EPIC 2021-2025 Investments in California's Energy Future

CPUC-CEC *En Banc* Meeting | EPIC 4 Investment Plan

October 8, 2021

Snapshot of EPIC's Past Decade

Laurie ten Hope, CEC Deputy Director, Energy Research &Development Division (ERDD)

Targeted Investments = EPIC Results

INVESTMENTS

$846 MILLION — EPIC funds invested in California-grown innovation

$3.5 BILLION — private investment raised by businesses following EPIC support

385 — projects funded in every corner of California*

68% OF TECH DEMONSTRATION AND DEPLOYMENT FUNDS — invested in underresourced communities**

730 ORGANIZATIONS — funded by EPIC across California

BENEFITS

3,500 JOBS — estimated average jobs per year from EPIC and associated economic activities.***

$18.6 BILLION — projected Californians' energy bill savings through 2045 from 19 EPIC-funded energy efficiency technologies.

$86–$191 BILLION — in health benefits from improved air quality projected through 2045 from 19 EPIC-funded energy-efficiency technologies.

MORE THAN 2,900 CITATIONS — of EPIC-funded research results.

850,000 USERS — of EPIC-funded online tools that make complex data more accessible and advance clean energy solutions.

CALIFORNIA'S INVESTMENT IN CLEAN ENERGY INNOVATION

EPIC is California's premier public interest research program investing over $130 million annually to unleash innovation.

Entrepreneurial Ecosystem

$143 million invested

Through EPIC, the CEC is building a world-class ecosystem supporting clean energy entrepreneurship.

Grid Decarbonization & Decentralization

$207 million invested

Improving the cost competitiveness and performance of key technologies.

Resiliency & Safety

$151 million invested

Helping communities, businesses, and public agencies build a safer, more resilient energy system.

Industrial & Agricultural Innovation

$119 million invested

Scaling specialized technology solutions to drive energy efficiency without compromising production.

Building Decarbonization

$194 million invested

Improving the affordability, health, and comfort of buildings.

