Think Green.® Think Waste Management.

California Energy Commission Workshop
Closing the Loop on Transportation Fuels
May 11, 2011
Sacramento, California

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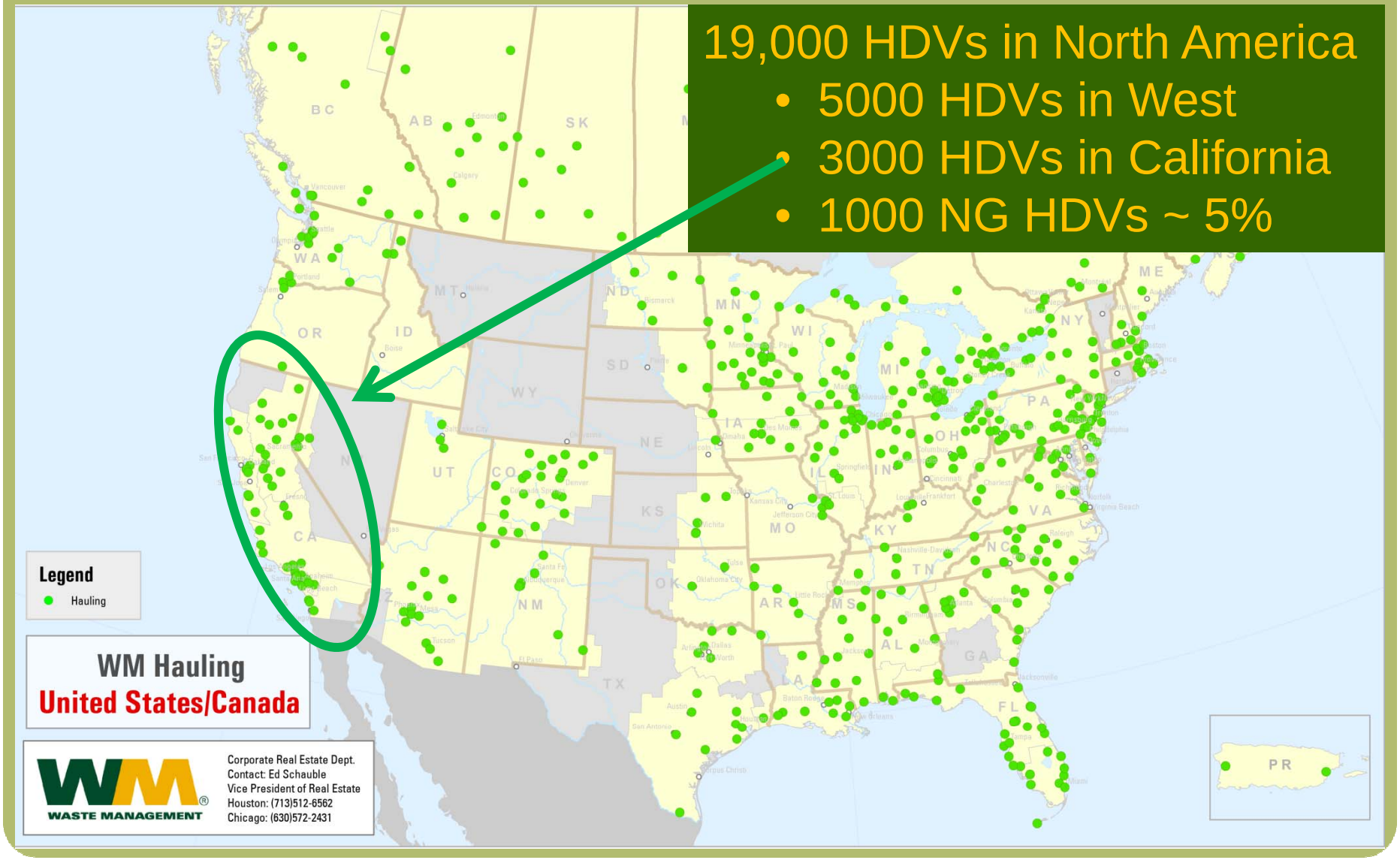
Director of Regulatory Affairs/West

