2nd annual international

COAL GAS 2011

"Vision 2020: National Option for Clean, Green and Sustainable Energy"

14 - 15 February 2011, Vigyan Bhawan, New Delhi, India

Viresco Energy's Advanced Gasification Technology

Arun Raju, Director of Research
Viresco Energy, LLC
arun.raju@virescoenergy.com

Mission Energy Foundation
http://missionenergy.org

www.virescoenergy.com

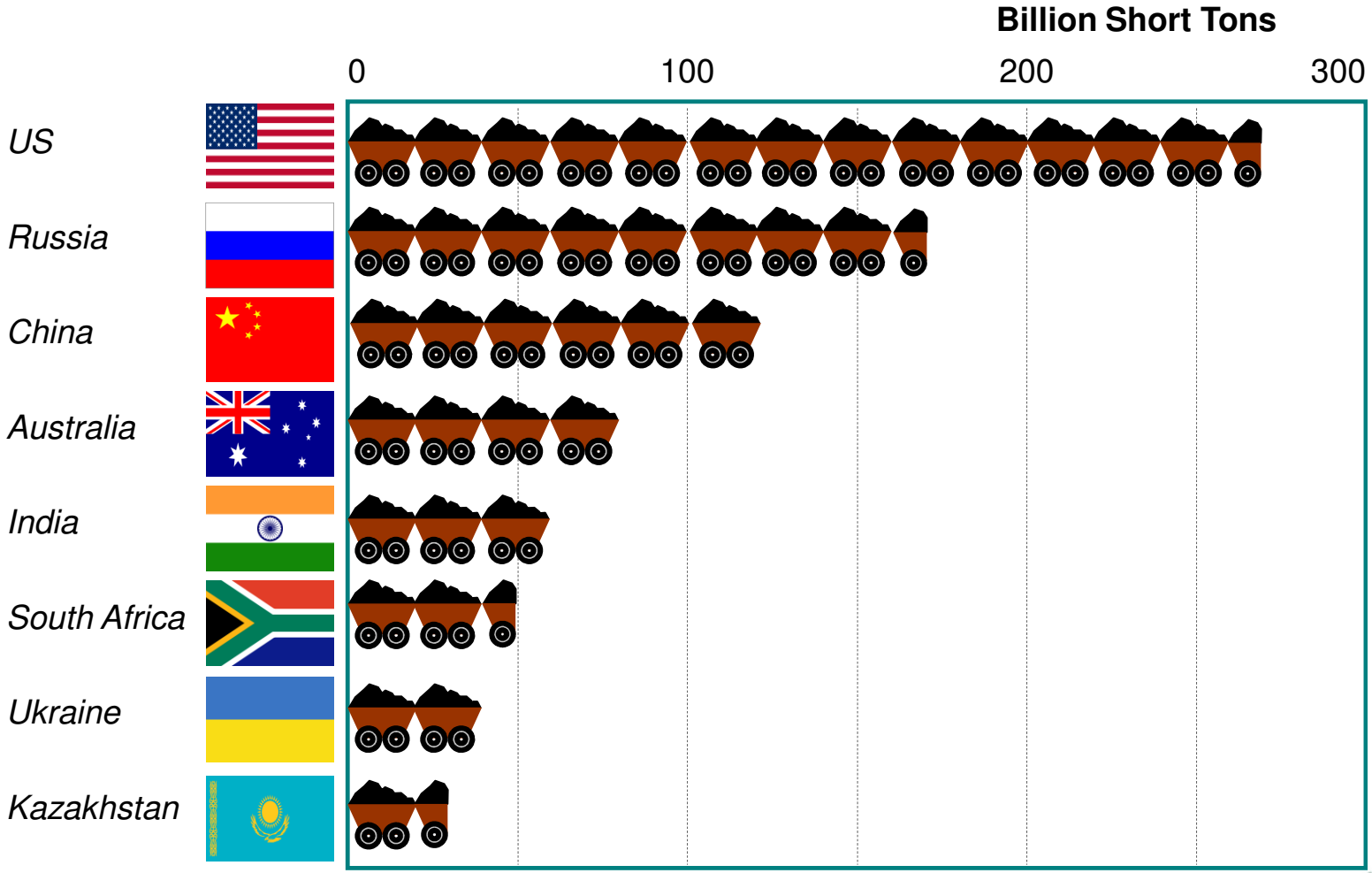
Presentation Outline

- Introduction to Viresco Energy
- Gasification Technology
- Technology Status
- Pilot Plant

