LSU Institute for Energy Innovation Webinar Transcript : *Assessing CO_2 Geologic Storage Impacts on Louisiana's Water Resources and Environment*

Air Date: July 25, 2024

Brad Ives
Good morning and welcome to the Louisiana State University Institute for Energy Innovations webinar series. My name is Brad Ives, and I'm the director of the institute. The institute was founded in 2022 with a $25 million gift from Shell. We also received financial support from ExxonMobil and Entergy. Our vision is to be a global leader that drives innovation, develops policy, and trains talent for the future of energy, and we believe that that future of energy is here. It's in Louisiana and it's now. Our mission is to be the independent and trusted voice and a leader and interdisciplinary collaboration to develop impactful solutions for an equitable, low-carbon energy future. And part of how we do this is by making grants here at LSU for research.

Today we are hosting LSU Professor Frank Tsai, who will be providing an overview of an institute-funded project he leads as principal investigator. The title of the project is "Assessing CO_2 Geologic Storage Impacts on Louisiana's Water Resources and Environment." Dr. Tsai's project is one of 10 that the institute funded in its first round of research grants that were announced at the end of last year. The Institute for Energy Innovation will be hosting future webinars to discuss these projects, and once the projects have been completed, the findings from them. To receive notice of future webinars and other events sponsored by the institute, please go to our website and register for our newsletter. I also encourage you to follow the institute on LinkedIn, where we post notices of our events and provide updates on our work. Now that the institute has finished its first full academic year, we're excited to host this webinar series.

We chose Dr. Tsai's project as our first topic because we've received a number of inquiries about his team's work. As Dr. Tsai will cover in more detail, this project is in its early stages and today's webinar will delve into how the work will be conducted and its goals. I want to emphasize that we do not have any results to share with you and won't do so until the work is completed. The study will not be complete until Dr. Tsai's team has been able to measure the impacts of carbon storage, which is yet to occur in the area where he is studying. I also want to emphasize that this project is being conducted independently by LSU. The team will be using publicly available data that is filed with the appropriate Louisiana state agencies. The Institute for Energy Innovation does not have any financial ties to Air Products and we are not obtaining data directly from them. If you would like more information about Air Products Carbon Sequestration project, please visit their website at airproducts.com/louisiana-clean-energy. We're placing this website link in the chat so you could find it easily.

At the conclusion of Dr. Tsai's remarks, we're gonna take questions from attendees. As you saw when you registered, you have the ability to submit some questions there. You also can submit questions through the Q and A button at the bottom of the screen. I apologize in advance if we run out of time to answer everyone's questions because we'll be concluding the webinar at 10:40 Central time.

And now I want to introduce Dr. Frank Tsai. Dr. Tsai is the Chevron Professor of Engineering in the Department of Civil and Environmental Engineering at Louisiana State University. He also serves as director of the Louisiana Water Resources Research Institute. Dr. Tsai received his PhD from the University of California at Los Angeles and holds a Master's degree from the National Taiwan University and a bachelor's degree from National Chung Hsing University in Taiwan. Frank, please tell us about your work.

Dr. Frank Tsai
Thanks, Brad, for the introduction, and it is really my honor to be the first speaker for the the IEI webinar series, and I can see that we have more than 100 people attended this webinar. That's really surprising me. Thank you very much for attending this webinar.

So the title of this webinar is "Assessing CO_2 Geological Storage Impacts on Louisiana's Water Resources and Environment." I'm a water resources engineer, so I'm really interested in Louisiana's geology and the groundwater. I've been with LSU for 21 years and this work basically founded by LSU Institute for Energy Innovation as well as by the NSF and the USGS. The outline I'm going to talk about is the motivation, why we want to conduct this study, and the second is the project overview founded by IEI. Then I will spend probably 80 to 85% of time talking about a larger-scale geological and groundwater model development as a basic information to understand geology and groundwater in Louisiana relating to CO_2 storage. Then we'll talk about some of my three co-PIs' work on CO_2 transport simulation and the baseline information collection for understanding the carbon budget and the land surface deformation. This is just the beginning of the project, so I will talk about what's the next steps for rest of the time within this project.

