



# Coal Gasification Hot Topic Hour 2/12/15

## Speakers

**Bob Mcilvaine, Mcilvaine** Overview

**Mike Bockelie**, Ex VP, **Reaction Engineering**, will discuss Syngas cooler fouling focused on two mitigation strategies:

- Soot blower technologies to periodically clean surfaces.
- Use of sorbents to capture and remove the vaporized metals that lead to deposit formation.

**Keith Moore**, President of **Castle Light Energy** will discuss gasification at existing power plants.

# Hot Gas Filter Market

## Most optimistic Forecast

Application	Hot gas volume- millions of cfm	Growth rate %	% 850F in place	850F elements in place in millions of cfm	Growth rate 850 F Million cfm/yr
Coal-fired power	8000	4	0.001	0.8	300
Coal gasification	15	15	50	7.5	3
Cement	100	4	0	0	3
Industrial including gasification	2000	4	0.4	8	5

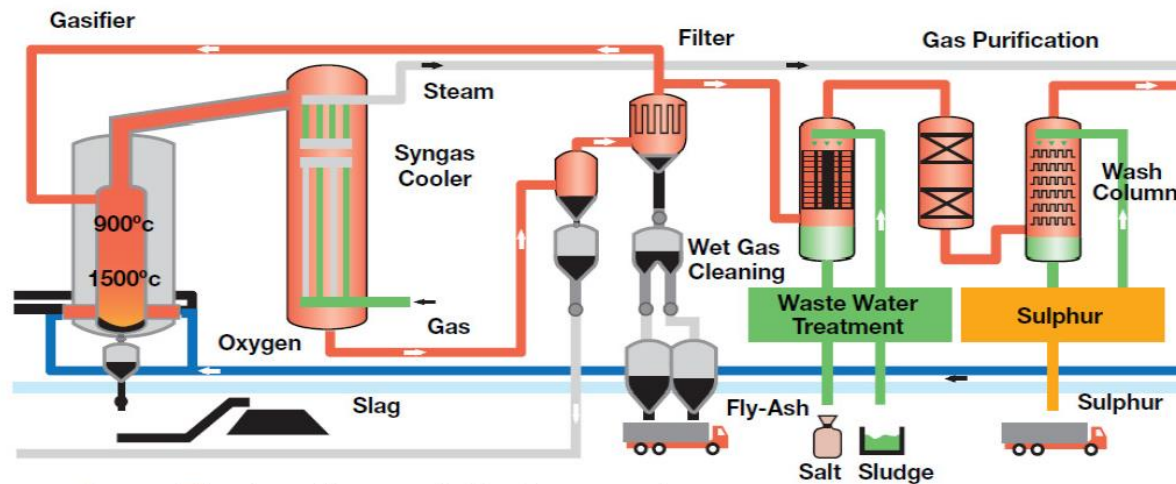
# Huge Gasification Program in China

Gas Use In China		
Source	2013 BCM	2025 BCM
Conventional	100	100
Shale	20	50
Pipeline imports	20	50
LNG	20	40
Coal to gas including CBM and UBC	50	200
Total	210	440

# Coal gasification process



Process Flow Diagram (Shell NL)\*



Syngas Filtration – Key to reliable plant operations  
Self Cleaning Filtration systems – Best in class by Pall  
Operational life between turnaroud to turnaroud

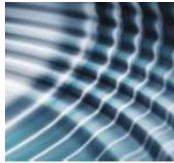
# GE has 150 Gasifiers in operation or underway

Installed fleet by the numbers

GE has **157** gasifiers in commercial operation ... the **largest fleet** in the industry ... with **95** additional gasifiers in development, engineering, or construction at **25** plants ... and a **global presence** in **15** different countries.



