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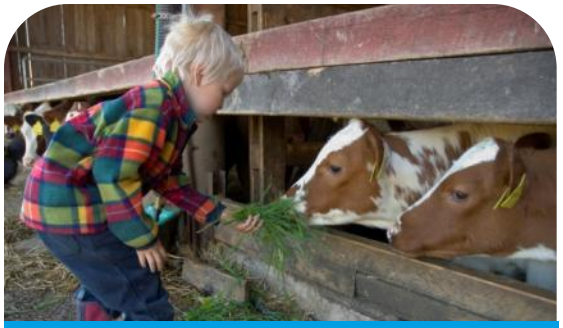
Waste to Wealth
DSM India Innovation Centre
Sahyog Program

Rajiv Agarwal

DSM's unique business positions

Health



Nutrition

Materials

- Global leader in nutritional ingredients for feed, food and personal care
- Market leader in anti-infectives and key pharma custom manufacturing player
- Market leader in sustainable high performance materials
- Merchant market leader in nylon precursor caprolactam
- Innovator active in advanced biofuels, bio-based chemicals and biomedical materials

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Bio-based Products & Services

- In *cellulosic bio-ethanol*:
  - Advanced C5 yeast and enzymes for cellulosic ethanol commercialized
  - Construction of POET-DSM 20-25m gallon ***cellulosic bio-ethanol*** facility (Iowa-USA), start up beginning 2014

- In *advanced biodiesel,* DSM and BP extended cooperation on the development of microbial oils to produce biodiesel from renewable sources

- In *advanced biogas,* DSM refocused on the development of an advanced biogas process: high intensity industrial biogas plant using DSM's advanced enzymes

- In *bio-based chemicals*:
  - Bio-succinic acid plant in Cassano Spinola (Italy) starting production
  - DSM achieved considerable technological progress in bio-based adipic acid and is in advanced discussions with prospective partners
  - Exciting pipeline of wide range of bio-based solutions

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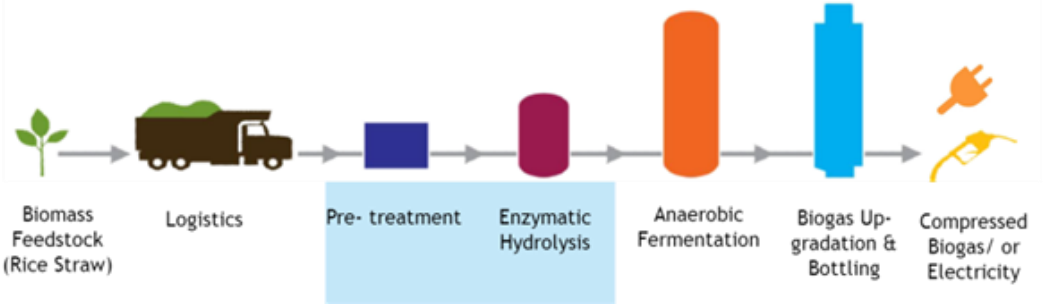
DSM India Innovation Center – Focus Areas