So the motivation is really come from the publication by USGS Circular 1386 in 2012, a document that the Coastal Plains Regions has the most storage potential for CO_2, accounting about 65% of the national total. Interestingly, the Gulf Coastal Regions of the United States has a large storage capacity for carbon dioxide through geological sequestration. It accounts for 59% of national CO_2 storage capacity. And you look into a figure to this one, you will see this is the publication of USGS in 2019 about the geological carbon storage potential in the US and you will see there's a major potential area in the Gulf Coastal Plain. So it is very important to study the groundwater for the Gulf Coastal Plain relating to CO_2 injection. So the figure to the middle basically is the three major aquifer systems. The system along the coastal lines is called coastal lowlands aquifer system, and within Texas, we have this Texas coastal uplands aquifer system, and in northern Louisiana all the way to Tennessee, and this is called Mississippi Embayment aquifer system. So in this study, we pretty much focus on the study area to the right. This is lower Mississippi Gulf region, which including nine states from Illinois to Louisiana to Florida. So basically we want to construct a geological model and groundwater model for this region. Then we can study CO_2 injection anywhere within this region.

The concern of the CO_2 geological storage has been discussed a lot. The figure to your left, I can show you that when you have a CO_2 injection well into the deformations and the potential leak of the CO_2 can go through around the casing of the CO_2 injection wells or the existing oil and gas wells. Those CO_2 can surface up to the surface direct through the air or sometimes they will go through some shallow aquifers, may be interacted into some lakes. Sometimes the geology is not perfect for CO_2 storage. Sometimes you might see the caprocks missing. Somewhere the CO_2 might be able to leak. And also, maybe there's a geological fault, for example, as a line over here, could create a passage for CO_2 to leak to the surface or to other groundwater systems. Then those CO_2 can be leaked into the abandoned wells or maybe leak into the shallow groundwater wells. So those are the concerns generally and the public want to know how and why the CO_2 could leak to near the surface.

In terms of Louisiana, as you can see the figure to the right, that's the Mississippi River Delta Plain, which you can see lots of growth faults and salt domes and that will create lots of build complexity of geology when we have this CO_2 injection in this area. So our project basically is talking about, this is a two-year project, the project team members, including me as a PI, and then we have Chris Kees at Civil and Environmental Engineering, a co-PI, and Dr. Xu from the School of Renewable Natural Resources as a co-PI, and Dr. Ahmed Abdalla as a co-PI. Each of us doing different things, but at the end of the day, we will combine all our research together. Our research is really focused on the Lake Maurepas, which is in the center, as you can see. The project goal is really develop the baseline information on geology, groundwater, carbon budget, land-surface deformation, and the scenario-based CO_2 transport simulation to assess potential impacts of CO_2 storage in Louisiana for porous rocks, drinking water, water supplies in the environment. So pretty much I'm working on the Module 1, which is look into the geology and the groundwater categorization. And Dr. Chris Kees looking into the CO_2 modeling in the geological formation, and Dr. Xu look into the CO_2 monitoring in the lake of Lake Maurepas. Then Dr. Ahmed Abdalla using the InSAR and GNSS looking into the potential land surface deformation. Now all the information will come together into the Lake Maurepas area.

All right. So the reason we are interested in Lake Maurepas is because we know they are going to have CO_2 injection in the lake, and based on our searching through the internet, we know that the Air Products has completed a multi-millions seismic survey around the lake, to the lake. And also there are two Class V test wells being approved for drilling. You can see that one classified test well in the north, another one in the south. Their depths will be more than 8,000 feet and it is expected that to have 12 to 16 CO_2 injection wells on the lake and expect to start a CO_2 injection 2026. So this study is two years, so will be finished, provide some baselines around 2025 or early 2026. You know, that's before, provide some baseline information before the CO_2 be injected in 2026.

