UCR College of Engineering- Center for Environmental Research & Technology

RENEWABLE NATURAL GAS SYMPOSIUM

RNG Adoption from Lab to Market – Advancing Technological Innovation and Efficiency Gains

Panel Discussion 1 – Thermochemical RNG Production – Barriers & Opportunities

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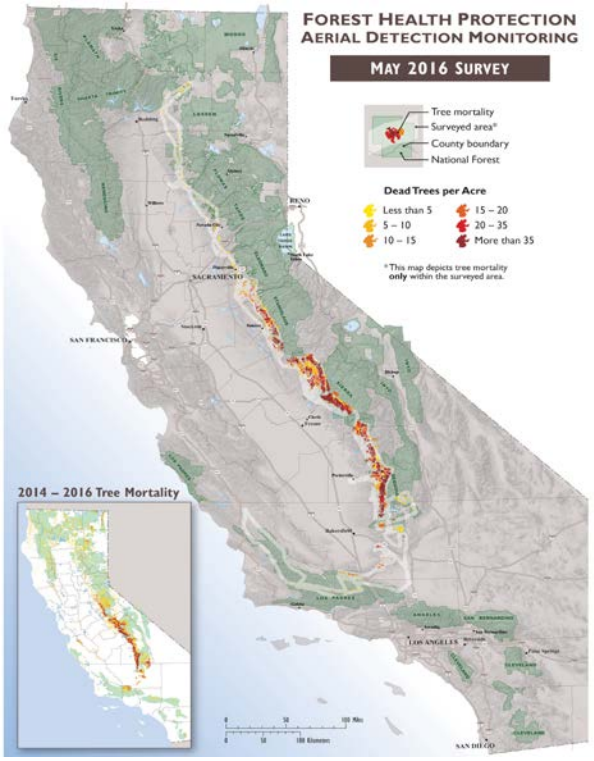
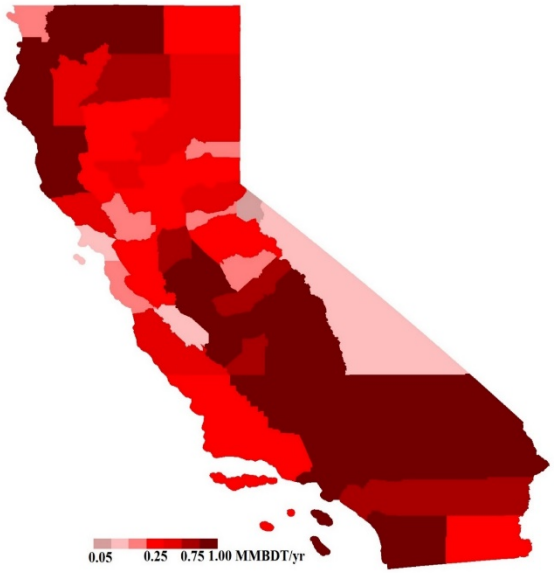
California Biomass Potential



	kBDT/yr
Agricultural residue	5,407
Food and fiber processing residue	3,373
Animal manures	4,242
Forest biomass	14,256
MSW	8,806
Total	36,083

Total energy content ~ 557×10^6 MMBtu/yr



- Estimated 100 million dead trees in California
- Located in 10 high hazard counties in the southern and central Sierra Nevada region
- Harvesting, processing & transportation challenges

https://www.fs.fed.us/news/releases/new-aerial-survey-identifies-more-100-million-dead-trees-california

Technology Options

- Extraction - Mechanical
- Transesterification - Chemical
- Anaerobic digestion
- Fermentation
- Gasification
- Pyrolysis

