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Biomass to Ethanol

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Arkenol's Experience with Pilot Facilities

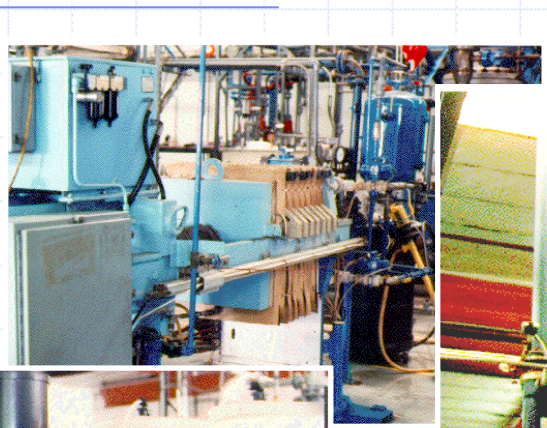
City of Orange, California

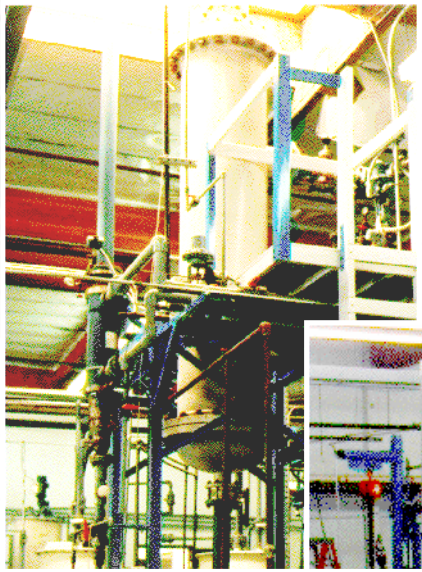
- Minimum permitting
- Fully enclosed, no significant waste discharged
- Used to test various equipment, test feedstock from U.S. and overseas
- Financed by Arkenol and ARK Energy, Inc.
- Operated for 5 years

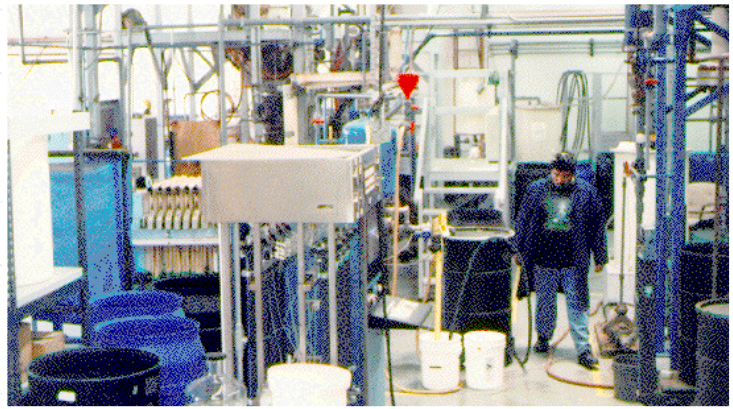
Izumi, Japan

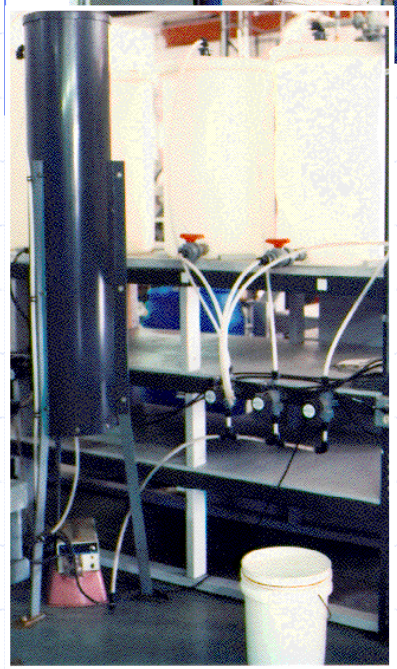
- Operated by Arkenol Licensee, JGC Corporation
- Facility required minimum permitting
- Located adjacent to existing ethanol plant
- Funded by JGC and NEDO (New Energy Development Organization)
- Integrated system operated since 2002
- Third party validation of Arkenol Technology

