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KRŠKO NPP MODERNIZATION PLAN

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1.0 INTRODUCTION

Regulatory bodies' requirements, international commissions' and missions' reviews, NPP Krško self assessment and review, all resulted in Krško NPP modernization plan which will be discussed in the second part of this article. The subject of the first part of this article are the requirements and recommendations made by regulatory and other bodies, as well as by the international missions.

2.0 REQUIREMENTS

2.1 Regulatory and other bodies requirements

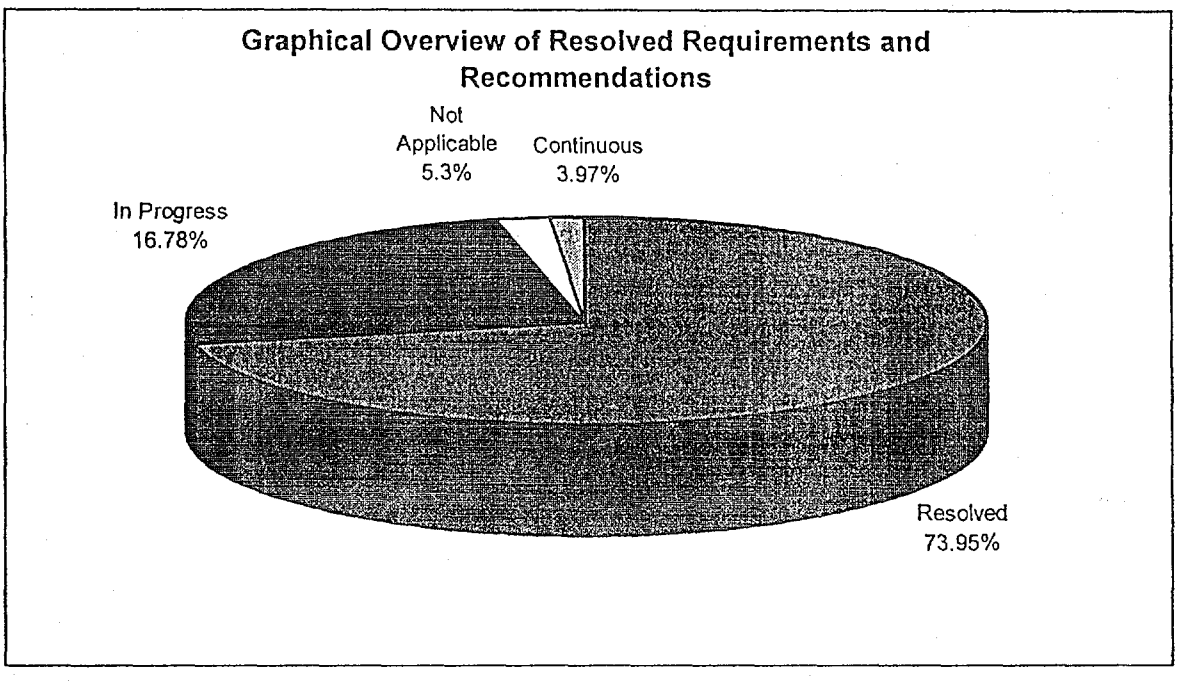
Statistical overview of the requirements and recommendations made by regulatory and other bodies and international missions is shown in Table 1.

Table 1

Requirement categories	Resolved	In Progress	Not Applicable	Continuos	Total	Percent
OSART '93	156	10	1		167	36.87%
ICISA '93	57	12	5		74	16.34%
URSJV (Slovenian Nuclear Safety Administration)	106	43	18	18	185	40.84%
OTHER STATE AUTHORITIES						
Local Authorities	2	2			4	0.88%
Ministry of Internal Affairs	2	1			3	0.66%
Environmental Protection Authorities	1	0			1	0.22%
Public Health Inspectorate	0	5			5	1.10%
Power Production Inspectorate	1	1			2	0.44%
Fire Protection Inspectorate	3	0			3	0.66%
Water Resources Management Inspector	1	0			1	0.22%
Industrial Safety Inspector	5	0			5	1.10%
Krško Operating Committee	1	2			3	0.66%
Total:	335	76	24	18	453	
Percent	73.95%	16.78%	5.30%	3.97%	100.00%	

In Figure 1 the graphical overview of resolved requirements and recommendations is shown.

Figure 1



Trends of resolving requirements and recommendations are shown on Figure 2 and Figure 3.

Figure 2.

