

# Potential of Repurposed Cooling Towers for Direct Air Capture in Germany

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**Abstract:** To successfully mitigate climate change, the use of renewable energy sources in all sectors is required. In addition, negative emission technologies (NETs) will play a crucial role to reduce the atmospheric CO<sub>2</sub> concentration, offset emissions from hard-to-abate sectors, and provide CO<sub>2</sub> as a feedstock for a circular carbon economy. Among NETs, the direct separation of CO<sub>2</sub> from ambient air (Direct Air Capture, DAC) is considered as a particularly scalable option. However, DAC faces major challenges in terms of high energy demands and high investment cost as large air mass flows must be processed given the low CO<sub>2</sub> concentration in ambient air (~400 ppm). Cooling towers of thermal power plants (e.g., coal-fired power plants) process air mass flows comparable to those anticipated for large-scale DAC units (i.e., 1 Mt<sub>CO2</sub>/a capture capacity). Consequently, as countries phase out coal-fired power plants, an opportunity arises to repurpose existing cooling towers as DAC units. Within the research project *ConTACTFuels*, funded by the German Ministry of Digital and Transport, the potential of repurposing components of thermal power plants for DAC has been investigated.

In this paper, the techno-economic potential of repurposing power plant infrastructure in DAC with subsequent storage or fuel synthesis is investigated for Germany. The Levelized Cost of Direct Air Capture (*LCODAC*) is used as main metric to illustrate trade-offs between reduction in investment cost and increasing operational cost due to the repurposed infrastructure. Overall, the repurpose of cooling towers from coal-fired power plants with a capacity > 150 MW<sub>e</sub> in Germany results in an annual capture capacity of up to 2.3 Mt<sub>CO2</sub>/a at an average *LCODAC* of 174.39 €/t<sub>CO2</sub>. To prove the validity of the results in real world application and enable a rollout, preliminary lab- and field tests as well as in-depth discussions of process integration, civil engineering, social, and ecological research questions must be carried out.

**Keywords:** Direct Air Capture, Cooling Tower, Repurpose, Sector coupling

## 1 Introduction

Achieving the climate targets formulated by the Intergovernmental Panel on Climate Change requires substantial reductions of greenhouse gas emissions across all energy and industrial sectors. Therefore, scenario-based energy system analyses predict the implementation of negative emission technologies (NETs) to reduce the atmospheric CO<sub>2</sub> concentration, offset hard-to-abate emissions, and enable a carbon-neutral economy [1], [2]. Among the portfolio of NETs, the direct separation of CO<sub>2</sub> from ambient air (Direct Air Capture, DAC) is of particular interest due to its scalability in the predicted multi-Mt<sub>CO<sub>2</sub></sub> scale of annual negative emission capacity [3]. Current DAC technologies include cryogenic, membrane-based, and sorption-based processes with various subcategories. From a techno-economic perspective, sorption-based processes are currently discussed as the most viable option for large-scale deployment [4]. In sorption-based processes, CO<sub>2</sub> is bound by a liquid (absorption) or solid (adsorption) sorbent. Subsequently, the CO<sub>2</sub>-rich sorbent is regenerated in an endothermic process step, which accounts for up to 80 % of the total energy demand of DAC systems [2]. Today, several sorption-based DAC processes have reached the pilot scale, with plants of up to 250 kt<sub>CO<sub>2</sub></sub>/a currently under construction [4], [5]. However, the low atmospheric CO<sub>2</sub> concentration inherently requires the processing of high air mass flows, which leads to large-scale capture facilities and high energy demands. For an idealized capture unit with an annual capture capacity of 1 Mt<sub>CO<sub>2</sub></sub>/a and complete removal of CO<sub>2</sub> from the processed air, this would result in

- 52.2 t<sub>air</sub>/s of required air mass flow,
- 31.4·10<sup>3</sup> m<sup>2</sup> of required cross-sectional area, and
- 2.2 TWh of electrical and thermal energy demand per year<sup>1</sup>.

Consequently, high capital expenditures (*CAPEX*) (i.e., due to large capture units) as well as significant operational expenditures (*OPEX*) hinder the rollout of DAC plants. To address investment-related barriers, recent studies discuss the impact of off-the-shelf components such as industrial cooling towers as capture units [6], [7]. *CAPEX* reduction are further expected from modularization and learning rates as deployment increases [8]. In parallel, research efforts focus on improving sorbent materials, capture unit design, and system integration to lower operational cost [4], [9], [10]. Despite these advances, the infrastructure scale and associated costs required for large-scale DAC remain a key barrier, motivating the exploration of alternative deployment concepts.

