

ACCELERATING THE TRANSFORMATION OF THE GLOBAL ENERGY ECONOMY JISEA 2020 ANNUAL REPORT



CATALYZING CHANGE

What will the U.S. and global energy landscapes look like in the next decade?

We are experiencing an astonishing energy transition in the United States and across the globe, making this question more exciting than ever. The benefits of clean energy are known and ready to take off.

Yet this transition isn't monolithic. Each country has its own set of natural and human resources, energy needs, and social preferences, so every clean energy solution will be unique. This raises important and difficult questions.

At the Joint Institute for Strategic Energy Analysis (JISEA), we identify and objectively analyze those hard questions. We know that innovative energy solutions will come from systems and not silos, which is why we focus on the nexus of the energy, finance, and social sectors.

Like the critical ingredient that speeds up the rate of a chemical reaction, our analysis can help catalyze new areas of energy-focused research, accelerating global progress on sustainability, resilience, and economic prosperity.

2019 was an exceptional year for JISEA. Our researchers published over 20 reports and articles focused on diverse questions from how South American economies can best leverage options for resilient and flexible power systems to how industry can generate necessary heat while reducing its reliance on emissions-intensive fuels.

This year I was invited to speak about JISEA's work and engage in strategic dialogue around our research findings at 12 events in the United States and four other countries—Japan, Canada, United Arab Emirates, and Saudi Arabia. JISEA researchers participated in similar discussions and events in many more countries.

The increasing intensity of JISEA's global engagement is a reflection of advances in technology, which are rapidly changing energy systems worldwide. But there are many energy challenges that still need to be solved. As we look to 2020, we are ready and excited to dig into new questions, from mining to food systems. As communities and sectors worldwide explore how they can adopt dynamic, diverse, flexible energy systems, our jobs as analysts will only become more important.

New technologies also need a human system to develop them—a system of manufacturers, engineers, policy makers, economists, managers, lawyers, and social scientists. Together, we can chart the course toward energy transformation and catalyze new solutions.

Thank you for your support, and we invite you to join us in our ongoing exploration in 2020.



JISEA Director





10 YEARS OF LEADERSHIP

A sustainable energy future is not possible without deeply understanding the connections among all energy pathways and the interactions among energy systems, Earth systems, and social and economic systems. The Alliance for Sustainable Energy recognized this and in 2010 launched the Joint Institute for Strategic Energy Analysis (JISEA).

JISEA leverages the deep knowledge and capabilities across six founding institutions and global affiliates to provide comprehensive insights for global energy transformation. I'm thrilled to celebrate and honor 10 years of JISEA!

In its first decade, JISEA has grown to be the operating agent for Clean Energy Ministerial programs, including the 21st Century Power Partnership (21CPP) and the Nuclear Innovation: Clean Energy Future (NICE Future) Initiative. JISEA analysis has supported modeling and analysis for international energy transitions, including a portfolio of collaborations with the Children's Investment Foundation Fund.

JISEA has been a leader in natural gas research, including detailed analysis of the opportunities to reduce product loss by identifying the biggest methane-emitting natural gas wells and, more recently, designing the integration of renewable energy into oil and gas operations. With partners at other national labs, JISEA researchers have led studies on the potential integration of renewable energy and nuclear energy, focused particularly on industrial energy demands. JISEA also leads analysis of the nexus of energy with water and land use.

Within the National Renewable Energy Laboratory (NREL), JISEA plays an important role in the Scientific Computing and Energy Analysis (SCEA) directorate vision to accelerate transformation of the global energy infrastructure through comprehensive, rigorous, and scalable computing and analysis. JISEA's seminal analysis and leading-edge research inform critical decisions at the intersections of diverse systems to advance sustainability, economic prosperity, and resilience, directly supporting NREL's critical objectives for the next decade: Integrated Energy Pathways, Electrons to Molecules, and Circular Economy for Energy Materials.

Insights gained from JISEA research have been seminal in launching several major NREL programs aligned with these objectives. JISEA continues to explore opportunities for insights with impact and has a growing reputation for objective, high-impact research and analysis. The highly attended JISEA annual meeting brings exciting new ideas and questions for further research efforts for JISEA and its partners.

But JISEA's work is perhaps most important in the context of the broader research landscape—answering unique, complex questions with unprecedented expertise. JISEA brings together an international cohort of wide-ranging experts to brainstorm critical unanswered questions within the energy sector. This expertise wouldn't intersect otherwise.

