

“How to make protein from
geothermal gas”

- The GEOGAS project



prokatín

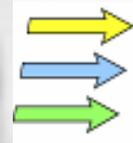
Dr. Arnþór Ævarsson

Prokatín ehf

GEORG málstofa: Frá úrgangi til verðmæta



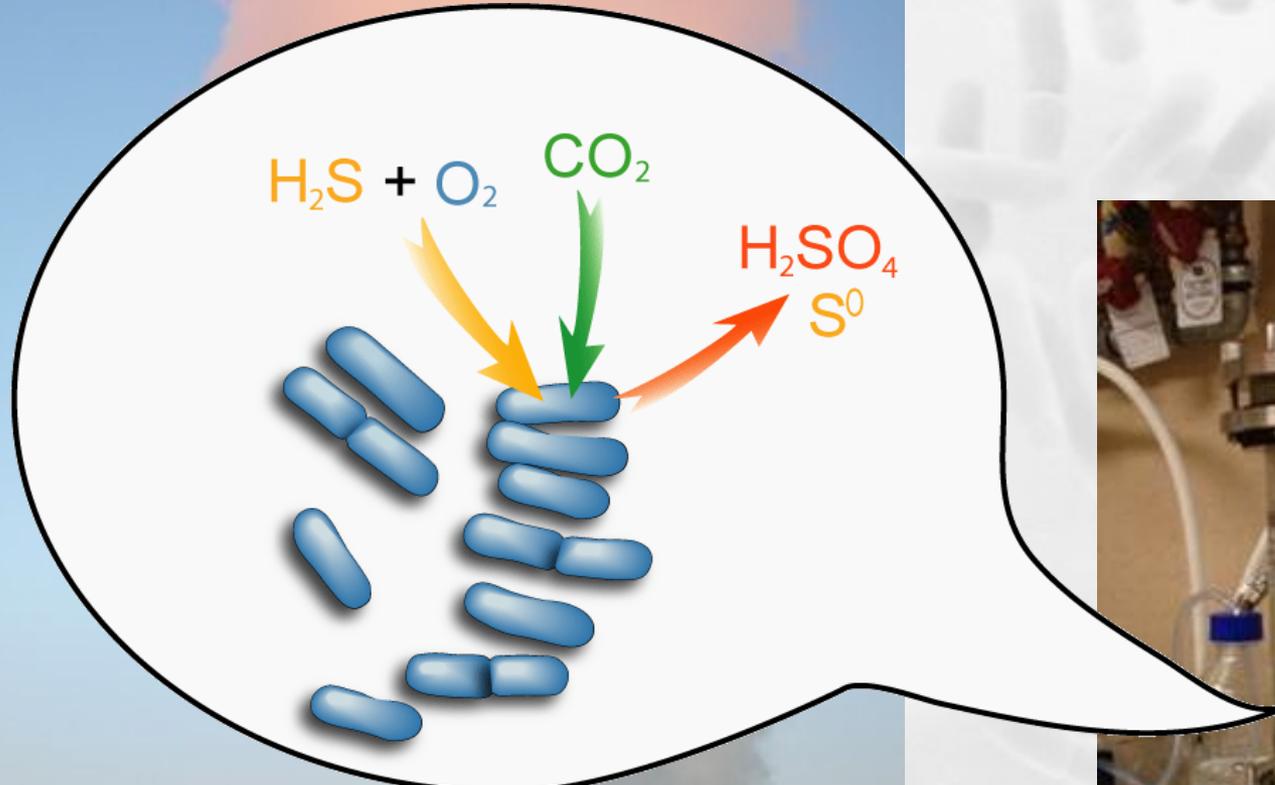
H_2S Hydrogen sulfide
 H_2 Hydrogen
 CO_2 Carbon dioxide

