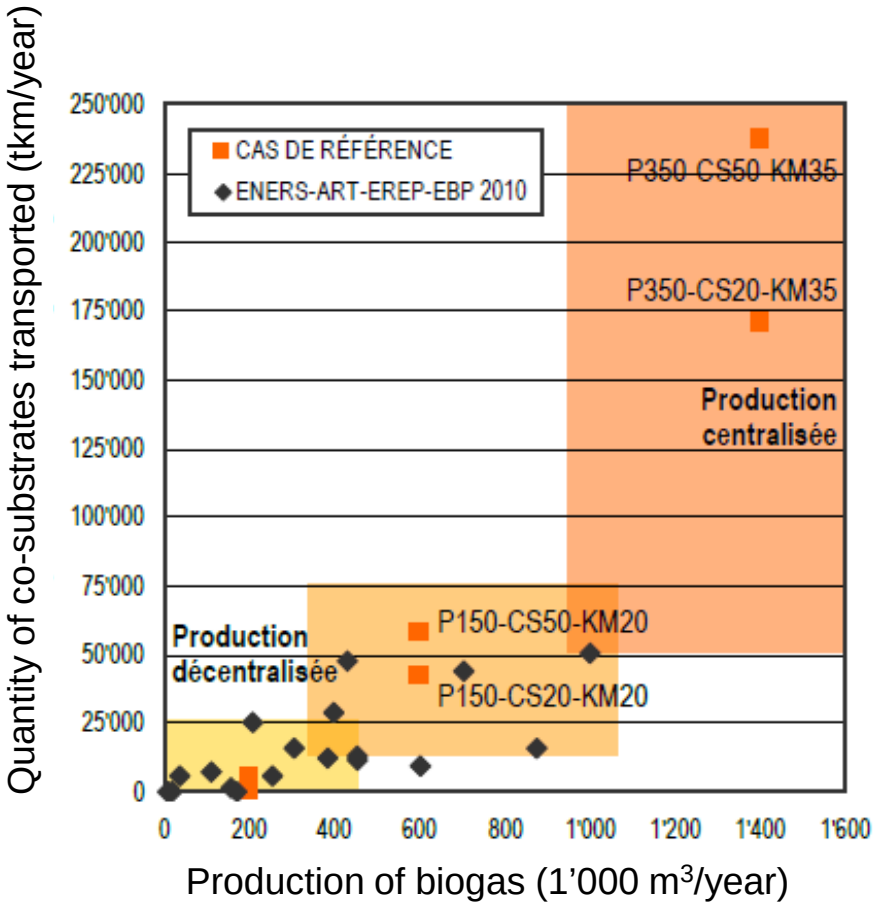
Use of co-substrates in agricultural biogas plants depends on proximity of co-substrate providers as well as geographical and economic factors, but not primarily on the size of the installation.

