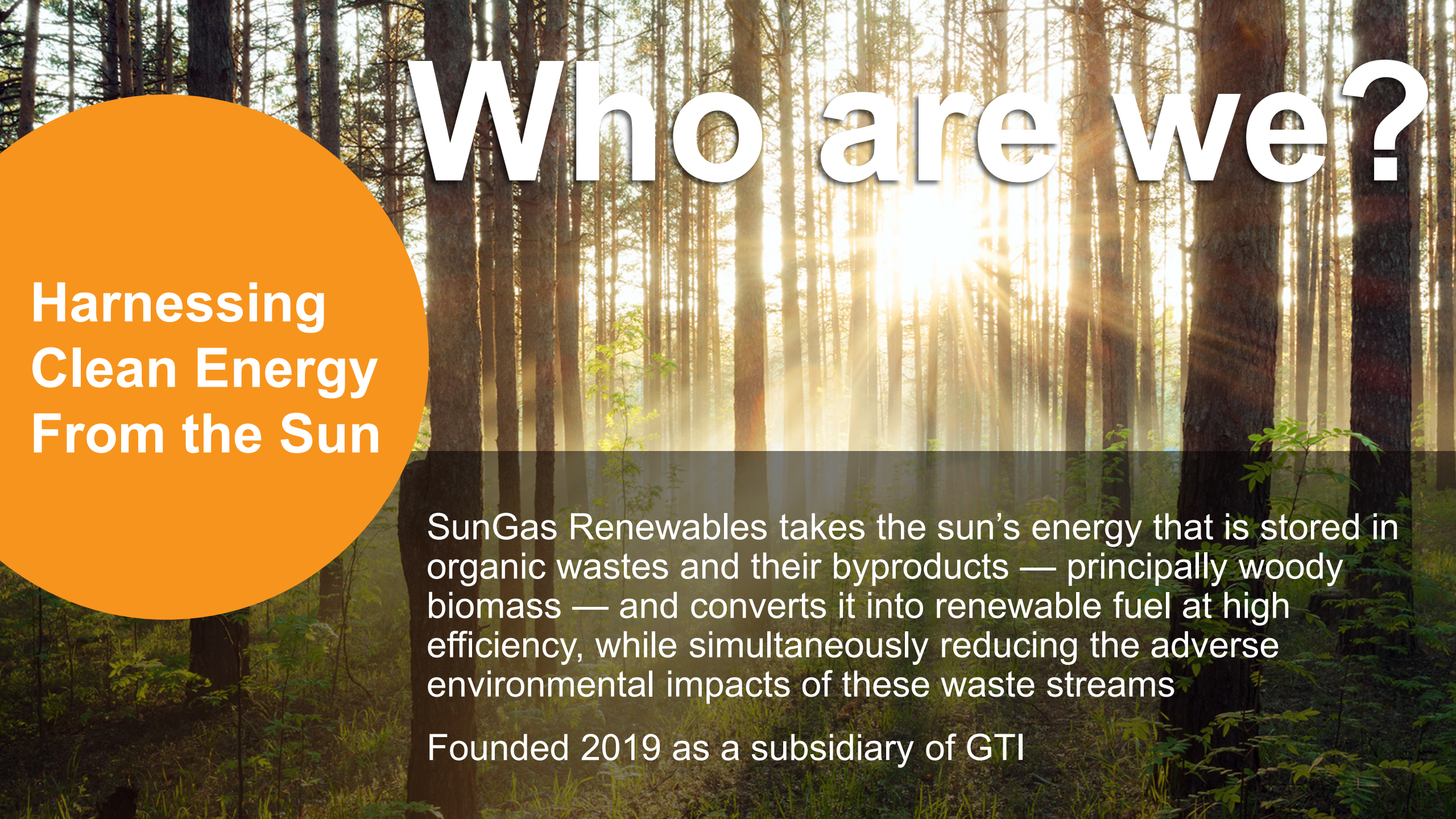
Low Carbon Renewable Natural Gas (RNG) from Wood Wastes

David LaMont, VP Project Development
TC Biomass Conference
October 2019



Who are we?

