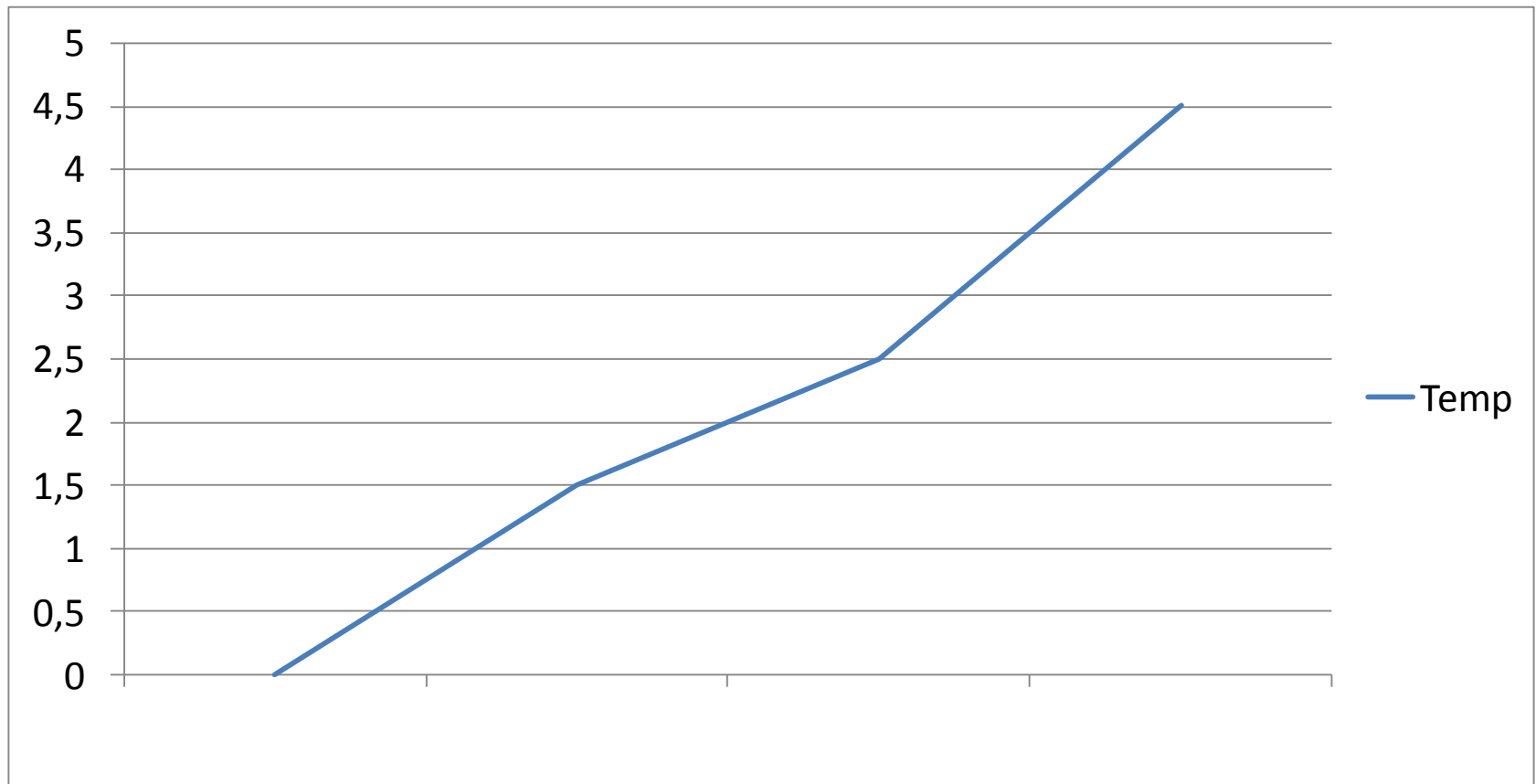


# Biogas on dairy farms in CA

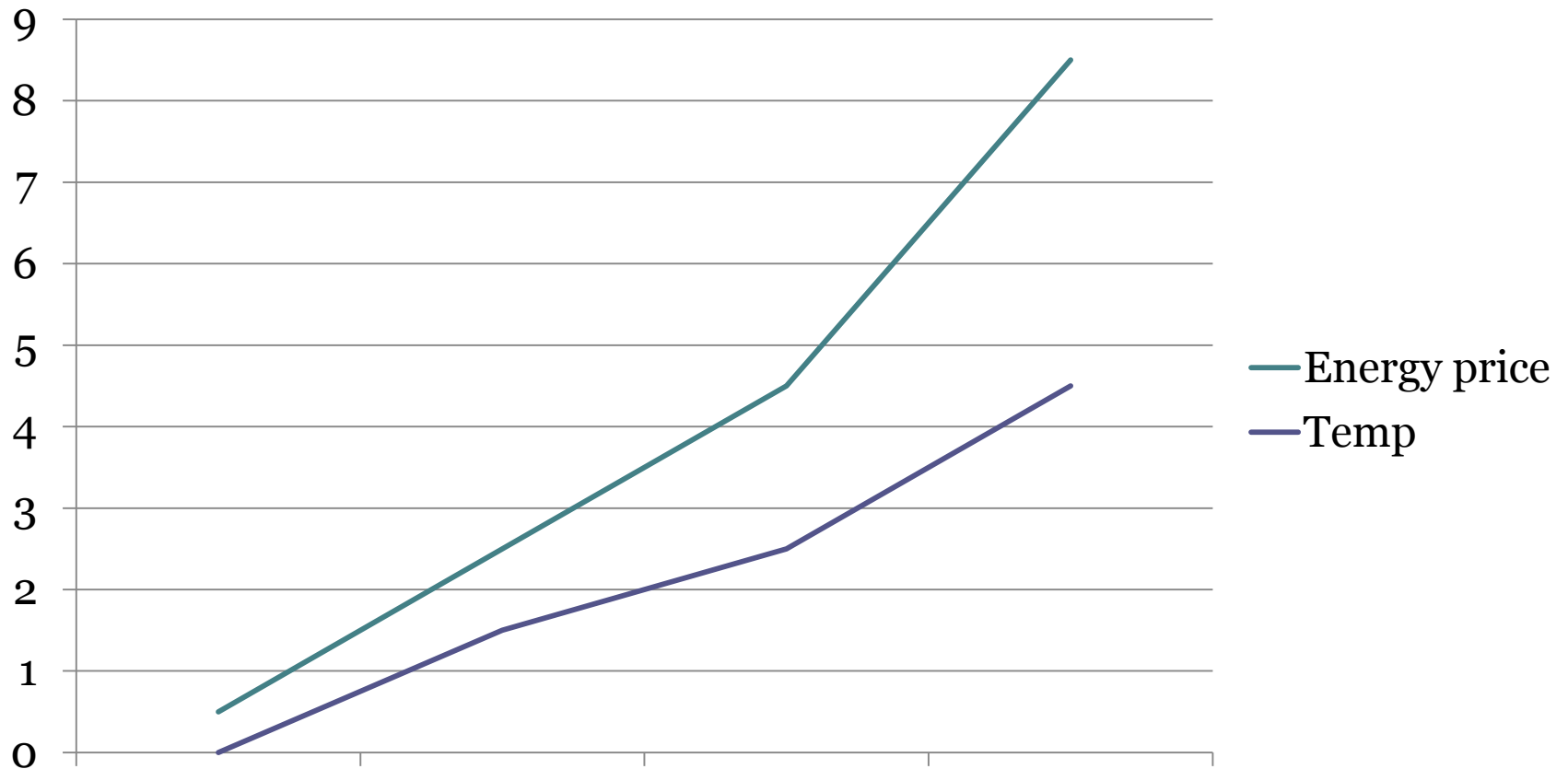
Introduction and methane  
synthesis

Kasper Vadstrup  
Morten Eghøj  
Martin Herse

# Hot or not



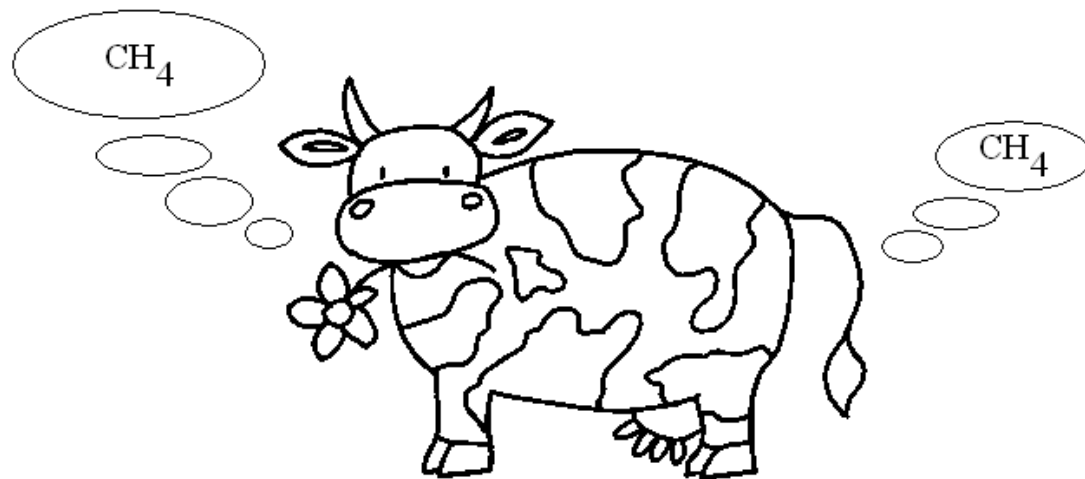
# Still cheap?



