

**Anaerobic Digestion**  
**“Garbage to Energy”**  
**is**  
**Twice as Dirty as Coal**

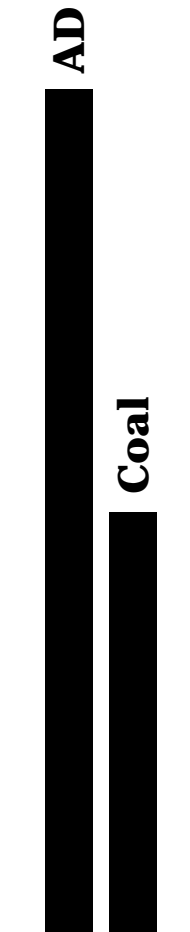
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# Executive Summary

- The Anaerobic Digestion (AD)-fueled “Garbage to Energy” process returns 1.6 metric tons of CO<sub>2</sub> to the atmosphere for each MegaWatt-hour (MWh) of energy it delivers
- A coal-burning generator—the benchmark of carbon-dirty energy—releases 0.8 metric tons CO<sub>2</sub> per MWh delivered
- AD / Coal CO<sub>2</sub> ratio =  $1.6/0.8 = 2:1$
- The AD “Garbage to Energy” carbon footprint is double that of a coal-burning generator
- The carbon in the biomass fuel for AD “Garbage to Energy” comes from the CO<sub>2</sub> nature sequestered from the atmosphere
  - A carbon-smart policy would keep that carbon sequestered
  - Shouldn’t Palo Alto adopt one?
    - If not Palo Alto, then who?

CO<sub>2</sub>  
per  
unit  
energy



Data Source:

<http://archive.cityofpaloalto.org/environment/news/details.asp?NewsID=1235&TargetID=59>

Follow link: “[C. deLa Beaujardiere Numbers \(4-2010\)](#)”

# 1. Plants Remove CO<sub>2</sub> from the Atmosphere



- This magnolia leaf is made of hydrogen, oxygen, and carbon
- That carbon comes from the CO<sub>2</sub> the leaf sequestered from the atmosphere
- An AD “Garbage to Energy” electrical generator would return this CO<sub>2</sub> to the atmosphere
  - at a major financial cost
  - for a negligible energy return
  - with a huge carbon footprint
- Why would Palo Alto want to do that?

I use a leaf as a visualization aid for aesthetic reasons. The discussion and conclusions apply to any AD feedstock: sludge, food scraps, ...

## 2. Make Biogas, Release 40% as CO<sub>2</sub>



Cumulative  
waste CO<sub>2</sub>  
returned to air:  
40%

- The AD process converts the feedstock to biogas
- That biogas consists of
  - Methane: 60%
  - Carbon dioxide: 40%
- The carbon dioxide yields zero energy
  - But it is returned to the atmosphere
- Cum score:
  - Sequestered carbon returned to the atmosphere as CO<sub>2</sub>: 40%
  - Saleable energy delivered: 0

### 3. Burn the Usable Biogas, Lose 70%



- Burn the biogas methane to H<sub>2</sub>O & CO<sub>2</sub>
- That yields heat energy...
  - which powers a motor...
  - that drives an electric generator
- But, per the laws of thermodynamics, 70% of that heat energy is lost as “waste heat”
  - That’s why your car’s engine gets so hot
- The unmasked leaf area shows the 18% carbon fraction that actually produces electrical energy
- Cum score:
  - Sequestered carbon returned to the atmosphere as CO<sub>2</sub>: 82%
  - Saleable energy delivered: 0

