

Restarting the construction of a nuclear reactor: the Cernavoda 5 case study

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This case study is for didactic purpose only.

Even if the reactor 5 in Cernavoda exists and the information about the Rumania are true the project and the people involved are not real.

Nuclear Power in Romania

- Romania has two nuclear reactors generating almost 20 percent of its electricity.
- Its first commercial nuclear power reactor began operating in 1996. Its second started up in May 2007.
- Plans are well advanced for completing two more units.
- Government support for nuclear energy is strong.

Electricity consumption in Romania has been growing since 1999, and further growth at about 4% pa is envisaged. In 2006, 62.7 billion kWh gross was produced, with net exports of 4.3 TWh. Nuclear energy now provides 10% of the electricity at very low cost, only hydro (29% of supply) is cheaper. In 2006, 40% of electricity came from coal, 19% from gas, 29% from hydro and 9% from nuclear. In 2007 13% was from nuclear, with unit 2 of Cernavoda coming on line.

In 2006, 5.6 TWh was supplied to the grid from Cernavoda-1, which reached a capacity factor of 90.1%. It also supplied 176 GJ of district heating.

Nuclear industry development

In the late 1970s a five-unit nuclear power plant was planned at Cernavoda, on the Danube River. After considering carefully both Russian VVER-440 and Canadian CANDU technology it was decided to adopt the latter. Cernavoda was based on technology transfer from Canada (AECL), Italy and the USA, with Candu-6 heavy-water reactors.

Construction of the first unit started in 1982, and of units 2-5 in 1983-86. In 1991 work on the latter four was suspended in order to focus on unit 1, responsibility for which was handed to an AECL-Ansaldo (Canadian-Italian) consortium. Unit 1 was connected to the grid in mid 1996 and entered commercial operation in December 1996.

Reactor	Type	Net Power	Gross Power	Construction start	Construction finish	Commercial operation
Cernavodă-1	CANDU	651 MW	706 MW	01.07.1982	11.07.1996	02.12.1996
Cernavodă-2	CANDU	655 MW	706 MW	01.07.1983	07.08.2007	28.09.2007
Cernavodă-3	CANDU	- MW	706 MW	01.01.1984	2014 (planned)	
Cernavodă-4	CANDU	- MW	706 MW	01.01.1985	2015 (planned)	
Cernavodă-5	CANDU	- MW	706 MW	01.01.1986	unknown	

Table 1 Characteristics of Rumanian Reactors

The state nuclear power corporation Societatea Nationala Nuclearelectrica (SNN), established in 1998, operates Cernavoda. Its capacity factor has averaged over 86% so far and operating and maintenance costs are USD 1.25 cents/kWh. The unit also provides district heating to Cernavoda township, and 148 TJ was supplied in 2003.

In 2000 the government decided that completion of Cernavoda-2 was a high priority and supplied some EUR 60 million towards it. It was seen as the least-cost means of providing extra generating capacity for the country. Further finance was raised in 2002-03, with a EUR 382.5 million package announced by the government, including EUR 218 million from Canada. In 2004 an EUR 223.5 million Euratom loan was approved by the European Commission for completion of unit 2, including upgrades.

