Proposal of a new approach for the asset replacement period in the natural gas distribution industry

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Abstract: Asset management is a key element for natural gas distribution companies. In order to ensure the optimal plant organization, the optimization of maintenance activities for all the elements of the network must be matched by the identification of their best replacement moment. In this way, in fact, it is possible to reduce the total management costs while necessarily keeping a high efficiency and effectiveness for the network and a time-sparing strategy of the unavailable periods. There are some key elements to define the replacement time of every asset of a plant. First of all, the natural gas distribution industry has its own specific return on investment since it is payed by users for the gas distribution service. Secondly, according to the new tender procedures (for a period of twelve years), the existing plants value depends on the VIR index, as defined by National Authority of Gas. In consequence, the identification of the best management strategy for a plant in the twelve years reference period needs specific analysis considering all these elements: for each asset it is essential to evaluate if its substitution might be appropriate or not, and which is the best change-over year. This paper presents an analytical model for the identification of the best renewal strategy for natural gas distribution plants. The proposed model was validated through a case study applied to a final reduction group, to its housing and finally to both of them. The related results show that the best change-over year of an asset could be different from the last year of its amortization, and that its correct identification allows economic benefits. This tool complies with applicable regulations and allows easy reading of the results in terms of optimal asset management strategy. Future developments are the integration of this approach in the company CMMS and ERP, in order to fully exploit its potentialities.

Keywords: Life Cycle Cost Analysis, Natural gas networks, Maintenance Management

1. Introduction

Natural gas is currently considered among the cleanest sources of energy. In fact, it is constituted for the most part of methane (CH_4) and, compared to other sources of available (non-renewable) fossil energies, is richer in hydrogen and has a lower percentage of carbon, the main cause of pollution. Natural gas is the substance which, during the combustion phase, produces the least amount of greenhouse gases (25% less than other fossil resources), fine dusts and polluting elements such as CO_2, NO_x and SO_x; its release into the atmosphere is not harmful neither to the nature nor to humans (unless you inhale an extremely high percentage).

The greater sensitivity to environmental issues that developed in the last decades (eg. the Kyoto Protocol) has attracted a broad interest in all those energy resources which, for domestic and industrial use, can minimize environmental impact and reduce pollution. In this historical context we can understand why, in the power generation sector, natural gas has become the main fuel, so that from the seventies to date its use has increased by about thirty-five times (Descalzi, 2015).

In general, the conveyance of natural gas is carried out through three successive procedural steps: the supply, the distribution and, finally, the sale of gas. The second step, distribution of gas, is made by networks spread throughout the national territory. They are managed by the companies responsible to bring the gas up to the users, therefore realizing both the distribution step and the final stage of product sales.

At present, natural gas is the source of fossil energy with the best prospects for progress. For this reason, the management of networks has great room for growth and development. More than ever before, today it is necessary to identify management methods more innovative and effective.

In particular, one of the aspects to be optimized, for a good company management, is planning the maintenance of the equipment in use. In the context of the natural gas distribution sector and, more generally, in the Operation Management, several engineering strategies have been honed and various management systems have been applied. However, it should be noted that in many companies, especially in the smallest, the organization and the decisions are based primarily on empirical insights and suggestions of the individual operator or administrator. In fact some companies don't struggle to increase the robustness of the scientific foundations of their choices which could provide the safest decision guidelines.

Also referring to the management of plant maintenance, only the support of appropriate mathematical algorithms allows to evaluate the useful life of a system and to estimate the convenience of replacing the components or maintaining them. Here arises the need for a scientific method that optimizes the decision in terms of manner and time. It should indicate the proper mode and the best period for the replacement of the components, in an ideal

