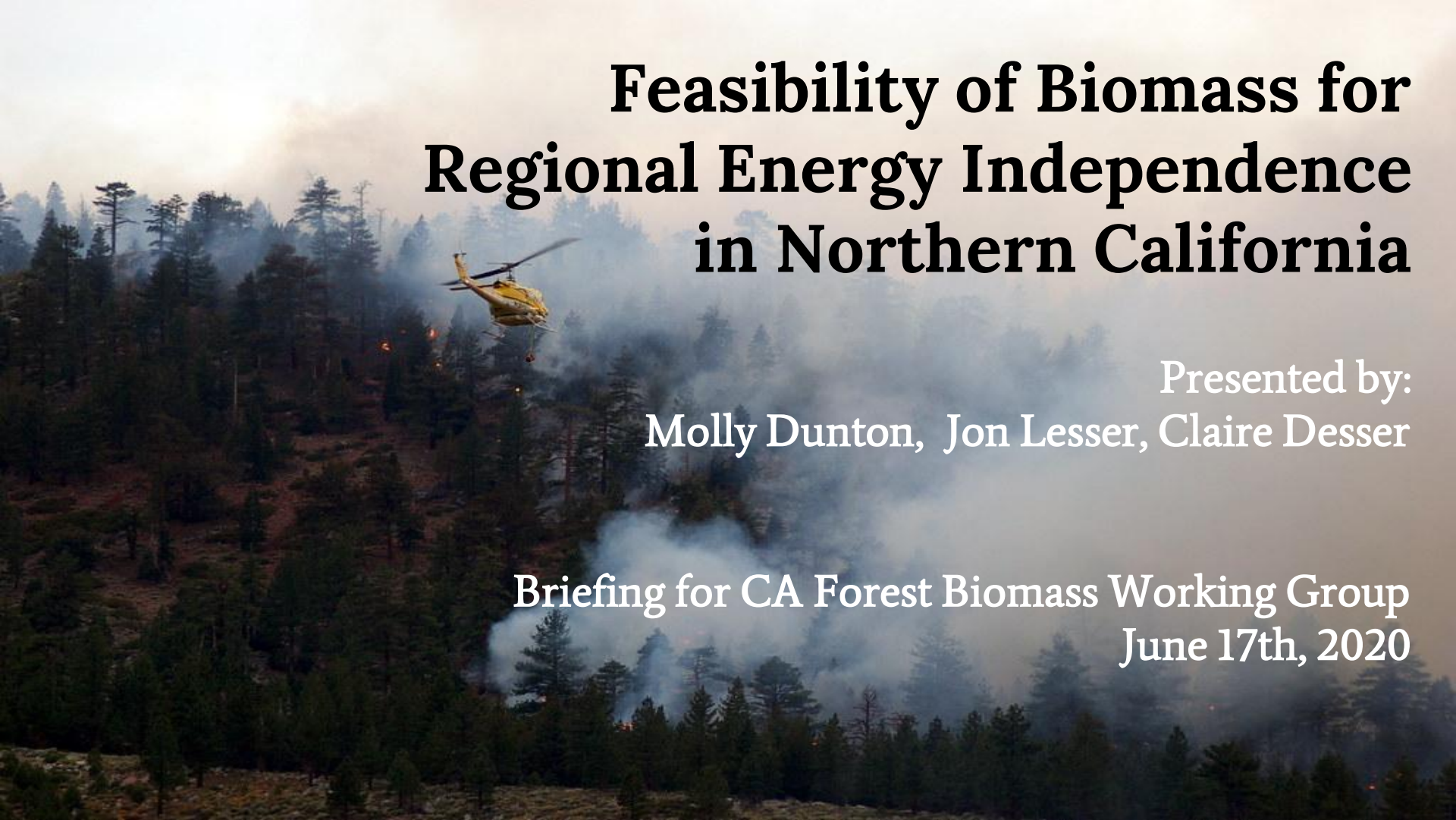


Feasibility of Biomass for Regional Energy Independence in Northern California

Presented by:
Molly Dunton, Jon Lesser, Claire Desser

Briefing for CA Forest Biomass Working Group
June 17th, 2020

Agenda

- ❑ Introduction
- ❑ Research Scope & Methodology
- ❑ Regional Context & Issues
- ❑ Biomass Energy: Overview & Feasibility
- ❑ Environmental Assessment
- ❑ Policy Analysis
- ❑ Considerations for the Future

Research Team

- Received MPA in Environmental Science and Policy
- Backgrounds in energy, urban planning, civil service, advocacy, and conservation

