



# 2021 **EPIC** ELECTRIC PROGRAM INVESTMENT CHARGE **HIGHLIGHTS**

California's premier public-interest research program driving clean energy innovation and entrepreneurship to help meet the state's climate and energy goals.



# LETTER TO CALIFORNIA



California Energy Commission  
Chair David Hochschild

Despite the challenges brought by the pandemic, California’s innovators and communities continue to forge the path toward California’s clean and equitable energy future. Nearly a decade since its inception, the Electric Program Investment Charge (EPIC) has invested over \$1 billion into the state’s clean energy economy. These public investments have helped mobilize the private sector to invest and adopt new

technologies and approaches that will help California achieve its clean energy policy goals faster and at lower cost. Clean energy technology companies in the California Energy Commission’s (CEC’s) EPIC portfolio have gone on to raise more than \$7.8 billion in private investments, successfully commercializing more than 60 technologies and related services that are now bringing benefits to the state’s electricity ratepayers.

EPIC is advancing an equitable clean energy transition in California. This includes directing 67 percent of technology demonstration and deployment funding to projects in and benefitting under-resourced communities, including California Native American Tribes, to build energy resilience to the increasing impacts of climate change. EPIC has also set its sights on ensuring a safe and secure domestic supply chain for the clean energy economy. Advancements in lithium recovery are opening up new possibilities for in-state supplies as the global demand for lithium continues to rise. New developments in battery technologies are helping to reduce reliance on materials such as cobalt that are connected to human rights abuses abroad. By identifying alternative materials and fostering in-state supply chains, EPIC supports a more responsibly sourced clean energy future.

Accelerating the pace of progress toward this future, EPIC is validating new technology innovations and providing

California’s clean energy leaders with the data and added confidence to push clean energy technologies further. At the CEC’s 2021 EPIC Annual Symposium, more than 800 cleantech innovators, researchers, community organizers, and policymakers convened to view a showcase of EPIC-funded innovations and share insights and perspectives on emerging clean energy technologies and approaches. Through EPIC and other venues, these visionaries are working together to find novel solutions to some our biggest challenges and advance California’s leadership in the decarbonized energy transition.

Our state’s goals are ambitious and our energy landscape is continuously evolving, requiring long-term commitment from public-interest R&D programs like EPIC to sustain investment in innovation, promote adoption of leading-edge technologies, and advance an inclusive and equitable clean energy future.

We look forward to working together across the state, to catalyzing the next key breakthroughs, and to remaining bold and brave in creating a brighter future for all Californians.

Sincerely,

## CALIFORNIA’S INVESTMENT IN CLEAN ENERGY INNOVATION

EPIC catalyzes clean energy innovation, enabling a safer, more reliable, equitable, decarbonized, and affordable electricity system. CEC awards EPIC funds to support the most promising technologies and scientific advancements across six investment areas: the entrepreneurial ecosystem, resiliency and safety, building decarbonization, grid decarbonization and decentralization, industrial and agricultural innovation, and transportation electrification. EPIC invests in technologies at every stage of development, progressing them from the lab and into market competition.



**Entrepreneurial Ecosystem**  
\$210 million invested

Fostering a world-class ecosystem that provides the resources, expertise, and knowledge base to foster and support successful clean energy innovation across the state, making California the destination for cleantech venture capital funding.



**Resiliency & Safety**  
\$182 million invested

Equipping communities, businesses, and public agencies with breakthrough technology solutions and tools to build a safe and resilient energy system, providing essential services especially during emergencies.



**Building Decarbonization**  
\$232 million invested

Transforming the built environment by investing in new sustainable energy technologies that improve the affordability, health, and comfort of homes and businesses.



**Grid Decarbonization & Decentralization**  
\$219 million invested

Building a fully decarbonized and more decentralized electric grid by making renewable energy even more affordable and driving market adoption of emerging forms of energy storage and other low-carbon technologies that improve grid reliability.



**Industrial & Agricultural Innovation**  
\$133 million invested

Developing technology solutions that improve energy performance, expand electrification, and increase production of goods and products in the industrial and agricultural sectors.



**Transportation Electrification**  
\$68 million invested

Advancing electrification technologies that reduce the cost and enhance the benefits of electric vehicle ownership and enable electric vehicles to serve as distributed energy resources that can support the grid.

# EPIC NUMBERS

Since 2012, EPIC investments have delivered tremendous benefits for Californians.