Definition of reference cases

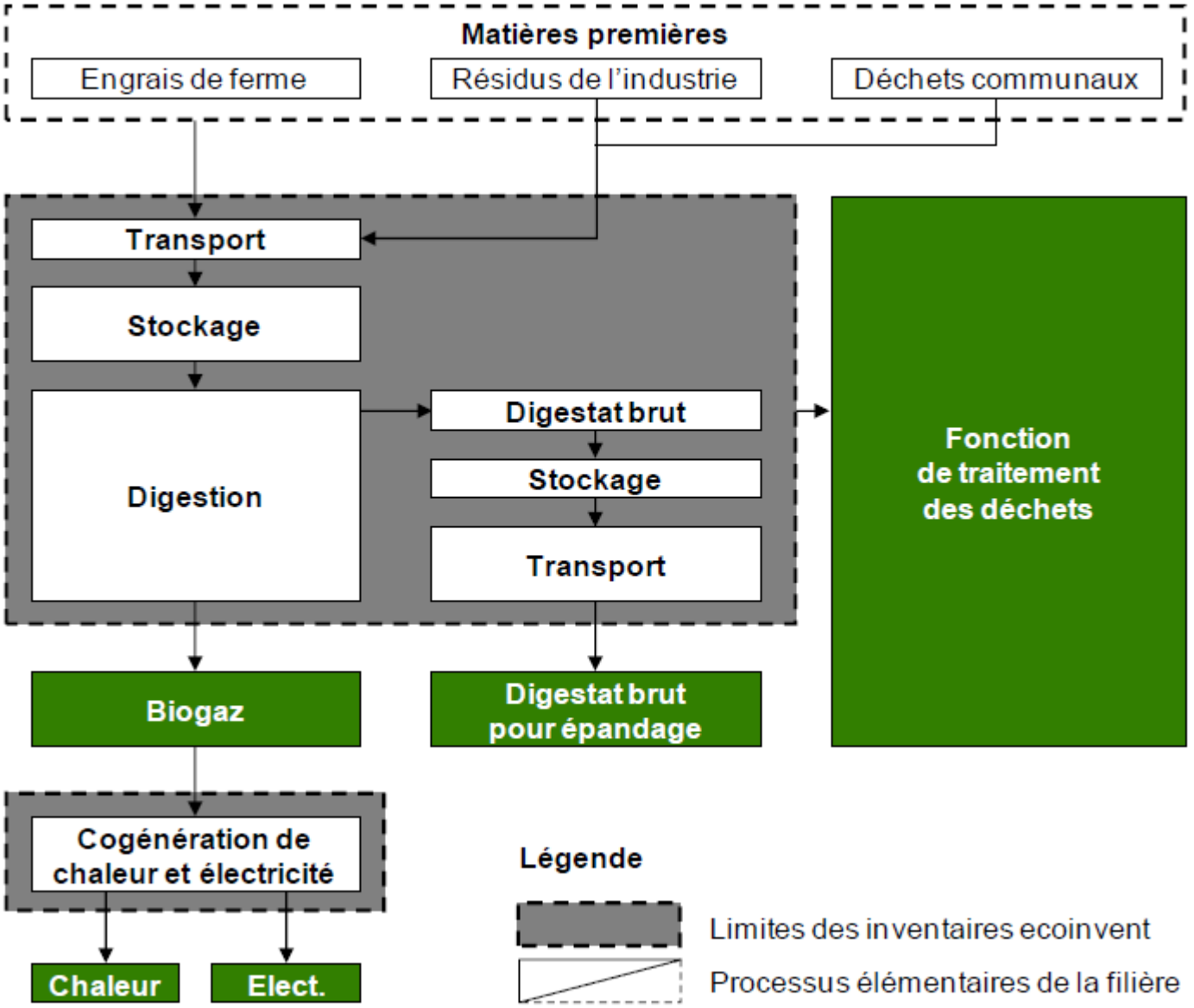


Definition of reference cases

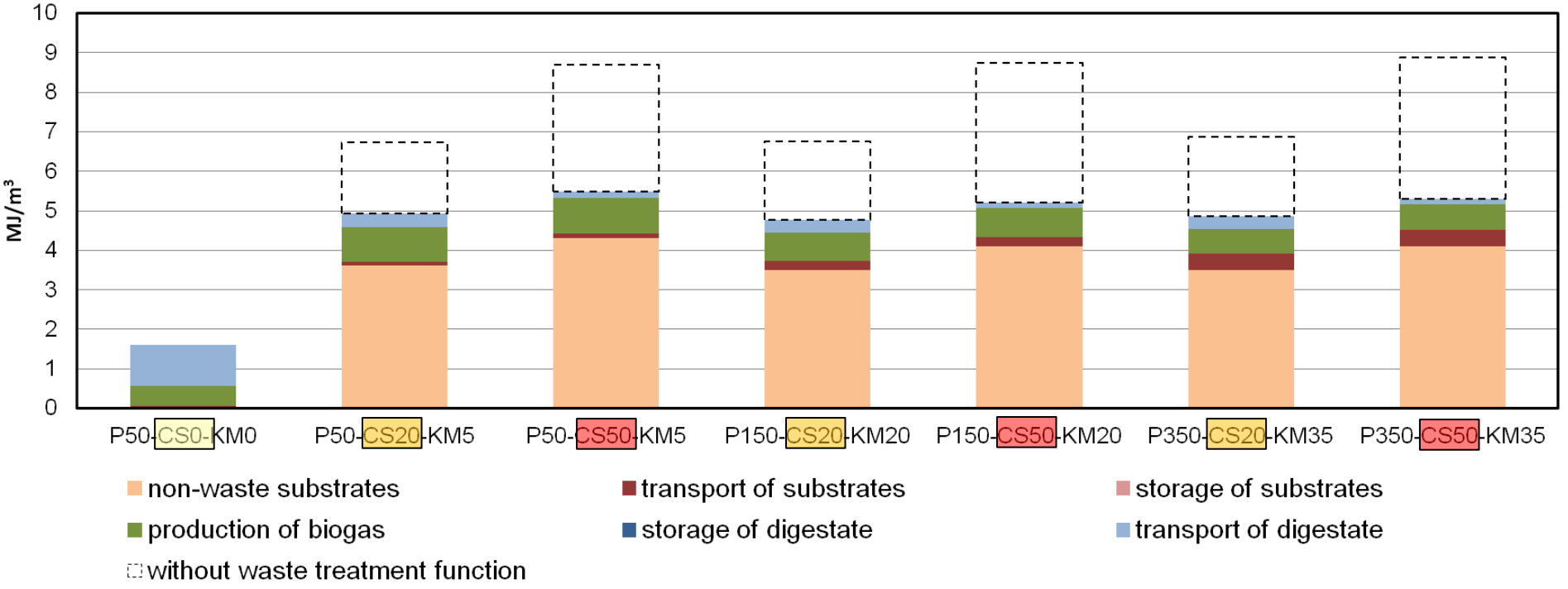




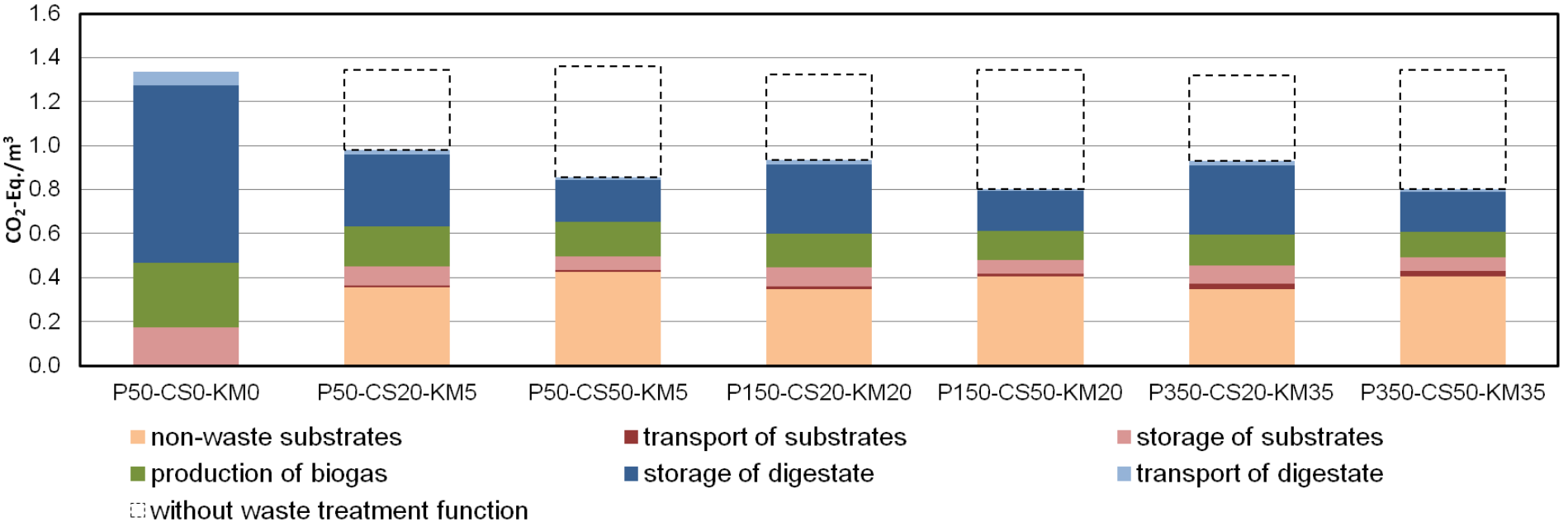
System boundaries



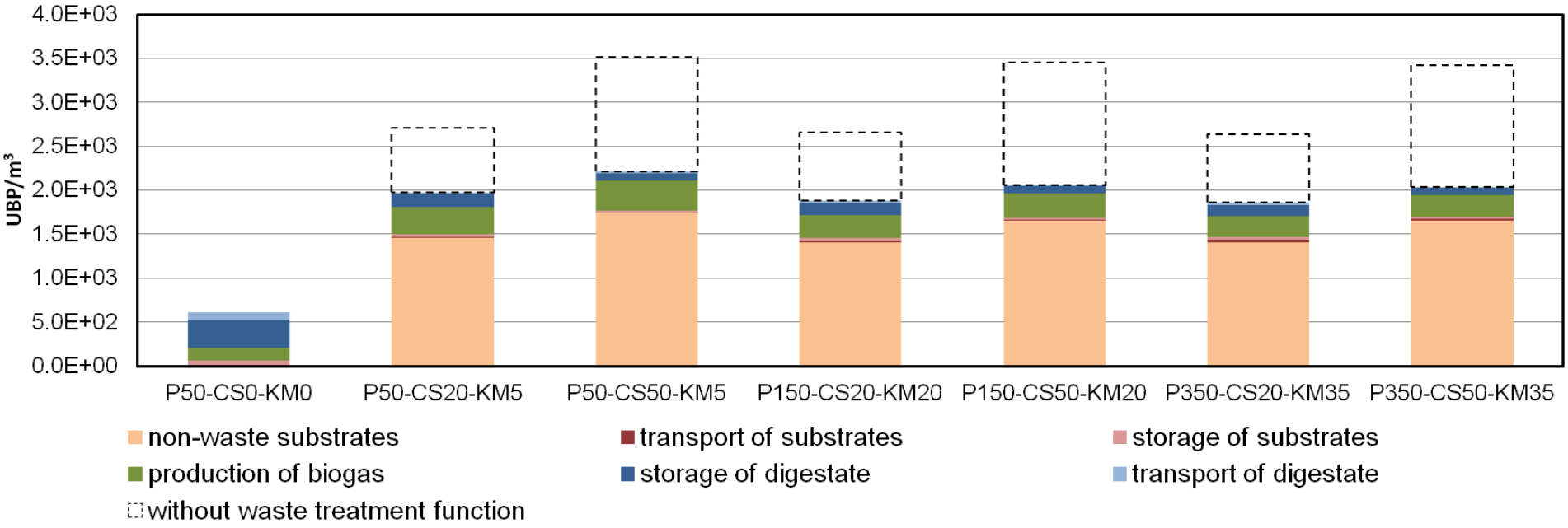
Energy demand per m³ biogas produced



GWP per m³ biogas produced