Harnessing Clean Energy From the Sun

SunGas Renewables takes the sun's energy that is stored in organic wastes and their byproducts — principally woody biomass — and converts it into renewable fuel at high efficiency, while simultaneously reducing the adverse environmental impacts of these waste streams

Founded 2019 as a subsidiary of GTI

SunGas is pursuing the opportunity for RNG

- Woody biomass, agricultural waste and wood waste offers attractive scale
  - Highest carbon efficiency of any approach
  - Further synergies with self-generation of power
- SunGas offers gasifier packages at maximum RNG project scale
  - Exclusive offeror for biomass applications
  - 3BCF/y per plant, larger with power-to-gas, even cleaner with CCS
  - >50 potential projects in California alone based on repurposing biomass power plants
- SunGas is also pursing multiple project development opportunities

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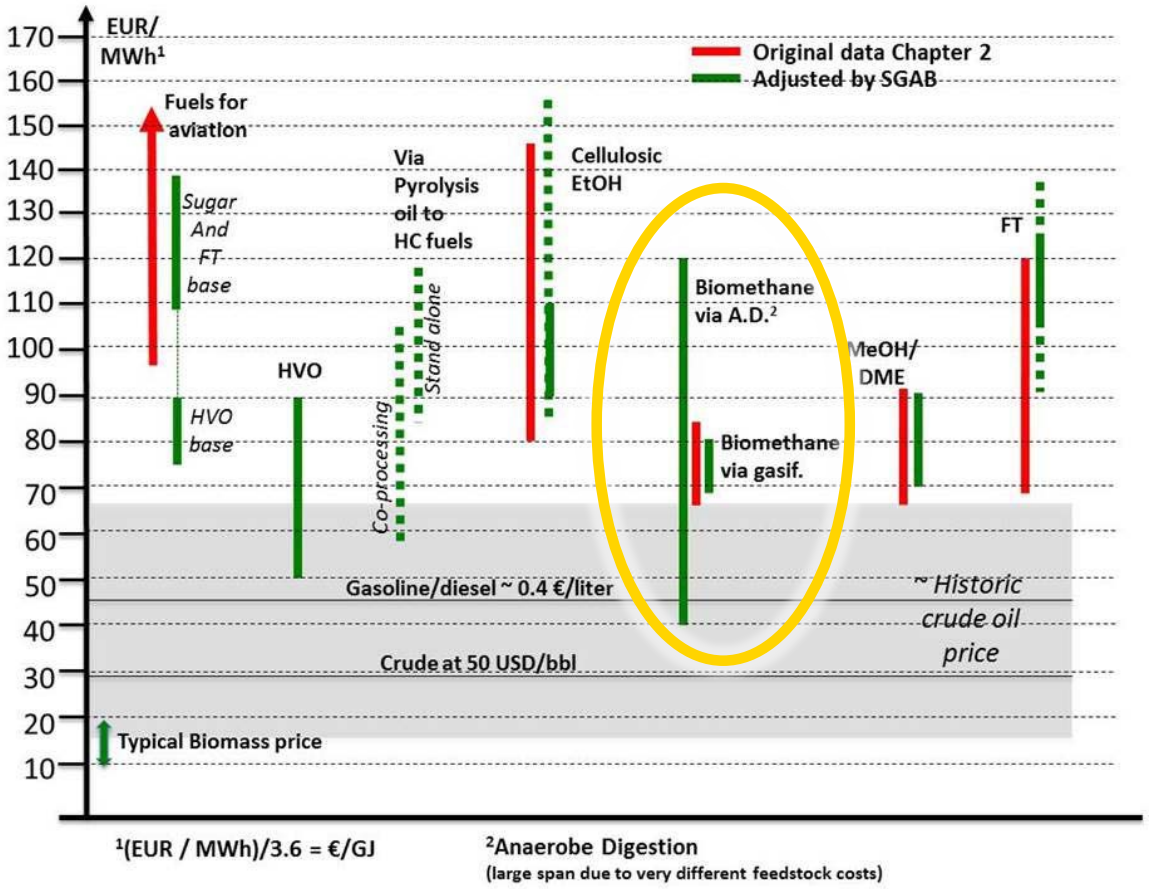
RNG market is emerging beyond California transportation

GTI RNG Production Costs at 8% ROE



Examples of North American RNG Offerings

Southern California Gas Company

A Sempra Energy company

Commitment to 20% RNG by 2030

FORTIS BC

Up to $30/GJ today

VermontGas

Up to 100% at $13/MCF premium

CenterPoint Energy

Opt-in Program Proposed

DTE

$2.50/month Program

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[Final Report: Building up the Future]
Sub Group on Advanced Biofuels
European Commission Sustainable Transport Forum
March 2017