# Puertollano IGCC



## Example – Puertollano, Spain, IGCC



- Elcogas IGCC: Worlds largest single-train coal/coke IGCC (300MWel); Uhde Prenflo® Gasification
- Petcoke (50%) / Coal (50%) / additional biomass
- 435.000 Nm<sup>3</sup>/hr; 3 t/h flyash removal
- Pall fly ash filter system since 2011
- 2 vessel a 756 candles; 42 candles/cluster
- Reduces particulate load to minimum (< 3mg/Nm<sup>3</sup>)
- Wet gas scrubber can be operated nearly particulate free
- Clean Syngas used for recycling in quenchgas (compressors); and burned in gas turbines
- Reliable, stable performance of hot gas filter



# Xinjiang Guanghui Coal-to-LNG Plant

- The Xinjiang Guanghui LNG project receives feed gas from a large coal gasification plant.
- The LNG unit handles 405 MMSCFD of feed gas which is about 15% methane. The remainder of the gas is H<sub>2</sub> (59%), CO (25%), and small amounts of nitrogen and ethane.
- The unit produces LNG with less than 0.5% CO and a H<sub>2</sub>/CO syngas product which contains less than 0.5% methane.
- This separation is achieved by using a modified Single Mixed Refrigeration (SMR) process to perform the syngas separation while producing an LNG product from the bottom of a cryogenic fractionation column.
- A secondary cold refrigeration loop has been integrated with the base process to provide the extremely low temperatures needed for the separation.
- The LNG product is trucked from the site and the syngas is used for methanol plant feedstock.

# Korean Steel Maker is building Coal-to-Gas Plants

- Posco, South Korea's top steelmaker, has established a subsidiary to operate a synthetic natural gas business.
- Posco Green Gas Technology was established in Posco's Gwangyang complex on the country's southern coast, where it is building an SNG plant with a capacity of 500,000 mt/year. The plant, which will produce SNG by processing low-cost coal, will be completed by August this year and start commercial production in January next year.
- Posco has spent Won 870 billion (\$824 million) since June 2011 on the coal-to-gas plant, which is expected save the company Won 200 billion a year on LNG imports.
- Posco has also agreed with Mongolia's energy-focused MCS Group to establish a 50:50 joint venture to build a SNG plant in Mongolia. The two companies are aiming to complete financing by the end of this year and start work on the plant with a target date for bringing it online of the end of 2018.
- Posco has recently picked the SNG business as one of its future growth engines. Posco has been conducting research since 2009 with the country's top oil refiner SK Innovation to develop technology to make SNG and coal-based oil through a coal-to-liquids process.
- The steelmaker currently consumes some 60,000 mt/month of LNG to fire its plants. It imports the LNG from the BP-led Tangguh project in Indonesia under a 20-year contract signed in 2009 for 550,000 mt/year.



# GE Sinopec Coal-to-Gas-to-Fertilizer

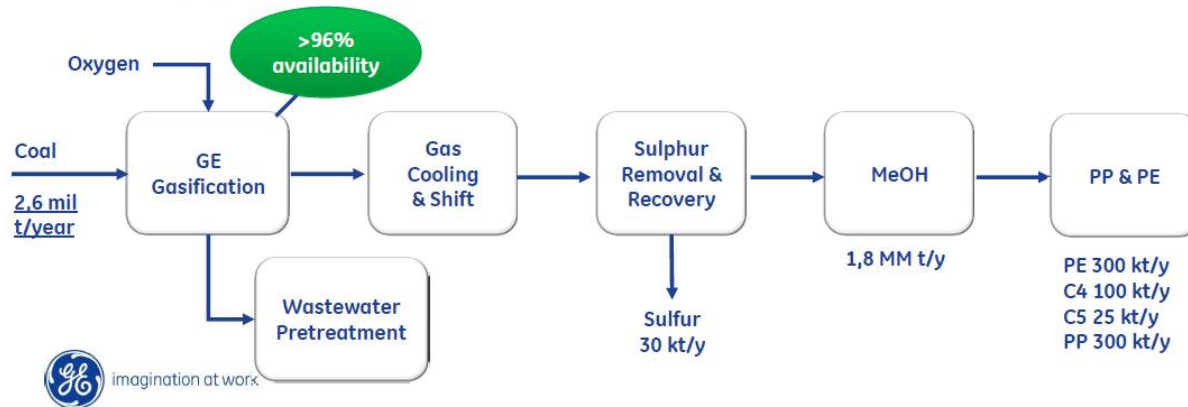
- The Sinopec Qilu No. 2 fertilizer plant in China has achieved the world's longest continuous operation record for a licensed GE coal-fuelled gasification facility, at 481 days. The record-breaking cycle began on December 14, 2011 and ended on April 8, 2013.
- "The reliability of GE gasification technology combined with our focus on excellent plant operations and equipment management, made this accomplishment possible," said Mr. Song Hong Peng, director of the Sinopec Qilu plant. "Now, we look forward to building on this success. Working with GE opens the door to additional technology innovations while we continue to find ways to enhance everything from feed-stock selection to preventive maintenance."
- The plant, located in Zibo, Shandong Province, uses three GE gasifiers, allowing two to operate while one is on standby for planned maintenance. GE gasification technology at the plant began operation in October 2008. The plant produces a gas consisting of hydrogen and carbon monoxide, which is used as raw material to produce butyl alcohol and methanol.