The Client

PACIFIC FOREST TRUST

Source: Pacific Forest Trust

Conserve Forests

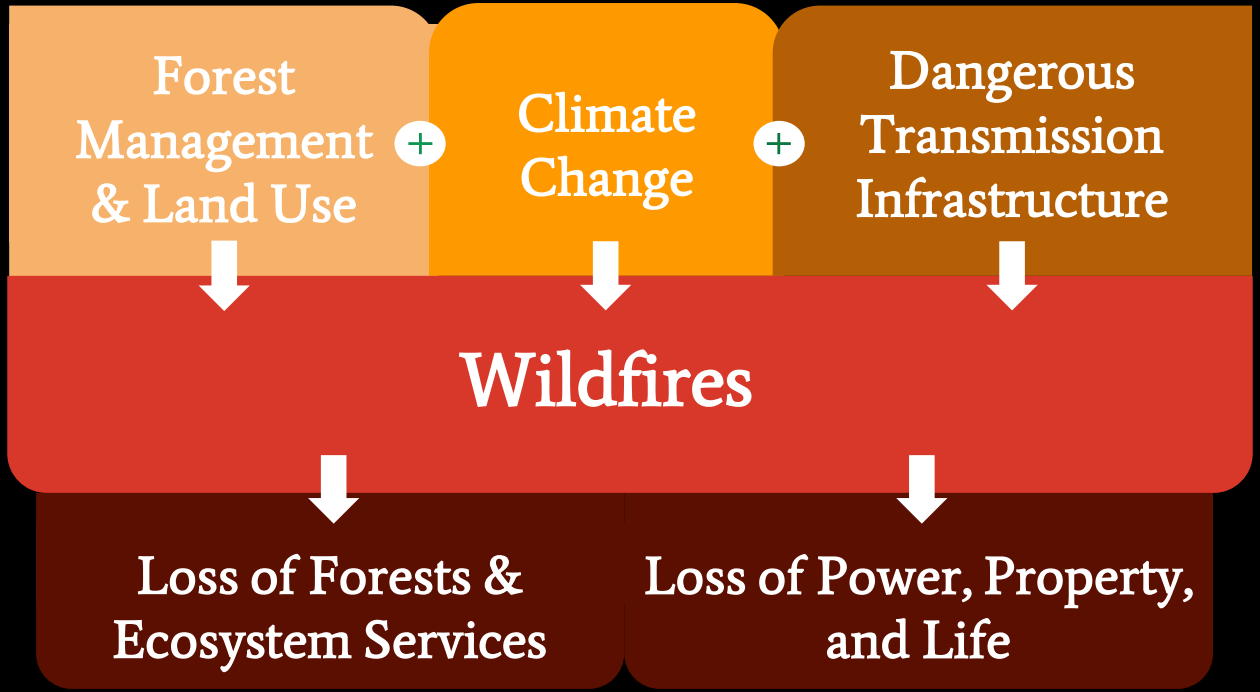
Advance Climate Solutions

Protect Water Sources

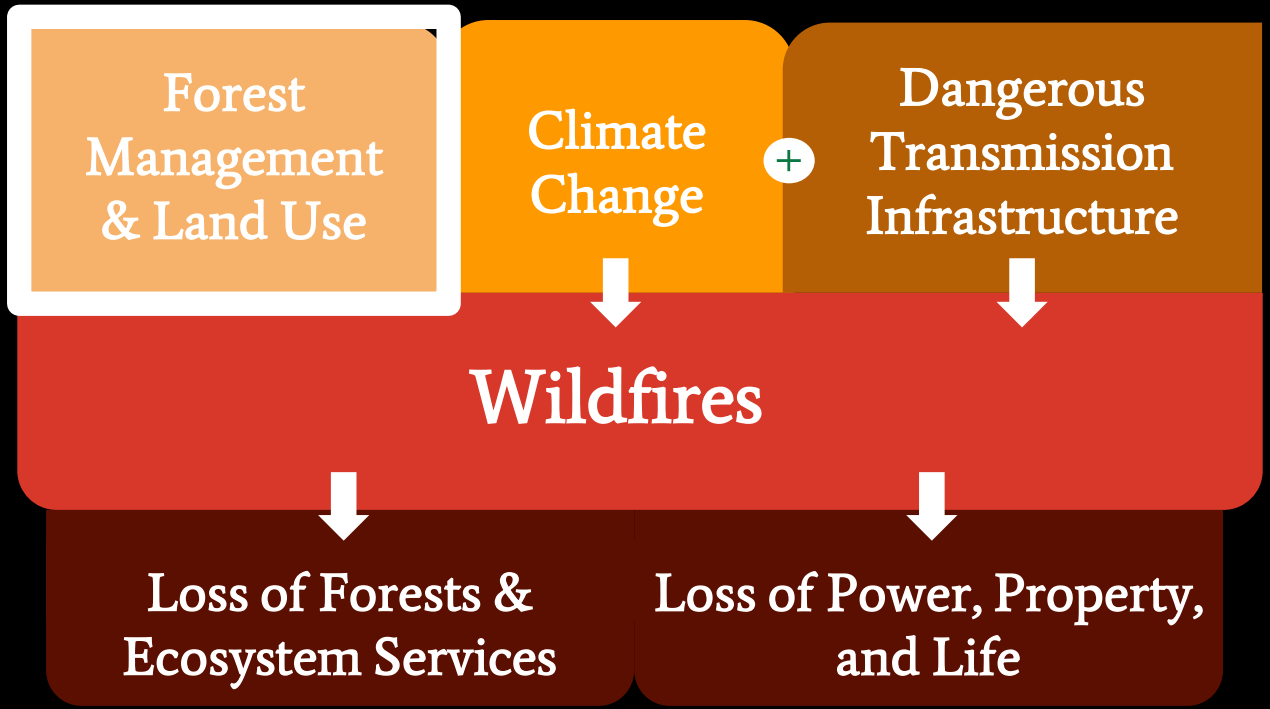
Save Wildlife Habitat

Our client's mission is "to sustain America's forests for their public benefits of wood, water, wildlife, and people's wellbeing, in cooperation with landowners and communities."

The Problem


Forest Management & Land Use
+
Climate Change
+
Dangerous Transmission Infrastructure
Wildfires
Loss of Forests & Ecosystem Services
Loss of Power, Property, and Life

