Biogas for urban transport application

Nuri AZBAR

Ege Üniversity
Bioengineering Department

Meeting location and dates

The meeting will be held on the 27th and 28th September 2007 in

EBSOBuilding Izmir–Turkey

Tel: +90 (232) 3880378 (ext.138) ; Fax: +90 232 38849555

There is no registration fee for the meeting.

The number of participants is limited.

If you wish to attend please inform the meeting secretariat as soon as possible.

Accommodation is available in the meeting hotel.

Accommodation and travel must be arranged and paid by the participants.

Secretariat Address

European Commission Joint Research Centre,

Institute for Energy

P.O.Box: 2

1755ZG Petten, NL

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Copy of the correspondence and the accommodation details to be sent to the local organizer:

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Cleanweb

prewin Network

The JRC-Institute for Energy

in collaboration with

Ege University, Bioengineering Department

Renewable Fuels from Waste for City Transport Applications.

Technical, Environmental and Social Considerations

Izmir, Turkey

04th & 05th October 2007

Institute for Energy of the Joint Research Centre and the FENCAB project

The role of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.
The Institute for Energy provides scientific and technical support to EU policy related to Energy. Special emphasis is given to safe and sustainable energy supply.

The FENCAB project is based at the JRC-Institute for Energy, the Netherlands. It addresses issues related to safe, clean and efficient production of energy from coal, biomass and waste. While the main focus of the work is the recovery of heat for electrical power generation or direct use in industry or district heating, the recovery of alternative and renewable fuels is a growing component of the work. This work involves the assessment of pathways for fuel production and necessarily includes studies on process parameters (e.g. for gasification) and cleaning processes for alternative fuels (e.g. filtration and catalysts). The PREWIN network (http://prewin.jrc.nl) is operated within FENCAB and is one of the main tools used to achieve the goals of the project related to energy from waste by incineration.

Scope of this Workshop

Minimising the harmful effects of waste and utilising waste and biomass as fuel sources is a key challenge of today. There are several environmental and economic drivers at the origin of this challenge. The European Union has set ambitious and necessary challenges to decrease its dependence on external energy sources and to develop sustainable energy and transport fuel systems. It is expected that a very large contribution will come from the appropriate treatment of all forms of waste and biomass. This workshop seeks to address the technical and environmental aspects related to the production of vehicle fuels derived from wastes and biomass, specifically for use in the urban environment. Izmir is currently assessing options for use of biofuels for municipal transport applications and sees waste and biomass as a currently under-used resource. The workshop aims to bring together those facing the challenges of production and utilisation of biofuels in cities.

Who Should attend:

People working in the areas of :

Waste and Biomass to Energy sector

Alternative fuels – production and cleaning

Waste and Energy management strategy development

National and regional policy makers

Programme.

Day 1.

14:00	**Arrival of participants - Registration**
15:00	**Opening Session** **Welcoming Words from:** ***Institute for Energy and Ege University- D. Baxter/N.Azbar***
15:30	**Review of EU Energy Supply and Demands - introduction** ***David Baxter, JRC-IE, the Netherlands***
16:00	**State of the Art Review on Biogas Production Processes** **Examples of Ongoing Projects World Wide** ***By: Charles Banks, University Southampton, UK***
16:30	**Practical Application of Biogas Processes** ***By: Suat Karakuz, Schmack Biogas AG , Germany.***
	Coffe break
17:00	**Up-grading of Biogas for Use in Vehicles** ***By Ulrich Schmack, Schmack Biogas AG , Germany***
17:30	**Biogas for transportation – practical experiences in Sweden** ***By: Owe Jonsson, Swedish Gas Centre, Sweden***
18:00	**Hydrogen: A Vision for theFuture** ***By Engin Ture, ICHET, Turkey***
18:30	**Round table Discussion**

Day 2.

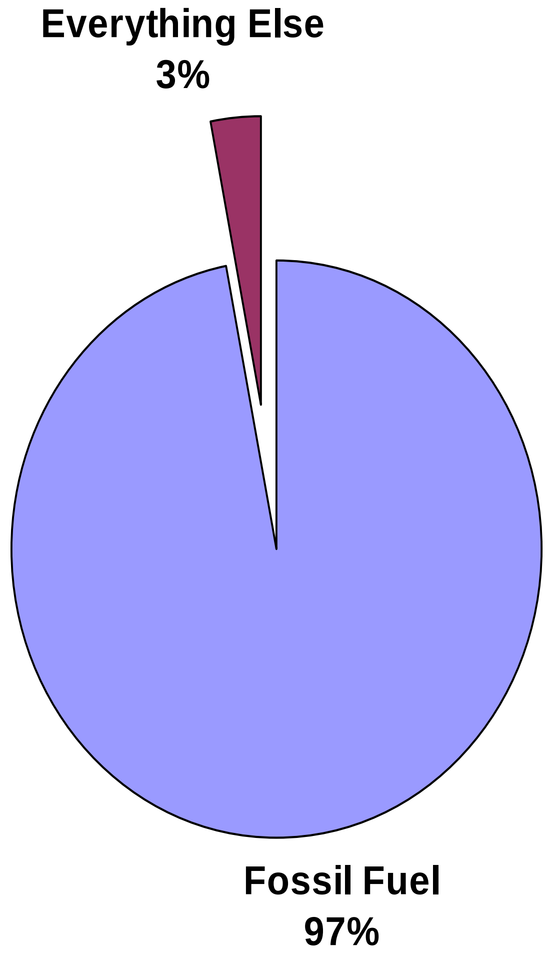
09:30	**Biofuel Cities European Project** **By Konstantinos Georgakopoulos, Exergia SA, Greece**
10:00	**Biofuels in Comparison: The Best Choice !** ***Nils Rettenmaier, IFEU - Institute for Energy and Environmental Research Heidelberg, Germany***
10:30	**State of the Art Review on Biodiesel Production Processes** ***By Selma Turkay, ITU, Turkey***
	Coffe break
11:00	**Biodiesel and SLUDERGY Concept** ***By Adnan Akyarli, Ege Bioetechnology, Turkey.***
11:30	**Review of EU and Turkish Standards on Biodiesel Production and Use** ***By Filiz Karaosmanoglu, ITU, Turkey***
12:30	**Lunch**
14:00	**State of the Art Review on Bio-ethanol Production Processes** ***By Fikret Kargi , DEU, Turkey***
14:45	**Bio-ethanol Production in Turkey, General Overview for Today and Future** ***By Vedat Aydınoglu, TARKIM, Turkey***
	Coffe break
15:30	**Turkish Energy Policy** ***(A speaker to be nominated from Ministry of Energy, Turkey)***
16:00	**Use of Alternative Fuels, Technical Regulations in Turkey** ***Bekir Oray Gungor, EPDK, Turkey***
16:30	**Round Table Discussion** ***What are the possibilities for Izmir ?*** ***What are the main advantages and disadvantages of the fuels presented in this workshop ?*** ***Have we identified needs for future collaboration or support ?***
17:00	**Conclusions and Closing Remarks**
18:00	**End of Workshop**

Due to the extensive combustion of reserve fossil fuels, carbon dioxide levels in the atmosphere has reached its critical levels which may cause irreversible catastrophic climate changes.

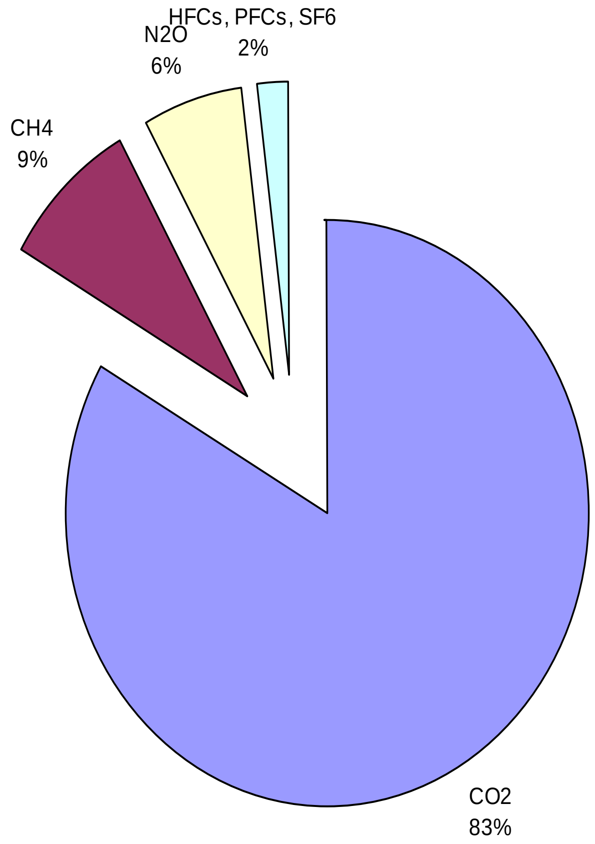
In addition to the natural causes, increased fossil fuel consumption as a function of rapid industrialization rates in recent years has also accelerated this process and had nations to reexamine the alternative energy resources, especially the renewable ones.

POLITICAL TENSION IS ALREADY HIGH, AND NOW OUR PLANET HAS HIGH FEWER DUE TO THE GLOBAL WARMING

CO_2 Emissions



Methane is 21 times more dangerous but luckly produced much less compared to CO_2



In this context, it has become indispensable to consider alternative energy sources (e.g. biofuels) in each sector where fossil fuels are used as a primary source.

It is well known that <u>one third of overall carbon dioxide emissions</u>, which is one of the main reasons of climate change, are generated during <u>transportation activities.</u>

In this study, it is aimed to take one more step towards realizing the concept of "Blue Bay, Green Izmir".

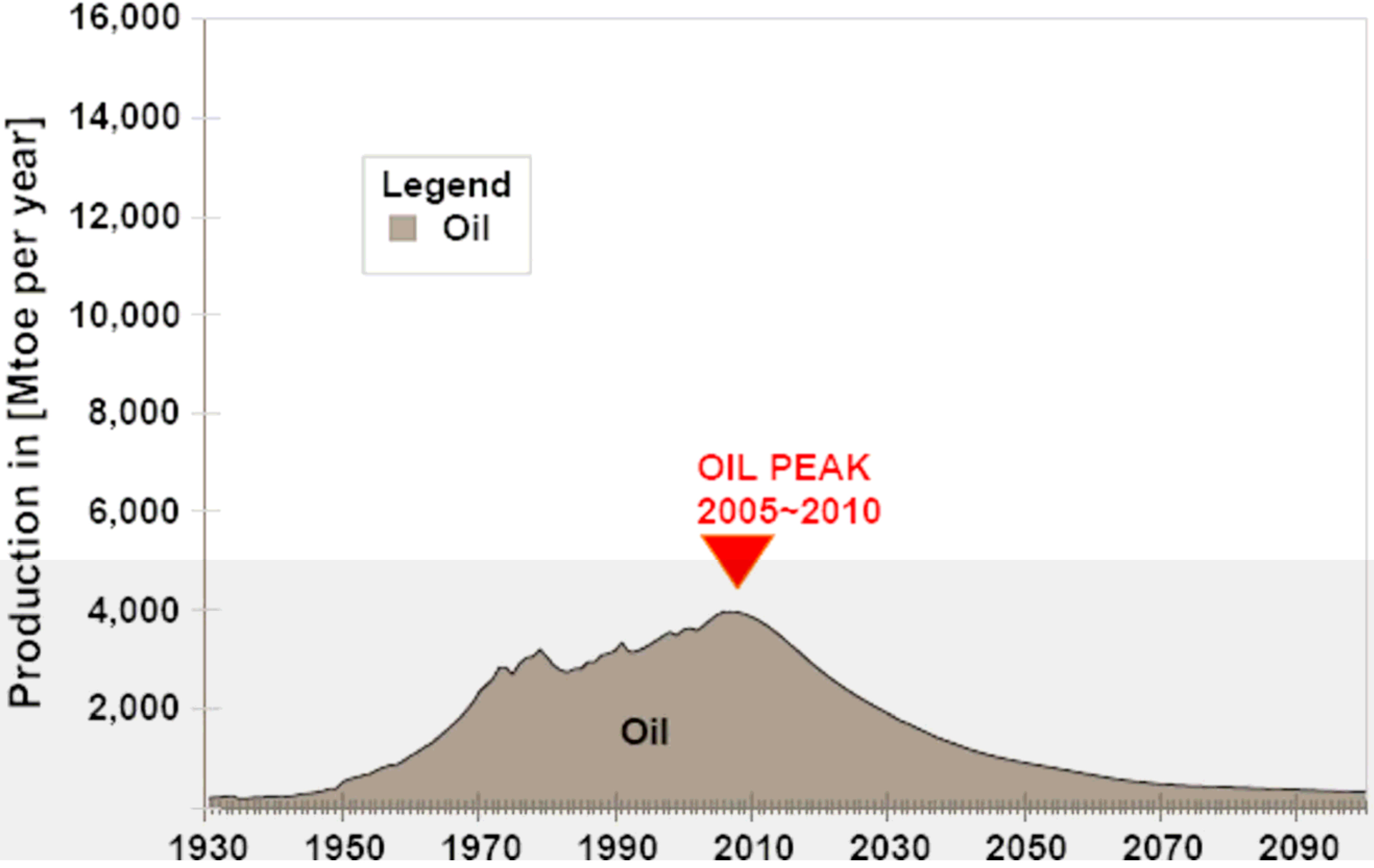
In this concept, the use of waste materials such as organic fraction of municipal solid waste (including agricultural wastes) and excess biological sludge from publicly owned treatment plants are promoted in order to liberalize the public transportation from fossil fuels.

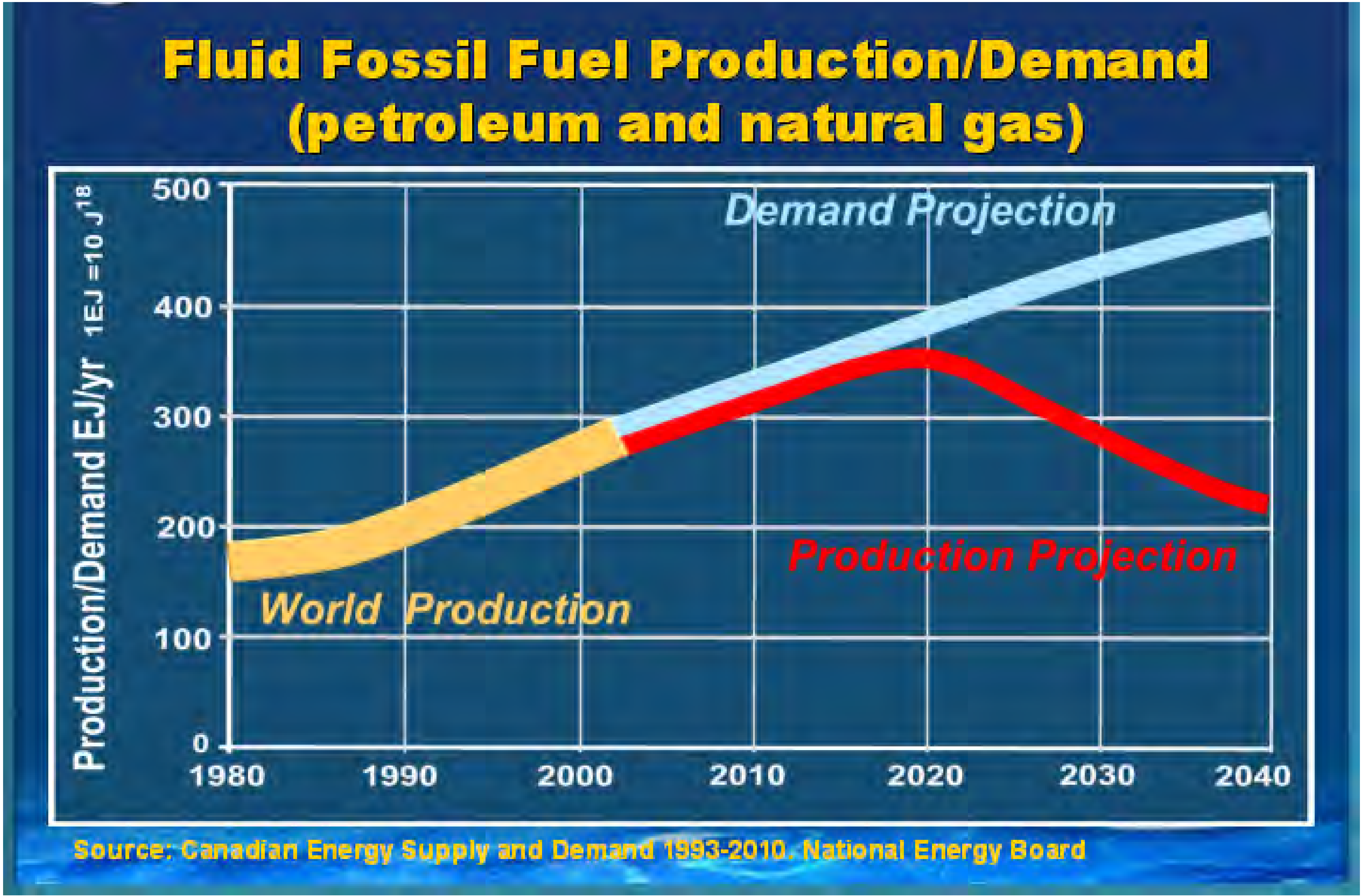
Upon signing the Kyoto protocol, it will especially be indispensible to minimize carbon dioxide emissions resulting from domestic, agricultural and industrial activities in our country.

