FUNDING AND FINANCE ISSUES RELATED TO THE DECOMMISSIONING OF BRAZILIAN NPPS

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2019 International Nuclear Atlantic Conference - INAC 2019
Santos, SP, Brazil, October 21-25, 2019

Guideline

- Almirante Alvaro Alberto Nuclear Center – Description;
- Decommissioning in the world;
- Decommissioning in Brazil;
- Normative framework;
- Timeline operation;
- Formation of financial reserve funds towards decommissioning;
- Calculation Premises;
- Conclusions.

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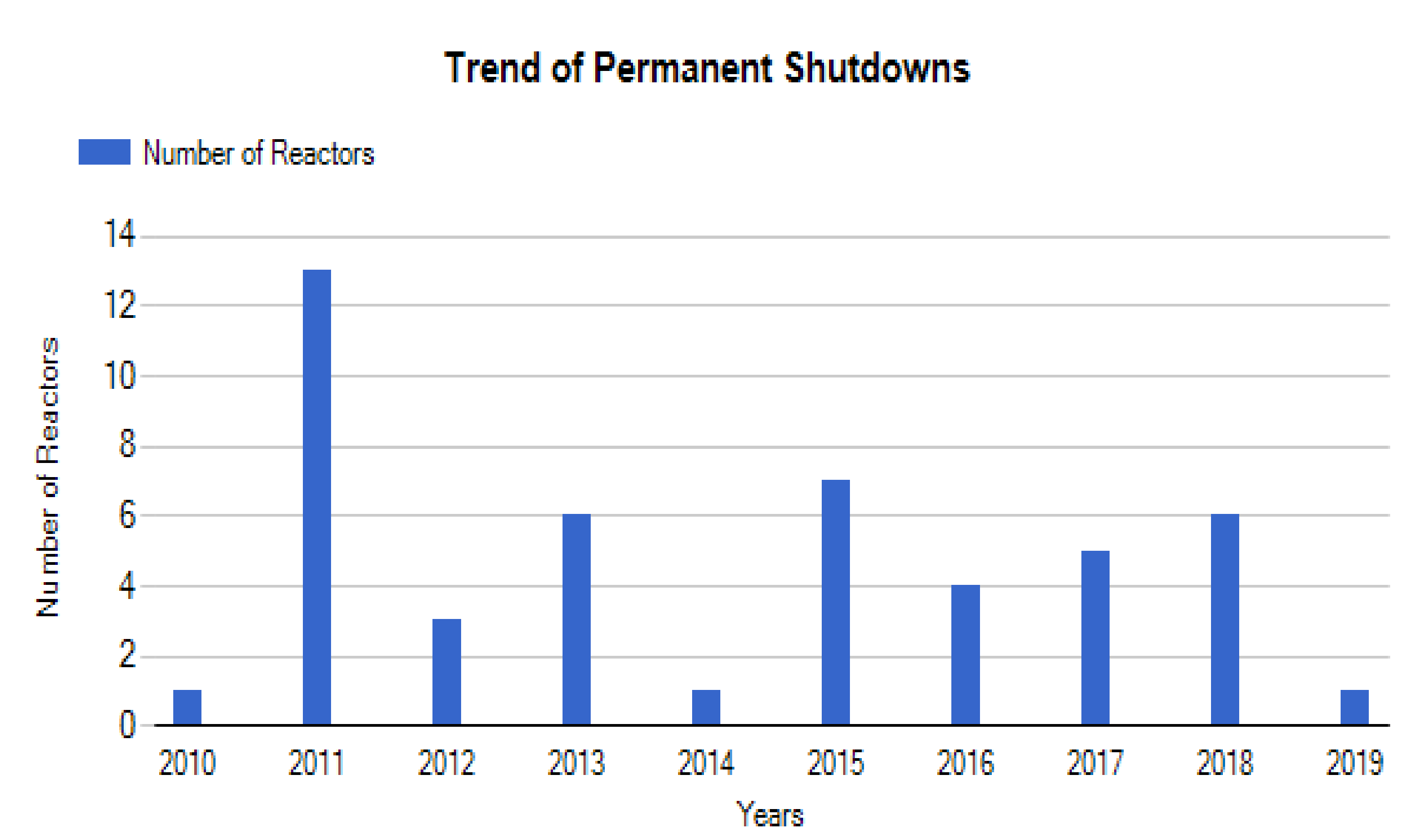
Decommissioning in the world

