

California Energy Commission Research & Development

Biomass In California's Energy Portfolio: Advancement Through Research and Development

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- □ California's Energy Portfolio and the role of biomass
- Key Policies Driving Bioenergy
- □ High Tree Mortality
- Energy Commission's R&D Programs Supporting Biomass
- Portfolio of Bioenergy R&D Projects
- R&D Plans and Proposed Initiatives Supporting Bioenergy



Installed In-State Electric Generation Capacity by Fuel Type



2016 Grand Total: 79,022 MW Biomass – 1,314 MW Natural Gas – 43,053 MW

These data show the nameplate capacity of all power plants 1 megawatt (MW) and larger; behind-the-meter or customer-side capacity and generation from facilities smaller than 1 MW are not accounted for.

Source: California Energy Commission, CEC-1304 Power Plant Data Reporting.



In-State Electric Generation by Fuel Type



Source: CEC-1304 Power Plant Data Reporting.



In-State Renewable Capacity

Figure 4: In-State Renewable Capacity by Resource Type, Includes Self-Generation (as of October 31, 2016)



Source: California Energy Commission staff based on Quarterly Fuel and Energy Report, source [8], Renewable Distributed Generation sources [D1]-[D14], Data include only facilities physically located in California. However, there are some instances where in-state facilities have contracted to sell power outside California. See notes for Table 1 for additional information about the data. Not included in Figure 4 are 1,650 MW of renewable energy facilities that are physically located out-of-state but have the first point on interconnection in California. Totals may not sum due to rounding. Also, not included in the pie chart are 157 MW of selfgeneration for which the fuel type is undefined. The 157 MW are included, however, in the 26,300 MW of total estimated capacity. Data updated October 2016.

Source: http://www.energy.ca.gov/renewables/tracking_progress/documents/renewable.pdf

Renewable Energy Generation (2016)

Figure 2: 2016 Generation From Renewable Facilities Serving California



2016 Adjusted Retail Sales: 256,400 GWh

2016 Estimated Renewables: 68,900 GWh

Source: California Energy Commission staff based on Quarterly Fuels and Energy Report (QFER) [8], 2015 Power Source Disclosure Filings [11], S-2 Filings [D2], CPUC compliance filings [12], and Energy Commission RPS Compliance Filings [13]. Updated October 2016.

Source: http://www.energy.ca.gov/renewables/tracking_progress/documents/renewable.pdf



Renewables Watch – Friday August, 11 2017 - CAISO

Renewable Resources	Peak Production Time	Peak Production (MW)	Daily Production (MWh)	
Solar Thermal	11:18	604	3,926	
Solar	11:37	8,944	84,843 42,636 11,365 4,266 6,122	
Wind	21:54 16:01 13:34 8:40	3,468		
Small Hydro		645		
Biogas		186		
Biomass		263		
Geothermal 5:56		973	22,785	
Total Renewables			175,942	
Total 24-Hour Sy	781.574			

24-Hour Renewables Production

This table gives numeric values related to the production from the various types of renewable resources for the reporting day. All values are hourly average unless otherwise stated. Peak Production is an average over one minute. The total renewable production in megawatt-hours is compared to the total energy demand for the ISO system for the day.

Source: http://www.energy.ca.gov/renewables/tracking_progress/documents/renewable.pdf



Bioenergy Facilities in California

Net Capacity by Project Status (MW)



Status	Gross Capacity - MW	Net Capacity - MW
Idle	264.85	194.05
Operational	725.90	648.60
Proposed	50	123
Total	1040.75	965.65



- Currently 34 operating solid fuel biomass power plants in 19 counties
- Source California Biomass Energy Alliance



Biomass Facility by Technology Type





Biomass Resources in California

- Gross resource 78 million bone dry tons per year (BDT/y)
- Biomass considered to be available on a technically sustainable basis 35 million BDT/y
- Gross electrical generation potential = 9,900 MWe
 - Agriculture 2,300 MWe
 - **Forestry** 3,500 MWe
 - **MSW** 3,900 MWe
- Biogas potential from animal manures, landfill gas, anaerobic digestion of food, leaves and grass from MSW disposal stream, and wastewater treatment plants = 93 billion cubic ft/year
- Report from CEC-funded Resource Assessment with California Biomass Collaborative, UC Davis. Published March 2015