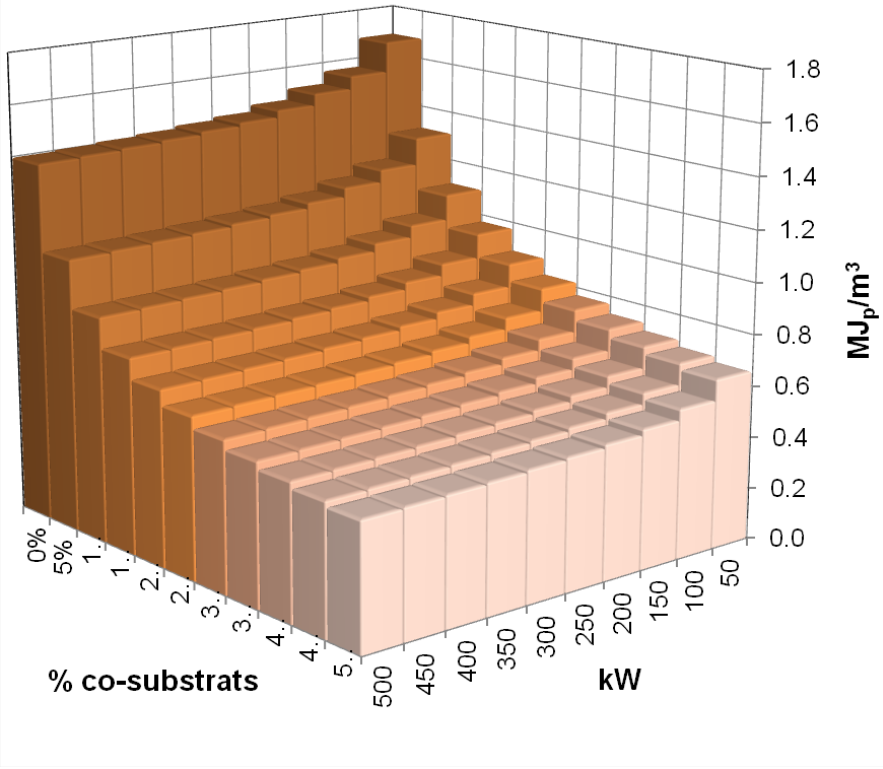


Global environmental impact per m^3 biogas produced

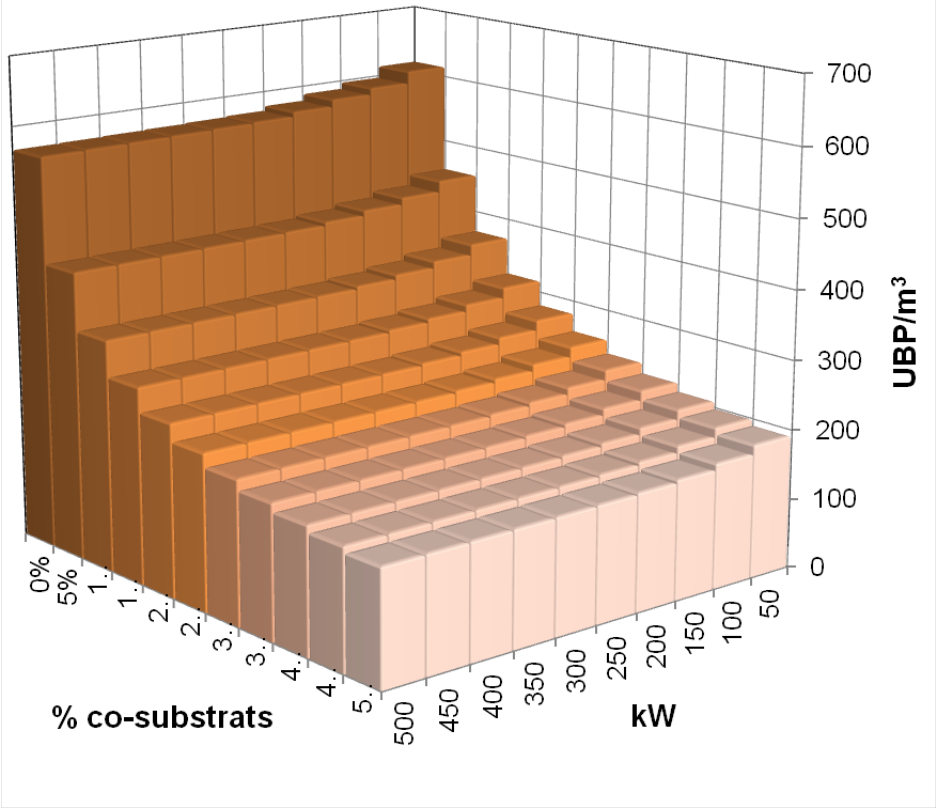


Share of co-substrates vs. size

Energy demand



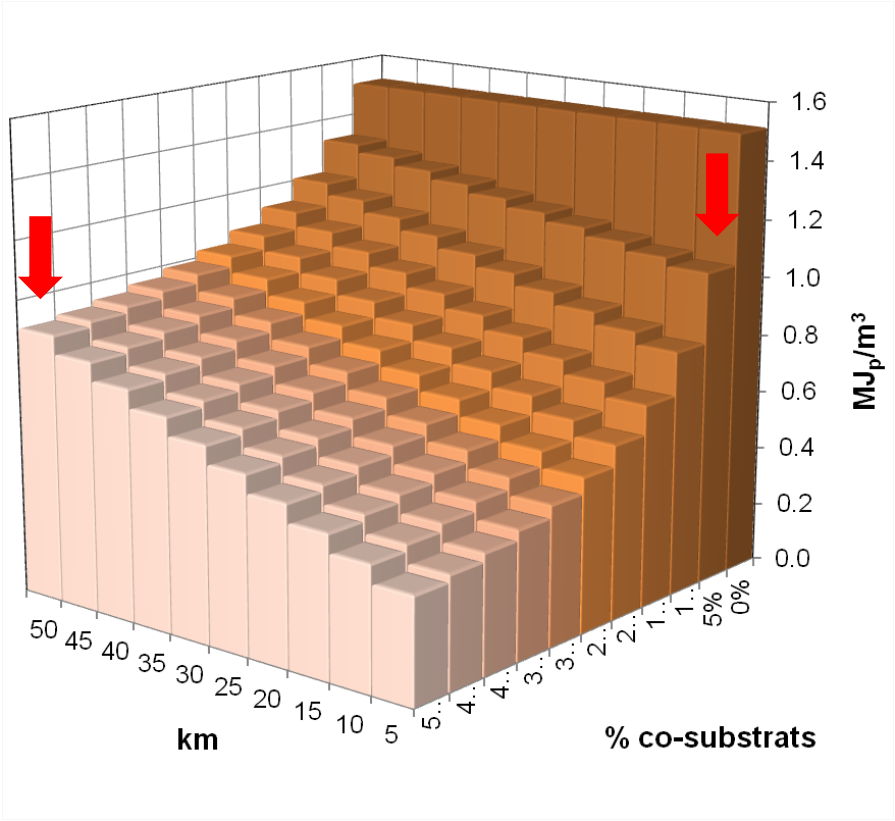
Global env. impact



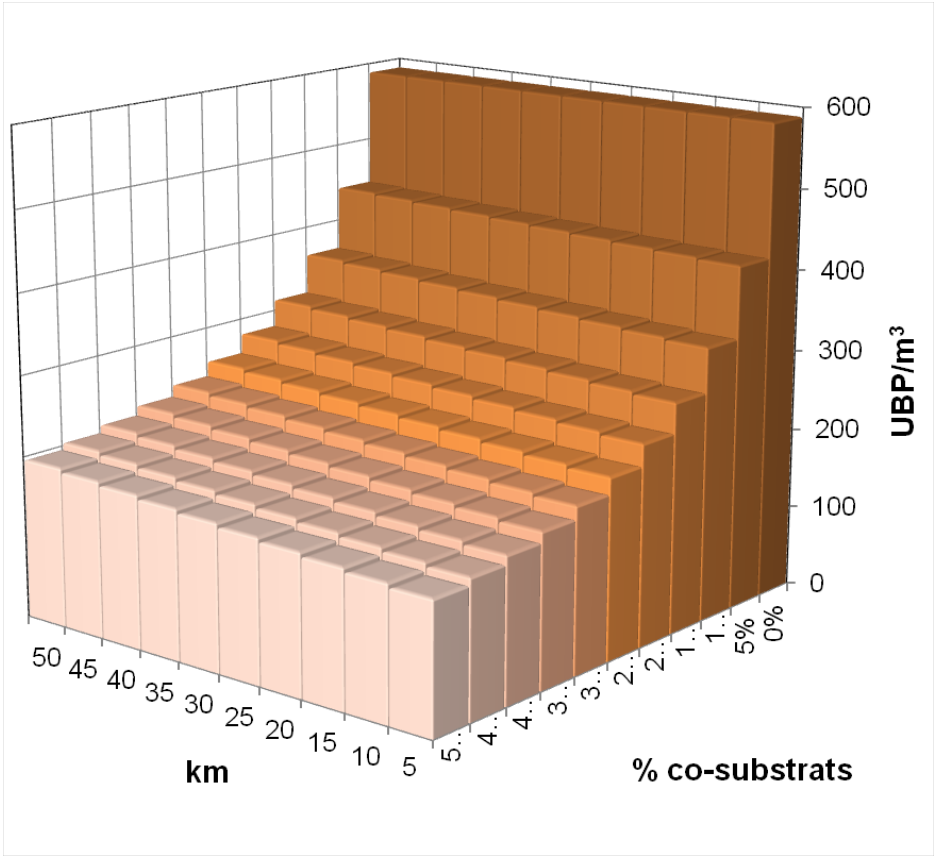
transport distance = 20km

Share of co-substrates vs. transport distance

