IWA CITIES OF THE FUTURE PROGRAM, TURKEY

Istanbul Special Topic Workshops, February 7 - 8, 2011

The Green Park Hotel, Merter

Integrated Wastewater and Waste Management Options for Istanbul Metropolitan Municipality

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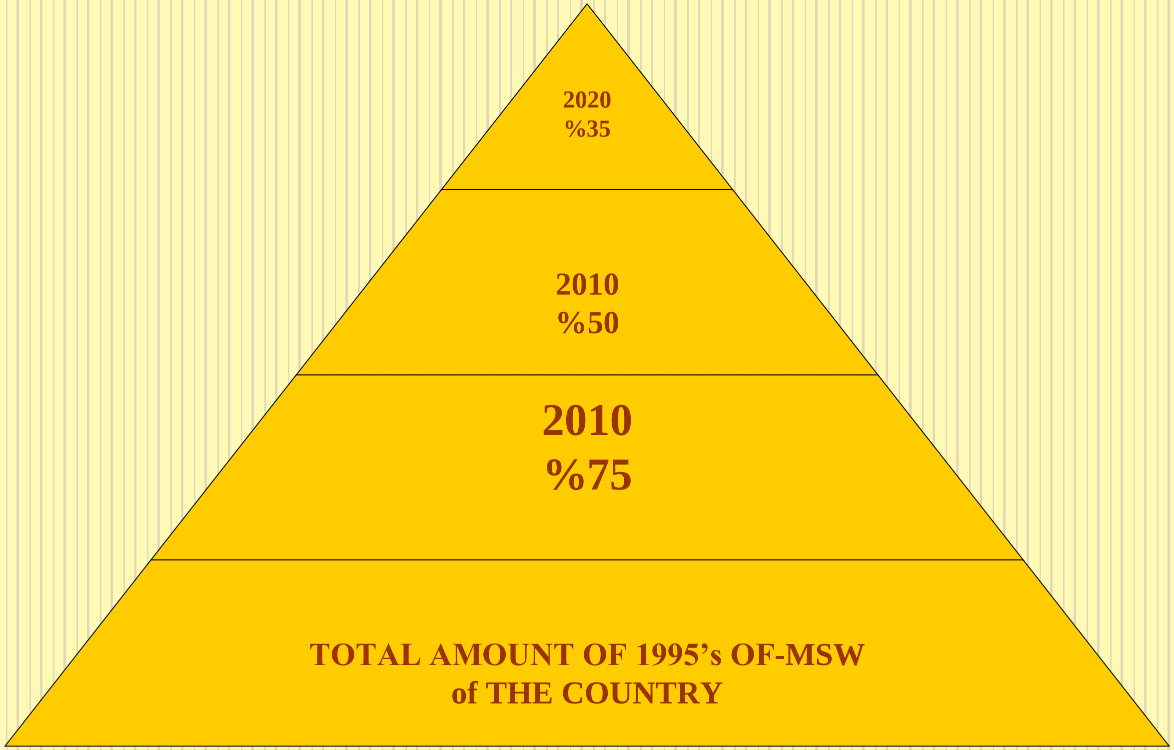
Contents

1. Introduction

- Municipal Solid Waste (MSW) includes high amount of Food Waste (organic waste)
- Food waste can have a varied rate amount between %30-60 in MSW, depending on socioeconomic and cultural factors.
- When the interest in management of the green-house gases continues to grow, the disposal capacity via traditional landfilling of biodegredable waste is diminishing by laws.

1. Introduction



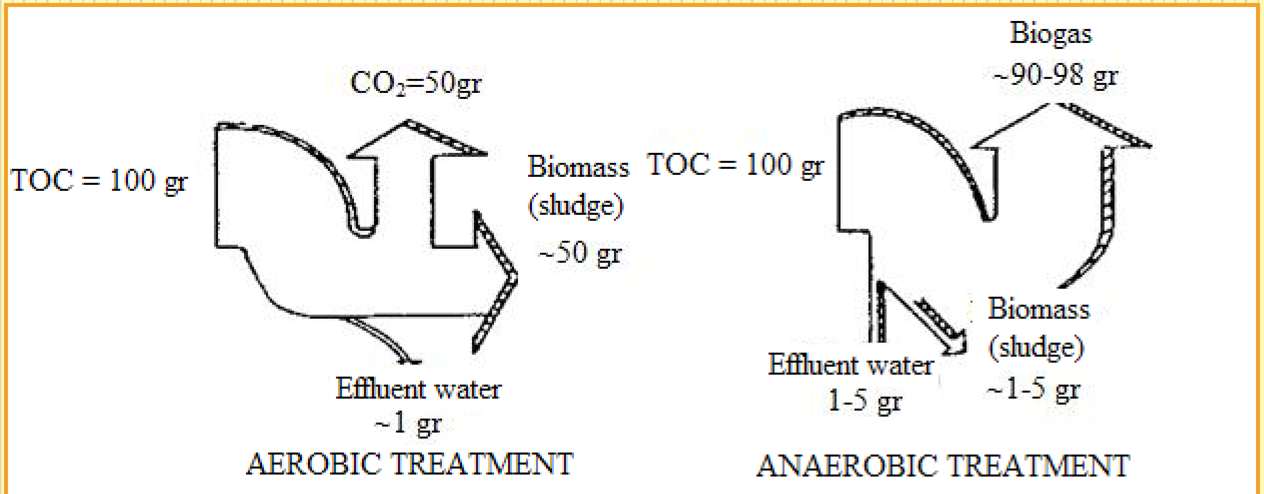
In the duration of accession to Europan Union; seperation of biodegredable fraction from MSW, which's huge amount is disposed to landfill with the general, for biomethane production/composting is one of the major duties for Turkey.

1. Introduction

- One of the major managment alternatives instead of landfilling for Organic fraction of Municipal Solid waste (OF-MSW) is production of biomethane/compost with anaerobic treatment after seperation in source.
- Public subsidy practise for recovery of renewable energy is widely used and makes the gained energy (bio-mass energy) vendition %50-100 higher in many countries.
- Todays world co-digestion of the organic fraction of municipal solid waste (OF-MSW), municipal waste waters and sewage sludge is an attractive alternative for sustainable management.
- This study evaluates the alternative co-digestion processes for municipal waste water with the OF-MSW.

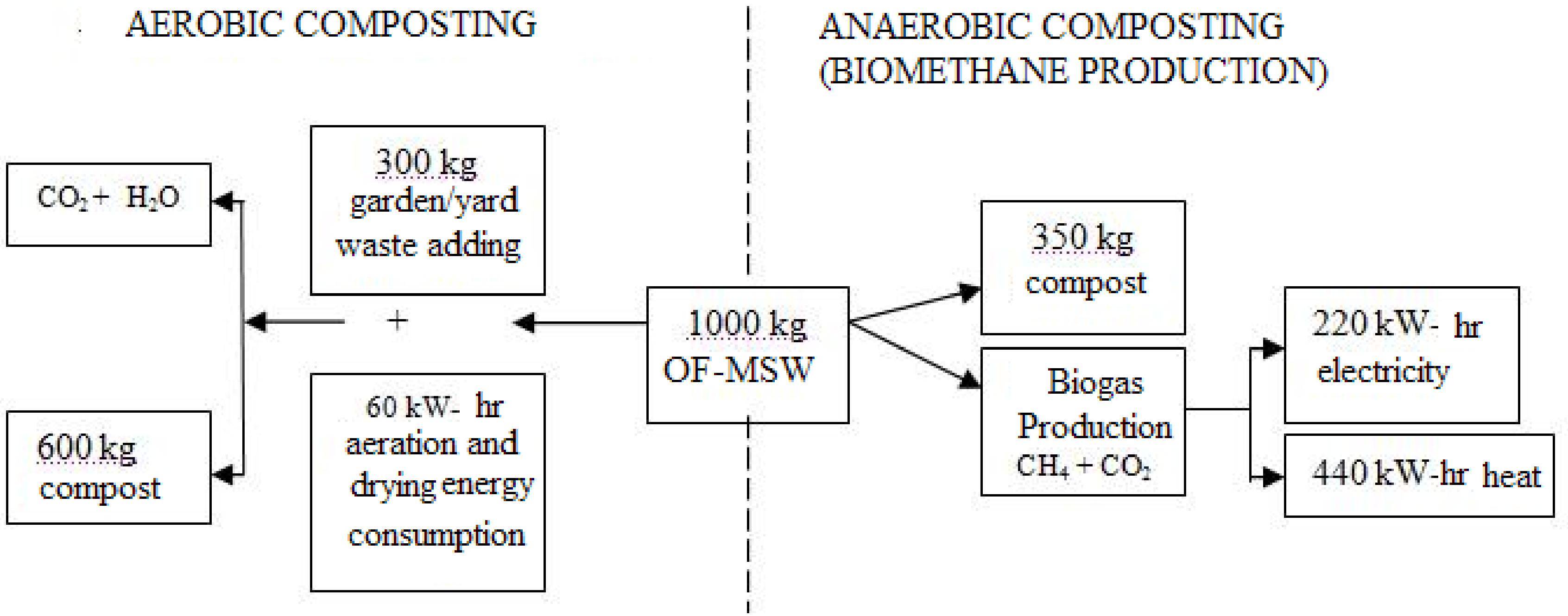
2. Recovery of Biomethane/Compost via Anaerobic Treatment