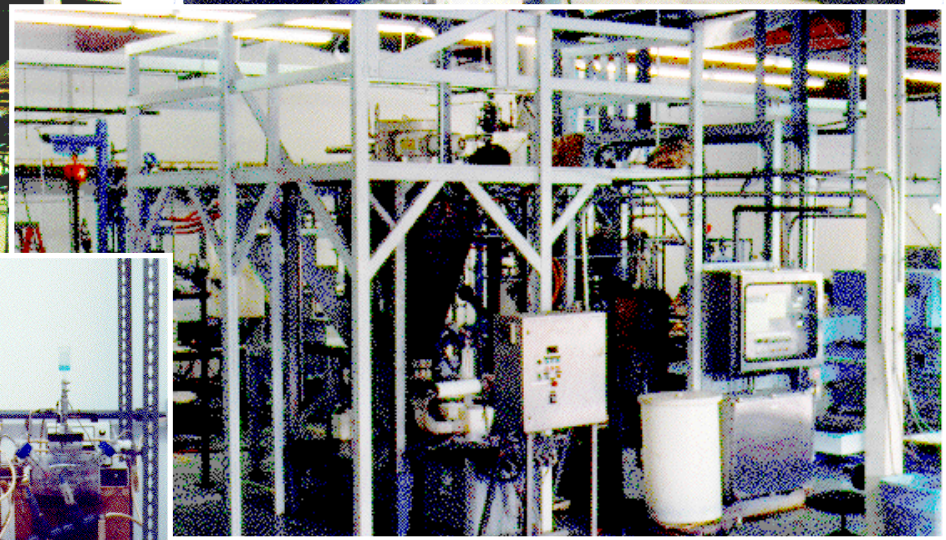
Arkenol Process Pilot Facility in U.S.

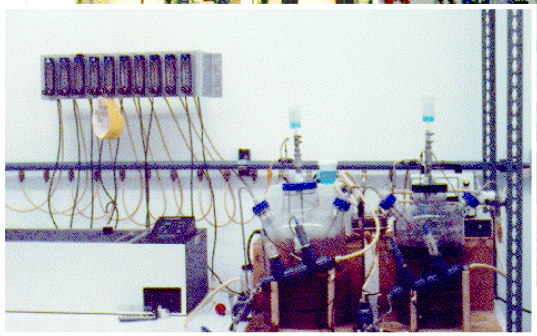












Continuous operation for 5 years!

Izumi Biomass to Ethanol Facility

Biomass

Drying, if necessary

moisture content < 10%

Crushing, if necessary

Particle Size < 3mm

Acid Hydrolysis

Filter Press

Filtrate

Sugar Acid Separation

Elution water

Sugar

Neutralization

Yeast, nutrient

Fermentation

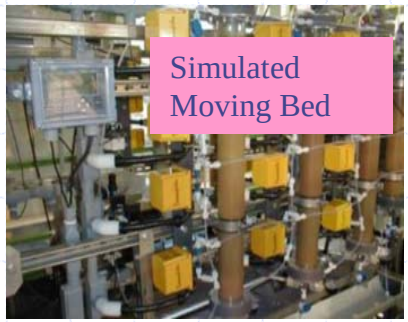
Distillation

Dehydration

Ethanol

Acid

Filter Cake



Izumi Highlights

- Fully integrated, Arkenol concentrated acid-hydrolysis system using waste wood chips as feedstock, operational since 2002.
- Cellulose conversion efficiencies optimized
- Sulfuric acid recovery at over 97% with reconcentration to 75% in continual use since 2002.
- Lignin combustion test (requiring 4 tons fuel lignin) completed successfully.
- Tested NREL developed rec. *Z. mobilis* (under license) in fixed bed and *S. cereviscae* to produce ethanol at 95% and above for over one year.
- 2 trains of ethanol fermentation capacity a.) 300 liters/day for fermentation assessments and b.) 6000 liters/day for engineering data collection
- Ethanol used by Japanese Government program for engine driveability tests and materials coupon tests.
- JGC commits to providing Design Specification Package for U.S.