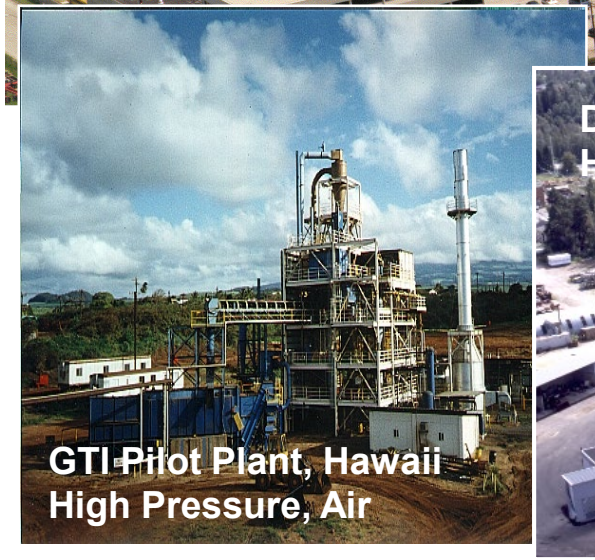
Berkeleyside

CITY

Berkeley first city in California to ban natural gas in new buildings

By Emilie Raguso,
July 17, 2019, 4:19 a.m.

GTI's gasification is a proven technology



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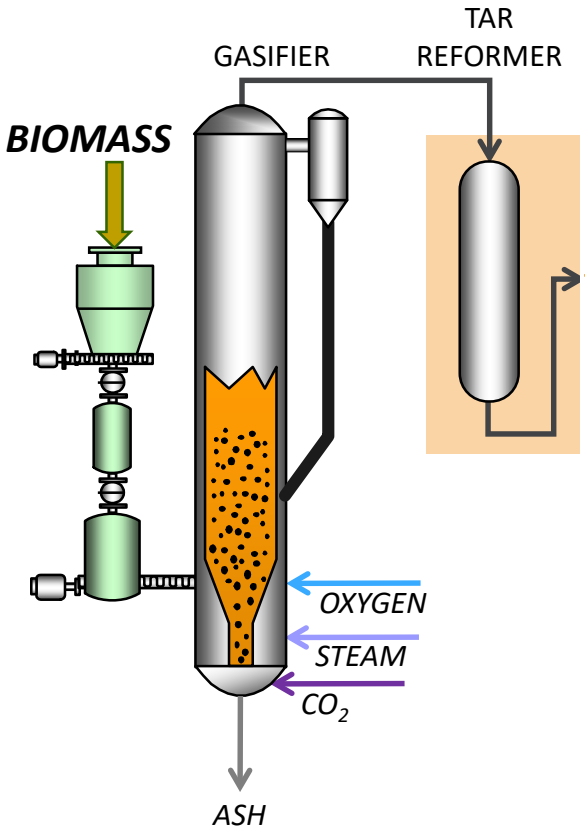
The SunGas offering: High quality syngas



- Pressurized bubbling fluidized bed gasifier by GTI
- Tar reforming by Haldor-Topsoe A/S
- Convert tar and unsaturated HC to CO and H_2 (~85% Conversion)
- Residual tar is removed in scrubber

	Reformed Syngas*
$CO+H_2$, mol%	67
CO_2, mol%	27
CH_4, mol%	5
NH_3, mol%	0.4
Tar, mol%	0.1

