Közvetlen szén-dioxid leválasztás levegőből: kumulatív energiaigény

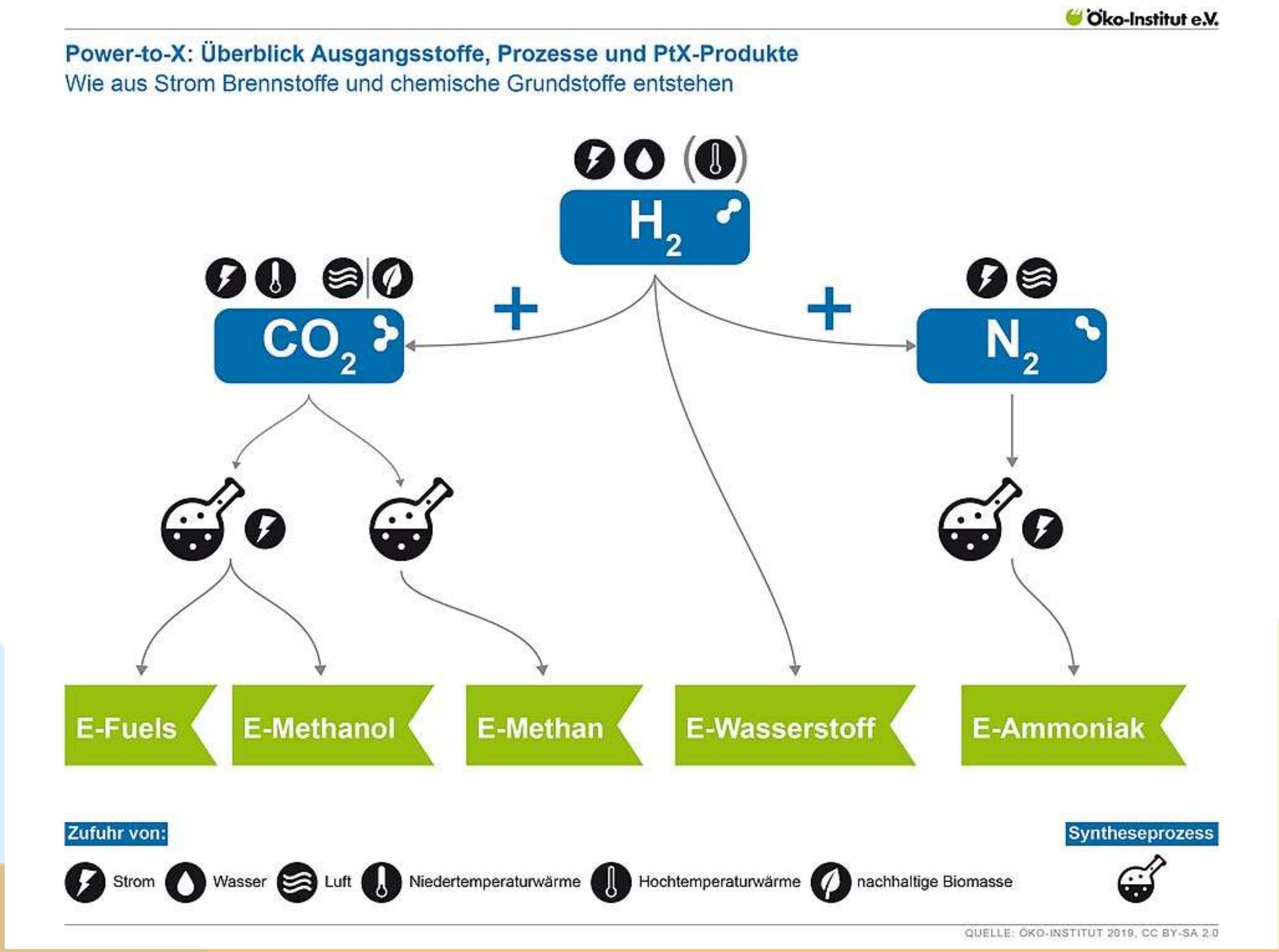
Simon Bálint,

XVI. LCA Konferencia

“Életciklus elemzéssel a fenntartható társadalom felé”