India protein project

India solar

Biogas India



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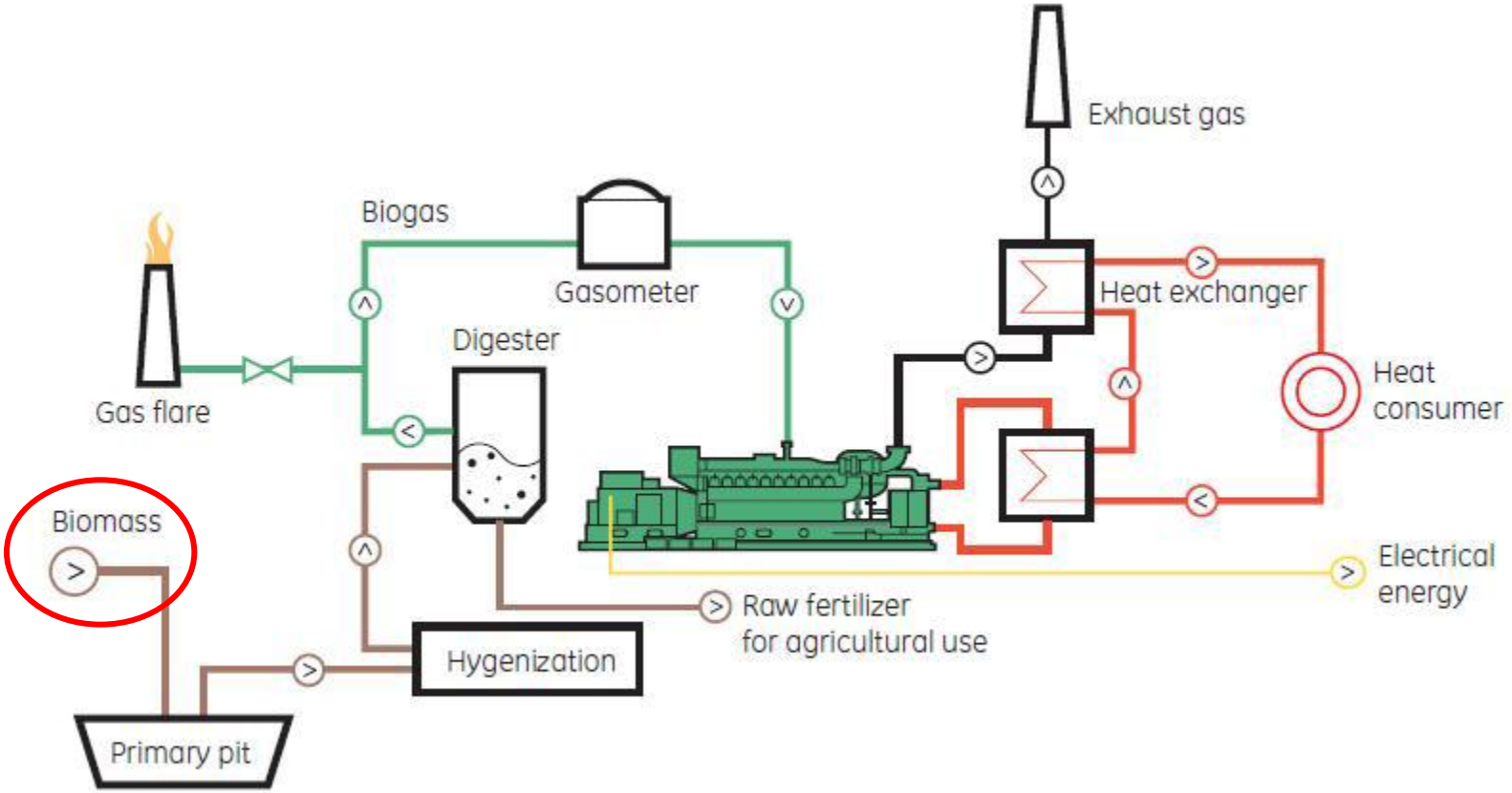
Ludhiana Biogas Plant

- 1 MW Cow dung based biogas plant (7-10.000 m^3 gas/day).
- Produced gas is used for electricity production.
- Since Jan 2012, DSM is operating the plant on a revenue share model.
- At full capacity requires 235 tons of Cow dung a day, or almost 25000 Cattle head in one place.

Process overview



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Challenges in the biogas plants

- Electricity model is not remunerative:
  - There is a need to improve support prices for electricity fed into grid
  - Look at value addition of products

- Biogas plants not replicable due to challenges in feedstock:
  - Animal manure availability is very fragmented. Where-ever available, quantities are limited. Plants > 2 MW capacity (Min. Economic Size) need concentration of > 50,000 cattle heads at one place.
  - Agricultural waste is available in plentiful through-out the country but its yield is not good. Economical pretreatment of Ligno-cellulosic matter for the biogas is important.