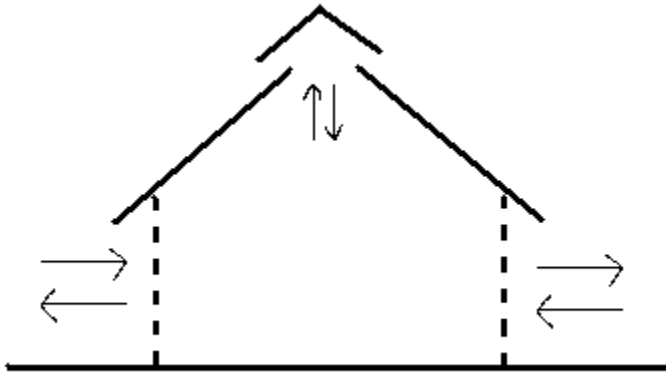
# Change is needed



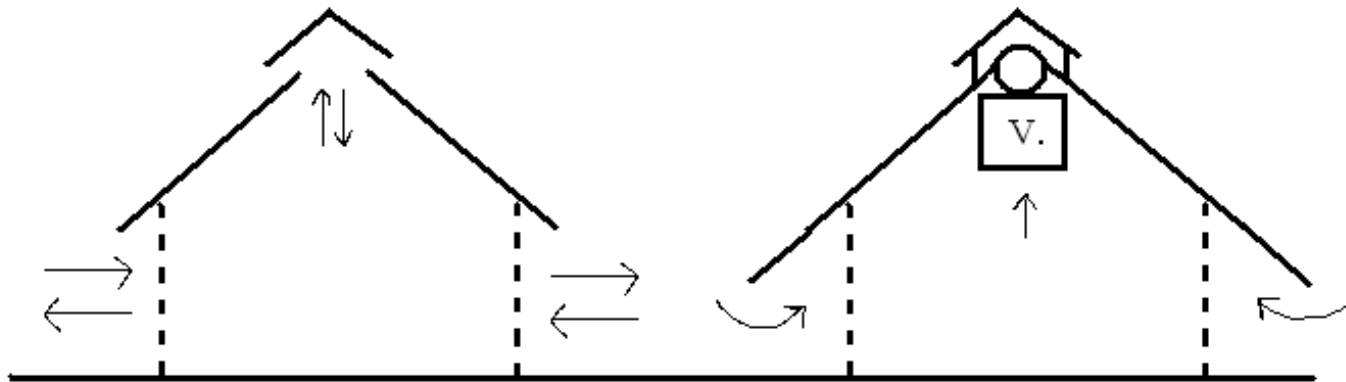
# Any solutions?