25-26.11.2021

DAC (direct air capture) létjogosultsága



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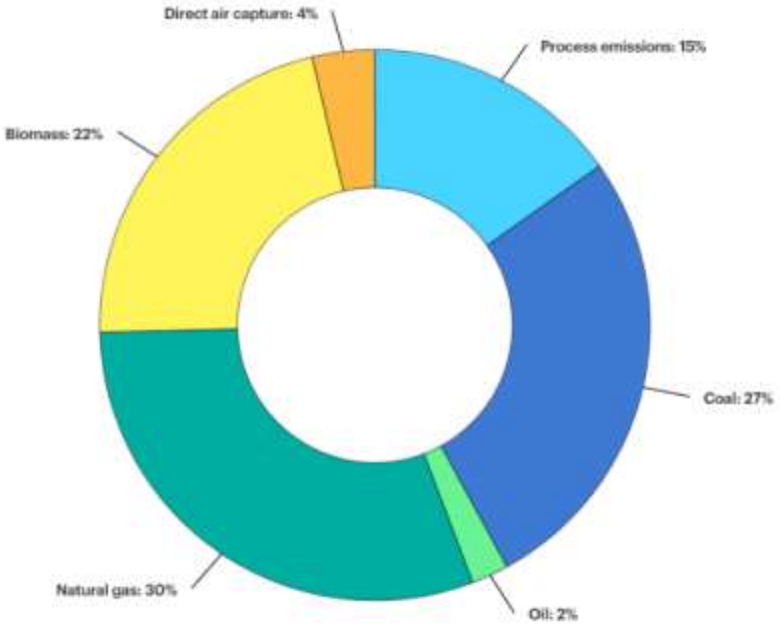
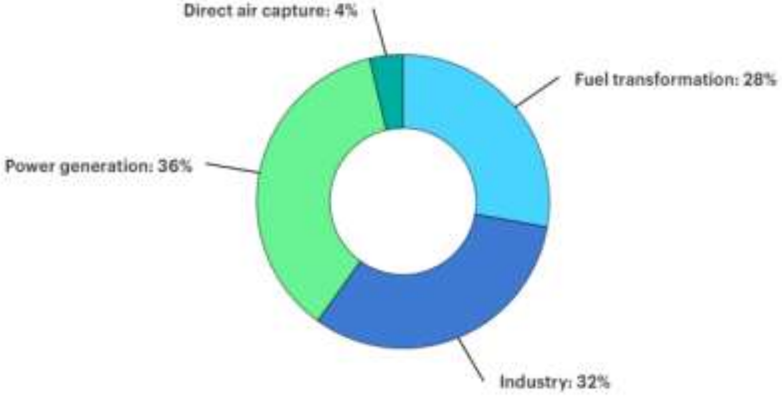
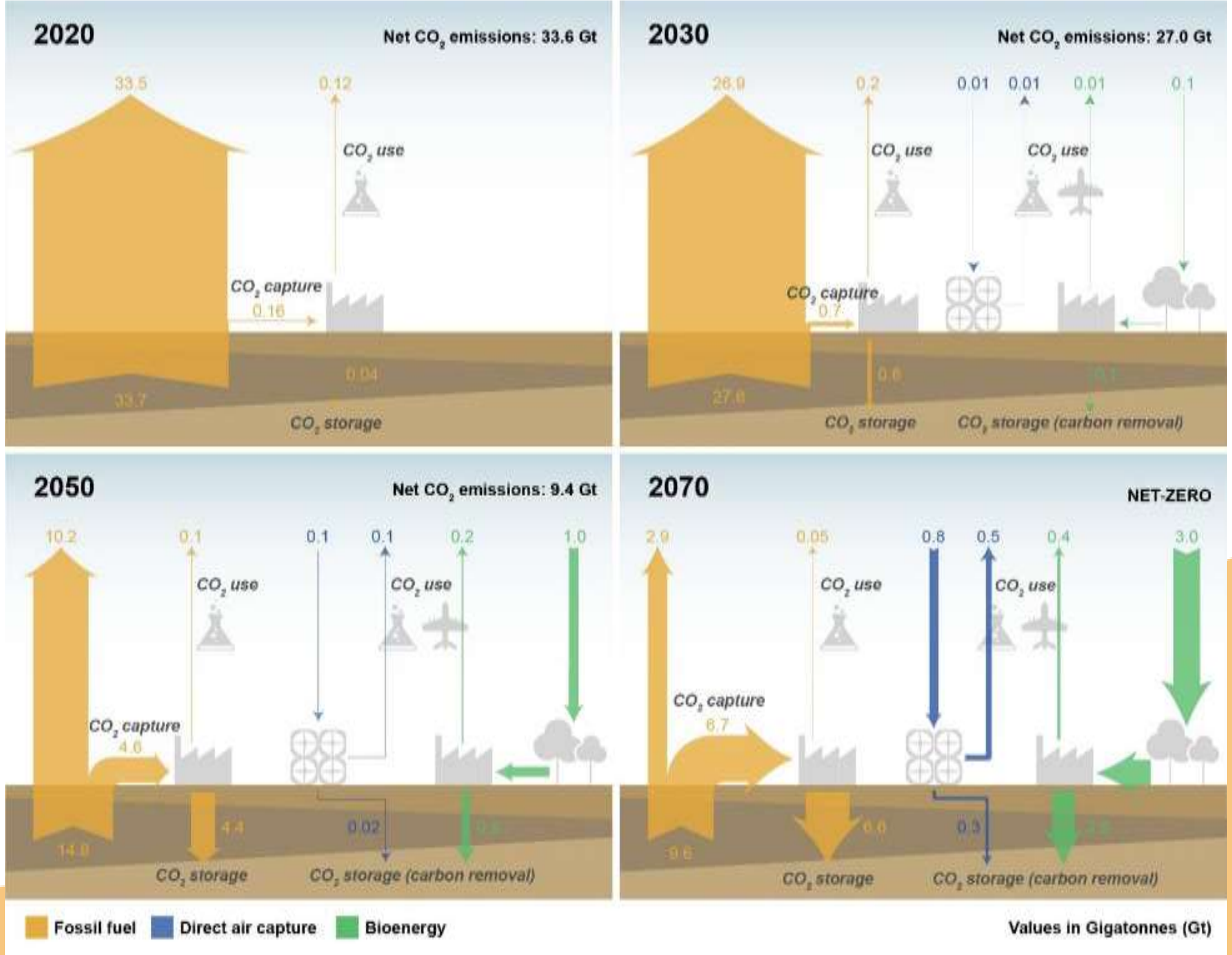


