Sweetening of Biogas by ***ISET Process***

Advanced Bio-Energy Technologies Society

CGPL, IISc

Sweetening of Biogas

is

Removal of Hydrogen Sulfide from the gas

Bio-gas

Biogas is a mixture of:

	Methane :	(50 – 65 %)
	Carbon dioxide :	(30 – 45 %)
	Hydrogen sulfide :	(1 – 8.0 %)
Uses:	As a fuel mainly in boilers and more effectively for Power Generation in Engines	
Limitation:	Presence of H_2S which is highly corrosive and toxic	

Need for Hydrogen Sulfide scrubbing

- Characterized by rotten egg smell is highly corrosive and toxic (threshold value for human inhalation – 10 ppm long term exposure)
- On burning releases Sulfur dioxide (SO_2) which is toxic and corrosive
- Maximum allowable limit for Gen-Set application – 1000 ppm
- Lower the content, better is the life

What is *ISET* Process?

- ISET is an acronym of Indian Institute of Science Sulfur Extraction Technology
- ISET Process is a liquid Redox process
- Redox – Reduction & Oxidation

Process Chemistry

H_2S when dissolved in water is ionized to H^+ and S^{2-}.

Reduction of Ferric ions by sulphur ions

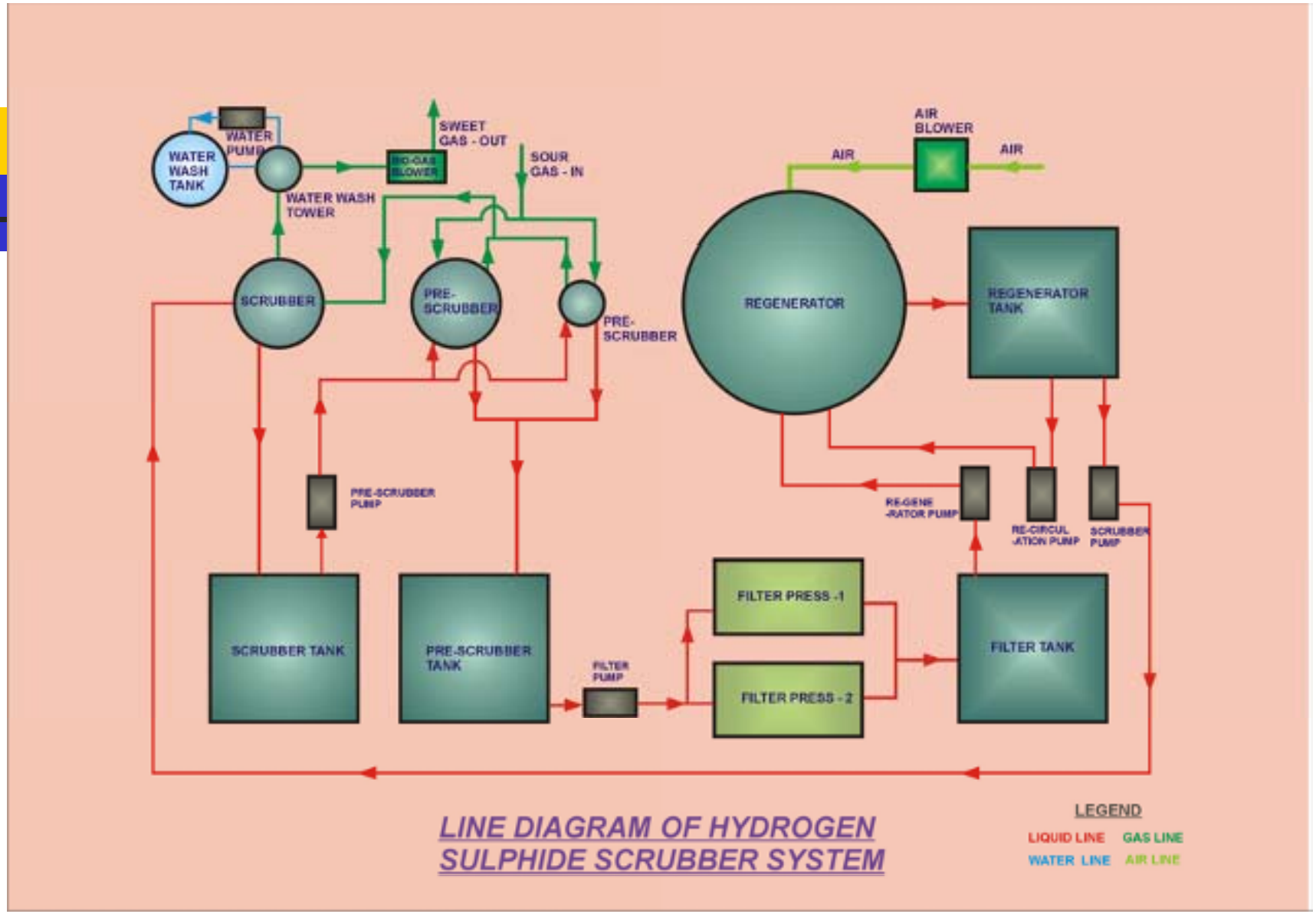
$$2Fe^{3+} + S^{2-} \rightarrow 2Fe^{2+} + S$$