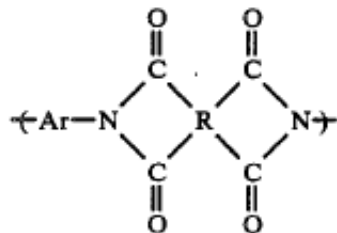
# A Solution



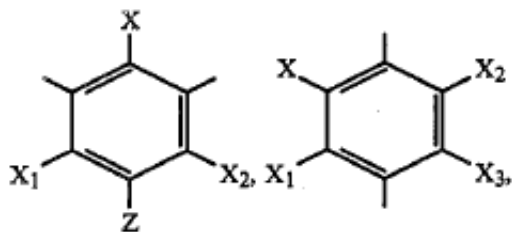
# A Solution



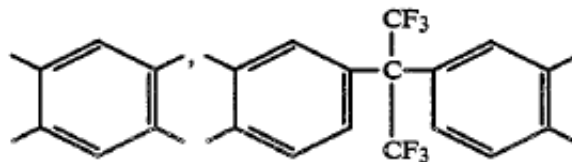
# A solution



where —Ar— is



or mixture thereof, and R is

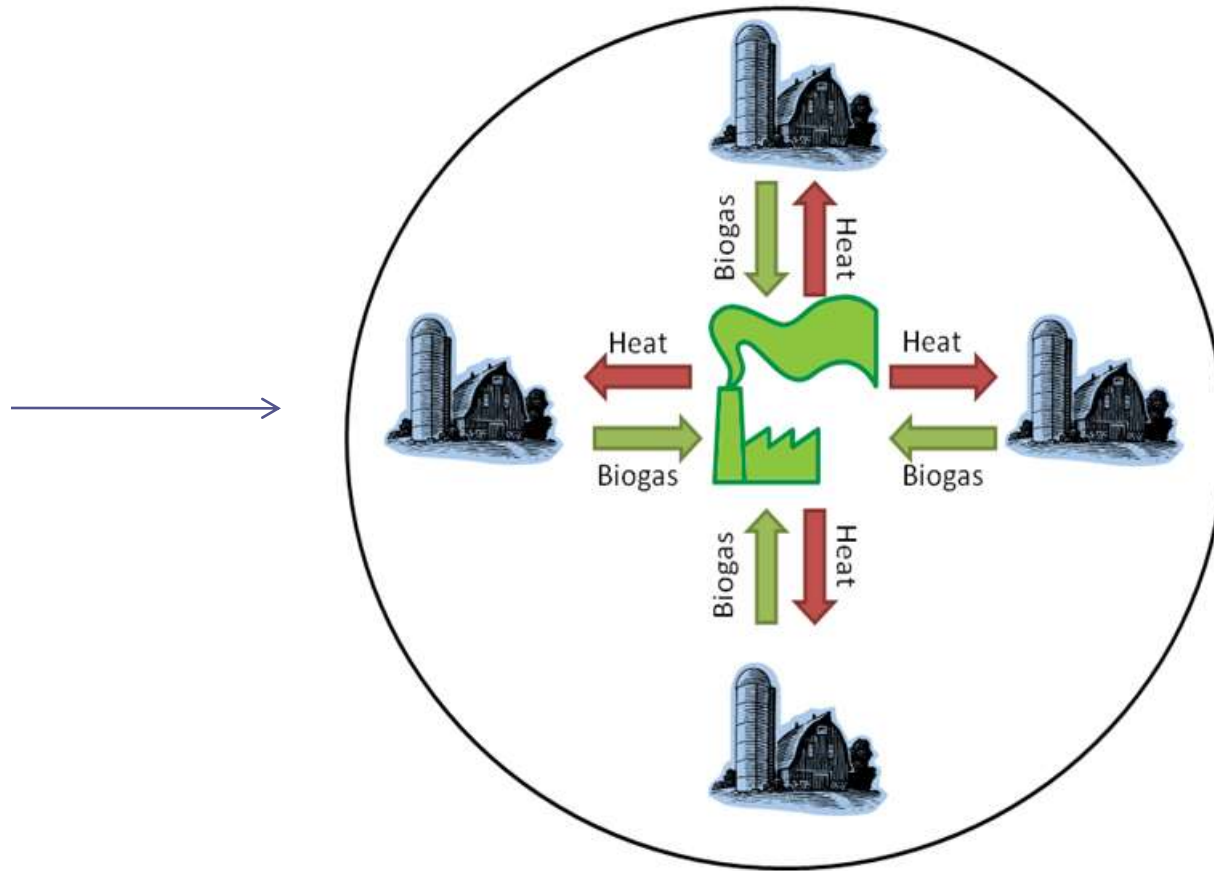




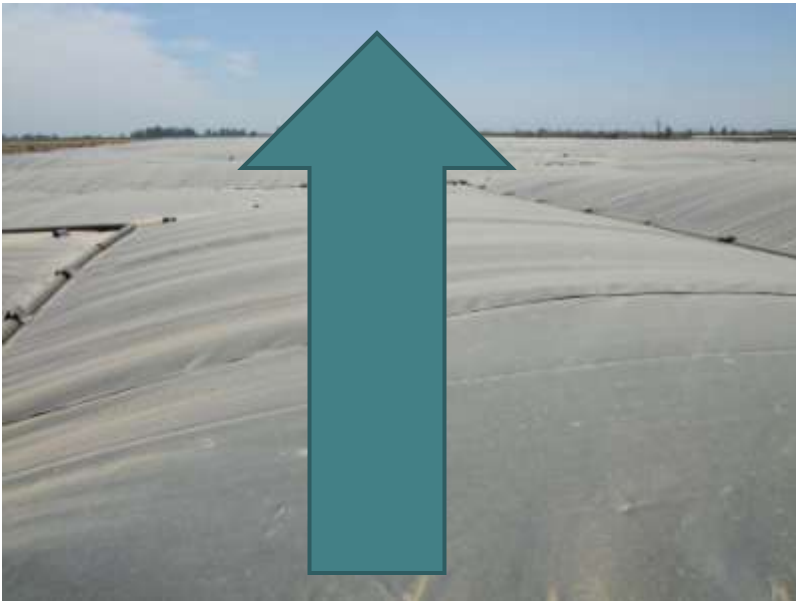
# Remember Gallo?