way for both the economic point of view (maximum gain-minimum expenditure) and the engineering one (ideal investment for the future evolution of the company). The scientific approach to this kind of choice has to be integrated with the industry expert's contribution to get the best economic return for the company.
Regarding the maintenance, it should be specified that you define "repairable system" a system that, having suffered some degradation over time and having failed, can be restored to an operating condition by means of any maintenance action, be it repair or replacement(Ascher, 2008).
There are in the literature multiple corrective and preventive maintenance policies (*UNI EN 13306 "Maintenance—Terminology,"* 2010) that are intended to increase the reliability of a system by reducing waste to a minimum. Among the various models of the literature, there are some who plan to economically optimize the replacements, including the fixed-period model, the calendar model and, finally, the predictive substitution pattern (Andriulo et al., 2015).
These methods, although leading to a better economic management of resources, have the disadvantage of not being easy to understand, of being time consuming and to require high skills in engineering in order to be applied. In addition, they provide guidance and general criteria, but none of them is specific to the gas distribution sector and no one refers to the existing regulations in this area, where there are special requests in terms of use of installed assets. From this issue this project is born, which wants to implement a simple and rapid application system that allows you to organize maintenance actions of a plant and at the same time to optimize the company's economic management.
A further element that makes the utility sector in a particular industry is the recent presence of market liberalization. This new situation, applied to networks built into a monopoly regime, has been studied for many years in international scientific literature (Golombek et al., 1995). Liberalization normally involves bidding, in which it is crucial to determine the imposed revenue cap and its tie to the concession fee (Dorigoni and Portatadino, 2009). This calculation is of fundamental importance in the tendering process and may vary from country to country. This is not a phenomenon that only affects Western Europe, but the whole world is moving in this direction, such as Turkey (Erdogdu, 2010) and Mexico (Rosellon and Halpern, 2001). Another important element is the length of concessions that, if too long, can be a hindrance to competition (Cavaliere, 2007). Moreover, the gas sector is very particular, since the amount of distributed gas is less important than the number of customers in a distribution company (Fabbri et al., 2000). A possible effect of liberalization in this area, given these premise, could be the creation of an oligopoly (Casarin, 2007). From this concise survey we understand that the problem covered in this article is of great interest and relevance for the international scientific community and it has many similarities with other sectors such as, for example, water distribution (Walter et al., 2009)
In this paper, we propose to define a specific approach model for the field of natural gas distribution, with the use of standard values obtained experimentally and indicated by the competent authorities in the field, in order to optimize the maintenance of a plant gas distribution.
Given that in every decision the company should go through the four phases of the Deming Cycle (plan, do, check, act) (Senni and Luisi, 2002), this calculation model is intended to speed up and simplify the transition from the planning to the implementation, demonstrating the convenience of a choice rather than another. In other words, the tool developed is intended to assist the company to control more accurately the suitability of any activity carried out on the system.
The analysis tool is compliant to the resolutions and rules and it provides a long period vision and an optimal prediction of resource management. In summary, the tool developed, allows to simplify the process of maintenance and replacement of assets, indicating the perfect time to replace an asset and thus determining a satisfactory economic impact for the company.
The analysis will be carried out on the components of a natural gas reducing and metering station (R&M), a part of the distribution system which will be described later.
The remainder of this paper is as follows: in Section 2 the main concepts of asset management are presented, with a focus on the natural gas distribution context, while in Section 3 the new approach proposed for the definition of the asset replacement period is explained. In Section 4 and 5 the case study and results are respectively presented, with discussion and, finally, conclusions.

2. Asset management for natural gas distribution context

Asset management optimization requires important decisions about the system life cycle.
The management and maintenance of the systems is closely related to the concept of "useful life" of an item. By this term, we refer to the acceptable period of use of a system or of an asset, or the time, starting from the time of installation of the element analyzed, during which the performance keeps a satisfactory level without signs of degradation which could compromise functionality, efficiency and safety (Bandelloni and Rinaldi, 1998).
As we said, the optimization of asset useful life calls for important decisions on the maintenance policies to adopt and, therefore, on the best change-over year.
In the choice between two or more possible management alternatives, the cash flows derived by each one of them should be considered: they are the monetary inputs and outputs for the company over the period considered.
Cash flows are:

- cash outflow: investments required for a specific project (or management solution) implementation
- cash inflow: they represent the actual gains (money saved, asset sold, etc.) derived by the project (or by the management solution) implementation.