Biomass Resources by Type



State Energy Policy Drives Energy RD&D Investments

40,000 GWh/year	63,000 GWh/year	Zero Net Energy ² Residential Buildings Goal	Zero Net Energy Double Ene	Commercial Buildings Goa ergy Savings in	^{al} Energy Efficiency
Economic DR at 5% of peak Goal	Achieve 100 Economic Poter	% of ntial Goal	Existing B	Buildings Goal	Demand Response
2008 2010	2013 2015 201	6 2020	2025	2030	2050
11% RPS Goal 20%	5 RPS Goal 8 G	33% RPS Goal 12 GW DG Goal W Utility-Scale G	oal Requi	re 50% RPS	Renewable Energy
	10% Light- Duty State Vehicles be ZEV	25% of Light- Duty State Vehicles be ZEV	Over 1 million ZEVs/near ZEVs on California Roadways Goal	Goal	Transportation Energy
Greenhouse	Reduce Level (A Reduct	e GHG Emissions to AB 32) – Represents ion from Projected C	1990 30% 5HG Redu	ce GHG Emissions	Reduce GHG Emissions 80% Below 1990 Levels
Gas Reductions		Emissions	40%	Delow 1990 Levels	11



Senate Bill (SB) 350 (Clean Energy and Pollution Reduction Act of 2015 (Statutes of 2015))

- 1) Amount of electricity generated and sold to retail customers per year from eligible renewable energy resources be increased to 50 percent by December 31, 2030;
- 2) Establish annual targets for statewide energy efficiency savings in electricity and natural gas final end uses of retail customers by January 1, 2030; and
- 3) Provide for transformation of the Independent System Operator into a regional organization.

Some Key Policies Driving Biomass Development

Renewables Portfolio Standard (Senate Bill (SB)) X1-2, (Simitian, Ch.1, Statutes of 2011); SB 107 (Simitian, Ch. 464, Statutes of 2006); SB 1078 (Sher, Ch. 849, Statutes of 2002).

• These measures, in sum, require retail sellers and local publicly owned electric utilities to increase the amount of energy procured from eligible renewable energy resources to meet at least 33 percent of their total retail sales by 2020, in what is known as the Renewables Portfolio Standard.



Assembly Bill (AB) 32 ("The Global Warming Solutions Act of 2006")

A comprehensive program to reduce greenhouse gas (GHG) emissions in California. GHG reduction strategies include a reduction mandate of 1990 levels by 2020 and a cap-and-trade program.

Executive Order B-30-15

Reduce greenhouse gas emissions to 40 percent below 1990 levels by 2030, to ensure California meets its target of reducing greenhouse gas emissions to 80 percent below 1990 levels by 2050.

Some Key Policies Driving Biomass Development

SB 1122 – Bioenergy Feed-in Tariff (Rubio, Chapter 612, Statutes of 2012).

• Bioenergy Market Adjusting Tariff (BioMAT)

Investor-owned electric utilities to collectively procure at least 250 MW of eligible renewable energy from small-scale bioenergy projects with capacities of 3 MW or less.

Category 1: Biogas from wastewater treatment, municipal organic waste diversion, food processing, and co-digestion - **<u>110 MW</u>**

Category 2: Dairy and other agricultural bioenergy - 90 MW

Category 3: Bioenergy using byproducts of sustainable forest management (including fuels from high hazard zones effective February 1, 2017) - **<u>50 MW</u>**

• Available Contract Price for each of the four Fuel Resource Pricing Categories set at \$127.72/MWh

AB 1923 (Wood) – BioMAT required 3 MW of capacity from bioenergy resources (increased to 5MW)



Some Key Policies Driving Biomass Development

Proclamation of a State of Emergency 10-30-15

Governor's 10-30-2015 Proclamation of a State of Emergency to protect communities against unprecedented tree die-off.