The research project *ConTACTFuels*, funded by the Federal Ministry for Digital and Transport in Germany, addresses the reduction of investment cost by investigating the utilization of decommissioned infrastructure of thermal power plants. A central element of this approach is the repurpose of cooling towers as capture units. Cooling towers of power plants are designed to handle air mass flows of the same order of magnitude for large-scale DAC. An assessment of installed cooling towers of power plants with a nominal net power output of >150 MW<sub>el</sub> in Germany revealed that >90 % are natural draft wet cooling towers (NDWCT). NDWCT facilitate density difference-induced air movement instead of fans as well as evaporative cooling as the main heat rejection mechanism. As the heat rejection implies direct contact between liquid and

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<sup>1</sup> Calculation based on 1.4 m/s air velocity [6] and 8 GJ/t<sub>CO<sub>2</sub></sub> specific energy demand [2].

air via spray nozzles and packings to increase the interface surface area, the internal geometry of wet cooling towers and the capture units of absorption-based DAC are highly similar. Hence, the major focus of *ConTactFuels* lies in the implementation of absorption-based processes into the cooling tower infrastructure.

In a thermodynamic analysis of repurposed power plant cooling towers as capture units (in the following *repurposing approach*), it has been shown that there is a technical trade-off between annual capture capacity of the DAC plant and the capture efficiency (i.e., ratio of actual and potential amount of CO<sub>2</sub> captured from the processed air) for each cooling tower [11]. In addition, a techno-economic analysis of the repurposed coal-fired power plant in Niederaußem has revealed a trade-off between annual capture capacity and the specific cost of the capturing process (i.e., Levelized Cost of Direct Air Capture) [12]. Building on these findings, in the present study, the techno-economic potential of the repurposing approach for coal-fired power plants is presented for Germany. Consequently, a rollout strategy for the repurpose of power plant infrastructure is proposed in this study.

## 2 Methodology

The absorption-based DAC process using aqueous potassium hydroxide (KOH) solution as the sorbent, as designed by Carbon Engineering [6], is chosen as a case study (cf. [11], [12]). Figure 1 illustrates a simplified schematic of the KOH process in Carbon Engineering's design, which consists of two cycles: a potassium hydroxide / potassium carbonate (KOH / K<sub>2</sub>CO<sub>3</sub>) cycle and a calcium hydroxide / calcium carbonate (Ca(OH)<sub>2</sub> / CaCO<sub>3</sub>) cycle. To realize a closed steady-state process, four basic process steps are required:

1. CO<sub>2</sub> separation from ambient air using KOH solution (air contactor)
2. Transfer of CO<sub>2</sub> to the second cycle (pellet reactor)
3. Heat-driven release of CO<sub>2</sub> with high purity (calciner)
4. Reconditioning of the second cycle for the pellet reactor (steam slaker)