## INVESTMENTS

MORE THAN  
\$1 BILLION

EPIC funds invested in California-grown innovation

\$7.8 BILLION

private investment raised by businesses after receiving EPIC support

437

projects funded in every corner of California\*

67% OF TECH DEMONSTRATION AND DEPLOYMENT FUNDS

invested in under-resourced communities\*\*

## BENEFITS

\$537 MILLION

match funds contributed by EPIC recipients as part of their project awards

60+

EPIC-funded technologies and related services successfully commercialized and now available to California customers

75+

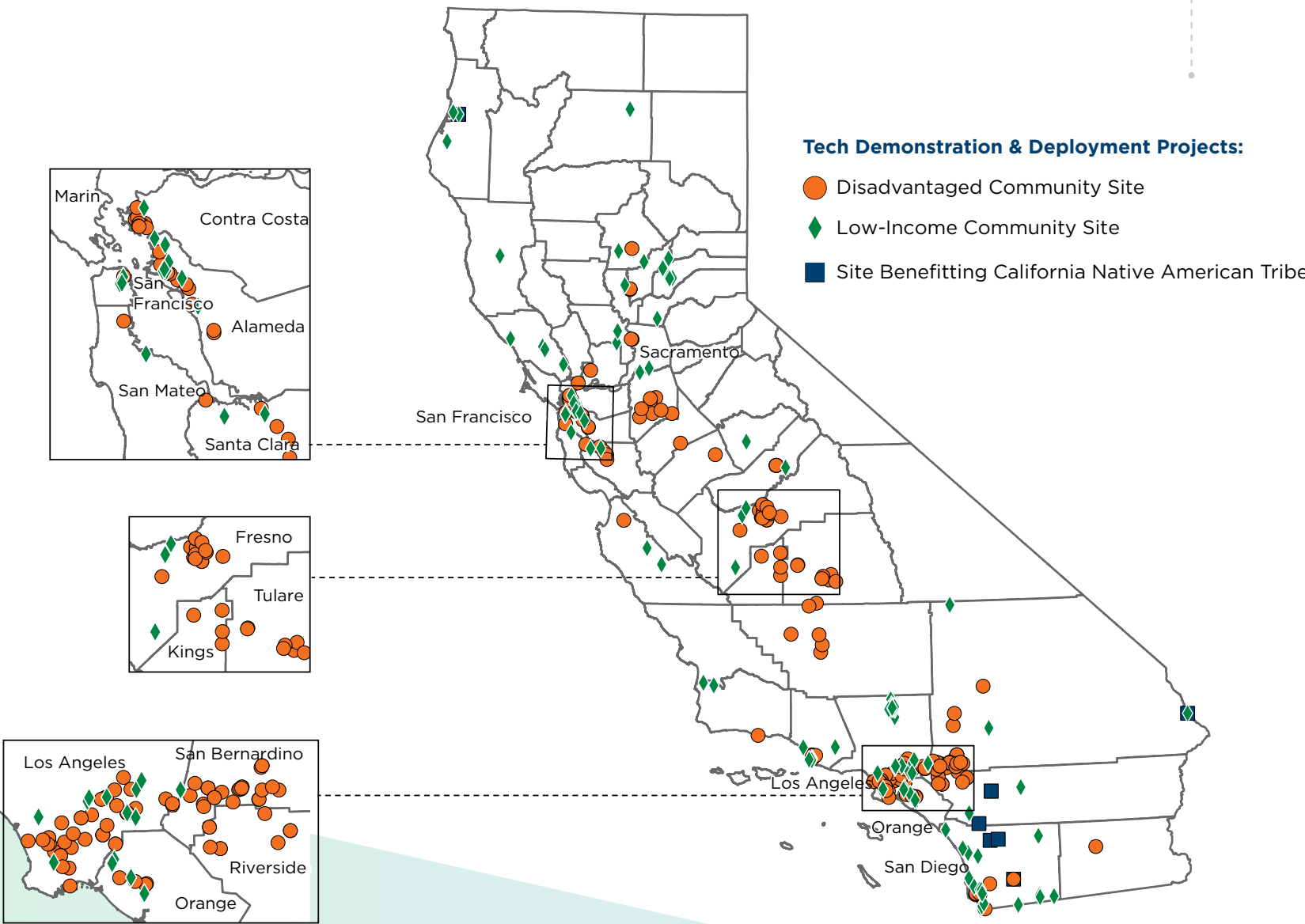
subsequent deployments that resulted from 18 EPIC-funded demonstration projects

58%

employment growth experienced by small- and medium-sized businesses following an EPIC award

\* The section "Discover the Power of Energy Innovation" maps EPIC projects, including headquarters and project sites.  
\*\* Including projects in disadvantaged communities and low-income communities, as defined by Assembly Bill 523, as well as projects benefitting California Native American Tribes.

# EPIC DEMONSTRATION PROJECTS IN UNDER-RESOURCED COMMUNITIES



Source: California Energy Commission

# YEAR IN REVIEW

## DRIVING INNOVATION TOGETHER

In 2021, the CEC's EPIC investments continued to support the state's clean energy economy, partnering with small businesses, researchers, and entrepreneurs to continue working toward a clean economy and bright energy future for all Californians.

