GASUNIE'S EXPERIENCES WITH LEAK DETECTION AND REPAIR AS A PART OF FOOTPRINT REDUCTION

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ABSTRACT

This paper will describe Gasunie's experiences in a specific area of the footprint reduction programme, the reduction of fugitive natural gas emissions and the results achieved by the so called “Leak Detection And Repair” programme (LDAR); it focuses on the uncontrolled fugitive emissions of methane (CH_4). Uncontrolled CH_4-emissions are the result of gas leakages, also referred to as "fugitive emissions", and incidents with gas release. Incidents however are not a topic in this paper. Emissions of CH_4 has got an environmental impact as the CH_4-greenhouse effect is 23 times the effect that of CO_2 (on the weight basis).

The background of footprint reduction and the role of LDAR are given and Gasunie’s chosen approach is explained. To give more insight in the LDAR method and overview of the necessary steps are described together with the references in which detailed information can be found. The results of the measurements are given and discussed and to what conclusions we have came completes the paper.

LDAR consists of a first leak measurement followed by a direct first repair attempt, followed by another measurement. As a result an average of approximately 37% of the leakages was reduced from a total emission of $935*10^3$ kg/a CH_4. Pay-back times of this campaign are typically between 1 to 2 years for large more complex facilities like compressor stations. This is an interesting outcome, because this generates the CAPEX capacity for further repair investments.

For the remaining repair of leakages an assessment must be made to determine the feasibility environmentally and economically before conducting the repair. In this assessment the leak flow (kg/a) is compared to the impact of performing a repair on safety, environment (blow down gas, CO_2 footprint, material ect.) and the gas transport planning.

The LDAR conducted by Gasunie gives an unique insight in the leakage behaviour of the whole span of gas transmission units at three different levels. It is found that leakage behaviour can be managed, giving good results in reducing emissions whilst staying economically feasible.

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1. INTRODUCTION

Gasunie is a European gas infrastructure company. Its network ranks among the largest high pressure gas pipeline grids in Europe, consisting of over 15,000 kilometres of pipeline in the Netherlands and northern Germany with its related facilities with a throughput of aprox. 125 billion cubic meters. Gasunie is the first independent gas transport provider with a cross-border network in Europe and offers transport services.

As far back as the 1980's Gasunie initiated its first, what now can be seen as, footprint reduction activities. The company's efforts are mainly based on the improvement of energy efficiency and the reduction of methane (natural gas) emissions because methane is a greenhouse gas with large impact.

This paper will describe Gasunie's experiences in a specific area of the footprint reduction programme, the reduction of fugitive natural gas emissions and the results achieved by the so called “Leak Detection And Repair” programme (LDAR).

2. BACKGROUND

The natural gas industry is a technologically highly developed sector which takes its responsibility towards environmental issues seriously. There is a growing awareness for the fact that methane emissions caused by the activities of various companies along the gas chain (production, transmission and distribution) can be significant, and therefore its environmental impact as methane's (CH_4) greenhouse effect is 23 times the effect that of CO_2 (on the weight basis). Typical Dutch natural gas consists of at least 85% CH_4.

The ambition of Gasunie is in line with European 20-20-20 goals: Gasunie aims to reduce its emissions by with 20% by 2020 as compared to the base year of 1990. The company has both direct and indirect emissions. Direct emissions are produced as the result of Gasunie's activities on its own sites. Indirect emissions are caused outside its own sites, mainly caused by electricity usage for Nitrogen production (gas blending) and electrical compressor drives. Further more, direct emissions are either controlled or uncontrolled. Examples of controlled CH_4-emissions are: emissions due to usage natural gas in pneumatic operating equipment such as valves, gas expansion motors, regulators but also blow-off gas from compressor housings and venting for maintenance purposes. Uncontrolled CH_4-emissions are the result of gas leakages, also referred to as "fugitive emissions", and incidents with gas release. The focus of the current paper is on the uncontrolled fugitive emissions of CH_4.

