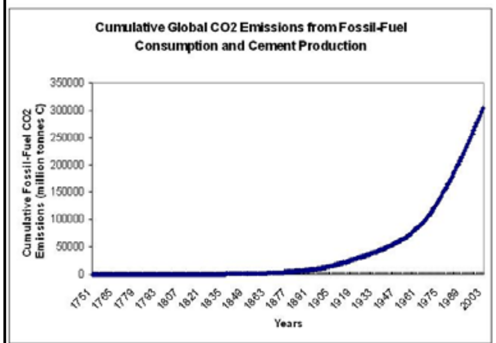
Energy & Nutrient Cycling

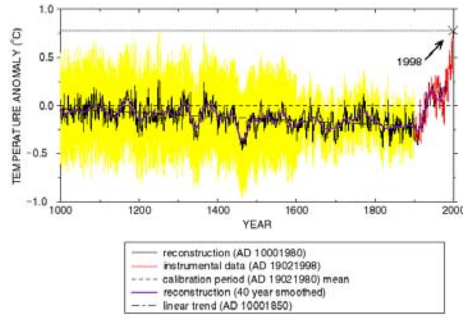
Manchester, 13-03-2014

Meers, E., Michels, E., Clymans, E., Declerq, L., Sigurnjak, I., Vaneeckhaute, C.,Vanrolleghem, P., Tack, F.M.G. & Buysse, J.

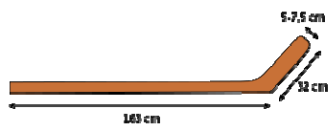
“Fossil Age”

The well known story…





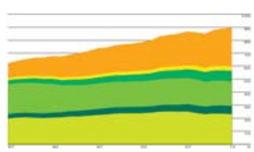
Bron: US Carbon Dioxide Information Analysis Center, Department of Energy



The well known story… part 2

BP Statistical Review
of World Energy
June 2013

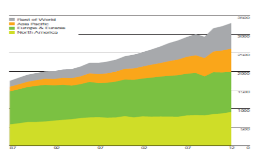
Oil



Annual consumption
+40% in 25 y

r/p = 52 y

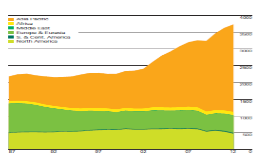
Gas



Annual consumption
+93% in 25 y

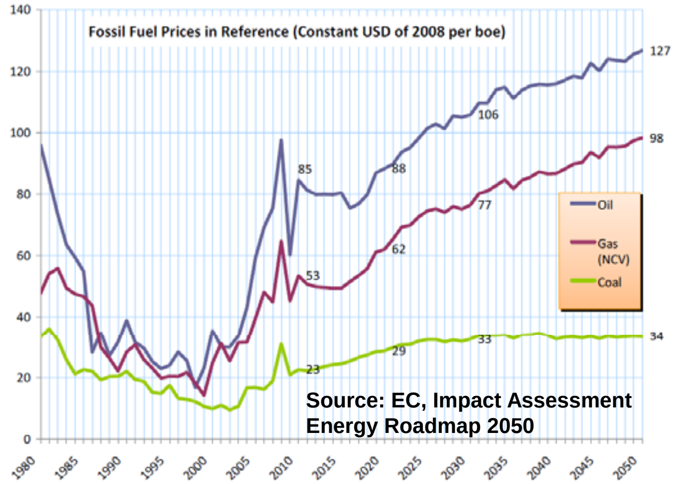
r/p = 56 y
(last year still 62-65y)

Coal



Annual consumption
+78% in 25y (+56% in last 10y)

r/p = 109 y
(last year 112y ; 4y ago 150y)



Proved reserves		r/p (y)
Coal	861 Billion ton	109 [1]
Gas	287 Trillion m3	55,7 [1]
Oil	236 Billion ton	52,9 [1]
Nuclear	19 Billion TOE	35-47 [2]

