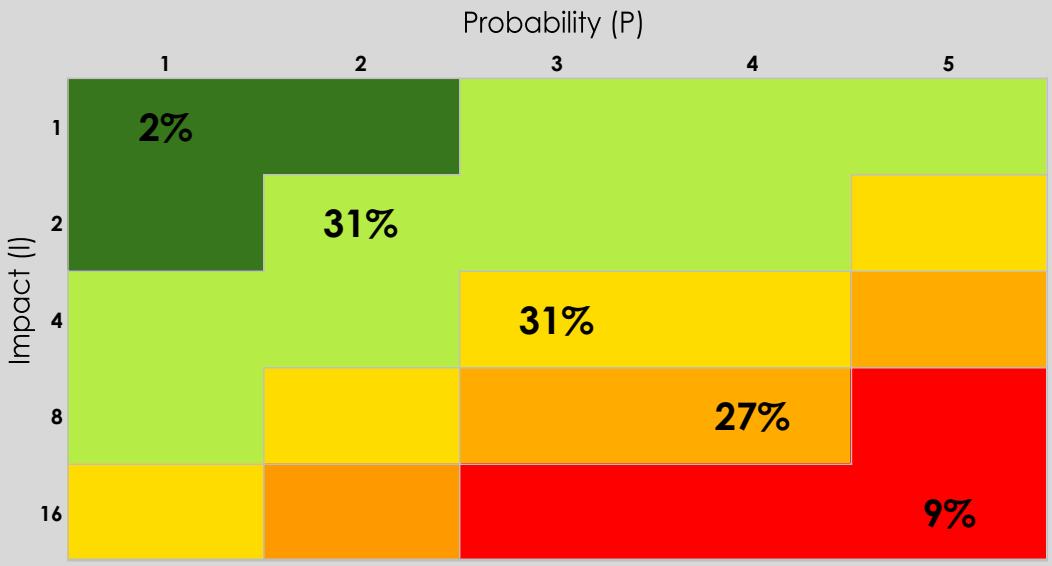
CETP Carbon Rhine Route project
Deliverable 4.1b: Risk mapping workshop – Taxonomy, heat map and risk register
26 June 2024

This research was funded by CETPartnership, the Clean Energy Transition Partnership under the 2022 CETPartnership joint call for research proposals, co-funded by the European Commission (GA N°101069750) and with the funding organizations detailed on https://cetpartnership.eu/funding-agencies-and-call-modules.

The project is supported by the French Environment and Energy Management Agency ADEME and the Swiss Federal Office of Energy SFOE.

Term		Definition
Status	**Active**	Currently in effect or ongoing
	Dormant	Temporarily inactive or on hold
	Retired	Permanently inactive or concluded
Type Risk	**Danger**	Potential negative impact or threat
	Opportunity	Potential positive impact or benefit
Phase	**01_Construction**	Initial building and development stage
	02_Operation	Active use and functioning phase
	03_Construction & Operation	Both contruction and operation phases
	04_Post closure	After project completion or decommisioning
Risk category	**01_Regulatory and political risks**	Issues with laws and government actions
	02_General market risks	Fluctuations in market conditions
	03_Financial risks	Economic and funding challenges
	04_Project management risks	Issues in project planning and execution
	05_Technological risks	Problems with technology and innvoation
	06_Supplier risks	Uncertainties with suppliers and supply chains
	07_CDR demand risks	Fluctuations in demand for carbon dioxide removal
	08_Stakeholders and reputation risks	Concerns related to stakeholders and their interest
	09_Health and safety risks	Potential harm to people
	10_Environmental risks	Negative impacts on the environment
	11_Operation and maintenance risks	Challenges in ongoing operations and upkeep
	12_Transportation risks	Issues in CO2 transport
	13_Storage risks	Issues in CO2 storage
	14_Societal risks	Public perception and societal impact
Impact	**Costs**	Financial implications
	Time	Schedule and timing effects
	Scope	Changes in project extent or boundaries
	Quality	Effects on standards and performance

Risk heat-map



P-I value • 1 – 80		Number
1 – 2	Negligible	1
3 – 8	Small	17
10 – 16	Moderate	17
20 – 32	High	15
40 – 80	Critical	5

