GREAT VALLEY ENERGY

Fractionated Sweet Sorghum to Biofuels and Products

California Agriculture Biofuels Forum

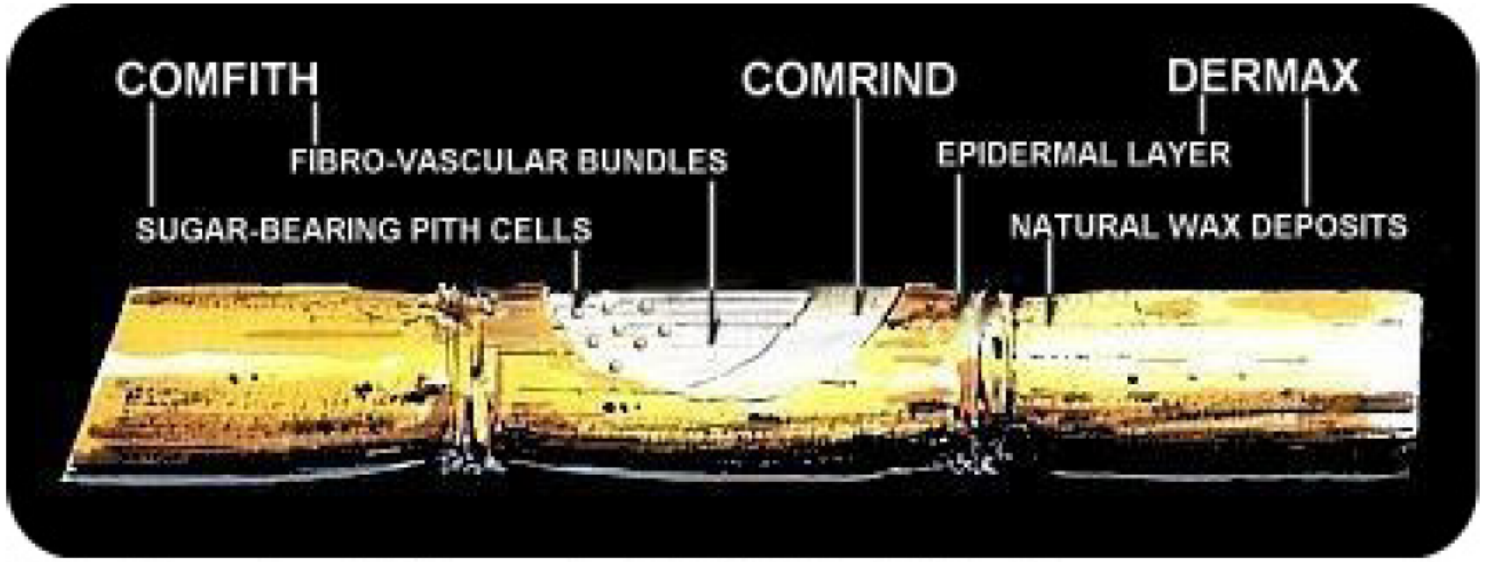
September 2011

Advanced Biofuels Using Sweet Sorghum

- Qualifies as Advanced Biofuel – Leading Edge
- No Impact on Corn Market
- Grows Well in San Joaquin Valley and Marginal Soils
- Low water use
- Can be Front-End Fractionated

Sweet Sorghum Can be Fractionated

- Comfith contains sugar juice in soft cellulosic material
- Comrind is woody outer material
- Dermax is epidermal layer containing natural waxes and bioactive compounds