The maximum use of alternative energy resources is compulsory in order to provide a sustainable environment, to provide energy security and economics.

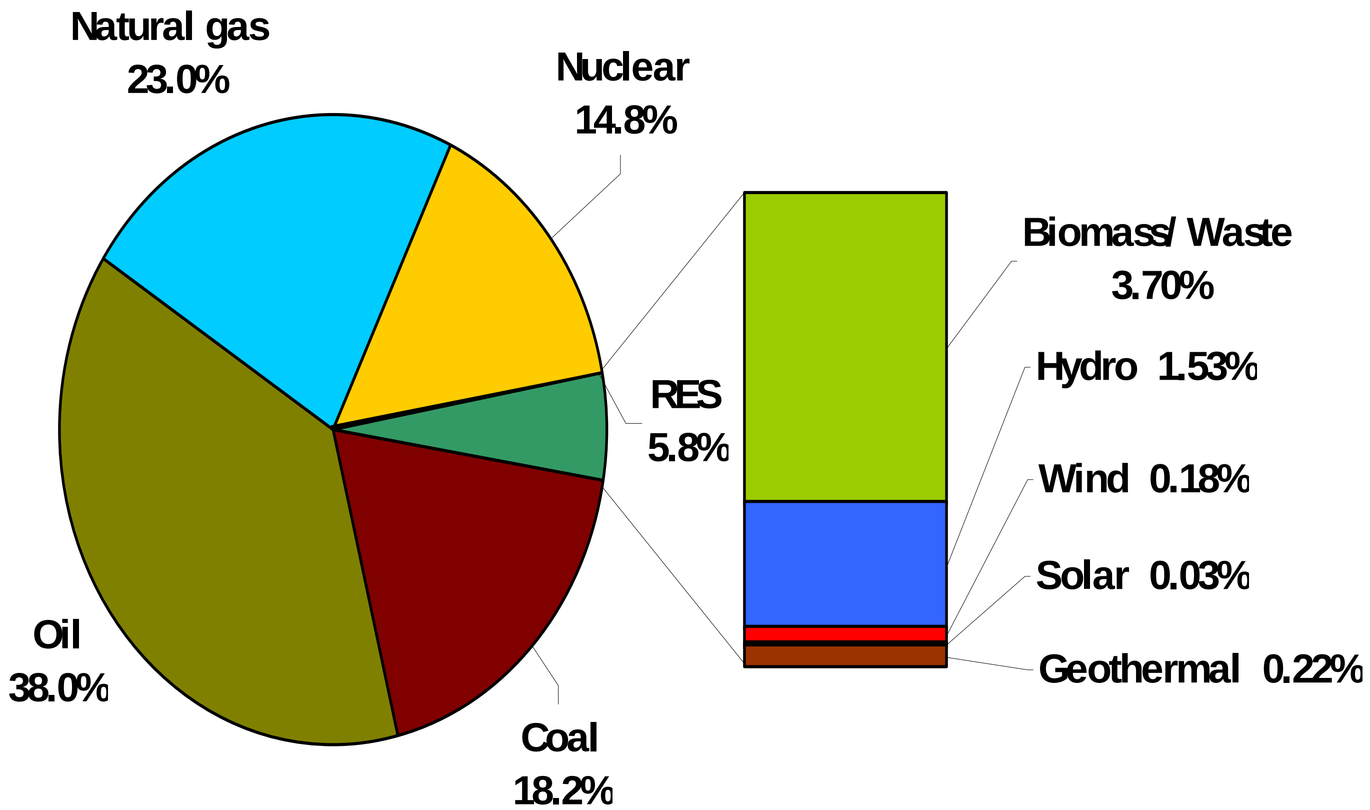
Izmir City could be a role model in putting the concept of "public transportation running on biofuels" into practice which has already alive application samples in Europe.

Global Oil Reservs (known)




Fluid Fossil Fuel Production/Demand
(petroleum and natural gas)
Production/Demand EJ/yr 1EJ =10 J^18
500
400
300
200
100
0
1980
1990
2000
2010
2020
2030
2040
Demand Projection
Production Projection
World Production
Source: Canadian Energy Supply and Demand 1993-2010. National Energy Board

Gross Energy Consumption (EU25) (by year 2002)



(* 2005 estimate for RES = 6.4%)

Slide Courtesy of J.Riesgo: EC-DG TREN

- According to The Ministry of Energy, Turkey consumes three times more energy than the amount she can produce. Dependecy on outsite energy resources are over 70%.

EU Policies and Targets: Energy

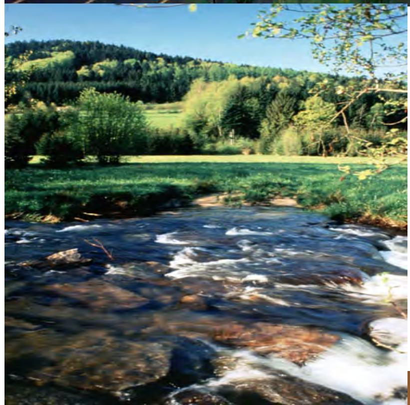
RES White paper 1997: increase share of RES from 6% to 12% of gross consumption by 2010

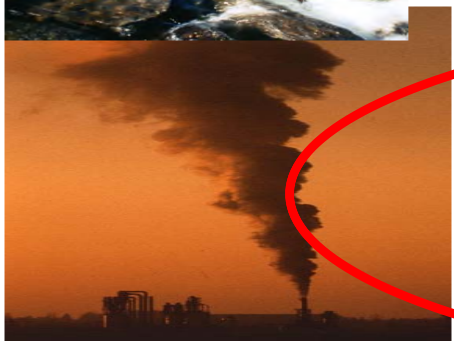
(~6.4% in 2005, of which 2/3 is from biomass/waste
- mainly heat: expected to reach 10% by 2010)

- To reduce greenhouse gas emissions (meet the commitments made by the EU under the 1997 Kyoto Protocol)

Slide Courtesy of J.Riesgo: EC-DG TREN

EU Legislation





Directive 2001/77/EC of 27.09.01 on RES-e : to increase the share of green electricity from 14% to 21% of gross electricity consumption by 2010 (expected to reach 18-19% by 2010)

Renewable Heating and Cooling Directive: under preparation

Directive 2003/30/EC of 08.05.2003 on the promotion of liquid and gaseous biofuels for transport: targets: 2% by 2005; 5.75% by 2010

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Joint Research

Joint Research Centre

Primary Biogas Production in the EU

Units = ktoe

	2004				2005			
	Décharges Landfill Gas	Station d'épuration Sewage sludge gas	Autres biogaz Other biogas	Total	Décharges Landfill gas	Station d'épuration Sewage sludge gas	Autres biogaz Other biogas	Total
United Kingdom	1 327,0	[illegible]		1 504,0	1 421,0	179,0		1 6?0,0
Germany	573.2	369,?	351.7	1 294.7	573.2	3?9.8	[illegible]	1 5?4.4
Italy	297,7	0.3	37.5	3?5.5	334.1	0.4	?2.0	?76,5
Spain	2?9.1	52,4	?3.6	295,?	236,5	56,8	23,6	?16,9
France	127,0	7?.0	[illegible]	207,0	129,0	77,0	3,0	209,0
Netherlands	67,1	53,?	28,?	149,8	59,8	50,7	29,6	140,1
Denmark	13,8	19,8	55,6	89,3	14,3	20,5	57,5	92,3
Belgium	56,3	9,7	7,8	?3,8	56,3	9,?	7,?	73,8
Czech Republic	18,6	28,7	2,?	5?,?	21,5	3?	?,8	55,8
Poland	21,5	23,9		45,4	25,1	[illegible]	0,3	50,7
Austria	11,8	19,1	14,5	45,4	11,8	?9,1	14,5	45,4
Greece	20,5	15,5		36,0	20,5	15,?		36,0
Ireland	19,9	4,8	5,1	29,9	24,9	4,8	5,1	34,8
Sweden	12,0	22,1	1,2	35,3	16,1	18,7	0,9	29,8
Finland	16,6	9,9		26,5	16,6	9,9		26,5
Portugal			4,5	4,5			10,0	10,0
Slovenia	5,8	0,9		6,6	6,0	0,7		6,8
Luxembourg			5,00	5,0			6,7	6,7
Slovakia		5,7	0,2	5,9		5,7	0,2	5,9
Hungary	0,7	2,6	0,2	3,5	0,8	2,9	0,2	3,8
Total EU	**2 808,6**	**893,1**	**541,7**	**4 243,3**	**2 961,4**	**898,0**	**855,6**	**4 715,0**

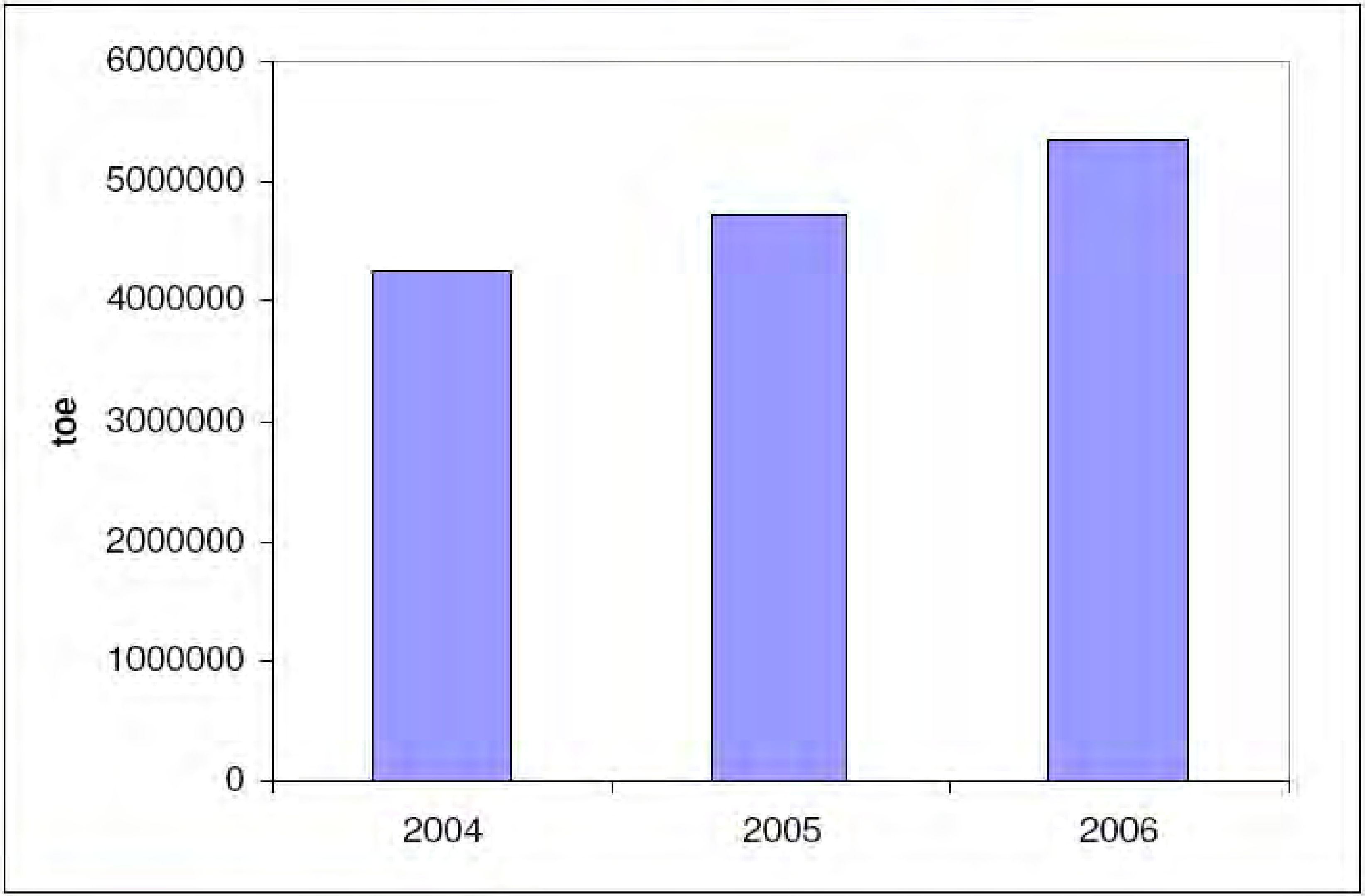
Landfill Gas

Water Treatment Gas

Agricultural Biogas etc.

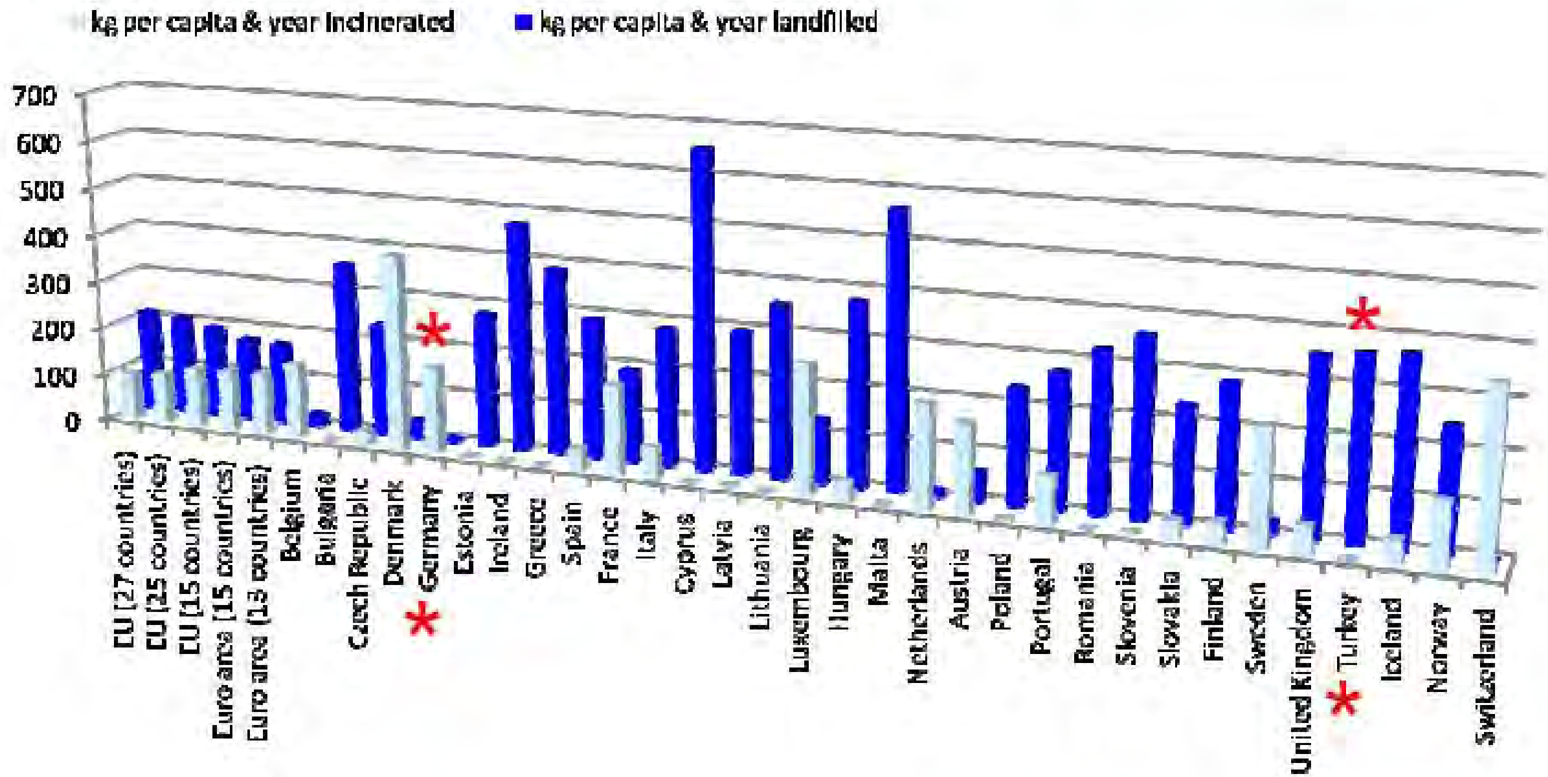
Source: EurObserv'ER 2006

Production of Biogas



Fate of municipal solid waste in the EU

EU landfill directive 99/31/EC influences dramatically domestic waste treatment technologies since 2005



