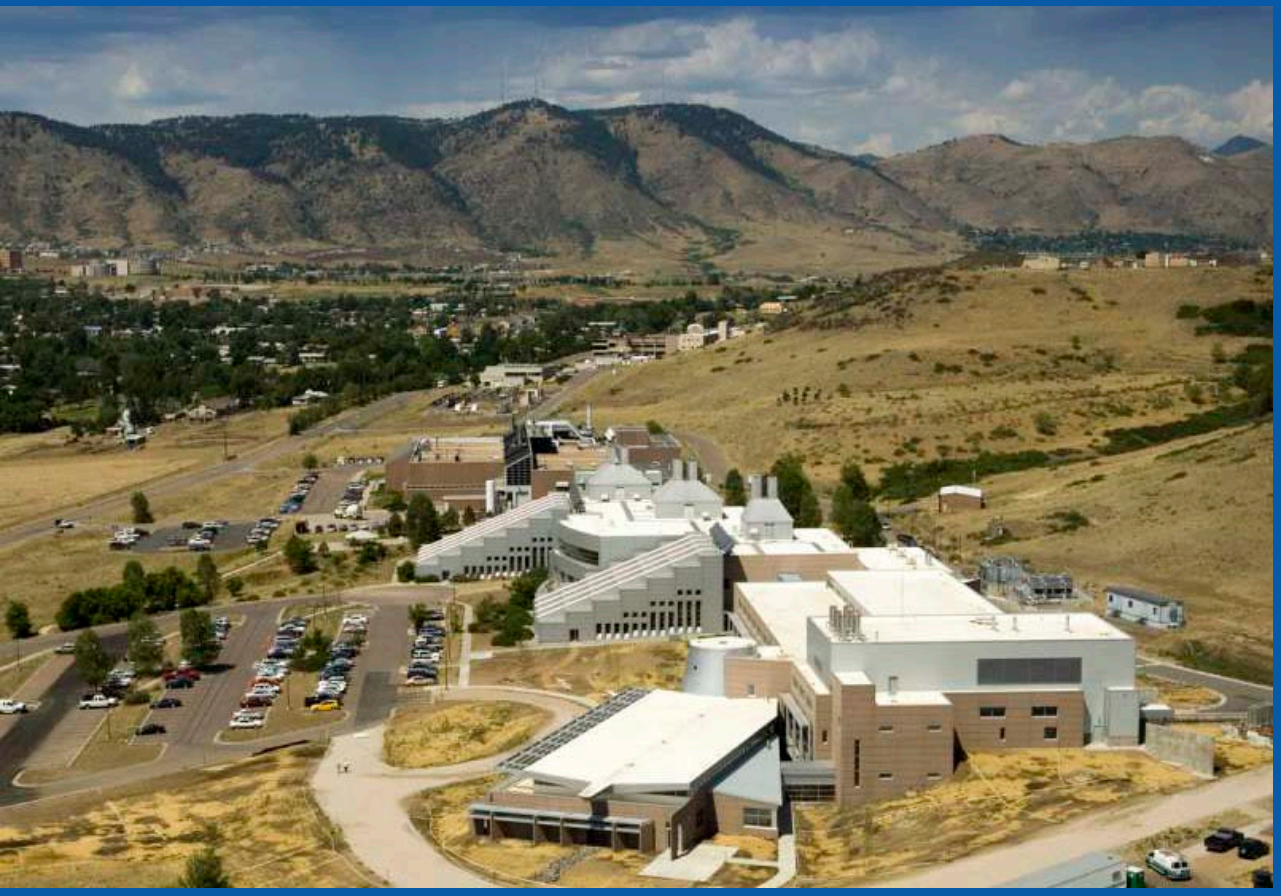
National Renewable Energy Laboratory
*Innovation for Our Energy Future*

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy
FEMP Federal Energy Management Program