- Anaerobic digestion is a series of processes in which microorganisms break down biodegradable material to CH_4, CO_2, NH_3 ve H_2S in the absence of oxygen with biochemaical processes.
- Anaerobic digestion processes generally survives at 35^oC or 55^oC's.
- The released biogas from anaerobic digestion contains %60 – 70 methane (CH_4) and %30 – 40 carbondioxide (CO_2).



Comparison of Aerobic and Anaerobic Treatment Processes with C-Balance

2. Recovery of Biomethane/Compost via Anaerobic Treatment



Comparison of aerobic and anaerobic biological treatment processec of OF-MSW

2. Recovery of Biomethane/Compost via Anaerobic Treatment

Potential of Biomethane Recovery from Organic (Typical Values)

- OF-MSW : 230 m^3/t VSS_{feed}
- Animal Wastes : 130 m^3/t VSS_{feed}
- Industrial WW : 350 m^3/t $COD_{reduced}$
- WW Sludge : 130 m^3/t VSS_{feed}

VSS : Volatile (organic) Suspended Solid
COD : Chemical Oxygen Demand

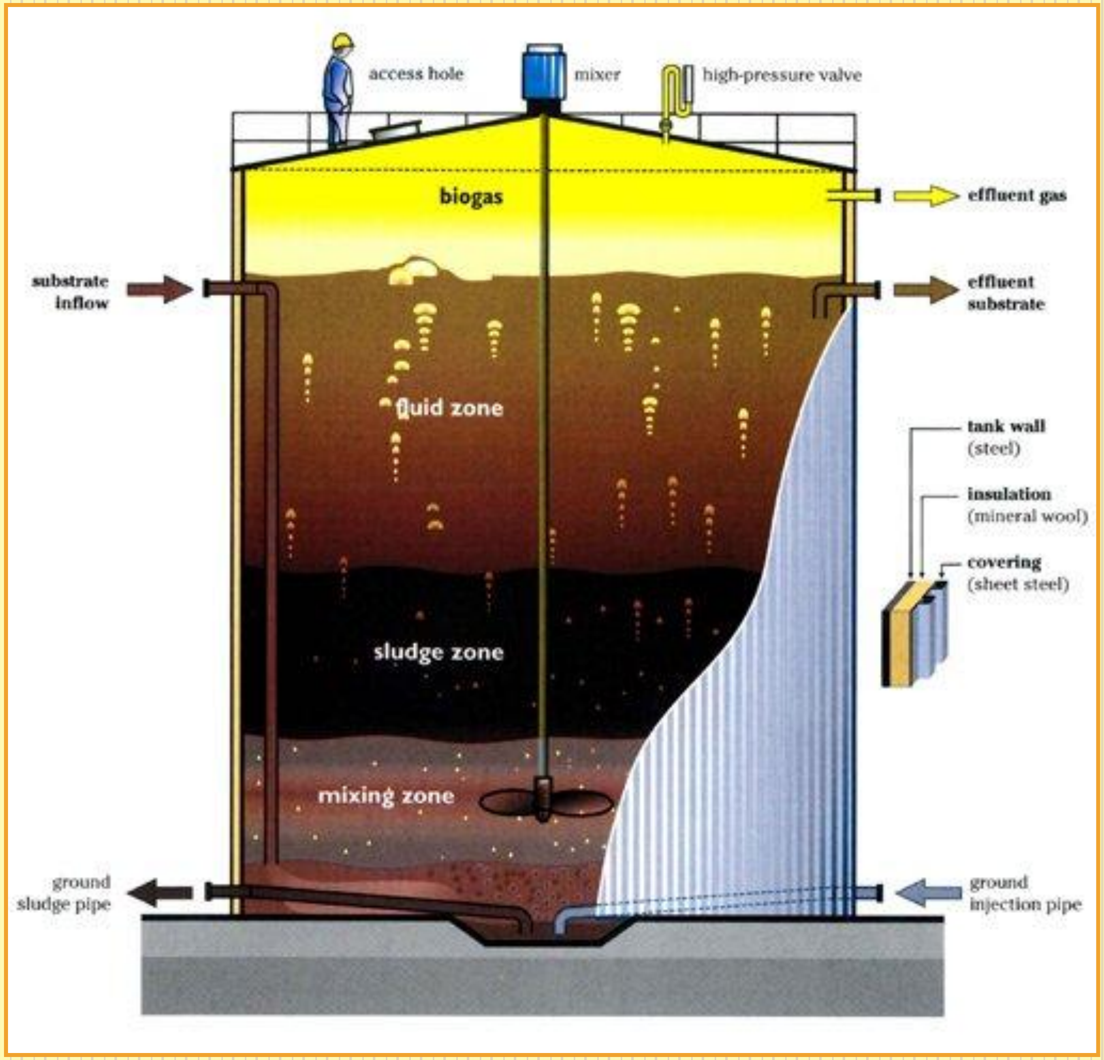
2. Recovery of Biomethane/Compost via Anaerobic Treatment

Biomethane Usage

	Efficiency (%)
Production of Electrical Energy :	~ 35
Electrical Energy + Heat Production :	~ 75 – 80
Utilization as Vehicle Fuel :	> 95

The most productive usage of biomethane is utilization as bulk trasfortation and farm vehicles fuel (Sweden and Switzerland).

3. Recovery of Renewable Energy (Biomethane) from Co-digestion of organic fraction of municipal solid waste with wastewater



3.1. Integrated Management of the OF-MSW and Sewage Sludge

- The co-digestion concept involves the treatment of several types of waste in a single treatment facility.