[1] BP Statistical Review of World Energy, 2013

[2] Bundesanstalt für Geowisenschaften und Rohstoffe, 2007

The LESS known story…

Marion King Hubbert
(1903 – 1989)

Shell	**1943-1964**
Prof. Berkeley & Stanford	**1963-1976**

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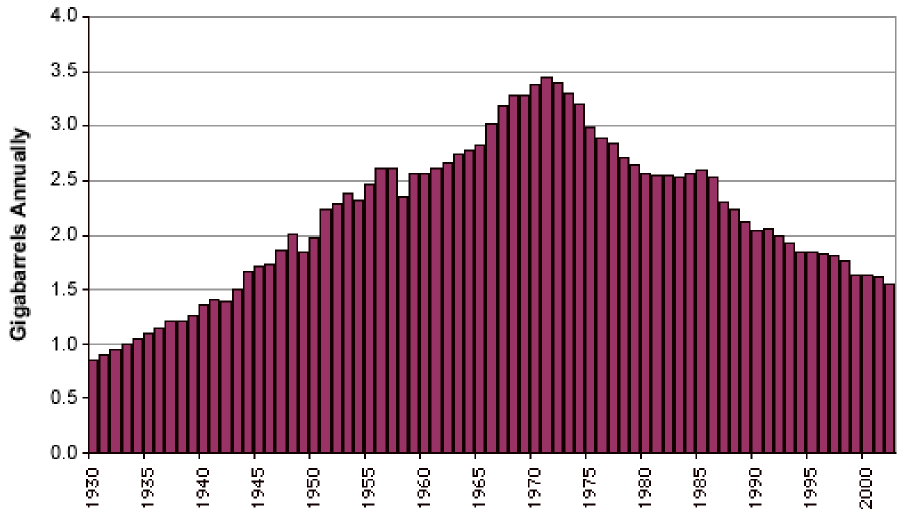
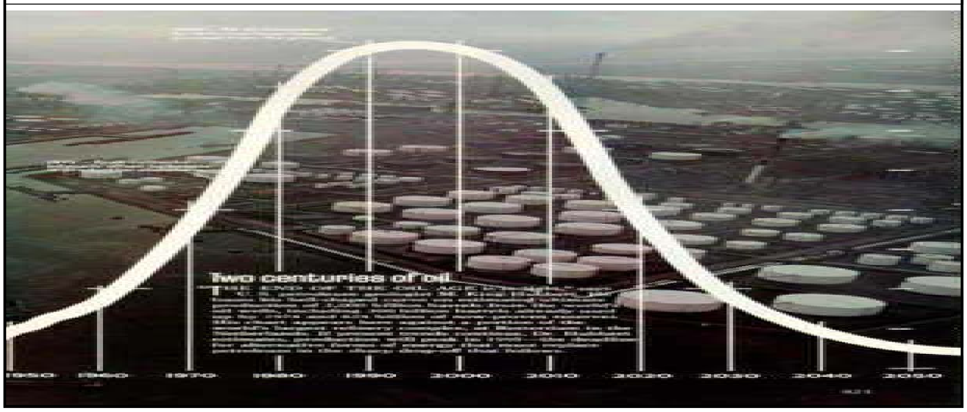
Biogas-E



Oil – the Dwindling treasure

National Geographic, Juni 1974

"'THE END OF THE OIL AGE is in sight,' says U.S. petroleum geologist M. King Hubbert.... If present trends continue, Dr. Hubbert estimates, production will peak in 1995 -- the deadline for alternative forms of energy that must replace petroleum in the sharp drop-off that follows."