Biological

Thermochemical

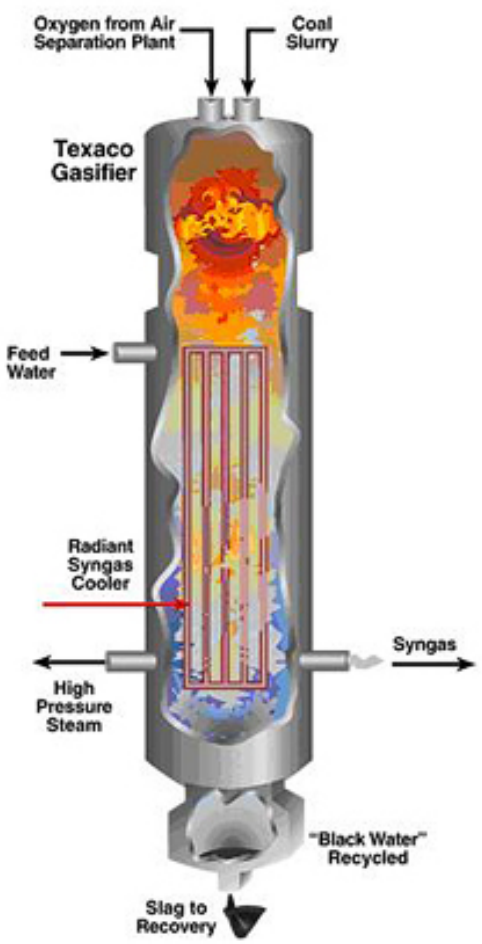
Biomass to Fuels

- **Thermochemical**
  - Extreme process conditions (temperature, pressure)
  - High capital costs
- **Biological**
  - Mild process conditions
  - Low capital costs

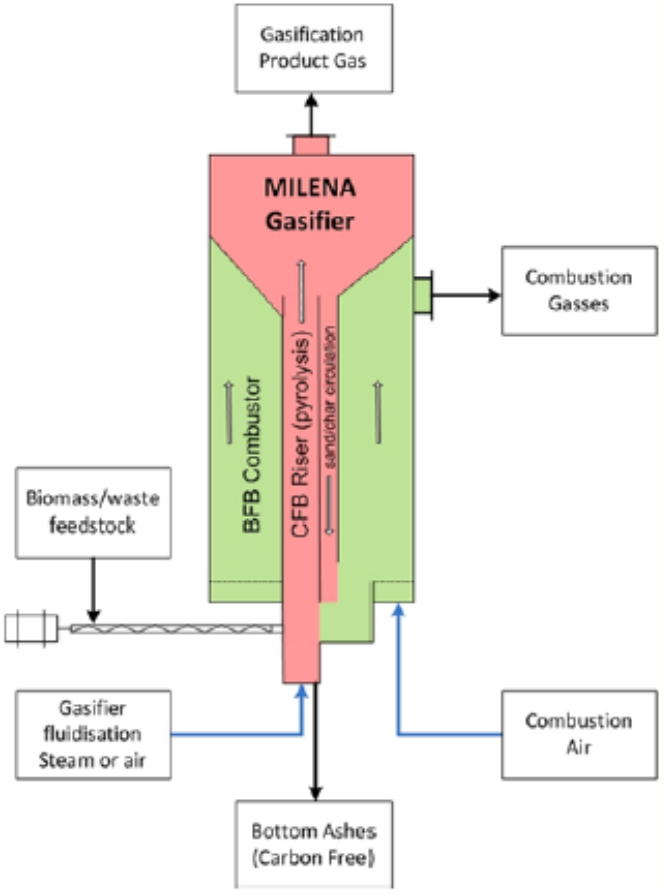
	Thermochemical	**Biological**
Reaction rates; g/L/h	10^3 - 10^4	10^1 - 10^2
Feedstock flexibility	High	Low
Thermal efficiency	High	Medium/low
Temperature, ℃	~1000	~30
Pressure, atm	20-50	1