Transportation Electrification

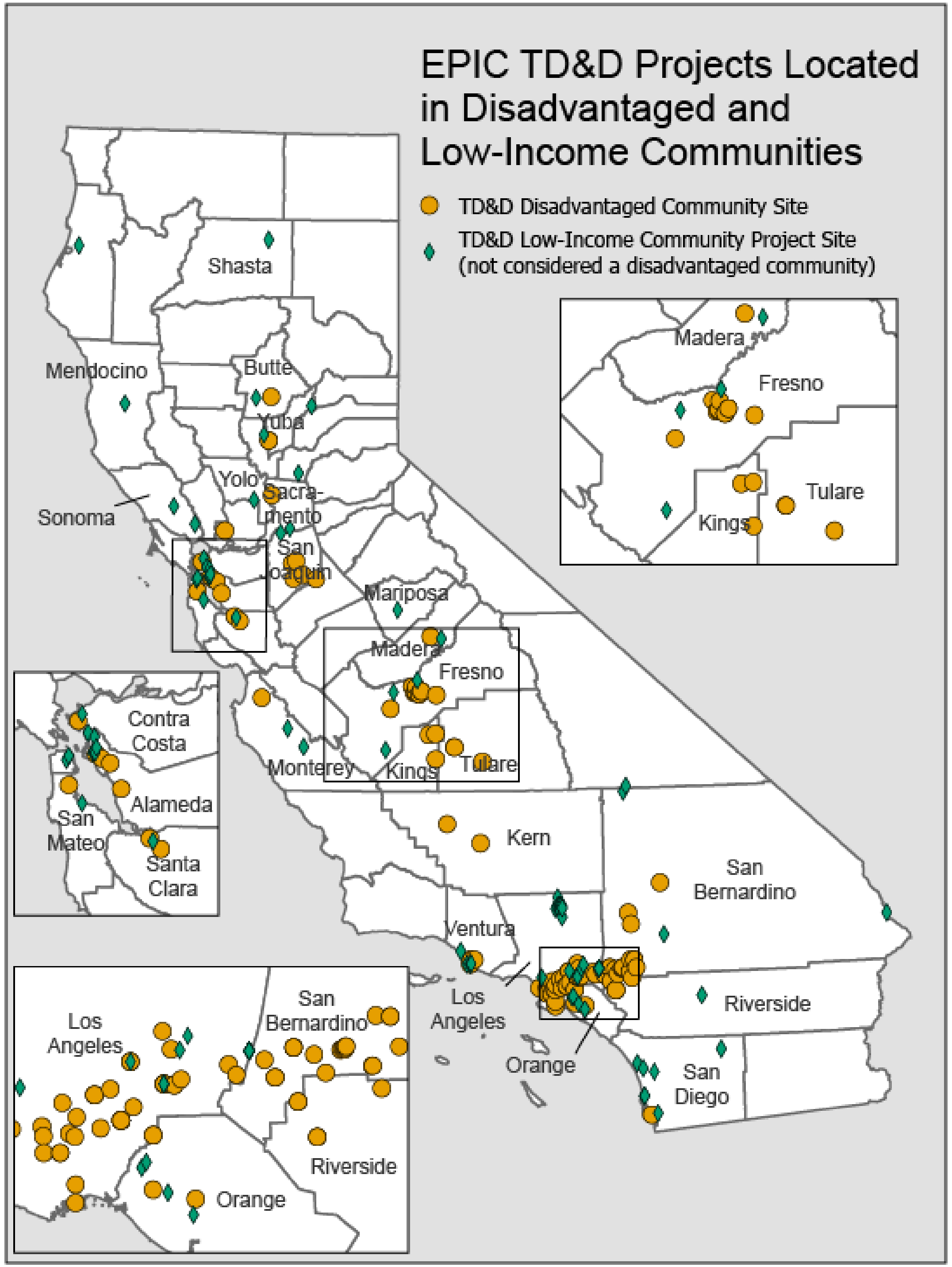
$32 million invested

Supporting advances that reduce the cost of electric vehicle ownership and support the grid.

Total investment, 2012-2020

Investing Equitably in Technology Demonstration & Deployment

- 68% in underresourced communities
- Seek geographic diversity
- Must bring tangible benefits to the community
- Meaningful engagement of community members



The EPIC Entrepreneurial Ecosystem

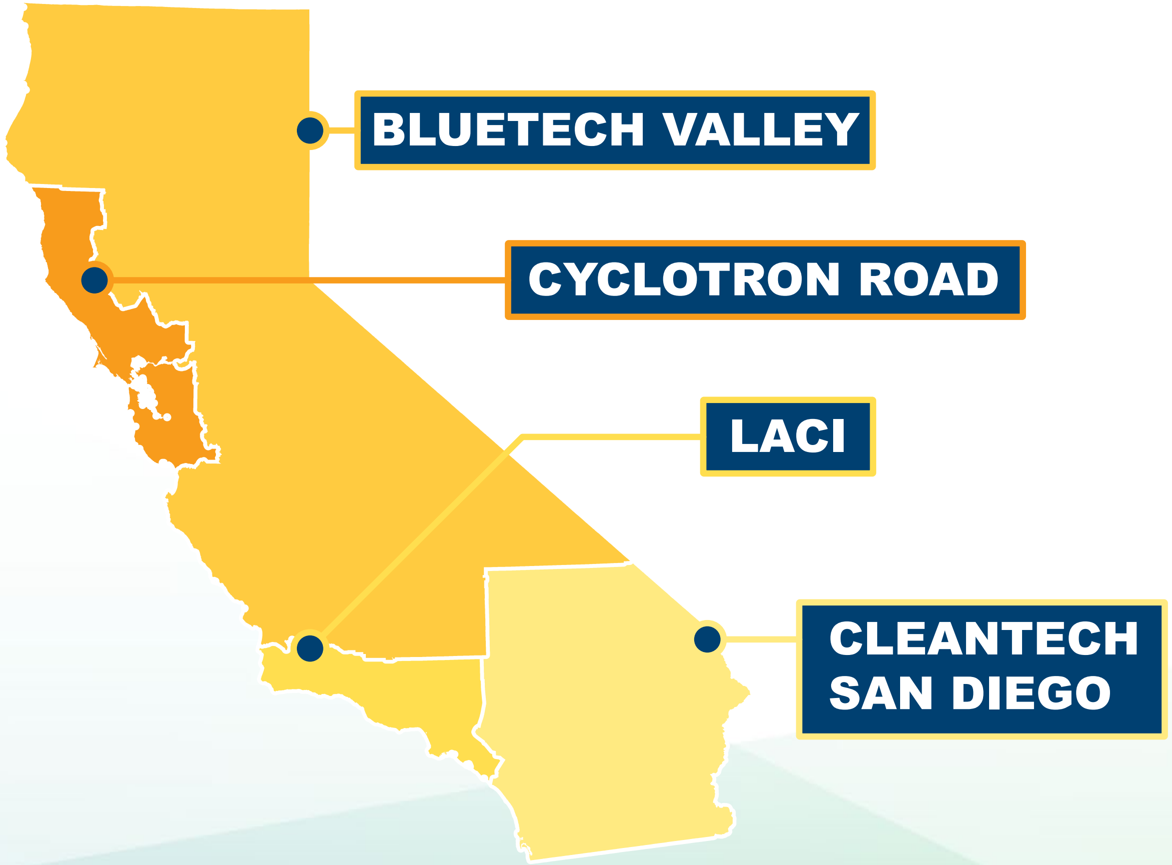
$3.5 BILLION

private investment raised by businesses following EPIC support

CalSEED

Helping early-stage clean energy startups across California bringing their concepts and prototypes to market