Energy demand



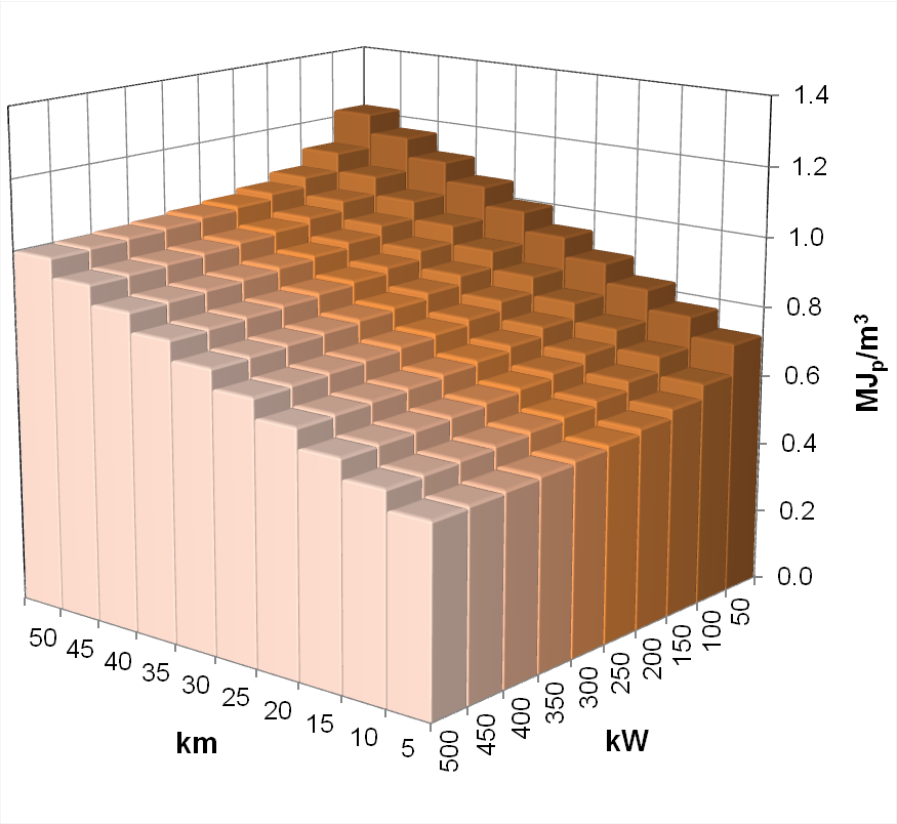
Global env. impact



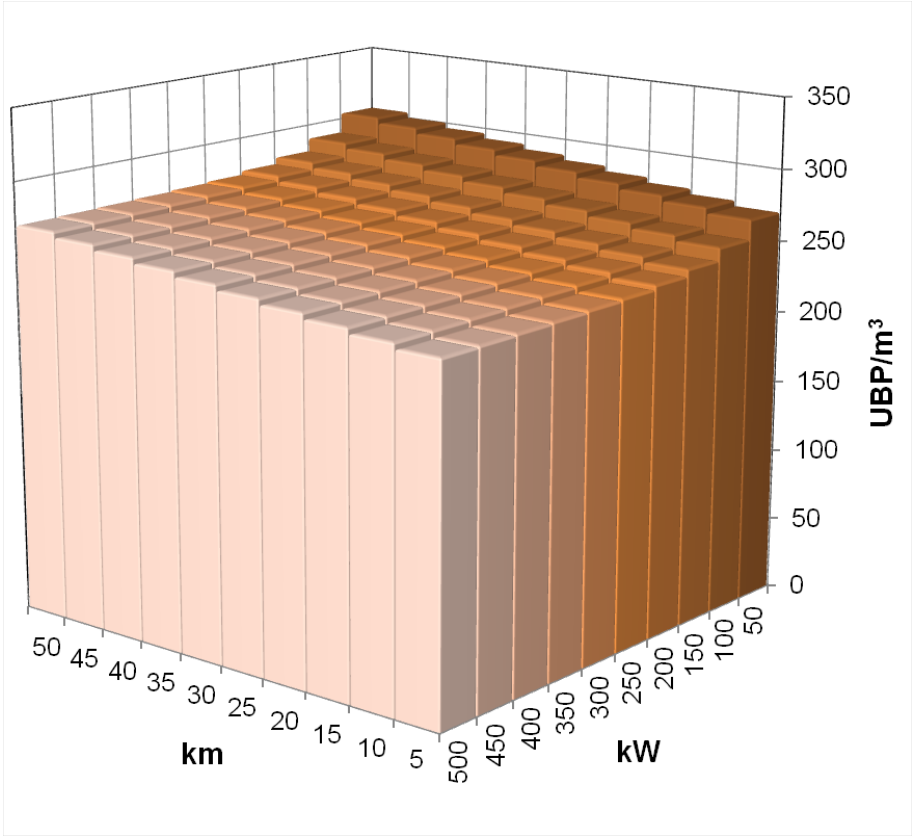
plant size = 150 kW_e

Size vs. transport distance

Energy demand



Global env. impact



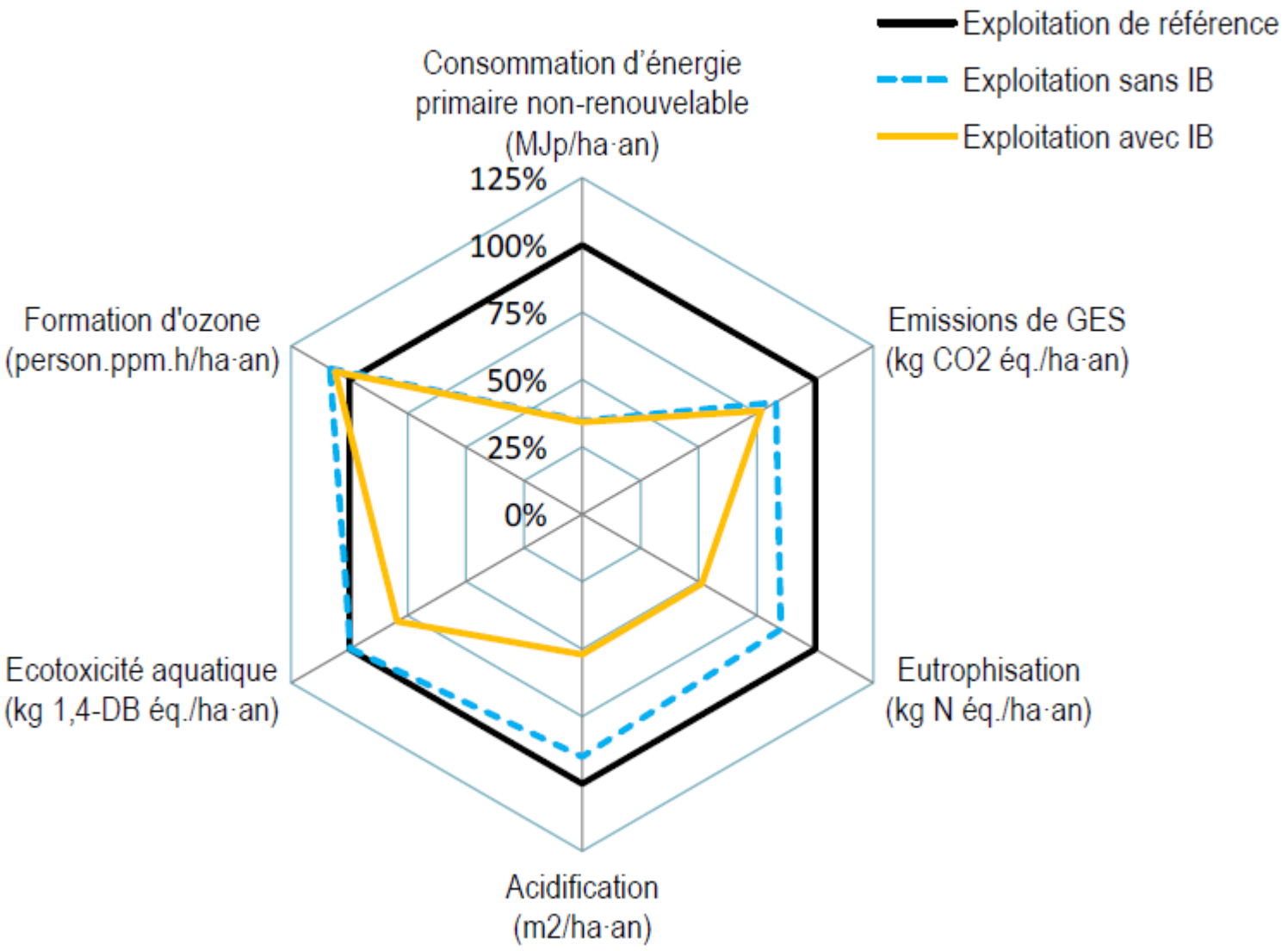
Share of co-substrates = 20%

Main determinants of the environmental impact of agricultural biogas plants

