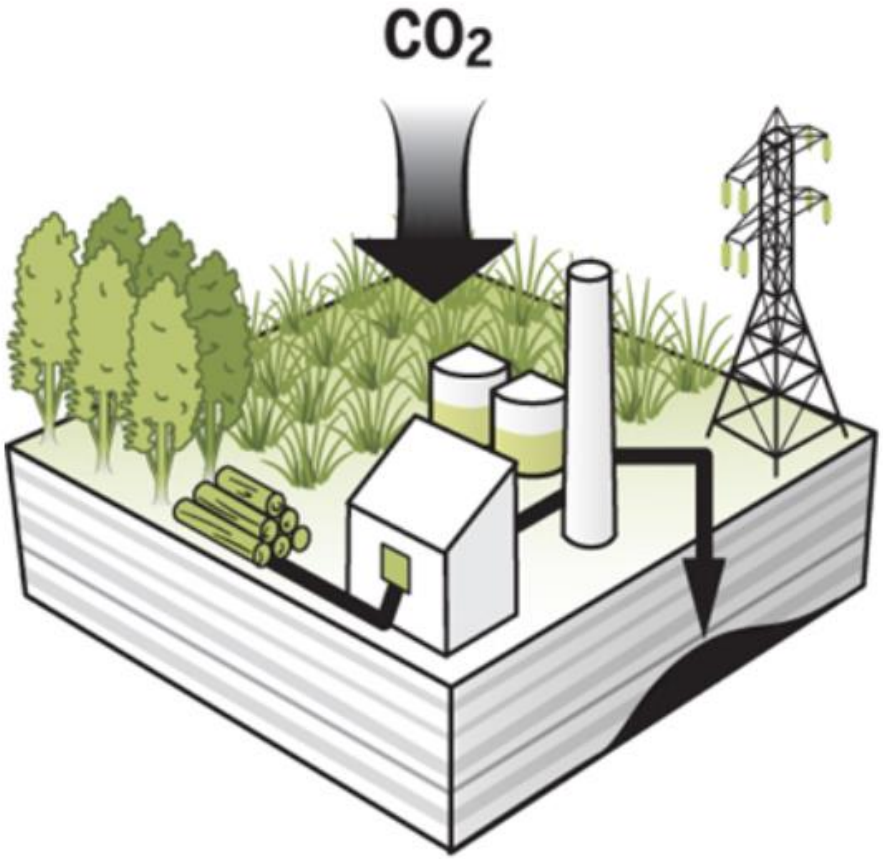
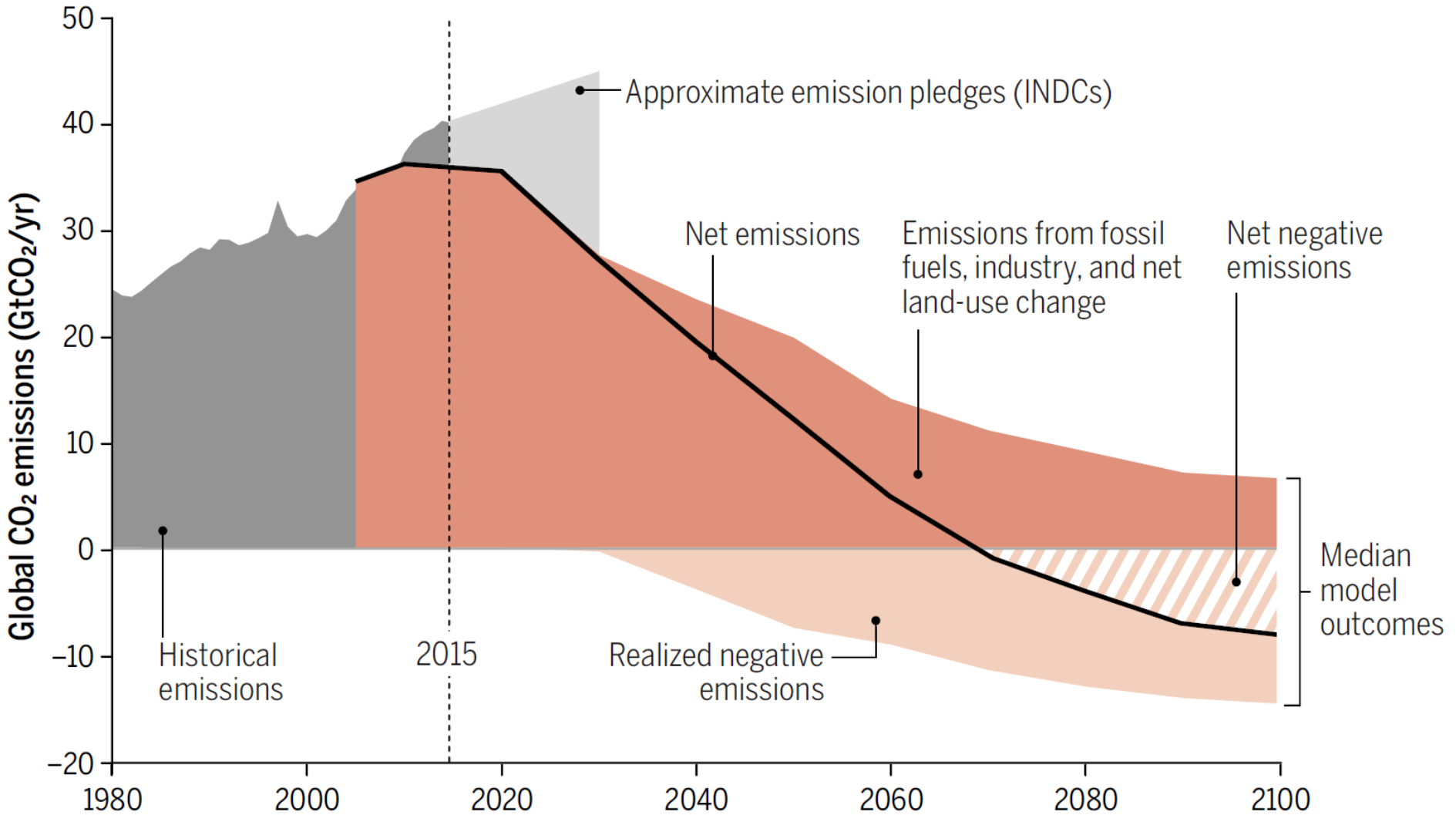


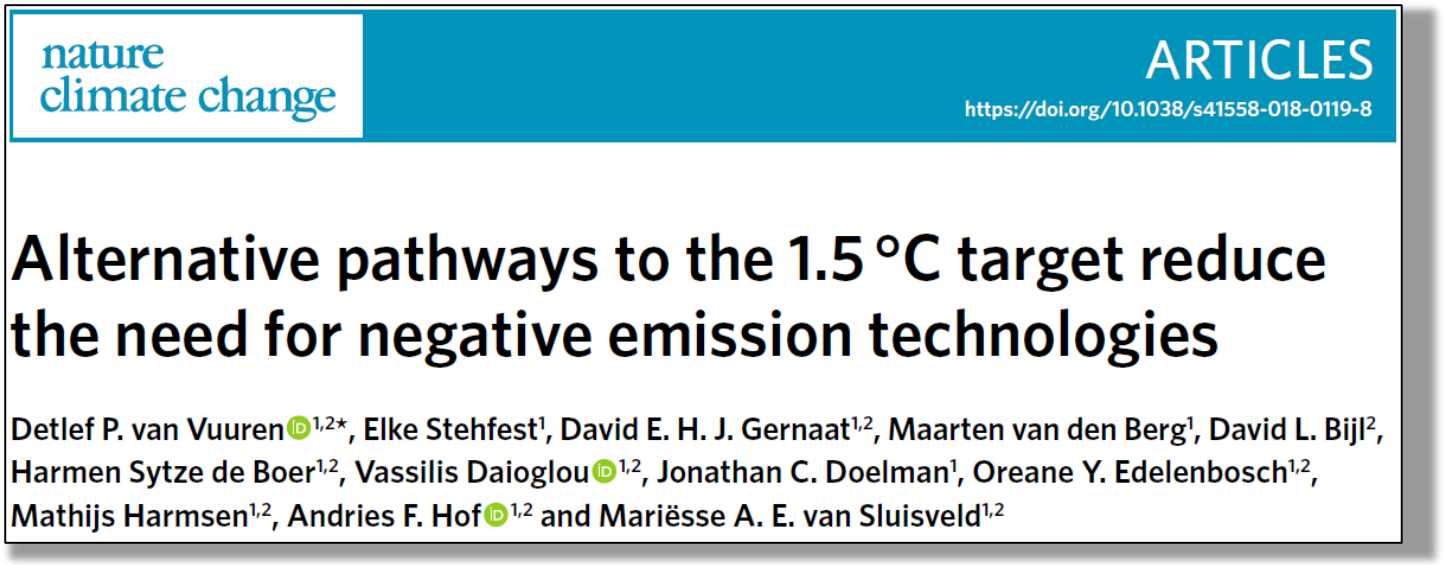
Planbureau voor de Leefomgeving

Negative Emissions in the context of the energy transition in the Netherlands

www.pbl.nl

June 7, 2018 | Bart Strengers
bart.strengers@pbl.nl


Global CO_2 emissions ($GtCO_2$/yr)
50
40
30
20
10
0
−10
−20
1980
2000
2020
2040
2060
2080
2100
Approximate emission pledges (INDCs)
Net emissions
Emissions from fossil fuels, industry, and net land-use change
Net negative emissions
Median model outcomes
Historical emissions
2015
Realized negative emissions



