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Perspectives on carbon capture technology in Houston:

A QUALITATIVE ASSESSMENT AND A POSSIBLE PATH FORWARD

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GLOSSARY

ANTHROPOCENE:

Period of time during which human activities have impacted the environment enough to constitute a distinct geological change, including climate change.

CARBON CAPTURE, UTILIZATION, AND STORAGE (CCUS):

Process of trapping CO_2 before it is released into the atmosphere, reducing emissions from power generation and industrial processes at the point source.

Carbon capture addresses emissions associated with burning fossil fuels, thereby extending the lifetime of extractive industries. This drives much of the criticism of carbon capture, especially among environmental justice organizations.

The term Carbon Capture and Sequestration (CCS) is sometimes used interchangeably with CCUS, and it is also seen as separated into two pathways as CCUS and CCS. For the purposes of this report, we will be using the umbrella term "CCUS" to cover all relevant projects and descriptions.

CARBON DIOXIDE REMOVAL (CDR):

Carbon Dioxide Removal (CDR) refers to both land-based and technological practices, and approaches that remove and durably store carbon dioxide (CO_2) from the atmosphere. Carbon removal draws down CO_2 already in the atmosphere, addressing legacy emissions from the last two centuries of human activity. CDR is required to achieve global and national targets of net zero CO_2 and greenhouse gas (GHG) emissions.

CARBON NEUTRAL:

No net release of greenhouse gases. This can include the use of offsets for 'hard to decarbonize' processes.

CARBON POLLUTION:

Polluting emissions of greenhouse gases, such as carbon dioxide and methane, which contribute to global warming. Sources of carbon pollution include industrial processes and burning fossil fuels.

DECARBONIZATION:

The transition of the built environment economy from high-carbon technology and activity to low-carbon technology and activity. Examples of decarbonization include the replacement of coal-fired power plants with solar and wind, encouraging mode shift from single occupancy vehicles to mass transit, conservation and expansion of natural area, and low-carbon agricultural techniques.

ENVIRONMENTAL JUSTICE (EJ):

The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. This goal will be achieved when everyone enjoys: the same degree of protection from environmental and health hazards, and equal access to the decision-making process to have a healthy environment in which to live, learn, and work (Source: Environmental Protection Agency).

ENVIRONMENTAL, SOCIAL, GOVERNANCE (ESG):

The consideration of environmental and social factors alongside financial factors in the investment decision-making.

GREENHOUSE GAS (GHG) EMISSIONS:

Gasses that absorb, retain and/or emit radiant energy, warming the earth. Greenhouse gasses, or GHGs, include carbon dioxide, methane, and nitrous oxide.

INTERNATIONAL PANEL ON CLIMATE CHANGE (IPCC):

The foremost international authority on the greenhouse effect, its consequences, and climate change mitigation.

EXECUTIVE SUMMARY

Words like "decarbonization," "net-zero," and "carbon management" are now part of the public lexicon as we continue to search for ways to prevent and mitigate climate harm. Few will disagree that emissions capture (or carbon capture) is a critical part of this work; however, some will agree on the best options for this process – options that are effective in removing carbon from the air and also environmentally just. Furthermore, few have engaged community members in their understanding of carbon capture and its impacts.

The Houston area is clearly positioned as the carbon capture headquarters of the country. Multiple projects, plans, and partnerships have been formed to advance carbon capture R&D, funding commitments, and even test facilities across the region, from Baytown to Fort Bend. ExxonMobil has recently proposed a $100 billion carbon capture hub in Houston, and numerous petrochemical companies have pledged their support toward the project. Federal climate health investments, such as the Inflation Reduction Act (IRA), also offer investments and incentives to industry to make progress on carbon management.

Air Alliance Houston (AAH) is a community-led advocacy organization working to reduce the public health impacts of air pollution and advance environmental justice in the greater Houston region. We have been closely following the carbon capture movement nationally and locally as many of the same air pollutants and sources that harm public health are also responsible for excess carbon and climate change. Our conversations with community members about these connections and about the growing carbon capture economy in their neighborhoods revealed a need to assess community concerns more strategically. The result is "Perspectives on carbon capture technology in environmental justice communities in Houston," a community-led needs assessment that explores the controversies surrounding carbon capture, details interviews with leading industry experts of varying perspectives as well as potentially impacted community members and offers a viewpoint on the path forward.

Based on our results, collective community knowledge of carbon capture in the Houston area is relatively low. In many cases, our carbon capture discussions were the first-time residents in environmental justice communities were learning about this technology. Our concern is that too few fully understand the potential impacts carbon capture infrastructure may have on their communities and will be unable to adequately advocate on their own behalf as major carbon capture investments materialize. We strongly recommend the following:

- Ramp up efforts to rapidly increase community understanding of carbon capture before projects like the ExxonMobil hub come to fruition.
- Dialogue with local communities, which is often the first opportunity for carbon management developers to ensure genuine, good-faith considerations related to their projects remain founded in and address community priorities.
- Consider how carbon capture technology stakeholders, including industry, universities, government, and advocacy groups can engage community members beyond the baseline expectation during the procedure.

Carbon management projects in the area typically meet procedural requirements but do not exceed them. In our experience with facility permitting, air monitoring, and more, procedural justice through the project's lifecycle, developers rarely have mechanisms for repeatedly engaging communities and incorporating their feedback. This could explain, in part, these deeply skeptical responses. This could be improved if community members from the host communities were included in the carbon capture conversation as these projects are taking off and not after the fact.

METHODOLOGY

Objectives

Air Alliance Houston (AAH) recognizes that carbon management technologies are increasingly a component of the decarbonization strategy in the Houston area as put forth by municipal and industry leaders. However, rarely are the opinions of community members about such technologies also represented. This is due in large part to a general lack of information about the perspectives of local communities about carbon management and decarbonization. AAH sought to help fill this gap in local knowledge by designing and implementing a qualitative review to elicit insights into community awareness and perceptions of carbon dioxide removal projects and their role in a broader movement towards decarbonization. We had three main objectives:

- Establish an internal understanding of Carbon Capture, Utilization, and Storage (CCUS) technology, existing infrastructure planning, and existing regulatory landscape for carbon capture efforts.
- Gauge public understanding and opinion of carbon capture technologies and their relation to climate change solutions, particularly in environmentally vulnerable communities of Houston.
- Outline a path forward for both the organization and the community in policy positioning on CCUS for the Houston area.