# GE-Shenhua Coal-to-MTO

## Shenhua Baotou Coal to MTO



**Location:** Baotou, Inner Mongolia, China  
**Feedstock:** Coal  
**Design Capacity:** 352 t/h  
**Operation Pressure:** 65 bar  
**Gasifier Size:** 5+2 x 900 ft<sup>3</sup> Quench



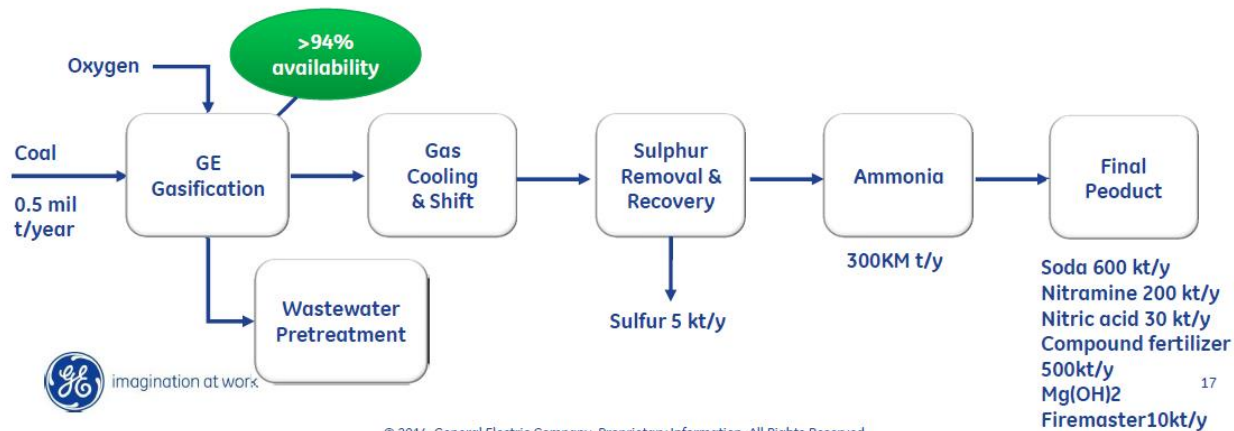
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# GE Dahua Coal-to-Gas-to-Ammonia

## Dahua Fertilizer, Coal to Ammonia



**Location:** Dalian, China  
**Feedstock:** Coal  
**Design Capacity:** 1,000t/d  
**Operation Pressure:** 87 bara  
**Gasifier Size:** 2+1, 450ft<sup>3</sup> Quench  
**Start-up Date:** 2009