The cash flow, evaluated considering the cash outflow, the cash inflow, the amortization and the tax rate, are therefore discounted using the discount rate, in order to have the present value PV of the project.
It is well known that a project strategy is advantageous when its final wealth is higher than the gain obtained by the

non-implementation. The PV value is usually considered in order to evaluate the advantage of a specific strategy, considering that when PV is greater than zero, the investment is cost-effective, while when PV is less than zero, the investment is not convenient.
Cash flows are strictly related to the sector concerned, since inflows and outflows depend on the features of each specific sector. Natural gas distribution sector, as said before, has specific features requiring a particular treatment. First of all, the natural gas distribution business usually operates on a concession regime for a variable period (in Italy, for example, it lasts twelve years, in Turkey thirty years, etc.), after which there are new tenders for the assignments of gas distribution services. The tender and proposal-assessment criteria for awarding concessions for gas distribution are defined by the national legislator: the tender could be based on both quality/technical awarding criteria and economic criteria, and prequalification, based on the financial strength and experience of the potential licensees, could be introduced. The definition of assessment criteria is certainly a crucial point in tender, and many aspects must be considered: for example, a tender based essentially on qualitative awarding criteria runs the risk of becoming a beauty contest unless, while the investment plan is crucial in the natural gas distribution activity.
The second main feature of this sector regards the definition of the residual value of assets. It is the value of an asset which was fully amortized over its use (Antonelli and Liberatore, 2012). While the most of asset has usually no residual value at the end of the useful life, assets of a natural gas distribution plant have usually residual value different from zero at the end of the management period. The residual value will depend on the asset management strategy during the typical twelve years reference period. Moreover, it impacts also on the amortizations definition, which is evaluated though the degradation level and the deflator.
The tenders for the assignment of natural gas distribution service, define some reference parameters, here explained.
They were used in the definition of the model here proposed since they are meaningful of the asset management in the concession period.
The first one is the Redemption Value (RV) that is the amount that the incoming operator must correspond to the outgoing operator to acquire the asset. RV value of a specific distribution plant depends on the general plant conditions, and it is usually considered equal to the IRV (the Industrial Residual Value) ignoring contribution or premium values for special plant transfers.
The IRV is evaluated as follow:

$$\boldsymbol{IRV = VRN - degradation} \qquad \{1\}$$

Degradation is evaluated according to specific tables defined by the Authority considering the year of installation of the plant, maintenance actions and special restoration activities carried out on the plant.
Degradation is usually considered as directly proportional to the plant age, even if experimental analysis showed that it is better explained through a curve rather than through a line (Figure 1).

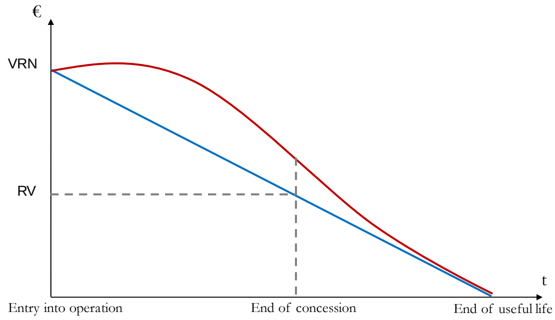

Figure 1: degradation curve (linear vs. non-linear curve trend)

VRN (Reconstruction value of the plant) is the actual value of the plant, as if it is bought today, and it is evaluated as follow:

$$\boldsymbol{VRN = price \cdot plant\ physical\ condition\ state} \qquad \{2\}$$

The VRN parameter, considering the plant physical condition state, highlights a general condition of the plant taking into account the year of construction and its constructive, functional and conservative features. It must consider all the asset of the natural gas distribution company (pipelines, R&M cabins, pressure reducing stations). This approach is essential for an effective management strategy of natural gas distribution plants.
The definition of these parameters is usually complicated because the required information could be difficult to obtain or difficult to estimate. The most of the knowledge summarized in this paper, in fact, derives by documents defined in the Italian context. At the same time, the main parameters here considered are related to industrial aspects, so they shall be valid in different contexts.