The Gasunie transport network system, which is one of the largest in Europe, represents many potential leakage sources. For example, the large number of physical connections within the gas transport network, which, when not optimally adjoined, can permit the methane to escape into the atmosphere.

According to the provisions of the Kyoto agreement, Gasunie is only responsible for its direct emissions. However this does not mean that the company takes the problem of its indirect emissions lightly. For example, it is theoretically possible to significantly reduce the direct emissions of Gasunie by switching to electrically driven compressors. However this is not a radical solution, but rather “passing the buck”, and this approach has therefore not been adopted.

3. APPROACH

Gasunie has been making an inventory of its fugitive emissions since the 1980s. Starting in 2004, however, due to more stringent requirements related to the environmental permits for its installations, Gasunie undertook concrete actions focussed on the reduction of its fugitive emissions.

One of the most important considerations is the environmental effect of fugitive emissions. As mentioned, the greenhouse potential of CH_4 is 23 times stronger than that of CO_2 in terms of its weight. Besides the environmental considerations, the CH_4 leakages cause economical commodity losses. Another important reason is safety: leaking CH_4 contributes to a less safe work environment and has a risk of explosion. Furthermore the CH_4 leakages have a number of subjective costs, expressed in the company reputation, corporate social responsibility, satisfying the expectations of various stakeholders, etc. Therefore decreasing these leakages brings other benefits to the company as well. This was all good reason for Gasunie to initiate the LDAR programme.

4. LEAK DETECTION AND REPAIR (LDAR)

At first more stringent requirements related to the environmental permits for some of its installations, obliged Gasunie to make a 100% survey of its potential leak sources, adequate database system and work practice to control the leakages. All these demands were met in performing LDAR, of which the method is described in detailed in a National Code of Practice called “Milieumonitor 15” (ref. 1) as laid down in the permit demands.

LDAR is based on the NEN-EN 15446:2008 (en): "Fugitive and diffuse emissions of common concern to industry sectors. Measurement of fugitive emission of vapours generating from equipment and piping leaks" (ref 2). This standard follows the EPA Method 21 "EPA Determination of Volatile Organic Compound Leaks" (ref 3), and EPA 453 "Protocol for Equipment Leak Emission Estimates (1995)" (ref 4). The measurements themselves are based on the Code of Good Practice of Measurements of diffuse Volatile Organic Compound emissions from the Reference Laboratory Air in Belgium (ref 5).

The accuracy of the leak measurement method is an important factor; however the costs and the speed of the large number of measurements should also be taken into account. The measurement should be performed as an optimum between the necessary accurateness on one hand, and the speed and the costs of the procedure on the other hand. The level of accuracy achieved in LDAR measurements was, lower than, for example, the "bagging" method but the LDAR method has allowed to achieve a good balance between speed, costs and accurateness (ref 6).

LDAR consists of a systemic and comprehensive monitoring and recording of emissions and therefore gives a detailed overview of gas leakage. A typical LDAR program consists of three main parts:

1. Preparation:
    a. Database preparation
    b. Source inventory: import all gathered information into database, preparation of measuring phase etc.
2. Measuring & first repair attempt:
    a. Performing initial measurement
    b. Executing first repair attempt, which consists of simple corrective maintenance actions on found leakages, done by re-tightening
    c. Re-measurement to establish result of first repair attempt
3. Reporting:

a. Consolidate all gathered data,
b. Create LDAR report with overview of losses in kg/a with top leakers (in costs and losses) with sort on most leaking sources and average leakage per source.

Four classes of leak sources are defined:

- Class 1: zero leakers: that are non-detectible emission, in practice with a detection level lower than 9 parts per million (ppm)
- Class 2: small leak sources between 9 ppm and 100.000 ppm
- Class 3: leak sources above 100.000 ppm
- Class 4: non-accessible leak sources.
- A repair threshold is set at 1000 ppm. This means that leakages above 1000 ppm need to be resolved.

The concentrations, measured in ppm, are converted into values expressed as kg per year (kg/a). The calculation rules are described in the aforementioned standards (ref 3). Expression in the unit of kg/a is easy to communicate and gives clear insight into the amount of commodity and economical losses.

