TECHNOLOGY TRANSFER 2023

ANNUAL REPORT

2023

INL
Idaho National Laboratory

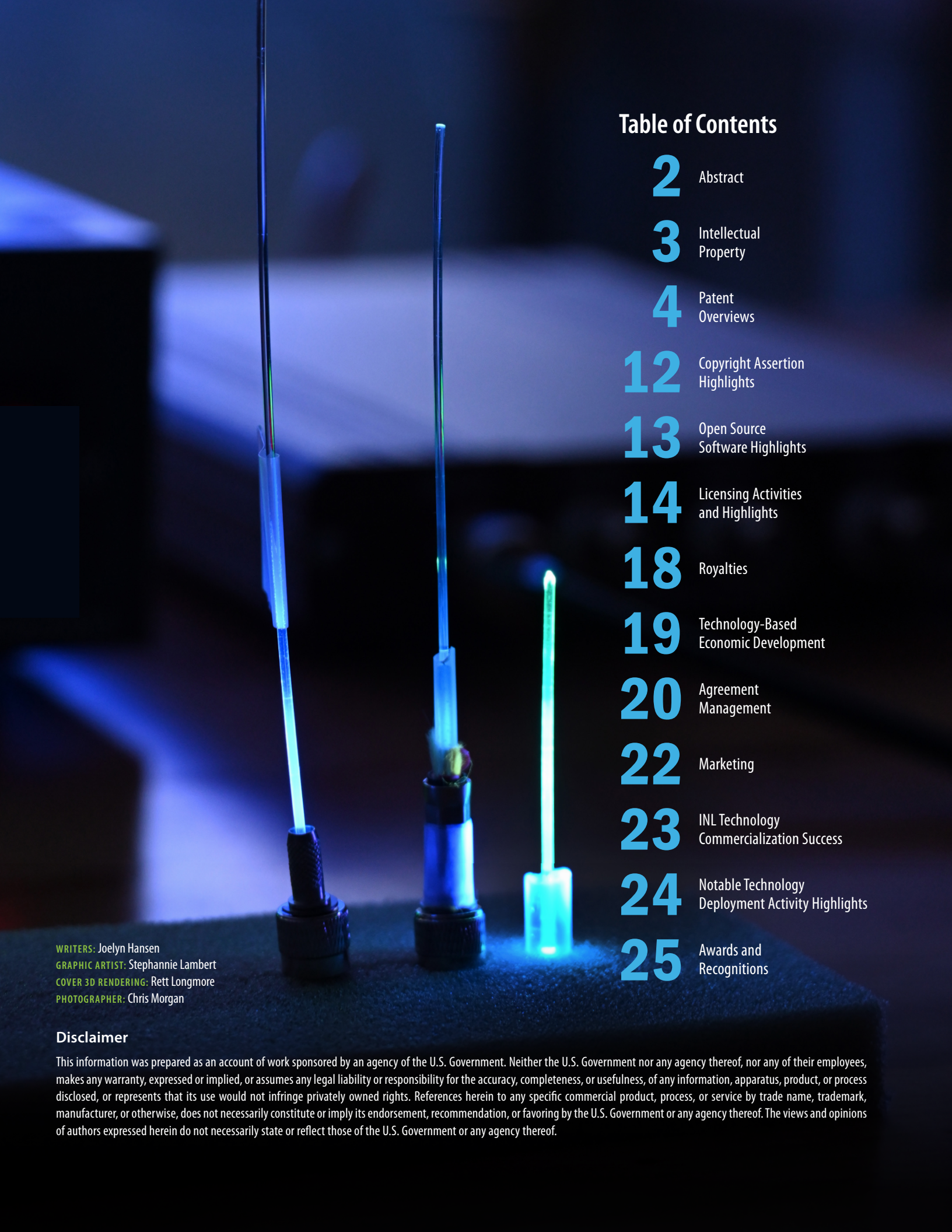

Table of Contents

2 Abstract

3 Intellectual Property

4 Patent Overviews

12 Copyright Assertion Highlights

13 Open Source Software Highlights

14 Licensing Activities and Highlights

18 Royalties

19 Technology-Based Economic Development

20 Agreement Management

22 Marketing

23 INL Technology Commercialization Success

24 Notable Technology Deployment Activity Highlights

25 Awards and Recognitions

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From the Technology Deployment Director

As director of Technology Deployment at Idaho National Laboratory, I am proud to serve an organization with such dedication to our mission, outcome and strong spirit of innovation.

Deploying laboratory technologies and capabilities for industry use continues to be our No. 1 goal. Technology transfers are imperative to improve lives, keep our nation safe and help our economy flourish. Every time industry leverages the lab to overcome a challenge, or a technology moves from the benchtop to the marketplace, INL makes an impact.

This cannot be done without our esteemed innovators, experts and champions who worked effortlessly to contribute to the many accomplishments in 2023. There have been many notable activities, success stories and growth in metrics that demonstrate how the lab is moving the needle and pushing closer to achieving mission goals.

Our innovators, experts and champions make an impact!

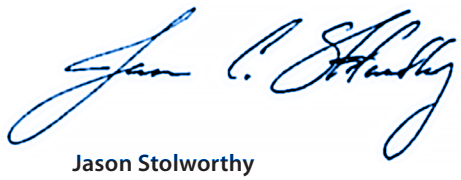
Our innovators and technology transfer staff members delivered impressive numbers of innovation disclosures and license agreements in 2023.

Through fiscal year 2023, there were 473 active licenses. We also captured more strategic partnership projects, user facility, and cooperative research and development agreements to address industry challenges. Five INL technologies won 2023 R&D 100 Awards – our largest number of wins in over two decades.

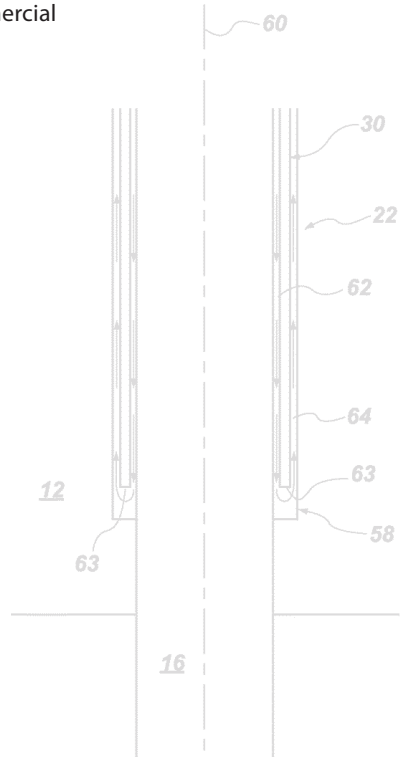
It's been wonderful to hear and see how companies and organizations that licensed INL technologies are finding success or continuing to grow in the marketplace. There's nothing more satisfying than looking at products or services and knowing that technology originated at the laboratory.

We appreciate the strong support from private and government sponsors, the Department of Energy, commercial partners, and laboratory leadership over this past year.

We encourage you to read more about the impactful deployments captured in this report. It truly is an exciting time to be at Idaho National Laboratory.



Jason Stolworthy
Director, Technology Transitions



Jason Stolworthy
Director of Technology Deployment

Sheena Kanyid
Manager, Agreements Management

Abstract

Idaho National Laboratory (INL) is a U.S. Department of Energy (DOE) multiprogram national laboratory that conducts research and development in all DOE mission areas. Like all national laboratories, INL is fully committed to its technology transfer mission to make its capabilities and technologies available to federal agencies, state and local governments, universities, and industry. Simply put, it's in our DNA.

To fulfill this mission, INL encourages its scientific, engineering and technical staff to disclose new inventions and creations to ensure the resulting intellectual property is captured, protected and made available to others who might benefit from it. As part of the mission, intellectual property is licensed to industrial partners for commercialization, job creation and delivering the benefits of federally funded technology to consumers. In some cases, unique capabilities are made available to other federal agencies, international organizations, domestic and foreign commercial entities or small businesses to solve specific technical challenges.

INL employees work with researchers and technical staff members from the university and industrial sectors to develop emerging technologies. In this global economy, INL helps develop the next generation of engineers and scientists by licensing software to educational institutions throughout the world.

This report is a catalog of select INL technology transfer activities, including commercialization transactions and research agreements, executed during the past year. The size and diversity of INL technical resources, coupled with relationships with other organizations, virtually ensures the report will fail to capture all interactions. Recognizing this limitation, this report focuses on transactions specifically authorized by technology transfer legislation (and corresponding contractual provisions) or involve the transfer of legal rights to technology to other parties. This report was compiled from primary records that were readily available to INL's Technology Deployment and Agreement Management offices. Accomplishments cataloged in the report reflect the achievements and creativity of INL's researchers, technicians, support staff and operators.

Prepared for the U.S. Department of Energy Under DOE Idaho Operations Office Contract DE-AC07-05ID14517

Technology Deployment works to identify and pursue opportunities for technology commercialization and business development.

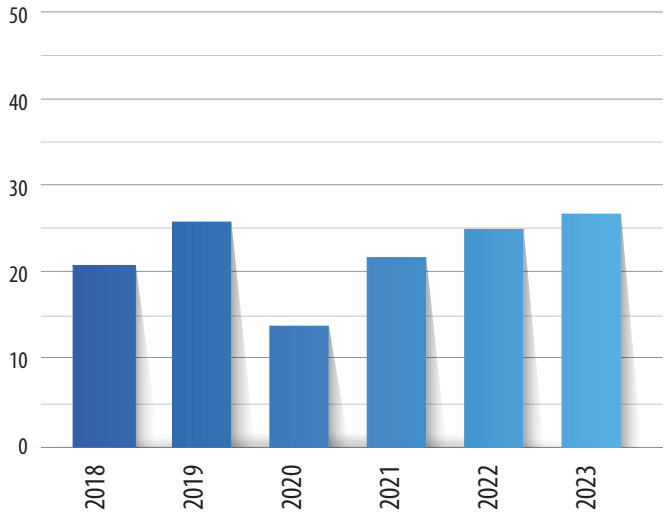
Intellectual Property

INL's intellectual property portfolio includes invention disclosure records, patent applications, issued patents and copyright assertions, providing a basis for collaboration with commercial enterprises, academia and other parties, both domestic and international. INL's science, engineering and technical intellectual property portfolios provide the laboratory with an opportunity to deploy its creative, meaningful research.

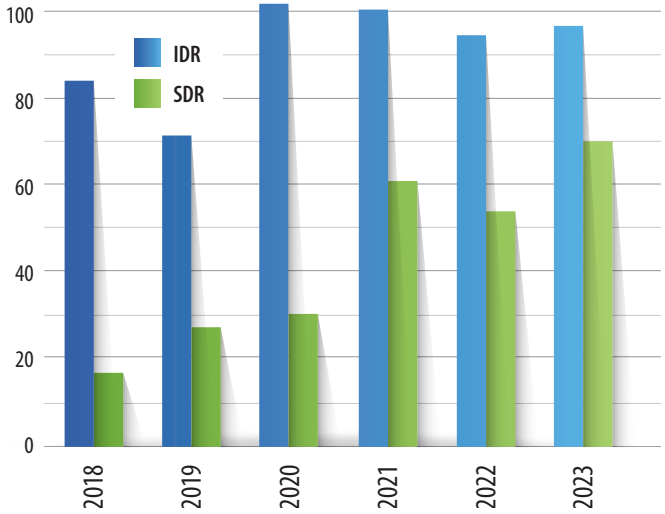
Technology Deployment works closely with INL leaders and researchers to identify and pursue opportunities for technology commercialization and business development.

In fiscal year 2023, INL innovators submitted 98 invention disclosure records and 70 software disclosures to Battelle Energy Alliance LLC (BEA). In FY-23, 27 U.S. patents were issued to either INL or DOE based on the inventions of INL scientists and researchers.

U.S. PATENTS ISSUED FY 2018–2023



DISCLOSURE RECORDS RECEIVED FY 2018–2023

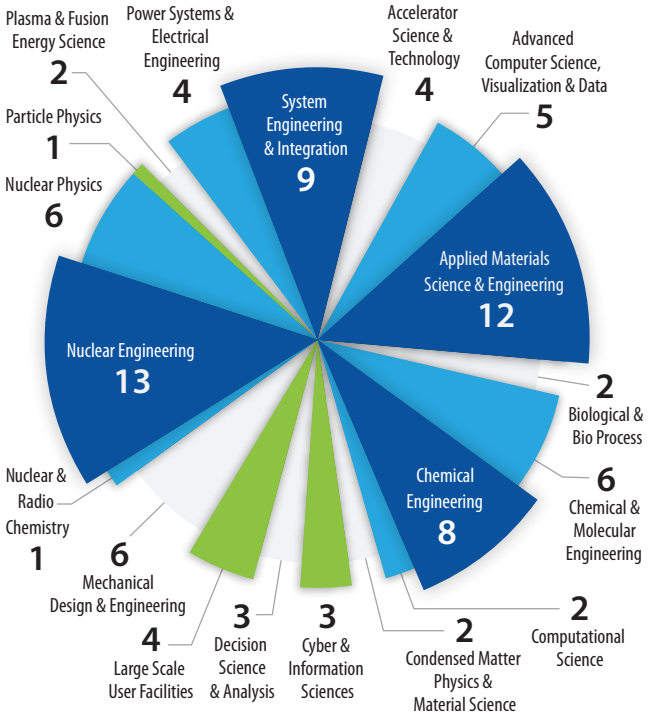


Since the commencement of BEA's contract to manage INL in 2004, laboratory researchers have submitted nearly 2,000 disclosures resulting in over 600 issued U.S. patents. The lab has executed over 2,000 new licenses during this period.