3. Proposal of the new approach for the asset replacement period

This section presents the proposed approach for optimal management of assets of a company operating in the distribution of natural gas. It is a useful support for the determination of the optimal replacement year of an asset: it refers to a time horizon of 12 years, corresponding to the duration of the reliance of the gas distribution service.
The proposed model foresees two different scenarios:

- "No asset replacement" scenario: you decide to maintain the old asset without replacing it (corrective maintenance). This scenario is convenient if you do not want to implement significant initial expenditures of money to make investments, therefore it is better if the company does not have large financial resources. The fact of not making any replacement of assets implies a saving related both to the absence of initial investment and to the absence of disposal costs. A further advantage of this scenario is the ability to exploit the entire useful life of the goods, without risking to replace some elements, still far from their maximum degradation condition.
- "Asset replacement" scenario: the old asset is replaced with a new one during one of the twelve years of management (replacement maintenance). This approach is convenient especially from the plant

safety point of view, as a new asset is subject to fewer unexpected breakdowns. Moreover, since the asset is new, you have an improvement related to different aspects including: modernity of the technologies installed, increase of the residual value, reduction of the expected number of faults, increase in the plant availability. Within this scenario, several cases are compared different by the year in which it is assumed to replace the considered asset.

This model considers only the differential costs, i.e. those that distinguish a particular scenario (not replace the asset in the 12 years of management, replace the asset at the very beginning of the period, during the first year, etc.). The different scenarios will be noted as follows:

- No asset replacement: $Scenario_{no\ rep}$
- Replacement at t_m: $Scenario_{y=0}$
- Replacement at the first year of the management period: $Scenario_{y=1}$

Table 1 are used to determine the two main items of the proposed model, Cash Inflow (C_{in}) and Cash Outflow (C_{out}), for each of the 12 years of plant management, within each scenario.

For each scenario, are estimated the cash flow CF and the Discounted Cash Flow DCF, with an interest rate r, while the index for the year of analysis is t:

$$CF_t = (C_{in\_t} - C_{out\_t})(1-\alpha) + A_t \cdot \alpha \qquad t = 0, \dots, 12$$

$$\boldsymbol{DCF_t = \frac{CF_t}{(1+r)^t} \quad t = 0, \dots, 12} \qquad \{3\}$$

Then the net present value PV can be calculated, through which is possible to evaluate the considered scenario: if PV> 0, then the investment is affordable. A higher PV value indicates a more profitable investment.

Figure 2 summarizes the algorithm. It shows first of all that there are two main scenarios: the scenario in blue "No asset replacement", in yellow the scenario of "asset replacement". The latter scenario, in turn, requires taking into account different cases, namely the replacement of the asset in each of the years of management. Overall, then, there will be 14 scenarios to be compared to determine which has the maximum PV.

- Replacement during the second year of the management period: $Scenario_{y=2}$
- …
- Replacement during the 12th year of the management period: $Scenario_{y=12}$

The data necessary for the application of the model are many and varied, and are of two main types:

- asset descriptive data (year of installation, years of operation since the beginning of the management period, a state of deterioration, etc.)
- asset management data (maintenance costs, disposal costs): they are both cash inflow and outflow. Maintenance costs depends obviously on the maintenance frequency ordered by the authority.

shows the model input data. As you can see, some of these items are specific to the gas sector as there are many constraints imposed by the Authority (AEEG).

