International Training Course on Bioenergy (March 19 – 31, 2006)

"An Overview on Prospects of Energy Recovery and Waste Management for Industrial and Municipal Wastes"

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March 27, 2006

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URBAN / INDUSTRIAL / FARMING WASTES

WASTES

URBAN

- SEWAGE
- MSW
- VEG. MARKETS

INDUSTRIAL

- DISTILLERY
- PAPER
- RAYON
- DAIRY
- STARCH/TAPIOCA
- ABATTOIR
- PHARMACEUTICALS
- SUGAR
- TANNERY
- PALM OIL

FARMING / AGRICULTURE

- CATTLE(MANURE)
- POULTRY(LITTER)
- CROP(RESUDUE)

BIOENERGY POTENTIALS OF SOME AQUEOUS WASTES.

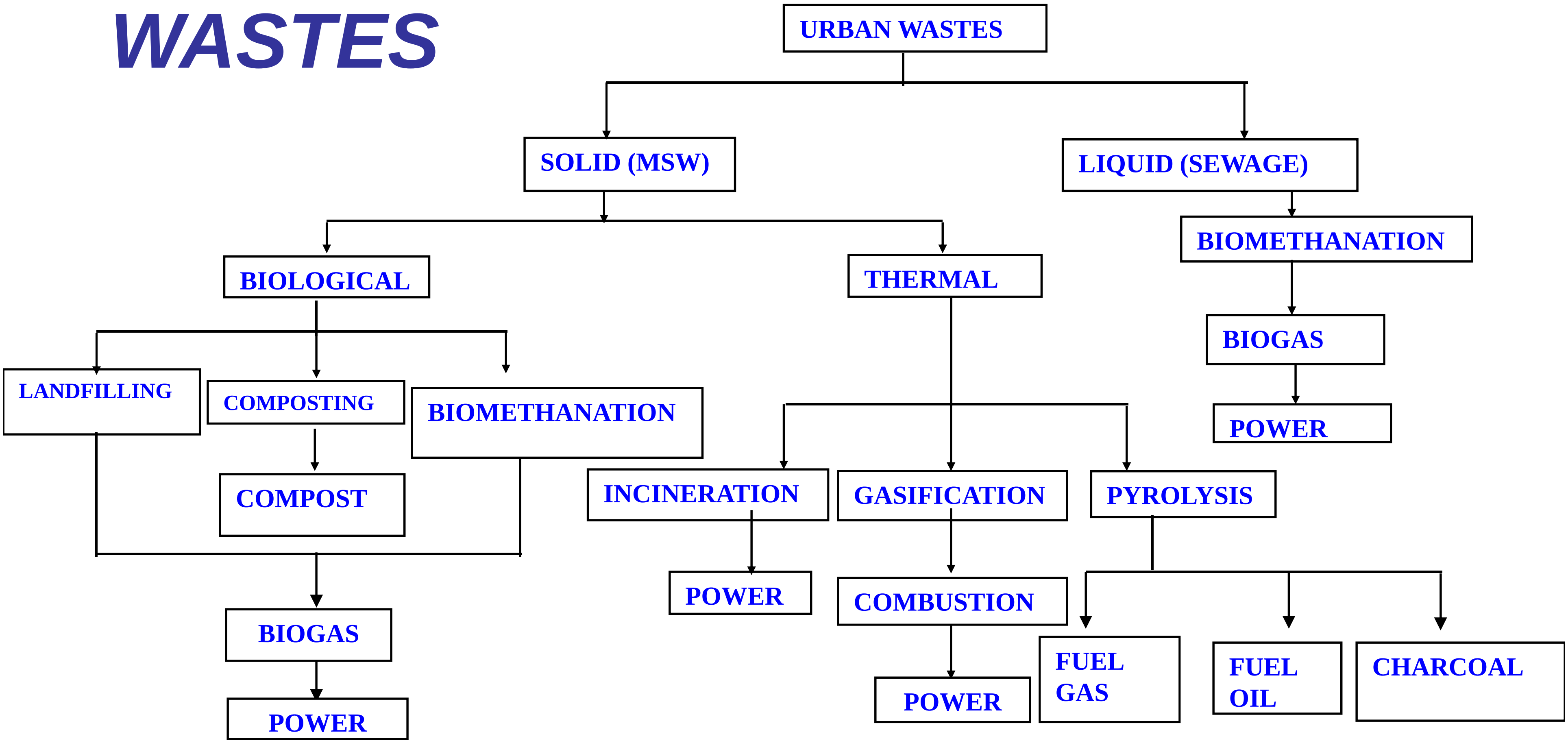
S.N	Waste Nature	BOD	COD
A. URBAN LIQUID WASTE			
1.	Sewage	200-400	400-750
B. INDUSTRIAL LIQUID WASTES			
2.	Distillery	45000-50000	90000-100000
3.	Mini Paper Mill	4000-9000	12000-25000
4.	Dairy	1000-12000	1800-2500
5.	Maize	4000-12650	10000-20000
6.	Tannery	1200-2500	3000-6000
7.	Abattoir	3500-4000	6000-8000
8.	Sugar	1250-2000	2000-3000