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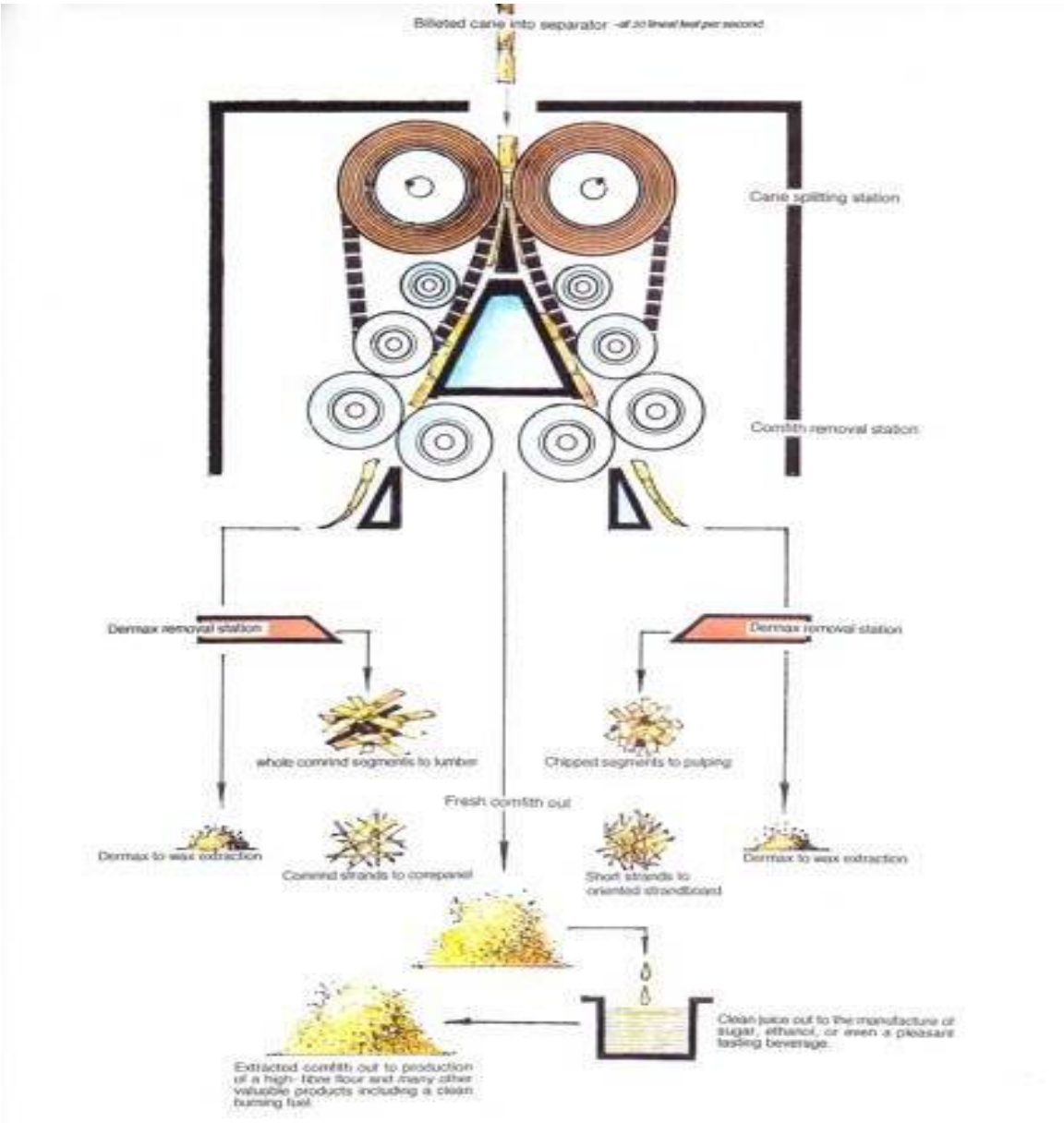
Fractions Can Be Processed to Products

Separation Technology



THE TILBY CANE SEPARATION SYSTEM

Fractions Can Be Processed to Products

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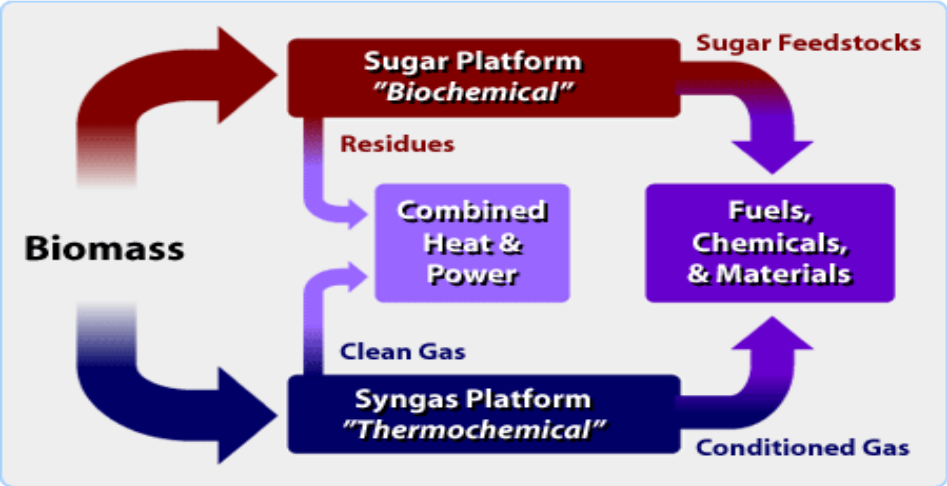
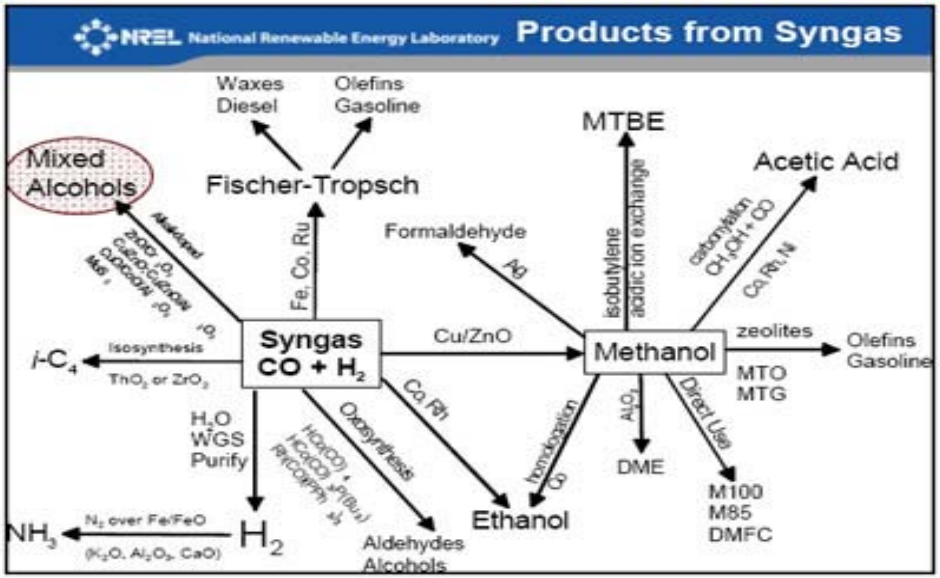
Fractionation - So What? Biorefinery.

