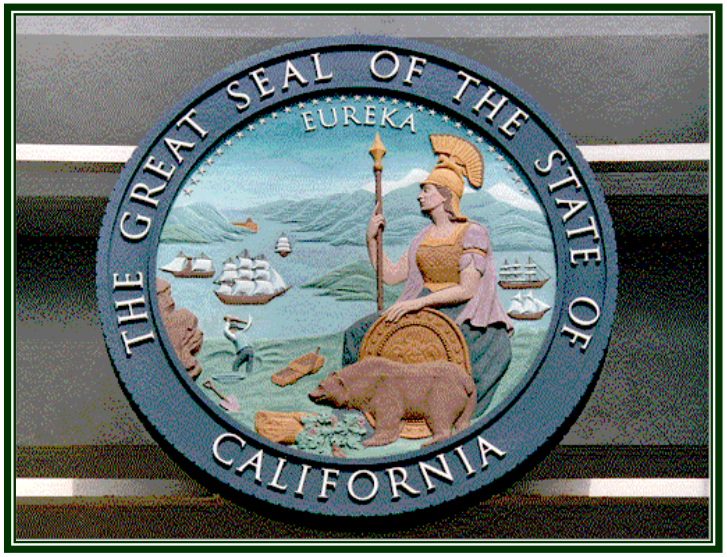
CONFIDENTIAL

BIOENERGY DEVELOPMENT, LLC

# CEC AB 118 WORKSHOP PRESENTATION




# CONVERSION TECHNOLOGIES AVAILABLE TO MEET SUSTAINABILITY GOALS

**BioEnergy Development, LLC (BED) & USDA RESEARCH LABS – Albany, CA**

# Sustainability Characteristics of BED/USDA

## Conversion Technologies for Biomass Waste

- Waste Streams for Feedstock
- Preliminary Commercialization of Cellulosic Technologies
- Integrated, Closed-Loop Systems – Optimize biomass-to-ethanol-and-co-generation
- Water Reduction & Reuse Technologies
- Minimal Criteria Emissions – Due to closed-loop processing
- $CO_2$ Capture and Use for Algae Production
- Potential for Extremely Low or Negative LCA-Scale GHG Emissions

# WASTE STREAMS FOR FEEDSTOCK

## AND DEDICATED, RENEWABLE ENERGY CROPS - USDA

### FRUIT

**All Citrus**:
- Whole/Spoiled Fruit
- Pulp/Membranes/Peel
- Field Cuttings

**Apples/Grapes/Wine**:
- Pomace/Skins
- Whole/Spoiled Fruit
- Cuttings
- Bad Wine or Juice

### VEGETABLES

**Corn**:
- Cob/Stalks
- Kernels
- Meal/Bad Flour

**High Starch/Sugar Crops**:
- Baby Carrots
- Potatoes
- Yams

### NUTS

**Almonds**:
- Hulls/Shells
- Cuttings

**Walnuts/Pistachios**:
- Hulls/Shells
- Cuttings

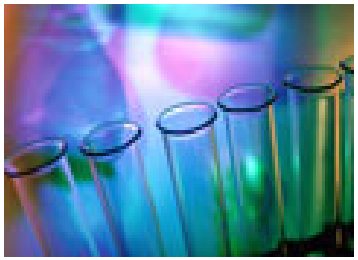
### BIOMASS

**Field Clippings**:
- Wood chips
- Tree Stumps
- Green Waste
- Wood Pulp

**Packaging** – Paper/O

**Sugar Cane**:
- Entire Crop

**Sugar Beets**:
- Entire Crop

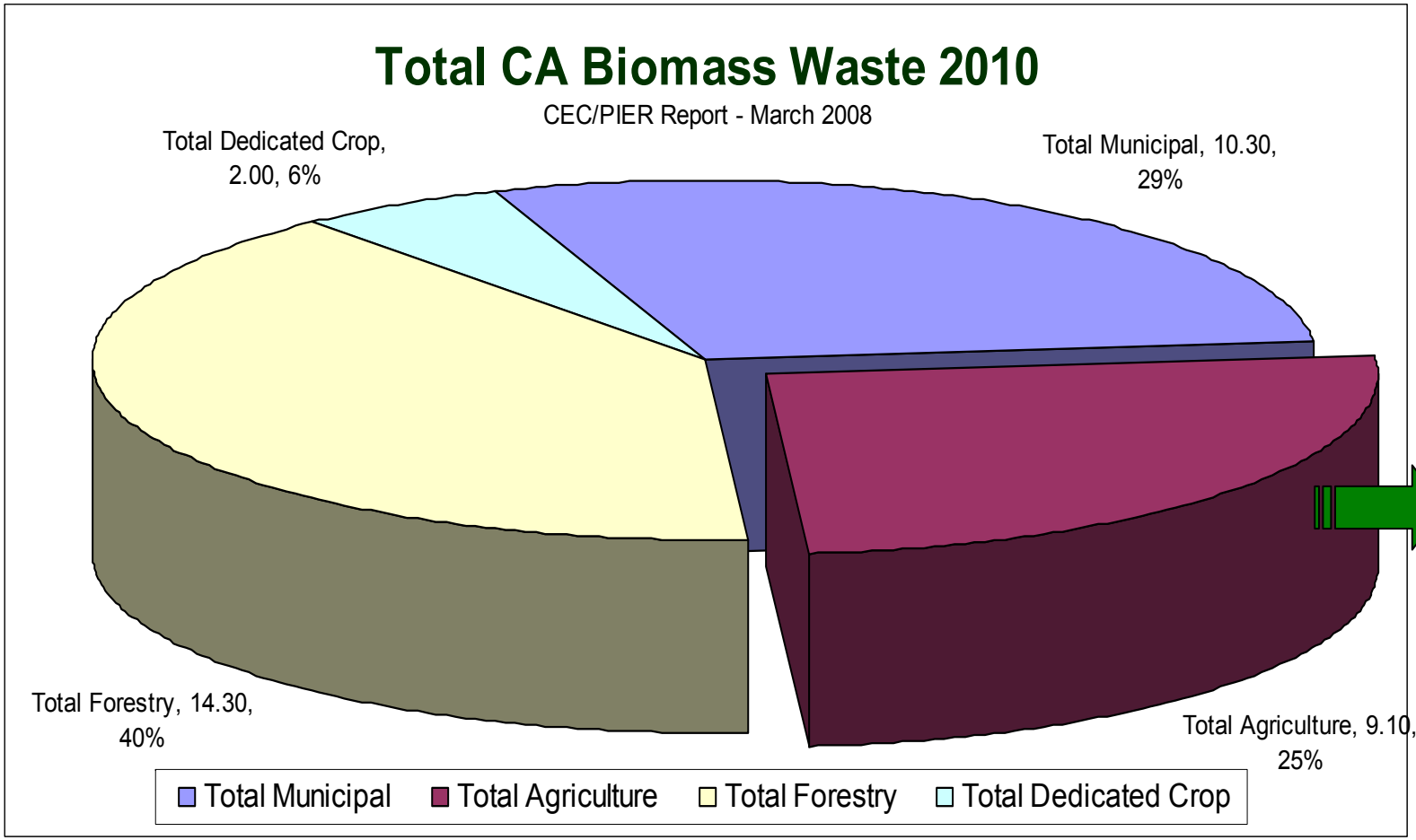


**OUR PLANNED CALIFORNIA, INTEGRATED, BIOREFINERY CAN HANDLE UP TO 4,000 TONS/DAY BIOMASS WASTE**

# PROJECTED 2010 CALIFORNIA BIOMASS

**Total Biomass** = 88.70 Million BDTY **Total Technical Biomass Available** = **35.70** Million BDTY

**40%**
**Total Biomass**




**15%**
**CA**

- **Orchard / Vineyard**
- **Field / Seed**
- **Vegetable**
- **Food Processing**

