

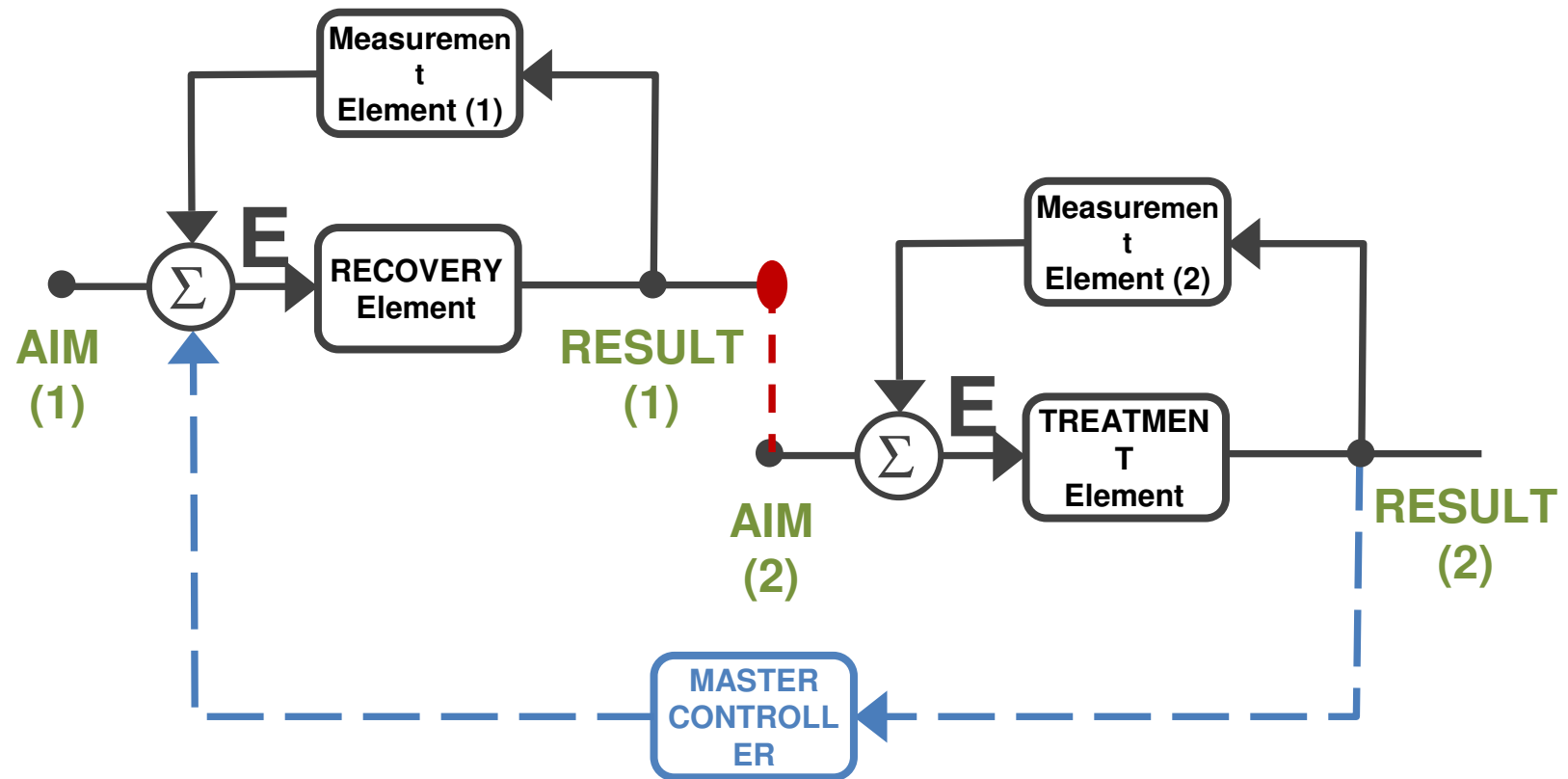
DESIGN OF LANDFILL GAS SYSTEMS

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EPA WASTE WORKSHOP 2009

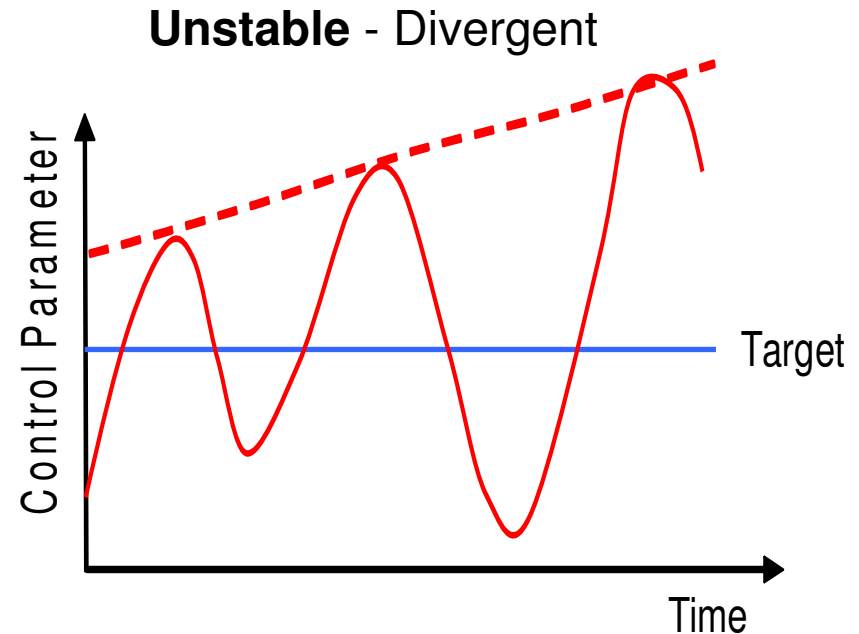
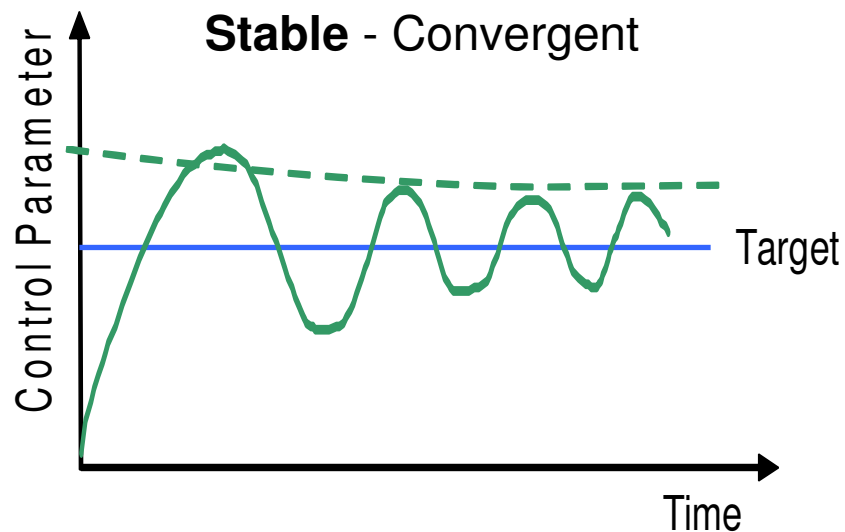
Hodson Bay Hotel, Athlone, Co. Westmeath
Wednesday 21st and Thursday 22nd October 2009

Framework for Design



Basic Control Concept

- **Input State** - The 'Aim' or target values for the System
- **Output State** - The values actually achieved by the System



