Gasification of Municipal Wastewater Primary Sieved Solids in a Rotary Drum Reactor

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Presentation Structure

New concepts for
energy recovery from wastewater

The microscreen process for removal of
primary solids

Ultra high temperature (uht) gasification

Primary fine-sieved solids to syngas

Conclusions and future plants

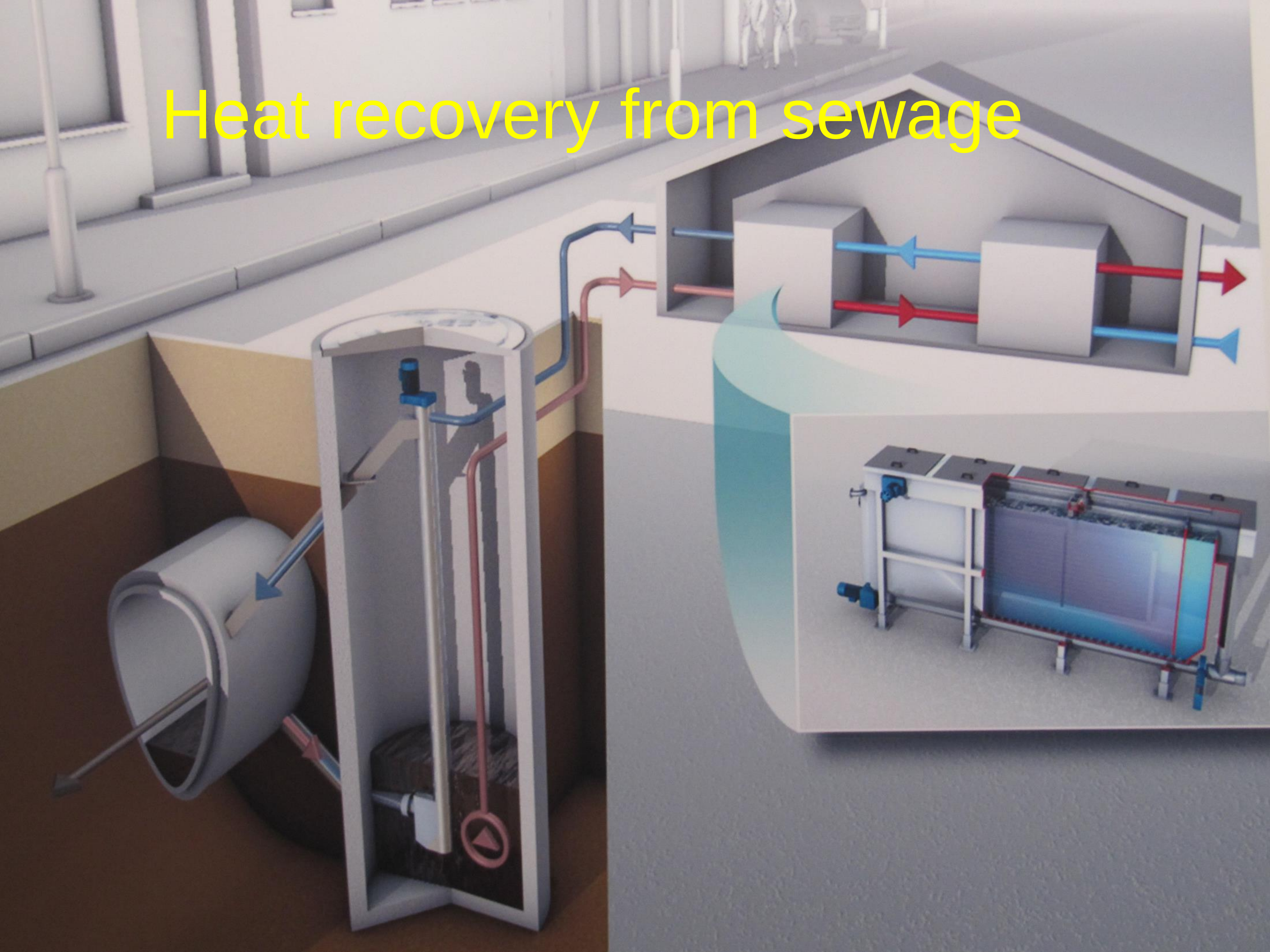
New Concepts for Energy Recovery from Wastewater

- Employ energy efficient design
- Use heat pumps to recover energy from sewage
- Use fine cloth screen as replacement for primary sedimentation at wastewater treatment plants
- Use fine cloth screen within the collection system to recover energy constituents
- Recover energy from dried solids by combustion, pyrolysis or gasification and generation of electricity