 **GEOGAS**

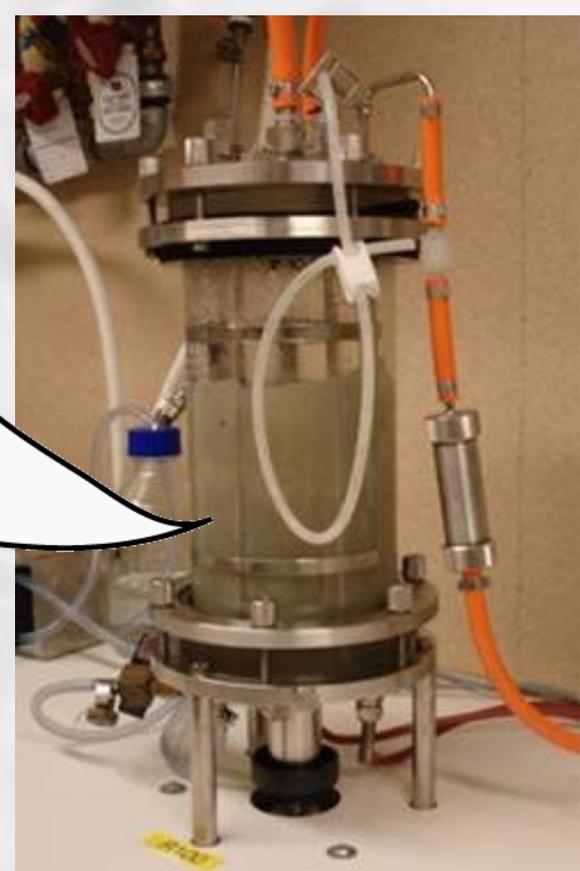
Future geothermal power plants will require control of hydrogen sulfide emission

H_2S Hydrogen sulfide
 H_2 Hydrogen
 CO_2 Carbon dioxide