**4.8%**
**4 County Area**

# PROJECTED 2010 CALIFORNIA BIOMASS

## CA Total Technical Biomass Available = 35.70 Million BDTY

| Year | Gross | | Technical | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | | 2007 | | | 2010 | | | 2017 | | | 2020 | | |
| | *4-County* | *4-County %* | CA | *4-County* | *4-County %* | CA | *4-County* | *4-County %* | CA | *4-County* | *4-County %* | CA | *4-County* | *4-County %* |
| **Total Biomass** | | | **32.60** | | | **35.70** | | | **39.60** | | | **40.40** | | |
| Excluding Dedicated Crops | | | 32.60 | | | 33.70 | | | 35.10 | | | 35.90 | | |
| Thermal Conversion[5] | | | 26.00 | | | 29.10 | | | 32.30 | | | 32.70 | | |
| Biological Conversion[6] | | | 6.10 | | | 6.70 | | | 7.30 | | | 7.70 | | |
| | | | | | | | | | | | | | | |
| **Total Municipal** | | | **9.60** | | | **10.30** | | | **10.90** | | | **11.30** | | |
| Biosolids Landfilled | | | 0.00 | | | 0.00 | | | 0.00 | | | 0.00 | | |
| Biosolids Diverted | | | 0.60 | | | 0.60 | | | 0.60 | | | 0.70 | | |
| MSW Biomass Landfilled | | | 9.10 | | | 9.70 | | | 10.30 | | | 10.70 | | |
| MSW Biomass Diverted | | | 0.00 | | | 0.00 | | | 0.00 | | | 0.00 | | |
| | | | | | | | | | | | | | | |
| **Total Agriculture** | **3.20** | 15% | **8.60** | **1.53** | 18% | **9.10** | **1.73** | 19% | **9.90** | **1.73** | 17% | **10.30** | **2.20** | 21% |
| Animal Manure | | | 3.50 | | | 3.90 | | | 4.30 | | | 4.60 | | |
| Orchard and Vineyard[1] | 1.00 | 38% | 1.70 | 0.70 | 41% | 1.80 | 0.80 | 44% | 2.10 | 0.90 | 43% | 2.20 | 0.90 | 41% |
| Field and Seed[2] | 1.40 | 30% | 2.10 | 0.60 | 29% | 2.00 | 0.60 | 30% | 2.00 | 0.50 | 25% | 2.00 | 0.50 | 25% |
| Vegetable[3] | 0.40 | 24% | 0.10 | 0.03 | 30% | 0.10 | 0.03 | 30% | 0.10 | 0.03 | 30% | 0.20 | 0.03 | 15% |
| Food Processing[4] | 0.40 | 27% | 1.20 | 0.20 | 17% | 1.20 | 0.30 | 25% | 1.30 | 0.30 | 23% | 1.40 | 0.30 | 21% |
| | | | | | | | | | | | | | | |
| **Total Forestry** | | | **14.30** | | | **14.30** | | | **14.30** | | | **14.30** | | |
| | | | | | | | | | | | | | | |
| **Total Dedicated Crop** | | | **0.00** | | | **2.00** | | | | | | **4.50** | | |

**4.8%**
**100 miles**

[1]Prunings and tree and vine removals. Close to 1 million tons is currently used as fuel inpower plants, such as urban wood and forest materials.
[2]Rice straw, corn stover, energy crop grasses such as bermuda grass and switch-grass, and high-fiber su
[3]To date, have not been generally considered for off-field utilization and are commonly incorporated into the soil. Baby carrots, potatoes, yams, etc.
[4]Nut shells, fruit pits, rice hulls, cotton gin trash, grape and tomato mace, winery, etc.
[5]All cellulosic and carbon based materials. Some of these can be processed by technologies other than Thermal Conversion.
[6]Putresible (Food) waste.

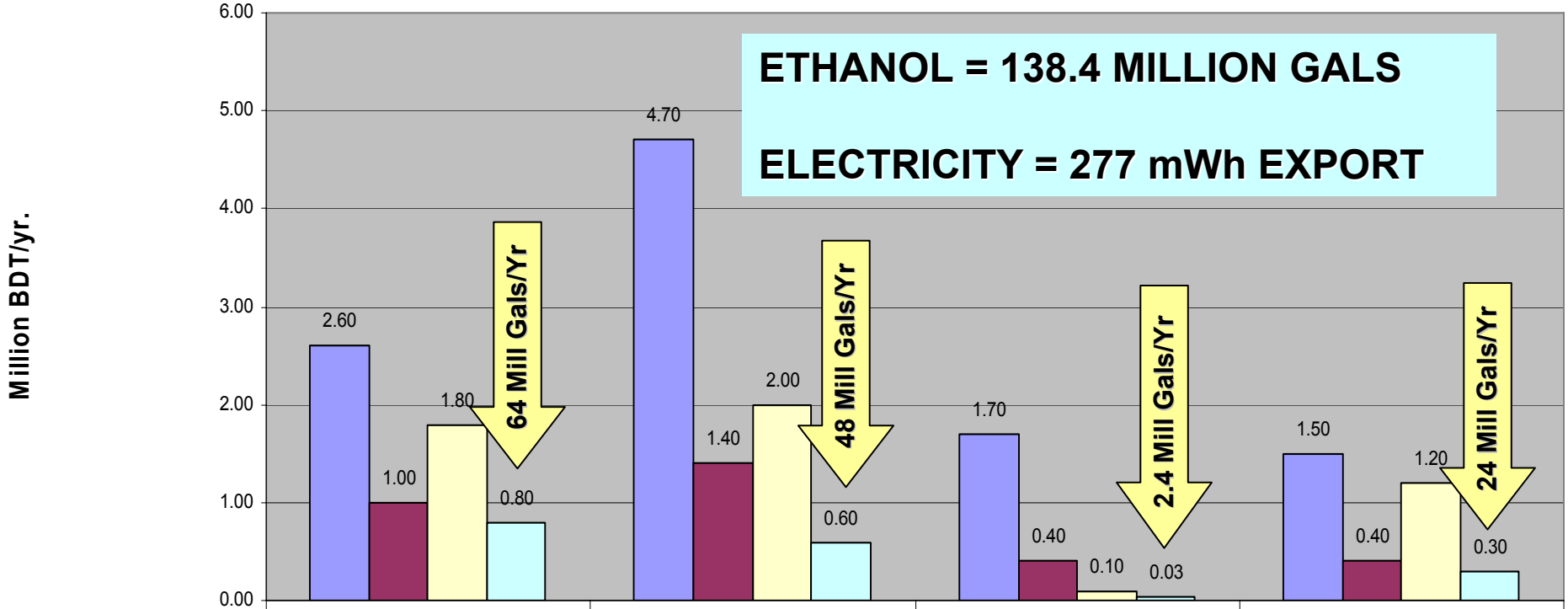
**COMMERCIAL PLANT LIES IN THE MIDDLE OF A 4 COUNTY AGRICULTURAL AREA**

All data is from the California Energy Commission and PIER Collaborative Report An Assessment of Biomass Resources in California, 2007 (Dated March, 2008)