# Remember Gallo?



# Gallo system or not?

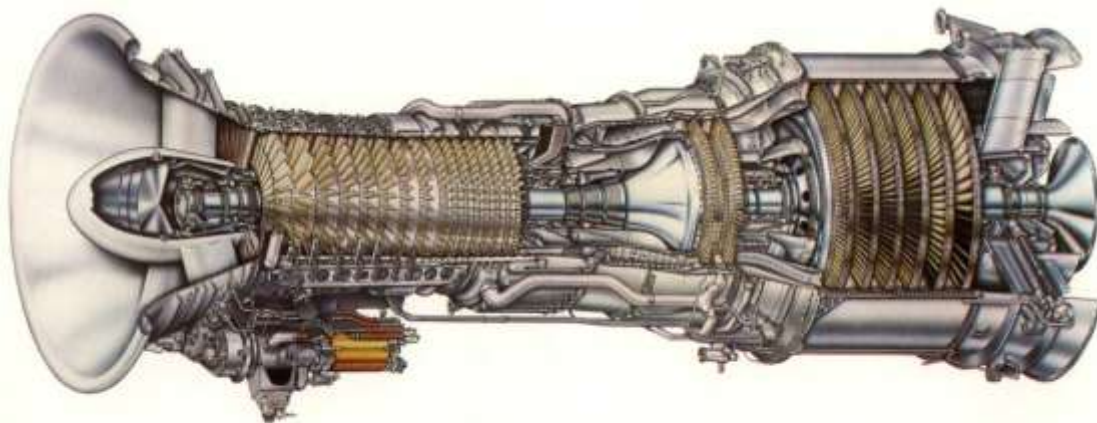


Covered Lagoon  
Low investment cost  
Low maintainance



Gas Engine  
Low investment cost  
Low maintainance  
Lower efficiency

# Combined Cycle instead of Gas Engine



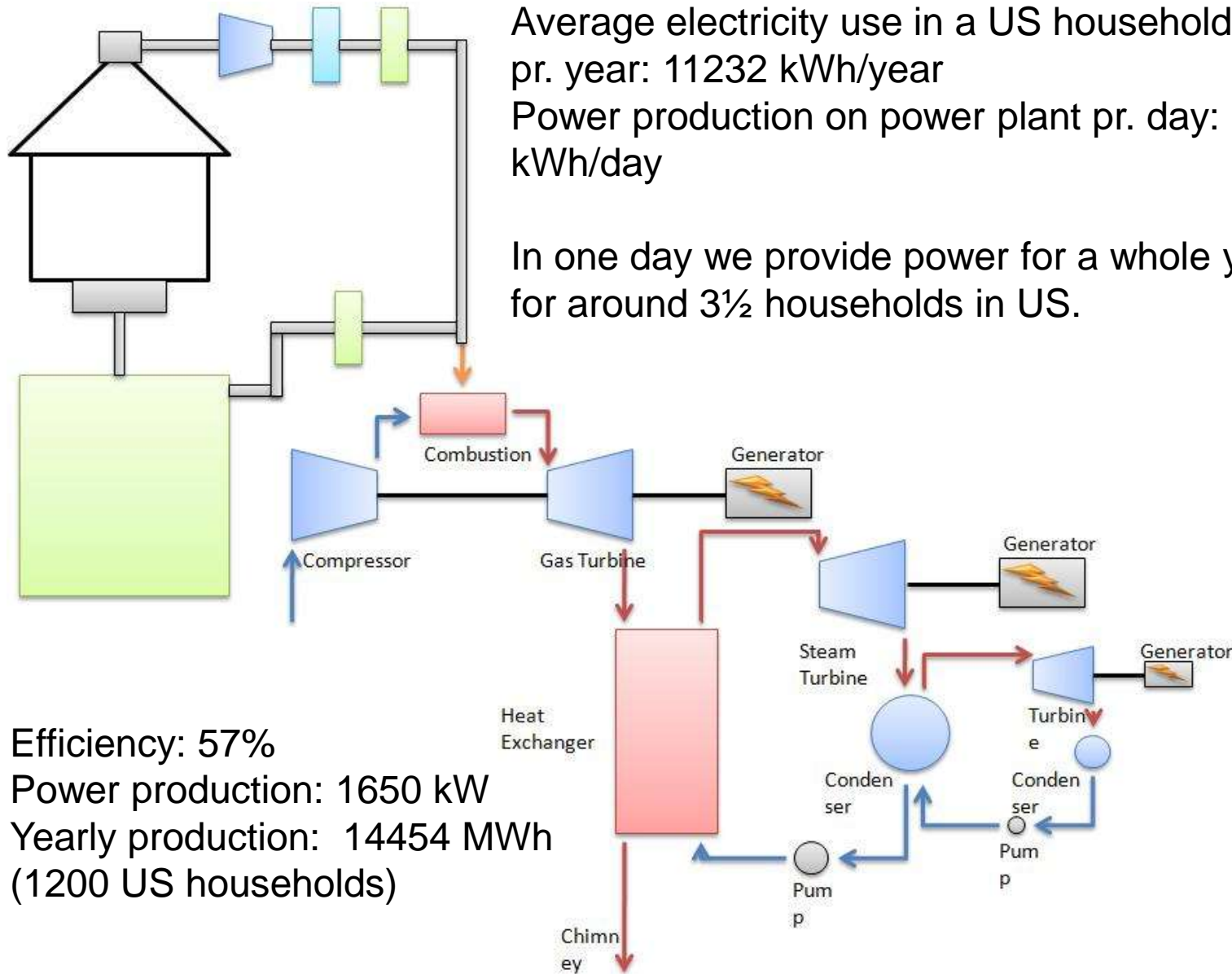
General Electric LM2500 Gas Turbine



How many of you have seen a steam turbine before?