\Rightarrow
 \Rightarrow
 \Rightarrow **GEOGAS**



Lithotrophic microbes



Problem:

Geothermal power plants release
 H_2S og CO_2

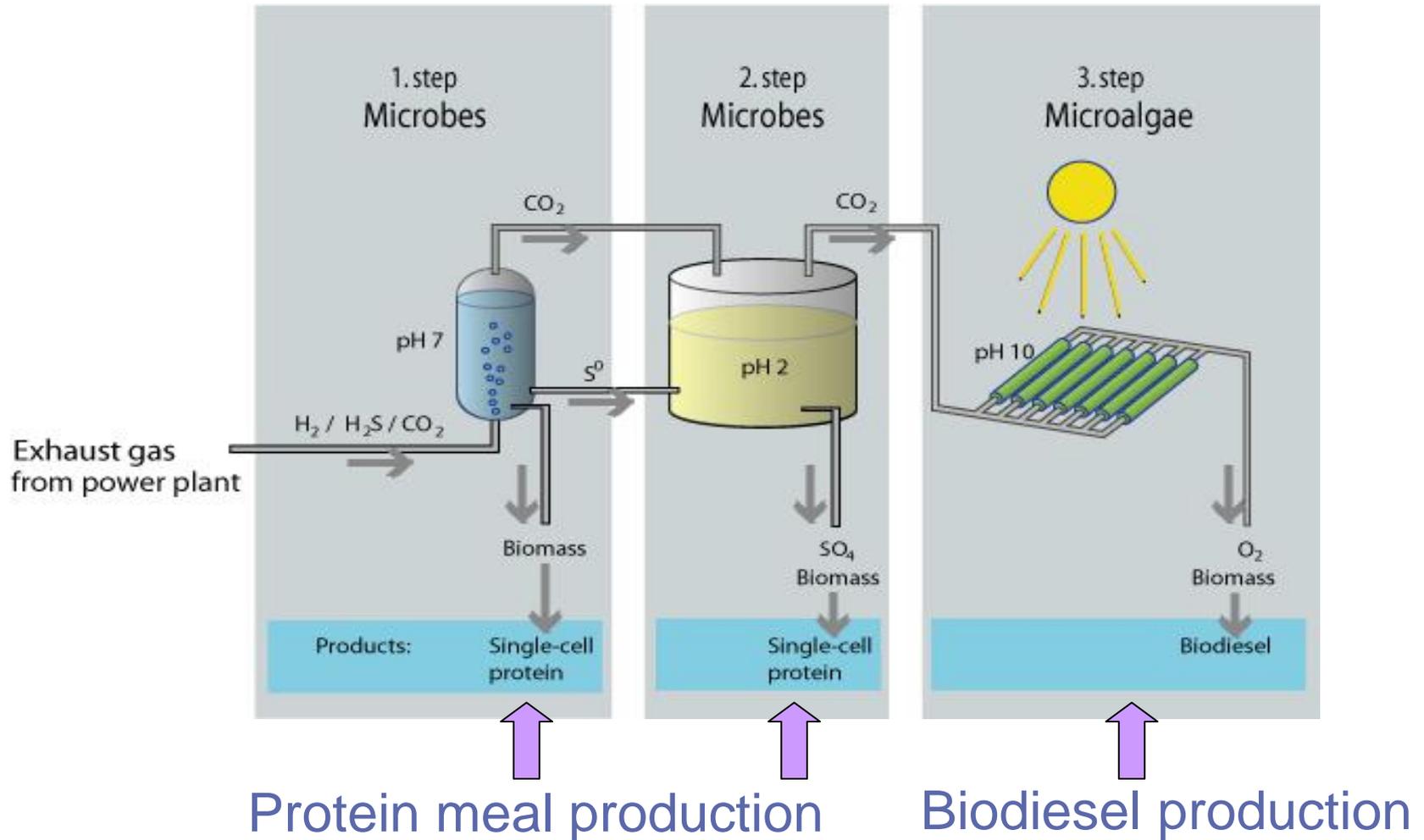
Our solution:

Microbes that “eat” H_2S and bind CO_2

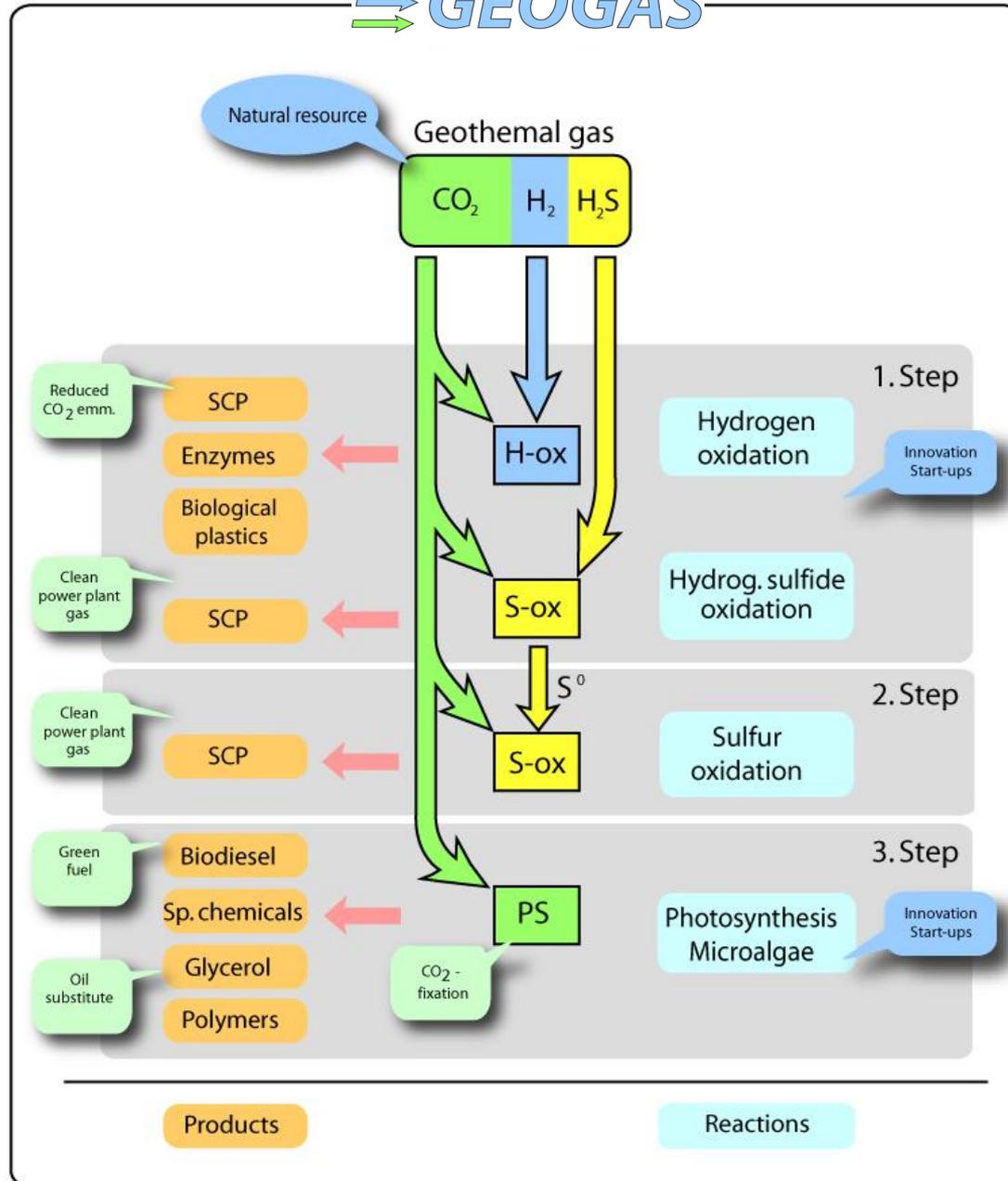
“ H_2S and CO_2 is a resource”