The Hirsch Report

Peaking of World Oil Production: Impacts, Mitigation, & Risk Management

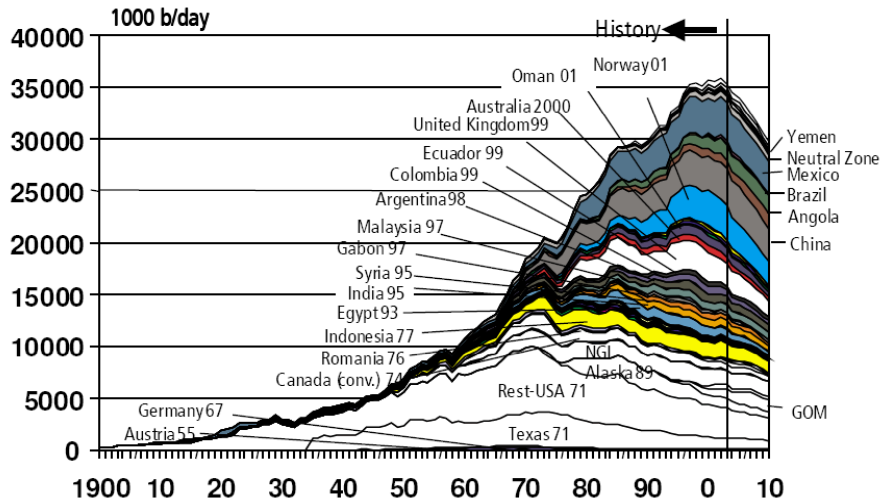
United States Department of Energy
(2005)

"The peaking of world oil production presents the U.S. and the world with an unprecedented risk management problem. As peaking is approached, liquid fuel prices and price volatility will increase dramatically, and, without timely mitigation, the economic, social, and political costs will be unprecedented.

Viable mitigation options exist on both the supply and demand sides, but to have substantial impact, they must be initiated more than a decade in advance of peaking."

Source: Hirsch Report, 2005

Observed production peaks in former Soviet Union & non-opec
US Government, 2004 predictions



Source: Industry database, 2003 (IHS 2003)
OGJ, 9 Feb 2004 (Jan-Nov 2003)

largest oilconcern in the world
ca. ¼ of world reserves

"[World] reserves are confused and in fact inflated.
Many of the so called reserves are in fact resources.
They're not delineated, they're not accessible, they're not available for production"

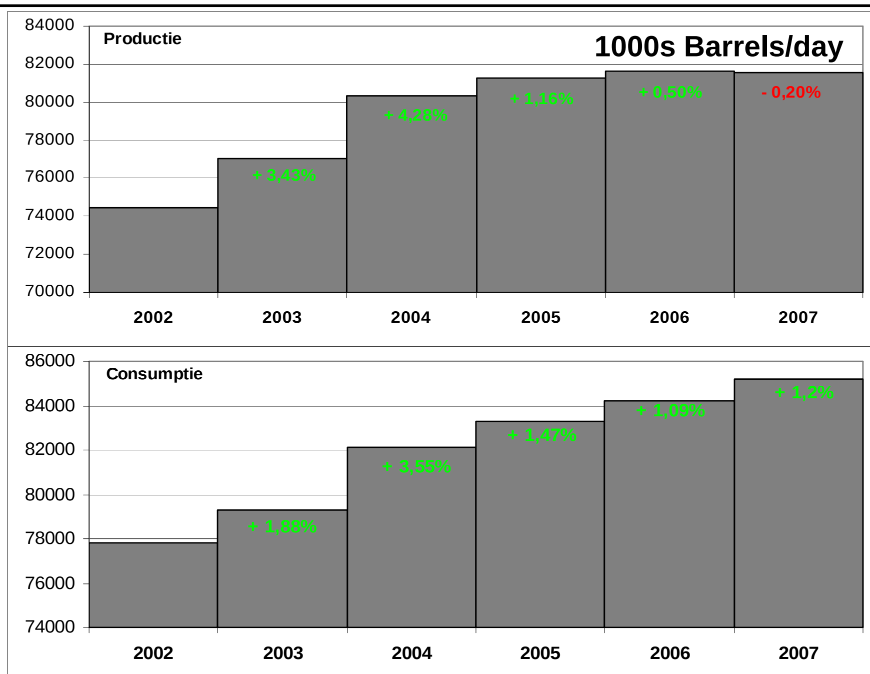
(October, 2007)