*On N_2, S, Ar and moisture free basis

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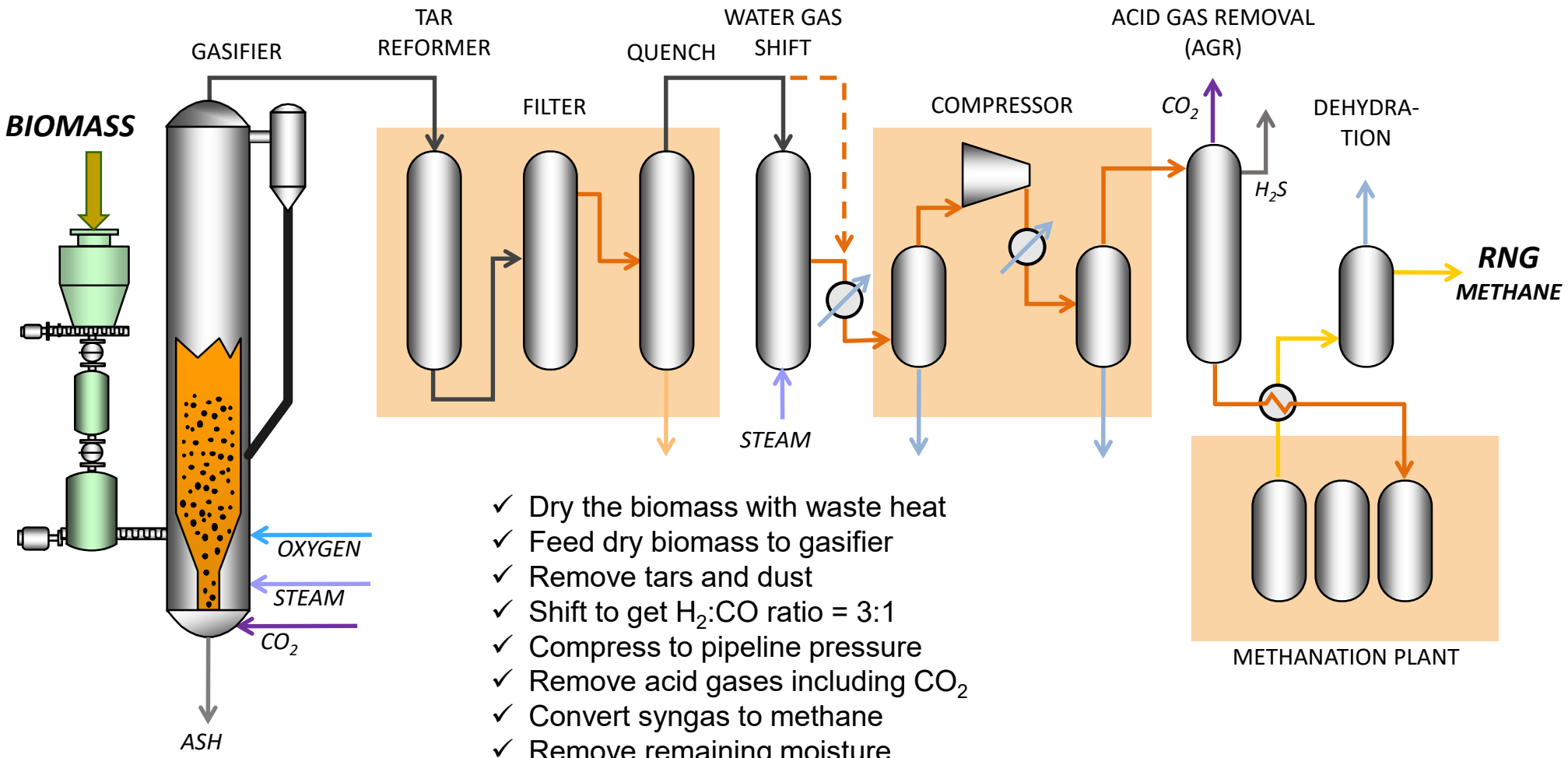
The Overall RNG Production Process



- ✓ Dry the biomass with waste heat
- ✓ Feed dry biomass to gasifier
- ✓ Remove tars and dust
- ✓ Shift to get H_2:CO ratio = 3:1
- ✓ Compress to pipeline pressure
- ✓ Remove acid gases including CO_2
- ✓ Convert syngas to methane
- ✓ Remove remaining moisture

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Clean syngas enables other products

- 1000 hours of pilot-scale testing including demonstration of fully integrated operation – on time and on budget
- Produced more than 10,000 gallons of 89-92 octane gasoline
- 61-65% syngas to motor fuel conversion (LHV energy basis)