	Germany	Turkey
Municipal waste (houshold and similar wastes) t	22.182.000	25.373.000
Kg per capita and year incinerated	179	0
Kg per capita and year landfilled	4	354

Data according to Eurostat database: http://epp.eurostat.ec.europa.eu/

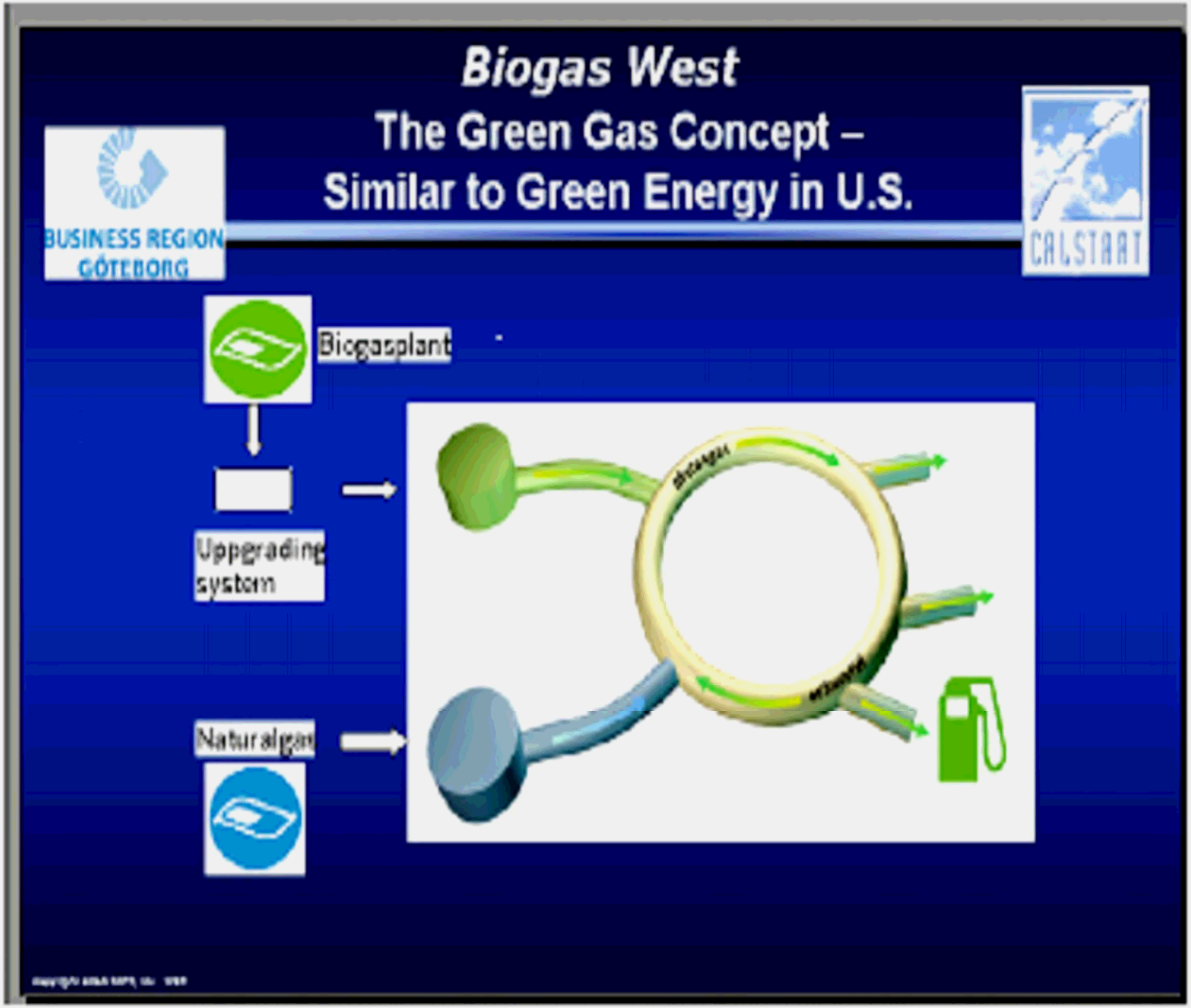
PROPOSAL FOR IZMIR CITY

1. Co-digestion of Cigli Treatment Plant Sludges (600 tons/day) and municipal solid wastes (4500 tons/day)

2. Production of biogas rich in methane)

3. Purification of biogas and removal of impurities (H_2S, dust, moisture etc)

4. Filling stations and use in public transportation


Biogas West
The Green Gas Concept –
Similar to Green Energy in U.S.
BUSINESS REGION
GÖTEBORG
CALSTART
Biogasplant
Uppgrading
system
Naturalgas


Biogas
as vehicle fuel
BIOGAS
DXG 883
Biogasbuss
SCANIA
DEPOT
10005
9156 YR 59
CNG

Financing

- #1: GOVERNMENTAL SUPPORTS
- #2: TÜBİTAK-COMMUNITY PROJECTS (1007)
- #3: TÜBİTAK-TEYDEP PROJECTS
- #4: EUROPEN UNION FRAMEWORK PROJECTS FP7 CALLS
- #5: REASONABLE ABROAD CREDIT SOURCES

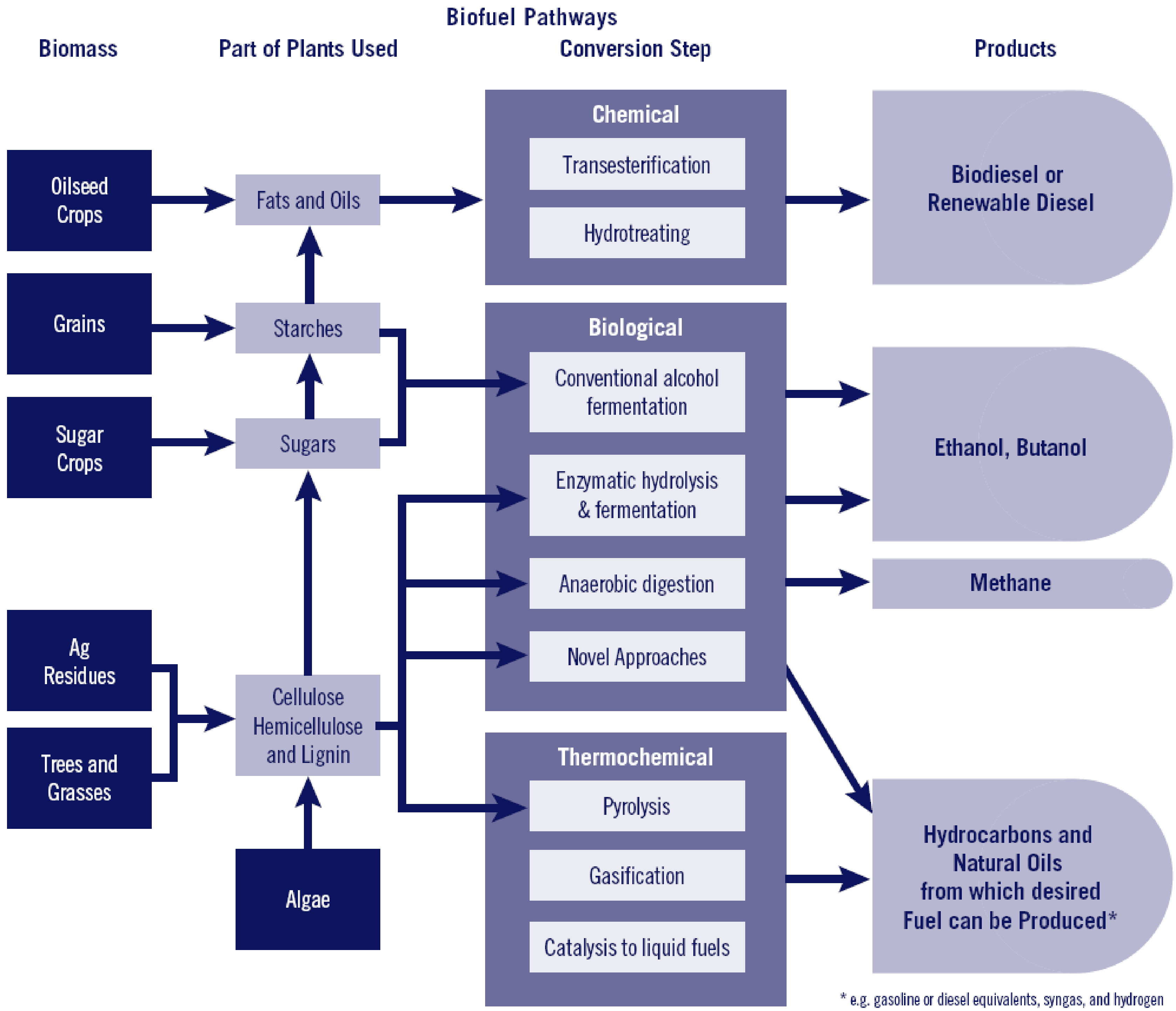
+

- IZMIR MUNICIPALITY

TARGET

SUSTAINABLE

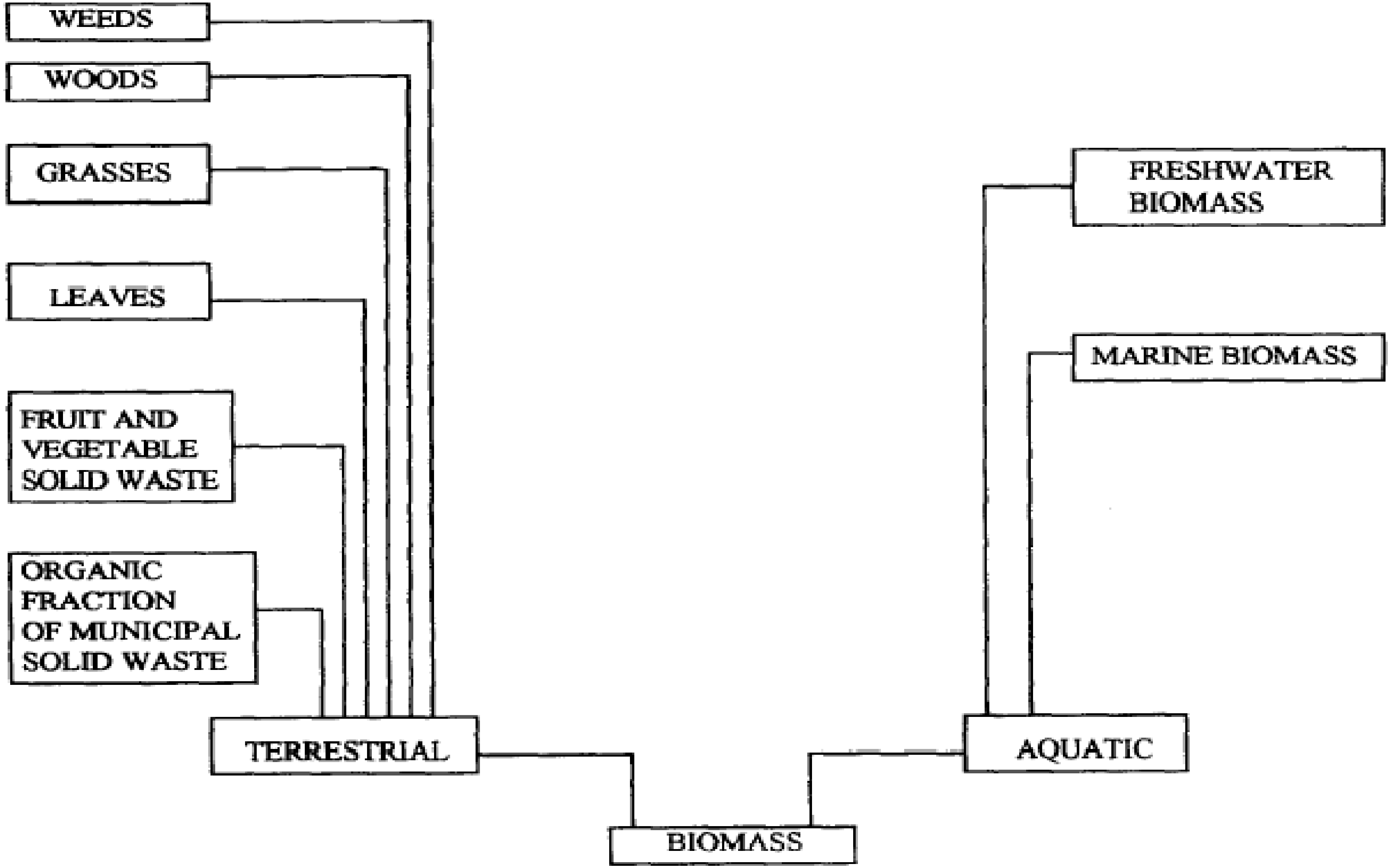
PUBLIC TRANSPORTATION AND ENVIRONMENT



Source: Peña and Sheehan, 2007.

Biogas is a methane rich, flammable gas that produced by the anaerobic digestion of organic matter including manure, sewage sludge, municipal solid waste, biodegradable waste or any other biodegradable feedstock.

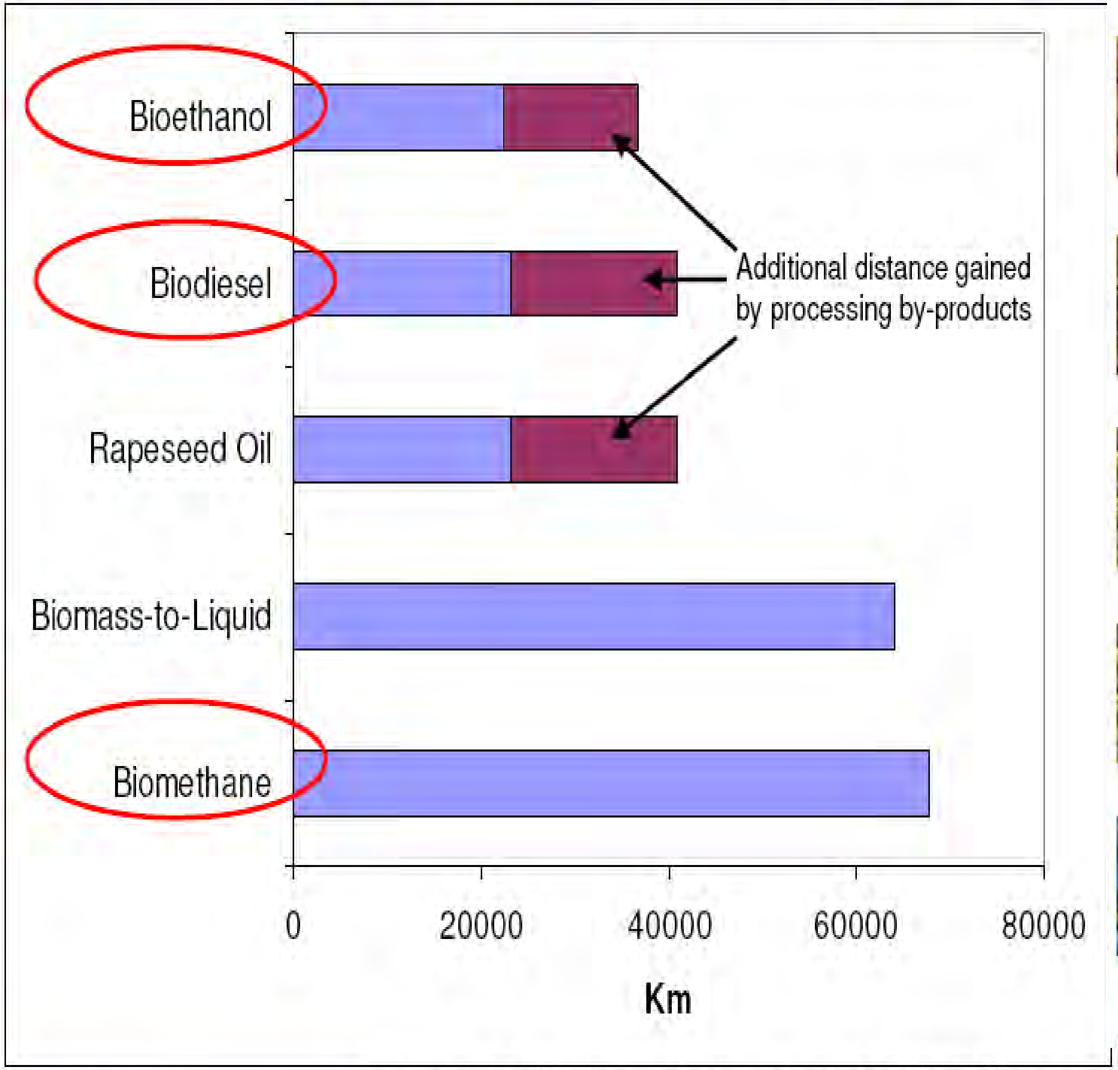
Selected types of methane yielding biomass