# PROJECTED 2010 CALIFORNIA BIOMASS

**CA Total Technical Biomass Available** = **35.70** Million BDTY

**USING BED/USDA TECHNOLOGIES TO CONVERT WASTE TO ETHANOL & ELECTRICITY**



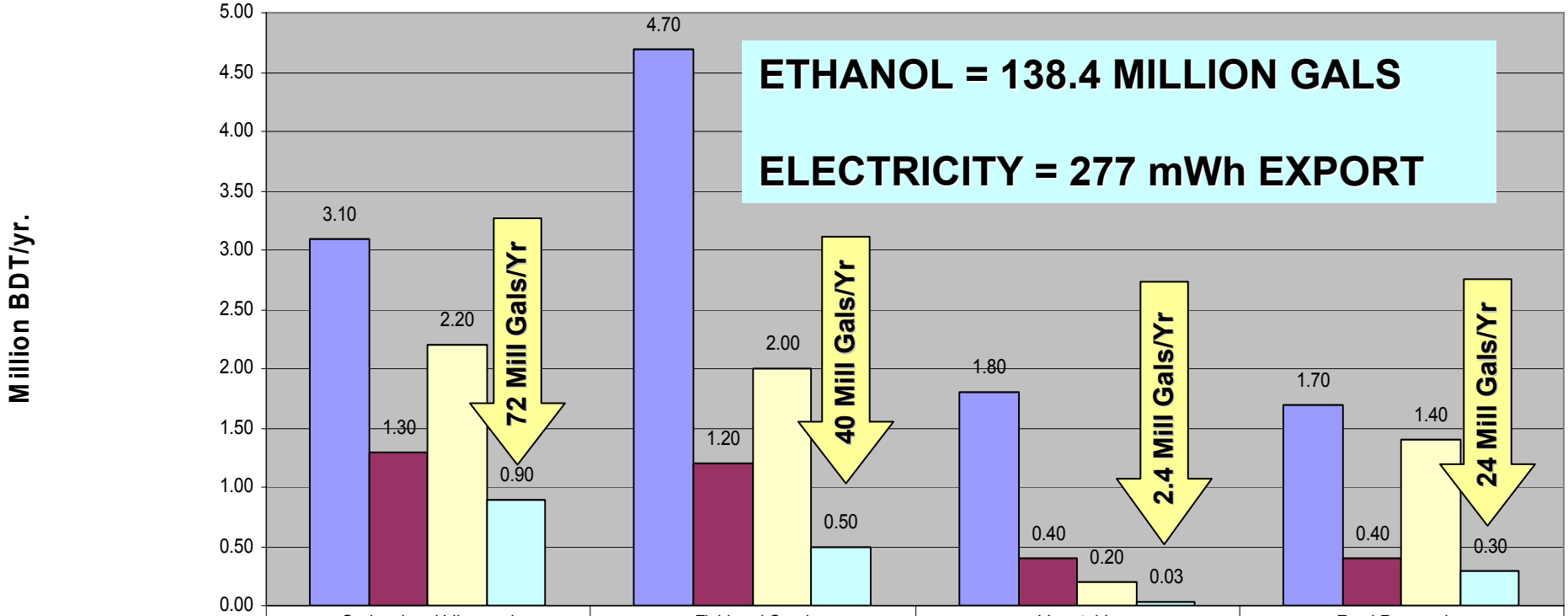

| | Orchard and Vineyard | Field and Seed | Vegetable | Food Processing |
|---|---|---|---|---|
| Gross 2010 CA | 2.60 | 4.70 | 1.70 | 1.50 |
| Gross 2010 4-County | 1.00 | 1.40 | 0.40 | 0.40 |
| Technical 2010 CA | 1.80 | 2.00 | 0.10 | 1.20 |
| Technical 2010 4-County | 0.80 | 0.60 | 0.03 | 0.30 |

**WITHIN A 100 MILE RADIUS OF THE FIRST COMMERCIAL PLANT**

# PROJECTED 2020 CALIFORNIA BIOMASS

**CA Total Technical Biomass Available** = **40.40** Million BDTY

**USING BED/USDA TECHNOLOGIES TO CONVERT WASTE TO ETHANOL & ELECTRICITY**




| | Orchard and Vineyard | Field and Seed | Vegetable | Food Processing |
|---|---|---|---|---|
| Gross 2020 CA | 3.10 | 4.70 | 1.80 | 1.70 |
| Gross 2020 4-County | 1.30 | 1.20 | 0.40 | 0.40 |
| Technical 2020 CA | 2.20 | 2.00 | 0.20 | 1.40 |
| Technical 2020 4-County | 0.90 | 0.50 | 0.03 | 0.30 |

**WITHIN A 100 MILE RADIUS OF THE FIRST COMMERCIAL PLANT**

# BED/USDA LABS

## INTEGRATED, BIOREFINERY PILOT PLANT

PRELIMINARY
COMMERCIALIZATION OF
CELLULOSIC TECHNOLOGY

# TECHNOLOGY ADVANCEMENTS

## BIOMASS TO BIOFUELS/BIOPRODUCTS

**INCREASED EFFECIENCY & PRODUCTION YIELDS**

**READY 3rd QTR 2009**

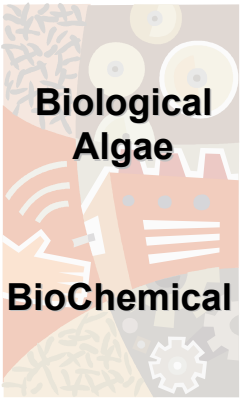
**3 TECHNOLOGY**
**PILOT PLANTS**
**BERKELEY, CA**

