Atlantic County Bio-Energy Facility
ACUA & NRG Partnership
December 3, 2010
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Today’s Speaker

Fred Rogers

Buck Rogers
NRG Energy, Inc.

Finalist for 3 Platt’s Awards (2010)
Added to S&P 500 (2010)
Fortune 500 -- #12 Fastest Growing Company (2009)
Fortune 500 -- Top 10% for “Best Investment” (2008)
Platt’s Energy Company of the Year (2007)
Platt’s Industry Leader of the Year (2007)

Headquartered in Princeton, NJ
Generating Capacity ~ 26,000 MW
NYSE : NRG
Market Cap ~ $5 billion
4,600 Employees Worldwide

NRG: Leading Competitive Energy Business
80% of people live within 60 miles of the coast.
Two Phases

Phase I
- Permitting
- Minimize Disruption to ACUA
- Minimize Capex
- US Reference Plant for MSW
- Will Facilitate Phase II Permitting

Phase II
- Evolution – Simple Cycle to Combined Cycle
- Construction Revenue for Phase I
- Devote Phase I Gasifier to High Value Specialty Waste
- DOE Loan Guarantee Eligible
Raison d’Etre

1. NRG Social Responsibility
2. NRG Strategy
3. Progressive Partner
4. Good Site
5. Sound Technology
6. Good Environmental Story
7. Good Economic Story
8. Supports NJ EMP
NRG Social Responsibility

**Help Shape Policy**

**Strategic Approach**
- Act as a resource to public policy makers
- Entering coalitions with key stakeholders (e.g. U.S. Climate Action Partnership (USCAP))

**Route**
- Federal greenhouse gas legislation that drives change but is pragmatic

**Benefits**
- Attractive baseload with no carbon
- Post combustion carbon capture
- No fuel cost; no carbon emissions
- No fuel cost; no carbon emissions
- Greenfield Waste-to-Energy; Retrofit waste incinerators
- High efficiency
- Integrate with green technology
- No carbon emissions

**Technology**
*(Our Green Lineup)*

- Nuclear
- Carbon Sequestering
- On-Shore Wind
- Off-Shore Wind
- Solar (CSP)
- Solar (Photovoltaic)
- Plasma Gasification
- CHP+ NRG
- EV Charging Stations

**Proactive Approach**
NRG Strategy

NRG 2003

- Gas
- Oil
- Coal
- Other Nuclear

NRG Today\(^1\)

- Gas
- Oil
- Coal
- Nuclear
- Renewables

NRG Tomorrow\(^2\)

- Retail
- Renewables
- Other Repowering projects
- STP 3&4
- Electric Car and Other
- Wholesale

...A highly leveraged, capital intense, fossil fuel burning power generator

...A competitive energy company tied to capital, carbon and commodity (natural gas) prices

...An energy provider increasingly driven by services, systems and the sun

\(^1\)Based on 2009 results

\(^2\)Not intended as guidance
Progressive Partner - ACUA

- Solar
- Wind Power
- Landfill Gas
- Recycling
- Composting
- CNG / Bio-Diesel
- Community Outreach
- Recommended by Rowan University

25% of Rowan’s Electricity Comes From Wind Power
- Up to 25 Acres within the existing ACUA facility
- Avoids wetlands and endangered species areas
- Add waste processing and storage to existing tipping floor building
- Gasification, syngas clean-up and power generation systems are constructed within enclosed buildings
- No change to existing truck traffic
- No change to 6-day waste collection
- 24/7 waste processing and power generation
Westinghouse developed Plasma Technology during a 30 year period and over $100 million R&D

- Initially for high temperature research
  - NASA re-entry tiles
  - Gas turbine blade coatings
- Expanded to metal melting in 1980s
- Tested for waste processing in 1990s
- Proven in waste processing in 1990s
- Commercial Facilities in 2000s

Alter Nrg continues to invest in product development.