5. PRESENT SITUATION

Since 2004 LDAR has been conducted on 8 compressor stations (out of 13), 40 pressure reductions stations (PRS) (out of 1200), a gas blending station and a gas export station. A large amount of measurements have been carried out by an external company The Sniffers in Belgium. In total almost 200,000 potential leakage sources have been identified and over 180,000 have been measured (covering factor of 90%). This has resulted in the identification of just more than 5000 actual gas leakage sources. A company strategy for the reduction of fugitive emissions has been developed with KEMA.

6. RESULTS

The results of the leakage measurements can be summarised into three categories:

- An overall gas transport network category
- A specific facility category
- A detailed installation equipment category.

The overall gas transport network category is important input for management decision-making related to maintenance and construction policy. The specific facility category gives valuable input for prioritising actions to be taken at facility level. The detailed installation equipment category is input for the onsite maintenance technicians.

- **Overall gas transport network category**

Every industry has its own typical profile of potential leakage sources. For the Gasunie this profile is given below. In total 12 groups have been identified according to required standards, see Figure 1. From this Figure it can be concluded that the largest numbers of potential leak sources can be found in the group connections, flanges (see Figure 2) and valves. This is characteristic for gas transport networks.

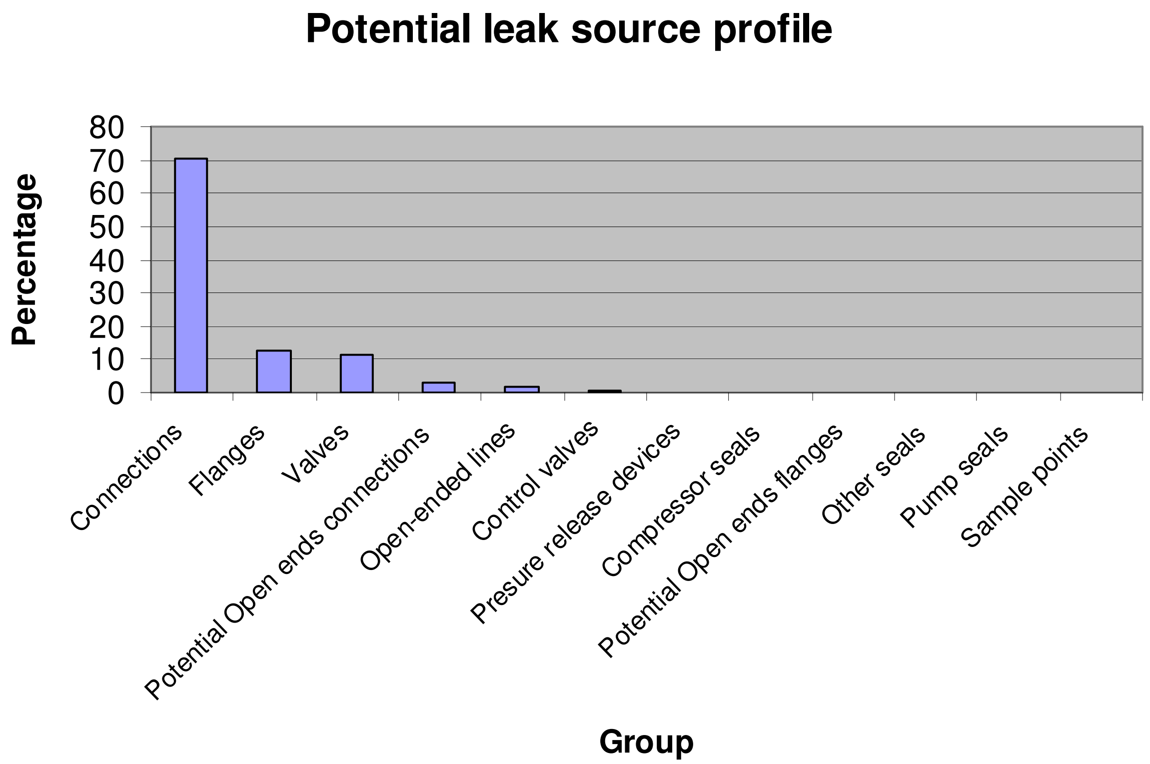

Figure 1 Potential leak source profile

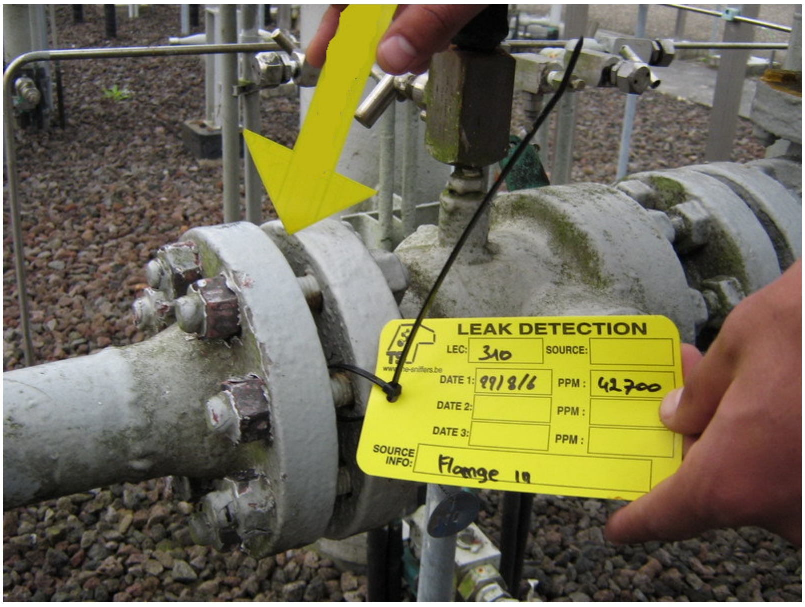

Figure 2 Flange

The results of the measurements for these groups of potential leak sources are given in Figure 3.