To achieve these goals, we developed an assessment methodology that could both engage with a new and complex topic like carbon management as well as produce meaningful dialogue with communities that are central to future climate change mitigation efforts. The scope, timeline, and tactics of this assessment are described in detail below.

Scope

Anthropogenic climate change is a complex topic. Understanding its many causes and potential mitigations is a difficult task for the seasoned climate scientist and layperson alike, particularly when considering technologically complicated concepts like carbon dioxide removal. This complexity lies at the heart of our project aims and spawned many of our initial questions in considering scope:

- How much is known about the relatively new and unproven technology of CCUS? How much reliable and trustworthy research is even publicly available?
- Is information about these technologies accessible to the general public (both in the immediate practical sense and in the ease of understanding)?
- Relative to other climate change mitigation efforts, how much resources are being invested into these technologies? Will investments in these technologies and their needed infrastructure affect Houston communities?

Underneath these questions is the underlying concern of the technologies' efficacy in reducing carbon emissions. Are CCUS worthwhile investments that will effectively reduce emissions, or are they merely tools to prolong the life of the fossil fuel industry? We returned to this question throughout when evaluating our own research and the various attitudes towards this topic we encountered through our discussions with communities and stakeholders.

Given the complexity of the topic, our team opted to conduct a qualitative study for the purposes of garnering a deep assessment of public understanding of the topic. We believe that an informed dialogue with small groups of participants would yield better results than a wider but shallower public opinion data collection effort. After determining the type of study we would be conducting, our team worked to determine the form of dialogue, the participants we would seek out, and the questions we would ask.

Location

In determining where to focus our data collection, we considered a number of variables. Primarily, we wanted to speak with Houston-area residents who were 1) more likely to be impacted by climate change-induced weather events and 2) more likely to be near existing or future carbon capture infrastructure. The first of these components is easy to determine - there is extensive data on the vulnerability of Houston communities to natural disasters.[1] Unfortunately, a number of Houston communities fit the bill of vulnerability to extreme weather events or other socio-ecnomic conditions, as dermined by tools like the EPA's EJScreen.

In combining these vulnerability assessments with the second component - proximity to carbon capture infrastructure current or proposed - we focused on communities in and around the Houston Ship Channel and Fort Bend County, home to the only and now formally operating Direct Air Capture (DAC) facility. Not only is the Ship Channel area already home to a majority of the petrochemical industry in Houston, but it is also the potential site of a massive CCUS hub proposed by a number of petrochemical companies. As of 2022, Air Liquide, BASF, Shell Calpine, Chevron, Dow, ExxonMobil, INEOS, Linde, LyondellBasell, Marathon Petroleum, NRG Energy, Phillips 66, and Valero were collectively evaluating "emissions reduction efforts" in and around the Houston Ship Channel. Exxon is heading this collective. In 2021, Exxon called on industry and government to jointly raise $100 billion to create infrastructure to capture carbon emissions from Houston Ship Channel point sources, transport it through pipelines and inject it into the sea floor.[2] As of February 2023, only a handful of other CCUS projects along the Ship Channel have been announced, and fewer have located capital funds.

Our team applied these considerations in determining stakeholders to interview as well. We define "stakeholder" as an individual who either has specialized knowledge of the topic, the power to affect the adoption of this technology in this region, or both. We reached out to local elected officials who represent the potentially affected communities and municipal staff who deal directly with local and broader efforts to mitigate climate change. In addition, we sought out affected residents, individuals representing community action groups, and other individuals with lived experience.

Timeline

This study was conducted between July 2022 and January 2023.

Methods

To engage with directly impacted residents about their understanding of CCUS and how they would view its place in an overall approach to decarbonization or a fossil fuel transition for the greater Houston area, we focused our data collection methods on qualitative

surveys and key stakeholder interviews. Surveys were administered at community meetings following a "101" presentation on carbon capture technologies and via tabling at high-traffic events such as local farmer's markets.

The community groups and events were selected based on location (see scope above), amenability to the topic, and audience participation. Community groups located in fenceline communities, groups with longstanding membership, and groups with routine interaction with the wider community were prioritized. At these meetings, AAH staff would present a slideshow on carbon capture basics, facilitate group discussion and Q&A, and then administer the assessment survey. Community groups hosted us in Jacinto City, Galena Park, and East Houston. Community members were advised that carbon capture would be a topic at the meeting. Community tabling events were hosted across the Houston area including in Northline and Fort Bend County. These conversations were often held unexpectedly, yielding a more candid discussion.

The qualitative surveys were given after the presentation and conversation with questions intended to measure the knowledge of community members about and gauge their attitudes and perceptions of carbon capture. The survey had eight questions, including open-ended questions, Likert scales, and multiple choice. All survey materials were prepared in both English and Spanish, and a $15 gift card was provided to compensate for time to complete the survey.

In addition to the community surveying, we conducted a series of stakeholder interviews. Interviewees were selected to provide a wide array of perspectives across multiple sectors, including environmental activists, industry representatives, academics, city and county government, and elected officials. They also differed in their exposure to carbon capture concepts and terms, technological expertise, climate policy experience, and lived experience.

Our aim was to interrogate interviewees' views of the role of carbon capture in Houston's energy transition. We wanted perspectives from potential supporters of carbon capture as well as its critics, opponents, skeptics, and those unsure or unfamiliar. We especially wanted to see where stakeholders would place carbon capture technology within the energy transition, their attitudes toward industry, and to their knowledgeability of climate change, CCUS, and decarbonization.

Our team contracted with The Working Partner, a project consultant, to conduct the interviews and allow for greater objectivity. The Working Partner contributed to the selection of interviewees, planned and scheduled interviews, facilitated interviews, transcribed, and summarized results. Interviewees were thanked for their participation and, in some cases, provided compensation.

Strengths and limitations

The qualitative nature of this assessment has several strengths. Our emphasis on testimony from community members provided deeper, more nuanced responses to our inquiries. Open-ended, discussion-oriented survey questions encouraged community members to answer in-depth and in detail about their observations and concerns. This type of survey permitted us to integrate the lived experiences of community members more easily into our background research and understanding of carbon capture.