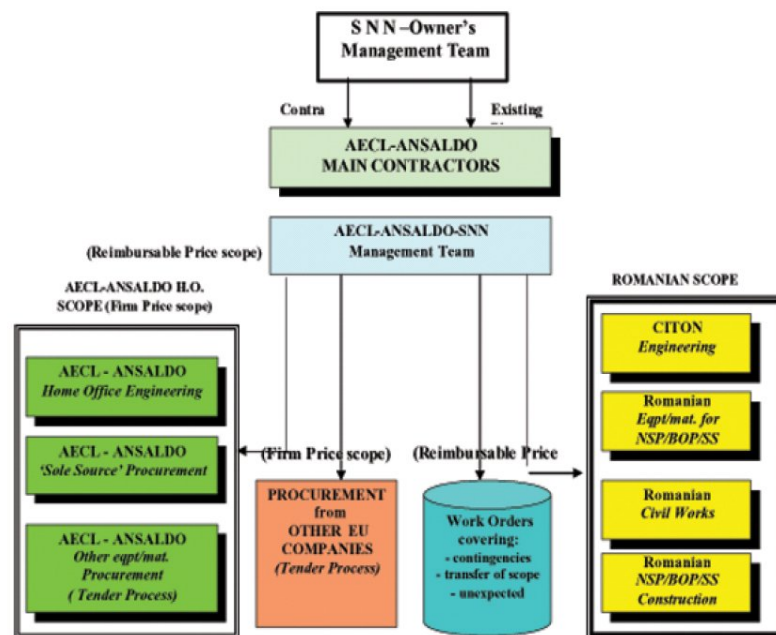


Figure 1 Cernavoda Unit 2 contract

The 700 MWe (gross) unit has been built by an AECL-Ansaldo-SNN management team, and entered commercial operation in October 2007. Total cost of the project was EUR 777 million. It started up in May 2007 and was grid connected early in August.

Further nuclear power capacity

In 2002 efforts got under way to resume work on Cernavoda unit 3, and SNN commissioned a feasibility study from Ansaldo, AECL and KHNP (S.Korea) in 2003. In August 2004 the government advertised for companies interested in completing Cernavoda unit 3 - a 700 MWe Candu 6 unit - through a public-private partnership arrangement. This proved impractical, and a feasibility study in March 2006 analysed further options for both units 3 & 4, including that of SNN completing unit 3 itself.

However, it was decided to proceed with creating a project joint venture with SNN to complete both 720 MWe units in a EUR 2.5 billion project and then operate them. This would be an independent power producer, with SNN providing operation and maintenance. Twelve potential investors were selected from 15 initial bidders, and in November 2007 binding offers from six companies were accepted: ArcelorMittal (steel maker) of Romania, CEZ of the Czech Republic,

Electrabel of Belgium, Enel of Italy, Iberdrola of Spain and RWE Power of Germany. The seven parties including SNN will spread the risk and ease the challenge of project financing.

After complex discussions, in March 2008 a draft investment agreement, including the charter of the new project company EnergoNuclear SA, proposed shares of: SNN 20%, Enel 15%, Suez/Electrabel 15%, RWE Power 15%, CEZ 15%, Iberdrola 10% and steelmaker Arcelor-Mittal 10%. Each would provide that proportion of the financing and take the same share of the power generated. However, the government then decided that SNN would take 51% equity and provide funding of EUR 1.02 billion in loans and loan guarantees. Other funds would be internal and from partial privatising of SNN in 2011. In November 2008 an investment agreement was signed between SNN, with 51% of the project, and Enel, CEZ, GDF Suez, RWE Power (each 9.15%), Iberdrola (6.2%) and ArcelorMittal Galati (6.2%).

EnergoNuclear was formally established in April 2009, and embarked upon an 18 month pre-project phase. Construction cost is expected to be about EUR 4 billion. Overall debt/equity ratio was earlier proposed to be 70/30. The first unit is now expected on line in 2016.



Figure 2 Location of Cernavoda site

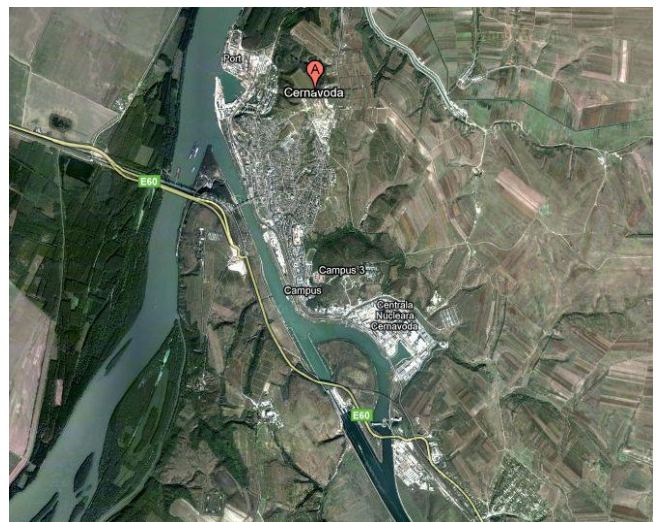


Figure 3 Cernavoda site



Figure 4 Cernavoda site: it is possible to recognise the 5 reactors

The Project

Due to the global warning concern the European Commission (EC) founds projects related to the reduction of green-house gas in emerging countries. To obtain this found is necessary to present a pre-feasibility study by 1 December 2010.