To understand the CO_2 injection, the first question is that where are fresh water zones and where are potential CO_2 injection zones? We're looking into a oil and gas well, which is a serial number 196347. This is electrical logs from depths 2,200 feet all the way to the depths 9,000 feet. So as you can see through an analysis of the diesel electrical logs, you will see the fresh water zones basically is above 1,000 feet. You will see the local aquifers, Gonzales-New Orleans aquifers, Upper Ponchatoula aquifers. Below 1,000 feet, you will start to see the saltwater aquifers, all the way down to Abita aquifer. It's very interesting in this log that the depths around 2,700 feet and 3,100 feet, you still have fresh water, which is the Covington aquifers and the Slidell aquifers. Then you keep looking down, you will see the huge thickness of permeable rocks starting from around the 3,600 feet all the way down to the 8,000 feet. So you can see those permeable rocks basically are sand and water and there's a potential more than 4,000 feet in thickness you can have a potential CO_2 injection. Below 8,000 feet, which basically is a shell-based formation, and when we look into those formations, those CO_2 injection zones basically is in the Miocene Jasper Formation. And by we look into the relative shallow aquifers here, below the 1,000 feet, will be the Chicot Formation, and in between will be the Evangeline Formation.

So once we identify the drinking water and the fresh water zones, then we look into the water well electrical logs. You can see those are the electric logs we already analyzed surrounding Lake Maurepas. And this Ta-435 well, which is in the Tangipahoa, tell us that we have these freshwater aquifers 1,000 feet and above, including Gonzalez-New Orleans aquifers and the Upper Ponchatoula aquifers. However, we do see in this area we have a freshwater Covington aquifers and the Slidell freshwater aquifers down to the 2,400 feet and the 3,000 feet. Looking at the south of the Pass Manchac over here and you will see the freshwater aquifer around the 1,000 feet. And you do see the freshwater around 2,800 feet, which is the Covington aquifer. And those waters have been pumped for human consumption.

This is the slides show you the groundwater pumping wells around the Lake Maurepas in terms of depths. So I specifically looked into the two pumping wells over here in the east of Lake Maurepas. You have a 2,950 feet and a 3,000 feet. And you look into this Saint John Baptist for the Baptist Parish wells, you will see they actually pump freshwater out of Covington aquifers, but majority of the pumping wells will be on the northern area of Lake Maurepas.

So to understand the groundwater impact and the environmental impact, we developed a workflow for large-scale, high-resolution groundwater modeling. You can see we starting from the well log data collection or groundwater use collection, we developed technologies to develop a geological model. Then we use MODFLOW 6 for the groundwater modeling, and at the end, we developed a high-resolution groundwater models for groundwater analysis and management. And this work is very tedious and take around like 10 years to complete this framework, and that involve many LSU graduate students to make this workflow possible.

So we look into the data first. So starting 10 years ago, we start to collect a huge amount of driller's logs and the electric flows down from Louisiana and we expand our work to the neighboring states, the Texas, Arkansas, Mississippi, Tennessee, Missouri, and so forth. So the reason is we really want to get a good picture about what's the geology and the groundwater system within this Gulf Coastal region. And we worked with USGS and lots of different state agencies to make this data possible. Then we started to focus on the lower-Mississippi Gulf hydrogeological framework. As you can see, those are the electrical logs and the driller's log we collected in this region and we classified those well log data into either clay facies or shell facies and sand facies. Sometimes they have limestone lithofacies. We have around more than 150,000 driller's logs and more than 8,000 electrical logs. Then we started to develop the hydrogeological framework. The table in the middle tell you about 15 hydrogeological units from the youngest, Mississippi River Valley Alluvium aquifer in the Holocene, Pleistocene all the way down to the Midway Confining Unit, which is Paleocene. So that, the figure to the right, you can see that the position of those geological units looking at the cross-section area from north to south, as you can see from here, the oldest will be the Midway over here and the youngest will be the Mississippi River Valley Alluvium aquifer. In the regional coastal lines, pretty much we focus on Chicot Formation, Evangeline Formation and Burkeville Formation and Jasper Formation, like I show you in the electrical logs. The CO_2 inject zones basically will be within the Jasper Formation, which is in the Miocene. And this figure show you the depths up to the 2,000 meters below lake surface.