Waste Management

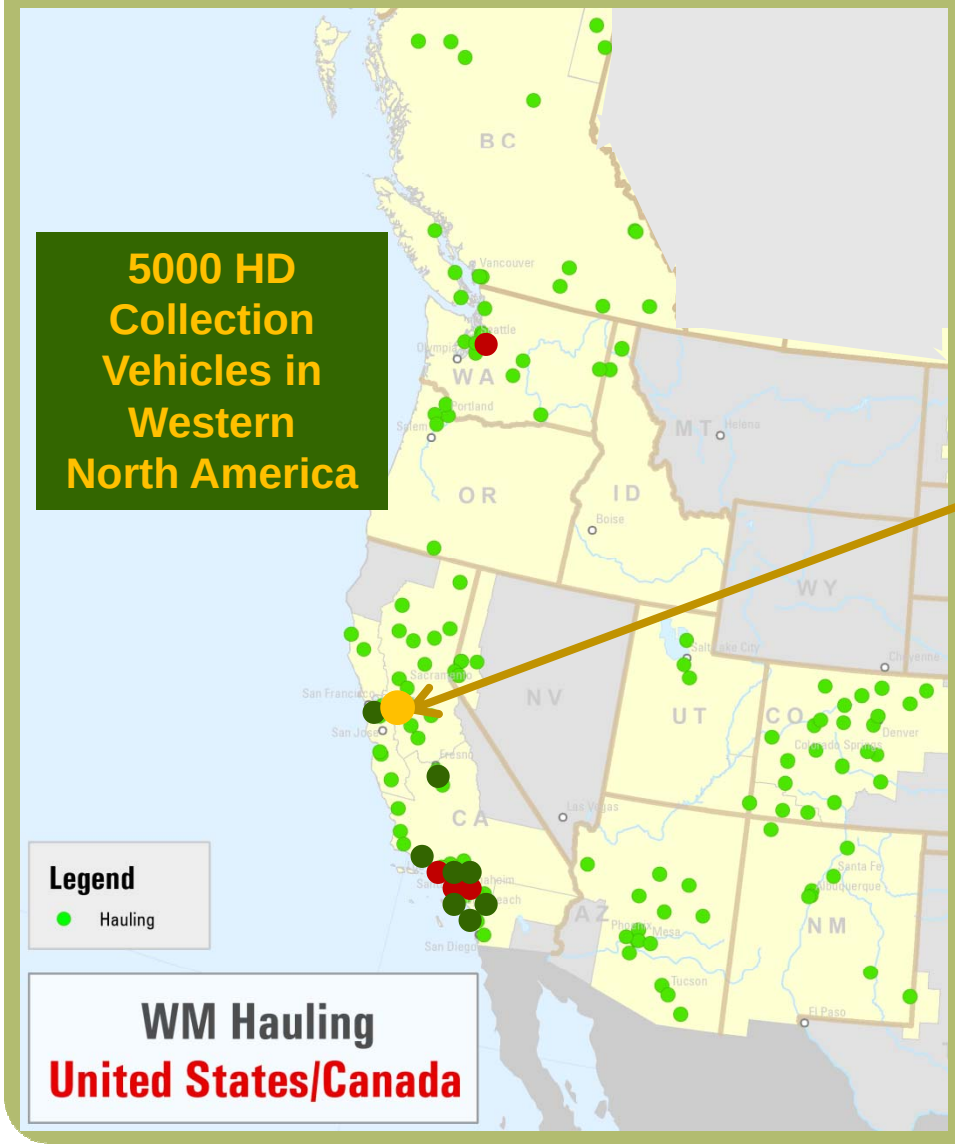
367 WM Hauling Districts in North America

19,000 HDVs in North America

- 5000 HDVs in West
- 3000 HDVs in California
- 1000 NG HDVs ~ 5%



WM West Group Hauling Districts



- 5 CNG Facilities
  (10 in construction process)
  - 500 Trucks
- 9 Bio/LNG Facilities
  (2 are LCNG)
  - 500 Trucks
- Altamont Bio-LNG Facility
  - 13,000 Gal/day of Bio-LNG
- 5 LCNG Facilities in development

WM's CA Natural Gas Fleet (31% and growing!)

WM's California Truck Fleet:

- *Diesel – 2200*
- *LNG/CNG – 1000*
- *Total -- 3200*

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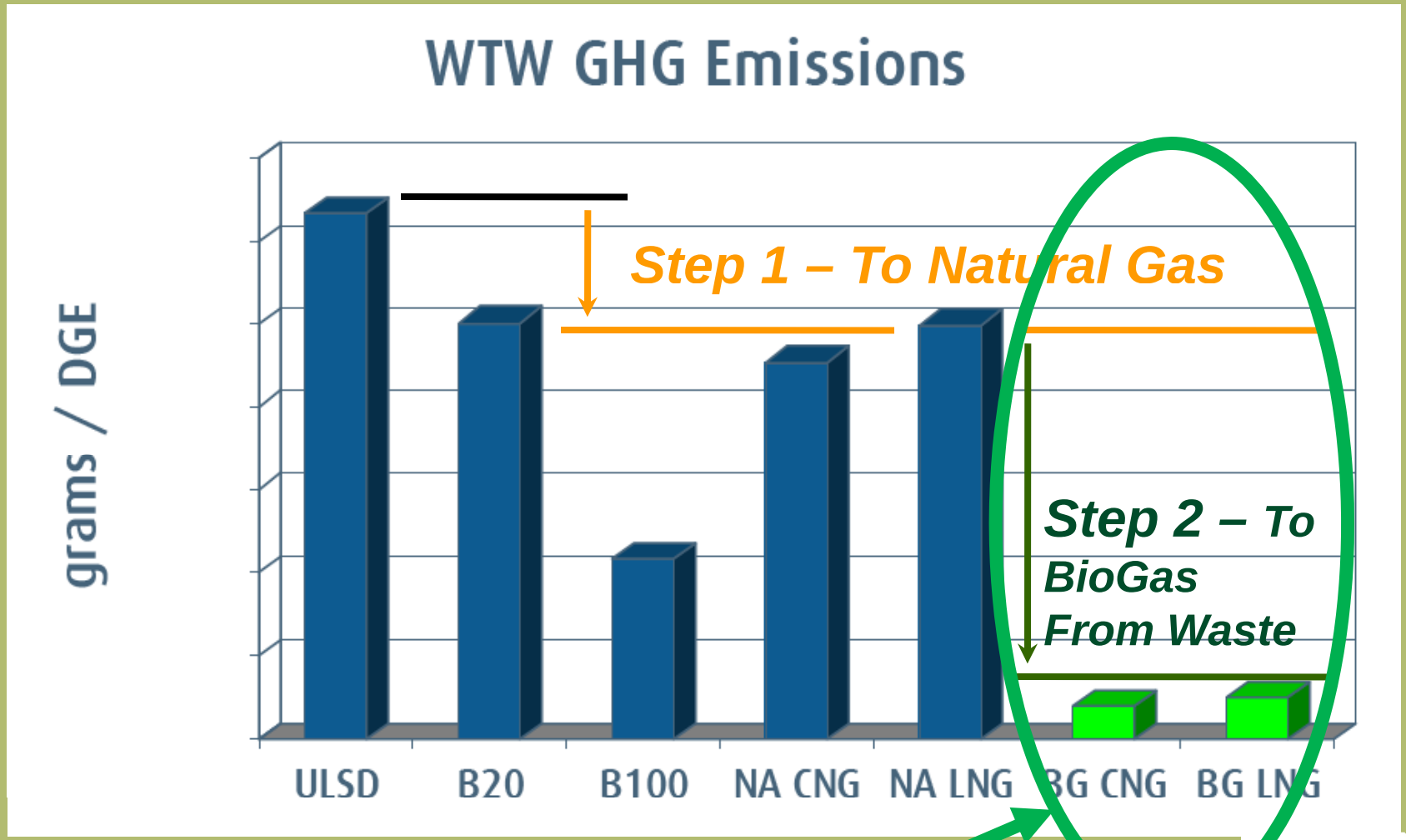
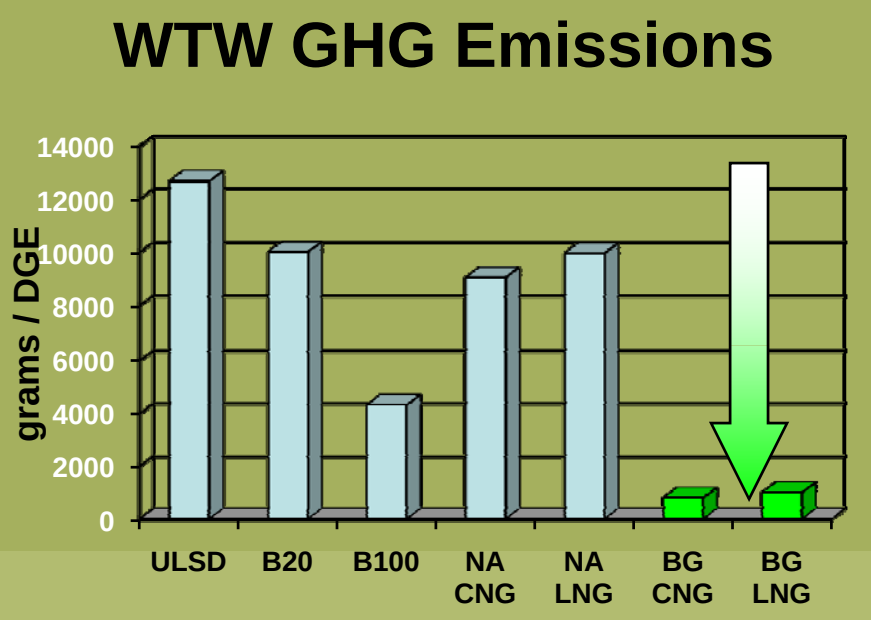
Carbon Intensity of Alternative Fuels



WOW !! Look at Biogas !!

Gee . . . Where Can We Find BioGas ?

- It's available from
  - landfills
  - anaerobic digestion of animal, food, sewage, & crop waste
- Can be upgraded to hi-purity bio-methane (& other fuels)
- Very low greenhouse gas emissions
- Can displace 10 billion GGE per year (DOE estimate)
  - GHG emission reductions equal to taking 90 million light-duty vehicles off the road



