Abilene Christian University

ACU TODAY

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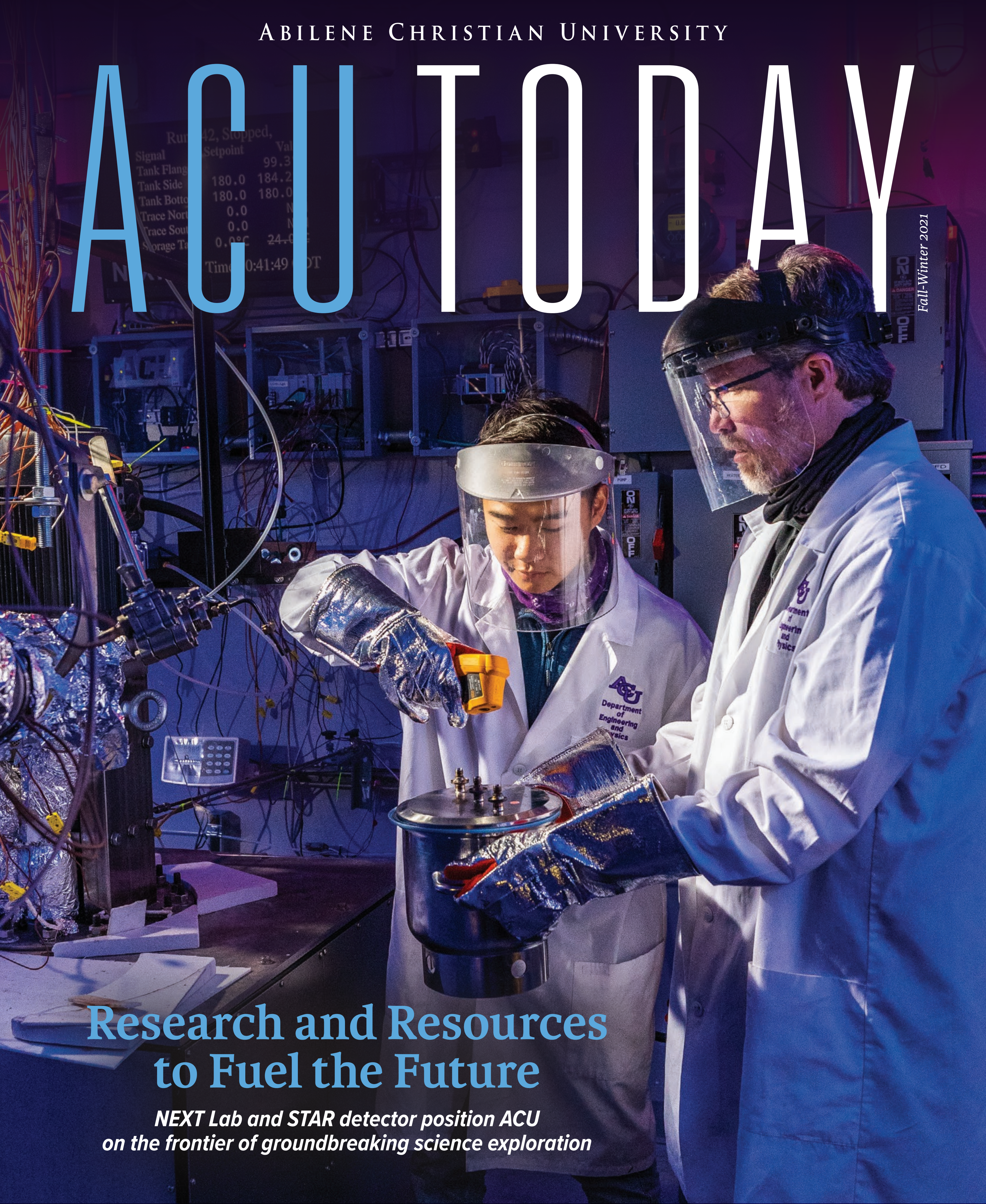


Research and Resources to Fuel the Future

NEXT Lab and STAR detector position ACU on the frontier of groundbreaking science exploration

Research engineer Jessica (Price '20) Yerger and senior engineering major Aline Ineza take a sample of molten salt at the NEXT Lab in ACU's Engineering and Physics Laboratories at Bennett Gymnasium.

