SoCalGas A Sempra Energy utility®

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Innovation

RENEWABLE GAS PRODUCTION – WHAT SOCALGAS IS DOING

RENEWABLE GAS ADOPTION FROM LAB TO MARKET – ADVANCING TECHNOLOGICAL INNOVATION AND EFFICIENCY GAINS

RENEWABLE GAS CONFERENCE

The University of California, Riverside
CENTER FOR RENEWABLE NATURAL GAS
Bourns Technology Center
May 17, 2017

Woodchips TO RG

2012 – 15 G4/CEC woodchips-to-methane

2017 GTI/Andritz engineering study for gasification at a former wood incinerator plant

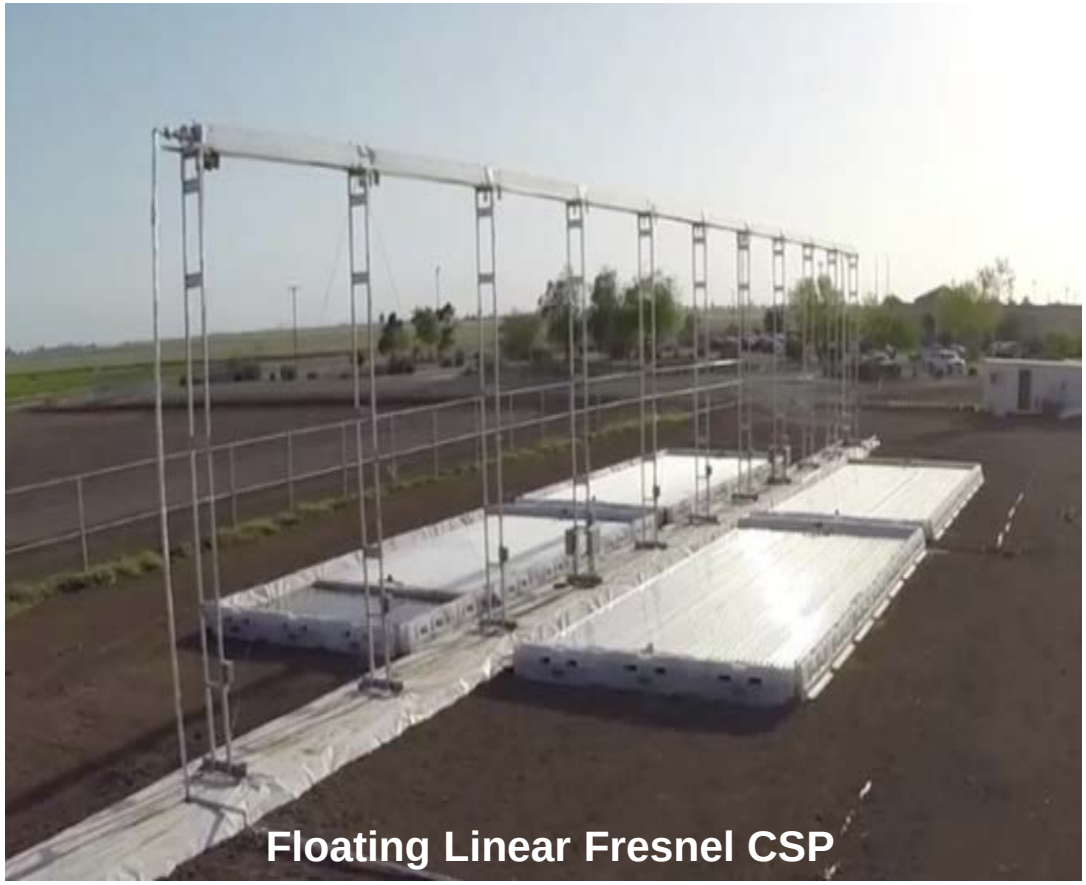
WASTE TO VALUE

low-cost feedstock is essential

Solar Thermal

low-cost solar thermal + thermochemical processes maximize RNG and H_2 yield

goal: <1¢/kWh_t, $3/MMBTU)