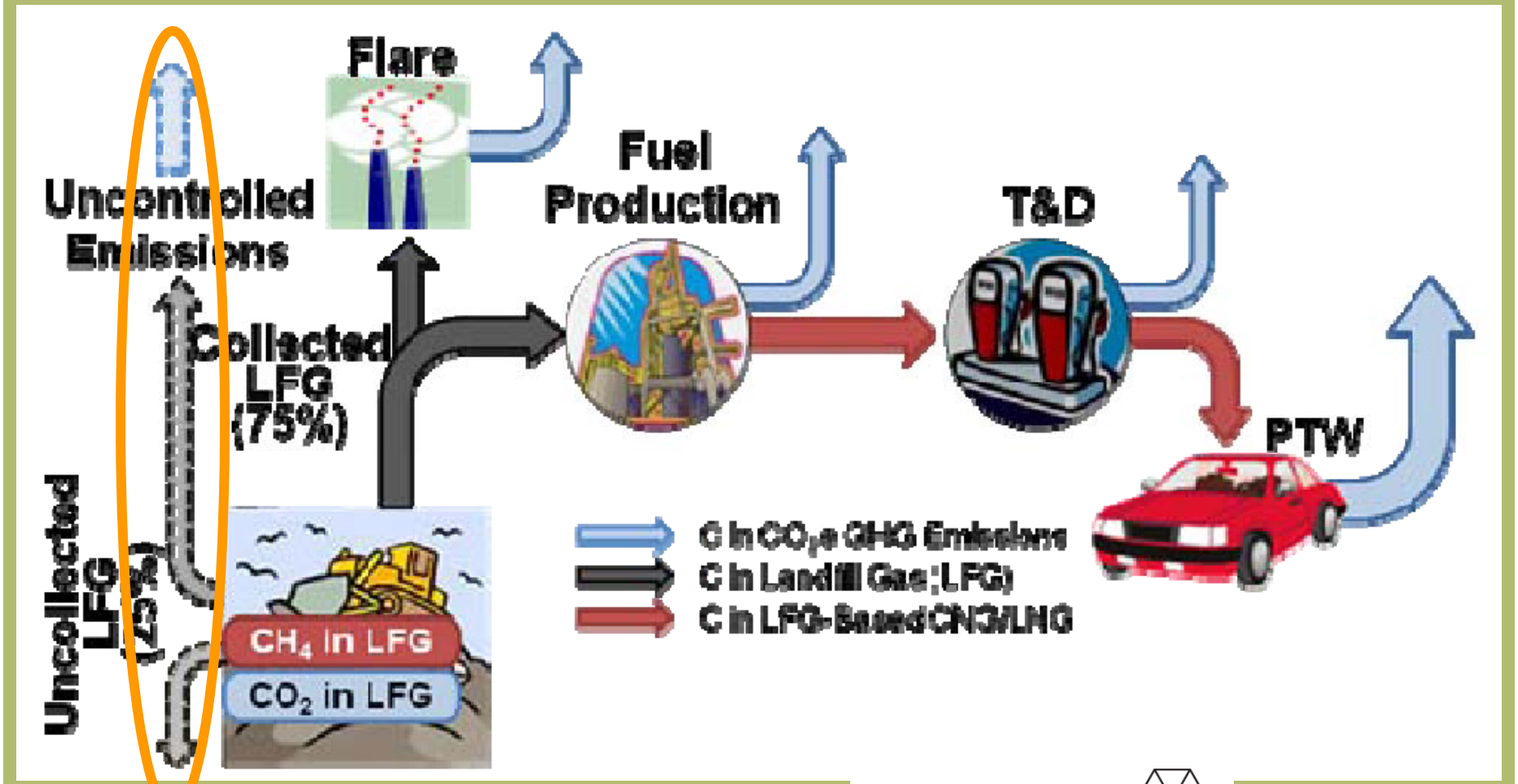
Landfill Gas: The Low Hanging Fruit

- **Landfill Anaerobic Decomposition of Organic Waste = Biogenic Gas**
- **Gas is about 1/2 METHANE and *1/2 CARBON DIOXIDE***

Landfill Gas Collection System

- ***Nitrogen and Oxygen* introduced by air intrusion + *additional impurities (NMOCs)***
- **450 to 550 BTU per cubic foot of landfill gas**
  - **Medium BTU gas**

LCFS Life-Cycle Assessment of LFG to LNG



What About Fugitive Emissions?

