FACTORS AFFECTING BIOGAS PRODUCTION

Biological Conversion

- Conversion of the biomass to fuel by exposing biomass to certain microorganisms is called biological conversion.
- The secondary fuels are produced as a result of metabolic activity of the microorganisms.
- Fermentation and anaerobic digestions are the two most common biological conversion processes and products of these processes are ethanol and biogas.

INTRODUCTION

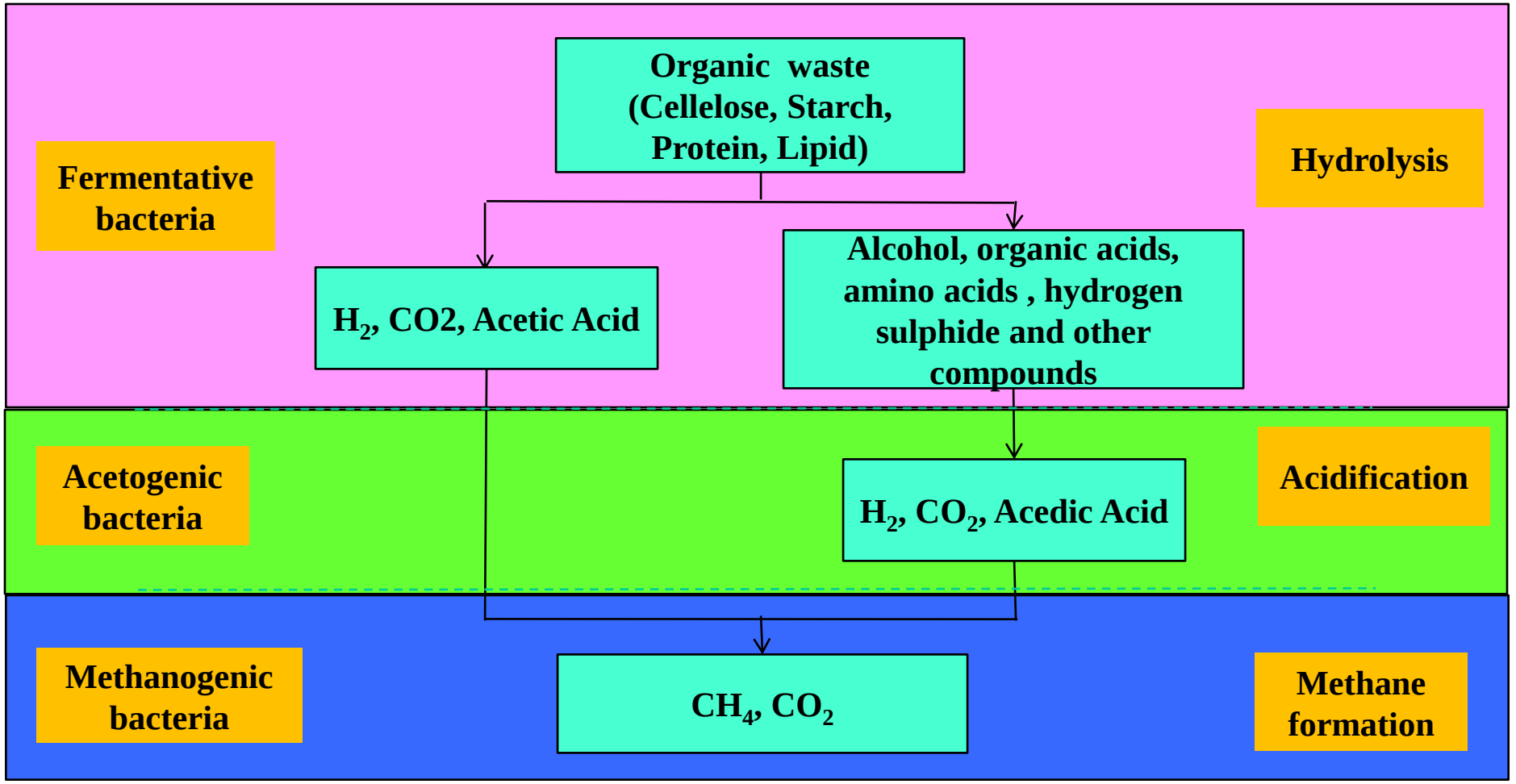
- **Biogas**
  - **Biogas originates from the bio-degradation of organic material under anaerobic conditions.**
  - **Today biogas has several applications such as industrial and household cooking, lighting, radiant heaters and incubators for agricultural purposes and absorption refrigerators.**
  - **Biogas system provides a whole range of benefits for their users, the society and the environment in general.**

