LOL-HECO-IR-43

Ref: "Live Working Profitability -- Methodology & Results". ICoLIM98 (Exhibit 7, EDM Report, page 37).

Question(s):

a. Please provide a copy, preferable in electronic format.

b. Do you agree with all of the all of the conclusions of the report?

HECO Response:

a. A copy, as published in the Proceedings of ICoLIM98, is attached as pages 2-12.

b. This paper presents a methodology for comparing the costs of LW to de-energized maintenance and the results of some sample calculations for the author's system. It does not offer any detailed conclusions.

Live working profitability-Methodology & Results

Rentabilité des TST – Metodologies et resultats

by

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Abstract.- This presentation explains a type of methodology used to establish the profitability of Live Working (LW), both as regards the Service Quality of a Company, i.e. the influence that this working has on it, and also as regards the monetary saving and the saved cost per kWh in absolute value, that the use of these technique means, as opposed to the techniques of Cold Working (CW) that it would have been necessary to use in order to carry out the work.

The different mathematical expressions that include all the costs that intervene in carrying out both techniques, LW and CW, are presented, not only for maintenance teams but also for operation and manoeuvring, so as to determine the following in each working and annual balance sheet: Cut-off time of the saved supply, balanced to the intervening power; Saving in energy not supplied; Monetary saving achieved, considering all the factors that intervene in Service Quality; Real cost per kWh saved.

In the same way, and to finish the paper, the results obtained in IBERDROLA for all these profitabilities are presented.

Resumé.-Cette présentation expose une méthodologie pour la prise en compte de la rentabilité des Travaux sous Tension aussi bien quant à la Qualité de Service d'une Entreprise, c'est-à-dire l'influence que ces travaux ont sur cette dernière, qu'en ce qui concerne l'économie monétaire réalisée et le coût du kWh économisé en valeur absolue. La comparaison que suppose l'utilisation de ces techniques se fait toujours par rapport aux Travaux san Tension auxquels il eût fallu recourir pour l'exécution du travail.

Les différentes expressions mathématiques présentées reprennent tous les coûts intervenant dans la réalisation des deux techniques, tant de la part des équipements de maintenance que d'opération et de manoeuvre, afin de déterminer dans chaque travail et bilan annuel: •Temps de coupure de la fourniture économisée, pondéré à la puissance intervenante; •Energie non fournie épargnée; •Economie monétaire obtenue, en considérant tous les facteurs intervenant dans la Qualité du Service; •Coût réel du kWh économisé

Par ailleurs, on trouvera présentés à la fin du rapport les résultats qu'a obtenus la compagnie IBERDROLA sur tous ces plans.

1. INTRODUCTION

The costs of LiveWorking (LW), as opposed to Cold Working (CW), are a continuous subject of debate among those responsible for maintenance and for financial control in utilities, especially at these times when they are undergoing great economic adjustments. It is argued that the high costs involved in training and recycling skilled workers, as well as the equipment which is needed to carry out work by this method, as compared with the costs represented by the workers and equipment required to carry out the same work using traditional procedures (CW), without considering the additional costs that these add, for operations, manoeuvring, ageing of equipment, losses, inspection, safety systems and, in many cases, for down time, as opposed to the use of Live Working.

Moreover, these is an essential factor, which is Service Quality, which would be lost by carrying out the work by traditional Cold Working procedures, and in most companies would mean exceeding recommendable limits. The importance of this factor in each company will depend on its situation in the market in terms of the market affected, image, economic interests, competition, etc. and will depend on the grid or mesh that its network has. It must be emphasized that basically the Live Working were born in order to face investments and impact that would be meant to grid the overhead network of medium voltage and to design a radial one, more economical in all respects. It is impossible today to consider changing from a radial network to a grid one. In the same way, in grid-type HV and VHV networks, it is not possible, for service requirements, to cut off the supply in order to carry out maintenance work, which obliges Live Working to be used. This implication will go incrising in the future, following the lines overloading.

This paper aims to explain a type of methodology to really compare the costs of work carried out using Live Working techniques as opposed to work carried out using Cold Working, and allow one or other method to be selected before issuing the Work Order (WO), such as knowing the profitability of all types and the true absolute costs per kWh saved by carrying out the work using Live Working methods.

