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FINANCIAL COMPENSATION DUE TO MUNICIPALITIES THAT HOST RADIOACTIVE WASTE DEPOSITS

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ABSTRACT

This work aims to perform calculation about the financial compensation due to municipalities where there is viability for construction of radioactive waste deposits from low and medium activity. Were used like base structure de Resolution No. 96 of August, 10, 2010, entitled “Model of Calculation For Financial Compensation to Municipalities” where are determinate those principal characteristics by the waste and deposits, such as the half-life, activity level, type of deposits (initial, intermediate or final), costs for construction and maintenance of deposits, demography, between others. The calculation was made according to the temporally or definitive storage for solids waste like personal protection equipment (gloves, shoes, masks, etc) resins and filters used in wastewater treatment, between others, from of nuclear and radioactivity facilities.

There are presented some countries that do the compensation, financial or not, for some municipalities for the construction of waste deposits and in some cases, the way that occurred the negotiation between the stakeholders, in other words, the local population and the companies. Also are presented others forms of financial compensation in Brazil in consequence of activities in large scale which result in potential risk for the surrounding population and for the environment, like compensation for oil and natural gas, hydropower plants and mining. Were used on methodology the inventory of waste presented on RMBN project (Repository of Waste of Low and Medium Activity) developed by the CDTN which present the implementation of a repository for final storage to radioactive waste. With this was possible to develop a case study with the creation of four scenarios. Values were found which initially range from R$2,6 mil to R$79,8 mil for month. Finally are analyzed the possible influences which that values may have on the municipality budget revenue and some divergent points about the resolution

1. INTRODUCTION

With the increasing amount of nuclear and radioactive facilities in Brazil [01], it becomes more necessary to build radioactive waste deposits. Therefore, the Brazilian Institute of

Environment and Renewable Natural Resources, IBAMA, has determined to grant the preliminary license for Unit 3 of the Central Nuclear Almirante Álvaro Alberto, CNAA, that the final repository of radioactive waste to be licensed and start being built until the beginning of operation of the unit.

With this, a researchers group coordinated by the Center for Development of Nuclear Technology, CDTN, developed a proposal for the construction of the deposit titled "Project RBMN - Radioactive Waste Repository for Low and Intermediate Levels of Radiation" [02], which approach topics such as the estimated volume of waste generated until 2080; storage forms in accordance with the geological parameters of the region; the deposition system characteristics; application of methodologies for site selection; licensing and safety analysis, among others.

One way to enable the installation of deposit in some municipality is to compensate the burden that would be assigned to the local population. For this, the National Commission of Nuclear Energy, CNEN, which is also responsible for the management of radioactive waste and the selection and choice of sites for building the deposit, has established the Resolution No. 96 of 10 August 2010 entitled "Model Calculation for Compensation Financial to Municipalities" for the municipality that host a radioactive waste deposit is rewarded financially [03]. This work aims to analyze and apply the proposed methodology.

Using the proposed methodology will be possible to create different scenarios for different municipalities according to the conditions of the waste to be deposited, which directly alters the amount of compensation. This article were based on the master`s degree dissertation submitted by Silva [04] for Post-Graduate Program of Institute Nuclear Engineering, PPGIEN.

1.1. Financial Compensation and Royalties

The aims of the compensation come from the need to compensate literally a region for a loss or damage which is a result of some local activity. According to Kunreuther and Easterling [05] compensation is equivalent to a compensatory measure at least compensate the burden assigned to a specific place, for example, the construction of landfills, oil and gas exploration, power generation plants, deposits of radioactive waste, mining, prisons, etc.. The compensation can be performed in different ways, but the most common is financial, where states and municipalities affected are given a monetary value paid by the waste generator.

The amount of compensation should be considered according to the type of installation and the potential impacts generated. Depending on the installation can exist many negative impacts, such as pollution of water from rivers or groundwater, release of toxic or radioactive, increased traffic in the region with constant use of cars and trucks, devaluation of property, fall in regional tourism, among others [05].

In some cases the compensation is not necessarily monetary. For example, the construction of a landfill involves concerns with the environment, health and transport. The employer could invest in hospitals and clinics of the region to provide care a large number of people if maybe occurs some kind of chemical leakage that could infected people, food, water, etc.. It could also refurbish and duplicate roads and streets nearby so that they can withstand the increased traffic with the many heavy loads that could daily transited through the region; invest in programs to guide people about the importance of separating waste and its recycling, generate jobs and hire people from the region are some forms of compensation [05].