**39 MW**

Load reduction from just three of EPIC's demand response projects in the residential and agricultural sectors in 2021, helping with California's extreme heat events and challenges to grid reliability in summer.

**1900+**

Stakeholders participated in the public scoping and vetting process for the EPIC 4 Investment Plan covering the next five years of funding. CEC held 12 public events involving state, national, and international expert panelists for topics such as industrial decarbonization, energy storage, and offshore wind energy R&D, as well as an en banc of California Public Utilities Commission and CEC commissioners.

**55%**

Increase in successful exits by start-up companies funded by the CEC through EPIC for 2021. Exits, such as mergers, acquisitions, or secondary transactions, benefit the start-ups, larger companies, and ratepayers — accelerating scale-up for the start-up and provision of new cleantech by the large company, thereby speeding associated benefits and access for ratepayers.

**2200+**

Attendees at the 2021 EPIC Annual Symposium and three EPIC technical forums on agricultural energy technology, medium- and heavy-duty vehicle electrification, and low-carbon reliability solutions.

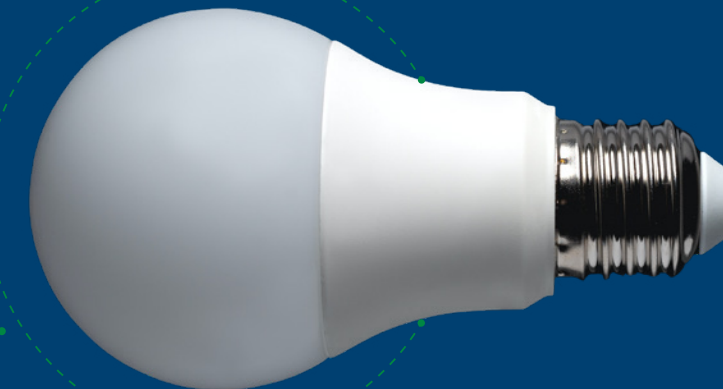
**20%**

Reduction in energy waste in healthcare, hospitality, industrial, and commercial facilities outfitted with the world's first cyber-physical platform to optimize the performance of buildings automatically through a cloud-based, artificial intelligence system.

**2800+**

Members participating on Empower Innovation.\* This platform enables easy access to funding opportunities, curated resources, and connections to California's thriving innovation ecosystem, from nonprofit organizations seeking solutions to help their local communities to startups creating new technology solutions.

\* Empower Innovation website <https://www.empowerinnovation.net/> accessed on 3/16/2022.





## EPIC PROJECT PROFILE

### Entrepreneurial Ecosystem



*We are thrilled that the California Energy Commission selected Ubiquitous Energy to award with another grant. This award is a recognition of the incredible progress our team has made in advancing our UE Power™ transparent solar technology towards commercialization and production.*



- Ubiquitous Energy CEO Susan Stone

### Reimagining the Site of Solar Generation

Achieving California's building decarbonization goals will require innovations to increase on-site generation capabilities while also reducing energy demand. Existing solar photovoltaic (PV) options are predominantly roof-based, and this is a challenge for tall commercial buildings, which have limited rooftop space, restricting the potential for on-site generation.

Ubiquitous Energy has developed a transparent PV window coating called UE Power™ that can harness solar energy from glass surfaces to generate electricity, all while remaining visibly indistinguishable from traditional windows. The window coating also features low emissivity and low solar heat gain, increasing the energy efficiency of the window. This innovation broadens the ability of the state's diverse building stock to participate in on-site generation.

Ubiquitous Energy's technology "allows windows to be windows; look, feel, and perform the same way as traditional windows do, but also enables the windows to generate clean, renewable energy from sunlight without you even knowing it,"

# UBIQUITOUS ENERGY, INC.



explains Veeral Hardev, Vice President of Strategy. Without sacrificing aesthetics or requiring alterations to building architecture and design, this technology unlocks completely new avenues for buildings to deploy on-site renewable generation. The company estimates their technology has the potential to deliver an annual 20 terawatt-hours of combined energy savings and renewable energy generation to the state — roughly 10 percent of California's total electricity needs.

This technology has already prompted partnerships with leading glass manufacturers and installations around the globe — from commercial developments in Boulder, Colorado to the Nippon Sheet Glass Company's headquarters in Japan.