2. SELECTION OF LIVE OR COLD WORKING

- Selection is a step prior to the launching of the Work Order (WO) and starts from detailed knowledge of the work to be carried out by those responsible for Maintenance, Development and Operation, which means knowing the type and number of activities and Compatible Units (CC.UU.) required to carry out the work both by Live Working (LW) and by Cold Working (CW), with their codes, as well as the different coefficients that the work is affected by and the Man x Hours of the company's own personnel who are involved in carrying this out.

- Materials that will affect both types of working equally will not be taken into account.

- The Man x Hours costs will include the amortization of equipment, general costs and overheads.

- The coefficients and the Number of reiterations (NR) by defect, will be 1.

1st WO Cost LW

- With contracted personnel

$$CLW = \sum CC.UU_{\cdot LW} \times C_{ex} + \sum MH_{ILW} \times C_{MHI} \times C_{ex} \qquad (\$)$$

in which:

$CC.UU_{\cdot LW}$ = LW ,Hand Basic Unit Price.
MH_{ILW} = LW Inspector man hours required
C_{MHI} = Man x H cost of the Inspector, updated to the year in question.
C_{ex} = Coefficient for overtime working

- With the company's own personnel

$$CLW = \sum M_x H_{LW} \times C_{MHLW} \times C_{ex} \qquad (\$)$$

in which:

MH_{LW} = Man hours assigned to LW activity
$C_{MH\,LW}$ = Man x H cost of LW, updated to the year in question.
C_{ex} = Coefficient for overtime working

2nd WO Cost CW

- With contracted personnel

$$CCW = \sum CC.UU_{\cdot CW} \times C_{ex} + \sum MH_{ICW} \times C_{MHI} \times C_{ex} \qquad (\$)$$

in which:

$CC.UU_{\cdot CW}$ = CW, Hand Basic Unit Price.
MH_{ICW} = CW Inspector man hours required

- With the company's own personnel

$$CCW = \sum MH_{CW} \times C_{MHCW} \times C_{ex} \qquad (\$)$$

in which:

MH_{CW} = Man hours assigned to CW activity
$C_{MH\,CW}$ = Man x H cost of CW, updated to the year in question.

3rd Cost of LW MANOEUVRING

- Obtention of the corresponding Control Centre (CC), the man hours of the Local Operator needed for the manual setting in order to carry out LW, as well as whether it is carried out in overtime hours.

$$CMLW = 2MH_{LO} \times C_{MHLO} \times C_{ex} \times NR \qquad (\$)$$

in which:

MH_{LO}	=	Man hours needed by the Local Operator
C_{MHLO}	=	Man hour cost of the Local Operator, updated to the year in question.
NR	=	Number of reiterations

4th Cost of CW MANOEUVRING

- Obtention of the corresponding Control Centre (CC), the man hours of the Local Operator, of the Brigade Operator and of the Work Zone Agent, needed for the preparation of the facility to carry out the CW, including the placing of notices, of the man hours of the CC Auxiliary to provide information to customers or companies in the Sector, as well as whether it is carried out in overtime hours.

$$CMCW = \left[2MH_{LO} \times C_{MHLO} \times C_{ex} + 2MH_{BO} \times C_{MHBO} \times C_{ex} + MH_{WZA} \times C_{MHWZA} \times C_{ex}\right] \times NR + MH_{AX} \times C_{MHAX} \times N_{CU} + \left[MH_{PM} \times C_{MHPM} + MH_{WM} \times C_{MHWM}\right] \times N_{SC} + C_{SA} \qquad (\$)$$

in which:

MH_{AX}	=	Man hours required of the CC Auxiliary
MH_{PM}	=	Man hours required of the CC Chief, of preparatory management
MH_{WM}	=	Man hours required of the CC, for work management
MH_{BO}	=	Man hours required of the Brigade Operators
MH_{WZA}	=	Man hours required of the Work Zone Agent
C_{MHAX}	=	Man hour cost of the CC Auxiliary
C_{MHPM}	=	Man hour cost of the CC Chief
C_{MHWM}	=	Man hour cost of the CC Operator
C_{MHBO}	=	Man hour cost of the Brigade Operators
C_{MHWZA}	=	Man hour cost of the Work Zone Agent
N_{CU}	=	Number of customers or TMPs informed
N_{SC}	=	Number of companies in the Sector informed
C_{SA}	=	Social advertisement cost

5th Calculation of the Effective Energie Not Supplied by WO (kWh)