Introduction

- Riverside, CA based synthetic fuel company
- Exclusive license to a new advanced gasification technology
  - CE-CERT Process
- Invented by the College of Engineering – Center for Environmental Research and Technology (CE-CERT) at UC Riverside
- Convert biomass, coal, waste & biosolids to high value fuels
  - Methane (CH_4)
  - Fischer-Tropsch Diesel / Jet fuel
  - Hydrogen & Electric Power
- Focus on Methane Production from Coal/Biomass
- IP: 19 patents/patent applications

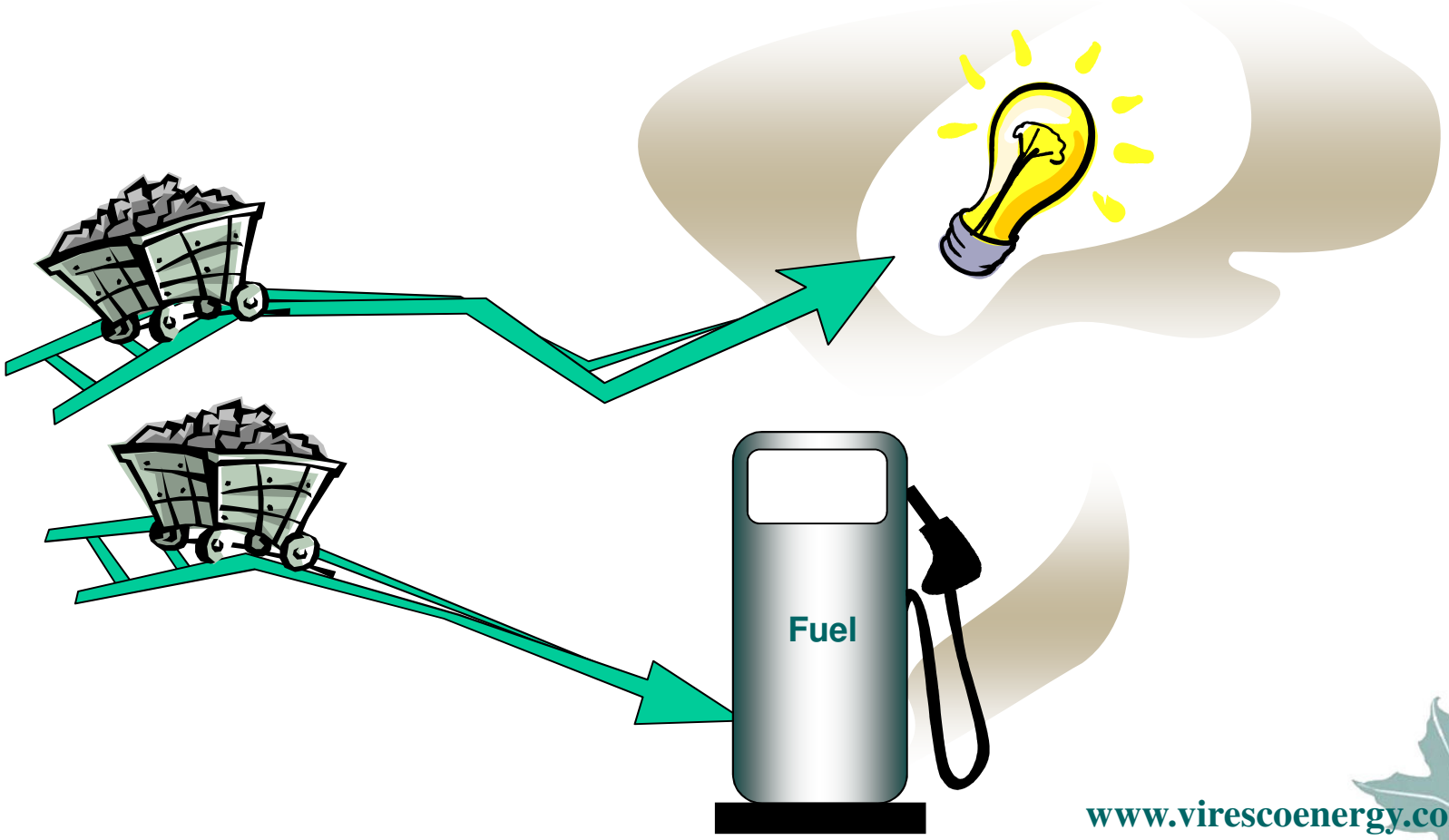
World Proven Coal Reserves



Source: World Energy Council, *Survey of energy resources, 2007*

Fuels from Domestic Resources

•Coal and other domestic resources can be converted into synthetic fuels – SNG, FT diesel, gasoline, jet fuel & electricity