Oxidation of Ferrous ions by air

$$4Fe^{2+} + O^{2-} \rightarrow 4Fe^{3+} + H_2O$$

Process Description

- Two stage counter current operation
- Reduction of ferric ions in the Pre-Scrubber and the Scrubber
- Filtration of the sulfur generated
- Oxidation of the ferrous ions in the regenerator.



LINE DIAGRAM OF HYDROGEN SULPHIDE SCRUBBER SYSTEM

Process Features

- Indigenous technology with capital investment lesser by 3 times compared to other processes outside the country.
- H_2S is converted into elemental sulfur, which has commercial value.
- Low H_2S concentration at the outlet (<100 ppm).
- Process works at ambient temperature with easy start up and shut down procedure.
- Capable of handling fluctuations in gas flow rates and H_2S percentages.
- Low running costs of US Cent 1.5- 1.2/kWh (at 3 % H_2S) as scrubbing solution is regenerated. Comparable with other liquid red-ox processes.

H_2S scrubbing system at KCPSIC Ltd

- What is seen in the picture is part of the anaerobic digester and the scrubber area at the far right

Detailed view of some of the scrubber elements at KCPSIC Ltd.

Three systems with scrubbing capacity of 300 m^3/hr each takes care of the gas Load at
UP Jal Nigam, Kanpur