nature climate change

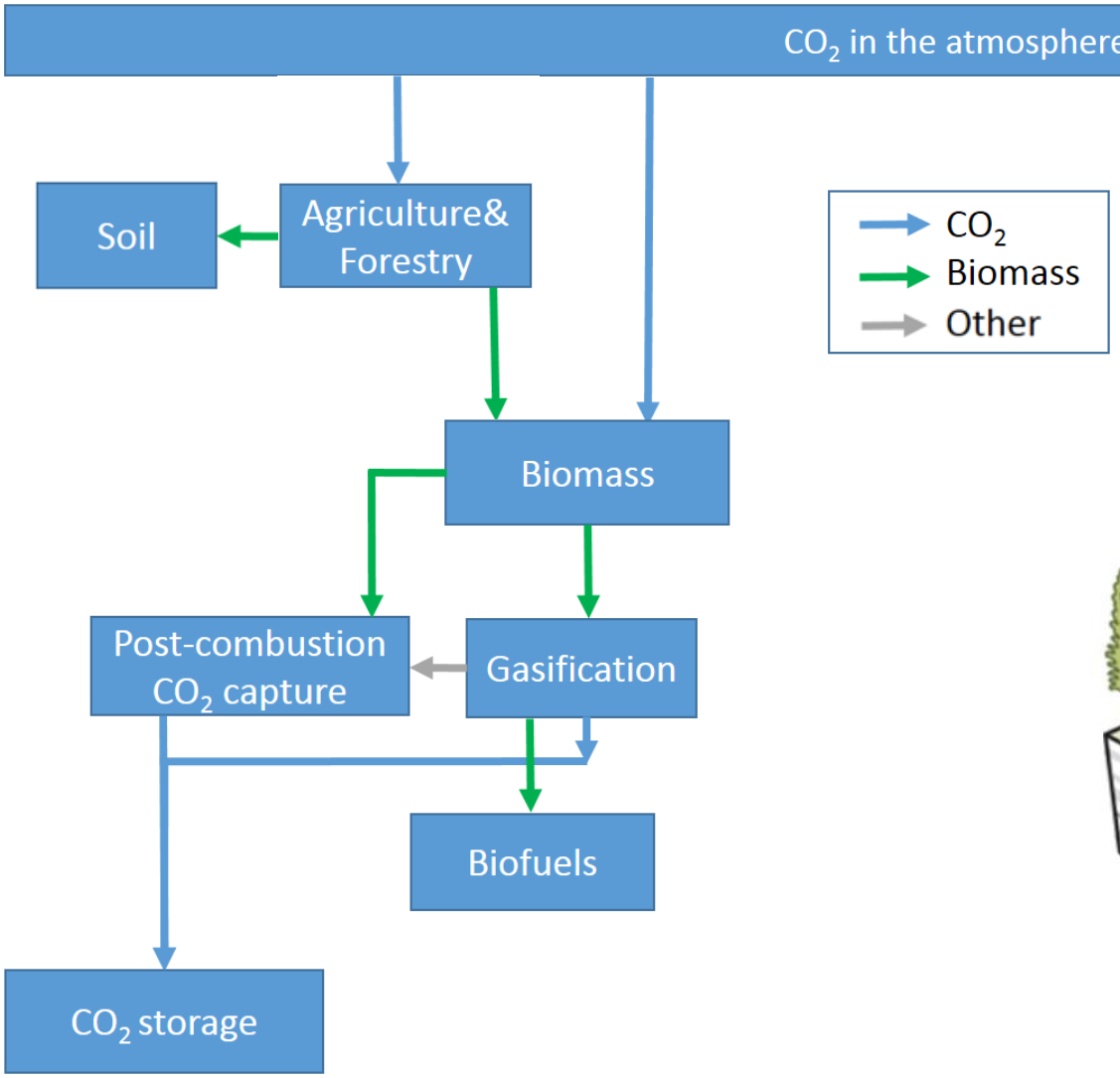
ARTICLES

https://doi.org/10.1038/s41558-018-0119-8

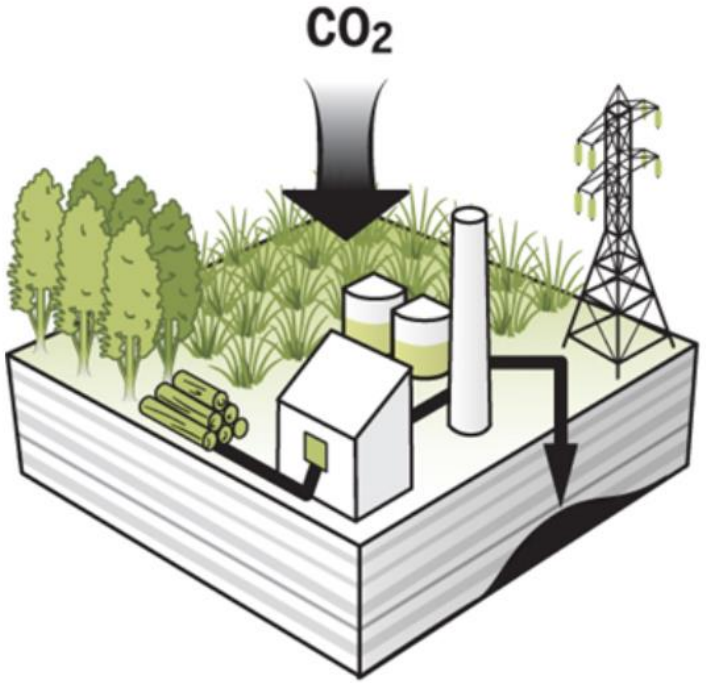
Alternative pathways to the 1.5 °C target reduce the need for negative emission technologies

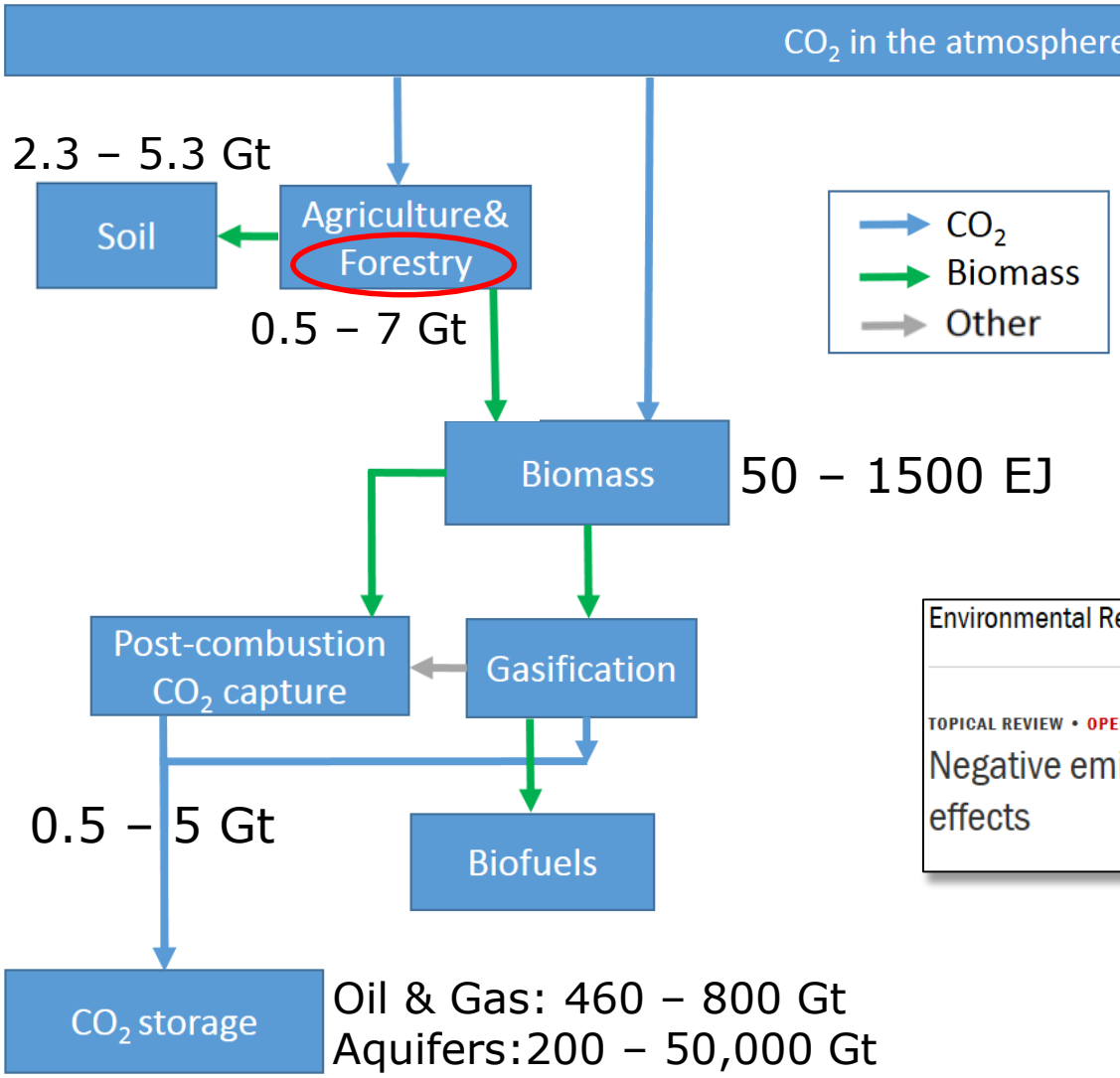
Detlef P. van Vuuren[1,2*], Elke Stehfest[1], David E. H. J. Gernaat[1,2], Maarten van den Berg[1], David L. Bijl[2], Harmen Sytze de Boer[1,2], Vassilis Daioglou[1,2], Jonathan C. Doelman[1], Oreane Y. Edelenbosch[1,2], Mathijs Harmsen[1,2], Andries F. Hof[1,2] and Mariësse A. E. van Sluisveld[1,2]

- High agricultural yields and application of intensified animal husbandry globally
- reducing non-CO_2 emissions and full adoption of cultured meat in 2050
- Lifestyle change! (meat, transport, heating&cooling)
- Low population growth



Global NETs mainly BECCS, AR & SCS





Global NETs mainly BECCS, AR & SCS

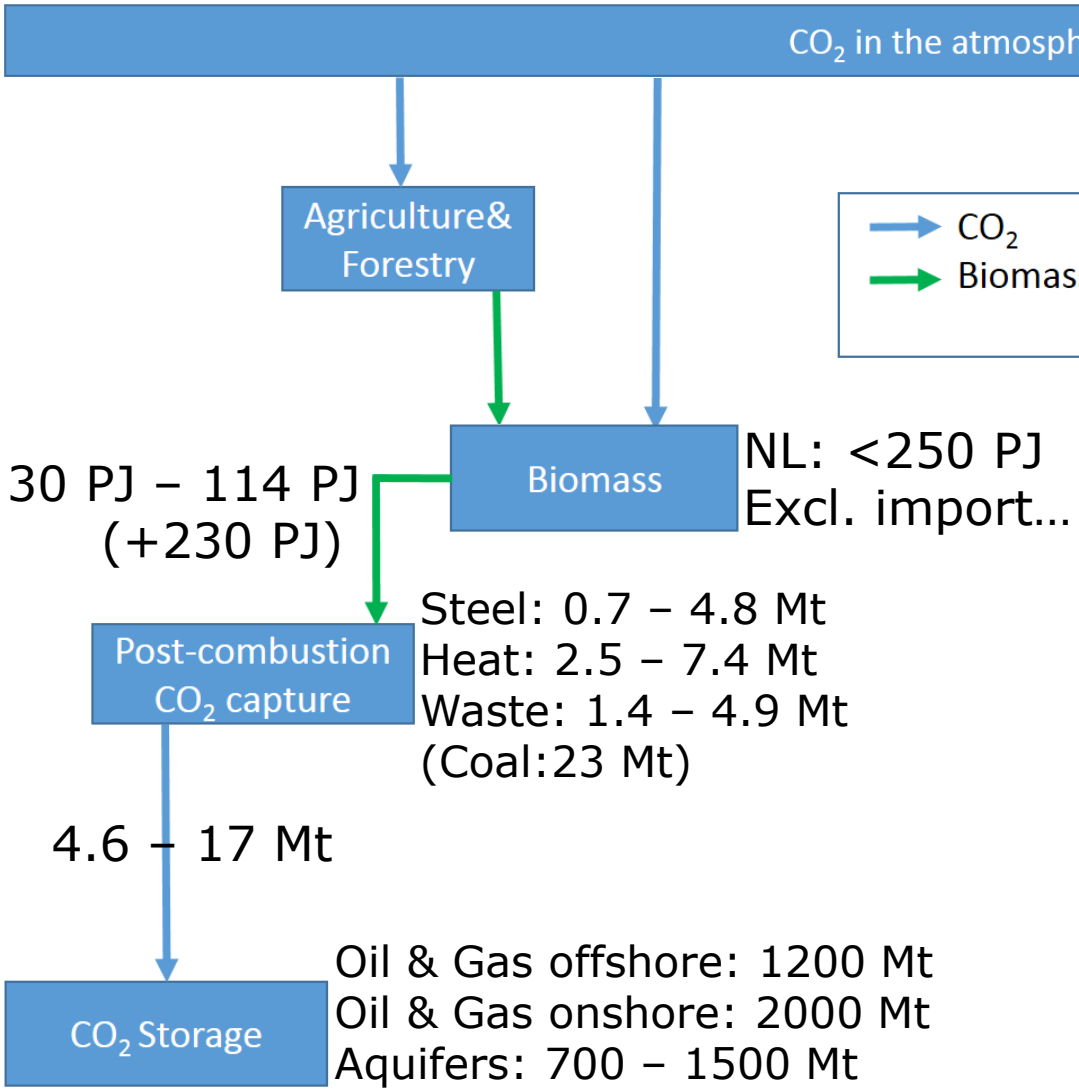
Environmental Research Letters

TOPICAL REVIEW • OPEN ACCESS

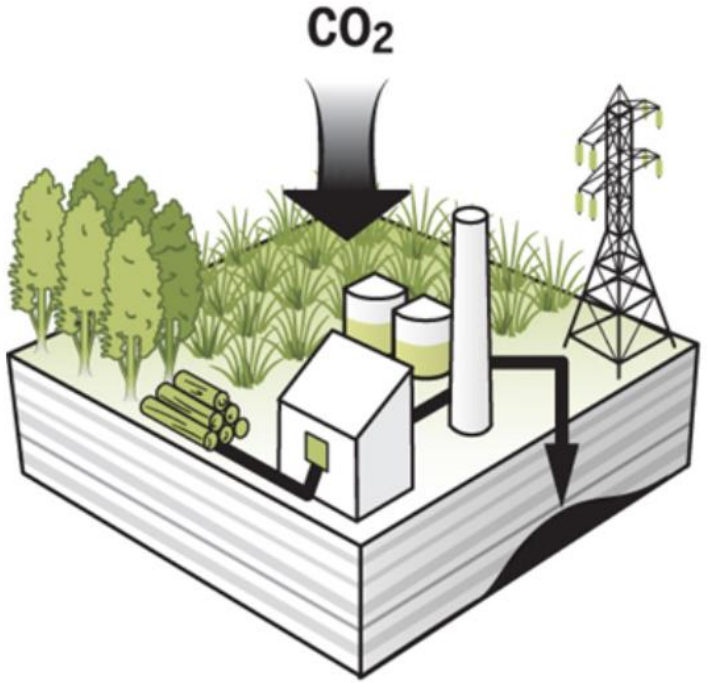
Negative emissions—Part 2: Costs, potentials and side effects