Total Risks	55
of which "Threat"	49
of which "Opportunity"	4

Probability 1-5	Impact 1-16
1 - Rare	1 - Insignificant
2 - Unlikely	2 - Minor
3 - Possible	4 - Moderate
4 - Probable	8 - Large
5 - Almost certain	16 - Heavy

Risk mapping and evaluation

Risk identification ("Due to a cause or condition, a risk event may occur that has an impact on either the cost, time, scope or quality").							Quantitative risk assessment			Risk mitigation	
Risk Ref.	Status	Phase	Risk category	Risk event	Cause / Condition	Impact	Probability (1-2-3-4-5)	Impact (1-2-4-8-16)	P x I	Mitigation strategy	Mitigation measures
1		02_Operation	01_Regulatory and political risks	Requirements for the use of biomass for BECCS (e.g. National Biomass Strategies; EU Directives)	National biomass strategy severely restricts thermal use of wood or other uses of sustainable biomass.	Prices for available sustainable biomass rise (demand exceeds supply). Wood-fired power plants (and capture plants) are only operated at peak times. Costs per ton of	3	16	48	Reduce or mitigate risk	Negotiate long-term supply contracts for biomass. Optimization of the use of biomass, long-term purchase agreements with CDR buyers that include dynamic pricing
2		02_Operation	01_Regulatory and political risks	Requirements for certification of BECCS projects (e.g. regarding sustainability of biomass - under CRCF, RED III, VCM standards)	Requirements for certification of BECCS projects are tightened after commissioning of the CCS project (e.g. regarding sustainability of biomass - under CRCF, RED III, VCM standards)	Project can no longer be certified (e.g. because biomass no longer meets the sustainability criteria)	4	2	8	Reduce or mitigate risk	Regular monitoring of the development of certification standards. If necessary, adapt the biomass used at an early stage. Possibly consider a standard with lower requirements.
3		02_Operation	01_Regulatory and political risks	New national or international safety requirements for handling CO2 (storage and transportation)	Regulations for CO2 transportation by rail will be tightened (following an accident): Limited number of wagons per train / maximum permitted volume in intermediate storage facilities near settlements is reduced.	Higher logistics costs as economies of scale (pooling of CO2, dedicated trains that only transport CO2) are no longer possible	2	16	32	Transfer risk	Transfer risk to transport company.
4		02_Operation	01_Regulatory and political risks	Amendment to the Carbon Dioxide Storage Act (KSpG – Germany only)	KSpG allows CO2 storage in Germany (onshore and offshore)	Costs for CO2 transport and storage fall	2	16	32	Accept risk	Possibly include a dynamic pricing system in the sale of CDRs - pass on cost reductions to customers (transparency regarding costs as a confidence-building measure)
5		02_Operation	01_Regulatory and political risks	Changes to the EU Emissions Trading Directive (EU ETS)	Negative emissions are integrated into the EU ETS	Higher demand for CDRs	3	8	24	Accept risk	Possibly include a dynamic pricing system in the sale of CDRs - pass on cost reductions to customers (transparency regarding costs as a confidence-building measure)
6		03_Construction & Operation	01_Regulatory and political risks	Nitrosamine or other chemical emissions	The regulations for nitrosamine or other chemical emissions from separation plants are tightened	Building permit for separation plant is not approved because it does not meet the requirements	2	8	16	Transfer risk	Contractual assurance with technology supplier / O&M partner that system complies with limit values. Should be addressed in permitting phase
7		03_Construction & Operation	01_Regulatory and political risks	Ratification of the amendment to the London Protocol	Government ratification of the London Protocol is delayed	Captured CO2 cannot be exported for geological storage (in the seabed)	3	4	12	Reduce or mitigate risk	Early negotiations with storage providers who store CO2 on land (e.g. in Denmark). To be addressed pre FID
8		03_Construction & Operation	01_Regulatory and political risks	Change in national or EU net-zero strategy	Elections lead to governance which affects net-zero target.	Negative emission technologies such as BECCS are no longer promoted. Demand for CDRS falls. Project is no longer financially viable and may have to be discontinued.	3	8	24	Accept risk	Lobbying to promote BECCS projects, development of alternative business models