Methane Production Rates of Potential Sources

Organic Waste Type	CH_4 yield (m^3/kg VSS)
-Organic fraction of MSW	390 – 430
-Fruit, vegetable solid waste and leaf feeds	409 – 529
-Grass, millet straw, wheat straw, sorghum	342 – 420
-woody biomass	326 – 426
-terrestrial weed	236 – 246
-marine biomass	310 – 480
-Freshwater biomass	362 – 410

Comparison: Range of car with biofuel from 1 Ha of land



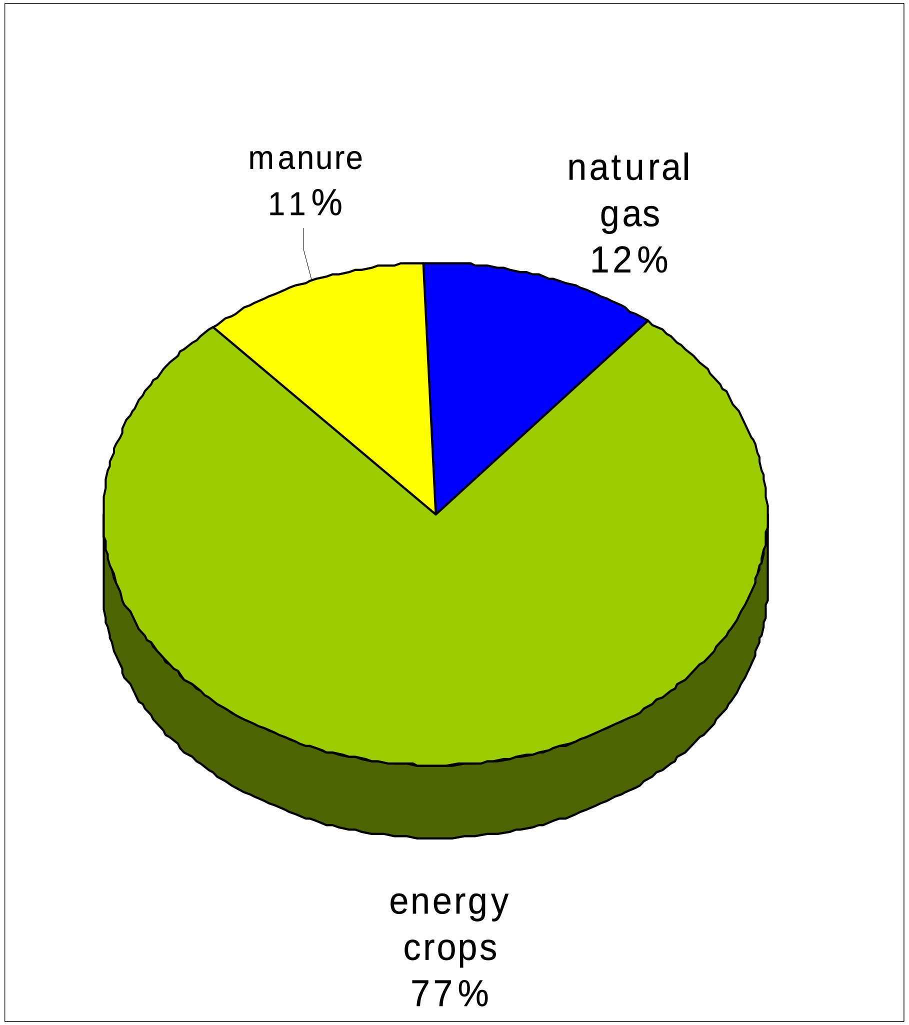
Source: Fachagentur Nachwachsende Rohstoffe e.V.

Biogas Potential in Turkey

- Natural gas consumption (year
  = 274 TWh (Terrawatt)
- Area:
  - Total area : 77.945.200 ha
  - Agricultural area : 26.423.422 ha
- Biogas potential of energy plants:
  (use of only 20% of the agricultural area for plantation)
  5.284.684 ha x 40.000 kWh/ha) = 211,4 TWh to get energy
- Biogas from cattle manure:
  (12.728.462 GV x 0,3 kW/GV x 8000 h)
  = 30,5 TWh

Total Energy = 241,9 TWh

TÜRKİYE



Quelle: FAO, CIA: The World Factbook 2006, BP: table of natural gas consumption 2006, Berechungen Schmack Biogas AG

Biogas potential of Turkey corresponds to the 88% of natural gas consumption.

Food or Fuel ????????

New European targets for biofuels (2007)

The move towards to 2nd generation biofuels

Binding minimum target of 10% for the share of biofuels in overall transport petrol and diesel consumption by 2020 was set at the beginning of 2007

..

increase political and industrial support for, and rapidity of, second-generation biofuel implementation from non food crops, including cellulosic biofuels. Second-generation biofuel production processes can use a variety of non food crops. These include waste biomass, the stalks of wheat, corn, wood, and special-energy-or-biomass crops (e.g. Miscanthus).

Third generation biofuels

Algae fuel

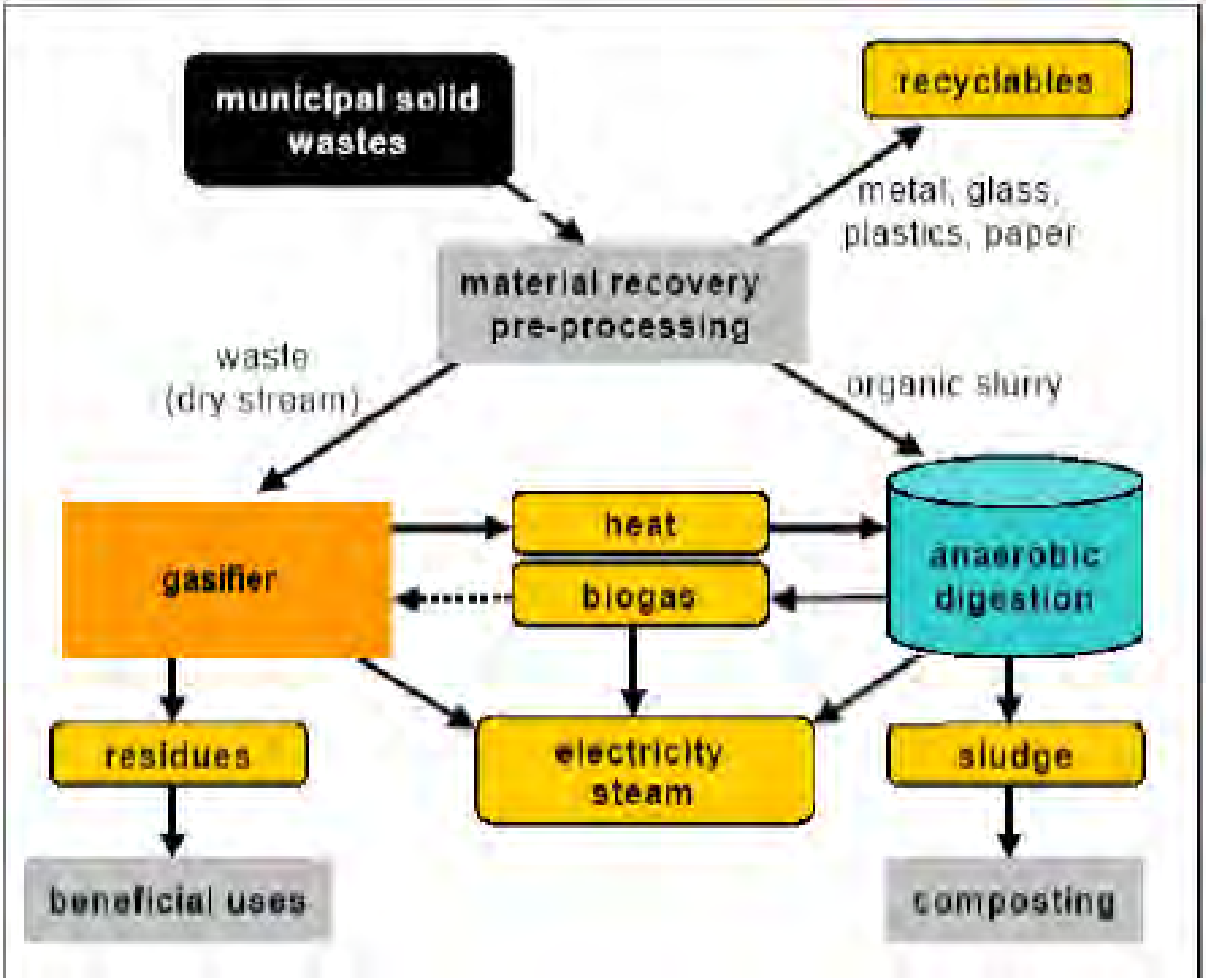
Algae fuel, also called oilgae or third generation biofuel, is a biofuel from algae. Algae are low-input, high-yield feedstocks to produce biofuels. It produces 30 times more energy per acre than land crops such as soybeans. With the higher prices of fossil fuels (petroleum), there is much interest in algaculture (farming algae). One advantage of many biofuels over most other fuel types is that they are biodegradable, and so relatively harmless to the environment if spilled.The United States Department of Energy estimates that if algae fuel replaced all the petroleum fuel in the United States, it would require 38,849 square kilometers, which is roughly the size of Maryland.

Second and third generation biofuels are also called advanced biofuels.

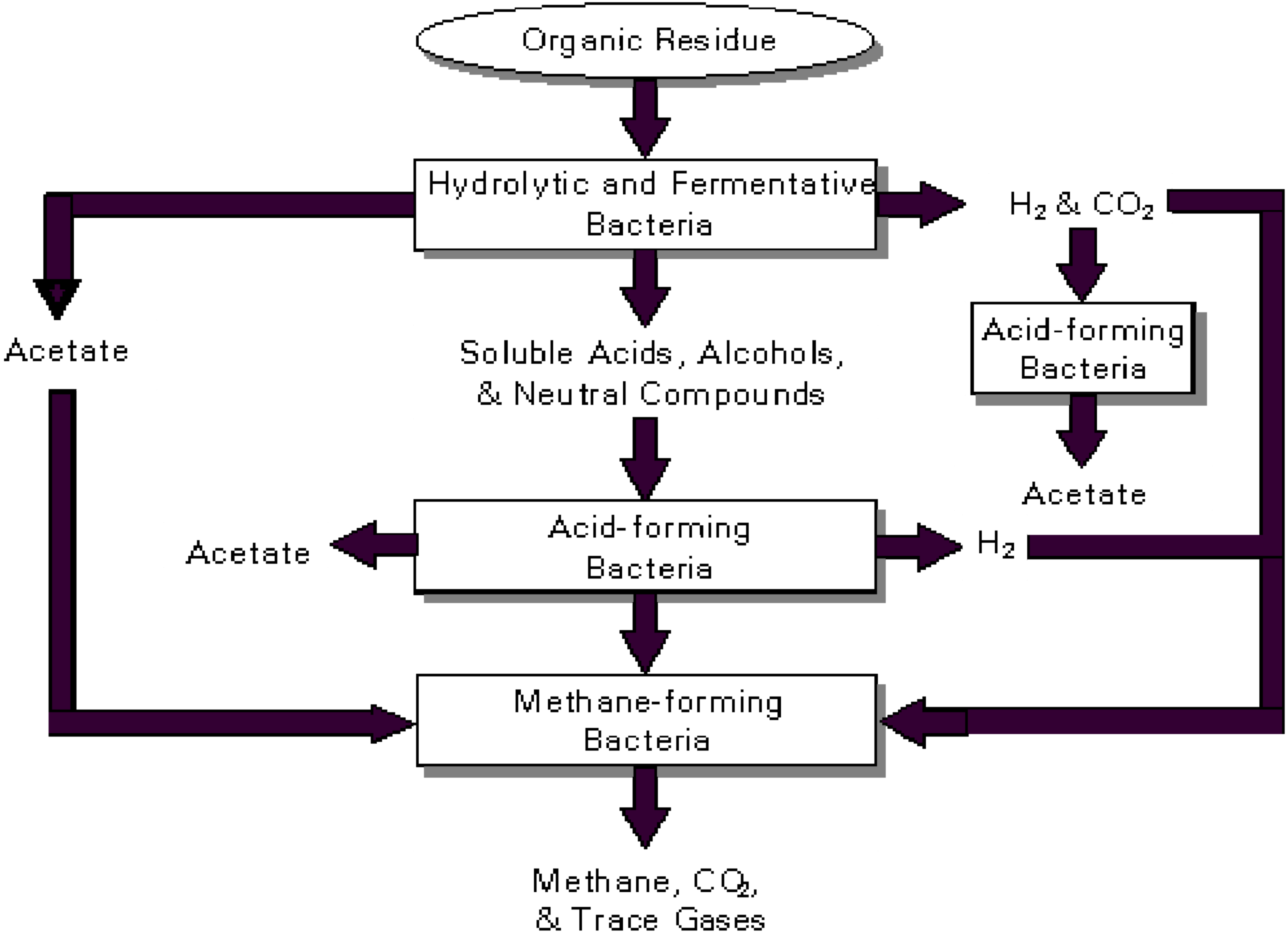
Algae, such as *Chlorella vulgaris,* is relatively easy to grow, but the algal oil is hard to extract. There are several approaches, some of which work better than others.

Fourth generation biofuels

An appealing fourth generation biofuel is based on the conversion of vegoil and biodiesel into gasoline. Craig Venter's company Synthetic Genomics is genetically engineering microorganisms to produce fuel directly from carbon dioxide on an industrial scale.


municipal solid wastes
recyclables
metal, glass, plastics, paper
material recovery pre-processing
waste (dry stream)
organic slurry
gasifier
heat
biogas
anaerobic digestion
residues
electricity steam
sludge
beneficial uses
composting

The Anaerobic Digestion Process



Biogas composition

- %55 -75 ***Methane, CH_4***
- %25 - 45 ***Carbon dioxide,* CO_2**
- **%1-10 Hydrogen, H_2**
- %0-0.3 ***Nitrogen, N_2***
- **%0-3 Hydrogen sulphide, H_2S**