REGIONAL INNOVATION CLUSTERS



Fostering Technological & Scientific Breakthroughs

Managed Charging

Solar

Microgrids

Wildfire Mitigation

Industrial Efficiency

Batteries

Storage

Residential Electrification

Proposed EPIC 4 Investment Plan Overview: Strategic Initiatives

CEC ERDD Office Managers: Virginia Lew, Mike Petouhoff, Jonah Steinbuck, Erik Stokes

EPIC 4 Strategic Initiatives:

- Accelerate Advancements in Renewable Generation Technologies
- Create a More Nimble Grid to Maintain Reliability as California Transitions to 100 Percent Clean Energy
- Increase the Value Proposition of Distributed Energy Resources to Customers and the Grid
- Improve the Customer Value Proposition of End-use Efficiency and Electrification Technologies
- Enable Successful Clean Energy Entrepreneurship Across California
- Inform California's Transition to an Equitable, Zero-Carbon Energy System that is Climate Resilient and Meets Environmental Goals

Strategic Initiative: *Accelerate Advancements in Renewable Generation Technologies*

1. Floating Offshore Wind Energy Technologies
2. Advancing Geothermal Energy and Mineral Recovery Technologies*
3. Emerging Solar Energy Technologies

***This formatting indicates research that staff will highlight in the EPIC 4 overview.**

(Descriptions for the remaining topics are given in the Plan Summary document.)

Floating Offshore Wind Energy Technologies (#1)

Innovations

- Optimize component designs for cost, efficiency, durability
- Develop methods for installation, operations and maintenance
- Advance grid integration and port readiness
- Assess environmental impacts and mitigation

Goals

- Lower cost
- Reduce technical and financial risk
- Minimize environmental impact
- Support grid reliability

Floating offshore wind platform (source: NREL)

Advancing Geothermal Energy and Mineral Recovery Technologies (#2)

Innovations

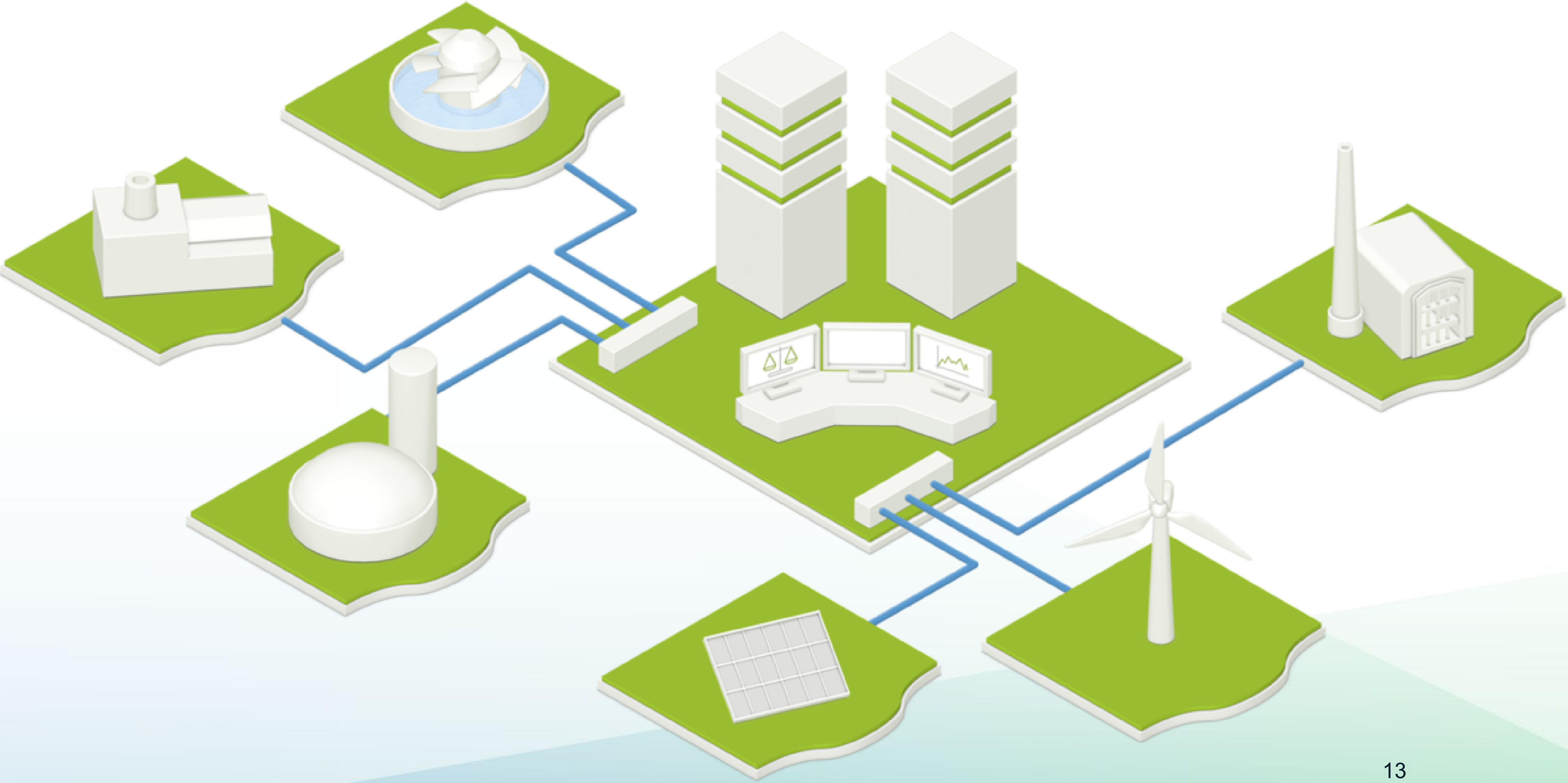
- Advance geothermal drilling technologies, well targeting, flexible operations, and address corrosion and scaling
- Demonstrate lithium recovery technologies and processes