Combined Cycle 50-60% Efficiency  $\leftrightarrow$  Gas Engine 30-40% Efficiency

Better Power/fuel ratio – Less Heat production – More power generation



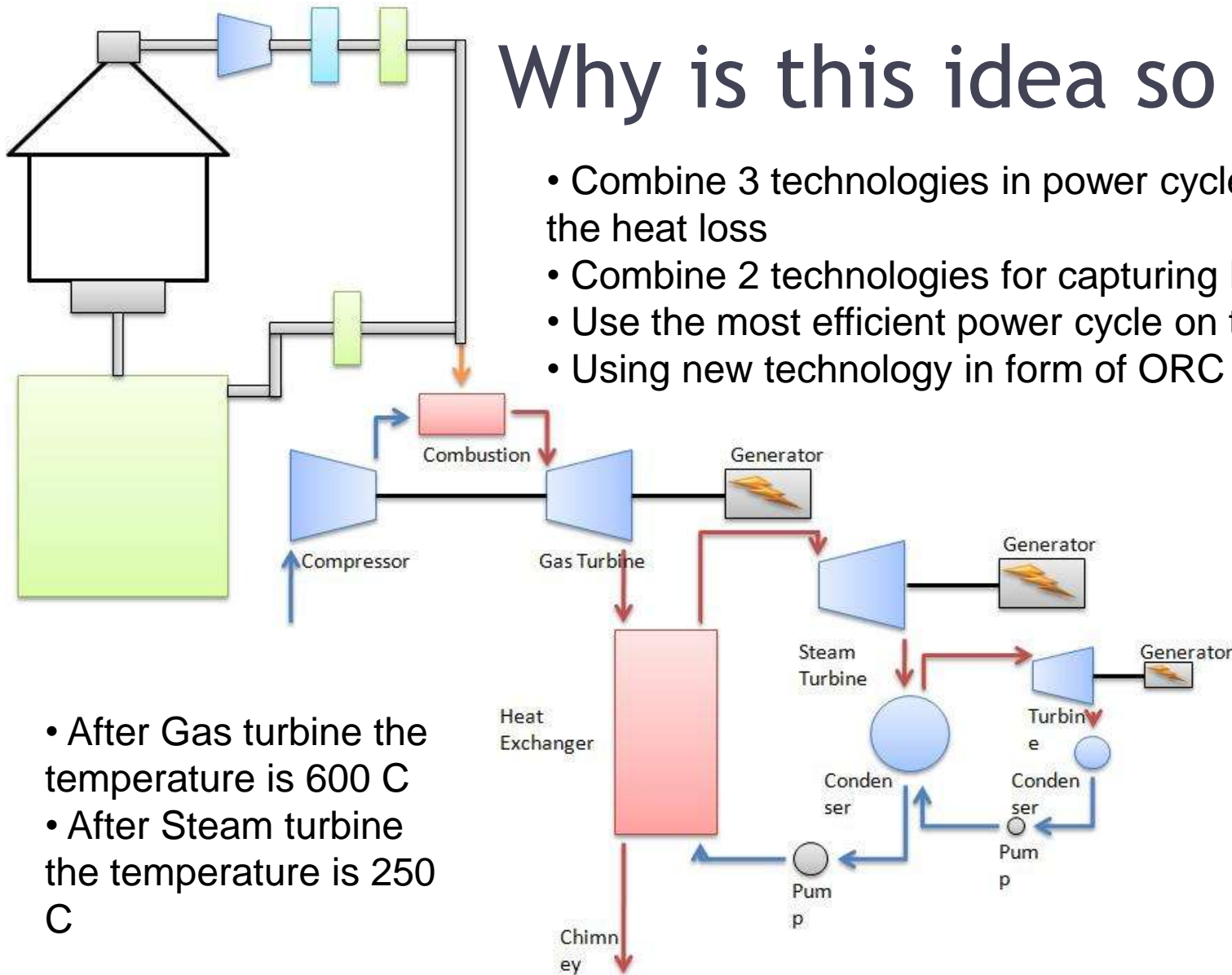
Average electricity use in a US household pr. person  
pr. year: 11232 kWh/year  
Power production on power plant pr. day: 39600  
kWh/day

In one day we provide power for a whole year of power  
for around 3½ households in US.