Decommissioning: Administrative and technical actions to allow the removal of some or all of the regulatory controls from a facility with no unacceptable risk to the public, the workers and the environment



Decommissioning in Brazil

- **Decommissioning Strategy for CNAAA:**

  - **Deferred Dismantling:** Radioactive materials will be processed or placed in such condition that they can be stored and kept safe during their radioactive decay → Angra 1 and 2 NPPs.

  - **Immediate Dismantling:** Equipment, structures and parts of the plant containing radioactive contaminants will be removed / decontaminated to levels that allow the site to be released for unrestricted use → Angra 3 NPP.

- **Desired end state –** Unrestricted use.

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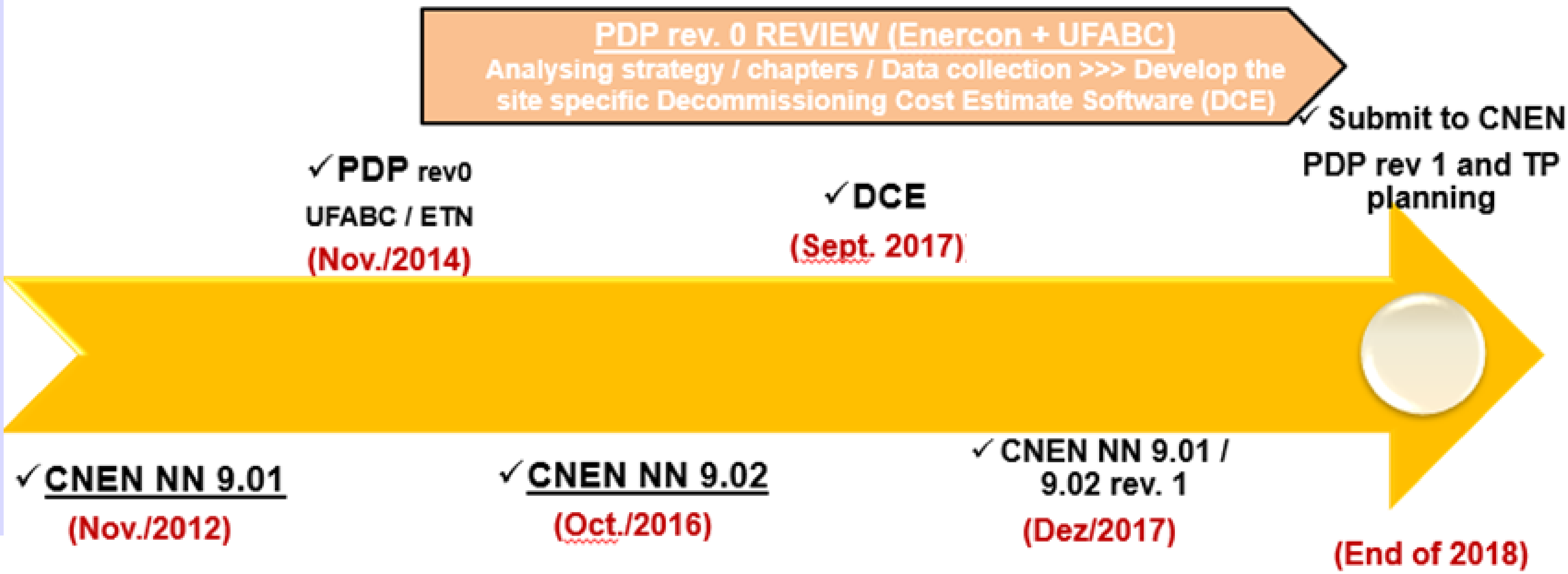
Normative framework

✓ <u>CNEN-NN-9.01 – DECOMMISSIONING OF NPPs (2012):</u> BASIC REQUIREMENTS OF NUCLEAR SAFETY TO BE ACHIEVED ON PLANNING / IMPLEMENTATION OF DECOMMISSIONING

✓ <u>CNEN-NN-9.02 – MANAGEMENT OF FINANCIAL RESOURCES FOR DECOMMISSIONING OF NPPs (2016):</u> DTF GUARANTEE WITH ANNUAL REPORTS, AUDITS AND ACTUARIAL CALCULATION SPECIFIC METHOD/REPORT.