There are some limitations to our approach as well. Due to the qualitative nature of the data collection, its results are not statistically significant or representative. As such, we do not intend to present these data as a comprehensive or statistically robust depiction of all Houston residents' attitudes, but rather as a concerted initial foray into community perspectives and views that can inform a more robust research, education, and advocacy strategy going forward.

There is also some bias present in our results. Due to widespread unfamiliarity with carbon capture technologies, we were required to present on the topic in addition to collecting data, so respondents would have sufficient baseline knowledge of the lines of inquiry themselves. We acknowledge that our presentation in such cases was not perfectly unbiased since our mission is solely focused on air quality concerns. This same asymmetry in prior knowledge can be seen in the stakeholder interviewer data as well. Answers to open-ended questions were not

prompted or corrected requiring interviewees to rely on their own understanding.

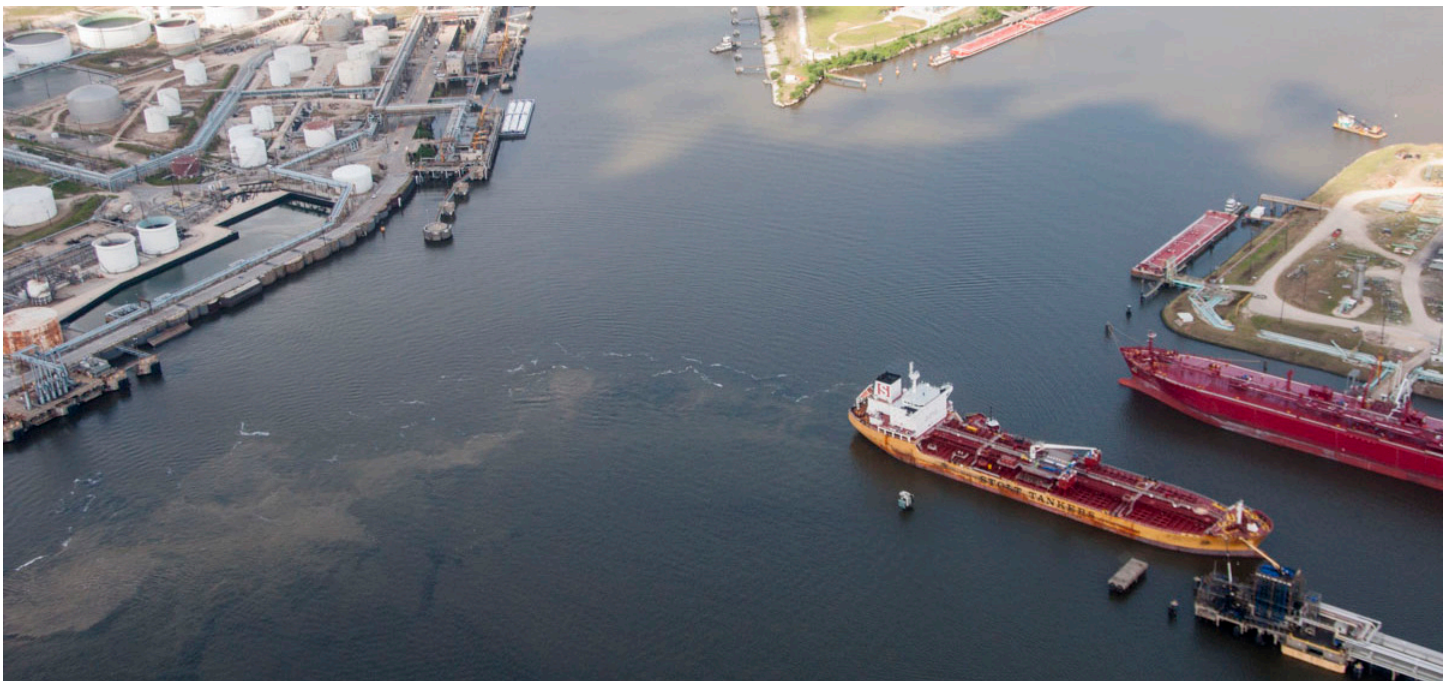
Opportunities for improvement

Our qualitative research approach could be enhanced. If we were to do another iteration of this study, focus groups or facilitated group discussions separate from speaking events could be employed to deepen our understanding of community concerns. This was initially part of our methodology but cut back to keep our study focused.

Expanding our stock of stakeholder interviews could prove valuable. Our interview series was carried out in December 2022 and January 2023, at the start of the Texas State Legislative Session. Several state level stakeholders were rendered unavailable due to time constraints.

The scale of the survey could be greatly increased, even while maintaining a qualitative study form. More surveys, speaking events, and tabling can provide a broader net of perspectives within Houston communities. Lynchburg, La Porte, and Baytown were deliberately excluded from this study to maintain a focused study area but are also viable candidates for carbon capture knowledgeability studies.

Additionally, a quantitative study of overall understanding and initial disposition to the technology could prove to be useful.



LITERATURE REVIEW

The impacts of a changing climate are growing in scale and concern and threaten not only human life but also the millions of other species that live on this planet - through hurricanes, droughts, flooding, crop failure, and other extreme disaster events. The entire global population is impacted by climate change to some degree; it is a universal, global crisis. What led up to this point? Mass industrialization over the past few centuries increased atmospheric levels of carbon dioxide, methane, and other greenhouse gasses due to emissions from the burning of fossil fuels. This led to the absorption and trapping of heat in the atmosphere (known as the greenhouse effect). All of this is occurring faster than the planet's natural cycles and processes can regulate, so the Earth's average surface temperature has increased at an unusually rapid rate. This is anthropogenic global warming.

Getting started: what is carbon capture?

Carbon capture broadly deals with capturing carbon, either from industry emissions or directly from the air, and utilizes it for an industrial process or stores it permanently underground. This is done to reduce atmospheric carbon, thus ideally mitigating the greenhouse effect to some degree. In the past few decades, the topic of climate change and its validity has become quite politicized and continues to be a point of contention within the political sphere. However, Carbon Capture, Utilization, and Storage (CCUS) has recently reached across the aisle to garner bipartisan support as a moderate approach to supporting the oil and gas industry while working towards climate change mitigation efforts.