BEA has intellectual property ownership rights under its contract with DOE and can retain title to inventions and seek patent protection, subject to some exceptions. The decision to seek patent protection is based on market and technical assessments of the technology and its subsequent programmatic value.

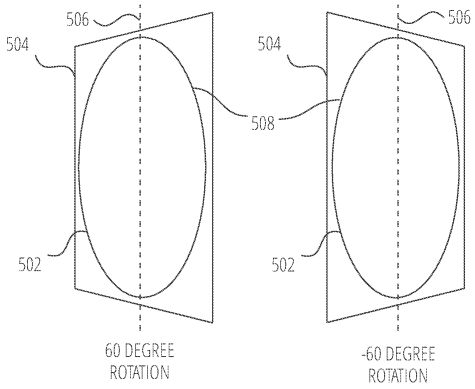
Technology assessments inform a recommendation presented to a committee composed of department or project managers, an assistant laboratory director or designee, market analysts, commercialization managers and a patent attorney. The Technology Deployment director makes a final decision to elect or decline the technology for patent protection. Generally, potential inventions judged to be commercially valuable, crucial to a primary mission or valuable in terms of motivating further research funding are elected.

CORE COMPETENCIES ASSOCIATED WITH FY 2023 PATENTS



- Accelerator science and technology
- Advanced computer science, visualization and data*
- Applied materials science and engineering*
- Applied mathematics
- Biological and bioprocess engineering*
- Biological systems science
- Chemical and molecular science**
- Chemical engineering*
- Computational Science
- Condensed matter physics and materials science**
- Cyber and information sciences*
- Decision science and analysis*
- Earth systems science and engineering
- Environmental subsurface science*
- Large-scale user facilities/ R&D facilities/advanced instrumentation*
- Mechanical design and engineering*
- Nuclear and radiochemistry*
- Nuclear engineering*
- Nuclear physics
- Particle physics
- Plasma and future energy sciences
- Power systems and electrical engineering and integration*
- Systems engineering and integration*

*Acknowledged ** Emerging



Patent 11,555,916

Patent Overviews

High-temperature, Irradiation-resistant Thermocouple, Coaxial Thermocouple, And Related Methods

A coaxial thermocouple includes a wire, an insulation layer surrounding the wire, a sheath surrounding the insulation layer, and an electrical junction formed between the wire and the sheath and at one longitudinal end of the coaxial thermocouple, the electrical junction including a swaged end with an outer diameter of the sheath reducing in diameter along a longitudinal length of the coaxial thermocouple until the sheath contacts the wire within the insulation layer. The wire includes a first material and the sheath includes a second material where the first material includes one of molybdenum or niobium and the second material includes the other of molybdenum or niobium.

Patent No. 11,460,351 granted Oct. 4, 2022, Richard S. Skifton and Joshua Daw

Consequence-Driven Cyber-Informed Engineering And Related Systems And Methods

Embodiments of the disclosure relate to a computer-implemented consequence-driven cyber-informed engineering tool for performing and reporting consequence-based prioritization, system-of-systems breakdown, consequence-based targeting, and mitigations and protections. Embodiments of a CCE tool may perform one or more steps of defining a target industrial control system (ICS), wherein the target ICS includes operational goals, critical functions and critical services; determining one or more scored high consequence events (HCE) associated with the defined target ICS; prioritizing the scored HCEs according to an HCE severity index; and updating a dashboard with one or more representations of the prioritized HCEs, wherein the updated dashboard is associated with the CCE tool and presented at a display.

Patent No. 11,483,331 granted Oct. 25, 2022, to Michael J. Assante, Curtis P. St. Michel, Sarah G. Freeman, Robert T. Smith and Andrew A. Bochman

Methods Of Producing Enriched Scandium-47, And Related Systems And Apparatuses

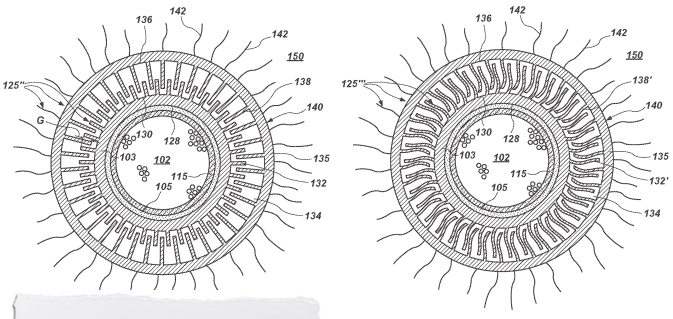
A method of producing enriched Scandium-47 comprises irradiating a V structure comprising ^{51}V with at least one incident photon beam having an endpoint energy within a range of from about 14 Maximal Extractable Value (MeV) to about 44 MeV to convert at least some of the ^{51}V to ^{47}Sc and form a ^{47}Sc-containing structure. The ^{47}Sc of the ^{47}Sc-containing structure is separated from additional components of the ^{47}Sc-containing structure using a chromatography process. Systems and apparatuses for producing enriched ^{47}Sc are also described.

Patent No. 11,501,890 granted Nov. 15, 2022, to Mathew S. Snow and Matthew T. Kinlaw

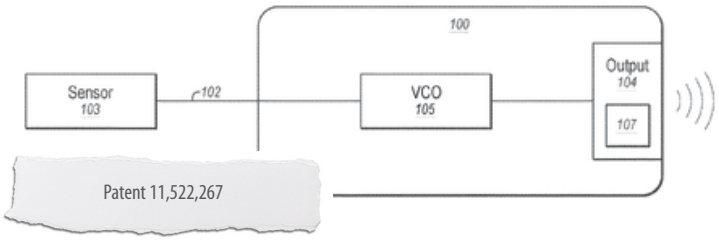
Heat Transfer Systems For Nuclear Reactor Cores, And Related Systems

A system for transferring heat from a nuclear reactor comprises a nuclear reactor comprising a nuclear fuel and a reactor vessel surrounding the nuclear reactor and a heat transfer system surrounding the nuclear reactor. The heat transfer system comprises an inner wall surrounding the nuclear reactor vessel, first fins coupled to an outer surface of inner wall, an outer wall between the inner wall and a surrounding environment, and second fins coupled to an inner surface of the outer wall and extending in a volume between the outer surface of the inner wall and the inner surface of the outer wall, the outer surface of the inner wall and the first fins configured to transfer heat from the nuclear reactor core to the second fins and the inner surface of the outer wall by thermal radiation. The heat transfer system may be directly coupled to the nuclear reactor vessel or may be coupled to an external reflector surrounding the nuclear reactor vessel. Related heat transfer systems and systems for selectively removing heat from a nuclear reactor are disclosed.

Patent No. 11,508,488 granted Nov. 22, 2022, to Abderrafi M. Ougouag, George W. Griffith and Ramazan Sonat Sen



Patent 11,508,488



Patent 11,522,267

Sensing Units Including A Radio-frequency Sensor, And Related Systems, Devices, And Methods

Systems, devices and methods related to generating and/or transmitting sensor measurement data are described. A device may include a first conductive pad positioned on a first surface of a substrate. The device may also include a second conductive pad positioned on a second, opposite surface of the substrate. Further, the device may include an inductive coil coupled between the first electrical pad and the second electrical pad. Also, the device may include a third conductive pad positioned on a third surface of the substrate and configured to couple to a sensor. The device may include a fourth conductive pad positioned on a fourth surface of the substrate and configured to couple to the sensor. The device may be configured to wirelessly transmit a signal.

Patent No. 11,522,267 granted Dec. 6, 2022, to James A. Smith

Automated Gauge Reading And Related Systems, Methods, And Devices

Computing devices and methods for reading gauges are disclosed. A gauge reading method includes capturing image data corresponding to a captured image of one or more gauges, detecting one or more gauges in the captured image, cropping a detected gauge in the captured image to provide a use image including the detected gauge, and classifying the detected gauge to correlate the detected gauge with a template image. The gauge reading method also includes attempting to perform feature detection rectification on the use image to produce a rectified image of the detected gauge, performing template matching rectification on the use image to produce the rectified image responsive to a failure to perform the feature detection rectification, and estimating a gauge reading responsive to the rectified image. A computing device may implement at least a portion of a gauge reading method.

Patent No. 11,544,916 granted Jan. 3, 2023, to Ahmad Y. Al Rashdan, Roger T. Lew, Michael L. Wheeler, Gregory D. Lancaster and Troy C. Unruh

Multi-core High-temperature, Irradiation-resistant Thermocouple, And Related Methods

A multi-core thermocouple includes a plurality of wires, an insulation core surrounding the plurality of wires, a sheath surrounding the insulation core, and a plurality of electrical junctions. The plurality of electrical junctions may include a first electrical junction formed between a first wire of the plurality of wires and the sheath at a first axial mid-section of the multi-core thermocouple, the first electrical junction including a first swaged axial mid-section of the sheath and a second electrical junction formed between a second wire of the plurality of wires and the sheath at a second, different axial midsection of the multi-core thermocouple, the second electrical junction including a second swaged axial midsection of the sheath.

Patent No. 11,555,747 granted Jan. 17, 2023, to Richard S. Skifton, Joshua Daw and Doug Corbett

Systems And Methods For Control System Security

A component security device may be disposed at an interface between a component and a cyber-physical system. The disclosed component security device may be physically and/or electrically coupled between the component and infrastructure of the cyber-physical system, such as a backplane, bus and/or the like. The component security device may be configured to monitor the component and selectively isolate the component from the cyber-physical system. Since the component security device is interposed at the interface of the component, the component security device may be capable of isolating the component regardless of whether the component has been compromised (e.g., regardless of whether the component can comply with system commands).

Patent No. 11,579,592 granted Feb. 14, 2023, to Craig G. Rieger, Edward E. Springer, Michael V. McCarty and Timothy R. McJunkin

Electrochemical Cells For Hydrogen Gas Production And Electricity Generation, And Related Systems, And Methods (as Amended)

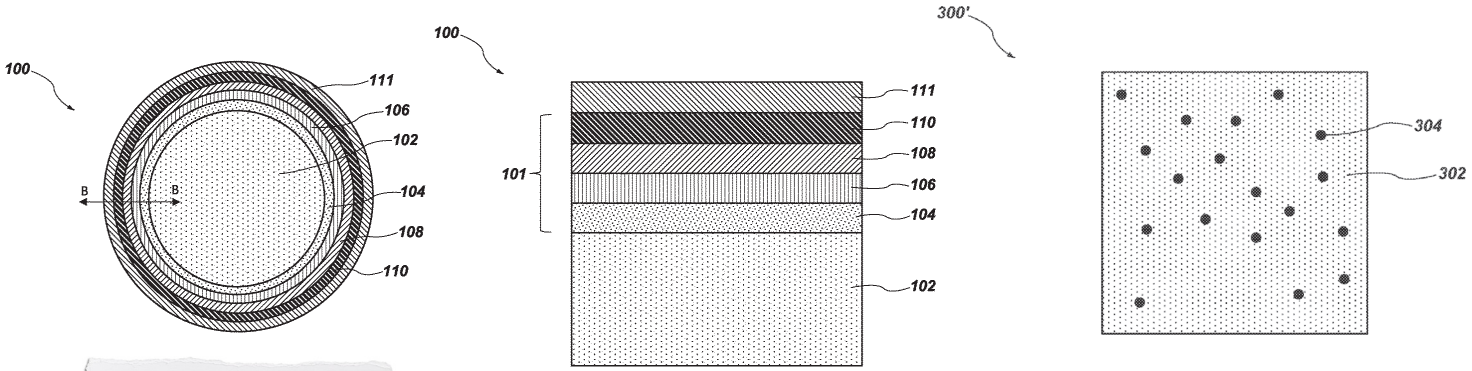
An electrochemical cell comprises a first electrode, a second electrode, and a proton-conducting membrane between the first electrode and the second electrode. The first electrode comprises Pr(Co1-x-y-z, Nix, Mny, Fez)O3-δ, wherein 0≤x≤0.9, 0≤y≤0.9, 0≤z≤0.9, and δ is an oxygen deficit. The second electrode comprises a cermet material including at least one metal and at least one perovskite. Related structures, apparatuses, systems and methods are also described.