Over 102 million trees, most of these trees are conifers (pines), have died from drought and bark beetles. The bark beetle epidemic has hit California's wildland forests in the coastal ranges, mountains and foothill communities, posing particular threat where dead trees are near homes and private property.





Tree Mortality Emergency

- Per the directives of the Governor's 10-30-2015
 Proclamation of a State of Emergency, the CPUC has been directed to:
 - Utilize its authority to extend contracts on existing forest bioenergy facilities receiving feedstocks from high hazard zones
 - Take expedited action to ensure that contracts for new forest bioenergy facilities that receive feedstock from high hazard zones can be executed within six months
 - And prioritize facilitation of interconnection agreements for forest bioenergy facilities in HHZ, and order the use of expedited mediation or other alternative dispute resolution processes when conflicts delay development of projects

August 14 2017 1:4.622.324 37.5 150 m County Boundaries 5 (Background Mortality) I from the Tree Montality Viewer (http://egis.fire.ca.gov/T

USFS Survey



Tree Mortality Emergency

The Energy Commission has been directed to prioritize grant funding from the Electric Program **Investment Charge for** woody biomass-to-energy technology development and deployment, consistent with direction from the CPUC





Progress in Attaining Energy and Climate Goals





Research & Development: The Science of Innovation





Natural Gas R&D- \$24M/yr

- Energy Efficiency
 - Renewable Energy & Adv. Gen.
- Pipeline Safety
- Environmental
 - Methane Leakage
 - Climate Adaptation and Infrastructure Risk Reduction
- NG Transportation

Electric Program Investment Charge - \$125M/yr

- Energy Efficiency & Demand Response
- Renewable Energy & Adv. Gen.
 - Smart Communities
- Smart Grid, Storage, DER
- Environmental
 - Climate Adaptation and Infrastructure Risk Reduction
- Electric Vehicle Grid Integration
- Market Facilitation



Electric Program Investment Charge

PIER – Natural Gas



Overview of EPIC Program

The Electric Program Investment Charge (EPIC) program is California's R&D investment in the 21st century electric power system.

•All EPIC research initiatives must:

- Address the state's pioneering energy priorities.
- Accelerate technology innovations and tools.
- Provide benefits to California ratepayers.

Transforming our state's electric power system is a significant undertaking that requires multi-dimensional solutions.

We want to use this as a catalyst for a larger discussion on how we best bring clean energy and its benefits to *all* of California's communities.



CEC Administered EPIC Funding

APPLIED RESEARCH AND DEVELOPMENT

Focuses on validating new ideas and technologies

TECHNOLOGY DEMONSTRATION AND DEPLOYMENT

Demonstrates strategies at real-world scales

MARKET FACILITATION

Overcomes non-technical hurdles to increase market adoption and expansion of emerging solutions

expansion of emerging solutions

Funding Areas

- Energy Efficiency
- Clean Generation
- Smart Grid
- Cost Share for Federal Awards
- Renewables
- Demand Response

- Integration of EE, DR, DG and Smart Grid
- Cost Share for Federal Awards
- Entrepreneurial support and assistance
- Innovative local strategies
- Streamlined customer adoption



Electric Program Investment Charge PIER – Natural Gas



GREENHOUSE GAS EMISSIONS

Context: Natural Gas in CA

- Natural gas comprises 57% of installed in-state electric generation capacity
- Commercial and residential buildings account for 33% of natural gas consumption
- Natural gas systems account for about 10% of methane emissions
 - Natural gas use for power generation declining due to renewable power generation and energy efficiency



 Natural gas consumption for transportation is increasing driven by medium- to heavy-duty vehicles

Source: California Energy Commission Tracking Progress - California's Installed Electric Power Capacity and Generation <u>http://www.energy.ca.gov/renewables/tracking_progress/documents/installed_capacity.pdf</u> Tracking Progress - Greenhouse Gas Emission Reduction <u>http://www.energy.ca.gov/renewables/tracking_progress/documents/Greenhouse Gas_Emissions_Reductions.pdf</u>