As we move into the uncharted territory of a sustainable energy future, JISEA will remain a beacon of insight in the next decade and beyond.

Rob Leland Associate Lab Director SCEA

OUR MISSION



The Joint Institute for Strategic Energy Analysis (JISEA) provides leading-edge, objective, high-impact research and analysis to guide transformative global energy investment and policy decisions.

Through strategic insights and worldwide dialogue, JISEA explores the intersections of the environmental, social, financial, technological, and political elements of energy systems on the path to a clean energy economy. JISEA's work informs innovative solutions that advance the goals of sustainability, economic prosperity, and resilience.

JISEA research and analysis provides decision-making support to industry, the financial sector, and government with a focus on the following strategic areas:

- Energy Systems Transformation
- S Circular Energy Economy for Materials and Global Supply Chains

Elean Energy for Industry and Agriculture

CONTENTS





ENERGY SYSTEMS TRANSFORMATION

USHERING IN A NEW ENERGY ECONOMY

Developing secure and resilient energy infrastructure that fosters economic growth while significantly reducing environmental impact is among the most critical challenges of our time. Scientists, engineers, and thought leaders have seized the opportunity, ushering in a new era of technical innovation born of necessity.

Converging with powerful environmental, business, and sociopolitical forces, rapid technological advances are fueling ambitious goals to transform energy systems for power, transportation, and commercial enterprises. As a result, industries around the world are undergoing a paradigm shift bolstered by strong economic incentives.

Variable renewable energy (VRE) sources like wind and solar are now the lowest-cost generating options in an increasing number of jurisdictions. Distributed energy resources, such as battery storage, demand response, and electric vehicles, are also becoming increasingly viable options to sustain the needs and activities of our daily lives and support grid reliability as renewable penetration grows. New nuclear energy technologies are clearing the way for the continued growth of emissions-free sources of dispatchable power that can potentially play a key role in a decarbonized grid.

As adoption of these technologies accelerates, however, the need for innovative approaches to power sector planning, regulation, and operations continues to grow.

JISEA is working to help stakeholders chart their respective energy transformations. Our research and analysis in this area help advance the policies, technologies, models, and social transformation needed to fast-track the journey toward fully sustainable energy systems and communities.





21CPP: ACCELERATING PATHWAYS TO POWER SECTOR TRANSFORMATION

It is no secret that access to reliable electricity is a major driver of economic growth. Propelled by goals such as enhanced reliability, affordability, and environmental sustainability, many countries are prioritizing grid modernization and power system transformation as they map their development strategies. A key enabler of this transformation is power system flexibility.

To support their progress, the 21st Century Power Partnership (21CPP) developed 10 principles that apply across multiple layers of power system flexibility to guide emerging economy decision makers as they navigate the policy, market, and regulatory environments along their power sector transformation pathways.

LEARN MORE: Ten Principles for Power Sector Transformation in Emerging Economies (www.nrel.gov/docs/fy19osti/73931.pdf)



LAYERS OF POWER SYSTEM FLEXIBILITY

Source: 21CPP and IEA, 2019.

Technical, economic, and institutional policy layers mutually influence each other and have to be addressed in a consistent way to enhance power system flexibility.

LEARN MORE: 21st Century Power Partnership (www.21stcenturypower.org)

21st Century POWER PARTNERSHIP Accelerating the transformation of power systems

EXPLORING NUCLEAR'S ROLE IN DECARBONIZATION

Led by the United States, Canada, and Japan, the Nuclear Innovation: Clean Energy (NICE) Future Initiative convenes global conversation on the potential role of nuclear energy in tomorrow's clean energy systems. In 2019, NICE Future presented webinars exploring an array of relevant topics ranging from technical opportunities, such as the promise of small modular nuclear reactors, to social issues, such as gender mainstreaming in the global nuclear sector and communicating nuclear energy's role in clean energy systems.

In November, the U.S. NICE Future Initiative Team received a 2018 Secretary of Energy Achievement Award, the U.S. Department of Energy's (DOE's) highest honor for teams of employees and/or contractors who have gone above and beyond in fulfilling DOE's mission and serving the nation.

LEARN MORE: Enabling Clean Energy Systems with Nuclear Innovation (www.nice-future.org/)



Members of the U.S. NICE Future Initiative Team accept the Secretary of Energy Achievement Award in Washington, D.C. From left to right: Dr. Shannon Bragg-Sitton, Idaho National Laboratory; Giulia Bisconti, DOE Office of Nuclear Energy; Dr. Jordan Cox, National Renewable Energy Laboratory (NREL).