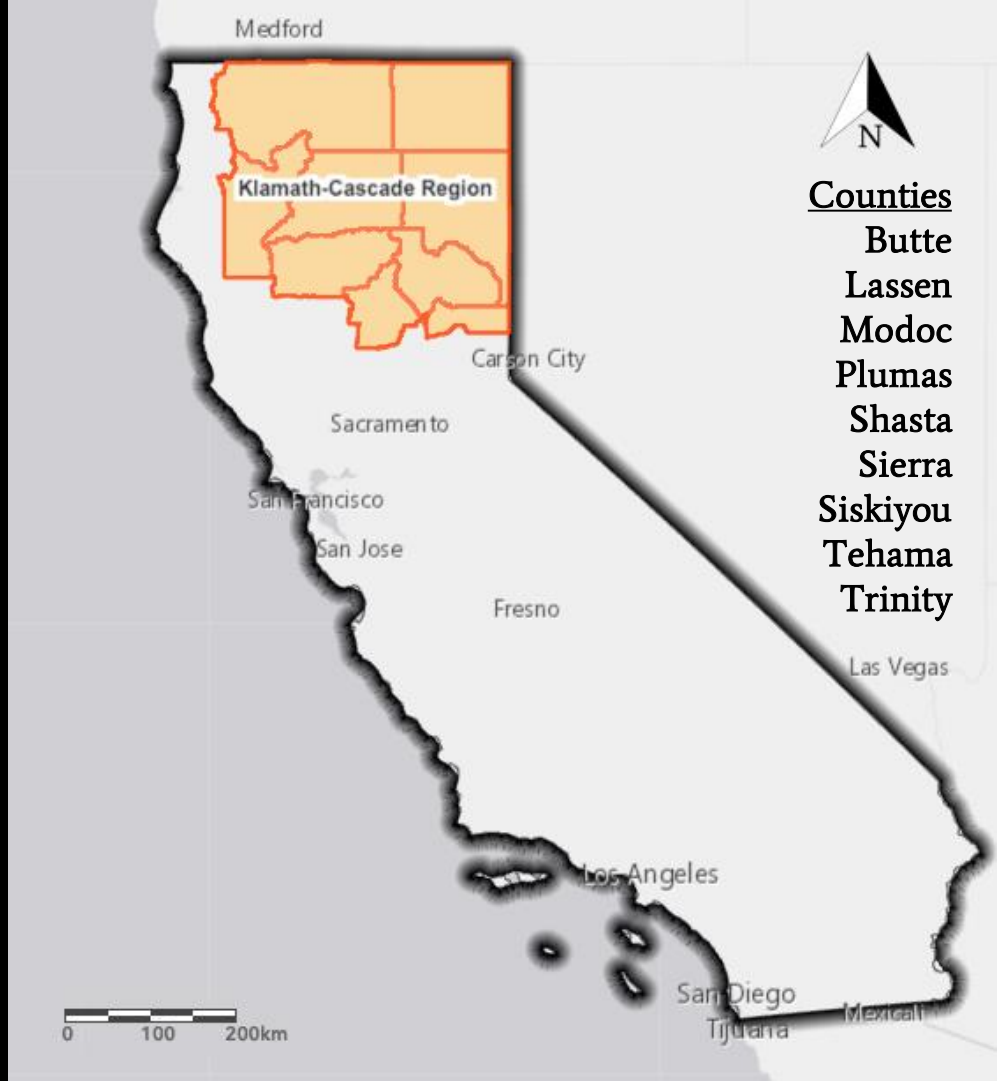
The Problem


Forest Management & Land Use
Climate Change
+
Dangerous Transmission Infrastructure
Wildfires
Loss of Forests & Ecosystem Services
Loss of Power, Property, and Life

Research Scope & Methodology

Research Scope

Can the 9-county Region sustainably utilize its surplus of woody biomass to minimize fire risk, generate energy, and transition off the grid?



Data Collection

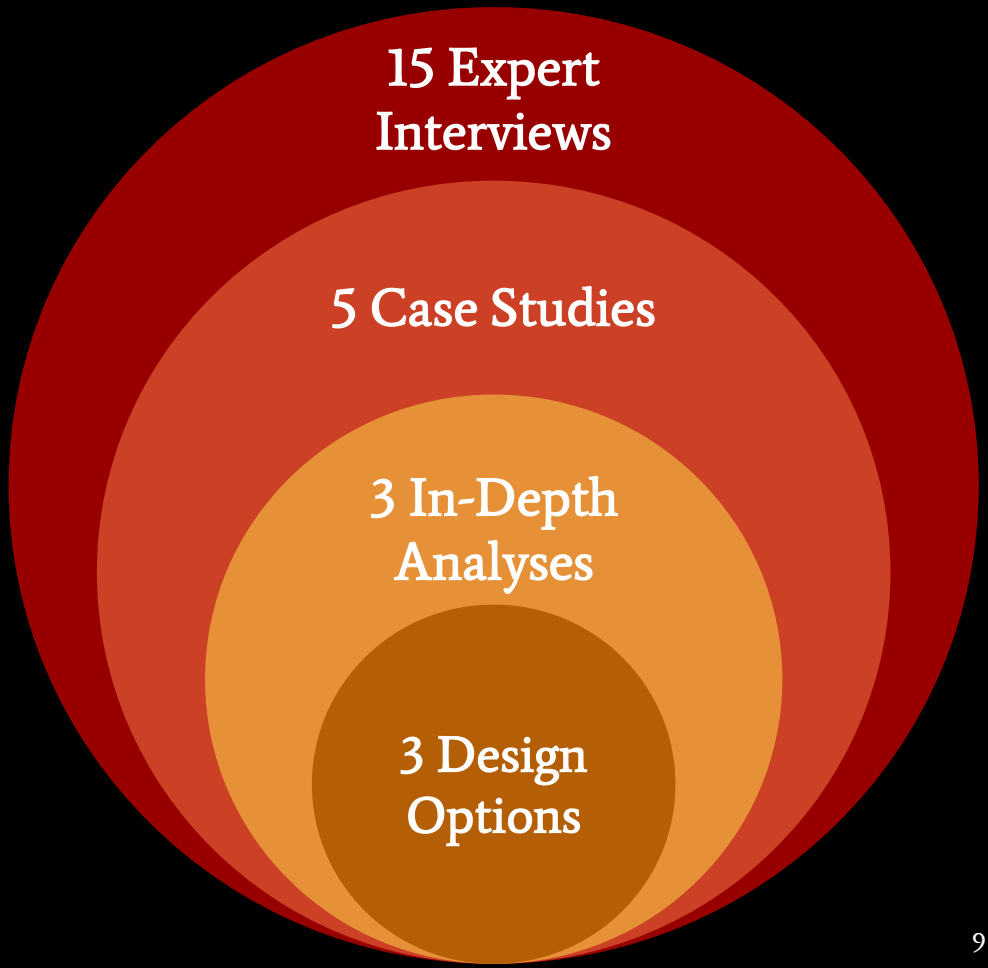
Population: US Census

Fuel Stock: Lawrence Livermore National Laboratory, US Forest Service

Wildfires: CalFire, US EPA

Biomass: US Forest Service, California Air Resources Board, Sierra Business Council, US EPA

Electricity: CA Energy Commission, CA Public Utilities Commission, US Energy Information Administration



Interviews

Non-profit
Simone Cordery-Cotter, Sierra Business Council
Craig Thomas, The Fire Restoration Group
Susan Britting, Sierra Forest Legacy
Nick Goulette, The Watershed Center
Jack Singer, Pacific Forest Trust
Jonathan Kusel, Sierra Institute
Dr. Gregg Morris, Green Power Institute

Academic
Matt Palmer, Columbia University
Stephen Kaffka, UC Davis

Energy Sector
Hugh Merriam, PG&E
Marino Monardi, PG&E
Tom Cuccia, CAISO
Rizaldo E. Aldas, CA Energy Commission

Government
Jessica Morse, CA Natural Resources Agency

Timber
Dan Tomascheski, Sierra Pacific Industries

Case Studies

1. Burney Forest Biomass Plant, Shasta County
   31 MW | Cogeneration Facility | Sawmill Residues | BioRAM: PPA with PG&E

2. Wheelabrator Shasta, Shasta County
   55 MW | Power Plant | Forest Residues & Logging Debris | BioRAM: PPA with PG&E

3. Honey Lake Power, Lassen County
   30 MW | Power Plant | Forest, Sawmill & Urban Waste | BioRAM: PPA with SDG&E

4. Camptonville Forest Biomass Business Center, Yuba County
   5 MW | Power Plant | High Hazard Fuel | BioMAT: PPA with PG&E