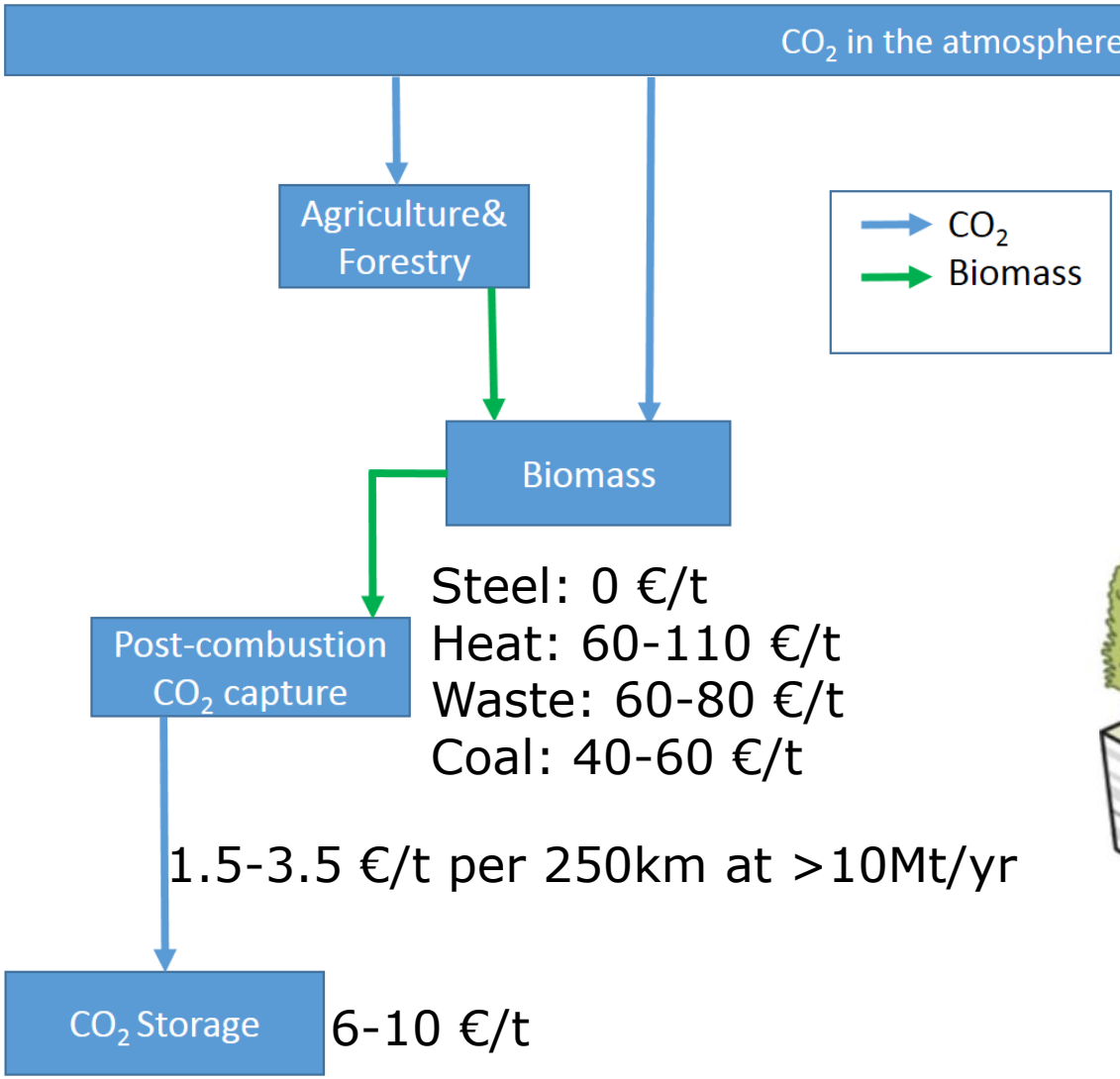
Potential and costs of NETs in the Netherlands

- First order estimate of technical end 'realistic' potential of NETs in 2030 and 2050
- Sources: literature, reports, experts, internet, own estimates
- Mainly based on *current* activity levels and roadmaps if available, so it is *not* a scenario-study
- *Additional* costs only

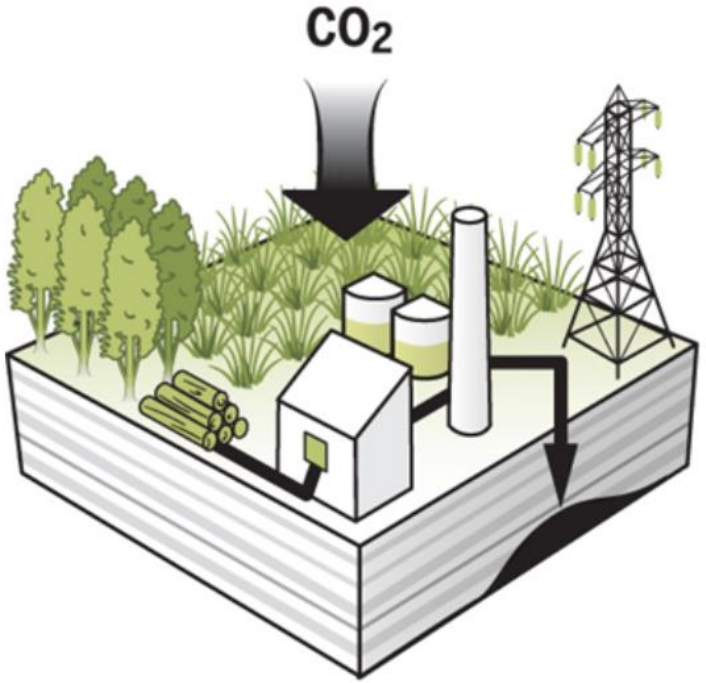


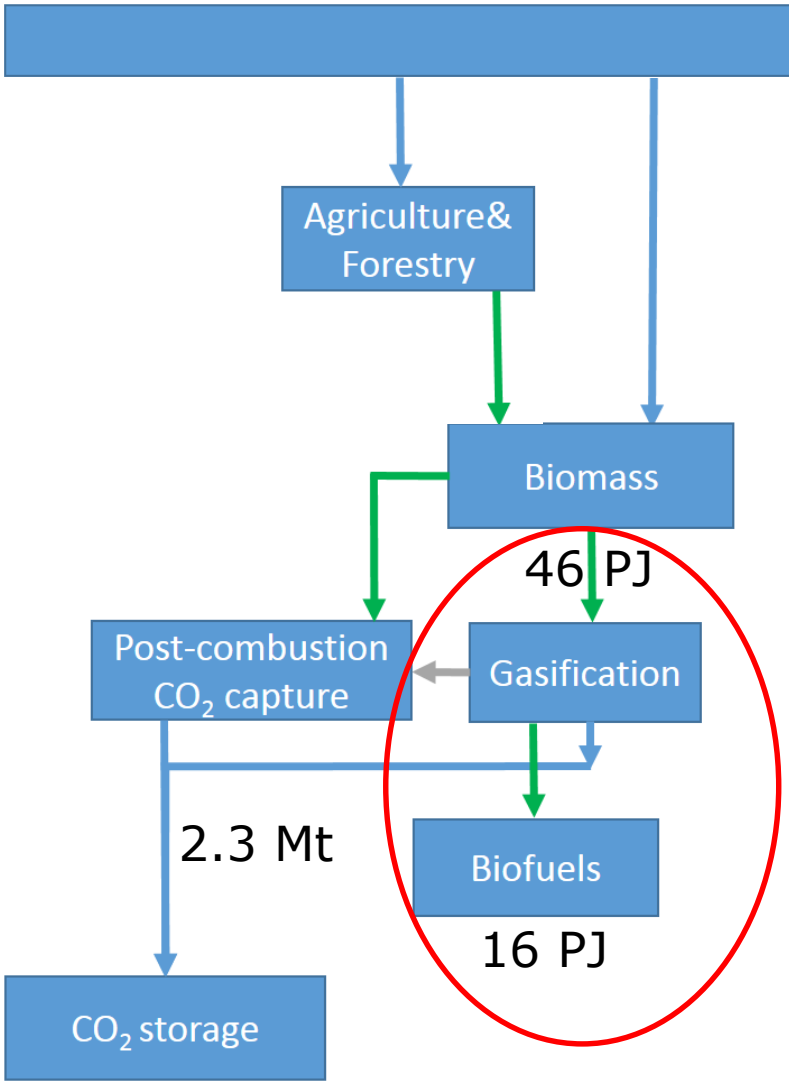
BECCS (Post-combustion)

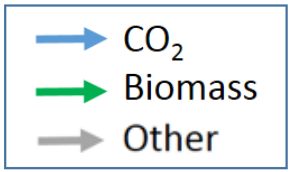




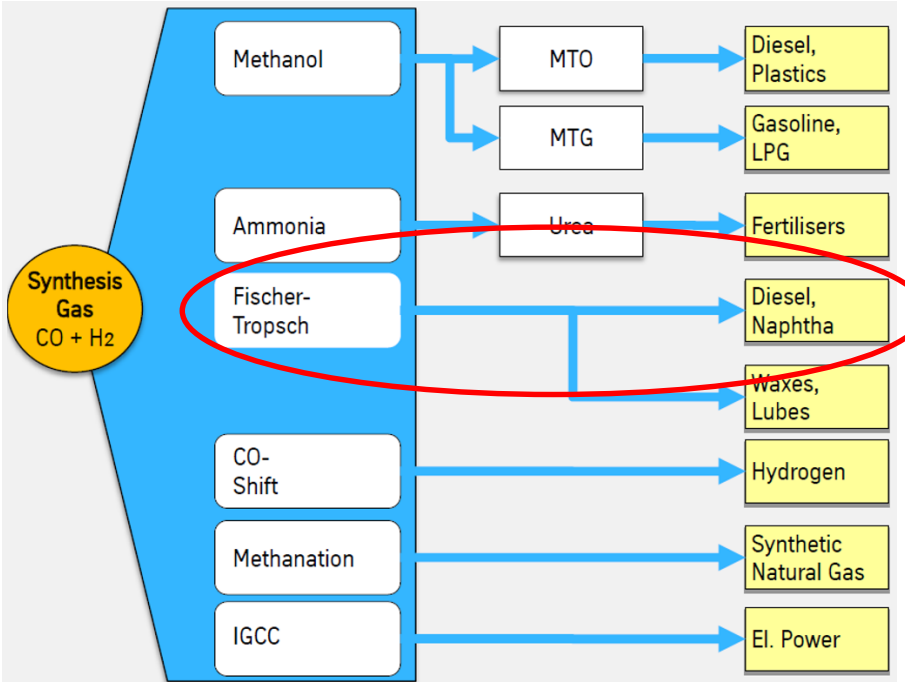
BECCS Costs (Post-combustion)