* Westinghouse Plasma Corp. Staff

Impressive Lineage Technology Based on a History of Successes
Plasma Gasification produces lower emissions than other Waste-to-Energy technologies

Landfills produce methane = 21 x CO₂

- Gasification better than incineration
- Incineration better than methane flare
- Methane flare better than landfill

Plasma Gasification is a Cleaner Technology
Good Economic Story

**Job Creation**
- 150 - 200 Construction Jobs
- 50 Full-Time Operations and Maintenance Jobs
- Safe Work Environment
- Family Supporting Wages

**Economics**
- Stabilizes Tipping Fees
- Produces Green Energy and Other Marketable Products
- Supports the Atlantic County Waste Hauler Industry
- No Capital Investment by Atlantic County or the State of NJ
- Supports Long-Term Waste Disposal Plan

**Helps ACUA**
- Extends Landfill Capacity
- Reduces Landfill Costs
- Promotes Recycling
- Enhances Bird and Odor Control

**Economic Development • Energy • Environment**
NJ Energy Master Plan

Demand Side:

☐ Goal 1: Maximize the State’s energy Conservation and energy efficiency to achieve reductions in energy consumption of at least 20% by 2020.

☐ Goal 2: Reduce peak demand for electricity by 5,700 MW by 2020.
   (Approximately 8,000 NJ Homes)

Supply Side:

☑️ Goal 3: Meet 22.5% of the State’s electricity needs from renewable sources.

☑️ Goal 4: Develop new low carbon emitting, efficient power plants and close the gap between the supply and demand of electricity.

☑️ Goal 5: Invest in innovative clean energy technologies and businesses to stimulate the industry’s growth in New Jersey.

Exceeds Goals from First Day of Operation
Gasification = Thermal Conversion

4 States of Matter

Solid | Liquid | Gas | Plasma

Ice | Water | Steam | Sun

Physical Changes Based on Temperature

32°F | 49.5°F | 212°F | 10,000°F +

0°C | 49.5°F | 100°C | 5,530°C +
<table>
<thead>
<tr>
<th>Why</th>
<th>Plasma Gasification</th>
<th>Incineration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher Temperature</td>
<td>Conversion at 3,000°F to 3,600°F</td>
<td>Destruction at 1,500°F to 2,500°F</td>
</tr>
<tr>
<td>Broader feedstock options</td>
<td>All organic matter (MSW, tires, medical, bio-waste, sludge)</td>
<td>Organic matter (some special waste prohibited)</td>
</tr>
<tr>
<td>More Energy (~50%)</td>
<td>820 kWh / ton MSW</td>
<td>540 kWh / ton MSW</td>
</tr>
<tr>
<td>Fewer emissions and impurities (particulates, mercury, sulfur)</td>
<td>Removed from Syngas prior to combustion</td>
<td>Removed from combustion exhaust</td>
</tr>
<tr>
<td>Fewer residuals Safer residuals Easier to dispose</td>
<td>Vitreous Slag 1% to 5% by vol.</td>
<td>Ash 10% to 20% by vol.</td>
</tr>
</tbody>
</table>

Gasification is **NOT** Incineration
What is plasma?
- An electrically charged gas (superheated air).
- Capable of temperatures exceeding 13,000°F.
- Examples in nature are lightning and the Sun.

What is plasma gasification?
- Break down of organic materials (MSW) into simpler molecular structures using extremely hot air.
- Converts all organic materials into gaseous fuel.

What is the end product?
- Synthesis Gas - “Syngas” – consisting of H₂ + CO.
- Syngas, similar to natural gas, can be used as fuel to generate electricity or steam.

What are the advantages?
- An efficient and environmentally responsible process to convert low value blended feedstock (MSW) to high value gaseous fuel to produce electricity.
- Waste conversion: Gasification (>95%); Incineration (~80%)
- Energy capture: Gasification (~60%); Incineration (~39%)[^1]

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[^1]: Knox, Andrew. An Overview of Incineration and EWF Technology as Applied to the Management of Municipal Solid Waste (MSW), University of Western Ontario. February 2005
Plasma Gasification is **NOT** Incineration

### Plasma Gasification
- Any type of waste, no separating
- Uses **Minimum** Oxygen
- No open flame
- **Disassociation** at 3,600°F

### Incineration
- Must separate unwanted waste
- Uses **Excess** Oxygen
- Open flame
- **Combustion** at 1,500°F to 2,500°F

