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SOUNDNESS OF KRŠKO NUCLEAR POWER PLANT PERFORMANCE IN TERMS OF ENERGY AND FINANCE

Abstract

Compared to existing conventional thermal power plants in the Croatian electrical power system, as well as to alternative (potential) imported coal and gas fired thermal power plants, Krško NPP (nuclear power plant) generates electricity with lower production costs. This cost margin in favour of the Krško NPP represents the soundness of this nuclear power plant in terms of energy and finance.

Introduction

Krško NPP is a power generating facility jointly owned by power utilities of Croatia and Slovenia. Having gross electrical output of 664 MW and net output of 632 MW, it has been generating power since 1982. Power and energy generated in Krško NPP are equally shared (50:50) by Croatian and Slovenian Power utilities in line with jointly invested construction of the plant.

Since Krško NPP (i.e., its Croatian half) contributes to the Croatian electrical power system (EPS) by some 10% in power and about 20% in energy supplied, the contribution/soundness of Krško NPP in terms of energy and finance deserves to be thoroughly analysed.

In terms of energy, the contribution is measured by the share of power and energy generated in Krško NPP in the Croatian EPS. In terms of finance, the contribution of Krško NPP is measured by a margin in production costs and price of electricity which is in favour of the NPP when compared to existing conventional thermal power plants in the Croatian EPS, as well as to potential new TPPs firing imported coal and gas.

1. Krško NPP contribution in terms of energy and finance compared to existing TPPs

Total electricity demand in the Republic of Croatia in the 1990-1996 period that was supplied from domestic sources (Krško NPP included) is given below (Table 1.1, Figure 1). In the given period, 93% of total demand was supplied by domestic generating facilities, while 7% was imported.

Table 1.1: Electricity generation in domestic sources

Year	GWh				Share %		
	HES	TPP	NPP	Total	HES	TPP	NPP
1990	3650	4030	2190	9870	37,0	40,8	22,2
1991	5305	2330	2360	9995	53,1	23,3	23,6
1992	4293	3772	1876	9941	43,2	37,9	18,9
1993	4287	4231	1875	10393	41,2	40,7	18,0
1994	4889	2568	2196	9653	50,6	26,6	22,7
1995	5164	2740	2279	10183	50,7	26,9	22,4
1996	7190	2523	2180	11892	60,5	21,2	18,3

Figure 1: Structure of electricity generation in domestic sources

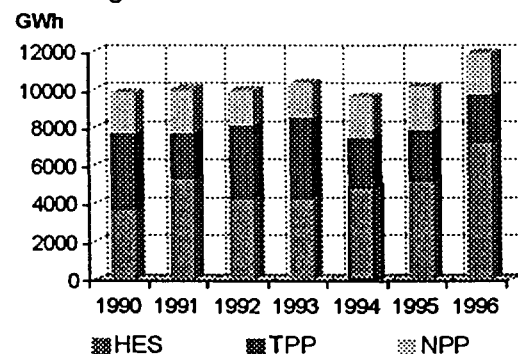
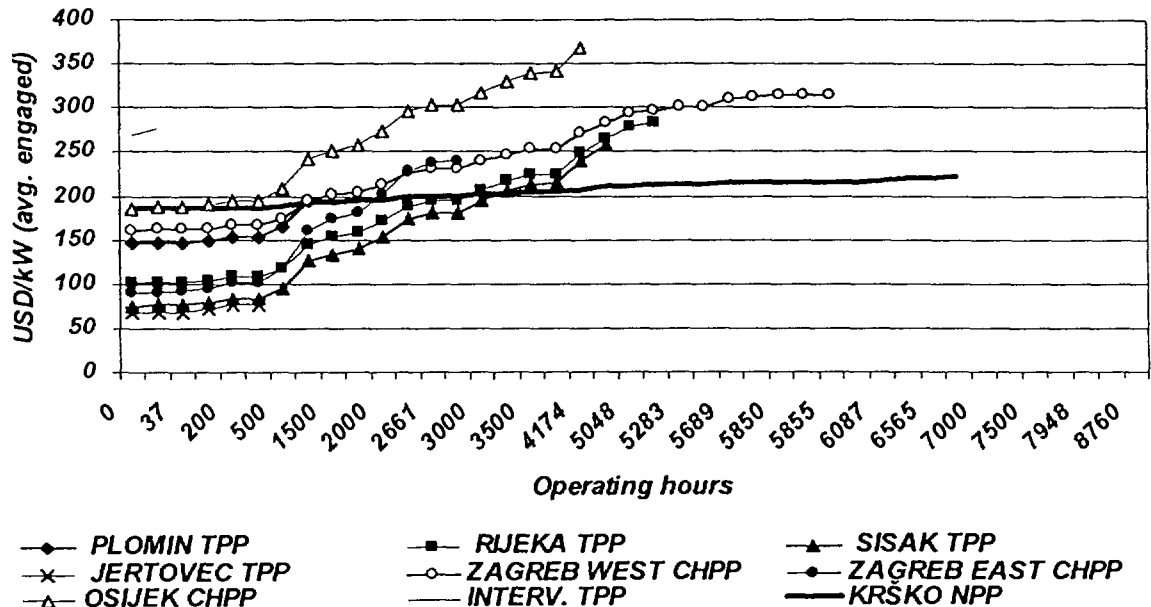