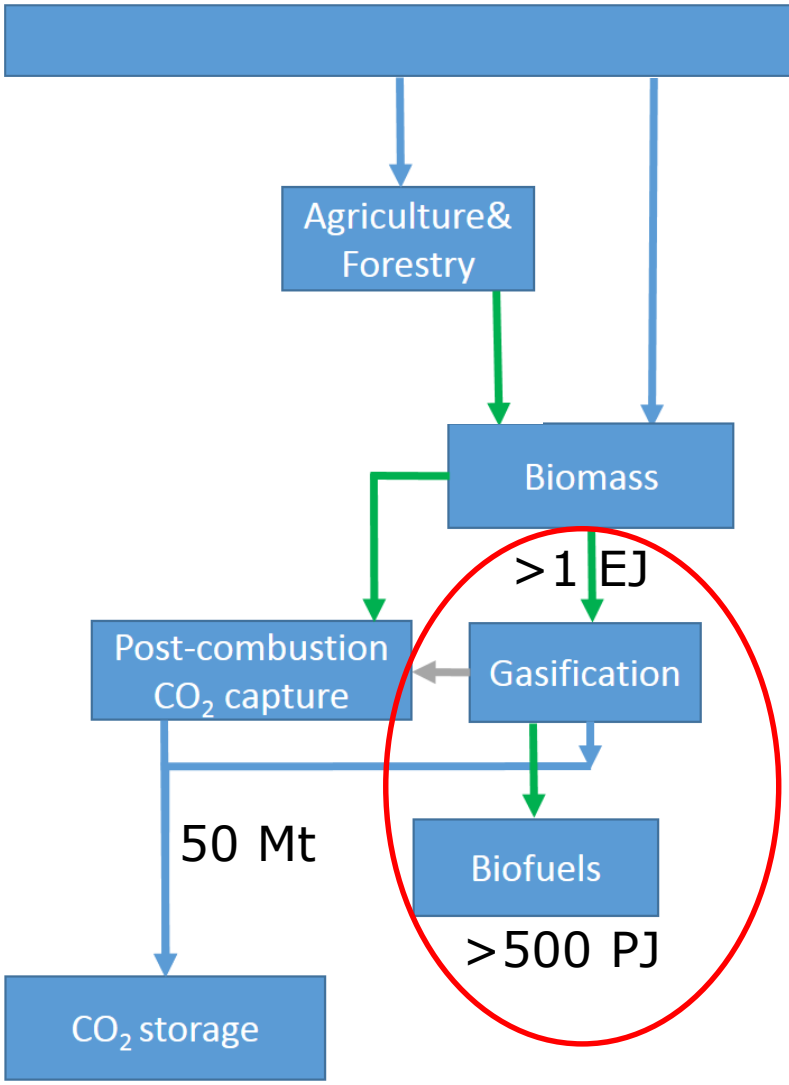


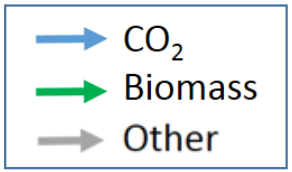


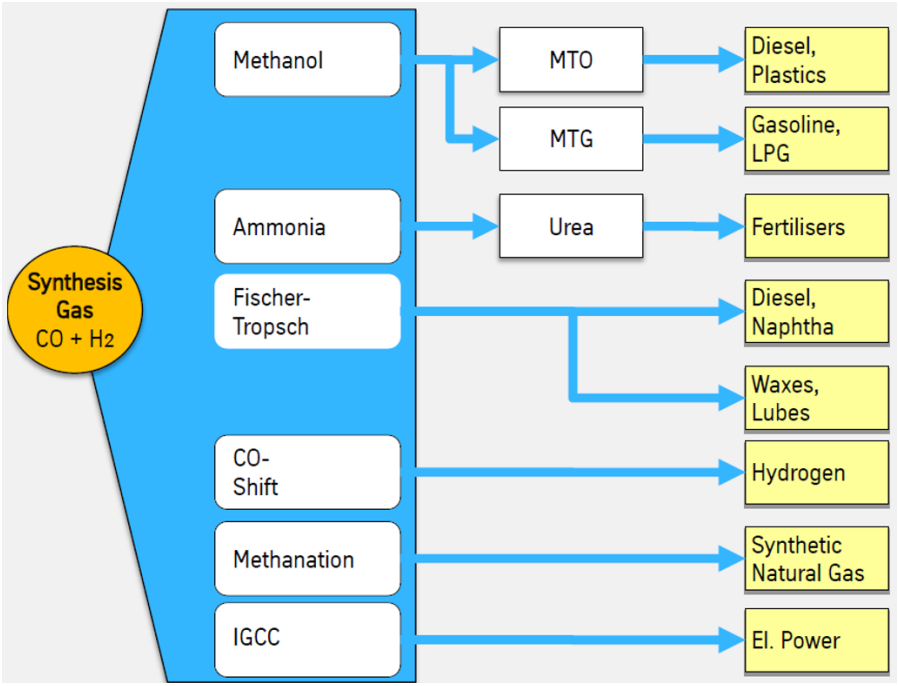
BECCS (Pre-combustion)



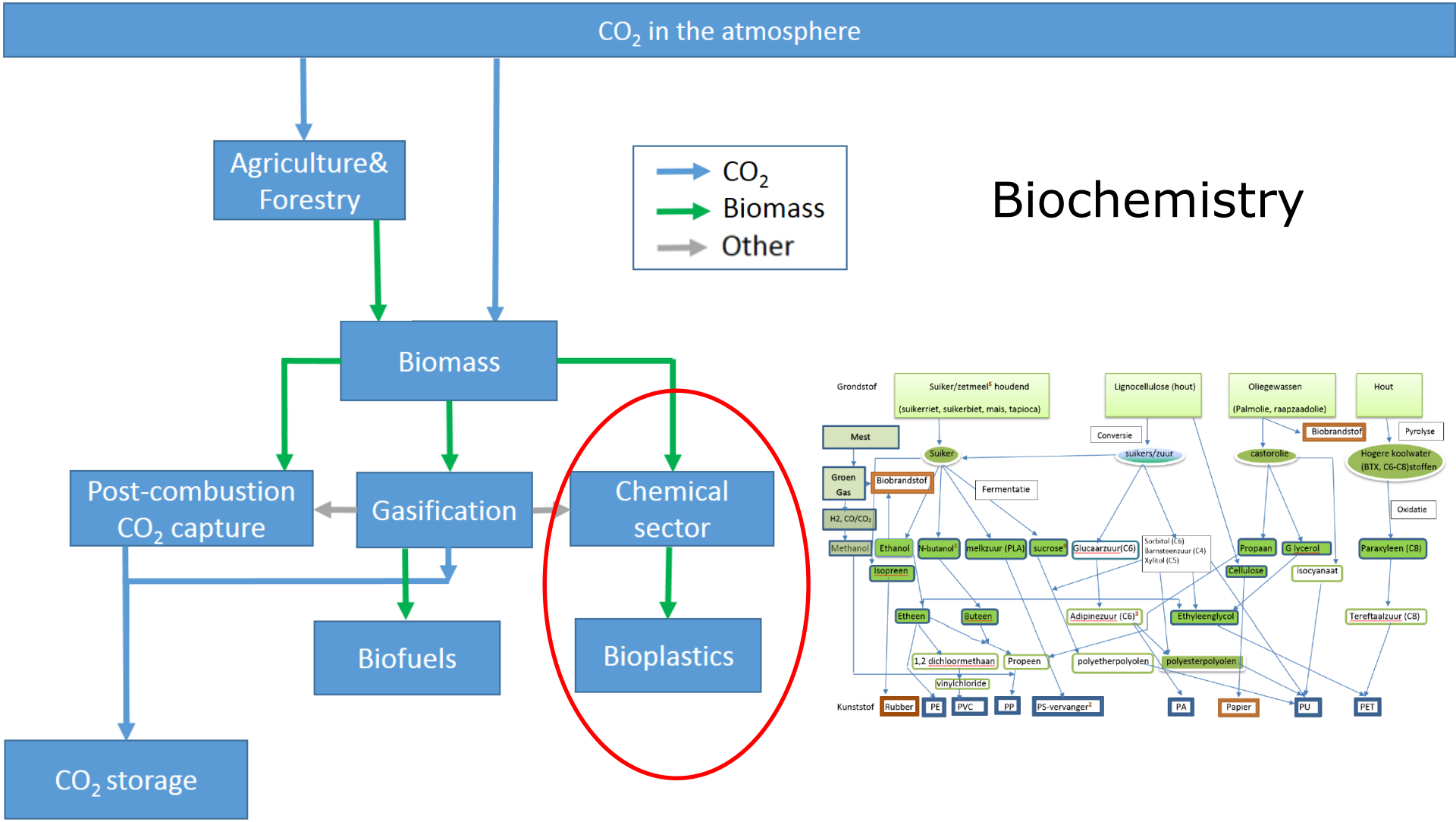
BECCS (Pre-combustion)

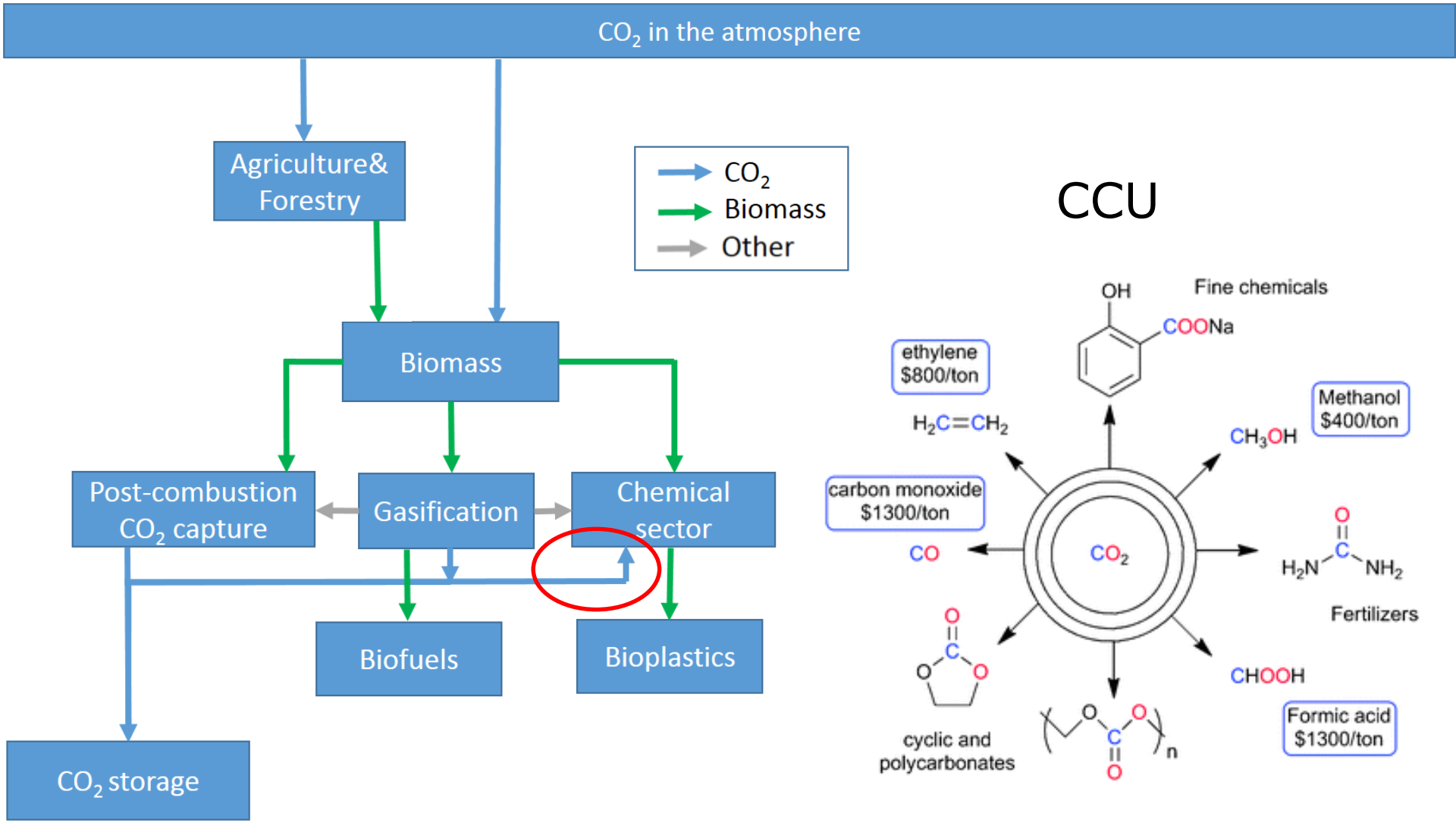




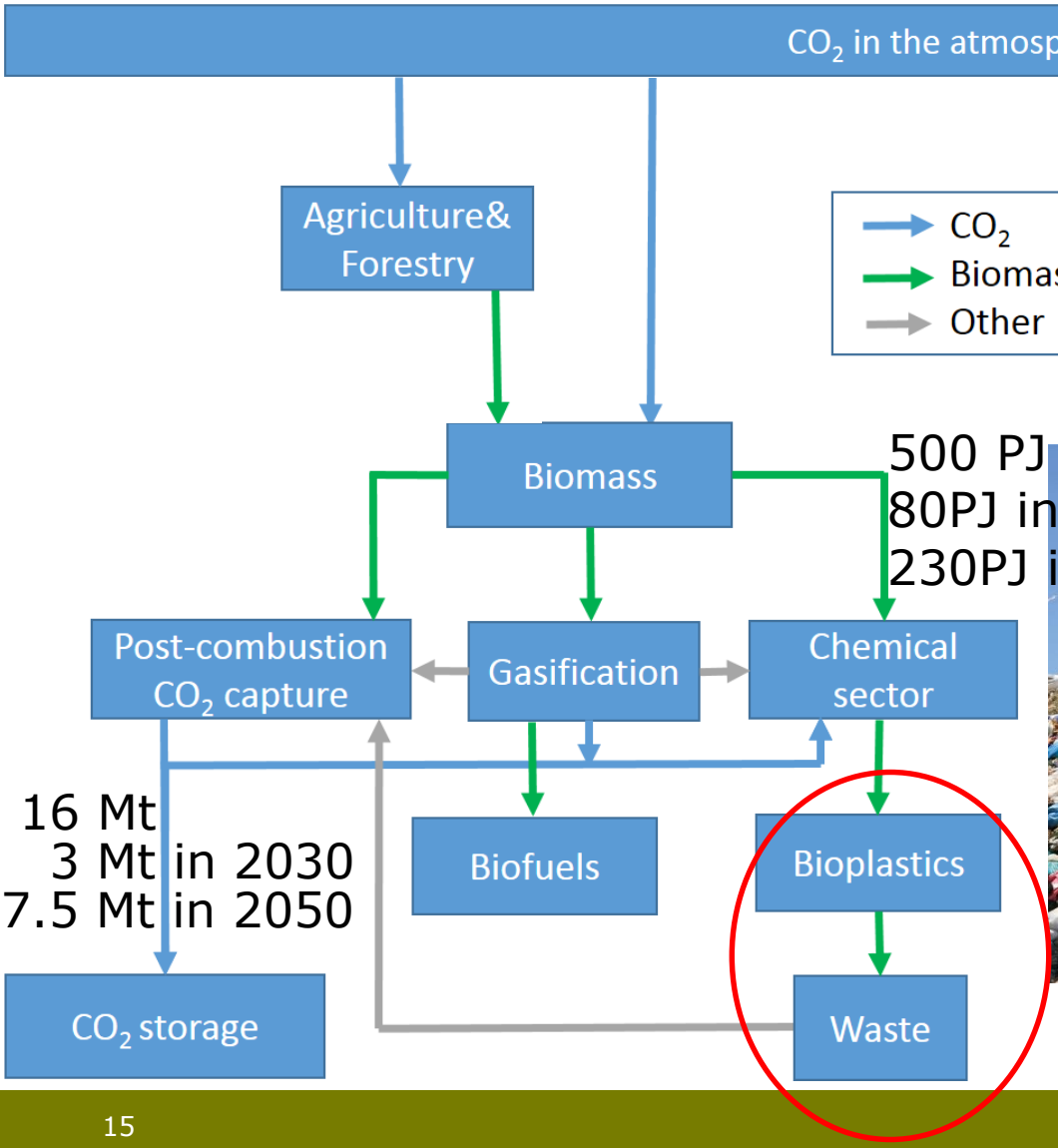


Biochemistry




CO_2 in the atmosphere
Agriculture& Forestry
CO_2
Biomass
Other
Biomass
Post-combustion CO_2 capture
Gasification
Chemical sector
Biofuels
Bioplastics
CO_2 storage
CCU
Fine chemicals
OH
COONa
ethylene $800/ton
$H_2C=CH_2$
Methanol $400/ton
CH_3OH
carbon monoxide $1300/ton
CO
CO_2
H_2N NH_2
Fertilizers
CHOOH
Formic acid $1300/ton
cyclic and polycarbonates
n

