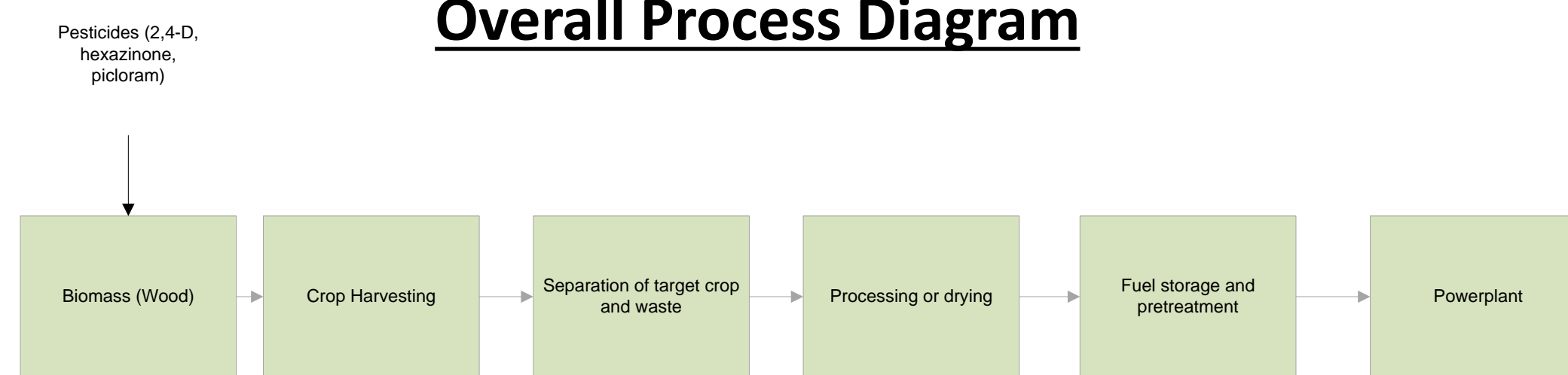


# How Does Electricity Generated from Woody Biomass Fit into California's Energy Future?