JISEA @ CEM10: Working Toward a Clean Energy Future

At the end of May, JISEA joined ministers from more than 25 countries in Vancouver, British Columbia, for the 10th Clean Energy Ministerial, or CEM10. Founded in 2010, CEM provides an opportunity for high-level policy dialogue and sharing of best practices to accelerate a transition to a low-carbon future.

JISEA was an active participant at CEM10 as an operating agent of CEM programs 21CPP and NICE Future, helping countries map their transition to clean power as part of its mission-driven work supporting energy transition planning in the United States and internationally.

LEARN MORE: www.jisea.org/20190621.html



NREL Deputy Associate Lab Director Doug Arent speaks as part of a 21CPP panel on innovative utility offerings at CEM10 in Vancouver, Canada.

SEEKING SUSTAINABLE AND FLEXIBLE ENERGY IN SOUTH AMERICA

Global energy landscapes are evolving. In South America, water scarcity, combined with expanding variable renewable energy markets and declining wind and solar energy costs, is prompting some rethinking of the energy generation status quo. Countries are reconsidering their respective energy mixes, seeking out more flexible, resilient, sustainable, and affordable options.

In 2019, JISEA researchers took a closer look at the unique energy challenges facing Argentina, Brazil, Chile, and Colombia; the resources they possess; and the road they must travel to achieve sustainable power systems. A few highlights of their findings:

- Argentina could become an energy leader in South America with the expansion of the Vaca Muerta shale gas and shale reserves site.
- Before 2010, 80% of **Brazil's** power came from hydropower. The country has since invested in sophisticated energy planning capabilities and the installation of more nonhydro renewables than any other South American country.

- Since 2014, Chile has successfully expanded its high-quality wind and solar resources. The next step is planning how to make the power consistently available for high-demand areas, such as Santiago, and sectors, such as mining.
- **Colombia** held its first successful auction for wind and solar in late 2019 as a first step on the path toward the vibrant VRE market its leaders envision.

LEARN MORE: Options for Resilient and Flexible Power Systems in Select South American Economies (www.nrel.gov/docs/ fy20osti/75431.pdf)









The evolution of energy economies—Graphs tracking the changing generation mixes of four South American countries show they have incorporated renewable energy sources at different paces and scales over the past 18 years.



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CIRCULAR ENERGY ECONOMY FOR MATERIALS AND GLOBAL SUPPLY CHAINS

SPURRING PROGRESS TOWARD SUSTAINABLE SUPPLY CHAINS

The global supply chain for manufacturing the technologies essential to energy transformation is both complex and largely linear, reflecting the results of decades of investment in industrial and economic development. On the one hand, clean energy manufacturing is part of a broader ecosystem wherein various manufacturing supply chains are connected through the interactions of integral products and materials—interactions that are not always obvious without further analysis. On the other hand, a number of advanced clean energy technologies are reliant on limited suppliers of critical materials, increasing vulnerability to supply-chain disruption.

As the manufacturing sector moves toward increasingly global supply chains, other major changes are also under way, such as increased automation and decentralized manufacturing. This shifting landscape opens new opportunities for innovation and economic development around the world. Deeper knowledge of global supply chains can help set research agendas and inform investment strategies optimized by location and technology. In turn, these efforts yield new dynamic industrial processes, sustainable materials, and advanced manufacturing technologies, catalyzing opportunities to transition to a circular energy economy.

JISEA's research and analysis in this area generate key metrics for better understanding the flow of materials intrinsic to the production and use of energy technologies. By elucidating options for creating a more circular and sustainable manufacturing supply chain, from the sourcing of raw materials through products' end of life, these insights help catalyze the transformation to a sustainable energy future.

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EXPLORING THE RAW MATERIALS LINK

Paving the Way for Improved Materials Management in Battery Manufacturing

The raw materials used to manufacture key components of lithium-ion batteries (LIBs)—including cobalt and lithium—travel a long path from the mines to the manufacturers to the cars in our garages.

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In 2019, JISEA/Clean Energy Manufacturing Analysis Center (CEMAC) researchers explored the raw materials link in clean energy technology supply chains, considered their impact on light-duty vehicle (LDV) development, and highlighted the benefits of LIB recycling from sustainability and value-chain perspectives.