- Multiple products = multiple income streams = greater economic stability
- Flexibility to adjust to market changes
- Foundation for further optimization (e.g., cellulosic ethanol when commercially available)
- Follows oil refinery model (many products – gasoline, diesel, LPG, waxes, fertilizers, etc.)

Biorefinery Concept



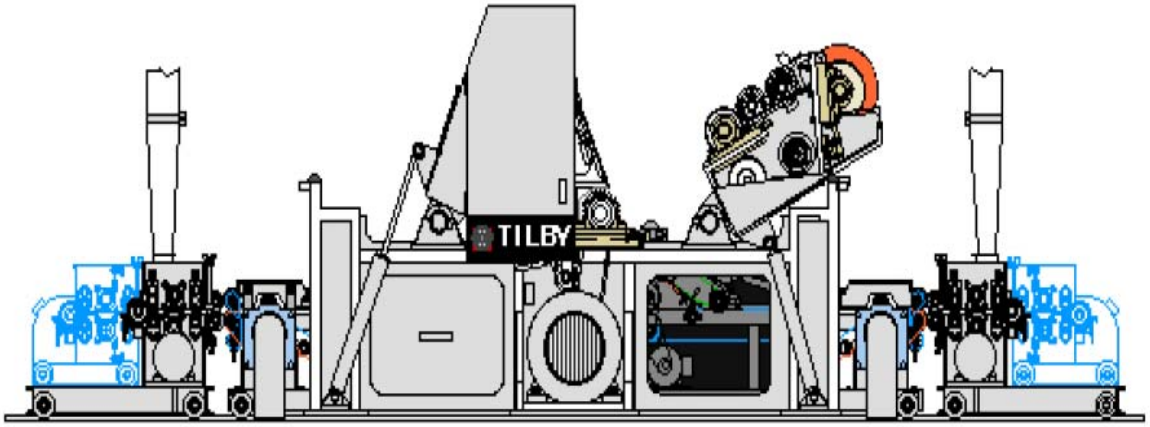


Typical Yield of Fractions and Economic Value

Component	Amount per Ton of Sweet Sorghum
Comfith	132 pounds @ 0% Moisture
Juice	1680 pounds @ 15-18 brix
Comrind	148 pounds @ 0% Moisture
Dermax	40 pounds @ 65% moisture

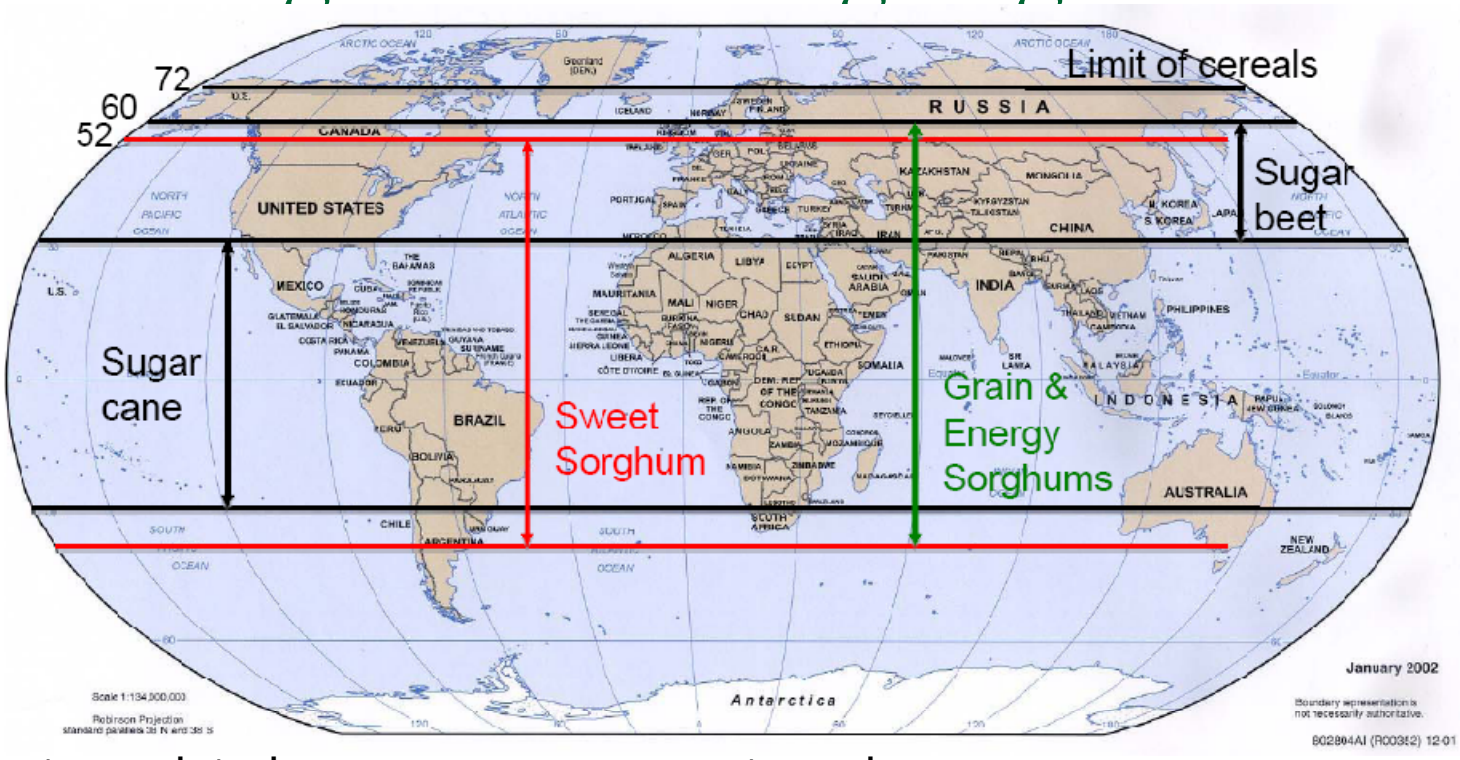
Component	Product	Amount Produced per ton	Economic Value	Weighted Value Per ton
Comfith	Biomass fuel pellets	132 pounds	$160 per ton	$10.56
Juice	Ethanol	18 gallons	$1.75 per gallon	$31.50
Comrind	Biogas	0.6 mmbtu	$4.50 per mmbtu	$2.70
Dermax	Bioactives	40	$1.00 per pound	$40.00
			TOTAL	$84.76