Gasification

C + Gasifying agent + Heat (700-1400 ºC) ⟶ Gases (H_2, CO…) + ash

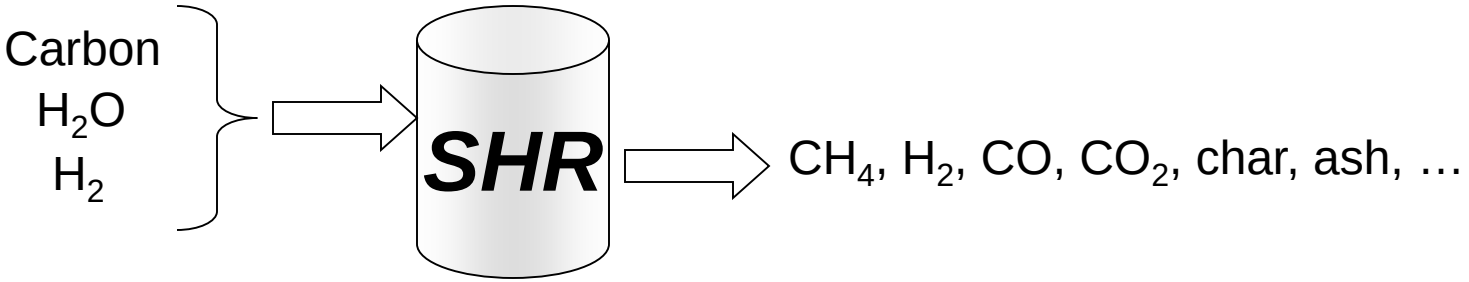


- Partial oxidation (O_2)
- Hydrogasification (H_2)
- Steam pyrolysis (H_2O)



https://www.netl.doe.gov/research/coal/energy-systems/gasification/gasifipedia/ge
http://www.royaldahlman.com/renewable/assets/Uploads/DAHLMAN-INFO-MILENA.pdf