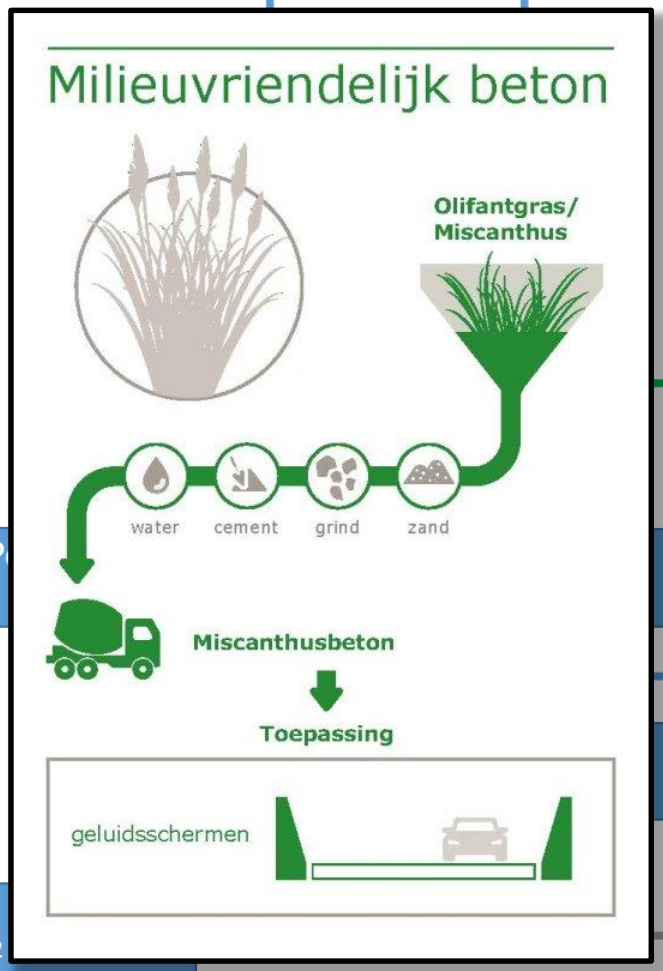
Waste incineration with CCS



CO_2 in the atmosphere
CO_2
Biomass
Other
Construction
2.8 -5.5 PJ
Chemical sector
Construction
Bioplastics
0.3 - 0.6 Mton
Waste
Buildings

Biobased concrete

CO_2 in the atmosphere



CO_2
Biomass
Other

90 PJ

Chemical sector

Construc-tion

Concrete

Bioplastics

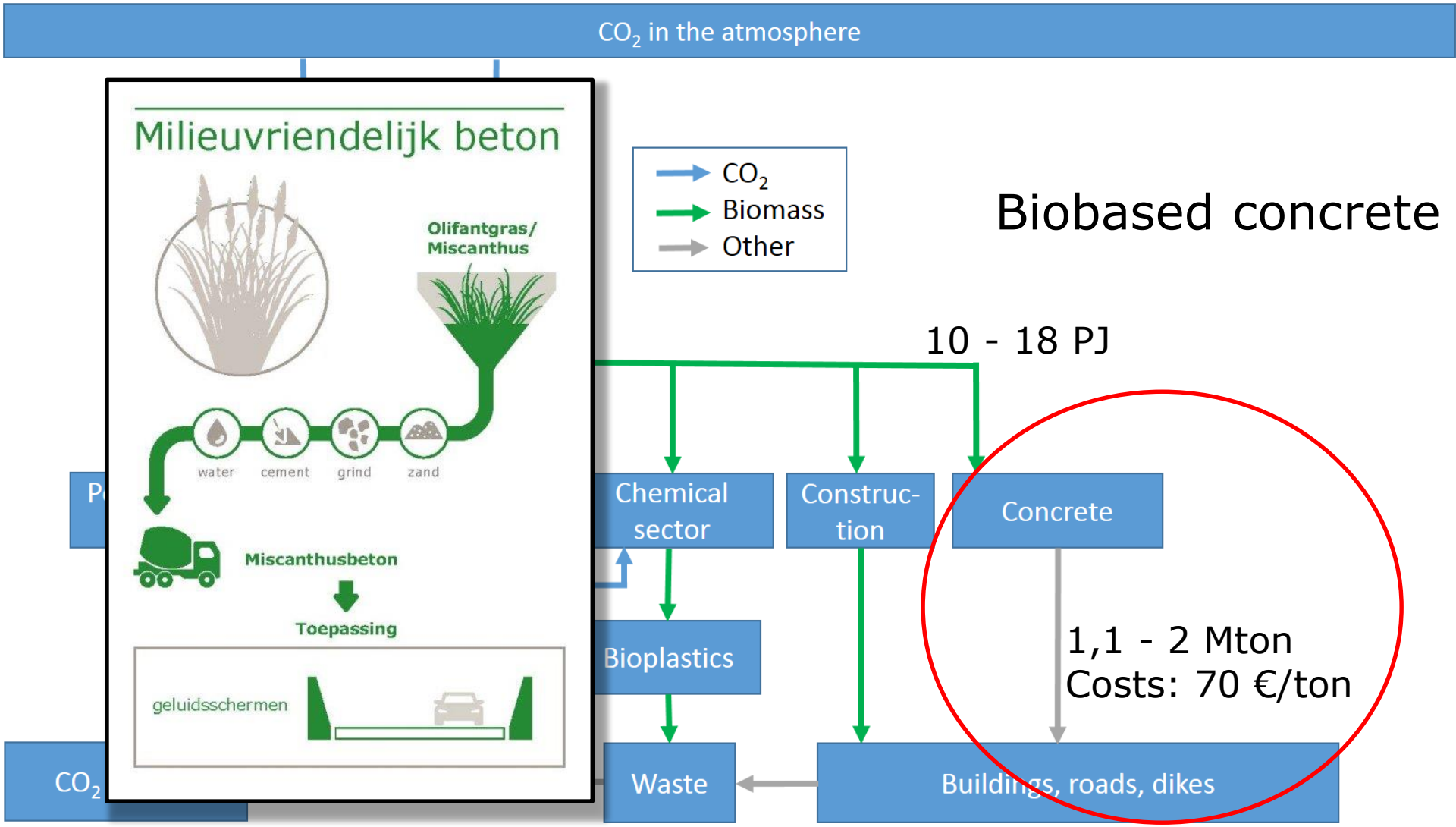
16 million m^3 =
10 Mton

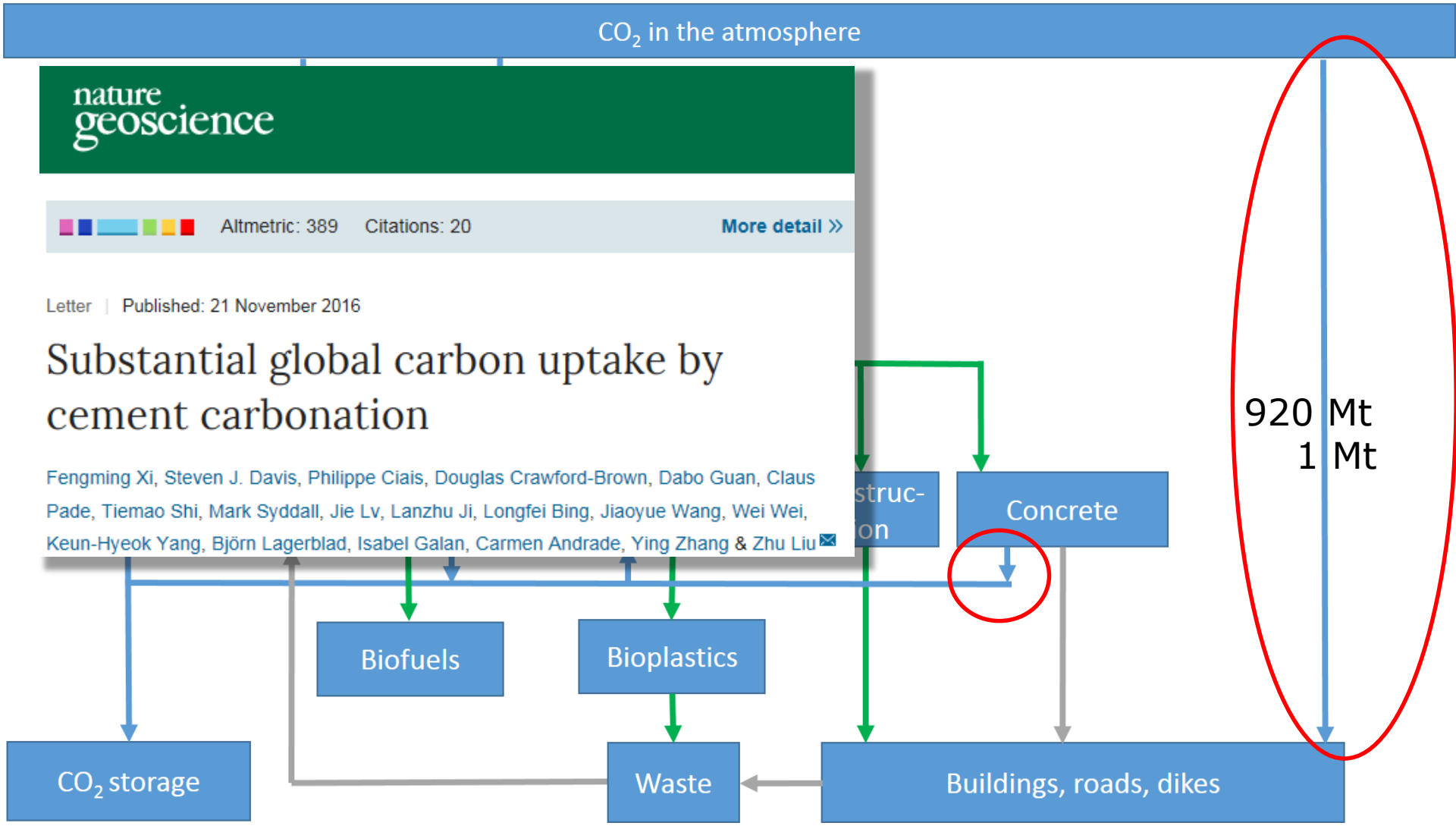
CO_2

Waste

Buildings, roads, dikes

Biobased concrete




CO_2 in the atmosphere
nature geoscience
Altmetric: 389 Citations: 20 More detail »
Letter | Published: 21 November 2016
Substantial global carbon uptake by cement carbonation
Fengming Xi, Steven J. Davis, Philippe Ciais, Douglas Crawford-Brown, Dabo Guan, Claus Pade, Tiemao Shi, Mark Syddall, Jie Lv, Lanzhu Ji, Longfei Bing, Jiaoyue Wang, Wei Wei, Keun-Hyeok Yang, Björn Lagerblad, Isabel Galan, Carmen Andrade, Ying Zhang & Zhu Liu
Concrete
Biofuels
Bioplastics
CO_2 storage
Waste
Buildings, roads, dikes
920 Mt
1 Mt