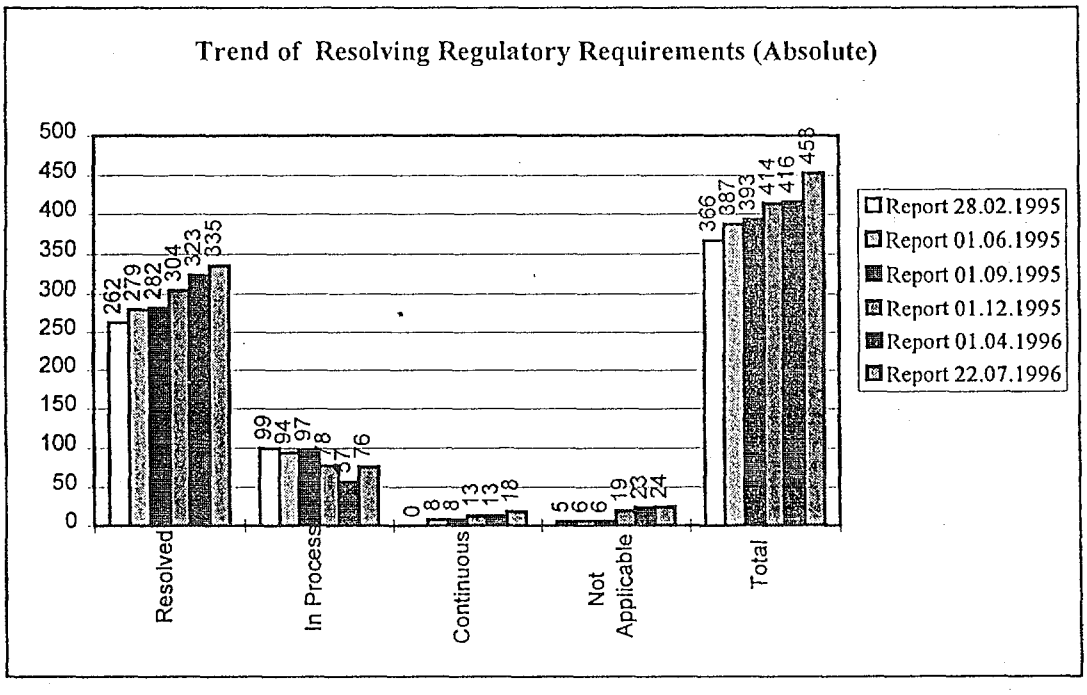
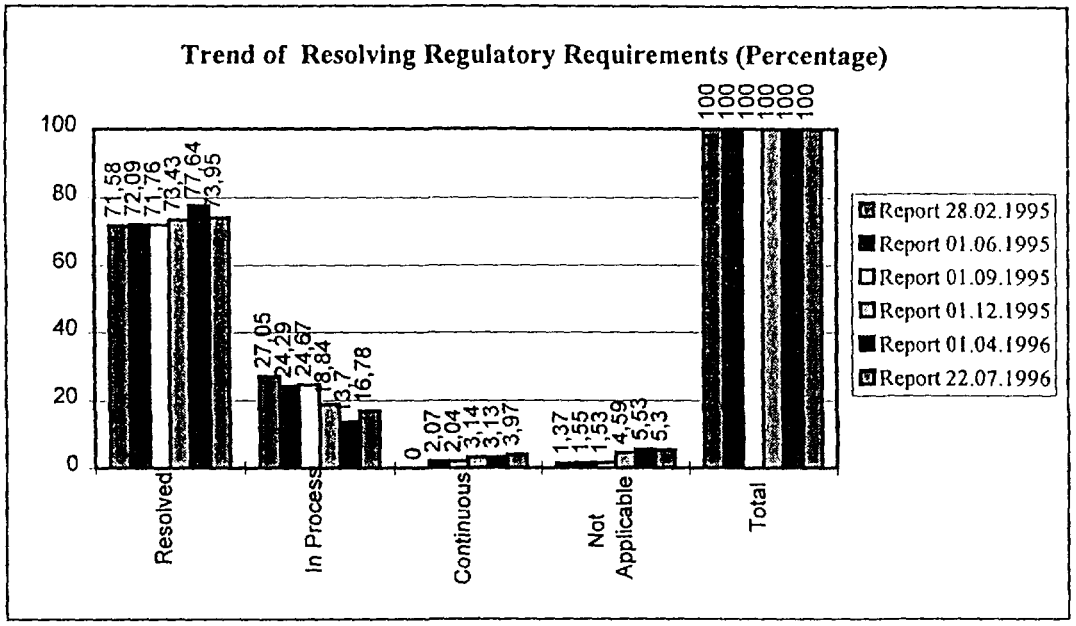


Figure 3.