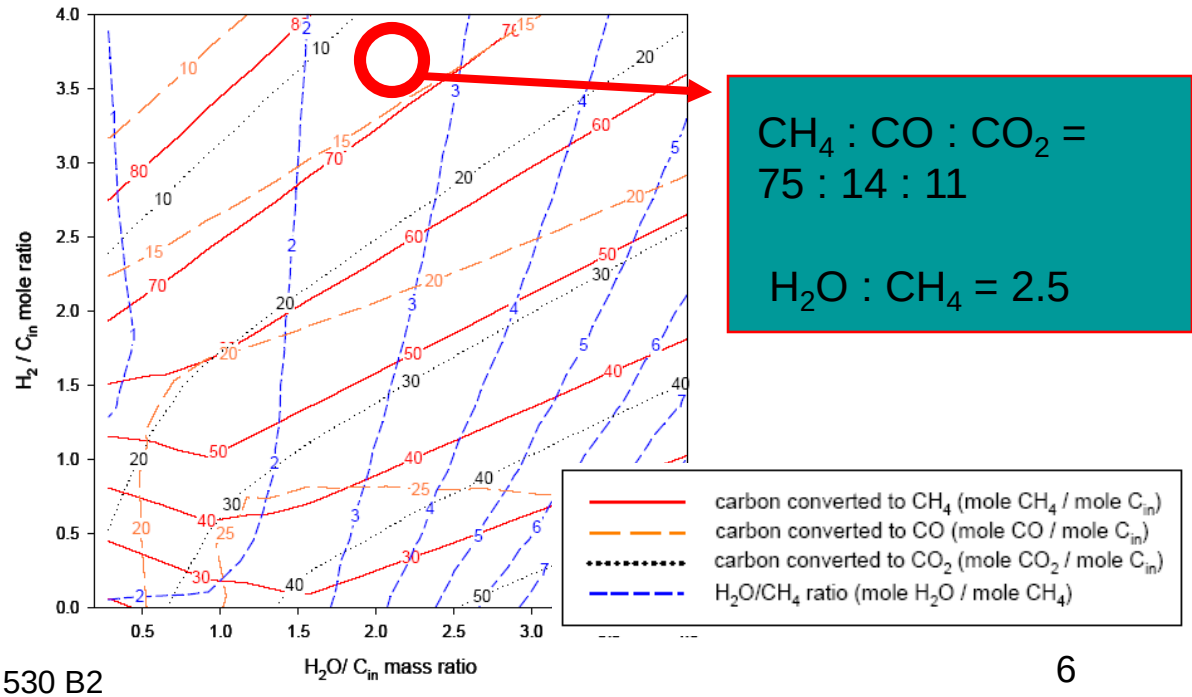
Steam Hydrogasification



$$C + H_2O + 2H_2 \rightarrow CH_4 + H_2O + 75kJ/mol + others$$

Hydrogasification in the presence of steam

Effect of H_2O/C and H_2/C Ratio

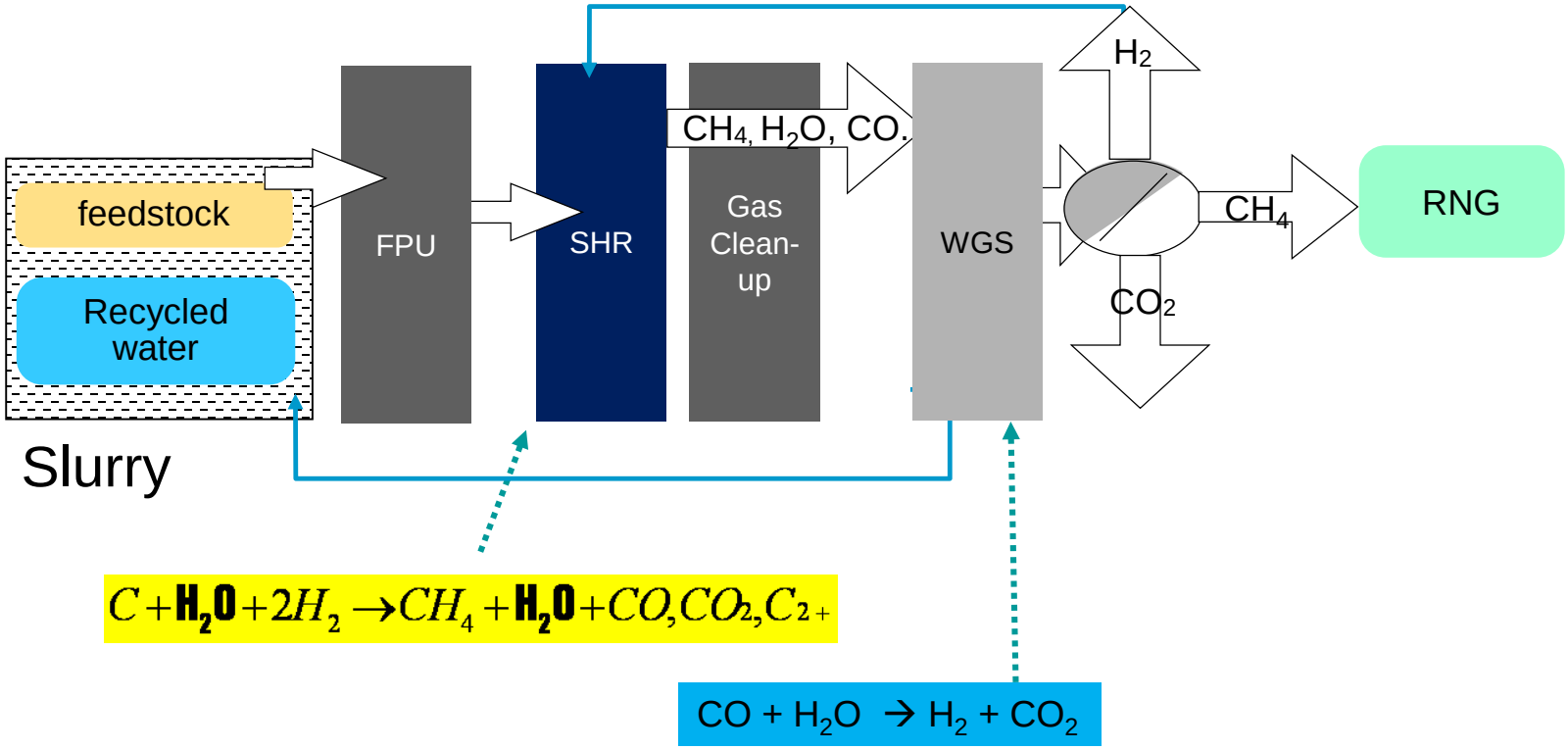


$CH_4 : CO : CO_2 = 75 : 14 : 11$

$H_2O : CH_4 = 2.5$

J.M. Norbeck & C.E. Hackett, U.S. Patent 7,208,530 B2

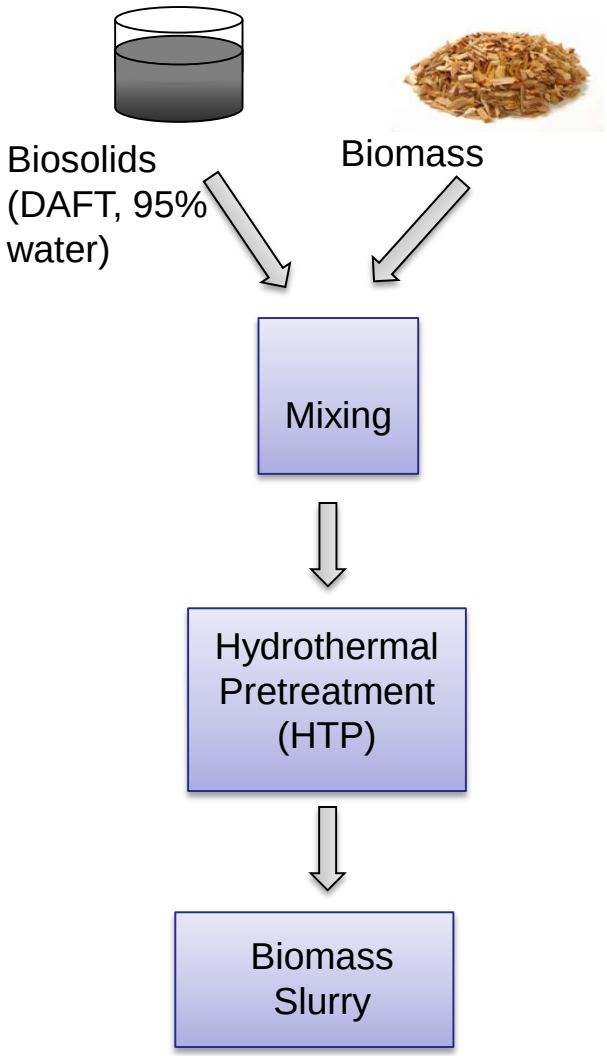
SHR based RNG production

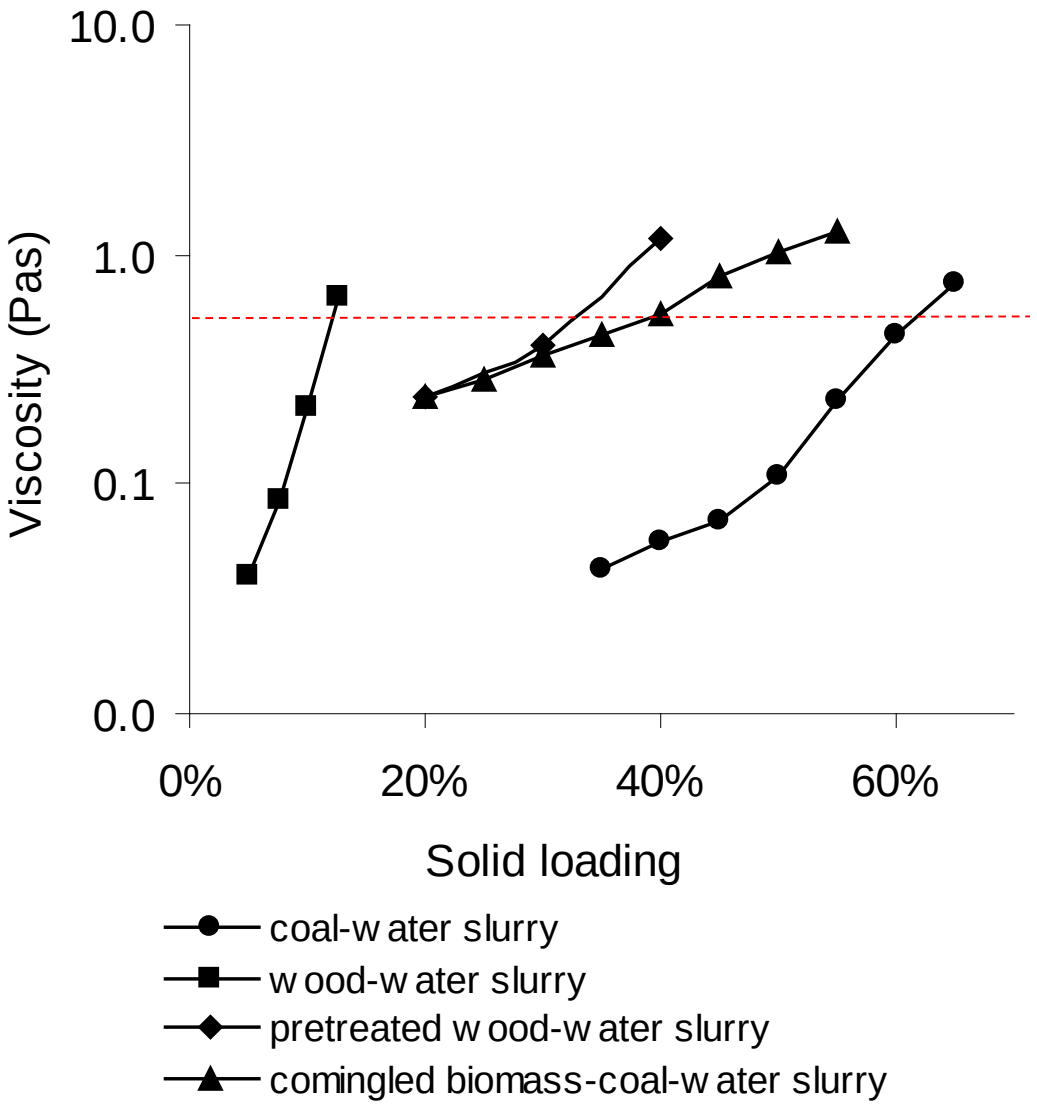