RESEARCH AND RESOURCES

TO FUEL THE FUTURE

Students and faculty in engineering, physics, chemistry and biochemistry bring new opportunities to ACU, building on a legacy of research and excellence

STORY BY WENDY KILMER • PHOTOGRAPHY BY JEREMY ENLOW

ACU's first physics department chair, **Dr. Charles Ivey ('65)**, joined the faculty in 1969 as a 20-something, fresh out of a Ph.D. program at The University of Texas at Austin and with some unconventional ideas about an undergraduate physics program.

His friend, **Ray McGlothlin Jr. ('49)**, a member and future chair of the ACU Board of Trustees, had recruited him with the promise of building a department from the ground up.

"We didn't have to follow the path of other departments; we could accelerate ourselves," Ivey said. "Instead of simply going to class and learning as an undergraduate, we went for a model of 'go to class, then go to the lab and do research, then present and defend it in front of peers.' What I wanted to do, and what we did, is get research grants, teach graduate-level material in undergraduate classes, and bring really high-quality physicists to become faculty."

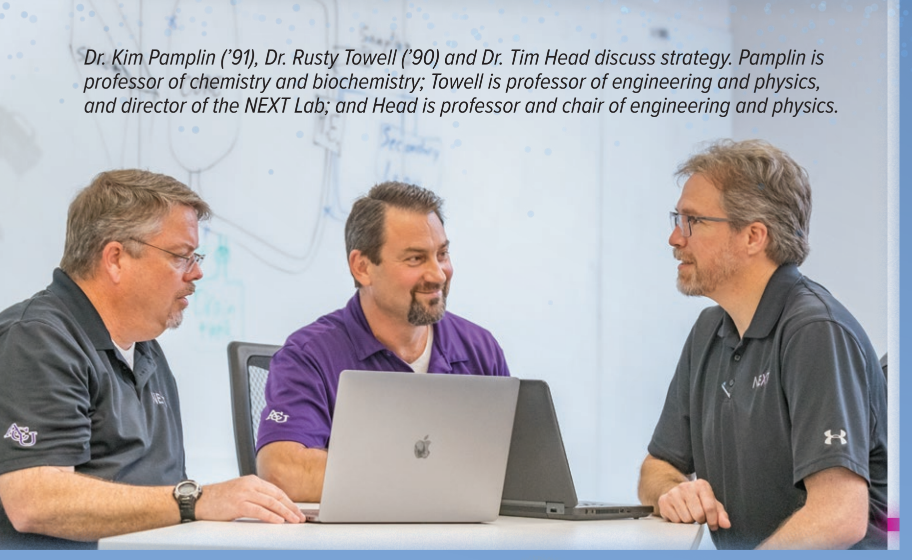
Those ambitious aims in the early days shaped the department for the next half century, taking students to the nation's top laboratories and, more recently, bringing industry-changing research opportunities to campus in Abilene through the Nuclear Energy eXperimental Testing Laboratory's foray into the world of advanced nuclear energy and the longtime work of the Atom Smashers research group in unraveling the mysteries of the building blocks of the universe.

NEXT LAB TOO GOOD TO BE TRUE

As president of the university, **Dr. Phil Schubert ('91)** knew he shouldn't pour cold water on the ideas of his faculty. But, realistically, this was too good to be true. Wasn't it?

Dr. Rusty Towell ('90), professor and then-chair of the Department of Engineering and Physics, and his colleagues had presented a vision for building a molten salt reactor that would create safe, clean energy and had potential to cure cancer, help the environment and provide clean, drinkable water.

"I'd always heard the phrase 'If it sounds too good to be true, it probably is,' and that's where



Dr. Kim Pamplin ('91), Dr. Rusty Towell ('90) and Dr. Tim Head discuss strategy. Pamplin is professor of chemistry and biochemistry; Towell is professor of engineering and physics, and director of the NEXT Lab; and Head is professor and chair of engineering and physics.

TOP RIGHT: Research engineer Vicente Rojas ('17), senior engineering major Yves Ngenzi and research engineer Jessica (Price '20) Yerger insert a molten salt storage container into its support frame.

LEFT: A NEXT research student monitors thermal images of the Molten Salt Test Loop during operation.

my thoughts immediately went," Schubert admits. "I was skeptical that the picture they were painting was reasonable."

Still, he trusted their expertise and instincts and wanted to support their interests.

"I kept asking questions, and the more I heard them describe it and saw their excitement, I began to think, 'Part of research is failure. Maybe it's credible, maybe not, but it'll be a good experience for faculty and students,' " Schubert said. "So I put aside whether it was realistic and said I'd try to help secure funding to get them out of the gate."