Before diving in, an important clarification must be made. CCUS is an acronym that encompasses the carbon capture process, as well as the subsequent utilization and/or storage/sequestration of said carbon. The term CCS is sometimes used interchangeably with CCUS (removing "utilization" from the lineup), and it is also seen as separated into two pathways as CCU and CCS. For the purposes of this report, we will be using the umbrella term "CCUS" to cover all relevant projects and descriptions.

Carbon capture for the purpose of climate mitigation was first deployed in the mid-1990s with the establishment of Norway's Sleipner Carbon Dioxide Storage Facility, the world's first geologic carbon storage project. It demonstrated scale and investment potential, and since that time, numerous projects have been established all over the world. By November 2019, there were nineteen total projects globally in operation, with thirty-two more in various stages of development and construction.[3] It is easy to assume that the number of projects has continued to increase since that statistic was published, as there has been much global movement and investment in the last few years. As of the writing of this report, we estimate 12 operational CCUS projects in the United States, with another 58 in the pipeline. While these numbers ebb and flow on a regular basis, it is safe to say that CCUS is on the rise locally and nationally.

Houston: the carbon capture ideal?

In April of 2021, ExxonMobil announced its intention to establish an expansive carbon capture hub in Houston, dubbed the "CCS Innovation Zone." This proposed $100-billion project was announced with the intention of attracting partnerships and investments from other local oil and gas companies. And so far, it's working. As of January 2022, the ExxonMobil Newsroom announced that several other companies have also pledged their support.

Supporters of this proposal argue Houston is a good location for this scale of CCUS investment. There are a few unique characteristics of the Texas Gulf Coast region that suggest somewhat of an 'ideal' for carbon capture projects. Firstly, Houston is dominated by the oil and gas industry, and carbon emission sources are plentiful in the region. There are numerous companies that are currently seeking opportunities to meet their corporate environmental, social, governance (ESG) and net-zero pledges and commitments - and many of these companies already have existing pipelines and infrastructure to support carbon capture. The region's geology also plays an important role, as there are large geological reservoir formations in the Gulf of Mexico with underground carbon storage potential.[4] According to Forbes, "Exxon estimates that the Gulf Coast endowment of potential underground storage space from Corpus Christi around to New Orleans could provide a total available capacity of roughly 500 billion tons ... [which] provides centuries of space available for use by this project".[5] These factors

contribute to Houston's position as a leading region for CCUS investment opportunities.

Additionally, this project also aligns with the climate goals set by the City of Houston in 2020, although these goals are somewhat loosely defined. The Houston Climate Action Plan indicates Houston's plan to reduce emissions and become "carbon neutral" by 2050. The vagary of a carbon-neutral-by-2050 goal is consistent with the mixed promises presented by carbon capture technology. In a statement released by Mayor Turner in April 2021, he expressed his approval for the local efforts:

"Our Climate Action Plan is about partnership. The energy industry is a key partner...Our region is home to some of the largest carbon emitters in the country, and we all have a responsibility and role to play in decarbonization...This proposal by ExxonMobil is the type of bold ambition and investment we will need to meet our climate goals and protect our communities from climate change." [6]

The proposed cost for this specific project is approximately $100 billion. However, that investment will not come directly from the fossil fuel pocketbook. Funding would rely on a variety of sources, including government and private-sector funding, as well as the development of supportive policy action like a higher market price on carbon.[7]

While driving around Houston, it is not unusual to see one or more billboards around the city promoting carbon capture. The fossil fuel industry is clearly working hard to market CCUS as appealing, safe, and environmentally friendly – through the usage of social media marketing and other promotional materials. It tends to be presented as an encompassing, all-in-one solution, rather than one component of a much larger system of decarbonization pathways.

Carbon capture financing

Above, we discussed two primary reasons for the support of advancing carbon capture infrastructure: its potential to 'clean up' petrochemical operations while still allowing them to proliferate, and its role as a component of a larger decarbonization strategy. However, there are substantial financial incentives in advancing carbon capture infrastructure as well.

The Sequestration Tax Credit (45Q) was first established in 2008. It provided a tax incentive for CCUS activity, establishing a fiscal value for each metric ton of carbon captured and used or stored. It has been modified over the years, and in 2018, was updated to include not only carbon dioxide emissions but carbon oxide as well.[9]

In March 2021, a group of Republicans from the House of Representatives introduced a bill called the Carbon Capture, Utilization, and Storage Innovation Act (H.R.1761). This legislation is intended to expand opportunities for CCUS loans and funding to include infrastructure and pipelines. It has not yet progressed past the introduction phase. However, it is possible for the bill to become a law at some point in the near future.[10]

The Bipartisan Infrastructure Law, signed in November 2021, allocated $12 billion towards CCUS investments, including technology, carbon storage validation and testing, geologic storage permitting, and carbon removal.[11] This will certainly spur investment into the establishment of new projects throughout the United States over the next few years.

In February 2022, the White House Council on Environmental Quality, or CEQ, issued guidance on CCUS to Federal agencies "to help ensure that the advancement of Carbon Capture, Utilization, and Sequestration (CCUS) technologies is done in a responsible manner that incorporates the input of communities and reflects the best available science" (CEQ).[12] That guidance framework is currently under review and is open to public comment until mid-April.

In order for the Houston hub to be successful, it requires a certain level of political buy-in and support. This may come in the form of an increased market price on carbon. At this time, "Exxon and its potential partners are proposing that the federal government raise its tax credit for every ton of carbon captured and stored from its current $50 to $85 per ton, saying that this is crucial for a final investment decision to be made."[13]

RESULTS

Carbon capture technology is oftentimes a high-level discussion debated by university researchers, industrial representatives, regulatory bodies, and advocates, leaving impacted community members living near industrial facilities out of the discussion. The objective of our project was to directly engage fenceline and frontline communities who are often left out of these carbon capture conversations to elevate and understand their needs and concerns. The results of these efforts are summarized below.

Community Survey Questions

How concerned are you about global warming and climate change?

How concerned are you about increased frequency and intensity of extreme weather such as Hurricane Harvey, Winter Storm Uri, or heat waves?

Do you feel government officials have taken enough action to protect you and your community from impacts of climate change?

What is the most important issue pressing your community right now? This could be any issue, not just climate or environmental concerns; there are no wrong answers.

Which of the following decarbonization strategies would be the most beneficial to you and your community? A) health improvements associated with air and water pollution reduction B) Expanded public transit C) training and job opportunities in clean energy D) expanded green space like public parks or nature reserves

When you hear about new investment in nearby industrial facilities, what is your first reaction? These can be feelings you have about the news or questions that you have about the facility. There are no wrong answers.