5. North Fork Community Power, Madera County
   2 MW | High Hazard Fuel | BioMAT

Key Findings

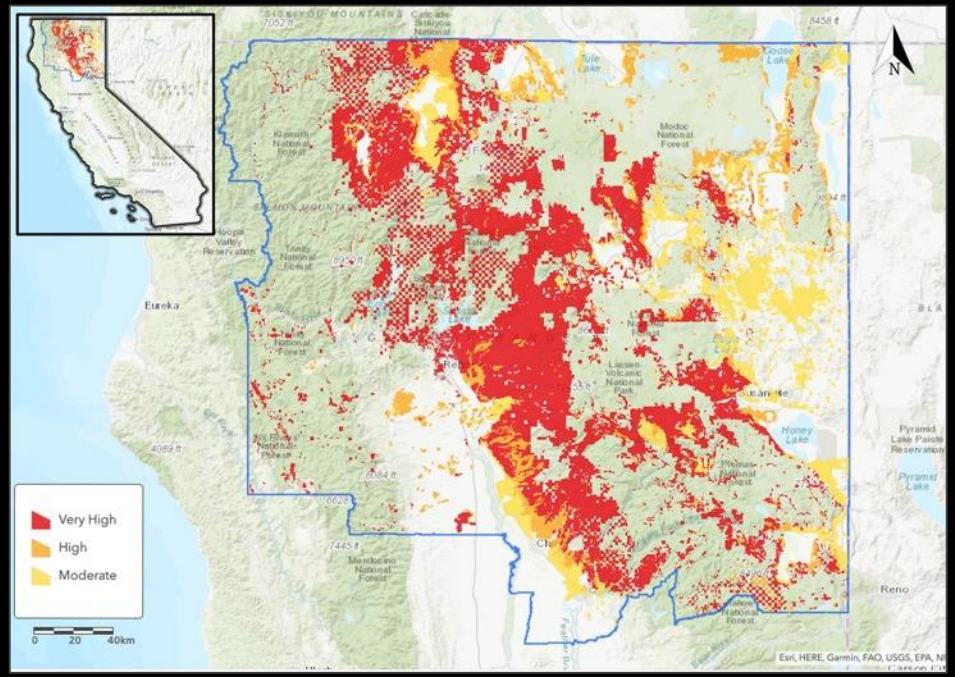
- Biomass energy as a tool for forest management? ✓
- Sufficient amount of woody biomass available? ✓
- Potential of biomass energy to reduce net emissions? ✓
- High cost to fully separate Region from the grid? ✓
- Feasible for new biomass facilities to integrate with the grid? ✓
- Economic viability of biomass energy facilities? ---
- Long-term sustainability of biomass energy industry? ✗

Regional Context & Issues

Wildfires in the Region

- Camp Fire, 2018
  - 150,000 acres burned
  - $16.5 billion in damage

- Carr Fire, 2018
  - 230,000 acres burned
  - $1.6 billion in damages

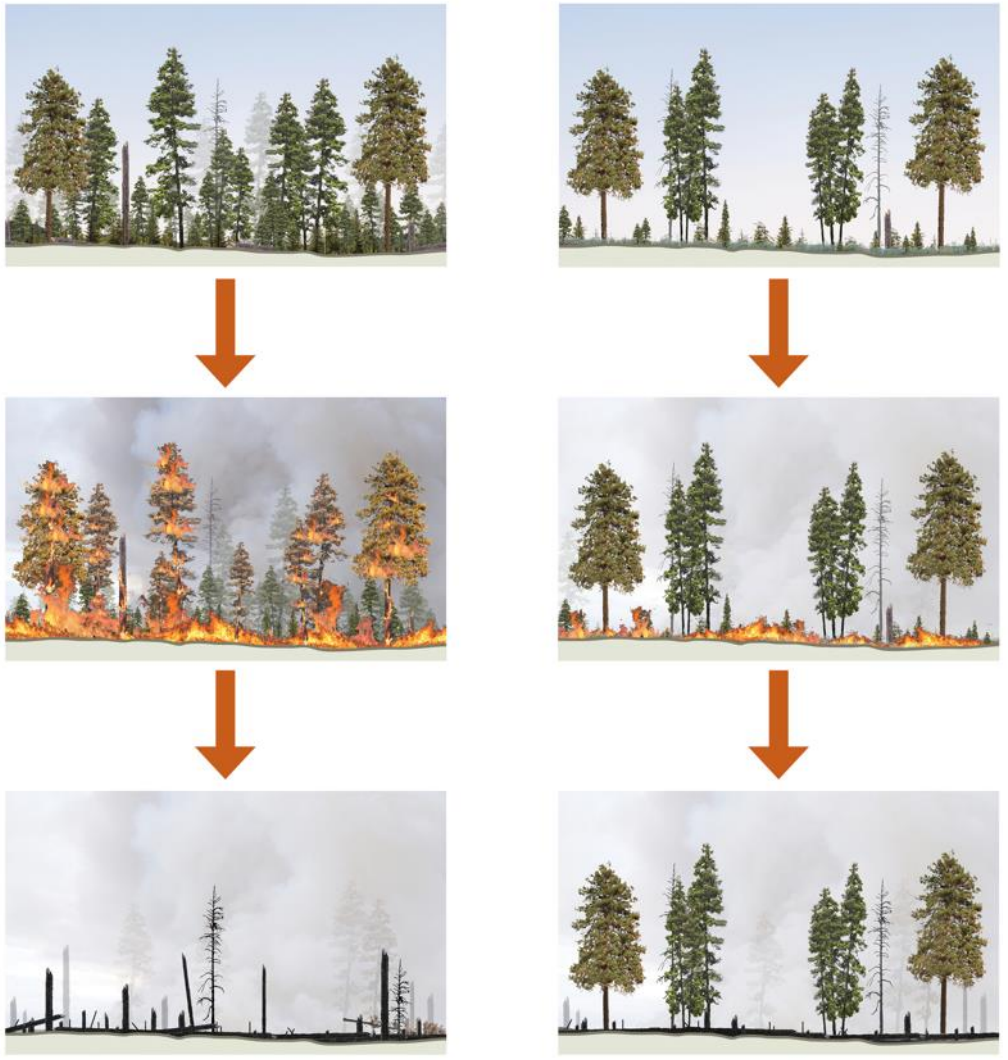


Regional Fire Hazard Zones

Forest Issues

Buildup of ladder fuels in California forests increases fire risk and decreases fire resiliency

Lack of adequate public resources or private financial incentives to thin forests



Energy Issues

- At least ⅓ of Californians live in the “wildland-urban interface”
- Pacific Gas & Electric serves 70% of Northern California
  - 5 of the 10 most destructive wildfires in California have been attributed to PG&E, who completed only 30% of required tree trimmings in 2019