Adding value to products

Raw Bio Gas – Methane -55-60% & CO_2 – 40-45%
H_2S – 100 - 1000 ppm

Methane > 95% (CBG)

CO_2 > 99.9%

- Cooking – Hotels & Restaurants
- Industrial Heating and Cooling.
- Transport
- Welding
- Dry Ice
- Extinguishers

- Technologies for up-gradation under evaluation.
- Availability of gas grid is limited. This infrastructure needs to be developed.

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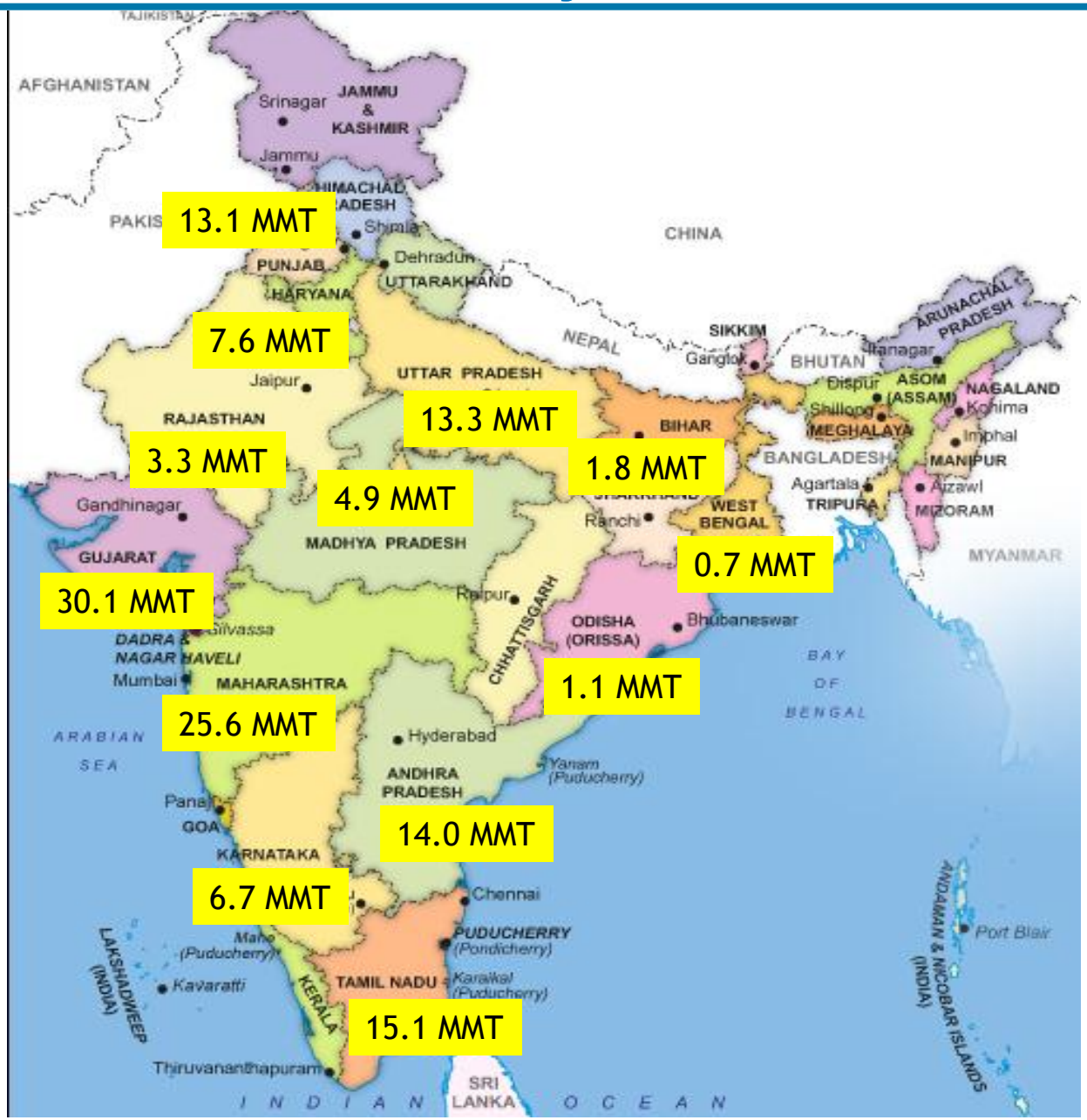
Biomass Availability in 2011-12