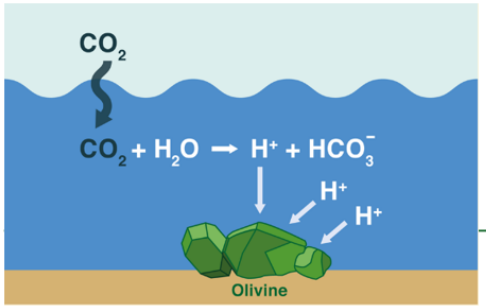
CO_2 in the atmosphere

Agriculture&

CO_2

Olivine

9 Mt



ENVIRONMENTAL Science & Technology

Article

pubs.acs.org/est

Olivine Dissolution in Seawater: Implications for CO_2 Sequestration through Enhanced Weathering in Coastal Environments

Francesc Montserrat,*[,†] Phil Renforth,[‡] Jens Hartmann,[§] Martine Leermakers,[†] Pol Knops,[∥] and Filip J. R. Meysman[†,⊥,#]

Silicates

Concrete

Biofuels

Bioplastics

CO_2 storage

Waste

Buildings, roads, dikes

Sea

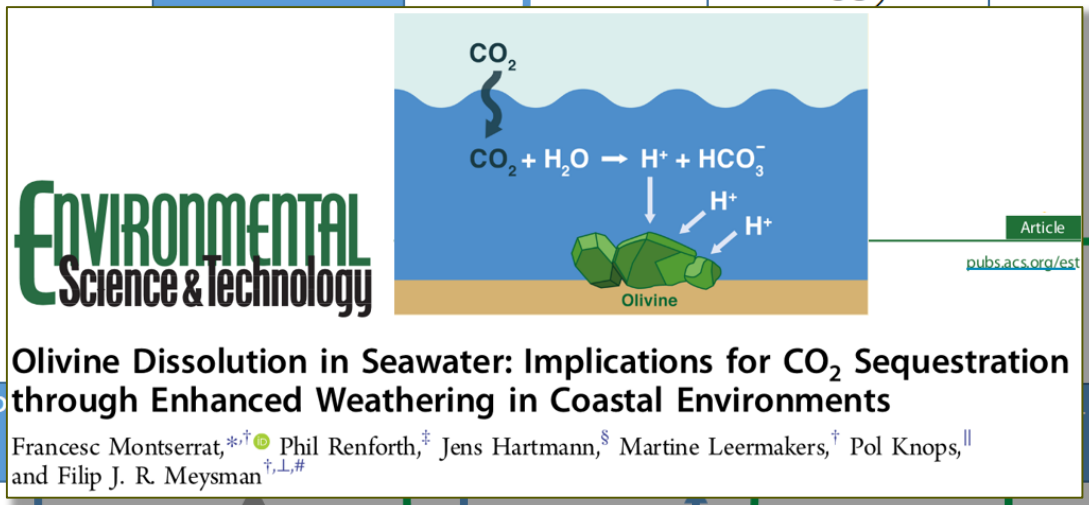
CO_2 in the atmosphere

Agriculture&

CO_2

Olivine

0.2 – 1.7Mt 70 €/t



ENVIRONMENTAL Science & Technology

Article

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Olivine Dissolution in Seawater: Implications for CO_2 Sequestration through Enhanced Weathering in Coastal Environments

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Silicates

Concrete

Biofuels

Bioplastics

CO_2 storage

Waste

Buildings, roads, dikes

Sea

CO_2 in the atmosphere

Olivine

© Jan de Groen

Grind rond Hoekse Lijn 'eet' CO2

De Hoekse Lijn krijgt een schouwpad van grind met verpulverd olivijn. Dit mineraal haalt het broeikasgas CO2 uit de lucht.

Leon van Heel 31-01-18, 22:05

mass

ner

Silicates

Post C

Construc-tion

Concrete

CO_2 storage

Waste

Buildings, roads, dikes

Sea

Direct Air Capture

510 €/t

CO_2 in the atmosphere

Silicates

Concrete

DAC

Biofuels

Bioplastics

CO_2 storage

Waste

Buildings, roads, dikes

Sea

CO_2 in the atmosphere

Agriculture& Forestry

0.5-1 Mt in 2030
1.2 Mt in 2050
50->200 €/t

CO_2
Biomass
Other

Afforestation
Reforestation

Biomass

Post-combustion CO_2 capture

Gasification

DAC

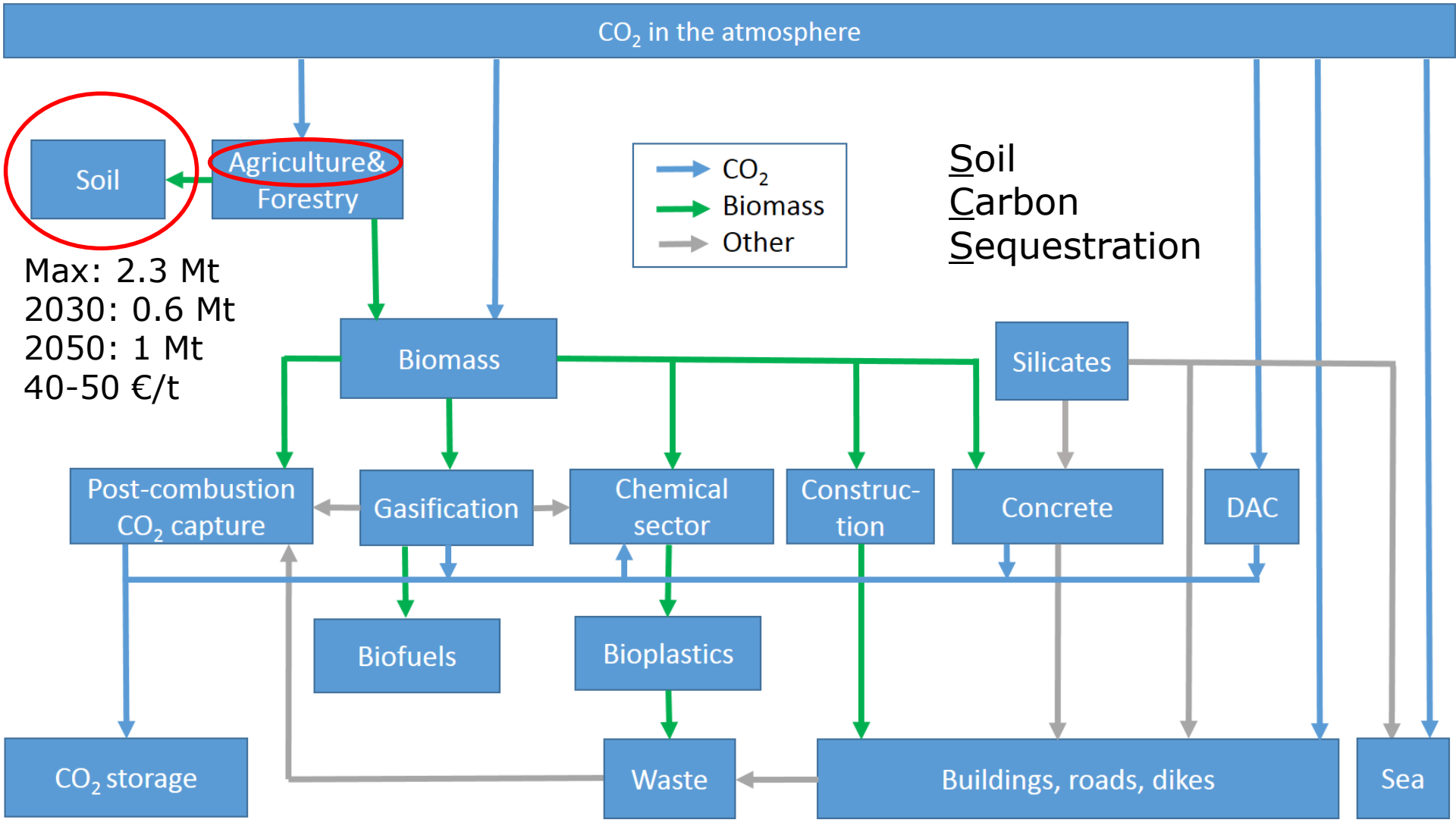
Biofuels

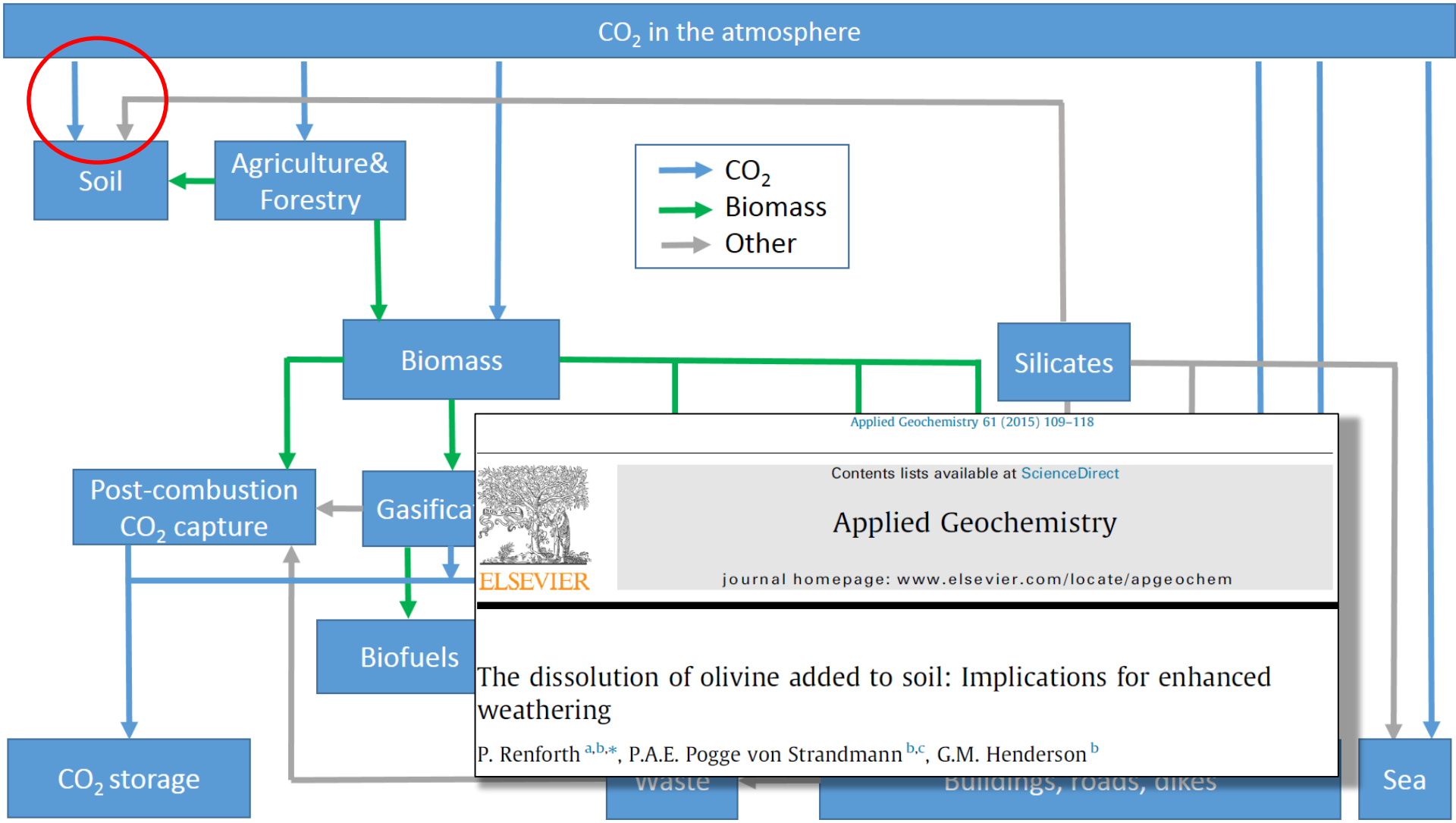
CO_2 storage

Waste

Buildings, roads, dikes

Sea


CO_2 in the atmosphere
Soil
Agriculture& Forestry
CO_2
Biomass
Other
Soil Carbon Sequestration
Max: 2.3 Mt
2030: 0.6 Mt
2050: 1 Mt
40-50 €/t
Biomass
Silicates
Post-combustion CO_2 capture
Gasification
Chemical sector
Construc-tion
Concrete
DAC
Biofuels
Bioplastics
CO_2 storage
Waste
Buildings, roads, dikes
Sea