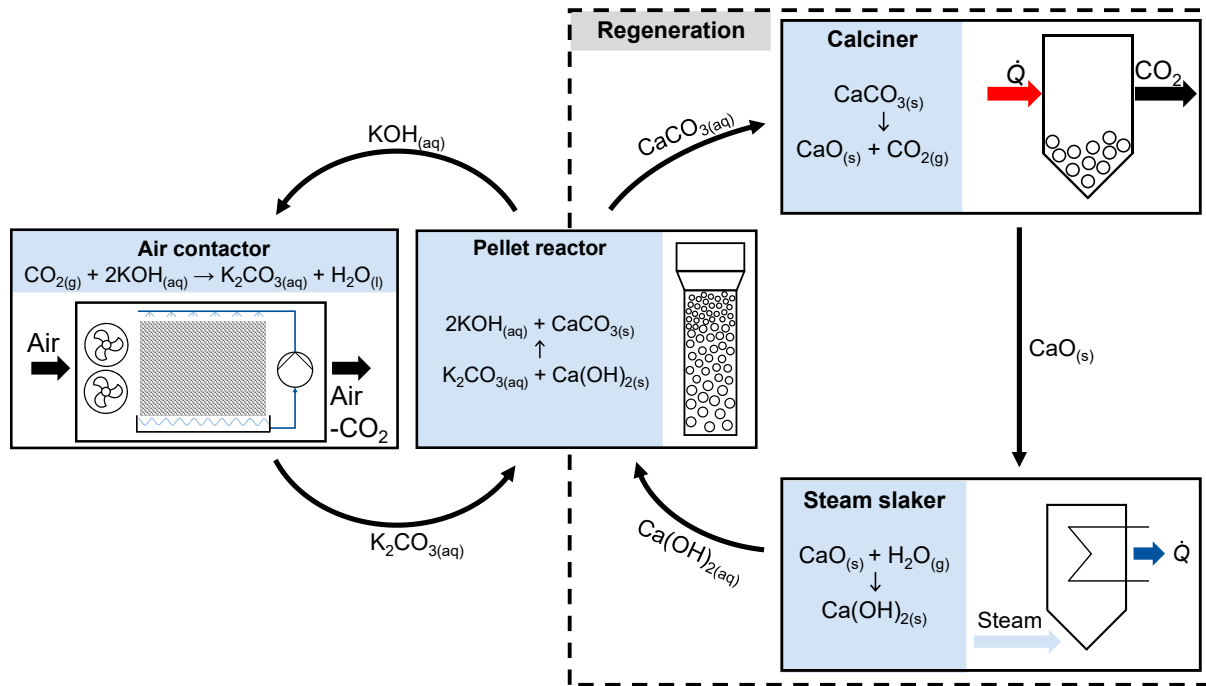


Figure 1: Schematic of the absorption-based DAC process according to Carbon Engineering's design

In the air contactor, the  $\text{CO}_2$  of the ambient air is bound chemically with dissolved  $\text{KOH}$  to form dissolved potassium carbonate ( $\text{K}_2\text{CO}_3$ ) solution. The mixture of loaded absorbent (i.e.,  $\text{K}_2\text{CO}_3$  solution) and remaining  $\text{KOH}$  solution is fed to the pellet reactor. Inside the pellet reactor,  $\text{K}_2\text{CO}_3$  reacts with a calcium hydroxide ( $\text{Ca}(\text{OH})_2$ ) solution, which regenerates the  $\text{KOH}$  solution and forms solid calcium carbonate ( $\text{CaCO}_3$ ) pellets. The regenerated  $\text{KOH}$  solution is redirected back into the air contactor. In the calciner, the bound  $\text{CO}_2$  is released from the  $\text{CaCO}_3$  pellets by the application of heat at temperatures of  $900\text{ }^\circ\text{C}$ . In Carbon Engineering's design, the heat supply is realized via an oxyfuel natural gas burner. The resulting calciner flue gas is composed of  $\text{CO}_2$  from the DAC process and combustion ( $1.89 \frac{t_{\text{CO}_2, \text{DAC}}}{t_{\text{CO}_2, \text{oxyfuel}}}$ ) as well as steam from the oxyfuel combustion. Finally, the flue gas components are separated using a condenser. To achieve complete independence from fossil fuels, research has been conducted on the use of electric calciners employing a resistance furnace [13], [14]. To close the  $\text{Ca}(\text{OH})_2 / \text{CaCO}_3$  cycle, solid calcium oxide ( $\text{CaO}$ ) at the outlet of the calciner is regenerated with steam to form  $\text{Ca}(\text{OH})_2$ .

The  $\text{KOH}$ -based DAC process with a repurposed cooling tower as air contactor is shown in Figure 2. The absorbent cycle is a simplified form of the design proposed by Keith et al. [6]. The air contactor performance of the repurposed cooling tower (i.e., the captured  $\text{CO}_2$  mass flow) is described by a process model, which has been proposed in Sager et al. [11] to incorporate the effect of fixed geometric boundary conditions of repurposed power plant infrastructure (i.e., primarily the cooling tower). Thus, the capture efficiency (capture rate,  $CR$ ) can be formulated as:

$$CR = \frac{x_{\text{CO}_2} - x_{\text{CO}_2,0}}{x_{\text{CO}_2,0}} = 1 - e^{-K_L \cdot He_{\text{CO}_2}^{\text{abs}} \cdot \frac{R \cdot T}{M_{\text{CO}_2}} \cdot SSA \cdot \frac{H_{\text{pack}}}{v_{\text{air}}}}$$

Based on  $CR$ , the captured  $\text{CO}_2$  mass flow is determined:

$$\dot{m}_{\text{CO}_2} = CR \cdot x_{\text{CO}_2} \cdot \frac{M_{\text{CO}_2}}{M_{\text{air}}} \cdot \dot{m}_{\text{air}}$$

The regeneration process is a black box, which scales the energy demand of regeneration linearly with the captured CO<sub>2</sub> mass flow. To ensure the validity of the linear scaling assumption, the concentrations at the inlet of the pellet reactor (point 6) given by Keith et al. are kept constant by using a bypass (point 8).