Efficiency: 57%  
Power production: 1650 kW  
Yearly production: 14454 MWh  
(1200 US households)

# Why is this idea so good?

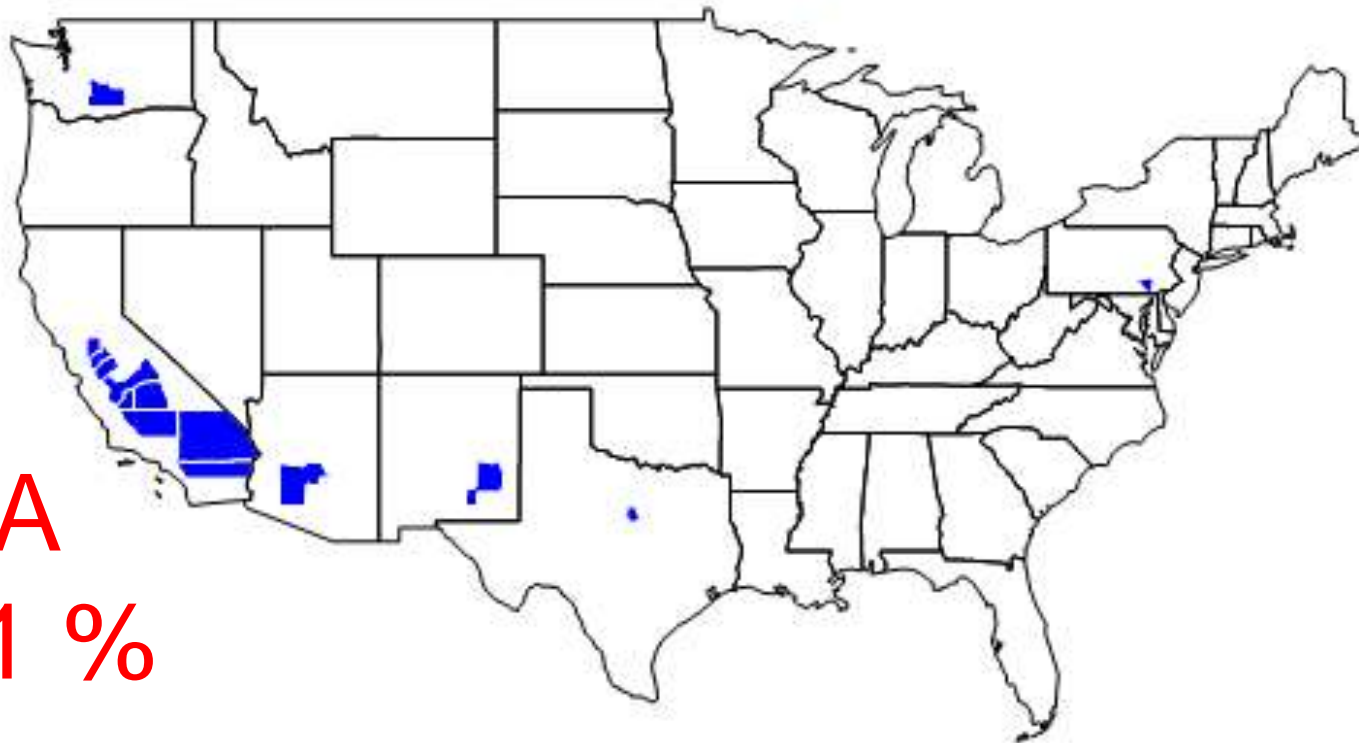
- Combine 3 technologies in power cycle to lower the heat loss
- Combine 2 technologies for capturing Methane
- Use the most efficient power cycle on the market
- Using new technology in form of ORC cycle



- After Gas turbine the temperature is 600 C
- After Steam turbine the temperature is 250 C