Applied Geochemistry 61 (2015) 109–118

Contents lists available at ScienceDirect

Applied Geochemistry

journal homepage: www.elsevier.com/locate/apgeochem

ELSEVIER

The dissolution of olivine added to soil: Implications for enhanced weathering

P. Renforth [a,b,*], P.A.E. Pogge von Strandmann [b,c], G.M. Henderson [b]

CO_2 in the atmosphere

Soil

Agriculture& Forestry

0.3–2 Gt in 2050

Biochar

5.4-36 EJ

Biomass

Post-combustion CO_2 capture

Gasification

Biofuels

CO_2 storage

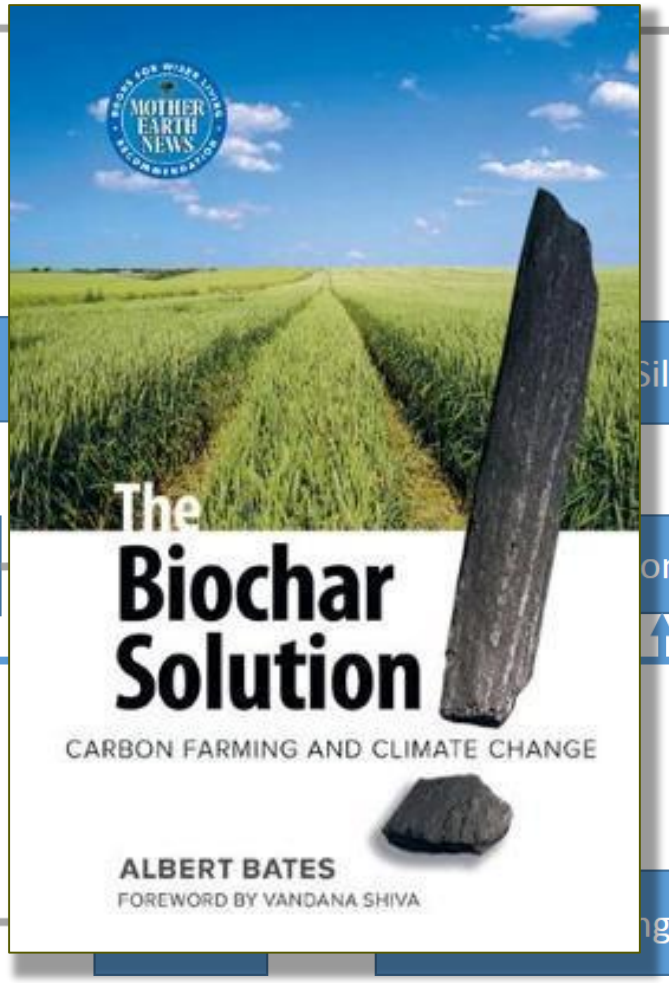
ilicates

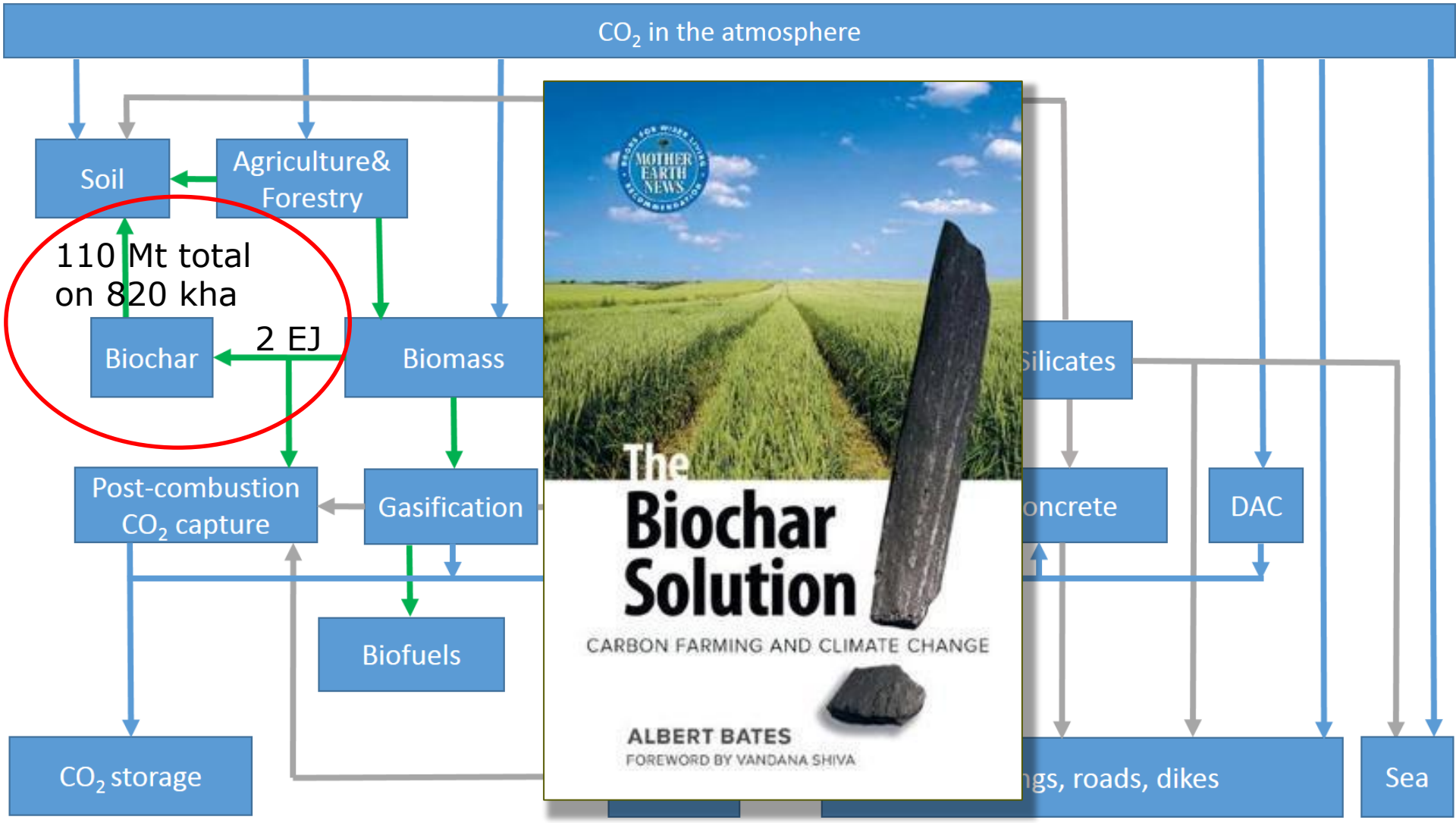
oncrete

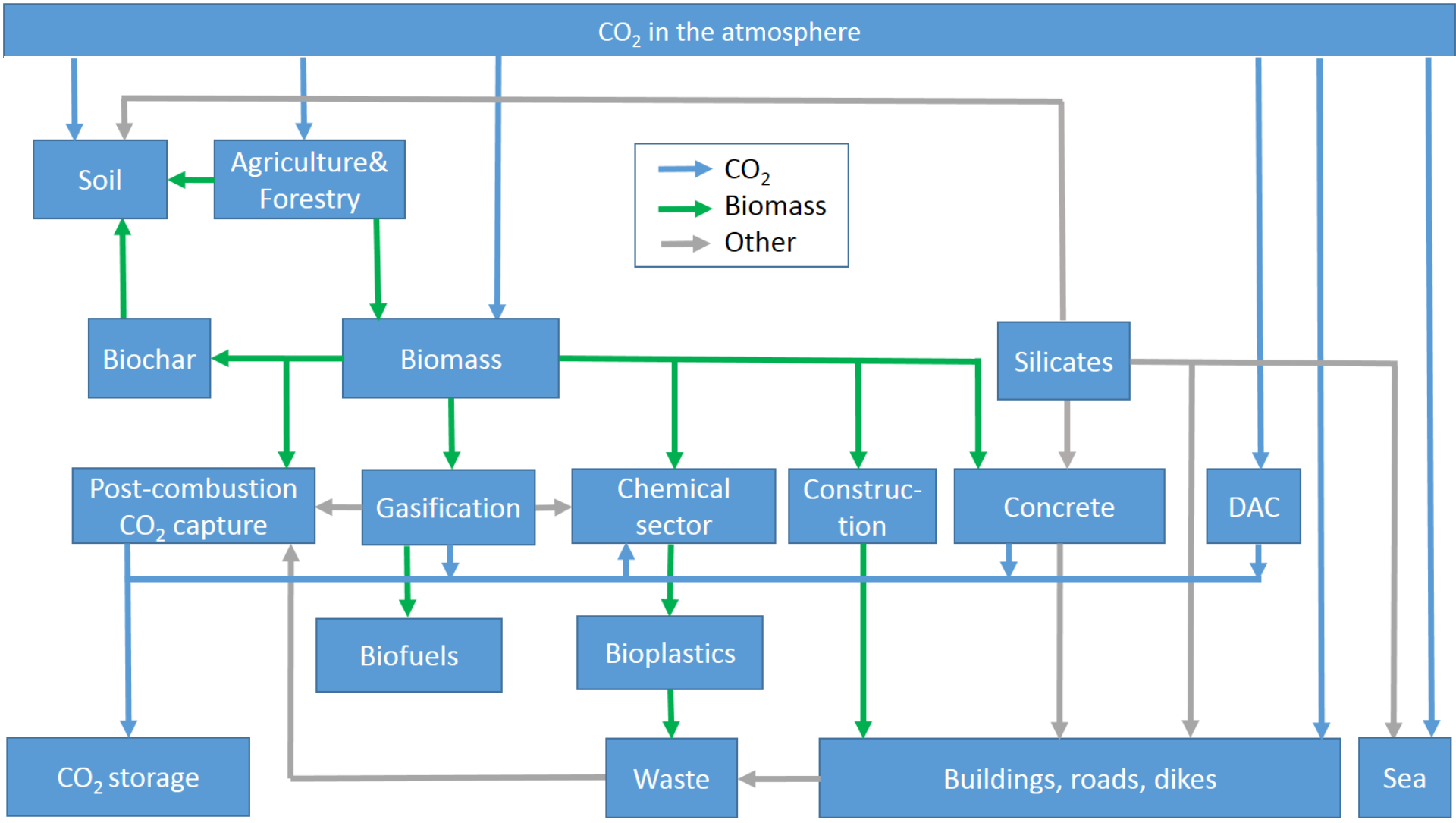
DAC

gs, roads, dikes

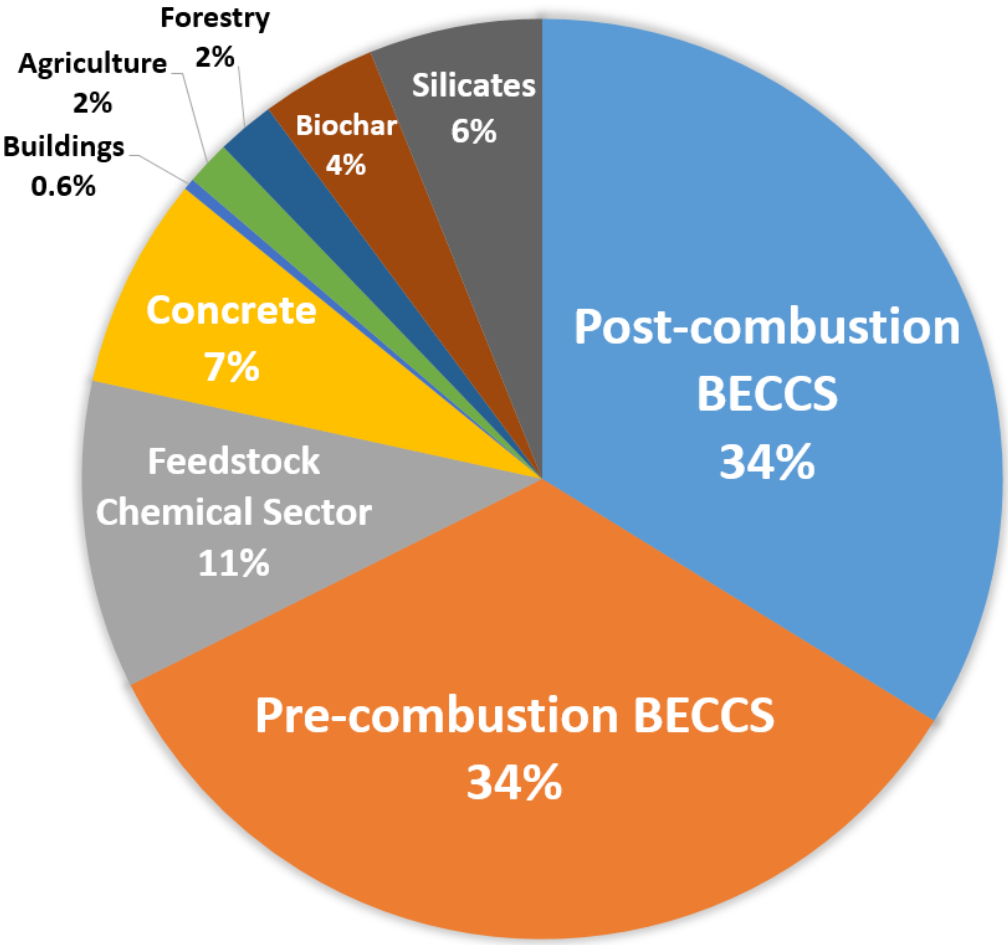
Sea

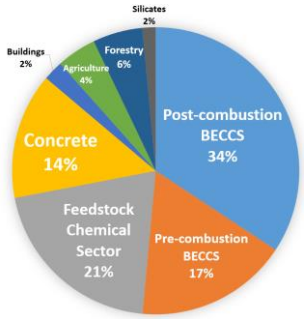



CO_2 in the atmosphere
Soil
Agriculture& Forestry
110 Mt total on 820 kha
Biochar
2 EJ
Biomass
Silicates
Post-combustion CO_2 capture
Gasification
oncrete
DAC
Biofuels
CO_2 storage
gs, roads, dikes
Sea
MOTHER EARTH NEWS
The Biochar Solution
CARBON FARMING AND CLIMATE CHANGE
ALBERT BATES
FOREWORD BY VANDANA SHIVA

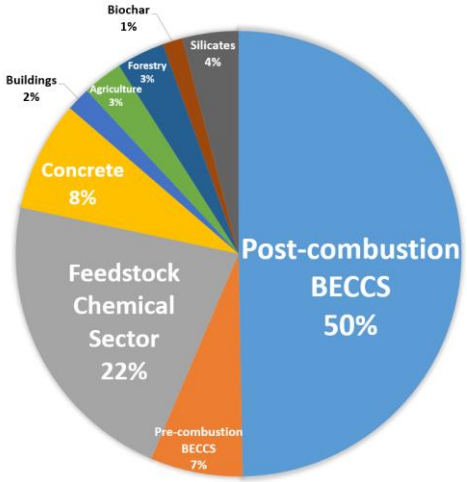

CO_2 in the atmosphere
Soil
Agriculture& Forestry
CO_2
Biomass
Other
Biochar
Biomass
Silicates
Post-combustion CO_2 capture
Gasification
Chemical sector
Construc-tion
Concrete
DAC
Biofuels
Bioplastics
CO_2 storage
Waste
Buildings, roads, dikes
Sea

How does it add up?





