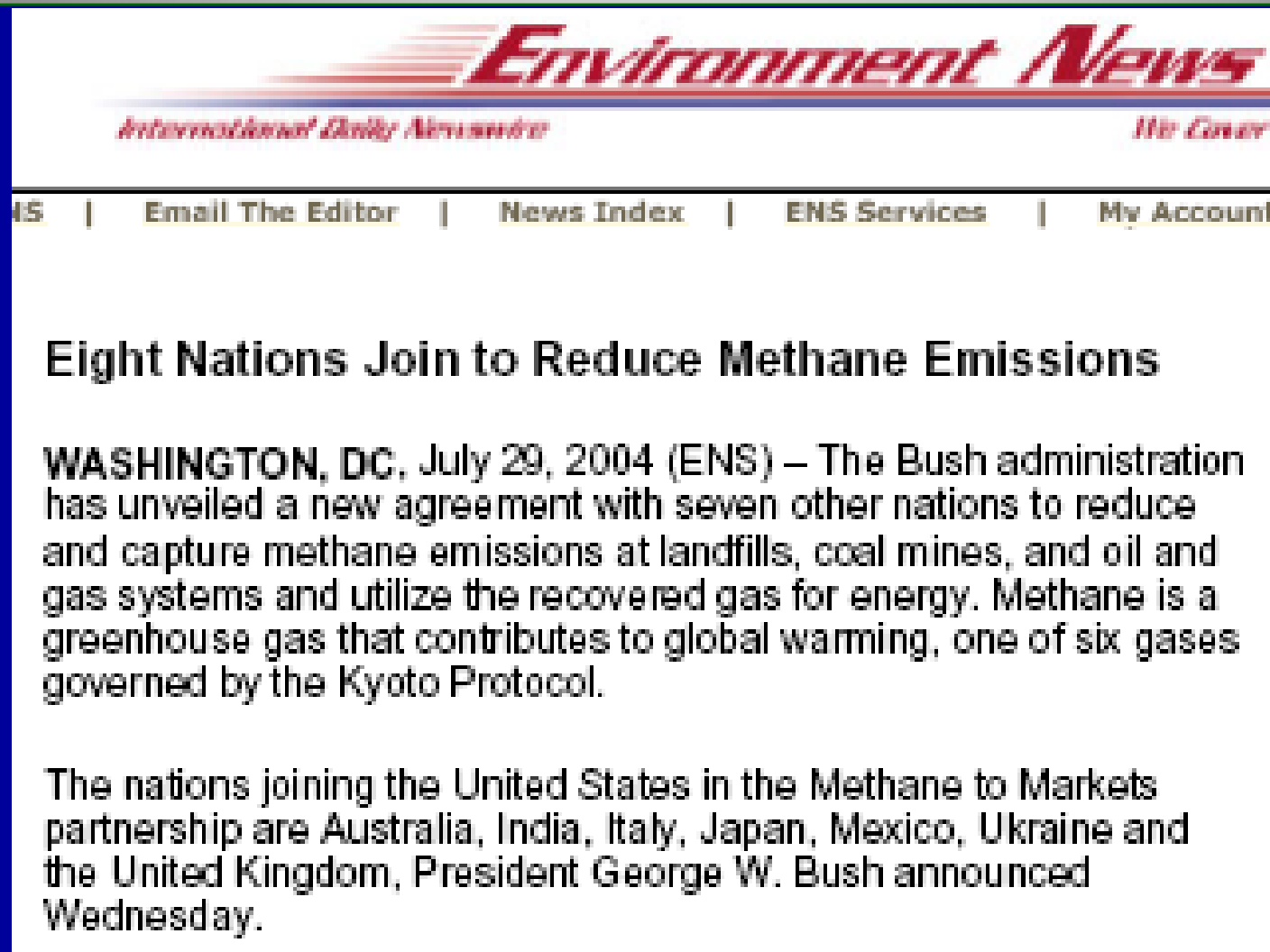


Landfill Gas Direct Use



Al Hildreth

Landfill Gas – Attracts International Attention



The screenshot shows the top portion of the Environment News International website. At the top, the logo "Environment News" is displayed in a stylized red font with a horizontal line through it. Below the logo, the text "International Daily Newswire" is on the left and "The Cover" is on the right. A navigation bar contains links for "Home", "Email The Editor", "News Index", "ENS Services", and "My Account". The main content area features a headline "Eight Nations Join to Reduce Methane Emissions" followed by a paragraph of text and a sub-paragraph.