Figure 2: Comparison of costs



Generation costs of electricity in TPPs of Croatian EPS, as realized in 1996, are compared in Fig.2. The curves pertinent to individual TPPs show their distinctive features in terms of energy and finance. Fixed costs normalized over average engaged plant output are attached to y-axis, while operating hours of individual TPPs are given on x-axis. Data show that the highest fixed costs per unit of engaged plant output are incurred in Krško NPP, and the lowest in Jertovec TPP. Taking into account fixed costs per unit of engaged plant output and hours of operation in the year (variable costs) leads to total costs, which are the lowest for Krško NPP. (The costs of Jertovec TPP are thereby neglected because of relatively low electricity generation in only 206 operating hours.)

Curves given in Fig.2 show some characteristic key points on the time axis - the points defining some characteristic total costs. For example, for 3200 and more operating hours per year Krško NPP has the lowest total costs. For less than 3200 operating hours per year other TPPs have total cost lower than Krško NPP. TPPs characterized by curves of higher inclination have also higher variable unit costs (fuel).

2. Power Generation Costs of Krško NPP

Power generation costs and price of electricity generated in Krško NPP (Croatian half) in 1996, are given in Table 2.1.

Table 2.1. Power generation costs and price of electricity (Krško NPP - Profit and loss account for 1996)

Item	Costs		Price of electr. (USc/kWh)
	Amount (000 USD)	Structure (%)	
I Gross output 332 MW			
II Net generation of el. 2179,7 GWh			
III Costs	89.216	100,00	4,09
1. Variable costs	17.616	19,74	0,81
- fuel	9.217	10,33	0,42
- decommissioning*	8.193	9,18	0,38
- water use tax	206	0,23	0,01

Table 2.1: contd.

	Costs		Price of electr. USc/kWh
	Amount (000 USD)	Structure (%)	
2.Fixed costs	71.600	80,25	3,28
- depreciation	20.374	22,84	0,93
- operation and maintenance	40.872	45,81	1,88
- interest on construction credits**	7.398	8,29	0,34
- interest on working capital cred..	1.827	2,04	0,08
- other financial expenditures	1.129	1,27	0,05

* NPP decommissioning costs as defined by Slovenian law (0,61 SIT/kWh)