The input data of

Figure 2: Comparison algorithm of replacement and maintaining scenarios

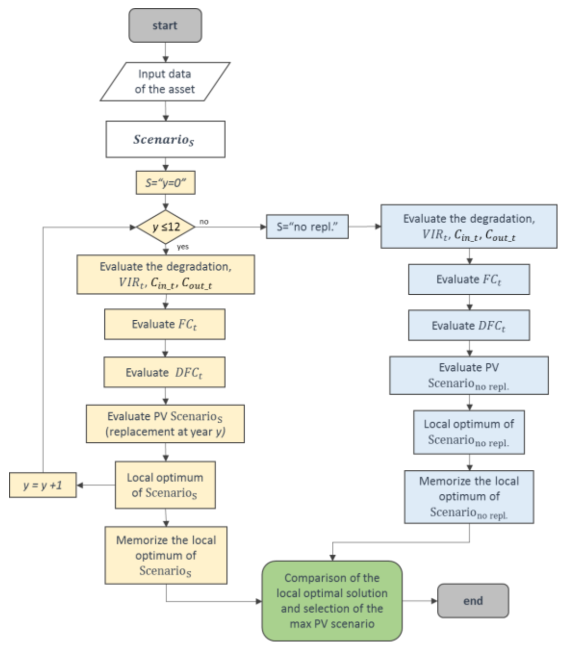

Table 1: input data for the model. In the columns are shown the symbol, the definition, the description and the source of each element

Symbol	Definition	Description	Source
t_0	Year of installation	Installation year of the considered asset	Company
t_m	Year of management beginning	Year in which the distribution company begins to operate the plant	Company
VRN_{old}	Reconstruction value of the installed	Reconstruction value as new of the installed asset	Company
VRN_{new}	Reconstruction value of the new	Reconstruction value as new of the new asset	Company
f_d	degradation factor	Value reduction for wear or obsolescence	Authority
d	Deflator	deflator for gross fixed capital formation	Authority
RV	Redemption Value	Amount that the incoming operator must correspond to the outgoing operator to acquire the asset	Derived
Return	Return on capital	Asset capability, at the end of the management period, to generate profit	Derived
C_d	Disposal cost of the asset	Expenditure to be sustained for the dismantling of the old asset (if replaced)	Company
A	Depreciation	VRN annual share	Derived
$C_{isp,ver}$	Cost of inspections and audits	Costs for inspection and verification activities	Company
C_m	Annual maintenance fee	Costs for maintenance	Company
C_{m_capex}	Maintenance costs capitalized	Cost for capitalized maintenance activities	Company

4. Case study

The model just presented was applied to determine the optimal replacement year of an asset for a company that operates natural gas distribution in Tuscany.

Figure 3 shows a system diagram of the natural gas distribution.

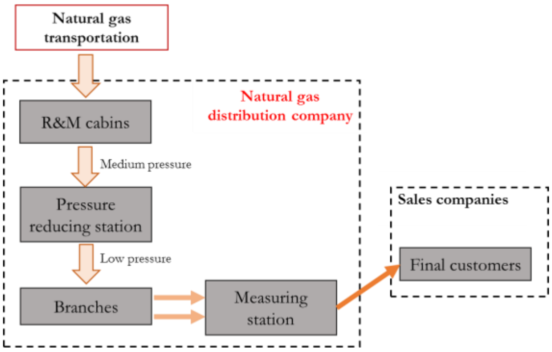

Figure 3: diagram of the natural gas distribution system in Italy

Specifically, we considered the reduction unit, which is responsible for the final adjustment of the gas pressure, before it arrives to the end users.

A reduction unit consists of several elements, such as filters, pressure reducer, block valves and silencers organs. The elements of greater criticality are also redundant for safety reasons, as required by current regulations.

The pressure reducer is definitely one of the most critical components inside the reduction unit, since it is intended directly to the gas pressure reduction. It is also one of the elements whose management requires particular attention with regard to the performance of inspection, testing and maintenance.

In order to optimize the entire lifecycle of the pressure reducer, it is possible to apply the model presented above to identify the optimal approach for the 12 years of plant management.