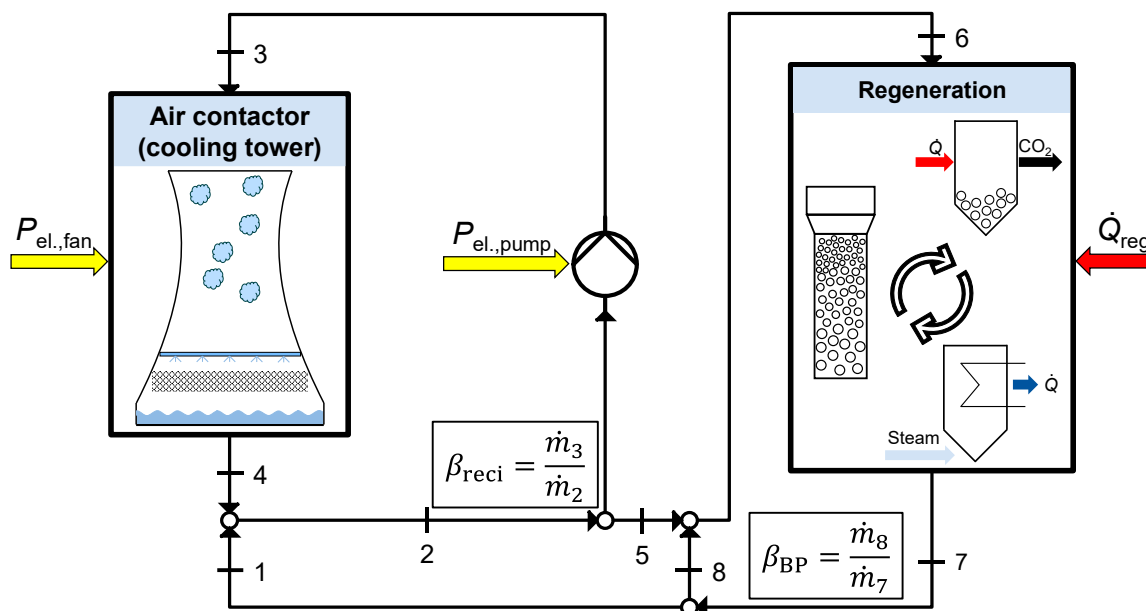


Figure 2: Simplified depiction of the modeling of the power plant DAC system

## 2.1 Technical evaluation

Key performance indicators (KPI) to assess the thermodynamic performance of the process are  $CR$ , the captured CO<sub>2</sub> mass flow and the specific energy consumption of the process ( $SEC$  in [GJ/t<sub>CO2</sub>]), which comprises the electrical demands of the fans and pumps in the absorption cycle as well as the heat demand of the calciner in the regeneration cycle.

Two degrees of freedom influencing the performance of the repurposed cooling tower in the DAC process are the air and absorbent mass flows. Figure 3 illustrates the impact of the air and absorbent mass flows on the captured CO<sub>2</sub> mass flow per year (in the following: *annular capture capacity*) as well as the  $SEC$  for the repurposed cooling tower of power plant block H in Niederaußem (Germany). It can be seen that increasing air and absorbent mass flows increase the annular capture capacity with a decreasing gradient. Moreover,  $SEC$  decreases with increasing air mass flows below an absorbent mass flow-dependent threshold. Thus, the sharp increase of the annular capture capacity overcompensates the increase in fan power demand at low air mass flows. However, beyond the threshold, higher air and absorbent mass flows increase  $SEC$  significantly. Consequently, the choice of air and absorbent mass flow is a trade-off between the anticipated annular capture capacity and the resulting energy demand of the repurposed power plant DAC facility.