Hydrogasification

$$C + 2H_2 \rightarrow CH_4 + Others$$

- Gasification in Hydrogen environment
- Used for SNG production from coal and biomass since 1930s
- Internal hydrogen supply through water gas reaction of the char or steam methane reforming of the product gas
- No oxygen plant required
- Requires high pressure (~100 atm) or catalyst
  →Lack of commercial success or interest

Steam Hydrogasification

- The unique feature of CE-CERT process is the introduction of water into the reaction scheme

$$C + \mathbf{H_2O} + 2H_2 \rightarrow CH_4 + \mathbf{H_2O} + others$$

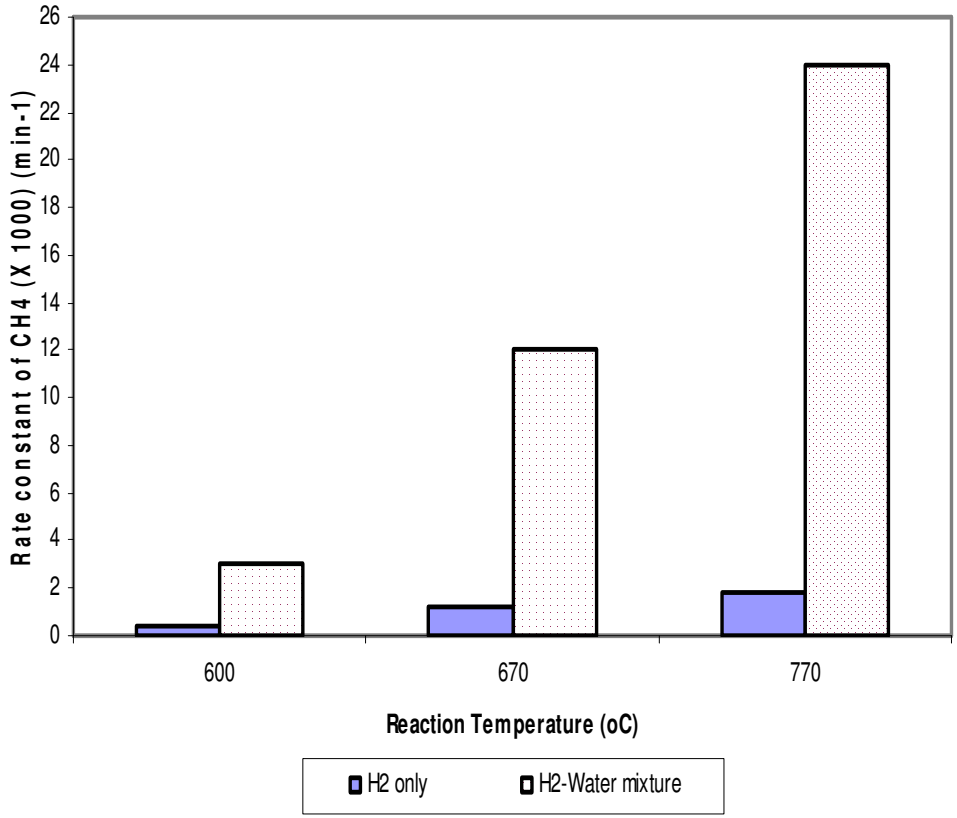
$$Others: CO, CO_2, C_{2+}$$

- Effect of steam on the hydrogasification of carbon has not been studied extensively
- Our initial research found that addition of water
  - →Increased the rate of methane formation*
  - →High efficiency at relatively moderate temp (~850 ºC)
  - →High efficiency at lower pressure (~25 atm)

* Jeon et al., Fuel, 2007

Hydrogasification with Steam

$$C + \mathbf{H_2O} + 2H_2 \rightarrow CH_4 + \mathbf{H_2O} + 75kJ/mol + others$$



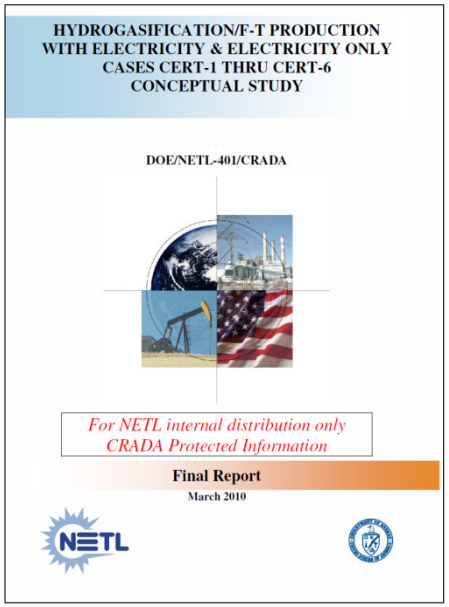
- Enhancing the CH_4 formation as increasing steam (H_2O/C ratio)

- Observed 10 to 20 times increase

Reaction Constants for the Hydro-Gasification of Wood with steam at different temperature @ 391 psi *

* Jeon et al., Fuel, 2007

Why Viresco Technology?