Sweet Sorghum As a Purpose-grown Energy Feedstock



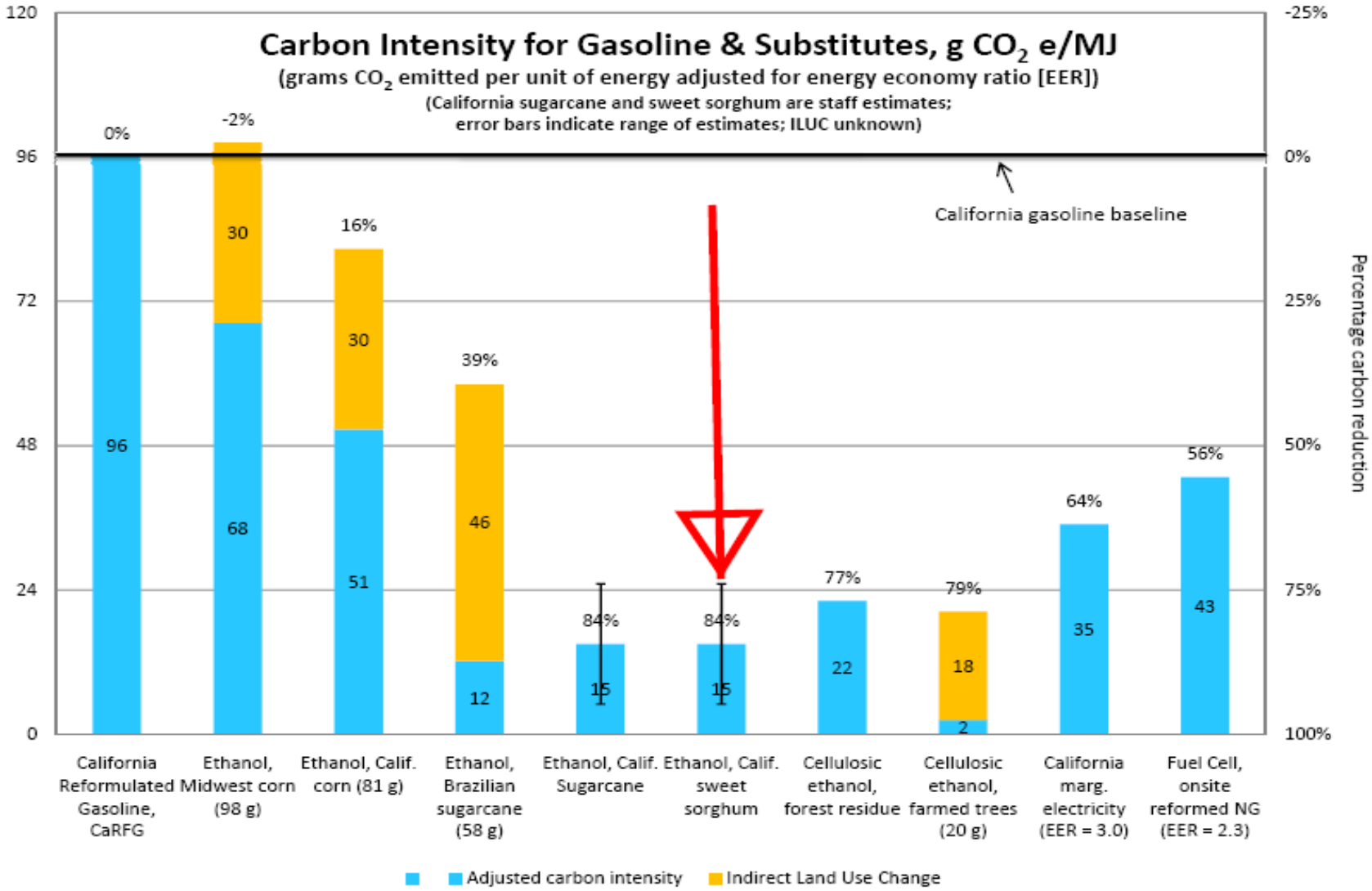
- Sweet sorghum is low water, low fertilizer, fast growing (90 days), even in marginal soils. May replace higher water users.
- Sweet sorghum will grow well in the Central Valley – 2 crops/yr
- Feedstock uncoupled from commodity markets
- Keeps economic benefits in California – “Value-Added Agriculture”
- Low carbon and low energy (no saccharification)
- Small-scale, but scalable
- Sweet sorghum-to-ethanol comparable to corn-to-ethanol pricing