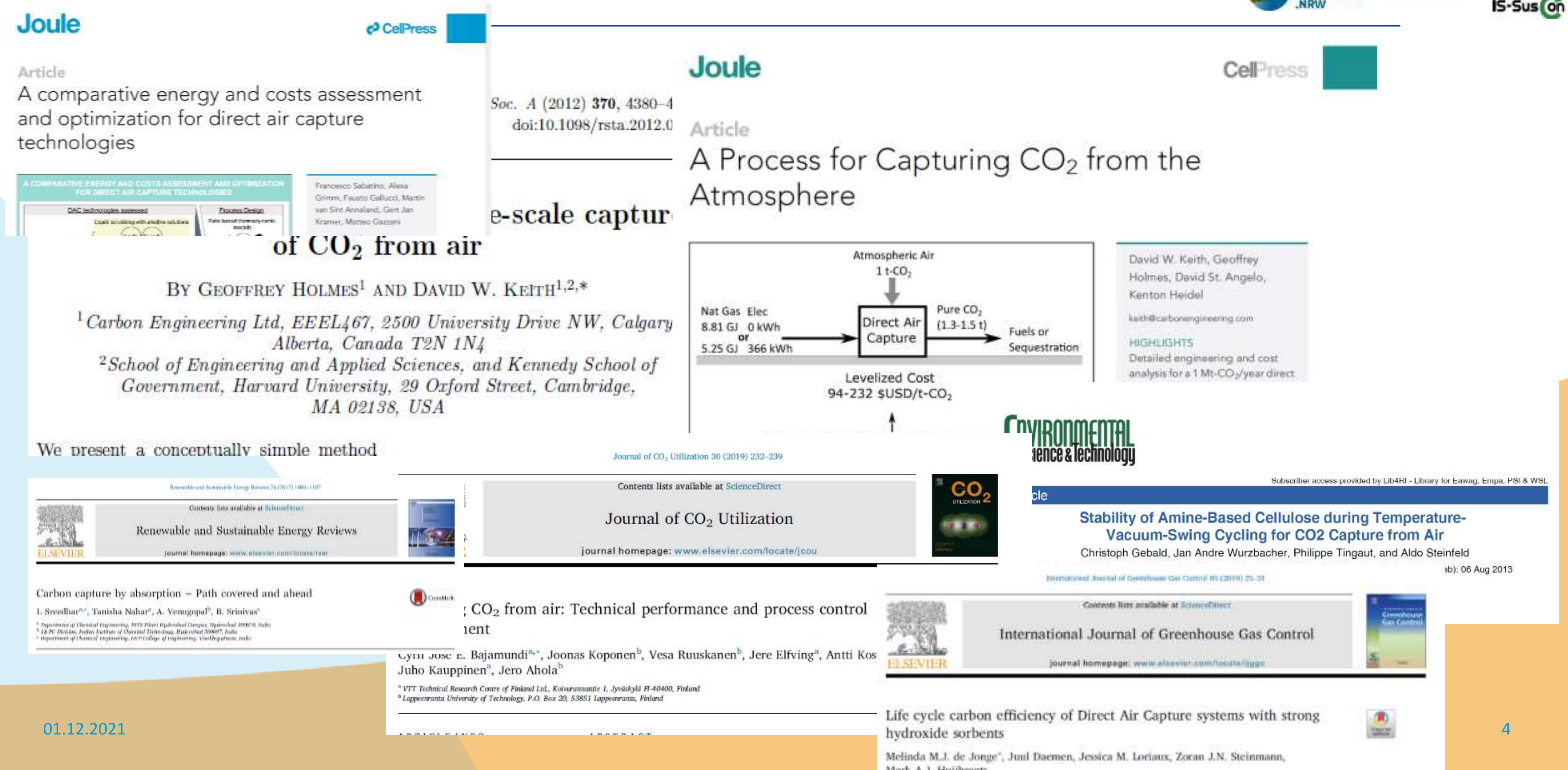


92% Stored
8% Used



https://www.iea.org/reports/ccus-in-clean-energy-transitions/ccus-in-the-transition-to-net-zero-emissions

Szakirodalom



Joule

CellPress

Article

A comparative energy and costs assessment and optimization for direct air capture technologies

A COMPARATIVE ENERGY AND COSTS ASSESSMENT AND OPTIMIZATION FOR DIRECT AIR CAPTURE TECHNOLOGIES

Francesco Sabatino, Alexa Grimm, Fausto Gallucci, Martin van Sint Annaland, Gert Jan Kramer, Matteo Gazzani

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Soc. A (2012) **370**, 4380–4

doi:10.1098/rsta.2012.0

e-scale captur

of CO_2 from air

BY GEOFFREY HOLMES[1] AND DAVID W. KEITH[1,2,*]

[1] *Carbon Engineering Ltd, EEL467, 2500 University Drive NW, Calgary Alberta, Canada T2N 1N4*

[2] *School of Engineering and Applied Sciences, and Kennedy School of Government, Harvard University, 29 Oxford Street, Cambridge, MA 02138, USA*