Future vision: 3-step process

⇒⇒ **GEOGAS**



GEOGAS



Natural resources

Biological diversity

90°C
pH 2

65°C
pH 8

H_2 H_2S
 CO_2

Thermophilic microbes

50°C
pH 4

Geothermal Ecosystems

80°C
pH 7

Laboratory at Nesjavellir plant



Nesjavellir



Hveraörverur



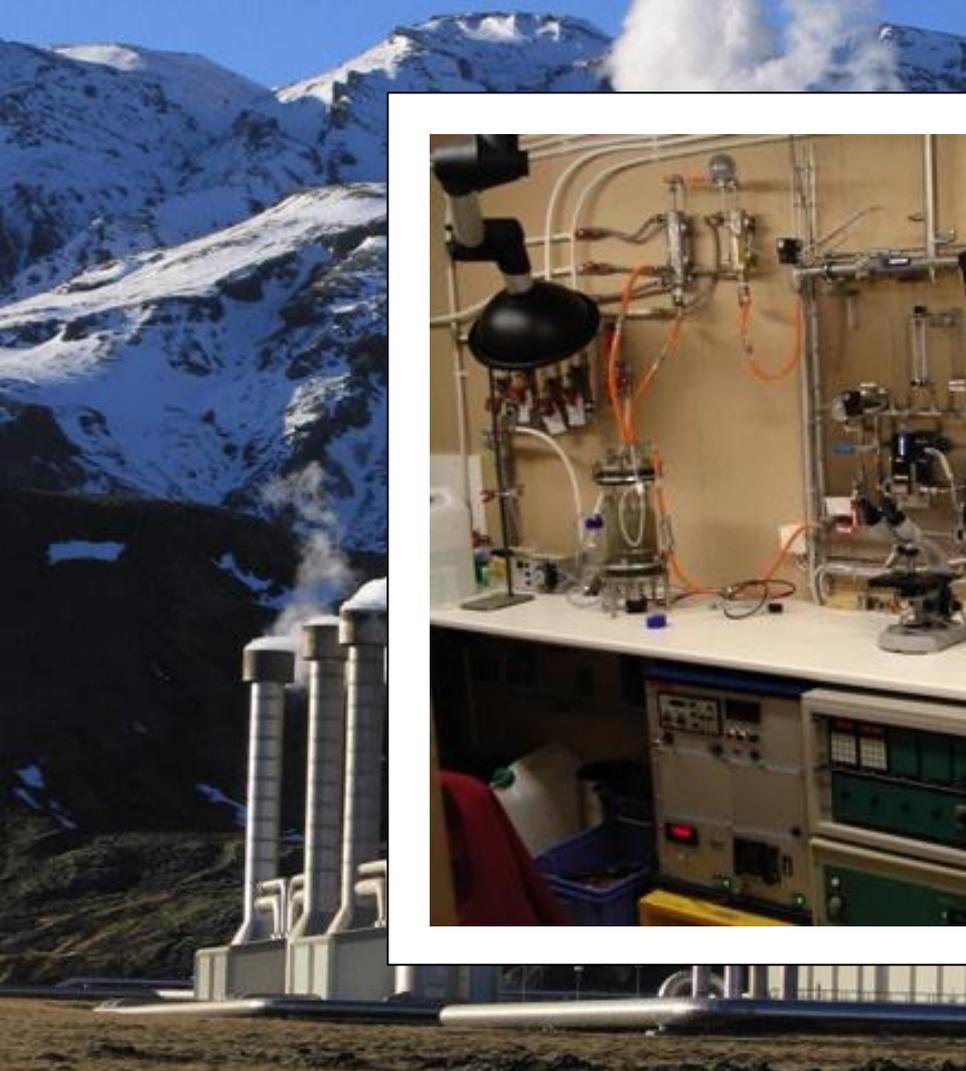
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Laboratory at Nesjavellir plant