Statistic of the ICISA and OSART recommendations is shown in Tables 2 and 3.

2.2 ICISA

In 1992 the Government of the Republic of Slovenia established the International Commission for Independent Safety Analysis (ICISA) and invited the neighboring countries (Austria, Croatia, Italy and Hungary) to participate. The general conclusions were that NPP Krško personnel had a good technical education level and showed constant attention and interest to their duties. It has been noted that a remarkable effort is in progress on the plant to revise and reorganize the Maintenance and the Surveillance activities, as well as to provide the plant with a fully developed Engineering Services Division. The level of safety of the Krško NPP is high, but it can be improved. In this objective ICISA has identified a number of specific issues which are recommended to be faced and resolved.

Current status of ICISA recommendations is shown in Table 2.

Table 2

ICISA RECOMMENDATIONS RESOLVED	RECOMMENDATIONS (percent%)	RECOMMENDATIONS (absolute)
N/A	6.76%	5
No	16.22%	12
Yes	77.03%	57
ICISA Total	100.00%	74

It has to be emphasized that the recommendations which are not fulfilled are those relating to financially very extensive projects such as Steam Generator Replacement, installation of Full Scope Simulator, etc..

2.3 OSART

At the request of the Government of the Republic of Slovenia, an IAEA OSART (Operational Safety Review Team) Mission was carried out during July 1993. An important aspect of the OSART review is the identification of areas that should be improved. OSART Mission is not a regulatory inspection to determine compliance with national safety requirements nor is it a substitute for an exhaustive assessment of a plant's overall status. The Team was composed of experts from Brazil, Canada, Germany, the Netherlands, Spain, the United Kingdom, the United States of America and IAEA staff members with scientific visitors from the Philippines, Romania and Slovakia. The Team's overall impression is that the Krško NPP is well maintained and efficiently and safely operated. The Team noted that a number of organizational, program, procedure and hardware changes had been initiated that should enhance safety and performance. These changes are based to a large extent on the plant involvement in and use of international experience and practices. There is also a strong environmental monitoring program and a motivation to protect the public. The Team made a number of proposals for management's consideration to improve plant activities. An IAEA Follow-up visit was carried out in October 1994. The purpose of the visit was to discuss the actions taken in response to the recommendations and suggestions of the OSART Mission, to comment on the appropriateness of the actions and to make a judgment on the degree of progress. The Follow-up Team's impression was that considerable progress on the OSART recommendations and suggestions had been made already.

Current status of OSART recommendations is shown in Table 3.

Table 3

OSART RECOMMENDATIONS RESOLVED	RECOMMENDATIONS (percent%)	RECOMMENDATIONS (absolute)
N/A	0.60%	1
No	5.99%	10
Yes	93.41%	156
OSART Total	100.00%	167

2.4 REGULATORY COMPLIANCE REVIEW

Phase 1 - Identification of regulatory requirements (American regulatory requirements from 1972 onwards have been taken into consideration and over 1500 NRC documents have been evaluated)

Phase 2 - Regulatory Conformance Program compliance review (solutions implemented at the plant in comparison with regulatory requirements).

Phase 3 - Safety Significance Assessment (determination of appropriate model - a tool necessary for making the order of priority of unresolved items; determination of solutions)

Phase 4 - Implementation Program of Safety Upgrades

In Table 4, the status of fulfilling NRC requirements expressed in percentage is shown.

Table 4

	% resolved	% under implementation	% in preparation
10 CFR	71	13	16
TMI	81	14	5
Unresolved Safety Issues	59	22	19
Generic Safety Issues	67	12	21
Generic Letters	86	6	8
Bulletins	80	4	16
Programmatic Requirements (FP, EQ, Security ...)	36	9	55
TOTAL	81	11	8

2.5 WANO Review

A WANO Team of experienced nuclear professionals conducted a review of Krško Nuclear Power Plant during November, 1995. It is recognized that many activities and practices performed by Krško NPP are routinely done well. Krško NPP appreciates the efforts of the WANO-Atlanta Center and the review team in performing the peer review. We consider the results of the review to be very important for us in achieving high operational standards of Krško NPP. We are especially pleased with positive feedback regarding the effective integration of the shift supervisors into the management team. We feel this has significant benefits in broadening the experiences and abilities of the Krško NPP staff, thereby enhancing safe and reliable plant operation.