Source: Argonne NATIONAL LABORATORY

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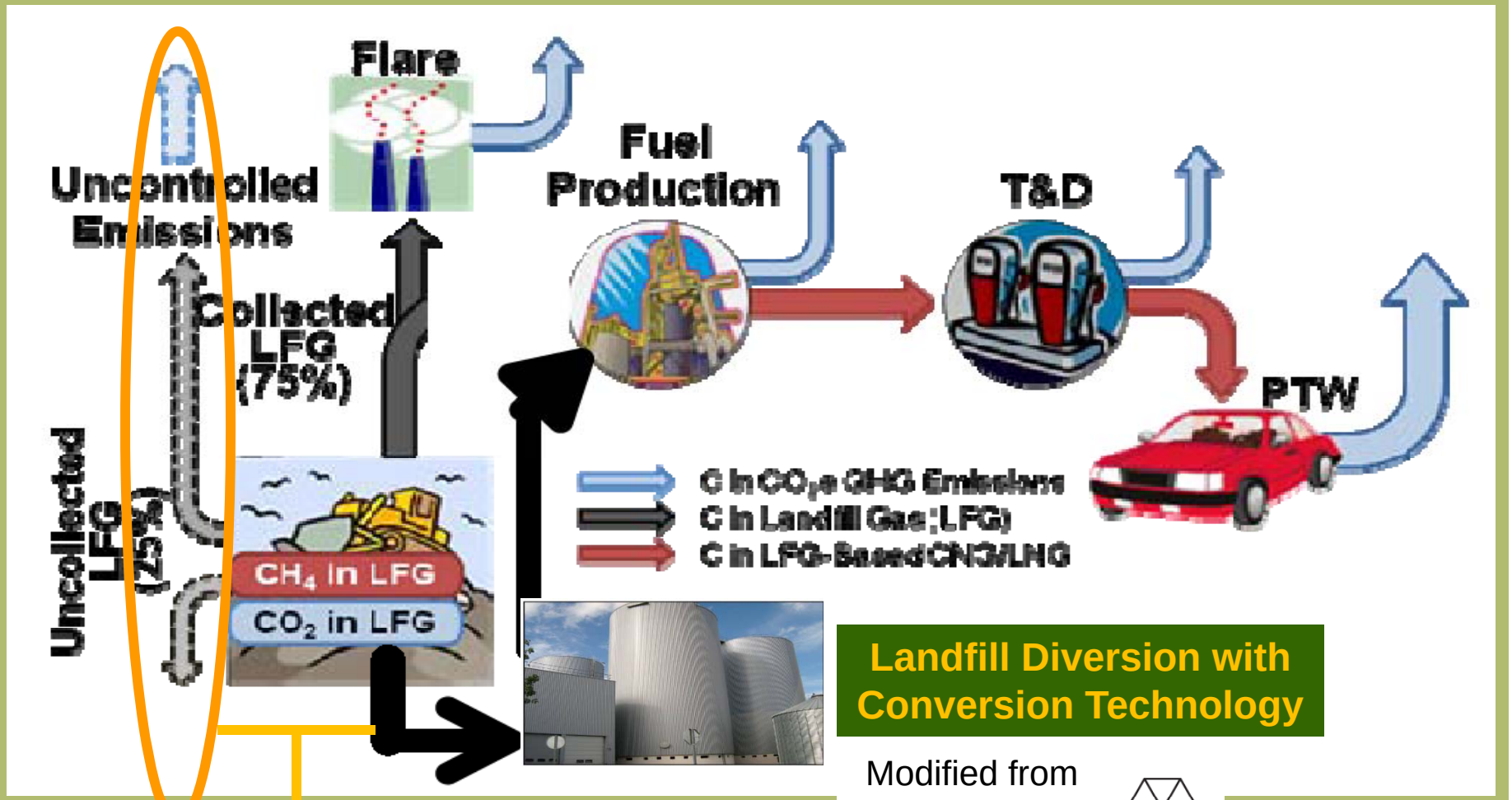
Comparison of LCFS Fuel Carbon Intensities (gCO2e/MJ)

Fuel Type	Direct WTW Emissions	Indirect Emissions	Total Emissions	% of Diesel
Gasoline (CARBOB)	95.86	0	95.86	101
Diesel (ULSD)	94.71	0	94.71	100
Ethanol (Midwest WetMill Coal)	90.99	30	120.99	128
Ethanol (Dry Mill Proprietary)	43.20	30	73.20	77
Ethanol (Brazillian Sugarcane)	12.40	46	58.40	62
Biodiesel (Midwest Soybeans)	21.25	62	83.25	88
Biodiesel (Waste Cooking Oils)	***15.84***	***0***	***15.84***	***17***
Biodiesel (Waste Corn Oil)	***5.90***	***0***	***5.90***	***6***
Renew-Diesel (Waste Tallow)	***19.65***	***0***	***19.65***	***21***
CNG (NA Fossil, CA Compressed)	68.00	0	68.00	72
Renewable CNG (Landfill)	***11.26****	***0***	***11.26****	***13****
Renewable LNG (Landfill)	***15.56****	***0***	***15.56****	***16****

*** Assumes use of Grid Power, Not Site Power. Use of Onsite LFG Power should lower CI by additional ~10%**

Are Even Lower Carbon Fuels Possible?



Landfill Diversion with Conversion Technology

Does Diversion of Waste From LF Result in Avoided Emissions as part of LCFS?

Modified from Original:

Argonne NATIONAL LABORATORY

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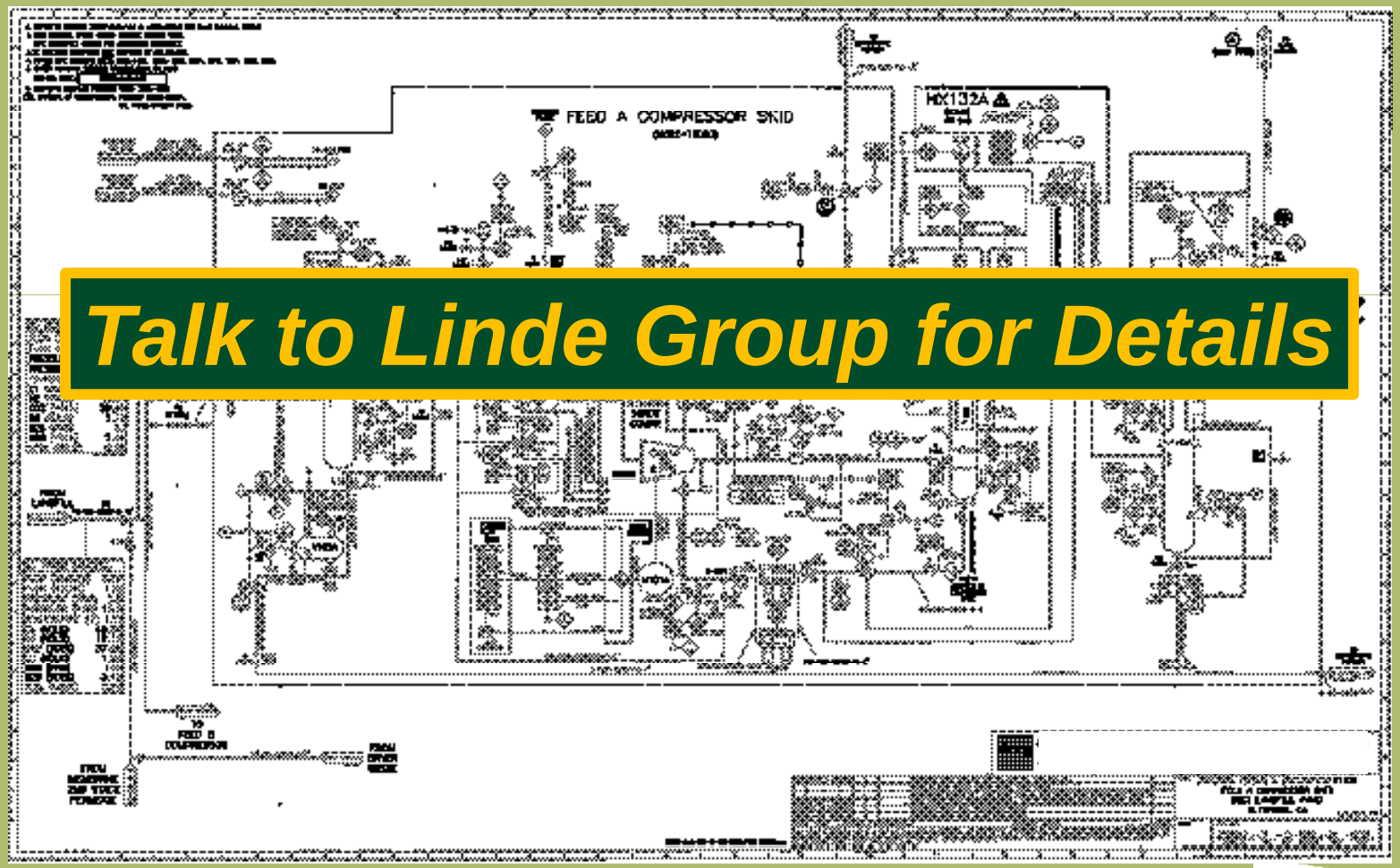
LFG to LNG

$2 million government funding -CIWMB, CARB, CEC, SCAQMD

- **Recovery and Utilization of Biomethane Landfill Gas for Transportation Fuel**
- **Altamont Landfill & Recycling Center, Fall 2009**
- **$15.5 million capital investment**
- **13,000 Bio-LNG Gallons/day**
- **Low Carbon Fuel" – lowest in CA**
  - **5% carbon intensity of diesel**
- **Largest effort to introduce onsite liquefaction for landfill gas recovery in North America**
- **Utilize biogas resources and displace fossil fuels**
- **2nd Plant being considered for SoCal**

Process & Instrument Diagram



Talk to Linde Group for Details

Bottom Line: It's Complicated & Expensive

Challenges . . . . . And Solutions

- Aligning multiple unit operations → Robust design and commissioning plans
  - Going from ~50% CH_4 → 96%+ CH_4
- Reducing CO_2 from ~50% to < 50 ppm → Polishing using Molecular Gate adsorbent
- Variable NMOC species and amounts → Multi-stage design
- Efficiently liquefying NG on a small scale → Gas Technology Institute design and heat exchanger developments

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The High Mountain Fuels Partners

Bio-methane Production

LNG Production and On-site Storage

Logistics/ Distribution

Fueling

LNG Consumption

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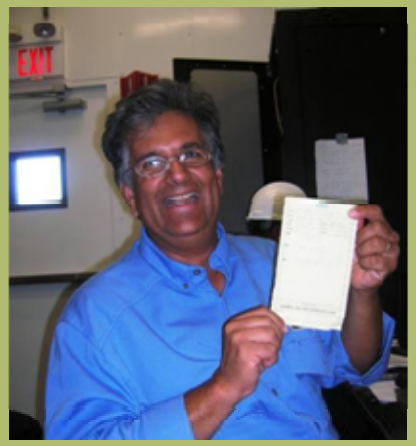
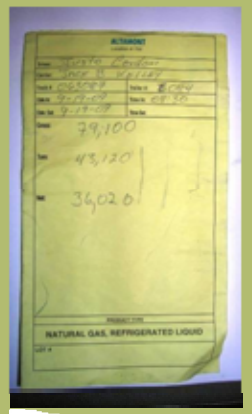
High Mountain Fuels Milestones

- Over 2.7 million gallons produced
- With proven maximum sustained production ~14,000 gpd
- Consistent uptime of >80%
- Plant efficiency is better than expected
- Numerous awards
  - EPA LMOP
  - East Bay Clean Cities
  - California Governor
  - Climate Change Business Journal
- Evaluating a larger, technically more advanced plant in southern California
  - CEC funding awarded