Goals

- Lower cost
- Reduce technical and financial risk
- Advance in-state lithium

Geothermal plants near the Salton Sea (source: Land Use Database)

Strategic Initiative: ***Create a More Nimble Grid to Maintain Reliability as CA Transitions to 100% Clean Energy***



Strategic Initiative: *Create a More-Nimble Grid to Maintain Reliability as CA Transitions to 100% Clean Energy*

4. Short Duration Energy Storage Technology Demonstrations
5. Long Duration Energy Storage Technology Demonstrations to Support Grid Reliability
6. Energy Storage Use Case Demonstrations to Support Grid Reliability
7. Green Hydrogen (H2) Roadmap Follow-up and Implementation
8. Infrastructure, Market Analysis, & Demonstrations to Support Firm Zero-Carbon Firm Dispatchable (ZCFD) Resources
9. Advancing Clean, Dispatchable Generation
10. Technology Demonstrations to Address Grid Congestion Resulting from 3X Generation Growth on the Path to a Decarbonized California
11. Demonstrate Technologies to Maintain Reliability and Power Quality (PQ) in the Inverter-Centric Grid of the Future Associated with High Levels of Renewable Penetration
12. Furthering Cybersecurity with Highly Modulatable Grid Resources

Energy Storage Demonstrations to Support Grid Reliability: Short & Long Duration Tech, Use Cases (#4-6)

Innovations

- **Short** Duration Storage Technologies
- **Long** Duration Energy Storage Technologies and comparison framework to ZCFD
- Energy Storage **Use Cases**

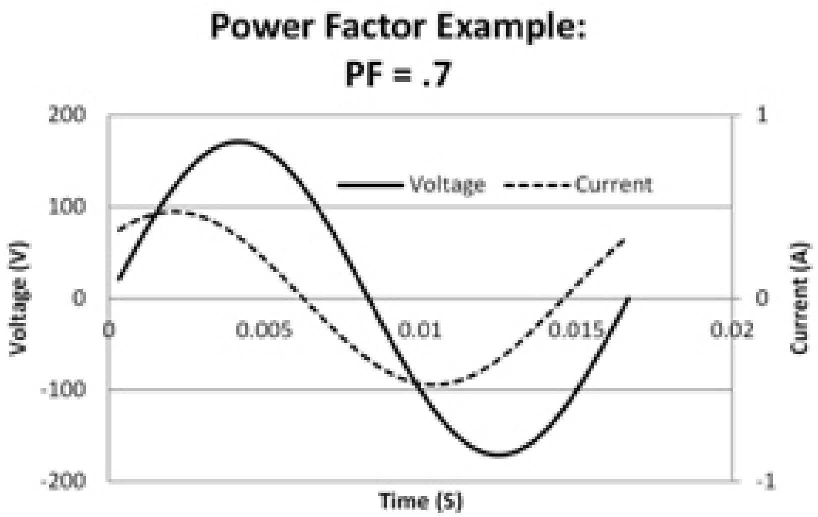
Goals

- Meet SB 100 projections for 8X storage increase with least cost and optimal performance
- Short duration: improve depth of discharge, degradation, thermal runaway & supply-chain diversity
- Long duration: minimize cost and environmental impact