Environment News
International Daily Newswire *The Cover*

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Eight Nations Join to Reduce Methane Emissions

WASHINGTON, DC, July 29, 2004 (ENS) – The Bush administration has unveiled a new agreement with seven other nations to reduce and capture methane emissions at landfills, coal mines, and oil and gas systems and utilize the recovered gas for energy. Methane is a greenhouse gas that contributes to global warming, one of six gases governed by the Kyoto Protocol.

The nations joining the United States in the Methane to Markets partnership are Australia, India, Italy, Japan, Mexico, Ukraine and the United Kingdom, President George W. Bush announced Wednesday.

What is Landfill Gas?



- Generated when waste in landfill decomposes
- Smells bad, is an explosion hazard, and a potent greenhouse gas
- Contains about 50% methane – the main component of natural gas
- A reliable and renewable fuel source
- If not collected and used, is wasted

Modern Municipal Solid Waste Landfill

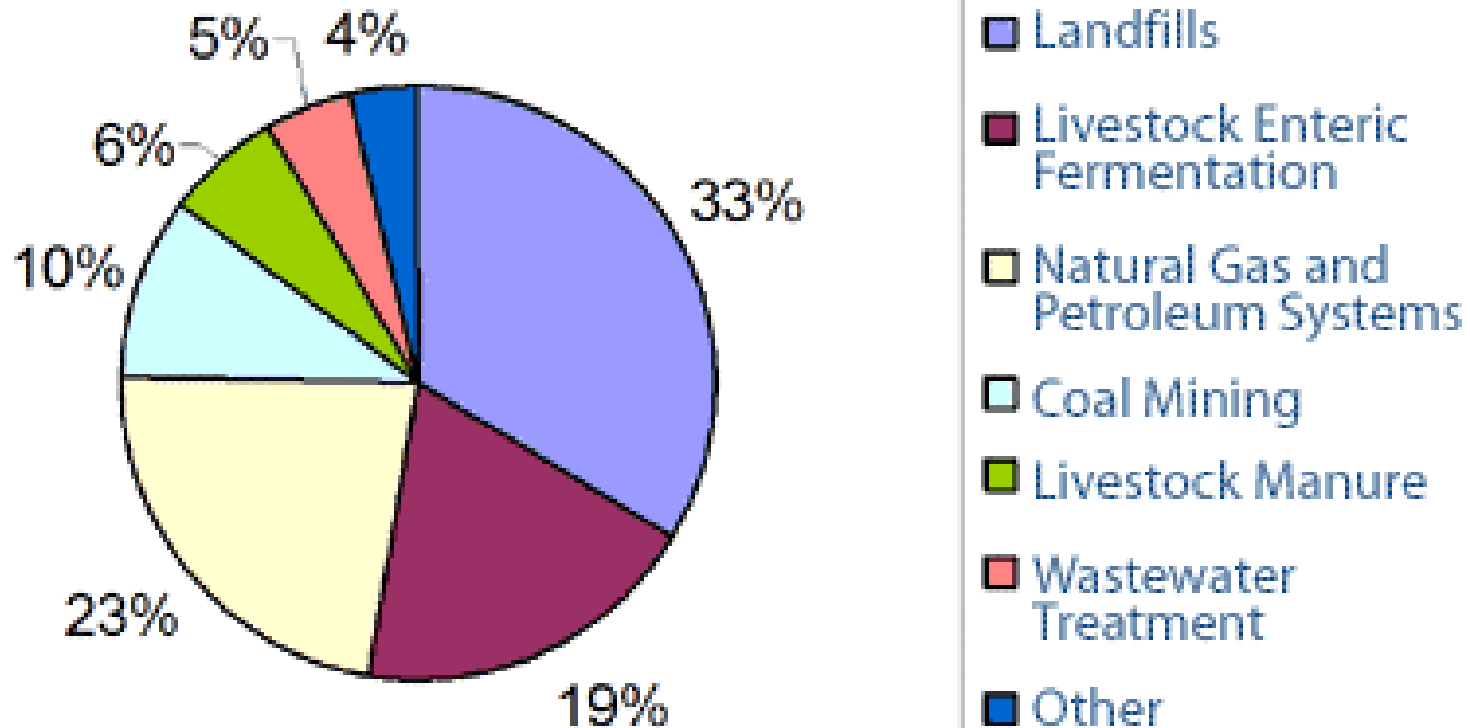