Patent No. 11,557,781 granted Jan. 17, 2023, to Dong Ding, Hanping Ding, Wei Wu, Chao Jiang and Ting He

Nuclear Fuel Elements Including Protective Structures, And Related Method Of Forming A Nuclear Fuel Element (as Amended)

A nuclear fuel element includes a core comprising a fissile element and an additional element. A protective structure surrounds the core and comprises at least a first material surrounding the nuclear fuel. The first material comprises the fissile element and the additional element and comprises a greater than stoichiometric amount of the additional element. An outer portion of the nuclear fuel element comprises a metal. Related nuclear fuel elements and related methods are also disclosed.

Patent No. 11,587,689 granted Feb. 21, 2023, to Isabella J. Van Rooyen and George W. Griffith



Patent 11,587,689

Ion Beam Profiling System And Related Methods

An ion beam profiling system includes a beam profiling element, an ion sensitive element electrically isolated from the beam profiling element, an ion source configured to emit an ion beam at the beam profiling element and the ion sensitive element, and a current measuring device coupled to the ion sensitive element. The beam profiling element includes a plate of material having two parallel major surfaces, a first slit aperture extending through the plate of material and having a first longitudinal length extending in a direction parallel to the two parallel major surfaces, and a second slit aperture extending through the plate of material and having a second longitudinal length extending in a direction parallel to the two parallel major surfaces, wherein the first longitudinal length of the first slit aperture is perpendicular to the second longitudinal length of the second slit aperture.

Patent No. 11,598,890 granted March 7, 2023, to Chase N. Taylor

Methods For Manufacturing Electrochemical Sensors, And Related Electrochemical Sensors

Methods for manufacturing an electrochemical sensor include forming at least one electrode by printing at least one conductive ink on a surface of at least one substrate. The conductive ink may comprise, e.g., a platinum-group metal, another transition-group metal with a high-temperature melting point, a conductive ceramic material, glass-like carbon, or a combination thereof. The electrochemical sensor may be free of another material over at least one electrode. An electrochemical sensor, formed according to such methods, may be configured for use in harsh environments (e.g., a molten salt environment). Electrodes of the electrochemical sensor comprise conductive material formed from a printed, conductive ink. In some embodiments, at least a portion of the electrochemical sensor is free of silver, gold, copper, silicon and polymer materials, such portion being that which is to be exposed to the harsh environment during use of the electrochemical sensor.

Patent No. 11,635,404 granted April 25, 2023, to Michael R. Shaltry, Prabhat Kumar Tripathy and David Estrada

Methods, Systems, And Electrochemical Cells For Producing Hydrocarbons And Protonation Products Through Electrochemical Activation Of Ethane (as Amended)

A method of forming a hydrocarbon product and a protonation product comprises introducing Ethane (C2H6) to a positive electrode of an electrochemical cell comprising the positive electrode, a negative electrode, and a proton-conducting membrane between the positive electrode and the negative electrode. The proton-conducting membrane comprises an electrolyte material having an ionic conductivity greater than or equal to about 10−2 S/cm at one or more temperatures within a range of from about 150 Celsius to about 650 C. A potential difference is applied between the positive electrode and the negative electrode of the electrochemical cell to produce the hydrocarbon product and the protonation product. A C2H6 activation system and an electrochemical cell are also described.

Patent No. 11,661,660 granted May 30, 2023, to Ting He, Dong Ding, Yunya Zhang, Wei Wu and Hanping Ding

Methods For Producing Hydrocarbon Products And Hydrogen Gas Through Electrochemical Activation Of Methane (as Amended)

A method of forming a hydrocarbon product and hydrogen gas comprises introducing Methane (CH_4) to a positive electrode of an electrochemical cell comprising the positive electrode, a negative electrode, and a proton-conducting membrane between the positive electrode and the negative electrode. The proton-conducting membrane comprises an electrolyte material having an ionic conductivity greater than or equal to about 10^{-2} S/cm at one or more temperatures within a range of from about 150 C. to about 600 C. A potential difference is applied between the positive electrode and the negative electrode of the electrochemical cell to produce the hydrocarbon product and the hydrogen gas. A CH_4 activation system and an electrochemical cell are also described.

Patent No. 11,668,012 granted June 6, 2023, to Dong Ding, Ting He, Wei Wu and Yunya Zhang

Systems, Devices, And Methods For Performing Augmented Reality Responsive To Monitor User Behavior

Systems, devices and methods are described for performing augmented reality (AR) to assist user performing a task in an environment. An AR device may be configured to capture real-time data. An AR engine may be configured to monitor user behavior from the real-time data responsive to feature extraction from the real-time data, compare the user behavior to pre-defined work procedures, and generate augmented reality objects to be output by the AR device.

Patent No. 11,681,357 granted June 20, 2023, to Su Jong Yoon, Jeffery A. Aguiar, Johanna Oxstrand and Katya L. LeBlanc

Composite Media For Non-oxidative Ethane Dehydrogenation, And Related Ethane Activation Systems And Method Of Processing An Ethane-containing Stream

A composite media for non-oxidative Ethane (C2H6) dehydrogenation comprises an aluminosilicate zeolite matrix, and an EDH catalyst on one or more of an external surface of the aluminosilicate zeolite matrix and internal surfaces within pores of the aluminosilicate zeolite matrix. The EDH catalyst comprises one or more of iron, zinc, platinum and gallium,alloys thereof, and oxides thereof. A C2H6 activation system, and a method of processing a C2H6-containing stream are also described.

Patent No. 11,684,910 granted June 27, 2023, to Lucun Wang, Dong Ding, Yunya Zhang and Ting He

Devices And Systems For Measuring The State Of A Valve, And Related Methods

A device for measuring a state of a valve may include a housing configured to connect to a handle of a valve or a body of a valve, a sensor supported on one of the housing or the valve stem, and an indicator detectable by the sensor. The indicator may be configured to move relative to the sensor in response to movement of a valve stem or valve handle during opening and closing of the valve. The sensor may be configured to detect a position of the indicator to determine a state of the valve. Related systems and methods are also described.

Patent No. 11,698,145 granted July 11, 2023, to Vivek Agarwal, Robert T. England, John Buttles and Sasa Kovacevic

Devices And Systems For Material Transportation

Various embodiments relate to devices for transporting high-assay low-enriched uranium (HALEU). A device may include at least one section, wherein each section of the at least one section includes a number of storage tubes. Each storage tube, which is configured to receive and hold a container, extends from adjacent of a first end of the section toward a second, opposite end of the section. Each section further includes a number of flux traps, wherein each storage tube of the number of storage tubes is at least partially surrounded by a flux trap of the number of flux traps. Associated systems are also disclosed.

Patent No. 11,699,534 granted July 11, 2023, to Elmar F. Eidelpes, Joshua J. Jarrell, Robert A. Hall, William J. Marshall, Harold A. Adkins and Brian M. Hom

Phase-change Valves And Related Methods

Valves may include an opening sized and shaped to permit a subject fluid to flow through the opening when the opening is unobstructed. A heat exchange element may be located proximate to the opening, the heat exchange element positioned and configured to induce a localized phase change in the subject fluid to form and unform a solid plug from the subject fluid around at least a portion of the heat exchange element. A heat transfer rate of the heat exchange element may be variable to control a rate of flow of the subject fluid through the valve by controlling a size of the solid plug from the subject fluid.

Patent No. 11,708,914 granted July 25, 2023, to Piyush Sabharwall, Paul Marotta and Richard Christensen

Ultrasonic Sensors And Methods Of Using The Ultrasonic Sensors

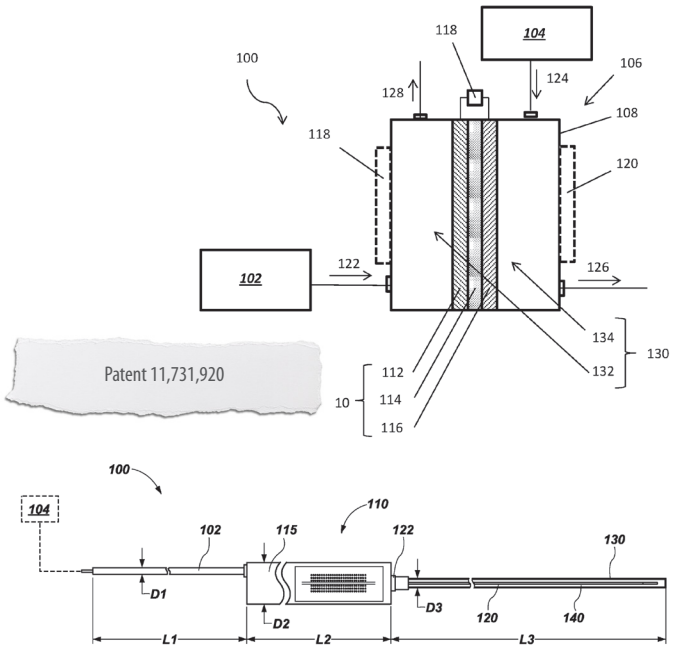
An ultrasonic sensor comprises a transducer in operable communication with a power source, a waveguide comprising a metal and at least one of a fissile material or a fertile material in operable communication with the transducer and configured to propagate and reflect acoustic waves generated by the transducer, the transducer configured to convert reflected acoustic waves to an electric signal, a thermally insulative material proximate the waveguide, and a control system in operable communication with the transducer, the control system configured to determine at least a temperature of the waveguide based on the reflected acoustic waves. Related methods are also disclosed.

Patent No. 11,714,009 granted Aug. 1, 2023, to Nicolas E. Woolstenhulme, Joshua Daw, Colby B. Jensen, James R. Parry and Lance A. Hone

Methods And Systems For Co-producing Hydrocarbon Products And Ammonia, And Related Electrochemical Cells

A method of a hydrocarbon product and ammonia comprises introducing C2H6 to a positive electrode of an electrochemical cell comprising the positive electrode, a negative electrode, and a proton-conducting membrane between the positive electrode and the negative electrode. The proton-conducting membrane comprising an electrolyte material having an ionic conductivity greater than or equal to about 10−2 S/cm at one or more temperatures within a range of from about 150 C to about 600 C. nitrogen (N2) is introduced to the negative electrode of the electrochemical cell. A potential difference is applied between the positive electrode and the negative electrode of the electrochemical cell. A system for co-producing higher hydrocarbons and ammonia (NH3), and an electrochemical cell are also described.

Patent No. 11,731,920 granted Aug. 22, 2023, to Dong Ding, Wei Wu, Hanping Ding and Bin Hua



Patent 11,731,920

FIG. 1

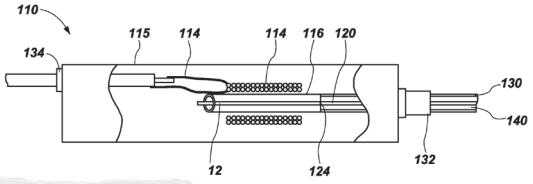
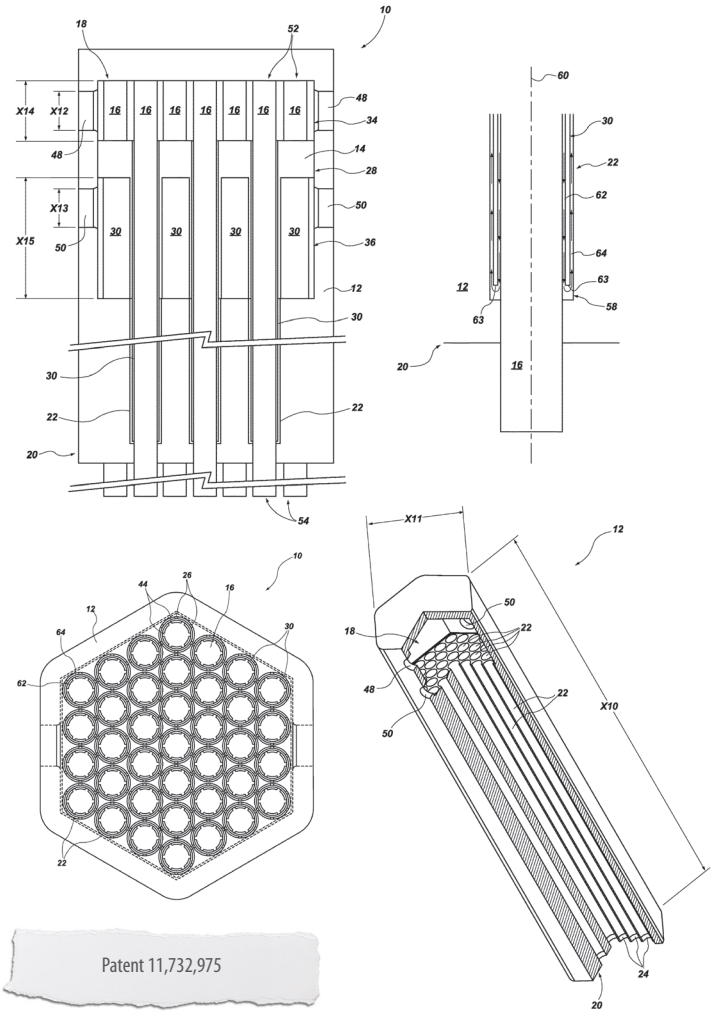


