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Evaluation of methane emissions from the Spanish gas distribution system

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Outline

1. Leakages in gas distribution networks
2. Objectives of the study for the Spanish case
3. Measurement of leak rates
4. Pressure variation method
5. Field tests and results
6. Conclusions

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Leakages in gas distribution networks

- A fraction of the gas natural distributed is released through leakages in the networks
- Consequences:
  - Significant economic losses
  - Release of methane:
    - » Greenhouse gas, GWP=21 tonCO_2eq/tonCH_4
    - » In Europe: ~80% of CH_4 emitted due to leakages
- Issues:
  - Reduce and quantify the leakages
- Assessment of methane leakages:
  - A few field results (BG, Ruhrgas)
  - Emission factors:
    - » Factors for different pressures, materials, …
    - » Calculation methods and emission factors are different for the diverse countries

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Estimations of methane emissions

Methodology	Distribution		Service lines		SMR's	
	$Nm^3/m/y$	$Nm^3/m/y$	Nm^3/Leakage/y		Nm^3/Leakage/y	
	HPA-S	MPB-PE	HPA	MPB		
PGM-087-E	5	1	11.9	9.1	1000	
USA EIA 95/96 without p distinction (plastic and N-p.)	0.156 / 0.684	0.017 / 0.172	-	-	0.08 / 0.4 $Nm^3/m/a$	
Steczko USA / Canada 2003	0.99 / 0.73 $Nm^3/m/y$ (network + service + EMR)					
IGU (2000) medium and low	2	0.1	-	-	5000	1000
Steczko. for not own data	2.89	0.385	-	-	High 50603	Med 27534
Lott (EEUU). without p distinction	1.321	0.039	0.929 Nm^3/Ser/y	0.767 Nm^3/Ser/y	4814 Nm^3/SMR/y	
Germany West / Est	0.165 / 1.648	0.034 / 0.247	0.55 /5.49 $Nm^3/m/y$	0.16/1.17 $Nm^3/m/y$	Low p 202 / 202	
British Gas at 30 mbar (distribution + service lines)	-	0.38	-	-	-	
Eurogas-Marcogaz (minimum / maximum)	0.233 / 0.339 Including VwNO	0.064 / 0.300	20 / 90%	20 / 90%	43 / 407 Nm^3/SMR/y	

The ranges are too wide

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Current procedure in Spain: PGM-087-E

	Pressure range				
Distribution network ($Nm^3/m/y$)	**HPB**	**HPA**	**MPB**	**MPA**	**LP**
Material					
Steel	7.5	5	2.5	0.62	0.5
Ductile cast iron	-	-	6.5	1.7	1.5
Grey cast iron	-	-	6.5	6	5
Polyethylene	-	-	1	0.22	0.2
PVC	-	1	10	5	3
Service lines (Nm^3/leakage/y)	13.7	11.9	9.1	6	3.4
SMR's (Nm^3/SMR/y)	1000				

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Revision of the Spanish procedure

- Large discrepancies with other methodologies. In particular:
  - Steel lines: emission factors are too high compared to others
  - PE – med. pressure B (MPB: 0.4-4 bar):
    - » Emission factors too high?
    - » Main source of emissions (after update of factor for steel)

- Project (2005):
  - Survey of methodologies in the world
  - Identification of critical emission factors
  - Field testing for selected parts of the network → PE-MPB

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Measurement of leak rates

- Used in field tests to evaluate actual emissions in the gas network

- Two main groups,

On whole sections:	On individual leaks:
Pressure decay method (BG) + *Reliable* - *Service off* - *High cost and effort*	Bagging method + *Service on* - *Only identified leaks* - *Excavation required*
Pressure variation method (RG) + *Reliable* + *Low cost and effort* + *Service on* - *Only if consumers' offtake ↓ ↓*	Suction method (RG) + *Service on* + *No excavation required* - *Only identified leaks* - *Sources of error*