And then we use the geostatistics. We create a sand probability model for the Lower Mississippi Gulf region. You will see the red color represents the high possibility for clay and white represents a high possibility for sand. As you can see on the surface expression, we have Holocene clay around the Gulf Coast over here and we also have lots of clay along the Mississippi River Alluvium aquifer as a confining unit. Then we created a geological model, gave the index above 0 will be the clay or shell and 1 will be the aquifer. So you can see the blue areas will be the aquifers and the brown areas will be the clay. We also have top two meter soil groups from 5, 6, 7, 8 represents the A, B, C, D in the USDA soil classification as a land cover for our groundwater model.

Once we have this lithological model, we can start to look into what's inside Louisiana. So we have a, I show you three cross-sections. The cross-section E and E prime represents the geology in the northern Louisiana, which you can see the dipping of groundwater towards to the east, pushing me towards to the Mississippi River, which is part of the Mississippi embayment and syncline system. Then we look into the cross-section around more towards the southern Louisiana, G, G prime, east, west. As you can see, we have a very complex groundwater system in this area and in the west, we have Chicot aquifers. In the middle, we have Mississippi River Alluvium aquifers. In the east, we have these Upper Ponchatoula aquifers and you also see lots of aquifers in the very deep depths. And this geological model down to probably 3,000 feet or around 900 meters. Then we look into the north/south cross-sections. You can see the complexity of geology within Louisiana and we have some aquifers merges together and then some clay disappear along, at the different locations. Specifically we focus on two geological faults. One is the Baton Rouge Fault over here and one is the Denham Springs-Scotlandville Fault in the Baton Rouge area. And you can see once we consider the fault lines within the geological system and you can see the complexity over here. Our focus is Lake Maurepas. So we are looking to this area for the IEI project. So that give you some provisional results about Lake Maurepas right over here within the 3,000 feet in the AA prime cross-sections and the BB prime cross-section, the vertical cross-section over here. So we do see some discontinuity of formations within the Lake Maurepas and surrounding Lake Maurepas. So that will be required a further investigation on those geology settings.

Then we created a groundwater model based on this current geological setting. We have pumping wells for the entire Louisiana and we do the model calibration and we use Parallel MODFLOW 6 unstructured grid. The groundwater model we have is around nearly 4.4 million 3D cells. We run 18 years. If we run one single model, it take about 15 hours or nearly 16 hours. However, if we run parallel, computing in LSU supercomputer, it only take about two hours and we get a very good calibration results. So the next step will be really analyze the groundwater levels around Lake Maurepas. This groundwater level just show you the lowest groundwater level on December 2021. You can see the height, the pumping within the state is in the Baton Rouge area and we also have a high groundwater pumping in Sparta aquifers and also in the Chicot aquifers. Some pumping, you can see the cone of depression in the New Orleans area and figure to the right just show you the historical groundwater pumping in Baton Rouge has been decreased more than 300 feet over the years.

So that's the Module 1. Now we build a geological model and a groundwater model. Then we will talking about this Module 2, Dr. Kees' research on the CO_2 transport. Basically he will going to develop and verify a high-resolution Finite Element Method to represent the detailed subsurface geology. And currently he's working on high-resolution Finite Element Method based on the Flux Corrected Transport. Then this is a preliminary result that's a geological setting, assuming we have some leaky faults. We see in the geology and you can see that if we have a water goes through this formation with those four traces and you'll see the impact of those faults in the geology and also Dr. Kees is testing three different method and you will find out the results regarding the numeric X-ray. You will see the EV with the FCT is better than the Kuzmin FCD and the EV.