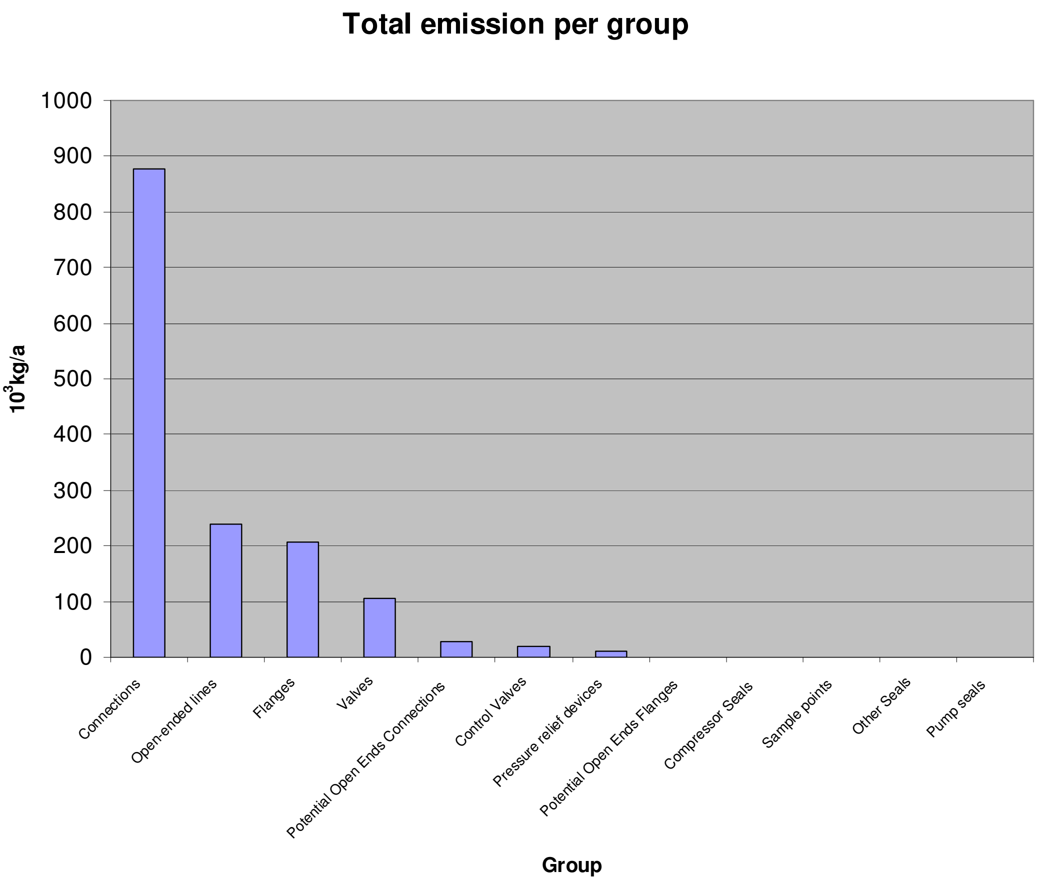

Figure 3 Total fugitive emission per group

From Figure 1 and 3 the following conclusions can be derived:

- As expected, the group connection has the largest number of potential leakage sources and consequently the largest amount of emissions;
- The second largest amount of emissions however is caused by the group open-ended lines (pipes open to the atmosphere or surrounding environment) and not as expected the flanges (see Figure 2);
- The third largest amount of emissions is caused by flanges.

So the measures for reducing the emissions should be focussed at the groups with the largest amount of emissions and not the largest amount of potential leakage sources.

As mentioned before, more than 5000 gas leakage sources have been identified in our investigation with a total emission of $935*10^3$ kg/a CH_4. The LDAR initial measurements were directly followed by an effective first repair attempt with impressive results. The first repair attempt gave a reduction over 37% ($355*10^3$ kgCH_4/a). See Figure 4. Not all the leakages, approximately 56% ($523*10^3$ kgCH_4/a), could immediately be successfully repaired. For these sources additional maintenance measures need to be taken. The