Two Important Rules

1. Build in Adaptability

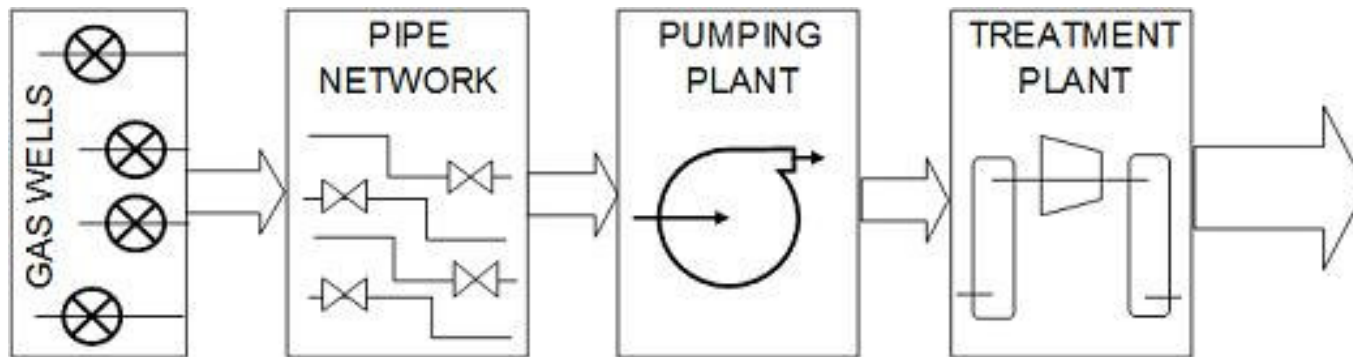
To enable extension, expansion or changes through the operational lifetime of the system

2. Duplicate Key Components

Avoid relying on single components or elements



Unit Operations Approach



INCREASING COMPLEXITY AND COST

Design – Gas Wells

Performance Quotients for wells (m³/hour per mbar):

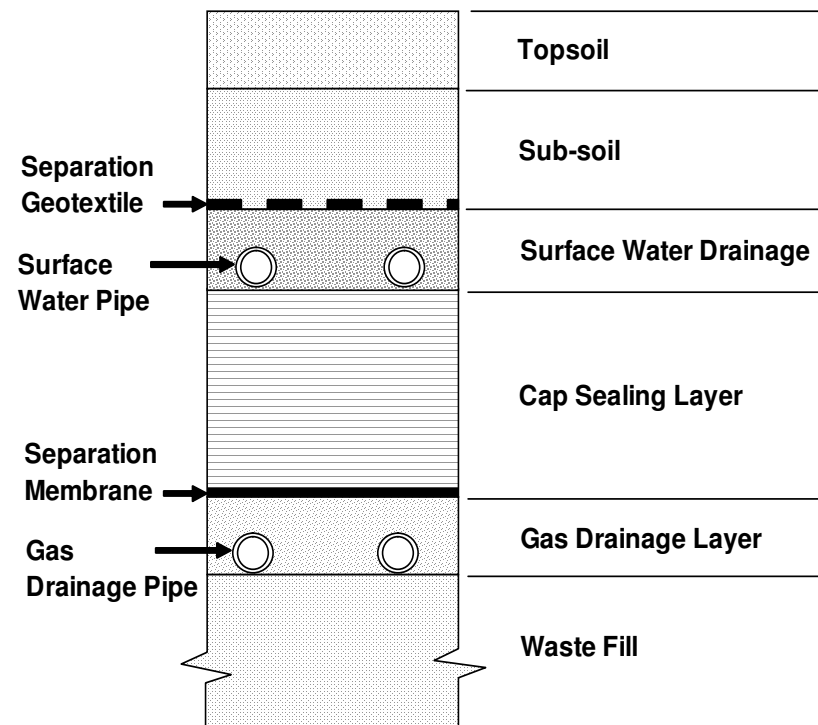
- ‘large diameter’ (~900 mm) 50
- vertical 10 – 30
- horizontal 10 – 15

Site Containment

Temporary Capping “Daily Cover”