# GE Biomass-to-Energy in Bulgaria

- To reduce Bulgaria's heavy dependence on imported energy, a landmark biomass-to-energy plant powered by GE's Jenbacher gas engine technology is being built near Stroevo, in Plovdiv province.
- The 5-MW Karlovo plant will use three of GE's fuel-flexible, robust and high-efficiency Jenbacher engines—one J612 and two J620 units—powered by syngas derived from straw and wood chips and will produce enough electricity to power 2,000 homes.
- Scheduled for completion by the end of 2014, the plant is being built by EQTEC Iberia, part of Spanish holding company Ebioss Energy AD. It is the latest development in Ebioss' strategy to apply its integrated biomass gasification cogeneration power plant (IBGPP) technology throughout Europe to help countries reduce their dependence on foreign energy supplies and to increase the proportion of energy from renewable sources. The country's target is for 16 percent of its energy demand to be met by domestic renewable sources by 2020, but at present more than 70 percent of its energy is from imported natural gas and oil.
- "Gasifying biomass for energy usage—in this case, straw and wood chips—requires special know-how, and our engineers and GE's team worked as one team to integrate EQTEC Gasifier Technology and GE's power generation technologies for improved performance and economics," said Luis Sanchez CEO, EBIOSS. "The IBGPP plant we developed achieves a far higher electrical efficiency than the thermal technologies traditionally used in a plant of this size. For example, a typical Rankine thermal cycle-based plant offers an electrical efficiency of 18 to 20 percent from converting biomass to electricity compared to using GE's Jenbacher gas engines that offer approximately 28 percent electrical efficiency and almost 70 percent total combined heat and power efficiency. This will enable us to deploy the IBGPP technology economically with GE elsewhere in Bulgaria and in other nations to help them enjoy greater energy independence and fuel diversity.

# GE Woodchip Gasification to Power

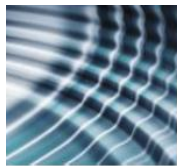
- General Electric and Indonesian state utility firm Perusahaan Listrik Negara signed a Letter of Intent to collaborate on a pilot biomass power plant in Sumba, East Nusa Tenggara.

Under the agreement, GE will help construct the plant which will employ Biomass Gasification technology to produce 1-MW of power using woodchips as fuel.

“GE is committed in bringing the latest technology and solutions to help Indonesia overcome its challenges in developing the country,” GE Indonesian CEO Handry Satriago said.

- GE's gas engine technology has been widely used in the Indonesian power generation sector. More than 700 units combining Jenbacher and Waukesha engines are in operation utilizing natural and non-natural gas fuels.
- Thirty percent of these engines are used to generate renewable and clean energy derived from waste such as palm oil mills effluent, agri-waste biogas, low-rank coal syngas, coal bed methane and oil & gas sector products, according to the company.
- GE's integrated biomass gasification technology, developed by the GE Global Research Center, converts syngas from biomass feedstock into power.

# Pall has 50 Coal Gas Installations



## Pall Track Record for Coal Gasification Systems

Aspect	Detail
Feedstocks	Coal Sub-Bitumen Lignite Petcoke Biomass Combination
Licensors approval(s)	8
Track record in Coal Gasification	<ul style="list-style-type: none"><li>➤ 50 installations</li><li>➤ 20 years systems experience</li><li>➤ 25k filter elements in service</li><li>➤ 1.5 million hours operating exp.</li></ul>
Track record in Hot-Gas applications	<ul style="list-style-type: none"><li>➤ 1,000 installations</li><li>➤ 35 years systems experience</li><li>➤ 210k filter elements in service</li><li>➤ 17 million hours operating exp.</li></ul>

# Porvair is booking \$10 Million Orders

## MICROFILTRATION

Results and progress – year ended 30 November 2014

	2014 £000	2013 £000
Revenue	73.9	55.8
Operating profit	8.7	8.6

### Revenue up 33% to £73.9m

Large projects progressing well: £19.5m revenue (2013: £6.0m). 2015 revenue likely to be closer to 2013

Operating profit held back by project accounting, dollar weakness, restructuring costs