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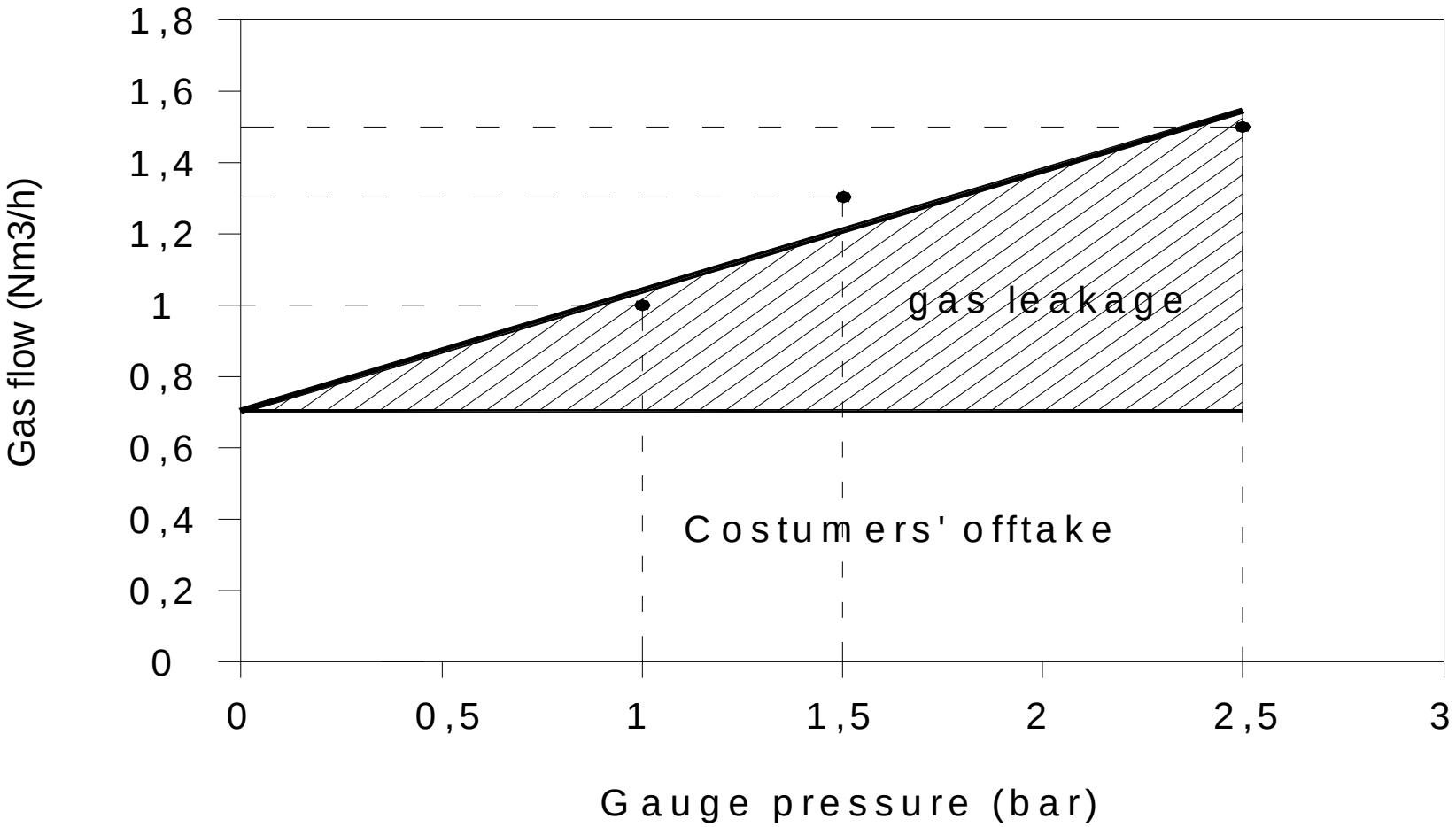
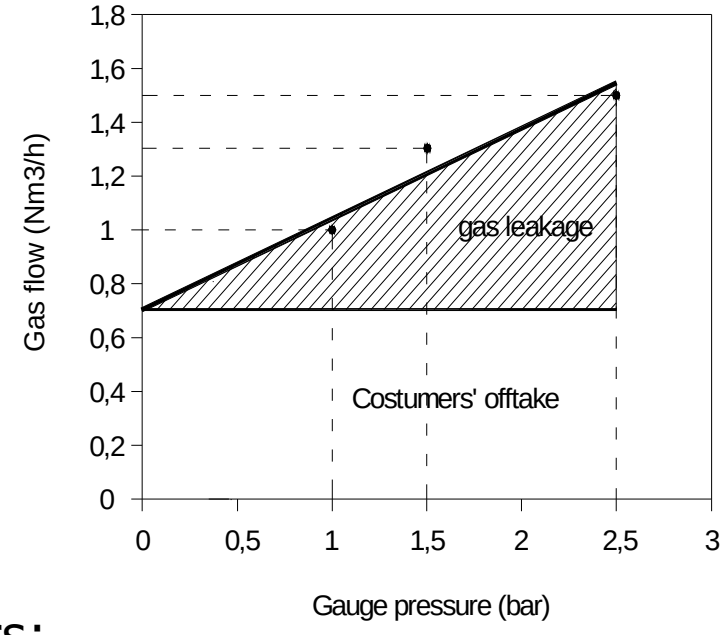
Pressure Variation Method - **PVM**