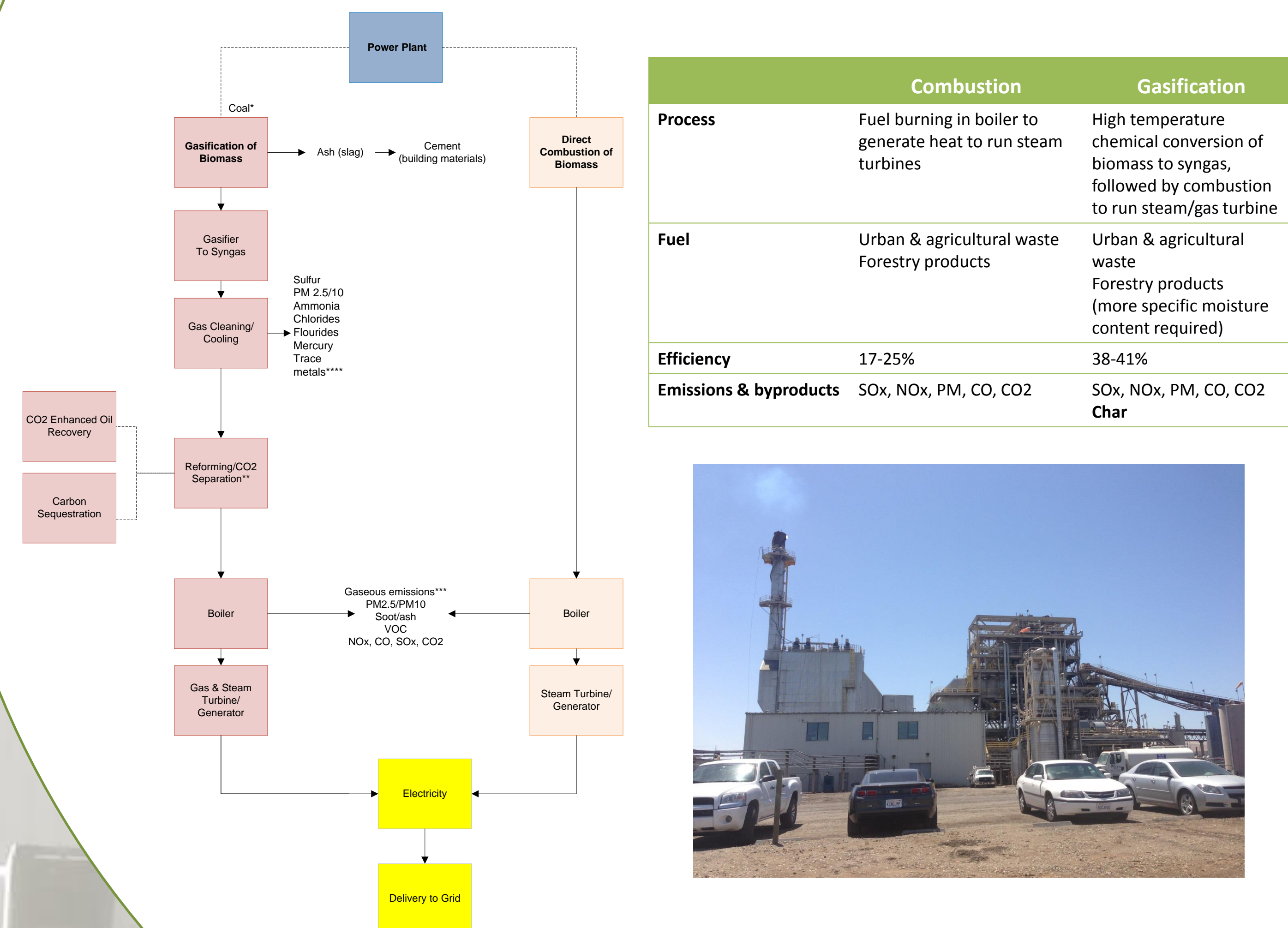
Shuk Han Chan, William Healey,  
Katie McKinstry, Daniel Shen  
University of California, Berkeley