** interest on construction credits, accounted in HEP (Croatian utility)

3. Activities planned for Krško NPP till the end of its lifetime

3.1. Investments

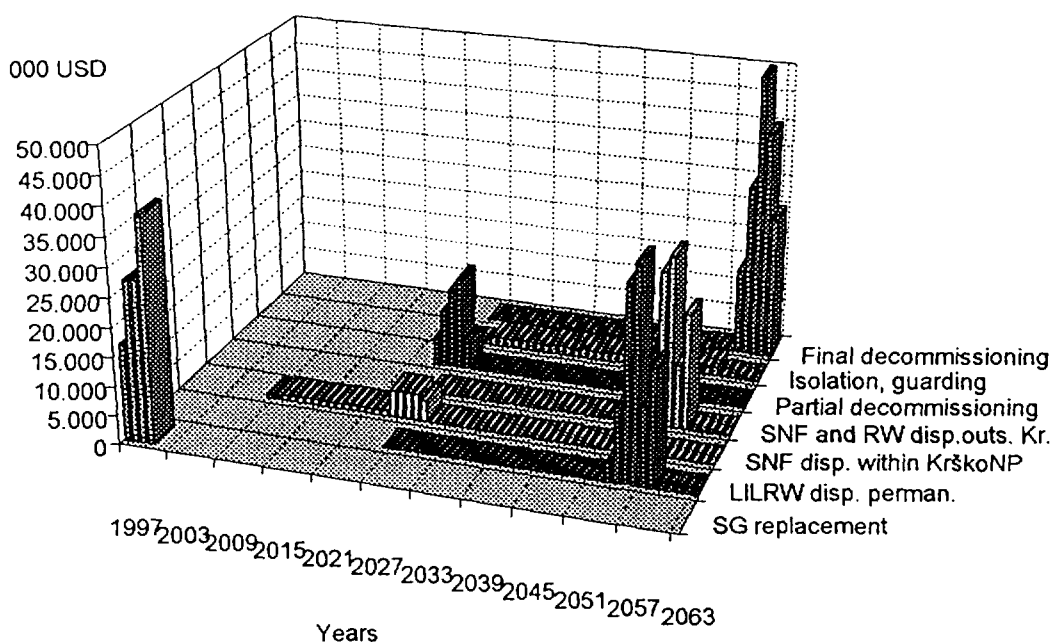
In the 1998 - 2063 period, the following activities are required to be performed in Krško NPP: steam generator replacement, construction of spent fuel and radioactive waste disposal within Krško NPP site boundaries, construction of spent fuel and radwaste disposal outside Krško NPP, partial decommissioning of the NPP, isolation and guarding, as well as final decommissioning of the NPP.

Table 3.1. Investments in Krško NPP, 1997-2063.

000 USD

Year	Steam generator replacement	Disposal and storage			Decommissioning		Final Decomm.
		Low and Intermed. Level Radwaste permanent	Spent fuel within Krško NPP	Spent fuel and Radwaste outside Krško NPP	Partial Decomm.	Isolation and Guarding of NPP	
1997.	16.597						
1998.	27.662						
1999.	27.662						
2000.	38.726						
2008-2009.			500				
2010-2022.			870				
2023.			870				
2024.			4.640		5.000		
2025.			4.640		10.000		
2026.			4.640		14.000		
2027.			4.640		16.000		
2028.			3.770		500		
2029-2052.						1.500	
2053.		3.380		2.704		1.500	
2054.		12.960		10.368		1.500	
2055.		33.300		26.648		1.500	
2056.		36.700		29.360		1.500	
2057.		13.660		10.920		1.500	
2058.		20.000		20.000		1.500	
2059.							15.000
2060.							30.000
2061.							50.000
2062.							40.000
2063.							25.000
TOTAL	110.646	120.000	35.510	60.000	50.000	45.000	160.000

Figure 3: Krško NPP investments structure and schedule 1997-2063.



4. Power generation costs and price of electricity in alternative facilities.

Soundness of Krško NPP performance can be determined by comparing its characteristics in terms of energy and finance with those of alternative (new) generating facilities. For this purpose, power generation costs and price of electricity have been calculated for existing TPPs - Sisak TPP and CHPP Zagreb East (TE-TO), for potential new sources - imported coal-fired TPP and gas-fired TPP, as well as for the case of importing electricity at price of 8 USc/kWh.

Table 4.1. Characteristics of alternative power plants in terms of energy and finance

Item	TPP imported coal	TPP gas
Net output MW	357	357
Operating hours per year	6600	6600
Electr. generation GWh	2358	2358
Net efficiency - %	40	50
Specific heat rate kJ/kWh	9000	7660
Fuel price USD/GJ	2,08	4,00
Electricity price USc/kWh	1,87	2,80
Inv. capital costs 10 ³ USD	734.800	342.000
Credit terms for financ.inv.	8%, 12 years	8%; 12 years

Based on data given in Tab.4.1, power generation costs and price of electricity are calculated and given in Tab.4.2. In order to compare these costs/prices for Krško NPP and alternative sources in the period 1998 - 2023, it is assumed that electricity will be imported at price of 8 USc/kWh till the year 2003 (when commissioning of an imported coal-fired TPP and a gas-fired TPP is scheduled). Furthermore, assumed annual price increase was taken into account - for imported coal 0.7 percent, for natural gas 2.1 percent.