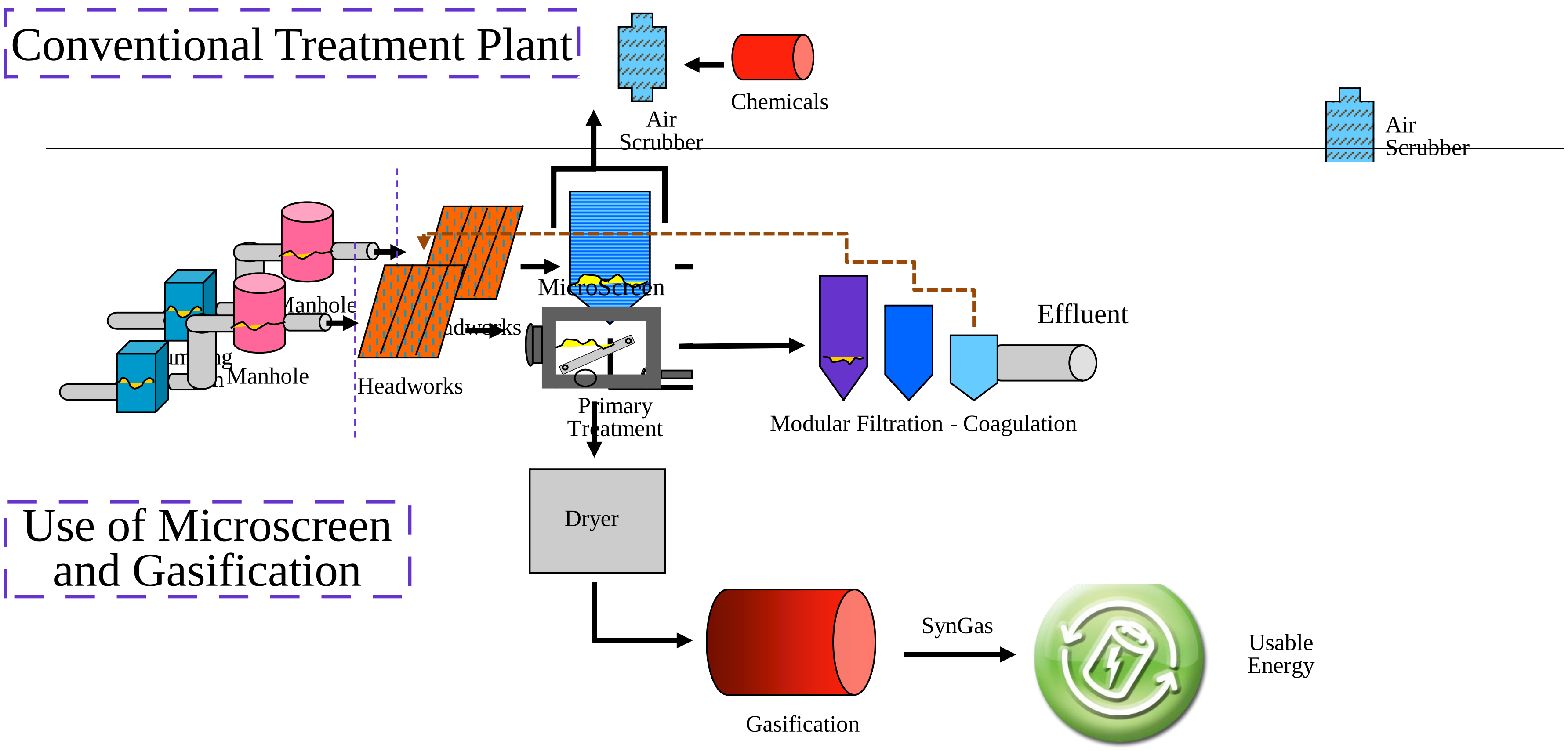
Deficient Energy Design

At 0.03 €/kWh Energy Efficiency was not an Issue.
Example: Excessive Headloss (Energy Loss)
at Primary Sedimentation Tank Weir