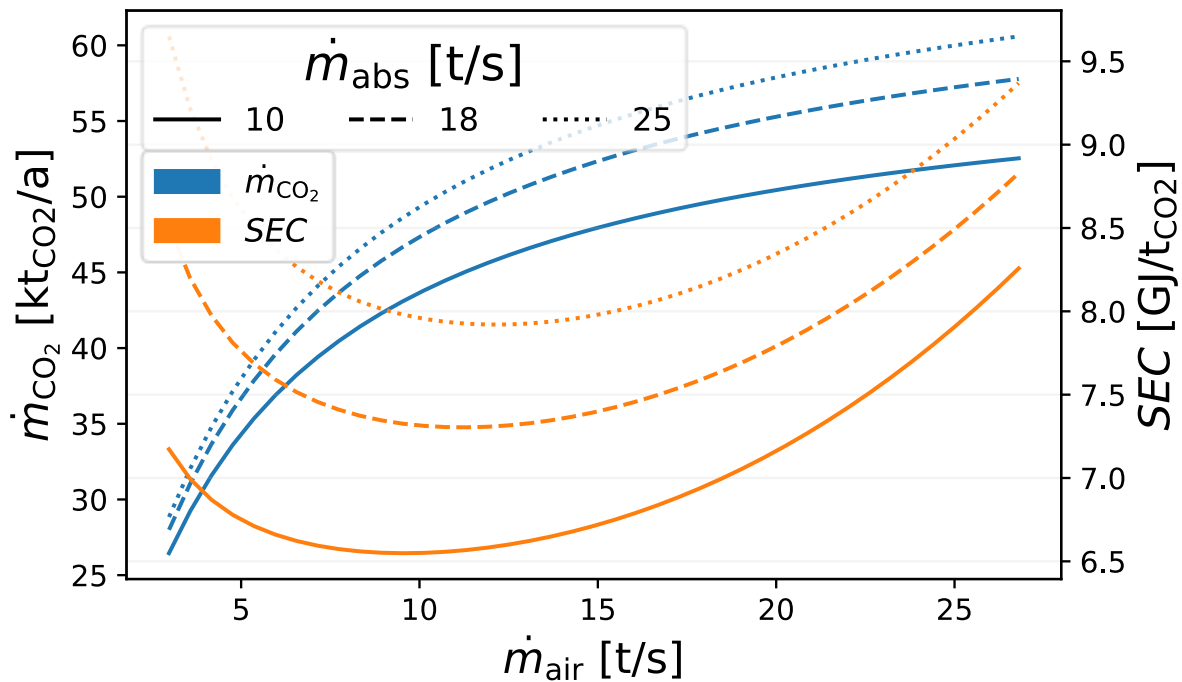


Figure 3: Annual capture capacity and specific energy consumption of a DAC plant based on the cooling tower of block H in Niederaußem (Germany) depending on air and absorbent mass flows

## 2.2 Techno-economic evaluation

The Levelized Cost of Direct Air Capture (*LCODAC*) is identified as a common and favorable performance metric. *LCODAC* comprises capital (*CAPEX*) and operational expenditure (*OPEX*). *OPEX* are further distinguished between fixed (e.g., maintenance) and variable (e.g., electricity procurement cost).

$$LCODAC = CAPEX + OPEX_{\text{fix}} + OPEX_{\text{var}}$$

$$CAPEX = crf \cdot \frac{I_0}{m_{\text{CO}_2}}$$

$$crf = \frac{(i+1)^n \cdot i}{(i+1)^n - 1}$$

$$OPEX_{\text{fix}} = \frac{x_{\text{OPEX,fix}} \cdot I_0}{m_{\text{CO}_2}}$$

$$OPEX_{\text{var}} = k_{\text{el}} \cdot SEC_{\text{el}} + k_{\text{gas}} \cdot SEC_{\text{th}}$$

Assuming a repurposed natural draft cooling tower as an air contactor of a DAC plant, the required fans must be retrofitted during the construction of the DAC plant. Consequently, *CAPEX* of the power plant DAC facility is evaluated considering the cost breakdown given by Keith et al. [6] without the air contactor cost excluding the fan cost (cf. [12]). The investment cost is scaled to the annular capacity of the DAC plant and given in €<sub>2030</sub> in accordance with [12]. *OPEX<sub>fix</sub>* are represented by a constant share of the investment cost  $x_{\text{OPEX,fix}}$ , while *OPEX<sub>var</sub>* is calculated using a constant electricity  $k_{\text{el}}$  and gas price  $k_{\text{gas}}$ . Further assumptions and detailed information can be found in Table A1 in the Appendix.

In previous techno-economic assessments of the repurposed power plant site at Niederaußem (Germany) the air and absorbent mass flows of each individual cooling tower have been adjusted to ensure minimum *LCODAC* at a targeted captured CO<sub>2</sub> mass flow. As a result, the variation of the targeted captured CO<sub>2</sub> mass flow has revealed a minimum *LCODAC* for the power plant DAC system. The resulting minimum is composed of the cost reduction with increasing plant size (i.e., scaling effects) and the increasing operating costs for higher absorbent and air mass flows to meet the targeted CO<sub>2</sub> mass flow. To achieve a reduction in *LCODAC* at this minimum compared to a newly built DAC plant of the same annular capture capacity and a lifetime of 25 years, the lifetime of the repurposed power plant DAC facility must be greater than 15 years if solely the air contactor is replaced by the cooling tower.

The present study broadens the techno-economic analysis of the repurposing approach to coal-fired power plants in Germany. Therefore, 8 lignite-fired as well as 12 hard coal-fired power plants with NDWCT with a net power output >150 MW<sub>el</sub> are assessed. Required geometry data of the power plants is provided by the corresponding operators or is extrapolated by using available information about similar cooling towers if the required information about the cooling tower packing is not available. An overview of the assessed power plant sites is available in Table 1. According to [12], lifetime of the power plant DAC facility of 10 – 25 years is compared to a newly built DAC plant with a lifetime of 25 years. As illustrated in Sager et al. [12], *LCODAC* show a minimum at a certain annular capture capacity, which is evaluated and compared for each power plant site.