# Where does the milk come from ?

14 Counties Marketed 25% Of All  
CA + Federal Order Milk During December 2000

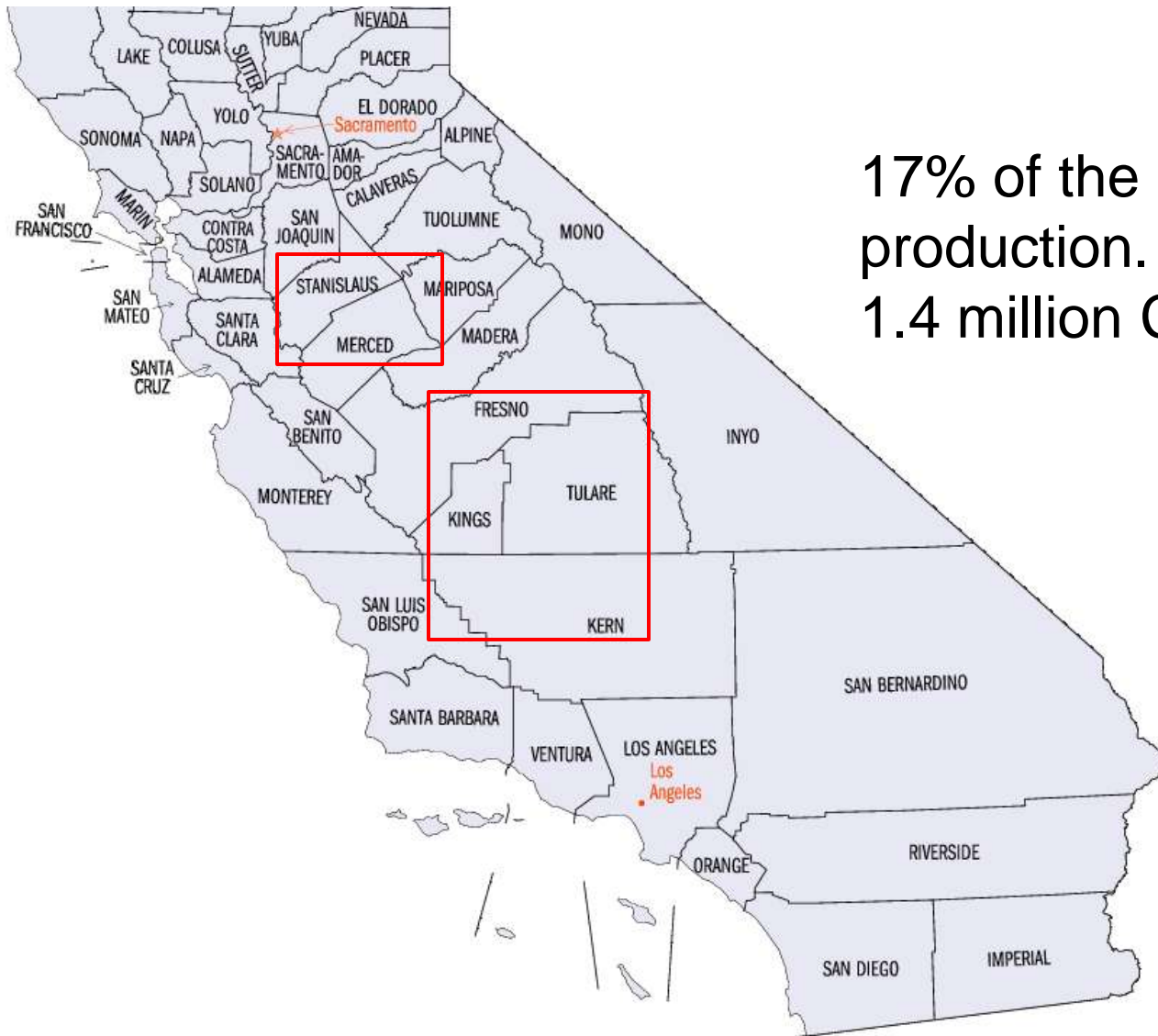


CA  
21 %

# Concentration of dairy's

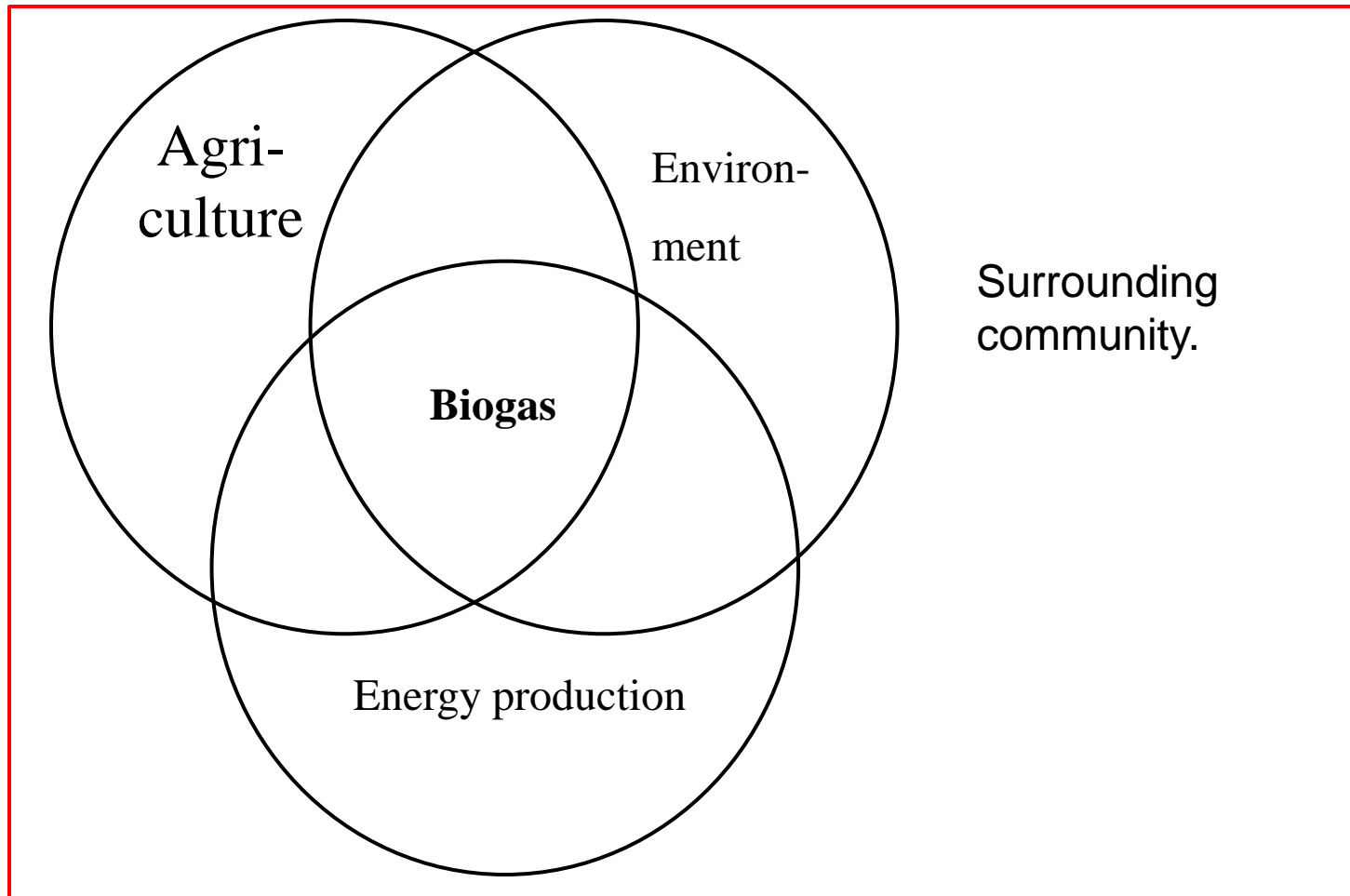
County	Number dairies	Average cows	% of total CA Cows
Tulare	332	1450	28%
Merced	312	843	15%
Stanislaus	301	621	11%
Kings	166	1076	11%
Kern	55	3137	10%
Fresno	115	1050	7%





17% of the US milk  
production.  
1.4 million Cows!