➔25% of reported reserves need to be reclassified to speculative resourcew

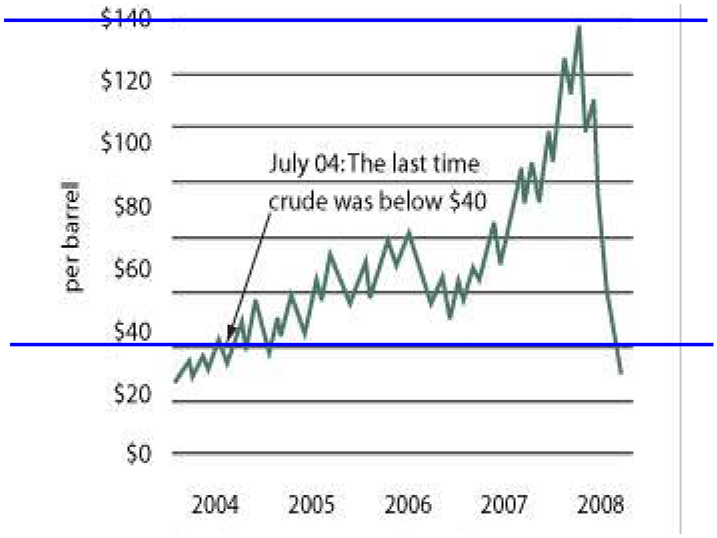
«*… under the current circumstances and outlook, oil is likely to peak at a 95 mmbd plateau by 2015 and can then be sustained well beyond 2020 at increasing real oil prices*."

Table I-1. Predictions of World Oil Production Peaking

Projected Date	Source of Projection
2006-2007	Bakhitari
2007-2009	Simmons
After 2007	Skrebowski
Before 2009	Deffeyes
Before 2010	Goodstein
Around 2010	Campbell
After 2010	World Energy Council
2010-2020	Laherrere
2016	EIA (Nominal)
After 2020	CERA
2025 or later	Shell
No visible Peak	Lynch



Bron: BP Statistical Review of World Energy June 2008



“Our ignorance is not so vast
as our failure to use what we know“

(Marion Hubbert)

Henry Ford
(1863 – 1947)

"Ethanol from biomass is the fuel of the future (1925)"

Rudolf Diesel
(1858 – 1913)

"Diesel demonstrated his engine at the Exhibition Fair in Paris, France in 1898. This engine stood as an example of Diesel's vision because it was fueled by peanut oil – the "original" biodiesel."

Robert Boyle

(1627 – 1691)

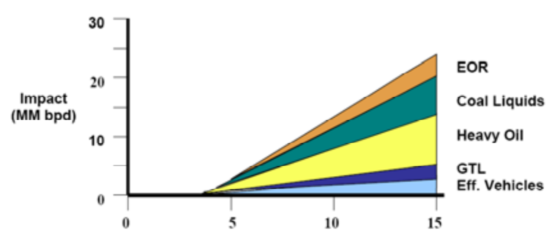
1808 Sir Humphry Davy
1859 First digester (India, leper colony)
1895 First digester in Europe (UK, gas for streetlighting)
1940-1945 France & Germany produce biogas from manure