Demonstrate Technologies to Maintain Reliability and Power Quality (PQ) in the Inverter-Centric Grid of the Future Associated with High Levels of Renewables (#11)

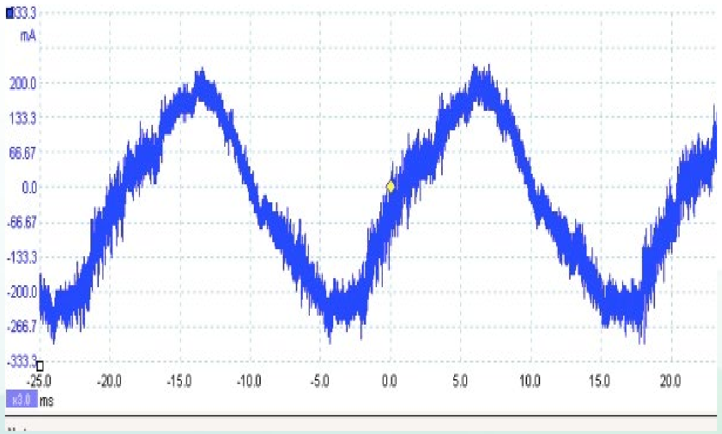
Innovations

- Address PQ:
  - Rotational inertia (synchronization)
  - Power factor (PF)
  - Harmonics



Goals

- Demonstrate solutions such as grid forming inverters, harmonics filters, and new PF correction technologies
- Provide recommendations on new standards and regulations



Furthering Cybersecurity with Highly Modulatable Grid Resources (#12)

Innovations

- Require best practices for CEC projects
- Work with IOUs to develop cybersecurity protocols: Apply cybersecurity learnings from previous work of CEC, IOUs, EPRI, DOD, DOE, and Homeland Security
- Develop cybersecurity testing and performance verification facility

Goal

- Ensure cybersecurity despite more access points and more points of modulation

Strategic Initiative: *Increase the Value Proposition of Distributed Energy Resources to Customers and the Grid*

13. Improving Forecasts of Behind-the-Meter Solar Storage, and Load Flexibility Resources
14. Direct Current Systems for Efficient Power Delivery
15. Behind-the-Meter Renewable Back-up Power Technologies
16. Design-Build Competition
17. Efficient Transportation Electrification and Charging Technologies
18. Technology Enablers for Using Electric Vehicles as Distributed Energy Resources
19. Integrating Distributed Energy Resources for Grid-Supportive Vehicle Charging
20. Lithium-ion Battery Reuse and Recycling Technologies
21. Enabling Grid Resilience with Load Flexibility in the Industrial, Agriculture and Water (IAW) Sectors
22. Virtual Power Plants with Autonomous and Predictive Controls
23. Increasing Reliability and Interoperability of Load Flexible Technologies

Technology Enablers for Using Electric Vehicles as Distributed Energy Resources (#18)

Innovations

- Develop grid-interactive inverters in bi-directional chargers
- Integrate charging with building management systems
- Demonstrate high-accuracy, low-cost submeters for chargers

Goals

- Lower site costs
- Enable EV operator benefits
- Ratepayer savings

Bidirectional charging (source: Nuvve EPIC project EPC-16-061)