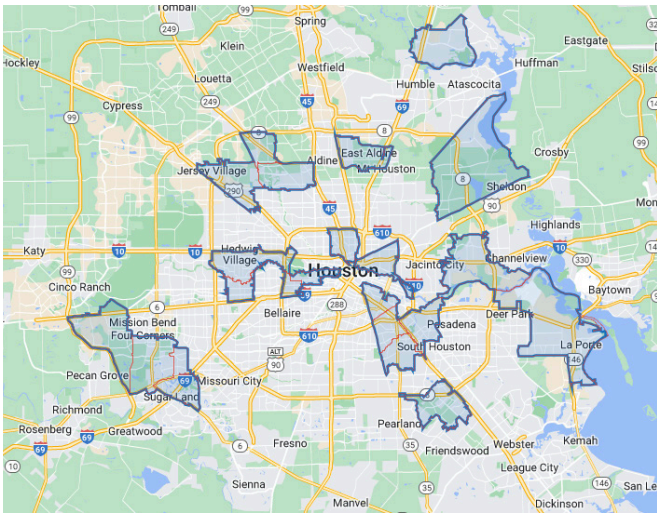
How confident are you in your understanding of carbon capture? Please circle your answer. (1 being not very confident, 10 being very confident).

Do you think that carbon capture is an effective climate change solution?

Community surveys

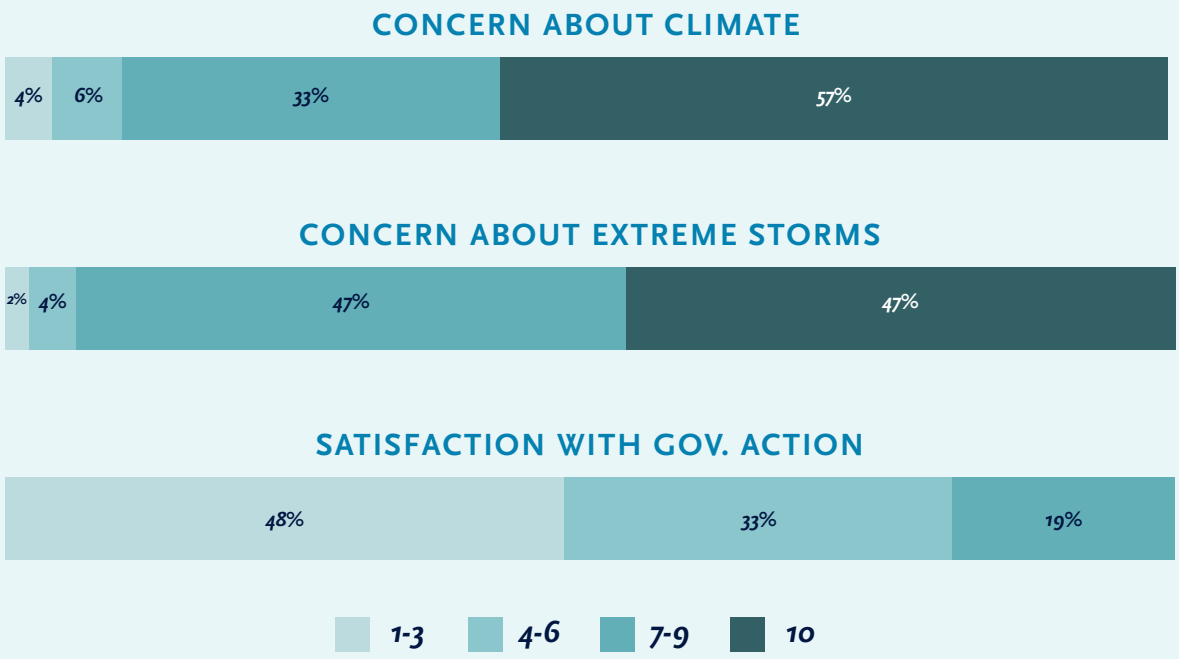
The presentation and survey component included seven (7) community meetings and yielded 49 surveys. Of respondents, 43% were male, 35% female, and 22% did not answer. The majority of respondents were Hispanic/Latinx from Southeast Houston, East Houston, Galena Park, Jacinto City, or Pasadena.

To start, the majority of survey respondents expressed concern about climate change and extreme storms. They also expressed general dissatisfaction with the job that government is doing to protect their communities from these effects. Respondents also expressed understanding of the severity of the climate crisis and connected the increased frequency and intensity of extreme weather events to global warming. Hurricane Harvey, summer excess heat, and Winter Storm Uri were all featured prominently in our pre-survey



Community survey respondent's self-reported zip codes, 2022 (n=49)

presentation. This may indicate trust in the speaker who connects the two issues, or it could indicate previous knowledge of climate change impacts locally. Government mishandling of flood funds, uneven city tree canopy, and broad feelings of underrepresentation may also have contributed to the attitude of frustration expressed in survey results.



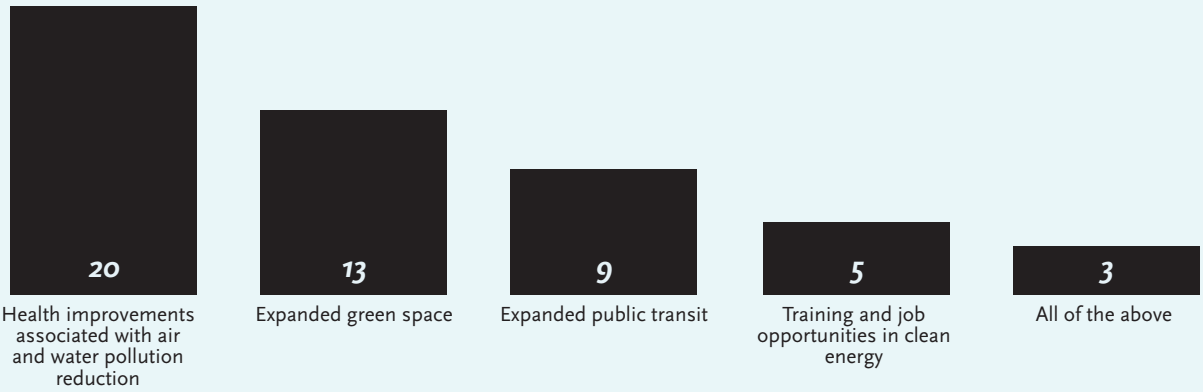
Furthermore, environmental concerns and air pollution was cited often as one of the most pressing issues facing communities today, exceeded only by crime, violence, and guns. Six of the seven community meetings were held during the Fall and Winter of 2022, a midterm election season in which crime and violence were dominant topics. The prevalence of crime and violence in the data is also informed by one community event sharing space with a presentation by the Houston Police Department. Even with these caveats, this does illustrate, to some degree, that climate and environment are often at the forefront of communities' minds.