**26 BILLION**

Approximate square feet of coated architectural glass produced and installed globally each year\*

**60 GW**

Additional solar generation capacity possible from that glass if treated with the UE Power™ coating

**10%**

The amount of California's annual electricity consumption that can be offset by full market penetration of UE Power™

**1x1 INCH**

The size of Ubiquitous Energy's solar window prototype when they first received EPIC funding in 2019

**14x20 INCH**

The size of solar windows to be produced from the first California production line that Ubiquitous Energy is developing under their current EPIC award

**2000**

The number of 14x20-inch solar windows Ubiquitous Energy seeks to produce per year by the end of their current CEC project in 2024

\* Veeral Hardev Interview in Energy Capital magazine July-August 2021  
[https://issuu.com/energycapital/docs/energy\\_capital\\_the\\_magazine-may-july\\_2021-edition\\_/s/12757165](https://issuu.com/energycapital/docs/energy_capital_the_magazine-may-july_2021-edition_/s/12757165)





## EPIC PROJECT PROFILE

### Resiliency & Safety

“

*We've got extreme heat, wind-driven wildfires, water shortages, and increasingly we're concerned about the condition of our roads, bridges, and airports. The playbook on infrastructure really has to get rewritten. This project checks all of those boxes and more.*

*-Congressman Jared Huffman, California's 2nd District*

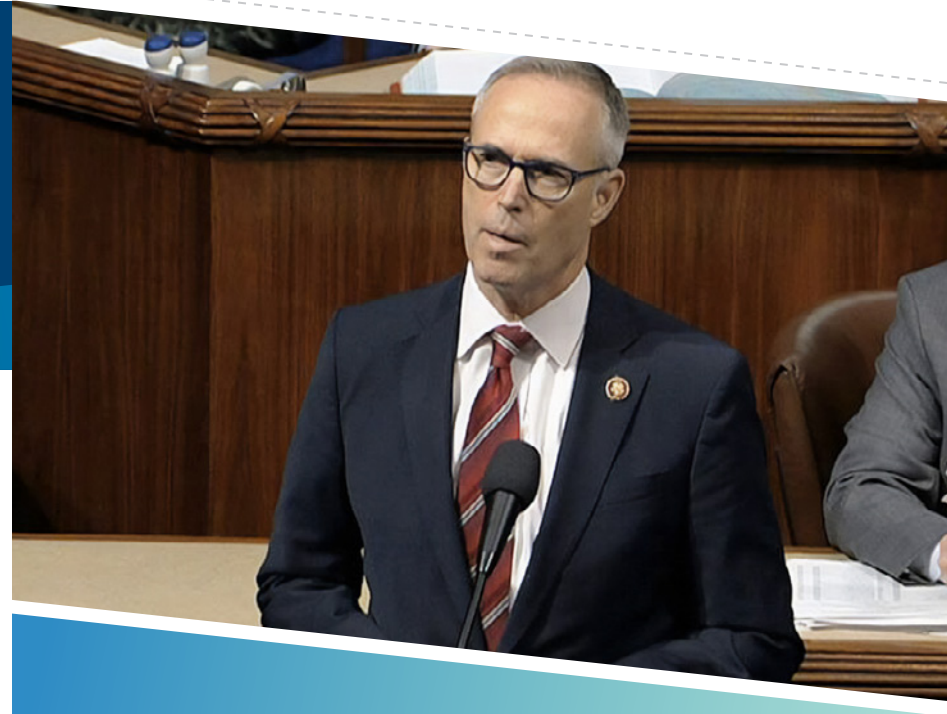
”

### Stabilizing and Securing Energy for California's Rugged North Coast

In 2019, more than one million Californians lost electricity during the largest public safety power shutoffs in state history. With the looming risk for future shutoffs, grid resilience has become a foremost concern for all Californians.

California's North Coast experiences frequent flooding, landslides, and wildfires and is especially vulnerable to earthquakes, tsunamis, and sea level rise because it sits on a tectonic triple junction. Roads into and out of Humboldt County are often closed by weather-related events, making the California Redwood Coast-Humboldt County Airport and the adjacent U.S. Coast Guard Air Station critical lifelines for this community. To bolster these facilities and regional energy stability, this airport is now home to the state's first ever, front-of-meter, multi-customer, 100 percent renewable microgrid. Currently, the microgrid supports 19 buildings and facilities including the airport and the Coast Guard Air Station, which supports search and rescue for nearly 250 miles of rugged, mostly rural, coastline.

# CAL POLY HUMBOLDT



The microgrid has begun to operate unmanned and fully automated on 100 percent dispatchable resources, helping with grid reliability for not only the airport but also the community. It will have advanced islanding capabilities and continue to serve as a testbed for tackling both the technical and non-technical barriers to microgrid deployment. Lessons learned from this project will help California increase its energy resiliency by advancing the integration of microgrids into the state grid.