# Biogas



# legislations

- Air Quality – Regarding biogas
  - Permitting – SB 700
  - AB 32 - California Air Resources Board
  - Best Available Control Technology
- Water Quality
  - Leakage from lagoons?
- NO<sub>x</sub> restrictions in California
  - EGR
  - SCR

# Current installations

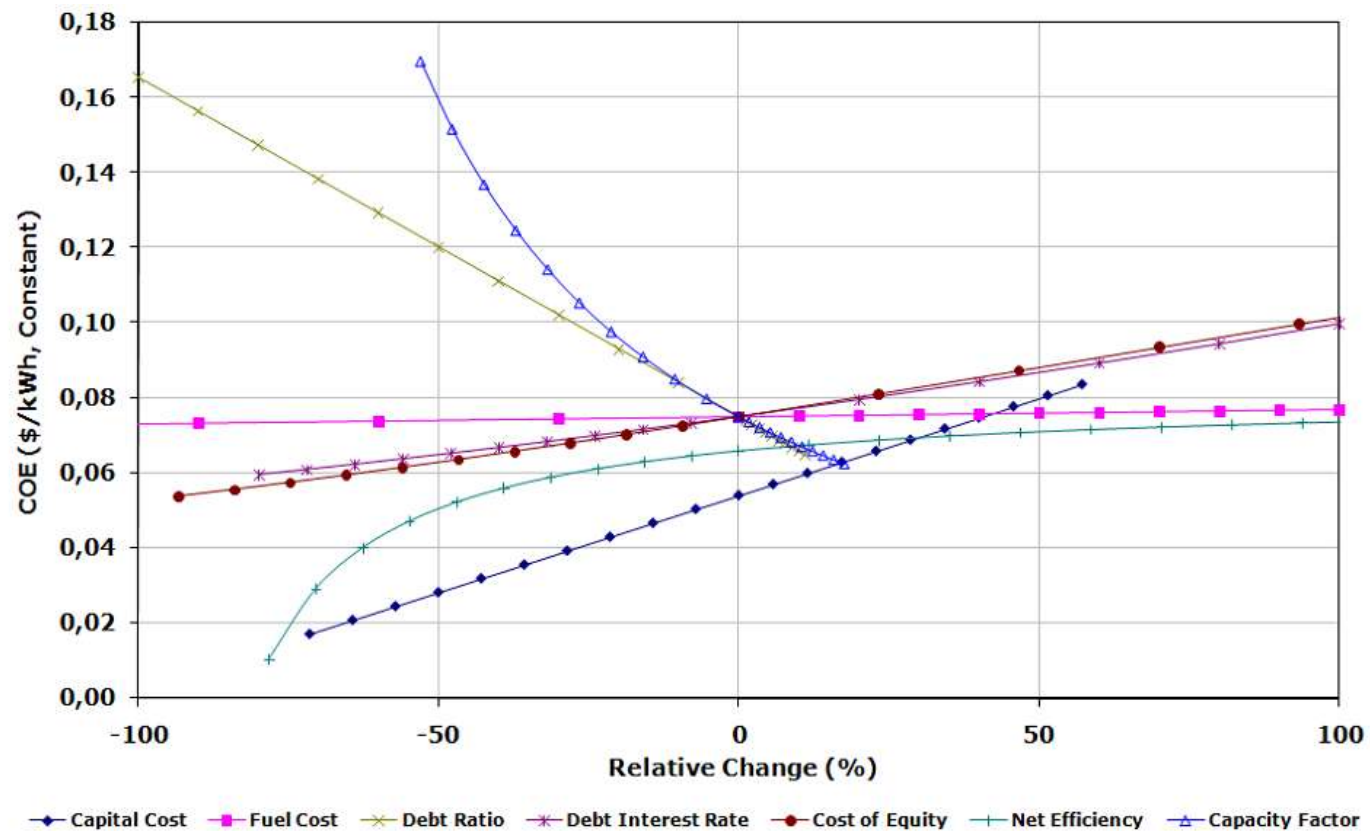
- Dairy Power Production Program
  - Fourteen approved
    - Teen build
      - Six in operation
- Regulations has short down several the last year

# Economy

NEM Bio Net Metering Rate, ¢/kwh	PG&E	SCE	SDG&E
Off-Peak	2.2 – 2.3 ¢	3.1 ¢	6.5 ¢
Mid-Peak	3.1 – 3.2 ¢	6.9 – 8.4 ¢	6.5 ¢
On-Peak	3.6 ¢	11.6 ¢	8.9 ¢

1 kWh with our system → **\$0.075**

# Economic analysis



# Discussion

- Energy is so cheap
- Electricity production is the main income
- Combined cycles possibilities
- Biogas has lot of potential

# Conclusion

- Mature technology in California
- Reducing greenhouse gas
- Minor trade off in NO<sub>x</sub>
- Flexibility in boards