- Picture showing the three Regenerators and the tanks

The scrubbing solution at UP Jal Nigam, Allahabad

The scrubbing solution at UP Jal Nigam, Allahabad

Small yet beautiful. Scrubbing system at CLRI plant at Melvisharam

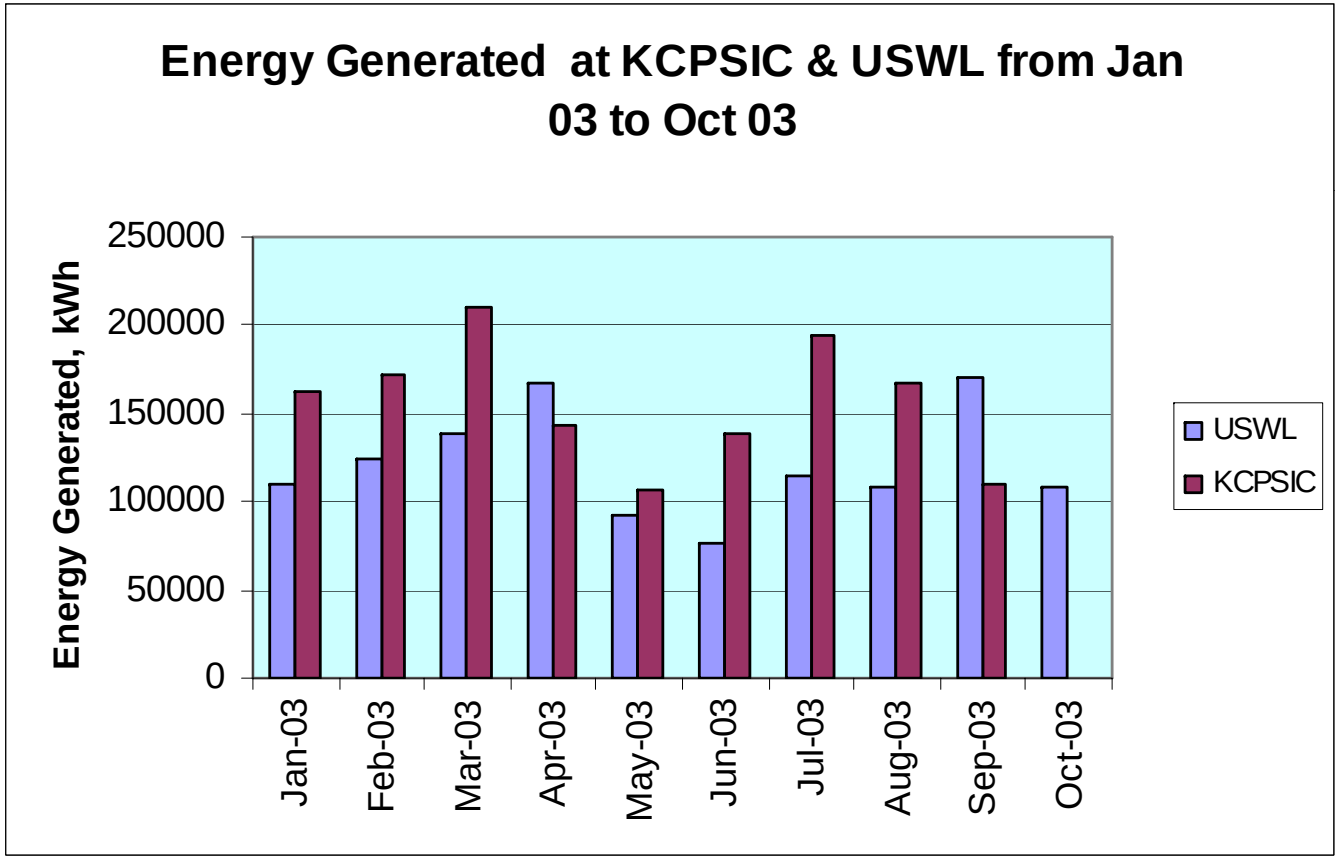
Filter is seen in the front and the scrubber at the back