- Treatment of several mixed waste types has positive effects both on the anaerobic digestion process itself and on the treatment costs.
  - Decrease in Treatment costs
  - Increase in Process efficiency and stability
  - Increase in Methane Yield
  - Integrated waste managment

- Sewage sludge is one of the most appropriate co-substrate for codigestion with OFMSW.
- In this way, co-digestion can be applied at existing treatment facilities without great investment and it combines the treatment of the two largest municipal waste streams

3.1. Integrated Management of the OF-MSW and Sewage Sludge

Wastes Suitable for Co-digestion

<u>Agricultural Waste</u>

- Farm Wastes
- Dairy Farm Waste Waters
- Slaughterhouse and Meat Packing Wastes
- Energy Plants

<u>Agro-Industry Wastes</u>

- Process Waste and Wastewaters
- WWTP Sludge (biosolids)

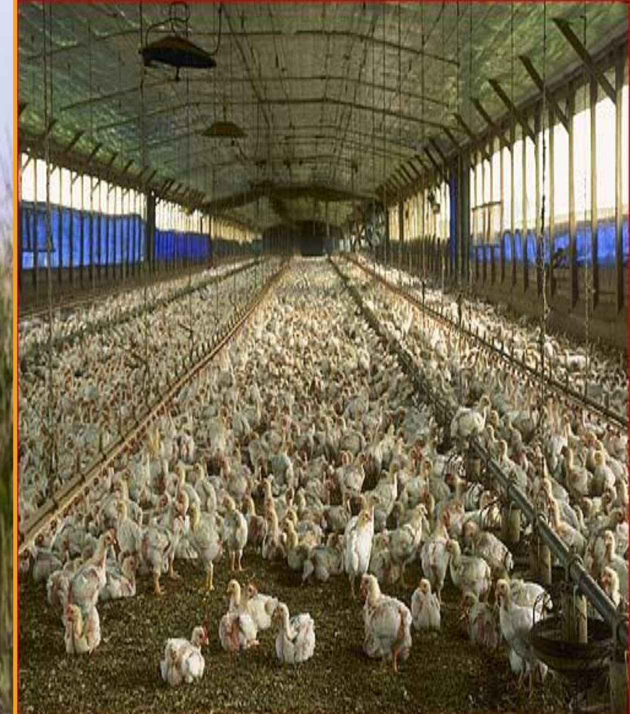
<u>OF-MSW</u>

- Markethouse Waste
- Restaurant Waste
- Food Waste (kitchen)

<u>Biomass Produced in Treatment Plants</u>

- Organic sevage sludge (biolagical sludge)
- Industrial WWTP’s sludge

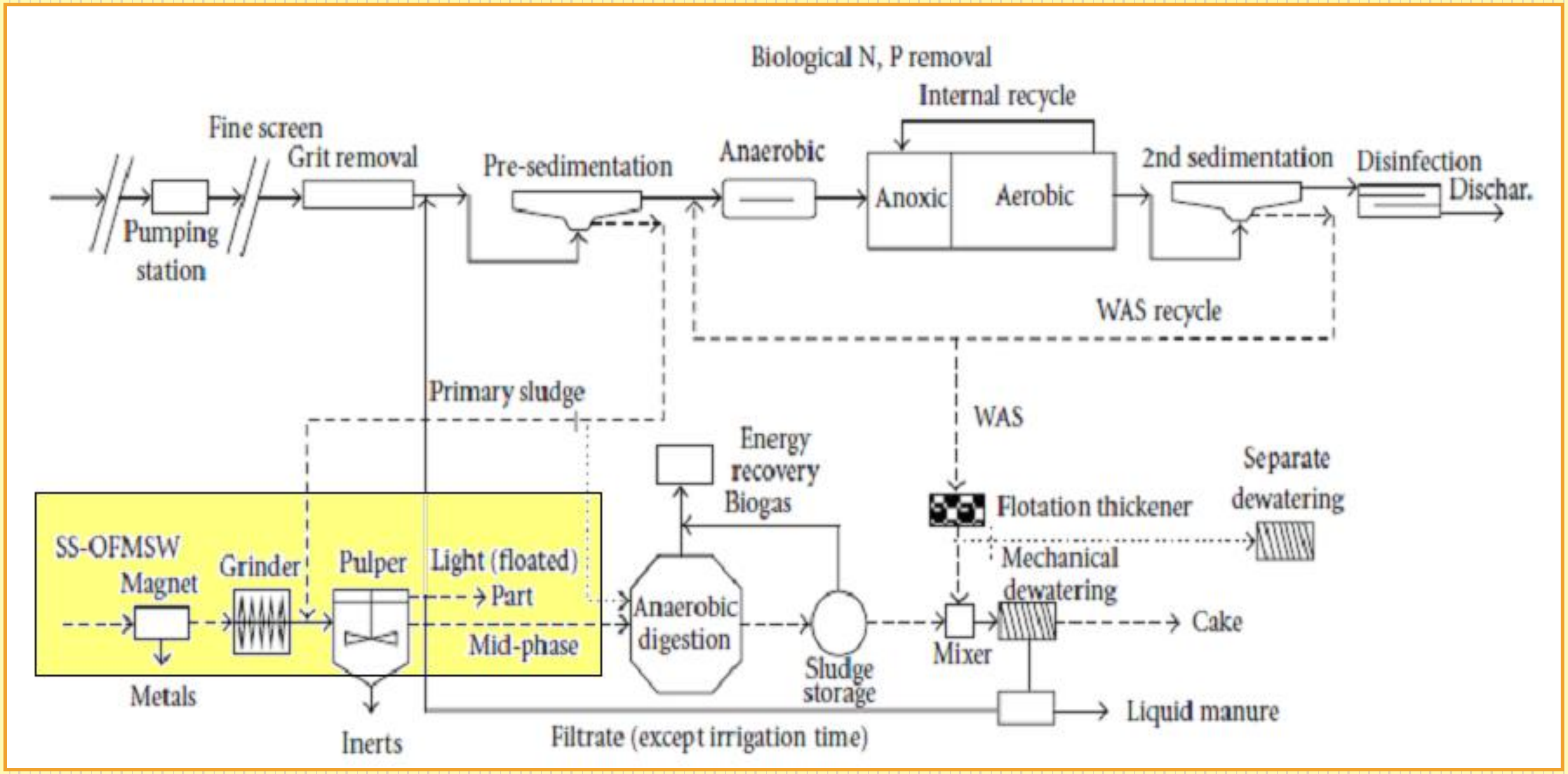
HARVESTING CROPS
FOR THE DIGESTER



GOOD SH*T

3.1. Integrated Management of the OF-MSW and Sewage Sludge

Integrated Management of Municipal WW and MSW

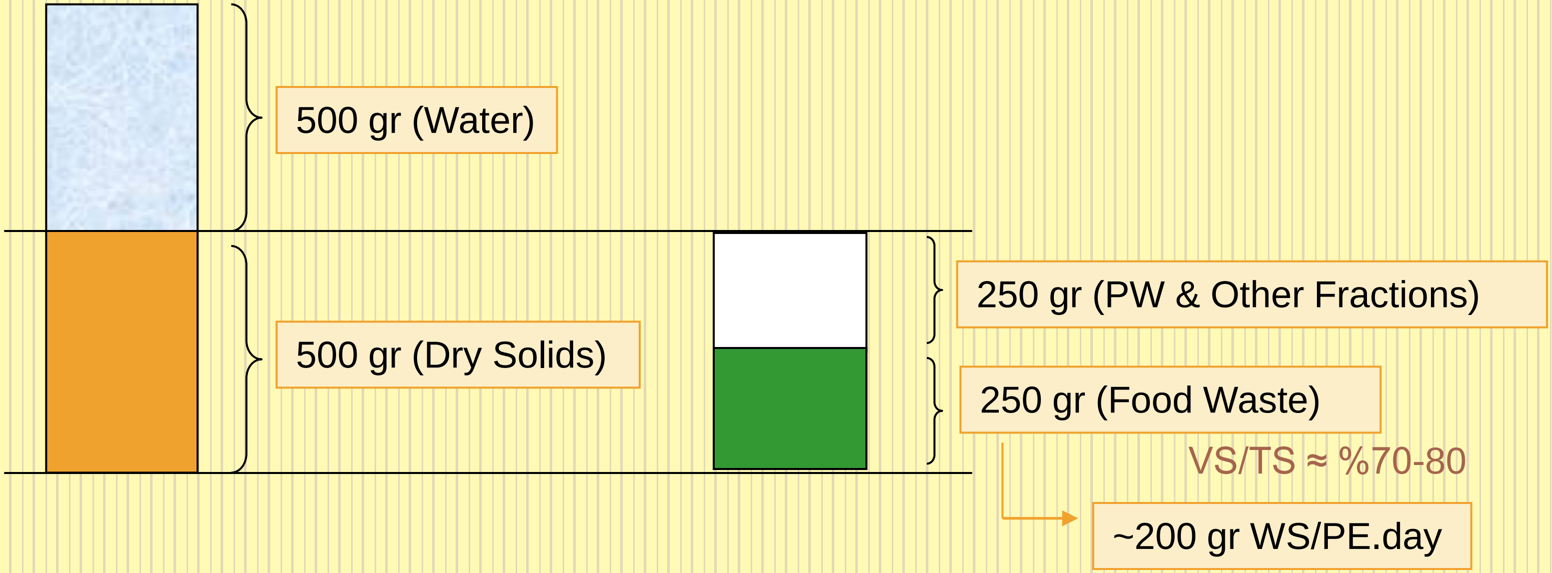


Process scheme of the municipal WWTP and the integrated biomethanization plant.