remaining emissions of $57*10^3$ kgCH_4/a (6%) is the summation of all the other emissions cause by non-accesibles, zero leakers and, leakers below the repair threshold of 1000 ppm. In compliance with the calculation rules of the “Protocol for Equipment Leak Emission Estimates” (ref 4), a number of Zero leakers contribute with a calculation factor to a certain amount of leakage

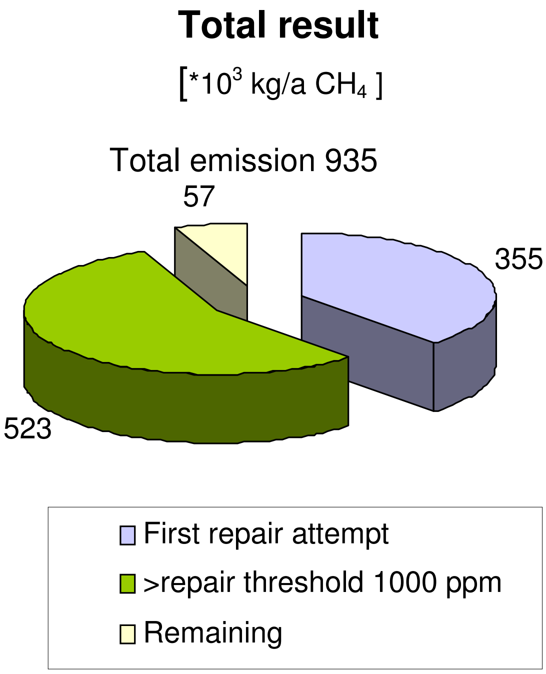

Figure 4 Total emission result

- **specific facility category**

A perfect example of the 80-20 rule can be found in the results at the specific facility category as shown in Figure 5 which shows the results after the first repair attempt. This is explicable as follows: after the first repair attempt at a compressor facility 107 remaining leakage sources above the repair threshold were responsible for just over 50*10^3 kgCH_4/a emission. Of the 107 sources only 21 leak sources above 100,000 ppm contributed to 39*10^3 kgCH_4/a. So, resolving the 20% (in this case #21) large leakage source will contribute to a reduction of 80% of the remaining CH_4 emissions. So, LDAR provides detailed information making sure it is clear which actions will be the most successful in reducing the fugitive emissions.