Picture of One of the Four Greaves Engines of 300 kVA Capacity Installed at USWL

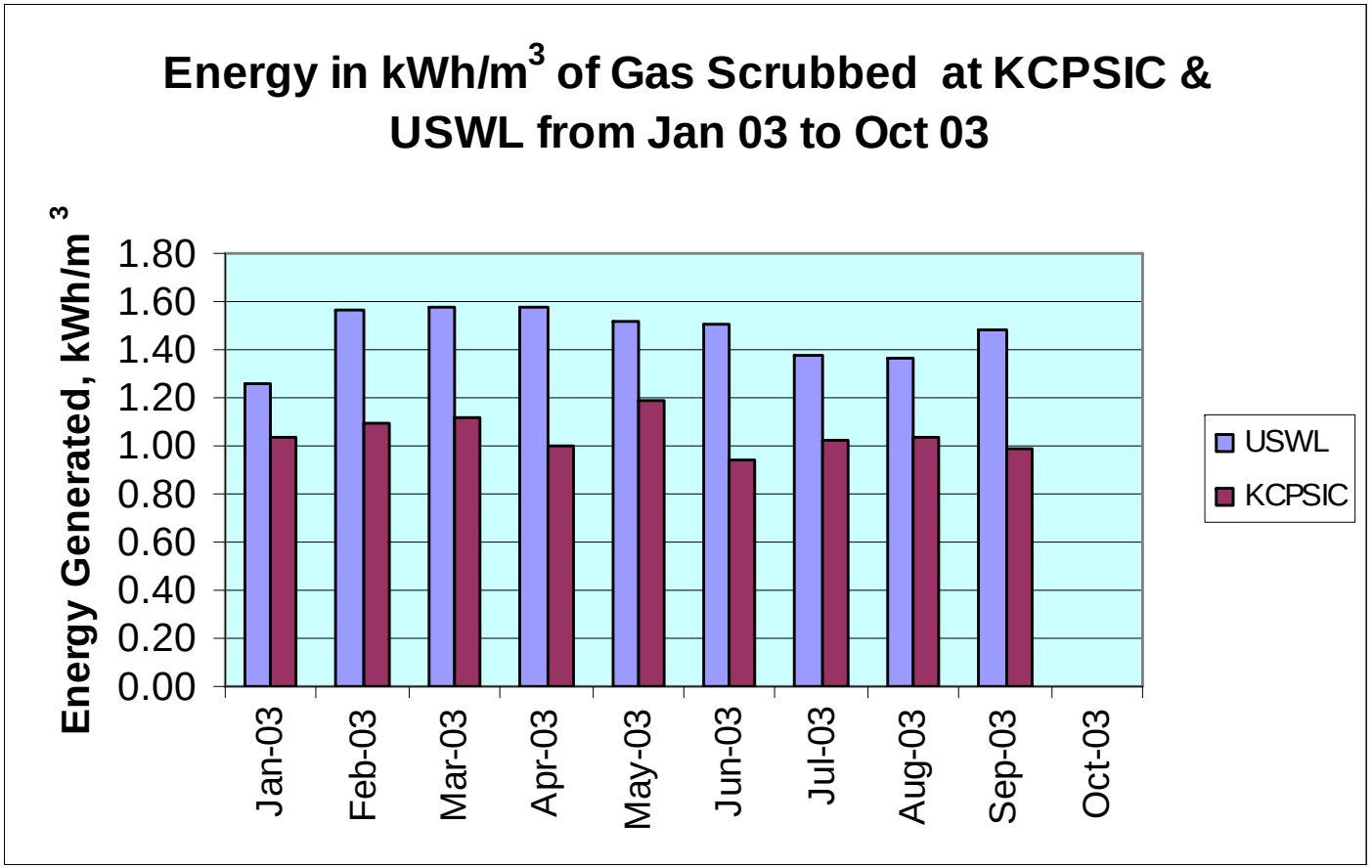
Field Installations

Sl. No	Location	Type of User	Design Capacity	Status
1	UP Jal Nigam, Kanpur	STP	900 m^3/hr 3 % H_2S 1.6 MWe	Commissioned in June 99. Running for 6 hrs a day. H2S in sweet gas - < 10 ppm
2	UP Jal Nigam, Allahabad	STP	600 m^3/hr 3 % H_2S 1.1 MWe	Commissioned in June 99. Running for 4 hrs a day. H2S in sweet gas - < 10 ppm
3	KCPSIC Ltd, Vuyyuru, Andhra Pradesh	ETP	600 m^3/hr 7.5 % H_2S 1.0 MWe	Commissioned in 2001 - 2002. 2.0 million kWh generated. H2S in sweet gas - < 50 ppm
4	USWL, Ugar Khurd, Belgaum, Karnataka	ETP	600 m^3/hr 7.5 % H_2S 1.0 MWe	Commissioned in 2000. 4.5 million kWh generated. H2S in sweet gas - < 50 ppm
5	VISHTEC, Melvisharam Ranipet, Tamilnadu	Leather fleshings	13.5 m^3/hr 3.0 % H_2S 30 kWe	Commissioned in 2000. Running for 6 hrs a day. H2S in sweet gas - < 10 ppm