We present a conceptually simple method

Joule

CellPress

Article

A Process for Capturing CO_2 from the Atmosphere

David W. Keith, Geoffrey Holmes, David St. Angelo, Kenton Heidel

keith@carbonengineering.com

HIGHLIGHTS

Detailed engineering and cost analysis for a 1 Mt-CO_2/year direct

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Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

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

Carbon capture by absorption – Path covered and ahead

I. Sreedhar[a,*], Tanisha Nahar[a], A. Venugopal[b], B. Srinivas[c]

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[b] I & PC Division, Indian Institute of Chemical Technology, Hyderabad 500007, India

[c] Department of Chemical Engineering, GVP College of Engineering, Visakhapatnam, India

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Journal of CO_2 Utilization 30 (2019) 232–239

Contents lists available at ScienceDirect

Journal of CO_2 Utilization

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

; CO_2 from air: Technical performance and process control

ıent

Cyril José E. Bajamundi[a,*], Joonas Koponen[b], Vesa Ruuskanen[b], Jere Elfving[a], Antti Kos

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Environmental Science & Technology

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cle

Stability of Amine-Based Cellulose during Temperature-Vacuum-Swing Cycling for CO2 Capture from Air

Christoph Gebald, Jan Andre Wurzbacher, Philippe Tingaut, and Aldo Steinfeld

eb): 06 Aug 2013

International Journal of Greenhouse Gas Control 80 (2019) 25–31

Contents lists available at ScienceDirect

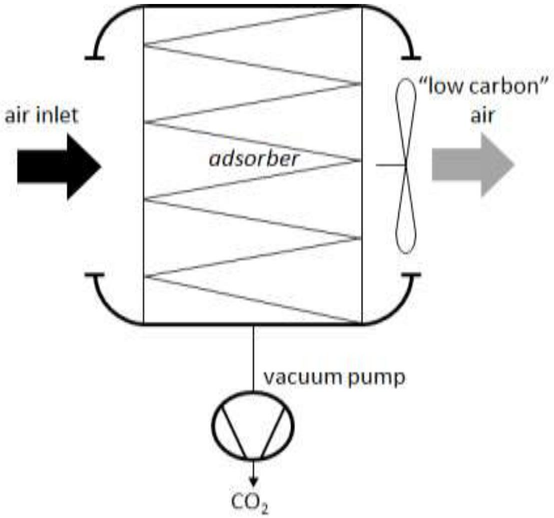
International Journal of Greenhouse Gas Control

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

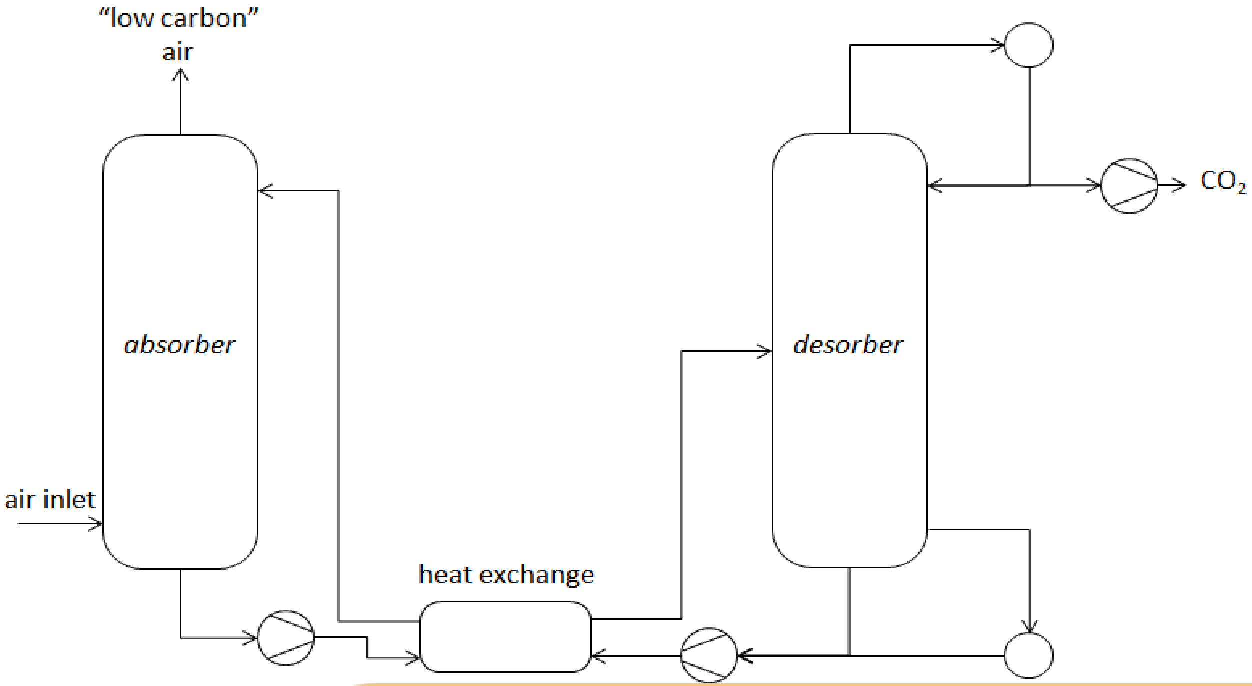
Life cycle carbon efficiency of Direct Air Capture systems with strong hydroxide sorbents