The EC provide specific guidelines for the pre-feasibility studies according to each type of intervention. In case of restarting a Delayed Nuclear Power Plant (DNPP) project the EC requires a feasibility studies that must cover the following 7 areas.

- Technical verification of the existing assets, equipment, material, work already performed, history files, documentation, suspended contracts and approvals, permits and licenses.
- Economic and financial evaluation of the existing assets and assessment for the future activities.
- Evaluation of the remaining work for DNPP finalization, acquisition of materials and assessment of documentation to be issued and evaluation of potential suppliers.
- Evaluation of the existing and available human resources for the project implementation.
- Establishment of the nuclear safety licensing bases and project licensing schedule as approved by the national nuclear safety regulatory body.
- Assessment of the local and international market for the identification of the potential suppliers for goods and services and verification of their qualification and capabilities.
- Performance of the detailed and logical schedule for DNPP completion.

The President of Romania (Traian Băsescu) and the Prime minister (Emil Boc) strongly promote the role of nuclear energy as source of affordable and green energy source. A group of experts suggested that the cheapest and faster way to increase the percentage of Electrical Energy nuclear generated is to restart the construction of the reactor Cernavoda 5. They also recognised as the founds provided by the EC could cover most of the engineering costs, therefore suggested the promotion of this project.

Cernavoda-5	
Country	Romania
Region	Europe and Central Asia
Type	Commercial Reactor
Capacity	630 MWe_Net
Owner	RENEL
Capacity Thermal	2180 MWt
Status	Construction suspended
Operation Status	Suspended indefinitely/Cancelled
Area	Cernavoda
Process	PHWR
Operator	n/a
Capacity Gross	706 MWe
Vendor	Atomic Energy of Canada Ltd (AECL)

Table 2 Main facts about Cernavoda 5



Figure 5 Reactors 5 - 4 and 3 at Cernavoda



Figure 6 Actual status of the reactor 5

The Cabined of Rumania's government approving the suggestions of the experts decided to nominate "Mihai Eminescu" as Project Manger of a team in charge to produce the feasibility study for restarting Cernavoda 5 as required by the EC.

Mihai Eminescu is a high skilled senior manager and was in charge of feasibility study of restarting the construction of Cernavoda 2. He decided to prepare the WBS of this new project according to the seven areas of investigation required by the EC., plus project management and final document preparation.