Sweet Sorghum Growing Regions



- Most populated areas can grow sweet sorghum
- Areas close to sugar cane latitudes can grow multiple crops per year
  - Minimum soil temperature for seeding and heat degree days are drivers
  - Sorghum will re-grow after initial cutting (ratoon)
    - Faster growth because root structure is intact
    - Sugar yield is slightly lower for ratoon crop

Sweet Sorghum to Ethanol is a Low Carbon Pathway



Project Team

- Great Valley Energy -
  - Site, Permitting & Ethanol Markets
- KTC Tilby –
  - Sweet Sorghum fractionation, Dermax refining, Comfith processing, Comrind processing
- California Biomass Collaborative, UC Davis -
  - Crop Trials, Agronomics and Planting and Harvest Scheduling
- Seed Technology Provider
  - San Joaquin Valley Sweet Sorghum seed varieties
- Sugar to biofuels
  - Sugar-based ethanol & drop-in replacements
- W.M. Lyles –
  - California Ethanol Production Engineering, Procurement & Construction
- Bioactive compounds
- Construction materials

Baseline Project Characteristics

- Pilot – 1 Ton/hour Sweet Sorghum
  - Subject of current CEC grant (funding through 2013)
  - Varieties include M81E, Dale, Keller and others
  - Samples to outside labs/project partners for characterization
  - Measurement of processing yields
  - 2012 trials to include other processing (e.g., bioactives) and different varieties

- Demonstration - 10 Tons/hour Sweet Sorghum Processing
  - Mid-2014 Schedule
  - $12-15MM
  - ~700 acres in Sweet Sorghum Production
  - Transport of beer or sugar juice to existing facilities
  - Comfith pelletizing
  - Comrind shipped or processed onsite
  - Dermax processing (bioactive compounds)