3.1. Integrated Management of the OF-MSW and Sewage Sludge

MSW Generation Figures for İstanbul Metropolitan Municipality

~ 1.0-1.1 kg/PE.day (~ %50 moisture content)



50 g VS/PE.day → ~ %25 of total MSW_{VS}
100 g VS/PE.day → ~ %50 of total MSW_{VS}

3.1. Integrated Management of the OF-MSW and Sewage Sludge

Basic Data for a city with 100.000 PE

Summary of the mass balance for the proposed integrated biomethanization plant (PE = 100,000; X_{PS} = 61 g TS/PE·day; $X_{SS\text{-}OFMSW}$) = 50 g TS/PE·day) (values in brackets show the case for $X_{SS\text{-}OFMSW}$ = 100 gr/PE·day).

Waste streams	TS (%)	VS/TS (%)	Density (kg/m³)	Total solids (t/day)	Flowrate (m³/day)
			Pulper		
Inlet (PS)	4.0	80	1010	6	150 (150)
Inlet (SS-OFMSW)	12 (15)	90 (85)	1015–1020	5 (10)	41 (66)
Supernatant phase	15	—	1015	~0.50 (~1.0)	3[(1)] (5.5)
Bottom phase	12	—	1010	~0.50 (~1.0)	4[(2)] (8)
Outlet (PS+SS-OFMSW)	5.5[(3)] (7)	90 (85)	—	10[(4)] (14.2)	184[(5)] (202.5)
			Codigester		
Inlet (PS + SS-OFMSW)	5.5[(3)] (7)	90 (85)	—	10[(4)] (14.2)	184[(5)] (202.5)
Inert solids	—	10 (15)	—	1.0 (2.13)	—
Excess sludge (P_x)	—	—	—	0.34[(6,7)] (0.45)	—
Outlet (digested sludge)	—	83[(8)] (75)	—	5.84[(8)] (8.615) 4.84[(7,8)] (6.485)	—
Solids converted into CH_4	—	—	—	4.16[(7,9)] (5.585)	~2220[(10)] (~2980)

[(1)] If 10% of VS of OFMSW is wasted from the pulper with supernatant, then $0.10 \times [(41 \times 10^3 \times 0.12 \times 0.90)/(0.15 \times 1015)] = 3$.
[(2)] If 10% of inorganic materials in OFMSW is wasted from the bottom of the pulper, then $0.10 \times [(41 \times 10^3 \times 0.12)/(0.12 \times 1010)] = 4$.
[(3)] $0.055 = [(150 \times 0.04 + 41 \times 0.12) - (3 \times 0.15 + 4 \times 0.12)/184]$.
[(4)] $10 = (184 \times 0.055)$.
[(5)] $184 = [150 + 41 - (3 + 4)]$.
[(6)] If VS/TS = 90%, = 0.05, VS Removal Y_{obs} = 50%, and 1 g VS = 1.5 g COD, then $P_x = [(10 \times 0.90) \times 0.50 \times 1.5 \times 0.05] = 0.34$.
[(7)] As volatile solids.
[(8)] $5.84 = [(10 \times 0.10) + 9 \times (1-0.50) + 0.34]$; $4.84 = (9 \times 0.50 + 0.34)$; $4.84/5.84 = 0.83$.
[(9)] $4.16 = [(10 \times 0.90) - 4.84]$.
[(10)] Net CH_4 recovery = 90%; 1 g VS = 1.5 g COD; CH_4 Production/1 kg $COD_{dest.}$ = 0.395 L (at 35°C), then $Q_{CH4} = (4160 \times 0.90 \times 1.5 \times 0.395) \cong 2220$.

3.1. Integrated Management of the OF-MSW and Sewage Sludge

Integrated Management of Municipal WW and MSW

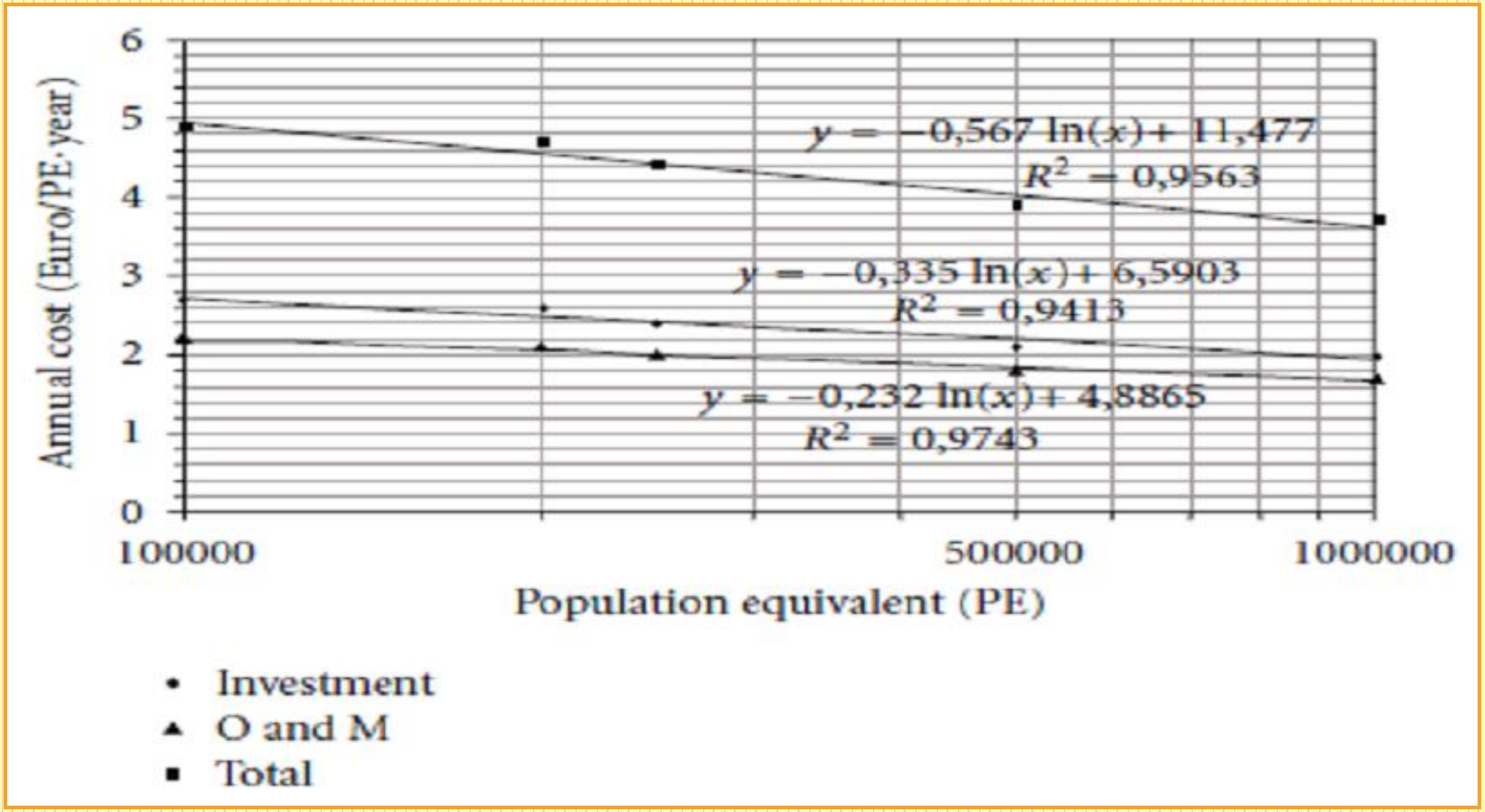
Municipal WWTP (Active Sludge System with C, N, P Removal) Avarage Cost Estimates(100.000 – 1.000.000 PE)