7x

The amount of time Humboldt County customers experienced sustained outages in 2020 as compared to other California customers

50K

Flights per year served by Humboldt County's airport, including commercial, private, and emergency medical flights, that could be significantly impacted by outages

20

The number of customer meters in Humboldt County, including the airport and Coast Guard Air Station, served by this first-ever, community-driven, front-of-meter microgrid

0

The number of times polluting diesel generators are expected to be needed for outages once the microgrid is fully operational





## EPIC PROJECT PROFILE

### Building Decarbonization

“Rising temperatures put an enormous strain on commercial and industrial cooling equipment. SkyCool’s panels will keep roofs cooler and reduce the strain on AC and refrigeration equipment ultimately ensuring that businesses that need cooling can continue to operate during the hottest days of the year.”

-Eli Goldstein, CEO and Co-founder, SkyCool Systems

### Turning The Sky Into A Renewable Resource

There are nearly 40,000 supermarkets and 2,500 cold storage facilities in the United States, and roughly 60 percent of their electricity is used to run refrigeration systems. Because these loads are 24/7/365, supermarket and cold storage operators spend anywhere from hundreds of thousands to millions of dollars per year on electricity to run their refrigeration systems. Putting the energy use into perspective, these operators spend roughly the same amount of money on utilities as they make in profit each year. This margin is worsening as air temperatures rise and older refrigeration systems struggle to maintain the appropriate setpoint temperatures.

While there are technologies to reduce electricity usage within commercial or industrial refrigeration systems, they often result in significant water usage or require the complete replacement of compressors and condenser equipment. Also, those technologies often use high global warming potential refrigerants. In contrast, SkyCool’s panels exploit radiative cooling, rejecting heat out past the atmosphere

# SKYCOOL SYSTEMS, INC.



and into the cold expanses of space, turning the sky into a renewable resource for cooling. This allows surfaces outfitted with this technology to dip below the temperature of the surrounding air. SkyCool’s technology also operates during daytime hours and reflects away 97 percent of sunlight. A single SkyCool Panel saves approximately two to three times as much energy as a solar panel generates given the same area and mounts with conventional solar racking.

Following its success at a Grocery Outlet in Stockton and a recent installation at Draeger’s Supermarket in Menlo Park, the company is in talks with larger retailers to deploy at multiple

other facilities in the years ahead. SkyCool Panels are well-poised to find a home atop grocery stores, data cooling centers, and general merchandise retailers across the state, providing a clean solution to California’s rising cooling demand and power bills.

42.5K

Approximate number of supermarkets and cold storage facilities in the United States

60%

Average amount of electricity used for refrigeration in supermarkets and cold storage facilities

10-40%

Efficiency improvement when SkyCool Panels are integrated with a refrigeration system

\$3K

The monthly electricity bill savings one grocery store achieved with SkyCool Panels\*

0

Refrigerants with global warming potential used in SkyCool Panels



\*The Washington Post <https://www.washingtonpost.com/climate-solutions/2020/10/07/radiative-cooling-climate-change/>



## EPIC PROJECT PROFILE

### Grid Decarbonization & Decentralization



*California has more offshore wind gross-potential than any other state in the continental US. When combined with onshore wind energy, its total wind resources could provide more than twice the electricity California presently consumes, while also providing high-paying jobs and economic benefits to its ratepayers. This CEC award is critical to continued development of the next generation wind technologies California needs to access these vast wind resources.*

-Jason Cotrell, CEO of RCAM Technologies

### Printing Big Solutions in Wind Energy

Since the 1980s, California's thousands of wind turbines have helped to support state renewable energy goals, with onshore wind accounting for over 7 percent of California's energy generation in 2020. Senate Bill (SB) 100 set a 100 percent clean electricity goal, and onshore and offshore wind resources are projected to supply more than 22 GW of electricity by mid-century.\* Taller towers can tap into stronger wind resources at greater heights, resulting in higher energy production. However, large wind turbines are constrained by transportable size and weight limitations. For example, large-diameter towers may not fit under bridges, overpasses, or traffic signals, and road widths and weight regulations have constrained towers to sub-optimal diameters. Such challenges are likely to become even more apparent as California explores its offshore wind resources.

\* 2021 SB 100 Joint Agency Report

<https://www.energy.ca.gov/publications/2021/2021-sb-100-joint-agency-report-achieving-100-percent-clean-electricity>

# RCAM TECHNOLOGIES



But what if turbine towers didn't need to be transported on roads at all? This is the question that RCAM Technologies and the University of California, Irvine set out to explore together. Their innovative 3D concrete printing (3DCP) manufacturing technology is unlocking the potential for on-site construction of low-cost, ultra-tall towers. With the development of robotic 3D printing capabilities, the team was able to design, fabricate, assemble, and structurally test a 3DCP tower sub-assembly as well as validate the competitive advantage of on-site 3DCP for wind turbine towers. While their current project is focused on land-based turbines, the team is looking to leverage their technology for on-site printing of offshore wind turbine components like anchors.