# Waste-to-Energy Technologies and Project Development



## DOE-DOD WTE Workshop

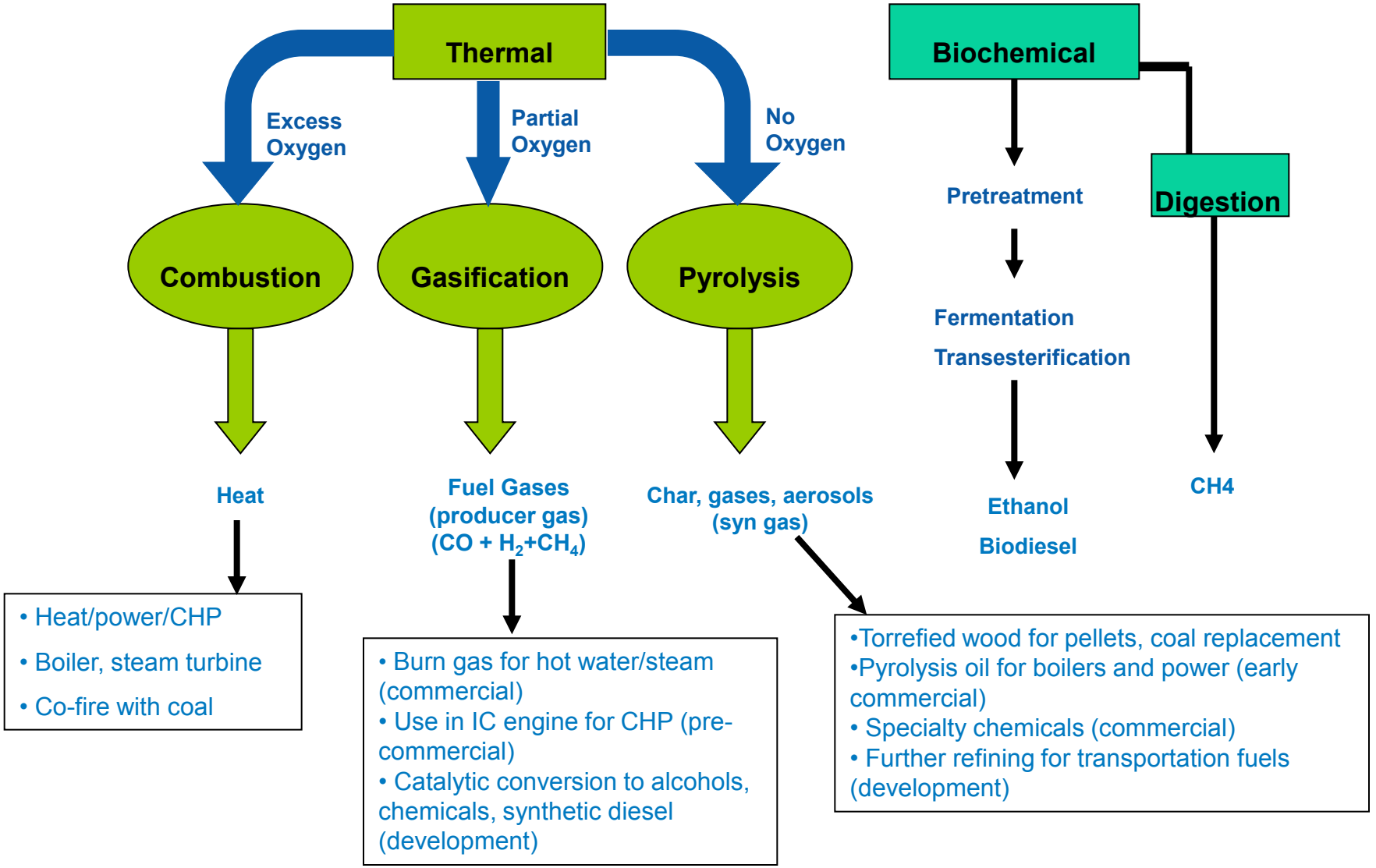
**Jerry Davis**

**July 13, 2011**

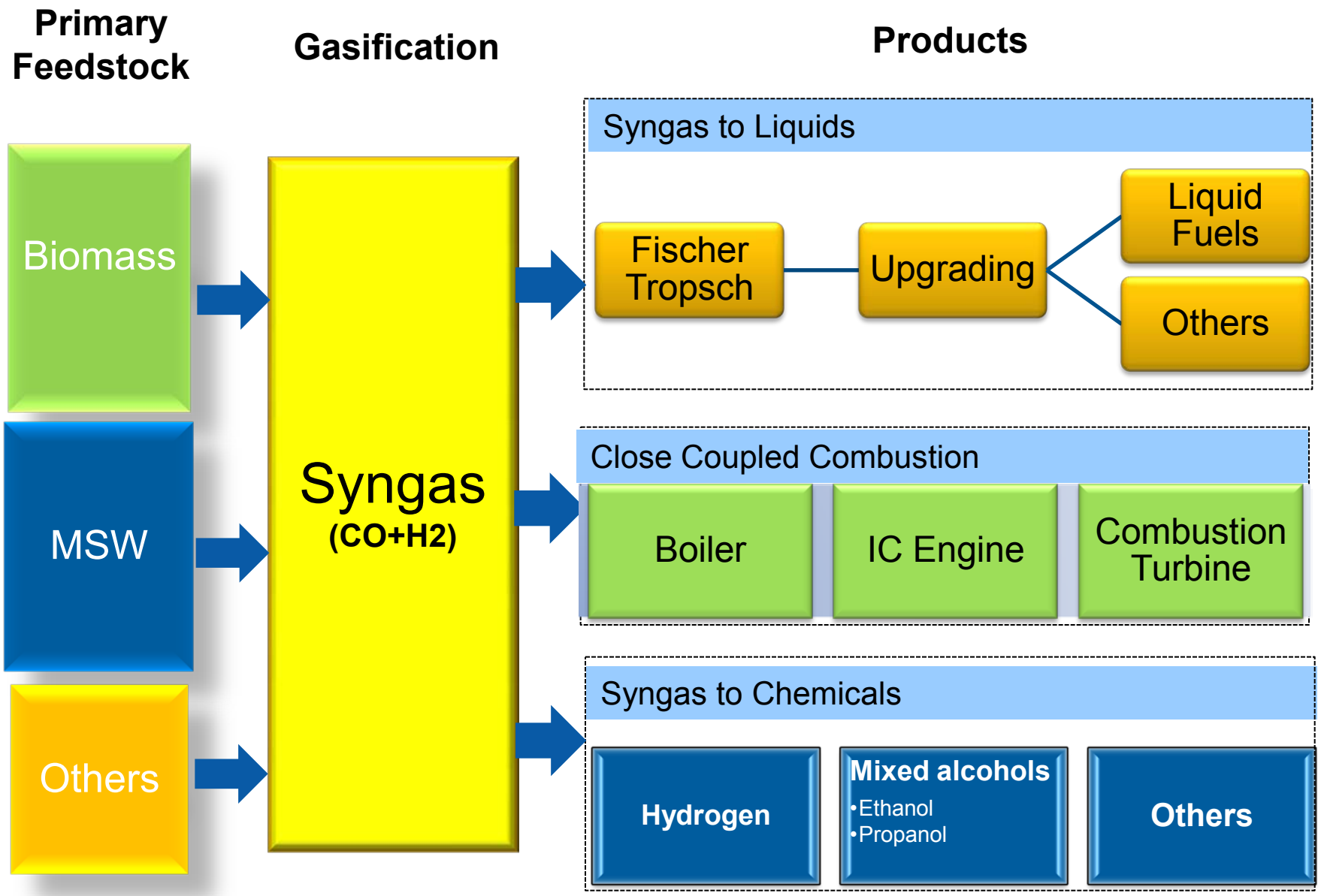
# Overview

- Gasification Technology Overview
- Technology Profile for Gasification WTE applications
- Driving Factors for WTE
- Project Development Considerations