Landfill Gas 101 from EPA

- Landfill gas (LFG) is a by-product of the decomposition of municipal solid waste (MSW)
- LFG:
 - » ~ 50% methane (CH_4).
 - » ~ 50% carbon dioxide (CO_2).
 - » <1% non-methane organic compounds (NMOCs).
- For every 1 million tons of MSW:
 - » ~ 1.0 MW of electricity
 - » ~ 550,000 cubic feet per day of landfill gas
- If uncontrolled, LFG contributes to smog and greenhouse gas, and may cause health and safety concerns

Methane Sources

Human-related Sources of Methane in the US
(% of total methane emissions)



Source: EPA April 15, 2003

LFG Constituents

Component	%
Methane	47.4
Carbon dioxide	47
Nitrogen	3.7
Oxygen	0.8
Paraffin hydrocarbons (HC)	0.1
Aromatic-cyclic HC	0.2
Hydrogen	0.1
Hydrogen Sulfite	0.01
Carbon monoxide	0.1
Trace compounds	0.5

Source: O'Leary & Walsh 2002

Landfill Gas is Collected



← Gas collection well (Orion)



Unused gas is flared

Landfill Gas Can Displace Coal, Natural Gas in Boilers

Landfill gas is compressed, piped underground to GM's powerhouse and burned in boilers



