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COST ESTIMATE AND ECONOMIC JUSTIFICATION FOR NUCLEAR REACTORS

- *IN PARTICULAR THE TRISO PEBBLEBED-REACTOR*

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Abstract

Aim and purpose: Before deciding to construct a nuclear power plant, the total costs and possible risks must be reliably calculated in order to secure financing and rule out risks.
Principles: The main principles are that no nicely colored assumptions or pessimistic input data are used. Only in this way can investors and other stakeholders be certain that their expectations will be met. Ranges from max to mid to min can easily be shown.
This requires:
- clear mathematical correlations must be firmly anchored in the model
- laws of nature and physics, as well as commercial relations are built in.
- only realistic assumptions are permitted
- and more

This will grant the ability to immediately recognize any changes of input and the effect on result
This is also called "what iffing"
As tool only a spreadsheet (e.g. Excel) is required. Sufficiently large monitors on powerful workstations are essential. It should be possible to process a table with up to 20 columns and 400 rows. Various data is required for input, such as
- target output in MW
- Market price for fuel
- Burn-up
– Efficiency

and more
As a result, numbers are returned for
- capital costs
- operating costs
- personnel costs
- Material costs
- Price of the MWh

and more.
What iffing is used to define the limits of the investment project. Benefits are financial feasibility for stakeholders, governments and investors, comparison with other reactors, alternative offers from suppliers
Significant changes during the planning and construction phase are immediately visible in their effect on costs and prices.

I. INTRODUCTION

Model

Aim and purpose

Before deciding to construct a nuclear power plant, the total costs and possible risks must be reliably calculated in order to secure financing and rule out risks. Teams of technical and scientific specialists oft calculate with so called “overnight” cost.
This is not sufficient to convince capitalists and governments to fund a project of such size and importance. Therefore, this model was developed and submitted to various experts of NPP. Their comments were welcomed and improved the model.

Principles

One principle is to gain a reliable picture of the obligations and possibilities well ahead of the first concrete pouring. It should be used also for easy modifying during the course of planning, construction etc. until the commercial operation starts. And even then it helps to map realities against expectations.
Optimistic assumptions and pessimistic input are not allowed. This resüonsibility must be borne by the project manager. His responsibility is to verify each and every input (e.g. price of heavy metals, personnel cost, rate of interest etc). He need not worry about the interrelations and influence of these data into the calculation process. E.g. the content of energy in thorium is not his decision but a natural constant.
Important is the fact, that results can read in seconds for any change to the data. Ranges from max to mid to min are shown.
By this way investors and other stakeholders will be certain that their expectations will be met.
This requires

- clear mathematical correlations must be firmly anchored in the model
- laws of nature and physics, as well as commercial relations are built in.
- they are not subject ot dicussions
- only realistic assumptions are permitted
- responsible educated guesses are obtained from experts
- transparent and simple mathematics are used
- complicated formulas are not allowed

Herewith the ability to immediately learn any changes of input in their effect to the final result (what iffing)

Tool

Only a spreadsheet (e.g. Excel) is required.
Sufficiently large monitors on powerful workstations are essential.
It should be possible to process a spreadsheet with about 20 columns and up to 400 rows

Practice

Data is required for input, such as the following (a selection of many more)

- Power of the projected plant in MW
- Market price for fuel heavy metals
- Burn-up percentage of the fuel elements
- Efficiency for parts and total
- Production costs of the fuel elements
- Material costs for fuel elements
- Planning costs and duration
- Construction costs and duration
- Interest rate and amortization period
- Approval costs
- Test costs
- Personnel costs
- Legal costs
- Maintenance rate

Some of these are there from the beginning, others may be recognized during the work.

Result

As a result, numbers are shown for

- capital costs
- operating costs
- personnel costs
- Material costs
- Price of the MWh, kWh for electricity and heat
- Quantity of MWh per year
- Return on investment
- partial and overall efficiency

and more

What iffing is used to define the limits of the investment project.

Benefits

Financial feasibility

Stakeholders are given certainty without delay about the risks and opportunities. By the model their questions can be answered almost in real time. So they can make and alter their decision based on facts rather than assumptions.

Comparison with other reactors

Alternative offers from suppliers are checked in minutes or hours and the better ones are selected. This applies to both:

- Selecting the best construction partner by pinpointing “omitted” positions in their tender. Also it is helpful when selecting new features and improved offerings.
- Choice between various types of reactors. In this case some modifications of the model may be needed.