# Energy Pathways



# Gasification Flexibility



# Gasification Overview

**Exothermic/Combustion Reaction**

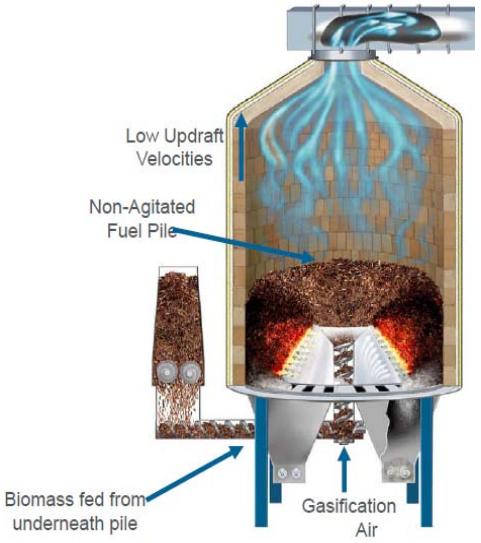
$C + O_2 \rightarrow CO_2$

**Endothermic/Gasification Reactions**

$C + H_2O \Leftrightarrow CO + H_2$ $\quad C + CO_2 \Leftrightarrow 2CO$

$C + 2H_2 \Leftrightarrow CH_4$ $\quad CO + H_2O \Leftrightarrow CO_2 + H_2$

Example of Biomass Gasifier




Gasification Emissions Profile: Kinsei Technology

| Item Tested | Location | Test Result | Unit | EPA Standard | Princeton vs EPA |
|---|---|---|---|---|---|
| Particulate | Stack | 00.0014 | gr/dscf | 0.0015 | 10% lower |
| CO | Stack | 32.2 | ppmv | 100 | 60% lower |
| HC | Stack | Not detectable | ppmv | 10 | 99% lower |
| NOx | Stack | 66.81 | ppmv | 150 | 60% lower |
| $SO_2$ | Stack | 15.88 | ppmv | 30 | 50% lower |
| HCl | Stack | 12.068 | ppmv | 25 | 50% lower |
| Cl2 + HCl | | 9.068 | ppmv | 21 | 60% lower |
| Hg/ | Stack | 0.0081 | $ug/m^3$ | 8.1 | 99% lower |
| Dioxin /Furan | Stack | 0.098 | ngTEQ/dscm | 0.11 | 10% lower |
| Opacity | Stack | 10% | | 10% | Same |

Source: Princeton Environmental

- About 25 units operable in the U.S. using waste material feedstocks, including biomass
- Primary challenge for WTE application is inconsistency of MSW as feedstock

# Snapshot of Gasification WTE Systems*

| *Company* | *Contact* | *Technology* | *Notes* |
|---|---|---|---|
| AlternNRG-Westinghouse Plasma Corp. | Mark A. Wright<br>770-696-7698<br>wrightm@westinghouse-plasma.com | Plasma arc gasification | o Biomass facilty operating in Pennsylvania<br>o WTE facilities operating in Japan and India |
| Biomass Energy Systems, Inc. (BESI) | Tony Calenda<br>100 Overlook Center 2nd Floor<br>Princeton, NJ 08540<br>321-795-3107<br>tony.calenda@biomassenergysystems.net | Rotary kiln gasification | o Operating a 100 TPD unit in South Korea, fueled by industrial waste (mainly fabric, wood, plastic, packaging materials) |
| International Environmental Solutions (IES) | Karen Bertram<br>714.372.2272<br>karenbertram@wastetopower.com | Horizontal auger-fed gasification | o Operating 30 TPD unit in Mecca, CA<br>o Finalist for LA County WTE projects |
| Organic Energy Gasification | Mr. Jan d'Ailly<br>32 Academy Crescent<br>Waterloo, Ontario, N2L 5H7<br>519-884-9170<br>jadilly@organicenergy.ca | Low temperature gasification | o WTE facilities operating in Ontario, Canada since 2001<br>o 25 TPD and 50 TPD modules<br>o 94.9% conversion claim |
| Plasma Power LLC | James Juranitch<br>730 W. McNabb Rd<br>Ft Lauderdale, FL 33309<br>262-443-9100<br>Jjuranitch@plasmapowerllc.com | Plasma arc gasification | o 250 TPD WTE facility planned for operation in Marion, Iowa<br>o 20 TPD WTE facility planned for operation in Ft Lauderdale, Florida<br>o WTE facilities operating in Europe and Asia |
| Princeton Environmental | Peter Tien<br>14-58 154th St<br>Whitestone, NY 11357<br>718-767-7271<br>peter.tien@princetonenvironmental.com | Gasification | o 30-60 TPD WTE facilities operating in Japan<br>o 30 years of experience in this field |
| Pyrogenesis | Philippe Chevalier<br>1744 William St, Ste 200<br>Montreal, Quebec H3J 1R4<br>514-937-0002<br>pchevalier@pyrogenesis.com | Plasma arc gasification | o 10.5 TPD unit operating at Hurlburt Air Field, Florida |
| Recyling Solutions Technology | Steve Jones<br>31 East 12th St<br>Cincinnati, OH 45202<br>513-241-2228<br>steve@jaap-orr.com | Rotary kiln gasification | o 300 TPD unit operating in Inez, KY |
| Rockwell - Intellergy | Richard Noling<br>1400 Hall Ave.<br>Richmond, CA 94804<br>510-837-6200<br>Rick_Noling@gmail.com | Rotary gasifier, steam reformer | o No WTE facility in operation<br>o Claim of 60% Hydrogen content in syngas<br>o 30 TPD and 75 TPD size units |