Compressor

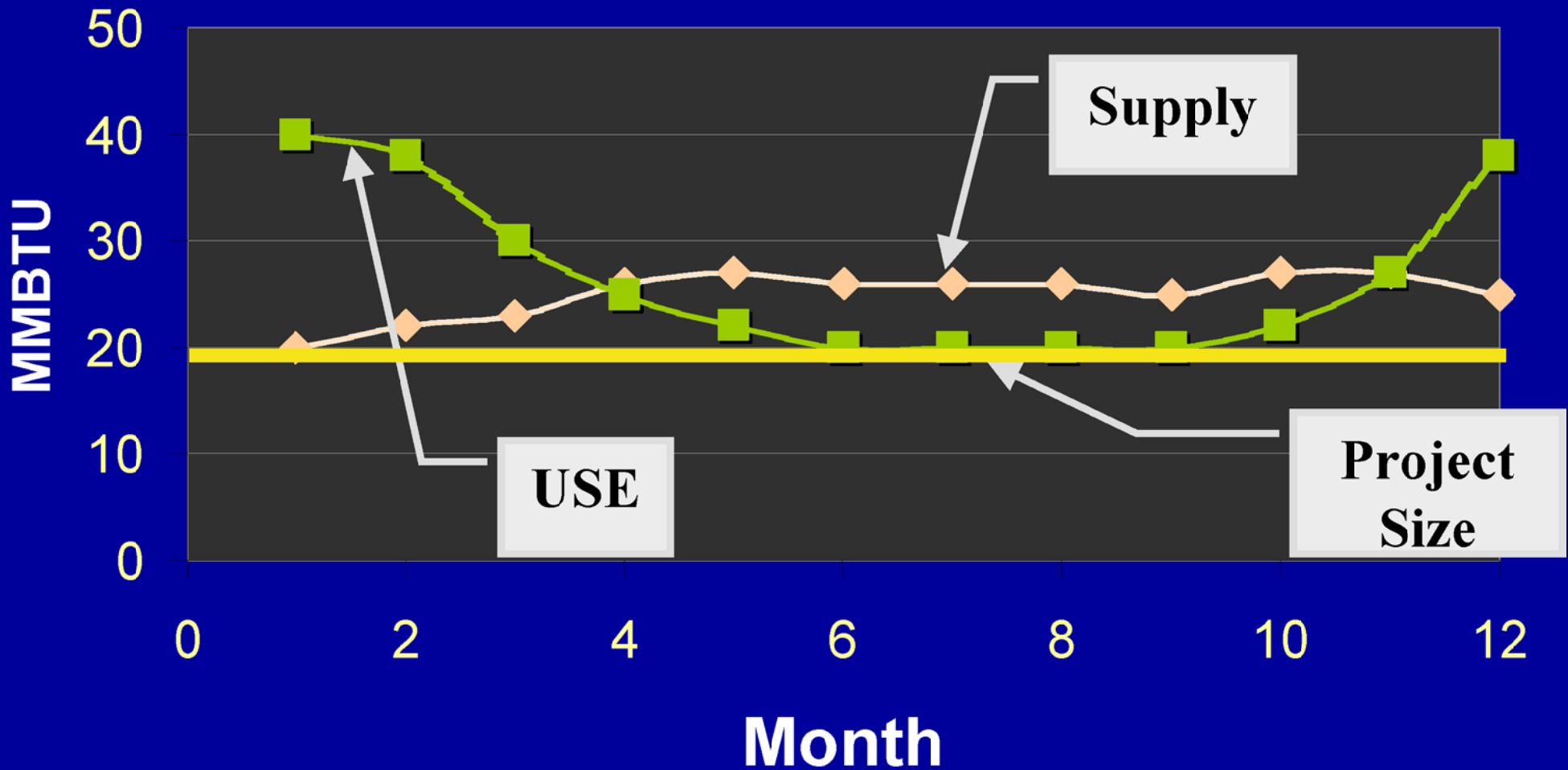
Boiler >



Viabile Landfill site screening

- LFG Output determines distance
 - » <500,000 MMBTU/Yr up to 10 miles
 - » Larger projects – new limit 23 miles
- Long term available LFG supply
 - » EPA's LandGem estimates supply
 - » Waste in Place equation (EPA, 2003)
- Match base load to supply

Match Size to base load use



Environmental

- Benefits
 - » NSPS site – Renewable Energy
 - » Non-NSPS site – reduce Methane
 - Methane 21 times Global Warming Potential
 - » US – Renewable Energy Use / Carbon Markets
 - » Internationally – Certified Emission Reduction credits through CDM
- Permitting Requirements

Quality of LFG

- Removal of Contaminants
 - » Boiler- Refrigerant Drying with filters
 - » Process – Siloxane Removal
 - Activated Carbon most prevalent use
 - » High-BTU Gas or direct-fired use
 - Complicated and costly

Direct Use Equipment

- Boilers – require modifications
 - » Retrofit burners and controls
 - » Dual fuel capability with Natural Gas
- Other combustion sources
 - » Indirect fired heat exchangers
 - » Blend in process heaters
 - » Thermal Oxidizers
 - » Displace natural gas injection

Business Case Evaluation

- Select a landfill and determine optimum output for sale
- Estimate supply and infrastructure costs:
 - » Landfill gas purchase
 - » Wells, filtration, compression, piping
 - » Boiler or Equipment conversion
- Identify Fuel savings basis