## Technology

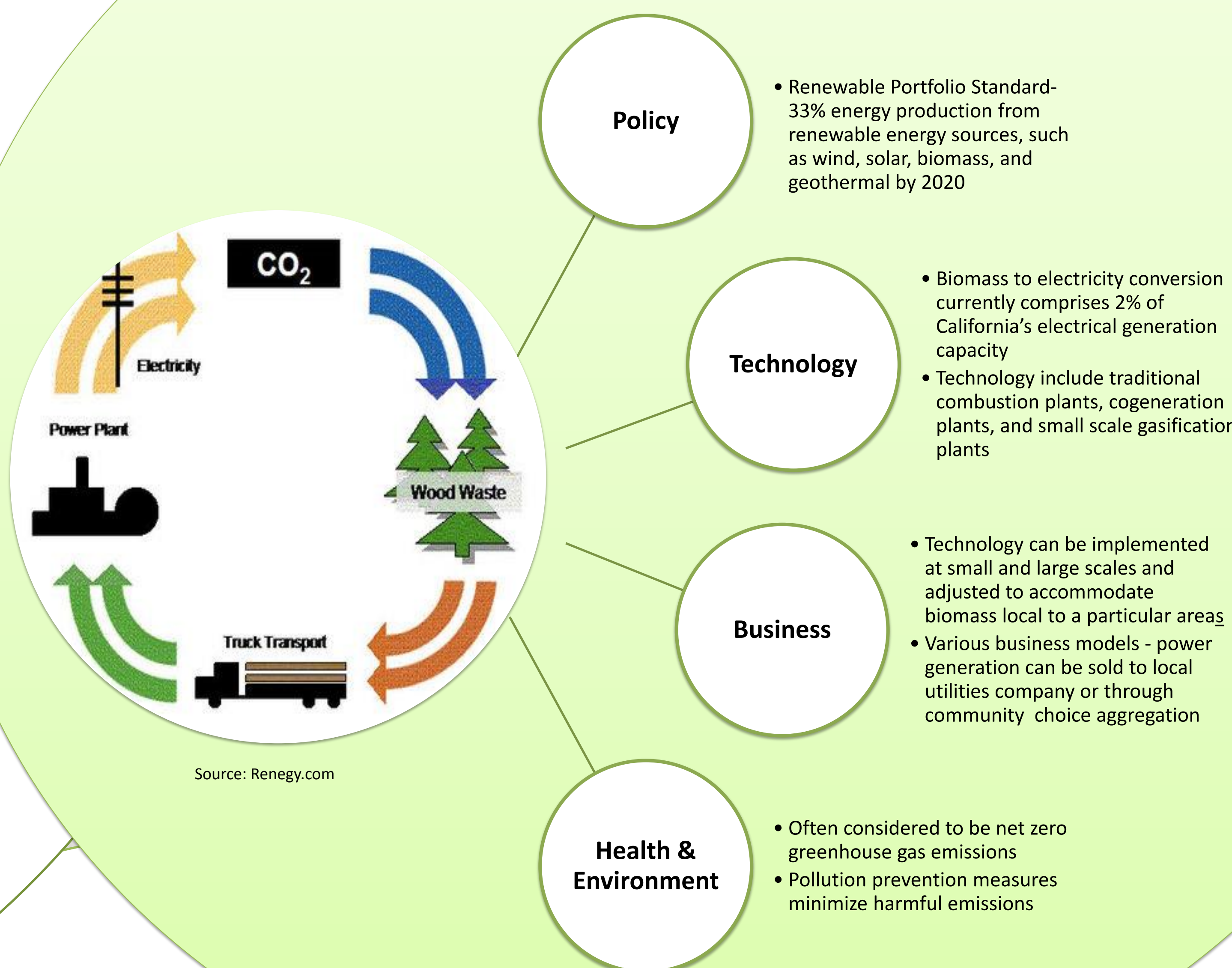
### Overall Process Diagram



### A Closer Look at Thermochemical Processes: Combustion vs. Gasification



## Introduction



## Health & Environment

When waste biomass is combusted in biomass power plants, toxic emissions are captured. If this waste biomass were disposed of in open burns, thousands of pounds of pollutants would be released.

Pollutant	Quantity Captured [lbs/ton biomass]
PM <sub>10</sub>	19-30
PM <sub>2.5</sub>	17-27