Reduce CO_2 emissions by 20%

20% of energy consumption based on renewables

Reduce energy consumption by 20%

versus

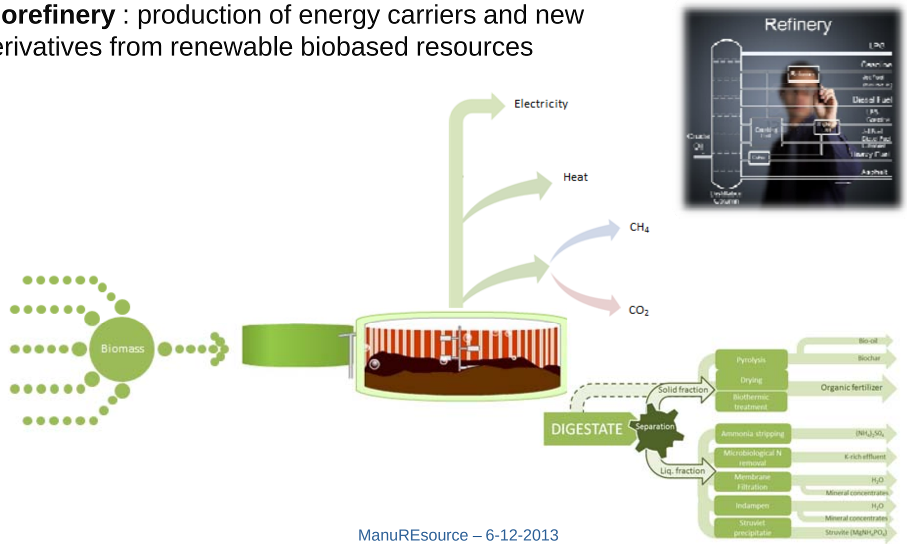


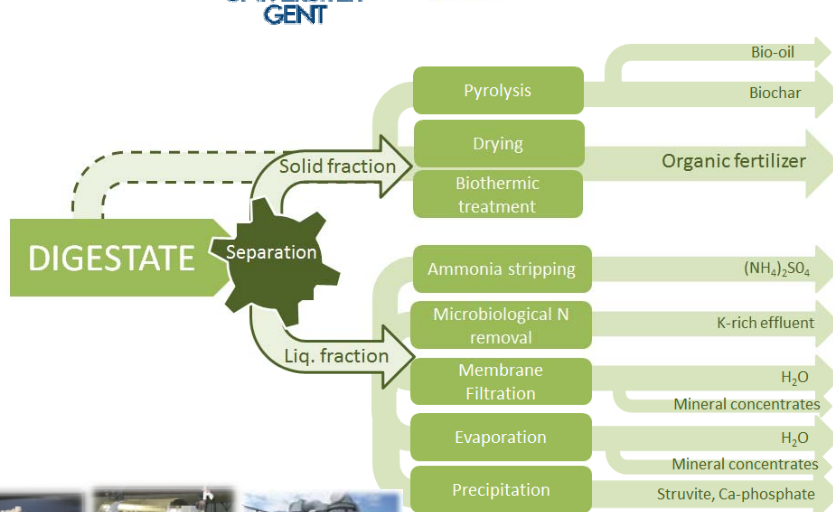
“From Bioenergy plants to Biorefineries”

Challenges (1)

- Investing in added values of bio-energy production facilities
- Sourcing sustainable biomass
- Quality assurance of biobased new products
- Discovering new synergies

Biorefinery : production of energy carriers and new derivatives from renewable biobased resources

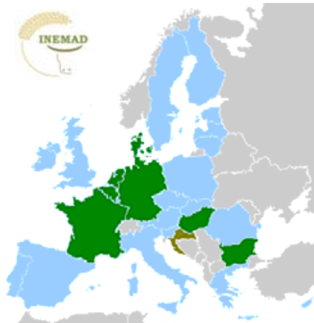




Stimulating bio-energy in NW Europe

www.arbornwe.eu

Reconnecting livestock & crop production



www.inemad.eu

Refining inorganic chemicals from waste(water) from agro & food

www.biorefine.eu

Refining inorganic chemicals from waste(water)from agro & food

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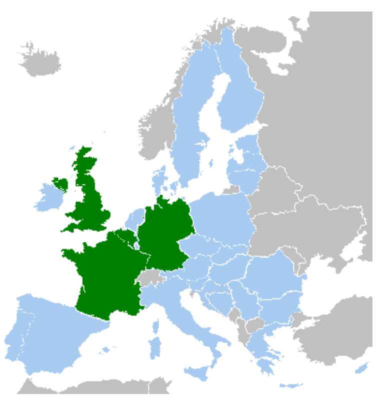