9		03_Construction & Operation	01_Regulatory and political risks	Inclusion of waste incineration plants in the EU ETS	EU decides that waste incineration plants will be included in the EU ETS from 2028 (fossil emissions only)	Waste incineration plants equipped with CCS. This results in lower costs	4	2	8	Accept risk	Possibly include a dynamic pricing system in the sale of CDRs - pass on cost reductions to customers (transparency regarding costs as a confidence-building measure)
10		03_Construction & Operation	01_Regulatory and political risks	New EU regulations	EU adopts new rules which have an impact on BECCS (CRCF, Green Claims Directive)	Effect on demand for CDRs by corporate buyers	3	8	24	Accept risk	Regular monitoring of CDR-relevant regulatory developments.
11		03_Construction & Operation	01_Regulatory and political risks	No regulatory framework for robust CDR business models in long term (mandatory demand for CDR)	Lack of long-term policy commitments and regulatory uncertainty around CDR, including absence of mandatory demand mechanisms or integration into compliance markets	Limits investment incentives, creates uncertainty for project financing and reduces the ability to scale CDR operations sustainably	3	16	48	Reduce or mitigate risk	Actively participate in policy discussions and industry groups to push for CDR inclusion in compliance markets (e.g., EU ETS integration). Develop voluntary market opportunities to reduce dependency on regulatory frameworks.
12		02_Operation	02_General market risks	Energy prices	Energy prices rise significantly	Costs for CO2 capture are rising - operation is no longer economical	4	4	16	Reduce or mitigate risk	Negotiate long-term energy contracts, further cost optimization, long-term purchase agreements with CDR buyers that include dynamic pricing Index CDR price to energy price if possible (as done in merchant CO2)
13		02_Operation	02_General market risks	Development of new energy sources	New energy sources (e.g. nuclear fusion, etc.) make the use of biomass for energy superfluous.	Wood-fired power plants and biomethane plants cease operation. BECCS no longer possible	1	16	16	Accept risk	
14		03_Construction & Operation	02_General market risks	Currency and interest rate changes	Interest rates rise / EUR loses value against other currencies	Higher CAPEX and OPEX reduce the profitability of the project	2	2	4	Reduce or mitigate risk	Currency hedging and other hedges
15		03_Construction & Operation	02_General market risks	Global crises (economy, conflicts, climate, health)	Geopolitical tensions, financial crisis, climate catastrophes, epidemics	Climate protection is given lower priority by politics and business. Negative emissions are seen as a 'luxury' and are reduced to a minimum.	4	8	32	Reduce or mitigate risk	Conclude long-term contracts with CDR buyers
16		01_Construction	03_Financial risks	Access to subsidies	Planned or existing national or international funding programs for BECCS are suspended or cancelled	Planned subsidies cannot be secured. IRR is too low without funding. FID is not taken until financing is clarified.	2	16	32	Reduce or mitigate risk	Search for alternative funding programs, private investments, state buyers
17		01_Construction	03_Financial risks	Higher CAPEX	Insufficient planning and controlling in the construction phase	Cost overrun in construction of CO2 capture plant / interim storage facility	2	8	16	Reduce or mitigate risk	Detailed budget planning, regular cost checks, allow for risk buffer. If necessary, transfer risk to general contractor (turn-key solution with fixed price)
18		01_Construction	04_Project management risks	Change in emitters' management's strategy	Emitter management decides to stop using e.g. wood-fired power plants for energy and heat supply. Focus on geothermal energy, solar and wind	Some BECCS projects are no longer realized.	3	16	48	Accept risk	Development and investment in geothermal, solar and wind energy projects Establish multi-year biogenic CO2 supply contract with emitters
19		01_Construction	04_Project management risks	Coordination between technology suppliers and/or with internal stakeholders	Insufficient coordination between technology suppliers and internal stakeholders	Delays, cost overruns or loss of quality	3	4	12	Reduce or mitigate risk	Regular meetings and communication, clear responsibilities and competencies