Module 3 is done by Dr. Xu to understand the carbon budget of Lake Maurepas. His objective is basically really determine the level and the fluctuation of dissolved organic and inorganic carbons in the lake and to quantify the mass input and the mass output of the carbons. Then estimated hourly, daily, and monthly outgas rate of CO_2 from the lake and the river to the air, then assess the factor affecting the dissolved carbon mass transport and the CO_2 outgassing from the Amite River and the Lake Maurepas continuum. So he and his students are working really hard to collect CO_2 and the related other water quality parameters in the Amite River and also around the Pass Manchac, north and south. And this is his current study starting from November 2023 and continue to collect those CO_2 concentrations. Dr. Abdalla is working on the InSAR signals around the lake and he analyzed 25 InSAR images in 2017 in Sentinel-1 Satellite images and these are usually good for the hard land, which may be like a city or not, and the signals will not be good in the vegetation area. And this is the current results, displacements per image from Dr. Abdalla.

As you can see on the figure to the left, the average velocity of 2017 is all positive, meaning that in 2017, it's always uplift of land between 0.5 to 0.8 millimeters. So when the CO_2 really inject into underground, we will see the difference of land formation, which will be kind of different from this baseline information produced by Dr. Abdalla.

All right, so what are our next steps? So we will first analyze the geology structures and the groundwater flows for Lake Maurepas areas. Then we'll use this information, give this information to Dr. Kees to develop a high-resolution Finite Element Method for CO_2 simulation. Then Dr. Xu will continue to understand what CO_2 or carbon budget, continuous CO_2 monitoring and analysis. And Dr. Abdalla will continue the land surface displacement analysis for this year, for the rest of years and this year's. Next year is for with the satellite data.

All right. Thank you. That will be my presentation. Thank you very much.

Brad Ives
Thank you very much, Frank. We've now got about, looks like we've got just under 10 minutes for a question and answer. We received several questions ahead of time through registration and we've got a couple that are coming in live. So we will do our best to get to as many of these as possible.

The first question that we received, which I think is very significant, is, quote, "LSU has a significant financial relationship with carbon energy companies. What reassurance is there of independent opinions?"

You know, this is a very fair and important question and I want to answer it both personally and institutionally. For me personally, I joined the institute as the head at the end of October last year. And in my diligence on taking the job, this was something incredibly important to me. I spoke with President Tate, Provost Haggerty, and extensively with the Vice President of Research, Robert Twilley, to ensure that the institute would be able to operate independently and with the highest academic integrity. I know that most of you on this call, this is the first time you're experiencing meeting me and don't know me yet, but during my time with the University of North Carolina, I dealt with some very difficult issues there and worked to always do the right thing, even when it brought some peril to my career. You can Google it and you can look it up and hopefully you can get some confidence that as a leader, I'm gonna ensure that we have the utmost integrity. But let me also talk about it institutionally.

Academic integrity is the key thing that a university has. And at LSU, you know, we have an unwavering commitment to ethical conduct of our research and it's something that our institution backs in a very meaningful way. We expect that Dr. Tsai, all the other investigators on this project and all of the projects that are conducted under funding from the institute and also across the university are conducted with the highest ethical standards. And the standards we adhere to are the ones issued by the National Academy of Sciences, the National Science Foundation, and the National Institutes of Health. Additionally, we have training for our researchers that is required. They undergo regular training and certification and research integrity. And finally, LSU's got a statement on academic integrity that we think is really important and it's the bottom line for what we do. And that is, quote, "The responsible conduct of research is an obligation fundamental to the process of scholarly inquiry." With that said, we also value our relationships with industry. I mean, Louisiana State University is uniquely positioned to work on the challenges facing the energy industry. And we do that by talking to members of industry to find out what the issues are. We are a land-grant institution and part of the reason that the United States set up land grants in the 1860s was to make sure that we had applied research that could be used to solve problems. And that's exactly what we're doing.

So we've conducted two workshops where we bring industry together with our professors to talk about what's going on in the marketplace, what they're seeing, what are the problems where universities are uniquely positioned to be able to solve them and that allows us to tackle them. And that's what has led to projects like Dr. Tsai's being funded. Once we get a proposal for a project, we send these out for third-party independent academic review that's done on a blind basis. We use a firm in Washington DC to do this. It's extensively peer-reviewed and we get the results back from that before selecting projects. So overall, you know, let me just be emphatic that academic integrity is paramount to everything that we do. We must maintain our independence. We are not gonna impact the researchers and the work they're doing. We're gonna let them find what the facts and science leads to and that's the type of result we're gonna produce. And ultimately the proof of that is gonna be what you, the public, what government, what other academics think of our research. And as a result, everything we do is public.