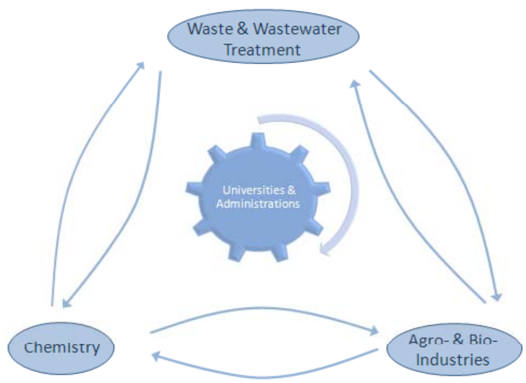

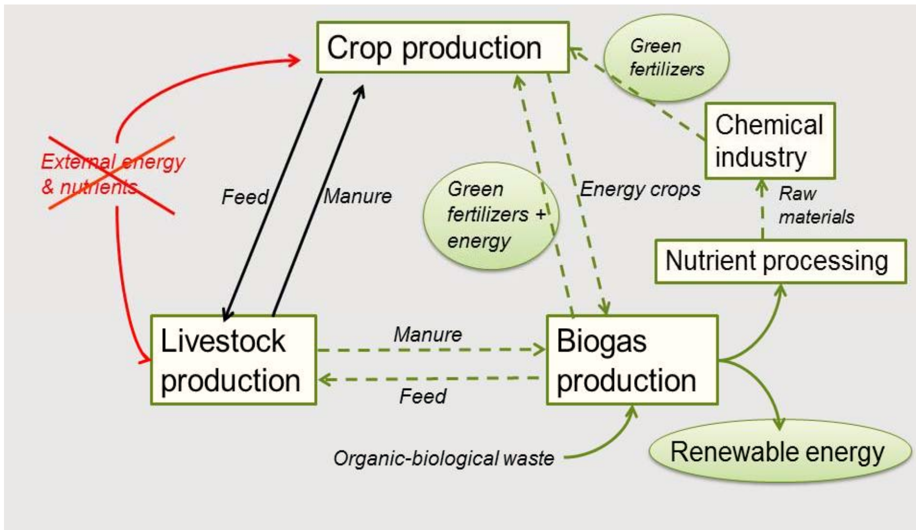

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Faculty of Bioscience Engineering

Full scale agronomic validation





Greenhouse trial (UGent – PCG)

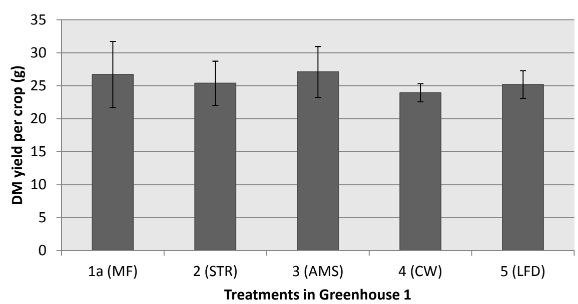
Struvite

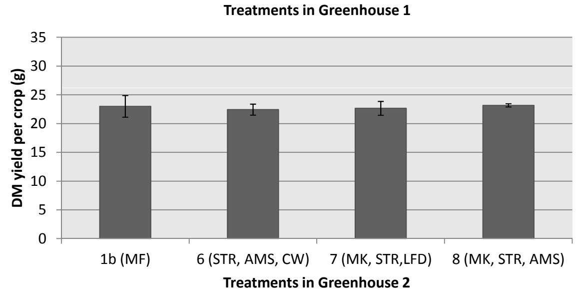
LF of digestate

CW effluent

Ammonium sulfate

Fertilizers	DM (%)	Total N (g/kg FW)	Total P_2O_5 (g/kg FW)	Total K_2O (g/kg FW)	pH	EC (mS/cm)	
Struvite	92	51	212	11	7,6	0,95	*P -fertilizer*
LF of digestate	3,5	5,3	0,86	4,4	8,7	48	*NK -fertilizer*
CW effluent	0,5	0,02	0,004	1,5	8,1	9	*K -fertilizer*
Ammoniumsulfate	33	86	0,11	0,18	2,3	291	*N -fertilizer*