THEME	MENTIONS
Crime/Violence/Guns	14
Environment or Air Pollution	12
Cost of living/Access to needs invluding energy	9
Health/Healthcare	6
Climate or other environmental issues	6
Other	11

Local concern for environmental and air quality issues is consistent with previous studies of this topic. A previous national and local study by the Clean Air Task Force (CATF) found that 41% of community members were very concerned about air quality, and 54% were concerned about extreme weather. Locally, they found that 60% of Houstonians see air quality as a major concern.[14]

Respondents were also asked to pick one of five benefits associated with a climate mitigation strategy. Of the five, health improvement associated with reduced exposure to air and water pollution was the most popular choice, followed closely by expanded green space, expanded public transit, and lastly, clean jobs programs.

WHAT ARE THE MOST BENEFICIAL DECARBONIZATION STRATEGIES? (N=50)



- **44%** of respondents mentioned environmental concerns as a first reaction to hearing about new industry
- **21%** of respondents had generally positive reactions to new industry, and **31%** had generally negative reactions
- Of those with positive reactions, **63%** mentioned economic good/jobs

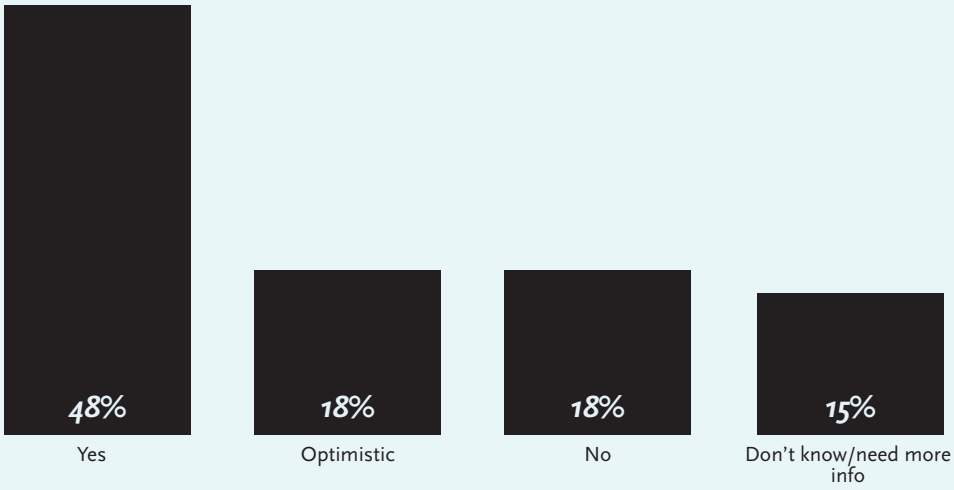
	MENTIONS
Environmental Concerns	17
Questions	13
Negative	12
Positive	8
Safety Concerns	5
No strong feelings	3
Economic good	5
Other Concerns	6

Perceptions of local industry by respondents proved additionally insightful for understanding community views. From those questions, close to half (44%) of respondents mentioned environmental concerns as a first reaction to hearing about new industry, 21% had generally positive reactions to new industry, and 31% had generally negative reactions. Of those with positive reactions, 63% mentioned economic good and/or jobs as the reason for that response.

Also consistent with other studies, community knowledge of carbon capture technology was overall low. When asked to rank their confidence in their knowledge of this technology, 58% of respondents gave a rating at or below the mid-

line. This is consistent with CATF's study finding, which found that only 12% of respondents reported awareness of carbon capture technology. This result is not surprising since carbon capture is a nascent technology with only a handful of local projects underway. Most respondents did think that carbon capture is or could be an effective climate change solution, but significantly fewer respondents answered the question. [11]

DO YOU THINK THAT CARBON CAPTURE IS AN EFFECTIVE CLIMATE CHANGE SOLUTION? (N-33)



Stakeholder interviews

In addition to collecting community perspectives on carbon capture, our team sought input from a variety of stakeholders. We define "stakeholder" as individuals or representatives of organizations who we anticipate: have a higher level of knowledge or understanding of carbon capture technology; have express authority over carbon capture investments, greenhouse gas reduction plans, or both. Stakeholder answers to these questions are summarized below.

HOW HAS CLIMATE CHANGE IMPACTED YOUR COMMUNITY? WHAT POTENTIAL IMPACTS ARE YOU MOST CONCERNED ABOUT? WHAT STEPS HAVE YOU SEEN TAKEN TO ADDRESS CLIMATE IMPACTS IN YOUR COMMUNITY?

Interviewee answers to this initial question reflected sentiments expressed throughout the survey responses. Nearly every response touched on either intense rainfall and flooding, extreme heat, or both. Respondents also alluded to the impacts of Winter Storm Uri, an unseasonable freeze that knocked out power for millions of Texans and resulted in the deaths of over 200 in 2021. One respondent layered in economic concerns as well noting the disruption of extreme weather events on business processes and the lack of infrastructure's ability to handle them.

Many respondents also discussed the three primary municipal climate action plans: Port Houston's Sustainability Action Plan, the City of Houston's Resiliency and Climate Action Plans, and the recently published Harris County Climate Action Plan. Although, most who mentioned these plans did not speak about them confidently and offered many qualifiers indicating their general lack of efficacy, particularly in discussing the City's efforts. One stakeholder specifically mentioned the need for more funding and enforcement of the municipality's plans.

Aside from government-driven efforts, multiple respondents pointed to industry's voluntary efforts to reduce emissions. Two stakeholders explicitly expressed confidence in carbon capture as part of industry's self-propelled push to rein in emissions.

WHEN YOU HEAR THE WORD "DECARBONIZATION," WHAT COMES TO YOUR MIND?