### 3 Results

Figure 4 illustrates the minimum *LCODAC* results for the assessed power plant sites in Germany as well as the corresponding annular capture capacities for a 25-year lifetime under optimistic energy procurement cost conditions. As low-emission energy supply is required to ensure a net-emission-negative CO<sub>2</sub> capture process, the background color indicates the local availability of photovoltaic (PV) and wind power. The given range in minimum *LCODAC* depicts the range between the different sites. The highest annular capacities and lowest *LCODAC* can be achieved for the lignite-fired power plant sites as the number and size of cooling towers is higher (i.e., corresponding to the net power output). Consequently, the lignite-fired sites would provide a total annular capacity of 1.5 Mt<sub>CO<sub>2</sub></sub>/a with an average cost reduction potential of 11.7 % compared to a newly built DAC plant if both plants have a lifetime of 25 years. Moreover, the availability of renewable energy is higher at the lignite-fired sites, which further favors lignite-fired sites. Nevertheless, hard coal-fired sites still have a relevant cost reduction potential of 9.2 % and would contribute to the total potential of annular capacity with 0.8 Mt<sub>CO<sub>2</sub></sub>/a. Among the hard coal-fired power plants, the sites in Staudinger, Datteln, and Walsum show the most competitive *LCODAC* compared to lignite-fired sites. On the other hand, the site in Zolling indicates the highest *LCODAC* as well as negative cost reduction potential compared to a newly built DAC plant of the same annular capacity. To further emphasize the cost reduction potential compared to the newly built DAC plant and minimum *LCODAC*, Table 2 illustrates the results for the evaluated energy procurement cost scenarios, lifetimes and coal types. It can be observed that the sensitivity of the cost reduction potential to the lifetime is higher for lower energy procurement cost as the share of CAPEX of *LCODAC*



## 4 Discussion

The results of the study illustrate the potential to accelerate the deployment of DAC in Germany through the repurposing power plant infrastructure. According to the International Energy Agency, a global annular DAC capacity of 90 Mt<sub>CO2</sub>/a in 2030 will be required [3], indicating that Germany could provide a substantial contribution to negative emissions. However, the results presented in this study constitute a theoretical potential assessment with high uncertainty. The current cost is based solely on reusing the cooling tower as an air contactor. Additional infrastructure utilization could further reduce the *LCODAC*. Conversely, necessary infrastructure conversions such as renovating cooling towers to withstand caustic atmospheres, could increase costs, which are not accounted for in the present assessment. Moreover, the lifetime of a power plant DAC facility is a critical factor for its techno-economic feasibility.

To reduce the uncertainty of the potential evaluation, the following aspects require further investigation:

- the choice of absorbent and its mass transfer performance,
- pressure losses inside a cooling tower packing,
- maintenance and renovation requirements.

A holistic, interdisciplinary investigation is therefore necessary to support a potential rollout of the repurposing approach while mitigating technical and economic risks. Figure 5 outlines the individual work steps and topics to be addressed. A key step in the proposed transition strategy is to improve the theoretical evaluations with laboratory tests (Phase 2). Therefore, the focus is to investigate the absorber performance with different absorbents and packing materials as well as variations in air and absorbent mass flows in a laboratory-scale cooling tower. Moreover, the specific conversion and renovation requirements on the cooling tower and the rest of the site must be clarified for the repurpose in a DAC. Building up on the aforementioned work packages, the presented techno-economic assessment can be expanded to assess social acceptance and ecological impacts of the repurposing approach. Following the lab-phase investigations, a first demonstration in an industrial cooling tower must be performed to further validate the results and complete Phase 2. The outcome of Phase 2 will determine whether Phase 3 can proceed or the project should be discontinued. In Phase 3, the repurposing approach will be implemented in cooperation with power plant operators. Initial demonstrators should focus on smaller cooling towers to enable scale-up to toward a full-site demonstration of the approach.

The presented results and rollout strategy are intended to facilitate the large-scale deployment of DAC and reduce barriers to widespread installation. Nonetheless, the construction of new greenfield DAC plants with annular capture capacities exceeding 1 Mt<sub>CO2</sub>/a could achieve lower *LCODAC* than repurposed power plant DAC facilities. Consequently, the construction of newly built DAC plants should remain a component of the overall rollout strategy.