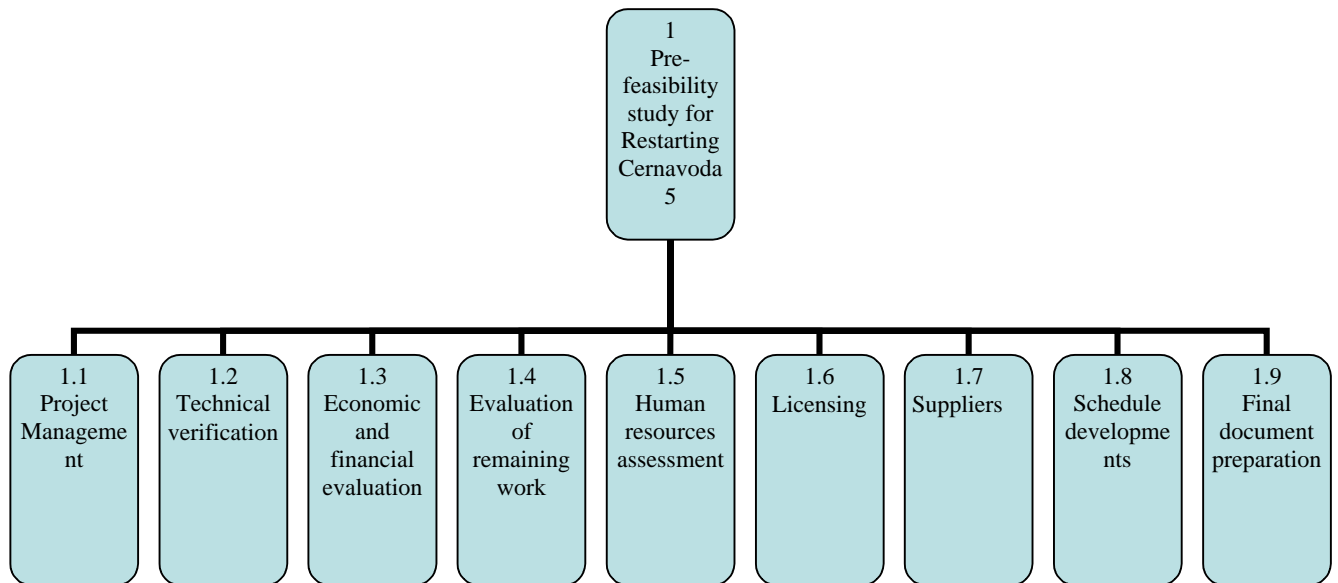


Figure 7 First level of the WBS for the preparation of the pre-feasibility study

Cost and resources

All the resources for the project had been identified except for the external experts.

For the Rumanian expert a flat rate of \$75/hour was traditionally used for estimating purposes. For some specific WP is necessary to hire some external experts. The costs of all the resources are in Table xxx

Mihai Eminescu estimated that 12 PC workstations (at € 3,000 each) and 5 specific international databases (at \$12,500 each) are necessary to perform the project. Beside the labour cost these are the only cost items of this project.

Name	Standard Rate	Overtime Rate
Mihai Eminescu (Project Manager)	\$ 75.00/hr	\$ 75.00/hr
Dora d'Istria	\$ 75.00/hr	\$ 75.00/hr
Emil Cioran	\$ 75.00/hr	\$ 75.00/hr
Ana Blandiana	\$ 75.00/hr	\$ 75.00/hr
Grigore Vieru	\$ 75.00/hr	\$ 75.00/hr
External Expert 1	\$ 165.00/hr	\$ 230.00/hr
Dan Lungu	\$ 75.00/hr	\$ 75.00/hr
Emil Botta	\$ 75.00/hr	\$ 75.00/hr
Dan Lungu	\$ 75.00/hr	\$ 75.00/hr
External Expert 2	\$ 165.00/hr	\$ 250.00/hr
External Expert 3	\$ 165.00/hr	\$ 250.00/hr

Table 3 Human resources involved in the project

Mihai's team created a complete WBS that detailed all the tasks, that needed to be performed for the project as of May 26, 2010 (the TIME NOW). They also estimated the working days, the Levelling days, predecessors and Resources required. All these information are in the Appendix A

YOUR WORK!

Now Mihai Eminescu needs to determine whether the proposed project can be completed in time for the EC deadline. He decided to involve you in the analysis and he assigned you this the following question:

1. What is the projected completion date? (Assume there are no holidays and)
2. What is the total cost? How much of the total costs are labour costs? Capital costs?
3. What is the critical path(s) in the project? How would you assess the level of risk in the project?
4. What is your opinion on the potential for the project to be completed on time? (Provide a best, expected and worst case)