PE	Investment Cost (€/PE)	Total Investment Cost (€)	Annual Investment €/yıl (€/PE/y)	Annual O&M (€/PE/y)	Total Annual Cost (€/PE/y)
100.000	165	$16{,}5.10^6$	1.475.000 (15)	9 (2)	24
2 x 100.000 (1)	157	$31{,}4.10^6$	2.803.000 (14)	8	22
250.000	148	37.10^6	3.319.000 (13)	8	21
2 x 250.000	132	66.10^6	5.900.000 (12)	7,2	19,2
4 x 250.000	124	124.10^6	11.665.000 (11)	6,8	17,8

Integrated Biomethanization Plant Cost Estimates for a city with 100.000 – 1.000.000 PE

PE	Investment Cost (€/PE)	Total Investment Cost (€)	Annual Investment €/yıl (€/PE/y)	Annual O&M (€/PE/y)	Total Annual Cost (€/PE/y)
100.000	31	$3{,}1.10^6$	266.000 (2,7)	2,2	4,9
2 x 100.000 (1)	29,5	$5{,}9.10^6$	505.000 (5,1)	2,1	4,7
250.000	28	$7{,}0.10^6$	299.000 (6,0)	2,0	4,4
2 x 250.000	25	$12{,}5.10^6$	1.064.000 (10,6)	1,8	3,9
4 x 250.000	23	23.10^6	1.995.000 (20,0)	1,7	3,7

3.1. Integrated Management of the OF-MSW and Sewage Sludge

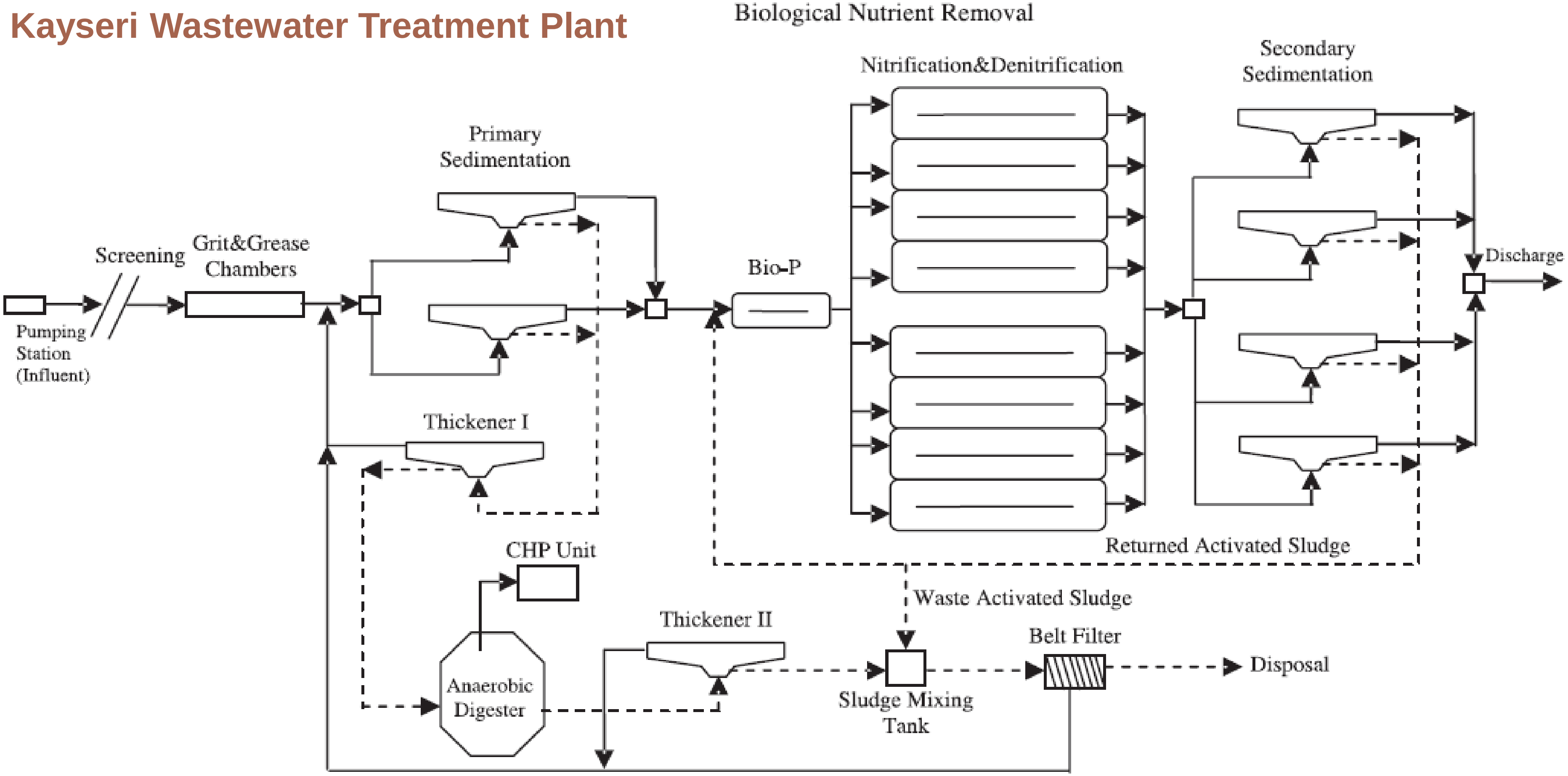


Change in annual cost values for 100.000-1.000.000 PE

3.1. Integrated Management of the OF-MSW and Sewage Sludge

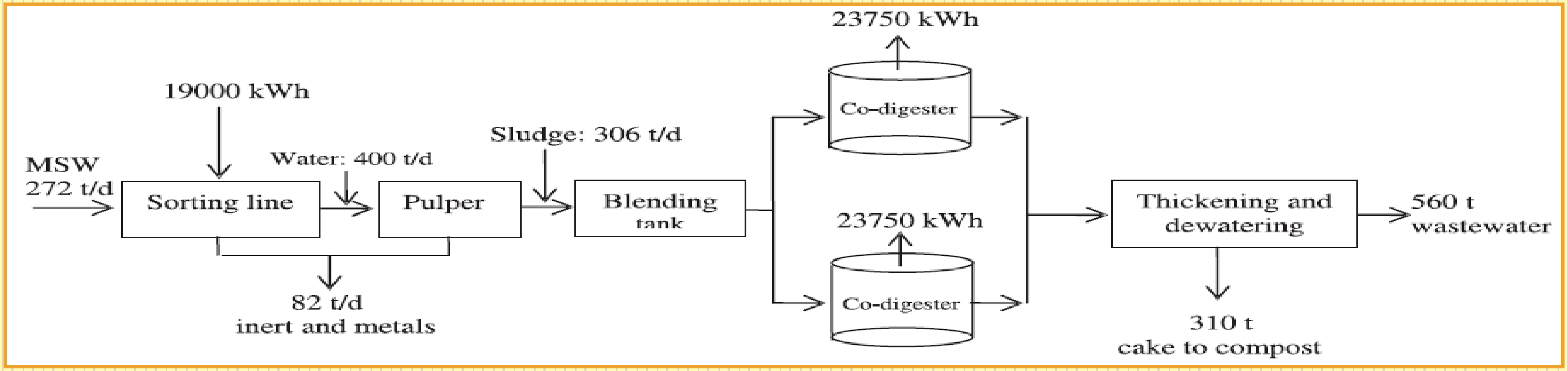
Integrated Management of Municipal WW and MSW