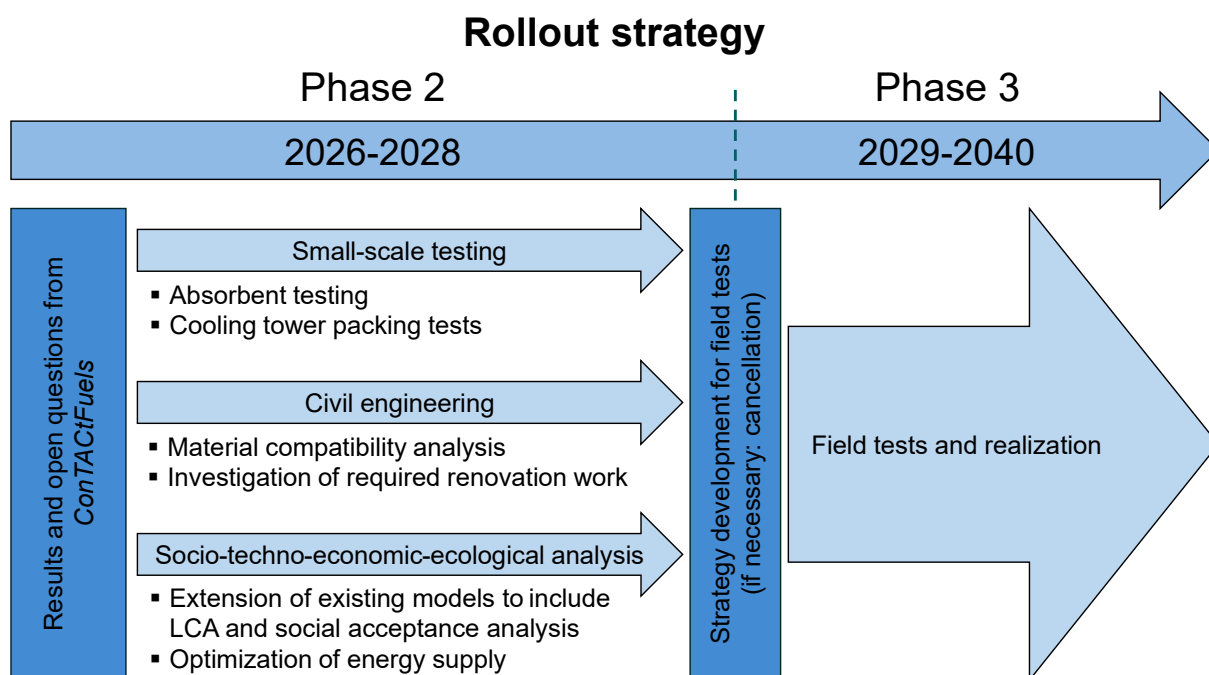


Figure 5: Overview of rollout strategy

## 5 Conclusion and outlook

The present paper explores the theoretical techno-economic potential of the repurpose of power plant infrastructure as Direct Air Capture (DAC) plants for Germany. Within this scope, the repurpose of cooling towers as capture units (air contactors) of absorption-based cooling towers is the main objective of this study. The repurpose of the cooling tower is modeled by a thermodynamic mass transfer model and evaluated for varying annular capture capacities considering the Levelized Cost of Direct Air Capture (*LCODAC*) as key performance indicator. All coal-fired power plant sites in Germany with a net power output  $>150 \text{ MW}_{\text{el}}$  with a natural draft wet cooling tower (NDWCT) are evaluated for lifetimes between 10 and 25 years. Key results of the present study are:

- The repurpose of NDWCT as air contactors of DAC plants has the potential of a total annular capacity of  $2.3 \text{ Mt}_{\text{CO}_2}/\text{a}$ , which would contribute with roughly 2.5 % to the negative emission goals predicted by the International Energy Agency [2].
- The *LCODAC* reduction potential compared to a newly built DAC plant depends on the overall size (i.e., power output) of the repurposed plants as well as the corresponding number and size of cooling towers.

For a rollout of the repurpose of power plant infrastructure, additional interdisciplinary research is required to decrease the uncertainty in the calculated techno-economic potential. Therefore, future studies should focus on the implemented absorption-based DAC process, rising civil engineering questions of the repurposing approach and a broader socio-techno-economic-ecologic potential evaluation.