Responses to this question were fairly uniform; most simply described reducing greenhouse gas emissions in some way. One speaker included a discussion of a "just transition," which they defined as "ensuring that we aren't leaving behind those who relied on the fossil fuel industry their whole lives for their livelihoods and skills."

HOW FAMILIAR DO YOU FEEL WITH THE CONCEPT OF "CARBON CAPTURE?" WHAT WOULD MAKE YOU MORE CONFIDENT IN YOUR KNOWLEDGE? WHAT ROLE DO YOU THINK CARBON CAPTURE PLAYS IN DECARBONIZATION?

In describing their familiarity with carbon capture technology, stakeholders varied from very little familiarity, to somewhat familiar, to a strong grasp of the technology. Nearly every respondent who expressed some or little knowledge of the concept included a desire to know more about it and its potential efficacy.

Answers to this question also revealed varying levels of confidence in the technology or its role in a comprehensive decarbonization strategy. For example, one recognized the ongoing development of the technology, but called it a "last resort for getting to a 1.5 °C pathway." Another respondent, who claimed a good deal of familiarity with carbon capture, stated it would be a "major technology for large-scale decarbonization," and mentioned the $100B carbon capture hub proposal.

WHY DO YOU THINK COMPANIES ARE INVESTING IN CARBON CAPTURE TECHNOLOGY NOW? WHAT WOULD YOU WANT THESE COMPANIES TO KNOW (ABOUT YOUR COMMUNITY) AS THEY ADOPT AND BUILD OUT THESE TECHNOLOGIES?

Nearly every answer included some discussion of "trust" – either trust *in* industry to self-regulate in reducing emissions, or trust between companies and communities they impact. Five stakeholders described a general expectation that industry will adopt carbon reduction technologies on their own accord for a number of reasons: corporate sustainability goals, public trust and image, and potential for profit.

Three different interviewees specifically pointed to a lack of trust between industry and affected communities in Houston as an issue to be overcome. Each alluded to a general history of industrial activities negatively impacting adjacent communities in the past. All three discussed the need for private industry to do more to garner the trust of the public.

TO WHAT EXTENT DO YOU THINK THESE COMPANIES WILL KEEP THEIR PROMISES ABOUT CARBON CAPTURE, ABOUT DECARBONIZATION, AND/OR ABOUT REDUCING THEIR CARBON POLLUTION FOOTPRINT?

Like the previous question, answers here varied significantly. Some interviewees answered this question by describing some mechanism of intellectual accountability - that private industry could and should be transparent about the

efficacy of this technology as it continues to grow, and that research institutions might enforce accountability by continuing to communicate research to the public. Others discussed a potential role for more tangible sources of authority in enforcing decarbonization strategies, such as the Texas Commission on Environmental Quality (TCEQ), the federal government, or the International Energy Agency.

WHAT DOES THE FUTURE OF THE "ENERGY CAPITAL OF THE WORLD" LOOK LIKE TO YOU?

In answering this question, many of the stakeholders argued that Houston's central role in energy commerce sets itself up to lead on energy transition as well. Industry professionals and community stakeholders alike discussed the region moving towards some mix of "cleaner" fossil fuel production and renewable energy sources. Responses from elected officials and their staff were somewhat less detailed; focusing less on energy production itself, their answers expounded on other aspects of climate change mitigation, such as cleaner transportation and planting trees. Overall, answers did not necessarily provide a comprehensive view of what this future might look like.

KEY FINDINGS

Concern about the environment

A majority of respondents in both the community surveys and stakeholder interviews expressed some level of concern about climate change or its impacts. Of the community members polled, 90% chose 7 or above when asked to rate their concern over climate change on a scale of 1-10. A question asking about concerns over extreme weather events elicited a similar response: 94% rated 7 or above. When asked the open-ended question "What is the most pressing issue facing your community?" air quality and environment was listed second, behind only crime/violence/guns.

Paired with the responses from the stakeholder interviews, we interpret these data to mean that Houstonians do hold concerns over climate change and likely understand the connection between climate change and extreme weather events. Furthermore, there is a concern about how this issue will continue to worsen and a recognition that steps should be taken to mitigate it.

Uncertainty about carbon capture technology

Among the most prominent themes in both the surveys and interviews was the overall lack of extensive knowledge and confidence in carbon capture technology especially by community members. More than likely, our presentation on the topic was the first time that respondents received fact-based exposure to the concepts and terms surrounding carbon capture technology.

Respondents who did express confidence in their knowledge of the topic were those who arguably work closest with the petrochemical industry. One such stakeholder stated that carbon capture was a "major technology for large-scale decarbonization." Others expressed the opinion that carbon capture could be an effective climate change solution among the many components of an overall climate change approach, but that more research is needed to fully instill confidence.

Wariness of expanding industry

Houston's communities are inexorably connected with the growth of the petrochemical industry over the past century. As with any city that grows around a particular industry, Houston's relationship with fossil fuels is one of push-and-pull. Undeniably, the petrochemical industry has facilitated Houston's explosive growth in the past decades and played a central role in its economic structure. Many Houstonians live and work in the region purely due to the industry's presence. However, the petrochemical industry's impacts on public health and the environment are well documented, and Houston communities are well-versed in these impacts.

Given this context, it makes sense that there were mixed responses to the question "What is your first reaction to hearing of new industrial infrastructure near your neighborhood?" 31% of respondents had an initial negative reaction, and 21% had an initial positive reaction. When asked about specific concerns related to new industry, the most common response was concerns over the environment, followed by safety. Similarly, stakeholders offered mixed responses to the same question. Community advocates and environmental professionals largely replied with skepticism or support for new renewable energy infrastructure instead; those closer to industry and elected officials offered qualified support for new industrial infrastructure, particularly if its intent is to clean up existing infrastructure.

Community perceptions of industry broadly will inform their perceptions of carbon capture going forward, since carbon capture is an industry-based activity.

DISCUSSION

We began this assessment with two primary objectives in mind. The first was to develop an internal understanding of carbon capture technology. The second was to develop and implement an effective methodology for assessing community understanding of carbon capture technology and concepts, and how they fit into a broader dialogue on climate change.