Permanent Capping to keep out water and air and keep in gases and odours

Site Lining to contain wastes, leachate and gases



Optimising Gas Well Operation

Minimise the gas velocity

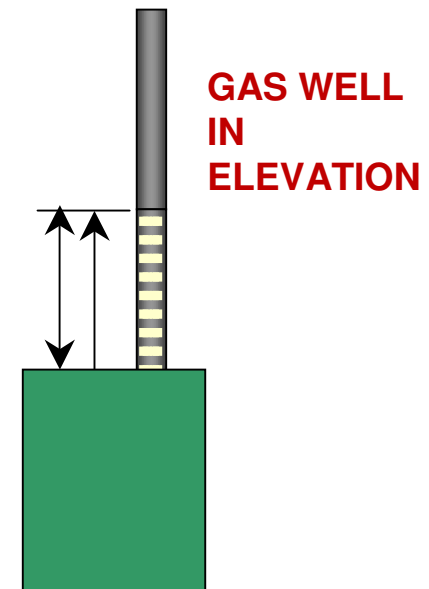
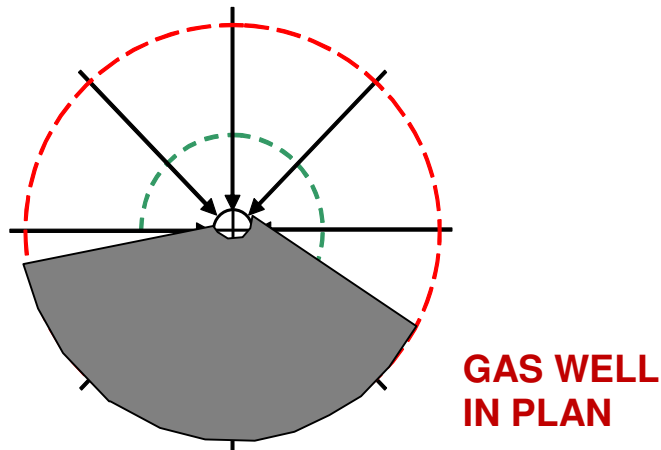
Gas approaching the well - make well diameter large

Maximise the effective length

Make gas well deep and keep it dry

Provide contingency measures

Flexible connections, movement joints at well heads



Design – Pipework

Pipes specified by **Outside Diameter** (OD) and either a **Pressure Rating** (in Bar) or **Standard Diameter Ratio – SDR** (defined as OD/wall thickness)

For landfill gas typical pipes are 6 Bar or SDR17.6

*Gas Flow **always** gives Pressure Losses*

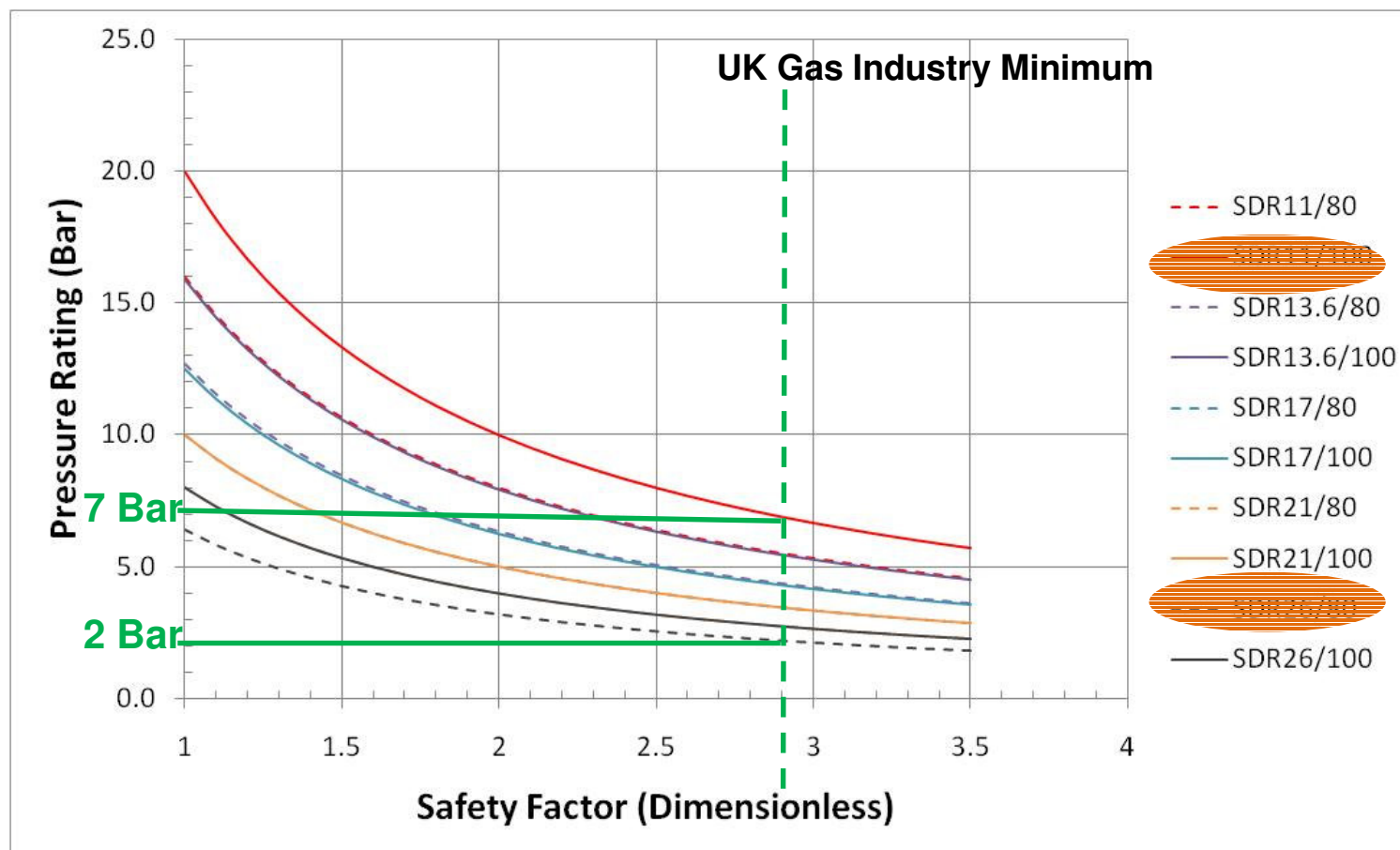
The loss in pressure, P (mbar/m) for gas flow rate of Q (m³/hour) through a 'smooth' pipe of inside diameter ID (mm) estimated using:

$$P = 60,000 Q^2 / ID^5$$

Rule of “100’s”

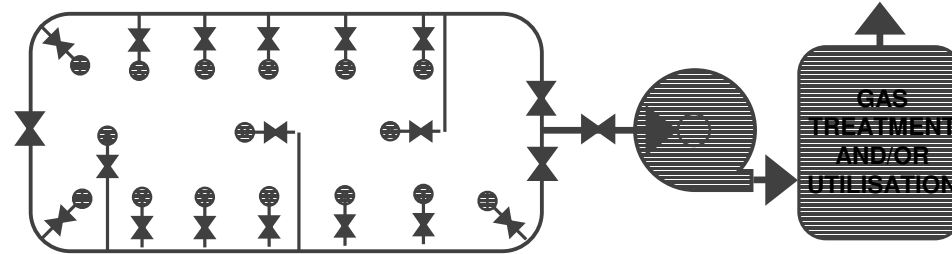
100 m³/hr flow in 100mm dia pipe 100m long gives 6 mbar loss

Design – Pipework New Wider Choice

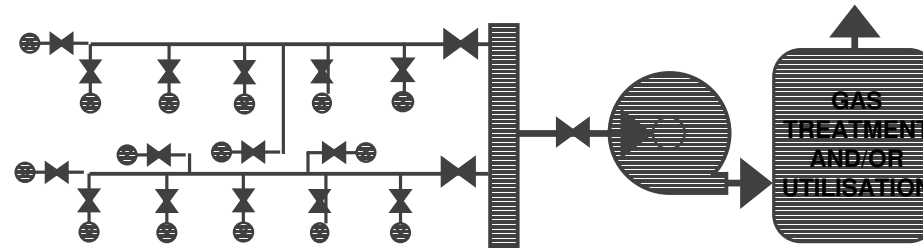


Pipework Connection

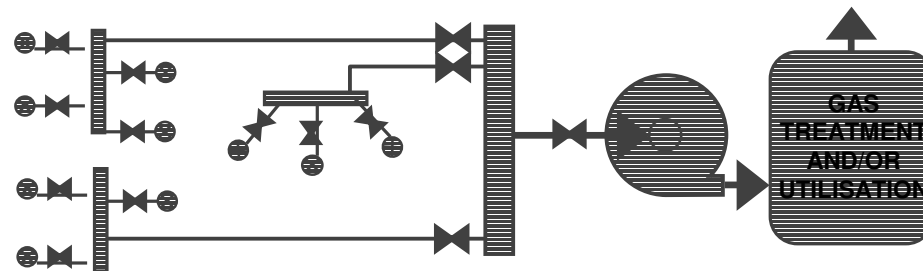
RINGMAIN



BRANCH HEADERS



MANIFOLD CASCADE



Dewatering and Condensate Management

Design pipes to fall towards drainage or pump out points

Minimum Falls 1% to 2% (1:100 to 1:50)