NO <sub>x</sub>	3.5
SO <sub>2</sub>	0.1
VOC	8-21
CO	154-312



### Processes to limit emissions in biomass electricity generation

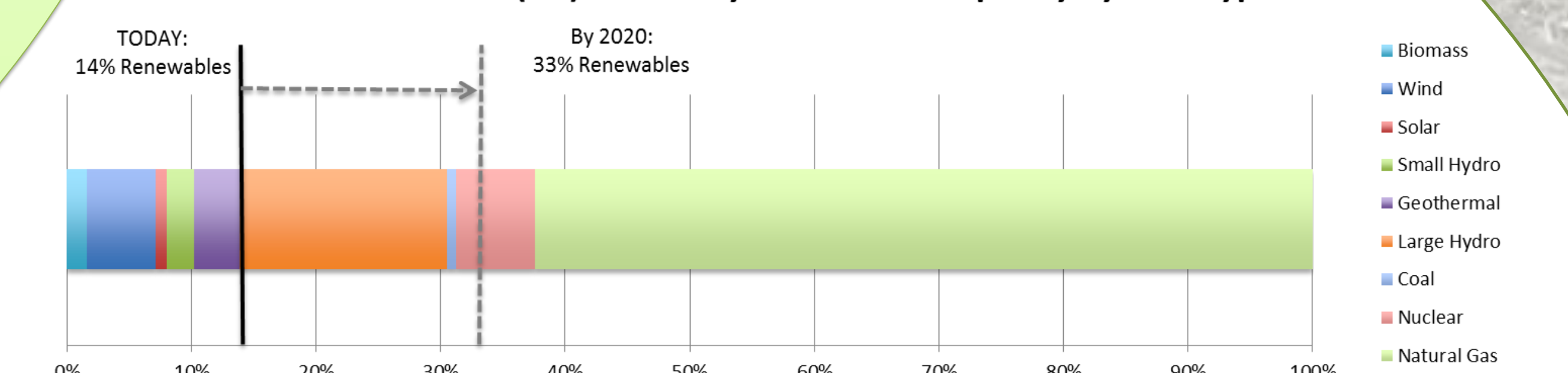
**Nitrogen Dioxide:** NO<sub>x</sub> + NH<sub>3</sub> (ammonia) → N<sub>2</sub> + H<sub>2</sub>O  
**Sulfur Dioxide:** SO<sub>2</sub> + CaO (calcium oxide) → CaSO<sub>4</sub> (gypsum)  
**Particulate Matter:** 99.99% is removed during "scrubbing" and collected as fly ash and recycled as concrete mix