Towell, now director of NEXT Lab and professor of engineering and physics, knew the feeling. It's what kept him from seizing the idea for a few years prior, even as Ivey, now a member of the department's Visiting Committee, peppered him on a regular basis with the question, "What do you think about a molten salt reactor?"

Ivey had heard about the molten salt reactor in its early days from **Dr. Eugene Wigner**, one of the pioneers of the technology and a Nobel Prize-winning nuclear physicist. Wigner visited The University of Texas at Austin while Ivey was a doctoral student doing graduate research, and the two met and had conversations about molten salt reactors. Although Ivey was intrigued by the technology, he was in the midst of his own research, and the idea took a backseat until his retirement.

"When I retired, I wanted to stay in Abilene and help students," Ivey said. "And in doing some reading, I saw the molten salt reactor subject had come back up. I started talking to Rusty and **David Halbert, M.D. ('54)**. David had this round table in his kitchen, and we met at that table regularly for the next year. I'd explain to him why this was so important: This is the way we can clean up our environment, we can produce water, we can do all kinds of things. And I kept talking to Rusty about it."

Persistence paid off, even though Towell's initial reaction was similar to Schubert's.

"When I first looked into it, it seemed too good to be true," Towell said. "But I had a sabbatical coming up, and I said I would use some of that time to think about it. I learned about advanced reactors, did more reading, attended conferences and talked to industry partners."

His sabbatical research culminated in an 18-minute talk at the first TEDxACU event in 2015. The presentation quickly captured the attention of several people – Ivey and Halbert, of course, but also **Jim Porter**, **G. Randy Nicholson ('59)**, **Jack McGlothlin ('51)**, and Jack's son, **Shawn McGlothlin ('89)** – who were interested in funding and supporting the idea. In 2016, ACU's Nuclear Energy eXperimental Testing Laboratory officially formed. The McGlothlins purchased the team a molten salt pump, and the group began learning what it means to melt salt, how to work with it and where the current technology gaps were – pieces such as a flow meter, pressure meters and level sensors.

"Detectors and instrumentation are things ACU has been doing at national physics labs for years, so that was where we began," Towell said. "We started small, building a loop and a flow meter. We reached out to engineers within our department and the Department of Chemistry and Biochemistry, and said, 'We want to build this program.' We started looking at nuclear energy. We knew we wanted to focus on building things, not just designing them."

Molten salt reactors have long been dubbed "chemistry reactors." That's because their success depends on understanding properties of corrosion, salt's interaction with anything it touches, the composition and purification of salt, and the types and amounts of elements created by nuclear reactions.

So involving ACU's Department of Chemistry and Biochemistry was essential from the beginning. NEXT Lab makes use of its equipment and facilities, and partners with colleagues to assess the best set of analysis tools. Two faculty and 10 students from the Department of Chemistry and Biochemistry are on the NEXT Lab team. Their department boasts a similar focus on undergraduate research on and off campus, and through internships around the nation.

NEXT also collaborates with faculty and students from the School of Information Technology, computer science, mathematics, accounting, and advertising/public relations.

The Right People, the Right Place, the Right Time

From the start and throughout the process, Towell said the initial skepticism of "too good to be true" was overcome by finding the right people, in the right places, at the right time. One of the first and perhaps most influential people was **Doug Robison, J.D.**

After getting the go ahead from a still-skeptical Schubert, Towell presented the NEXT Lab's molten salt research reactor idea to the President's Venture Council, a group of ACU benefactors and entrepreneurs who provide funding for emerging opportunities outside the normal budget.

Towell had barely made it to the back of the room after his presentation when Robison pulled him aside and asked, "If you were fully funded, what could you do?"

The question took Towell aback, but it was a genuine and natural question for Robison. In addition to running an oil and gas exploration and production company at the forefront of the hydraulic fracturing revolution, Robison had served on the Texas Energy Planning Council. He chaired its Energy Supply Committee and spent a year conducting hearings around the state about how to maximize energy production.

