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# ***Landfill Gas-to- Energy in California***

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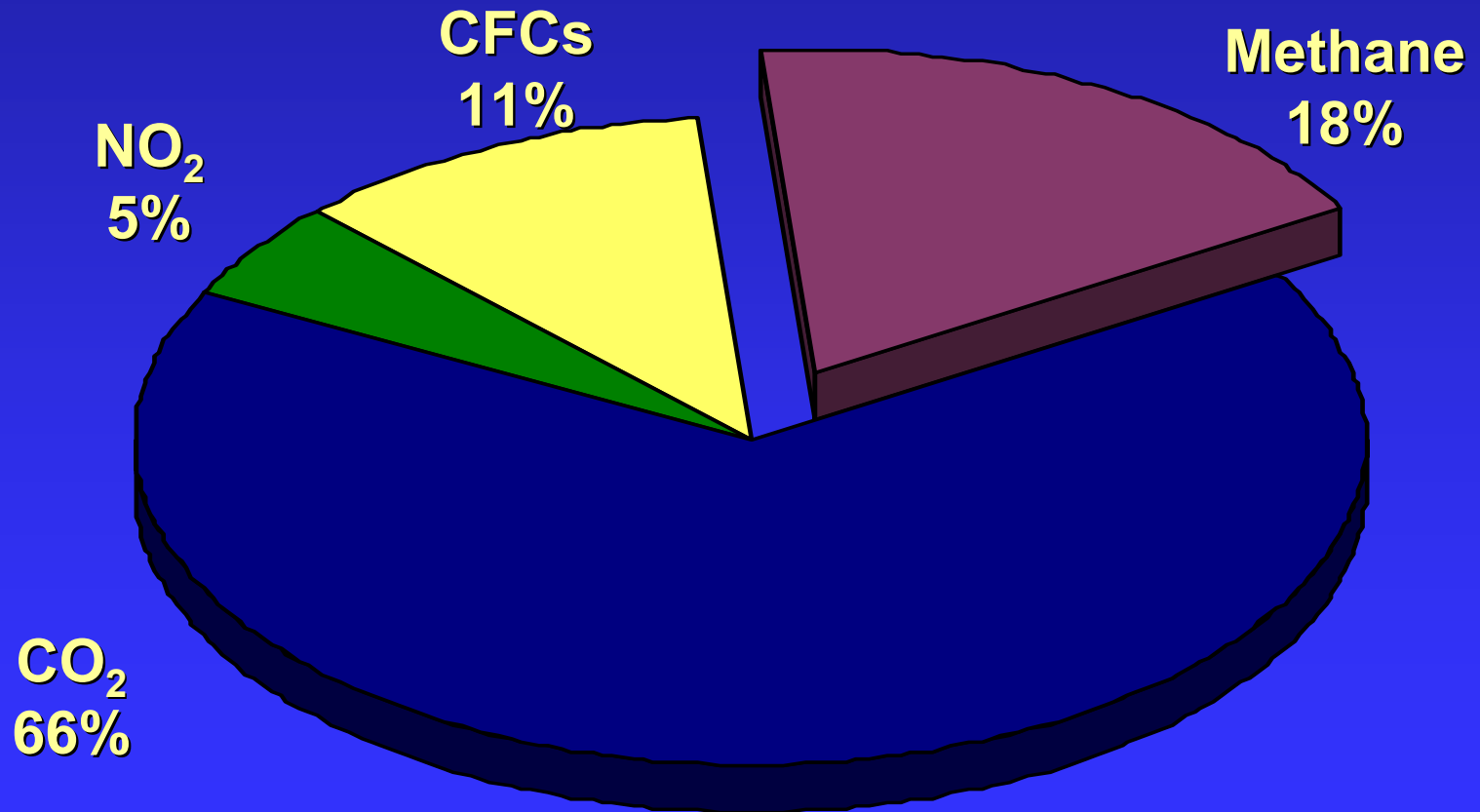
SCS ENGINEERS