1.2 Experience in Other Countries

The compensation for the construction of deposits for temporary storage or permanent radioactive waste of low, intermediate and high activity is a commitment of the companies producing waste. In Brazil, this practice has not yet was implemented, but in some countries the compensation is already made. So we can see that compensation plays an important role in decision making for implementation of radioactive facilities, in this case, the deposits of radioactive [06].

In a municipality on Finland, for example, the operation of a deposit for fuel nuclear used there was an intense public participation in decision-making along with business representatives. Community representatives and political members had the power of veto and approval along with the companies responsible for the generation of wastes.

The generating company has proposed to pay as compensation part of the loans from the municipality of and invest in the construction of an ice hockey stadium, a secondary school and a home for elderly care. In addition, the company secured the creation of jobs during the construction of the repository.

The municipality still has determined the financial compensation of € 1.19 million for the construction of the repository and an annual payment of € 50,000 during five years applied to development of the region. The compensation in principle is a modest value, but what is striking is that the end of negotiations between businesses and the community more than 60% of people were in favor of the construction of the deposit, while in the beginning were a little over 40 %, then, the power of participation and decision gave conditions for the population expose their priorities and needs, and opened doors to new local businesses [06].

Another example can also be seen with the residents of some towns in Massachusetts (Brockton, Chelsea, Newton, Sturbridge and Ware). They were interviewed about building a site for the treatment of toxic wastes. Initially, without the submission of the proposal of any compensation or damages in all cities over half of the respondents oppose the construction.

The employers then proposed some economic incentives for the region, for example, pay taxes to the city as a result to the amount of waste treated; hiring local residents for the facility, repaving roads due to large number of trucks on the road daily, construction of 5 schools in each city; compensation for possible devaluation of residence, among other.

After the proposed compensation, percentages of acceptance for construction increased in four of the five cities. However was not a very significant increase, with the exception of the town of Ware, which increased from 22.8% to 56.4%, which is probably related to the fact that a large percentage of the population was opposed to the construction. According to the author, economic incentives are not enough to get acceptance in larger proportions of the local population, since the fear lies strongly associated with the risk of hazardous facilities, but is considered an important step in the negotiation process among employers and the public [07].

With respect to the payment of royalties and compensation for the exploration of natural resources in Brazil, the both municipalities Campos de Goytacazes and Macaé, both in the state of Rio de Janeiro, are the two municipalities that most receive payment for royalties and financial compensation in national level. In 2006, Fields Goytacazes and Macaé together received about R$1.2 billion in the form of compensation [08].

Another example of compensation is the hydropower which paid for the states and municipalities as a result of flooding caused by construction of the reservoir. Between 1997 and 2007, Brazil raised in financial compensation and royalties from hydropower around R$11.5 billion. In the same period the state of Minas Gerais has benefited from approximately R$ 800 million in compensatory resources. A study in 54 municipalities of Minas Gerais showed that the financial compensation of hydropower correspond on average 4.5% of the taxes paid to these municipalities, being the third highest tax revenue followed the Municipal Participation Fund, FPM and Tax Circulation of Goods and Services, ICMS. In some municipalities the compensatory resources representing up to 20% of the total budget. It was found that in most municipalities there was a significant and positive change in health investments and sanitation, education, infrastructure, housing, among others [09].

1.3 Resolution No. 96, 2010, August 10

The CNEN established in Resolution No. 96 on August 10, 2010 the methodology entitled "Model for Calculating Financial Compensation for Municipalities".

The resolution determines the compensation to be paid monthly to the municipality that will be host for initial, intermediate or final deposits for waste radioactive of low and medium activity for a period of 300 years, with the exception of waste mining and ore beneficiation, recommended by International Atomic Energy Agency, IAEA [10].

It should be emphasized that the resolution does not apply criteria for selection of sites for installation of deposits and waste management. Such criteria are established norms Selection and Choice of Sites for Radioactive Waste Deposits (CNEN-NE-6.06) [11] and Management of Radioactive Waste of Low and Medium Levels of Radiation (CNEN-NE-6.05) [12].