MF = mineral fertilizers

STR = struvite

AMS = ammonium sulfate

CW = effluent from constructed wetlands

LFD = liquid fraction of digestate

MK = mineral potassium (patentkali)

Results: crop quality assessment

Quality parameters:

- **uniformity, volume, color**
- **weight, tipburn, basal rot, yellow leaves, bremia, crop filling and crop closure**

Results: lettuce nutrient uptake

Physico-chemical assessment:

- **Fresh weight, Dry weight, *Total NPKS, Cu and Zn***

	Objects	Total N (g/kg DW)	Total P (g/kg DW)	Total K (g/kg DW)	Total S (g/kg DW)	Cu (mg/kg DW)	Zn (mg/kg DW)
1a	MF	45 ± 1	3,72 ± 0,17	52 ± 7	3,10 ± 0,28	7,55 ± 1,63	72 ± 12
2	STR	43 ± 3	4,03 ± 0,25	51 ± 4	2,98 ± 0,33	7,57 ± 0,91	69 ± 10
3	AMS	43 ± 2	4,12 ± 0,56	56 ± 5	3,31 ± 0,33	7,03 ± 0,93	80 ± 12
4	CW	43 ± 1	3,93 ± 0,18	57 ± 8	3,15 ± 0,04	8,05 ± 0,90	86 ± 9
5	LFD	41 ± 1	4,14 ± 0,52	44 ± 9	3,13 ± 0,38	8,34 ± 2,28	76 ± 22
1b	MF	45 ± 2	3,53 ± 0,32	66 ± 10	3,18 ± 0,30	7,71 ± 0,61	60 ± 4
6	STR, AMS,CW	41 ± 3	3,61 ± 0,13	68 ± 4	3,34 ± 0,10	7,50 ± 1,78	62 ± 9
7	MK,STR,LFD	44 ± 3	3,51 ± 0,20	72 ± 4	3,27 ± 0,23	6,77 ± 1,20	67 ± 9
8	MK,STR,AMS	44 ± 5	3,61 ± 0,40	62 ± 5	3,20 ± 0,20	6,65 ± 0,99	63 ± 7

MF = mineral fertilizers
AMS = ammonium sulfate
LFD = liquid fraction of digestate
STR = struvite
CW = effluent from constructed wetlands
MK = mineral potassium (patentkali)

Results: lettuce nutrient uptake

***Physico-chemical assessment*:**

- **Fresh weight, Dry weight, *Total NPKS, Cu and Zn***

Objects	Total N (g/kg DW)	Total P (g/kg DW)	Total K (g/kg DW)	Total S (g/kg DW)	Cu (mg/kg DW)	Zn (mg/kg DW)
Range in reference (MF)	***4.5%***	***0.35 – 0.37 (%)***	***5.2 – 6.6 (%)***	***0.31 – 0.32 (%)***	***7.5 – 7.7 (mg/kg)***	***60 – 72 (mg/kg)***
Normal range*	3.1 – 4.5 (%)	0.35 – 0.60 (%)	4.5 – 8.0 (%)	0.20 – 0.30 (%)	7 – 80 (mg/kg)	25 – 250 (mg/kg)
Range in objects	3.8 – 4.5 (%)	0.35 – 0.41 (%)	4.4 – 7.2 (%)	0.29 – 0.33 (%)	7.0 – 8.3 (mg/kg)	55 – 86 (mg/kg)
1b MF	45 ± 2	3,53 ± 0,32	66 ± 10	3,18 ± 0,30	7,71 ± 0,61	60 ± 4
6 STR, AMS,CW	41 ± 3	3,61 ± 0,13	68 ± 4	3,34 ± 0,10	7,50 ± 1,78	62 ± 9
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8 MK,STR,AMS	44 ± 5	3,61 ± 0,40	62 ± 5	3,20 ± 0,20	6,65 ± 0,99	63 ± 7