Natural Gas Research and Development Program

California Energy Commission STAFF REPORT

Natural Gas Research and Development Program

Proposed Program Plan and Funding Request for Fiscal Year 2017-18

ENERGY COMMISSIO

California Energy Commission Edmund G. Brown Jr., Governor

March 2017 | CEC-500-2017-XXX



- Energy Efficiency
- Renewable Energy & Advanced Generation
- NG Transportation
- Infrastructure
 - Pipeline Safety
 - Methane Leakage
 - Climate Adaptation and Infrastructure Risk Reduction



Broad Range of Biomass-to-Energy Research and Development Projects



Altamont Landfill LFG to LNG Project



Dairy waste management (Various digester projects)



Gills Onion Energy System converts onion waste to energy. (Source: Gills Onion)



The UC Davis Renewable Energy Anaerobic Digester (Source: UC Davis)



Brown Grease Processing System at San Francisco's Oceanside Wastewater Treatment Plant (Source: SFPUC)



Biodiesel Production System (bottom)at San Francisco's Oceanside Wastewater Treatment Plant (Source: SFPUC)



Community Power Corporation's BioMax 50 demonstrated in Winters, CA for almond shells (Source: CPC)



Current EPIC Portfolio: Tree Mortality Creating innovative solutions to address tree mortality





New Award: Mariposa Biomass Project

- Design and construct a 2.2 MW forest waste thermochemic al biomass-toenergy conversion facility
- CA's first small scale WFM



New Award: Fall River Resource Conservation District

- Burney-Hat Creek Bioenergy Facility – one of California's first community-scale biomass renewable electricity projects
- Further develops West Biofuel's CircleDraft gasification technology
- Power generation at full rated capacity = 2.88 MW





New Award: AllPower Labs

- Powertrainer+ multimodal power and products gasification platform
- Develop the Powertrainer+ multi-modal power and products gasification platform to generate renewable energy, process forestry waste, and sequester carbon
- 210-250 kW system





New Award: Online Siting Tool - UC Davis

Develop a robust webbased facility siting application that allows potential users to quickly evaluate economic feasibility and environmental performance of potential biopower or CHP facility at particular locations





- Kompogas SLO state of the art highsolids anaerobic digestion system designed specifically to meet the organics diversion goals of SLO county
- Participation in BioMAT, proposed facility will provide energy price certainty for 136,000 MWh over 20 years





New Award: Compact Digester - UC Davis

Develop a compact, containerized anaerobic digestion system as an on-site solution for converting food waste to electricity, heat, and fertilizer

 First deployment in California





Culmination of Research - Biogas Energy System from Food Wastes From Pilot Demonstration to Full Commercial Deployment of UCD's High Solids Digester Through CleanWorld Partners

> American River Packaging Organic Waste Recycling Center





- Capacity –3-5 tons per day
- Digester volume –200 m³
- Electricity output 600-1200 kWh/day



- day of food waste with 0.5 tons per day of unrecyclable corrugate
- Generate approximately 1,300 kWh of renewable electricity per day
- Diverts more than 2,900 tons of waste annually from area landfills



2014 Clean Tech Innovator of the Year: Dr. Ruihong Zhang

UC Davis Renewable Energy Anaerobic Digester (READ)



- Converts 50 tons of organic waste to 12,000 kWh_e each day
- Diverts 20,000 tons of waste from local landfills each year.
- Blends with landfill gas to create a total of 5.6 million kWh per year of clean electricity
- Will reduce GHG emissions by 13,500 tons per year



Current NG Portfolio: Advancing Biogas and Biomethane

Biogas is an abundant renewable resource

- forest and agriculture-derived woody biomass, food waste, organic fraction of municipal solid waste, municipal sewage, food processing wastewater, landfills, and animal manure.
- Can directly produce renewable heat and power, or cleaned up and upgraded to renewable natural gassuitable for injection into natural gas pipelines.
- Biogas as a replacement for fossil natural gas in burners & DG systems
- Low Cost emissions control for biogas-fueled power systems
- Low cost emissions control for biogas-fueled power systems
- Pre-commercial demonstrations