PVM: Procedure and requirements

- Procedure:
  1. Measurement of Qgas @ different pressures
  2. Estimation of consumers' offtake
  3. Estimation of leak rate @ operating pressure



- Requirements:
  - Consumers' offtake: **Low** and **stable**
  - Critical instruments → flow rate meters:
    - » **Span:** large enough to reach maximum flow rate (offtake+leak)
    - » **Uncertainty**: low enough to resolve very low leak rates

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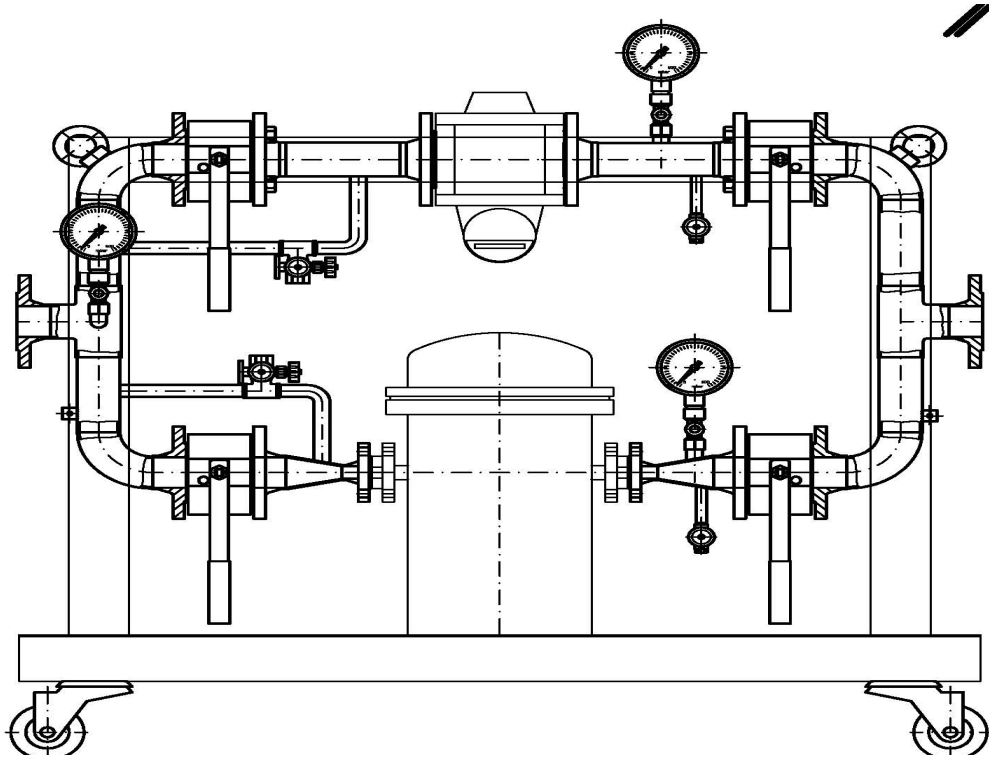
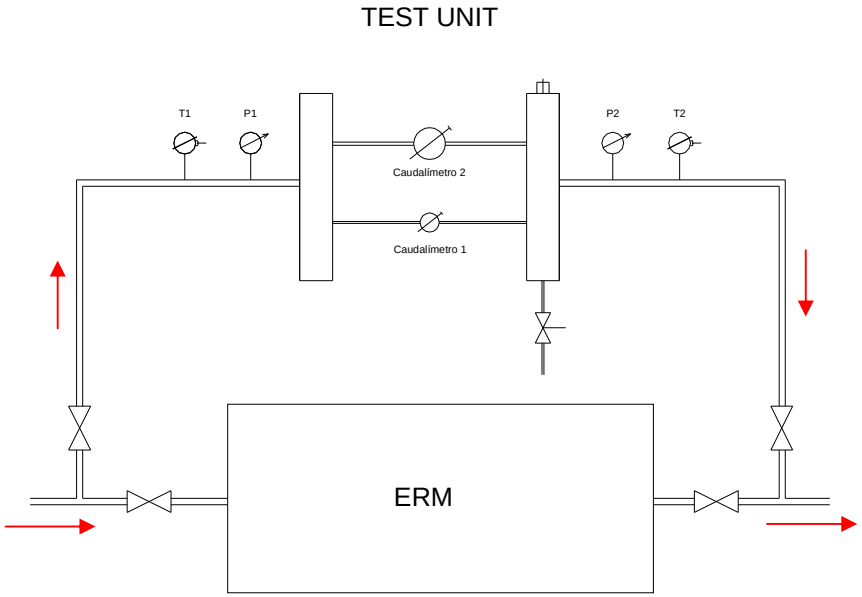
Test unit