SHR – Steam Hydrogasification Reactor, WGS – Water Gas Shift Reactor, FPU – Feed Pretreatment Unit

Feed Pretreatment

Hydrothermal Pretreatment for Pumpable Slurry Formation

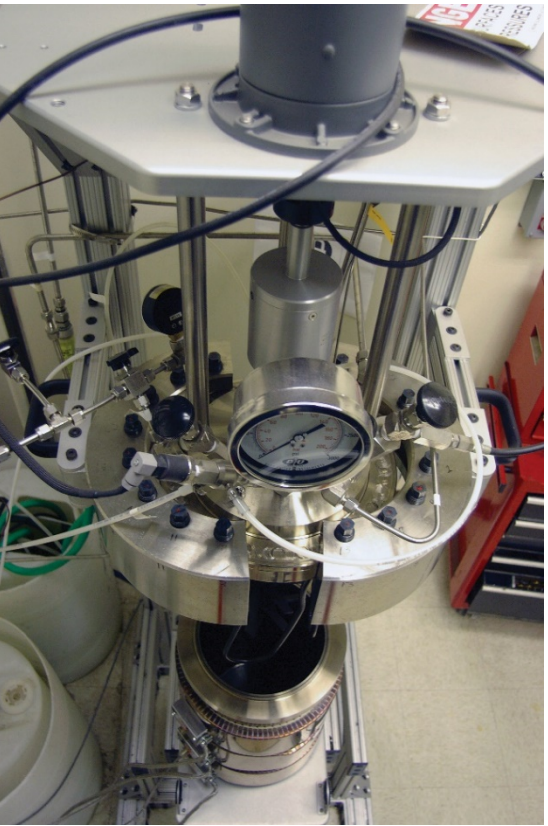




SHR Gasifier

PDU scale →

- *O.1 TPD (Dry Basis)*
- *Slurry Feeding System*
- *Bubbling / Circulating Fluidized Bed Gasifier*



Feed Pretreatment

Thermochemical Conversion

- Feedstock Flexibility
  - Accept most carbonaceous matter
  - Waste conversion
- Product Flexibility
  - Syngas is a versatile feedstock
- Environmental Benefits
  - GHG and criteria pollutant mitigation
- High Efficiency
- High capital costs
  - Distributed facilities
- Technology maturity
  - Innovative solutions needed
  - Demonstration & pre-commercial activity
- Policy barriers
  - Public perception

Thermochemical Conversion

Significant potential but unrealized

- Invest in RD&D
- Technological innovation
- Policy advocacy
- Outreach/education

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