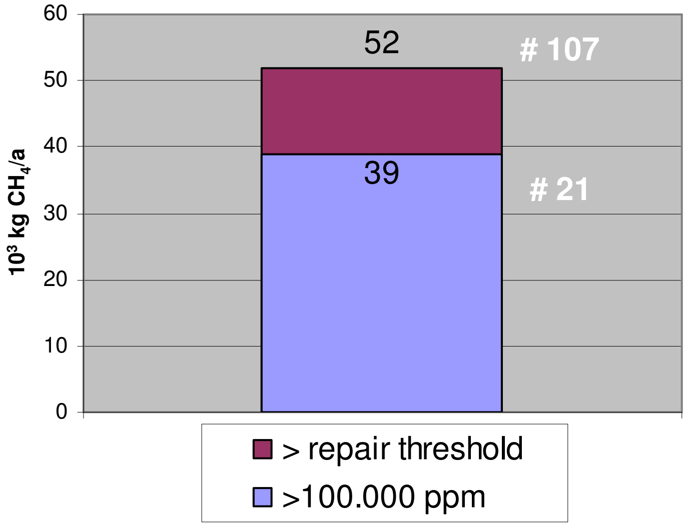

Figure 5 remaining leakages at facility category

- **detailed installation equipment category**

At the detailed installation equipment category level, the leakage database gives information of every potential leakage source. From this, specific repair orders can be generated. These repair orders, see Figure 6, provide specific and detailed information of remaining leakers which is useful for maintenace. But also data of the individual bad actors within the population of installation equipment can be derived, which can be linked to specific equipments (brand and type) that can be used to improve procurement and engineering standards.

Leak equipment code : 828 **NER :** P8

Source code : 1

REPAIR ORDER

Site : Gasunie
Unit : CS Schinnen
Section : BRANDSTOF
Drawing : A-408-LS-200
Stream : METHAAN-G
Service : Gas
Composition : methaan gas
Product type : B

System : C-101
Equipment ID :
Level : 0
Routing_number :
Access : Accesible
Manufacturer :
Line :
Production hours : 1.000

Very big
Blind req.
Remark
Insulated
Corrosion

Equipment : Valve
Equipment type :
Equipment location : 3m tOZOv C-101, h=0,3m
Detection equipment : TVA-FIDC
Calibration medium : Methane (natural gas)
Calculation method : Correlation Socmi

Source : Flange
Source location : Top
Size : 0,75 IN
RF 500 : 1,00
RF 10000 : 1,00
Status :

Leak Def. : 1000
Repair Def. : 1000

Historical measurement data :

Date	PPM	Loss Kg/yr	Operator	Remark	Repair Action
07/12/2009	45900	40,74	GP		

MAINTENANCE INFORMATION

Calculated loss next year : 3.126,17
Repair period :
Repair action :
Repair date :

Repair cost :
Repair code :
Gasket/Sealing :
Repair executor :

Repair memo:

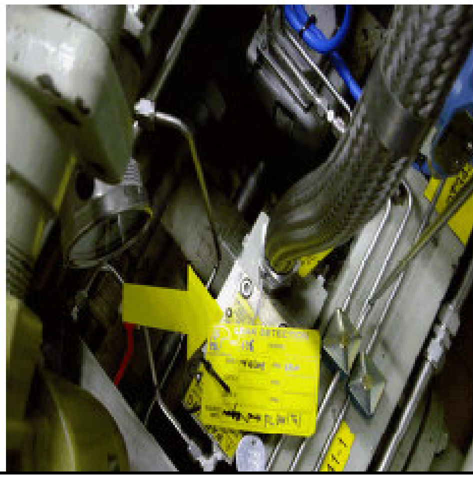

Figure 6 Example repair order

7. ECONOMICS

Besides the environmental and safety benefits there is also a financial part of the equation. As said the emission of CH_4 means an actual loss of commodity. This commodity has a value of its own.