Krško management is firmly committed to address all improvement areas identified by WANO. Special focus is being placed on watchstanding practices and follow-up of abnormal conditions as well as additional efforts to improve the control of radioactive material and to reduce exposure to personnel.

The effectiveness of corrective actions will be assessed in December 1996 and additional corrective actions will be taken as appropriate.

3.0 KRŠKO PLANT MODERNIZATION PROJECT

3.1 BACKGROUND/INTRODUCTION

From the beginning NPP Krško steam generators with SG tubes made of INCONEL 600 and not optimal secondary chemistry environment limited by secondary system material have experienced the complete spectrum of tube defects: primary side stress corrosion cracking,

intergranular attack and intergranular stress corrosion cracking above the tubesheet within the sludge pile and under the tube support plates. These defects have resulted in a high percentage of plugged tubes. As the number of plugged tubes increases, the potential for unit derating and for additional licensing restrictions becomes significant. Therefore an economic decision based on the lost power generation revenue of the plant has been made to replace steam generators.
As mentioned above, the expenditure required to keep the steam generators in safe and operational condition was high during each refuelling outage. The sophisticated maintenance (plugging, sludge lancing, crevice flushing, FOSAR, shoot peening, U-bend heat treatment, boric acid addition, tube sleeving) and inspection techniques required highly specialized and expensive services. Additional manpower had to be hired for jumper activities to distribute the total radiation dose among a large number of individuals. The radiation accumulated over the years in carrying out maintenance and inspection activities reached the figure in excess of that prescribed for the complete steam generator replacement project.

All activities on the steam generators had to be done on the critical path resulting in a prolonged outage time and loss of plant availability. Maintenance of components like steam generators is also very costly.

NEK Management analyzed steam generators history, maintenance and inspection expenditure, authority position, possibilities for plant uprating to provide a basis for decision making relating to a steam generator replacement project.

Possible scenarios were analyzed:

- Tube Plugging (requires power reduction);
- Extensive Sleeving Program (unsuccessful for the type of defect and high location);
- SG Replacement;
- SG Replacement + Plant Uprate;

NEK performed an economic assessment which shows that steam generator replacement project is attractive if combined with plant uprating. The feasibility studies have indicated that power uprating to 2000 MWt (6.3%) should be possible without major modifications.

3.2 PROJECT ORGANIZATION

The established Project organization is closely related to all the phases of the Krško NPP Modernization Project, i.e. from preparatory activities, evaluation of bids and negotiations, to awarding of a contract. The four main packages are being covered by the project:

- Replacement Steam Generators - New Steam Generators (RSG),
- Removal/Replacement of the Steam Generators (SGR),
- Software Services (UPR), and
- Plant Specific Full Scope Simulator (SIM).

Interdisciplinary activities such as technical, commercial and legal are incorporated in the project.