9% underlying revenue growth

13% growth in Seal Analytical

### Year of investment

UK expansion for aviation and industrial

US expansion for industrial. 18% growth in 2014

### 2015 outlook

Healthy order books; \$10m gasification order for CNOOC

Further benefit from large projects

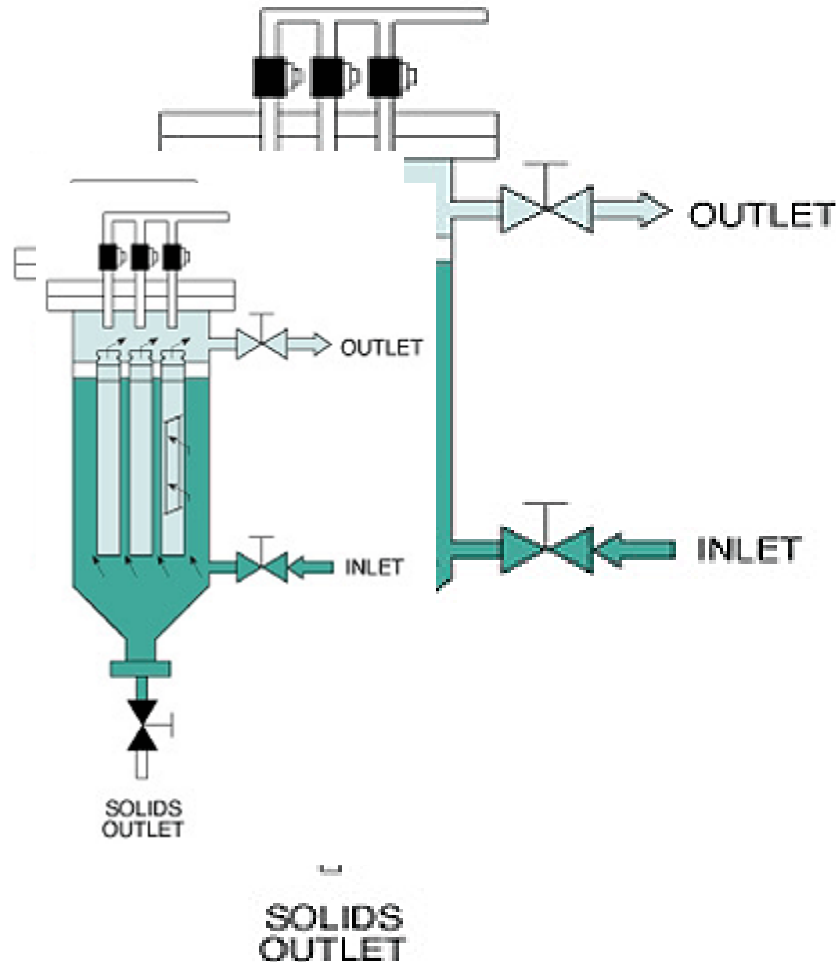


## Mott Hot Gas Filter

Mott has proven their product and performance in applications such as:

- Catalyst Retention
- Process Gas Filtration
- Hot Gas Filtration
- Radioactive Waste Removal
- Product Recovery
- Oxygen Filtration

Systems can be fully automated, with solids discharged periodically. The unique nozzle-venturi arrangement of the blowback system minimizes the pressurized gas required for blowback. AND not only are porous metal elements cleanable, they also come in a wide array of alloys that can withstand a variety of atmospheres.





Pavlos Papadopoulos of Clarcor Purolator cannot participate but will be at AFS Q and A session. He provides the following analysis:

- Our metallic sintered fibers technology is achieving up to 99,999% efficiency at 1 micron. We have very low dP with our technology.
- We can therefore go with higher face velocities than other technologies, enabling end user either to get a higher capacity or a more compact footprint for a same flow rate.
- We assume emissions levels down to 1 mg/Nm<sup>3</sup> in some applications.
- We can also work at high temp, with tube type of elements or pleated.
- Active in coal gas but under CA.