North State Rendering Anaerobic Digester Facility



RNG from Landfill Gas via Novel Cleanup and Upgrading Technologies

- **Recipient:** Gas Technology Institute
- Goal: Improve effectiveness, efficiency, and cost of removing landfill gas contaminants
- Technology:
 - Liquid scrubber systems for carbon dioxide and nitrogen removal which utilize organic solvents with high absorption capacity at low energy input
 - Oxygen, siloxane, hydrogen sulfide removal using subcontractor Nrgtek's patented process
 - Compact, skid-mounted systems for streamlined installation and commissioning
- Key features:
 - Aims to clean and upgrade landfill gas into pipeline-quality renewable natural gas (SoCalGas Rule 30, 990 BTU/scf, non-detectable siloxanes)
 - 1 year or demonstration at an existing landfill
 - Compact, low cost, and low energy input



Simplified representation of the landfill gas cleanup process



Skid-mounted removal subsystems: H2O/CO2 (left), and O2/H2S/Siloxanes (right)



Pre and Post-Combustion NOx Control for Biogas Engines

- Recipient: CHA Corporation
- Goal: Demonstrate pre- and post-combustion NOx control for biogas engines
- Technology:
 - Hydrogen Assisted Lean Operation (HALO) allows stable engine operations at ultra-lean conditions
 - Pre-combustion system consists of microwave H2S removal unit and microwave steam reformer to produce H2 to implement HALO
 - Post-combustion system consists of an exhaust cooler and two activated carbon absorbers in series to remove NOx, SO2 and VOCs

Key features:

- Aims to meet CARB 2007 DG NOx standards, 0.07 lb./MW-hr
- Reduces warm-up time of emission control equipment and subsequently startup emissions



Schematic of the anaerobic digester, biogas engines, and NOx removal subsystems



Biogas Energy Recovery System

- Recipient: Las Gallinas Valley Sanitary District
- Goal: Install and operate a pre-commercial biogas energy recovery system at a small wastewater treatment plant
- Technology:
 - Utilizes a biogas cleanup skid, microturbines, hydronic boiler, and CNG refueling station
 - New system replaces aging internal combustion engine and diesel-fueled vehicles with cleaner, more efficient technologies.
 - Combines existing technologies in a configuration new to California and at a small WWTP

Key features:

- Utilizes 100% of biogas produced by the existing digester to provide renewable electricity, heat, and transportation fuel
- Replaces diesel vehicles with cleaner CNG vehicles



Simplified schematic of the biogas energy recovery system



Photograph of microturbines, gas cleanup system, and digester

New Challenges: Getting to 2030 and Beyond

California's pursuit of a low-carbon future will hit a critical milestone in 2030. The pace of technological progress will need to increase exponentially to overcome challenges for meeting the state's energy and climate goals in 2030:

- Electrification of energy services and climate change impacts are expected to increase electricity demand considerably.
- Greatest opportunities for energy savings are in hard-to-reach sectors such as existing buildings and industrial facilities.
- Marginal value of new solar PV capacity will decline without cost-effective lowcarbon solutions that provide system flexibility and stability.
- Climate change will lower the performance of both renewable and conventional generation and limit the availability of hydropower in hot summer months.
- Clean energy markets for low-income and disadvantaged communities have grown slowly.



Going Forward

The Energy Commission submitted its EPIC 2018 – 2020 Proposed Investment Plan to the CPUC on May 1, 2017.

The research initiatives presented in this investment plan will ensure the Energy Commission's EPIC program continues to provide energy leadership and innovation necessary to carry out California's progressive energy policies and inform decisions and actions at local, state, federal and international levels; and further position California as the primary destination for top talent and investment in the clean energy economy.