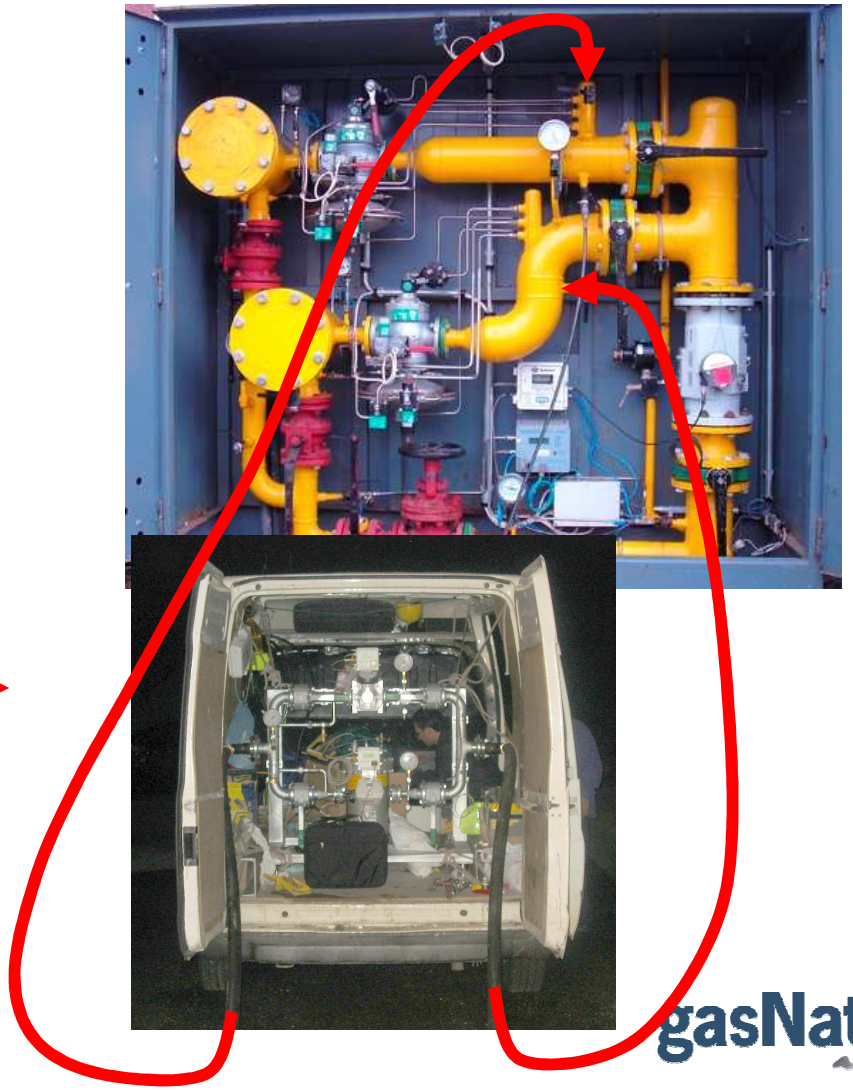
- Test unit:
  - Two flowmeters (in parallel, selectable): a wide range of flow rates (0.04-100 m^3/h), with good accuracy (down to 0.0012 m^3/h)
  - Auxiliary instruments: P, T
  - Data recording: PC + ADC board