* Respondents to recent request for industry information, not all-inclusive

- Gasification Technology Overview
- **Technology Profile for Gasification WTE applications**
- **Driving Factors for WTE**
- Project Development Considerations

# Small-scale Gasification WTE Profile

- 10 – 100 tons per day (tpd) advanced conversion technologies in demonstration phase
  - Good fit for the typical volume of solid waste at a DoD installation
  - 600 – 800 kWh per ton MSW
  - Synthetic gas (CO + $H_2$ + $CH_4$) can be used in IC engines, gas turbines, steam turbines or to make liquid fuels
  - Potential for reduced water usage
  - Installed Cost $6,000+ per kW
  - Residual material about 10% by volume, 20% by weight
  - LCOE = $0.15 – $0.20+ per kWh (LCOE depends on tipping fee revenue)

**IES 30 tpd unit Mecca, CA**

# Driving Factors: DoD Installations

- Cost
  - National average solid waste disposal cost is $44 per ton
  - Lifecycle costs for DoD landfills can exceed $150 per ton
- Space
  - 71 active landfills on DoD installations; these are quickly reaching capacity
  - 400 closed landfills occupy over 5000 acres; with continued advancement, WTE may help recover this land
  - Currently not considered diversion per DoD's Integrated Solid Waste Management plan (a challenge for net zero waste goals)
- Energy
  - WTE contributes to renewable energy generation and greenhouse gas reduction executive orders and goals