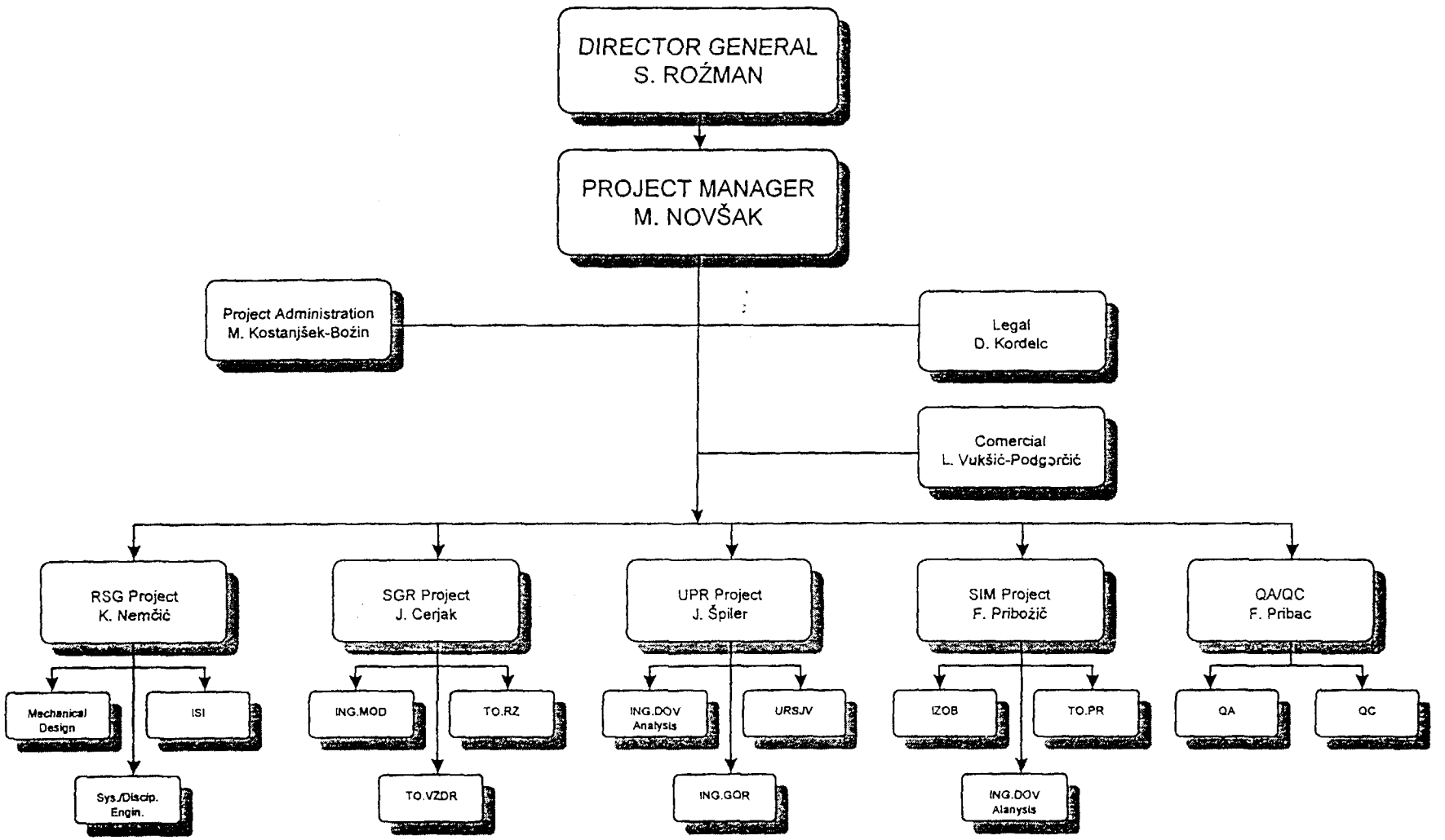
The Project Manager (Mr. Martin Novsak) is responsible for efficient organization of activities and personnel to achieve the set goal.

He is in charge of assigning different tasks to Team Leaders. Their activities have to be carried out in time and of high quality.

Team Leaders for individual packages are as follows:

RSG - Mr. Krešimir Nemčić
SGR - Mr. Janko Cerjak
UPR - Mr. Jože Špiler
SIM - Mr. Franc Pribožič

NEK MODERNIZATION PROJECT ORGANIZATION CHART - PREPARATION PHASE



3.3 *PROJECT SCHEDULE*

New steam generator fabrication

Activity	**Planned start**	**Planned finish**
Biding phase	15.01.96	15.04.96
Proposal evaluation/contracting	15.04.96	15.11.96
Selection of the supplier	15.11.96	
Contract preparation	15.11.96	20.12.96
SG manufacturing	01.01.97	01.09.99
Transport	01.09.99	01.11.99

Steam Generator Replacement

Activity	**Planned start**	**Planned finish**
Biding phase	15.01.96	15.04.96
Proposal evaluation/contracting	15.04.96	15.11.96
Selection of the contractor	15.11.96	
Contract preparation	15.11.96	20.12.96
Modification packages preparation	01.03.97	01.03.99
Containment walkdowns	outage 96, 97, 98	
Old SG storage facility construction	31.05.99	30.08.99
SG Replacement	01.05.2000	15.07.2000

Uprate project

Activity	**Planned start**	**Planned finish**
Biding phase	15.01.96	15.04.96
Proposal evaluation/contracting	15.04.96	15.11.96
Selection of the contractor	15.11.96	
Feasibility Study	01.01.97	01.07.97
Regulatory review/approval	01.07.97	01.05.98
Safety analysis	01.01.97	01.07.98
Operating window confirmation	01.01.98	01.02.99
Validation/component analysis	01.02.98	01.07.99
Final documentation and licensing	01.01.98	01.04.2000
SG Replacement	01.05.2000	15.07.2000