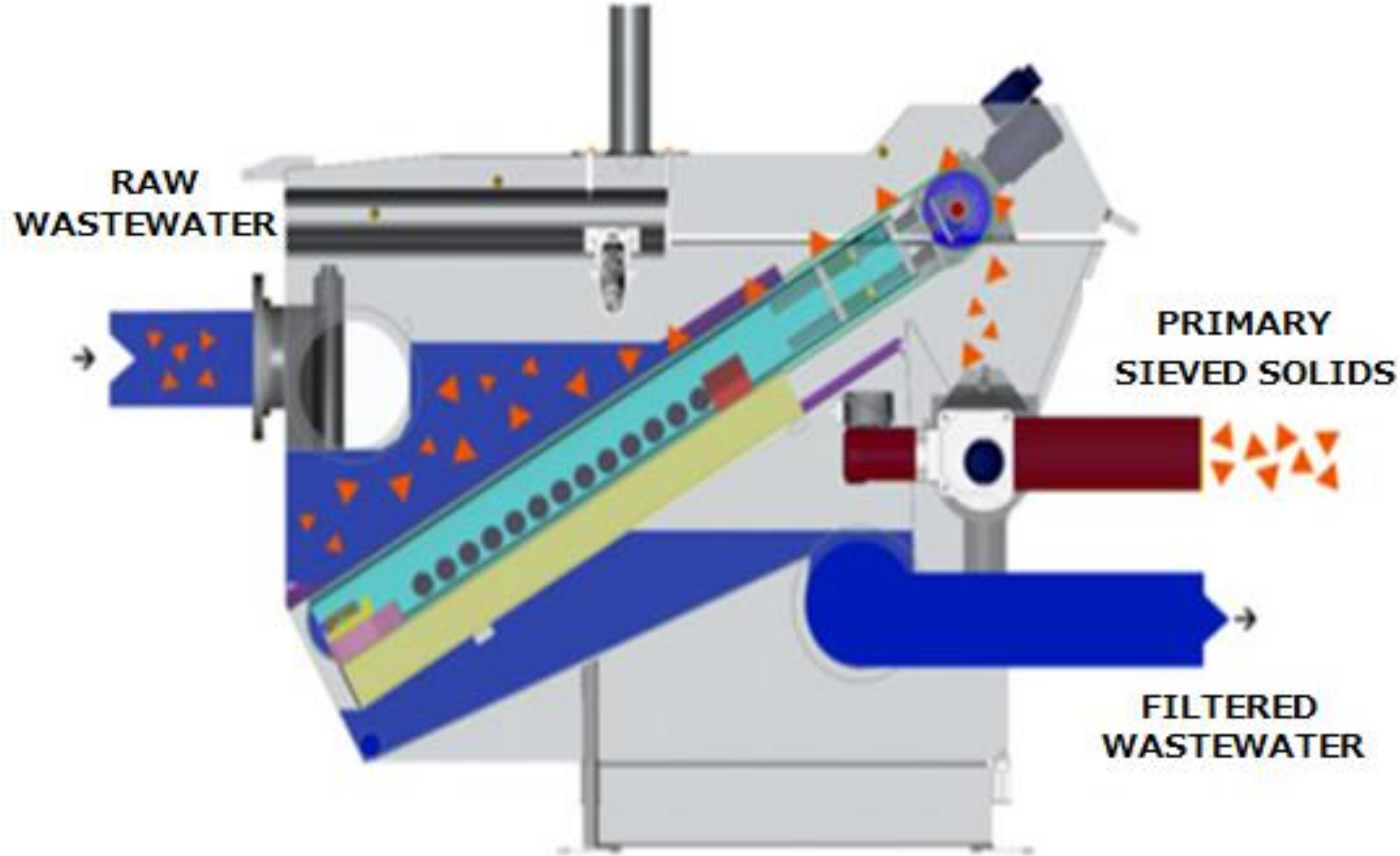
Heat recovery from sewage



Wastewater Treatment Process Flow Diagrams



Microscreen - Operating principle




a

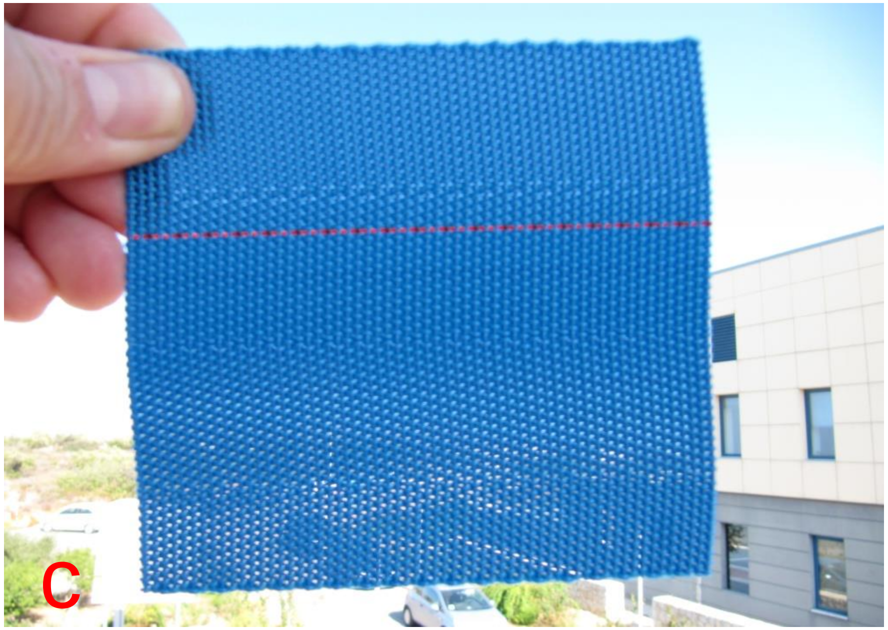
Microscreen

a. Microscreen with open housing

b. Belt Scraper and Screw Auger

c. Microscreen cloth (350µm openings)


b


c

Primary Fine-Sieved Solids

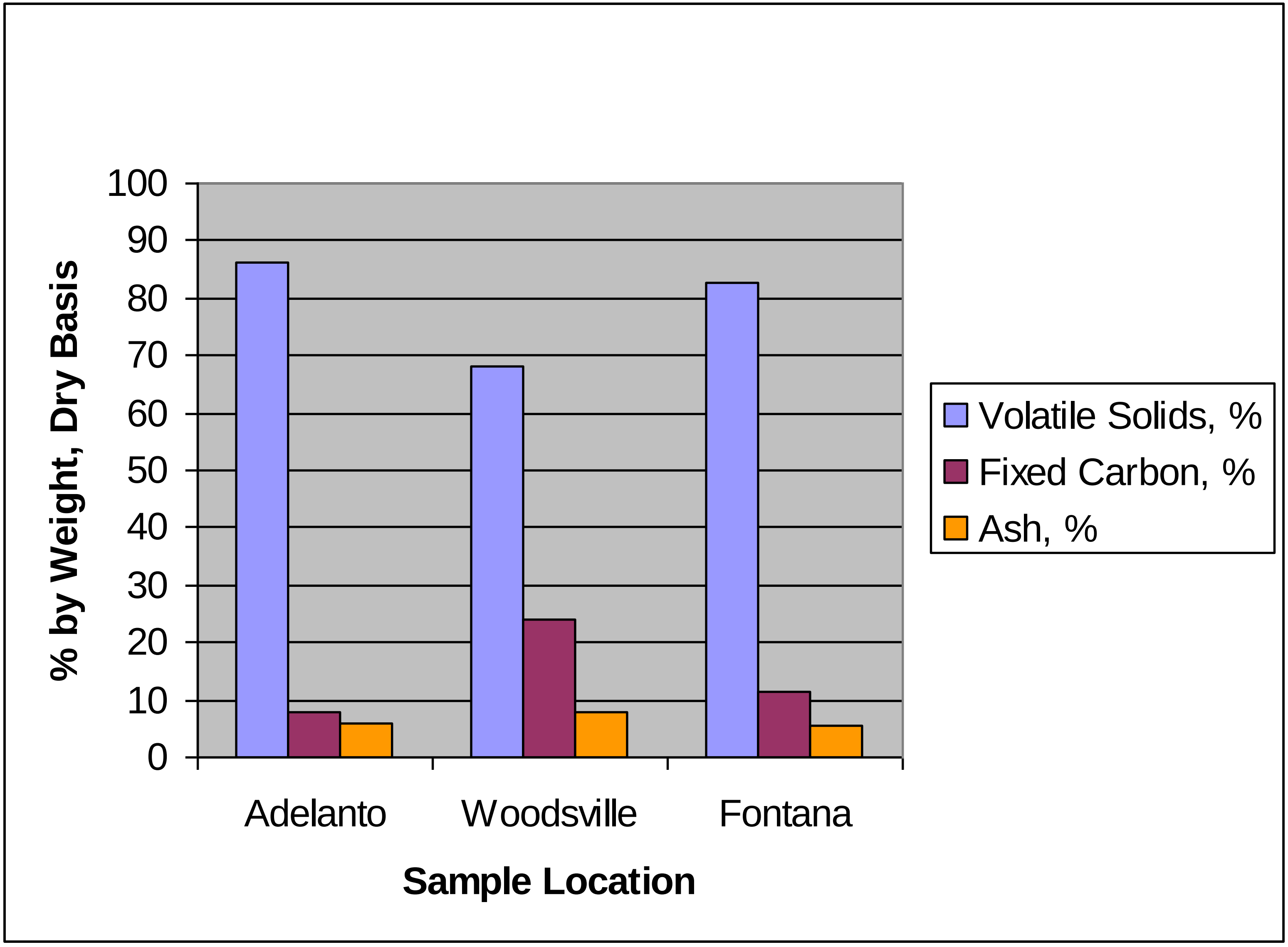
Pressed “primary fine-screened solids” exiting compression auger