Hveraörverur



Nesjavellir



Pilot Plant Hellisheiði

Pilot scale - 2000 liters



Vísindagarðar, Hellisheiðarvirkjun, mars 2011

Pilot Plant Hellisheiði



The Biology works



← **Bakteria
ca 10⁹/ml**

← **Solid sulfur**

Chemical reactions:



Formation of sulfur from hydrogen sulfide

Examples of products



Biologically formed sulfur

“Biosulfur”

Single-cell protein

“Geoprotein”

Biosulfur

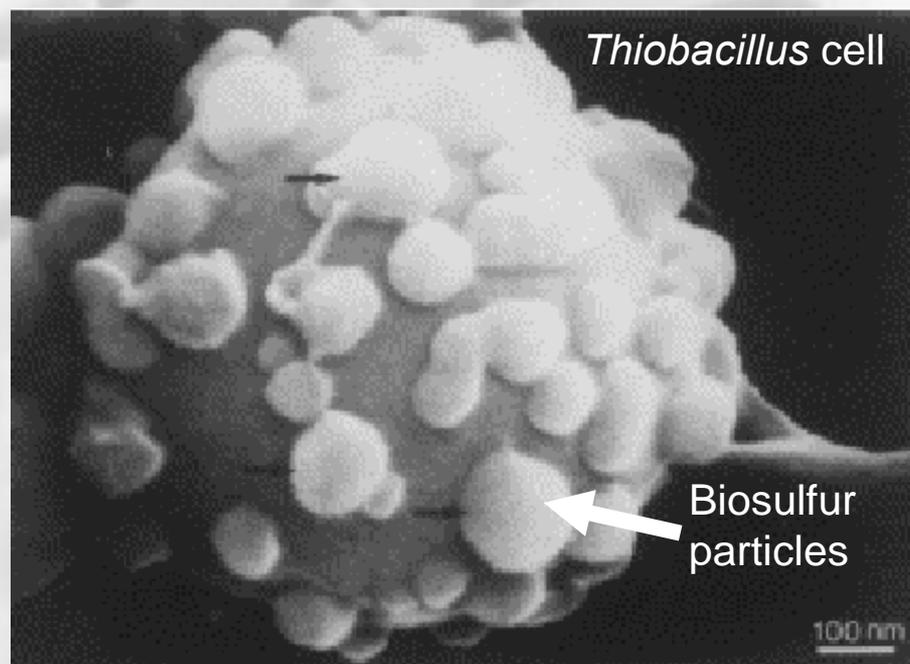
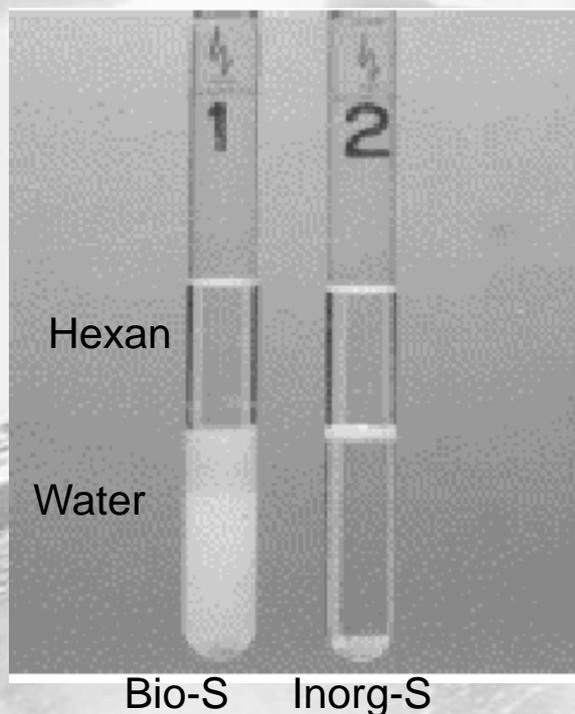