Performing a cumulated discounted cash flow calculation shows the break-even-point (BEP) of LDAR as shown in Figure 7. Only the out-of-pocket costs are taken into account. On average the BEP of LDAR for larger and more complex installations, like compressor stations, is less than 2 years. So LDAR is profitable but it can also generate the CAPEX capacity for repair investments depending on the policy of required BEP for investments.

For smaller installations (PRS) the BEP is often longer than 5 years. It was therefore decided that for smaller installations LDAR would be carried out at a sampling base and maintenance activities are carried out in analogy with the LDAR approach. For this reason maintenace technicians have been equipped with hand-held explosion-proof gas detectors for locating the leakages and so being able to perform a first repair attempt.

The remaining commodity savings, i.e. the value of the remaining emitted commodity, can be used for justifying the investments needed for repairing the remaining leakages expert judgement is necessary to keep a balance between environmental impact, repair preconditions and economics.

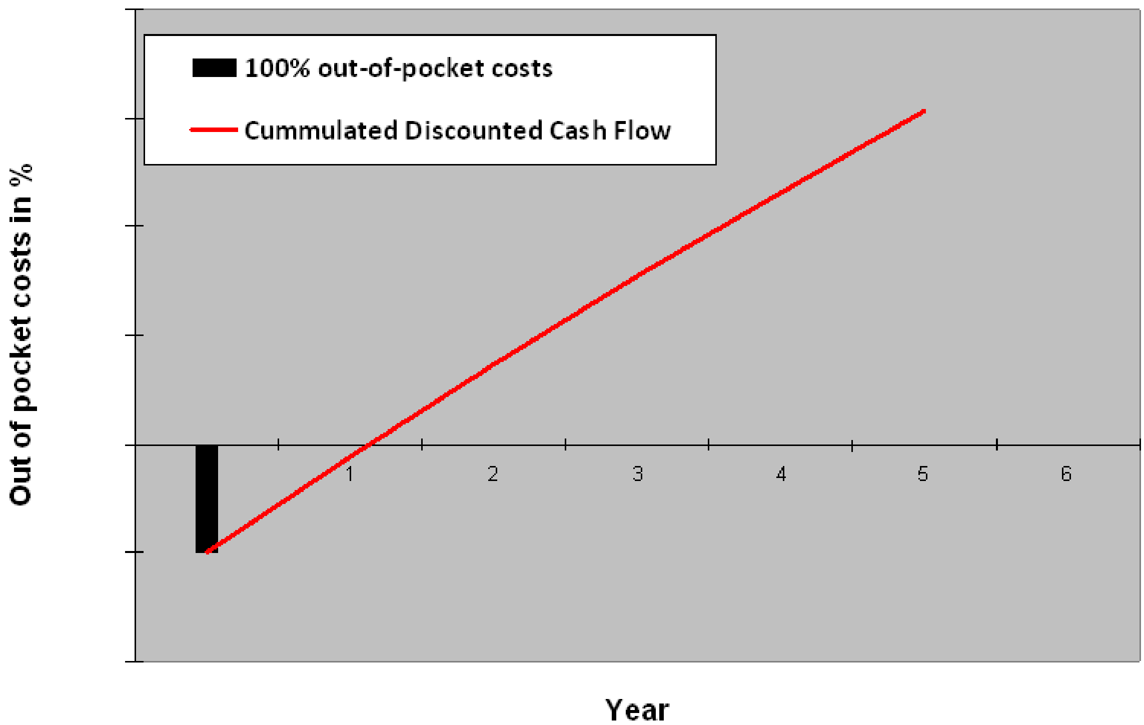

Figure 7 Break even point LDAR large installation

8. NOTEWORTHY CONSIDERATIONS

Gasunie is aware of discussions around the accuracy of the LDAR method. At present this method is compulsory and is recognised as a best available technique.