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Normative framework

CNEN-NN-9.01:

✓Article 15 of the standard provides that operator should ensure that adequate financial resources should be at hand to cover the costs associated with a safe decommissioning of the plant, and that such resources should be readily available as soon as they are required, even if in the case of an early stoppage of the operation due to an accident or after a corporate decision of the operator;

CNEN-NN-9.02:

✓Article 6 of the standards provides that the operator should appoint a Federal Financial Institution to accumulate the funds set aside, in a conservative investment option, so that such funds see a guaranteed and stable monetary adjustment, with the least risk of financial loss;

✓Article 9 of the said standard also provides that the financial institution chosen to bank such funds should demonstrate, at any time, that a conservative path for the management of the funds has been adopted, as they are set aside for the time of decommissioning, at the same time allowing audits of such custody and management by the regulatory agency, as set in Article 15, §4 of the CNEN NN 9.01 standard.

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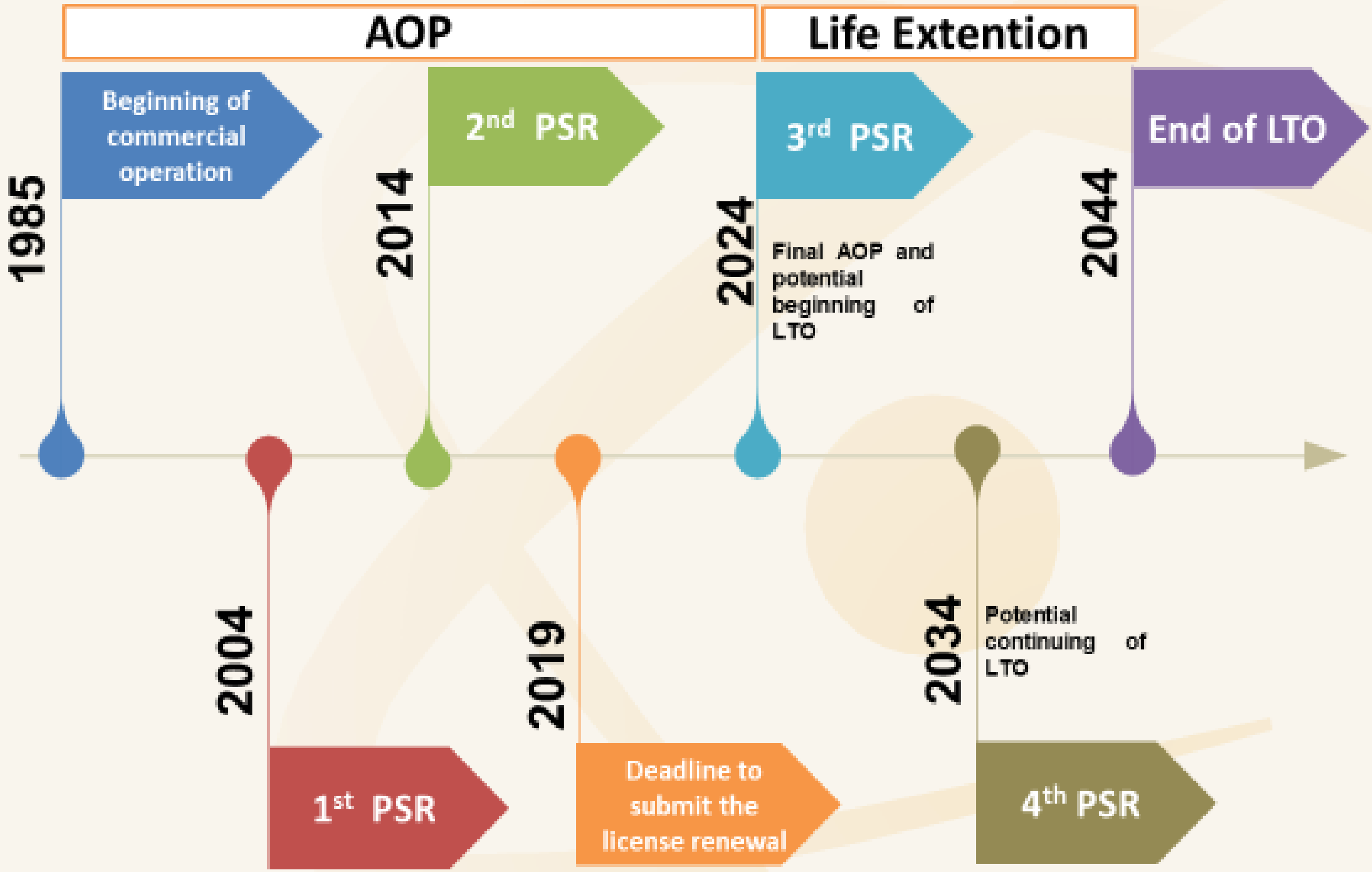
Timeline Operation