Single-cell protein

Biosulfur – properties:

Biologically produced sulfur is more soluble than conventional “inorganic” sulfur

The bacteria may produce the sulfur as polysulfides. The sulfur particles may then be coated with polymers such as proteins and secreted from the cell exterior



Biosulfur: market opportunities ?

- Biologically produced sulfur is considered “organic”
- Makes an excellent fertilizer and fungicide
- Can be land-applied using standard farm equipment
- Non-hazardous for landfilling as a 50wt% to 65wt% cake



Examples of products



Biosulfur

Single-cell protein

Protein rich meal



Biosulfur



Single-cell protein
“Geoprotein”

Single-cell protein: methane oxidizing bacteria

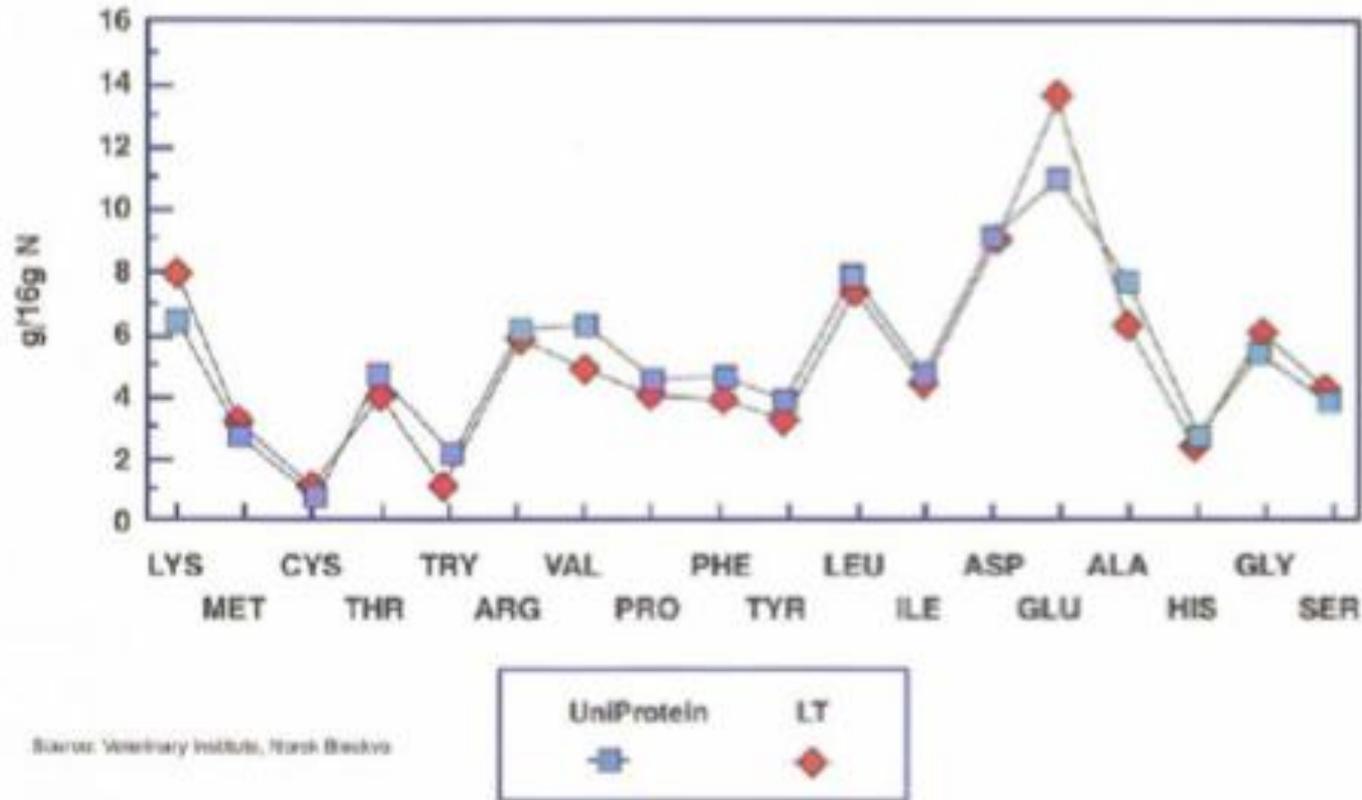
Norferm in Norway

9000 t biomass/year
250.000 L



Single-cell protein: methane oxidizing bacteria

AMINO ACID PROFILE IN UniPROTEIN® AND LT-FISHMEAL



➡ Amino-acid composition similar to fish meal

➡ Single-cell protein certified for use in feed in the EU

Geothermal gas for production of single-cell protein

Chemical flow from geothermal plants



Gas release from
Nesjavellir (120 MW):

- CO_2 : 25.000 tonn / y
- H_2 : 400 tonn / y
- H_2S : 7.500 tonn / y



Rich resource for single-
cell protein production

Geothermal gas for single-cell protein production

Average geothermal plant (120 MW) per year:

2000 tonn single-cell protein

Produce 7000 t. of solid sulfur

Fix 4000 t. of CO₂

Large-scale factory?

Technical / engineering aspects

Large scale factory is on the drawing board

Modular design - 200-1000 m³

Stepwise implementation

Economical aspects

Comparison with other solutions

Market for biosulfur?

Large-scale factory?