- Obtention of the corresponding Control Centre (CC), the Manoeuvring Sequences with the installed or contracted power capacity affected (Pi) and their required interruption times (Ti), for the preparation and resetting of the facility in order to carry out CW, as well as the power (P_{CW}) affected by it.

$$ENS = \sum Pi \frac{2Ti}{60} + P_{cw} \times \sum H_{cw} \qquad (Kwh)$$

in which:

ENS	=	Energy nor supplied, in kWh
Pi	=	Power interrupted in a sequence, in kVA
Ti	=	Interruption time in a sequence, in minutes
P_{CW}	=	Power interrupted during the CW, in kVA
H_{CW}	=	Hours assigned to CW activities

- Calculation of the Load Factor of the facility

  - ❖ If it is possible to know the Real Power of the facility, on the part of the Control Centre

$$F_L = \frac{P_R}{P_I}$$

in which:

F_L	=	Load factor
P_R	=	Estimated Real Power of the facility on the dates of the CW, in kVA
P_I	=	Installed Power in the facility, as the sum of the nominal power ratings of the TMPs and the mx contracted for the MV customers, in kVA

  - ❖ If it is not possible to know the Real Power of the facility.

It will be obtained through the updated value in the previous year of the load factors of the ST/STR line headers, in terms of the season of the year in which the WO is to be carried out and of the code for the facility affected. If these load factors are not known by ST/STR, the F_L will be calculated according to the following expression:

$$F_L = \frac{ES_{ZI}}{2190 \times 0{,}9 \times PI_{ZV}}$$

in which:

ES_{ZY} = Energy supplied in the specific season of the year, by the Zone in the previous year, in kWh.

PI_{ZY} = Installed Power in the specific season of the year, in the Zone in the previous year, as the sum of the nominal power of the TMPs and the mx contracted of MV customers, in kVA.

ST/STR/ZONE	SPRING	SUMMER	AUTUMN	WINTER
XXXX	F_L1	F_L2	F_L3	F_L4

- **$ENS_E = ENS \times F_L$** **(kWH)**

in which:

ENS_E = The Effective Energy Not Supplied by the WO with CW.

6th **Cost of the kWh saving by WO with LW**

The cost of kWh saving by carrying out live working is really the difference between the cost of carrying out the WO with LW instead of with CW, since the cost of CW will always be present to carry out the WO.

$$C_{KWh} = \frac{CLW + CMLW - CCW - CMCW}{ENS_E} \quad \textbf{(\$/kWh)}$$

in which:

C_{KWh} = Cost of the kWh saved by the WO, in $/kWh

7th **LW selection criteria**

To select the carrying out of a WO with LW or CW, the following criteria will be applied:

- If $C_{kWh} \leq$ ___ $/kWh

LW IS SELECTED

- If ___ $< C_{kWh} \leq$ ___ $/kWh

AND
TIEPI or (n-1) criterion
Supply area of the facility in the ZONE is **HIGH**

LW IS SELECTED

AND
TIEPI or (n-1) criterion
Supply area of the facility in the ZONE is **MEDIUM or LOW**

CW IS SELECTED

- If $C_{kWh} >$ ____ $/kWh

CW IS SELECTED

3. SAVING IN TEIPI PROGRAMMED

With the data obtained from the corresponding Control Centre (CC) in the first subsection of the 5th point in the section above.

$$TIEPI_{Saved} = \frac{ENS}{PI} \qquad \textbf{(H)}$$

In the case of the TIEPI Saved in the Zone or Region the ENS, would be the sum corresponding to all Facilities in the Zone or all the Zones in the said Region respectively, and the PI will be replaced by PI_Z or PI_R, the sum corresponding to the power installed in all the Zone or in all the Region respectively. The same criterion will be followed for the calculation for all the Utility.

Understanding that PI, PI_Z, PI_R and PI_T represent the installed power in the Facility, Zone, Region and Total for the Utility in the year in which the TIEPI SAVED is calculated, in kVA.

4. SAVING IN ENERGY NOT SUPPLIED

With the data previously obtained

$$ENSS = \frac{ES_Z x TIEPI_{Saved}}{8760} \qquad \textbf{(KWh)}$$

in which:

ENSS = Saving in energy not supplied
ES_Z = Energy supplied by the zone in the management year, in kWh.

In the case of the calculation of the ENSS for the Region or of the Total for the Utility, the respective ES_R and ES_T, would be the sum of the ES_Z of the Region and

of the ES_R of the Utility respectively, and the TIEPI saved would be those of the REGION and that of the Total for the Utility respectively.