Kayseri Wastewater Treatment Plant

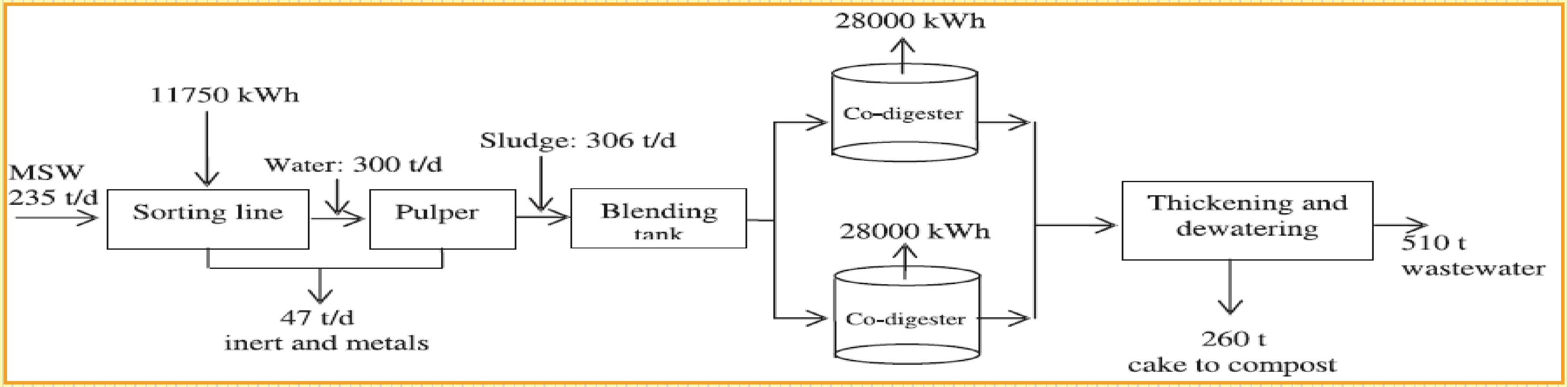


3.1. Integrated Management of the OF-MSW and Sewage Sludge

Kayseri Wastewater Treatment Plant



Treatment of Mixed OF-MSW



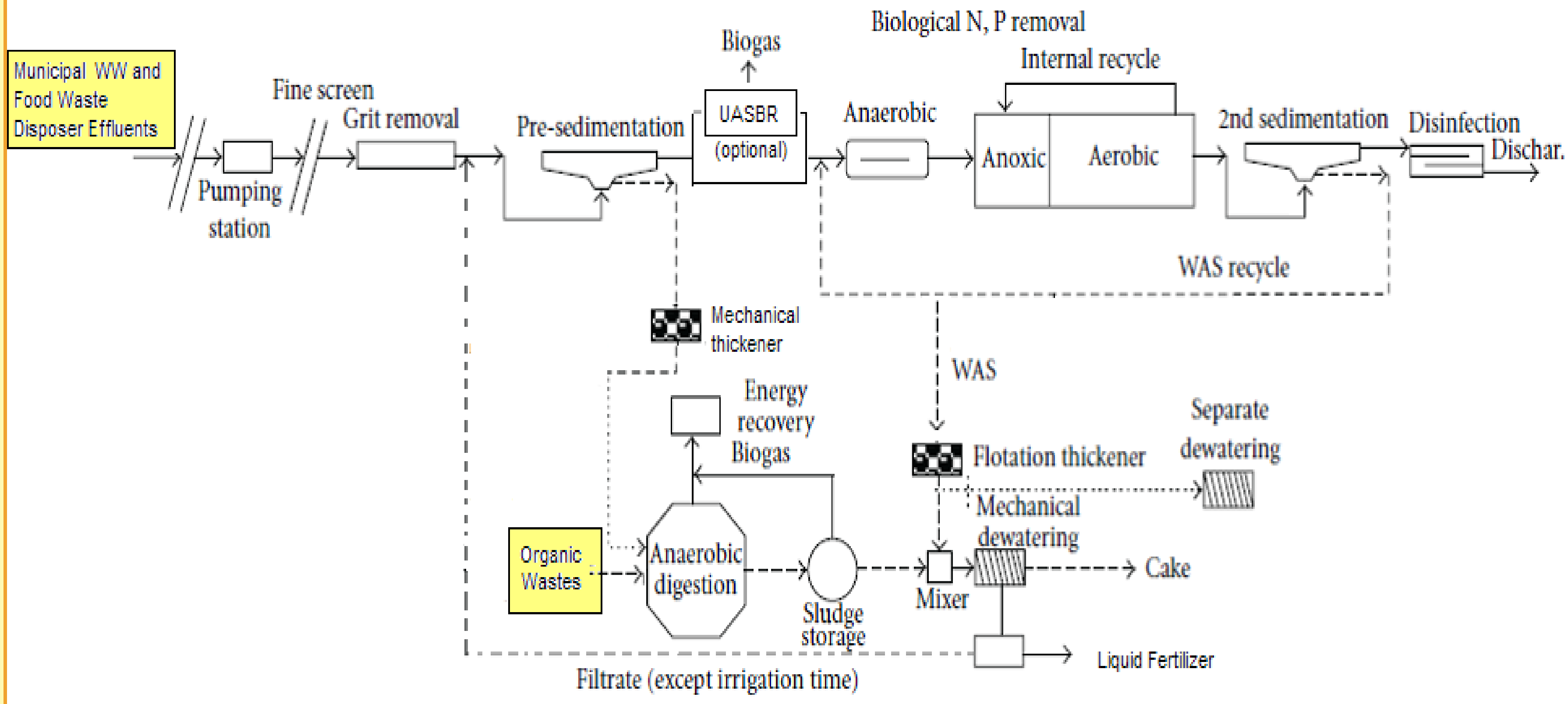
Treatment of Source Seperated Organics of MSW

3.1. Integrated Management of the OF-MSW and Sewage Sludge

Kayseri Wastewater Treatment Plant

Parameter	Current situation	Option 1	Option 2
Wet organic solid waste, in (tonne $year^{-1}$)	–	70,000	68,600
TS content in the digesters (%)	7	10	10
HRT (day)	22.5	15.4	17.3
OLR (kg TVS m^{-3} day^{-1})	2.0	3.9	3.9
Methane production (m^3 day^{-1})	4730	16,300	19,500
Electrical energy production (kWh day^{-1})	12,700	47,500	56,000
Energy recovery (%)	30	77	100

3.2. The Effect of Food Waste Disposers on Municipal Wastewater Managment



Process scheme of the municipal WWTP for co-treatment with food waste disposer effluent

3.2. The Effect of Food Waste Disposers on Municipal Wastewater Managment

Major Problems:

For 25-75% application coverage (market penetration):

- 20-60% increase in BOD
- 2-7% increase in TSS
- 25-40 gr/capita.day increase in biological sludge production
- 20-30% increase in WWTP investment
- 25-30% increase in annual O&M costs

Major Benefits:

For 25-75% application coverage (market penetration):

- 10-40% decrease in collected solid waste amount
- 50-70% increase in biogas production

4. Utilization of Biogas as Vehicle Fuel

- The below parameters play an important role in widespreading the utilization of biogas as transport fuel:

  - Decrease in air pollution resulting from vehicles
  - Decrease in noise pollution
  - Decrease in dependency to foreign petroleum resources
  - Prevention of incineration of the biogas at the flare for nothing
  - Raising funds through utilization of biogas as transport fuel

- According to recent data, ~14 European cities biogas is currently been utilized as transport fuel. The leading countries in this field are Sweden and Switzerland.