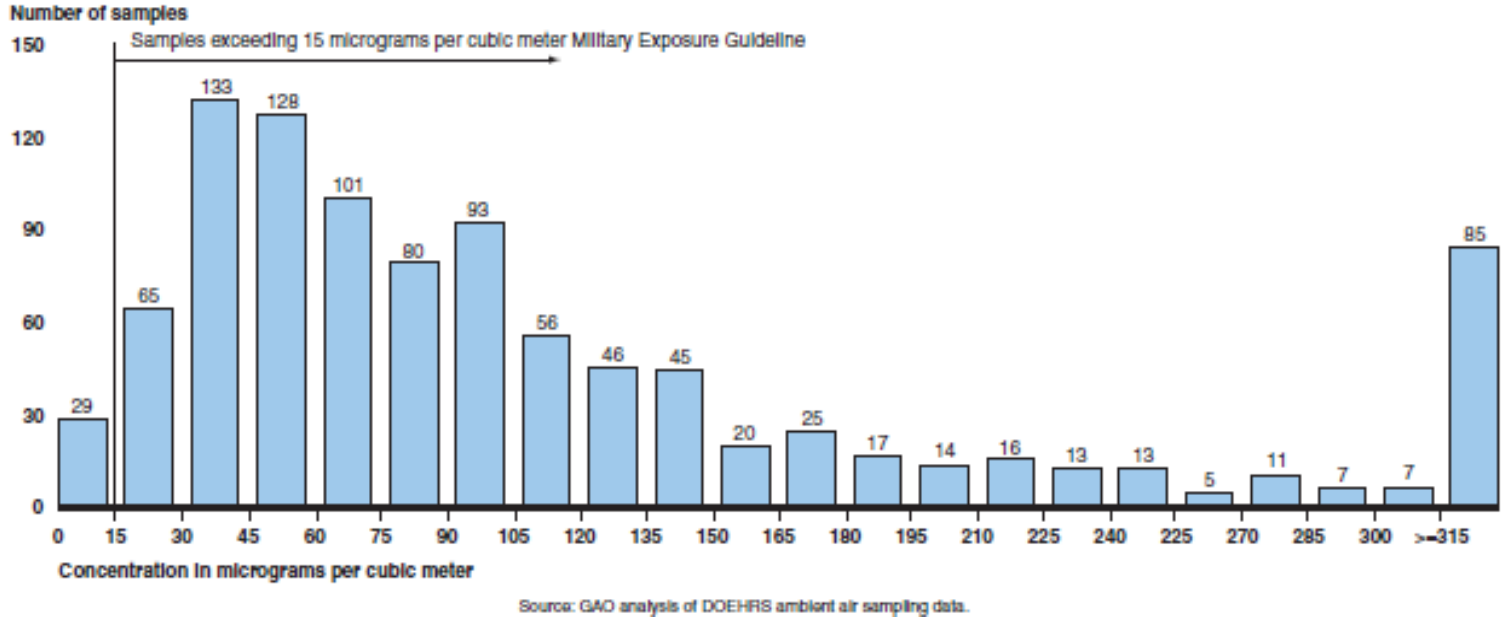
# “Micro-scale” WTE Profile

- Expeditionary scale (.5 – 3 tpd) WTE entering limited demonstration phase
  - Demonstration projects at Ft Irwin and Edwards AFB
  - Forward operating base (FOB) assumptions
    - Estimated loads of .32 KW – .8 KW per person
    - 3 – 18 lb of waste generated per person per day
    - 250 – 600 kWh per ton MSW
    - WTE may provide 7 – 38% of the power requirement

**Community Power Corp: MEWEPS System**

# Driving Factors: Operational Energy

- Fully Burdened Cost of Waste Disposal
  - $500 per ton
- Government Accountability Office (GAO) Report
  - 251 burn pits in Afghanistan, 21 in Iraq as of Aug. 2010
  - Poor air quality: Over 90% of air samples exceeded Military Exposure Guidelines for particulate matter (see graph below)
  - Lawsuits filed in 43 states against Government waste management contractors




Source: GAO analysis of DOEHRS ambient air sampling data.

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# WTE Factors to Consider

- Economics
  - Electricity rate (>$.12/kWh favorable)
  - Tipping fees (>$70/ton favorable)
- Site selection
  - Grid interconnection
  - Environmental screening (NEPA process)
  - Mission compatibility
- Resource
  - Waste stream
    - Large-scale, commercially proven, systems require >300 tpd (partnership with local municipality)
    - Small-scale, yet-to-be proven systems can operate at smaller scales
- Off-take
  - Electricity or heat sales to site (3rd party PPA? Expected Rates?)
  - Export of electricity via PPA with utility

# RE Project Financing Factors

**In general, Federal RE projects are economically viable when three revenue sources can be leveraged.**

- Federal tax credits (investment tax credit (ITC) or production tax credit (PTC))*
- Sale/purchase of power produced
- State incentives ("make or break" project revenue source)

**Bottom line: RE project economics are in general "razor thin" (incremental "project costs" are potential show stoppers).**

* Ownership by private sector required (e.g. developers including investor owned utilities)

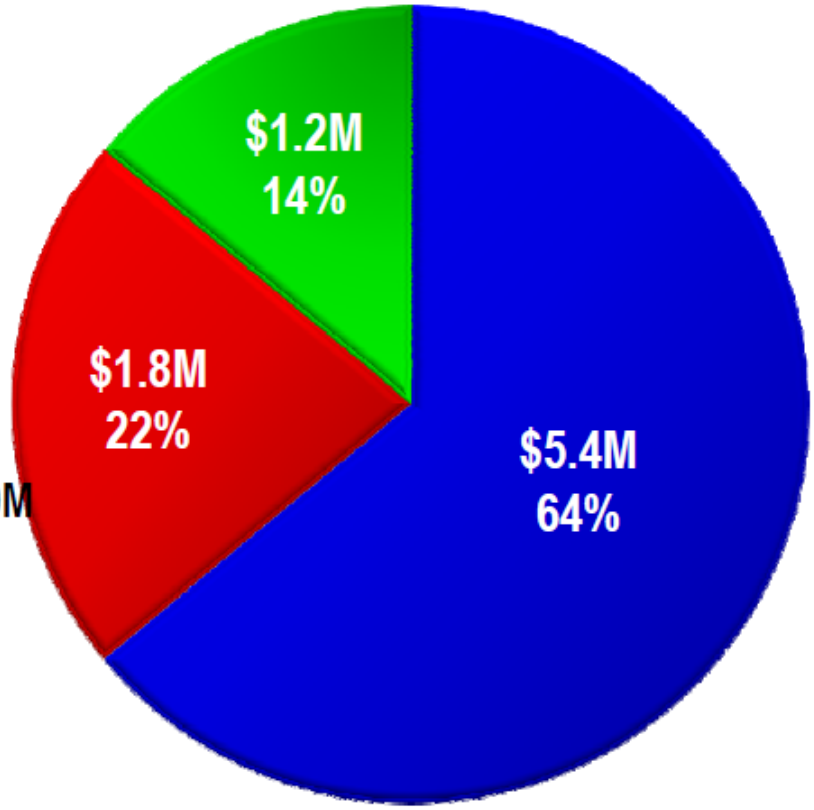
720 KW PV Project at NREL

# PV PPA Economics Example: NREL

## Actual Project Economics

**Project**

- PV: 720 kW/ 1,200 MWh/year
- CO (Xcel Energy)
- "Behind the meter"
- **Cost estimate:$7.0M**
- Circa 2007