Their analysis found the cobalt supply chain to be less secure than that of lithium and examined efforts to secure the future availability of raw materials via mine and refinery ownership. It also revealed how closing the materials loop through LIB recycling can help mitigate material shortages.

LEARN MORE: Supply Chain of Raw Materials Used in the manufacturing of Light-Duty Vehicle Lithium-Ion Batteries (www.nrel.gov/docs/fy19osti/ 73374.pdf) and The case for recycling: Overview and challenges in the material supply chain for automotive li-ion batteries (www.sciencedirect. com/science/article/pii/S2214993718302926)



Understanding the raw material extraction and processing steps of the cobalt supply chain in lithium-ion battery manufacturing can aid in assessing the risks (e.g., material sources, sustainability, competing products) associated with scaling up clean energy technology deployment.





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Advancing Cool Methods for Building Compressors as Air-Conditioning Market Heats Up

The refrigeration and air-conditioning industries are developing innovative approaches to reduce potent emissions from hydrofluorocarbon refrigerants and improve energy efficiency. The industry is projected to grow significantly, particularly in developing regions. As global demand for room air conditioners grows, so does the market for compressors—key components of these systems.

JISEA/CEMAC market analysis in 2019 provided an industry snapshot and studied countries' efforts to promote adoption of higher-efficiency air-conditioning compressors that use low-global-warming-potential (GWP) refrigerants.

Researchers found that countries' attempts have had varying degrees of success in overcoming challenges stemming from factors such as building flammability codes, public awareness, and availability of higher-capacity, low-GWP refrigerant compressors.

LEARN MORE: Mapping the Supply Chain for Room Air Conditioning Compressors (www.nrel.gov/docs/fy19osti/73206.pdf)



A trade flow wheel from CEMAC's analysis of the global room airconditioning compressor supply chain shows China is the largest exporter.

Values in millions of compressor units CEMAC analysis plus data from TradeMap

MANUFACTURING COMPETITIVENESS: PRODUCING IN VOLUME LEADS TO SAVINGS IN VOLUME

Scaling Up Production of Hydrogen Refueling Station Systems To Lower Cost Barriers and Accelerate Electric Car Adoption

By 2030, California aims to have 1,000 hydrogen refueling stations to support the more than 1 million fuel cell electric vehicles (FCEVs) expected to traverse its highways and byways by 2030.

However, high initial vehicle costs and a dearth of hydrogen refueling infrastructure pose significant challenges to FCEV market expansion. Given these potential roadblocks, how can the FCEV industry extend its market growth?

JISEA/CEMAC research revealed that by producing more key parts and systems for the hydrogen refueling stations ecosystem, manufacturers can reduce capital costs by as much as 35%. The study suggested economies of scale could translate to lower prices at the pump—and speed FCEV adoption. And reductions in capital costs could mean drivers will pay less at the pump, fueling their cars as well as FCEV expansion.

LEARN MORE: Manufacturing competitiveness analysis for hydrogen refueling stations (https://www.sciencedirect.com/ science/article/abs/pii/S0360319919307505)







The waterfall charts show that the advantages of Chinese and Mexican manufacturers come from low labor and building costs. While other countries (e.g., Germany, Japan, and South Korea) have manufacturers that produce key parts used in the hydrogen station, such as compressors, heat exchangers, pressure vessels, and dispensers, the manufacturing cost in these countries tends to be higher than the United States because of the higher labor rates and building/facilities costs.



A cohort from Saudi Arabia visits NREL to gather knowledge and insights for developing renewable energy projects for the King Abdullah City for Atomic and Renewable Energy.

JISEA Workshop Supports Saudi Arabia's Renewable Energy Initiatives

To support NREL's partnership with the King Abdullah City for Atomic and Renewable Energy (K.A. CARE), JISEA hosted workshops in June 2019 and January 2020. In exploring topics ranging from process heat and microgrids to tri-generation, each of these two-week trainings considered strategies for cost-competitive manufacturing of renewable energy products and services to be deployed in Saudi Arabia.



NREL's Flatirons Campus provides K.A. CARE team with on-the-ground experience they can apply as they scope and implement renewable energy projects to power their sustainable Saudi city.

JISEA ANNUAL REP



ADVANCING DECARBONIZATION BEYOND THE POWER SECTOR

Renewables are making rapid inroads in the power and transportation sectors, accelerating the transformation of the global energy economy. To build on this momentum, we must shift our strategic focus increasingly toward the more heterogenous energy demands of industry and agriculture. Significant progress in these sectors is critical to realizing the world's ambitious decarbonization goals.