20		01_Construction	04_Project management risks	Delay in building permit	Delay in the preparation of an 'environmental impact assessment' for the project	Delayed start of construction and probably commissioning of the project. Delayed income from sale of CDRs.	3	4	12	Reduce or mitigate risk	Involvement of experts for environmental impact assessments, timely submission of the required documents. Permitting finalised pre FID
21		01_Construction	04_Project management risks	Delay in construction / sub-projects	Various reasons	Commissioning of the BECCS system is delayed. Higher costs as revenues are delayed	3	2	6	Transfer risk	Contractual security vis-à-vis the general contractor.
22		02_Operation	05_Technological risks	Technological advancement of CO2 capture systems	More efficient CO2 capture systems reach market maturity	Cost disadvantage of existing capture plants compared to new plants (e.g. more competition from cheaper CDRs from 'new' plants)	3	4	12	Reduce or mitigate risk	Process optimizations, long-term purchase agreements with CDR buyers that include dynamic pricing
23		02_Operation	05_Technological risks	Maintenance costs	Corrosion of the CCS system is higher than planned	Shorter maintenance intervals reduce the annual operating hours and increase the costs for maintenance / spare parts	3	4	12	Transfer risk	Contractual guarantees from technology and O&M providers including claims for damages. Corrosion and other failure mechanisms to be considered
24		02_Operation	05_Technological risks	Retrofitting the liquefaction plant	CO2 pipeline arrives earlier than expected. Liquefaction plant must now compress CO2 to 'supercritical'. (Impact for fluegas projects is limited, but higher for biogas projects as means	Additional CapEx costs (as well as OpEx as more electricity is needed). However, transportation costs decrease	1	8	8	Accept risk	Unlikely for small projects, at least 10 years visibility for pipelines
25		03_Construction & Operation	05_Technological risks	Technology performance	CO2 capture rate is lower than planned	Small amount of CO2 is captured. Costs per ton of CO2 are higher than planned.	3	4	12	Transfer risk	Contractual assurance with technology supplier that agreed efficiency is achieved.
26		02_Operation	06_Supplier risks	Biomass availability	Supply bottlenecks and delays in biomass delivery	Operation of plants (energy and separation) must be reduced	4	8	32	Transfer risk	Long-term procurement contracts with penalties if contractually agreed quantities cannot be delivered.
27		02_Operation	06_Supplier risks	Availability and costs of the amine solution	Demand for amine solutions for CCS plants exceeds supply	Higher costs for amine solutions	2	4	8	Transfer risk	Long-term procurement contracts with penalties if the contractually agreed quantity cannot be delivered. Regularly obtain offers from other providers.
28		02_Operation	06_Supplier risks	Availability of biomass	Extreme weather events such as heat lead to lower availability of biomass + competition for biomass	Operation of the biomethane plant and wood-fired power plants must be reduced. Accordingly, lower quantities of CO2 are captured. The costs per ton of CO2 increase.	3	8	24	Accept risk	Force-majeur clause in contracts with storage providers
29		02_Operation	06_Supplier risks	Reputation of certification authorities	Certification body/standard used comes under criticism.	Market value of CDRs falls	2	4	8	Reduce or mitigate risk	Establish multi year offtake agreements
30		03_Construction & Operation	06_Supplier risks	Bankruptcy of a supplier	Supplier ceases business activities	Lack of operating resources. Possible interruption of operations	2	2	4	Reduce or mitigate risk	IP transfer clauses in contract with OEM
31		02_Operation	07_CDR demand risks	Oversupply of CDRs in the EU region	Lack of demand. A large number of large BECCS projects in the EU are close to FID and are looking for future buyers of larger volumes of CDRS	Difficulty in securing long-term 'offtaker agreements'. Competition from BECCS projects that can offer cheaper CDRS (access to cheaper biomass, shorter transportation	3	16	48	Reduce or mitigate risk	FID only with the conclusion of long-term purchase agreements for CDRs. Sell CDRs as part of a portfolio (with cheaper CDRs). Focus sales on the public sector (LHM and Bavaria).