Sacramento, California

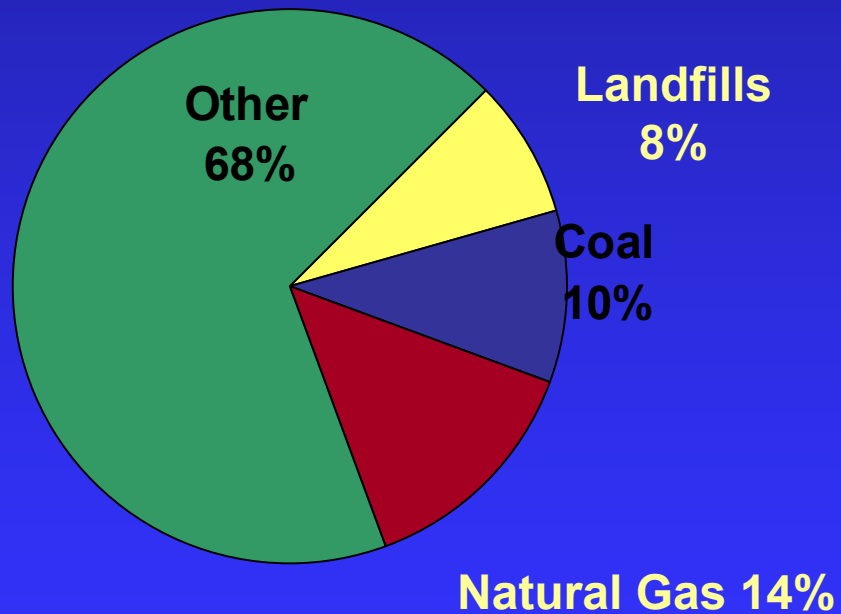
# LANDFILLS AND CLIMATE CHANGE

- Landfills generate landfill gas (LFG) from the decomposition of municipal solid waste (MSW)
- LFG contains approximately ~55% Methane, ~45% Carbon Dioxide, and small amounts of Non-Methane Organic Compounds (NMOCs)
- As such, landfills are major sources of greenhouse gas (GHG) emissions and other pollutants
- But also they have a significant potential for energy recovery and GHG reductions