TIEPI PROGRAMMED

Extract the different TIEPI's programmed for the management year for each facility affected, Zone, Region and Total for the Utility, in Hours.

6. ENERGY SUPPLIED

Extract the different Energies Supplied in the management year by Zone, Region and Total for the Utility, in kWh.

7. INSTALLED POWER

Extract the different installed powers for the management year for each facility affected, Zone, Region and Total for the Utility, in kVA.

8. LW MANAGEMENT RESULTS

Different type TABLES which show the annual results of LW management are presented in the Appendix, for work carried out, types of work, times taken, and also their performance in relation to the Service Quality and Economics of IBERDROLA for 1996.

In which:

$$\%\ TIEPI\ \ PROGR. = \frac{TIEPI_{Saved}}{TIEPIPROGR.} \times 100 \qquad \textbf{(\%)}$$

$$\%\ TIEPI\ \ TOTAL = \frac{TIEPI_{Saved}}{TIEPITOTAL.} \times 100 \qquad \textbf{(\%)}$$

$$\nabla ENS = \frac{ENSS \times 300}{1000} \qquad \textbf{(Kpta)}$$

$$COST.KWh_s = \frac{\Sigma[CLW + CMLW - CCW - CMCW]}{ENSS} \qquad \textbf{(pta/kwh)}$$

in which TIEPI's SAVED/PROGRAMMED/TOTAL and ENSS's, corresponding to the work carried out in MV and HV that only affect MV and LV, respectively, for ZONE, REGION and Total for IBERDROLA, in terms of their respective TIEPI's, ENSS's and costs of all the work carried out, in the period considered.

IBERDROLA

GESTION T.E.T.
AÑO 1.996

LINEAS AEREAS MEDIA TENSION

		NORTE			OESTE			CENTRO			ESTE			TOTAL		
		M.D.	M.C.	Tot	M.D.	M.C.	Tot	M.D.	M.C.	Tot	M.D.	M.C.	Tot	M.D.	M.C.	Tot
Nº ACTIVID.	PROPIA	1.186		1.186	2.785		2.785	519		519	1.466		1.466	5.956		5.956
	CONTRATA	2.684		2.684	2.609		2.609		923	923	752	3.184	3.936	6.045	4.107	10.152
	TOTAL	3.870		3.870	5.394		5.394	519	923	1.442	2.218		5.402	12.001	4.107	16.108
DIAS TRABAJ.	PROPIA	420		420	667		667	260		260	543		543	1.890		1.890
	CONTRATA	601		601	285		285		530	530	471		471	1.357	530	1.887
	TOTAL	1.021		1.021	952		952	260	530	790	1.014		1.014	3.247	530	3.777
H°HOMBRE TOTALES	PROPIA	9.730		9.730	19.303		19.303	9.446		9.446	21.296		21.296	59.775		59.775
	CONTRATA	14.390		14.390	10.467		10.467		16.933	16.933	22.665	17.585	40.250	47.522	34.518	82.040
	TOTAL	24.120		24.120	29.770		29.770	9.446	16.933	26.379	43.961	17.585	61.546	107.297	34.518	141.815
H°HOMBRE T.E.T.	PROPIA	7.888		7.888	14.310		14.310	4.156		4.156	14.485		14.485	40.839		40.839
	CONTRATA	13.058		13.058	8.579		8.579		5.837	5.837	21.166	14.933	36.099	42.803	20.770	63.573
	TOTAL	20.946		20.946	22.889		22.889	4.156	5.837	9.993	35.651	14.933	50.584	83.642	20.770	104.412
TIEMPO MUERTO	PROPIA	1.842		1.842	4.993		4.993	5.290		5.290	6.811		6.811	18.936		18.936
	CONTRATA	1.332		1.332	1.888		1.888		11.096	11.096	1.499	2.652	4.151	4.719	13.748	18.467
	TOTAL	3.174		3.174	6.881		6.881	5.290	11.096	16.386	8.310	2.652	10.962	23.655	13.748	37.403
TIEPI AHORRADO (HORAS)	PROPIA		1,26			*2,10*			*0,87*			*2,85*			*1,80*	
	CONTRATA		2,34			*1,25*			*0,18*			*5,73*			*2,70*	
	TOTAL		3,60			*3,35*			*1,05*			*8,58*			*4,50*	
TIEPI-Progr.(H)	TOTAL		0,37			0,33			0,27			0,80			0,49	
TIEPI-Total (H)	TOTAL		2,99			1,97			2,14			2,54			2,32	
ENERGIA AHORRADA (MWH)	PROPIA		1.014			*1.182*			*1.368*			*5.678*			*9.242*	
	CONTRATA		1.884			*702*			*260*			*11.279*			*14.125*	
	TOTAL		2.898			*1.884*			*1.628*			*16.957*			*23.367*	