# Shell Filter lasts more than 3 Years

## Reliability HPHT filter 2008

### Best Practices

1. Buggenum replaces HPHT filters every 2-3 years
2. Dong Ting has operated 3 years with no filter issues

### HPHT reliability factors:

- Construction quality
- Need to monitor filter blowback performance
- Use dry gas for filter blowback to avoid valve corrosion



Construction quality finding



Improved support brackets

Beijing service team has virtually eliminated filter downtime in 2009

- set up real time monitoring
- ensured clear filter operating window known
- best practices shared

# Filter Options

## Hot Gas Filtration

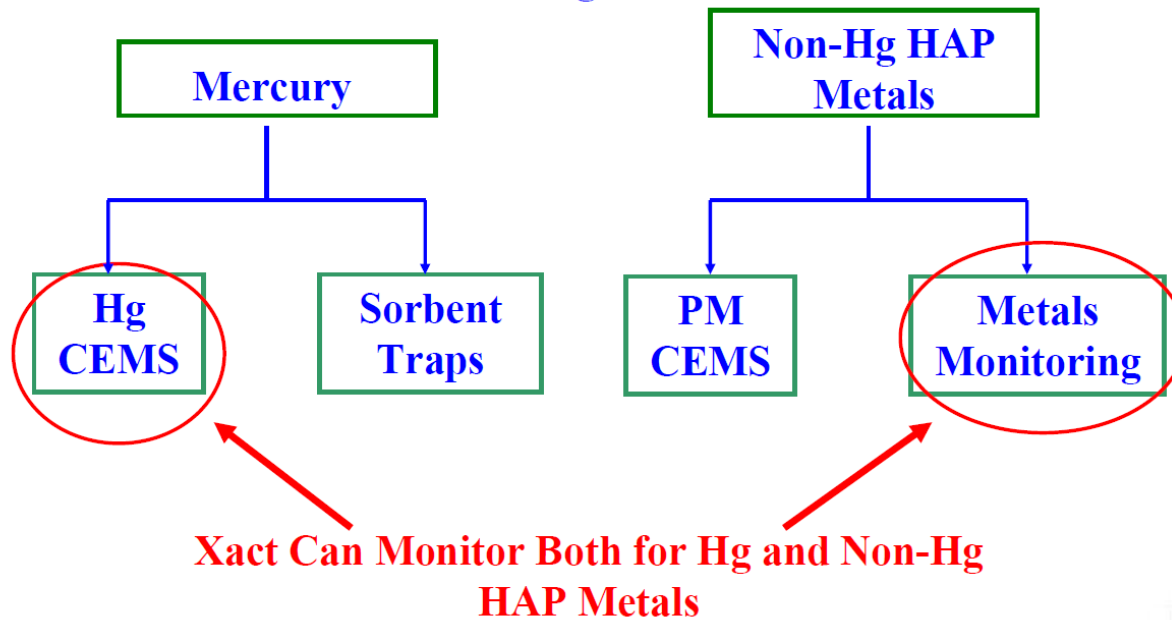
- ⇒ Hot Gas Filters
  - Generally operate at >250 degC
  - Filtration media are normally rigid
  - Reverse pulse cleaning for on-line solids removal
  
- ⇒ Ceramic Media
  - Granular
    - ⇒ SiC + surface coating e.g. Dia-Schumalith
  - Vacuum Formed Fibres
    - ⇒ Alumino-silicate e.g. Cerafil
    - ⇒ Calcium silicate e.g. Firefly
  
- ⇒ Metal Media
  - Metal fibre felts
  
- ⇒ Filter Vessels
  - Vertical elements suspended from header plate
  - Solids discharge from hopper at base

# Air Pollution Decisions

- Wet venturi or dry candle filter for particulate.
- One stage scrubbing for  $\text{SO}_2$  and HCl or two scrubbers and use hydrochloric acid for flyash rare earth leaching.
- Metal or ceramic filter elements
  - Pressure drop vs. size
  - Cost
  - Performance efficiency
  - Life
- Can DSI be used with dry filter?
- RTI WDP (warm desulfurization process) with dry sorbents?
- Granular activated carbon for mercury?

