New gases, old-time quality

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New gases, old-time quality

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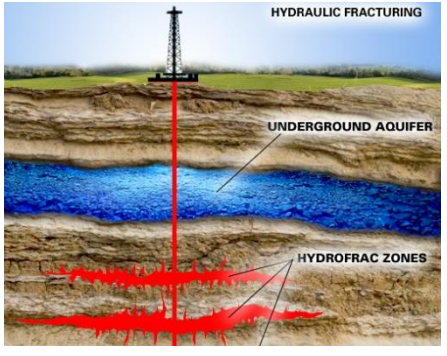
Natural gas (fossil fuel)

- Main component is methane (CH_4)
- Usually, some higher hydrocarbons: mainly ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10}).
- Other components can be N_2, CO_2, He, H_2S and other S-compounds



- LNG = Liquefied Natural Gas
- Shale gas = less accessible Natural Gas

Main natural gas groups

- H gas — high calorific gas
  comparable to 100% CH_4
- L gas — low calorific gas
  comparable to a mixture of 86% CH_4 and 14% N_2

The Netherlands are so used to “Groningen” natural gas,
that we call it G gas instead of L gas

This presentation focuses on G-gas, but H-gas case is similar

Natural gas composition (vol%)

	G-gas	L-gas Germany	H-gas Russia	H-gas Norway	LNG Nigeria	LNG Lybia
CH_4	81.3	87.1	97.7	87.8	91.3	81.6
C_2H_6	2.9	0.7	1.0	7.6	4.6	13.4
C_3H_8	0.4	0.06	0.3	1.3	2.6	3.7
C_{4+}	0.2	0.03	0.1	0.3	1.4	0.7
CO_2	0.9	2.3	0.1	2.0	-	-
N_2	14.3	9.8	0.8	1.0	0.1	0.7

New gases: methane + ……..

- Biogas (from digestion) ~40% CO_2, some N_2, trace H_2
- SNG (from gasification + methanation) 1-10% H_2, some CO_2, N_2, trace CO, C_xH_y
- H_2 or CH_4/H_2 mixture from P2G 1-100% H_2, (+ some CO_2, CO)

  (+ CO_2 methanation)

Gas (e)quality: Wobbe index

Interchangeability of gases is not determined by heating value (HV), but by the Wobbe index