Biomethanation

NREL P2G Demonstration

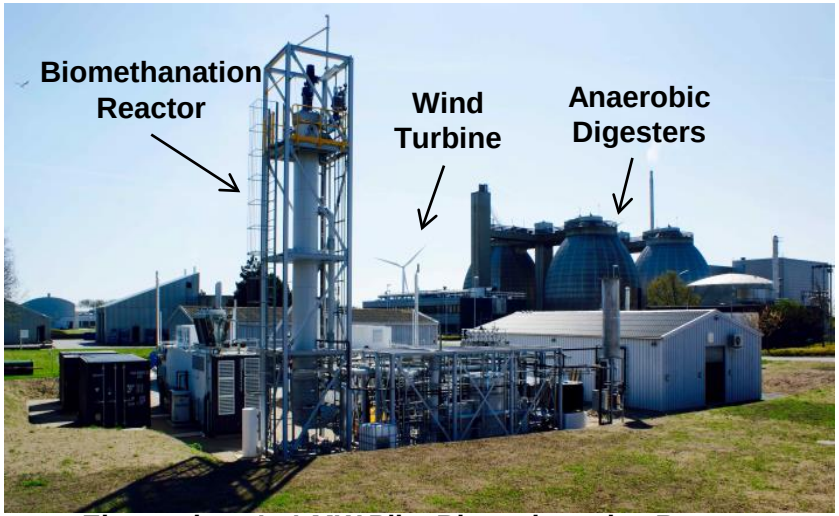
cycle

- PV (e-) → water electrolysis (H_2) → biological methanation
- (CH_4) → steam methane reforming
- (H_2) → fuel fell (e-)

Archaea

commercial development

10 MW power-to-gas plant is being developed by the Hungarian utility Magyar Villamos Művek and Munich-based startup Electrochaea GmbH.