BOD represents biochemical energy potential

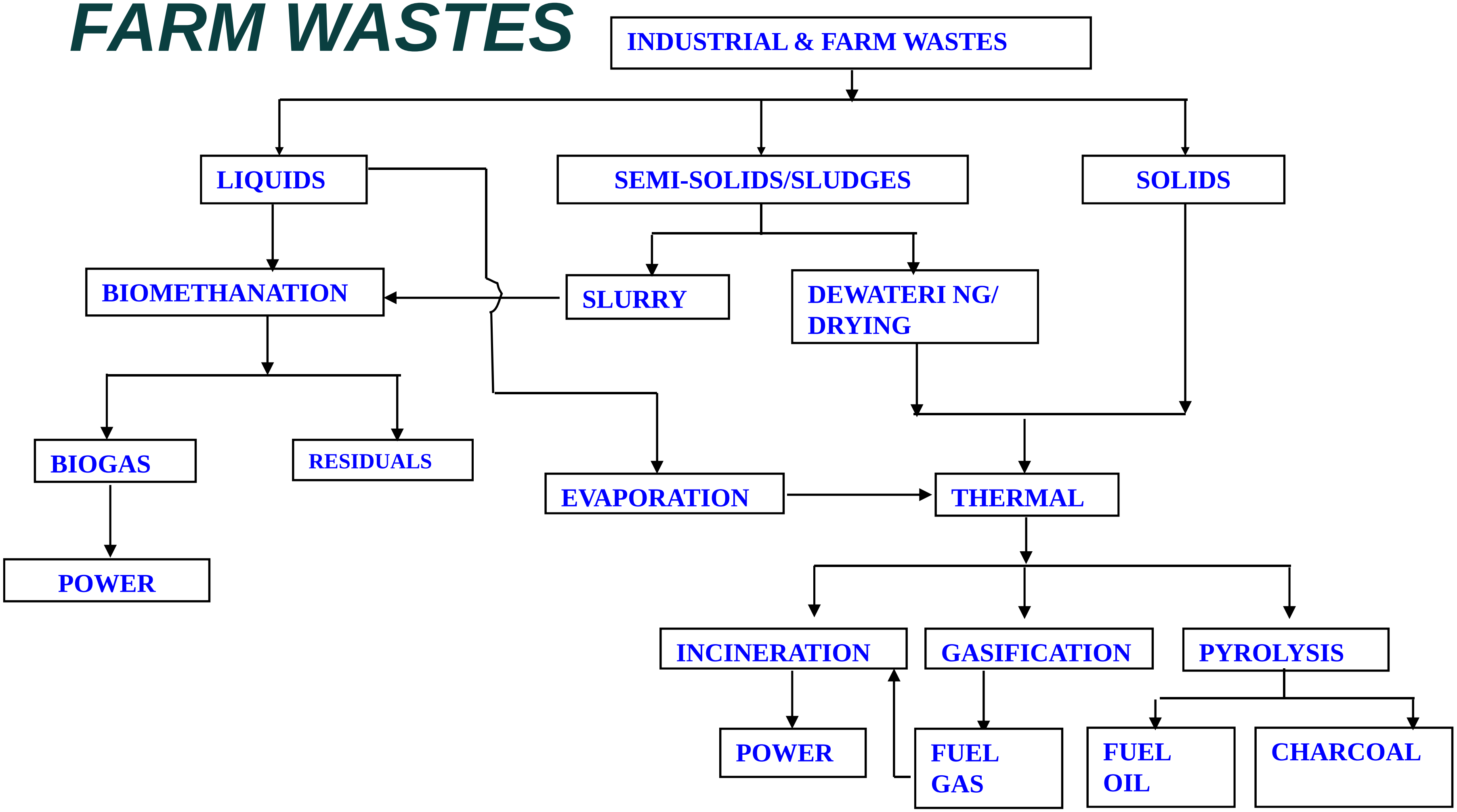
THERMAL ENERGY POTENTIAL OF SOME SOLID WASTES

S.No.	Waste Type	Total Solids %	Organics (VS) % TS	Calorific Value * Kcal / kg (Dry basis)
1.	MSW	60-80	50-65	800-1000
2.	Poultry	20-25	75	1000-1400
3.	Sugar			
a.	Pith	55-65	85-90	2000
b.	Pressmud	20-25	75-80	4000
c.	Bagasse	50	80-90	4000
4.	Corn cobs	85-90	95	3500
5.	Rice husk	70-78	75-80	3000
6.	Coal (Bituminous)	90	70-75	4500
7.	Fuel Oil	100 (l)	100	10000