### Chemical Reactions

#### Input
- MSW

#### Reactions
- $\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2$
- $2\text{C} + \text{O}_2 \rightarrow 2\text{CO}$
- $\text{C} + \text{CO}_2 \rightarrow 2\text{CO}$
- $\text{C} + \text{H}_2\text{O} \rightarrow \text{CO} + \text{H}_2$

#### Output
- Heat + Gaseous Fuel (Syngas)
- Syngas contains potential energy

#### Energy is spent after the reaction
Plasma Gasification DVD
Plasma Torch System

Electricity

Air or Oxygen

Plume of Superheated Air
Not a Flame

Plasma (10,000°F)

Plasma Torch Features
- High thermal efficiency
- Operation on air or oxygen
- Rugged design used in steel mills, foundries and power generation

Robust Heat Source
Operating Conditions

- Foundry Cupola Design
- Heat Resistant Refractory
- 4 to 6 Plasma Torches
- Feedstock (500-750 tpd)
- Organic Materials Convert to Syngas, exits at top
- Inorganic Materials Melt to Slag - exits at bottom

- Organic material dissociates into elemental structures, e.g.; H₂, C.
- Do not recombine into complex structures, e.g.; Furan, Dioxin

~ 1,650°F – 2,000°F (Syngas Outlet)
9,000°F – 12,600°F (Plasma Plume at Torch)
Uses 2 – 5% of energy produced

~ 3,600°F Conversion Temperature

Coke Bed (retains heat)

~ 3,000°F (Molten Slag Outlet)

Single-Stage, Non-Pressurized Gasifier
Process Flow: Combined Cycle

Integration of Four Proven Technologies
Atlantic County Bio-Energy Project
(Buck Rodgers Perspective)

**Phase I**
- One gasifier (W-15)
- Air Blown (oxygen short term)
- Environmental Clean-up System
- Boiler and Steam Turbine
- 150 TPD MSW
- 5 MW

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**Phase II**
- Additional, larger gasifier (G-65)
- Oxygen Blown
- Environmental Clean-up System
- Increase to full capacity
- 3 Gas Turbines
- 2 Steam Turbines
- 1050 TPD
- 60 MW
## Waste Generated Feedstocks

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Btu/lb</th>
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</thead>
<tbody>
<tr>
<td>MSW</td>
<td>~ 5,000</td>
</tr>
<tr>
<td>Tires</td>
<td>~ 13,000</td>
</tr>
<tr>
<td>Greenwood Biomass</td>
<td>~ 4,500</td>
</tr>
<tr>
<td>C&amp;D Wood</td>
<td>~ 6,000</td>
</tr>
</tbody>
</table>

**Choice of Dedicated or Mixed Feedstocks**
Pre-Combustion Clean-up

- **Particulate Matter and Dust Removal**
  - Removes (99%) of Particulate Matter and Dust
  - Recirculates PM back through gasifier

- **Mercury Removal by Carbon Filtration (95%)**

- **Syngas Desulfurization**
  - Converts Hydrogen Sulfide to Elemental Sulfur
  - Removes 95% of Sulfur
  - Recovered Sulfur has Beneficial Use as Fertilizer

More Efficient than Post-Combustion Clean-up
Emissions: Achieves RPS on Day 1

**RPS Timelines**

Federal (Waxman) 20% by 2020
Federal (Bingaman) 15% by 2020
NJ 22.5% by 2020

Atlantic County Bio-Energy Facility 56%* on Day 1 (2015)
- 5 years ahead of curve
- 33% above the bar

Plasma Slows Landfill Development

TECHNOLOGY: Plasma Gasifier

Municipal Solid Waste → Plasma Gasifier → 5% (glass) → Recycle

RESIDUE: Water-cooled slag

Incinerator → 20% (ash) → Landfill

DISPOSAL: Recycle → Landfill

Less Residue. Safer Residue
Recycle Inert Vitrified Slag

US EPA Approved For:

- Roadbed Aggregate
- Sandblasting Grit
- Recycled Glass Cullet
- Architectural Tile Manufacture
- Glass Fiber Rock (Rock Wool Insulation)
- Roofing Granules (Shingle Manufacture)
- Passes the Toxic Characteristic Leaching Procedure

By-Product Also Has Value
New Jersey could have generated 1,124 MW of power in 2007

- The large proportion of waste-based biomass in the state supports the recommendation that NJ pursue development of an energy-from-waste industry.