Schematic classification of AD systems

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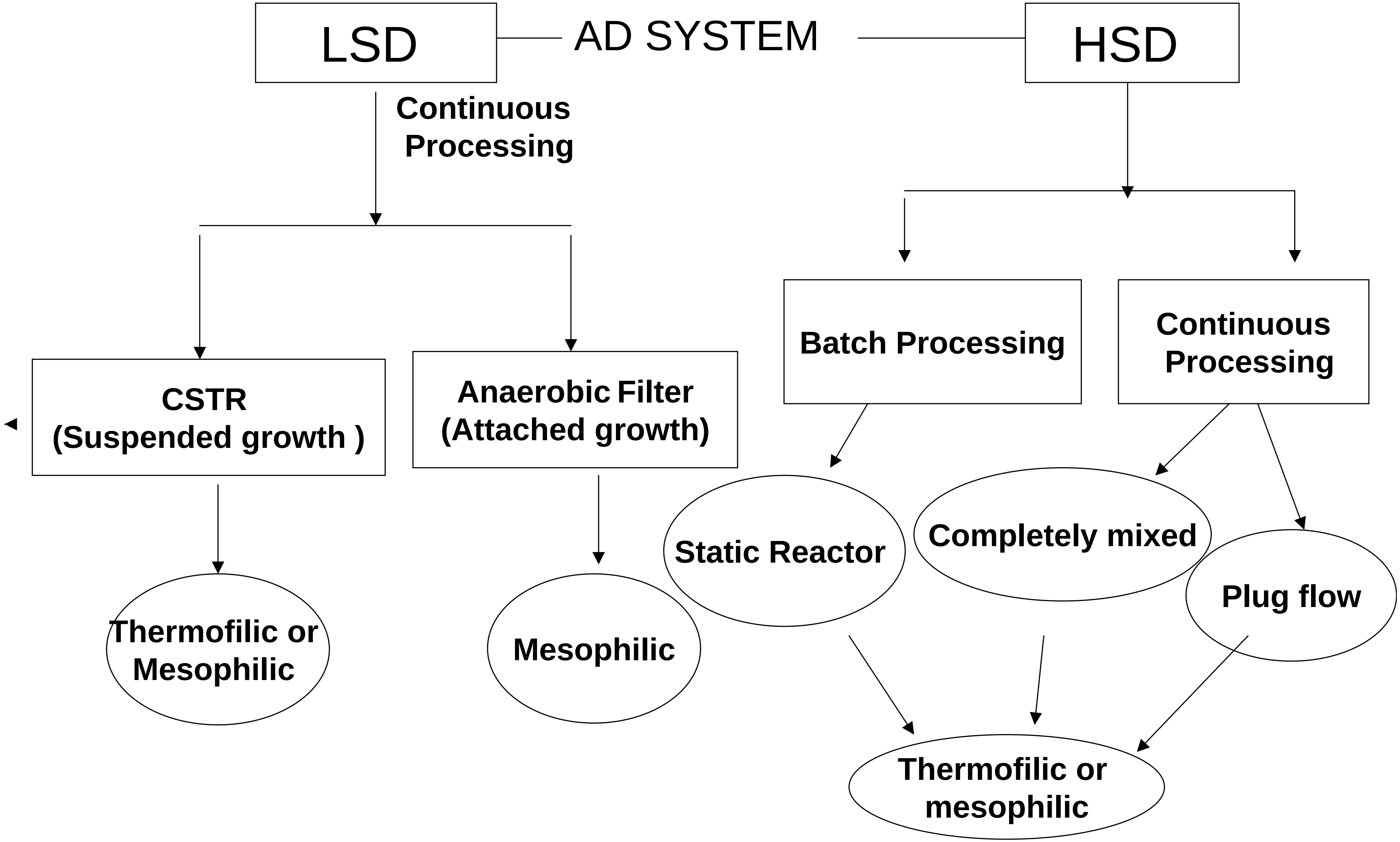
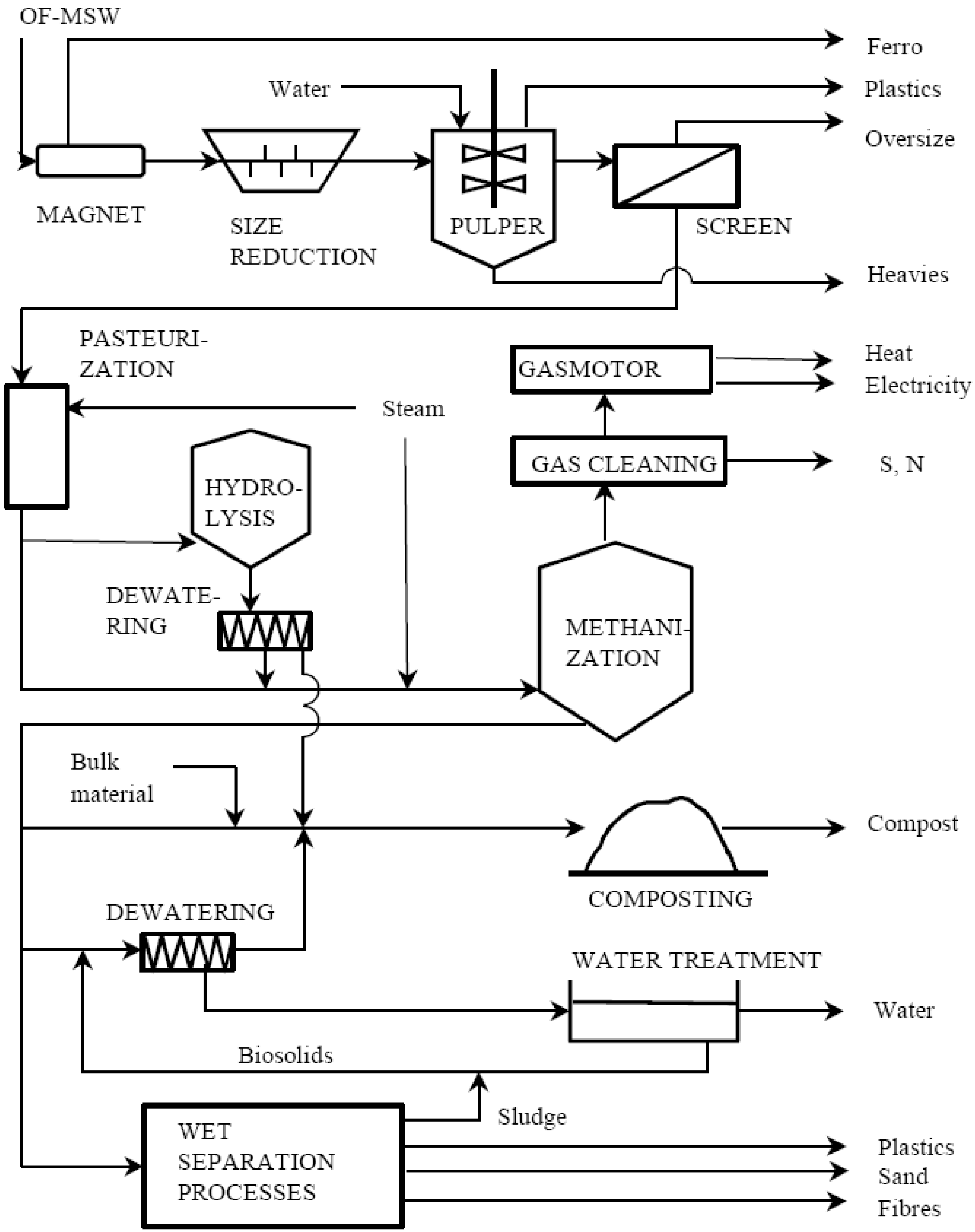


Country of AD Plants with capacity of 2,500 tonnes/yr

Country	No. of Plants in Operation	No. of Plants under Construction
Austria	10	0
Belgium	1	2
China	0	1
Denmark	21	1
Finland	1	0
France	1	0
Germany	30	9
India	0	4
Italy	4	2
Japan	0	1
Netherlands	4	0
Poland	0	1
Spain	0	1
Sweden	7	2
Switzerland	9	1
Thailand	0	1
UK	0	1
Ukraine	1	0
USA	1	2

Companies supplying AD Plants with capacity of 2,500 tonnes/yr or larger

Company & Nationality	No. of Plants in Operation	No. of Plants under Construction
Arge Biogas, (Austrian)	2	0
Entech, (Austrian)	7	4
Kompogas, (Swiss)	10	0
OWS-Dranco, (Belgian)	**4**	**1**
BTA, (German)	**11**	**0**
Steinmuller Valorga, Sarl (French)	2	4
Ecotec, (Finish)	**1**	**7**
C.G.Jensen, (Danish)	1	0
BWSC, (Danish)	3	0
NNR, (Danish)	6	0
Kruger, (Danish)	12	2
Bioscan, (Danish)	1	1
Prikom/HKV, (Danish)	2	0
Jysk, (Danish)	1	0
CiTEC, (Finish)	1	1
Linde – KCA, (German)	1	0
Schwarting UHDE, (German)	1	0
ANM, (German)	1	0
Haase Energietechnik (German)	1	1
DSD Gas und Tankanlagenbau (German)	2	0
IMK BEG Bioenergie (German)	0	1
Bioplan (Danish)	1	0
TBW (German)	**1**	**0**
BRV Technologie Systeme (German)	2	0
D.U.T. (German)	1	0
Paques Solid Waste Systems (Dutch)	3	1
Unisyn Biowaste Technology (USA)	1	0
Duke Engineering (USA)	0	2
WMC Resource Recovery (UK)	0	1
R.O.M. (Swiss)	1	1
Purac (Swedish)	1	0
SWECO/VBB (Swedish)	0	1
NSR (Swedish)	1	0
BKS Nordic (Swedish)	1	0
Projektror (Swedish)	2	0
Biocel/Heidemij Realisatie (Dutch)	1	0
Ionics Italba (Italian)	1	0
Kiklos (Italian)	1	0
SPI (Italian)	1	0
RPA (Italian)	1	0


OF-MSW
Ferro
Water
Plastics
Oversize
MAGNET
SIZE
REDUCTION
PULPER
SCREEN
Heavies
PASTEURI-
ZATION
GASMOTOR
Heat
Electricity
Steam
GAS CLEANING
S, N
HYDRO-
LYSIS
DEWATE-
RING
METHANI-
ZATION
Bulk
material
Compost
COMPOSTING
DEWATERING
WATER TREATMENT
Water
Biosolids
Sludge
WET
SEPARATION
PROCESSES
Plastics
Sand
Fibres

System	Organic Material	Pre Treatment	Process	Post treatment	Digester Volume
Ecotec, Germany (1995)	Source Separated household waste	Organic waste to fluidised Bed boiler	Single Stage T: 35 ^{0}C HRT:15-20 days	Slurry to be pasteurised at 70°C for 30 mins	5.0 m3 6500 tonnes/yr capacity

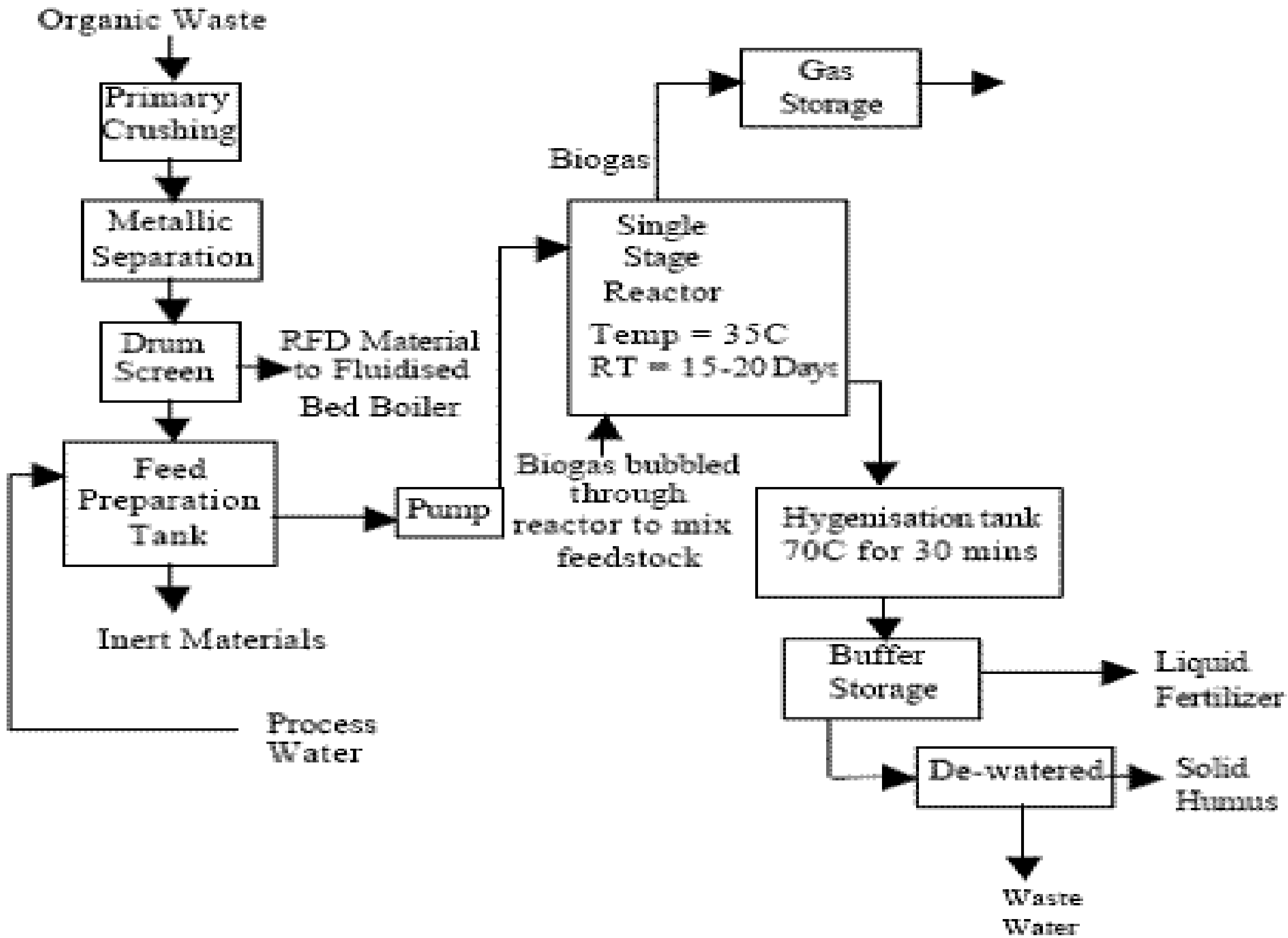
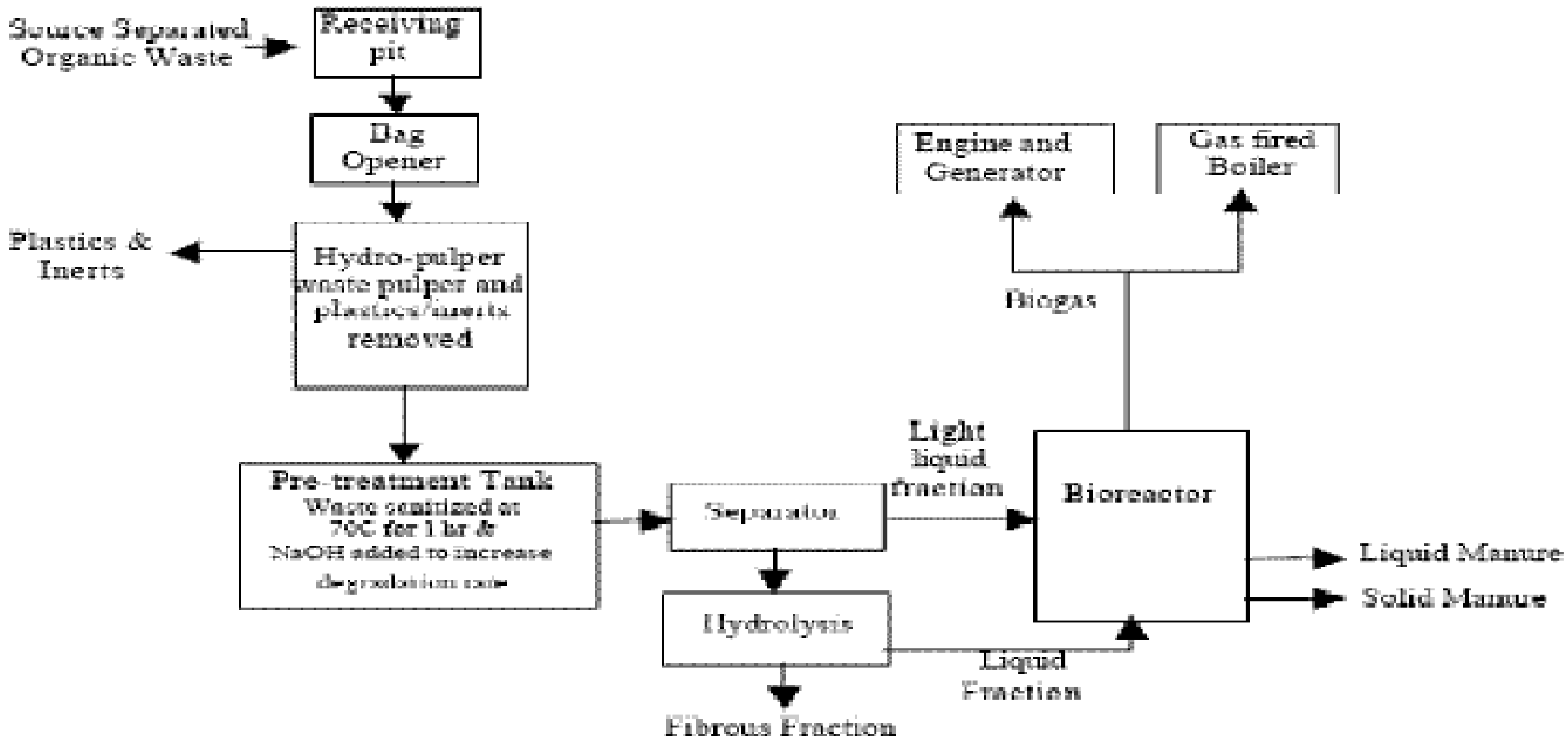


Figure 3.3.1 -1 Ecotec JVV Oy System

BTA, Denmark (1993)	Source Separated household waste	-Pulped -Plastic removed - Sanisitation - NaOH added - Material Separated into liquid and slurry	-Multi Stage -T: 38°C -Liquid from separation and Hydrolysis digested in reactor.	2.4 m3 20000tonnes/yr capacity