Angra 1 (PWR 2 loops)



LTO → Direct implication on the amount of short-term financial funds required.

FORMATION OF FINANCIAL RESERVE FUNDS TOWARDS DECOMMISSIONING

Problem 1: Knowing that in X years an amount equivalent to Y US dollars will be needed to face the costs of decommissioning a nuclear installation, what would the monthly amount set aside be as deposited by the operator, in the knowledge that the earnings of such a fund are constant and equal to I%/mo?

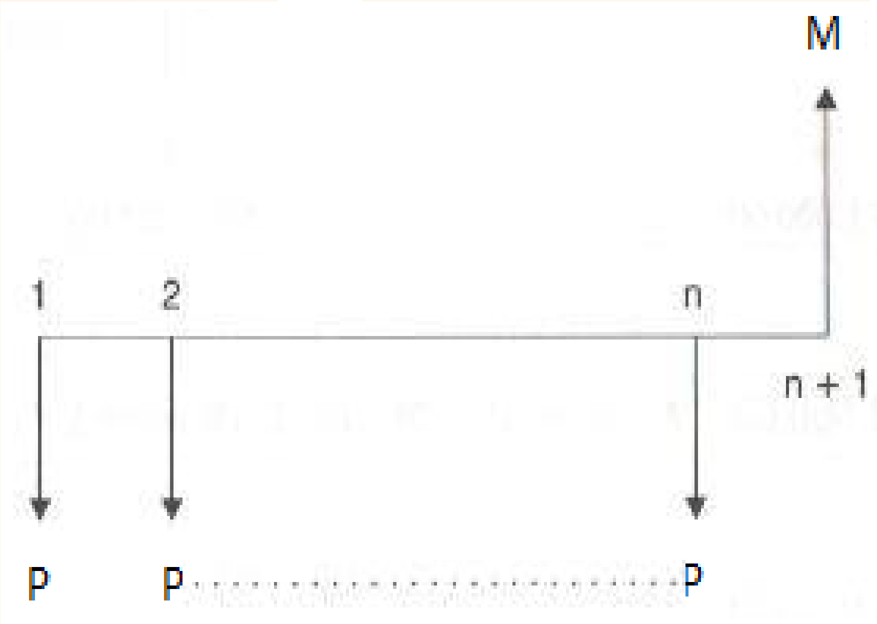


Chart for the cash flow of an early series. Adapted from Azevedo

Capital Accrual Factor - $FAC(i,n)$

$$M = P(1+i)\left[\frac{(1+i)^n - 1}{i}\right]$$

$$P = \frac{i}{(1+i)[(1+i)^n - 1]} \times M$$