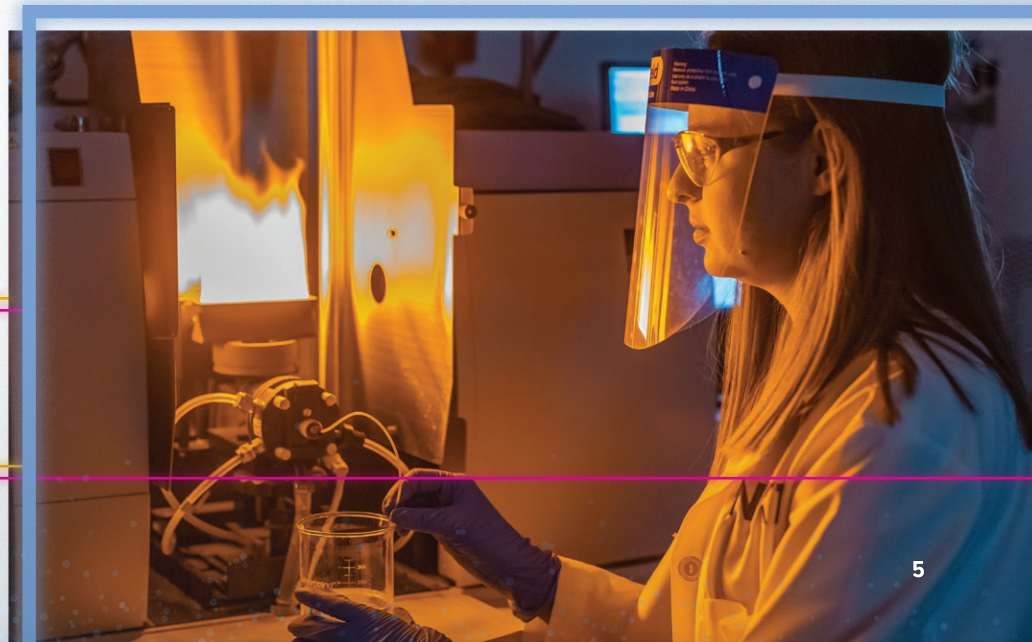
One of the major findings in his report? *The only technology that exists to replace hydrocarbons is nuclear.* That was in 2004, more than a decade before his "right time, right place" encounter with Towell.

"I had been working on things like this for close to 20 years," Robison said. "It was easy for me to see the potential and importance of this technology, knowing that we have to, at some point, move on to the next form of energy production. Non-renewables are nonrenewable for a reason. There's a finite supply. Our current nuclear power is a great source of energy, but there are issues with it. This technology solves those issues. That's what got me excited about it and made it easy for me to make that leap. I saw the fulfillment of things I had been working on for well over a decade."

Robison's initial commitment came in the form of $3.2 million contributed through the Robison Excelsior Foundation in 2018, and in that same year, molten salt flowed through a test loop at NEXT Lab for the first time.

Any lingering skepticism lurking in Schubert's mind was disrupted by a phone call to his office in 2018 from then-U.S. Secretary of Energy Rick Perry. The former Texas governor had heard of the nuclear energy project and wanted to send someone from his office to ACU to learn more.

"Wow," was Schubert's reaction.



Senior chemistry major Melissa Powell performs chemical analysis on a salt solution with a flame atomic absorption spectrometer in Onstead Science Center.

LEFT: Architectural rendering of the proposed Science and Engineering Research Center (SERC) at ACU.

BELOW: Junior biochemistry major Benjamin Ash (left) and junior chemistry major Emma Bonamie work on a process to perform chemical analysis of molten salt in Onstead Science Center.

Perry's office sent the nation's then-chief nuclear energy official, **Ed McGinnis**, to Abilene to visit the newly formed NEXT Lab and hear from Towell and others about plans for the future. He was impressed and told Schubert as much.

"He pulled me aside and said, 'What your scientists are doing is amazing. This is what the U.S. needs to do. You are in exactly the sweet spot of what needs to take place. I'd like to get my whole team in a room and have you explain what you're doing, so we can be engaged and advise you and proceed down this road. We believe this is really important,' " Schubert said.

McGinnis made arrangements for Robison, Schubert, Towell and **Dr. Tony Hill ('90)** to meet with his team at the U.S. Department of Energy in Washington. It was the first of several trips the group would take to D.C., beginning the processes of acquiring necessary materials and seeking licensing through the Nuclear Regulatory Commission.

All along, ACU's planning and research wasn't taking place in a silo; Towell, Ivey and Hill reached out to colleagues from other universities. They shared ideas, brainstormed and looked at possibilities for collaboration. In 2018, those plans formalized as Georgia Institute of Technology, Texas A&M University and The University of Texas at Austin joined ACU to form NEXTRA, the NEXT Research Alliance, with the goal to design, license and commission a molten-salt-cooled, liquid-fueled research reactor to be hosted on or near ACU's campus.