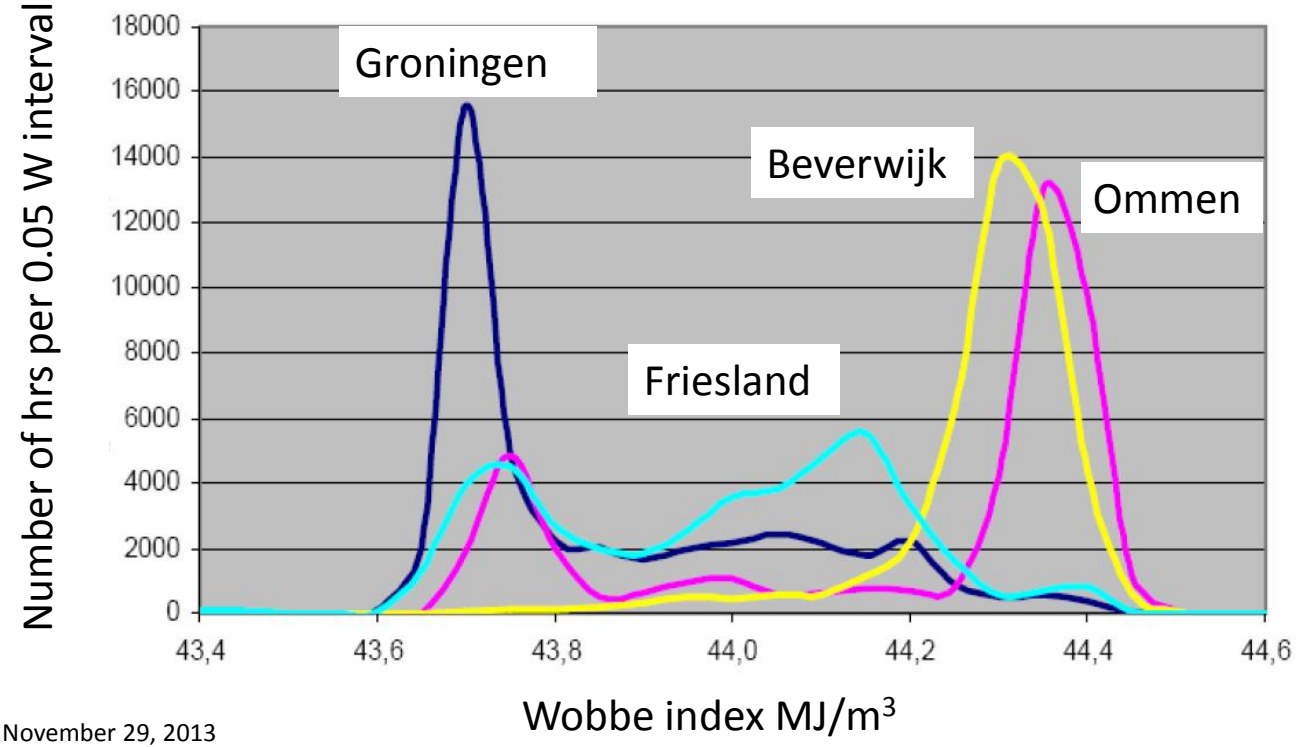
$$W = \frac{HHV}{\sqrt{d}}$$

HHV = higher heating value, i.e. including heat of condensation of water vapour (in MJ or kWh/m^3, volume at 0°C and 1 bar)

d = density relative to air

Wobbe importance (1)

Identical Wobbe indices guarantee identical heat output => safety



Wobbe importance (2)

Identical heat output does not mean identical gas consumption

=> You may not get what you pay for

GC (expensive) or sensor (cheap?) for measurement of heating value required

=> **Here it gets political: how accurate should your bill be?**

Wobbe is not a cure-for-all

=> not naturally occurring or extreme gas compositions may require additional safety measures (e.g. limit values, detectors, smart systems)

=> **This is technical, but quickly becomes even more political**

Transition to Green Gas

http://groengas.nl/wp-content/uploads/2012/05/BioNoF1.jpg

Groen Gas 2.0
Milena-Olga-SNG

New gas compositions (vol%)

	G-gas	Upgraded biogas			H_2 rich (SNG or P2G)
		low CO_2	high CO_2	high CO_2 + LPG	
CH_4	81.3	87.0	88.9	76.7	78.5
C_2H_6	2.9				
C_3H_8	0.4			8.0	
C_{4+}	0.2				
H_2					10.0
CO_2	0.9	3.5	9.8	15.3	-
N_2	14.3	9.5	1.3		11.5
HHV	35.1	34.6	35.4	38.6	31.3
W_{273K}	43.7	43.7	43.7	43.7	43.7