Schematic of LFG System

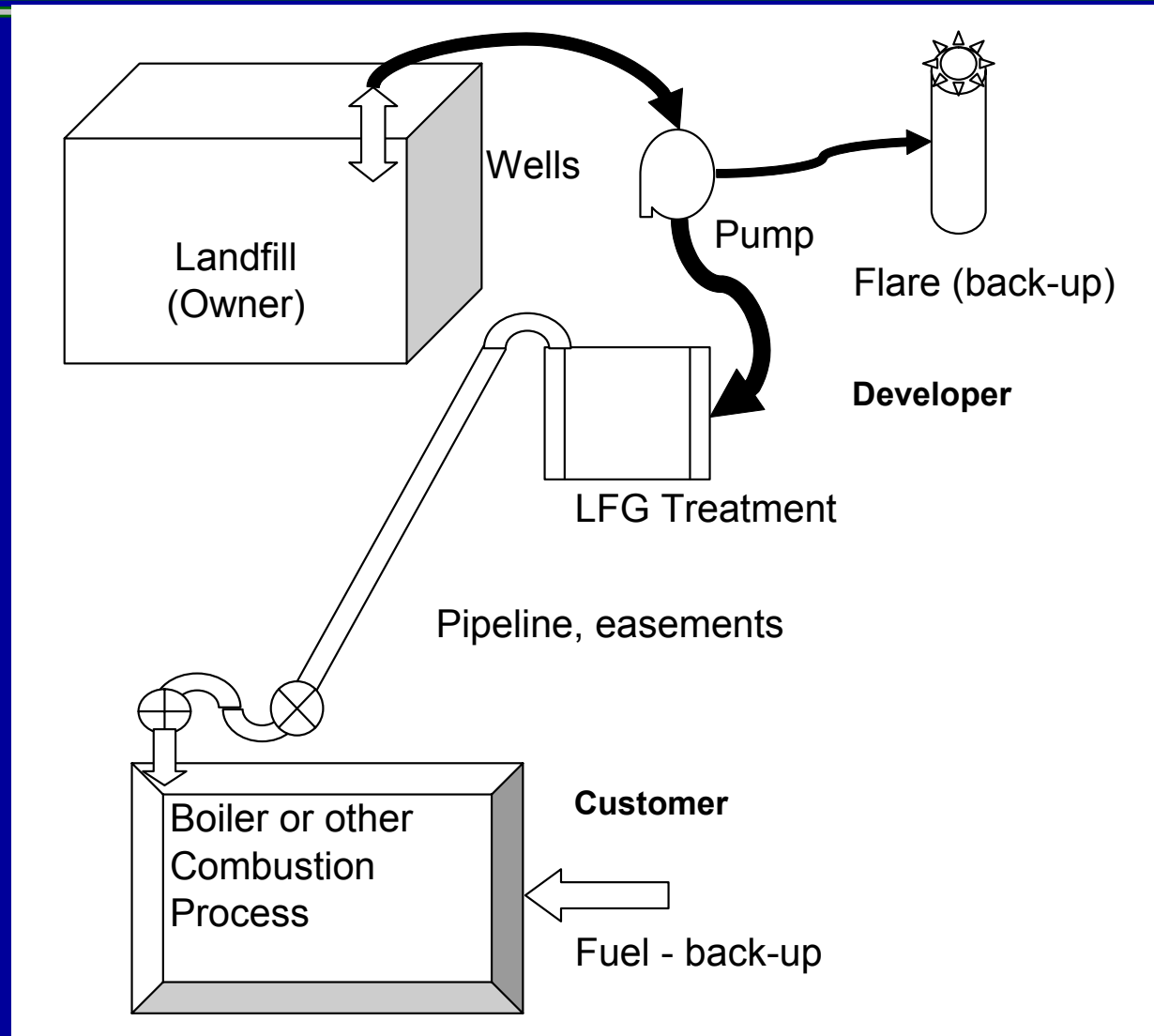
Parties:

Landfill Gas Owner

Developer (possibly)

-construction
-operations

Customer



Example Business Case

- Landfill without collection system
 - » Non-NSPS site with 1.5 MM Tons
 - » Facility is 5 miles from site
- Scope of Project
 - » Landfill is capable of 100,000 MMBTU's per Year
 - » Facility uses 200,000 MMBTU's with base-load from process boilers

Example Business Case

- Estimate LFG from equation
 - » 395 CFM at 500 BTU/ft³
- Estimate project costs
 - » Infrastructure \$ 2.2 M
 - » Boiler conversion \$ 0.1 M
 - » Supply price LFG \$ 0.51/MMBTU
- Fossil Fuel Savings \$
5.68/MMBTU