The resolution in question considers a single parameter for the municipality, the demography. The others are mainly related to the characteristics of the waste and deposit and financial factors as determined by CNEN.

The operations with all these factors will result in the value that will be paid to the CNEN by the waste generator to bear the costs of construction and maintenance of the deposit, knowing that the law 10.308 [13] determine that 10% of this amount must be paid to the municipality as a way compensation for the use of space to build the deposit.

2. METHODOLOGY

Were used the base of the inventory of waste radioactive provided by Project RBMN, which is an estimate of the volume of waste generated up to 2080. According to RBMN, the proposed to repository is the storing radioactive waste results from nuclear activities in power generation, research, industry and medicine, as well as for waste from the decommissioning of such facilities (see reference 02).

The Table 1 presents an estimate of the amount of waste that will be produced until 2080 [14] by facilities that are currently operating or which are still in the design or construction. From that date the deposit would be closed, no longer receive radioactive waste, but would not be decommissioned.

Table 1: Volume of radioactive waste produced by nuclear plants until 2080

Facilities generating radioactive waste	Volume (m^3)
CNAAA (Angra 1, Angra 2 e Angra 3) and 4 Future Facilities	22.840
Centro Tecnológico da Marinha (CTMSP)	8.692
Reator Multipropósito Brasileiro (RMB)	7.020
Decommissioning of nuclear facilities	6.392
Out-of-used sealed radioactive sources	608
Institutes of CNEN (IEN, IPEN, CDTN e LAPOC)	509
Fábrica de Combustível Nuclear (FCN-INB)	479
Lightyining rod and smoke detectors	400
Total	46.940

Scenario with 8 new facilities	10.560
Total	57.500

According to researches by Martins [15] who present a methodology for the construction of final repositories in the state of Rio de Janeiro for disposal of spent nuclear fuel, we assume that this methodology can also be applied with regard to the selection of sites for construction and operation of tailings low and medium activity. It is noteworthy that the deposits of low and medium activity have much lower risk to the environment than repositories of spent fuel, because this the demands on safety and radiation protection are not as strict, but still are within the standards required by the CNEN -NE-6.06.

To calculate effective compensation were considered factors in percentage they represent particular variable, shown in the following tables. Among the municipalities with greater viability to implement a deposit, the demography was less than 500 inhabitants/km^2 for all of them (see reference 03), then the factor of 1.0 was assumed.

Table 2: Types of deposits

Fd	Type of deposits
5%	Initial
10%	Intermediate
20%	Final

Table 3: Waste conditions for storing

Fr	Waste conditions for storing
5%	Treated
10%	Semi treated
20%	Untreated

Table 4: Half-life of waste

Fm	Half-life of waste
40%	<1year, beta and gamma emission, specific activity alpha equal or less them 3.700Bq/g
50%	>1year and <30 years, beta and gamma emission, specific activity alpha equal or less them 3.700Bq/g
60%	>30 years and alpha emission

Table 5: Activity of waste

Fc	Activity of waste
25%	Low concentration; >74Bq/g and <1.000Bq/g
60%	Medium concentration; >1.000Bq/g and <10.000Bq/g
100%	High concentration; >10.000Bq/g

Some factors are already determinate, such as:

Fb: Base Factor, from the Law 10.308 fixed in 10% for initial and intermediate deposits and higher to 10% for final deposits.

T: Time, represent the time that the municipality will receive the financial compensation, fixed at 300 years or 3600 months.

Cr: Unit Cost Reference, represent the cost per m^3 that the CNEN would take to deploy the deposit with untreated waste, long half-life and high concentration, fixed at R$10.000,00/$m^3$. That value could be review for decision by CNEN.

k2: Correction Factor, applied over Cr in cases when the costs on final disposal are basically from the operator, fixed at 1.0.

2.1 Methodology Applied For The Calculation Of Financial Compensation For Initial And Intermediate Deposits

The RBMN project describes the disposal of radioactive waste according to its definitive storing. However, considering a case of study, we applied the methodology for initials and intermediate deposits considering that in the future this repository will be built for temporary storage of these wastes.