Decarbonization of heavy industry and agriculture will require the fast-tracking of technologies to improve system efficiencies and address often-competing priorities at the nexus of energy, water, and land use. JISEA leverages its partners' analytical capabilities to support clean tech development and its application to commercial systems, streamlining the path from invention to commercialization and increased market share.

JISEA research in this thematic area seeks to advance innovative approaches and technologies for providing low-carbon heat and power to industry while building resilience in the face of the escalating threat of natural and human-caused disruptions. Timely and economic achievement of these goals, however, demands proactive measures backed by data-driven decisions.

JISEA research and analysis inform these increasingly critical decisions.

Our work provides companies, suppliers, and other industrial and agricultural stakeholders with the tools and resources they need to successfully implement clean, resilient energy solutions. By supporting the integration of clean technologies in economic sectors beyond power systems, we act as a catalyst for global energy transformation.



Building Resilience

The costs of a power outage—in terms of loss of products, revenue, productivity, and customers—can be staggering. As extreme weather events become more frequent and severe, businesses need effective and economic strategies to protect their assets, minimize downtime, and mitigate losses in the event of an outage. Accordingly, the cost and reliability of backup system configurations have become a central concern across industries.

In 2019, JISEA researchers considered the real-world costs and benefits of natural gas- and diesel-driven power generation, comparing grid-connected and backup-only systems.

They found that the reliability and economics of backup generation options are largely situationally dependent; factors such as availability of natural gas connects, fuel tank space constraints, and noise and emissions concerns should guide the decisionmaking process.

LEARN MORE: A Comparison of Fuel Choice for Backup Generators (www.nrel.gov/docs/ fy19osti/72509.pdf)

Net Present Values by Case Study Region and Fuel Type

Generator type	Diesel			Natural gas		
Region	ТХ	FL	NJ	тх	FL	NJ
CAPEX + Non-fuel O&M (\$/kW)	-\$1,205			-\$1,405		
Fuel cost for grid services (\$/kW)	-\$187	\$O	-\$341	-\$199	\$O	\$272
Total revenues/ savings (\$/kW)	\$968	\$1,380	\$3,064	\$1,091	\$1,380	\$3,153
NPV of backup power per unit (\$/kW)	-\$425	-\$175	\$1,518	-\$513	-\$25	\$1,476

JISEA compared the duration of power outages by region and found that Florida—with the highest likelihood of generator failures and the largest difference between natural gas and diesel reliability—experienced the highest prevalence of long outages.



Assuming consistent reliability of the generators, JISEA researchers analyzed the likelihood of survival of diesel versus natural gas supply. They found that because the natural gas supply can fail even during short outages, natural gas tends to be less reliable in such cases. But during longer-duration outages, when resupply from fuel trucks is less secure than the natural gas supply, the opposite is true. The large drop in diesel reliability depicted in this graph at 36 hours is due to failure of diesel fuel supply.



Sparking Energy Innovation

The support energy entrepreneurs receive as they navigate the vast expanse between the spark of an idea and entry into the market can spell the difference between a soaring ascent and a resounding flop.

In the 2019 paper "New Approaches to Energy Hardware Innovation and Incubation," JISEA researchers analyzed a variety of emerging approaches to support early-stage clean tech development of commercial systems. Part analysis, part score card, the study offered a landscape view of some of the innovative approaches that have developed in recent years.

Early data suggest such support programs yield meaningful impact for the participating entrepreneurs. Accordingly, demand for this type of assistance is on the rise.

LEARN MORE: New Approaches to Energy Hardware Innovation and Incubation (www.nrel.gov/docs/fy19osti/73438.pdf)



Incubating innovation—Comparing the cumulative investments over time of companies in the Wells Fargo IN² Innovation Incubator program to those of IN² applicants who were not accepted reveals the average company's rate-of-investments-received increases upon entering the IN² program. This finding underscores the importance of supportive technology incubators.

Rate of investment in IN² Companies vs. IN² Applicants

Integrating Renewables into Industrial Operations

The rapid decline in the price of clean energy technologies, combined with growing pressure to cut both operating costs and emissions, is compelling the oil and gas industry to investigate deploying renewables to power their operations. For industries that have not traditionally used renewable technologies, there can be a learning curve associated with incorporating them into day-to-day operations.