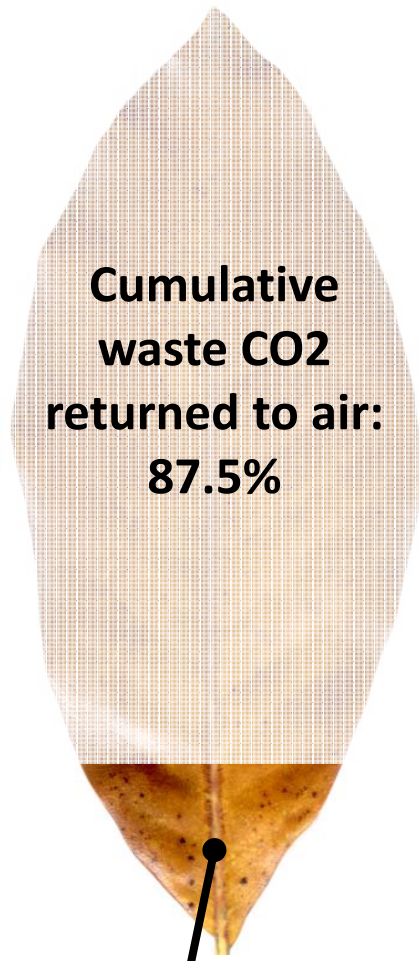
## 4. Pay 30% Operating Tax



Cumulative  
waste CO<sub>2</sub>  
returned to air:  
87.5%

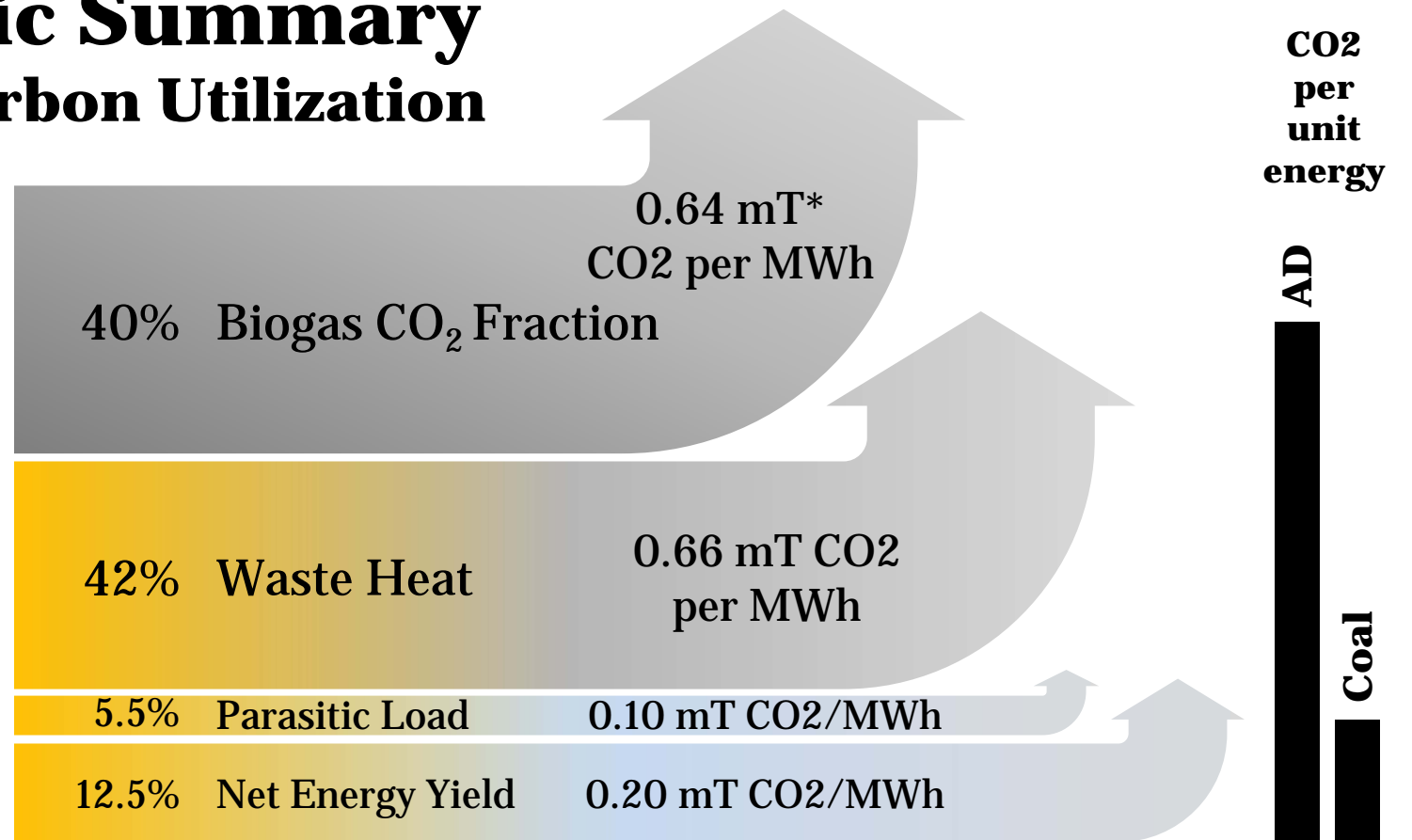
- Thirty percent of the generated electrical energy is spent upfront to power the “Garbage to Energy” operation
  - Trade term: “parasitic load”
- Associated carbon release: 5.5%
- Cum score:
  - Sequestered carbon returned to the atmosphere as CO<sub>2</sub>: 87.5%
  - Saleable energy delivered: 0

# 5. Deliver Energy to Users



- Fraction of the feedstock carbon that delivers “Garbage to Energy” electricity to users: 12.5% (1/8)
- Fraction for a coal-fired generator: 30% (~1/3)
- Final score:
  - Sequestered CO2 returned to the atmosphere: 100%
  - Fraction released unproductively: 87.5%
  - CO2 per AD-generated MWh delivered: 1.6 metric tons
  - CO2 per coal-fired MWh delivered: 0.8 metric tons
  - CO2 ratio: AD “G2E” / Coal = 1.6/0.8 = 2:1
- Bottom Line: The carbon footprint of an AD-fueled generator is twice that of a coal-burning generator

# Graphic Summary of AD Carbon Utilization



Total AD CO<sub>2</sub> per MWh delivered: 1.60 mT

Coal generator CO<sub>2</sub> per MWh: 0.80 mT

AD to Coal CO<sub>2</sub> ratio: 2:1

\* mT = metric ton = 2,200 lbs

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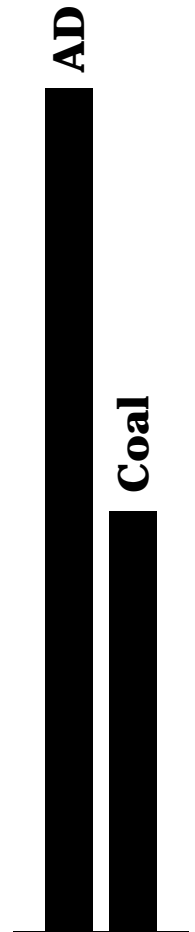
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# Takeaways

- All the carbon in the biomass that fuels an AD “Garbage to Energy” electrical generator comes from CO<sub>2</sub> that plants sequestered from the atmosphere
- An AD-fired generator returns all of that CO<sub>2</sub> to the atmosphere
  - at a major financial cost
  - for a negligible energy return
  - with a huge carbon footprint
- Per unit of energy delivered, the AD process has double the carbon footprint of a coal generator—the benchmark of carbon-dirty energy
- A carbon-smart policy would keep the sequestered carbon sequestered
- Shouldn’t Palo Alto adopt one?
  - If not Palo Alto, then who?

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