Leaking gas in the greenhouse

Max K. Wallis

Greenhouse gas emissions by the United Kingdom could be significantly reduced by replacement of old and leaking gas mains. Such a programme could even be cost-effective for the utility concerned.

BRITISH Gas plc, the newly privatized utility, estimates leakages of natural gas from distribution mains and service pipes, principally from aged cast-iron mains, to be less than 1%. But others[1] estimate leakage to be up to 11% of total supply. If leakage were as high as several per cent, the value of the lost gas means that replacement of the pipes could be financially advantageous. Because methane in the atmosphere is a potent greenhouse gas[2] it is important to account for leakages when calculating the comparative greenhouse effects of competing energy technologies.

Pipes laid before 1969 to carry town gas (mainly carbon monoxide) are expected to be several times leakier than post-1969 pipes designed to retain natural gas (methane)[1]. In Britain, there are 5 million service pipes (of a total of 17 million) and 140,000 km of mains (of 240,000 km) still in use from 1969 or earlier. These pipes leak badly because the hemp–lead joints dry out in methane. Efforts to recondition the gas have been partially successful for medium-pressure mains (operating up to pressures of 2 bar) but hardly effective for low-pressure distribution mains (about 30 mbar). Leakage via pipe breaks has been tackled by an enhanced detection and repair programme, presumed to be 80–90% effective (serious explosions have been cut from about 20 per yr in the 1970s to 4 per yr[3]).

To calculate leakage rates, I adopt the 'median case' assumption of Mitchell *et al.*[1] to derive the figures in the table. Although there is uncertainty to within a factor of 2, Mitchell *et al.* believe this case is 'conservative' in the sense of underestimating the real leakage rate.

I estimate the cost of relaying new mains to average £20 per m for low-pressure and £35 for medium-pressure mains, to be consistent with the £135 million spent in 1989 on laying 4,667 miles of mains (59% new mains, 85% low-pressure). I also take renewal of a service pipe to cost £85, consistent with the £45 million spent on 356,000 renewals and similar numbers of new services, mostly to new housing, at £40 each. British Gas assumes that new mains depreciate over 55 yr and service pipes over 35 yr. At 10% discount rate and a value of gas (to the company) of 20 p per therm (ref. 4), replacement of a service pipe saving 50.5 therms per yr (table) results in an average net saving of £10.10 − £8.76 = £1.34 per yr while replacement of low- or medium-pressure mains (saving 4,500 or 5,800 therms per km per yr) results in a net cost of £1,100 or £2,350 per km per yr. Because of substantial variation in relaying costs and leakage rates, there may be cases where replacement of mains gives net saving.

From these average figures, one can calculate costs of saving greenhouse gas emissions in terms of tonnes CDE (carbon dioxide equivalent; 1 therm of methane weighs 2.0 kg). I adopt an equivalence factor between methane and CO_2 per unit mass of 50, uncertain to a factor of 2. This differs from the IPCC figures[5] of 21 and 63 derived for 'time-horizons' of 100 and 20 years because I have allowed for extra indirect atmospheric effects and assumed effective discount rates (of 1–2.5% per yr) instead of time-horizons. With the methane factor of 50, the marginal discounted annual costs of CDE savings then become 25, 40 and −3 p per tonne CDE, for accelerating the renewal of low- and medium-pressure mains and service pipes, respectively, at 10% discount rate. For a higher 'commercial' discount rate of 13%, the annuitized mains cost double and the service replacement cost is +3 rather than −3 p per tonne CDE.

GAS LEAKAGE RATES

	Low-pressure (therms per km per yr)	Medium-pressure (therms per km per yr)	Services (therms per yr)
Basic leakage Joints (median case)	4,875	13,370	52.5
Breaks	3,600	9,880	
Reduced rate*	4,684	6,162	
New pipe leakage†	177	353	2.0
Net savings	4,507	5,809	50.5

Rates are recalculated from data in ref. 1.
* Adopting median-case figures[1]: conditioning 15% effective for low-pressure mains, 65% effective for medium-pressure mains, repair of breakages 85% effective.
† Partitioning the total leakage of post-1969 pipes assumed as 47 Mtherms per yr (0.25%) between medium-pressure mains, low-pressure mains and services, per km length in the ratio 2:1:1; lengths of medium- to low-pressure mains in the ratio 1:6.4.

Such costs are very low compared with the previous estimate of £25 per tonne CDE (ref. 4). They are also very low compared with typical values of £5–10 per tonne CDE for various greenhouse-gas abatement technologies. The total saving via pipe replacement on the figures in the table is 908 million therms per yr (4.8% of production) or 90 megatonnes CDE, 2–3 times that achievable via technologies such as energy-efficient lighting or building pressurized water nuclear reactors[4].

Prices quoted by British Gas for contract work on pipe relaying in 1991 are higher than used above, from £25 per m for the smallest to £80 per m for 200-mm diameter pipes. If the appropriate averages were 50% higher than the £20 and £35 per m I have used above, the marginal annuitized costs rise to 56 and 71 p per tonne CDE for renewing low- and medium-pressure mains.

The levels of fossil methane in the atmosphere appear to imply[6] up to 6–9% leakage of gas worldwide. In direct terms, the gas industry is a big contributor to UK CO_2 emissions. Burning 18,800 million therms gives 103 megatonnes CO_2 per yr, amounting to one-sixth of the UK total. But the avoidable leakage (908 million therms on the median figures) contributes to the global greenhouse almost as much in CO_2 equivalence, and possibly 2 or 3 times higher.

It seems from my calculations that this avoidable leakage can be saved at very low cost, and that accelerated replacement of service pipes could even save money for British Gas. Even if gas leakage were at the much lower level claimed by the company, so that pipe-replacements save only 15–20% of the amounts used in the table, the costs at less than £3 and probably less than £1 per tonne CDE are still relatively low. The present programme for replacing pre-1969 gas piping would take 45 yr for gas mains and 15 yr for services at current rates. The replacement of service pipes has been cut to only 2.1% per yr, below the 2.5% per yr that the King report[7] (on gas explostions) considered "reasonable". The case for accelerating this programme to reduce global greenhouse pollution is surely very strong. □

Max K. Wallis is in the School of Mathematics, University of Wales, PO Box 915, Cardiff CF2 4AG, UK.

1. Mitchell, C., Sweet, J. & Jackson, T. *Energy Policy* **18,** 809–818 (1990).
2. Hogan, K. B, Hoffman, J. S. & Thompson, A. M. *Nature* **354,** 181–182 (1991).
3. Keay, M. *Gas Regulation, the Environment and Energy Efficiency* (Office of Gas Supply, London, 1991).
4. Jackson, T. *Energy Policy* **19,** 35–46 (1991).
5. Houghton, J. T. Jenkins, G. J. & Ephaums J. J. *Climate Change. The IPCC Scientific Assessment* Ch. 2. (Cambrige Univ. Press, 1990).
6. Crutzen, P. J. *Nature* **350,** 380–381 (1991).
7. King, P. Clegg, G. & Walters, M. *Report of the Inquiry into Serious Gas Explosions* (HMSO, London, 1977).