Monitoring during the process

Significant changes during the planning and construction phase are immediately visible with their effect on costs and prices. This has to be a must in reasonable intervals to the investors, administration and government.

Some Screenshots to examplify

Calculation of nuclears Reactor	Type	TRISO Pebble bed, modular		
			green: variable input	
	reference	Unit		
capacity	ongoing	MW el	100	
Hours per year	ongoing	h/a	8.760	
operating hours	ongoing	h/a	8.000	
production target	per year	MWh el / a	800.000	
Energy content in one ton of raw heavy metal (HM)	natural	MWh th/to	28.600.000	
experienced harvest in the THTR 300 Hamm in MW-days	HTR burnup	MWd th/to SM	110.000	
hours per day		h/d	24	
experienced harvest in the THTR 300 Hamm in MW-hours	year	MWh th/to SM	2.640.000	
efficiency of the plant	year	Prozent	43,00%	
possible elect. Energy from theis quantity of HM	year	MWh el /to	1.135.200	
for the expected Quantity of kW hours	year	MWh el	800.000	
resulting needed quantity of heavy metal (Th and U)	year	to SM	0,7047	
energy contained in the needed quantity	year	MWh th	20.155.039	
Price of Yellow cake Uran (or Thorium)	market	€/to	250.000	
cost of the needed quantity	year	€/Jahr	176.180	
				Mio.

Capital, Investment, Operation	Reference	Unit		Mio. USD
Turbine-performance	ongoing	MW	100	
Planning phase	years	2		24
cost of the planning phase		Mio.USD	10	
cost of licensing		Mio.USD	7	
tests, proofing etc.		Mio.USD	7	
Construction	years	3		
reactor pressure vessel				90
Core (RPV) in steel	Invest	Mio.USD	0	
or in prestressed concrete	Invest	Mio.USD	50	
Containment in prestressed concrete	Invest	Mio.USD	0	
pebble feeding cycle apparatus	Invest	Mio.USD	40	
Steam generation				50
stment of existing steam generator (if available in an existing plant)	Invest	Mio.USD		
or installation of a new steam generator	Invest	Mio.USD	50	
Electricity (power) generation				20
refurbish of turbine set	Invest	Mio.USD	0	

sum of (re-) construction				
preparation für (re-) construction	Invest	Mio.USD		**248**
cost of financing, funding				
interest from preparation until commissioning	7,50%	Mio.USD	46,50	**47**
sum of construction, preparation, construction a	Invest	Mio.USD		**295**
NOAK Faktor (Economy of scale)				**1,00**
invest per MW capacity		Mio.USD		***2,945***
target below		Mio.USD		***3,000***
ongoing operation				
Operating life		years	40	
Depreciation period		years	30	
Depreciation amount per year		Mio.USD	9,82	
Interest, from commissioning, on half of construction costs		7,50%	11,04	
Summe Kapitalkosten pro Jahr	year	Mio.USD	21	**21**

	Sum of operating cost	year	Mio.USD		**30**
	Capex plus Opex in Mio. Euro	year	Mio.USD	**51**	**51**
	same in Euro	year	USD	**50.655.082**	
	MWh el generated per year	year	MWh el	800.000	
	kWh el generated per year = work = producti	year	kWh el	800.000.000	
	Total costs per MWh		USD/MWh	**63,32**	
	same per kWh		USD/MWh	**0,0633**	
	Cents per kWh		**Cent/kWh**	**6,33**	
Gesamt-Wi.-grad	Energy content in the input quantity of raw material		(MWh power /MWh	**3,969%**	

Personal profile

7. from 2010 the only one in Germany, saving the ingenious TRISO-HTR technology from oblivion.
6. 1981 to 1984 CEO of a medium sized data center in the pharma industry
5. 1973 to 2010 self-employed management consultant– some 200 publications in IT-Financial Mgt.
4. 1970 to 1973 management consultant with Booz Allen Hamilton / PWC Strategy&
3. 1960 to 1970 Robert BOSCH / IBM Germany, France, US
2. to 1960 University Berlin and Cologne, industrial engineer, after being certified locksmith craftsman at DEUTZ, Cologne
1. 1933 born in Cologne Germany

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REFERENCES

[1] General knowledge of spreadsheet calculatiosn