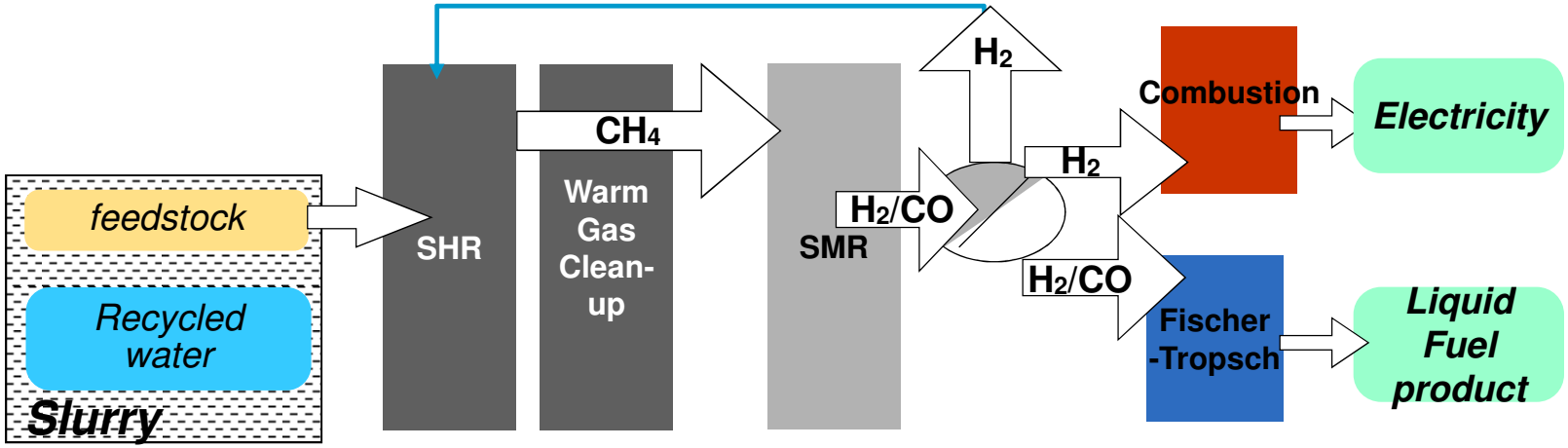


- Independent techno-economic analysis by the Department of Energy (DOE-NETL)
- Six different scenarios
- Coal Liquids with Electricity with 65% and 90% CO2 Capture
- Electricity via IGCC with no capture/Fuel Cells with No Capture and greater than 80% CO2 Capture
- "Technology has the potential to offer higher efficiencies at lower capital costs compared to state of the art POX based processes"

Versatile with respect to feedstocks and products

Viresco Energy's Technology

Simplified process flow diagram - FTD production



- Steam Hydrogasification based – Avoids oxygen plant
- Slurry feed – Pretreated biomass/wastes & other feedstocks
- Adjustable syngas ratio – By controlling feed ratios