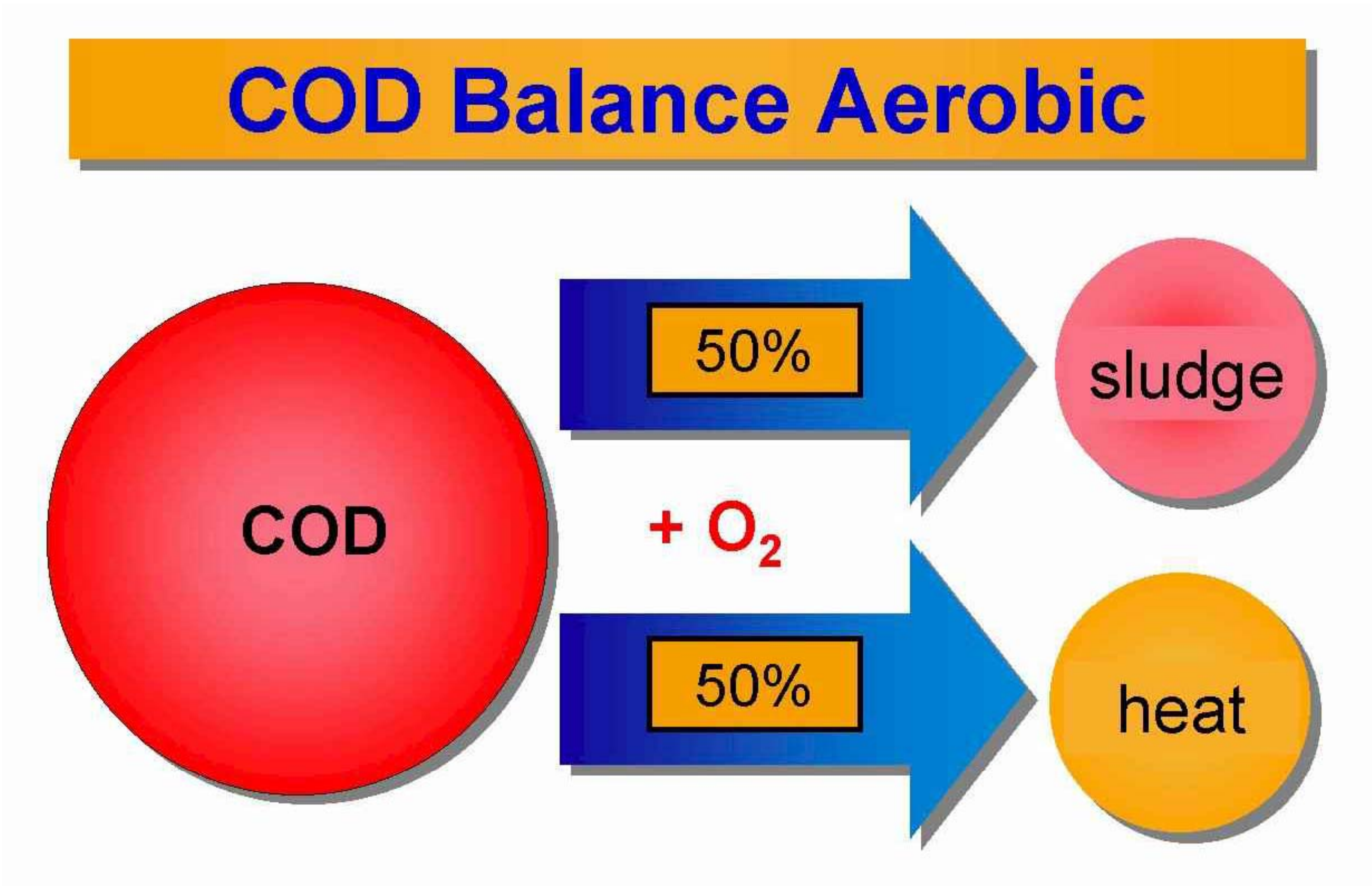
TECHNOLOGICAL OPTIONS FOR ENERGY RECOVERY FROM URBAN WASTES



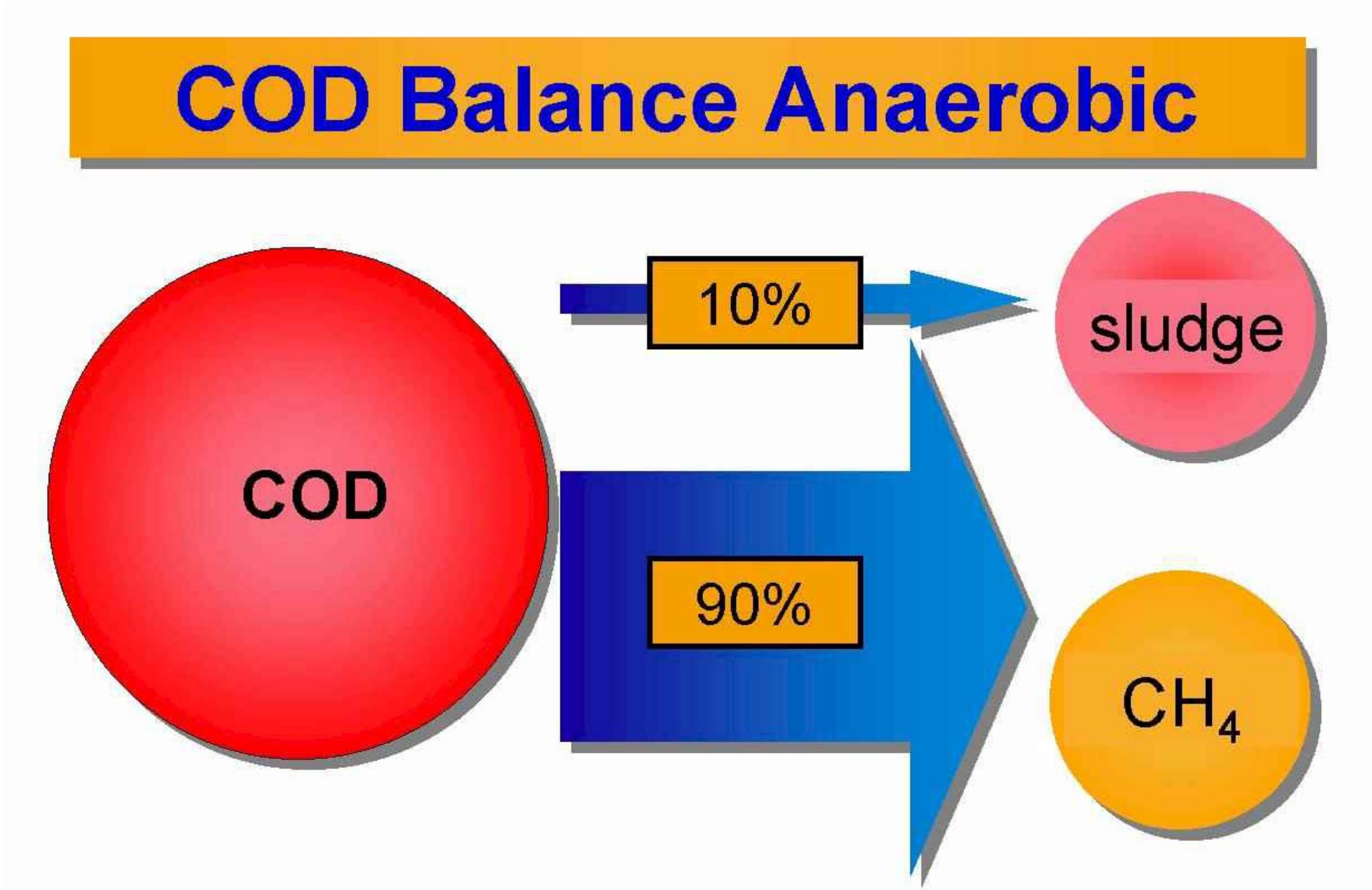
TECHNOLOGY OPTIONS FOR ENERGY RECOVERY FROM INDUSTRIAL AND FARM WASTES



COD Balance Aerobic Biodegradation



COD Balance Anaerobic Biodegradation



ASSESSMENT / SELECTION OF BIOMETHANATION TECHNOLOGIES

Energy recovery as electric power is a feature of all waste-to-energy systems. In order to match the quality and amount of waste to be processed with an appropriate technology package requires diverse expertise and skills in materials management, engineering skills, finance, judiciary, statutory regulatory aspects, ecological and socio-economic issues

Some of the more significant aspects of biomethanation processes and systems include Nature of Waste, Technology, Technology Status, Effectiveness and implementability, Operability and Maintainability, Safety, Economic Factors, Capital and Operating Costs, Revenue From By-Products, Public and Political Factors, Waste Management Hierarchy.