103.6 MMT

Bio Mass in Million Metric Tons. Includes:

- Cane Tops
- Rice Straw
- Cotton Stalks

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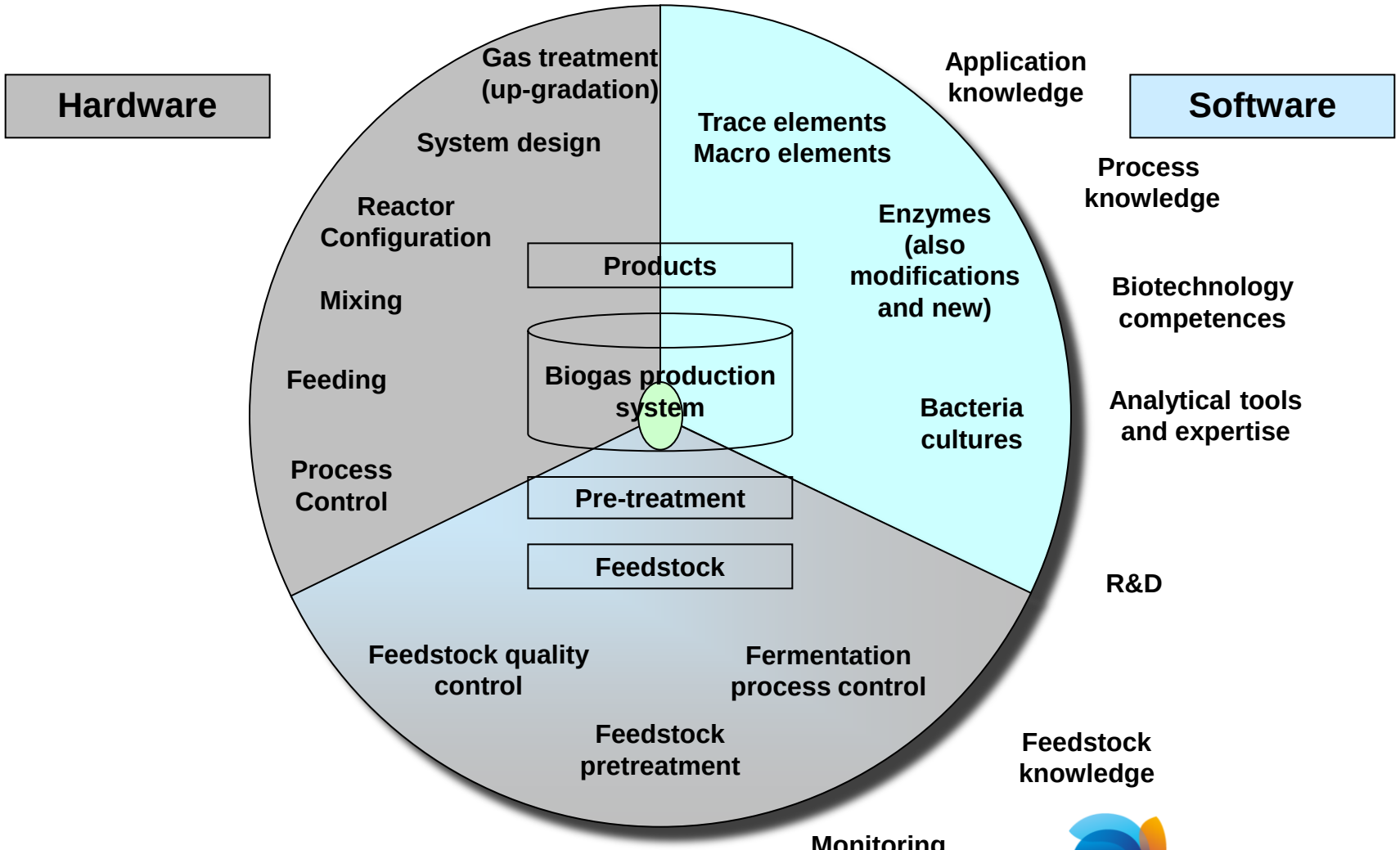
Key suppliers/ partners recognized towards biogas production