- Solids removed right after the headworks at a wastewater treatment plant
- Composition (mainly): tissue paper, food waste, feces particulate, mixed plastics
- May be dewatered mechanically to over 40% solids, due to high cellulose content
- May be used as a feedstock to generate energy
- Removing solids at the beginning of the plant will increase treatment capacity, improve biology kinetics and reduce or eliminate secondary sludge

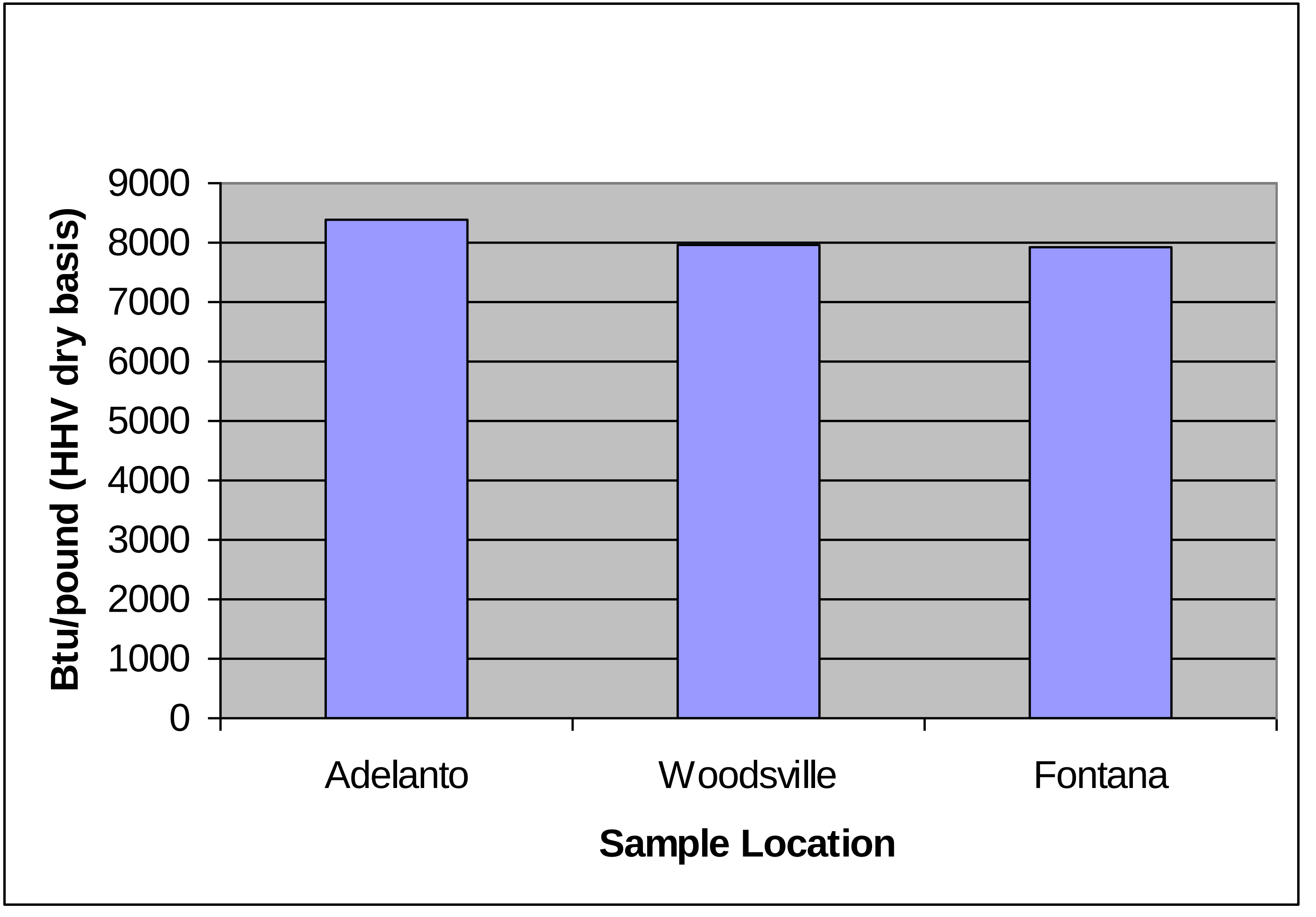

Microscreen Installations: (a) Adelanto, CA
(b) Fontana, CA
(c) Woodsville, NH

Microscreen (Patra, Greece)

Primary Fine-Sieved Solids Proximate Analysis



Primary Fine-Sieved Solids BTU Value (dry basis)



Btu value of dry woodchips is about 8000 Btu/pound

Biosolids management for energy production

BIOSOLIDS

Anaerobic digestion

- Converts only a fraction of carbon to methane
- Produces sludge as byproduct
- Bioprocess, and thus susceptible to instability
- Well received by the public

Direct combustion

- May produce harmful byproducts
- Production of solid residue (with tar)
- Incomplete conversion of carbon to gaseous species
- Not well received by the public

Gasification

- Production of clean combustible gas
- Production of solid residue (no tar)
- Technology still under development
- Complete conversion of carbon to gaseous species
- Confused with combustion by the public

Biosolids: Gasification versus anaerobic digestion*

Net electrical energy production per 1000 m^3 of raw wastewater

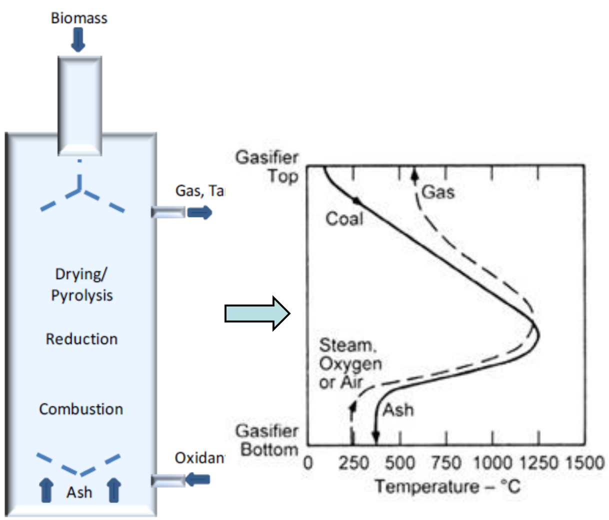
450 kWh

237 kWh

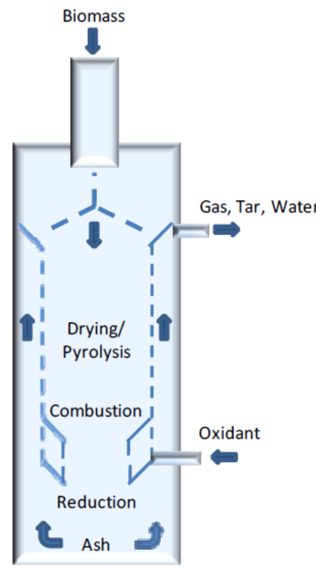
Wastewater treatment energy requirements per 1000 m^3 (kWh)	
Upfront solids removal process	Activated sludge process
150-230	**330-660**