Business Case Results

- Environmental Benefit of reduced CO₂ –
 - » 48,600 Tons per Year (Renewable + Methane)
- Return on Investment
 - » \$ 2.34 M investment
 - » \$568k / Year savings in expense
 - » Yields about 18% ROI based on 15 Yr.
- Alternative Supply Contract
 - » Purchase price estimate: \$ 3.85/MMBTU
 - » Annual savings of \$185k / Year

Conclusion

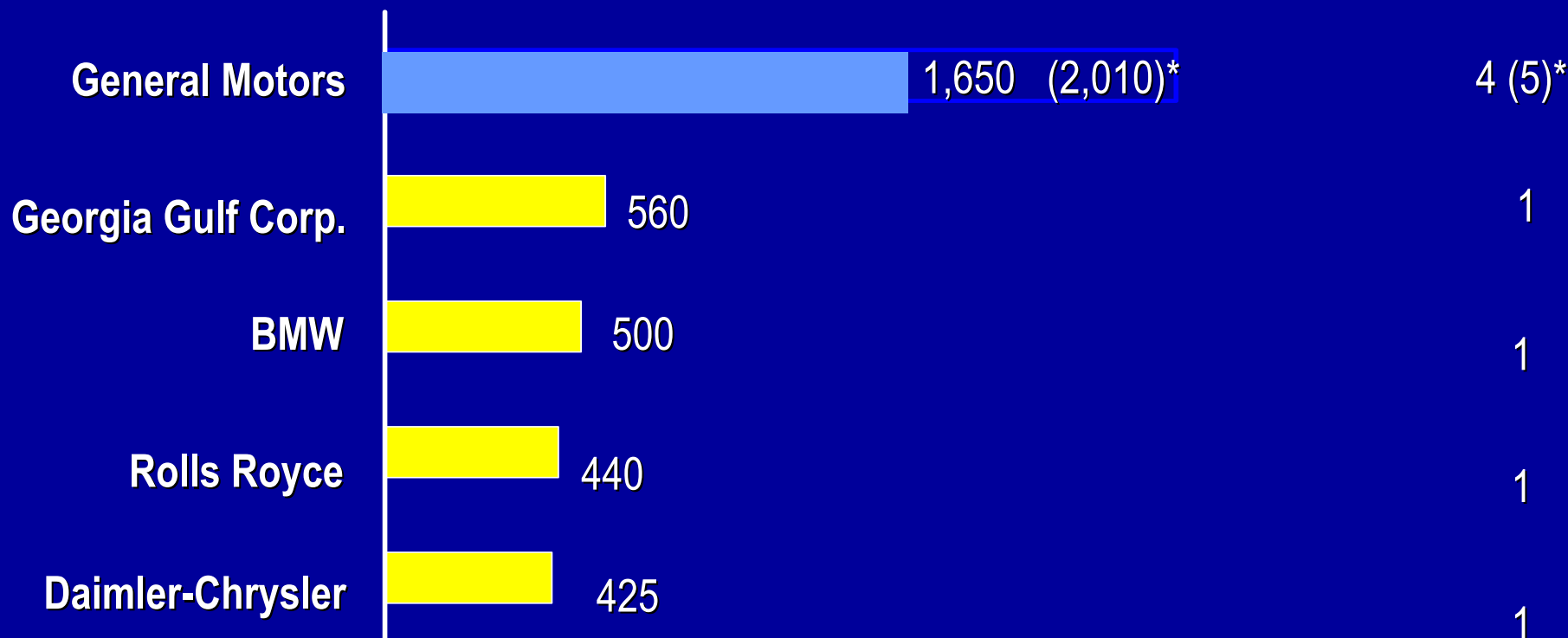
- Landfill Gas can be a significant Greenhouse Gas contributor
- Optimum use is beneficially as a Renewable Energy source
- Understanding of development process enables implementation
- Results: Environmental Benefit and economical feasibility create Win-Win