2030: 13 Mton
170 PJ



2050: 34 Mton
415 PJ

Technical potential: 140-160 Mton, 2250 PJ

To summarize…

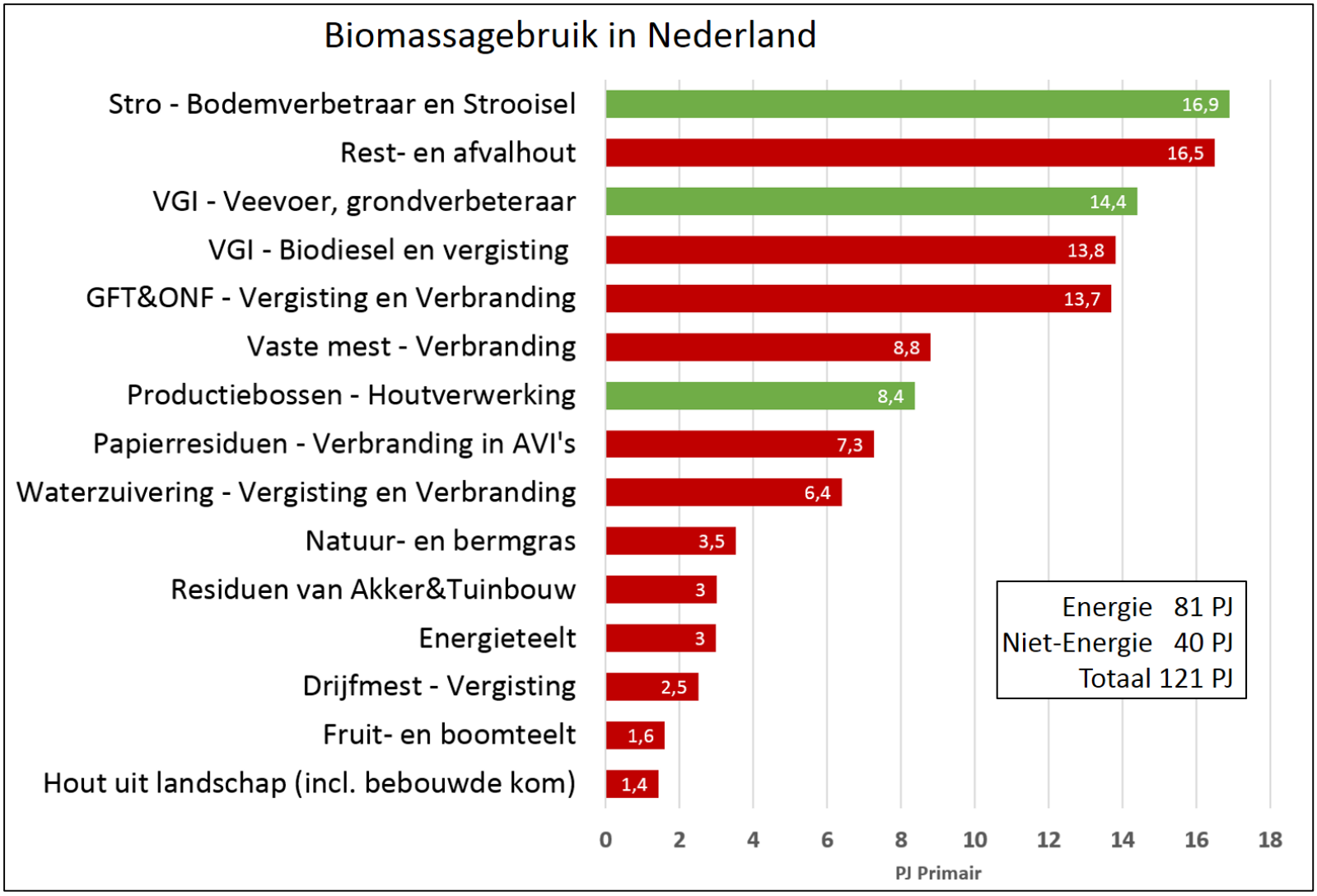
- Post-combustion BECCS *is* the most important NET, also in the Dutch case.
- Biofuels with CCS (Pre-combustion BECCS) are important in scenario-studies, but need further upscaling
- Other promising NETs, also in terms of cascading, are:
  - Biomass feedstocks in the chemical sector
  - 'Green' concrete
- AR plays a relative small role in the Dutch case
- Options that deserve more attention:
  - Silcates (olivine)
  - Biochar
- Crucial: availability of *sustainable* biomass

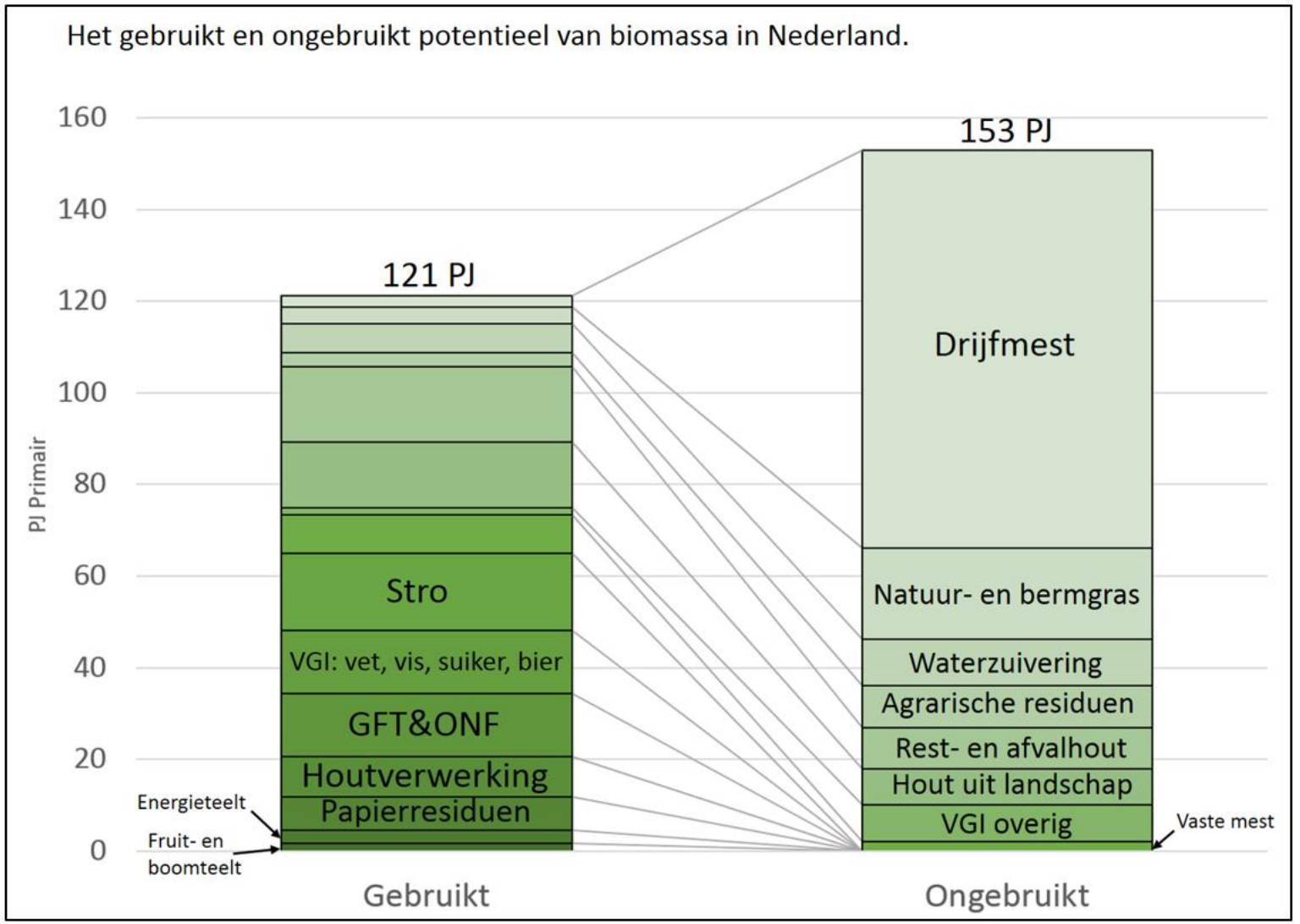
Questions?

Report (in Dutch) can be found at:
http://www.pbl.nl/publicaties/negatieve-emissies-technisch-potentieel-realistisch-potentieel-en-kosten-voor-nederland

Or send an email: bart.strengers@pbl.nl

	Technisch	Realistisch	
		2030	2050
	PJ		
Potentieel biomassa, binnenland	275	<230	<230
Potentieel zeewier, Noordzee	350	nihil	18
Totaal aanbod in NL	**625**	**<230**	**<250**
Totale vraag naar biomassa		**430-600**	**670-1470**
Benodigde biomassa obv tabel B.2	**>2250**	**>170**	**>410**
Minimale noodzakelijke import		**200-370**	**420-1220**
Mondiale import obv inwonertal			230-430
Mondiale import obv BNP			660-1420
Europese import obv inwonertal		150-525	
Europese import obv BNP		270-950	


Biomassagebruik in Nederland
Stro - Bodemverbetraar en Strooisel
Rest- en afvalhout
VGI - Veevoer, grondverbeteraar
VGI - Biodiesel en vergisting
GFT&ONF - Vergisting en Verbranding
Vaste mest - Verbranding
Productiebossen - Houtverwerking
Papierresiduen - Verbranding in AVI's
Waterzuivering - Vergisting en Verbranding
Natuur- en bermgras
Residuen van Akker&Tuinbouw
Energieteelt
Drijfmest - Vergisting
Fruit- en boomteelt
Hout uit landschap (incl. bebouwde kom)
16,9
16,5
14,4
13,8
13,7
8,8
8,4
7,3
6,4
3,5
3
3
2,5
1,6
1,4
0
2
4
6
8
10
12
14
16
18
PJ Primair
Energie 81 PJ
Niet-Energie 40 PJ
Totaal 121 PJ


Het gebruikt en ongebruikt potentieel van biomassa in Nederland.
PJ Primair
160
140
120
100
80
60
40
20
0
121 PJ
153 PJ
Stro
VGI: vet, vis, suiker, bier
GFT&ONF
Houtverwerking
Papierresiduen
Energieteelt
Fruit- en boomteelt
Drijfmest
Natuur- en bermgras
Waterzuivering
Agrarische residuen
Rest- en afvalhout
Hout uit landschap
VGI overig
Vaste mest
Gebruikt
Ongebruikt

Schatting technisch potentieel

- Uitgangspunt *huidige* productie van 7 bulkchemicaliën die 80% van de totale productie omvatten (6,6 Mton): PE, PP, PVC, PUR, PS, PET, en PA.
- Bevatten ~3,9 Mton C-atomen of 14,4 Mton in termen van CO_2
- Vervanging feedstock door biomassa levert negatieve emissies indien CCS bij AVI's: 90% van 14,4 = **13 Mton**
- Biogene C of CO_2 als grondstof: minimaal **3 Mton**
- Maximaal 2,1 Mton negatieve emissies kan in NL worden gerealiseerd.