SHR – Steam Hydrogasification Reactor; SMR – Steam Methane Reformer

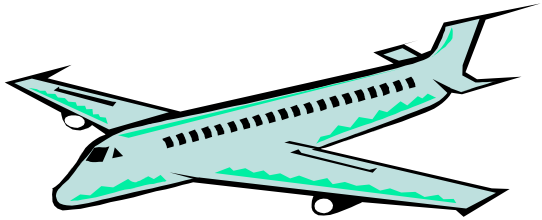
Viresco Energy's technology

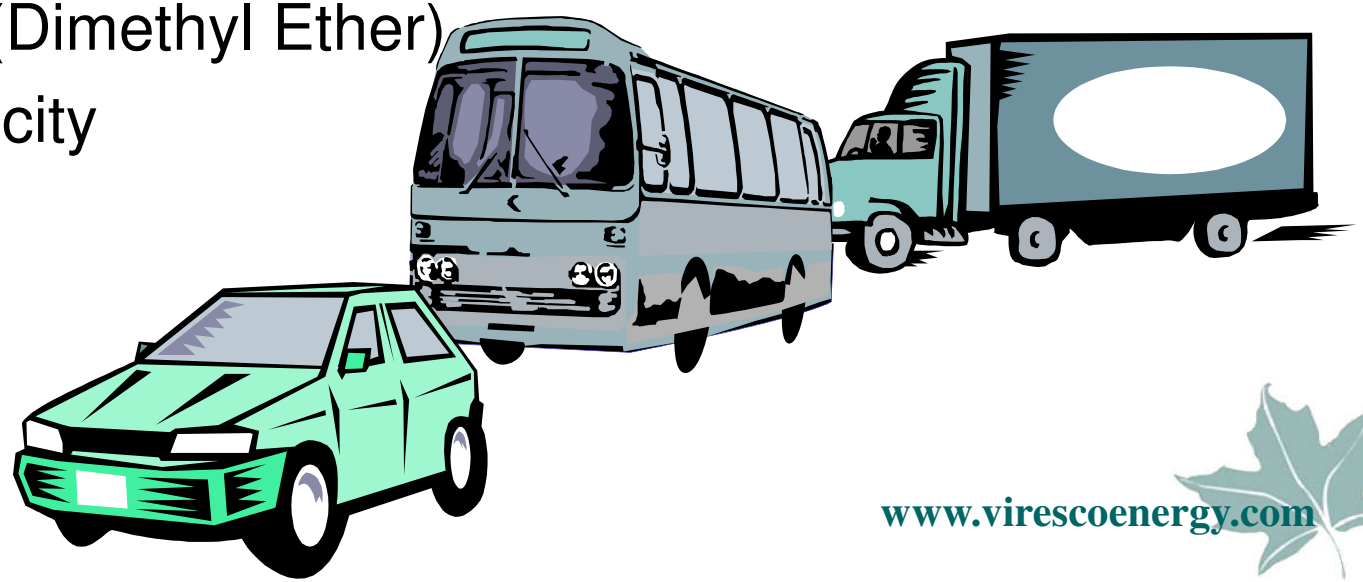
- **Steam Hydrogasification based innovative gasification Process**
- **Internal H_2 feedback**
- **Process can handle wet feedstock w/o drying.**
  - Utilize a high pressure slurry pump to reduce costs
  - Suitable for low-rank coal with high moisture content, ex. Lignite
  - Low water usage
- **No oxygen plant required**
  - Process is suitable for smaller scale, distributed facilities (ideal for biomass/waste, coal/biomass feedstock)
- **Higher Thermal Efficiency**
  - Suitable for low-rank coal with high ash content
- **High CH_4 production capacity**
- **Proprietary process to convert biomass into slurry**

Transportation fuel products

•The Viresco process creates synthesis gas, which can be converted to a variety of transportation fuels:

- ***Methane (SNG)***
- Fischer-Tropsch diesel
- Jet fuel
- Hydrogen
- DME (Dimethyl Ether)
- Electricity

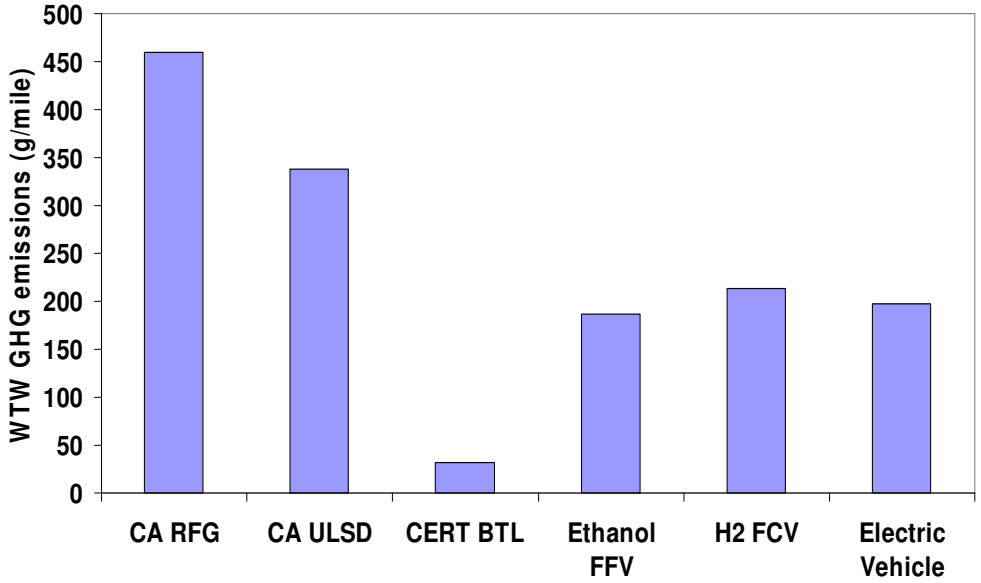




www.virescoenergy.com

Sustainability

- Listed in a recent report* by the 'Clean Air Task Force' as one of the most promising advanced gasification technologies in the pipeline
- Complete Life Cycle Analysis has been conducted+
- Semifinalists in the 'CleanTech Open' competition