### Comparison To Natural Gas

- Methane is a non-renewable fossil fuel
- Woody biomass is regenerated, net zero CO<sub>2</sub> emission
- 3-8% methane leaks during well operation
- 20x worse than CO<sub>2</sub> as a greenhouse gas

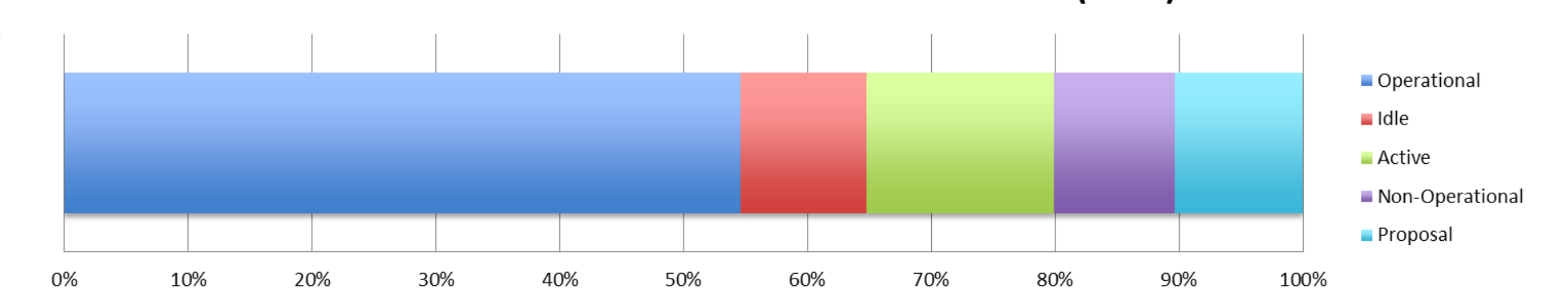
## The Market: Present & Future

### Installed In-State(CA) Electricity Generation Capacity by Fuel Type<sup>12</sup>

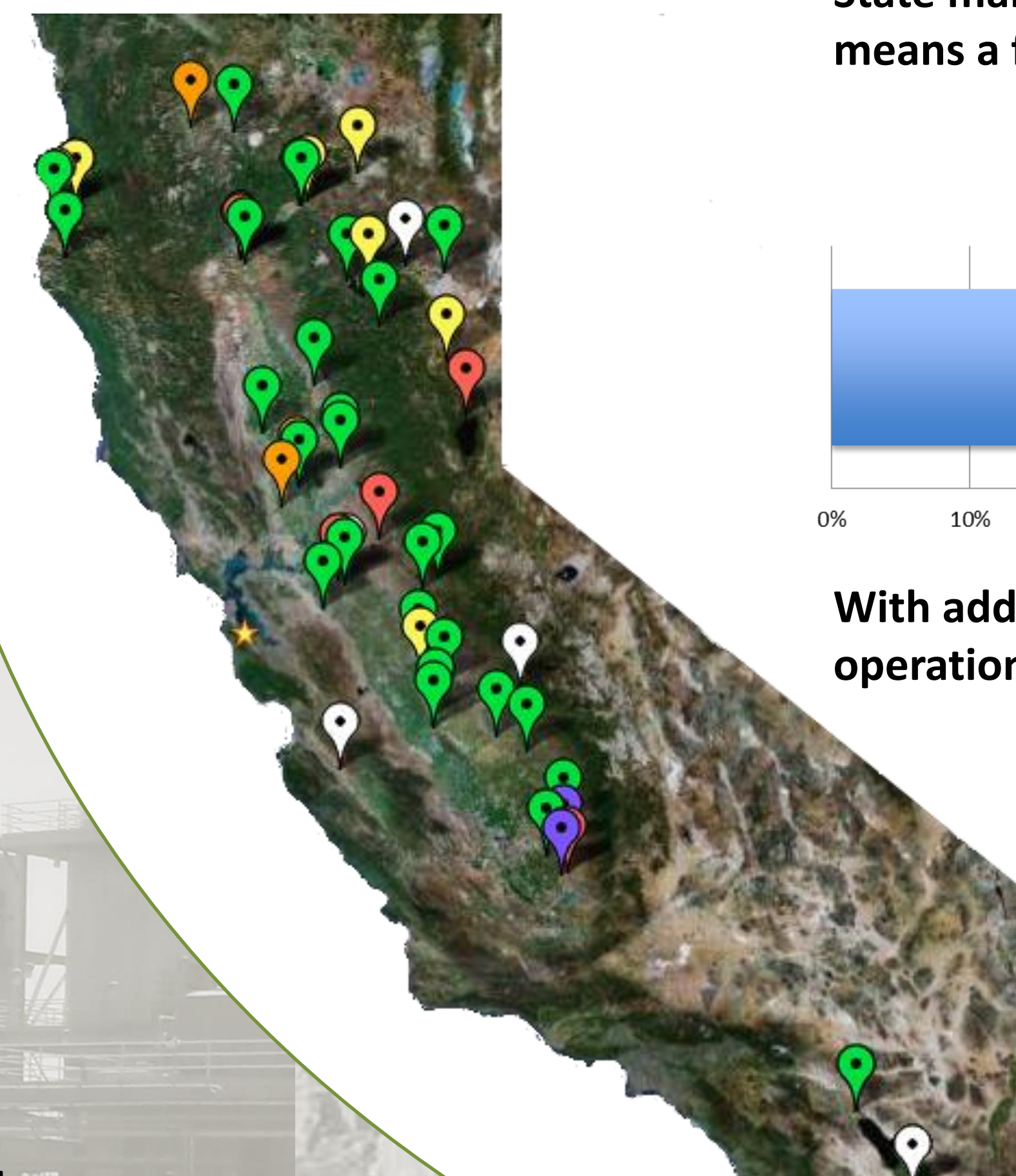


State mandates to increase renewable energy and biomass energy specifically means a favorable outlook for this sector.