ENERGIA SUMINIST.(MWH)	7.052.766	4.912.690	12.345.071	17.281.291	41.591.818
POTENCIA INST.(MVA)	4.158	2.864	9.802	10.008	26.832

IBERDROLA

GESTION T.E.T.
AÑO 1.996

LINEAS AEREAS MEDIA TENSION

TIPOS DE TRABAJOS

		NORTE			OESTE			CENTRO			ESTE			TOTAL		
		M.D.	M.C.	Tot	M.D.	M.C.	Tot	M.D.	M.C.	Tot	M.D.	M.C.	Tot	M.D.	M.C.	Tot
GRUPO 1 AISLAM.	PROPIA	93		93			1.013	133		133						
	CONTRATA	377		377			379		76	76						
	TOTAL	470		470			1.392	133	76	209						
GRUPO 2 DERIV.	PROPIA	67		67			533	20		20						
	CONTRATA	51		51			48		198	198						
	TOTAL	118		118			581	20	198	218						
GRUPO 3 APOYOS	PROPIA	5		5			17	6		6						
	CONTRATA	78		78			41		114	114						
	TOTAL	83		83			58	6	114	120						
GRUPO 4 PUENTES	PROPIA	397		397			640	149		149						
	CONTRATA	1.368		1.368			1.645		169	169						
	TOTAL	1.765		1.765			2.285	149	169	318						
GRUPO 5 ARMADOS	PROPIA	20		20			136	27		27						
	CONTRATA	221		221			78		23	23						
	TOTAL	241		241			214	27	23	50						
GRUPO 6 PR.Y MAN.	PROPIA	162		162			189	133		133						
	CONTRATA	330		330			252		170	170						
	TOTAL	492		492			441	133	170	303						
GRUPO 7 CONDUC.	PROPIA	62		62			57	14		14						
	CONTRATA	122		122			114		138	138						
	TOTAL	184		184			171	14	138	152						
GRUPO 8 VARIOS	PROPIA	380		380			200	37		37						
	CONTRATA	137		137			52		35	35						
	TOTAL	517		517			252	37	35	72						
TOTAL	PROPIA	1.186		1.186			2.785	519		519	1.468		1.468			5.956
	CONTRATA	2.684		2.684			2.609		923	923	752	3.184	3.936			10.152
	TOTAL	3.870		3.870			5.394	519	923	1.442	2.218	3.184	5.402			16.108

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IBERDROLA

GESTION T.E.T.
AÑO 1.996

RENTABILIDAD

LINEAS AEREAS MEDIA TENSION

CALIDAD DE SERVICIO

		NORTE			OESTE			CENTRO			ESTE			TOTAL		
		M.D.	M.C.	Tot	M.D.	M.C.	Tot	M.D.	M.C.	Tot	M.D.	M.C.	Tot	M.D.	M.C.	Tot
	PROPIA			341			636			322			356			367
% TIEPI	CONTRATA			632			379			67			716			551
PROGRAMADO	TOTAL			973			1.015			389			1.072			918
	PROPIA			52			107			41			112			78
% TIEPI	CONTRATA			97			63			8			226			116
TOTAL	TOTAL			149			170			49			338			194

ECONOMICA

	PROPIA			304.200			354.600			410.400			1.703.400			2.772.600
- ENS	CONTRATA			565.200			210.600			78.000			3.383.700			4.237.500
KPta	TOTAL			869.400			565.200			488.400			5.087.100			7.010.100
COSTE	PROPIA			1,0			- 7,4			4,9			- 3,0			1,6
KWh. Ahorrado	CONTRATA			- 3,6			- 23,7			50,3			2,4			1,2
Pta/Kwh	TOTAL			- 2,0			- 13,45			12,1			0,6			1,3

ENERGIA SUMINIST.(MWH)	7.052.766	4.912.690	12.345.071	17.281.291	41.591.818
POTENCIA INST.(MVA)	4.158	2.864	9.802	10.008	26.832