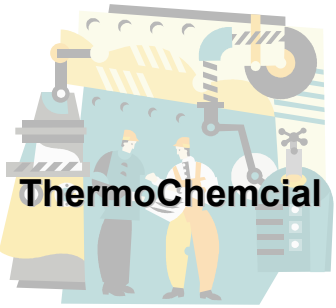
**Basic Science Transfer UC Berkeley**

**ENZYMATIC GMO**

**DILUTE ACID HYDROLYSIS**

**GASIFICATION GMO/CATALYTIC**




**ETHANOL**

**BUTANOL**

**BIOCHEMICALS**

**ENZYMES**

**YEAST**

**BIODIESEL**
**GHG Seq**

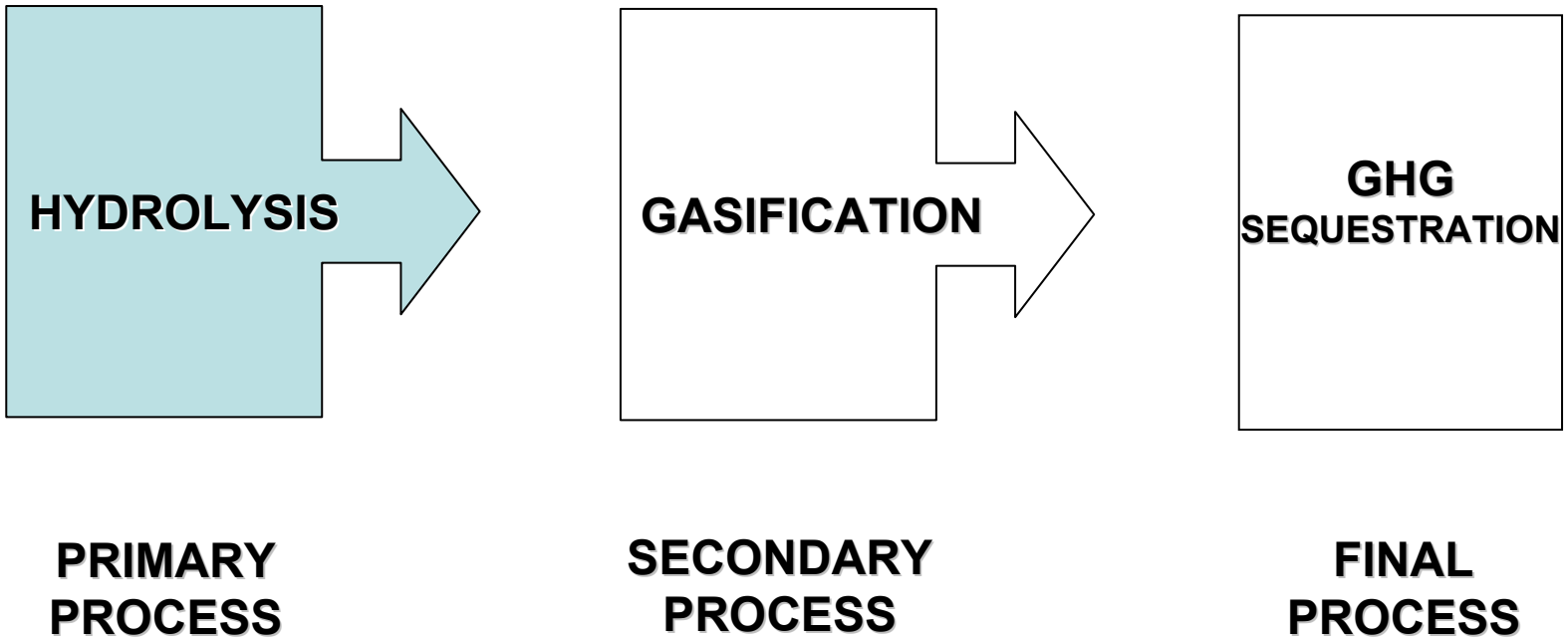
**ELECTRICITY**
**HEAT**
**POWER**

**Capacity of 5 tpd ea.**

**BASED ON BED MULTI-STAGE PATENT-PENDING TECHNOLOGIES**

# BED/USDA INTEGRATED BIOREFINERY PILOT PLANT

## R&D