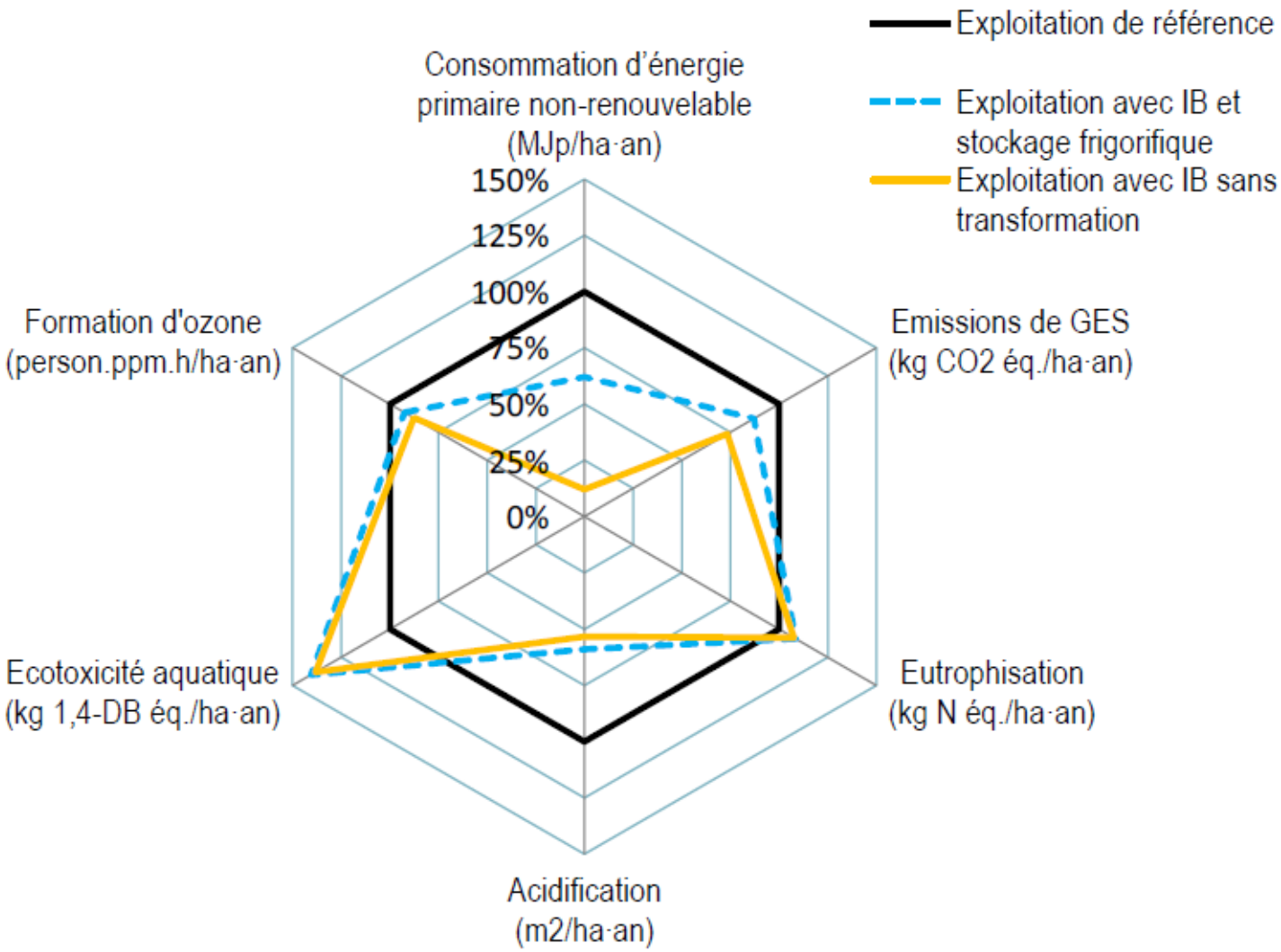
Paramètres et principaux déterminants	Catégories d'impacts		
	Consommation d'énergie primaire non-renouvelable	Emissions de GES	Impact environnemental global
Substrats « non-déchets »	+++	+++	+++
Part des co-substrats	+++	+++	+++
Fonction « traitement des déchets » (allocation)	+++	+++	+++
Caractérisation du mix de co-substrats	+++	+++	+++
Temps où le substrat est stocké chez le producteur de biogaz	ø	+++	+++
Transport des digestats	+++	+	+/++
Approvisionnement en électricité (auto/externe)	+++	+	+/++
Distance d'approvisionnement des co-substrats	+++	+	+
Rendement(s) de biogaz (par type de substrat)	+	+/++	+/++
Type de stockage des digestats (couvert/ciel ouvert)	ø	ø	+++
Taille de l'installation	+	+	+
Valeur économique des co-substrats	+	+	+
Post-fermentation	+	+	+
Rendement électrique de la cogénération	+	+	+
Nombre de jours d'arrêt (émissions directes de biogaz)	ø	+	+
Type de stockage des substrats (couvert/ciel ouvert)	ø	ø	+