HALDOR TOPSØE

gti UPM ANDRITZ PHILLIPS 66

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

PALL e·on

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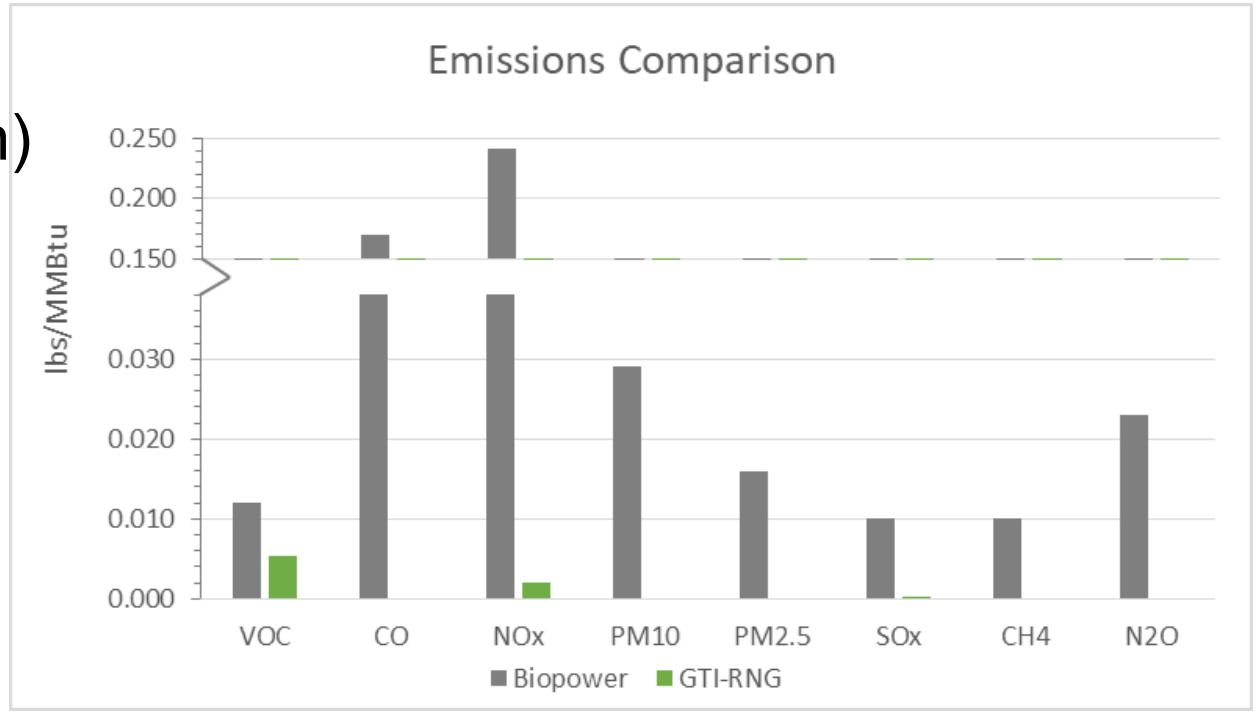
Benefits of RNG vs. biomass power generation

- Decarbonization (pipelines, transportation, power generation)
- Reduction in GHG emissions
- Improved air quality
- Diversity in energy supply
- Highly efficient use of waste biomass



Source of biopower data: Assessment of the Emissions and Energy Impacts of Biomass and Biogas Use in California, January 14, 2015

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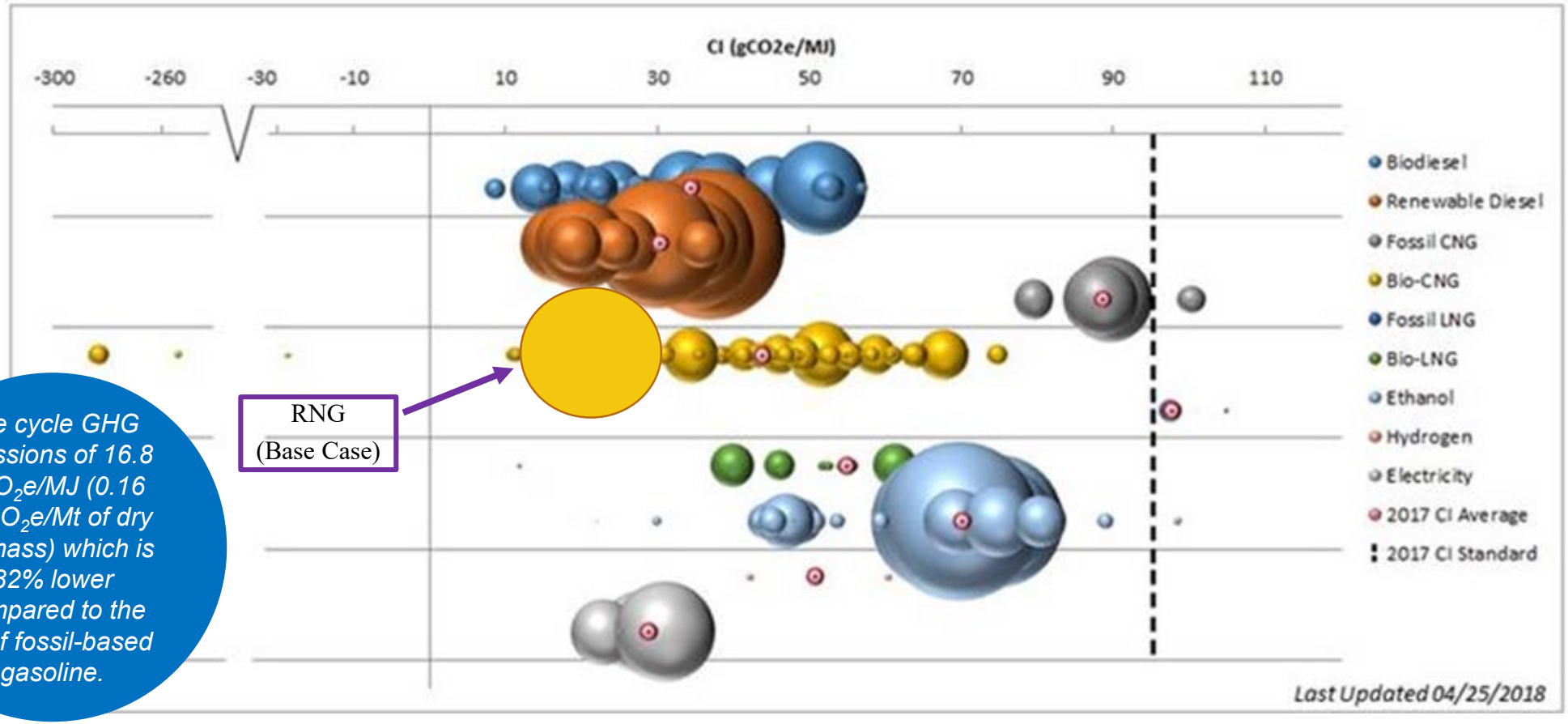
Low carbon intensity is another benefit