DEPARTMENTS OF SPECIALIZATION

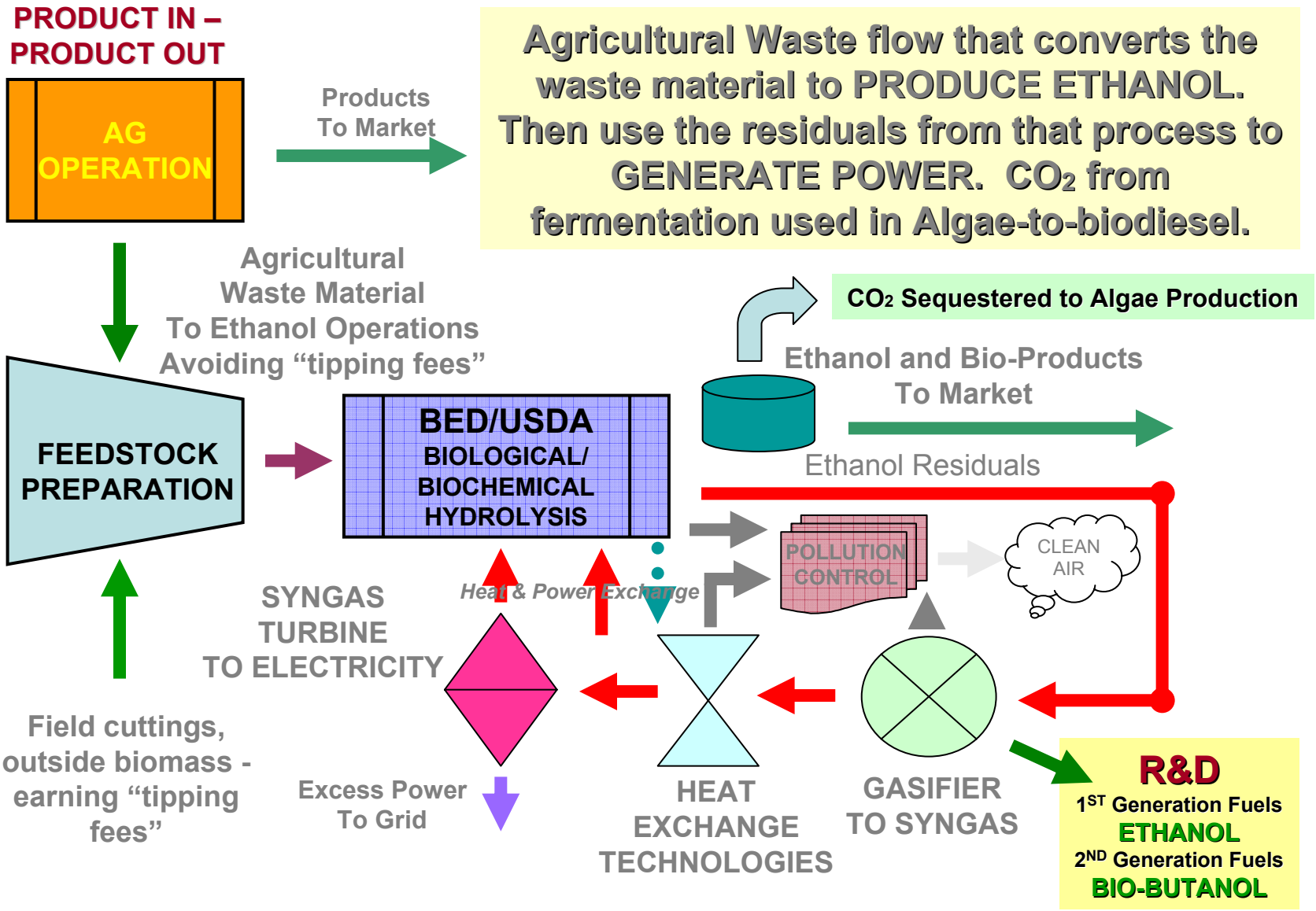



**4TH GENERATION HYDROLYSIS PROCESS**

4 CONVERSION TECHNOLOGIES USED IN 1 COMMERCIAL PLANT

Process

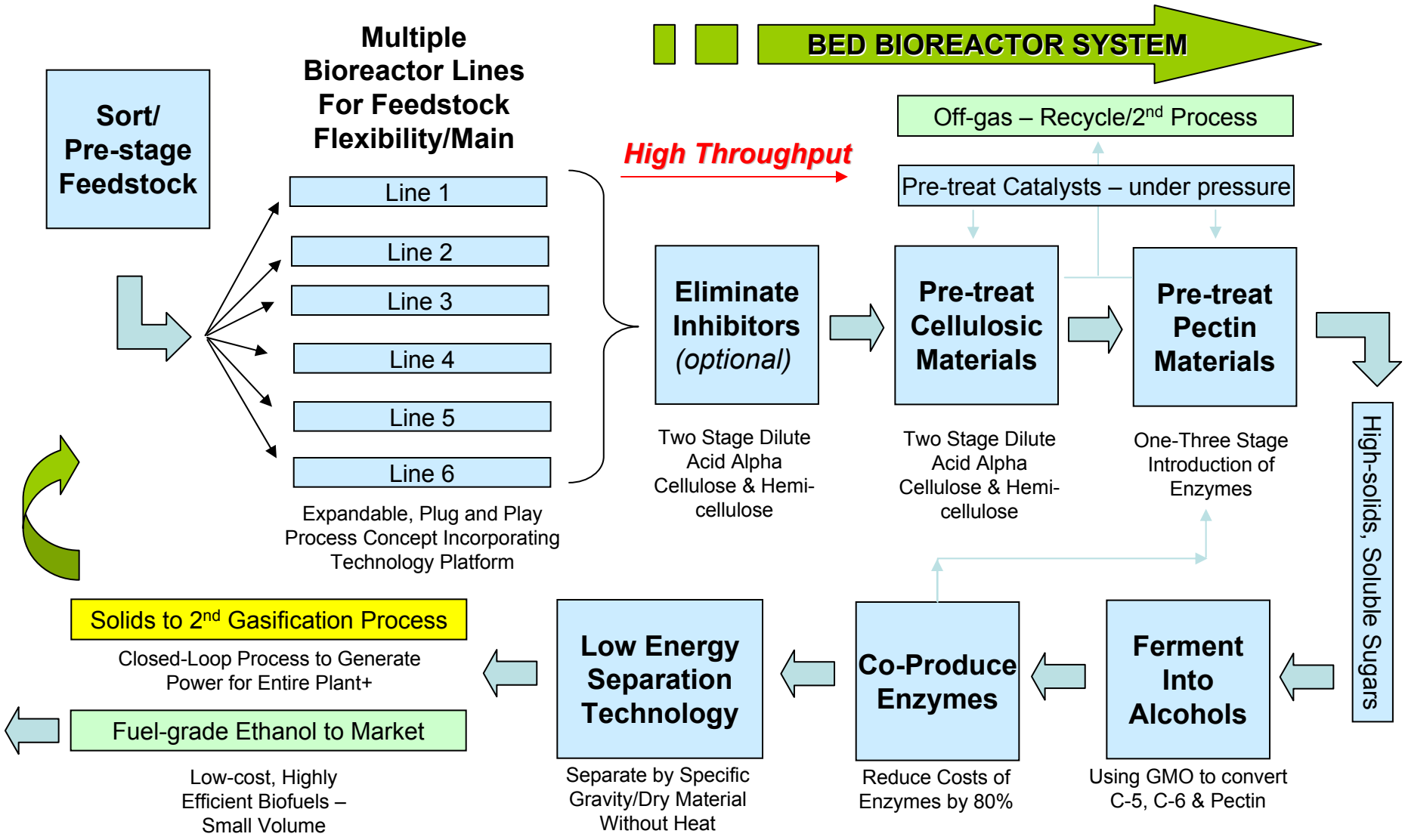
# Ethanol Closed-Loop Operation



# PRIMARY PROCESS

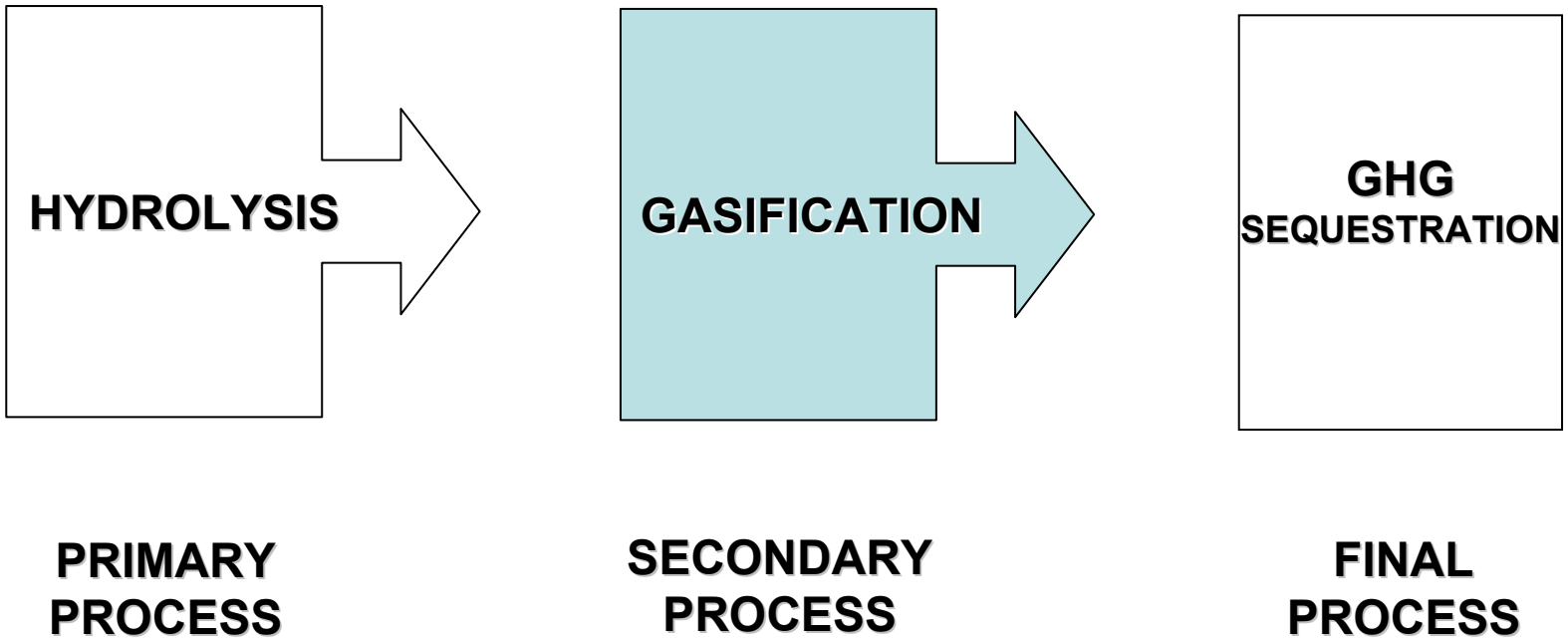
## Hydrolysis of Cellulosic Waste

# Patent-pending – High Solids, Continuous Flow, Multiple-Stage, Biological/BioChemical Catalyst, In-Line BioReactor System