On-site installation

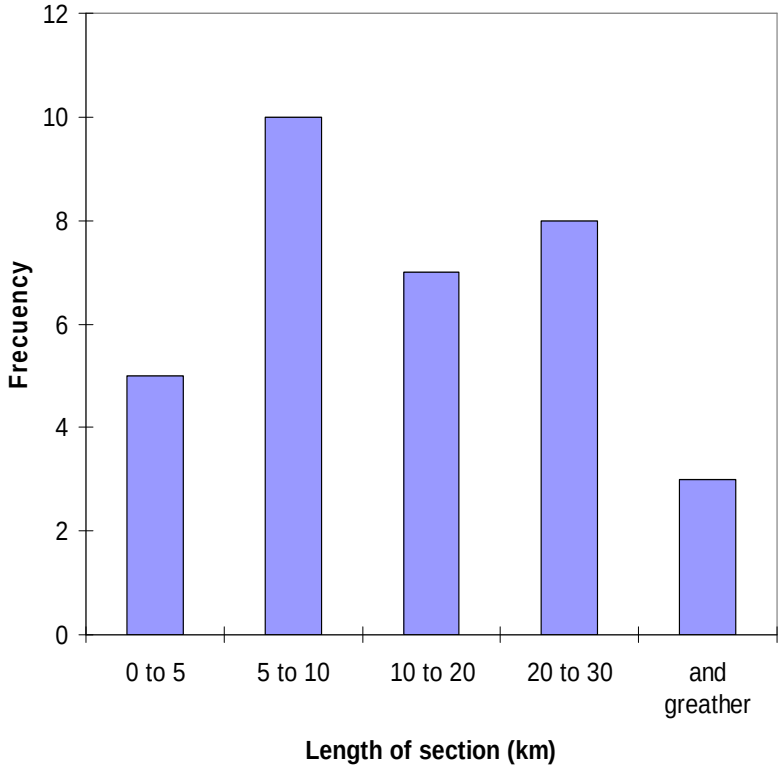
- Test unit inserted into district Metering and Regulating Stations