Table 4.2a. **Power generation costs**

000 USD

Year	KRSKO NPP		TPP import. coal		TPP gas		Import
	VC	FC*	VC	FC	VC	FC	VC
1998	9047	84689	221400	0	221400	0	177200
1999	9047	83564	221400	0	221400	0	177200
2000	9047	82652	221400	0	221400	0	177200
2001	9635	91584	235791	0	235791	0	188633
2002	9635	90047	235791	0	235791	0	188633
2003	9635	88388	46028	157514	76929	76105	188633
2004	9635	86663	46351	151740	78545	73410	188633
2005	9635	84869	46675	145982	80194	70730	188633
2006	9635	81708	47002	140223	81878	68050	188633
2007	9635	77025	47331	134465	83598	65369	188633
2008	9635	82924	47662	89426	85353	45043	188633
2009	9635	82984	47996	83667	87146	42362	188633
2010	9635	66824	48332	77909	88976	39682	188633
2011	9635	60982	48670	72150	90844	37002	188633
2012	9635	60982	49011	66392	92752	34322	188633
2013	9635	53005	49354	61509	94700	32052	188633
2014	9635	51541	49699	55751	96688	29372	188633
2015	9635	51541	50047	92503	98719	47062	188633
2016	9635	51541	50398	92503	100792	47063	188633
2017	9635	51541	50750	92503	102908	47063	188633
2018	9635	51541	51106	93469	105070	47516	188633
2019	9635	51541	51463	93470	107276	47517	188633
2020	9635	51541	51824	93469	109529	47516	188633
2021	9635	51541	52186	93470	111829	47517	188633
2022	9635	51541	52552	93469	114177	47517	188633
2023	9635	51541	52920	102364	116575	51776	188633

VC= variable costs

FC = fixed costs

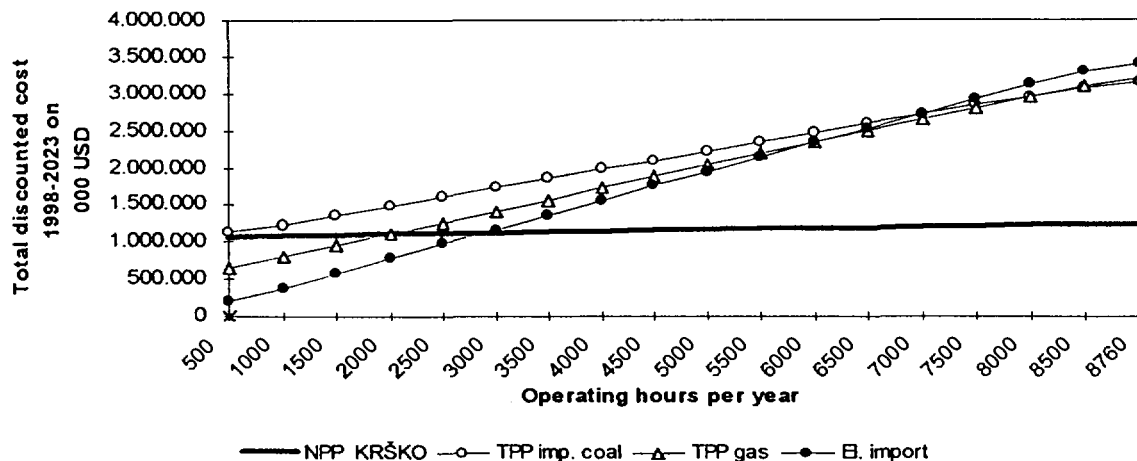
* Raising of funds for disposal and storage of RW and NF, as well as decommissioning of the NPP acc. to proposal of Croatian Utility (HEP)

Table 4.2.b **Costs and price of electricity (for the period 1998-2023)**

Item	Krško NPP	TPP import. coal	TPP gas	Import 8 US¢/kWh
Discounted costs 10 ³ USD	1.192.467	2.521.235	2.428.373	2.680.499
Discounted energy GWh	33.505	33.505	33.505	33.505
Discounted el. price US¢/kWh	3,56	7,53	7,25	8,00

Discount rate 5%

Figure 3: **Costs comparison - Krško NPP versus alternative sources**



5. Conclusion

Based on analyses performed, the soundness of Krško NPP performance in terms of energy and finance (i.e., its contribution to Croatian Electrical Power System) has been determined and compared to existing and new potential thermal power plants, as well as to electricity import option.

The results show that total generation costs of Krško NPP (Croatian part) are:

- lower than those in existing thermal power plants of Croatian EPS, if the NPP operates more than 3200 hours per year,
- lower than those in a potential new imported coal fired TPP, regardless of the number of operating hours per year,
- lower than those in a potential new gas fired TPP, if the NPP operates more than 1500 hours per year,
- lower than those in case of electricity import, if the NPP operates more than 2500 hours per year.

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