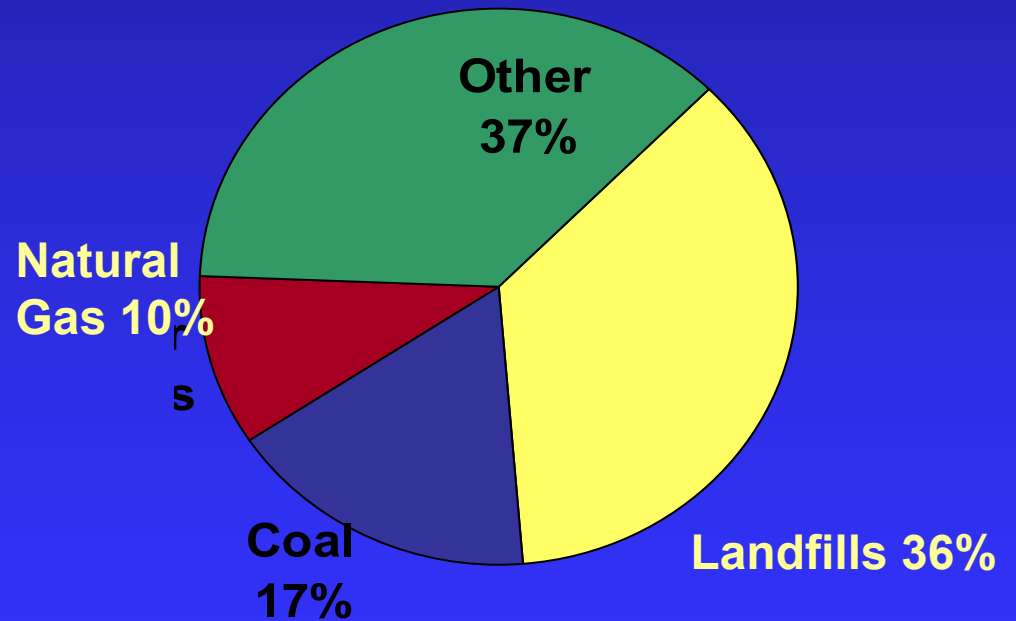
# CONTRIBUTING GREENHOUSE GASES



# ANTHROPOGENIC METHANE EMISSIONS



**Global Sources**



**United States Sources**

# BREAKDOWN OF PROJECTS IN CALIFORNIA

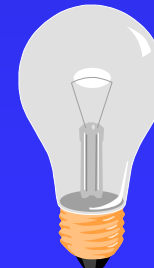
- Over 60 operational facilities
- Over 20 projects under construction or in the planning phase
- Total of approximately 250 MW on-line
- Largest single state = about 20% of national total

# BREAKDOWN (cont.)

- Produce electricity ~65 %
- Direct gas end-use ~25 %
- Pipeline quality upgrade ~2 %
- Specialized applications ~8%  
(e.g., leachate evaporation, vehicle fuel, etc.)

# LFG COLLECTION AND CONTROL

- Required due to air quality regulations, odor concerns, and/or LFG migration
- Reduces greenhouse gas emissions
- LFGTE projects capture energy from LFG



# OPTIONS FOR LFGTE PROJECTS

- Fuel for I.C. engines, gas turbines, or steam turbines to produce electricity
- Direct use as a fuel for industrial boilers, heaters, etc.
- Upgrade to pipeline quality gas
- Alternative uses



# Energy and Emission Reduction Estimates for Typical Landfills

<b>Electric Generating Potential (MW)</b>	<b>Landfill Size Waste in Place (MM tons)</b>	<b>Estimated Energy Available (MM BTU/yr)</b>	<b>Avoided CO<sub>2</sub> Emissions (tons/yr)</b>	<b>Typical Technology</b>
<b>0.8-1.0</b>	<b>1.0</b>	<b>100,000</b>	<b>7,000</b>	<b>Reciprocating engines</b>
<b>2.5-5.0</b>	<b>3.0-6.0</b>	<b>300,000</b>	<b>21,000</b>	<b>Reciprocating engines or gas turbines</b>
<b>5.0-10</b>	<b>6.0-12.0</b>	<b>428,145</b>	<b>42,000</b>	<b>Reciprocating engines or gas turbines</b>
<b>10.0-20.0</b>	<b>12.0-25.0</b>	<b>856,290</b>	<b>65,700</b>	<b>Gas turbines or steam turbines</b>

# DIRECT GAS SALES

- Simplest technology
- Most cost-effective
- Gas pumped to nearby customer for use in boiler or other industrial equipment
- Pipelines up to 15 miles
- Becoming more common

# DIRECT LFG USE IN A BOILER



*Industrial  
Boiler*

*Industry Hills*

# ELECTRICAL GENERATION

- Most prevalent
- Electricity sold to utility, nearby customer, or used on-site
- Size: 500 kW - 50 MW (microturbines = 30 or 70 kW)
- Capital: \$800 - \$1,200/kW
- O&M: 0.9 - 1.5 cents/kW-hr