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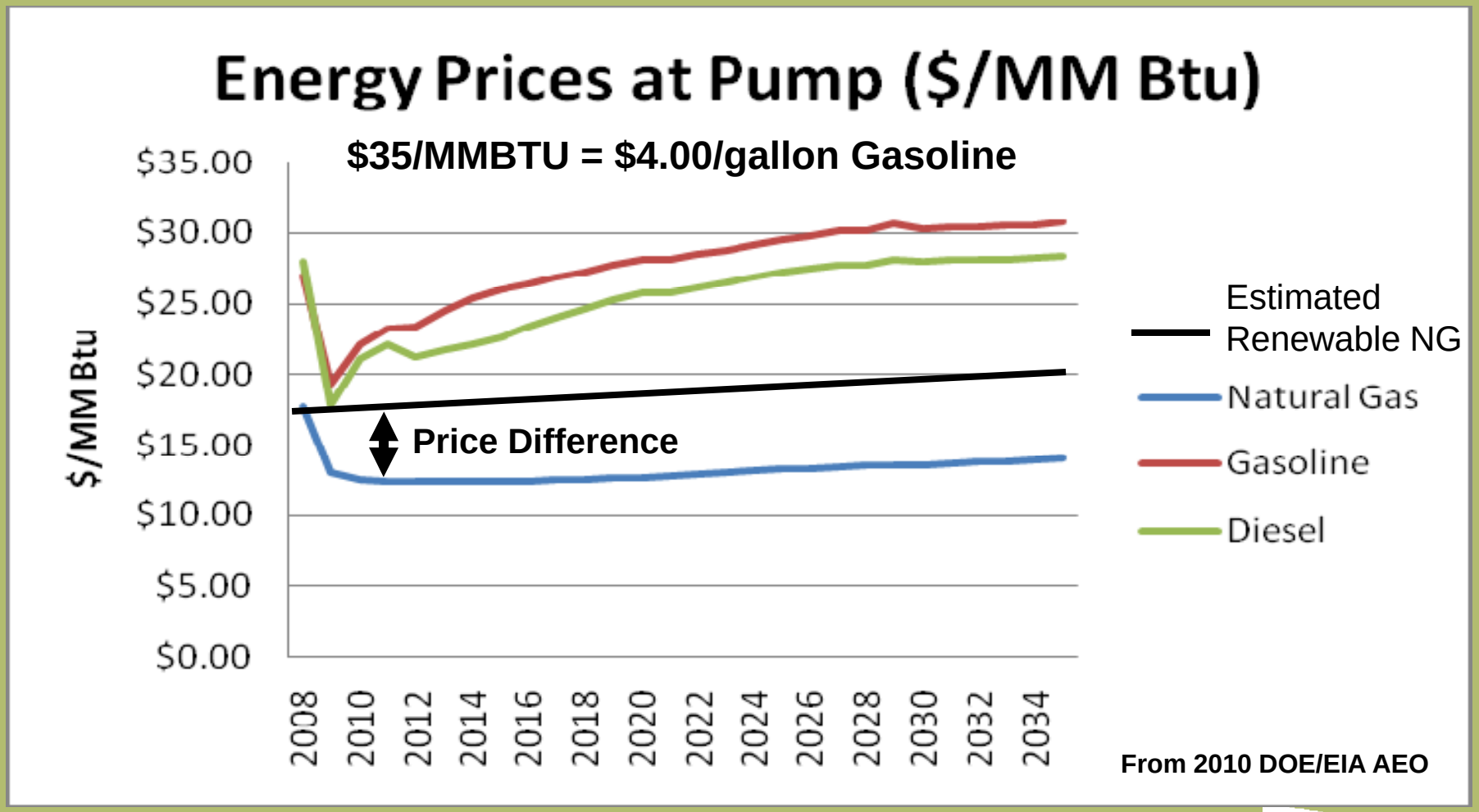
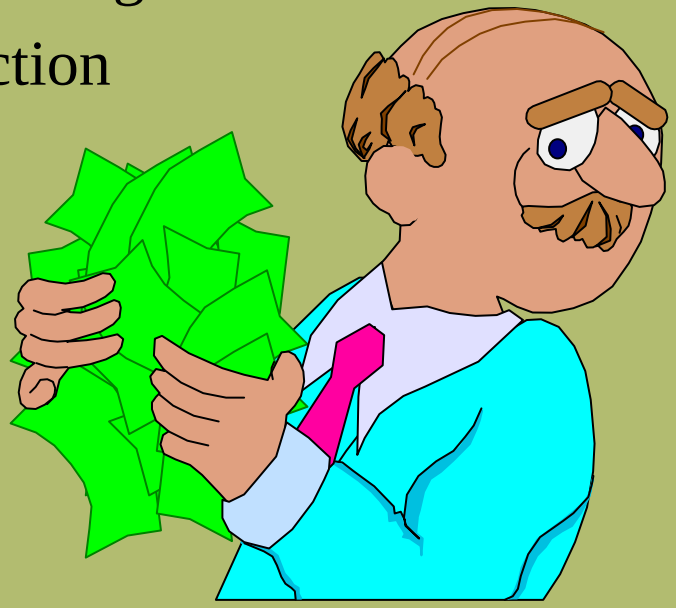
Fossil Fuel Prices: Opportunity or Challenge?



Note: Estimates for approximate example only.
Does not reflect high petroleum price scenario.