# Measuring Metal Toxics is more important than Total PM

### Proposed Utility MACT Rules for HAP Metals Monitoring On CFPPs



# E Gas uses separate HCl Scrubber

- The product gas exits the gasifier at 1,900°F and is cooled in a fire-tube cooler to 1,100°F, generating saturated steam.
- The E-Gas process utilizes a dry solids-gas separation system to remove particulates from the raw syngas stream. This system is reliable and more efficient than wet solids scrubbing systems and has none of the grey or black water treatment and disposal issues associated with wet solids removal.
- Downstream of the particulate dry scrubber, chlorides are removed from the cooled syngas in a wet scrubber.
- The syngas is then treated for removal of carbonyl sulfide and hydrogen sulfide before being used for energy conversion or other applications.

# More on Sorbents

**McIlvaine will be investigating sorbents for SO<sub>2</sub>, mercury and other contaminants e.g.,**

- **IsGA 2014 Vienna Bimetallic Sorbents for the Removal of Elemental Mercury from the Coal Derived Fuel Gas**, Han, Lina Taiyuan University of Technology
- **The mechanism of coal gas desulfurization by iron oxide sorbents.** [Lin YH<sup>1</sup>](#), [Chen YC<sup>1</sup>](#), [Chu H<sup>2</sup>](#). [Chemosphere](#). 2015 Feb;121:62-7. doi: 10.1016/j.chemosphere.2014.11.010. Epub 2014 Nov 27.
- **TDA Mercury Sorbents**  
TDA Research Inc. (TDA) is developing a sorbent-based system that can reduce the concentration of the trace metal contaminants (i.e., mercury, arsenic, selenium and cadmium) to less than parts per billion levels in the coal-derived synthesis gas at elevated temperatures (260°C).

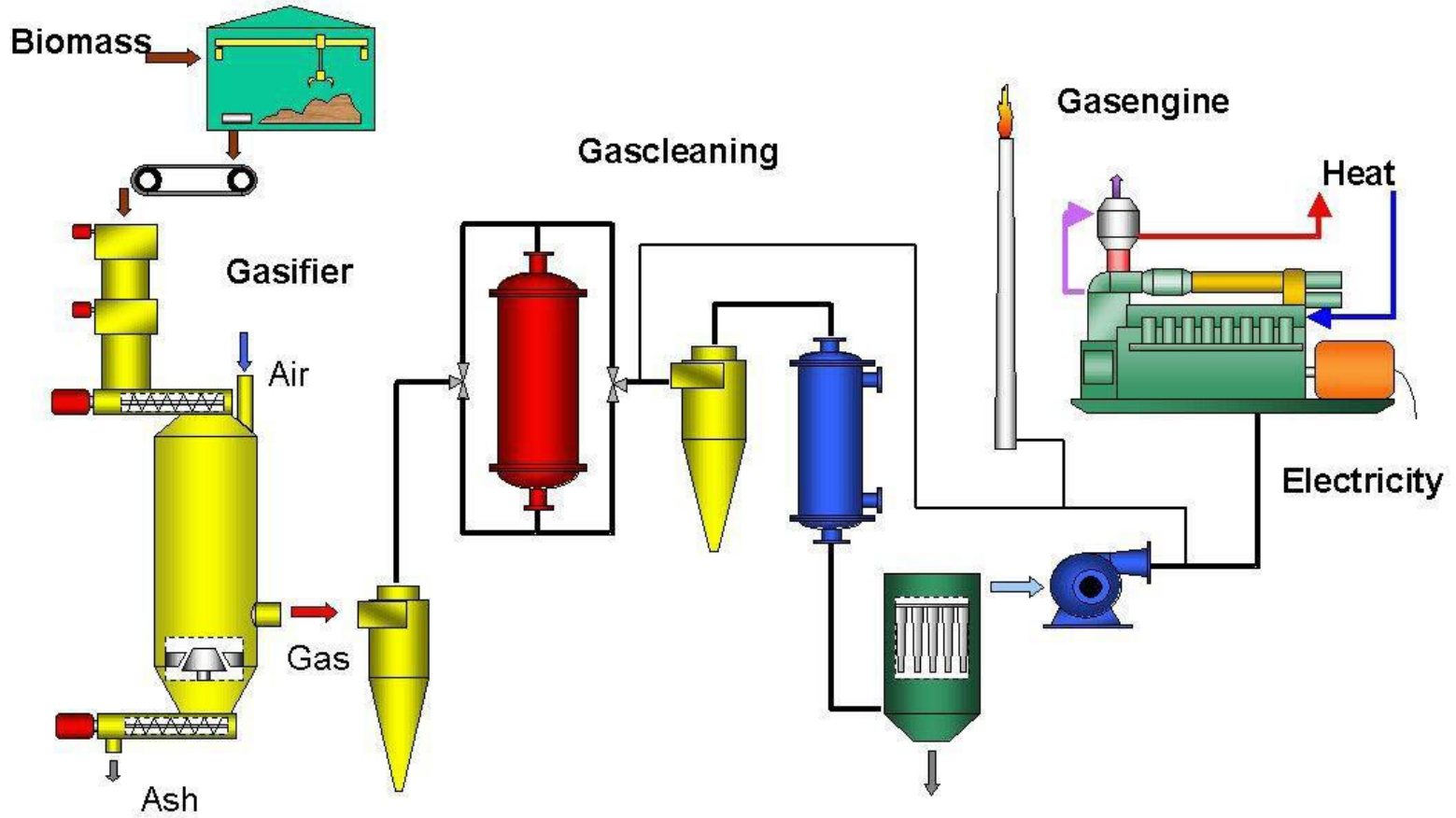
# Wet Precipitators and Scrubbers used on smaller plants