BIOMETHANATION PROCESSES

Solid and liquid wastes consist of organic and inorganic constituents and the degradation of the organics can take place in the presence or absence of air. The latter process is known as anaerobic digestion or biomethanation, and results in the generation of methane gas. Anaerobic processes can proceed in a reactor, covered lagoon or landfill to recover the methane as biogas.

Biomethanation systems are mature and proven processes that convert waste-to-energy efficiently, and achieve the goals of pollution prevention/reduction, elimination of uncontrolled methane emissions and odour, recovery of bio-energy potential as biogas, production of stabilized residue for use as low-grade fertilizer.

PRINCIPLES OF BIOMETHANATION

The anaerobic microbial conversion of organic substrates to methane is a complex biogenic process involving a number of microbial populations, linked by their individual substrate and product specificities.

Methanogenic Reactions

acetoclastic methanogenesis

$$CH_3COOH \longrightarrow CH_4 + CO_2$$

Acetate → **Methane** + **Carbon dioxide**

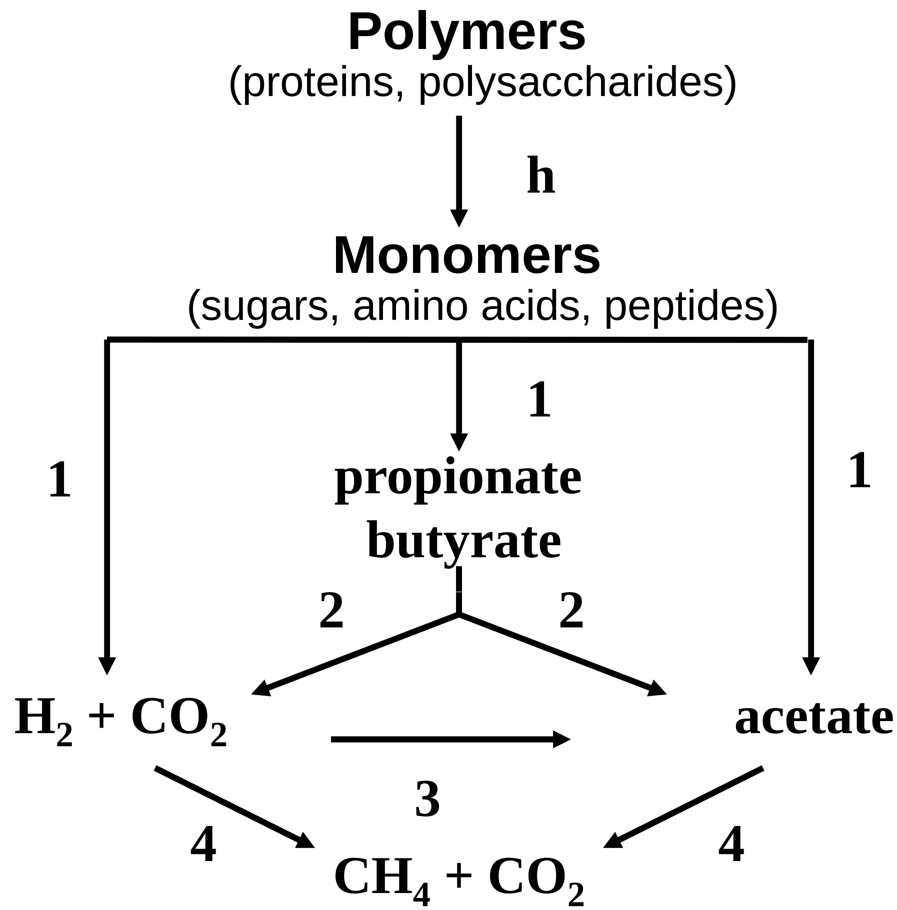
autotrophic methanogenesis

$$CO_2 + H_2 \longrightarrow CH_4$$

Carbon dioxide + **Hydrogen** → **Methane**

BIOTRANSFORMATIONS DURING ANAEROBIC TREATMENT OF INDUSTRIAL, MUNICIPAL (MSW) AND AGRICULTURAL WASTES

Methanogenic Consortium



h Hydrolytic enzymes
1 Fermentative bacteria
2 Syntrophic acetogenic bacteria
3 Homoacetogenic bacteria
4 Methanogens

Waste composed of particulate organic material (waste sludges, MSW, etc.) must first be solubilized by the action of extracellular enzymes that are produced by hydrolytic bacteria. The solubilization of particulate material is relatively slow and accomplished by providing long contact time between the substrate and an anaerobic microbial consortium.

Wastes containing mainly soluble organics will require short anaerobic reactor retention times for good treatment efficiency since the kinetic rates of the acidogenic and methanogenic bacteria are relatively rapid.