Life cycle GHG emissions of 16.8 gCO_2e/MJ (0.16 $MtCO_2e/Mt$ of dry biomass) which is 82% lower compared to the CI of fossil-based gasoline.

Carbon Intensity for RNG (this study) Compared to Certified Pathways by Fuel Type

(Source: CARB 2017. Current base case study result added as a yellowish circle to show the CI, and an ***estimate*** of the production volume)

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Summary of Biomass Gasification

- Bubbling Fluidized Bed gasifier is proven
- Downstream gas conditioning is proven
- Applications include RNG, liquid fuels and chemicals
- Commercial reference in operation since 2006 with over 90% efficiency

Technology developed over 40 years to handle waste biomass materials from agricultural residues to wood wastes to refuse-derived fuel.

Thousands of hours of testing and over a decade of reference commercial operations provide technical confidence in the GTI-developed direct bubbling fluidized bed gasifier.

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Brownfield (site-specific) FEL-2 study rationale

- Biomass powerplants are closing and numerous
  - Supply of locations is increasing
  - Technical synergies with RNG production
- Supply chain synergies
  - Supply of feedstock is increasing
- Enables acting quickly if market develops soon

DTE Energy, Stockton, CA

***Funders**:*
SoCalGas
PG&E
Northwest Natural
SMUD
CARB

Partners:
Black & Veatch
ANDRITZ
Haldor Topsoe
DTE Energy Services

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Why a site-specific study was important

- Understand technical feasibility
  - Wood supply access
  - Fuel processing and handling
  - Natural gas pipeline injection options
  - Water access
  - Utilization of site acreage
- Develop ‘real’ economic picture of a project development
  - Capital costs
  - O&M cost breakdown
  - Quantify carbon intensity
- Assess local support
- Basis for market engagement
  - Offtakers
  - Regulators

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Key learnings of the study

- 3 BCF/yr of RNG from 945 tons/day of wood
- All in capital cost are $340 million ±30%.
- Operating cost for RNG of $13-15/MMBtu
- Stockton not likely the best site
  - Pipeline capacity issues
  - Site layout constraints
- Next steps
  - Path to lower NOAK capex
  - Continued RNG ecosystem engagement

This plant alone could displace approximately 170,000 tons of CO_2 vehicle emissions each year. (equal to offsetting the emissions from 400 million vehicle miles, or consuming 15 million gallons of gasoline)

*Assuming there are 148 million dead and dying trees in CA, there would be 258 million bone dry tons of wood available. That would feed 832 plants of the size of the Stockton RNG plant design for a year, or 27 of those plants for 30 years of operation.**

**Dead Tree Utilization Assessment. Project report May 2017, prepared for CALFIRE & California Tree Mortality Task Force.*

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Thank You

David LaMont
Vice President, Project Development
dlamont@sungasrenewables.com