4. Utilization of Biogas as Vehicle Fuel

Utilization of Biogas Produced at the Integrated Biomethanization Facility as Transport Fuel in a City with PE 100,000

- Integrated biomethanization facility is fed with 60 gr TSS/PE.day (Primary Sludge) + 100 gr TSS/PE.day (OF-MSW) to produce biogas with 95% CH_4, then it is enriched with scrubber technology to be utilized as transport fuel replacing approximately 810,590 lt of diesel fuel and 1,019,370 lt gasoline annually.

- 1 m^3 enriched biogas (95% CH_4) results in fuel savings equivalent to approximately 0.8 lt diesel fuel or 1 lt of gasoline.

- Enriched biogas could be utilized in 34 diesel-fueled heavy-duty vehicles or 723 gasoline-fueled vehicles.

5. Overlook at Production of Renewable Energy from Waste

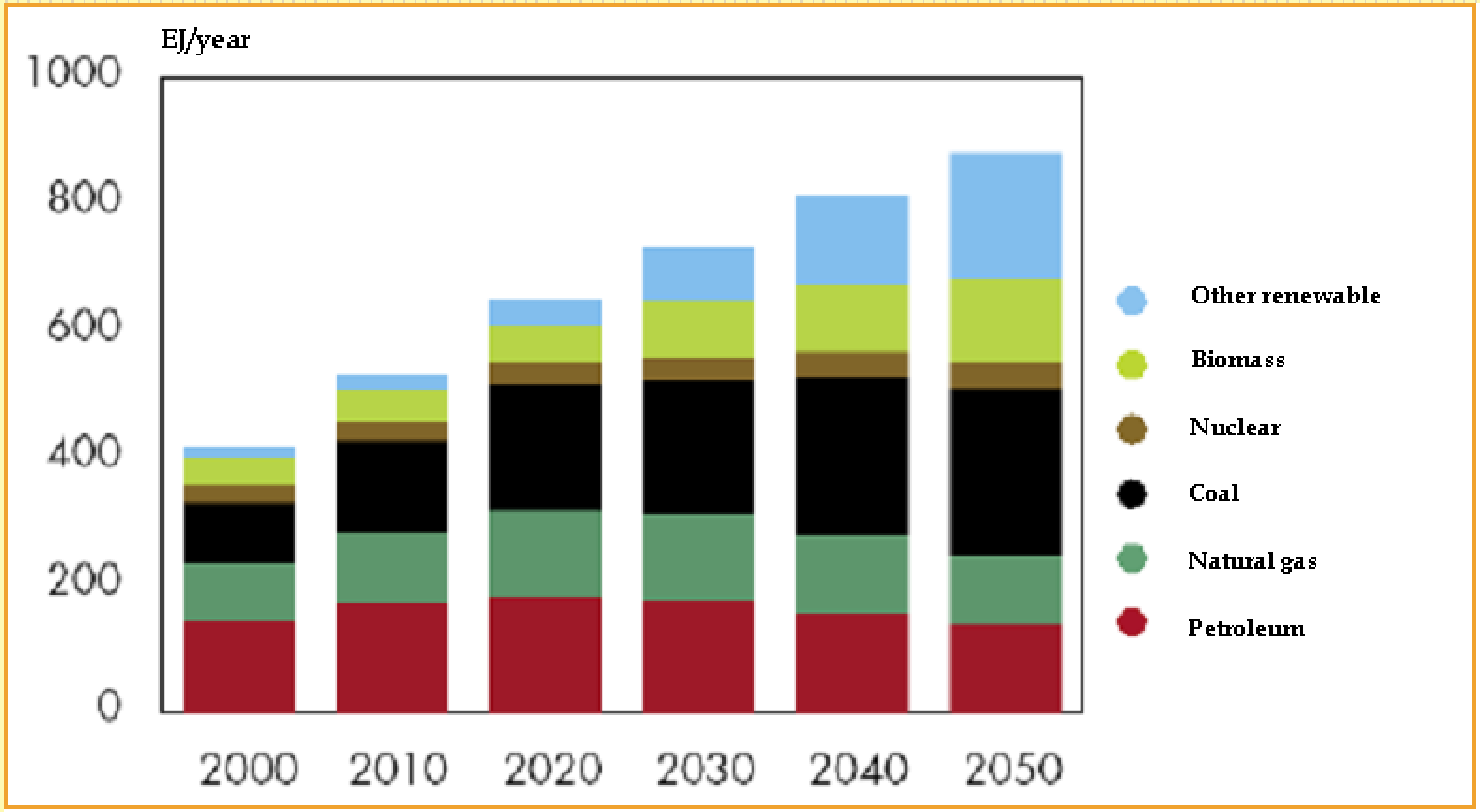
World Wide Approaches and Applications of Renewable Energy Production

Renewable Energy Incentives

- Investment grants : 20 – 40% of project value
- Electrical energy incentives : Renewable energy purchase with 50-100% increase then average market price
- Tax exemption for energy consumption
- Disposal permit for other organic wastes (waste disposal fee collection)

5. Overlook at Production of Renewable Energy from Waste

Renewable Energy Production Projections in the World



- Primary Energy with respect to Source for 2000-2050 (Shell, 2008)

5. Overlook at Production of Renewable Energy from Waste

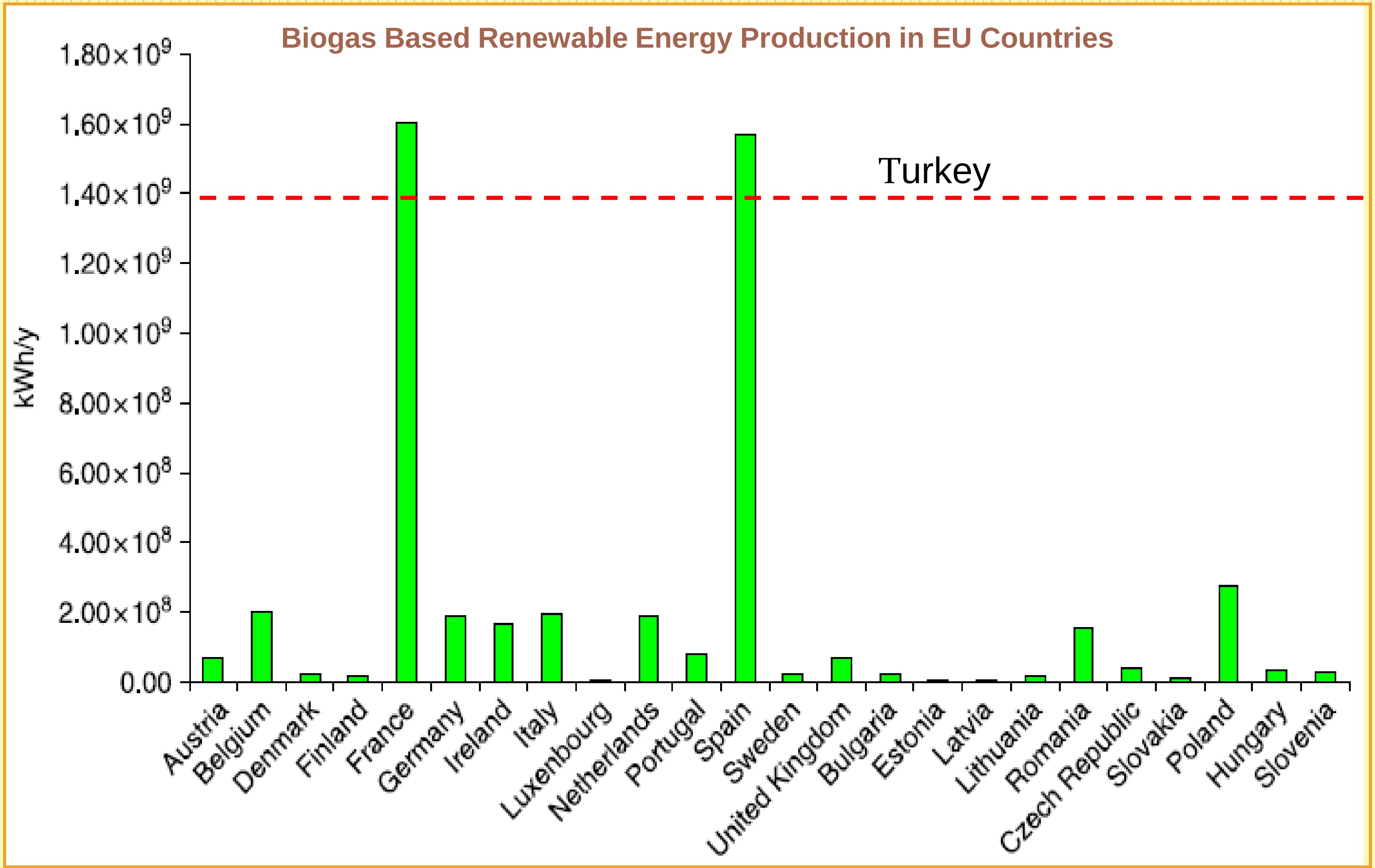
Renewable Energy Production Projections in the World