Anaerobic treatment has evolved into a mature technology suitable for both municipal and industrial wastes, utilizing various innovative reactor designs.

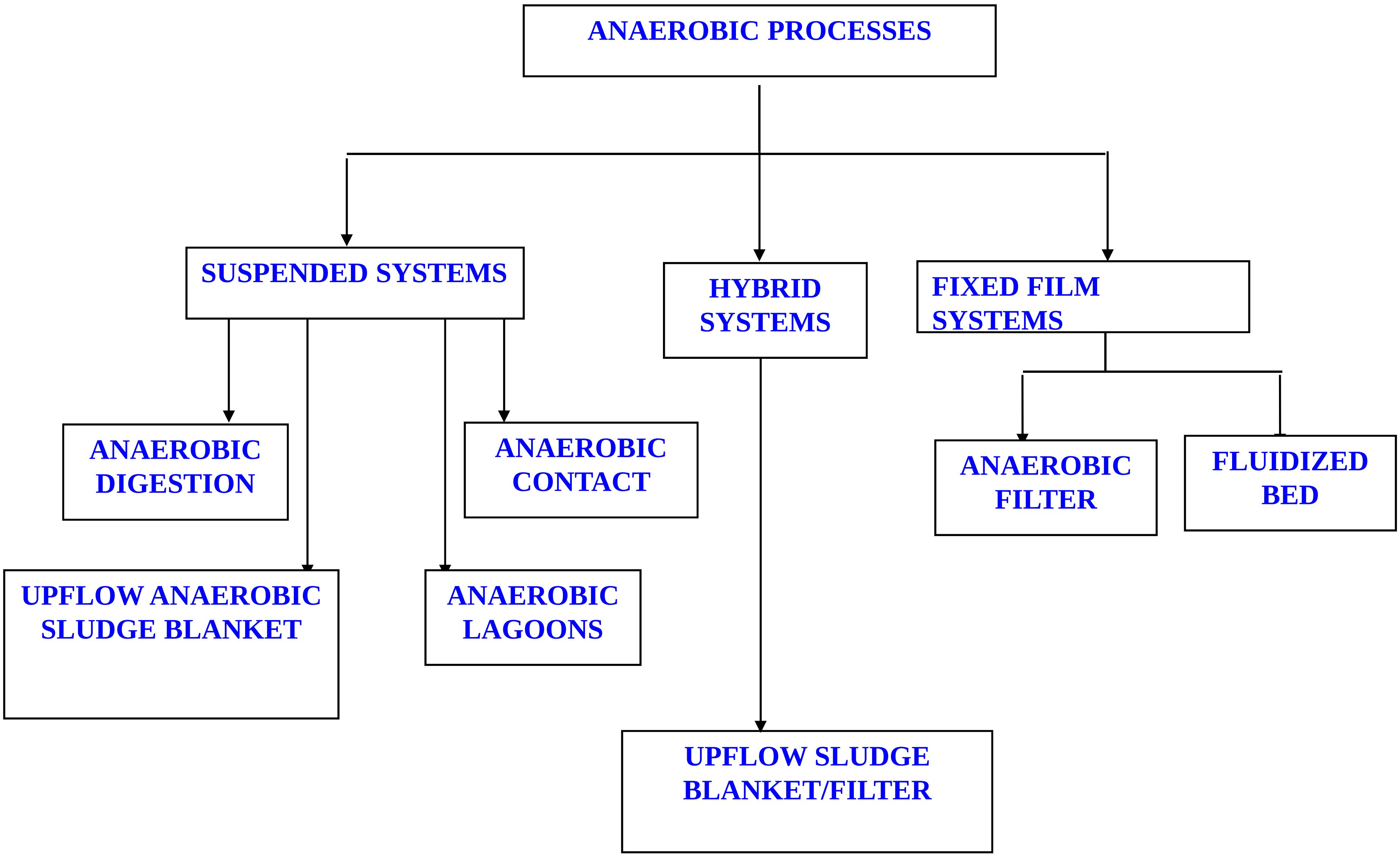
Anaerobic processes offer several benefits like methane production (biogas as fuel), low capital, and operating costs, power savings with no aeration requirement and high treatment efficiency.

Full scale anaerobic treatment plants are in operation world-wide in many countries including India, in the following industrial and urban sectors like distilleries, breweries, chemical manufacturing, dairy, food processing, landfill leachate, pharmaceuticals, pulp and paper, slaughterhouse, sugar, sewage sludge and MSW.

Some factors to be considered for screening the suitability of anaerobic treatment technology include Source and nature of wastewater, Flow rate, Concentration of organic pollutants (BOD, COD) and suspended solids, Temperature, presence of toxicants and biogas and sludge generation potentials.