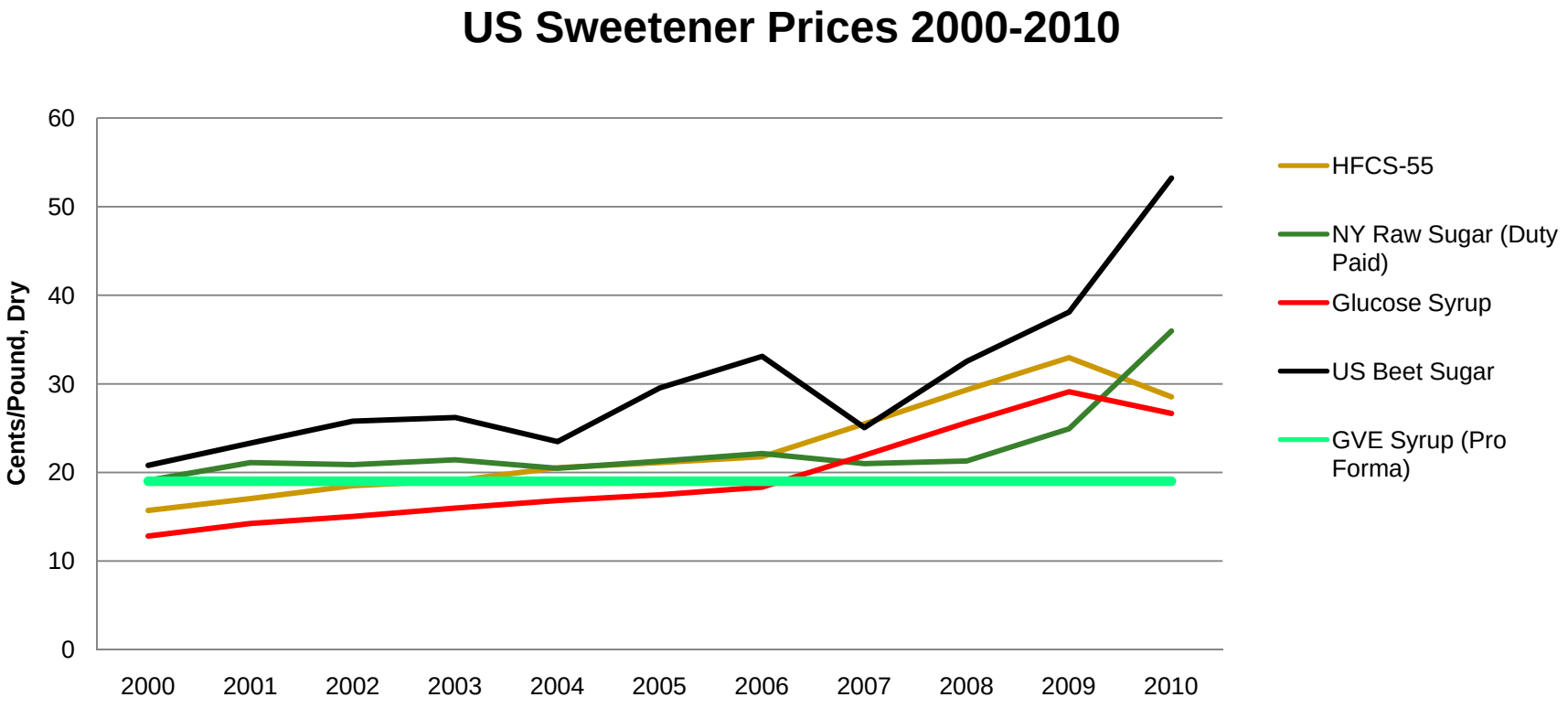
Baseline Project Characteristics

50 + 10 Ton per Hour Commercial Plant

- Commercial – Add 50 Tons/hour Sweet Sorghum Processing
  - 4500 acres in Sweet Sorghum Production
  - With 10% of nearby acreage in planted Sweet Sorghum, trucking distance is less than 10 miles
  - Mid 2016 Start-up
  - $56MM Total Installed Capital
  - 8 million gallons per year biofuel capacity
  - Fresh Sweet Sorghum June through November
  - Other from stored sorghum/sugar feedstocks
- 1000 TPD Biomass feedstock from Comfith and Comrind
  - Pelletizing
  - Cellulosic sugar processing
- Dermax Processing
  - Wax
  - Bio Active Compounds/Cosmetic feedstocks

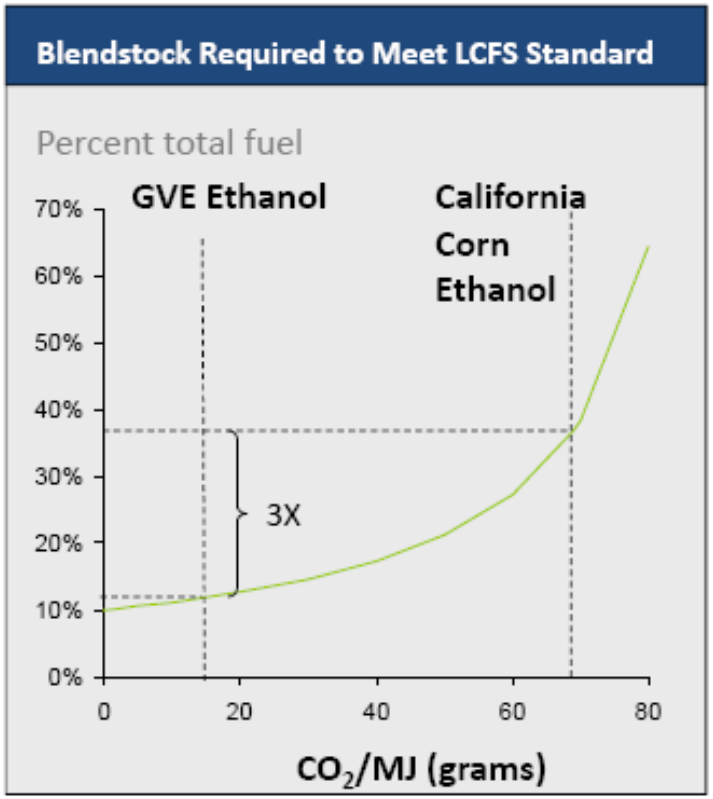
Drivers to Implementation

- The price of oil and sugar and corn make sweet sorghum process attractive.
- The sweet sorghum development activity is very well placed and will bridge the gap between starch and cellulose.