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Various pretreatment options under evaluation

Physical Treatments

Milling
- *Ball*
- *Two-roll*
- *Hammer*
- *Knife*
- *Colloid*
- *Vibro energy*

Irradiation
- *Gamma ray*
- *Electron-beam*
- *Microwave*

Others
- *Expansion*
- *Extrusion*
- *Pyrolysis*

Physico-Chemical Treatments

Explosion
- *Steam*
- *Ammonia fiber (AFEX)*
- *CO_2*
- *SO_2*

Others
- *Hydrothermolysis*
- *High pressure steaming*
- *Microwave-chemical*

Chemical Treatments

Alkali
- *Sodium hydroxide*
- *Ammonia*
- *Ammonium sulfite*

Acid
- *Sulphuric*
- *Hydrochloric*
- *Phosphoric*

Gas
- *Chlorine dioxide*
- *Nitrogen dioxide*
- *Sulfur dioxide*

Oxidizing Agents
- *Hydrogen peroxide*
- *Wet oxidation*
- *Ozone*

Solvent extraction of lignin
- *Ethanol/water*
- *Benzene/water*
- *Ethylene glycol*
- *Butanol/water*
- *Swelling agents*

Biological Treatments

- *Microbial (fungi and actinomycetes)*
- *Enzymatic hydrolysis*

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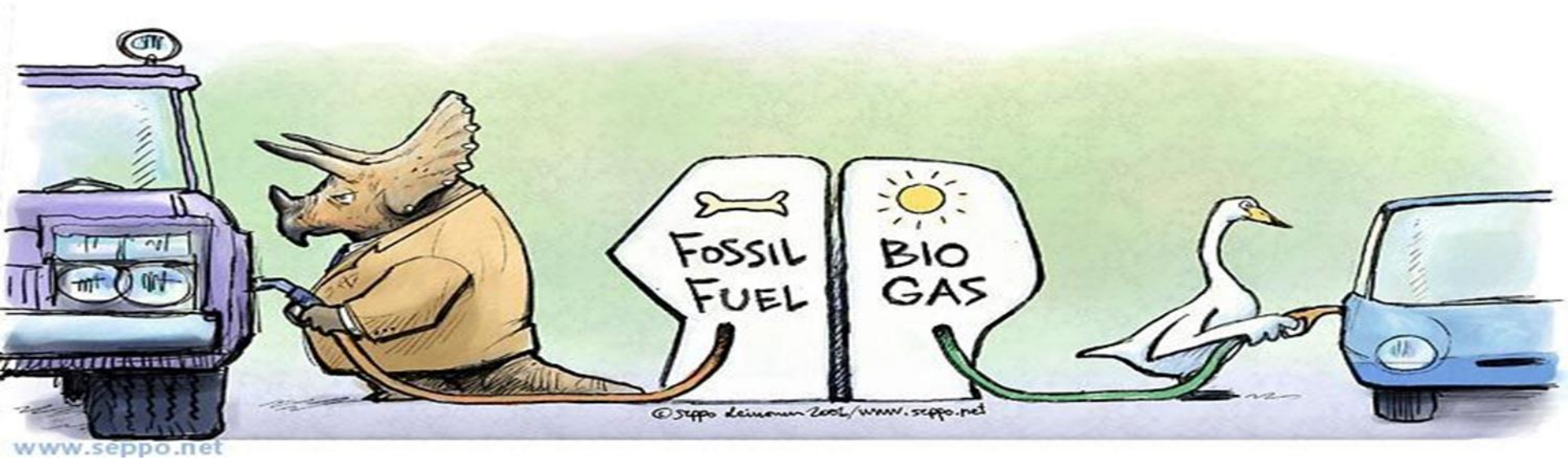

Thank you

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