In Table 2 are visible the input data for one of the reducers installed by the Company, for the scenario with replacement of the reducer in the fourth year (*y=4*). Assuming that the reducer unit was installed in 2006($t_0 = 2006$) and that the plant management period is started in 2016 ($t_m = 2016$), the scenario shown in Table 2 ($Scenario_{y=4}$) refers to the replacement of the gearbox in 2020. It is also assumed $\text{VRN}_{\text{old}} = 3350, \text{VRN}_{\text{new}} = 3950$.

Table 2 provides the information needed to calculate the PV, including the index of the year (0, 1, ..., 12) the age of the analyzed component (dependent on t_0), RV (calculated from VRN_{old} by considering the deflator and the degradation for that year), from which will be calculated the Return values.

The degradation factor f_d is evaluated according to specific guidelines defined by national authorities, while the deflator d, with an increasing trend, depends on the age of the component.

VRN_{new} will obviously be present only for t=4 (year of replacement of the reducer in the considered scenario); the same thing will be true for C_d, on the disposal of the installed reducer. $C_{isp,ver}$, C_m e C_{m_capex} are supplied by the Company on the basis of the internal plan of maintenance, while the annual depreciation is calculated from VRN_{old} or VRN_{new}.

C_{in} e C_{out} are obviously the sum of the incoming and outgoing flows. From them we can derive FC, DFC and finally the PV of the scenario.

As shown in Table 2, all the variables of the algorithm were calculated, according to the diagram of Figure 3, for all the other scenarios. Comparing the PV values obtained, it is clear that the shown scenario is precisely the one with the maximum PV, as visible in the graph of the PV trends of Figure 4.

Table 2: input data and calculated values for the determination of the time of optimal replacement for the pressure reducer component (substitution scenery at year y = 4)

t	age	d	f_d	RV	VRN_{new}	C_d	Return	$C_{isp,ver}$	C_m	C_{m_capex}	VR (t=12)	A	C_{in}	C_{out}	FC	DCF
0	10	1,18	0,50	1784,18	-	-	108,83	175,00	-	-	-	198,24	307,08	175,00	158,54	158,54
1	11	1,20	0,55	1625,03	-	-	99,13	192,50	-	320,00	-	200,62	619,75	192,50	336,60	325,21
2	12	1,21	0,60	1461,80	-	-	89,17	210,00	-	-	-	203,03	292,20	210,00	130,53	121,85
3	13	1,23	0,65	1294,43	-	-	78,96	227,50	-	-	-	205,46	284,42	227,50	116,34	104,93
4	0	1,00	0,05	2864,25	3950,00	450,00	174,72	0,00	-	-	-	197,50	372,22	4400,00	-2337,67	-2037,14
5	1	1,01	0,10	2748,78	-	-	167,68	15,00	-	-	-	200,07	367,74	15,00	291,67	245,58
6	2	1,03	0,15	2629,81	-	-	160,42	30,00	-	-	-	202,67	363,09	30,00	280,92	228,53
7	3	1,04	0,20	2509,77	-	-	153,10	45,00	-	-	-	205,51	358,60	45,00	270,36	212,50
8	4	1,06	0,25	2385,85	-	-	145,54	60,00	-	-	-	208,38	353,92	60,00	259,70	197,22
9	5	1,07	0,30	2257,97	-	-	137,74	75,00	-	-	-	211,30	349,04	75,00	248,94	182,66
10	6	1,08	0,35	2126,04	-	-	129,69	90,00	-	-	-	214,26	343,95	90,00	238,07	168,77
11	7	1,10	0,40	1989,97	-	-	121,39	105,00	540,00	-	-	217,26	338,65	645,00	-96,91	-66,38
12	8	1,12	0,45	1849,68	-	-	112,83	120,00	-	-	1849,68	220,30	2182,81	120,00	1325,81	877,40