BENEFITS OF BIOGAS

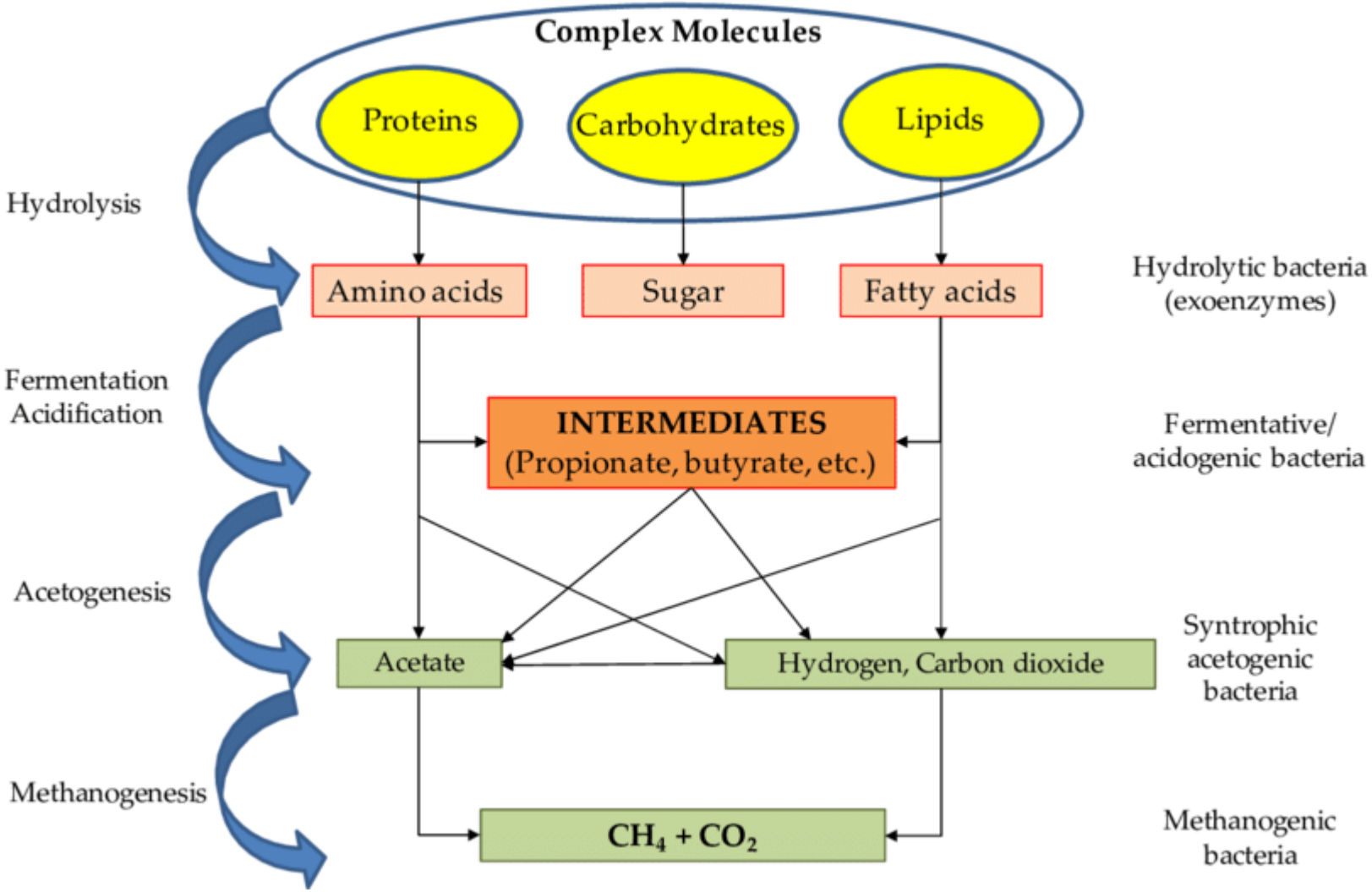
- ✓ Production of energy (heat, light, electricity),
- ✓ Transformation of organic waste into high quality fertilizer,
- ✓ Improvement of hygienic conditions via reduction of pathogens,worm eggs and flies,
- ✓ Increase of productivity, mainly for women, in firewood collection and cooking,
- ✓ Environmental advantages through protection of soil, water, air and woody vegetation,
- ✓ Micro-economical benefits through energy and fertilizer substitution,
- ✓ Additional income sources and increasing yields of animal husbandry and agriculture,