To bridge this gap, JISEA has established a collaborative program targeted to businesses and organizations interested in integrating highly reliable, affordable, clean power into oil and gas operations. Along with identifying, evaluating, and implementing clean energy solutions, the program will validate the performance of promising technologies, analyzing scenarios to pinpoint return on investment and environmental and social impacts.





In November, JISEA held an interactive workshop focused on clean energy in oil and gas operations that included a separate meeting for Clean Energy for Oil and Gas Consortium members. Workshop participants considered what new technologies, analyses, demonstrations, and policies could better enable collaboration between the renewables and oil and gas industries. They also explored how emissions rates and other site data can support responsible policy decisions.

LEARN MORE: Approaches for Integrating Renewable Energy Technologies in Oil and Gas Operations (https://www.nrel.gov/ docs/fy19osti/72842.pdf)

The Renewable Opportunity in Mining workshop was organized by JISEA and hosted at NREL in partnership with the Payne Institute of Public Policy at Colorado School of Mines and the Missouri University of Science and Technology.

Attendees considered what decisionmaking tools and capacity-building tactics can be instrumental in overcoming barriers to integrating renewables into mining operations.

LEARN MORE: Mining for a Solution: Integrating Renewable Energy into Mining Operations (www.jisea.org/ 20191121.html)

Mining for a Solution: Integrating Renewable Energy into Mining Operations

On November 21, mining industry professionals, equipment manufacturers, engineering firms, and other stakeholders along the minerals and metals supply chains convened in Golden, Colorado, to discuss a proposed program to integrate renewable energy into mining operations.



Workshop participants engage in discussions that flag commercial risk, technologies, tool-building, and demonstration projects as high-priority areas for future collaboration.

"It was one of the best workshops I've ever attended.... The format and the diverse profile of participants allowed for some frank and engaging conversations."

-Victoria Gosteva, Sr. Marketing Manager Global Mining, Black & Veatch Corp.



The extended JISEA team. Back left to right: Mark Jacobson, Garvin Heath, Mark Ruth, Jeff Logan, Jordan Cox, Josue Prado. Front left to right: Jill Engel-Cox, Anna Garcia, Liz Weber, Madeline Schroeder, Pat Statwick, and Tsisilile Igogo.

JISEA is operated by the Alliance for Sustainable Energy, LLC, on behalf of its founding partners.







Stanford University



Massachusetts Institute of Technology



CONTACT US

JISEA partners with numerous research affiliates and sponsors to analyze pathways to a sustainable energy future. To establish a new partnership with JISEA, contact us at **JISEA.Coordinator@nrel.gov** or visit our website: **www.jisea.org**.

Follow us on Twitter 🔰 (@JISEA1) and LinkedIn in.

JISEA PROGRAM COMMITTEE

JISEA's Program Committee provides guidance on program direction to the executive director and reviews JISEA's research agenda, priorities, and research program plan.

Tom Bradley

Professor, Department of Mechanical Engineering, Colorado State University; Interim Department Head, Systems Engineering Program

Jared Carbone

Associate Professor, Division of Economics and Business, Colorado School of Mines

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RESEARCH AFFILIATES: CURRENT AND FORMER

JISEA augments the capabilities of its founding institutions with those of leading analysis centers across the globe.

Rice University's Baker Institute Center for Energy Studies (CES)

BAKERINSTITUTE.ORG/CENTER-FOR-ENERGY-STUDIES

CES provides new insights on the role of economics, policy, and regulation in the performance and evolution of energy markets.

Carnegie Mellon University Department of Engineering and Public Policy

CMU.EDU/EPP

The Department of Engineering and Public Policy, a unique department within the College of Engineering at Carnegie Mellon University, focuses on addressing technology-based policy problems.

Energy Institute at The University of Texas at Austin

ENERGY.UTEXAS.EDU

The Energy Institute is dedicated to broadening the educational experience of students by creating a community of scholars around energy issues of importance to Texas, the nation, and the world.

Eskom

ESKOM.CO.ZA

Eskom generates, transmits, and distributes electricity to industrial, mining, commercial, agricultural, and residential customers and redistributors in South Africa and throughout the continent.

Houston Advanced Research Center (HARC)

HARC.EDU

HARC provides independent analysis on energy, air, and water issues to people seeking scientific answers. HARC focuses on building a sustainable future that helps people thrive and nature flourish.