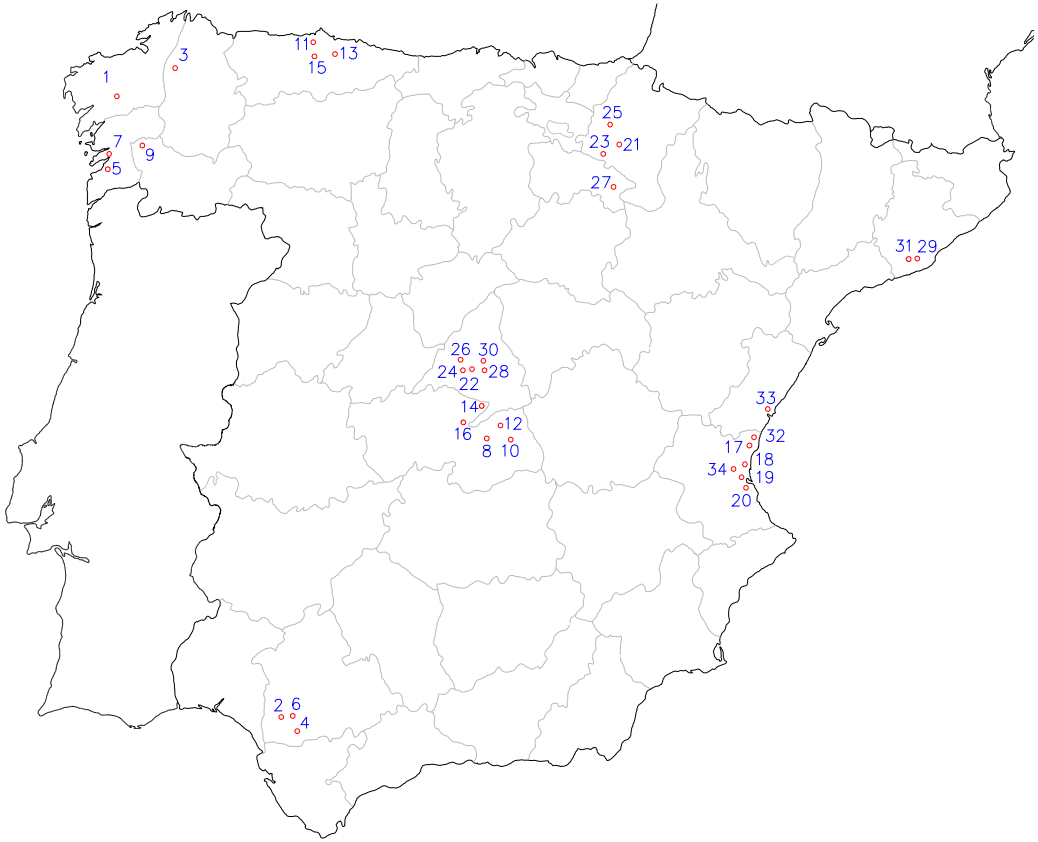




Test campaign

- Sections of PE-MPB (0.4-4 bar):
  - 34 sites (2-63 km)
  - Total=547,7 km





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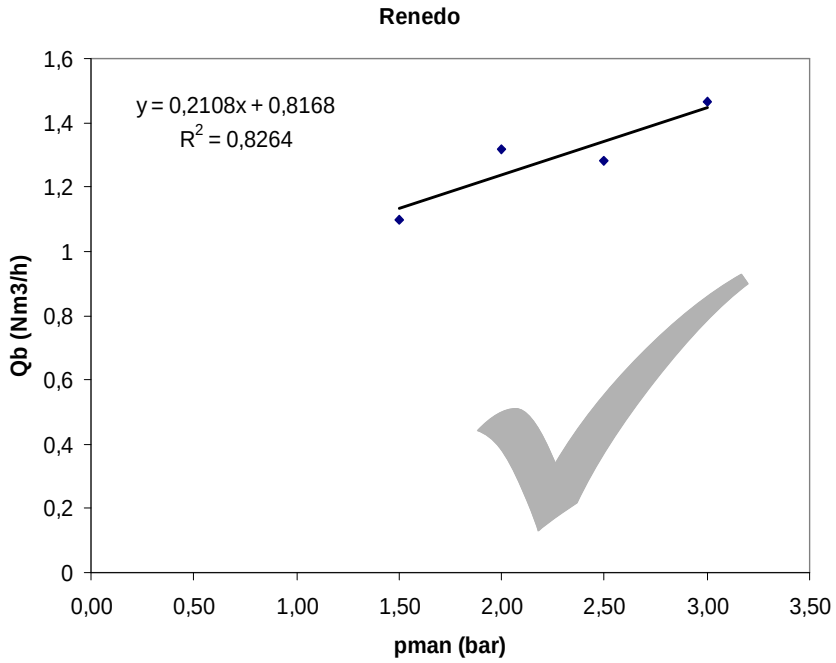
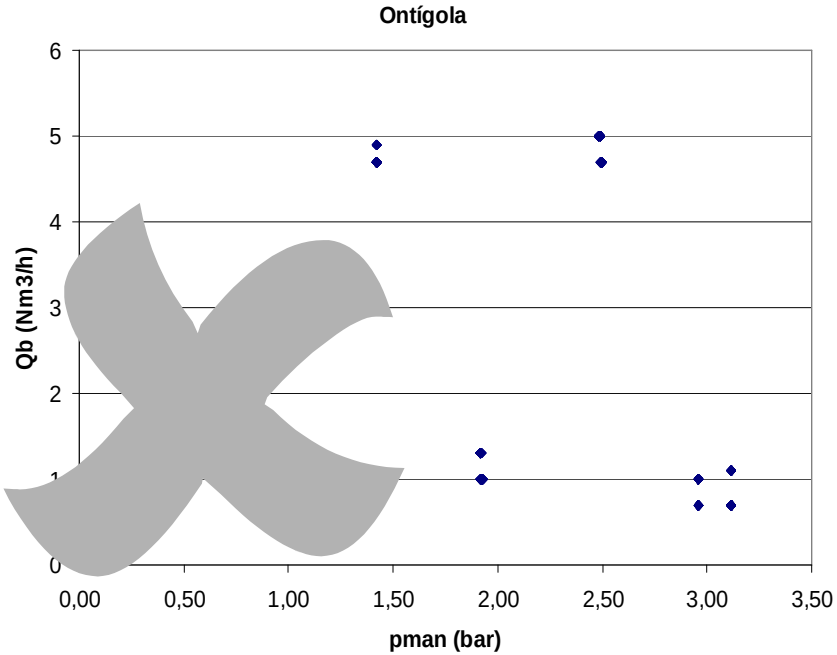
Data analysis (1)

- 1st Step: Results are validated only if:
  - Flow rate < 100 m3/h
  - Fluctuations < Mean value
  - Flow rate and pressure variations are consistent