* P. Gikas, 2014, Environmental Technology, 35(17), 2140-2146

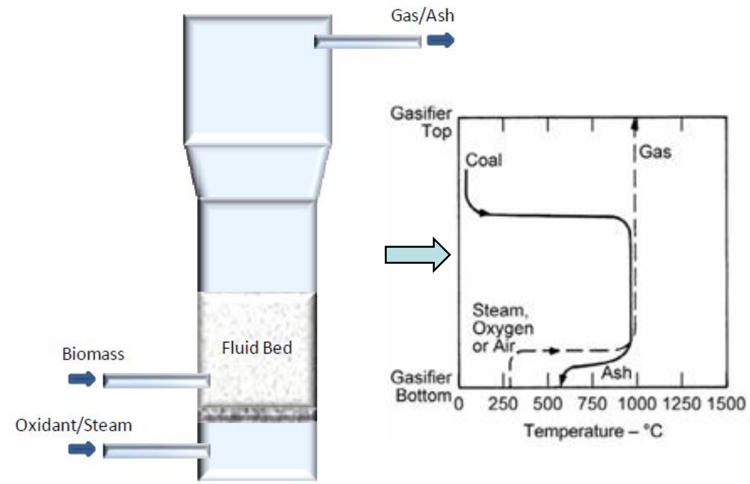
Main types of gasifiers



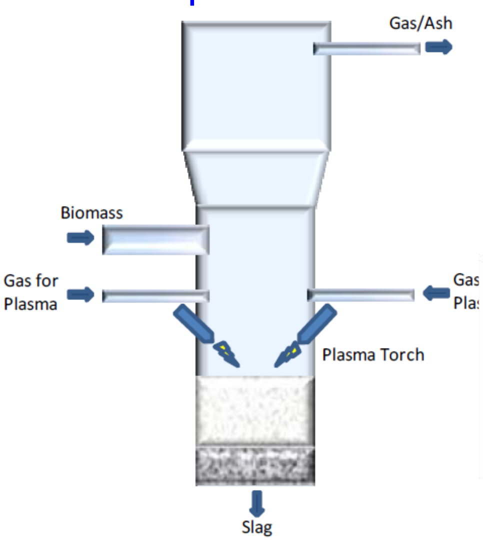
Updraft



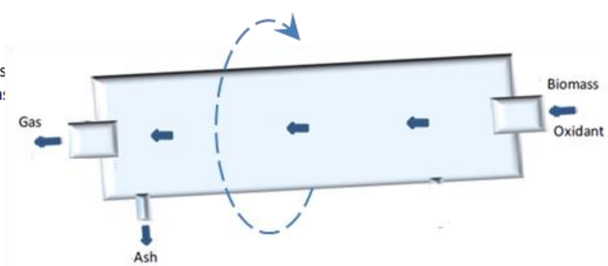
Downdraft



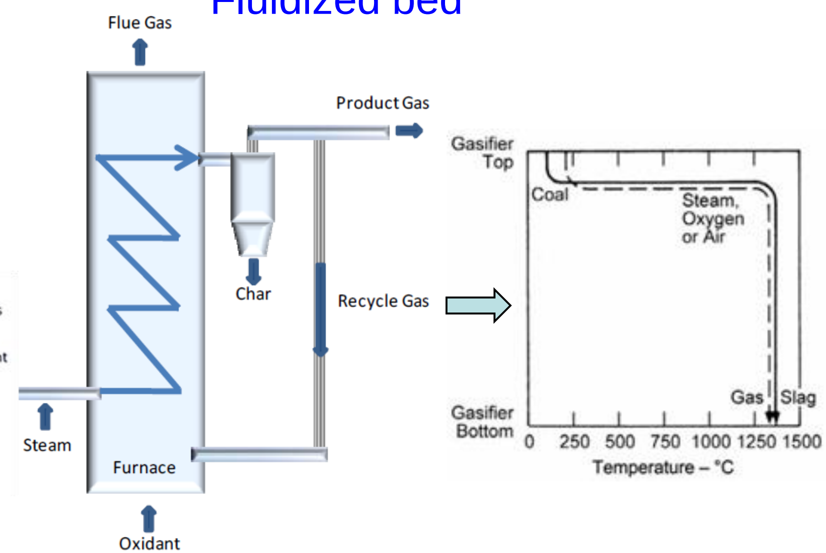
Fluidized bed



Arc plasma



Rotary drum

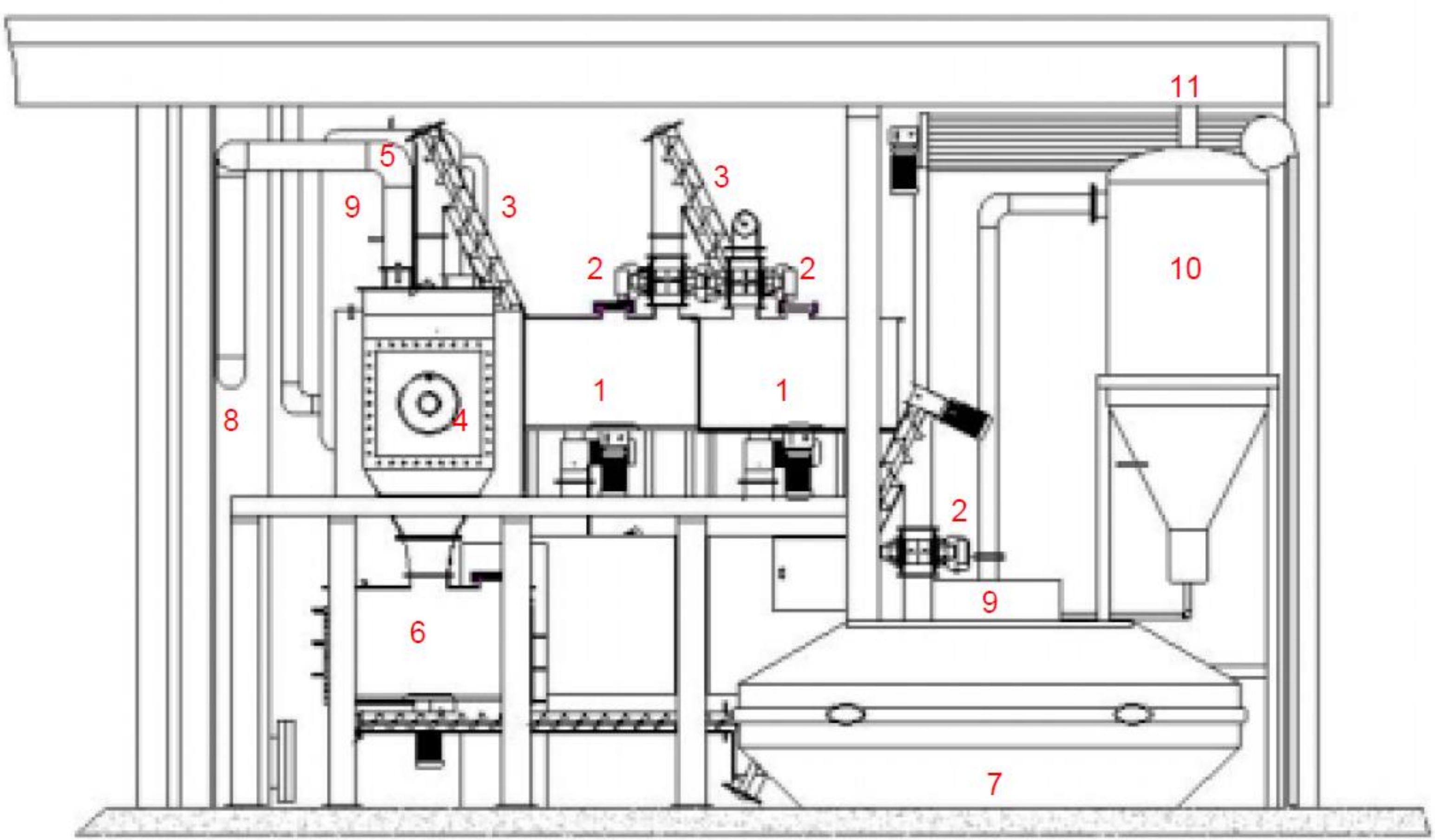


Entrained flow

Ultra High Temperature (UHT) Gasification

- Standard sizes: 5 tpd or25 tpd
- Rotating cylindrical nickel-chromium or molybdenum alloy reactor with impregnated heat resistant coating and proprietary electric heating element