Biological aspects

Other biological systems on same scale

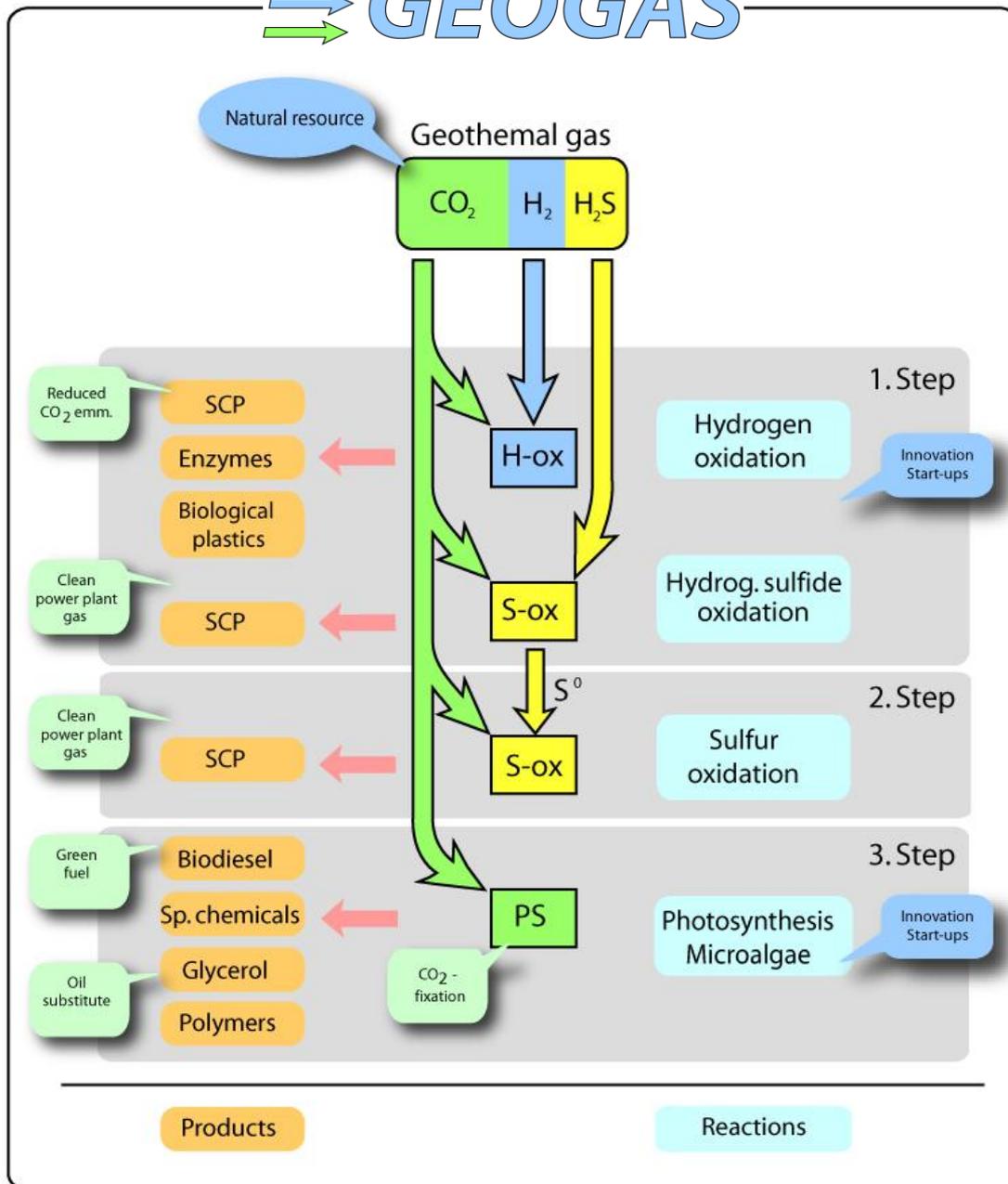
Improve yields

Less than full-scale factory?

Combine with other solutions for H₂S reduction

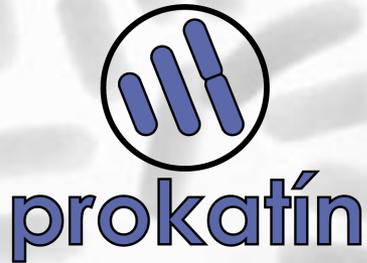
Market-based operation for sulfur products

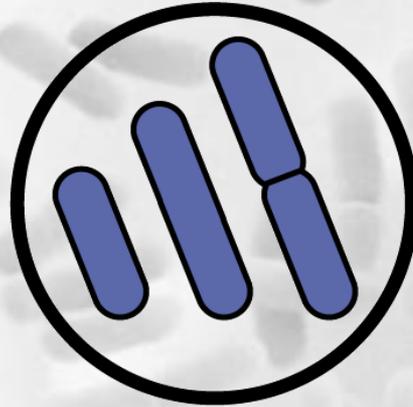
High value products



Future vision of the GEOGAS research and development framework

Collaboration and support





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....Orka og Líftækni