Meanwhile, Robison undertook a different kind of research – exploring the best way to fund such work, beyond dependence on governmental grants. After consulting with legal experts, Robison landed on sponsored research as the best solution and formed Natura Resources, a for-profit entity designed to be the funding instrument for the research.

In 2020 Natura Resources announced funding of $30.5 million to NEXTRA over the next three years, with $21.5 million going to ACU and the remaining $9 million divided among the other three universities.

"Money is a tool," Robison said. "We all have some measure of time, talent and treasure, and we're going to spend those accordingly – maybe for good, maybe for bad – but we're going to use them for something. And I couldn't think of many other things that could have as much impact for good."

The potential for good is explicit in the mission of NEXT Lab: to provide global solutions to the world's most critical needs.

"Ultimately, we want to advance liquid-fueled molten salt reactors to address the world's need for clean, inexpensive and safe energy, water, and medical isotopes to treat cancer," Towell said. "When thinking about the potential impact on the world, this project is like no other; its long-lasting implications are amazing. To be part of that is very exciting. When I think about that goal of blessing the world through this technology and how it aligns with ACU's mission, it seems to be a perfect match."

Natura Resources
SUSTAINABLE ENERGY

Next Steps

In working toward the ultimate goal, a significant intermediate one is to complete construction of a molten salt research reactor by 2025.

To date, the NEXT Lab's progress includes having secured the first patent – for a high-temperature flow meter – and having a second patent in the provisional stage. A second version of the salt test loop was installed in the Engineering and Physics Laboratories at Bennett Gymnasium in January, and by early summer 2021 the former Taylor Elementary School gymnasium will become the new home of research space to include a radiochemistry lab and a larger scale molten salt test system. Abilene ISD built a new Taylor campus in northeast Abilene, and ACU purchased the original school property on the corner of East North 16th Street and Judge Ely Boulevard.

Once funding is secured, ACU will break ground on a 28,000-square-foot Science and Engineering Research Center on the former Taylor property.

The SERC is scheduled for completion in 2022 and will house the next iteration of molten salt test system, allowing all the components to be tested in full size before constructing the actual research reactor. This research facility will be the centerpiece of the renovation and development of the former Taylor site.

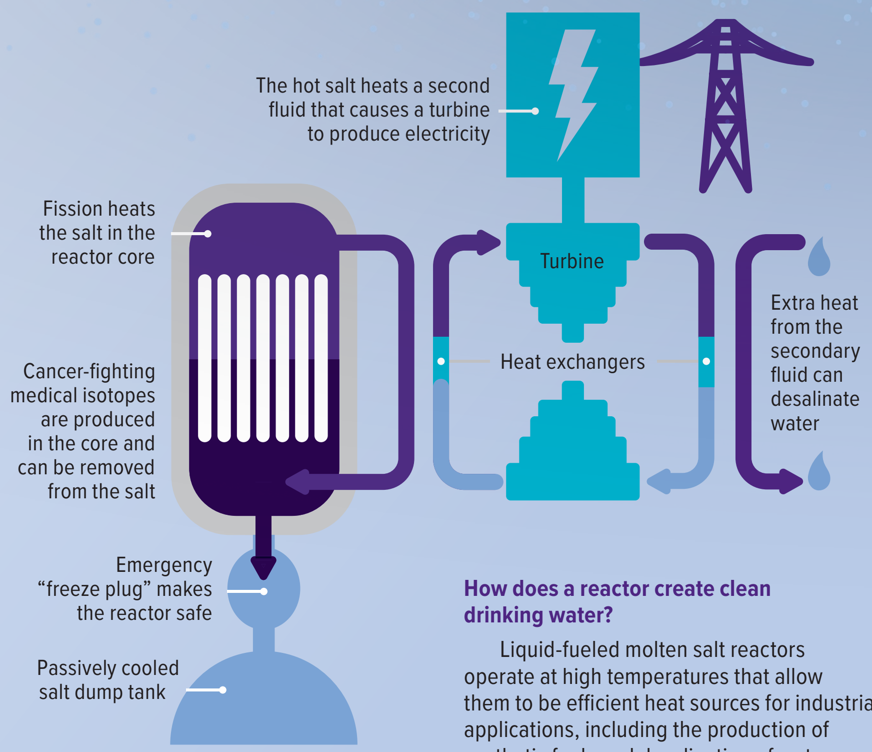
A Whole Lot of Sense

The view in 2021 is a bit different than in the early days of dreaming in 2015.