+ : peu significatif / ++ : significatif / +++ : très significatif / ø : pas significatif

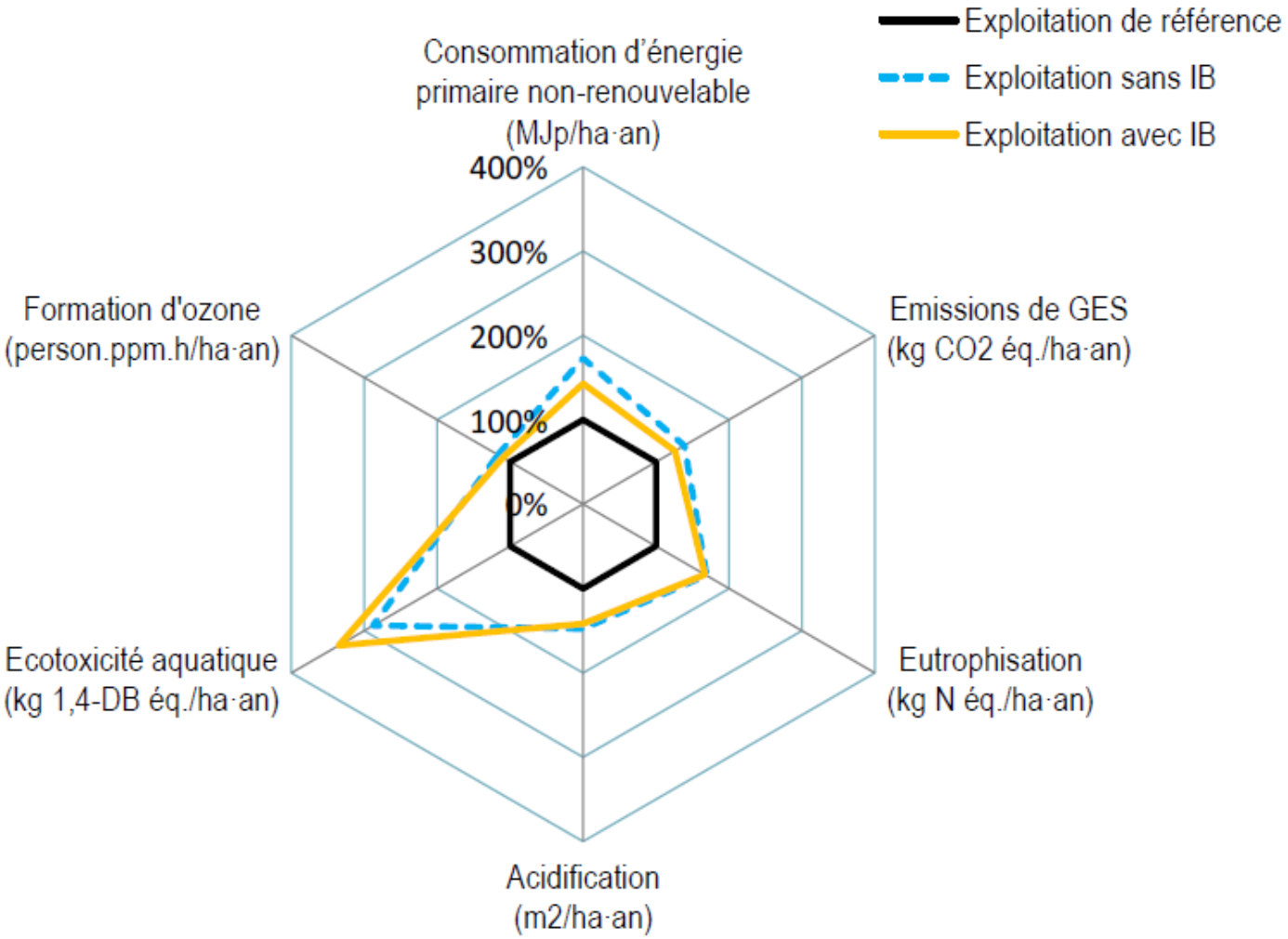
Case study I: Farm with small biogas plant (15 kW_e) without use of co-substrates



Case study II: Farm with small biogas plant (45 kW_e) with use of co-substrates



Case study III: Farm with big (common) biogas plant (200 kW_e) with use of co-substrates



Conclusions

- **Use of non-waste substrates** significantly augments energy demand and global environmental impact of biogas production, but reduces GWP
- Without use of non-waste substrates:
  - Energy demand dominated by **transport distances** (substrates and digestates
  - GWP and Global environmental impact dominated by **storage of digestates**
  - The more co-substrates are used the **smaller the environmental impacts**
  - For the same amount of co-substrates:
    - Augmentation of size compensates augmentation of transport distances for GWP and Global environmental impact, but not for energy demand
- **Farm level**: Installation of biogas plant can significantly reduce energy demand and - to a smaller extent - also GWP on farm level.

Recommendations

- Treatment function important, avoid non-waste substrates
- Augmentation of the share of co-substrates to the maximum (50%) advantageous
- High transport distances worsen energy demand
- Size of a biogas installation has no important influence on environmental performance, except for very small installations (between 50 and 150 kW_e installed power)
- Size has to be adapted to the amount of co-substrates available within a reasonable distance

=> Optimal size of a biogas plant is the one which allows to optimize the share of co-substrates in the allowed radius of 50km around the installation without using non-waste substrates!

Thank you!

martina.alig@art.admin.ch
Phone +41 44 377 71 71

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