Manufacturing towers onsite will greatly reduce transportation costs and allow for the deployment of taller wind turbines at sites that are currently inaccessible to large trucks carrying traditional turbine towers. These 3DCP tower advancements could enable a potential 10-fold increase in the state's wind energy deployment: a significant leap toward SB 100 clean energy goals.

The project has garnered additional funding from the National Science Foundation, the U.S. Department of Energy, the National Offshore Wind R&D Consortium, and the Carbon Trust to further advance this 3DCP technology and its manufacturability.



# 80 METERS

The approximate height of conventional wind turbine towers in the United States due to logistical constraints

# 140 METERS

The potential height of a 3DCP wind turbine printed onsite using RCAM's technology

# >20%

Increase in turbine energy captured from 140-meter towers compared to conventional 80-meter towers

# 11%

The levelized cost of energy reduction for 3DCP towers compared to conventional towers

# <1 DAY

The amount of time RCAM is targeting for on-site fabrication of a new tower



## EPIC PROJECT PROFILE

### Industrial & Agricultural Innovation

“ Having the transparency of all water & energy costs in one place was critical as we moved from flood to drip irrigation and invested in solar. [AgMonitor] caught anomalies early and saved us time and money. ”

-Cannon Michael, President of Bowles Farming Co., 6th generation family-owned farm in Los Banos, California

### Growing California's Resource Efficiency

California produces more than one-third of the country's vegetables and two-thirds of the country's fruits and nuts, but shrinking freshwater reserves are increasingly straining farmers, who must contend with rising water and energy costs. To help farmers take control of their resources, AgMonitor's software-as-a-service provides a way to track and manage water, reduce energy costs, and improve revenues, all without hardware installs.

AgMonitor now tracks over 120,000 acres in California and is working to solve the most pressing problems that growers and processors have in their fields or facilities, offering pump, ranch, and crop monitoring solutions that leverage existing SmartMeters within its single platform. Using advanced data mining techniques, these solutions provide farms and facilities 100 percent water measurement coverage, enable customers to manage energy costs across meters, and help improve irrigation and fertigation by helping users identify problems, find solutions, and track results — three solutions in one platform.

# AGMONITOR, INC.



From the use of CropMonitor alone, which is intended to close the loop in irrigation and fertigation, users were able to achieve an increase of 9 percent in water use efficiency. With PumpMonitor, which provides 100 percent water measurement coverage by turning existing electric SmartMeters into flow meters, users found that they reduced the energy intensity of pumping by approximately 13 percent per acre. For those customers who implemented both, farms saw an increase in profits of \$200 per acre, helping the state's agricultural economy.

As of 2020, AgMonitor has expanded the use of its technology to achieve consistent load shifting — enabling California growers to irrigate outside of peak demand times. This has empowered farmers to plan for load shifting given their unique irrigation constraints and to integrate the feedback seamlessly with both manual and automated irrigation systems. Deployed on over 10,000 acres of farmland as part of an EPIC demonstration, AgMonitor's new, programmable irrigation load shifting demonstrated that even smaller farms can improve their energy efficiency by 20 percent and cut their electricity costs by up to 30 percent by irrigating off-peak.

## 9 MILLION

Acres of irrigated farmland that contribute to California's \$21.7 billion\* in agricultural exports

## \$200 PER ACRE

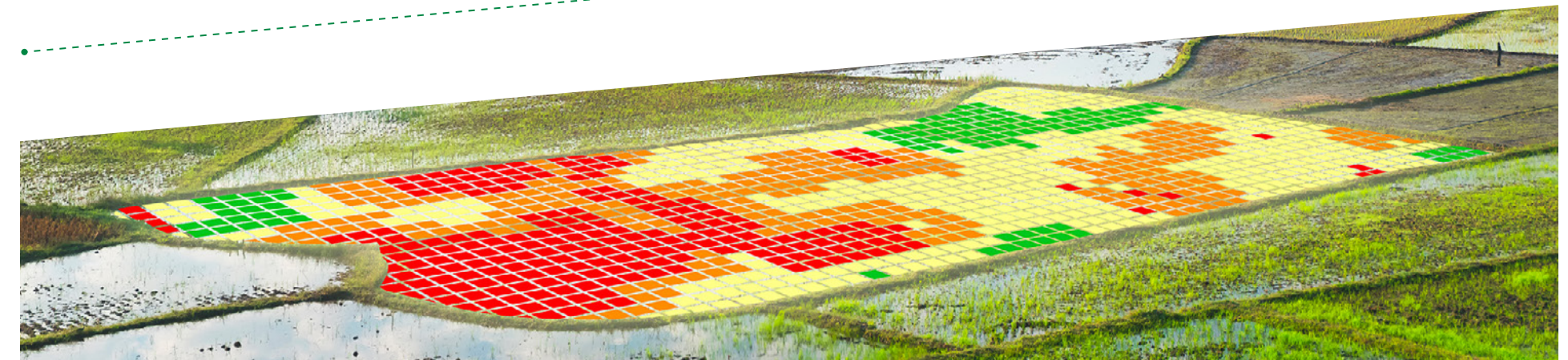
Increase in profits from electricity and water savings for farms that implemented AgMonitor's PumpMonitor and CropMonitor solutions