# BED/USDA INTEGRATED BIOREFINERY PILOT PLANT

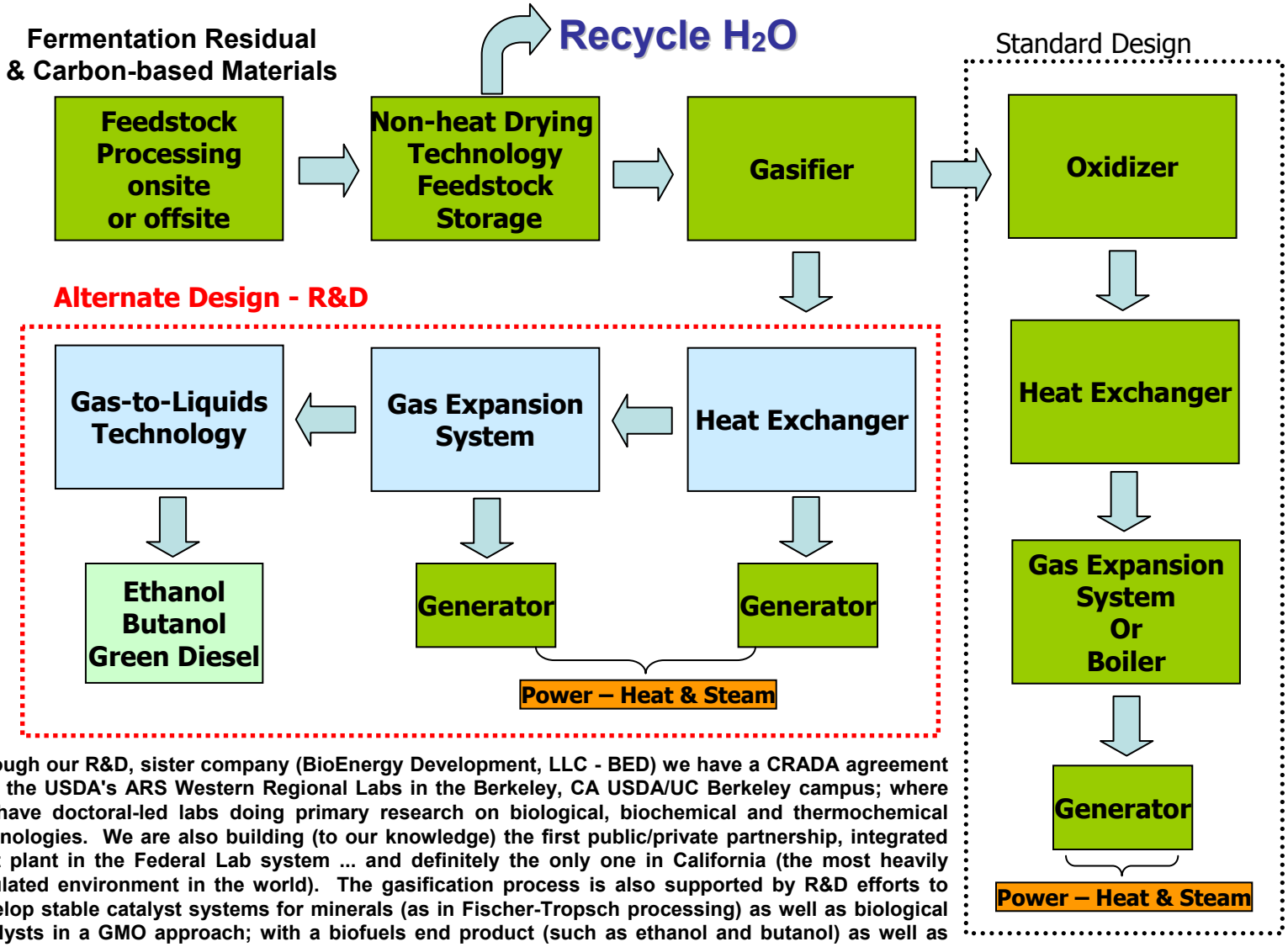
## R&D DEPARTMENTS OF SPECIALIZATION




**GMO & FISCHER TROPSCH BIOFUEL CONVERSION**

## SECONDARY PROCESS

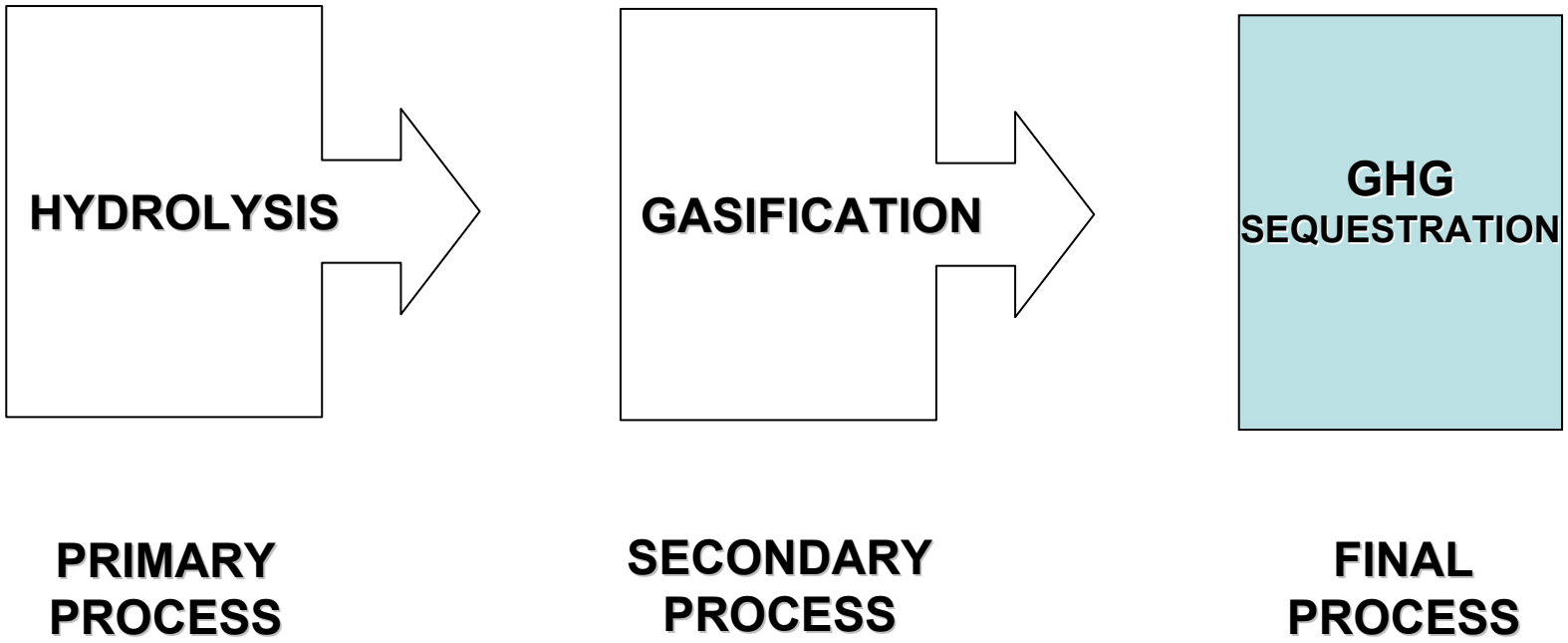
# BED/USDA GASIFICATION PLATFORM




Through our R&D, sister company (BioEnergy Development, LLC - BED) we have a CRADA agreement with the USDA's ARS Western Regional Labs in the Berkeley, CA USDA/UC Berkeley campus; where we have doctoral-led labs doing primary research on biological, biochemical and thermochemical technologies. We are also building (to our knowledge) the first public/private partnership, integrated pilot plant in the Federal Lab system ... and definitely the only one in California (the most heavily regulated environment in the world). The gasification process is also supported by R&D efforts to develop stable catalyst systems for minerals (as in Fischer-Tropsch processing) as well as biological catalysts in a GMO approach; with a biofuels end product (such as ethanol and butanol) as well as bioplastics and other biochemical substitutes for petro-chemical products.

# BED/USDA INTEGRATED BIOREFINERY PILOT PLANT

## R&D DEPARTMENTS OF SPECIALIZATION




**Experimental Stage GHG Sequestration**

# BED/USDA INTEGRATED BIOREFINERY PILOT PLANT

## BED/USDA Research & Development

### Algae growth to produce oils for biodiesel

**Closed Photobioreactors**

***Advantages:***

- ***Higher Productivity***