The rates of methanogenesis in anaerobic microbial conversion processes depend primarily upon substrate availability and viable microbial population besides environmental factors of reactor operations like pH, temperature, ionic strength or salinity, nutrients, BOD, COD, SS, and toxic or inhibitory substances.

ANAEROBIC BIO-REACTOR CONFIGURATIONS



Several proprietary anaerobic reactor designs are currently in use for full-scale applications for urban and industrial wastewaters.

In general the suspended biomass growth of the processes on the left are advantageous for the treatment of sludges or wastewaters containing high proportions of particulate biodegradable material.

The fixed film processes on the right are well suited to wastewaters that contain primarily soluble organic substrates.

The hybrid processes in the middle of the figure can be applied to wastewaters with intermediate levels of particulates, although performance is usually better with soluble wastewaters.

BIOMETHANATION SYSTEMS (MSW)

LOW- SOLIDS AD

The Low-solids anaerobic fermentation process is used in many parts of the world to generate methane gas from human, animal and agricultural wastes, and from the organic fraction of MSW. Low-solids anaerobic digestion is a biological process in which organic wastes are fermented at solids concentration of 4 to 12 percent. One of the disadvantages of this process is the water required for dilution, which must be dewatered prior to disposal. The disposal of this liquid stream resulting from the dewatering step is also an important consideration.

There are three basic steps involved in low-solids anaerobic digestion process.

1] The first step is the preparation of the organic fraction of the MSW and involves sorting and separating.

2] The second step involves the addition of water and nutrients, blending, pH adjustment (6.5-7) and heating of the slurry to 55 - 60^{o}C. (if necessary) and the anaerobic digestion is carried out in a continuous flow stirred reactor. The required moisture content and nutrients can be added to the wastes to be processed, in the form of wastewater sludge or cow manure.

3] The third step involves the collection of biogas (50-60 % CH_4). The dewatering and disposal of the digested sludge is an additional expensive task.

HIGH SOLIDS AD

High solids anaerobic digestion is a biological process in which the fermentation occurs at a total solids content of 25 – 30 percent for energy recovery from the organic fraction of MSW.

Two important advantages of the high-solids anaerobic digestion process are lower water requirement and higher gas production per unit volume of the reactor.

The effects of many environmental parameters on microbial populations are more severe in the case of the high-solids concentration. For example ammonia toxicity can effect the methanogenic bacteria which will have an adverse effect on system stability and methane production.

In most cases, the ammonia toxicity can be prevented by a proper adjustment of the C/N ratio of the input feedstock.

LOW vs HIGH SOLIDS MSW ANAEROBIC DIGESTION

Waste feature	Low solids	High solids
A. WASTE CHARACTERISTICS		
Feed	Shredded for pumping and mixing	Shredded for feeding and discharging
Mixing	Mechanical	Plug Flow
HRT, days	10-20	20-30
Loading $kg/m^3.d$	0.6 to 1.6	5 to 7
Feed conc. %	8 to 12	20 to 35
Temperature (^oC	30 to 38, 55-60	30 to 38, 55-60
VS Destruction %	60 - 80	90 -98
TS destroyed %	40 - 60 percent	50-60
Biogas m^3/kg of VS destroyed	0.5 -0.75	0.6 - 1.0
Biogas % CH_4	50-55	50-55

B. DESIGN AND OPERATIONAL PARAMETERS		
Reactor Design	Complete-mix reactors	Plug-flow
Reactor Volume	Large	Smaller reactor
Water addition	High	Low
Organic loading	Low	High
Mass removal rate	Low	High
Feed/discharge arrangement	Pumps	Screw pumps and conveyors.
Toxicity	less	High
Sludge dewatering	Expensive.	Inexpensive
Technology status	Proven	Proven

ENVIRONMENTAL AND REGULATORY ASPECTS

- **Biomethanation processes have been very successfully adopted for handling both urban (MSW and sewage) and industrial process wastewaters.**

- **The primary driving force has been the significant savings in energy requirements compared to conventional aerobic processes.**

- **The pollution load (BOD or COD) to the latter can be reduced considerably by an anaerobic pretreatment process.**