## Philippine Gasification Plant to Install Beltran WESPs

- True Green Energy Group (TGEG) has announced a contract with Beltran, reports *digitaljournal.com*. TGEG is a public company involved in waste management. The plant in the Philippines will be comprised of modular 50 ton/day MSW gasification systems. Each will supply around 4000 Nm<sup>3</sup>/hr syngas for power generation. The expected power output of the proposed gasification plant is up to 2 MWe plus surplus thermal heat up to 2 MWth.
- The gasification system, provided by Beltran, includes the gasifier reactor with ash discharge, a gas cleanup system including cyclone filters, heat exchangers and WESP, instruments with control system and the steel frame structure. The gasifier will use a modified moving bed gasifier which is designed to produce a combustible syngas from a variety of solids. Each gasifier system is designed to process up to two tons per hour of dry biomass and dried refuse derived fuel (RDF) pellets, as well as a range of other industrial and domestic waste products. The resulting syngas is then converted into heat/electricity.
- The process of manufacturing RDF fuel pellets involves placing ground biomass under high pressure and extruding it through a die. Pelletizing is a way to make use of raw garbage that might otherwise pollute the water table. Since the pellets replace fossil fuels, they help reduce greenhouse gas emissions. Pellets are easier to store and are much cleaner to handle than coal.
- The WESP equipment at this plant will be located just after the scrubber and is specifically designed by Beltran for biomass waste gasification syngas cleanup. The single module WESP system will achieve an overall removal efficiency of above 98 percent and will be comprised of a vertical flow tubular system.
- Beltran wet electrostatic precipitators are in use at more than 1,000 installations throughout the world. The WESPs are of rigid frame design with fixed-point suspension for the high voltage discharge electrode system. Beltran WESPs are now operating on biomass, MSW and coal gasification plants, as well as coke ovens and town gas production furnaces. Besides tars and aerosols, particulates are also collected including flyash, glass melting furnace emissions, and dust containing cement, lime and sodium sulfate.



# Biomass Gasification with WESP



# Rare Earth recovery from Ash

- Recovery of metals from coal ash could be relatively more efficient than mining it from rock ores.
- Production and consumption of rare earth minerals totaled over 100,000 metric tons in 2012. IHS's study estimates that from 2012 to 2017, global demand for rare earth products will grow by 7.6 percent annually and reach more than 150,000 metric tons, with China leading consumption growth at 8.3 percent annually.
- There isn't a high density of rare earth elements in flyash – a few parts per million. But better chemical engineering techniques are leading to more efficient metal extraction.
- Using acid from the coal gas would make the process more economic.