- Operating temperatures of 1100˚C to 1500˚C
- Air tight operation to prevent nitrogen dilution
- Complete thermal decomposition of all organic matter into syngas, typically 62% H_2 and 31% CO (depending upon feedstock and reactor temperature range)

The Pyromex UHT gasification process



(1) input material storage tank
(2) rotation valves
(3) feed auger
(4) Reactor
(5) raw syngas pipe
(6) inert residue outfeed
(7) inert residue silo
(8) condenser
(9) scrubber
(10) cyclone
(11) clean syngas pipe to storage tank

25 ton/d UHT Pyromex Gasifier

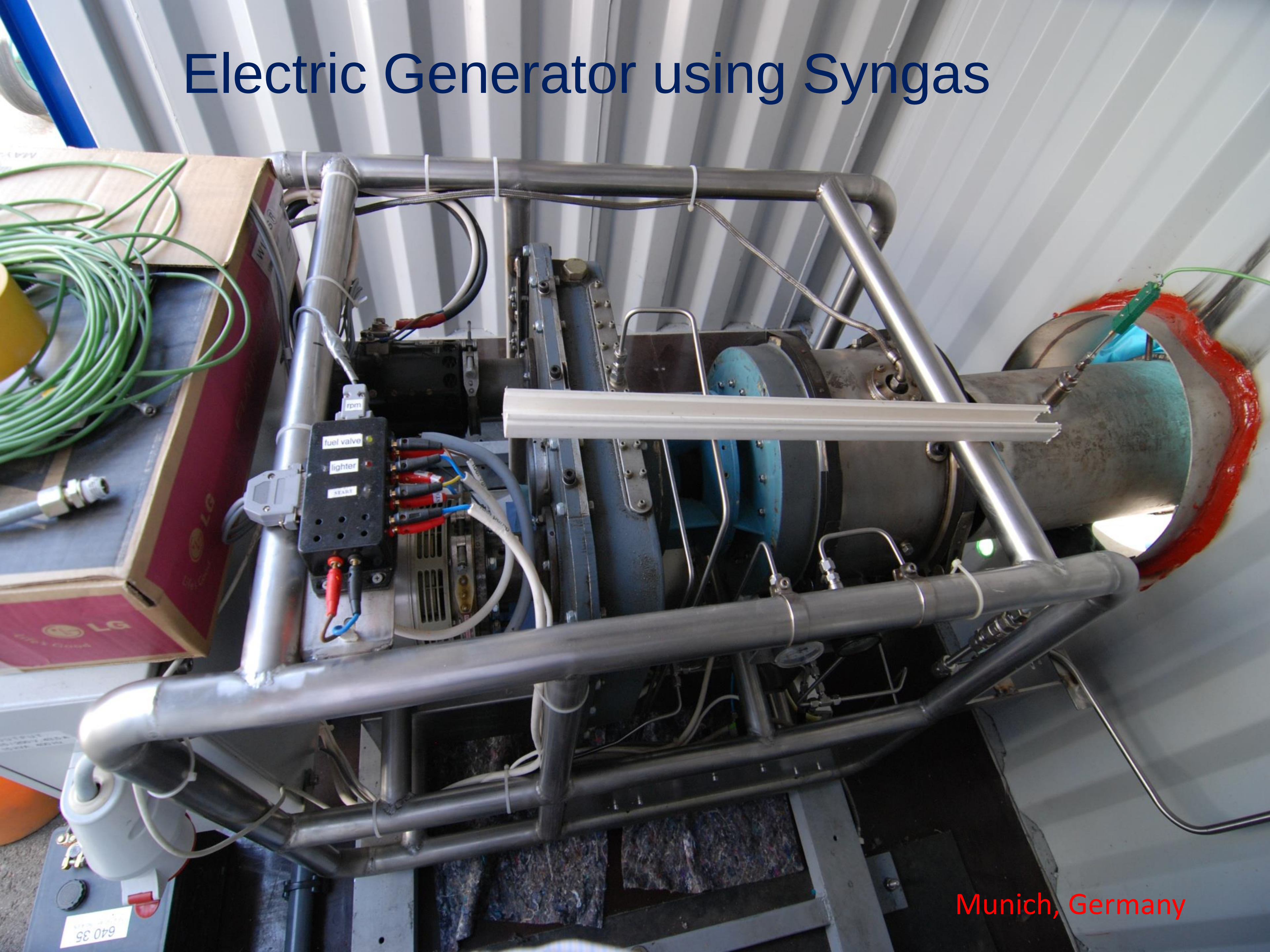
25 ton/d UHT Pyromex Gasification Cylinder