Add in access/maintenance points

Design Must Allow for Site Settlement

Allow for levels to change by 10% to 20%

Provide contingency to repair/re-align pipes



Gas Treatment

Gas from site must be **Treated**:

Primary Processing

Recovery of gas at a specified and controlled rate

Secondary Processing

Gas oxidised to remove methane and use the energy for power generation

Tertiary Processing

Gas clean-up for pipeline or vehicle fuel substitute



Design - Pressure Boosters

‘Suction Losses’ + ‘Delivery Losses’ = Total Loss

Total Loss = Pressure Rise for Booster

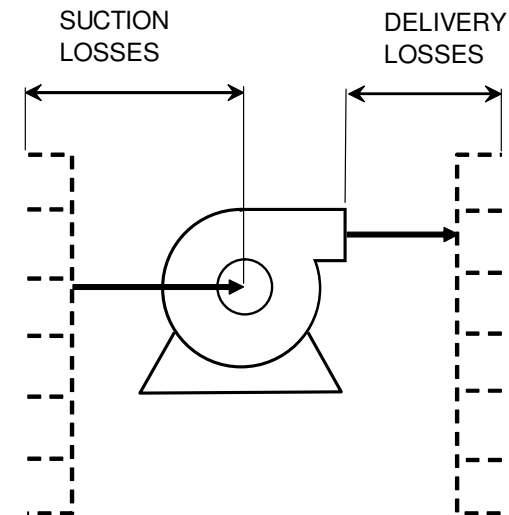
Design Rule of Thumb

Set ‘Suction losses’ at 50 mbar

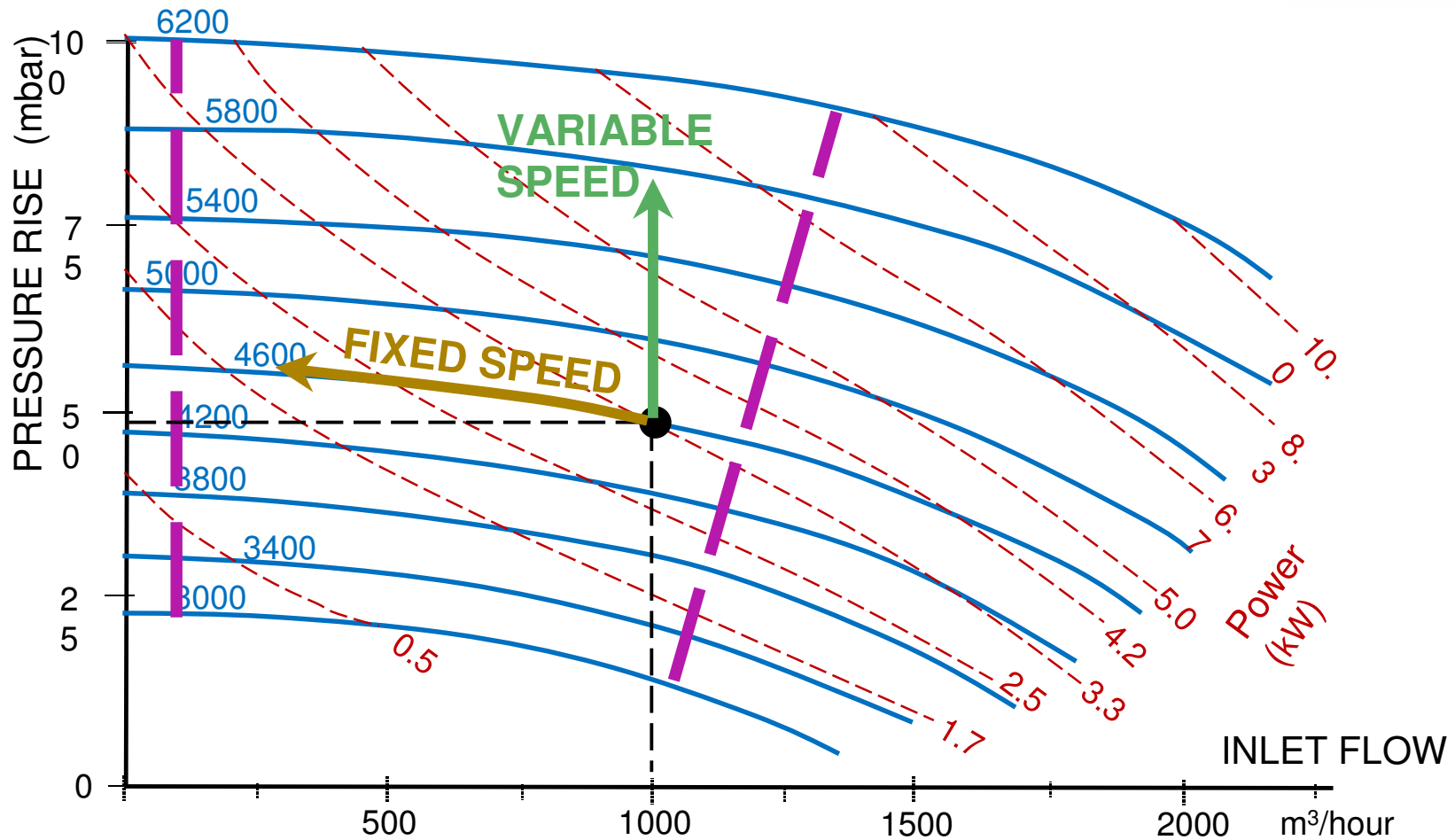
Set ‘Delivery Losses’ at 50 mbar

Total pressure loss will be $50+50=100$ mbar

Booster selected with a duty or pressure rise of 100 mbar