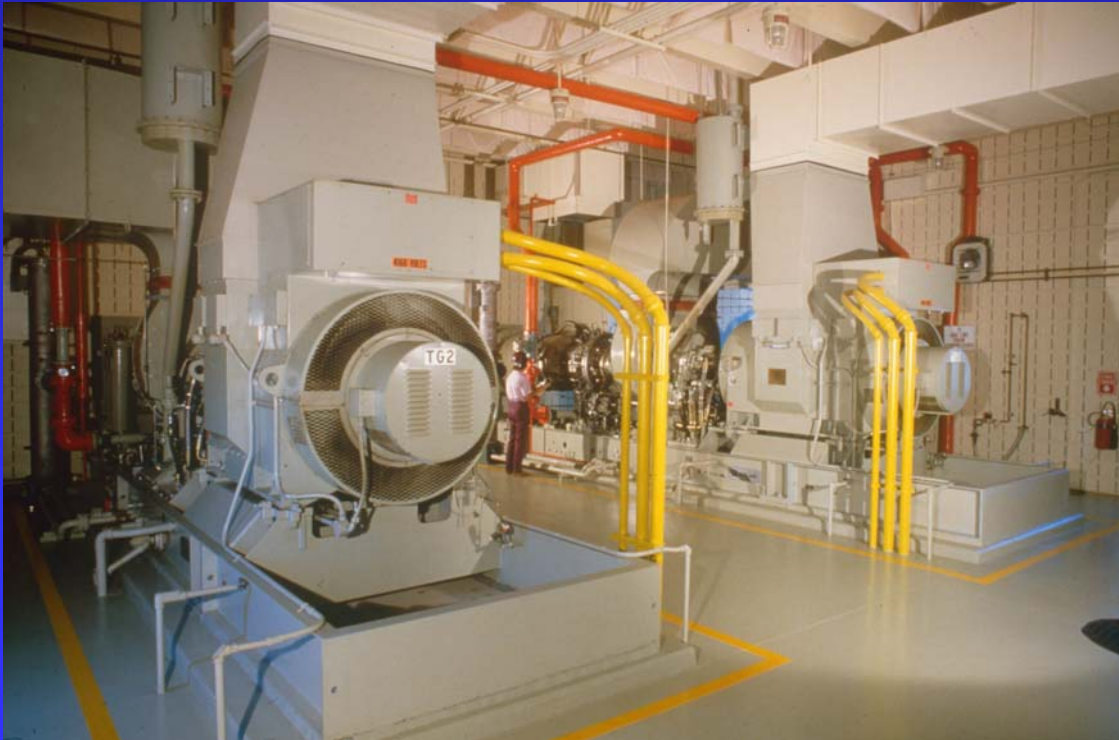
# I.C. ENGINES



*Caterpillar  
IC Engine  
Genset*

*Sacramento*

# COMBUSTION GAS TURBINE



*Solar Gas  
Turbine*

*San Diego*

# STEAM TURBINE



*Steam  
Turbine*

*Whittier*

# PIPELINE QUALITY GAS

- Inject into natural gas pipeline
- High capital costs
- Extensive gas treatment (sulfur, carbon dioxide, and organics removal)
- Conform to strict quality specifications



# Pipeline Upgrade



*High BTU Plant*

*Los Angeles*

# ALTERNATIVE USES

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- On-site Use of Gas
- Vehicle Fuel (CNG/LNG)
- Evaporation of Leachate/Condensate
- Microturbines
- Fuel Cells

# ALTERNATIVE USE PROJECTS



***280 kW Microturbine Plant  
San Diego***



***CNG Vehicle Fuel  
Whittier, CA***

# POTENTIAL OBSTACLES

- No extension of Section 29 tax credits (expire 2002 or 2007)
- No new tax credit under Sections 29 or 45
- Bush Administration not signing Kyoto Treaty
- Inability to get long-term energy contracts
- Air quality permitting can be difficult
- LFG is a “dirty” fuel
- Landfills have not always had the best reputations

# CONCLUSIONS

- LFGTE Industry in California has Long History of Success
- Small Size of Projects Makes Economic Viability Difficult without Incentives
- LFG will get Combusted Anyways Creating Emissions while Wasting Methane
- Even with Environmental Regulations, only a Small Quantity of Generated LFG is Being Collected