Understanding these technologies is incredibly important in the Houston context. For nearly a century, the Houston economy has been inextricably linked with the fossil fuel industry. Many colloquially refer to Houston as the "Energy Capital of the World" due to its vast petrochemical complex and central role in global energy commerce. We believe few would question the assertion that the energy industry plays a substantial role in directing a variety of municipal functions, such as public policy setting and infrastructure development. As we discussed in our literature review, many view CCUS technology as a proliferation tool for the fossil fuel industry since carbon capture may provide an avenue for continued extraction while potentially offsetting GHG emissions. However, as we also discussed in our literature review, the technology has not yet proven to be totally effective in this regard.[15]

Our assertion: the fossil fuel industry as a whole has a concerted interest in the efficacy of this technology. Or, at the very least, the perceived efficacy of the technology. The climate crisis is a somewhat intangible concept, and solutions offered are often ambiguous in nature. The rigor or validity of any solution must be considered, particularly if the party(s) deploying the solution has an interest in its potential to proliferate fossil fuel extraction. We believe Houston is already subject to biased accounting of petrochemical impact on the environment; this technology and concept, in our view, is particularly susceptible to taking advantage of this ambiguity and intangibility. This is especially concerning for fenceline communities who already are victimized by impacts from industry, both directly and indirectly via climate change.

Temporality is another central consideration. Some temporal considerations particular to this issue are the timeline of the global climate crisis and the specific time limits suggested for maintaining emission levels that would prevent catastrophic ecological collapse; and the timeline of infrastructure development. In other words, the global community has laid out very specific emissions targets; realistically, how long would it take to design, fund, and build carbon capture infrastructure? Can fossil fuel companies be relied on to shepherd these projects in good faith and in accordance with the goals laid out by the IPCC, or will they follow a timeline comporting to industry's financial cycles? And what if the emissions reductions are never realized, as many skeptics of CCUS assert?

There is a temporal aspect to the ambiguity of it all, as well. Attempting to detail the temporal aspects of this issue is difficult enough for us who deal with climate issues daily. Project timelines, emissions targets years or decades away, future technology not yet realized - we hypothesize these aspects and they all add to the murkiness of the situation, particularly for a layperson unfamiliar with these concepts. Our fear is that the ambiguity of the issue and the potential solutions being offered, in combination with the region's heavy reliance on and interconnectedness with the fossil fuel industry, make Houston communities particularly susceptible to being sold a bill of false goods. The ultimate fear is double victimization: suffering the impacts of both the ongoing climate crisis and carbon capture infrastructure without achieving sufficient greenhouse gas reductions.

Underlying this discussion is the potential investment in a $100 billion carbon capture 'hub' widely discussed among the industry's biggest players. This hub would be located somewhere along the Gulf Coast in the Houston region. This hub proposal is being championed as a climate mitigation project. Among its primary supporters are big industry names, such as Exxon, but trade associations as well, such as the newly formed Houston CCS Alliance. The CCS Alliance is affiliated with the Greater Houston Partnership (GHP), the primary chamber of commerce in Houston. GHP counts among its members a huge volume of Houston energy businesses.

CONCLUSIONS AND NEXT STEPS

Overall, this report represents the initial steps toward developing a comprehensive understanding of carbon capture technology, policy, and the technology's efficacy in the fight against climate change. Numerous scientific, governmental, and regulatory bodies have plotted a complex system of greenhouse gas emissions reduction targets intended to prevent catastrophic ecological collapse brought on by climate change. Many of these bodies have prescribed a variety of technological and policy solutions to meet these targets; carbon capture technology features prominently in these discussions. Carbon capture technology is particularly relevant to Houston and Texas, as our state and region's extensive petrochemical infrastructure would be a likely site for carbon capture projects. Extensive proposals, such as the $100 billion Exxon carbon capture 'hub,' affirm this focus.

The temporal and cumulative aspects of the climate crisis necessitate fast *and* effective solutions. According to numerous IPCC reports, we have a very small window of opportunity to reduce carbon emissions enough to prevent the worst impacts of a changing climate. Because of this, it is important to marshal our resources behind technology and policies that are actually feasible. As we discuss in this report, while carbon capture is presented as a solution that is both feasible and effective, there is ample reason to be skeptical of both claims as the technology is brought to scale and is done so in environmentally vulnerable communities. While carbon capture could substantially reduce carbon emissions, its widespread implementation effectively translates to a guaranteed proliferation of the fossil fuel industry it captures carbon from at the potential expense of communities already overburdened with air pollution, disease, and lower life expectancy.[16] The petrochemical industry has already shown a propensity for intentionally offering misleading science for the sake of industrial growth (see: deliberate climate misinformation); is carbon capture and/or removal another instance of this?

To answer this question, and to gauge the efficacy of the technology, it is imperative that we grow our collective understanding of carbon capture. Based on our own limited understanding, as well as the relative unfamiliarity of the community members and stakeholders we interviewed, it feels that society is leaning into this technology with incomplete information, relying on the leadership of an industry that has a concerted interest in ensuring this technology is perceived as effective.

We urge local elected leaders to take a greater interest in the efficacy of this technology, and to expand their role in directing investments into climate change solutions. As discussed, the proposed Exxon Mobile carbon capture "hub" in Baytown, Texas represents a massive investment in this technology, with a large portion of the estimated $100 billion coming from public funds. The $100 billion price tag does not account for the more obscure costs of years of infrastructure development and potential human costs that it would entail. Before we embark on this or other similar investments, local leaders must develop a fuller understanding of what they are investing in. This includes additional research into both the specific carbon capture proposals in the Houston region and community sentiments toward expanding carbon capture infrastructure.

Outside of the efficacy of the technology itself, engaging communities in their understanding of the technology and its impacts are imperative. Based on our initial assessment, collective community knowledge of carbon capture is relatively low. In many cases, our carbon capture discussions were the first-time residents were learning about this technology. Our concern is that too few fully understand the potential impacts carbon capture infrastructure may have on their communities and will be unable to adequately advocate on their own behalf as major carbon capture investments materialize. We strongly recommend efforts to rapidly increase community understanding of carbon capture before projects like the Exxon hub come to fruition.

This report represents AAH's first steps towards developing a comprehensive carbon capture platform formed on community-based participatory research and including Houston context-specific policy recommendations on carbon capture's role in climate change mitigation and decarbonization. Going forward, we will use these findings to inform our organizational position on the existentially critical issue of decarbonization and a just transition.

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