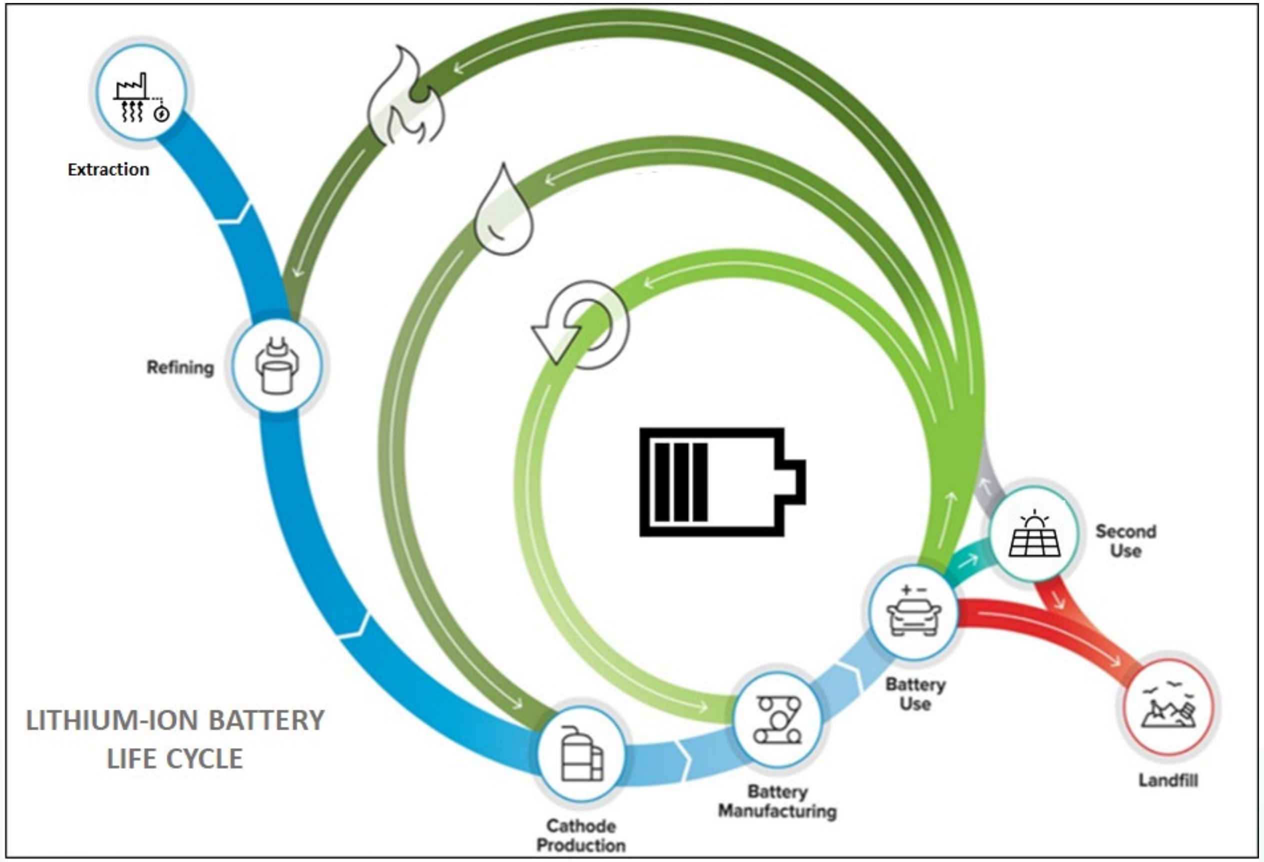
Lithium-ion Battery Reuse and Recycling Technologies (#20)

Innovations

- Advance battery designs for reuse and recycling
- Demonstrate recovered materials in new batteries
- Develop methods for battery collection, sorting, testing

Goals

- Spur investment in battery end-of-life
- Lower battery costs
- Promote environmental sustainability



Modified from Argonne National Lab, ReCell Center, 2020.

Lithium-ion battery lifecycle (source: ReCell Center)

Enabling Grid Resilience with Load Flexibility in the Industrial, Agriculture and Water (IAW) Sectors (#21)

Innovations

- Establish the *California Industrial, Agricultural, and Water Flexible Load Research and Deployment Hub*
- Promote flexible demand management technologies
- Facilitate and increase grid resiliency and demand response participation

Goals

- Improve grid stability
- Increase load flexibility and efficiency
- Improve value proposition
- Support renewable resources
- Provide data to policymakers and others

Source: piqsels.com

Strategic Initiative: *Improve the Customer Value Proposition of End-use Efficiency and Electrification Technologies*

Industrial Decarbonization

- Enabling Grid Resilience with Load Flexibility in the Industrial, Agriculture and Water Sectors
- Low-Carbon / High-Temperature Industrial Heating
- Energy Efficiency and Decarbonization of Concrete Manufacturing
- Energy-Efficient Separation Processes

Building Decarbonization

- Building Electrification Technology Prize Competition
- High Efficiency and Low-GWP Heat Pump Water Heaters and HVAC Heat Pumps.
- Innovative Solutions for Improving the Value Proposition for Building Envelope Upgrades
- Combination Heat Pump for Domestic Hot Water & Space Conditioning
- Nano-Grid HVAC Module Development and Demonstration
- Demonstrate Smart Energy Management Systems to Accelerate Electrification of Homes at a Reduced Cost. Energy Management Systems (SEMS) for Homes
- HVAC Decarbonization for Large Buildings

Source: US DOE, IEPR Presentation

Low-Carbon / High-Temperature Industrial Heating (#25)

Innovations

- Tailor electrification to specific processes
- Use zero-carbon heat sources
- Switch to zero-carbon fuels like green H2

Goals

- Reduce capital and operating costs
- Provide industry flexibility for decarbonization
- Reduce industrial GHG emissions and criteria air pollutants

Example of electric heat pump
Source: flicker.com

High Efficiency & Low Global Warming Potential (GWP) Heat Pump Water Heaters (HPWH) and HVAC Heat Pumps (#28)