PV $\text{scenario}_{y=4}$ = 719,68

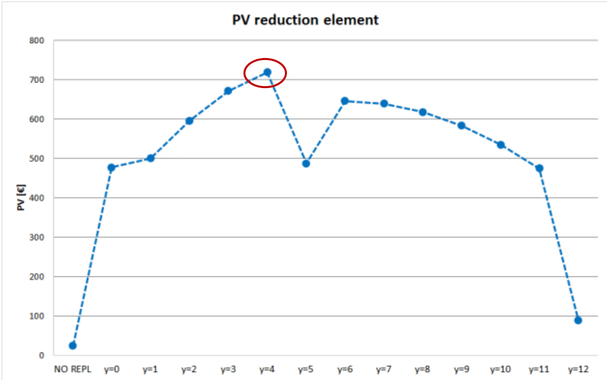

Figure 4: PV for the different scenarios considered for the pressure reducer component

Observing the performance of PV for the reducer, we can note that, the 5th year – which is the one following the optimal one - the PV is greatly reduced, then it rises again at year 6 and starts to decrease from 7th year onwards. In the light of this result, we understand well the importance of this tool as it allows you to quantify the effects of a specific maintenance choice for the plant management period (no substitution, replacing the year 0, year 1, etc.).

The graph shows that there is a definitely optimal choice, as well as there are some which are particularly disadvantageous with respect to the others. To these belongs the case of non-replacement and the case of replacement during the last year of operation, so the PV is positive but still with very low values.

The approach shown for the reducer component was also applied to its housing. In Figure 5 are shown just the final results, in particular the performance of the PV. The housing here considered was installed in 2015 ($t_0 = 2015$), the plant management period is started in 2016 ($t_m = 2016$) and it is assumed $\mathrm{VRN_{old}} = 950$, $\mathrm{VRN_{new}} = 1200$, $C_d = 200$. Looking at the PV results of Figure 5, we can note that the best management strategy is not replacing the housing of the reducer component. Alternatively, substitution is proposed during the 6th year of the management period. The worst case is the housing substitution in the same year as the management period started (here in 2016).

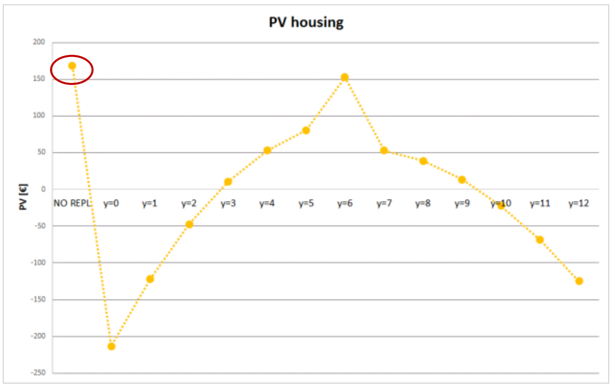

Figure 5: PV for different scenarios considered for the housing of the pressure reducer unit

The model was finally applied to the system constituted by the reducer and by the housing.

It is important to point out that the whole PV "reducer and housing", was not obtained by simply summing the individual PV of the two substitutions (only reducer or just housing), but it was obtained making actual hypothesis of aggregation or cost reduction. In particular, considering the two elements as a single aggregate, it is conceivable a reduction in the cost of installation and of periodic maintenance (for the reduction of the number of necessary displacements). On the basis of business data analysis and on what said by personnel inside the company, we defined a reduction of the 40% of the expected cost for the installation and maintenance of the housing.

Figure 6 shows the trend of the PV, for both components to the aggregate. In particular:

- in blue the reducer PV;
- in yellow the housing PV when replaced individually;
- in red if the housing PV when replaced with the reducer;
- in green the aggregate PV.

In Figure 6 we note that replace the two elements at the same time is convenient in the sixth year, with a PV of 870, while it is less convenient in the twelfth year, when the PV of both assets considered (blue line and red line) is among the lowest values.

In addition, the PV of the gear-housing assembly is never negative, contrary to what happens for the single housing, whose replacement investment is less than zero in 6 of the 14 scenarios (Figure 5).