Operation - Pressure Boosters



Gas Treatment - Utilisation

Technical Specification:

- Minimum supply pressure
- Target calorific value
- Temperature and dew point
- Entrained particle limits
- Corrosion restrictions (e.g. Cl^- or H_2S)

There will be further constraints:

- Planning restrictions
- Grid connection charges
- Emissions monitoring requirements

But there are incentives

- ROCs (UK) REFIT €70 per MWh
- CHP scheme exemptions

Gas Yields

- 1000 tonne of MSW \cong 1 m³/hour gas
- 600-750 m³/hour \cong 1MW_e electricity
- Plus \cong 2.5MW_{th} heat
- Yield is highest at site completion
- Site factors affect actual yields

Plant Size

- 0.5 and 1.0 MW_e units readily available
- Smaller units from 0.2 MW_e
- Micro-generators 50-100 kW_e
- CHP link to on-site AD?

Gas Treatment - Flaring

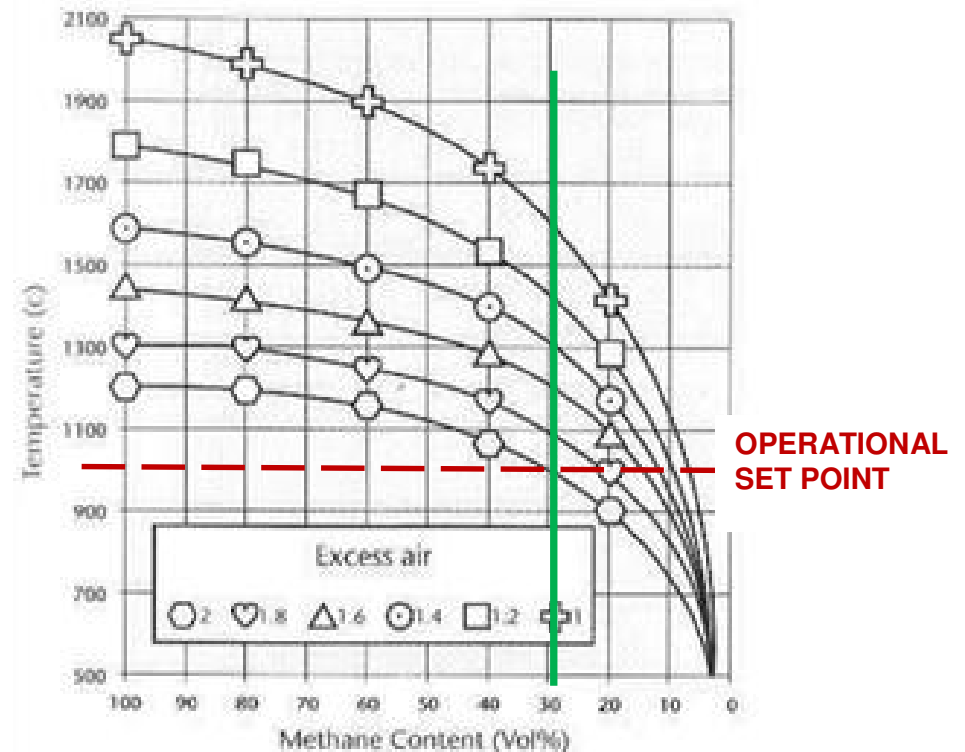
Operational Requirement:

Emission Standard

	[mg/m ³]
CO	50 (100)
NO _x	150
Total VOCs	10
NM VOCs	5

Plant Control Requirement

Temperature	≥1000 °C
Residence Time	≥0.3 sec



Source: *Guidance on Landfill Gas Flaring.*
Environment Agency. Nov 2002

Gas Treatment - Flaring

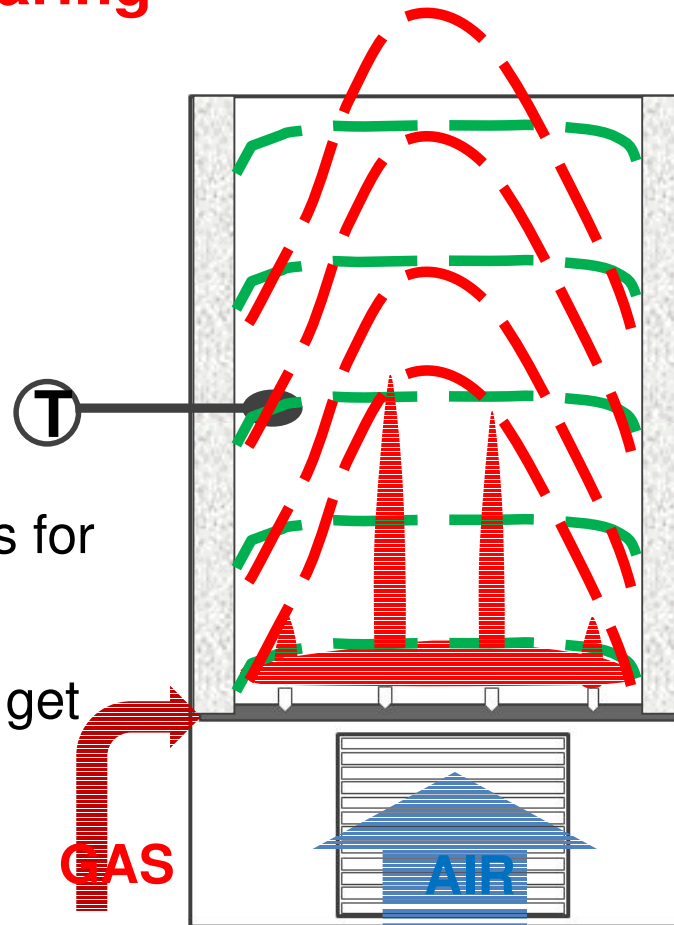
Simplified Operational Behaviour

PLUG FLOW

- what the design calls for

JET FLOW

- sometimes what we get



Safety in Design



WARNING SIGN FOR PLACES WHERE
EXPLOSIVE ATMOSPHERES MAY OCCUR

DESIGN AIM FOR AREA
CLASSIFICATION:

ZONE 2

OR BETTER STILL –

NON-HAZARDOUS

Safety is governed by three scenarios
which apply to normal operation:

ZONE 0 - areas where an explosive
atmosphere will always occur

ZONE 1 - areas where an explosive
atmosphere may occur

ZONE 2 - areas where an explosive
atmosphere is unlikely to occur

Operational Troubleshooting

Landfill gas systems can and do go wrong
so remember that landfills are:

1. Hostile to process systems
2. Wet – water blocks pipes
3. Geotechnically unstable – expect breaks/collapsed pipes
4. Full of grit and dirt – blocks off gas wells
5. Full of fickle methanogens – gas yield fluctuations
6. Often more responsive to weather than operator adjustments

And Finally:

Landfill gas systems are never fully balanced – they need
constant and regular monitoring, adjustment and maintenance

Questions/queries/comments



Comments and queries relating to this presentation would be welcomed by the author who may be contacted at:

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