- Less contamination, water use, & $CO_2$ losses
- Better light utilization & mixing
- Controlled culture conditions

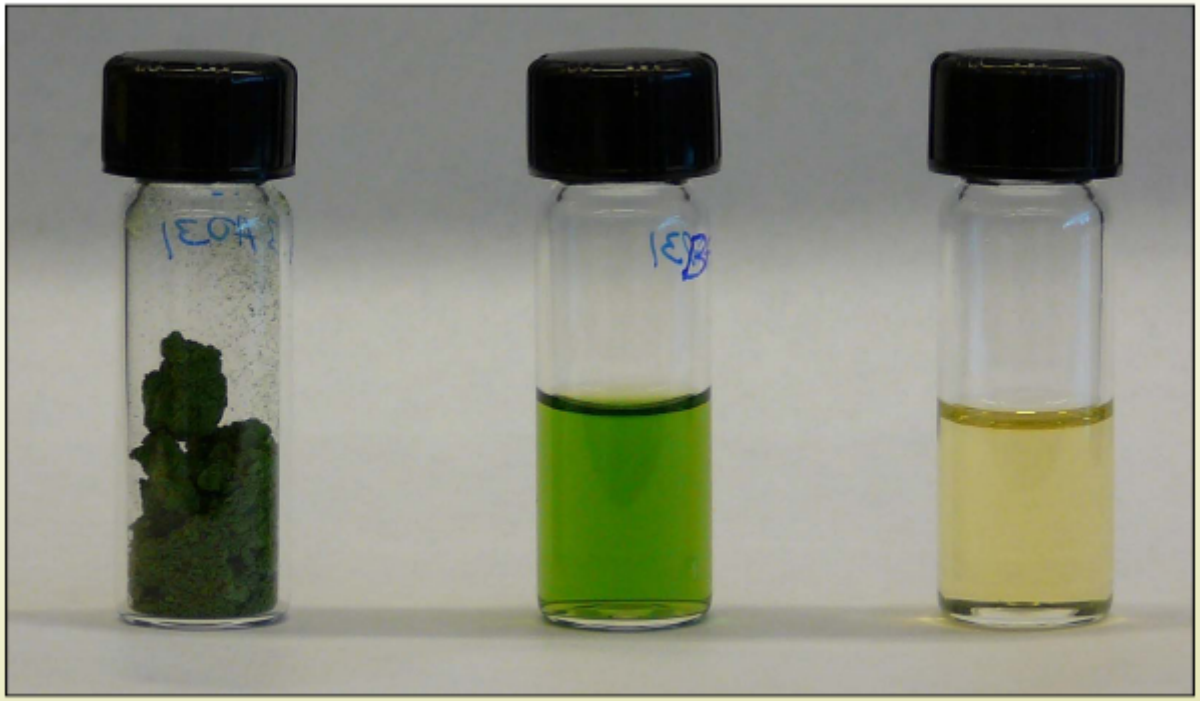
***Disadvantages:***

- Cost/complexity
- Thermal management
- Oxygen accumulation
- Biofouling
- Cell damage by shear stress
- Deterioration of materials

**$CO_2$ sequestration from ethanol fermentation process**

# BED/USDA INTEGRATED BIOREFINERY PILOT PLANT

## Algae to Biodiesel



Dried Algae | Algae Lipid Extract | Biodiesel

# $CO_2$ SEQUESTRATION

ALGAE

## R&D Goals

- Finalize vertical, enclosed bioreactor design
- R&D work on conversion of algae to biodiesel
- GMO development of algae
  - Geographic strains
  - Growth rate
  - Oil concentrations
- Oxygen release, filtering and clean-up
- Transesterfication

# CLOSED-LOOP PROCESS

## WATER & RECLAIMED WATER

- **BED BIOREACTOR – HIGH SOLIDS**
  - Use moisture content of biomass to process + recycled water
  - Steam vented from reactor to recovery
- **BED/USDA FERMENTATION – HIGH SOLIDS**
  - Use moisture content from bioreactor materials + recycled water
  - Distillation Process – separation of $H_2O$ to recovery
- **BED/USDA THERMOCHEMICAL**
  - Steam recovered to boiler for "front hydrolysis process"
- **BED/USDA ALGAE BIOREACTOR – HIGH SOLIDS**
  - Use recycled water
  - Extraction process separates $H_2O$ from algae biomass
- **GRAY WATER TO LANDSCAPE**
  - Any left-over water used to support photosynthesis from landscape