FIG. 2

Patent 11,714,009



Patent 11,732,975

Heat Exchangers And Related Systems And Methods

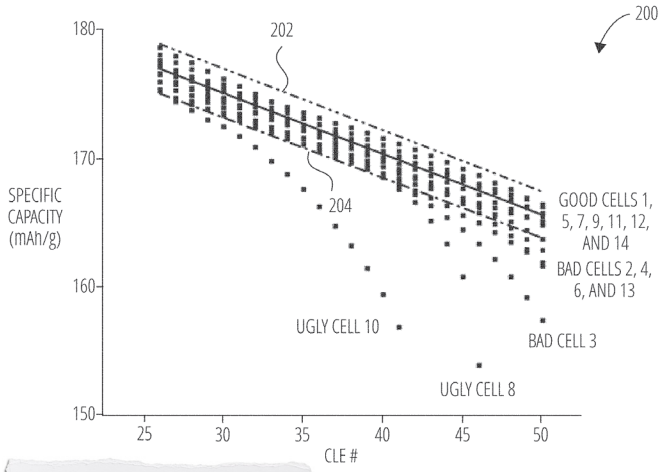
A heat exchanger may include a main body with an inlet plenum and an outlet plenum at the first end, and a header at a second end. At least one elongated shaft may extend from the outlet plenum to the header. At least one heat pipe may be coupled to the header and a portion of each heat pipe may be positioned within a corresponding elongated shaft defining an annular space between each heat pipe and each corresponding elongated shaft. A flow skirt may include a manifold located between the inlet plenum and the outlet plenum of the main body. At least one elongated tube may extend from the manifold. Each elongated tube may be positioned within a corresponding annular space between each heat pipe and each corresponding elongated shaft, dividing the annular space into two concentric annular channels comprising an inner annular channel and an outer annular channel.

Patent No. 11,732,975 granted Aug. 22, 2023, to Su Jong Yoon and James E. O'Brien

Energy Storage Cell Qualification And Related Systems, Methods, And Devices (as Filed)

Energy storage cell qualification and related systems, methods, and devices are disclosed. A method of qualifying rechargeable battery cells includes taking measurements on the rechargeable battery cells, determining specific capacity distributions of the rechargeable battery cells as a function of a number of discharge cycles based on the measurements, determining one or more specific capacity thresholds to separate the specific capacity distributions of the rechargeable battery cells into two or more classifications, and qualifying the rechargeable battery cells into the two or more classifications based, at least in part, on the specific capacity distributions and the one or more specific capacity thresholds. A method of implementing rechargeable battery cells into product manufacturing and qualifying the rechargeable battery cells and deploying those of the rechargeable battery cells qualified into a first classification of the two or more classifications into the product.

Patent No. 11,740,290 granted Aug. 29, 2023, to Boryann Liaw, Yulun Zhang and Qiang Wang



Patent 11,740,290

Methods And Systems For Diagnosis Of Failure Mechanisms And For Prediction Of Lifetime Of Metal Batteries

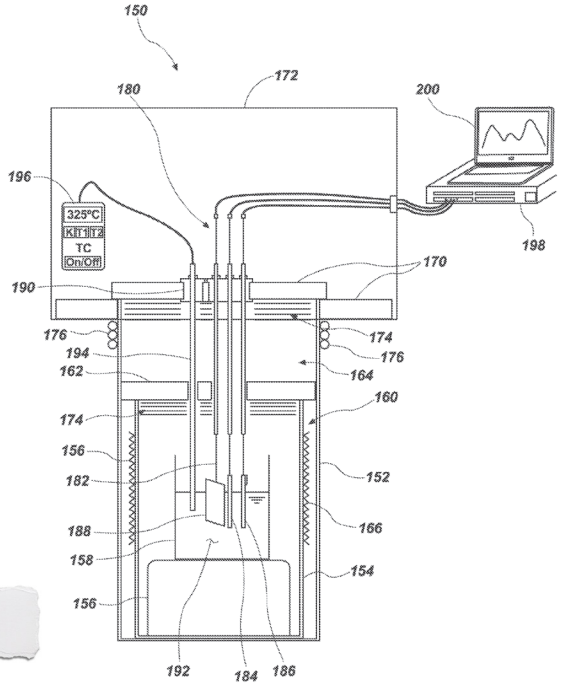
Methods for diagnosing failure mechanisms and for predicting lifetime of metal batteries include monitoring rest voltage and Coulombic Efficiency over relatively few cycles to provide profiles that indicate, by the trends thereof, a particular failure mechanism (e.g., electrolyte depletion, loss of metal inventory, increased cell impedance). The methods also include cycling over relatively few cycles an anode-free cell, having the same cathode and electrolyte as the metal battery, but with a current collector instead of the anode. Discharge capacity is monitored and profiled, and a discharge capacity curve is fitted to the discharge capacity profile to discern a capacity retention per cycle. The lifetime of the metal battery is determined using the capacity retention per cycle discerned from the anode-free cell. Related systems include a metal-based battery and an anode-free cell or a battery cell reconfigurable between a metal-based and an anode-free cell.

Patent No. 11,740,297 granted Aug. 29, 2023, to Bin Li, Eric J. Dufek and Ningshengjie Gao

Methods Of Forming A Metal Coated Article

A method of forming a metal coated article comprises forming a metal halide in a molten salt plating bath at a first temperature, wherein forming the metal halide in the molten salt further comprises forming at least one functional metal halide electrolyte; and forming at least two auxiliary metal halide electrolytes at eutectic conditions; increasing the first temperature to a second temperature; forming a plated metal coating from the at least one functional metal halide electrolyte onto a thermally conductive substrate; and introducing at least one of deuterium and tritium into the plated metal coating.

Patent No. 11,746,434 granted Sept. 5, 2023, to Prabhat Kumar Tripathy

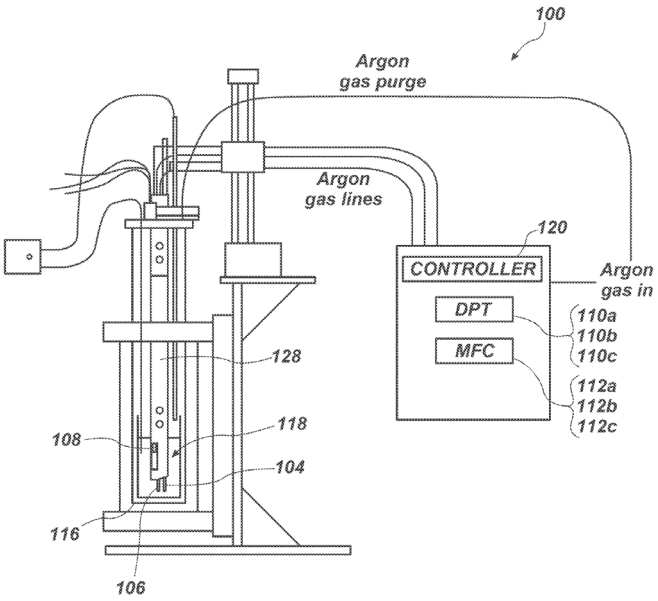


Patent 11,746,434

Triple Bubbler System, Fast-bubbling Approach, And Related Methods

A triple bubbler system includes a first fluid probe, a second fluid probe, a third fluid probe, a gas source operably coupled to the first fluid probe, the second fluid probe, and the third fluid probe and configured to meter gas through the first fluid probe, the second fluid probe, and the third fluid probe to form bubbles at tips of each of the first fluid probe, the second fluid probe, and the third fluid probe, and a cover member disposed over the tips of the first, second, and third fluid probes and configured to at least partially prevent bubbles formed and escaping the tips of the first, second, and third fluid probes from interfering with other bubbles formed at each other tips. The bubbler system includes a thermocouple having a plurality of junctions disposed along an axis parallel to longitudinal axes of the first, second and third fluid probes.

Patent No. 11,747,256 granted Sept. 5, 2023, to Gregory G. Galbreth and Ammon N. Williams



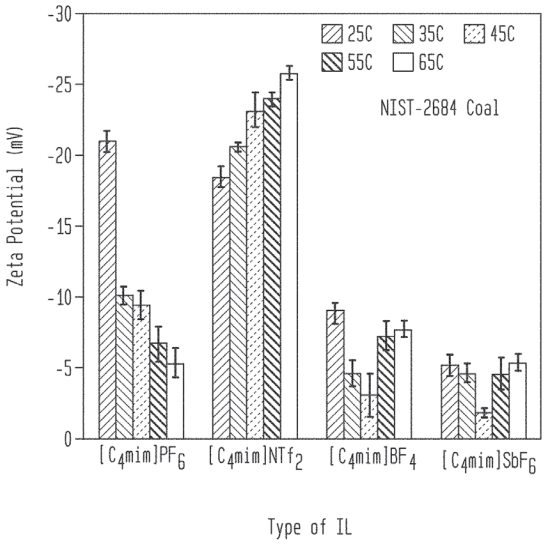
Patent 11,747,256

FIG. 4E

Materials Derived From Coal Using Environmentally Friendly Solvents

In a first embodiment, a coal treatment process includes exposing a material comprising coal to ionic liquid(s) to form a first mixture, isolating a residue from the first mixture, forming a second mixture comprising the residue, and electrospinning the second mixture to form a carbon fiber precursor material. In a second embodiment, a coal treatment process includes exposing a material comprising coal to ionic liquid(s) to form a mixture comprising solids and a liquid fraction, separating and filtering the liquid fraction from the mixture, and isolating one or more compounds from the liquid fraction. In a third embodiment, a coal treatment process includes exposing a material comprising coal to ionic liquid(s) to form a first mixture comprising residues, exposing the first mixture to (a) an acid, (b) a solvent, or (c) both to form a second mixture, and isolating rare earth elements and rare earth element compounds.

Patent No. 11,761,058 granted Sept. 19, 2023, to Dongmei Li, Shuai Tan, Luke Williams and Chenlin Li



Patent 11,761,058

Copyright Assertion Highlights

Copyright is a legal right that grants the creators of original work, such as software, exclusive rights for its use and distribution. INL employees assign such rights to the company as a condition of employment. In accordance with BEA's contract with DOE, all rights are assigned to DOE unless BEA specifically requests authority to assert copyright. BEA requests permission to assert copyright on software it intends to license via open source and traditional agreements.

During FY-23, INL received permission to assert copyright on 26 software programs. Since 2005, INL has been authorized by DOE to assert copyright protection on close to 200 pieces of software.

ACORN

ACORN (Autonomous Controls fOr Reactor techNologies) software uses data, obtained from an experimental test bed and/or simulation, to implement a control command for microreactor operation. The control command recommended by the code is derived based on future predicted states of a microreactor, allowing proactive and autonomous microreactor operation.

Cobalt REE

Cobalt REE investigates the interactions between the cobalt and rare earth supply chains in supporting clean energy technologies such as electric vehicles, wind, etc. The model also serves as a platform for testing a magnet substitution that uses less heavy rare earths and more cobalt. Users can test different scenarios to see how to meet an ambitious EV deployment goal.

Field SIM

Field operations planning is critical for efficient agricultural activities, in terms of time and cost. One key metric focuses on field efficiency (ratio between the real and the theoretical productivity of a machine). This model extends field data to simulate field efficiency on a variety of agricultural free-of-obstacles fields.

FRI3D

The complexity of fire phenomena and multiple operational procedures makes fire analysis in a nuclear power station costly and labor-intensive. Current analysis methods make it difficult to computationally provide assurance that mitigation methods are adequate for critical areas. The FRI3D software consists of two main parts: an application program interface back end with the logical fire model, and a graphical program interface with a 3D viewing front end. This combination allows users to develop and see spatial relationships along with existing fire models.

MaSDE

The MSE technology provides a distributed state estimation scheme for power utilities by making it a real-time dynamic system compared to a static snapshot method. It allows utilities to verify power grid readings and identify false data on the communication network. The MFD distributes an algorithm to devices installed at various locations on the power grid allowing for much faster computer times. When each distributed estimator completes its calculation, it sends the results back to the master device to check against all other distributed estimators.