Enriched biogas and H_2-rich CH_4 require 9% lower c.q. 12% higher gas flows

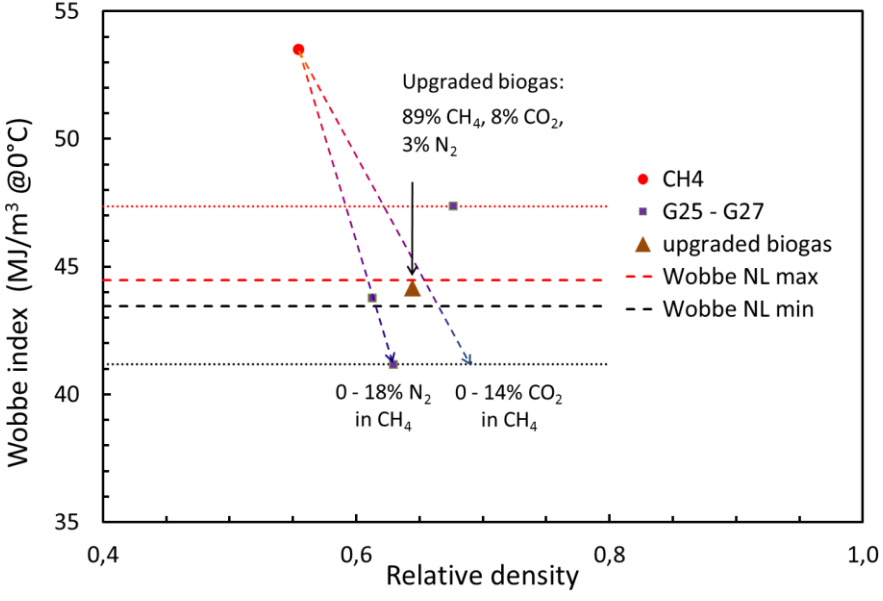
Biogas upgrading debate

Digestion => ~40% CO_2 + ~60% CH_4

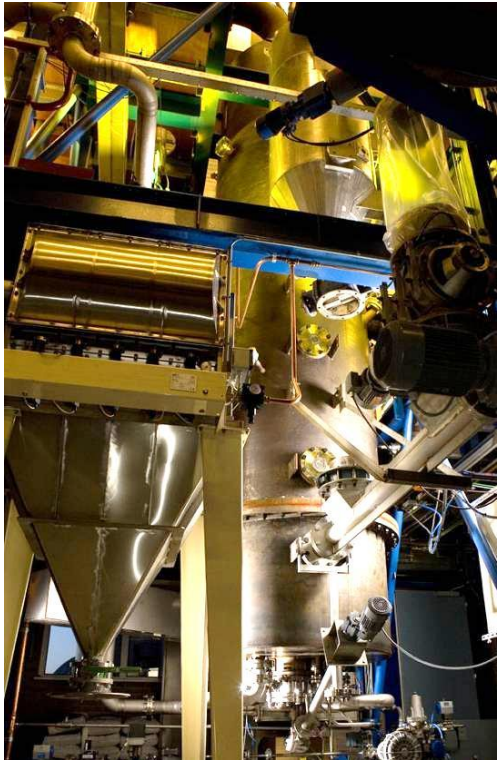
Remove CO_2 => ~90% CH_4 + some CO_2 (+ trace N_2)

Additional CO_2 removal to below 2.5 or 8% and N_2 mixing would increase cost

=> Upgrading biogas becomes less attractive



BioSNG: gasification + methanation



Biomass + heat + steam => producer gas

(mainly CO, H_2, CO_2, CH_4, C_xH_y)

Gas cleaning (removal of catalyst posions)

Catalytic reactions

shift	$CO + H_2O \Rightarrow CO_2 + H_2$
hydrogenation,	e.g. $C_2H_4 + H_2 \Rightarrow C_2H_6$
methanation	$CO + 3H_2 \Rightarrow CH_4 + H_2O$
Sabatier	$CO_2 + 4H_2 \Rightarrow CH_4 + 2H_2O$

Removal of CO_2 and H_2O => “pure” CH_4

BioSNG

	G-gas	Town gas	Biomass producer gas	BioSNG
CO		13	33	0.1
H_2		51	27	4
CH_4	81	23	14	90
C_2H_6	3	2		
C_2H_4		2	4	
C_{3+}	1	1	1	
CO_2	1	3	20	3
N_2	14	5	1	3
HHV	35	21	16	36
W_{273K}	44	31	18	48

Methanation is equilibrium reaction

$$CO + 3H_2 \Leftrightarrow CH_4 + H_2O$$

Some CO and H_2 remain

Lower concentrations

=> higher cost

How much is acceptible/safe?