Pumpable slurry from biomass

+ Norbeck et al., Consultant Report for CEC, CEC-500-99-013, September 2008

* http://www.catf.us/resources/publications/files/Coal_Without_Carbon.pdf

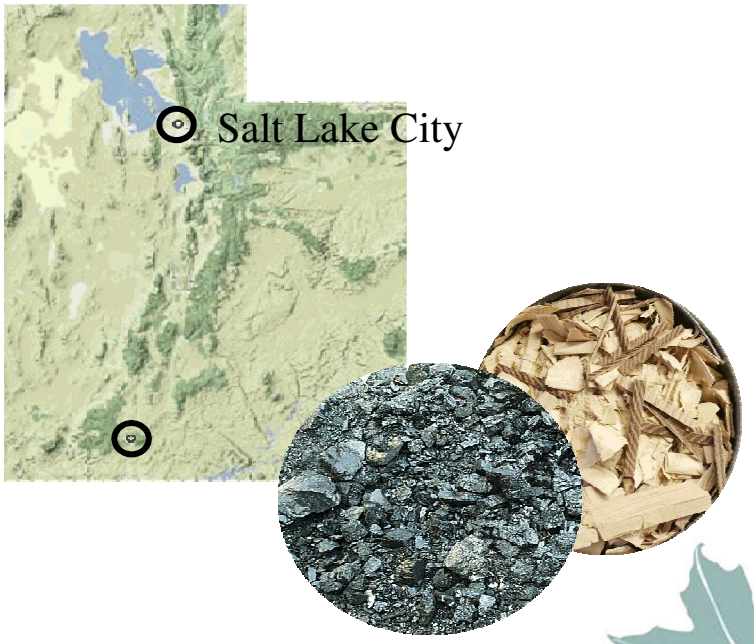
Technology Milestones

- Viresco Energy founded in 2003 to fund UCR research on steam hydrogasification
- Laboratory scale studies conducted at CE-CERT
- Entered into global option for technology transfer with UCR in 2006
- Entered into CRADA with NETL in 2007
- NETL CRADA draft report released in 2008 – final report released March 2010
- Viresco received Phase I SBIR to study comingled Coal/Biomass conversion – completed in 2010
- Received $2.4 million grant for pilot in 2009
- Exclusive global rights to technology acquired in 2010