MaSTI

The MSE cyber sensor offers a novel approach for scalable network monitoring using heterogeneous computing. Packet data is collected, analyzed and stored by a standalone cyber sensor. Machine learning algorithms discover patterns in communication without the need for deep packet inspection. Tuning the detection algorithms happens automatically, without the need for an engineer to manually create detection rules.

Transformer Health Monitoring Using Dissolved Gas Analysis

Power plant transformers supply generated electricity to the grid. As a transformer ages and degrades it produces specific gases that can be monitored and used to predict needed maintenance. This software code uses four complementary techniques to predict when maintenance should be performed based on gas concentrations within the transformer.

Open-Source Software Highlights

INL has expanded efforts to release open-source software, which is freely available to the public and open to collaboration directly with researchers and engineers outside of the laboratory. Fostering widespread distribution of this software can accelerate adoption within industry and fuel innovation in other research organizations. INL's Technology Deployment group is defining and refining an overarching strategy around open source and commercial releases to capitalize on the strengths of each. INL's open-source software can be acquired cost-free at

https://github.com/idaholab
https://github.com/idaholabresearch
https://github.com/idaholabUnsupported

Hydropower Flexibility Valuation Tool

The timing of electricity generation is becoming more and more valuable. This creates greater potential for tension between environmental and power system objectives since both systems require their own flow patterns. Identifying win-win outcomes in this context requires being able to discuss the value of flexibility across stakeholder groups. This research proposes a two-stage optimization method to understand hydropower flexibility to meet both environmental and power system requirements. The optimization tool denoted as the "Hydropower Flexibility Valuation Tool" aims to maximize the revenue from market participation after satisfying flow requirements, considering a range of power market price signals and water availability scenarios. The proposed tool is demonstrated in the U.S., showing how to make more informed decisions to weigh the cost of specific flow requirements in the context of the overall license. Results from the case study show that revenue is more sensitive to the ramping constraints than the minimum flow constraints.

DaRT (Disassembly and Reassembly for Transport)

To disassemble potentially malicious code into benign pieces that can safely be transported via any number of traditional methods without fear of infection.

MaCaw

MaCaw is a MOOSE-based application that enables domain-decomposed neutral particle transport calculations in MOOSE. It leverages the ray tracing MOOSE module for unstructured mesh tracking and OpenMC for collision physics, handling material definitions, and tallying quantities.

Anomalous and normal High Performance Computing data center activities

This code provides annotation and an interface to 10-plus hours of video activities in a high-performance data center with 20-plus different types of anomalous activities. The purpose is to enable machine learning for video surveillance systems in high performance computing centers. This is the first code of this type addressing the space of high performance computing data centers.

Advanced Electrolyte Model (AEM), developed by distinguished scientist Kevin Gering, is tooling battery manufacturers and companies with the technology to build a better battery.

Licensing Activities and Highlights

In fiscal year 2023, Technology Deployment modified or entered 171 new licensing agreements. At the end of the fiscal year, INL had nearly 500 active licenses on technologies with patents, copyright assertions or open-source rights held by its researchers. Licensees include domestic and foreign businesses, universities, laboratories, governments and other industry partners.

Annotated Translated Disassembled Code (@DisCo)

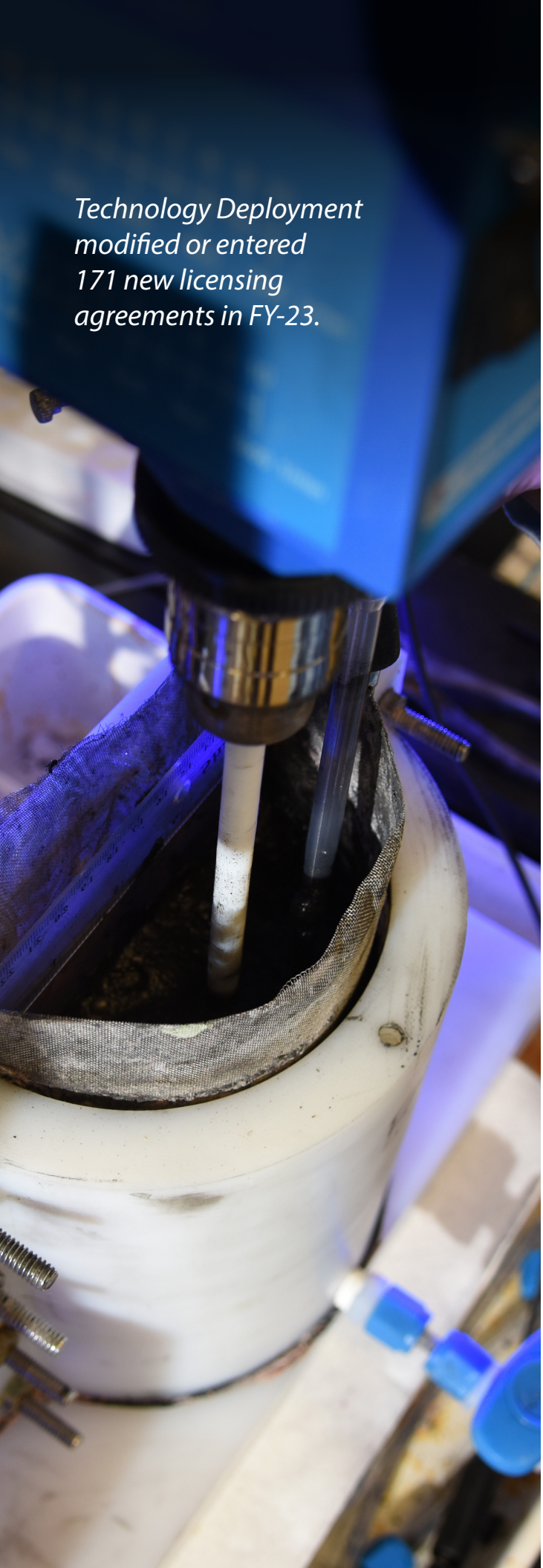
Netrise Inc., based in Austin, Texas, licensed the laboratory's award-winning Annotated Translated Disassembled Code (@DisCo), a scalable translated binary analysis platform that improves cyber defense by using machine learning and sophisticated visualization tools to reverse engineer firmware and malware binaries. Netrise will implement @DisCo into its automated firmware analysis products. The Netrise platform helps users identify risks in the software components running on devices that have historically been considered black boxes.

Advanced Electrolyte Modeling (AEM)

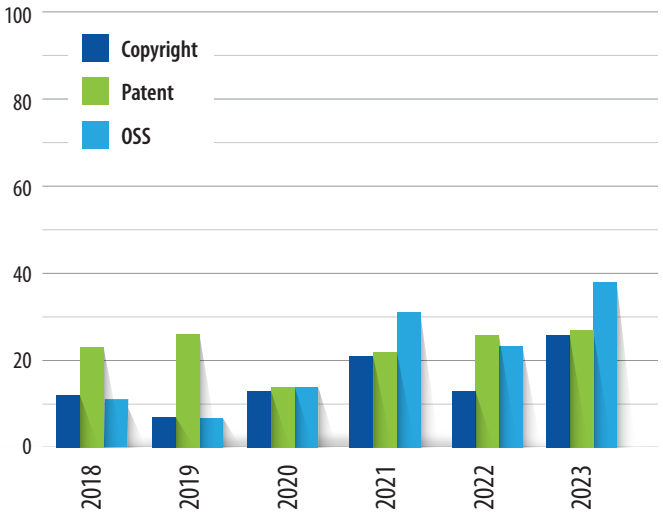
Ridgetop Group, headquartered in Tucson, Arizona, entered an exclusive distribution license for the laboratory's Advanced Electrolyte Model (AEM), a computer simulation program that provides information on properties of complex electrolyte formulations and how they can influence battery performance. The agreement gives Ridgetop the right to distribute AEM to a growing customer base via technology sublicense and standard software licensing agreements. The licensing model allows Ridgetop to take ownership of AEM marketing and sales efforts, which will attract customers while INL leads and enhances the technology.

Master State Awareness Estimator (MSE)

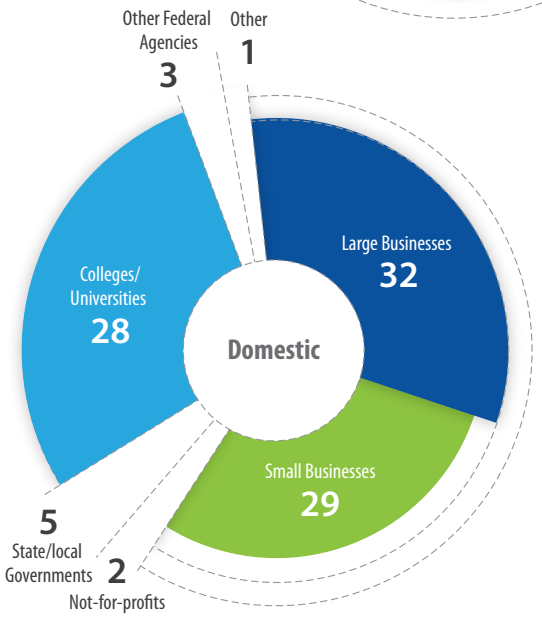
Innovyz USA, a Chicago-based company, licensed INL's Master State Awareness Estimator (MSE) and created the startup company Psymetis Inc. The MSE device has built-in software that is installed to a substation, reports the real-time status of a power system's condition and can prevent cyberattacks from progressing. Psymetis focuses on protecting the electrical grid and innovating the tools and solutions necessary to ensure the resilience and security of these complex systems. This is the fourth startup from Innovyz USA based on the lab's technologies.

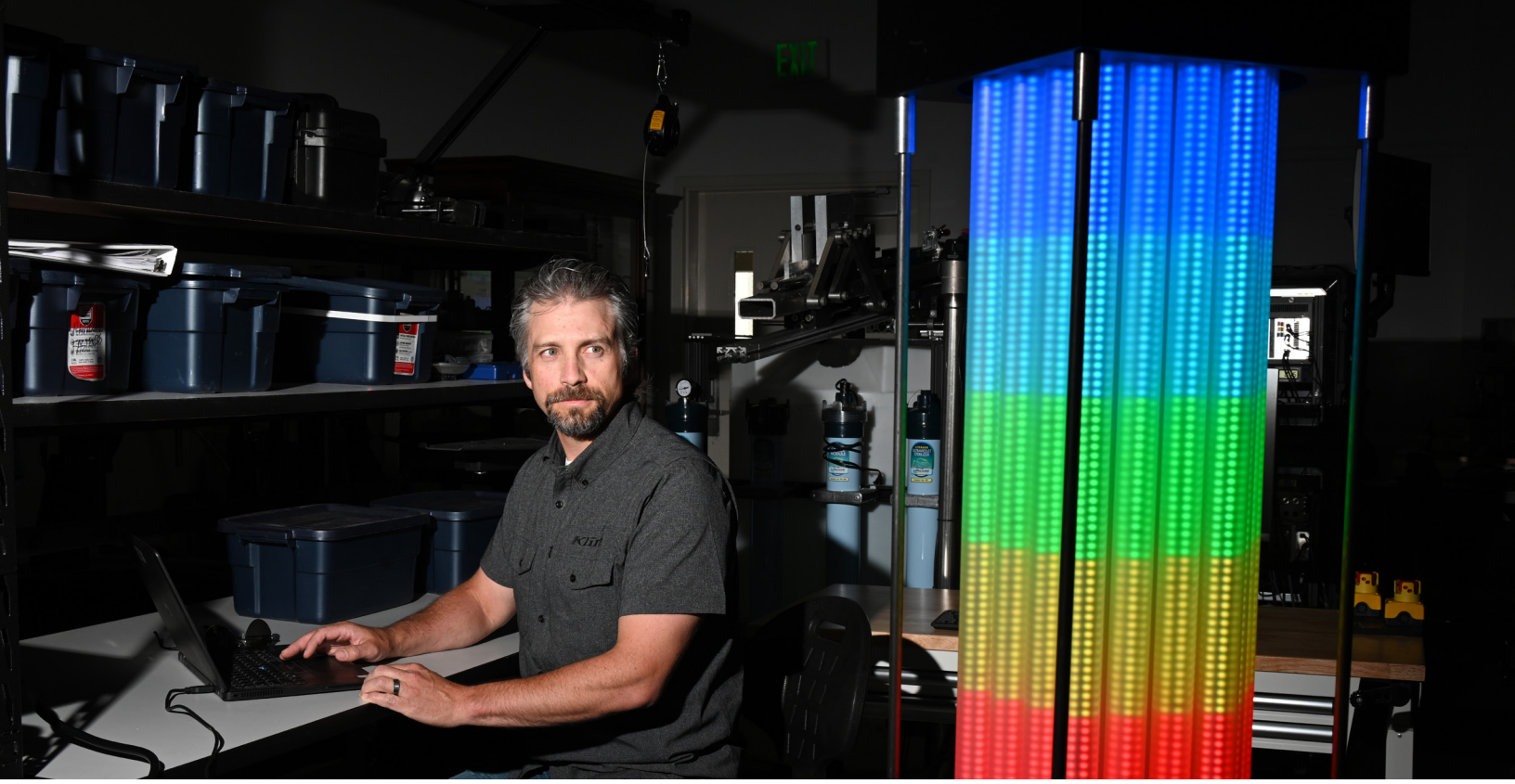


Technology Deployment modified or entered 171 new licensing agreements in FY-23.