APPENDIX A – TASK INFORMATION

Task ID	WBS ID	Task Name	Work Estimate (days)	Predecessors	Resource Name
1	1	Pre-feasibility study for Restarting Cernavoda 5			
2	1.1	<i>Project management</i>			
3	1.1.1	Manage project	127	59FF	Mihai Eminescu (Project Manager)
4	1.2	Technical verification			
5	1.2.1	General Assessment of nuclear island (NI)	8		Dora d'Istria, Emil Cioran
6	1.2.2	Reactor building	4	5	Dora d'Istria, Emil Cioran
7	1.2.3	Balance of Plant (BOP)	6		Ana Blandiana
8	1.2.4	Concrete structure	15	5, 6	Dora d'Istria, Emil Cioran, Ana Blandiana
9	1.2.5	General overview	2	7, 8	Ana Blandiana
10	1.3	Economic and financial evaluation			
11	1.3.1	Economic assessment of existing infrastructure		5, 6, 8	
12	1.3.1.1	Definition of guidelines for the economic assessment	4		Dora d'Istria
13	1.3.1.2	Value of civil work in the Nuclear Island	6		Dora d'Istria
14	1.3.1.3	Value of civil work in the BOP	3	13	Dora d'Istria
15	1.3.1.4	Value of mechanical structures	6		Emil Cioran
16	1.3.1.5	Total value of existing facilities	4	12, 13, 14, 15	Dora d'Istria
17	1.3.1.6	Updating at 2010 values	3	16	Dora d'Istria
18	1.3.2	Meeting with ACL engineers	3	12, 13	Emil Cioran
19	1.3.3	Definition of financial plan	7	16SS	Emil Cioran
20	1.3.4	List of possible project sponsors	4	11SS	Emil Cioran
21	1.4	Evaluation of remaining work		10	
22	1.4.1	Mechanical systems	13.5		Grigore Vieru, Dora d'Istria [50%]
23	1.4.2	Electrical system	13.5		External Expert 1, Dora d'Istria [50%]
24	1.4.3	Piping	6	23	External Expert 1, Dora d'Istria
25	1.4.4	Steam system	6		Grigore Vieru, Emil Cioran
26	1.4.5	Balance of Plant	16	22, 23, 24, 25	Grigore Vieru, Dora d'Istria
27	1.4.6	Connections among NI and BOP	4	26	Grigore Vieru, Dora d'Istria
28	1.4.7	Assessment of documentation	18		Dan Lungu, Emil Cioran
29	1.4.8	Evaluation of potential suppliers	20	22, 23, 24, 25	External Expert 1, Emil Cioran
30	1.5	Human resources assessment			
31	1.5.1	Qualified workers	14	11	Emil Botta, Lucian Blaga
32	1.5.2	Architectural engineer	20	31, 21	Emil Botta, Lucian Blaga
33	1.5.3	Nuclear engineer	22	32	Emil Botta, Lucian Blaga
34	1.6	Licensing			
35	1.6.1	Acquisition of IAEA guidelines for restarting NPP	20	9	Ana Blandiana

36	1.6.2	Gathering and summarising information from Cernavoda 2	34.2	35	Ana Blandiana [90%]
37	1.6.3	Gathering and summarising information from Cernavoda 3-4	3.8	35	Ana Blandiana [10%]
38	1.6.4	Gathering and summarising information from other DNPP	46	36	Ana Blandiana
39	1.6.5	Development of guidelines for Cernavoda 5	4.6	47	Dan Lungu [10%]
40	1.7	Supplier		35	
41	1.7.1	Mechanical systems supplier	13	22	External Expert 2
42	1.7.2	Electrical system supplier	12	23	External Expert 3
43	1.7.3	Piping supplier	7	24, 42	External Expert 3
44	1.7.4	Steam system supplier	6	25	External Expert 2
45	1.7.5	System integration supplier	24	26, 41, 42, 43, 44	External Expert 2, External Expert 3
46	1.7.6	IT suppliers	6	27	Grigore Vieru
47	1.7.7	Lawyer and consultants	15.5	28	Dan Lungu [50%]
48	1.7.8	Establish contacts with potential new suppliers	18	29	External Expert 1
49	1.7.9	Development of guidelines for the bidding phase	46	21	Dora d'Istria, Emil Cioran
50	1.8	Schedule developments			
51	1.8.1	Human activities		31	
52	1.8.1.1	Licensing	12	41, 42, 43	Grigore Vieru
53	1.8.1.2	Workers mobilization	20	44, 45, 46, 52, 47, 48	Grigore Vieru, External Expert 1, External Expert 2, External Expert 3
54	1.8.2	Construction of modules by the suppliers	160	51, 32, 33	Emil Botta, Lucian Blaga, Grigore Vieru, External Expert 1, External Expert 2, External Expert 3, Dora d'Istria, Emil Cioran
55	1.8.3	Installation in the site	80	54	Emil Botta, Lucian Blaga, Grigore Vieru, External Expert 1, External Expert 2, External Expert 3, Dora d'Istria, Emil Cioran
56	1.9	Final document preparation		50	
57	1.9.1	First draft	80		Emil Botta, Lucian Blaga, Grigore Vieru, External Expert 1, External Expert 2, External Expert 3, Ryan Neff (Functional Lead), Emil Cioran
58	1.9.2	Second draft	8	57	Emil Botta, Lucian Blaga, Grigore Vieru, External Expert 1, External Expert 2, External Expert 3, Ryan Neff, (Functional Lead), Emil Cioran
59	1.9.3	Final detailed document	90	58	Emil Botta, Lucian Blaga, Grigore Vieru, External Expert 1, External Expert 2, External Expert 3, Ryan Neff (Functional Lead), Emil Cioran, Ana Blandiana