Melinda M.J. de Jonge*, Juul Daemen, Jessica M. Loriaux, Zoran J.N. Steinmann,

Vizsgált technológiák

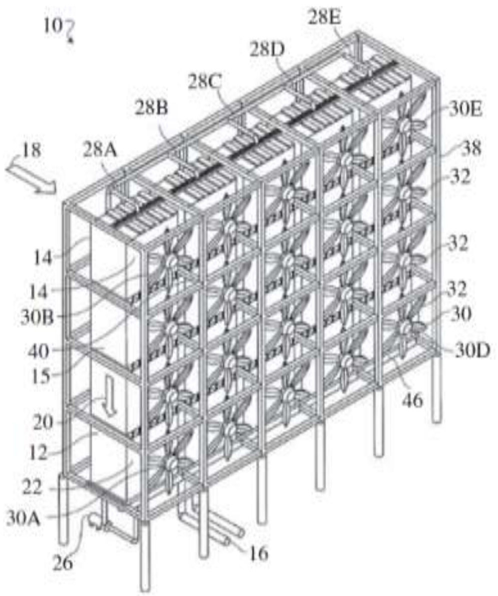


adszorpció



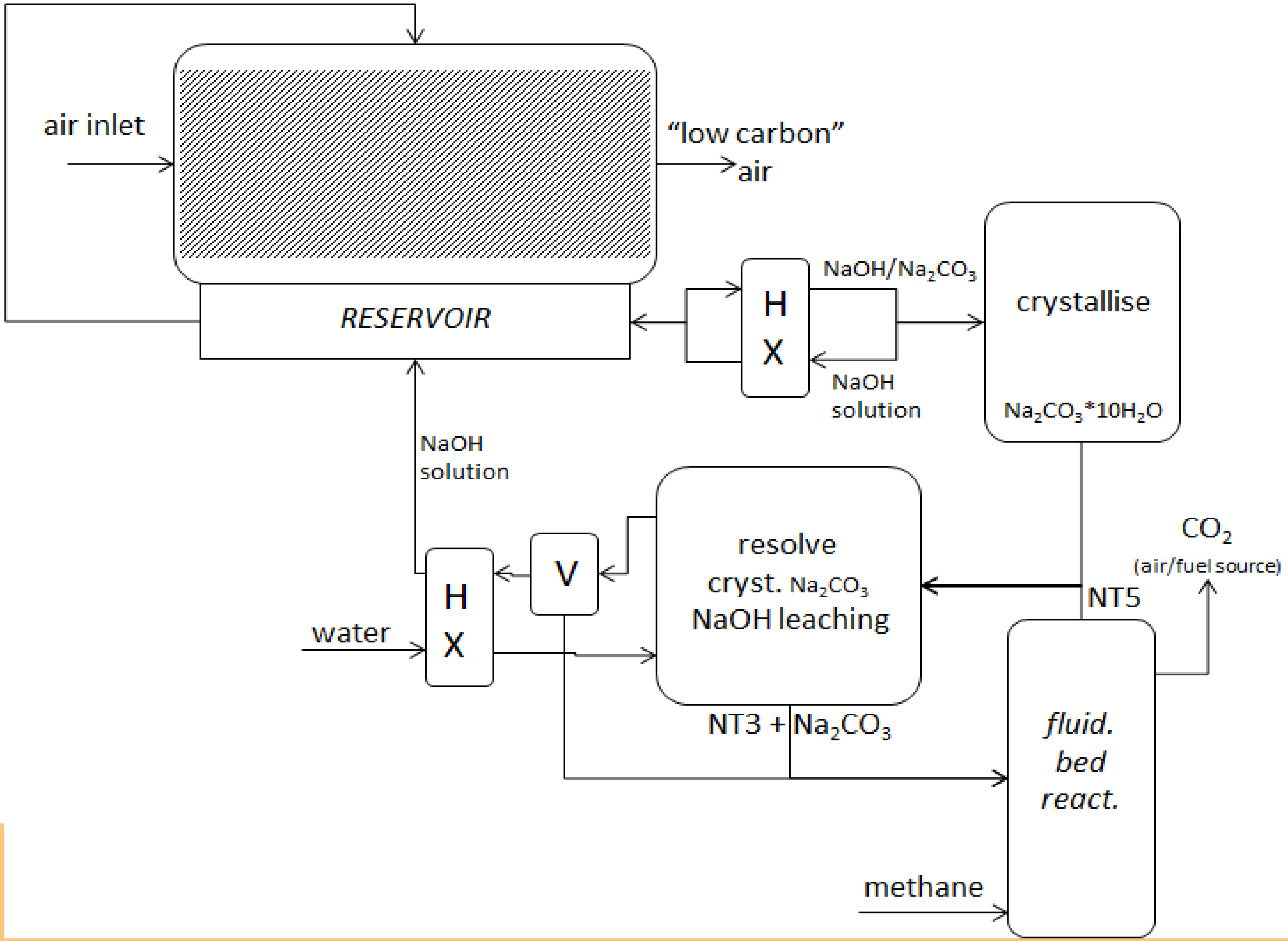
abszorpció

Vizsgált technológiák



Phil. Trans. R. Soc. A (2012) **370**, 4380–4403
doi:10.1098/rsta.2012.0137

NaOH “abszorpció”