## 10K ACRES

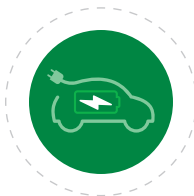
Current scale of AgMonitor's demonstration for its new, programmable irrigation load shifting software, helping California farmers improve energy efficiency, save water, and cut costs

## 3 MW

Permanent load shift as of August 2021 provided by California agricultural irrigation pumps intelligently controlled with AgMonitor, supporting grid reliability



\* California Agricultural Exports 2019-2020 [https://www.cdfa.ca.gov/Statistics/PDFs/2020\\_Exports\\_Publication.pdf](https://www.cdfa.ca.gov/Statistics/PDFs/2020_Exports_Publication.pdf)



## EPIC PROJECT PROFILE

### Transportation Electrification

“Cuberg’s CEC award helped address its biggest risk at the time, building out a pilot production line with sufficiently good quality control to produce attractive customer prototypes and samples. The project has been extremely successful and has allowed Cuberg to attract substantial customer interest for our products.”

—Richard Wang, Founder and CEO of Cuberg

### Driving Innovation in Battery Technology

All-electric vehicles are transforming the way people live and work, moving us from place to place more efficiently, at lower cost, and with reduced environmental impact. However, better battery technology is crucial to that vision.

Current lithium-ion batteries have limits in energy density that constrain battery performance in the automotive and aviation sectors. Many emerging approaches to improve battery performance suffer from major challenges with scalability and incompatibility with established manufacturing processes. Cuberg is developing a next-generation battery technology that bridges these technology gaps to accelerate the rise of electric mobility.

Cuberg is building a groundbreaking lithium-metal battery system, integrating exceptional performance and safety to unlock the true potential of all-electric vehicles. Verified in 2020 by the U.S. Department of Energy’s Idaho National Laboratory, Cuberg’s battery cell architecture radically increases energy density up to 48 percent along with exceptional

# CUBERG, INC.



power output and cycle life, enabling greatly increased range and capacity for electric vehicles and aircraft.

In 2021, Cuberg was acquired by Northvolt, a large Swedish battery manufacturer who signed a \$15 billion agreement with Volkswagen to be their primary battery suppliers. Cuberg now leads Northvolt’s U.S. operations from a new advanced technology center in California, and since the acquisition, Cuberg has tripled its staff to over 65. This partnership will allow Cuberg to leverage Northvolt’s in-house cell design expertise, advanced manufacturing capabilities, and experience with maturing battery products to accelerate its scaling.



**250** MILES

Median range of electric vehicles offered for sale in the United States

**70%**

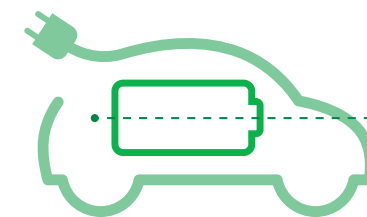
Increase in range enabled by Cuberg’s lithium-metal battery technology

**3K**

Number of battery cells Cuberg is able to produce per month as a result of their CEC EPIC award

**3x**

Increase in California jobs at Cuberg since 2021



# EPIC OPPORTUNITIES IN 2022

The CEC continues to develop EPIC research and solicitations in 2022 on the following topics:



1. Advanced Prefabricated Zero-Carbon Homes



2. Energy Efficiency and Demand Response in Industrial and Commercial Cold Storage



3. Energy Efficiency and Load Shifting in Indoor Farms



4. Optimizing Long-Duration Energy Storage to Improve Grid Resiliency and Reliability in Under-resourced Communities



5. The Role of Green Hydrogen in a Decarbonized California—A Roadmap and Strategic Plan



6. Valuation of Investments in Electricity Sector Resilience



7. Vehicle-to-Building for Resilient Back-up Power



8. Offshore Wind Energy Technologies



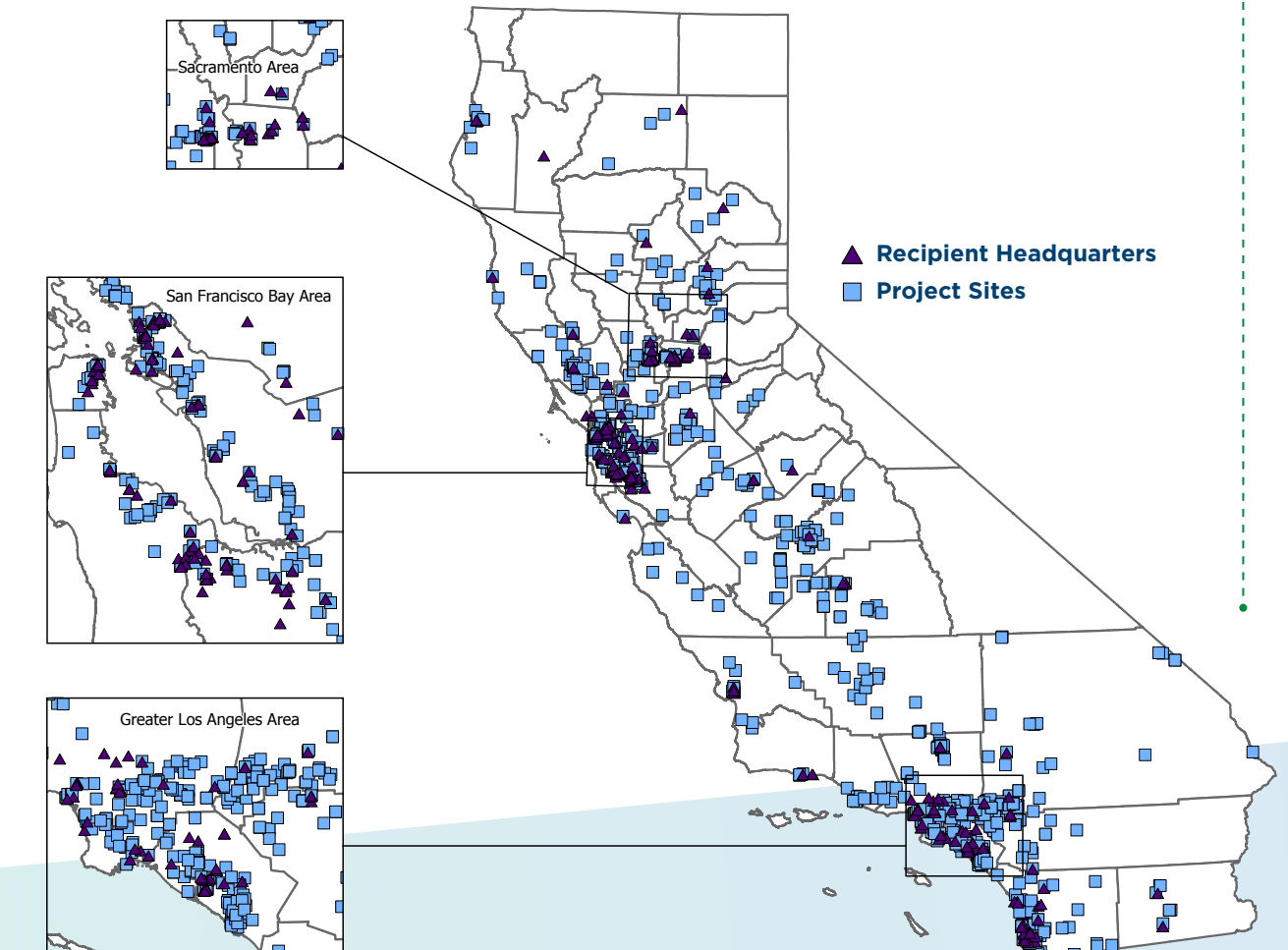
9. Realizing Accelerated Manufacturing and Production for Clean Energy Technologies (RAMP) 2022

# DISCOVER THE POWER OF ENERGY

## INNOVATION

Successful transfer of clean energy innovations from lab to market requires technological learning and feedback from local installers, early adopters, inspectors, and regulators. This map includes active and completed CEC EPIC awards through 2021 for applied research and development, technology demonstration and deployment, and market facilitation projects. For more information on specific projects, visit the [Energize Innovation Project Showcase](https://www.energizeinnovation.fund/projects) at <https://www.energizeinnovation.fund/projects>.

### EPIC Recipient Headquarters and Project Site Locations



Source: California Energy Commission



**EMPOWER**  
**INNOVATION**

[empowerinnovation.net](http://empowerinnovation.net)



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Kourtney Vaccaro

**April 2022**

CEC-500-2022-002-SUM

Additional EPIC budget details and required information for 2021 are available in a separate appendix volume (CEC-500-2022-002-AP-CMF).

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