*ALL INCOMING AND OUTGOING WATER IS TREATED – SOLIDS RECYCLED BACK INTO HYDROLYSIS PROCESS*

# CLOSED-LOOP PROCESS

## MINIMAL CRITERIA EMISSIONS

- **BED BIOREACTOR – CONTINUOUS FLOW – LOW HEAT**
  - Vent gases to closed-loop, secondary process
  - USDA R&D to develop new substitute chemicals
- **BED/USDA FERMENTATION – HIGHLY EFFICIENT**
  - Convert all C-5, C-6 (& Pectin – if fruit is feedstock) Sugars
  - Lignin represents the vast majority of material left-over – to secondary process. Lignin is a medium-high BTU value material.
- **BED/USDA THERMOCHEMICAL – LOW HEAT**
  - Residual materials from process converted into SYNGAS
  - Any air emissions left are collected thereafter and mitigated
  - Only 6.1% of all current ethanol plants use CHP technologies
- **BED/USDA ALGAE BIOREACTOR – Start of GHG R&D**
  - Sequesters $CO_2$ from Fermentation
  - Creates Oxygen, biofuels and carbon credits (future)

*The BED/USDA Labs have a vigorous R&D program to mitigate all GHG and convert them to Beneficial Uses*

# CLOSED-LOOP PROCESS

## EXTREMELY LOW OR NEGATIVE LIFECYCLE ANALYSIS GHG EMISSIONS

**BED/USDA LABS CONVERSION TECHNOLOGIES**

- **BED/USDA TECHNOLOGIES – NEGATIVE $C0_2$ EMISSONS**
  - Biomass left to decay in the fields emit fugitive $CO_2$
  - BEB/USDA Technologies create $CO_2$ from biofuel production – but, captive … same with particulate matter, NOx, SOx and other GHG
- **BED/USDA TECHNOLOGIES – DISPLACE PETROLEUM**
  - Replaces sequestered GHG (from oil) with Renewables
  - Lower emissions from vehicles per Argonne & CE-CERT studies
  - Biomass Waste eliminates corn-based use: fertilizers, insecticides
- **BED/USDA ALGAE BIOREACTOR – Start of GHG R&D**
  - Sequesters $CO_2$ from Fermentation: 5,440 tpy/100,000 tpy feedstock
  - Creates Oxygen, biofuels and carbon credits (future)

*The BED/USDA Labs have a vigorous R&D program to mitigate all GHG and convert them to Beneficial Uses*

*Draft AB 118 Framework*

# CEC Sustainability Characteristic Goals

# BED/USDA/Commercial Project Analysis

- **GOAL 1 – CLIMATE CHANGE**
  - Char #1: **Reduced GHG**: $CO_2$ conversion into biomass/green fuels & biochemicals – R&D USDA on rest of GHG to similar goals.
- **GOAL 2 – NATURAL RESOURCE PROTECTION**
  - Char #2: **Use of Waste Streams**: Use of 100% agricultural waste materials – protects environment
  - Char #3: **Efficient Use of Resources**: UC Berkeley/DOE & USDA Labs to verify – Pilot Plant actual test data on various feedstocks with all CTs – Interact with CA State Agencies
  - Char #4: **Forest Biomass Sustainability**: Follows our R&D commitment to energy crops & and use of waste materials only
  - Char #5: **BMP for Energy Crops**: USDA R&D commitment: contaminated soil R&D
  - Char #6: **Energy Crops – CA Specific**: USDA R&D: specific algae species/other energy crops
  - Char #7: **Feedstocks from Historic Ag Areas**: Our current commercial project is such
  - Char #8: **Renewable Energy & Co-Generation**: Use of secondary CTs for CHP
  - Char #9: **Generation of Natural Resource Co-Benefits**: See contaminated soil #5
- **GOAL 3 – CERTIFIED SUSTAINABILITY PRACTICES**
  - Char #10: **Best Available Sustainable Fuels**: Closed-loop process – self generating – see #3
  - Char #11: **Certified Sustainable Feedstock**: USDA/DOE/UC Berkeley Validation
- **GOAL 4 – MINIMIZE RISK OF UNANTICIPATED CONSEQUENCES**
  - Char #12: **Avoid Impacts/Create Economic Benefit**: Rural area – commercial plants

# STAKEHOLDER PROPOSAL

- **BED/USDA – Pilot Plant** – Infuse $7.3 million for Pilot Plant equipment and $1,176,500 per year for on-going yearly R&D with the USDA
- **Commercial Plant** - $472,367 for permit technology support and $1,526,724 for permitting
- **CEC – AB 118 Funds**
  - **Fund** – ARS Western Regional Labs
    - $7.3 million for equipment for the BED/USDA CRADA # 58-2K95-7-1216 Pilot Plant:
      - Fully integrated biorefinery pilot plant
      - GHG Testing Equipment
      - Real-time data for permitting and State use for all CT types
    - $1,176,500 per year, for 7 years for on-going yearly R&D with the USDA
      - $CO_2$/GHG R&D – Green BioDiesel and petro-chemical substitute products
      - Various biomass feedstock R&D for California, including energy crops
  - **Fund** – Commercial Plant (@50%) $1,526,724 for permitting process on the 1st CA Project in one of the most severe air non-attainment zones of California

**PUTS PROJECT ON FAST TRACK**

**THIS YEAR**

# BED/USDA PILOT PLANT & FIRST COMMERCIAL PLANT

## SUMMARY

- **Secured Technologies**
  - Patent-Pending BioReactor and BioRefinery Equipment
  - Strategic Partnerships -- for additional technologies
  - Multiple-Technology Platform – grow with the market
  - USDA CRADA – long-term product development
- **Long-Term Commitments for Commercial Products**
  - Price stability - with 25 year long-term feedstock agreements
  - Very competitive pricing/operational position
  - Long-term product demand
  - Ability to make different energy products
- **Good Public Relations**
  - Ties with USDA – **only Biomass, Integrated Pilot Plant in California**
  - California – meets BioEnergy Action Plan & Carbon Initiative Goals
    - Conforms to all Sustainability Characteristic Goals set forth in AB 118
      - Reduced water usage
      - Reduced Lifecycle Analysis of GHG
      - Uses Waste – NOT FOOD
  - National Security – cuts into demand for imported energy sources
    - Reduces imported oil and energy sources – CA independence

# CALIFORNIA RESOURCES & INGENUITY

## CONVERT CALIFORNIA AGRICULTURAL WASTE TO ALTERNATIVE ENERGY

## NOT FOOD

CALIFORNIA
The Golden State

U.S. DEPARTMENT OF ENERGY

BED
BioEnergy Development
PILOT PLANT

California Integrated Waste Management Board

Climate Action Team
Working to reduce climate change emissions in California...

AG BIOMASS TO ETHANOL

**CALIFORNIA FARMERS, CO-OPS AND FOOD PROCESSORS**

## A POWERFUL IMAGE THE AMERICAN PEOPLE CAN COUNT ON!

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