For the both deposits the methodology is the same. The main equation from de calculation is:

$$\boldsymbol{VM} = \frac{\boldsymbol{Fb} \times \boldsymbol{Fdd} \times \boldsymbol{Vr'} \times \boldsymbol{Cr'} \times (\boldsymbol{Fd} + \boldsymbol{Fr} + \boldsymbol{Fm} \times \boldsymbol{Fc})}{\boldsymbol{T}} \qquad \text{(Eq. 1)}$$

Where:

Fb: Base Factor
Fdd: Demography.
Vr’: Volume of waste, in m^3.
Cr’: Unit Cost Reference
Fd: Type of deposit (5% for initial and 10% for intermediate)
Fr: Condition for storage of waste
Fm: Half-life
Fc: Concentration
T: Time, fixed on 3600 months.

Were created two scenarios where the parameters represent maximum and minimum values. The minimum parameters corresponds the more adequate condition of waste for storing, with low level of half-life and concentration, and the maximum parameters correspond the less adequate condition. We consider this option because this we can find the maximum and minimum values of financial compensation.

2.1.1 Scenario 1 (minimum parameters)

The time of disposal is already fixed on 3600 months according to Resolution No. 96, just like Cr, at R$10.000,00; the k2 factor is equal 1.00, and the Fb, fixed at 10%. All these values were considered like standard data because they are already determined by the Resolution.

According to the variable referent to waste and deposits, we have Vr equal to 46.940m^3; the factors Fd and Fr are both 5%, The half-life correspond to 40% and the waste activity is equal to 25%.

2.1.2 Scenario 2 (maximum parameters)

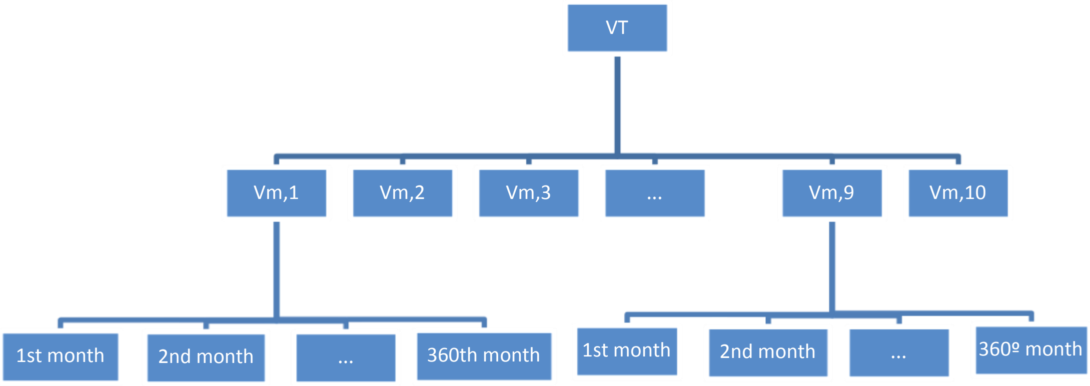
The second scenario presents the same standard datas them Scenario 1. However the the variables now assume maximum values. The Vr correspond to 57.000m^3; the Fd factor is 10% (intermediate deposit); the half-life is equal to 60%; the waste presents high activity, corresponding to 100% and the waste treatment is 20% (untreated waste).

2.2 Methodology applied to the calculation of financial compensation for final deposits

This methodology is similar to the previous method, except for some attributions.

The period of 3600 months of compensation was maintained, however that was divided in 10 periods equals to 360 months where the total amount for each period is directly proportional to radioactive decay of waste disposal. Considering this, after 30 years the value of compensation in some period is less them previous period.

The following organogram shows how is done the payment of compensation:



Organogram 1: Payment of financial compensation according to period of 360 months

The item *VT* (total value) correspond to sum of all 10 periods divided in 360 months, *Vm,n*. The item *Vm,n* is described as *Vm,1*, *Vm,2* until *Vm,10* and the factor *n* correspond to some determined period.

$$VT = \sum_{n=1}^{10} Vm,n \qquad \text{(Eq. 2)}$$

The main equation from this method is:

$$Vm,n = \frac{Fb \times Fdd \times Vr \times Cr \times (Fd + Fr + Fm \times Fc) \times fd,n}{T} \qquad \text{(Eq. 3)}$$

Where:

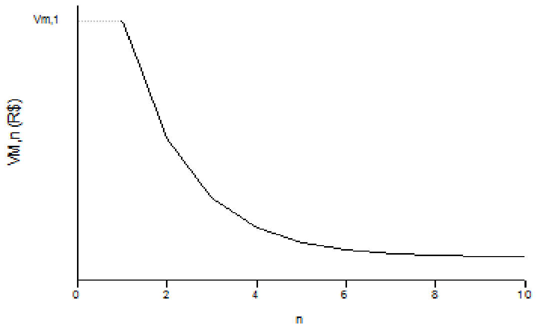
Vm,n: value of monthly compensation during period *n*.
Fb: Base Factor
Fdd: Demography.
Vr: Volume of waste, in m^3.
Cr: Unit Cost Reference
Fd: Type of deposit (5% for initial and 10% for intermediate)
Fr: Condition for storage of waste
Fm: Half-life
Fc: Concentration
fd,n: factor of radioactive decay for *n* period.
T: time fixed in 360 months correspond to n period.

The factor *fd,n* is calculated by the follow equation:

$$fd,n = 2^{-n} \quad \text{(Eq. 4)}$$

Where *n* varies from 1 to 9 and the value of *fd,10* will be the same to *fd,9*.

According to Eq. 4, the value of compensation decreases exponentially from one period to other. Considering that, when *n* increases, the factor n decreases always by half, how is shown on the following diagram. Them on the first periods the value of the compensation will be higher them last ones, because the activity is also higher.



Graph 1: Vm,n x n

Following the same calculation's guideline from initial and intermediate deposits, was consider more two scenarios where the parameters assume maximum and minimum values.

2.2.1 Scenario 3 (minimum parameters)

The third scenario presents the same standard data, except for the Fd factor which now is fixed at 20%, corresponding to final deposit. The factor time used on the calculation correspond to 360 months which equals to the first period of 30 years, n=1. For the second period, the time also is 30 years. Then for the last period, n=10, the sum of all periods correspond to the total time of 3600 month.

Applying the smaller parameters to the variable we have to the third scenario the same values that the first scenario.

2.2.2 Scenario 4 (maximum parameters)

The fourth scenario is similar to the third, except for the parameters which now assumes maximum values. The value of characteristics of waste and deposit are the same of the second scenario. The standard data stay the same.

3 RESULTS

The found results for amount of compensation are presented on the following tables. The Table 6 show the results for initial and intermediate deposits for Scenarios 1 and 2.

Table 6: Values of financial compensation for initial and intermediate deposits

Scenario	Monthly financial compensation
1	R$ 2.607,78
2	R$ 14.375,00

The tables 7 and 8 presents the results of monthly compensation for the final deposits for Scenarios 3 and 4, respectively, applied to period *n* and the decay factor *fd,n*.

Table 7: Values for financial compensation for final deposits considering minimum parameters

Scenario 3			
n	fd,n	Amount of period n	Monthly payment
1	0,5	R$ 8.214.500,00	R$ 22.818,06
2	0,25	R$ 4.107.250,00	R$ 11.409,03
3	0,125	R$ 2.053.625,00	R$ 5.704,51
4	0,625	R$ 1.026.812,50	R$ 2.852,26
5	0,03125	R$ 513.406,25	R$ 1.426,13
6	0,015625	R$ 256.703,13	R$ 713,06
7	0,0078125	R$ 128.351,56	R$ 356,53
8	0,00390625	R$ 64.175,78	R$ 178,27
9	0,001953125	R$ 32.087,89	R$ 89,13
10	0,001953125	R$ 32.087,89	R$ 89,13

Table: 8: Values for financial compensation for final deposits considering maximum parameters

Scenario 4			
n	fd,n	Amount of period n	Monthly payment
1	0,5	R$ 28.750.000,00	R$ 79.861,11
2	0,25	R$ 14.375.000,00	R$ 39.930,56
3	0,125	R$ 7.187.500,00	R$ 19.965,28
4	0,625	R$ 3.593.750,00	R$ 9.982,64
5	0,03125	R$ 1.796.875,00	R$ 4.991,32
6	0,015625	R$ 898.437,50	R$ 2.495,66
7	0,0078125	R$ 449.218,75	R$ 1.247,83
8	0,00390625	R$ 224.609,38	R$ 623,91
9	0,001953125	R$ 112.304,69	R$ 311,96
10	0,001953125	R$ 112.304,69	R$ 311,96

At the end of 300 years the municipality will receive the amount correspond to initial, intermediate and final deposits. The table 9 presents the values of these amounts.