## 6 Nomenclature

Symbol	Description	Unit
$\beta$	Mass flow ratio	-
CAPEX	Capital expenditure	€/t <sub>CO2</sub>
crf	Capital return factor	-
CR	Capture rate	-
H	Height	m
He	Henry coefficient	mol Pa/m <sup>3</sup>
K <sub>L</sub>	Mass transfer coefficient	kg m/(s mol)
LCODAC	Levelized cost of Direct Air Capture	€/t <sub>CO2</sub>
$\dot{m}$	Mass flow	kg/s
M	Molar mass	kg/mol
OPEX	Operational expenditure	€/t <sub>CO2</sub>
P	Power	W
$\dot{Q}$	Heat flow	W
R	Gas constant	J/(mol K)
SEC	Specific Energy Consumption	
SSA	Surface-area-to-volume ratio	m <sup>2</sup> /m <sup>3</sup>
T	Temperature	K
v	Velocity	m/s
x	Mole fraction	-
<b>Abbreviation and indices</b>		
abs	Absorbent	
BP	Bypass	
DAC	Direct Air Capture	
el	electrical	
KPI	Key Performance Indicators	
NETs	Negative Emission Technologies	
pack	Packing	
reci	Recirculating	
var	variable	

## 7 Appendix

	Name	Unit	Optimistic	Conservative	Comments	Reference
Investment costs	Air contactor	[M€ <sub>2030</sub> ]	280.8		Data for a KOH-based DAC plant based on Carbon Engineering's design (adjusted for inflation) with an annual capacity of 1 Mt <sub>CO2</sub> /a. The breakdown of the costs of calciner and steam slaker according to the values of Young et al.[15]	[6]
	Pellet reactor	[M€ <sub>2030</sub> ]	173.0			[6]
	Calciner	[M€ <sub>2030</sub> ]	64.3			[6]
	Steam slaker	[M€ <sub>2030</sub> ]	38.6			[6]
	Air separation unit	[M€ <sub>2030</sub> ]	71.9			[6]
	CO <sub>2</sub> compressor	[M€ <sub>2030</sub> ]	26.3			[6]
	Steam turbine	[M€ <sub>2030</sub> ]	9.9			[6]
	Filter	[M€ <sub>2030</sub> ]	40.9			[6]
	Further components	[M€ <sub>2030</sub> ]	136.2			[6]
	Buildings	[M€ <sub>2030</sub> ]	8.9			[6]
	Transformer	[M€ <sub>2030</sub> ]	26.2			[6]
	Fans	[€ <sub>2030</sub> /m <sup>2</sup> ]	1155.40			[6]
Operating cost	Fixed operational cost	[% <sub>Invest</sub> ]	3.7		Mean value of Carbon Engineering	[6]
	Electricity price	[€ <sub>2030</sub> /MWh]	52	135		[16]
	Gas price	[€ <sub>2030</sub> /MWh]	18	59		[16]
Scaling factors	Air contactor	[-]	1			[6]
	Pellet reactor	[-]	1			[6]
	Calciner	[-]	0.7447		Calculated	[6]
	Steam slaker	[-]	0.57			[8]
	Air separation unit	[-]	0.67			[8]
	CO <sub>2</sub> compressor	[-]	0.73			[8]
	Filter	[-]	0.67			[8]
	Further components	[-]	0.7		Assumption based on Sievert et al. [8]	
Further assumptions	Lifetime of repurposed power plant of DAC	[a]	10	25	Assumption based on RWE	
	Lifetime of Carbon Engineering	[a]	25			[6]
	Interest rate <i>i</i>	[%]	7			[8]

Table A2: Information of the considered power blocks of the coal-fired power plant in Niederaußem (Germany)

Power plant site	$P_{el}$ [MW <sub>el</sub> ]	Type of coal	Type of cooling tower	Number of cooling towers
Bergkamen	720	Hard coal	NDWCT	1
Bexbach	726	Hard coal	NDWCT	1
Boxberg	2639	Lignite	NDWCT	5
Datteln	1052	Hard coal	NDWCT	1
Herne	435	Hard coal	NDWCT	1
Heilbronn	778	Hard coal	NDWCT	1
Jänschwalde	2000	Lignite	NDWCT	4
Lippendorf	1782	Lignite	NDWCT	2
Lünen	746	Hard coal	NDWCT	1
Neurath	2120	Lignite	NDWCT	2
Niederaußem	2356	Lignite	NDWCT	3
Rostock	514	Hard coal	NDWCT	1
Schkopau	900	Lignite	NDWCT	2
Scholven	690	Hard coal	NDWCT	2
Schwarze Pumpe	1510	Lignite	NDWCT	2
Staudinger	522	Hard coal	NDWCT	1
Walsum	725	Hard coal	NDWCT	1
Weiherr	655	Hard coal	NDWCT	1
Weisweiler	1399	Lignite	NDWCT	2
Zolling	472	Hard coal	NDWCT	1

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