What does RFS/LCFS mean to Altamont RLNG?

- 13,000 Gallons of RLNG/day = 4.75 million gallons/yr
  - = 400,000 MMBTU/yr @ 84,000 BTU/gal
  - = - 33,300 MTCO2e/yr GHG Reduction
- What is the Value of RFS (RINs)?
  - @ $0.60 per LNG gallon
  - = $7/MMBTU
- What is the Value of the LCFS?
  - @ $15/MTCO2e = $1.25/MMBTU
- What is the Value of the Fuel?
  - $7/MMBTU + $1.25/MMBTU = $8.25/MMBTU
    - Fuel Value = $4.50/MMBTU ($8- $12 @ pump)
    - ~ Triples the basic value of the fuel



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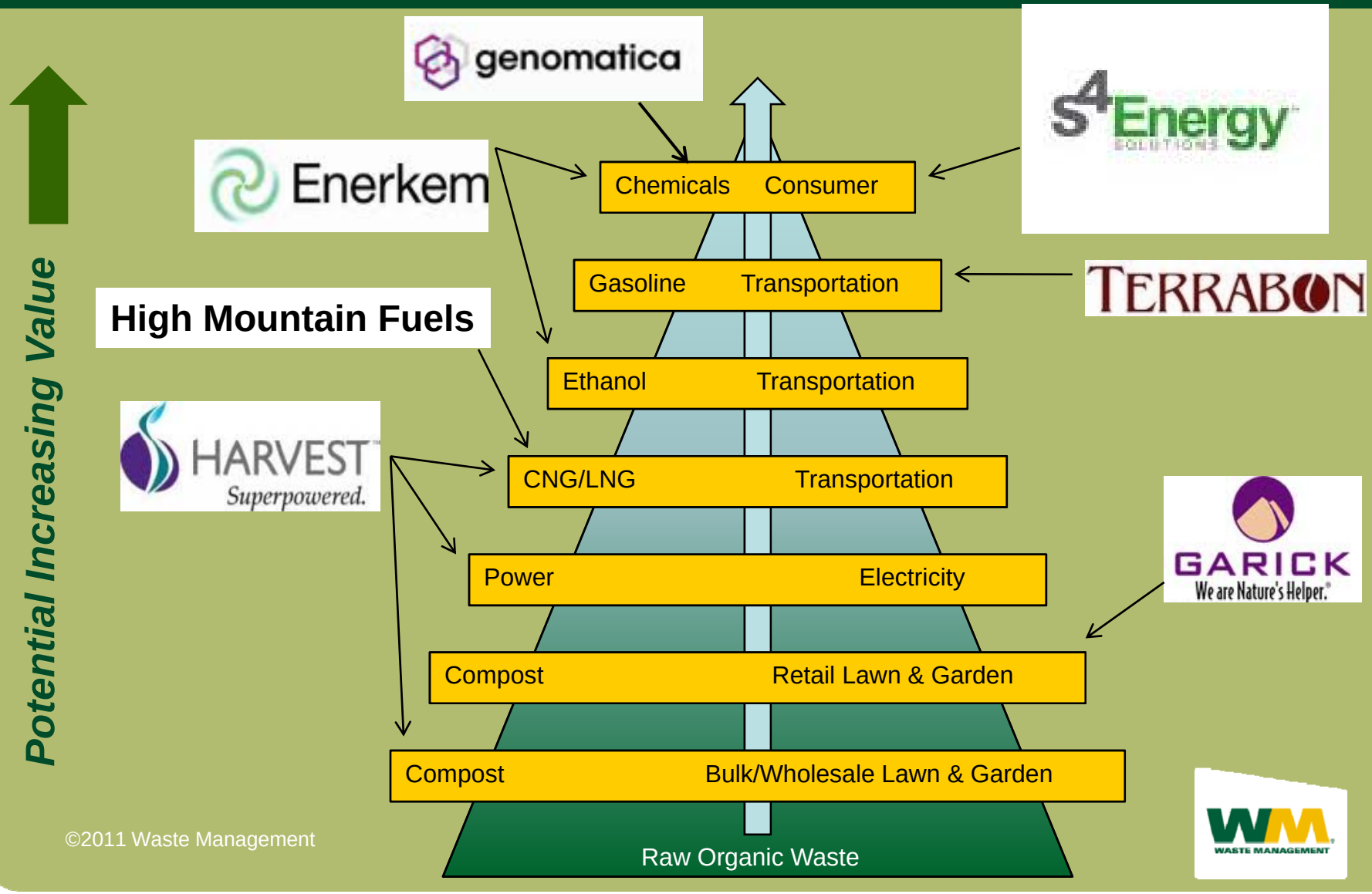
Emerging Organics Technologies



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In Summary . . .

- BioGas Resources are Readily Available
  - landfills & waste materials
- Waste Derived Fuels have ***Lowest*** Carbon Intensity
- Renewable LNG/CNG is cheaper than diesel
  - but more expensive than fossil NG
- RFS-2 and Low Carbon Fuel Standards
  - Can provide supplemental revenue
  - can bridge the gap
- What can Government do to help?
  - Provide incentive programs (AB 118, RFS, LCFS, SB 71)
  - Maintain Predictability

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Any Questions?