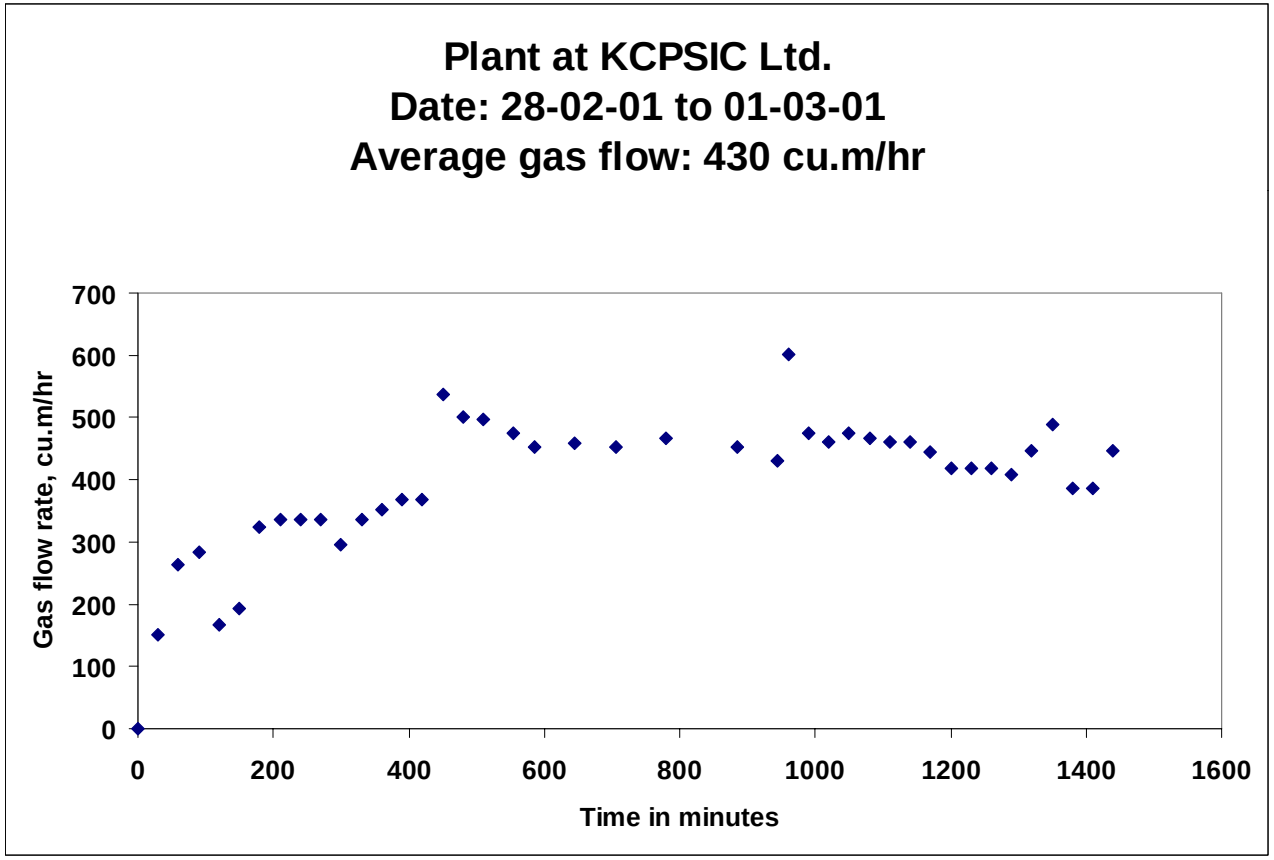
Energy generated in kWh



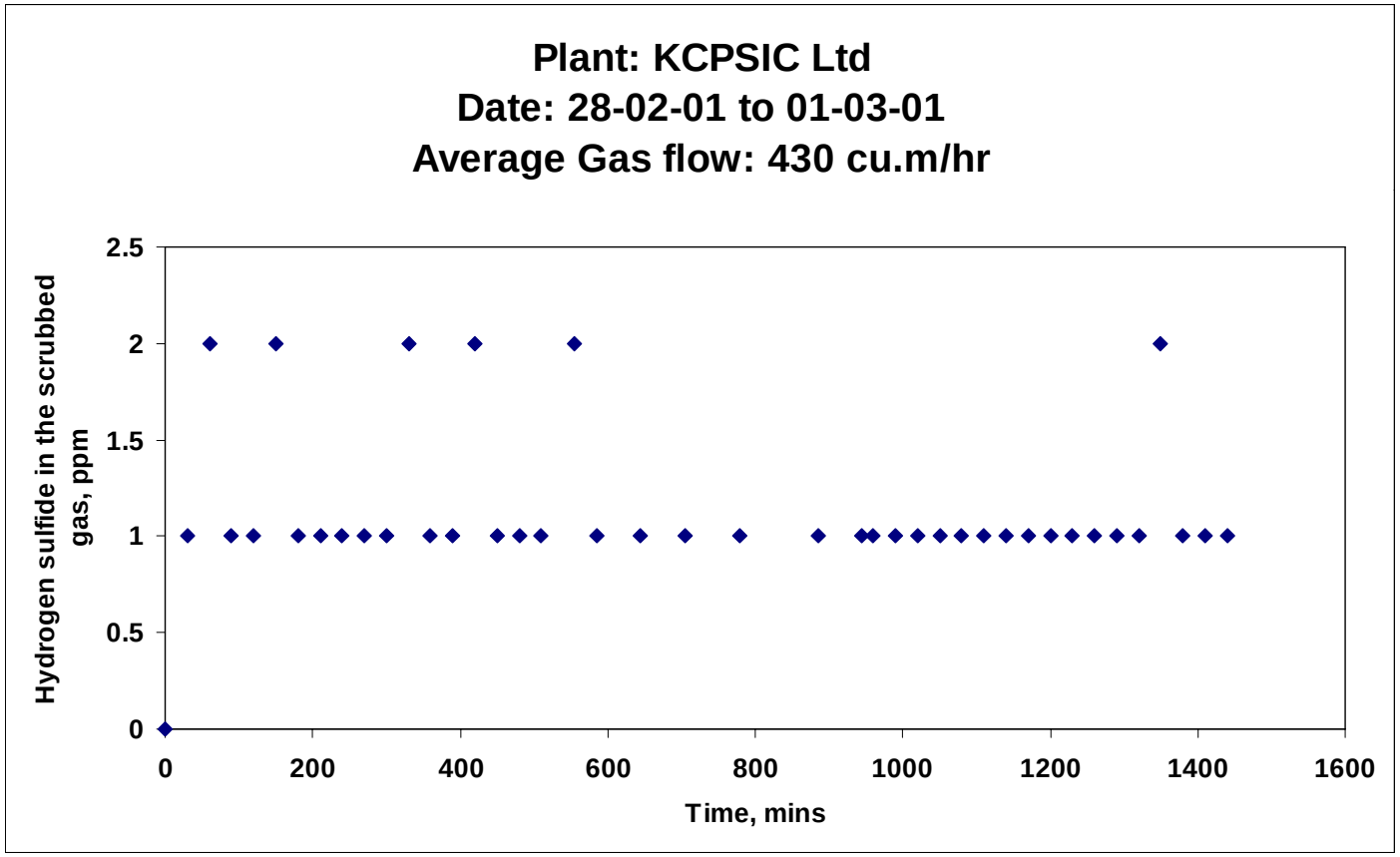
Power produced per m3 of Biogas



Typical gas flow rate at KCPSIC Ltd



Performance of the Hydrogen Sulfide Scrubbing system



Techno-economics for Power Generation from Biogas with ISET process for Hydrogen sulfide scrubbing (H2S concentration – 3.0 %)

Sr. No.	Description	Cost in Million USD		
		0.5 MWe	**1.0 MWe**	**2.0 MWe**
1	Gas Engine directly coupled with alternator, 50 Hz with controls	0.18	0.33	0.62
2	***ISET*** H_2S scrubber	0.13	0.22	0.40
3	Building and Infrastructure	0.045	0.075	0.11
4	**Capital Investment (1+2+3)**	**0.35**	**0.63**	**1.13**
5	Energy generated at 7000 hrs running time per year (million units)	3.5	7.0	14.0
6	**Revenue per annum by power generation at energy cost of cent. 9 /kWh**	**0.31**	**0.62**	**1.24**
7	Annual O & M costs of Scrubber + Engine	0.10	0.16	0.31
8	**Payback period (inclusive of Interest @ 12 % and 10 % Depreciation)**	**2.3**	**1.9**	**1.6**

ISET Process

- Economical
- Highly efficient
- Value addition in the form of elemental sulfur obtained during scrubbing

Thank You