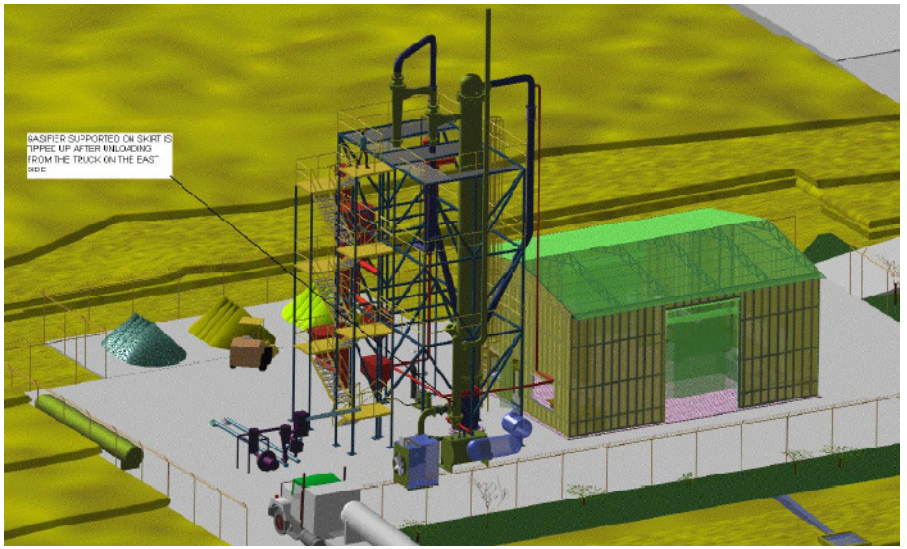
Technology Status

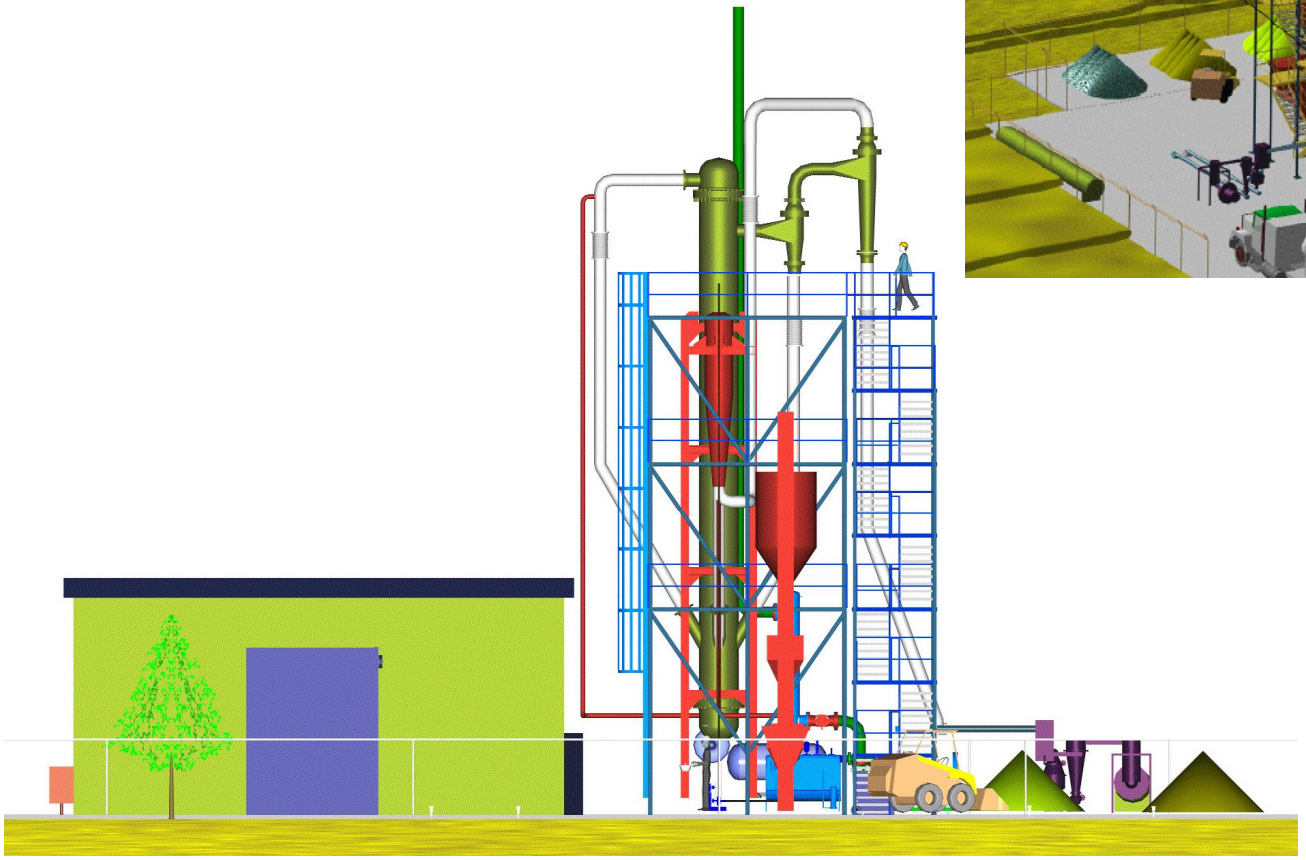
Coal and Biomass to Fuel Pilot Plant

- U.S. Department of Energy Grant: **$2.4 million**
- Performance period: Start date1 October 2010
- Project objective: To design, build and test a **5 Tons Per Day** capacity gasifier
- Location: **Kanab, Utah**
- Feedstock: Initial testing with coal; future testing with **coal/biomass** mixtures and other feedstocks
- Engineering Design nearing completion