Munich, Germany

25 ton/d UHT Pyromex Syngas Striping

Munich, Germany

Electric Generator using Syngas



Munich, Germany


UHT Pyromex Gasifier
(Used in the Experiments)
Munich, Germany

Feedstock

a. Primary fine sieved solids partially dried

b. Primary fine sieved solids after size reduction

Overall Inlet and Outlet from the Gasifier

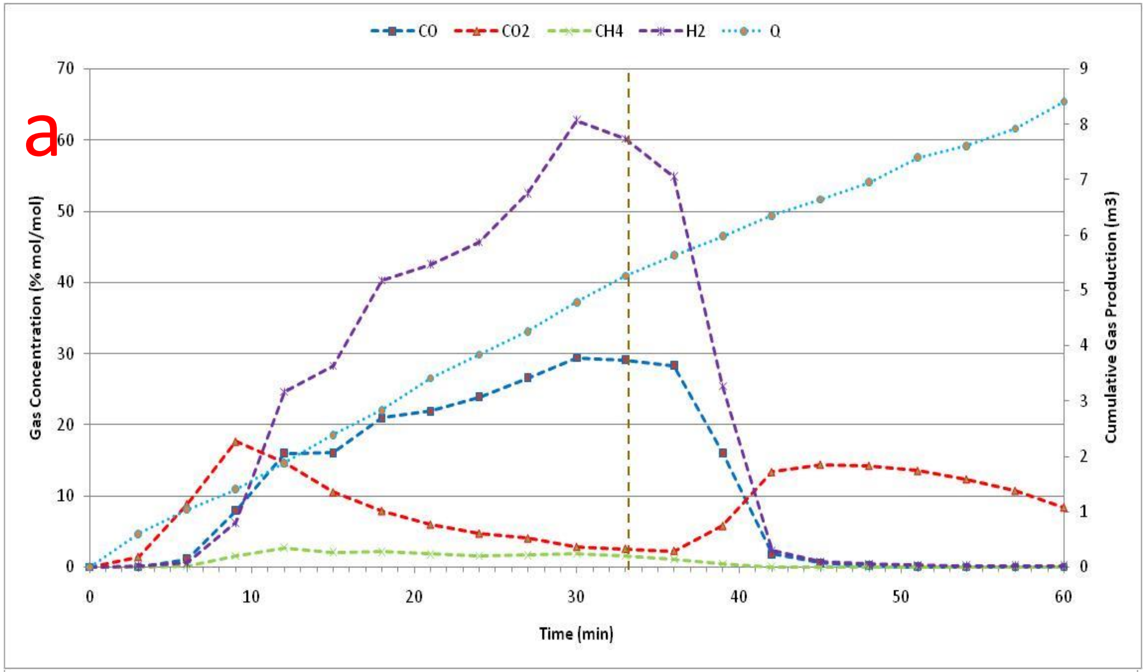
Run No	P F-S solids (kg)	Moisture (%)	Temp. (˚C)	CO (%)	CO_2 (%)	CH_4 (%)	H_2 (%)	Other gases (%)	Ash (kg)
Run1	8.15[a]	17	1050	29.87	2.63	1.79	62.96	2.75	0.52[b]
Run2	8.15[a]	17	950	29.86	4.14	2.92	62.18	0.90	0.52[b]

a: Combined weight of infeed charge for Run1 and Run2
b: Total measured weight of ash from both Run1 and Run2 combined

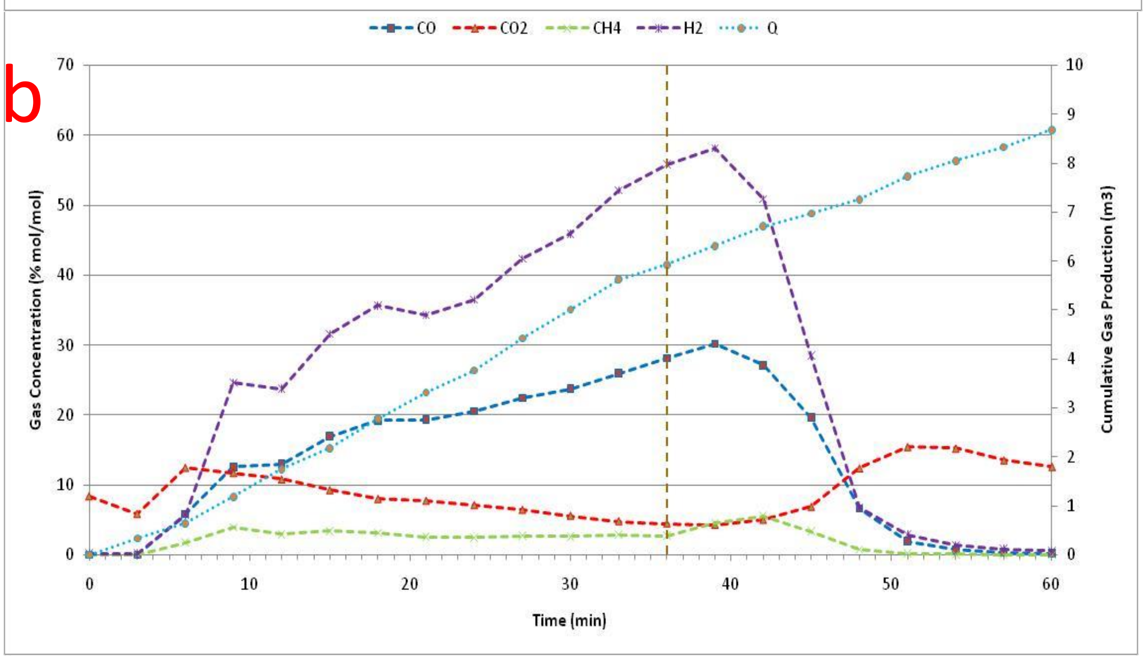
Syngas production → 1.56 m^3 / kg (17% wet basis)