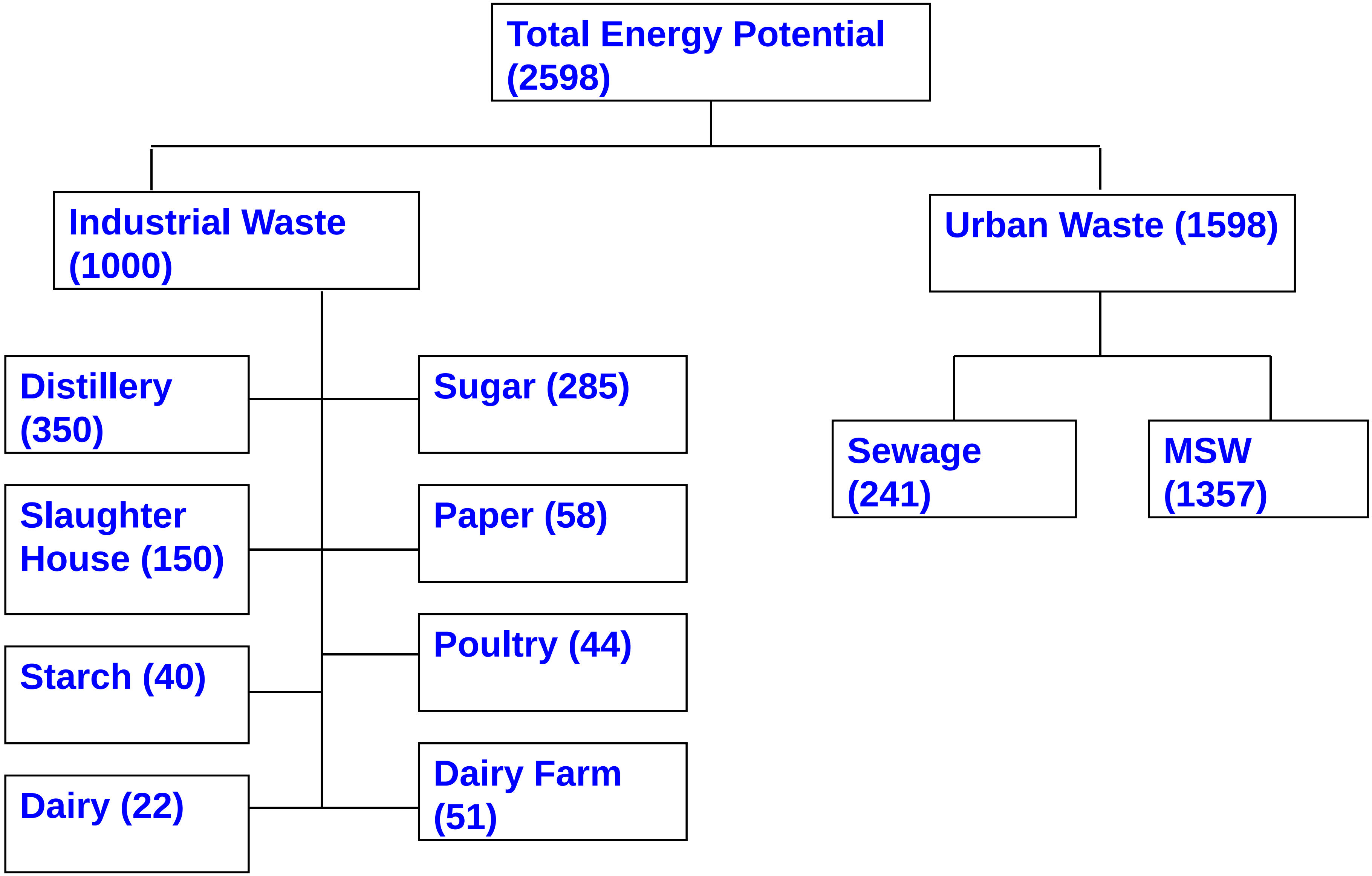
- **The energy required to operate the latter is very low and offers an opportunity for energy recovery corresponding to the bio-chemical energy potential of the waste.**

- **The sludge produced by anaerobic processing of urban waste is also well stabilised for potential use as manure.**

- **Downstream treatment of the post-anaerobic treated waste by aerobic or other suitable techniques will be mandatory for compliance with regulatory stipulations. Consequently, environmental and regulatory considerations would apply for the pollution control facility as a whole.**

- **This will be a matter of concern where stand-alone anaerobic (biomethanation) systems have been adopted for the treatment of urban and industrial wastes. The performance of the down-stream pollution control facility must meet the stipulated norms as applicable for the specific application.**

ESTIMATION OF ENERGY POTENTIAL



CURRENT STATUS OF BIOMETHANATION- 2006

- **PROVEN TECHNOLOGY**

- **MULTIPLE BENEFITS (ENERGY RECOVERY, MANURE, POLLUTION CONTROL, WASTE MANAGEMENT)**

- **CODIGESTION OPPORTUNITIES**

- **PROFESSIONAL EXPERTISE AND SERVICES AVAILABLE**

- **NETWORK OF TECHNOLOGY AND EQUIPMENT AND SUPPLIER**

- **POSITIVELY POSITIONED OPTIONS**

THANK YOU