ANAEROBIC DIGESTION

- **Basic Process**
  - **The four stages anaerobic fermentation of biomass**



ANAEROBIC DIGESTION



FOUR PHASES OF ANAEROBIC DIGESTION

- **HYDROLYSIS**
  - In hydrolysis aerobic micro-organisms convert complex organic compounds (carbohydrates, proteins and lipids) into simple forms which are soluble and can be consumed by the micro-organisms.
  - As an example, Polysaccharides are converted into monosaccharides, lipids to fatty acids, proteins to amino acids and peptides.
- **ACIDIFICATION**

  - Acid-producing bacteria (acetogenic bacteria), convert the intermediates of fermenting bacteria into mixture of acetic acid (CH_3COOH), H_2, CO_2, alcohols, organic acids, amino acids and hydrogen sulphide.

FOUR PHASES OF ANAEROBIC DIGESTION – contd…

- **ACETOGENESIS**
  - The oxygen requirement for producing acetic acid is fulfilled by the oxygen solved in the solution or bounded-oxygen.
  - The acid-producing bacteria create an anaerobic condition which is essential for the methane producing microorganisms.
- **METHANE FORMATION**
  - In the third step, methane-producing bacteria utilize hydrogen, carbon dioxide and acetic acid formed in acidification process to form methane and carbon dioxide.

FACTORS INFLUENCING THE BIOGAS PRODUCTION

– **SUBSTRATE TEMPERATURE**

- **Optimal temperature range for biogas production: 20-28°C.**
- **This can be achieved in a satisfactory level only where mean annual temperatures are around 20°C or above or where the average daily temperature is at least 18°C.**
- **If the temperature is below 15°C, gas production will be so low that the biogas plant is no longer economically feasible.**

- **CHANGES IN TEMPERATURE**

  - **The process is very sensitive to changes in temperature.**
  - **Most of the biogas plants are built underground in order to overcome this issue.**
  - **The temperature fluctuations between day and night are no great problem for plants built underground, since the temperature of the earth below a depth of one meter is practically constant.**

FACTORS INFLUENCING THE BIOGAS PRODUCTION

- **AVAILABLE NUTRIENT**
  - In order to grow, bacteria need organic substances as a source of carbon and energy.
  - In addition to carbon, oxygen and hydrogen, the generation of bio-mass requires an adequate supply of nitrogen, sulfur, phosphorous, potassium, calcium, magnesium and a number of trace elements such as iron, manganese, molybdenum, zinc, cobalt, selenium, tungsten, nickel etc.

- "Normal" substrates such as agricultural residues or municipal sewage usually contain adequate amounts of the mentioned elements.

- Higher concentration of any individual substance usually has an inhibitory effect, so that analyses are recommended on a case-to-case basis to determine which amount of which nutrients, if any, still needs to be added.