Siting/Environmental Impacts of Arkenol's Process are Minimal Enabling Maximum Siting Opportunities

- Feedstock used up in process. All process streams converted to useful products
  - Sugars to Ethanol
  - Lignin to Solid Fuel for sale to biomass plants in the region or used on site to fuel boiler for steam
  - Neutralized sugars create gypsum sold as soil conditioner or as material for construction
  - Small amounts of spent yeasts may be sold as animal feed
- Air emissions – from combustion source providing steam and power to ethanol plant (eg. natural gas or landfill gas)
  - Well established regulatory process in place to evaluate emissions and controls

Siting/Environmental Impacts May Be Reviewed Within Existing Well Established Permitting Process

- Wastewater Discharge – process water recycled, wastewater discharge is primarily cooling water blow-down
  - Well established regulatory process in place to evaluate issues
- Other Public Health & Safety issues are addressed
  - More efficient acid recovery requires minimum make-up requirements – minimize storage, handling, deliveries
  - Use of common, less toxic sulfuric acid under mild conditions minimizes health and workplace hazards.
  - No requirement for high pressure/temperature vessels
  - Minimum fugitive dusts from biomass handling – process does not require energy intensive grinding of feedstock to small particle size
  - No enzyme risks (e.g., cost, health, workplace).
- Zoning
  - Locally determined - AG in some, (M2) Heavy Industrial in others

Arkenol California Permitting Experience

- Sacramento Ethanol Project (late 1990's)
  - Obtained long-term contracts with growers for rice straw supply
  - Obtained LOI for ethanol purchase and sale
  - Obtained all regulatory approvals after nearly 2 years of permitting
  - Project was proposed to be constructed with a new power plant
  - County of Sacramento had jurisdiction on ethanol plant and CEC had jurisdiction on power plant
  - CEQA review for both projects conducted by the California Energy Commission under a MOU with County of Sacramento – one process, one document
  - Project profile did not meet requirements for non-recourse project financing and was not built
    - Growers were not considered financeable (uncertainty in long-term supply from agricultural production)
    - Ethanol market uncertainty – at that time, MTBE was choice oxygenate, policies did not encourage ethanol use

Regulatory and Siting Hurdles in CA to Construction of Conversion Technologies

- CEQA Compliance Review – Who will do it?
  - Land use agency (County) but could include other agencies (Federal (NEPA) or State (CEC if Cogen)
  - Additional Local Permitting may be required if CTs are considered Disposal Facilities requiring review under the County Disposal Facilities Siting Element
  - CIWMB may require Solid Waste Permit under certain circumstances
- Issues:
  - Duplication of public hearings/public notices
  - Time and Money
- Need
  - Coordination (MOUs among agencies to determine who leads review, scope of review and how enforcement of permit conditions will be done)
  - One comprehensive document that all other agencies can use to issue relevant permits (CUP, Rezone, ATC, EA or FONSI, WDR, etc...)

Regulatory and Siting Hurdles in CA to Construction of Conversion Technologies

- Other Regulatory Issues
  - Issues
    - Agencies may not be staffed to handle nuances of technologies (some may require 3rd party consultants)
    - Air emission reduction credits (availability and cost)
    - Environmental benefit of biomass utilization/solid waste management unaccounted for
    - Environmental benefits from use of the products not considered
  - Need to acknowledge benefits of biomass to renewable fuels
    - avoidance of open-field burning – develop offsets for use
    - reduction in forest fires – provide incentives for use of forest residues
    - compliance with landfill diversion mandates- provide diversion credits
    - extension of landfill life from diversion of materials – remove barriers to conversion technologies – clarify definitions
    - Provide liquids supply – develop State RFS with requirements for in state production of ethanol
    - GHG emission reductions – acknowledge role and monetize GHG reduction benefits

Synergistic Opportunities for Siting Arkenol Facilities

- Use of MRF residuals, locate adjacent to MRF
  - Arkenol tests show residuals are high in cellulose and provide good opportunity for use in Technology
- Locate adjacent to landfill
- Cogeneration opportunities next to existing power plants (eg. Biomass plants)
  - As per ARK Energy/Arkenol original concept
- Biorefinery as anchor facility within an eco-industrial park
  - Arkenol technology found to be viable technology in such studies by USC
- Locate close to market (within blending terminal)

California Can Create Change

- California has a reputation to set trends and with its large transportation fuel market, California can turn the tide towards a meaningful shift to a new fuels paradigm built on biomass resources.

California must act to:

- Create the Markets For Biomass Fuels and Power
- Encourage Investments in Production Facilities
- Establish Sound Environmental Policies (update rooted environmental biases)