### Status of California's Biomass Power Plants (2012)<sup>6</sup>



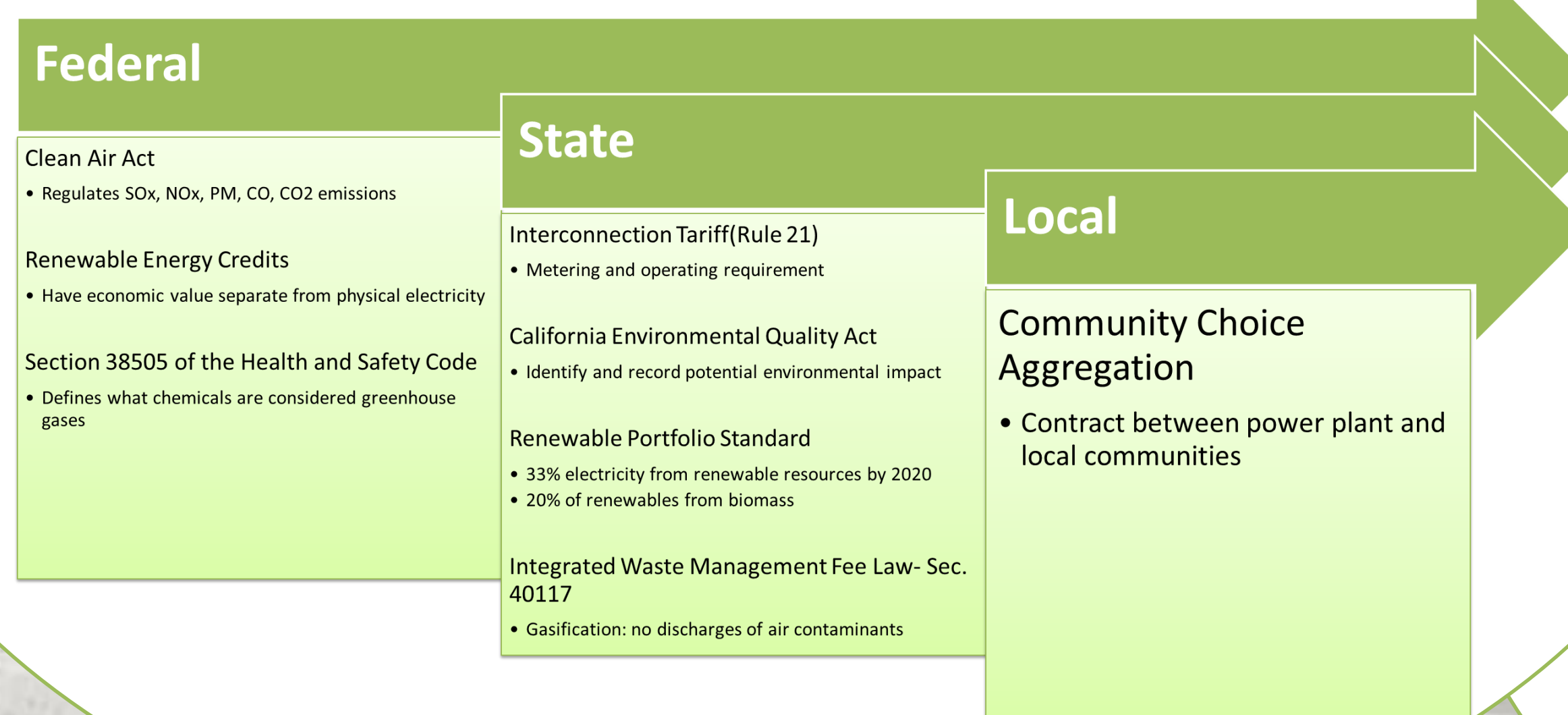
With additional funding and improved market conditions, idle and non-operational plants can be brought back into working order.



Legend
Operational Facilities
Idle Facilities. Restarting relatively simple.
Pilot Projects
Active Project (in transition: new construction, conversion or restart)
Proposed Projects
Non-Operational facilities (requires significant capital to restart)

Location and status of California's biomass plants<sup>6</sup>

## Law & Policy



## Conclusion

Technology	<ul style="list-style-type: none"><li>Direct combustion is a mature technology</li><li>Gasification is still in R&amp;D phase</li></ul>
Market	<ul style="list-style-type: none"><li>Not competitive on price without RPS mandates</li></ul>
Policy	<ul style="list-style-type: none"><li>State policies that require increasing renewable energy mix support further adoption of biomass generated electricity</li></ul>
Environment & Health	<ul style="list-style-type: none"><li>Utilizes waste products, thereby capturing harmful emissions that might occur with open burns</li><li>Considered net-zero GHG emissions process</li></ul>

## Acknowledgements

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