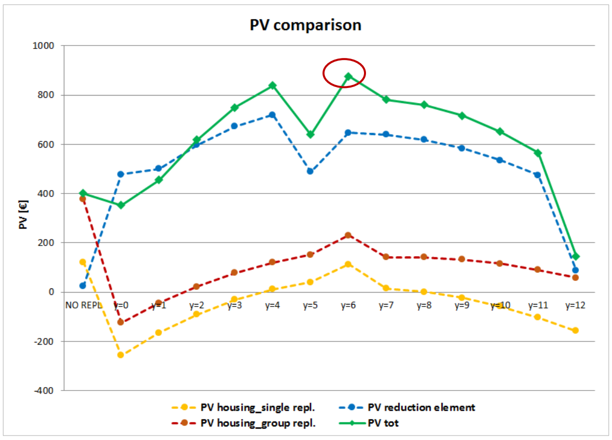

Figure 6: PV for different scenarios for the reducer (blue), for the housing (yellow), and for the group made by the two of them

Inside the reducer-housing assembly, the reducer is definitely the most critical component, both for its function inside the reduction unit, both for costs (purchase and management). You can note how, in the determination of PV_{tot} (green line of Figure 6), the reducer weighs much more than its housing. In fact, the blue line ($PV_{reducer}$) corresponds to PV values far higher in absolute value of the $PV_{housing}$. For this reason, a user might decide to replace both in year 4, in which there is the maximum PV of the reducer. But, doing so the PV_{tot} is less than the absolute optimum corresponding to the sixth year of operation.

5. Discussion and Conclusion

The aim of this paper is to propose a new approach for the determination of the asset replacement period in the natural gas distribution industry. After verifying the main methods proposed in literature to evaluate the best asset management strategy, here a new approach is proposed.

The main feature of this approach is its specificity for the gas sector. As described in section 2, in fact, the gas sector is highly regulated: information such as the degradation, the RV and depreciation, for example, should be determined according to specific and rigid patterns arranged by the authorities. Therefore, it is certainly advantageous to have an instrument constructed ad hoc for this sector. It is able to provide an estimate of the goodness of an investment, by evaluating the best among many possible maintenance activities on the elements of the system.

The proposed model is versatile and easily adaptable and can also be extended to other components of the natural gas distribution systems. An application limit could only be derived from the unavailability of certain information necessary for its implementation. It was tested on a specific case study (an Italian natural gas distribution company) but it could be simply extended to non-Italian context.

The use of this tool could also be a distinguishing element during the calls for tenders, in which are considered both the economic and the technical aspects.

The adoption of this approach, in fact, shows that the distribution company taking part in a tender, has a vision on the entire management period and aims to reduce costs without compromising the respect of standards and of the fixed maintenance frequencies.

Having a clear and accurate picture of the financial impact of an asset maintenance investment, also allows you to make choices supported by numerical data rather than only by experience or acumen of business managers.

Typically, the company managers tend to replace the old elements of the system in the early years of management and the new ones in the last. During the middle management period they tend not to preventively replace items, but to perform maintenance, preventive and, when necessary, on failure. Anyway, in the case of the reducer considered here, however, we saw that such a strategy is certainly not optimal. This model could bring out the convenience to replace some assets even at the end of the management period, or not to undertake any kind of replacement. It is important to emphasize the importance of the instrument, even when applied to systems consisting of multiple elements. The Authority also provided the ability to create clusters of components. Each cluster contains all the elements that carry out one final function. For example, considering the pressure reduction of the natural gas pressure, there is a cluster including all the components of the reduction unit, including reducer, monitor, silencers and block valves. Thus, for each tender, competitors will be provided with information and data on the entire group and not on each individual item.

A development of this work will be the adoption of the approach to the mentioned clusters. It will be possible to identify the best strategy, for example, for the entire reduction block: in this way there would be a considerable reduction in the unavailability time of the system, with all the positive consequences connected.

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