air inlet

“low carbon” air

RESERVOIR

H X

$NaOH/Na_2CO_3$

crystallise

NaOH solution

$Na_2CO_3*10H_2O$

NaOH solution

H X

V

resolve cryst. Na_2CO_3 NaOH leaching

water

NT3 + Na_2CO_3

NT5

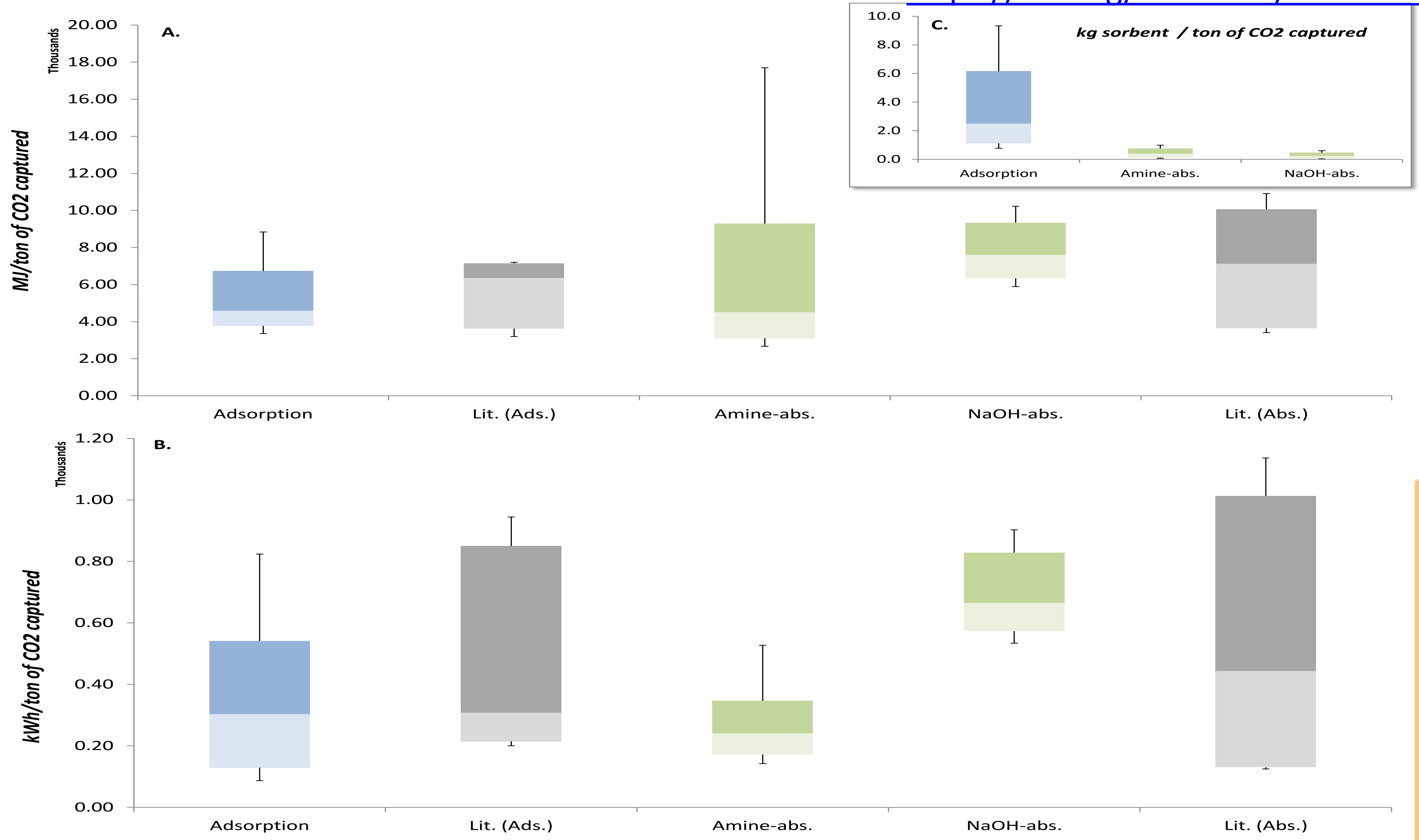
CO_2 (air/fuel source)

fluid. bed react.

methane

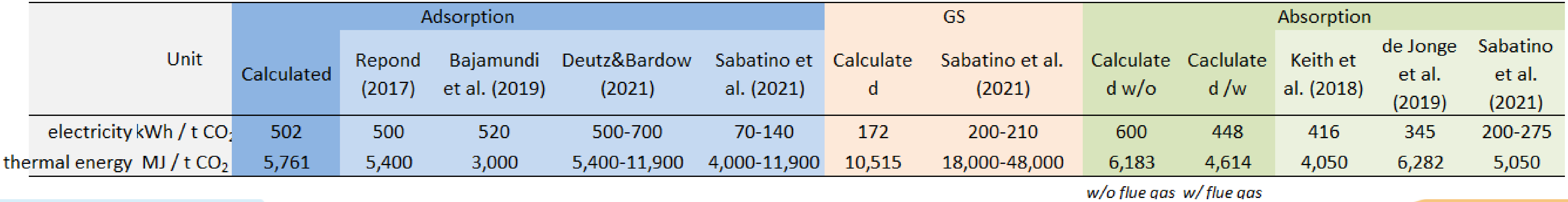
Irodalmi és kalkulált értékek (közvetlen energiigény)