FACTORS INFLUENCING THE BIOGAS PRODUCTION

– Retention time

- The effective retention time may vary widely for the individual substrate constituents depending on the vessel geometry, the means of mixing, etc.
- Selection of a suitable retention time depends on process temperature as well as on the type of substrate used.
- For liquid manure undergoing fermentation, the following approximate values apply:
  - liquid cow manure: 20-30 days
  - liquid pig manure: 15-25 days
  - liquid chicken manure: 20-40 days
  - animal manure mixed with plant material: 50-80 days
- If the retention time is not maintained properly and it is too short, the bacteria in the digester are "washed out" faster than they can reproduce, and fermentation practically comes to a standstill.

FACTORS INFLUENCING THE BIOGAS PRODUCTION

–pH VALUE

- The best condition for the methane-producing bacteria is neutral to slightly alkaline conditions.
- Once the process of fermentation has stabilized under anaerobic conditions, the pH will normally take a value of between 7 and 8.5.
- If the pH value drops below 6.2, the medium will have a toxic effect on the methanogenic bacteria.

– NITROGEN INHIBITION

- Nitrogen in the substrate inhibits the process of fermentation.
- Noticeable inhibition occurs at a nitrogen concentration of roughly 1700 mg ammonium-nitrogen (NH4-N) per liter substrate.
- The main prerequisite is that the ammonia level does not exceed 200-300 mg NH_3-N per liter substrate.

FACTORS INFLUENCING THE BIOGAS PRODUCTION

– C/N RATIO

- Microorganisms required both nitrogen and carbon for assimilation into their cell structures.
- Various experiments have shown that the metabolic activity of methanogenic bacteria can be optimized at a C/N ratio of approximately 8-20, whereby the optimum point varies depending on the nature of the substrate.

– SUBSTRATE SOLID CONTENT

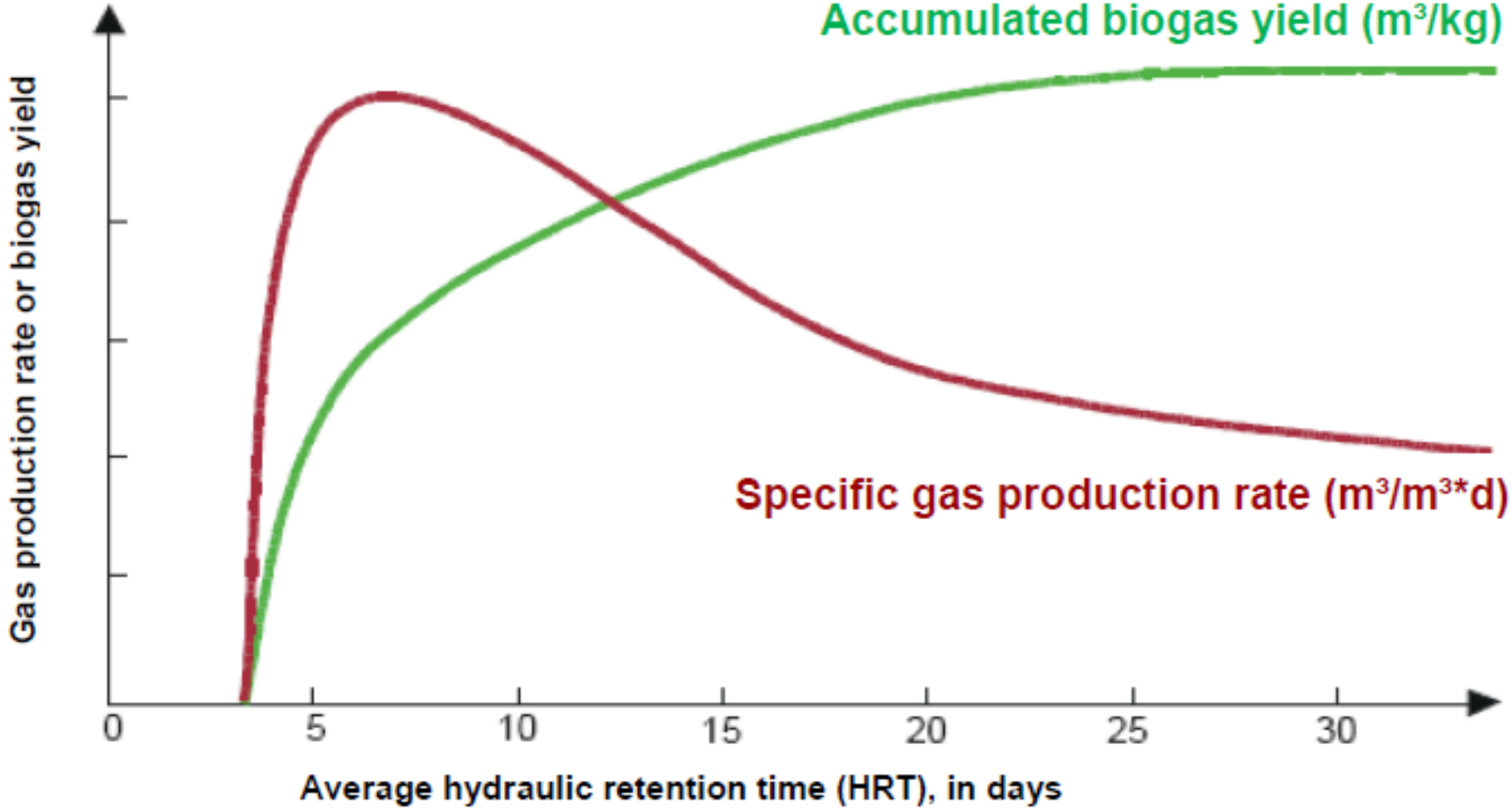
- Solid content of the substrate impaired the mobility of the methanogens within the substrate.
- Therefore the biogas yield decreases with the increase of solids content.
- No general valid guidelines can be offered with regard to specific biogas production for any particular solids percentage.