Full scope simulator

Activity	Planned start	Planned finish
Biding phase	15.01.96	15.04.96
Proposal evaluation/contracting	15.04.96	15.11.96
Selection of the contractor	15.11.96	
Project specification development	01.05.96	01.07.97
Simulator panels fabrication	01.01.97	01.05.98
Mathematical modeling and programming	15.10.97	01.05.98
Factory preshipment testing	01.05.98	01.04.99
Site testing	01.06.99	02.07.99

3.4 PROJECT SCOPE DESCRIPTION

From the assessment of the feasibility studies it comes out that no feasibility issue exists, from steam generator standpoint, which would preclude the SG replacement and plant uprating to 2000 MWt. In fact, installation of steam generators designed to use the current technology and materials (INCONEL 690) will enhance the performance and reliability of the plant.

The following assumptions are made which form the basis for the assessment of steam generators replacement:

- The replacement steam generators are assumed to have essentially the same outlet envelope as the existing steam generators ("drop-in replacement").
- The replacement steam generators will be of the feedring design (extensive industry experience).
- The replacement steam generators will be compatible with the remainder of the existing NSSS.

The old steam generators will be removed from their cubicles after cutting off the primary system pipes (2-cut method) and removal of all supports and obstacles. The rigging and handling process will be accomplished by using modified existing polar crane. After removal of old steam generators from reactor building via the existing equipment hatch they will be stored in the facility for the old steam generators. New steam generators will be installed and welded to the primary system pipes with a narrow gap weld method. A major feedwater rerouting and associated feedwater control is expected due to different design of new steam generators (top feed v.s. top/bottom feed). In addition, a significant amount of Blowdown, Auxiliary Feedwater pipes, various instrumentation tubing rerouting is also expected due to different steam

generators design.

In order to support the whole project reliable temporary services as well as temporary and permanent facilities have to be provided: adequate warehouse, mock-up facility, fabrication/test shop, decontamination facility, new steam generators facility, containment access facility.

3.5 SG Replacement and Power Uprate

Since SG's replacement arises as the best solution it is reasonable to think about power uprating. With minor constructional changes it is possible that power uprate be extended by 6.3% which means approximately 40 MW of additional power. It also has to be emphasized that environmental impacts will not increase, but rather remain below acceptable limits.

Goals/Objectives

When selecting the most convenient scenario among the proposed ones the following parameters have been taken into account:

- plant availability,
- frequency of unexpected shutdowns,
- duration of repairs and their long-term efficiency,
- radiological consequences, and
- financial effects.

The assessment of different scenarios leads us to the best solution possible: SG's replacement and power uprate. This decision being in place is confirmed by prevalence of such interventions worldwide. With new constructional solutions and better materials of new SGs as well as optimized secondary chemistry the plant's reliability will be much higher and its power increased for its lifetime.

To complete the scope of uprate/modernization project the modifications on the following systems are required or potentially required:

- RTD manifold removal
- Blowdown system
- Auxiliary Feedwater system
- Condensate, Feedwater, Heater Drain systems
- Cooling Tower system

3.6 Krško NPP Specific Full Scope Simulator

A plant specific full scope simulator which accurately reflects a plant's control room and correctly models how the plant parameters respond to a broad range of operations and malfunctions has a major impact on the safety and reliability of the plant. The simulator will be designed to completely and accurately replicate the actual control room and remote shutdown panels, and simulate plant systems. Simulator will be

designed in accordance with ANSI/ANS-3.5 standard and will consist of five hardware elements: the simulated control room, the remote shutdown panels, the simulator instructor room, the computer complex and software, and the process information system.

The completition of the project will comply with the Slovenian Nuclear Safety Administration license amendments and recommendations of international missions, as well as conform with SG Replacement Project.

4.0 CONCLUSIONS - KRŠKO NPP MODERNIZATION GOALS

- International transparency:
  international standards of operation and modernization.

- Main purposes of modernization project:

  * long-term operational stability,
  * power increase up to 2000 $MW_{thermal}$ (+6 %),
  * availability increase up to 85%,
  * forced shutdown factor reduction below 2%,
  * annual power generation increase up to 5 TWh (+ 1 TWh).

- Signing of the Krško NPP modernization contract by the end of 1996.