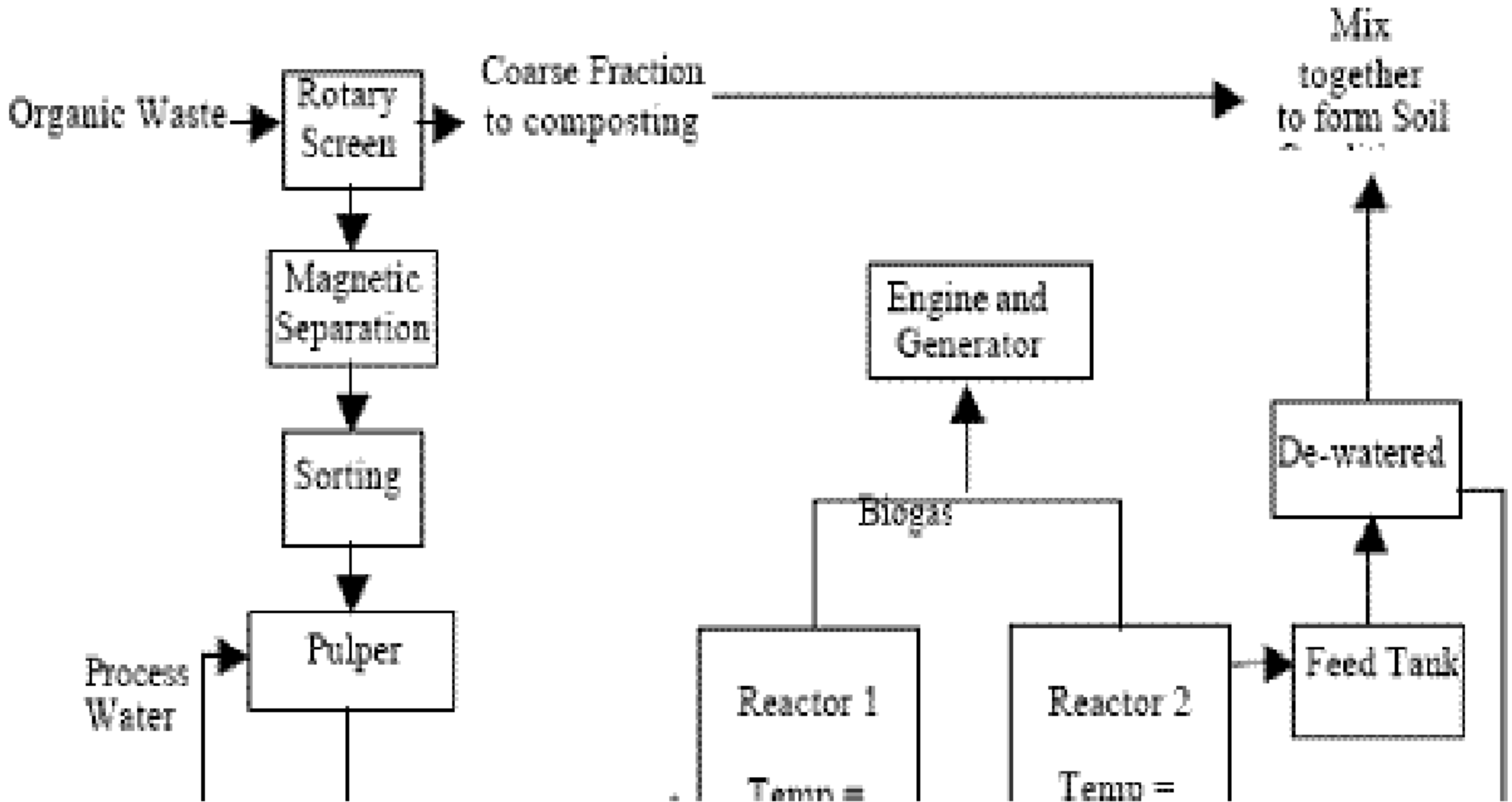


BTA/Carl Bro (Multi-Stage) System

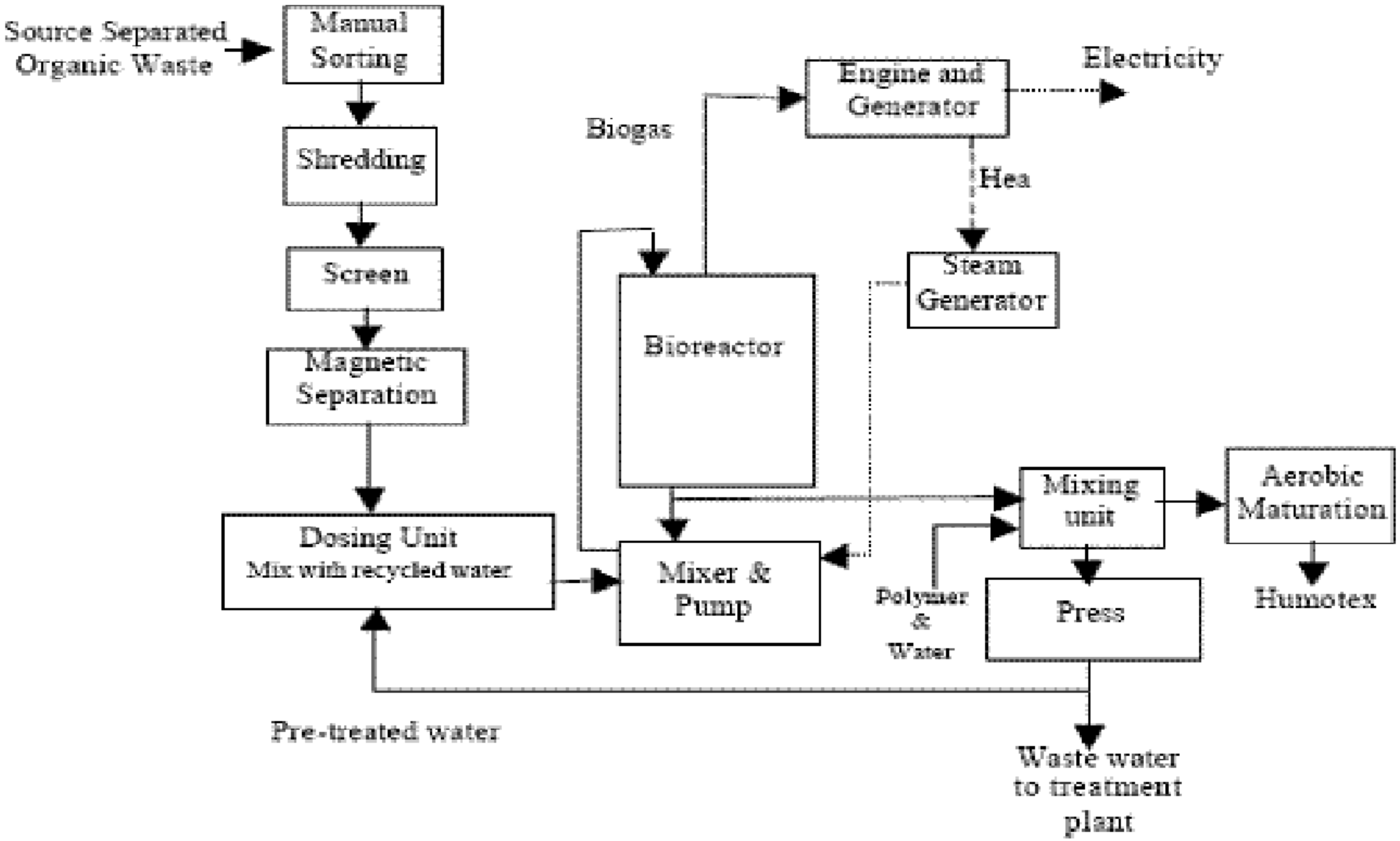
Operating BTA Plants

Location	Year	Capacity (Tons/year)	Waste Type
Newmarket (Canada)	Started in July 2000	150,000	Biowaste commercial waste organic sludges
Mertingen (District Donau-Ries)	Operation in spring 2001	1,000	Biowaste
Wadern-Lockweiler (Saarland)	-	20,000	Biowaste commercial waste
Erkheim (District Unterallgäu)	-	11,500	Biowaste commercial waste
Kirchstockach (Munich District)	Start-up in 1997 as MS digestion	20,000	Biowaste
Karlsruhe	Start-up in 1996. On a landfill area; automated feeding system; biogas utilisation.	8,000	Biowaste
Dietrichsdorf (Kelheim District)	Start-up in 1995 as SS digestion	17,000	Biowaste commercial waste
Elsinore* (Denmark)	Start-up in 1991 as MS digestion	20,000	Biowaste
Garching**	Operated 1986 till 1998. Used for tests in the area of R & D	6**	Tested various waste streams

TBW Biocomp Process, Germany (1996)	Source separated MSW	- Organic fraction seperation -Coarser material to aerobic decomp. by composting -Fine fraction pulped and mixed with liquid from digested sludge	2 stage reactors Stage 1: 35°C mesophilic Stage 2: 55°C thermophilic Retention time is 2 weeks in each reactors.	Solid part of sludge mixed with matured compost.	1000 m3 (for each reactor) 13000tonnes/yr capacity

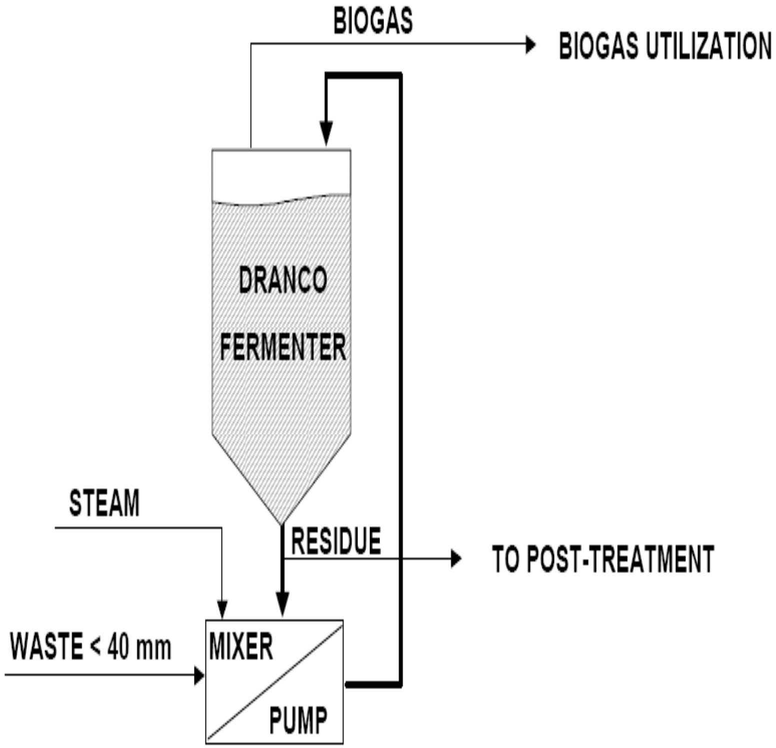


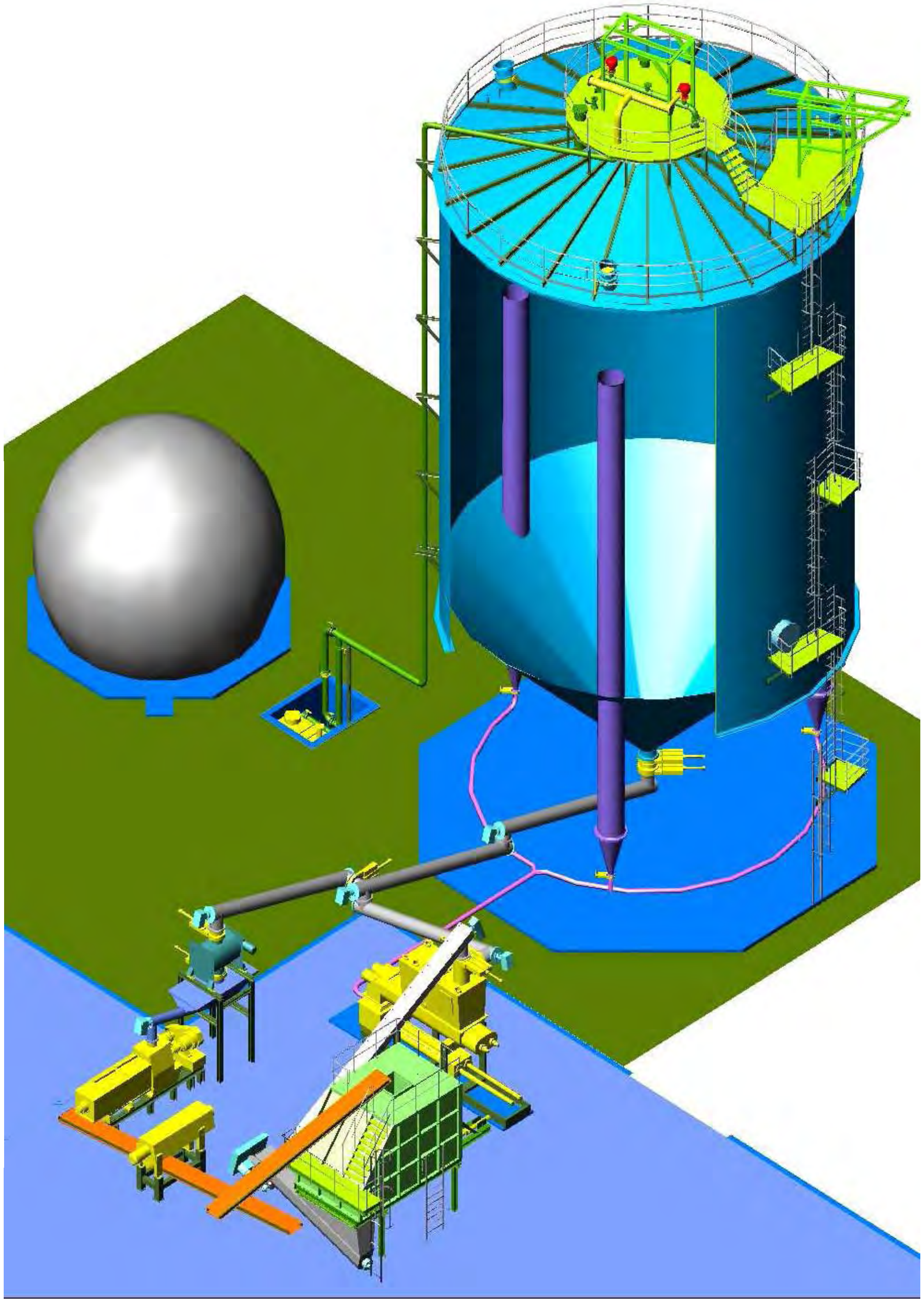
Organic Waste Systems-DRANCO Process (1992)	Source Separated household waste	Manually sorted - Shredded - Magnetic separator - Mixed with water	- Single Stage Thermophilic (50 –58°C) - Retention Time = 15 to 30 days	Sludge dewatered and stabilised aerobically for 2 weeks.	Capacity of Plant tonnes/yr 11,000 to 35,000



Organic Waste Systems - DRANCO Process

DRANCO PROCESS





Dranco installation Brecht, Belgium

	2002	2003	2004	2005*
FEEDSTOCK (T/Y)				
- BIOWASTE	45 394	45 691	51 229	52 190
- OTHER	966	1 776	2 525	2 110
TOTAL	46 360	47 467	53 754	54 300
PRODUCTION OF BIOGAS				
- M^3 BIOGAS (IN MILLIONS)	5.8	6.0	6.9	-
- M^3 BIOGAS/TON INCOMING	125	127	127	-
- M^3 BIOGAS/M^3/DAY	6.6	7.4	7.4	-
VOLUMETRIC CAPACITY USED	83%	70%	81%	-

*2005 BASED ON 31 WEEKS

Operating DRANCO Plants

Country	City	Year	Capacity (Ton/Year)	Waste Type
Belgium	Brecht	1992	12000	Biowaste/non recyclable paper
Austria	Salzburg	1993	13500	MSW/Sewage sludge
Switzerland	Aarberg	1997	11000	Biowaste
Germany	Bassum	1997	13500	Grey Waste
Germany	Kaiseser--slautern	1998	20000	Biowaste
Switzerland	Villeneue	1998	10000	Biowaste
Belgium	Brecth	1998	35000	Biowaste
Reference: www.ows.be				