GM- largest corporate user of landfill gas for Thermal energy in the US in 2003 (WRI)

billion Btu/year

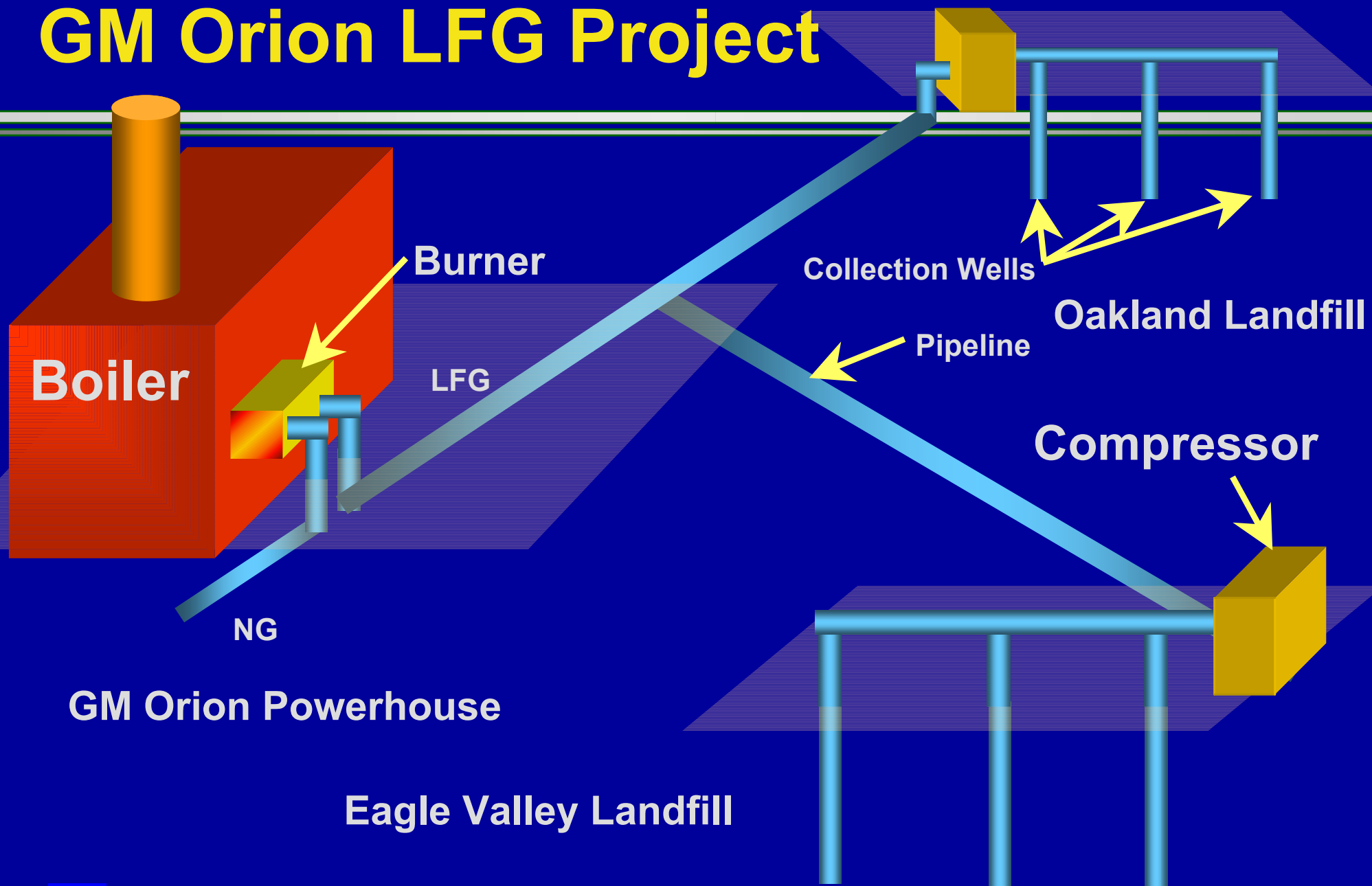
America's "top five" corporate users of lfg in 2003

Number of projects



* Includes Oklahoma City project being announced on September 17, 2003. Operational in 2004
 Source: U.S. Environmental Protection Agency (Landfill Methane Outreach Program)

Example: GM Orion LFG Project



Status of Operational LFGE Projects and Candidate Landfills (EPA)