NEW LICENSING ACTIVITIES





ViBRANT: A simulated MARVEL reactor core employing a light medium which to represent the various phenomena.

Consequence-driven Cyber-informed Engineering (CCE)

The growing popularity of Consequence-driven Cyber-informed Engineering (CCE) continued in FY-23. INL licensed the CCE methodology, which focuses on securing critical infrastructure systems through a "think like the adversary" approach, with five additional companies.

The Department of Energy and the lab developed the Cyber-Informed Engineering (CIE) framework to guide the application of cybersecurity principles across the engineering design life cycle. CCE applies CIE's core principles to an organization, facility or mission by identifying the most likely ways an adversary would manipulate or compromise them and determining the most effective way to remove or mitigate those risks.

Mission Secure Inc.

Mission Secure Inc., an operational technology cybersecurity company headquartered in Charlottesville, Virginia, will incorporate CCE into its operational technology cyber offerings and deploy it to customers in chemicals, government, maritime, manufacturing, oil and gas power fields, and smart cities.

MAG Aerospace

MAG Aerospace will apply CCE within its government services operations. MAG Aerospace provides and operates contractor-owned/contractor-operated aircraft and crews to provide real-time intelligence and surveillance for multiple U.S. government customers.

National Grid US

National Grid US is an energy company focused on electricity and natural gas distribution in the United Kingdom and the U.S. It is one of the largest investor-owned U.S. energy companies, serving 20 million people throughout New York and Massachusetts. The company will use CCE internally within its gas, renewables and electricity generation, storage, and distribution operations.

Sentar

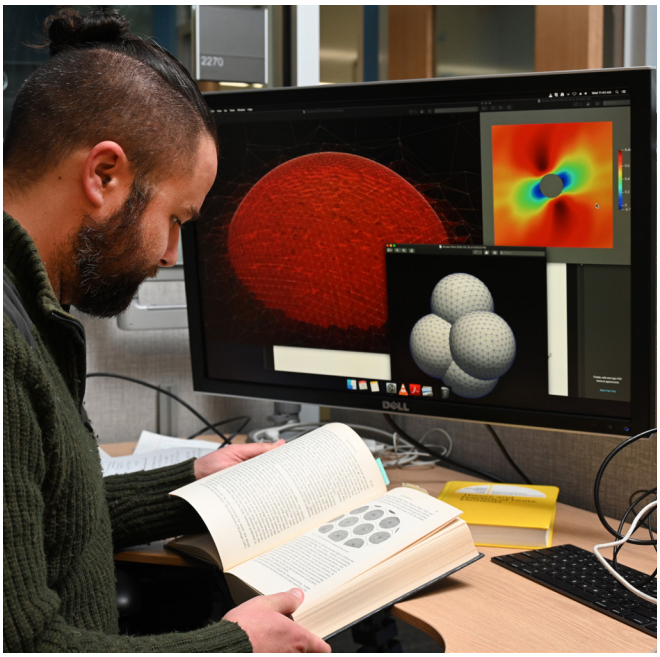
The lab has nonexclusively licensed its CCE-related patent and copyrighted training materials to allow Sentar to provide training programs for U.S. government customers. Sentar is a cyber intelligence company applying advanced analytics and systems engineering expertise to protect critical assets.

OpsWright

OpsWright, a cybersecurity startup based in Florida, has licensed CCE for use with various prospective private sector and government customers. OpsWright has strong ties to multiple existing CCE licensees and will help them better train their customers.

EC-Leach

The lab teamed with Arizona-based Airtronics to commercialize a lithium-ion battery recycling technology developed by the Department of Energy's Critical Materials Institute. The technology won a 2022 R&D 100 Award. The lab and Airtronics are scaling up the technology for commercial deployment. This technology could significantly increase domestic capacity to competitively produce cathode materials from discarded batteries.



Griffin software is licensed by multiple users in FY23.

Reactor Excursion and Leak Analysis Program 5-3D (RELAP5-3D) has become a widely licensed software since its introduction.

Griffin

Griffin is a finite, element-based reactor multiphysics application. It is suitable for steady-state and time-dependent coupled neutronics calculations leveraging the various MOOSE-based thermal-fluids applications (Pronghorn, Relap-7, SAM, Sockeye, etc.) and fuel performance application BISON. Griffin solves the linearized Boltzmann transport equation in 1D, 2D and 3D heterogeneous and homogeneous geometries. It has been used in the analysis of pebble-bed, prismatic, molten-salt and fast sodium-cooled reactors, microreactors, nuclear thermal propulsion and several experimental facilities.

Multiple universities, including Idaho State University, University of California-Berkley and the University of Florida, licensed Griffin software to help create a variety of nuclear reactor designs.

Reactor Excursion and Leak Analysis Program 5-3D (RELAP5-3D)

Reactor Excursion and Leak Analysis Program 5-3D (RELAP5-3D) has become a widely licensed software since its introduction. This program code primarily analyzes potential accidents and transients in water-cooled nuclear power plants and advanced reactor systems. While other codes can also model what happens inside a nuclear reactor, they are often limited to one part of the system or one phenomenon, like fluid dynamics. RELAP5-3D models the entire system (i.e., reactor core, primary cooling system and secondary coolant loops) for every type of nuclear reactor, including light-water, heavy-water, molten-salt, liquid-metal and high-temperature gas reactors.

The University of Sheffield

The University of Sheffield licensed RELAP5-3D to generate time-series data for the purpose of developing and accessing novelty detection and classification algorithms.

Radiant Industries Inc.

Radiant Industries Inc. is developing a microreactor simulation package using various INL software, including BISON, Marmot, Grizzly, Sockeye and RELAP5-3D. It pairs the heat pipe application Sockeye with Griffin, which is a multi-application reactor design consisting of Rattlesnake, BISON, Grizzly and RELAP-7. Radiant has partnered with the lab and submitted a concept paper for ARPA-e GEMINA, with a proposal to make reduced-order models from code outputs. The company will push NQA-1 standardization for reactor control systems developed by this method to ease regulatory burden and lower development costs and time to market.

Oceanit Laboratories Inc.

Oceanit will conduct thermal simulations looking at heat transfer for oil and gas flow assurance and heat exchanger performance. Specifically, the company is assessing the effects of coatings and depositions on overall system heat transfer.

Constellation Energy

Constellation Energy will use RELAP5-3D to benchmark and compare safety analysis and thermal hydraulic transients for the evaluation of the Updated Final Safety Analysis Report, as required for the licensing and operation of nuclear reactors under the jurisdiction of the Nuclear Regulatory Commission. RELAP5-3D could be used on all Exelon Nuclear reactors.

Royalty, TCF and IDF Highlights

Royalties

From fiscal years 2005 to 2023, INL signed more than 2,000 new licenses to commercialize technologies developed at the laboratory. License agreements generate royalties, and the lab has earned more than $24 million in royalties since the inception of Batelle Energy Alliance's contract in FY-05. During FY-23, the lab earned close to $700,000 in royalties.

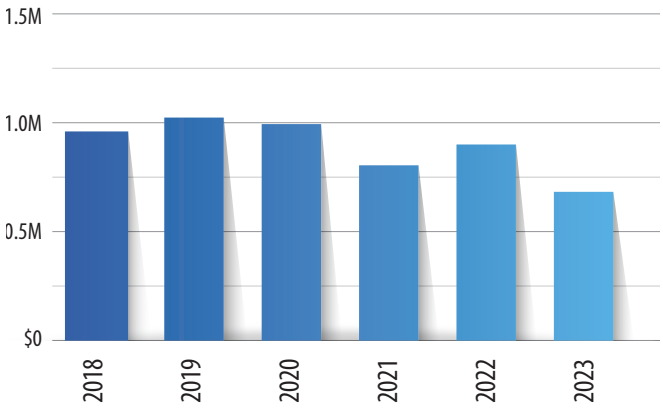
Royalties are one indicator that laboratory innovations are meeting market needs. The lab encourages innovation and reinvesting a significant portion of royalty revenues to promote development of promising early-stage technologies.

Federal regulations govern royalty spending, which must support technology transfer activities. Roughly 30% of INL royalty funds go to inventors of licensed technologies. Additional spending goes to employees who have supported technology transfer activities throughout the laboratory, independent of a specific technology having commercial application. The remaining royalties are reinvested into two funds, the Science and Technology Strategic Investments Fund and the Innovation Development Fund.

The Science and Technology Strategic Investments Fund supports research and development capabilities that will lead to new technology development and increase INL's potential to generate new business. A key to the success of these investments is the lab's ability to attract industry partners essential to advancing future INL technologies.

In FY-23, the lab earned close to $700k in royalties. Roughly 30% of INL royalty funds go to inventors of licensed technologies.

ROYALTY RECEIPTS FROM FY 2018–2023



The Innovation Development Fund supports advancement of technologies and intellectual property (IP) developed at the Idaho National Laboratory. Specifically, funding is used to help with the maturation of technologies and provide support to researchers by funding education, training, licensing and patent costs, etc., that potentially increases the licensing of INL technologies.

Technology Commercialization Funds

The Department of Energy announced $21 million across 16 national laboratories for 30 projects improving clean energy resources for FY-23. DOE allocated $4.8 million to the laboratory's focus on seven projects advancing nuclear energy, hydrogen and fuel cell technologies, cybersecurity, and streamlining national lab processes. DOE will fund these projects in FY-24. INL's funded projects:

Low-cost hydrogen manufacturing

The lab is working with a university research team to develop high-performance, proton-conducting solid oxide electrolyzers. Technology Commercialization Funds will enable researchers to scale up the technology to bring about low-cost hydrogen production as part of DOE's Earthshots initiative to produce hydrogen at $1/kilogram by 2031.

Commercializing OmniTap

The lab is using Technology Commercialization Funds to accelerate the commercialization of OmniTap – a cybersecurity technology for any existing or new industrial control systems inside the nation's critical infrastructure.

Designing nuclear reactors

The lab is working with Sandia National Laboratories and Coreform LLC to improve safety and confidence in reactor designs through deployment of MOOSE. Many nuclear energy entities, including national laboratories and commercial partners, are interested in the analysis tool and its potential to accelerate the design of nuclear reactors.

Advancing radiation-tolerant liquid level instrumentation

The lab, its partners at Industrial Measurement Systems Inc., BWR Owners Group and Massachusetts Institute of Technology will advance commercialization of a highly radiation-tolerant liquid level sensor. This project will design, fabricate, test and qualify a robust, radiation-tolerant level instrument in representative environments under high pressure, high temperature, and high neutron flux and gamma fields.

Improving processes

The lab, in collaboration with Ames Laboratory, Argonne National Laboratory, Kansas City National Security Campus, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory and SLAC National Accelerator Laboratory, will undertake three projects to streamline laboratory processes and document best practices for rapid research and development.

Technology-Based Economic Development

Idaho National Laboratory is a vital and fervent partner in Idaho's economic development at all levels. Not only does the lab employ 6,000 people, Battelle Energy Alliance provided several grants in fiscal year 2023 to aid job creation and workforce development. Batelle also worked with numerous businesses through the Technical Assistance Program in FY-23.

Technical Assistance Program

The Technical Assistance Program (TAP) provides organizations with access to the laboratory's world-class expertise, state-of-the-art facilities and advanced research capabilities. Whether you are an entrepreneur, small business, local government or municipality, TAP offers a range of resources to support your technical needs and foster innovation.

In this program, INL scientists and engineers provide, without fees, assistance that is not normally available to a community or small business with the aim of promoting national competitiveness. TAP helps in areas where organizations may find their problems too complex or technical to solve on their own.

The lab partnered with multiple businesses and government entities through this program. In FY-23, INL provided 188 hours of work and assisted multiple small businesses and government entities in nine different projects. Here are a few highlights from FY-23 projects:

Town of Stowe Electric Department

The lab assisted the electric department in the town of Stowe, Idaho, in developing a microgrid for resiliency, black start, load shedding and outage restoration. For electric utilities, electric grid resiliency is always top of mind. The lab's assistance specially addressed a distribution circuit that carries the load of a small hydroelectric dam, an existing 1-megawatt solar facility, most of the town's critical infrastructure and approximately 90 net-metering customers.