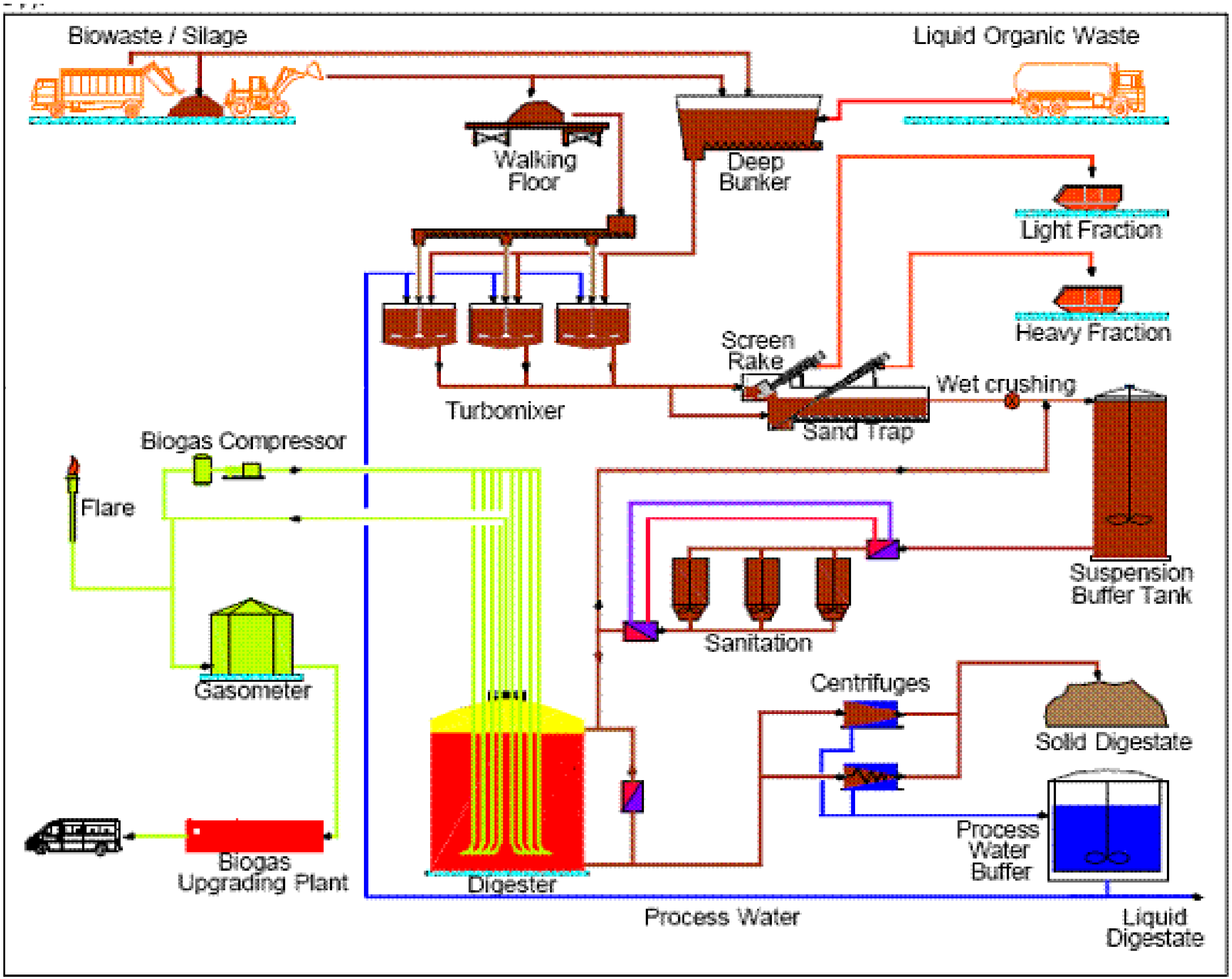


Illustration 3: **Procees flow diagram, Växtkraft digestion plant, Västerås, Sweden, 23.000 t/y**

Brecht AD facility outputs per ton of feed material

	Quantity (tons)
Compost product	0.3
Biogas	0.13
Wastewater	0.32
Residue	0.2
Costs and revenues	
Item	Millions of dollars
Investment Cost Administrative & Labor Cost** Operational Cost** Annual Charges**	$6.1 $0.24/year $0.24/year $0.32/year
Revenue Compost Total Revenue**	$122 per ton/feed $13 per ton /compost $1.51 million per year

Operating Valorga plants

Plant	Plant Start-up Year	Waste Type	Treatment capacity (Ton/year)	Digester Volume (m^3)	Gas Yield Nm^3/ton input digestion	Biogas end-use	Compost Use
Amiens, France	1988 1996	MSW MSW	85,000	3*2400 1*3500	140-160	High pressure steam for industrial use (5500 kW)	Agriculture
Engelskirchen(Germany	1998	Biowaste	35 000	2*3000	100-110	Heat & electricity (940 kW)	Agriculture
Tilburg, Netherlands	1994	Biowaste Or Biowaste + Paper	52 000 or 40000 + 6000	2*3300	80-85	Biogas treated and injected into Tilburg City distribution network	Agriculture
Hanover. Germany	Start-up 2002	MSW + sewage sludge	100000 +25000	3*4200	90	Heat & electricity	Landfill according to new legislation
Bottrop, Germany	1995	Biowaste	6500	1*1000	100-120	Heat & electricity	Agriculture
Varennes-Jarcy, France	2001	MSW + biowaste	100000	2*4200 1*4500	110-120	Electricity	Agriculture
Cadiz, Spain	2000	MSW	115000	4*4000	145	Heat & electricity	Agriculture
Geneva, Switzerland	Start up phase	Biowaste	10000	1*1300	110-120	Heat & electricity	Agriculture
Mons, Belgium,	2000	MSW + biowaste	23000 +35700	2*3800	110-120	Heat & electricity	Agriculture
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

EXAMPLE BIOGAS PLANT

- Karlsruhe: 156.575 tons of domestic waste from households (2007)

10.011 tons source-sorted (wet) biowaste

↓

Anaerobic digestion after defibering in the BTA hydropulper

Wet fermentation: Liquidification of biowaste

Rough crushing of stored biowaste in a grinding mill, transport to the hydropulper via a conveyor belt

The hydropulper is filled with **6 m^3** biowaste + **12 m^3** process water for 0.5 h defibering (320 kWh)

A spiral rotor creates shear forces for defibering of organics

After defibering removal of

- Plastics by flotation and skimming with a screen and of
- Coarse minerals, sand, glass debries etc. by sedimentation

Capacity:

→ 15 pulper fractions = ~ 70 t per day

Wet fermentation: Removal of fine sand

Fine sand removal by two hydrocyclons during interim storage of the suspension

Accumulation of **fine sand** in the digester to 2-3 m height after ~ 2 years due to ineffective fine sand removal

Anaerobic digestion in the methane reactor

CSTR reactor: Sized for **8000 t/a**

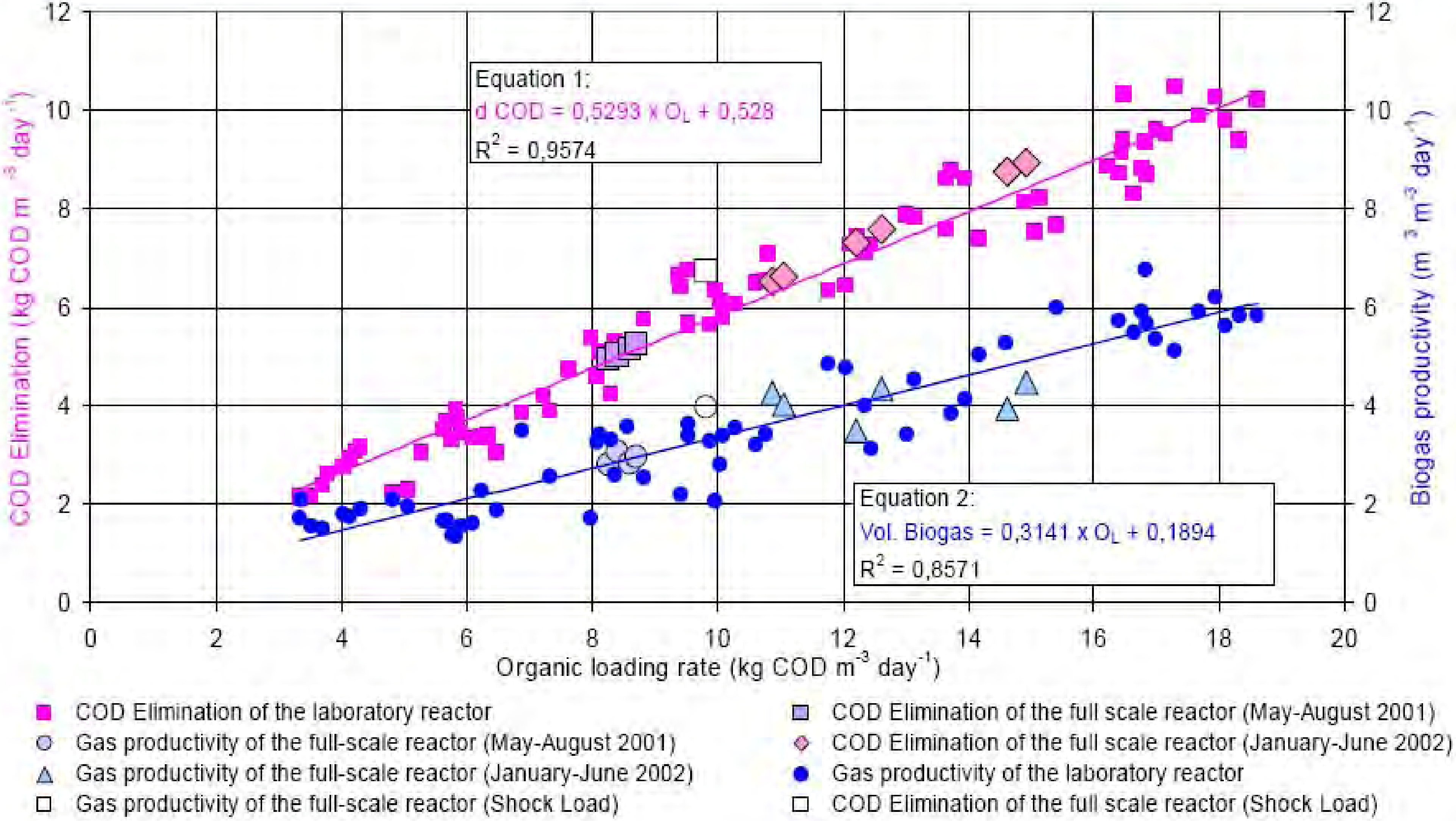
V_{Total} (m^3)	1350
$V_{Reactor\ min\text{-}max}$ (m^3)	960 - 1220
HRT (d)	12
O_L (Kg COD m^{-3} d^{-1})	7.5 – 8.5
$COD_{Elimin.}$ (%)	60
Biogas (m^3 d^{-1})	2234
Biogas (m^3 m^{-3} d^{-1})	2.3
CH_4 content (%)	65 – 70

↓

Increase of the biowaste amount in Karlsruhe by collection in all townships from 8000 t/a to → **12000 t/a**

HRT = Hydraulic retention time
O_L = Organic loading rate

Prediction of COD elimination and biogas formation with increasing organic loading rate



According to Eq. 2: Increase of the biogas productivity from **2.70** to **3.95** $m^3 m^{-3} d^{-1}$ by increasing the OLR from 8 to 12 $kg\ m^{-3} d^{-1}$

C. Gallert, A, Henning, J. Winter. Scale-up of anaerobic digestion of the organic fraction from domestic wastes. Water Res. 37,

Separation and composting of the digested residues

The digested suspension is separated into process water and solid residues in a centrifuge → addition of flocculants

"Process water" is re-used for preparation of the biowaste suspension

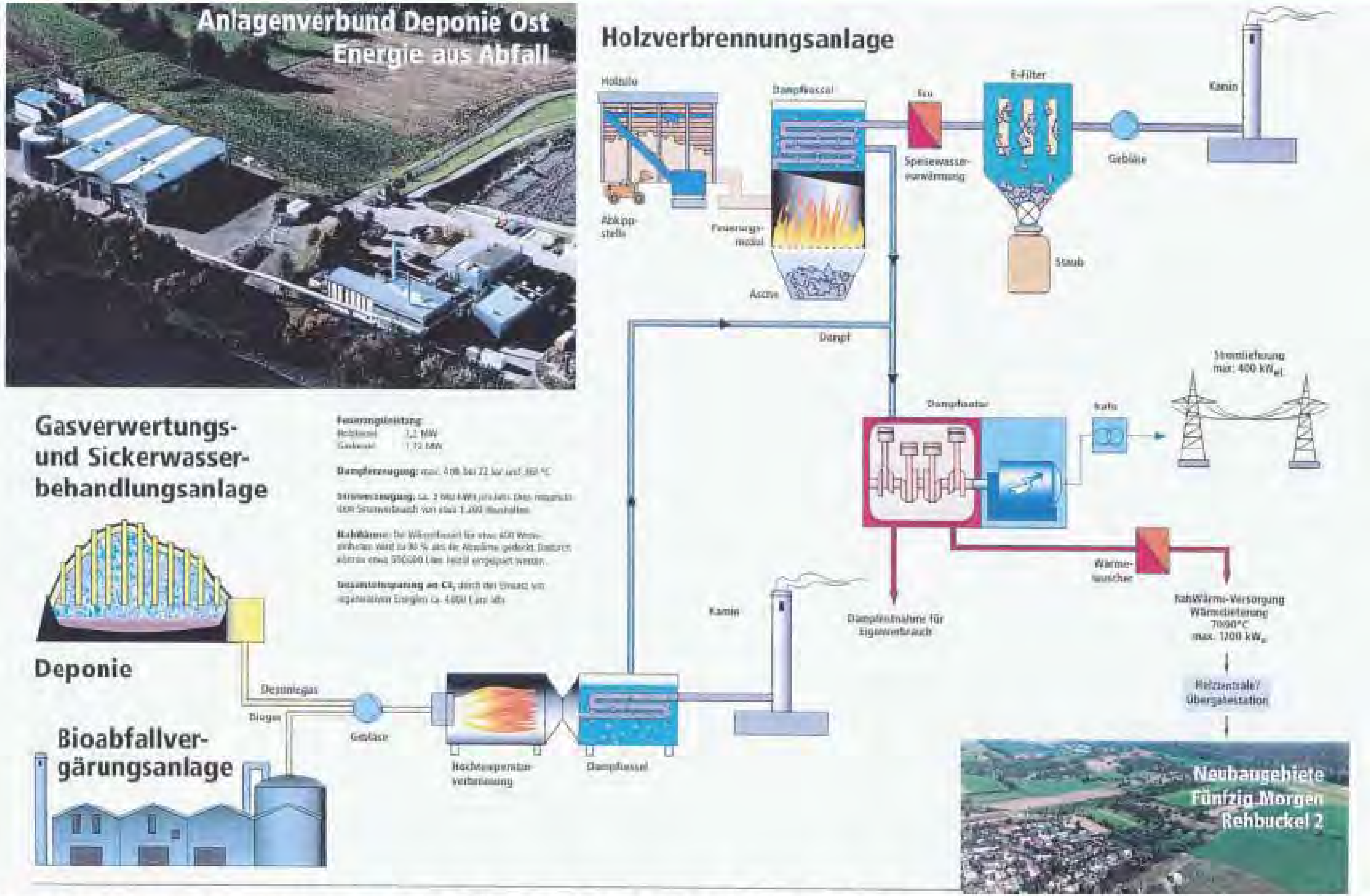
The solid residues are hygienised by composting in BIODEGMA-Boxes

Energy production from biogas

- Piping of the biogas (35 mbar) to a high temperature furnance and burning together with landfill gas (CH_4 content 52 %) → steam generation
- Conversion of steam in a Spilling steam engine → off-heat and electricity

At > 50 mbar the pressure valve will guide the biogas to the emergency torch

Integrated energy concept of Karlsruhe



Decreasing amounts of landfill gas increased the CH_4 content in the biogas to 62 % → gas burning is no longer an efficient method → Replacement of the steam driven engine by a biogas engine

Evaluation of Dry Anaerobic Digestion
for Izmir city

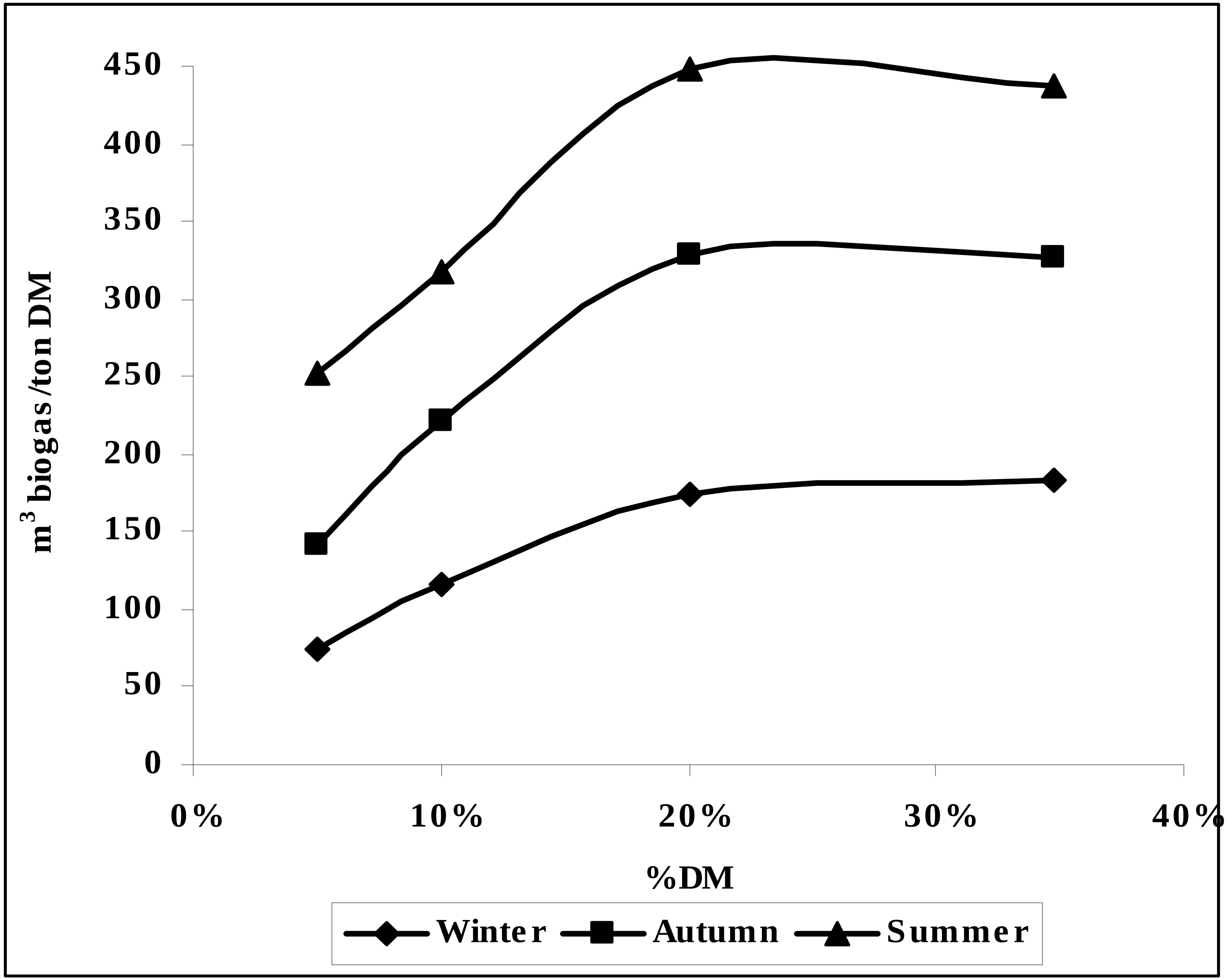


Table. Reduction fo GHG gases depending upon biofuel production method (Renewable Energy Directive COM (2008) 19