P2G (Power-to-Gas)

- H_2 production by water electrolysis, using excess renewable power

  H_2 addition to natural gas

  OR

- CH_4 production by Sabatier reaction ($4\ H_2 + CO_2 \Rightarrow CH_4 + 2\ H_2O$)

- Variable load & limited number of operating hours

  => varying H_2 content & high cost

Future G-gas quality

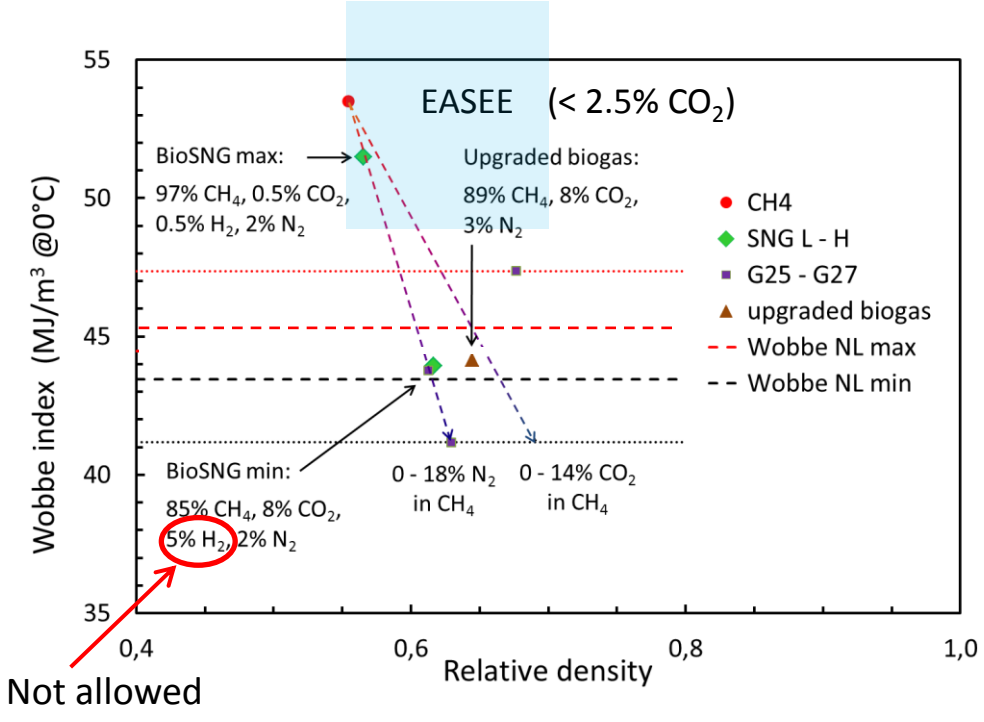
From 2021 (or later):

Wobbe upper limit will be increased to 45.3 MJ/m^3

CO_2 limit will be increased to 10.5%

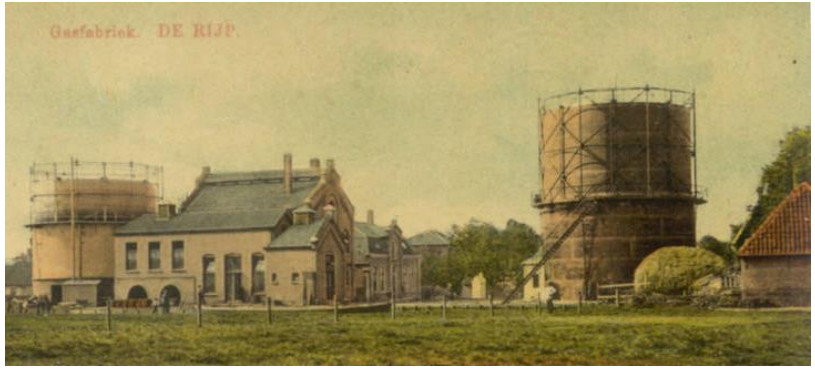
H_2 will be limited to 0.5%

(**unless need arises**, but only after consultation of parties involved)



Conclusion

- Old-time gas quality may not fit modern world
- New gas may resemble old gas
- Innovation needed for flexibility in gas production and use
- Legal issues to be solved, e.g. responsibility, liability and cost distribution



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