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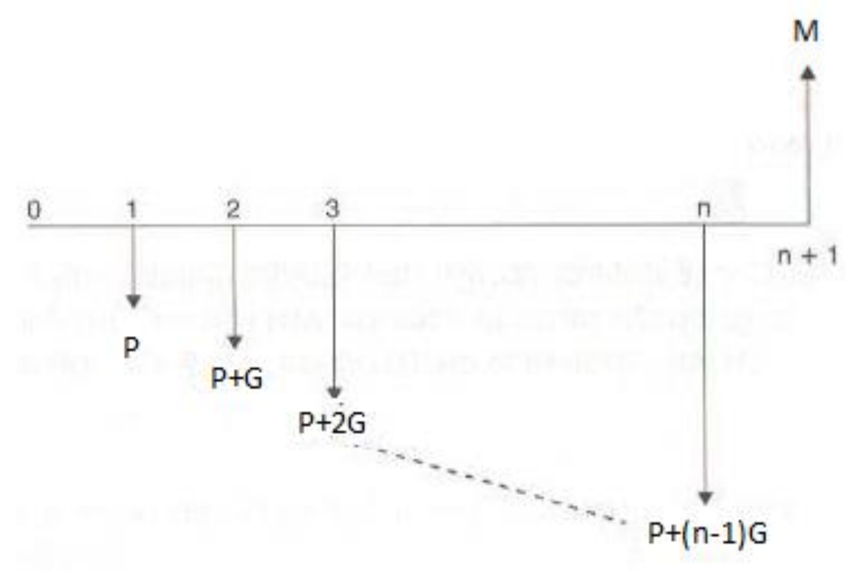
Problem 2: In the case where X US dollars are needed to face the costs of decommissioning a nuclear installation, what would the increasing monthly amount set aside as in a finite arithmetic progression at the rate of G be as deposited by the operator, in the knowledge that the earnings of such a fund are constant and equal to I%/mo?



Cash flow chart for a non-uniform series of payments whose transfers increase in an arithmetic progression at the rate of G. Adapted from Azevedo

$$M = (1+i)^{n+1} \times (SU + SG)$$

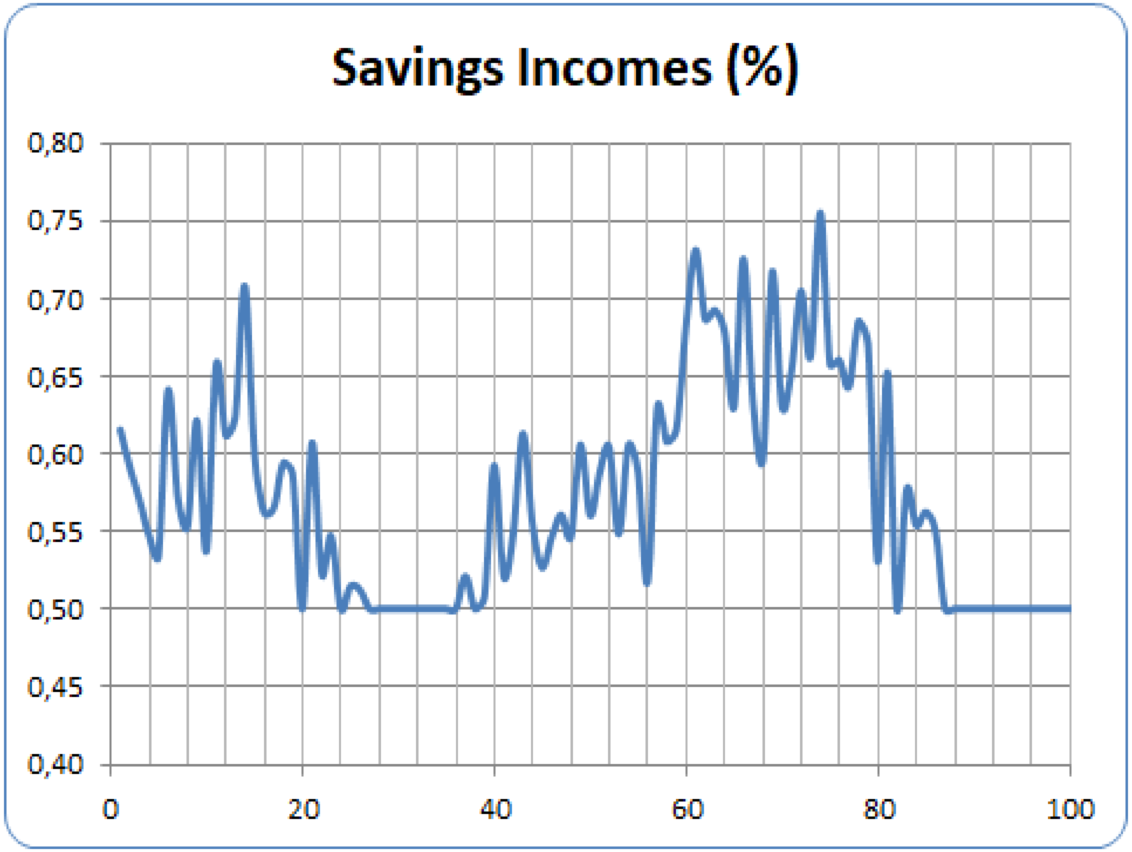
$$SU = P \times \left[\frac{(1+i)^n - 1}{(1+i)^n \times i}\right]$$