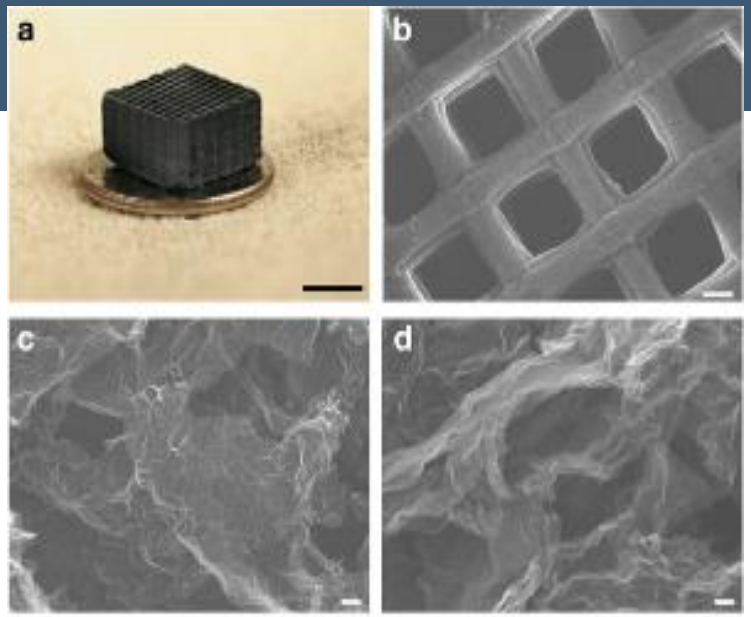


Electrochaea's 1 MW Pilot Biomethanation Reactor, Copenhagen

Electro-Methanogenesis

3-D Printed Reactors

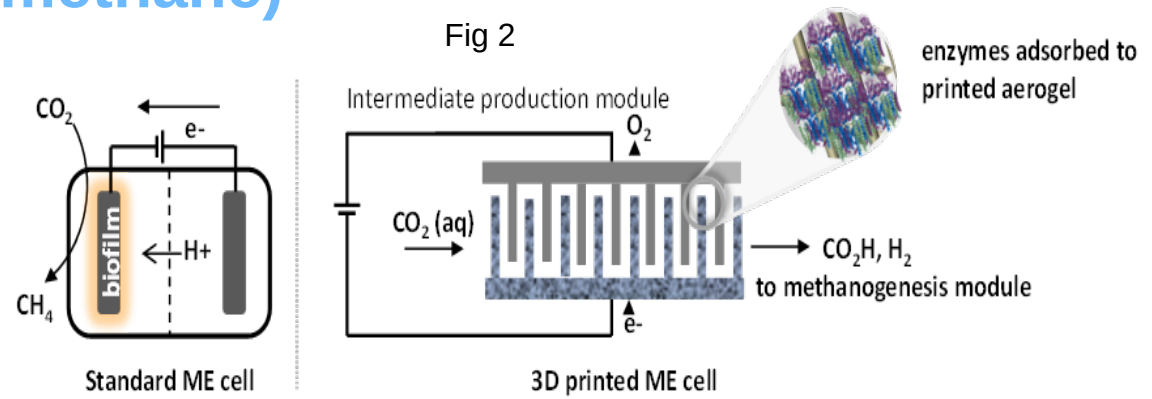
Fig 1



With Stanford and LLNL -
3D printed, high surface area electrode-based reactors for microbial electromethanogenesis

Using adsorbed enzymes for P2G (1-step electrons to methane)

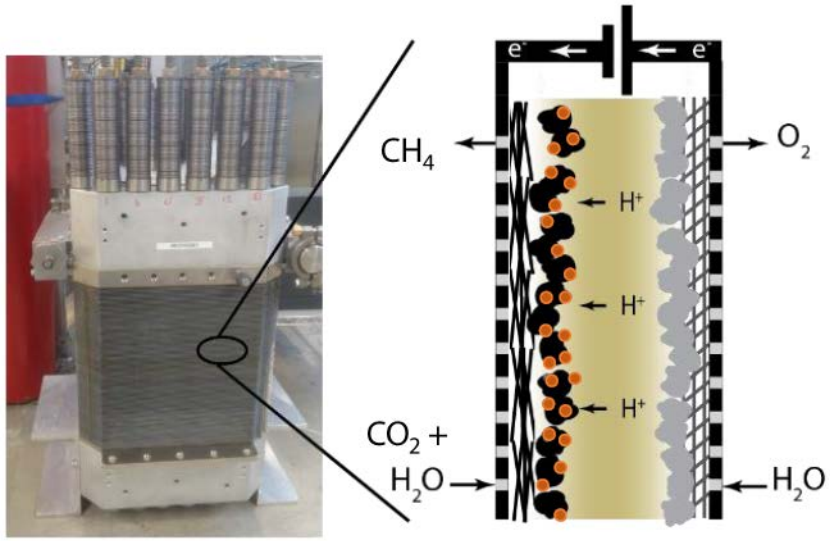
Fig 2



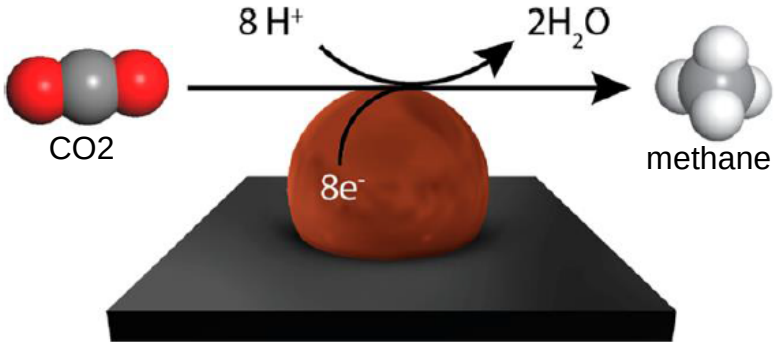
Electrochemical

CO_2 Reduction

Opus 12 metal nanoparticle catalyst and polymer membrane combination methane from CO_2, water, and electricity.



co-electrolysis pathway for producing RNG from excess renewable electricity.