- Over 3 million Californians lost power during the 2019 Public Safety Power Shutoff (PSPS) Events

Woody Biomass and Electricity

Basis of Fuel Supply Estimate

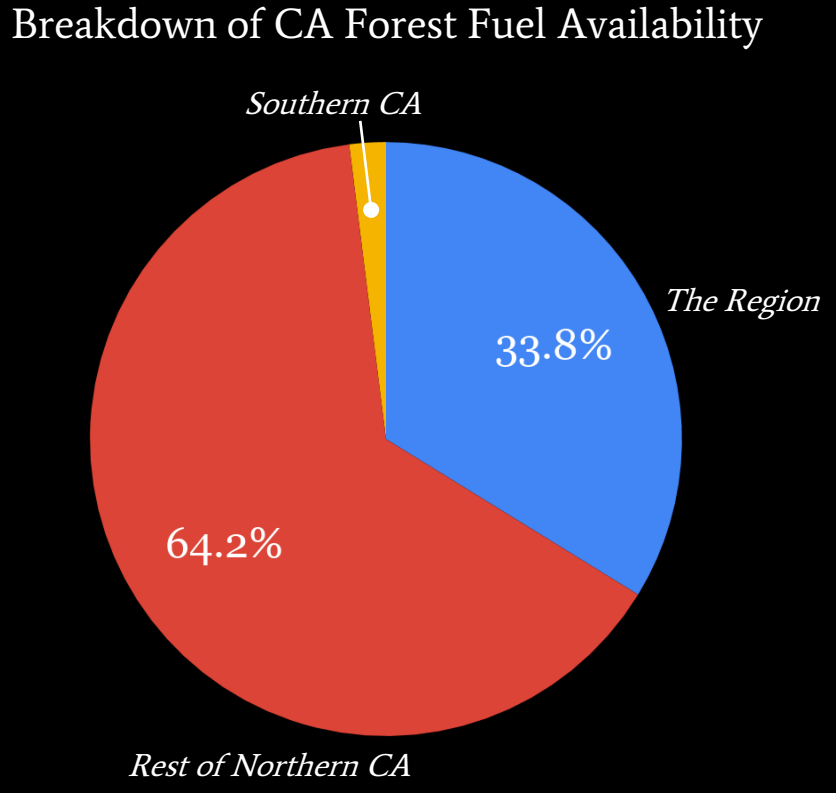
- Lawrence Livermore National Laboratory analyzed biomass fuel available from residues of forest management on public and private land in CA
    - Based on potential to reduce fire mortality, generate net revenue, and maximize in-stand carbon.

“The data from these plots is statistically representative of all economically available biomass from fire- and carbon-beneficial forest management on California timberland.”

Biomass Fuel Supply

California's forests contain 15.1 million BDT of biomass fuel available annually, from management of around 800,000 acres per year through 2045.

Of this, 5.1 million BDT would be available from the forests in the Region.



Fuel Supply & Electricity Consumption

Annual electricity consumption

5 million MWh =
5 million Bone-Dry Tons

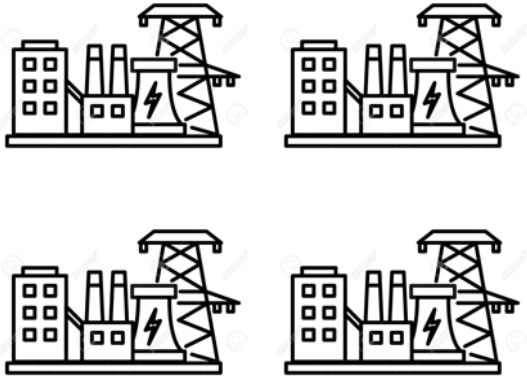
Sustainable amount to harvest

5 million Bone-Dry Tons

Scaling Up Biomass Power

Existing biomass capacity

250 MW



Total biomass capacity needed to meet average demand

750-950 MW

Feasibility of Expanding Biomass Generation for the Region

Redirecting Capacity

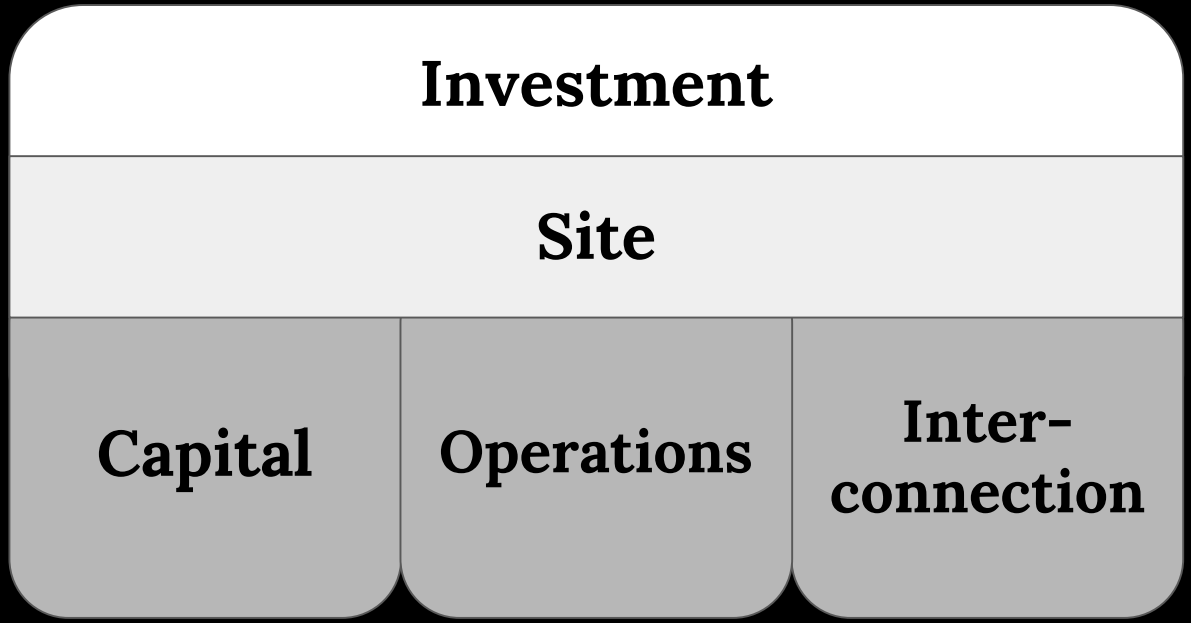
Existing regional capacity (250 MW)

- Combined heat and power at sawmills
- State-mandated biomass procurement
  - BioRAM
  - BioMAT