International Institute for Applied Systems Analysis (IIASA)

IIASA.AC.AT

IIASA conducts policy-oriented research into the most pressing areas of global change energy and climate change, food and water, poverty, and equity—and their main drivers.

KTH Royal Institute of Technology

KTH.SE/EN

KTH, the largest and oldest technical university in Sweden, offers education and research ranging from natural sciences to engineering, architecture, industrial management, and urban planning.

Masdar Institute of Science and Technology

MASDAR.AC.AE

The Masdar Institute is the world's first graduate-level university dedicated to providing real-world solutions to issues of sustainability.

Renewable and Appropriate Energy Laboratory (RAEL)

RAEL.BERKELEY.EDU

Based at the University of California, Berkeley, RAEL focuses on designing, testing, and deploying renewable and appropriate energy systems.

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PUBLICATIONS

Learn more about JISEA's impactful analysis by reading our recent publications and visiting our websites and social media channels.



Research note: LED lighting-A global enterprise

https://journals.sagepub.com/doi/10.1177/1477153520901757

Options for Resilient and Flexible Power Systems in Select South American Economies

www.nrel.gov/docs/fy20osti/75431.pdf

Techno-ecological synergies of solar energy for global sustainability

www.nature.com/articles/s41893-019-0309-z

Managing the Electricity-Gas Interface: Current Environment and Emerging Solutions

www.nrel.gov/docs/fy19osti/71750.pdf

Using facility-level emissions data to estimate the technical potential of alternative thermal sources to meet industrial heat demand

www.sciencedirect.com/science/article/pii/S0306261919300807?via%3Dihub

New Approaches to Energy Hardware Innovation and Incubation

www.nrel.gov/docs/fy19osti/73438.pdf

A Comparison of Fuel Choice for Backup Generators

www.nrel.gov/docs/fy19osti/72509.pdf

Innovations in Upstream Oil and Gas Operations in Close Proximity to Communities

www.nrel.gov/docs/fy19osti/72151.pdf

Approaches for Integrating Renewable Energy Technologies in Oil and Gas Operations

https://www.nrel.gov/docs/fy19osti/72842.pdf

https://www.jisea.org/manufacturing.html

21ST CENTURY POWER PARTNERSHIP

21stcenturypower.org

Refrigerants: Market Trends and Supply Chain Assessment

www.nrel.gov/docs/fy20osti/70207.pdf

Supply Chain of Raw Materials Used in the Manufacturing of Light-Duty Vehicle Lithium-ion Batteries

www.nrel.gov/docs/fy19osti/73374.pdf

The case for recycling: Overview and challenges in the material supply chain for automotive li-ion batteries

www.sciencedirect.com/science/article/pii/S2214993718302926

Evaluation of Agricultural Equipment Manufacturing for a Bio-Based Economy

www.nrel.gov/docs/fy19osti/71570.pdf

Mapping the Supply Chain for Room Air Conditioning Compressors

www.nrel.gov/docs/fy19osti/73206.pdf

End Uses of Advanced Refrigerants

www.nrel.gov/docs/fy19osti/72250.pdf

Cost Modelling for Energy Efficient Window Replacements

www.nrel.gov/docs/fy19osti/70967.pdf

Manufacturing competitiveness analysis for hydrogen refueling stations

www.sciencedirect.com/science/article/pii/S0360319919307505

Supply and value chain analysis of mixed biomass feedstock supply system for lignocellulosic sugar production

onlinelibrary.wiley.com/doi/full/10.1002/bbb.1975

Innovation Utility Offerings at the Distribution Edge: Case Studies from Around the Globe

www.nrel.gov/docs/fy19osti/73800.pdf

Expedite Energy Transformation by Adopting Proven Practices

www.tdworld.com/overhead-transmission/article/20972235/expedite-energy-transformation-by-adopting-proven-practices

Renewables-Friendly Grid Development Strategies: Experience in the United States, Potential Lessons for China (Chinese Translation)

www.nrel.gov/docs/fy16osti/66729.pdf

Transforming Power Systems through Global Collaboration

www.nrel.gov/docs/fy19osti/73780.pdf

Ten Principles for Power Sector Transformation in Emerging Economies

www.nrel.gov/docs/fy19osti/73931.pdf

A Report on the Implementation of Smart Grids in Mexico

www.nrel.gov/docs/fy19osti/72699.pdf

15013 Denver West Parkway Golden, CO 80401 | 303-275-4607

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