Innovation

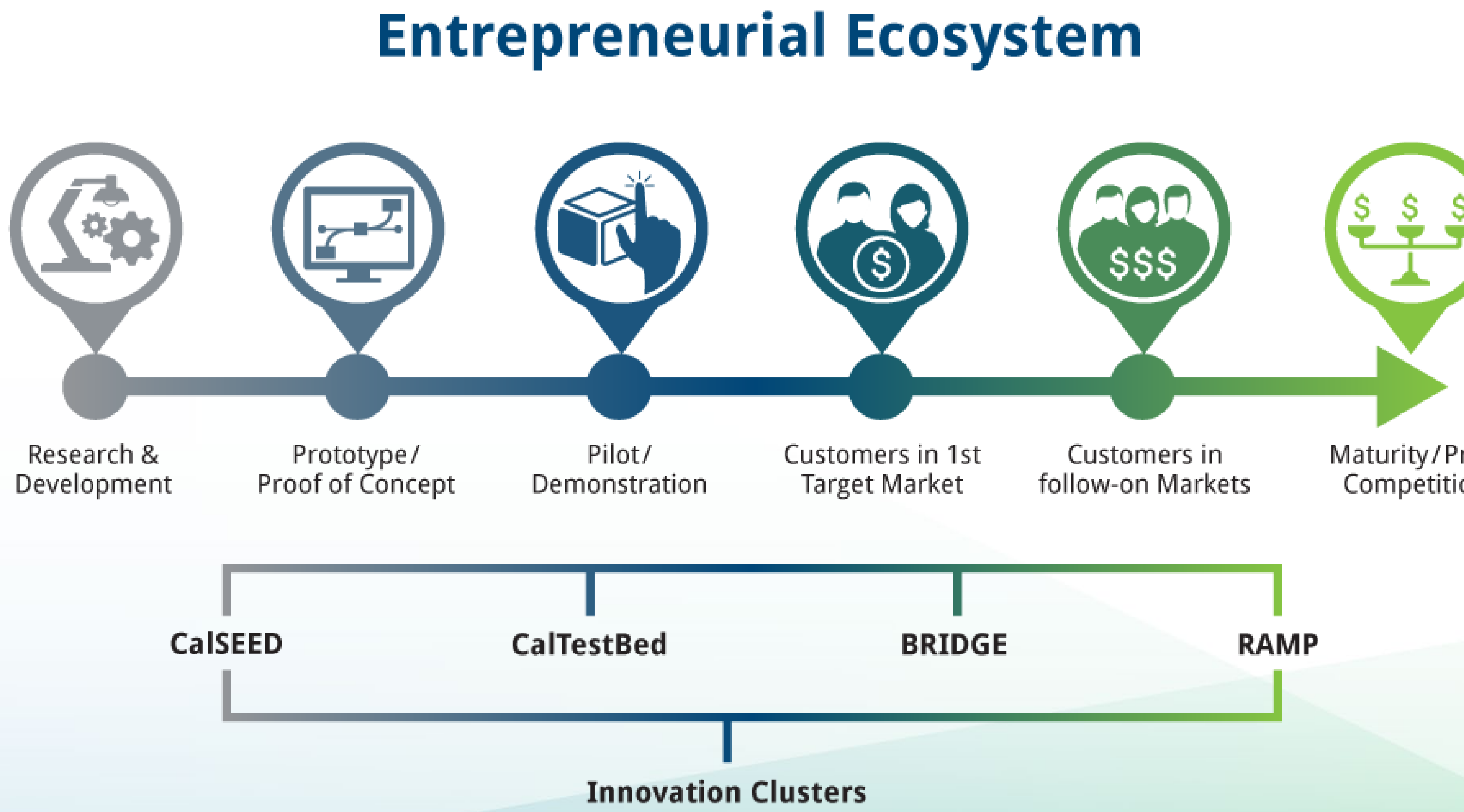
- Design and develop energy efficient 120 and 240V heat pumps

Goals

- Use low-GWP refrigerants
- Reduce refrigerant leakage
- Operate at high efficiency
- Have life and maintenance like existing heat pumps
- Be cost competitive

High Efficiency Heat Pump
Source: From DOE-IEPR Presentation

Strategic Initiative: *Enable Successful Clean Energy Entrepreneurship Across California*



Strategic Initiative: *Enable Successful Clean Energy Entrepreneurship Across California*