Link1 and Link 2

RH_2 Production

Renewable hydrogen from NG

20% incremental renewable energy attribute

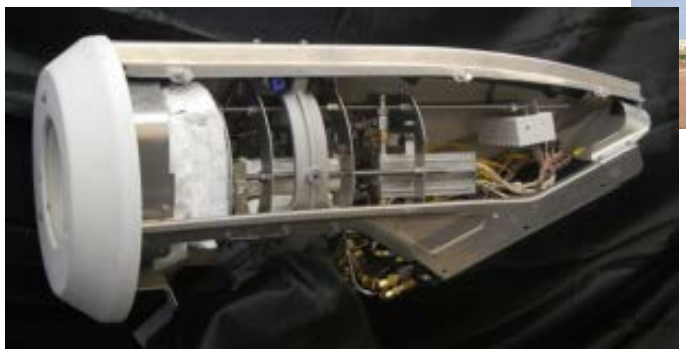
solar-to-thermal energy conversion
~ 84%

solar-to-chemical energy conversion
~ 70%

overall energy conversion efficiency
~ 90+%

when co-producing H_2 and CH_3OH, the carbon intensity of the H_2 is very low

Dish CSP SMR



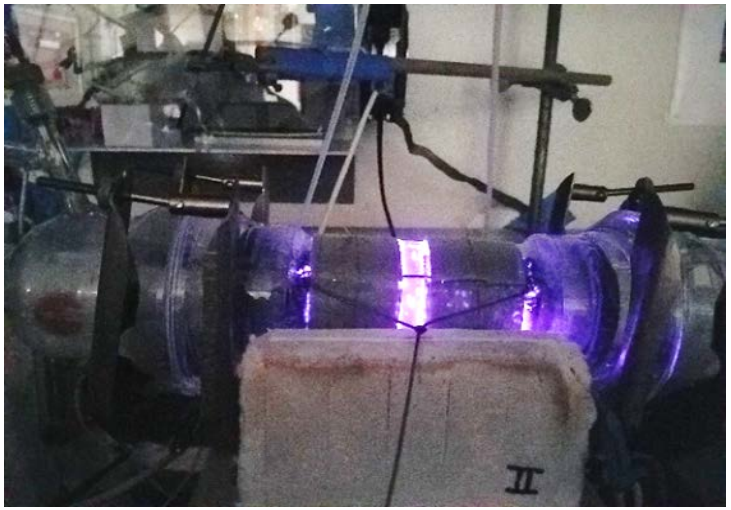
Microchannel SMR Nacelle

Catalytic Nonthermal Plasma

JPL

efficiently producing hydrogen as-needed from natural gas and water.

- **Efficiency (> 75%)**
- **Small form factor**
- **Low temperature (450°C)**
- **Multiple stop/start capability**
- **Production ~ 5 Kg H2/day**
- **$ 2-4 gge H2**



CNTP SMR Reactor

JCAP

Joint Center for Artificial Photosynthesis

SoCalGas participates as an "Industry Partner"

direct solar hydrogen and methane production

end-game technology

SLAC BERKELEY LAB UCI Caltech U.S. DEPARTMENT OF ENERGY UC San Diego

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Conclusions

Renewable methane and hydrogen RH2 offer important pathways to high levels of penetration of renewable energy

Technology, economic and regulatory challenges must be addressed

We need "all of the above and more" to meet future requirements for low carbon resources

Utility companies like SoCalGas have an important role to play in creating California's energy future

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THANK YOU!