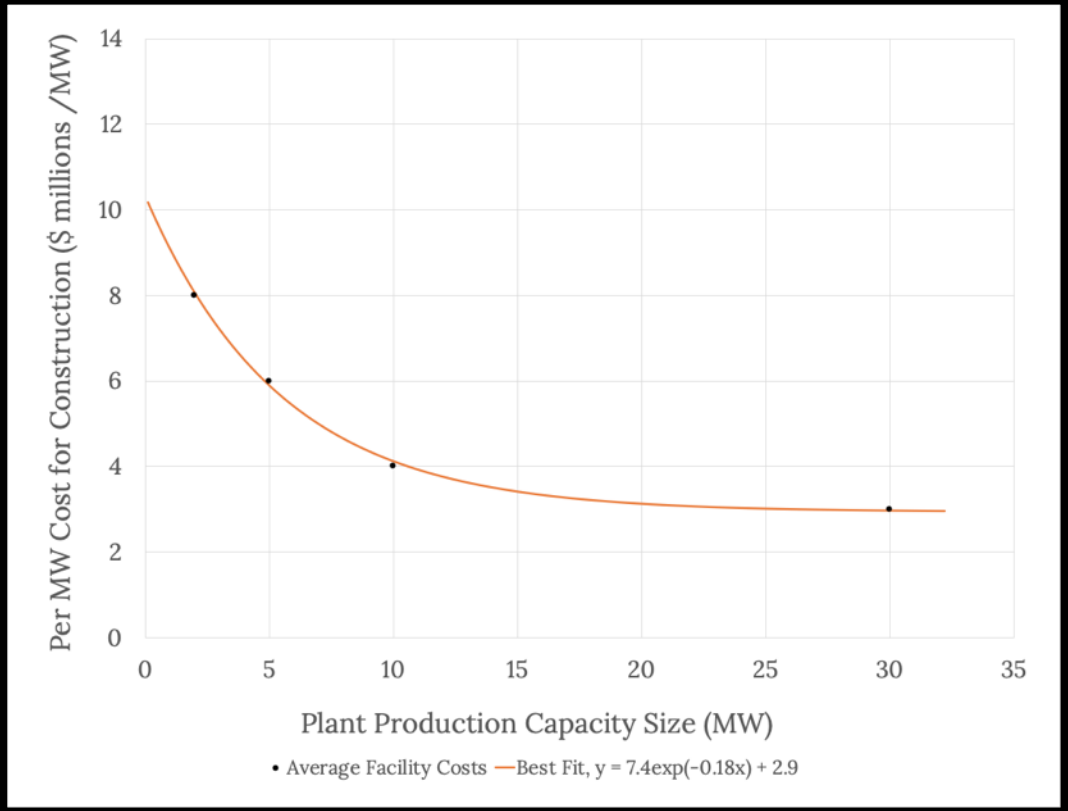
Case Study: Honey Lake Power

- 30 MW woody biomass plant
- Operates in Lassen County but serves SDG&E via PG&E's infrastructure
- During power shutoffs, supplies Lassen Municipal Utility District instead of SDG&E

Bringing New Capacity Online



Economies of Scale: Capital



Consumer Electricity Prices by Utility ($/kWh)

City of Shasta Lake	Lassen Municipal Utility District	Pacificorps	Plumas-Sierra Rural Electric Co-Op	PG&E	Redding Electric Utility	Surprise Valley Electrification Corporation	Trinity Public Utilities District
$0.162	$0.135	$0.153	$0.148	$0.117	$0.143	$0.074	$0.078

Electricity Generation Costs ($/kWh)

Biomass LCOE: $0.095/kWh

Cost of fuel procurement: $0.10/kWh (= $100/BDT)

BioMAT: $0.20/kWh BioRAM: $0.115/kWh

PG&E Consumer Electricity Price: $0.117/kWh

Levelized Cost of Energy by Source (2019 $/MWh)

Energy Type	Levelized Tax Credit	Total System Levelized Cost of Energy	Levelized Cost of Energy including Tax Credits
Dispatchable Technologies			
Coal	-	76.44	76.44
Nuclear	-6.75	81.65	74.88
Biomass	-	94.83	94.83
Non-dispatchable Technologies			
Wind (onshore)	-	39.95	39.95
Solar Photovoltaic	-2.61	35.74	33.12
Hydroelectric	-	52.79	52.79

Scenarios for Grid Utilization

Grid Utilization: Option 1

Integrate with PG&E Substations

Capital Costs	Biomass meets Peak Demand (147 MW)	Biomass meets half Peak Demand (74 MW)
One facility per substation	$568M	$397M
One facility per city	$517M	$330M

Grid Utilization: Option 2

Community Choice Aggregation

Estimates for providing Butte County with 200 MW:

Plant Capacity	Number of Plants	Total Capital Costs
5 MW	40	$1,200M
25 MW	8	$600M
40 MW	5	$587M

Grid Utilization: Option 3

Urban-Based Facilities

City	Facility Capacity	Cost
Chico	83 MW	$243M
Paradise	24 MW	$73M
Redding	110 MW	$323M
Total	217 MW	$639M

Environmental Assessment

Biomass Emissions By Type

	Woody Biomass	*Green and Food Waste*	*Landfill Gas*	*Manure Gas*
Units		metric tons/MWh		
VOC	1.16E-04	1.58E-05	3.45E-04	3.58E-04
CO	1.50E-03	5.29E-05	1.08E-03	1.12E-03
NO_x	2.14E-03	9.14E-05	2.62E-04	2.80E-04
PM_{10}	2.38E-04	6.68E-05	2.40E-05	3.58E-05
$PM_{2.5}$	1.21E-04	2.05E-05	2.20E-05	3.08E-05
SO_x	8.13E-05	6.44E-06	1.11E-05	1.86E-05
CH_4	1.17E-04	7.17E-05	1.73E-03	1.74E-03
N_2O	1.98E-04	6.80E-07	3.40E-06	3.56E-06
CO_2	1.63E+00	3.43E-02	2.26E-01	2.32E-01

Wildfire Emissions in the Region

In 2018, California wildfires

- burned 1.6 million acres
- released an estimated 45 to 61 million metric tons of CO_2

The USDA estimates that biomass energy in California could lead to:

- 22% reduction in acres burned
- 65% net reduction in greenhouse gas emissions

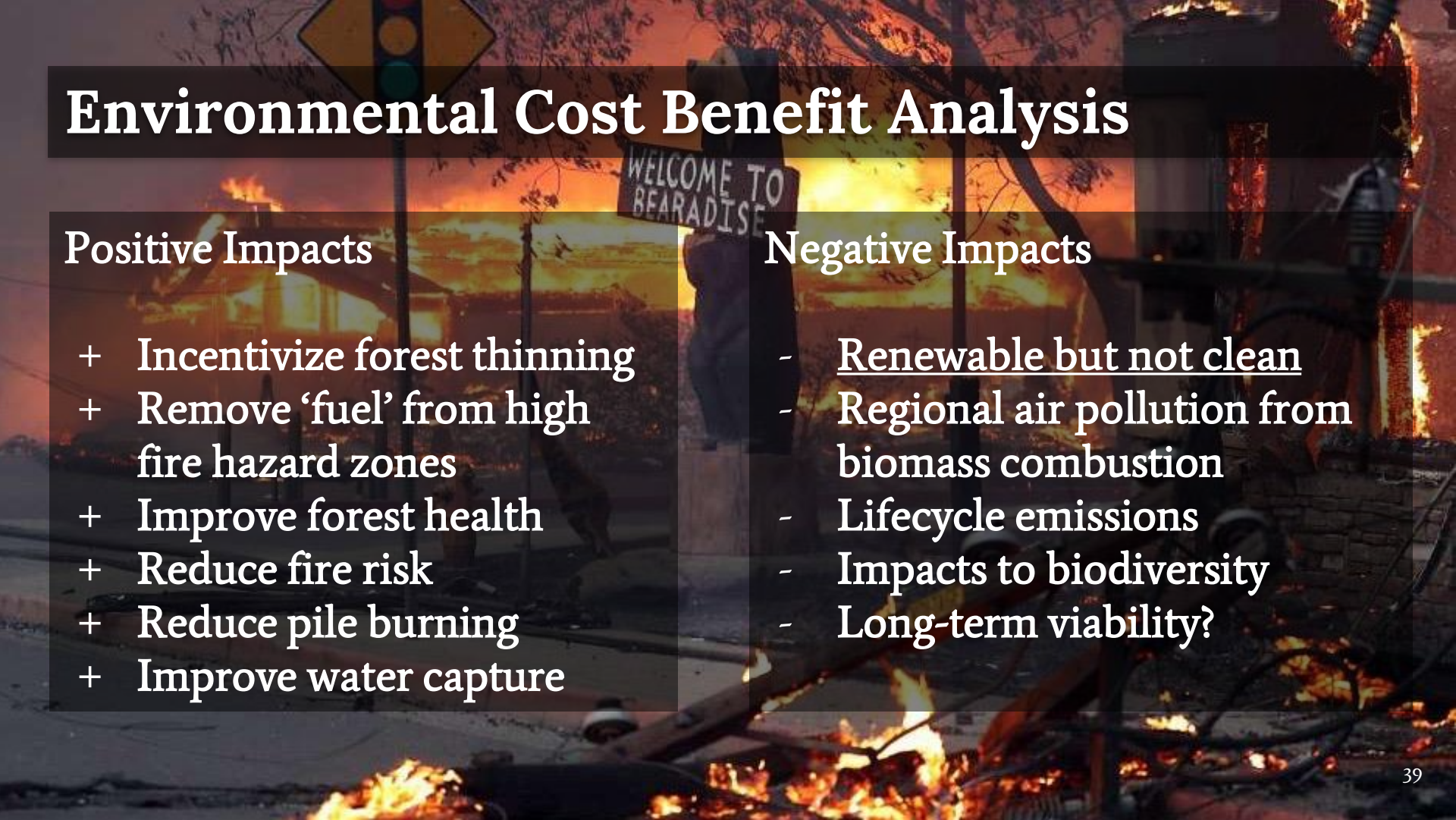
Wildfire Emissions in the Region

County	Number of Fires	Acres Burned	Estimated Emissions (metric tons)					
			PM	Min CO_2	Max CO_2	CH_4	CO	NO_x
Butte	13	155,553	21,403	4,402,443	5,967,757	30,531	178,149	5,099
Lassen	10	20,289	2,792	574,217	778,383	3,982	23,236	665
Modoc	4	41,554	5,718	1,176,057	1,594,210	8,156	47,590	1,362
Plumas	2	137	19	3,877	5,256	27	157	4
Sierra	-	-	-	-	-	-	-	-
Shasta	16	343,503	47,264	9,721,783	13,178,417	67,420	393,400	11,260
Siskiyou	10	38,738	5,330	1,096,358	1,486,175	7,603	44,365	1,270
Tehama	14	12,465	1,715	352,783	478,217	2,447	14,276	409
Trinity	2	2,051	282	58,047	78,686	403	2,349	67
Total	**71**	**614,290**	**84,522**	**17,385,566**	**23,567,101**	**120,568**	**703,522**	**20,136**

Wildfire vs Electricity Generation Emissions

	Wildfires (entire Region)	Wildfires (5 mil BDT)	Biomass Facility (5 mil BDT)	Ratio (1 BDT wildfires/ 1 BDT facility)
Units	metric tons	metric tons	metric tons	metric tons/metric tons
VOC	-	-	581	-
CO	703,522	589,583	7,518	78
NO_x	20,136	16,875	10,696	1.6
Particulate	84,522	71,458	1,188	60
SO_x	-	-	604	-
CH_4	120,568 (4,099,321 CO_2,eq)	101,042 (3,435,417 CO_2,eq)	583 (19,810 CO_2,eq)	173
N_2O	-	-	990 (295,010 CO_2,eq)	-
CO_2	20,476,333	17,160,096	8,159,203	2.1

Environmental Cost Benefit Analysis



Positive Impacts

+ Incentivize forest thinning
+ Remove ‘fuel’ from high fire hazard zones
+ Improve forest health
+ Reduce fire risk
+ Reduce pile burning
+ Improve water capture

Negative Impacts

- Renewable but not clean
- Regional air pollution from biomass combustion
- Lifecycle emissions
- Impacts to biodiversity
- Long-term viability?

Policy Analysis

Stakeholders

Private Landowners and Timber Industry

Local Communities

Investor Owned Utilities

Legislative Framework

Biomass

- BioRAM
- BioMat

Forest Mgt.