Alquimista

Alquimista, a Florida-based company, used TAP to determine whether the lab's Electromechanical Leach (EC-Leach) might be used to extract platinum group metals from tailings it was buying from mining operations in South America. These metals – platinum, palladium, rhodium, osmium, iridium and ruthenium – are critical to advanced manufacturing. The INL team found that the metals could be successfully extracted using EC-Leach, with 60% less acid than chemical leaching and without hydrogen peroxide.

The best-fit TAP requests fall into the lab's core areas of expertise, including:

- Nuclear energy
- Renewable energy
- Energy storage and grid integration
- Advanced materials
- Cybersecurity
- Environmental science and engineering
- Robotics and automation
- Manufacturing and industrial processes
- Data analytics and machine learning

VIA Science Inc.

VIA Science Inc. requested INL's help in testing their Web3 software method to verify the fuel mix of the energy discharged by an electric vehicle (EV), which impacts DOE and grid operators seeking valuable carbon emission information. The software is designed to provide proof of fuel mix that is both publicly and mathematically verifiable, and simultaneously maintain the privacy of the EV's charge and discharge profile details, location, time and date in charging. The lab found the software successfully provides credible, verifiable information and privacy for EV carbon computations.

TAP helps in areas where organizations may find their problems too complex or technical to solve on their own.

Agreement Management

The Agreement Management organization is responsible for several functions, including:

- Preparing, negotiating and executing all funds coming to INL through collaboration agreements with industry, academia and other government agencies to advance INL's mission objectives.
- Leading the process to determine appropriate agreement mechanisms.
- Managing expectations of technical leads, principal investigators, managerial staff members and sponsors related to implementing sound contracting practices.

Agreement Management Summary

Agreement	Agreement Customer Name	Agreement Title
CRADA	University of Baltimore	University of Baltimore (UB MSB) Cybersecurity/Risk Management Curriculum Integrating Cyber-champ for Current and Aspiring Cybersecurity Managers
CRADA	Electric Power Research Insititute (EPRI)	Targeting Analytic Tool Development Supporting Licensing of Higher Burnup/Higher Enrichment Nuclear Fuels for the U.S. Light Water Reactor Fleet
CRADA	Japan Atomic Energy Agency (JAEA),Hitachi-GE Nuclear Energy, Ltd.,Global Nuclear Fuel-Japan Col, LTD (GNF-J),Nippon Fuel Development, Co. Ltd	Drop-In Capsule Light-Water Reactor Fuels Testing in Idaho National Laboratory's Advanced Test Reactor
CRADA	Curio Solutions, LLC	Process Development and Demonstration for Curio Solutions
CRADA	NextAxiom Technology, Inc.	Resource Virtualization and Management Framework for ION
CRADA	Eden Modern Tech , Inc	DME-Driven Water Treatment Proof of Process
CRADA	Pebble Bed Modular Reactor SOC Ltd (PMBR)	Report on Post-Irradiation Examination and Safety Testing of TRISO Particle Fuel
SPP	Opticslah, LLC	High Precision Broadband Optical Spectrometer for Molten Salt Reactors STTR Phase 2
SPP	Deep Isolation US LLC	Serve on Technical Advisory Committee for DOE ARPA-E awardee, UPWARDS: Universal Performance Criteria and Canister for Advanced Reactor Waste Form Acceptance in Borehole and Mined Repositories Considering Design Safety
SPP	Exotanium, Inc.	Intelligent, real-time migration of scientific computing applications on commercial cloud-based HPC platforms
SPP	Product Innovation and Engineering LLC	Advanced Mechanical Testing (AMT) System for Highly Irradiated Materials
SPP	GTI Energy	Fluidized Bed Gasification for Conversion of Biomass and Waste Materials to Renewable Hydrogen
SPP	CoDeAc Solutions, Inc.	Solutions Plutonium Detection; Plutonium and Uranium Bioassay
SPP	University of Utah	Process Intensification of Hydrogen Production through Sorption-Enhanced Gasification of Biomass
SPP	Oregon State University	Fabrication and Shipping of Uranium Alloy to Oregon State University
SPP	Quanterion Solutions Incorporated	Quanterion Solutions Incorporated, DoD SBIR 22.2, SBIR/STTR FY 2022 Phase I, AF222-0003 Cloud-based IoT Acceptance Test Methodologies for Air Force Systems Integration
SPP	University of Southern California's Information Sciences Institute	STudy of INL for rAdio naTional fAcility (STRATA)
SPP	H3D, Inc.	Phase-1 Testing
SPP	PacifiCorp	Cybersecurity Competency Health and Maturity Progression (CyberCHAMP) Analysis for SCAN
SPP	Korea Institute of Nuclear Safety	Support Korea Institute of Nuclear Safety in Probabilistic Safety Assessment and Human Reliability Analysis
SPP	BASF Corporation	Wood Waste Torrefaction and Size Reduction for Producing an Advanced Gasification Feedstock
SPP	Environmental Alternatives, Inc. (EAI)	FX Hg Mercury Vapor Abatement Demonstration
SPP	Charm Industrial	Corn Stover Fractionation and Pellets for Charm
SPP	University of Southern California's Information Sciences Institutes	ASPIRE: Advanced SPectrum Initiative for Research and Experimentation
SPP	Nano Nuclear Energy Inc.	Zeus Design Overview
SPP	California Nanontechnologies Inc.	Large part development in the DCS-800 with CalNano

Select summaries from FY-23 are provided. This list is not inclusive of every agreement.

Agreement Mechanisms

Agreement	Purpose/Use	Funding	Benefits	Requirements
Cooperative Research and Development Agreement (CRADA)	Collaborative research between INL and public and/or private entities for the mutual benefit of the parties	Private and/or federal funds	• Collaborative research efforts with funding by the lab and the partner • Five year data protection • Designed for multi party collaborative research	• Substantial U.S. manufacturing requirements (or benefit to U.S.) for projects embodying CRADA generated intellectual property • 90-day advance payment when privately funded • Government-use license to generated IP • Approval by DOE
Strategic Partnership Projects	Allows INL to perform mission-related reimbursable work	Private or federal (federal sources through nonfederal sponsor)	• **Access:** Highly specialist or unique DOE facilities, services or technical expertise; helps private entities to accomplish technology goals that may otherwise be unattainable • **Inventions:** IP ownership subject to project parameters; transfer INL technologies to marketplace for further development or commercialization • **Confidentiality:** Generated data treated as proprietary when marked; partners proprietary information can be protected • **Strategic:** Maintain core competencies and enhance INL science and technology base	• Sponsor pays full costs recovery • No exclusive third-party license to protect generated IP unless manufactured substantially in the U.S. • Sufficient advance payment • Government use license to generated IP • Approval by DOE
Proprietary User Agreement	User can have merit-based access to designated facilities to conduct its own proprietary research	Private funds	• User may elect title to its Subject Inventions • User may protect generated data as proprietary • Access to unique facilities and equipment so that users may conduct their own proprietary	• User facilities are designated by DOE • Proprietary users pay full cost recovery • Users own their generated data and inventions, subject to no reserved government rights
Non proprietary User Agreement	Users can have merit-based access to designated facilities and perform nonproprietary research	N/A	• Lab and user may elect their own subject inventions • Non proprietary users engage in precompetitive research and share the costs of their research with the government	• User facilities are designated by DOE • Unlimited government rights to generated data • Expected to publish data generated from the research

2023 Publications

Org	Peer Reviewed Journal Articles	Books and Chapters	Conference Contributions (Abstracts, Papers, Posters, Proceedings)	Review Article	Editorial	Total by Org
Energy & Environment Science & Technology	175	12	31	16	5	239
Nuclear Science & Technology	245	1	25	8	6	285
National & Homeland Security	34		11	1	2	48
Advanced Test Reactor	2					2
Materials & Fuels Complex	73	2	1	1		77
Other	5					5
Blank	2		1	1		4
Total	536	15	69	27	13	660

Marketing

A summary of the metrics

Technology Deployment set a market goal in Fiscal Year 2023 to improve its industry outreach to increase licensing opportunities and outcomes. To achieve this goal, the marketing team increased social media outreach and distribution of marketing emails. Social media posts went from six in FY-22 to 12 in FY-23 and email marketing efforts dramatically increased from 115 messages in FY-22 to 414 in FY-23. These efforts resulted in three executed licenses in FY-23 and numerous discussions with high-value contacts.

Other significant marketing efforts

- Provided marketing contributions to the launch of the software store. Since launch, the software store has had over 8,000 views from over 2,300 unique visitors and at least 355 inquiries into software licenses.
- Coordinated INL participation at Consumer Electronic Show.
- Updated and edited INL's profile on the Lab Partnering Service, including overhauling success stories and adding additional researcher biographies.

INL Facilities Marketing Program

INL's Technology Deployment and Industry Engagement launched a pilot program in FY-23 to market the lab's facilities to prospective industry partners. The goal of the project is to create long-term partnerships between industry and facilities resulting in lab revenue and growth. The groups currently part of this project include:

- Biomass Feedstock National User Facility (BFNUF)
- Center for Advanced Energy Studies (CAES)
- Temporal Analysis of Products Reactor System (TAP)
- Microreactor Applications Research Validation and Evaluation Project (MARVEL)

The facilities marketing project addresses the following challenges presented at the lab:

- Finding prospective facility partners when a facility manager/director may not have the time/resources
- Marketing the diverse portfolio of INL facilities and capabilities that may otherwise go unnoticed or unexposed to target industries
- Opening new channels of revenue for INL and Technology Deployment, increasing revenue and technology commercialization
- Other challenges unique to individual groups

	FY-23 YTD	FY-22 YTD
Outbound Leads	414	115
Inbound Leads	122	99
Other Leads	1	30
Intro Discussions Held	70	58
Licenses Executed	3	7
Summaries Created	136	
Summaries Posted	56	44
Social Media Posts	12	8

At launch, participating groups met with the marketing team to explain the project and methods and identify target industries. Next, we created marketing materials for each group detailing the partnership opportunity, background on the facilities and requirements for a partnership set by the individual groups. The materials were distributed at Sam.gov and through email marketing to companies. Beginning in May, we began outreach via phone and email to prospective companies. Ultimately, the process of the developing a partner follows the current model:

1. Inquiry in the form of listing or email response.
2. Introductory meeting to vet company.
3. Secondary meeting including facility point of contact for technical discussions.
4. If a company meets opportunity criteria, partnership can begin an agreement phase.

INL saw a 25 percent response rate between May and June, much higher than originally anticipated. Most respondents inquired about the MARVEL (14 inquiries) and BFNUF (9 inquiries) groups. These groups were the focus of outreach until July, when campaigns for TAP and CAES began. In total, 26 inquiries about facility partnerships were made, and after discussions with their respective facilities, six companies are in discussions with the facilities with one developing an agreement.

Armored Transformer Barrier might look like a low-tech solution to a primitive threat, but it represents sophisticated research and development conducted in response to a grave and growing problem.

INL technology commercialization success

Technology center opens featuring HelioStorm

Heartland Water Technology Inc. completed construction of its 30,000-square-foot Robert E. Cawthorn Technology Center in Murfreesboro, Tennessee. The state-of-the-art facility is part of the company's multimillion-dollar investment in developing and launching a holistic, distributed, climate-friendly solution for addressing its customers' most complex waste treatment, conversion and destruction challenges. The technology center features a commercial-scale version of Heartland's HelioStorm technology – an ultra-high temperature, electrically driven and combustion-free ionic gasifier, which efficiently converts organic material into a clean, hydrogen-rich syngas used to generate power, recover clean hydrogen and/or convert carbon for reuse into products, such as carbon black. The technology's roots, now licensed to Heartland, can be traced to plasma gasification research conducted over a decade ago at Idaho National Laboratory. This achievement represents a significant milestone in the journey to commercialize this DOE laboratory technology.

INL technology finding its niche

American Ceramic Fiber has grown substantially as it garners many multiyear contracts from national and international businesses since its creation nearly a decade ago. Retired laboratory researcher John Garnier started the Idaho Falls-based company with a focus on providing Direct Conversion Process. Garnier co-created the technology that converts the outer nano layer of carbon material into metallic carbide fibers while leading the laboratory's armor program for the National and Homeland Security directorate.

Garnier and his partners financed the company for the first three years before obtaining a Small Business Innovation Research grant through the Department of Defense to create extreme temperature fibers for advanced turbine engine components. They continue to receive Small Business Innovation Research grants and Phase III transition to advance the technology and expand its applications, such as yarns and composite fasteners.

"We're taking this company to the next level," Garnier said. "It's exciting to come here every day because you've got people calling you and excited by your tech."