EU Countries Targets

Waste Type	Current level ($*10^6$ m^3/day CH_4)	Potential level ($*10^6$ m^3/day CH_4)
Organic fraction of solid wastes	4.5	15
Treatment sludges	1.7	4
Industrial wastes	0.8	3
Agricultural wastes	0.5	10
Total	7.5	32

- 100-150 m^3 CH_4/ton waste
- EU countries are planning to produce 12.5% of their total energy from renewable energy sources (biogas, wind, etc.) in year 2010

5. Overlook at Production of Renewable Energy from Waste



Production potential of the 26 EU Countries regarding net biomethane energy derived from animal wastes that could be brought to central biogas facilities in liquid form

5. Overlook at Production of Renewable Energy from Waste

Situation in Turkey

- Law No: 5346 – Renewable Energy Law (10.05.2005)
- Law No: 5627 – Energy Efficiency Law (18.04.2007)
- Law No: 5784 – Amendment in the Electricity Market Law (09.07.2008)
- Official Gazette No : 25956 – Regulation on Certification of Renewable Energy Sources (04.10.2005)
- Official Gazette No: 27899 – Law on Amendment in Utilization of Renewable Energy Sources in Electrical Energy Production Law (5346)

5. Overlook at Production of Renewable Energy from Waste

Situation in Turkey

- Purchase guarantee of the renewable electrical energy produced (biogas energy) for 10 years with respect to the recent year's country average energy bulk sale price (the price for biomass-sourced energy: 0,133 $/kW-hour)

- Renewable Energy Source Certification exemption for self-sufficient facilities with installed capacity lower than 200 kW

5. Overlook at Production of Renewable Energy from Waste

Biomethane energy production potential estimate for Turkey in 2008

Sector	Renewable Energy Production Potential (10^9 kW-hr/yıl)		Prevented Greenhouse Gas (10^6 m^3/yıl)	
	E_{el}	E_{ISI}	Methane	Biogas
Organic MSW (1)	2.3	2.8	644	920
Animal Waste (2) *	1.3	1.6	377	535
Industrial Wastewater (3) **	0.18	0.22	50	71
Municipal Wastewater Treatment Plant Biological Treatment Sludge (4)	0.20	0.24	54	77
Total	~4.0	4.8	1.125	1603

(1) ~ 10×10^6 t organic MSW/year (50×10^6 municipal population)

(2) ~ 10×10^6 t wet waste/year (%12 TS,67% of ~ 11×10^6 cattle and ~ 240×10^6 poultry waste)

(3) COD = 5000 mg/lt, flowrate = 1000 m^3/day from ~ 100 industrial facility

(4) 50×10^6 anaerobic digestion of MWWTP sludges

* Modern breeding techniques can double this potential.

** Widespread application can double this potential.

6. Outcomes and Propositions

- Due to mesophilic anaerobic treatment of Municipal Wastewater Treatment Plant (MWWTP) sludges (preferably primary sludges) together with source-separated and/or dual collected organic municipal solid wastes (O-MSW), pilot-scale treatability experiments have shown biomethane production from volatile solid waste (VS) fraction of such wastes in comparable amounts to expected biomethane potential (TUBİTAK-KAMAG Project No: 105G024).

- Due to mesophilic anaerobic treatment of MWWTP primary sludges together with O-MSW (marketplace/park/garden and restaurant wastes), biomethane energy could be recovered up to x1,5 the energy requirement of the MWWTP (PE ≥ 100,000).

- Given the condition that electrical energy resulting from biomethane is subject to 100% renewable energy incentive, the above ratio increases to ~ x3.

- Therefore, Integrated MWWTP & Biomethane Facilities is converted into a renewable energy power station that treats both wastewater and waste, along with selling its excess energy to outside.

34

6. Outcomes and Propositions

- Integrated MWWTP & Biomethane Facilities not only enables electrical energy production, but also provides ~ x1,3 heat recovery.

- Such heat could be utilized in building/facility heating, greenhousing and also for drying WWTP and Biomethane Facility biowastes (anaerobic sludge and WWTP excess sludge) after condensation. This way large-scale MWWTP sludges would not require a separate natural gas power station for drying.

- Combined digestion of MWWTP primary sludges together with O-MSW enables effective stabilization, therefore resulting in decrease of the VS fraction of waste (~%50) along with diversion of such organic wastes outside of waste landfills (as agricultural fertilizer or soil conditioner).

- Due to the fact in Turkey, the organic matter content of the municipal solid waste is ~50% higher than of the rich EU countries (45 – 65%), the amount of biomethane to be recovered from O-MSW poses a unique advantage.

- Biogas to be recovered from waste, enriched for methane, and pressured (200 – 250 bar), presents a great opportunity for our cities with EP > 100,000 in terms of utilization as transport fuel, as in many Scandinavian countries.

35

6. Outcomes and Propositions

- In anaerobic treatment of WWTP sludges (preferably primary sludge) together with O-MSW and other wastes (animal wastes, industrial process wastes, agricultural wastes, industrial vegetable wastes (corn sludge, sugar beet wastes ,etc.)) to produce biomethane, initially the capacities of especially anaerobic digesters in existing MWWTPs and anaerobic reactors in some industrial WWTPs could be utilized.

- Accrodingly, the existing anaerobic sludge digesters within Kayseri Metropolitan Municipality WWTP, Ankara Metropolitan Municipality WWTP, together with İSKİ Tuzla, Ataköy and Ambarlı WWTPs are considered to be used.

- Food/kitchen wastes from in-sink grinders could be treated together with municipal wastewater in MWWTPs for recovery of renewable energy. Through such method, the organic waste amount could be reduced up to 50-70%.

- Organic wastes treated with municipal wastewater in central WWTPs, post-treatment could be required on digester supernatant flow with respect to heavy nitrogen loads.

6. Outcomes and Propositions

- The below matters are important in terms of organic waste reduction and especially for diminishing the external energy gap at Large-Scale WWTPs:

  - Efficient monitoring & control of the quotas for accepting biodegradable waste at landfills as provided by the Landfilling of Waste Regulation
  - Enabling Anaerobic Treatment and Sludge Digestion Facilities that produce biomethane from organic wastes to collect waste disposal fee (gate fee)
  - Tax practices on waste landfill fee with respect to tonnage of waste disposed at Landfill Sites.
  - Continuity of renewable energy incentive on recovered energy from organic waste and biomass (electrical+heat)
  - Promoting the private sector initiative through legislative and managerial measures (service take-on period in operational tenders, etc.) in the renewable energy sector from recovery of biomass and other organic wastes

THANK YOU...