$$SG = \frac{G}{(1+i)^n \times i} \times \left[\frac{(1+i)^n - 1}{i} - n\right]$$

$$G = \frac{i}{(1+i)^n - (1+ni)} \times \left\{\frac{Mi}{1+i} - P[(1+i)^n - 1]\right\}$$

Calculation Premises

1 – The interest rate considered will be that of the mean earnings of savings accounts, taking the financial data from Jan 2010 to Mar 2019. The data on savings accounts were obtained from the IPEA - Institute for Applied Economic Research.



average (0.574%)

maximum (0.756%)

minimum (0.500%)

standard deviation (0.069%)

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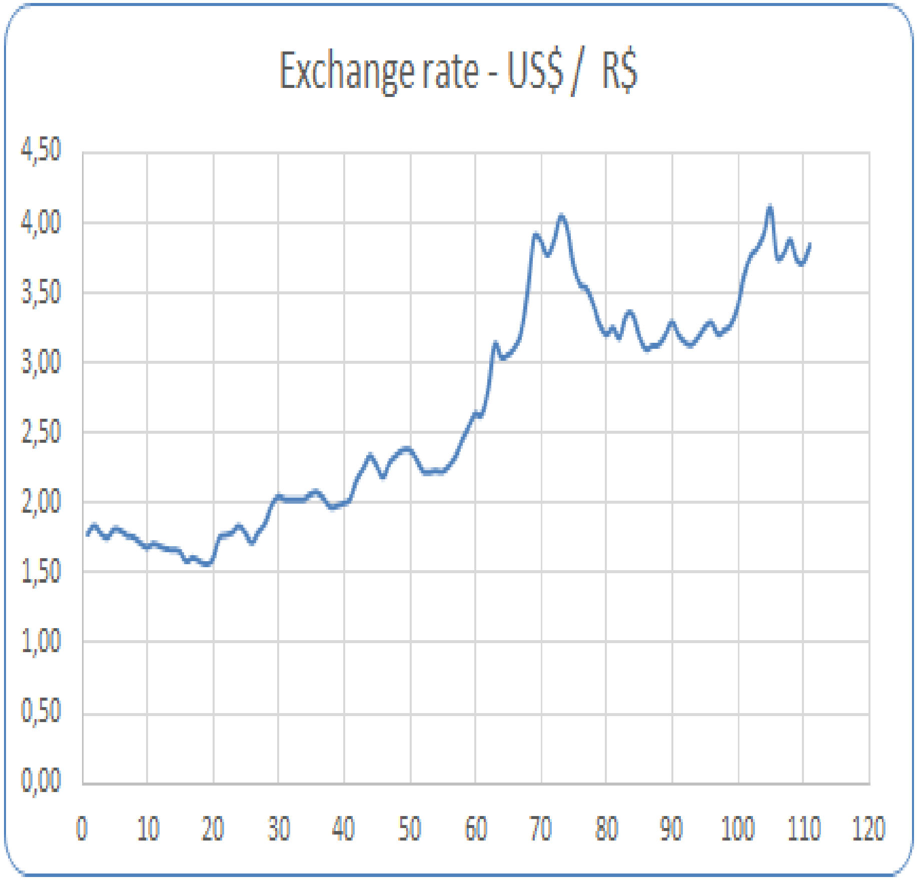
Calculation Premises

2 – In order to correlate he sums in BRZ into USD, the currency upon which some 20% of the cost of decommissioning is calculated, we used the rates published from Jan 2010 to Apr 2019, collapsed per month, using IPEA data as the source (IPEA, 2019).