American Ceramic Fiber most notably developed a lightweight, ultra-temperature material for NASA's Interstellar Probe's solar shield that can withstand temperatures as high as 3,500 degrees Celsius and, based on models, endure probe speeds to one-third that of light, or about 56,000 miles per second.

Protecting our infrastructure

Armored Transformer Barrier might look like a low-tech solution to a primitive threat, but it represents sophisticated research and development in response to a grave and growing problem.

Although some attacks on the electrical grid have been traced to people with simple criminal intent, there is a growing concern about domestic extremists' intent on anarchy and societal collapse. An online sabotage manual offers this chilling guidance: "The power generation and distribution systems of most major Western cities are surprisingly vulnerable. ... A simultaneous attack against a number of these targets can shut down power ... with the advantage that service cannot be quickly restored by diverting power from another source. ... An individual, equipped with a silenced rifle or pistol, could easily destroy dozens of power transformers in a very short period of time."

The threat has begun to register in the power industry and elsewhere. The laboratory licensed the technology to Waltonen Engineering of Warren, Michigan, a full-service design and engineering company founded in 1957. Under the licensing agreement, the lab continues to host visitors to its test range site, performing demonstrations for customers.

Platts Global Energy Awards named the technology as a finalist in their "Infrastructure Project of the Year" competition in 2023.

Notable Technology Deployment activity highlights

Software Marketplace website launches

Idaho National Laboratory officially launched its Software Marketplace website in spring 2023.

The lab developed the website to widely distribute its innovative software. The goal is to accelerate industry adoption and fuel innovation in other research organizations. Ultimately, the marketplace will help fulfill the lab's vision to change the world's energy future and secure our nation's critical infrastructure.

The marketplace provides access to software codes and data sets developed at the lab through various forms of licenses, including open-source and proprietary options. The site will expand as more software is developed. View the site at inlsoftware.inl.gov.

Lab debuts at international Consumers Electronic Showcase

The laboratory debuted as an exhibitor at the internationally renowned 2023 Consumer Electronics Showcase in Las Vegas, Nevada. INL's Technology Deployment directorate, partnered with the U.S. Department of Energy Office of Technology Transitions, joined multiple national laboratories to showcase their respective innovations at the event that draws more than 3,200 exhibitors from 173 countries. INL demonstrated eight technologies, including a mixed reality HoloLens demo that gave attendees a unique view of MARVEL – the lab's first modern microreactor technology.

U.S. Department of Energy Secretary Jennifer Granholm attended two INL technology demonstrations for MIRACLE and C3D. INL researcher Ahmad Al Rashdan presented MIRACLE, an INL machine learning technology that is making reviewing faster, easier and more efficient. INL researcher Jake Gentle and commercialization manager Jonathan Cook, along with Sierra Nevada Corporation, demonstrated the C3D and Binary Armor technologies that can help block cyberattacks from impacting the nation's electric power grid.

Laboratory innovators celebrated

The lab hosted the INL's annual Innovation Celebration to recognize the achievements of 94 inventors receiving patents, copyright assertions, open-source software designation and R&D 100 Awards. In total, these inventors amassed 25 patents, 13 copyright assertions, 20 open-source software designations, three R&D 100 Awards, and five R&D 100 Awards finalists in fiscal year 2022.

INL Director John Wagner and Micron Technology Vice President of Products, IP and Technology Dave Kaplan provided inspiring and thought-provoking speeches on innovation. Department of Energy Secretary Jennifer Granholm and Chief Commercialization Officer Vanessa Chan provided congratulatory video messages.

Lab hosts third annual Innovation Week

The laboratory hosted its third Innovation Week. The annual event draws attention to innovation's pivotal role in the lab's mission to discover, demonstrate and secure innovative nuclear energy solutions, other clean energy options and critical infrastructure.

This year, events included an Innovation Celebration luncheon, invention disclosure record workshop, "Unleashing Artificial Intelligence (AI) for Innovation" panel discussion, and an open house/poster session. All activities were well-received, especially the panel discussion, which brought in a wide range of expert panelists to discuss how AI can be the catalyst for transformative change and how to gain the knowledge and confidence to embrace AI's possibilities.

More than 100 employees attended Innovation Week events in person and virtually.

Top photo: INL, partnered with DOE's Office of Technology Transitions, showcased a variety of technologies during the renowned 2023 Consumer Electronics Showcase in Las Vegas. Bottom photo: Technology Deployment hosted its third annual Innovation week, which included an open house.

Five INL technologies were honored as R&D 100 Award winners in 2023. Since 1986, INL has won more than 70 R&D 100 Awards.

Awards and Recognition

Peers recognize INL for technology transfer efforts


The Department of Energy's Technology Transfer Working Group honored two INL employees with best-in-class awards for their technology transfer efforts in FY-23. **Paige Price** received the Early Career Professional of the Year award, and **Jon Cook** received an award for his licensing efforts with Consequence-driven Cyber-informed Engineering (CCE).

Price, who has worked at the lab since July 2019, contributed to the lab's technology transfer work, including improving processes and communications. Her leadership and initiative have sparked more researcher involvement in technology transfer activities. Most recently, Price and Wendy Skinner, INL senior business analyst and software specialist, conducted extensive research to improve efficiency and participation in INL software release and patent processes.

Cook was honored for his creative, multifaceted approach to protecting multiple types of intellectual property and licensing CCE in the marketplace. This methodology uses a "think like the adversary" approach to providing critical infrastructure owners and operators with a four-step process for safeguarding their infrastructure. CCE is nonexclusively licensed to five commercial entities that are helping deploy the methodology to government and public critical infrastructure owners and operators.

Federal Laboratory Consortium of Technology Transfer recognizes Tech Scout Webinars

The Federal Laboratory Consortium for Technology Transfer honored INL's Tech Scout Webinars with a Far West Regional Award for impacting technology transfer. The consortium is a nationwide and regional network of over 300 federal laboratories, agencies and research centers that foster best commercialization practice strategies and opportunities to advance federal technologies into the marketplace.

Tech Scout Webinars help Battelle-operated national labs create more business opportunities for the labs and companies. INL's Jon Cook launched the effort with four goals:

1. Increase industry and Battelle Commercialization Council laboratory collaboration on industry or federally funded research projects.
2. Increase awareness of national laboratory capabilities and personnel.
3. Improve licensing prospects for laboratory and company portfolios.
4. Encourage customer discovery for laboratory staff members and researchers to understand industry needs.

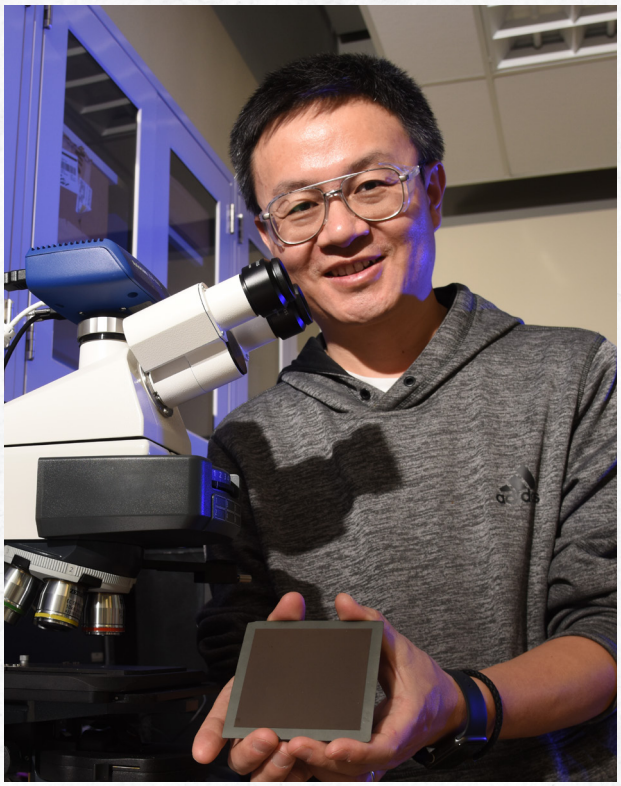
The webinars have met these goals and increased meaningful conversations between the laboratories and businesses.

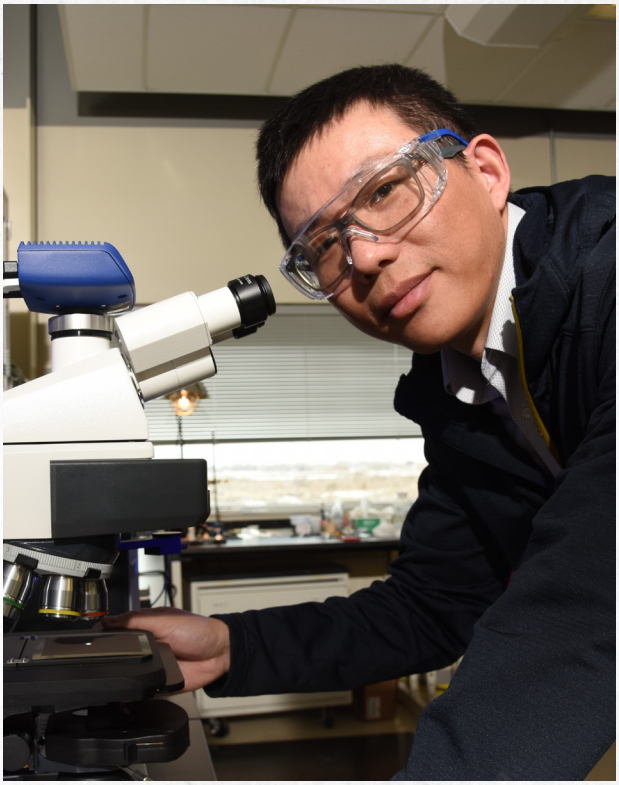
R&D 100 Award winners

PATENT MILESTONES

Reaching 10 patents in FY23

Tim Mcjunkin





Reaching 5 patents in FY23

CLOCKWISE FROM TOP LEFT: Dong Ding, Joshua Daw, Prabhat Kumar Tripathy and Wei Wu

Annotated Translated Disassembled Code (@DisCo)

@DisCo is a scalable translated binary analysis platform that improves cyber defense by using machine learning and sophisticated visualization tools to reverse engineer firmware and malware binaries. The tool then translates these into intermediate languages that enable vulnerability discovery and code analysis.

Researchers: Jed Haile (co-principal investigator) and Rita Foster (co-principal investigator)

Cardinal: Accelerating Discovery in Fusion and Fission Energy*

Cardinal is an open-source simulation software package that accelerates scientific discovery in nuclear fusion and fission energy, delivering state-of-the-art integration of scalable algorithms that enable first-of-a-kind scientific exploration. Cardinal is applicable to neutron transport, fluid flow, heat transfer, thermos-mechanics and material behavior on platforms ranging from laptops to extreme-scale computers.

Researchers: April Novak (Argonne National Laboratory principal investigator) and Derek Gaston (INL lead investigator)

*INL partnered with Argonne National Laboratory on this award nomination.

Cerberus

United States government policy calls for establishing a network of high-speed charging stations for electric vehicles. These charging stations handle a lot of energy and depend on the internet – a vector for criminals and national adversaries. Cerberus is anti-hacker hardware and software that protects equipment and the people using it.

Researchers: Kenneth Rohde (co-principal investigator), Barney Carlson (co-principal investigator), Sean Salinas and Matthew Crepeau

Ether-based Aqueous Separation and Extraction

@DisCo is a scalable translated binary analysis platform that improves cyber defense. It is an R&D 100 Award winning technology.

Cerberus – selected as a 2023 R&D 100 Award winner – is an anti-hacker hardware and software that protects equipment and the people using it.

The RAVEN team included a diverse and talented group of researchers to create the award-winning technology.

EASE is a state-of-the-art technology for critical material recovery and reuse.

(EASE)*

EASE is an emerging technology to separate valuable mineral salts as solids from wastewater and dilute sources. This process significantly reduces the energy and chemicals used for water treatment and mineral recovery without creating a new waste stream.

Researchers: Aaron Wilson (co-principal investigator), Ikenna Nlebedim (Ames National Laboratory co-principal investigator), Caleb Stetson, Denis Prodius (Ames National Laboratory), Christopher Orme, Hyeonseok Lee and Ashini Jayasinghe

*Ames National Laboratory is a partner.

RAVEN

RAVEN is an open-source software platform that facilitates and enhances a variety of model exploration, risk analyses and design optimizations for nuclear reactors, energy grids and other complex systems.

Researchers: Diego Mandelli (co-principal investigator), Congjian Wang, (co-principal investigator), Paul Talbot, Joshua Cogliati, Mohammad Abdo, Dylan McDowell, Ramon Yoshiura, and Robert Kinoshita

Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy.

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Idaho National Laboratory