BIOGAS YIELD

- Biogas yield of a biomass material depends on the organic fraction of dry matter in the material and the waste management system associated with it.
- The dry matter (DM) of the waste is the matter left after removal of its moisture content. It may be obtained as the weight loss on heating to a temperature of 105 °C.
- Whereas, Volatile Solids (VS) are defined as the organic fraction of dry matter in waste.
- Around 50-60% of the initial energy content in the organic material can be converted to biogas in a properly operated digester.

BIOGAS YIELD

– **BIOGAS PRODUCTION AFTER ADDITION OF SUBSTRATE**



BIOGAS YIELD

– The resultant gas mixture consists of about 50 - 70%, CH_4 and the rest is CO_2 with small amounts of water vapours, H_2S, NH_3, and some organics that give bad odour.

ESTIMATION OF BIOGAS YIELD

- Amount of biogas that can be potentially produced from recoverable wastes

  = Amount of dry matter recoverable (kg DM/year) × Volatile solids fraction in dry matter (kg VS/kg DM) × Biogas yield (m^3/kg VS)

- Energy potential of the biogas recoverable (MJ /year)

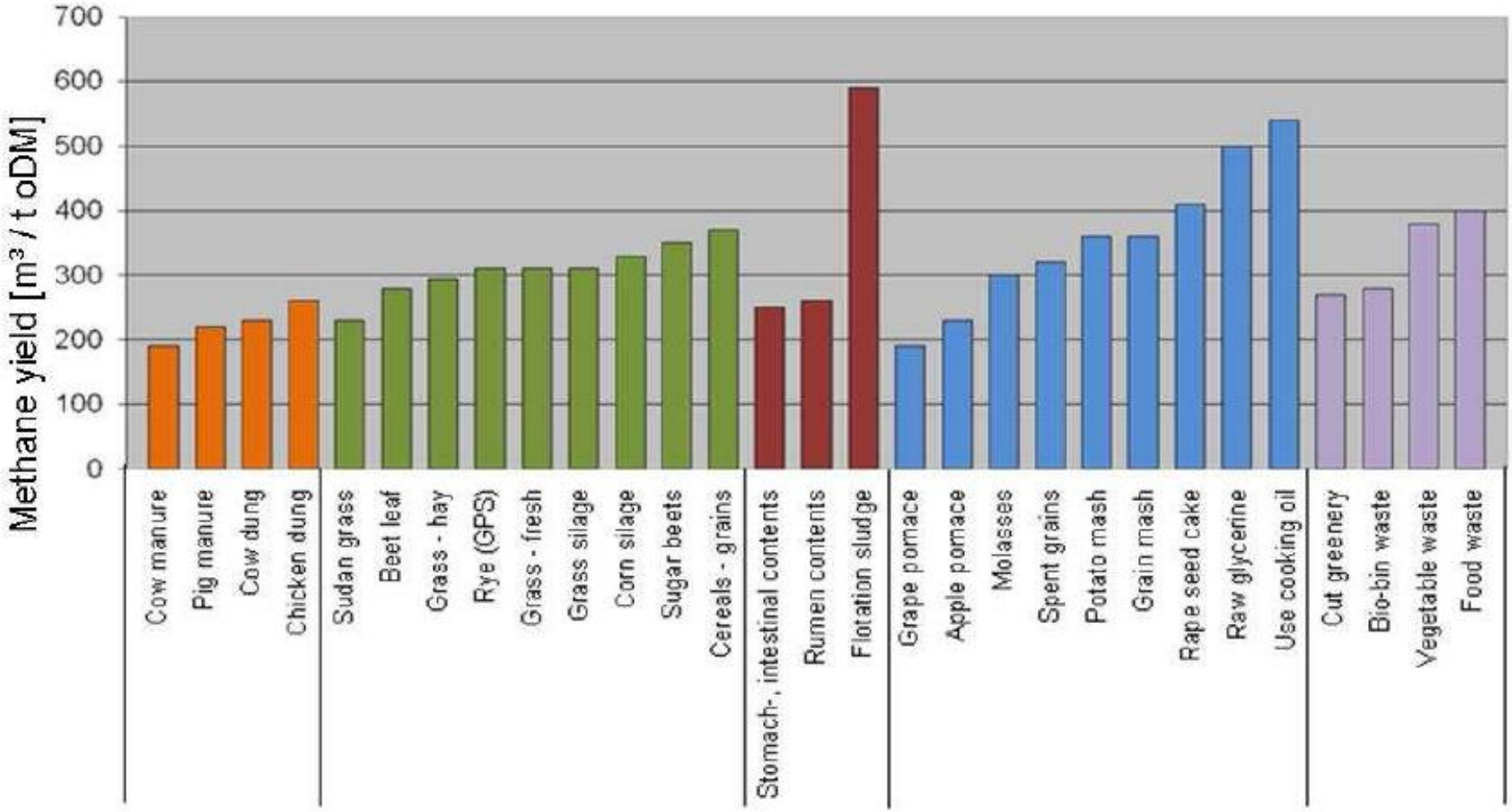
  = Amount of biogas recoverable (m^3/year) × Heating value of biogas (MJ /m^3)

BIOGAS YIELD OF DIFFERENT BIOMASS

- The heating value of the biogas depends on its composition, especially the amount of methane.
- HHV of methane is about 35.8 MJ/m^3 and therefore biogas with 60% methane, HHV could be taken as 20 MJ/m^3.
- Selected values for waste characteristics

BIOMASS	Fraction of Volatile Solid (VS/DM)	Biogas Yield (m^3/kg of VS)
Cattle	0.8	0.20 – 0.3
Poultry	0.8	0.35 – 0.60
Pigs	0.7 – 0.8	0.25 – 0.50
Straw	0.8 – 0.9	0.15 – 0.35
Grass	0.9	0.55
Fruit Waste	0.75	0.25 – 0.50
Garden Waste	0.9	0.20 – 0.50

BIOGAS YIELD -
BENCHMARKS FOR SPECIFIC METHANE YIELDS



Thank you...