In this work a constant value of R$ 3.39 will be used, although it is known that the present balance is calculated based on the last rate (R$ 3.85). This amount was chosen due to its being equally distant from the average (R$ 2.65) and the maximum (R$ 4.12) rates.

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Calculation Premises

3 – The cost of decommissioning considered in this work is estimated at USD 600.000.000,00 →, a sum compatible with that of other similar plants, and complies with the calculation methodology of the International Structure for Decommissioning Costing (ISDC)" as published by the OECD/NEA. This mount will be considered in USD both for the decommissioning with no extension of the working life as for that with its extension. In both cases and for the sake of simplicity, we use the same rate of exchange. We also take into account the fact that there already exists a fund of R$ 900.000.000,00 and that the deposits will be made on a monthly basis

4 - As regards the problem of non-uniform series in which there is a gradient that arithmetically increases the volume of monthly deposits, we will consider that there already exists a R$ 900.000.000,00 fund that should reach the required USD amount until 2025, when the license to operate of the plant will no longer be in force. In this case, the remaining life of the facility will be of 6 years and the progression as well as the G gradient, along with the interest rate will be capitalised on an annual basis at a rate of i=0.574% a.m=[(1+0,574/100)^12-1]×100≅7,1% a.a.. We will also consider an annual payment of USD 41.000.000,00 made last year and the point is to find what the G gradient would be in order to reach the sum needed to bear the costs of decommissioning.

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Results

Problem 1: Knowing that in X years an amount equivalent to Y US dollars will be needed to face the costs of decommissioning a nuclear installation, what would the monthly amount set aside be as deposited by the operator, in the knowledge that the earnings of such a fund are constant and equal to I%/mo?

For the case with no extension of the working life, n=6x12=72, i=0,574% a.m. and M=U$600.000.000,00-R$900.000.000,00=U$334.513.274,34 one obtains the following value for the monthly USD transfers:

$$P = \frac{i}{(1+i)[(1+i)^n - 1]} \times M$$

An annual deposit of USD 40.494.617,64

$$P = \frac{0.574 \times 10^{-2}}{(1+0.574 \times 10^{-2})[(1+0.574 \times 10^{-2})^{72} - 1]} \times 3.3 \times 10^8 = US\$\ 3.374.551{,}47/month$$

For the case of extending the working life, n=6x12 + 20x12 = 312, with all the other variables remaining unchanged:

$$P = \frac{0.574 \times 10^{-2}}{(1+0.574 \times 10^{-2})[(1+0.574 \times 10^{-2})^{312} - 1]} \times 3.3 \times 10^8 = US\$\ 384.590{,}16/month$$

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Results

Problem 2: In the case where X US dollars are needed to face the costs of decommissioning a nuclear installation, what would the increasing monthly amount set aside as in a finite arithmetic progression at the rate of G be as deposited by the operator, in the knowledge that the earnings of such a fund are constant and equal to I%/mo?

In this case, and according to the premises described in the previous section one has that in n=6 years and where the operator should produce a sum of U$ 334.513.274,34:

$$G = \frac{i}{(1+i)^n - (1+ni)} \times \left\{ \frac{Mi}{1+i} - P[(1+i)^n - 1] \right\}$$

$$G = \frac{0.071}{(1+0.071)^6 - (1+6\times 0.071)} \times \left\{ \frac{3.34\times 10^8 \times 0.071}{1+0.071} - 4.1 \times 10^7 [(1+0.071)^6 - 1] \right\} = U\$1.109.982,98$$

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Conclusion and remarks

- The CNAAA is a multiple plant site with dates of operation start very different.
- The strategy selected for the NPPs is of deferred dismantling for Angra 1 and 2, and Immediate Dismantling for Angra 3, with unrestricted use.
- The LTO could be a reality, what would push the decommissioning 20 years in the future.
- Two different scenarios were considered, and for both of them, disregarding an LTO something around the annual USD 40.000.000,00 would be suffice.
- This paper does not consider the formation of decommissioning funds for both Angra I and II plants and the site as a whole, that is, it focuses only on one installation.

Thank your for your attention

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