32		02_Operation	07_CDR demand risks	High price sensitivity of buyers	CDR buyers are not prepared to buy 'expensive' CDRs	Lack of demand for own CDRs. Revenues lower than planned	3	8	24	Reduce or mitigate risk	Develop long-term offtake agreements and explore cost-sharing or incentive mechanisms to enhance buyer affordability.
33		02_Operation	07_CDR demand risks	Oversupply of 'cheap' CDRS	Large number of Biochar projects	Lack of demand for own CDRs. Revenues lower than planned	2	8	16	Reduce or mitigate risk	Advocate for policy frameworks that incentivize a diversified CDR portfolio and c
34		02_Operation	07_CDR demand risks	CDR in corporate sustainability strategies	Companies' sustainability strategies contain little CDR	Lack of demand for own CDRs. Revenue lower than planned	2	8	16	Reduce or mitigate risk	Contribute to market education (e.g. through national associations such as DVNE and AFEN)
35		02_Operation	07_CDR demand risks	Reduced climate ambitions of companies	Economic environment causes companies to reduce their climate ambitions	Lack of demand for own CDRs. Revenue lower than planned	1	8	8	Reduce or mitigate risk	Establish multi year offtake agreements
36		02_Operation	08_Stakeholders risks	Negative media coverage and publicity	BECCS scandals outside emitter's sphere of influence (incl role of oil and gas lobby)	Less support for the project from politicians and SWM management	3	4	12	Accept risk	Regular & transparent communication about own efforts, safety and quality standards
37		03_Construction & Operation	08_Stakeholders risks	Acceptance of BECCS projects by taxpayers	High project costs lead to low acceptance by taxpayers	Reduced support/fewer CDR purchases by the public sector	3	4	12	Reduce or mitigate risk	Increase transparency on cost-benefit trade-offs and engage the public early through education, stakeholder dialogues and just transition policies
38		03_Construction & Operation	08_Stakeholders risks	Change in local government composition	New local government is less 'green'	Local government/ emitter suspends BECCS projects	3	2	6	Accept risk	
39		01_Construction	09_Health and safety risks	Accidents and injuries during construction work	Lack of compliance with safety regulations	Injuries, deaths lead to delays	1	8	8	Reduce or mitigate risk	Training and regular safety checks, provision of protective equipment EHS policy
40		02_Operation	09_Health and safety risks	Leak at liquefaction plant	CO2 escapes in the event of a leak at the liquefaction plant	Health impact on staff / local population. Negative reporting. Shutdown of the CO2 capture plant	1	4	4	Reduce or mitigate risk	Implement rigorous leak detection systems, regular maintenance protocols and emergency response plans to minimize risk and ensure rapid containment
41		02_Operation	10_Environmental risks	Nitrosamine or other emissions	During operation, there are higher emissions (either in general or due to an incident) which exceed the maximum permitted quantity.	Health impact on personnel / local population. Negative reporting. Shutdown of the CO2 capture plant	2	16	32	Transfer risk	Contractual guarantees from technology and O&M providers
42		02_Operation	10_Environmental risks	Biomass sourcing: negative impact on soil, water, air quality or biodiversity	Unsustainable biomass harvesting practices, land-use change, excessive water consumption or air pollution from biomass processing could degrade ecosystems and harm biodiversity	Environmental damage, regulatory scrutiny, loss of public trust, and potential restrictions on biomass sourcing for BECCS	3	8	24	Reduce or mitigate risk	Implement strict sustainability criteria, source certified biomass (e.g., FSC, PEFC), conduct life-cycle assessments and engage stakeholders on responsible sourcing practices
43		02_Operation	11_Operation and maintenance (O&M) risks	Lack of skilled workers	The training of skilled workers for the operation and maintenance of CCS plants is not keeping pace with the commissioning of new CCS plants	Personnel costs for skilled workers are rising. Bottlenecks lead to business interruption	4	4	16	Reduce or mitigate risk	Investment in training programs, collaboration with educational institutions, promotion of the project as 'meaningful'.