  → 21 valid results (out of 34 tests)





Data analysis (2)

- 2nd Step:
  - Calculation of local emission factor:

$$(EF)_i = \frac{Q_{leak}}{L} 24 \frac{hous}{day} 365 \frac{days}{year} (Nm^3 / year / m)$$

  - Calculation of ensemble emission factor:

$$EF = \frac{\sum_i Q_{leak,i}}{\sum_i L_i} 24 \frac{hous}{day} 365 \frac{days}{year} (Nm^3 / year / m)$$

- 3rd Step: Uncertainty analysis; Sources of error considered:
  - Accuracy of Q, P, T sensors
  - Fluctuations for constant pressure
  - Consumers' offtake: Uncertainty due to extrapolation
  - Estimated leak rate: Uncertainty due to interpolation
  - Variability among sites

- Results are given in terms of: $EF \pm U_i$, for a given confidence level

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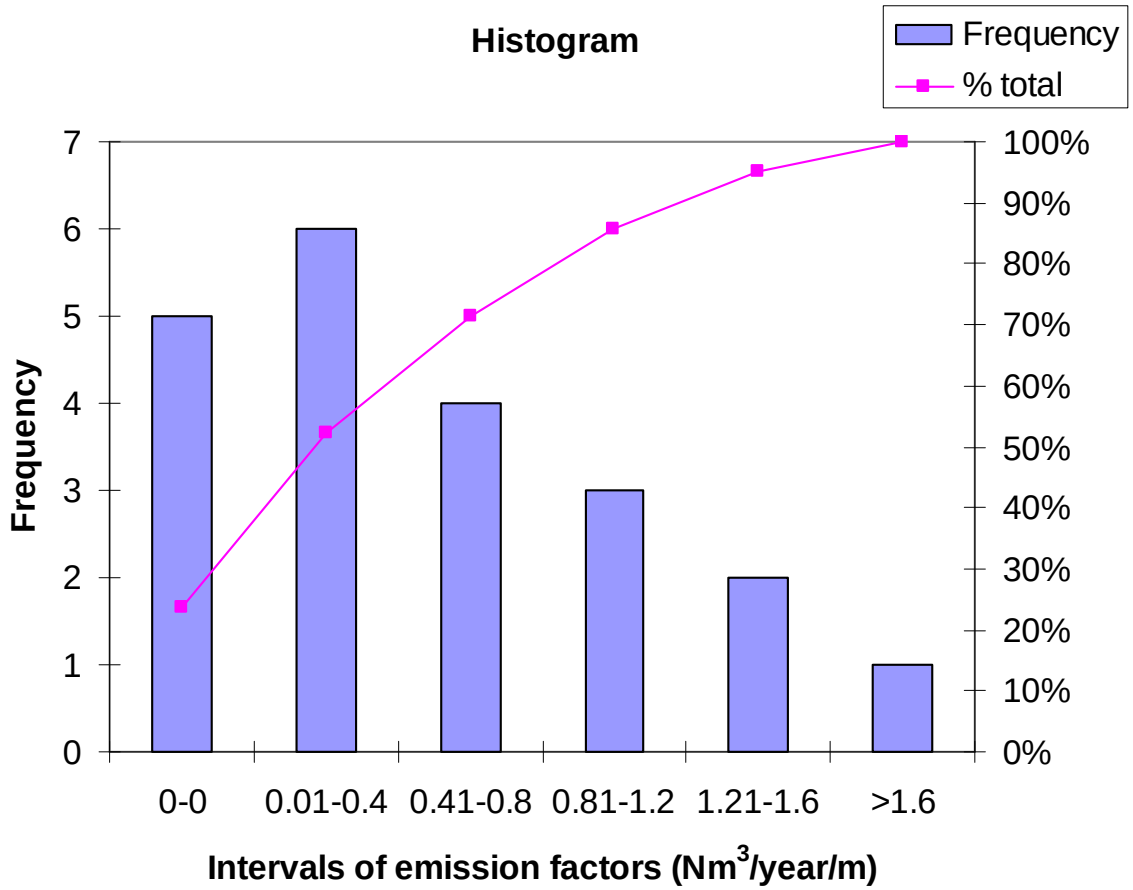
Emission factors

- Statistics of measured emission factors (21 tests):
  - 0.46 ± 0.14 Nm^3/year/m (confidence=80%)
  - 54% lower than factor currently used in Spain