Production Method of Biofuel	Reduction in GHG emission (%)
- Ethanol from wheat (use of coal in combined heat and power plant)	21
- Ethanol from wheat (use of natural gas as a process fuel)	45
- Ethanol from wheat (use of straw as a process fuel)	69
- Ethanol from corn (use of straw as a process fuel)	56
- Ethanol from sugarcane	74
- Biodiesel from rapeseed seed	44
- Biodiesel from sunflower	58
- Biodiesel from Palm oil (process is not defined)	32
- Biodiesel from Palm oil (no CH4 emission to atmosphere)	57
- Biodiesel from waste cooking oil and animal oil	83
- Biodiesel from vegetable oil	57
- Biogas poduction from municipal solid waste and use as CNG gas	81
- Biogas poduction from wet animal manure and use as CNG gas	86
- Biogas poduction from dry animal manure and use as CNG gas	88

HOPE TO BE LOOKING AT OUR OWN PLANT IN NEAR FUTURE IN IZMIR

Thank you for your attention!

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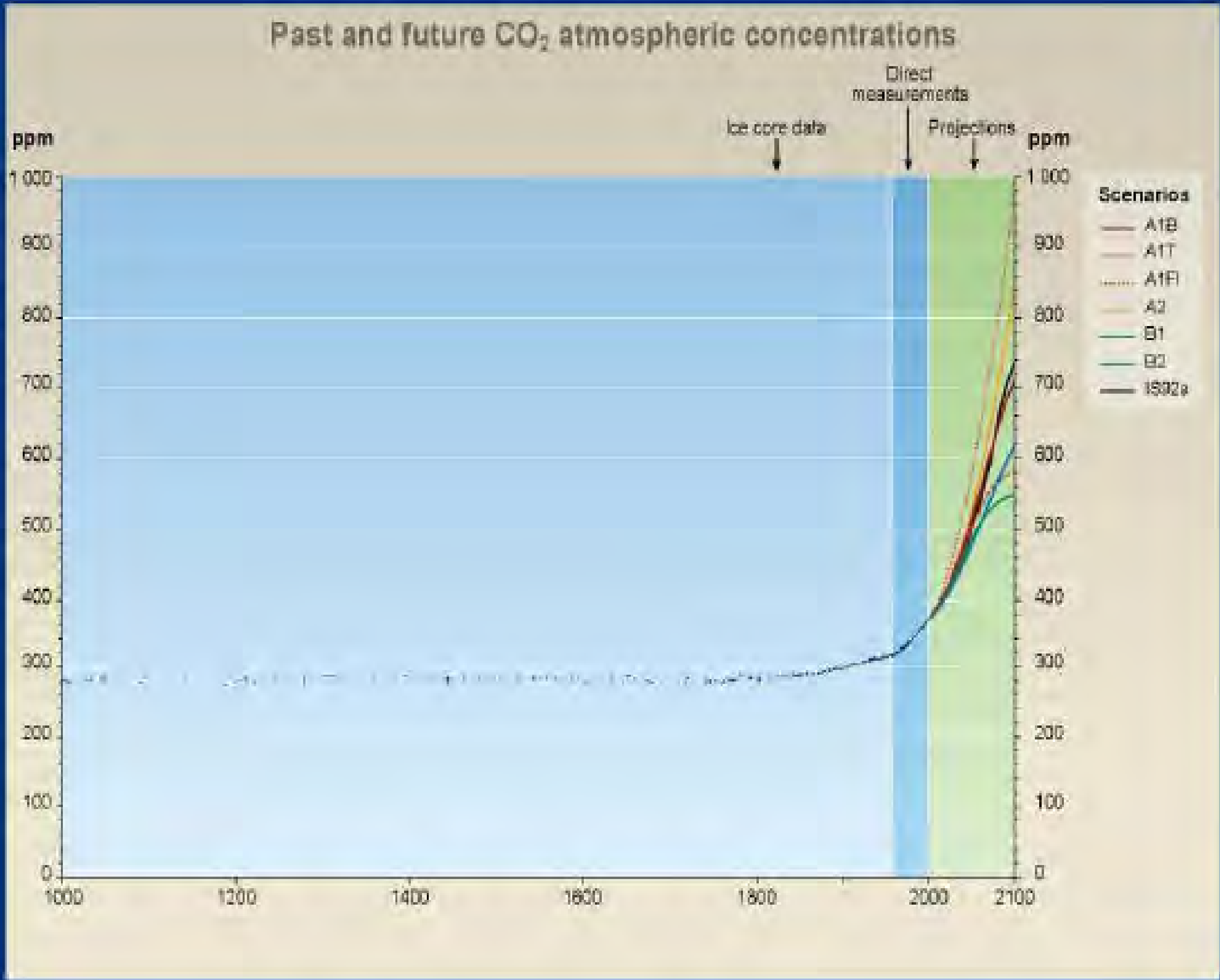


SYR - FIGURE 9-1a

IPCC

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

WMO UNEP

Global Warming: Arctic ice cap, 1979 and 2003.

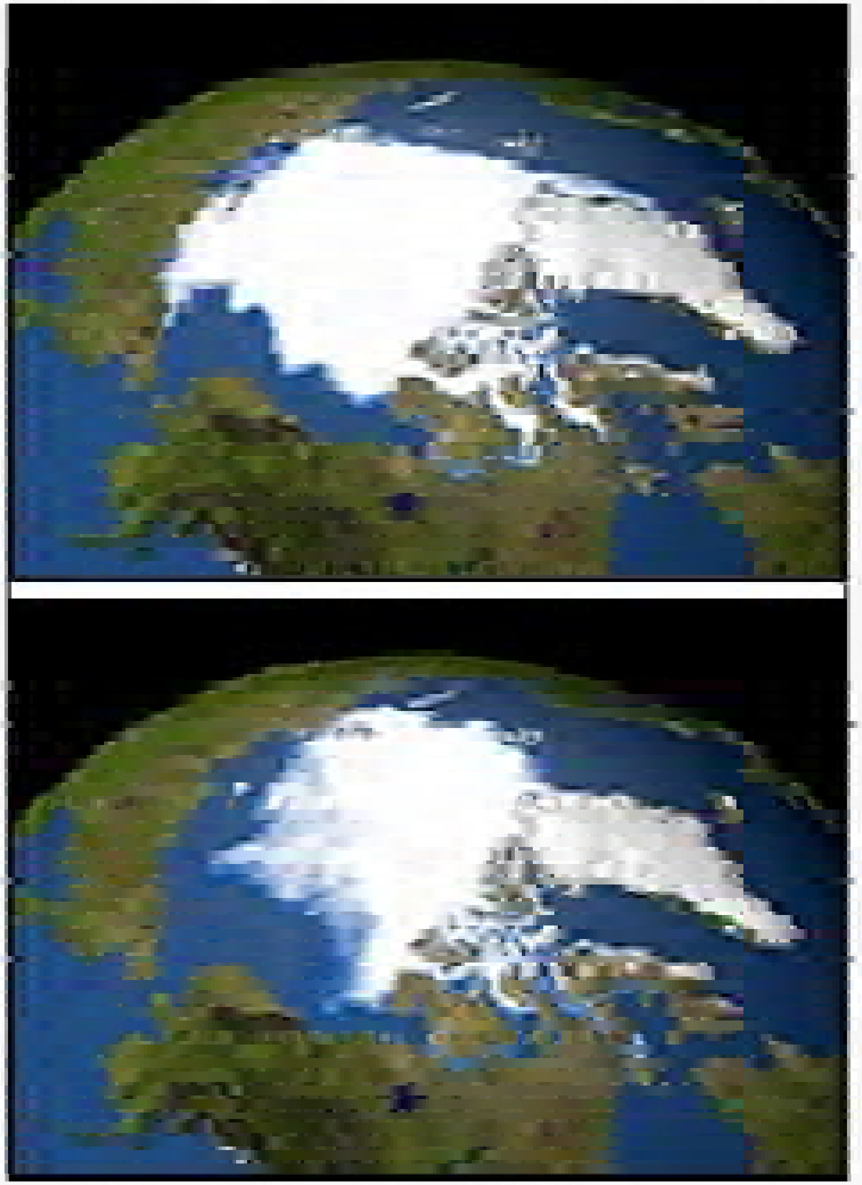
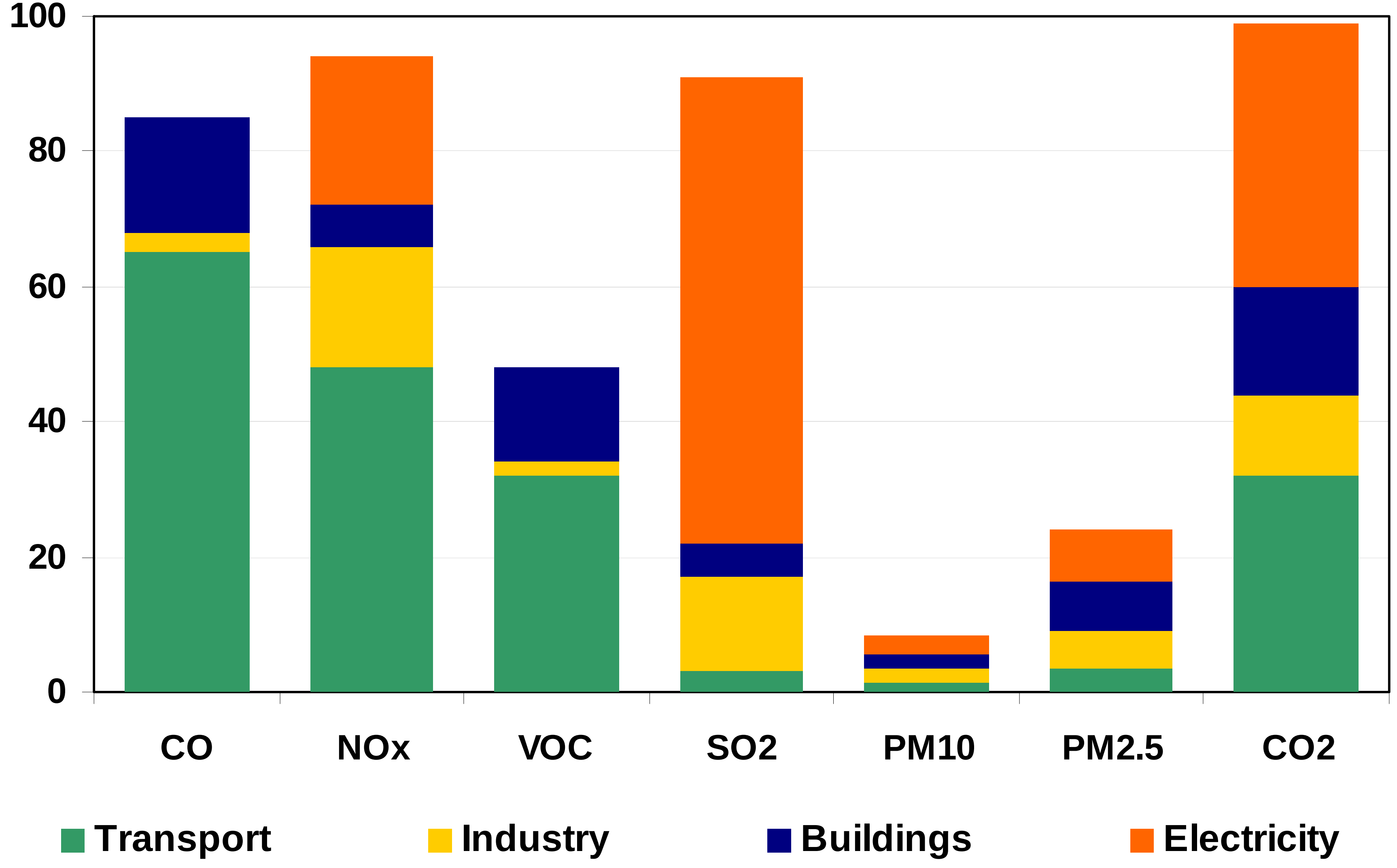
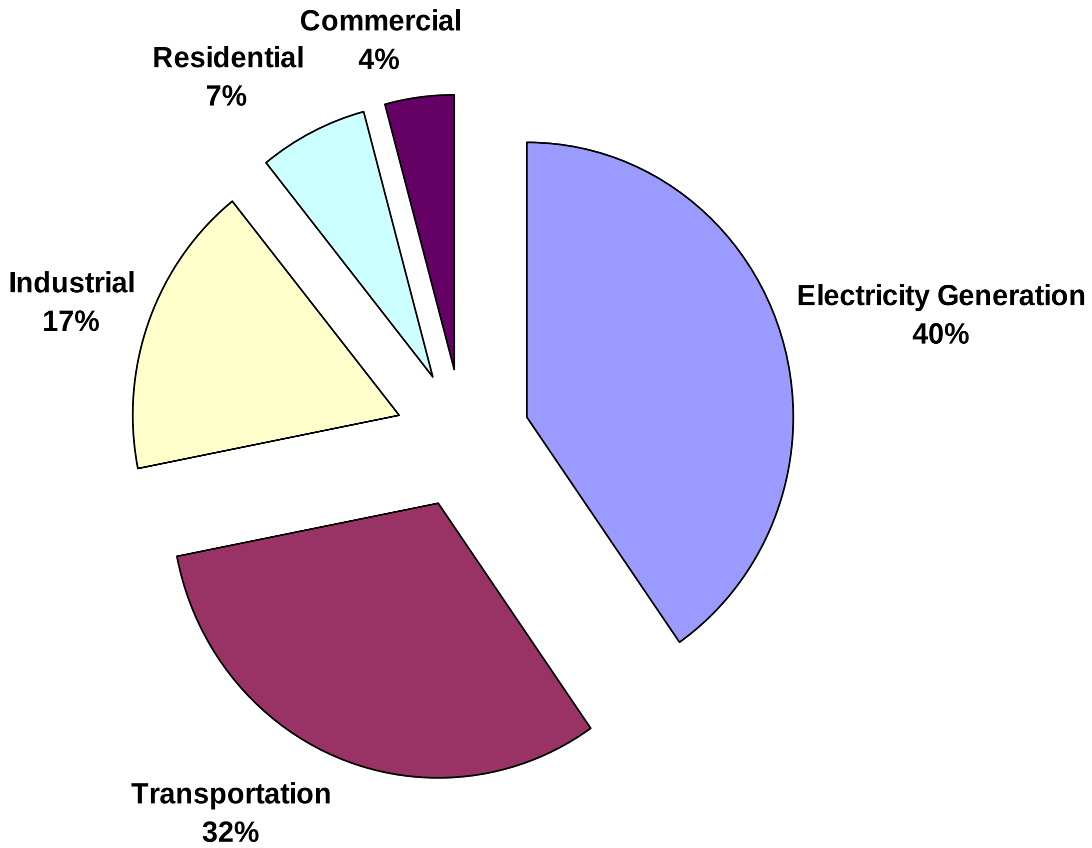


Photo: NASA/
New York Times

Pollution parameters by each sector (%)



US Fossil Fuel CO2 Emissions



Recoverable Bioenergy Potential in Turkey

Type of biomass	Energy potential (ktoe)
Dry agricultural residue	4560
Moist agricultural residue	250
Animal waste	2350
Forestry and wood processing residues	4300
Municipality wastes and human extra	1300
Firewood	4160
Total bioenergy	16,920