https://doi.org/10.33774/chemrxiv-2021-bpg5d



Közvetlen energiaigény validálás

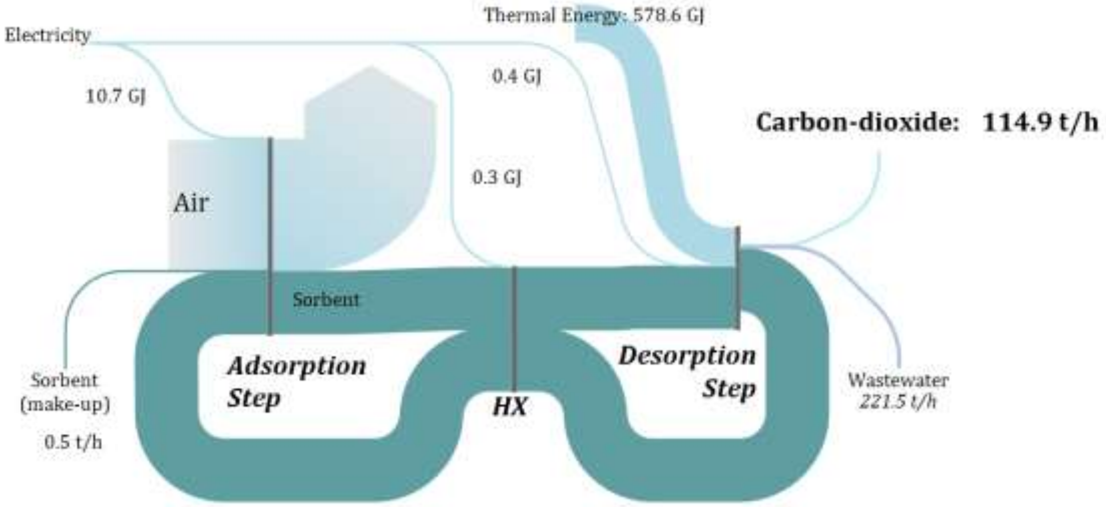
Table S1.1 Summary of direct energy consumption capturing 1 metric ton of CO2 at atmospheric pressure