Drivers to Implementation

Low Carbon Ethanol Value in a Carbon-Constrained Market



- California Low Carbon Fuel Standard requires 10% decrease in Carbon Intensity by 2020
- Force increased blending of low carbon feedstocks
- Lower carbon ethanol can be blended at lower ratios = higher value
- U.S. produced ethanol won't have import Tariff = +$0.54 per gallon
- Several other states and federal modeling regional and national Low carbon fuel standards after California

Significant price premium for sugar to ethanol routes are predicted

Barriers to Implementation

Barriers:

- Austerity measures, another recession, and regulatory/tax uncertainty will continue to weigh on capital investment decisions.
- Uncertain commitment to long-term domestic energy plan will keep investors somewhat sidelined for biofuels and renewable chemicals.
  - Will BCAP or substitute program(s) be there when we are ready?
  - Will DOE/USDA loan guarantees be available?
  - When blender credits and tariffs expire, what will the long-term biofuels price outlook be?
- Sweet Sorghum market pricing and volumes are undeveloped and undefined
- Technical and Logistical Risk for overall process value chain

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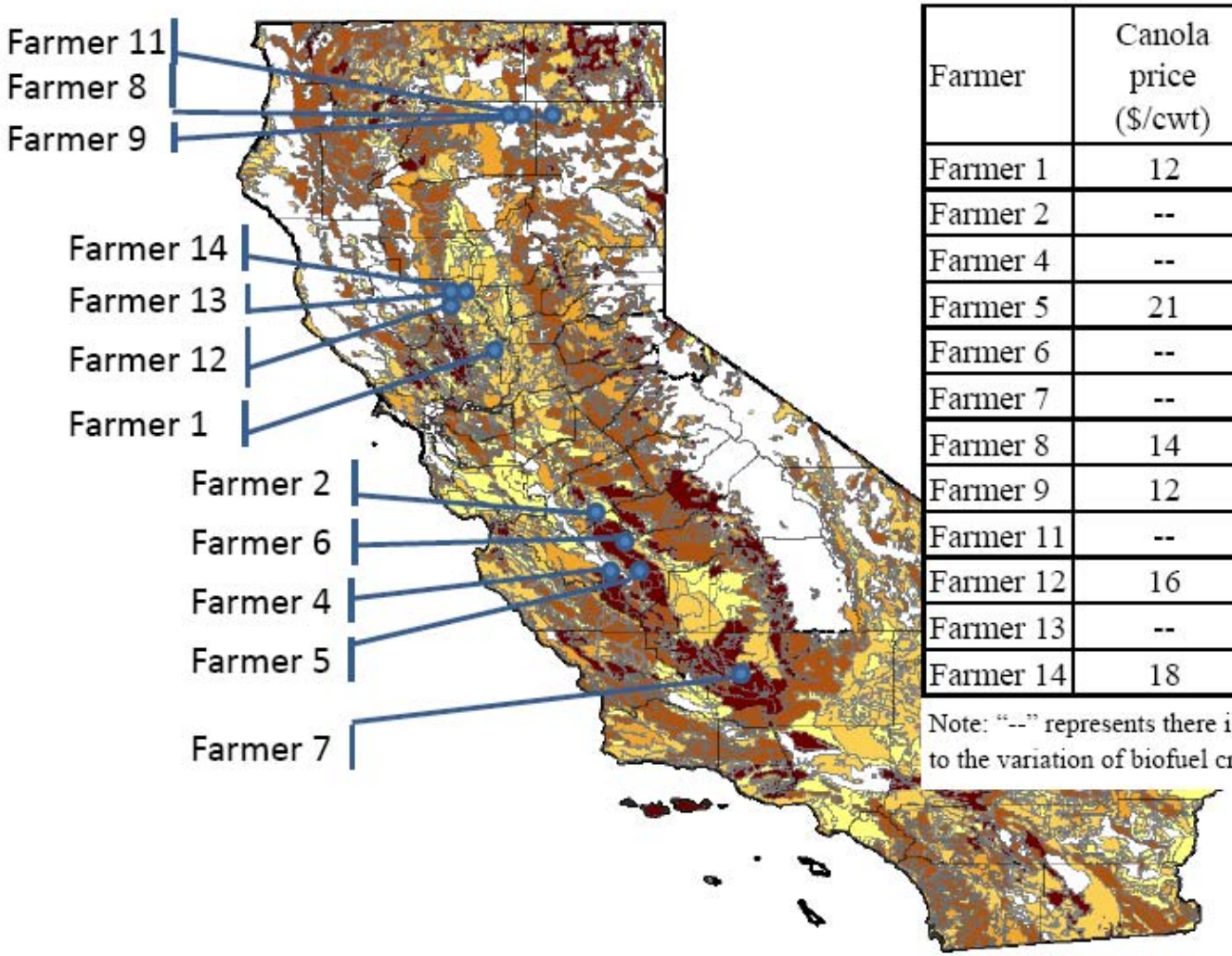
Additional Slides