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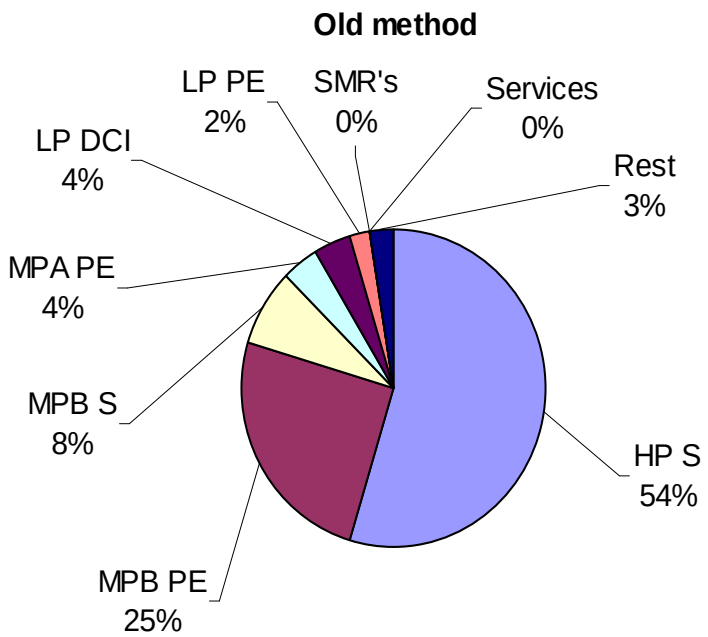
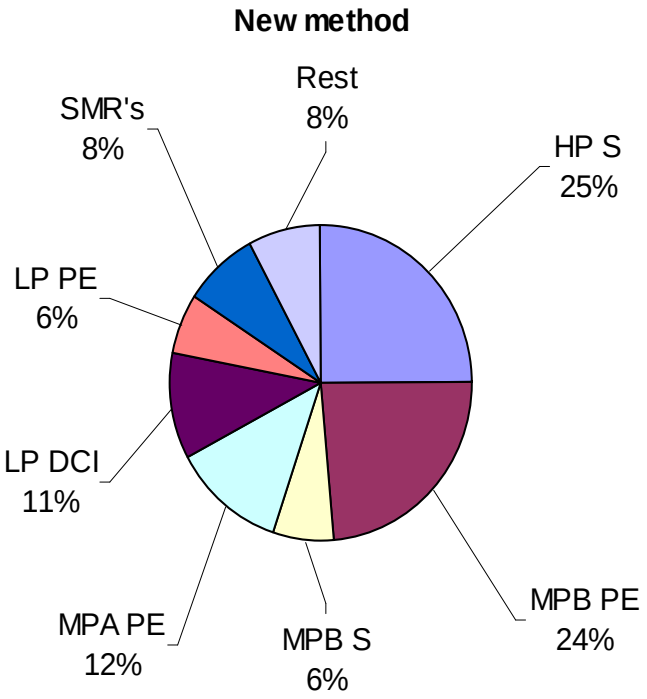
Emissions in Spain: New *vs.* Old method

- Old procedure:
  - 0.905 ton CH_4/km
  - HP-Steel: 0.49 ton CH_4/km
  - MPB-PE: 0.23 ton CH_4/km



- New procedure:
  - 0.478 ton CH_4/km
  - HP-Steel: 0.119 ton CH_4/km
  - MPB-PE: 0.113 ton CH_4/km



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Conclusions (1)

- Test method:
  - Procedures and equipment have been developed for the measurement of leak rates, based on the pressure variation method.
  - In cases of low, stable consumption patterns, PVM offers the advantages of reliability and low cost+effort.
- A field campaign has been accomplished in PE-MPB sections in the Spanish distribution network.
  - 21 out of 34 sites yielded valid results.
  - New results have been obtained, which are thought to be applicable to many countries having networks of similar characteristics.

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Conclusions (2)

- A new procedure for the estimation of methane emissions in Spain has been developed and submitted to the Ministry of Environment:
  - Emissions attributed to steel mains are significantly reduced (to levels similar to other countries)
  - The emission factor for PE-MPB has been updated, according to the field tests
  - As a result,
    - » The total annual emission has been reduced in 53%
    - » The relative contributions of the different types of lines is significantly modified
- Gas Natural SDG is planning additional field tests on MP steel sections for this summer.

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