"This has grown so quickly and so big, it's sometimes challenging for me to understand where we are," Towell said. "We now have 26 faculty and staff and 46 students working on the project, just at ACU, and more than 100 if you include the other institutions. That sort of rapid growth is something I never envisioned as possible. But belief in it by president Schubert and Doug Robison, having their funding and support, put us in this position."

Schubert's perspective has

Q&A: Understanding molten salt reactors



Where did this technology originate?

Liquid-fueled molten salt reactors are not a new idea, but the concept has been dormant for some time. A successful research program at Oak Ridge National Laboratory in Tennessee was dedicated to this work from 1958-76, and from it came important advances in nuclear reactor research. The objective was the development of liquid-fueled molten salt reactors, and this work successfully demonstrated their viability.

If it was so successful, why didn't it continue?

The research program was canceled prematurely, not because the technology was invalid or impractical, but for various non-scientific reasons, such as the development time and political, military and commercial issues. The primary developer paying for the original nuclear power plants was the U.S. Navy, which wanted the quickest path to deploying nuclear power for submarines.

Is it safe to have a nuclear research reactor on a university campus?

Yes. Nuclear power in western countries enjoys the best safety record in the world, and the improvements in liquid-fueled molten salt research reactors provide significant safety enhancements.

It's impossible for a molten salt reactor to cause a nuclear explosion and release of harmful radiation. The use of low-pressure coolants removes the largest single risk from current nuclear plants. The use of liquid fuel allows for a drain in the bottom of the small reactor.

If anything were to go wrong with the plant, the fuel and coolant would drain to a passively cooled sub-critical storage location where the salt would then solidify, safely containing all of the fuel and radioactive fission fragments.

What size is the research reactor to be housed at NEXT Lab?

The research reactor will be small, roughly the shape of a cylinder 6 feet tall and 5 feet in diameter. A small amount of low-enriched uranium-235 is the nuclear fuel required, and it is only available through the U.S. Department of Energy. It is not high-enriched uranium used by the military for making weapons.

Are there reactors on other university campuses?

Yes, reactors at other universities have been safely located for years in urban areas. There are 31 research or test reactors in the U.S., including three in Texas. The one on the campus of The University of Texas at Austin is the newest in the nation, having been built in the 1990s. Another in a densely populated major city is in Boston at Massachusetts Institute of Technology.

Others are at universities in California, Colorado, Florida, Idaho, Indiana, Kansas, Maryland, Missouri, New Mexico, New York, North Carolina, Pennsylvania, Utah, Washington and Wisconsin.

How does a reactor create clean drinking water?

Liquid-fueled molten salt reactors operate at high temperatures that allow them to be efficient heat sources for industrial applications, including the production of synthetic fuels and desalination of water. Given that one in three people around the world suffer from a shortage of fresh water, development of this technology can meet a fundamental global need.

How do medical isotopes come into play?

Radioisotope treatment and diagnostic methods are common in a variety of clinical practices, including oncology, cardiology, hematology, urology and nephrology. Molybdenum-99 (Mo-99) and bismuth-213 (Bi-213) are two radiopharmaceuticals that show great promise, especially for cancer treatment.

Mo-99 is in high demand because of its applications in radiodiagnostic procedures that allow doctors to make diagnoses quickly without the need for an invasive procedure. Bi-213 has opened doors for targeted alpha therapy, used to kill dispersed cancers such as leukemia and lymphoma. This provides a new treatment option, one that would spare patients from chemotherapy, and in limited trials it has been effective.

Bi-213 and Mo-99 are both formed most efficiently in the natural nuclear processes inside a liquid-fueled molten salt reactor. ▲

expanded as well, from an idea that was "too good to be true" to a project that makes too much sense to pass up.

"This work extends from an existing area of competency and strength – our longstanding incredible excellence in the Department of Engineering and Physics for 30-plus years," he said. "And now we're looking at pushing forward to provide basic needs of humanity. I can't think of anything that fits better with what we're about at ACU – being God's hands and feet in the world. For those reasons, this just makes a whole lot of sense." ▲

Visit *acunextlab.org* to learn more

Keaton Chance installs thermocouples to monitor system temperatures.

LEFT: Research chemist Alli Mae Berry ('19) examines the torch from an inductively coupled plasma mass spectrometer.

ABOVE: Michael Ranger works on the remote control and data acquisition system for the molten salt test loop in Bennett Lab.

NEXT

Nuclear Energy eXperimental Testing

Natura Resources

SUSTAINABLE ENERGY

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