4

Strategic Objective 4

Increase the Cost-competitiveness of Renewable Generation

This theme seeks technology advancements needed to open new market opportunities for renewables:

- Increase the economic potential of renewables within California
- Enable renewables to compete in grid service markets
- Develop technologies whose unique attributes can create new uses and markets for renewables



Bioenergy in the 2018-2020 EPIC Investment Plan

- Managing biomass wastes from forests, including sustainable forestry management strategies to reduce wildfire risk, agriculture, and other organic wastes while helping achieve the state's RPS.
- Emphasis on the thermochemical conversion of biomass due to the unprecedented issue of dead and dying trees and the closure of a number of biomass power plants.
- Support the full realization of biomass gasification potentials and other conversion strategies that are clean, efficient, and cost-effective, and that will help address location-challenged biomass resources.
- Technologies and strategies that reduce the LCOE and help bring bioenergy into cost parity with fossil fuels.
- Low-emission generation technologies, pollution control, and other technologies that can cost-effectively utilize low-quality biogas for bioenergy.



S4.4 Improve the Value Proposition of Bioenergy

S4.4.1 Tackling Tar and Other Impurities: Addressing the Achilles Heel of Gasification

• Demonstrate methods to cost-effectively remove impurities such as tar

S4.4.2 Demonstrating Modular Bioenergy Systems and Feedstock Densifying and Handling Strategies to Improve Conversion of Accessibility- Challenged Forest Biomass Resources

- Demonstrate modular gasification systems in forest/urban interface areas
- Demonstrate innovative systems, such as densification and torrefaction, that reduce biomass volume and improve energy density

S4.4.3 Demonstrate Improved Performance and Reduced Air Pollution Emissions of Biogas or Low Quality Biogas Power Generation Technologies

- Develop and demonstrate low-cost emissions control technologies
- Demonstrate fuel-flexible and cost effective generation technologies that can use low quality biogas to produce electricity



Going Forward

The Energy Commission submitted its Natural Gas Budget Plan for Fiscal Year 2017-18 to the CPUC on March 31, 2017

The research initiatives presented in this budget plan will ensure the Energy Commission's natural gas research program continues to provide energy leadership and innovation necessary to carry out California's progressive energy policies and inform decisions and actions at local, state, federal and international levels.



FY 2017-18 Proposed Funding Initiative Specific to Biomass

Piloting Pipeline Quality Renewable Natural Gas from California's Forest Biomass Resources

- Research will support pre-commercial technologies and strategies to enable economic conversion of forest waste biomass to renewable natural gas of suitable quality for pipeline injection in California.
- Possible technologies and strategies include, but are not limited to, the following:
 - A pilot-scale demonstration of woody biomass conversion to renewable natural gas and subsequent injection into a California pipeline;
 - Improvements to the methanation reaction to enable cost-effective conversion of woody biomass-derived syngas to renewable natural gas;
- Projects must demonstrate a "whole system approach" from feedstock to end use conversion of woody biomass to pipeline quality renewable natural gas.
- Technologies should focus on improving efficiency, reducing costs, and reducing environmental impact compared to conventional systems, and should be demonstrated with support from a California utility.



Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP)

- Since the first investment plan, the Energy Commission has invested \$606 million in projects that will support alternative and renewable fuels and advanced vehicle technologies
- Cumulative Awards to Date:
 - **Biomethane Production** \$50.9 million for 16 projects
 - Gasoline Substitutes Production \$27.2 million for 14 projects
 - **Diesel Substitutes Production** \$57.4 million for 20 projects
 - **Upstream Biodiesel Infrastructure** \$4 million for 4 infrastructure sites



ARFVTP - Ethanol

- Plans to fund over 180 new E-85 fueling stations in California by 2016
- Invested \$6 million to encourage CA ethanol producers to utilize and retrofit new production technologies in the California Ethanol Producer Incentive Program (CEPIP).



ARFVTP - Diesel Substitutes (Biodiesel)

- The Energy Commission has invested over \$23.5 million for diesel substitute infrastructure
- \$7 million has been awarded or allocated for diesel substitute blending and storage terminal projects
- \$17 million has been awarded for diesel substitute production

ARVFTP - Biomethane and Renewable Natural Gas (RNG)

- The Energy Commission has invested more than \$50.9 million on 16 biomethane feasibility, demonstration, and production projects
- When fully commercialized, these projects are expected to displace over 100 million diesel gallon equivalents



Thank You!