In general the execution of LDAR delivers valuable information (both management and otherwise) on reducing CH_4 emissions. It turns out that the effect of the first repair attempt is substantial and gives a valuable contribution to the footprint reduction programme. From an economic point of view LDAR is not a “nice to have” but a “must do”.

At a network level clear insight is given into which equipments are the bad performers and consequently which effective measures can be taken. For instance Gasunie has started studies on improvement of flanges and the use of connections.

With “only” 5000 leakers of a total of 180.000 measured potential leak sources it is clear that over 175.000 potential leak sources (88%) have been measured “utterly in vain”. This demonstrates the need for further development of LDAR measuring methods. There are promising developments in infra red gas cameras. These cameras make leaks visible via infra red detection, but at the moment their detection limits needs to be improved.

The 100% measurement of all potential leak sources is essential for identifying abnormalities in leakage behaviour. This makes it possible to take the right measures effectively to reduce emissions. From the point of controlling emissions this is far more preferable to calculating the total emission based on a few measurements and extrapolating.

9. FUTURE OUTLOOK

At present LDAR is incorporated in the Gasunie workflow for large facilities. For smaller facilities Gasunie is undertaking actions to adapt LDAR in the maintenance workflow. Possible changes are expected in engineering in changing design standards with fewer potential sources and for procurement making the leak performance of equipments a part of the procurement strategy. A lot of work has still to be done.

10. CONCLUSIONS

Gasunie initiated its footprint reduction activities as far back as the 1980's. The ambition of Gasunie is in line with European 20-20-20 goals: Gasunie aims to reduce its emissions with 20% by 2020 as compared to the base year of 1990.

Besides the environmental considerations, the CH_4 leakages cause economical commodity losses. Another important issue is safety. Further more the CH_4 leakages have a number of subjective costs, expressed in the company reputation, corporate social responsibility, satisfying the expectations of various stakeholders, environmentally-conscious work force, etc. Therefore decreasing these leakages brings other benefits to the company as well. Al this was good reason for Gasunie to initiate LDAR.

At first the more stringent requirements related to the environmental permits for its installations obliged Gasunie to make a 100% survey of its potential leak sources, adequate database system and work practice to control the leakages. All these demands were met in performing LDAR, of which the method is described in a National Code of Practice as laid down in the permit demands.

The accuracy of the leak measurement method is an important factor; however the costs and the speed of the large number of measurements should also be taken into account. The level of accuracy achieved in LDAR measurements was, lower than, for example, the "bagging" method but the LDAR method gives a good balance between speed, costs and accurateness. Still Gasunie is aware of discussions around the accuracy of the LDAR method and the need for this to be investigated further.

LDAR consists of a systemic and comprehensive monitoring and recording of emissions and therefore gives a detailed overview of gas leakage. A typical LDAR program consists of three main parts: Preparation, Measuring and first repair attempt and Reporting.

The measures for reducing emissions should be aimed at the groups with the largest amount of emissions and not the largest amount of potential leakage sources.

The first repair attempts were successful with an average efficiency of 37%. These efforts led to the realised emissions reduction of $355*10^3$ $kgCH_4/a$. The total initial emission was $935*10^3$ $kgCH_4/a$; emission after first repair attempt $580*10^3$ $kgCH_4/a$.

Leakage behaviour can be managed, giving good results in reducing emissions whilst staying economically feasible. The average BEP for larger and more complex installations is less than 2 years and very interesting because this generates the CAPEX capacity for repair investments.

LDAR will lead to more maintenace activities. These are not only directly related to the repair of the leak (for instance the actual re-tightening of flanges) but are also related to side-effects of the initial repair like the damaging of coating as can been seen at Figure 2. The consequences of these “side-effects” must be further investigated.

Concerning the repair of remaining emissions it is important to keep a balance between environmental impact, repair preconditions and economics therefore expert judgment is necessary.

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