**** Reference: R J Hill Laboratories Ltd. Crop guide – Glasshouse lettuce.***

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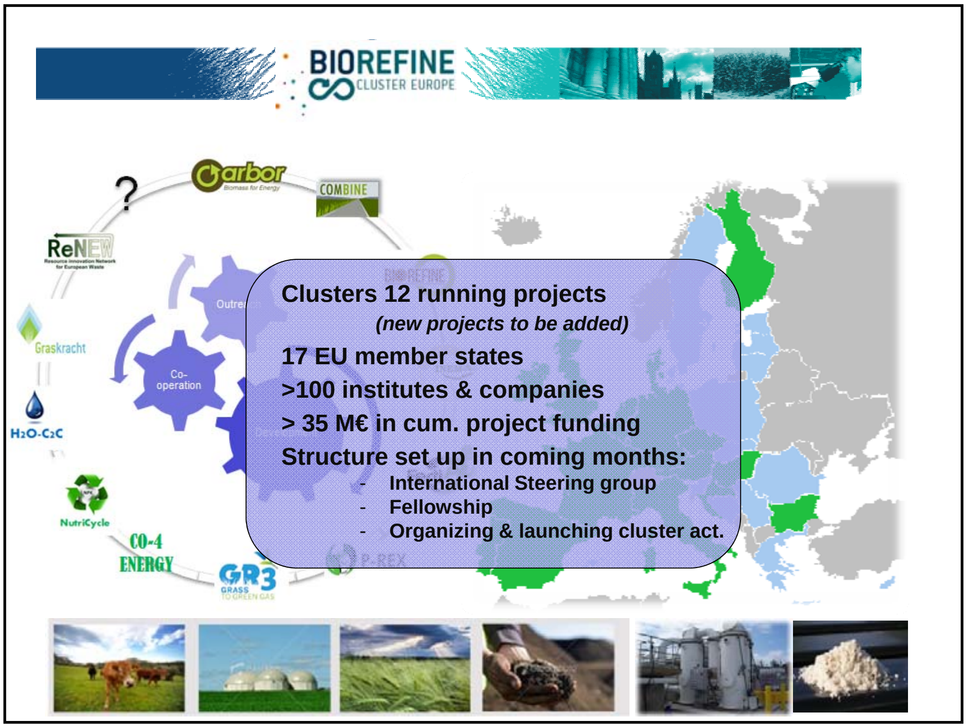
FACULTEIT BIO-INGENIEURSWETENSCHAPPEN

Challenges (2)

- Interlinkeage between projects (defragmentation)
- Project after-life
- Technology development to business implementation
- Triple helix approach to stakeholder interaction


ReNEW
Resource innovation Network for European Waste
COMBINE
arbor
Biomass for Energy
P-REX
INEMAD
GR3
GRASS TO GREEN GAS
H2O-C2C
CO-4 ENERGY
NutriCycle
BIOREFINE
FertiPlus
Graskracht


BIOREFINE
CLUSTER EUROPE
?
arbor
Biomass for Energy
COMBINE
ReNEW
Resource innovation Network for European Waste
BIOREFINE
Graskracht
Outreach
Co-operation
Development
INEMAD
H2O-C2C
FertiPlus
NutriCycle
CO-4 ENERGY
GR3
GRASS TO GREEN GAS
P-REX


BIOREFINE
CLUSTER EUROPE
Clusters 12 running projects
(new projects to be added)
17 EU member states
>100 institutes & companies
> 35 M€ in cum. project funding
Structure set up in coming months:
- International Steering group
- Fellowship
- Organizing & launching cluster act.
arbor
COMBINE
ReNEW
Graskracht
H2O-C2C
NutriCycle
CO-4 ENERGY
GR3
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Co-operation


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