PROCESS for BIO NATURAL GAS PRODUCTION from FORESTRY RESIDUE

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Overview

- Bio-natural gas as a meaningful bio-energy pathway
- Size, siting and production considerations
- G4 approach
- Market uses for bio-natural gas
G4 Insights Team

• Multi-disciplinary technology & commercial development
• Bio-natural gas technology under development with commercially driven focus
• Current external support by:
  – National Research Council Canada (IRAP)
  – Ethanol BC, a BC government and forest industry fund
G4 Experience

• Founders, senior management and R&D roles in QuestAir Technologies Inc.
• **Technology:** Developed and commercialized gas separation equipment for industrial gas and petro-chemical industries
Natural Gas Business

- 125 Billion GJ/yr world consumption
- Supplies ~23% of world energy requirements
  - **Electricity** → Natural gas generates 21% of all electricity
  - **Heating/combustion** → a growing, preferred fuel source
  - **Transportation** → Currently accounts for only ~ 1% of transportation fuel
- **World-wide commodity with mature and broad distribution**
  - Low transportation/distribution losses over large distances
  - Economical large-scale energy storage
  - Large & accepted infrastructure
  - Infrastructure continuing to be developed
  - Robust trading/displacement/wheeling to allocate gas to buyers
SNG & Bio-Natural Gas

- **Synthetic & bio-natural gas:**
  - Must meet gas utility defined heating values and quality specifications
  - Injected into natural gas pipelines or regional distribution network
  - Can be used by any natural gas equipment, appliance or vehicle

- **Proven methods: anaerobic digester gas, landfill gas**
  - Low-cost purification is key
  - Limited resource: estimate maximum production of 0.4 Billion GJ/yr

- **Emerging methods: biomass gasification with methanation**
  - Low-cost biomass transportation is not well developed
  - Large central plants needed for cost reasons
    → funding, permitting and time-to-market hurdles

- **New Method: G4 Bio-Natural Gas Process**
Biomass Availability

- 350 million dry tonnes/year sustainable forestry residue biomass available in US and EU
  - a ~ 7 Billion GJ/yr source of carbon neutral energy available now
  - an impressive ~15% of current US+EU natural gas use
- Does NOT include harvest for sole purpose of energy generation
- Does NOT include agricultural residues with seasonal availability
- Does NOT include regional degradation issues
Biomass Availability

• **Near-Term Challenges**
  – Difficult to secure long-term biomass supply contracts
  – Unstable and rising feedstock costs ($10-100/dry tonne)
  – Additional forestry jobs to harvest/transport residues

• **Long-Term Challenges**
  – Low-cost methods of residue harvesting & transport
  – Forest industry needs to think/act like an energy provider
  – Energy crops are a long-term investment
  – Seasonal availability & use patterns
Biomass & Energy Transport

• **Low density of biomass increases transport costs**
  →Largest factor of raw material costs
  →Distributed plant model keeps transport costs reasonable
  →Transport the ‘energy’ in existing infrastructure

• **Are forests close to pipelines?**
  →Compressor station spacing averages about 100 km
  →Utilization of existing distribution systems
  →Match the sustainable forest harvest practice area with spacing
  →Typical 60km radius biomass supply for each G4 BNG plant
  →Plant feed volumes similar to small/medium sawmill

**Logical Conclusion:**

- Distributed conversion plant is the most appropriate model
- Appropriate where NG use or distribution infrastructure exists
G4 BNG Process

- Proprietary process to convert biomass into Bio-Natural Gas
- Wood and wood waste is size reduced, dried and thermally vaporized
- Vapors preferentially converted to methane in hydrogen atmosphere
- Gas separation to produce BNG product and re-use other gases
- Reformer generates hydrogen required for the process
G4 BNG Process

• **Industrial Plant:**
  - Similar site considerations as current forest processing plants
  - Use all parts: cellulose, hemi-cellulose, lignin & avoid waste streams

• **Environmental:**
  - Bio-ash from inorganics in wood for redistribution back to forest
  - Carbon neutral CO₂ in flue gas
  - Process water, cooling water optional re-use
  - No contaminated liquid discharge

• **High Energy Conversion Yields**
  - Selling price: US$8 - 10/GJ with US$40 - 50/BDT wood
    (Using typical Independent Power Producer economics and mature design)
Markets

• **G4 BNG with Natural Gas Power Plants:**
  - Large fleet of existing and new power generation stations
  - Purchase “green certificates” and use pipeline gas for immediate renewable power for ANY natural gas powered plant
  - No additional risk or operational impact to power plants
  - Potential biomass heat value to electricity conversion of 40% to 50% when used in new combined cycle (NGCC) plants
  - Lowest cost, large scale production of renewable electricity
Markets

‘Renewable Premium’ Natural Gas

• Bio-Natural Gas sold by gas utility companies
  – Residential/commercial users buy premium Bio Natural Gas
  – Use with existing appliances, no need to convert

• Bio-Natural Gas for CNG vehicles
  – Existing supply distribution technology and infrastructure
  – Current: limited adoption, primarily used by fleets
  – Emerging consumer market
    → room for incentives for adoption: both $/GJ & $/gasoline equiv.
  – Mainstream CNG & dual-fuel automotive technology
Markets

Remote Energy Supply
- Remote communities, mining and forestry operations
- Total self sufficiency with high efficiency:
  - coupled with standard NG genset for CHP
  - A stream of BNG for CNG transport fuel
  - Third use of BNG for residential/commercial uses
  - Local employment for energy generation

On-site Industrial Natural Gas Displacement
- BNG is direct substitute for natural gas
  - No burner/boiler modifications required
  - No backup equipment required
  - Can be used for NG space heating, CNG forklifts and vehicles
  - Export BNG if not consumed on-site
G4 BNG - Distribution

- Current Renewable Electric Power Generation

Independent Power Producer - Renewable Electricity
G4 BNG - Distribution

- G4 BNG into pipeline for renewable power generation
Summary

G4 Bio-Natural Gas

• Nearly 15% of current NG consumed in US +EU can be displaced by renewable Bio Natural Gas with:
  – No change in technology or infrastructure
  – Additional sustainable forest-related jobs
  – No change to consumer preferences
• More can be displaced with advanced forest practices
• Low cost renewable electricity
• Most expedient way to make fleets 100% green