- Gasification is suitable for municipal wastes, and could offer lower emissions than conventional incineration.

- Conversion of solid waste to clean energy could become the major source of renewable energy to help NJ meet its goal of 22.5% renewable energy by 2020.

- Compare: PSE&G’s Hudson Coal Plant 1,246 MW.

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Details</th>
</tr>
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<tbody>
<tr>
<td>1987</td>
<td>Plasma Fired Cupola</td>
<td>Melt iron fines; General Motors; Defiance, Ohio</td>
</tr>
<tr>
<td>1989</td>
<td>Various Industrial Applications</td>
<td>Over 500,000 hours of industrial use</td>
</tr>
<tr>
<td>1995</td>
<td>Incinerator Ash Vitrification</td>
<td>IHI; Kinuura, Japan</td>
</tr>
<tr>
<td>2002</td>
<td>1st Commercial Scale Plasma Gasifier</td>
<td>Hitachi Metals, Mihama-Mikata, Japan</td>
</tr>
<tr>
<td>2003</td>
<td>Largest Plasma Gasifier for MSW</td>
<td>Eco-Valley; Utashinai, Japan</td>
</tr>
<tr>
<td>2008</td>
<td>World’s Largest Plasma Haz Mat Facility</td>
<td>Pune, India – commissioned early 2009</td>
</tr>
<tr>
<td>2009</td>
<td>Syngas to Ethanol</td>
<td>Coskata Sept. 2009</td>
</tr>
<tr>
<td>2010</td>
<td>Biomass-to-Energy Facility</td>
<td>Wuhan, China – under construction</td>
</tr>
<tr>
<td>2010</td>
<td>Plasma Gasification of MSW</td>
<td>Hitachi Metals; Yoshi, Japan - commissioned in 1999</td>
</tr>
<tr>
<td>2010</td>
<td>Plasma Milestones</td>
<td>Proven Technology Based On A History of Success</td>
</tr>
</tbody>
</table>
“One technology which potentially can use various types of waste, produce electricity and hydrogen without emitting dioxin, furan and mercury, is plasma arc technology. Municipalities can install a plasma arc facility which will eliminate land filling…”

U.S. Environmental Protection Agency

“Producing ultra-clean energy from gasification is the most environmentally attractive alternative to utilize solid fuels, including coal.”

U.S. Department of Energy

“These emissions will be substantially lower than traditional mass burn or refuse derived fuel processes commonly used in the waste to energy industry.”

ENSR / AECOM

Recognized as a “Clean” Technology
Questions?

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Princeton, NJ 08540
(609) 524-4500
plasma-power@nrgenergy.com
www.nrgenergy.com

Additional Information
www.westinghouse-plasma.com
Gasification Technology Council
www.gasification.org

Thank You
Reference Facilities
Reference Facilities

Eco Valley Utashinai

- Operational since April 2003
- Design MSW capacity: 240 tpd
- Actual processing: MSW 83 tpd, ASR 83 tpd
- Gross Power: 8 MW

Mihama-Mikata

- Operational since March 2003
- Design MSW capacity: 24 tpd
- Actual processing: MSW 80 tpd, Waste Water Sludge 4 tpd
- Gross Power: Steam for waste water processing plant

MSW Application
Additional Reference Facilities

• General Motors – Defiance, Ohio
  ➢ Melt scrap metal to form engine blocks
  ➢ Same WPC torches operating since 1989
  ➢ No Power generation

• ALCAN, Jonquiere, Canada
  ➢ Aluminum Dross Recovery Furnace
  ➢ Commissioned in 1992
  ➢ Material quality increased and waste reduced

• Two facilities in India - Pune (2008) & Nagpur (2010)
  ➢ Plasma waste vitrification plants
  ➢ Electricity output (Boiler and Steam Turbine)
  ➢ Process 72 tons/day hazardous waste (each plant)

Plasma Torches Used in Specialty Applications