We're a public university. We're subject to Freedom of Information Act laws and we're gonna post everything that we do to the internet. So we welcome the scrutiny on our work and we expect our work will be groundbreaking and will lead to interesting results that none of us can predict right now. But we're gonna do that the right way. So I thank you for the question and I really appreciate the opportunity to address that. Moving on to a second question, we've actually had a number of similar questions, and Frank, I want to throw this one over to you. One of the representative questions of these is, quote, "What are the possible impacts of CO_2 leaks and to underground drinking water aquifers?"

Dr. Frank Tsai
If you go back to the first few slides, I show you the impact of the CO_2 into drinking will be potentially will increase the acidity in aquifers and also reduce, potentially reduce the pH values. That's the CO_2. Common sense, CO_2 reacted with water. However, groundwater is different from surface water because they are geology involved. There are some geochemical reactions will be beyond my imaginations and those questions will be answered by geochemist once the CO_2 really reach to the drinking water.

Brad Ives
Great. Thank you for that. Here's the next question. Quote, "Is there a significant geological difference between southeast Louisiana and southwest Louisiana for geological carbon storage?"

Dr. Frank Tsai
There is no significant difference in the southwest Louisiana and southeast Louisiana in terms of geology. The only difference you can see is the Mississippi River. The Mississippi River in the Pleistocene and Holocene create a tremendous sediment deposit along the Mississippi corridors. So that created a very unique deposition in the southeast Louisiana. Other than that, the Southern Louisiana geology pretty much similar.

Brad Ives
Great. Thank you for that. Here's the next one. By surface displacement, do you mean the surface elevation would increase due to injection of CO_2? And then another part of that is what order of magnitude would you expect for the change?

Dr. Frank Tsai
Yeah, that's a very interesting question because normally you inject the CO_2 into the deformation, maybe below 6,000 feet to 8,000 feet. You are going to inject tremendous amount of pressure into the formation. So naturally the pressure will push the ground upwards, create a kind of land uplift. That's the land surface displacement meaning. Yeah. Because of pressure, huge amount of pressure under the ground created by the CO_2 injection. And how much, I don't know at this moment, and I believe this answer can be found in the literature somewhere. Okay. Yeah.

Brad Ives
Great. We've got time for one last question. Will Dr. Tsai's study be published or otherwise available to the public?

Dr. Frank Tsai
Yes. Several groundwater studies I present are already published in two journal articles and the third one is under review right now. And I believe the other co-PIs' results will also be published in the near future. So that will be all shared with the public.

Brad Ives
Great. Thank you. Thank you very much. And we've come to the end of our time. We've got a number of questions that have come in. We'll take a look at these and try and post some answers to the internet. And as I mentioned, we'll be posting a recording of this presentation along with Dr. Tsai's slides to the Institute for Energy Innovation website. So I want to obviously thank Dr. Tsai and his team for all the work that they've done and for the time today. It was a fantastic presentation.

I also want to thank all of you for attending. It's an amazing turnout, probably, you know, five times as many people as we expected would be interested in this. So thank you all for attending. We'll be emailing out a link to where we're posting the replay of this along with the slides to all of you later today. And as I mentioned at the start of our broadcast, we're gonna be hosting future webinars about our research activities. We'll also be hosting speakers on campus on various energy-related topics. To receive notice of these, again, please go to our website and sign up for our newsletter and also follow us on LinkedIn for additional updates.

We look forward to seeing you at a future energy event and if there's anything that the institute can do for you or for any organization that you work with, please don't hesitate to reach out to us.

And in the meantime, just remember the future of energy is here, it's here in Louisiana, it's now, and we're all gonna be working on it. So thank you very much for attending and I hope you have a great rest of your day.