Energy production → 12.63 kJ / kg (17% wet basis)

Syngas composition and production rate

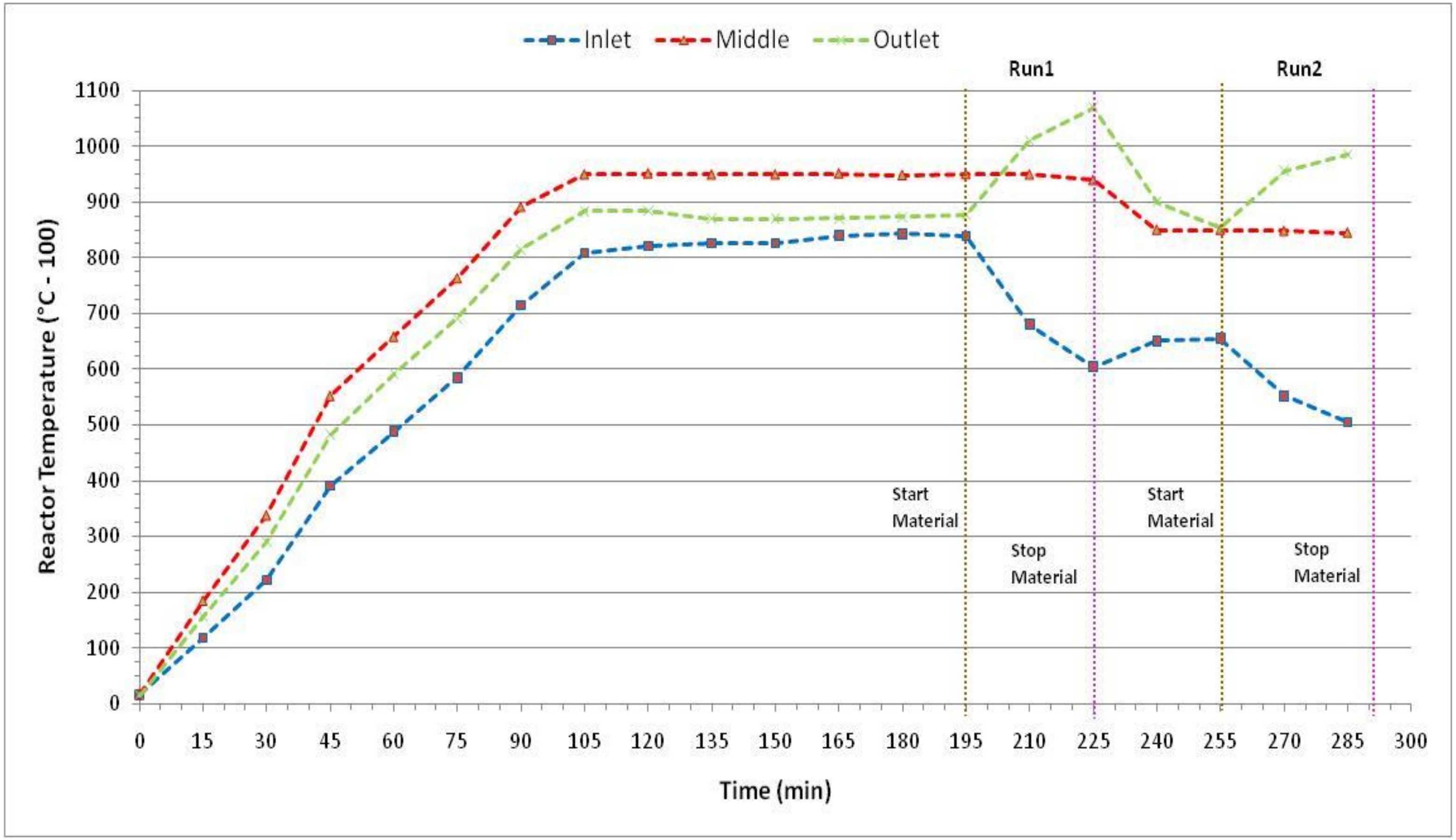


a. Run 1: Maximum temperature = 1050 °C



b. Run 1: Maximum temperature = 950 °C

Reactor Temperature versus Time



Ash from the UHT Pyromex Gasifier

Mass and Energy Balance (Combined Runs)

29.8% CO
3.8% CO_2
2.3% CH_4
62.7% H_2
1.4% other

Heating value of "other gases" is not included

Energy produced: 18.15kg PFS(17% H_2O) $\rightarrow$ 12.75m^3 syngas = 160.9MJ

Energy consumed (electrical): 12 kW for 90min = 66.2MJ

Energy yield: 160.9 MJ / 66.2 MJ ~ 2.4

Conclusions- Future Work

- MicroScreen Primary Fine-Sieved Solids provide a high Btu value, suitable for gasification
- Ultra High Temperature gasifier produces a high calorific value syngas from Fresh Solids
- Moisture content of gasification feedstock may be regulated by the addition of tire crumb rubber
- Energy yield of more than 2.4 (MJ produced /MJ consumed) is feasible
- The use of mixture of Primary Solids with Secondary Sludge should be investigated

Thank you for your attention