Table 9: Value of total amount collected in 300 years for the four scenarios

Scenario	Total amount collected in 300 years
1	R$ 9.388.000,00
2	R$ 51.750.000,00
3	R$ 16.429.000,00
4	R$ 57.500.000,00

Nine municipalities presented positive technical viability for construction of deposits. According to Instituto Brasileiro de Geografia e Estatística, IBGE, [16], these municipalities have monetary incoming in 2009 which varies from R$88,7 million (municipality with less incoming) to R$1,5 billion (municipality with higher incoming).

Considering a municipality that have initial, intermediate and final deposits in operation on its territory and the previously listed four scenarios, were calculated the sums of the amount collected in 01 year for each scenario and compared to the values of monetary incoming of that municipality during that year. The Table 10 bring the results for the municipality that presents less monetary incoming and the Table 11, for the municipality with bigger incoming.

Table 10: Comparison between the monetary incoming and financial compensation

Municipality 1		
Incoming: R$88,7 million		
	Amount collected in 12months	Percentage of financial compensation over annual incoming (2009)
Scenario 1	R$31.293,36	0,03%
Scenario 2	R$ 172.500,00	0,19%
Scenario 3	R$ 273.816,96	0,31%
Scenario 4	R$ 958.333,33	1,07%

Table 11: Comparison between the monetary incoming and financial compensation

Municipality 2		
Incoming: R$1,5 billion		
	Amount collected in 12months	Percentage of financial compensation over annual incoming (2009)
Scenario 1	R$31.293,36	0,002%
Scenario 2	R$ 172.500,00	0,011%
Scenario 3	R$ 273.816,96	0,018%
Scenario 4	R$ 958.333,33	0,062%

4. CONCLUSIONS

Comparing to other kinds of indemnities such as royalties and financial compensation from oil, gas and hydric resources exploration, the compensation for the construction of waste radioactive deposits don’t even approach of the values of these indemnities.

We can argue that the potential risk generate by big industries in a region is generally higher them those related to the operation of a surface waste radioactive deposit of low and medium level. However there are many common troubles to all those industry, such as the expropriation of lands, increase of the local traffic, public acceptance, among other factors.

Investments from financial compensation and royalties could be very important in a local community considering that there exists political control on those investments. In some cases that indemnity could represents a considerable percentage on municipality's monetary incoming, which does not occurs in that work where the payment of compensations little higher them 1% and even like this where were considered the scenario with more risk for the environment.

In case of initial and intermediate deposits were noted, although they have a life cycle equal or highest them own facility, the method of compensation developed by CNEN has determined a time of 300 years for the total payment of compensation. At the same way, the method give priority the half-life and the activity level of waste and put on second plan the type of deposit, which result that waste deposits with activity and half-live generate similar values of compensation, disregarding if the deposit is initial or final.

The volume estimated of waste for final disposal will ensure that the total amount designed to municipality for the next 300 years. However a question arises: how will be possible determinate the compensation for initial and intermediate deposits for the same period if the waste will be temporarily storage? For the final deposits the estimative is justifiable because the storage is definitive, but for initial and intermediate deposits that estimative don't correspond with the time of compensation. The estimated time to operation of deposit is from 40 to 50 years and the initial and intermediate deposit will be decommissioned before that period, while for the final deposits will be on the post-operation phase which is the area monitoring step.

Considering international experiences related to financial compensation for radioactive waste disposal, we can consider beyond the financial payment, other ways of compensation to municipality where it could determinate how will be used the indemnity. The own facility could be applied the resources directly to the local community. The process of compensation applied on Finland shows, although divergent voices, when exist the popular participation on decision make process, the stakeholders could point the best choice for both sides.

Were noted on that work that only the methodology proposed by CNEN will not be enough to get the acceptance of local population for the operation of deposit, in sight of the estimate values are practically worthless. It is necessary, according to international examples, the communication with the public with the aim to explain the process of implementation of deposits with determinate associated risks and listening from local representatives the real need for the region for then to evaluate some alternative options of compensation.

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