Risk mapping and evaluation

Risk identification ("Due to a cause or condition, a risk event may occur that has an impact on either the cost, time, scope or quality").							Quantitative risk assessment			Risk mitigation	
Risk Ref.	Status	Phase	Risk category	Risk event	Cause / Condition	Impact	Probability (1-2-3-4-5)	Impact (1-2-4-8-16)	P x I	Mitigation strategy	Mitigation measures
44		02_Operation	11_Operation and maintenance (O&M) risks	Bankruptcy of technology provider	Technology provider for separation system goes bankrupt.	Maintenance work and spare parts can no longer be supplied.	2	4	8	Reduce or mitigate risk	Regular contact with alternative technology providers and O&M companies.
45		02_Operation	11_Operation and maintenance (O&M) risks	Higher downtime than planned for maintenance work, etc.	Higher corrosion on system, other problems.	Less CO2 is captured	3	8	24	Transfer risk	Failure mechanisms to be considered
46		02_Operation	12_Transportation risks	CO2 handling	CO2 leakage during capture, temporary storage or transportation	Accidents, injuries, fatalities during operational activities.	2	4	8	Avoid risk	Ensure strict compliance with safety regulations. Regular training and safety checks, emergency plans for CO2 leaks
47		02_Operation	12_Transportation risks	Delays in CO2 transportation	Unforeseen short-term strike or temporary route closure, or delay in build-up of cross-border CO2-pipeline due to coordination issues	If transported in tank wagons: CO2 must be released into the atmosphere. Booked storage capacities cannot be fulfilled (take-or-pay)	3	16	48	Reduce or mitigate risk	Identify alternative transport routes at an early stage, plan for sufficient interim storage, force majeure clause in contracts with storage providers
48		02_Operation	12_Transportation risks	Delays in CO2 transportation	Logistics service provider cannot provide the transportation service as agreed for internal reasons (lack of availability, maintenance problems, etc.)	CO2 cannot be transported from the intermediate storage facility. If intermediate storage is full, capture plant must be shut down.	4	8	32	Transfer risk	Contractual security vis-à-vis transport providers (penalty payments if obligation cannot be fulfilled). Regular monitoring of offers from alternative transport providers.
49		02_Operation	12_Transportation risks	CO2 pipeline comes earlier than planned	Earlier-than-expected deployment of a CO_2 pipeline requires a shift from planned liquefied CO_2 transport to pipeline transport, leading to additional conversion costs	Conversion costs for liquefaction plant - lower transportation costs	1	2	2	Accept risk	
50		01_Construction	13_Storage risks	Storage rights	It is not possible to secure sufficient storage rights / capacities in good time (before FID) (lack of supply, difficulty in securing the necessary bank guarantees in good time)	FID is delayed	3	8	24	Reduce or mitigate risk	Proactive dialog with several storage providers. Negotiation of term sheets. Timely contact with financial institutions to establish the necessary credit lines in advance.
51		02_Operation	13_Storage risks	CO2 purity	Storage providers are increasing the requirements in terms of CO2 purity (higher than the current purity of the captured CO2).	CO2 can no longer be stored. Systems must be technically retrofitted.	3	2	6	Transfer risk	Design the system for a high degree of purity from the outset. Guarantees from technology providers that the system can be retrofitted.
52		02_Operation	13_Storage risks	Lower injection capacity	Lack of injection capacity and/or CO2 leakage during injection	Storage provider is unable to meet the contractually guaranteed CO2 volumes.	1	4	4	Transfer risk	Contractual security with storage providers (take-or-pay). Alternative use of CO2 as a backup (e.g. temporarily as 'utilization').
53		04_Post closure	13_Storage risks	CO2 leakage after the end of the project	Geologically stored CO2 is released via cracks	Sink capacity is partially canceled out	1	8	8	Transfer risk	Take out carbon insurance To be covered by storage providers or state
54		01_Construction	14_Societal risks	Concerns and resistance from the local population	Local population opposes BECCS project due to fear of accidents with CO2 and other emissions	Objections delay the project	3	4	12	Reduce or mitigate risk	Proactive involvement of the population: organization of information events, transparent communication about risks and benefits
55		03_Construction & Operation	14_Societal risks	Public opinion on climate protection	Public opinion tilts - wants less spending on climate protection	Lower support for BECCS projects, companies buy fewer CDRs	2	8	16	Accept risk	