Sweet Sorghum Trigger/Switch Price

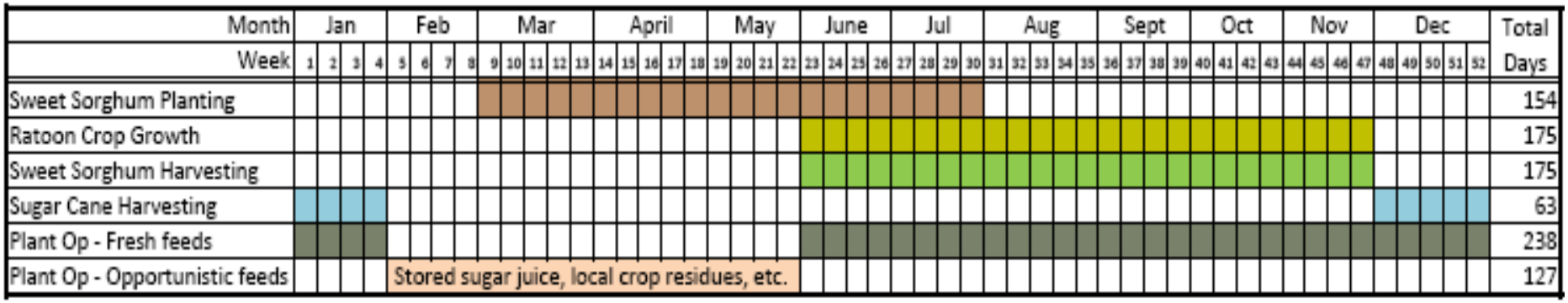


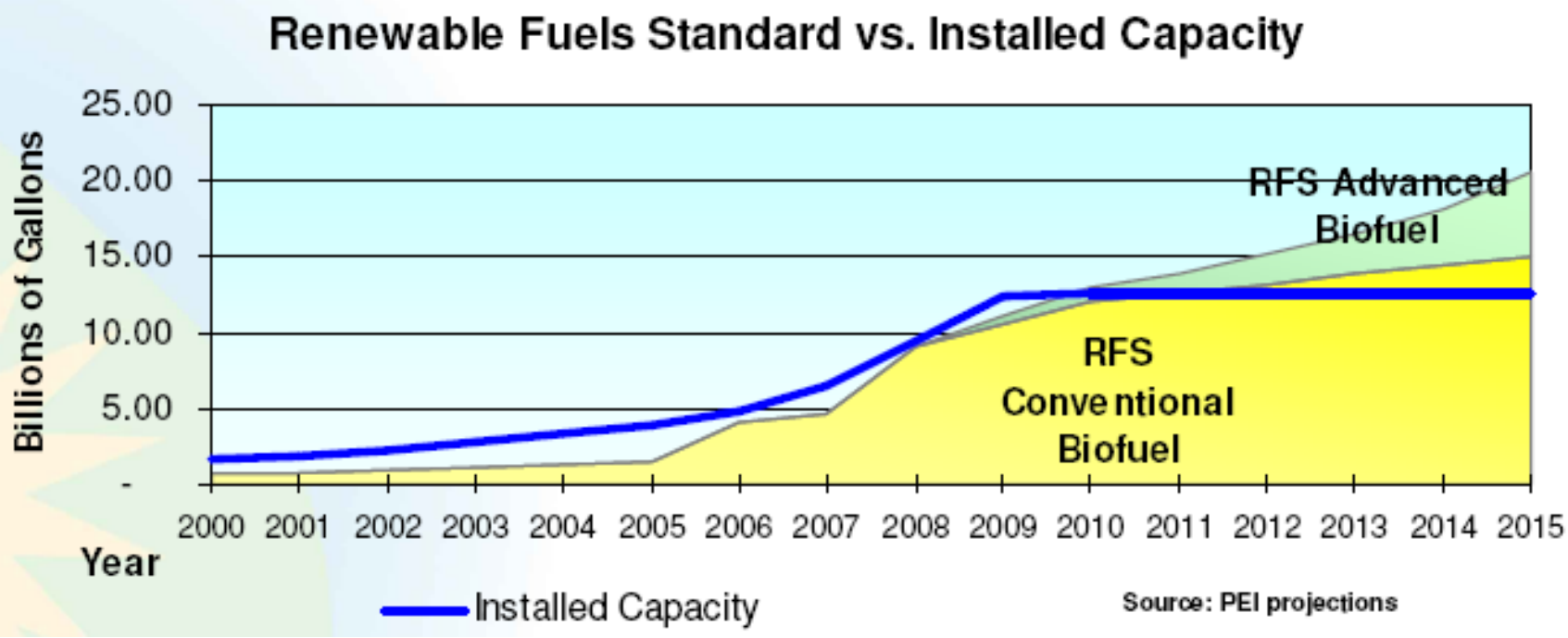
Farmer	Canola price ($/cwt)	Sweet sorghum price ($/ton)
Farmer 1	12	16
Farmer 2	--	30
Farmer 4	--	28
Farmer 5	21	22
Farmer 6	--	28
Farmer 7	--	44
Farmer 8	14	18
Farmer 9	12	18
Farmer 11	--	32
Farmer 12	16	20
Farmer 13	--	30
Farmer 14	18	20

Note: "--" represents there is no change due to the variation of biofuel crop price

Planting and Harvest Schedule

- Planting and harvesting is tightly scheduled
- Sugars will start to auto-ferment in 24-48 hours
- Storage of fresh sorghum is possible with proven food preservation
  - Dilute SO2 has been used to store sweet sorghum for 180 days
  - Other methods are likely too expensive
- Sugar juice can be concentrated to >65% for long term storage
- Local crop residues may be opportunistically used from Feb – May for pellets/briquettes
- Major plant maintenance is scheduled advantageously between February and May



Corn Ethanol – Existing Capacity vs. RFS

- New Corn to ethanol capacity not needed. Future conventional capacity will be met through existing facilities – expansion and efficiency enhancements.
- New Ethanol Production will be Advanced Biofuel.