- AB 2480
- AB 2551
- SB 859

Renewable Energy

- CA Solar Initiatives
- SB 100
- ITC
- PTC

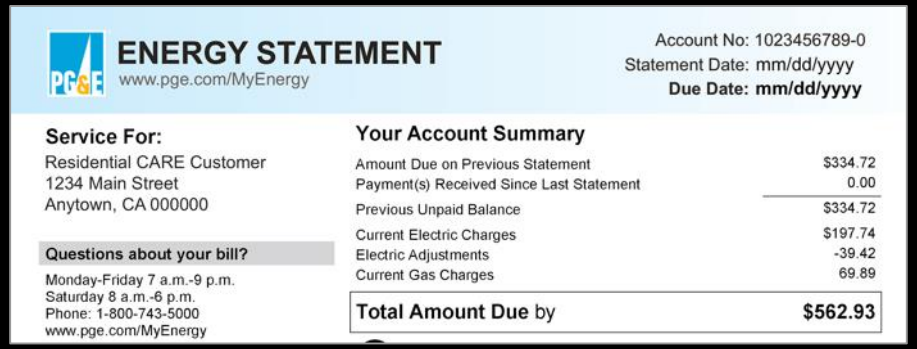
Policy Opportunities

1. BioRAM & BioMAT - expand high hazard zones & funding
2. Extend lengths of contracts and/or procurement requirements
3. Other renewable energy funding to include/switch over to biomass
4. Focus on funding forest management directly

Additional Funding Opportunities

Charge more for social benefits on PG&E electricity bill?

...or tax for improved forest management?



ENERGY STATEMENT
www.pge.com/MyEnergy

Account No: 1023456789-0
Statement Date: mm/dd/yyyy
Due Date: mm/dd/yyyy

Service For:
Residential CARE Customer
1234 Main Street
Anytown, CA 000000

Questions about your bill?
Monday-Friday 7 a.m.-9 p.m.
Saturday 8 a.m.-6 p.m.
Phone: 1-800-743-5000
www.pge.com/MyEnergy

Your Account Summary

Amount Due on Previous Statement	$334.72
Payment(s) Received Since Last Statement	0.00
Previous Unpaid Balance	$334.72
Current Electric Charges	$197.74
Electric Adjustments	-39.42
Current Gas Charges	69.89
Total Amount Due by	**$562.93**

Significant Barriers

- Cost: high capital cost; transportation = highest operational cost; lengthy permitting processes; cheaper alternatives
- Technological Limitations: carbon capture and other technologies can be expensive or not scalable (e.g.., biochar, gasification, cross-laminated timber)
- Public Sentiment: local air pollution

Further Considerations & Research Needs

Considerations for New Facilities

- Location: Road access, distance to forest, reliable connection to grid
- Size & Scale: Lower MW capacity = less pollution, but higher MW capacity = lower capital cost/MW
- Combined heat and power: Most efficient & still eligible for the Investment Tax Credit
- Collocation: Hybrid microgrids (solar *and* biomass)
- Community Choice Aggregation: Local approval, but can take 1.5 years and process can cost $2-$3 million

Future Research Needs

- Quantifying fire reduction
- Other viable options for currently non-merchantable wood
- Total funding needed
- Sustainable and cost effective forest thinning techniques
- On-site heating
- Power line safety
- Urban planning in wildland urban interface

Key Findings

- Biomass energy as a tool for forest management? ✓ Yes!
- Sufficient amount of woody biomass available? ✓ 5.1 BDT
- Potential of biomass energy to reduce net emissions? ✓ Emission Controls
- High cost to fully separate Region from the grid? ✓ Power Lines = $800K/Mile to $3 Million/Mile (Underground)
- Feasible for new biomass facilities to integrate with the grid? ✓ PG&E Substations, Community Choice Aggregation, & Urban-Based Facilities
- Economic viability of biomass energy? --- $2.1-$5.6 Billion (Capital Costs)
- Long-term sustainability of biomass energy? ✗ CA Carbon Neutral by 2045


Thank you!

Image Citations

Slide 1: https://peakvisor.com/park/shasta-trinity-national-forest.html
Slide 2: https://www.brinknews.com/can-we-use-nature-to-mitigate-wildfire-risk/
Slide 4: https://www.pacificforest.org/
Slide 8: Map generated by Maya Fuller using USGS data
Slide 14: Map generated by Maya Fuller using CalFire data
Slide 15: https://www.nature.org/en-us/about-us/where-we-work/united-states/california/stories-in-california/californias-wildfire-future/
Slide 16: https://www.businessinsider.com/pictures-of-californias-latest-wildfire-2016-6
Slide 20: https://shop.chefrubber.com/item/815036S/Cedar-Wood/
Slide 23: https://www.redding.com/story/news/local/2016/11/19/burney-biomass-plant-sawmill-get-fiveyear-reprieve/94161638/
Slide 24: https://www.greenleaf-power.com/facilities/honey-lake.html
Slide 31: https://www.pge.com/
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Slide 33: http://anewscafe.com/
Slide 35-36: http://www.klamathriver.org/clean-water-act-you-youre-invited/
Slide 36-37: https://www.audubon.org/sites/default/files/styles/hero_image/public/lassen-volcanic.jpg?itok=wXR_GSZE
Slide 39: https://www.sfchronicle.com/california-wildfires/article/Camp-Fire-Paradise-before-and-after-photos-13378605.php
Slide 41: https://www.kswo.com/2018/11/17/trump-visit-california-fire-scene-death-toll-rises/
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Slide 47: https://www.youtube.com/watch?v=UuMJS6zI7DQ
Slide 48: https://www.vox.com/the-highlight/2019/10/16/20908291/camp-fire-wildfire-california-paradise-survivors
Slide 50: https://www.forestavedental.com/

Regional Energy Mix

Utility Name	Renewable Energy					Non-Renewable Energy				
	Biomass	Geo-thermal	Solar	Wind	Hydro	Coal	Large Hydro	Nuclear	Natural Gas	Unspecified
Trinity Public Utilities District	-	-	-	-	100%	-	-	-	-	-
Redding Electric Utility	-	-	-	25%	4%	-	27%	-	36%	9%
City of Shasta Lake	-	7%	20%	-	-	-	-	-	-	64%
Pacificorps	2%	4%	10%	10%	3%	4%	15%	34%	9%	9%
Surprise Valley Electrification Corporation	-	-	-	-	85%	-	-	11%	-	3%
Lassen Municipal Utility District	7%	1%	-	13%	5%	-	13%	-	-	61%
Plumas-Sierra Rural Electric Cooperative	-	4%	-	-	1%	1%	40%	-	32%	23%
Pacific Gas & Electric	4%	4%	18%	10%	3%	-	13%	34%	15%	-
All of California	***2%***	***5%***	***11%***	***11%***	***2%***	***3%***	***11%***	***9%***	***35%***	***11%***

Site, Operations, Interconnection

- Not all sites are ideal: balance of fuel proximity, interconnection costs, other site characteristics
- Economy of scale: labor
- High cost of building distribution lines with low returns
  - 1 mile of power line: $800,000