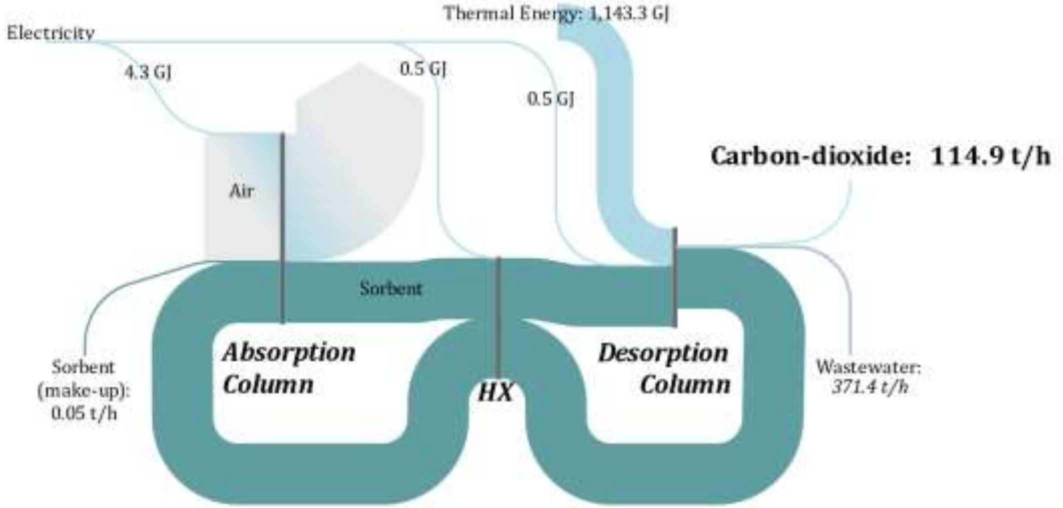


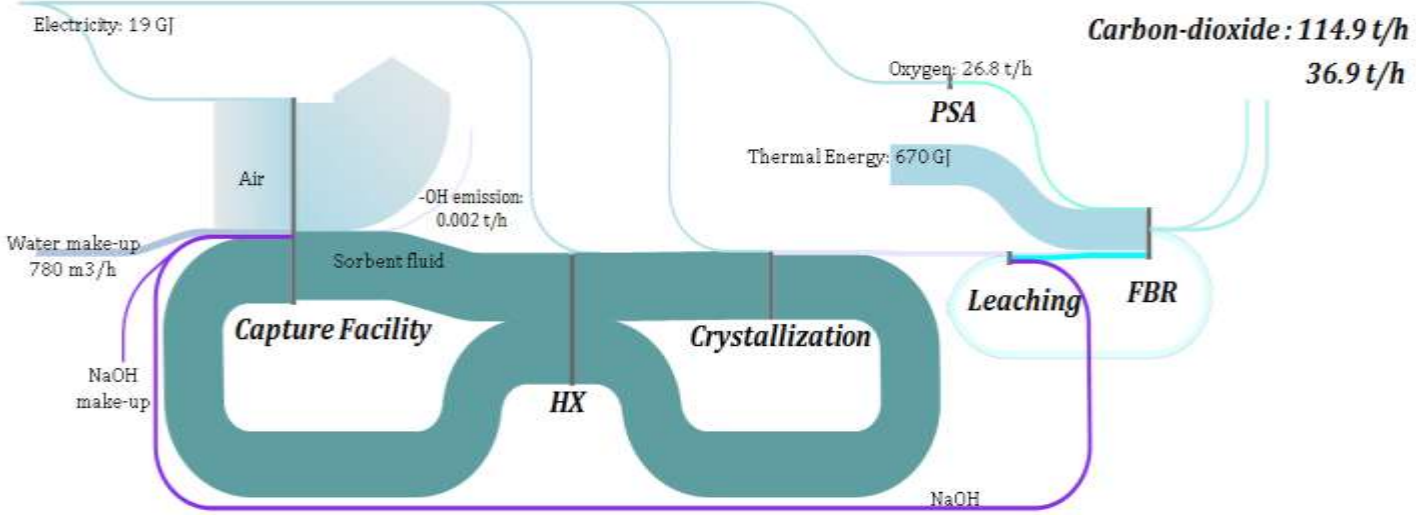
		Adsorption					GS		Absorption				
	Unit	Calculated	Repond (2017)	Bajamundi et al. (2019)	Deutz&Bardow (2021)	Sabatino et al. (2021)	Calculated	Sabatino et al. (2021)	Calculated w/o	Caclulated /w	Keith et al. (2018)	de Jonge et al. (2019)	Sabatino et al. (2021)
electricity	kWh / t CO_2	502	500	520	500-700	70-140	172	200-210	600	448	416	345	200-275
thermal energy	MJ / t CO_2	5,761	5,400	3,000	5,400-11,900	4,000-11,900	10,515	18,000-48,000	6,183	4,614	4,050	6,282	5,050

w/o flue gas w/ flue gas

Anyagáram és energia analízis







Cradle to gate energiaigény

	Adsorption MJ/t CO2		Absorption - GS MJ/t CO2		*Absorption NaOH MJ/t CO2*	
capital "costs"	*best case*	*worst case*	best case	worst case	*best case*	*worst case*
			plant			
concrete	*4.5*	*6.6*	3.3	4.9	*3.4*	*5.01*
steel rebar	*2.1*	*4.4*	0.60	1.24	*1.6*	*3.4*
gravel	*0.17*	*0.89*	0.023	0.12	*0.029*	*0.15*
sand	*0.15*	*0.78*	0.022	0.11	*0.025*	*0.13*
soil work	*0.11*	*0.73*	0.039	0.25	*0.025*	*0.16*
steel (alloyed)	*3.7*	*42*	2.2	25	*0.103*	*1.2*
steel (unalloyed)	*3.05*	*35*	0.01	0.16	*0.70*	*8.00*
aluminum	*13*	*280*	n.a.	n.a.	*0.012*	*0.25*
copper	*0.38*	*2.8*	n.a.	n.a.	*0.013*	*0.096*
mineral wool	*3.1*	*6.1*	1.1	2.3	*0.016*	*0.033*
plastics	*4.9*	*6.1*	0.12	0.15	*32*	*40*
PUR					*2.3*	*2.9*
"cap. cost" sum	*35*	*385*	*7*	*34*	*40*	*62*
running "costs"			sorbent			
sorbent (lifetime)	*67*	*12,240*	36	50	*3.8*	*8.6*
			energy			
electricity	*1,688*	*5,331*	700	2,209	*2,425*	*7,656*
air fan	94.3%		78.8%		8.7%	
evacuation (vacuum)	3.3%		0.1%			
water pump (HX)	2.4%		10.2%			
fluid pump (sorbent)			1.5%		51.2%	
heat pump					26.7%	
sorbent recovery			9.5%			
crystallizer					0.2%	
PSA - oxygen					13.2%	
thermal energy	*4,277*	*6,426*	8,180	12,288	*8,743*	*20,813*
"run. cost" sum	*6,033*	*23,996*	*8,916*	*14,548*	*11,171*	*28,478*
sum (overal)	***6,068***	***24,381***	**8,924**	**14,582**	***11,211***	***28,539***

CO_2 képződéshez kapcsolható maximális energia:

8-18 GJ/t CO_2

Take-Home

Indeed, another study says that global **restoration of cultivated lands by 15%** would sequester up to **299 Gt of atmospheric CO_2** (Strassburg et al. 2020). To capture the same amount by DAC, based on current calculated values, requires at least **40,000 TWh of electricity**. It corresponds to **150% of the global production in 2019** (BP 2020).

↓

DAC önmagában nem megoldás → Inkább CO_2 körforgás zárására alk.

It was found that all modelled DAC technology **exhibits embodied energy in the calculated grey zone** (8.94-18.2 GJ/tCO_2). However, selecting the appropriate sorbent material for adsorption can decrease the energy demand below this value.

↓

Adott esetben direkt energiahasznosítás (megújuló) előnyösebb

Balint Simon, balint.simon@om.rwth-aachen.de