**State Incentive**
$225/MWh, 20 years

**Federal Tax Credits**
30% ITC, ACRS

**Sale of Power**
$0.05+/kWh, 2% escalation

**$8.4M**
(not adjusted for time value of money)

FEMP

# Implementation Mechanisms
## (What's working)

- **Power Purchase Agreements (PPA)**
  - Multiple projects across the agencies
  - Project examples (Nellis AFB (14MW), USCG-Petaluma (855 kW), Ft. Carson (2MW), NREL (4MW ), etc.

- **Energy Savings Performance Contracting (ESPC)**
  - Up to 25 year term authorized
  - Tax credit issue (agency retains project ownership)-Energy Services Agreement (ESA) embedded in ESPC
  - "Bundled solutions" (Hill AFB (210 kW))
  - Projects examples (biomass combustion)
    - ✓ NREL Renewable Fuel Heating Plant (6-8mmBtu/hr hot water boiler-displaces natural gas use)
    - ✓ Savannah River Site biomass CHP (240,000 pph, 20 MW)
    - ✓ Oak Ridge National Laboratory biomass gasification
  - Hill AFB Landfill Gas to Energy Electrical Generation (2,250 kW)

- **Utility Energy Service Contracts**
  - Project examples
    - ✓ Marine Corps Barstow/SCE-1.5 MW wind turbine
    - ✓ Camp Pendleton/SDG&E-75 KW PV system

Nellis Air Force Base, Nevada


NREL Renewable Fuel Heating Plant

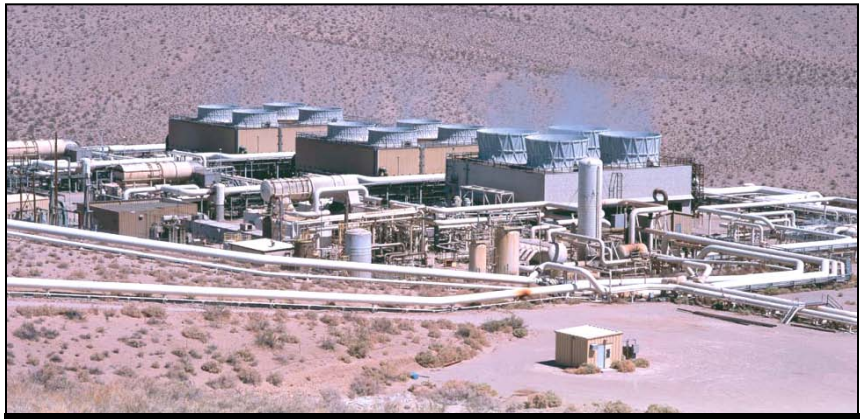
# Implementation Mechanisms
## (What's working) - continued

**Enhanced Use Lease (EUL)**

- Real estate transaction ("under utilized land" requirement; <50 year term)
  - Current agency authorities ( DoD:10 USC 2667, NASA)
- Benefit: "fair market value" plus "in kind" value (competitive determination)
- Project example (NASA Kennedy Space Center (10 MW PV FP&L , 990 kW in kind PV system))
- Proposed projects (Air Force Real Property Agency (AFRPA) actively promoting (proposed Edwards AFB project), Army COE (proposed Ft. Irwin project)
- DOE Brookhaven National Laboratory (37 MW, 0.5-1.0MW in kind PV system ("one off" LIPA lease arrangement)

**"Energy Joint Venture"**

- Contracting authority for energy related procurements (10 USC 2922a (DoD), <30 year term)
- Benefit: Agency takes project development risks/costs in exchange for financial benefits commensurate with project value
- Project example: Navy China Lake (Coso Geothermal-270 MW, site power and significant sale of energy to SCE [some $17M annually])



Coso Geothermal Development (NAWS China Lake)

# Contact Info

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