34. Activating Innovation and Expanding California's Clean Energy Entrepreneurial Talent Pool*
35. CalSEED
36. Provide Support for Entrepreneurs to Test, Verify, and Validate Their Innovations
37. Bringing Rapid Innovation Development to Green Energy (BRIDGE)
38. Realizing Accelerated Manufacturing and Production for Clean Energy Technologies (RAMP)
39. Mobilizing Significant Private Capital for Scaling Clean Energy Technologies*
40. Supporting Advanced Battery Scale-up in California*
41. Cost Share for Private, Non-Profit Foundation, or Federal Clean Energy Funding Opportunities
42. Outreach and Events

* New additions to the CEC's Entrepreneurial Ecosystem

Activating Innovation and Expanding California's Clean Energy Entrepreneurial Talent Pool (#34)

Innovation

- New incubator program to attract entrepreneurial talent, particularly from diverse and under-resourced backgrounds
- Match talent with IP developed at research institutions that is ready to be commercialized
- Assist in negotiating licensing agreement and other initial business setup

Goals:

- Lower entry barriers to clean energy entrepreneurship
- Increase the commercialization of IP from research institutions
- Broaden and expand clean energy entrepreneurship

Mobilizing Significant Private Capital for Scaling Clean Energy Technologies (#39)

Innovations

- Establish a Clean Energy Innovation Financing Cluster
- Conduct due diligence on new clean energy start-up companies ready for scale
- Provide a portfolio of bankable clean energy investments for investors
- Pool capital from early-stage investors along with CEC funding to deploy as catalytic capital

Goals

- Pool $100 million in early-stage capital
- Secure a $1 billion+ in later-stage investment
- Minimum of 50% to underresourced communities

Financing Gap to Scale New Clean Energy Technologies

Technology Development	R&D	Demonstration Proof of Concept	Deployment Pilot Facility	Commercialization First Commercial	Commercial Maturity
Financial Instrument	R&D Grants, Corp R&D Funds, Tax Credits	Private Equity, Convertible Debts	Private Equity, Convertible Debts	Private Equity, debts, bonds, Stocks	Debts, Bonds, Stocks
Form of Intermediation		Direct	Indirect (GP/LP Fund)	No (a few if any) investment vehicle	Direct, Indirect
Source of Funding	Governments, Corporates, Foundations	Angels, Startup Accelerators, Seed Stage VC	VC/PE, Strategic Ventures, Corporate Ventures	Potential investors remain untapped	Banks, Corporate Investors, Public Market

Source: Financing Energy Innovation: The Need for New Intermediaries in Clean Energy

Strategic Initiative: *Inform California's Transition to an Equitable, Zero-Carbon Energy System that is Climate Resilient and Meets Environmental Goals*

43. Evaluating Air Quality, Health, and Equity in Clean Energy Solutions

44. Integrating Climate Resilience in Electricity System Planning

45. Advancing the Environmental Sustainability of Energy Deployments

Evaluating Air Quality, Health, and Equity in Clean Energy Solutions (#43)

Innovations

- Examine air quality, health, and equity in clean energy strategies and demonstrations
- Develop tools, metrics, data for integrating health and equity in energy policy

Goals

- Enable prioritization of equity
- Maximize air quality and health benefits
- Promote affordability of solutions

Poor outdoor air quality (source: Sacramento Bee)

Measuring indoor air quality (source: LBNL)

Integrating Climate Resilience in Electricity System Planning (#44)

Innovations

- Evaluate climate impacts on electricity demand, supply, distribution
- Quantify societal benefits of strategies for grid reliability and community resilience

Goals

- Integrate climate in electricity system planning, investment, operations
- Support resilience and reliability

Lake Oroville in drought conditions (source: EPA)

Wildfire in the Sierra Nevada mountains (source: Unsplash)

Roundtable Discussion: Input on Strategic Initiatives

Where do you think the greatest <u>emphasis</u> should be placed and why (policy priority, weight)?

Are there any <u>gaps</u> in the proposed research?

Accelerate Advancements in Renewable Generation Technologies

Create a More Nimble Grid to Maintain Reliability as CA Transitions to 100% Clean Energy

Increase the Value Proposition of Distributed Energy Resources to Customers and the Grid

Improve the Customer Value Proposition of End-use Efficiency and Electrification Technologies

Enable Successful Clean Energy Entrepreneurship Across California

Inform California's Transition to an Equitable, Zero-Carbon Energy System that is Climate Resilient and Meets Environmental Goals

Public Comment

Zoom:

- Use the "raise hand" feature to make verbal comments

Telephone:

- Dial *9 to raise your hand
- *6 to mute/unmute your phone line. You may also use the mute feature on your phone.

When called upon:

- Your microphone will be opened
- Unmute your line
- Spell your name for the record, state your affiliation, then start your comment

1-MINUTE TIMER

(Please limit to 1 representative per organization.)
https://www.online-stopwatch.com/

Written comments due **October 15, 2021.**
(https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=20-EPIC-01)