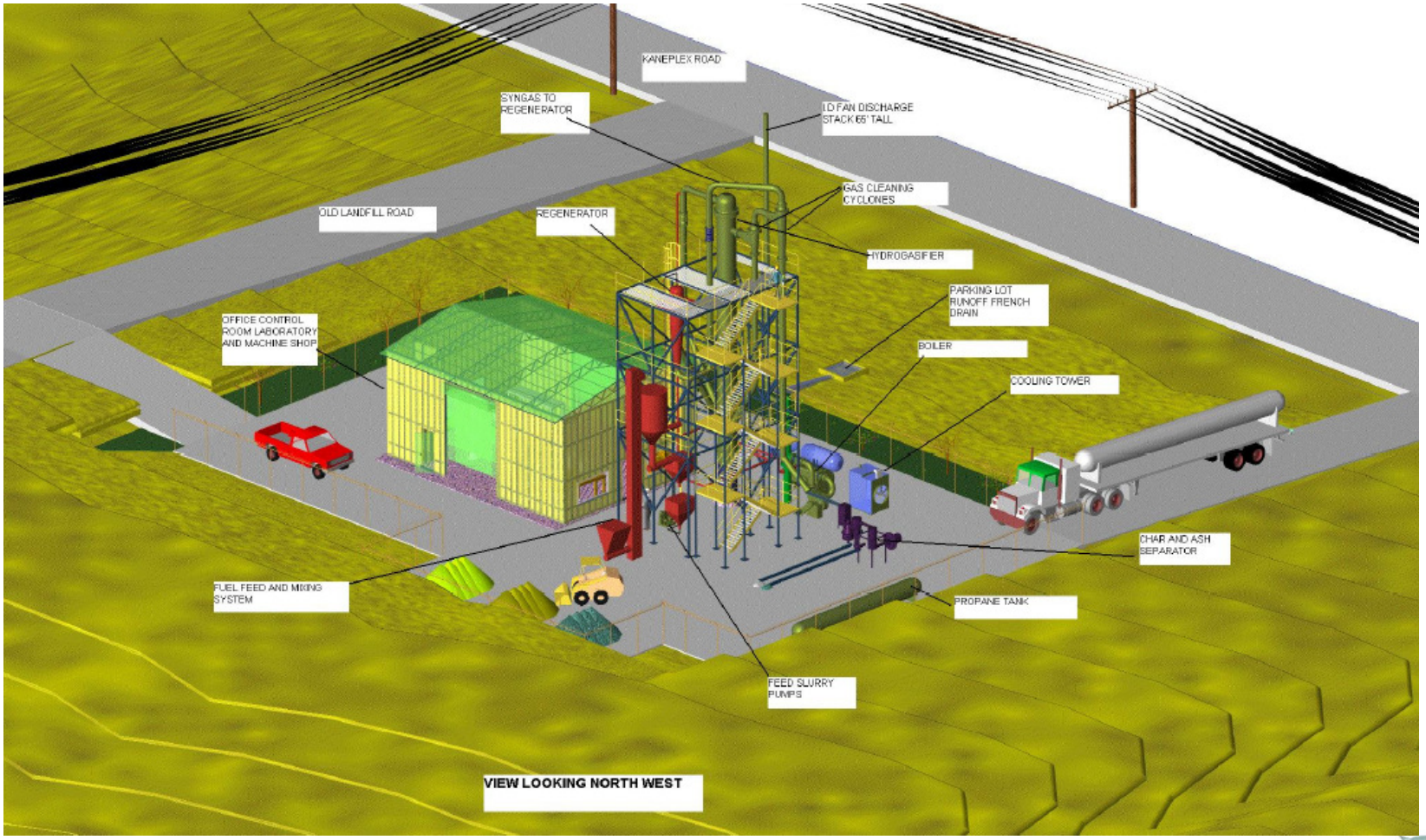


Pilot Plant


GASIFIER SUPPORTED ON SKIRT IS
TIPPED UP AFTER UNLOADING
FROM THE TRUCK ON THE EAST
SIDE



Pilot Plant


KANEPLEX ROAD
SYNGAS TO REGENERATOR
I.D FAN DISCHARGE STACK 65' TALL
GAS CLEANING CYCLONES
OLD LANDFILL ROAD
REGENERATOR
HYDROGASIFIER
PARKING LOT RUNOFF FRENCH DRAIN
OFFICE CONTROL ROOM LABORATORY AND MACHINE SHOP
BOILER
COOLING TOWER
CHAR AND ASH SEPARATOR
FUEL FEED AND MIXING SYSTEM
PROPANE TANK
FEED SLURRY PUMPS
VIEW LOOKING NORTH WEST

Technology Status

- Tentative agreement with an India based multinational coal company - build 100 TPD plant in India
- Talks with a large ethanol company - produce SNG from 2400 TPD of bagasse & sugarcane residues.
- Viresco is also in talks with several major coal companies to form a commercial partnership following the successful demonstration of the pilot plant.
- Strategic partnerships to produce high value fuels from locally available feedstocks

Questions?

THANK YOU

www.virescoenergy.com