

# REPORT ON EVALUATION OF KUDANKULAM SITE FOR LOCATION OF 2 x 1000 MWe VVER NUCLEAR POWER PLANT

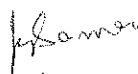

## 1. INTRODUCTION

The acceptability of a site for locating a Nuclear Power Plant is dependent not only on site characteristics, related primarily and directly to safety, but also on a large number of other aspects which are only indirectly related to safety. These include the reliability and stability of the electrical grid, the adequacy of communications etc.

The siting of Nuclear Power Plant (NPP) generally involves studies in three stages, namely:

- 1) Site survey stage: The purpose of a site survey is to identify one or more preferred candidate sites after both safety and non-safety considerations have been taken into account. This involves the study and investigation of a large region. It results in the rejection of unacceptable sites, and is followed by systematic screening, and comparison of remaining sites.
- 2) Site evaluation stage: This stage involves the study and investigation of one or more of the preferred candidate sites to evaluate their acceptability from various considerations, and in particular from the safety considerations. The site-related design bases are established at this stage. Subsequent to this a preliminary safety analysis report is submitted for clearance before site construction is started.
- 3) Pre-operational stage: This stage includes studies and investigations of the selected site after the start of construction and before the start of operation in order to complete and refine the assessment of site characteristics and to confirm assumptions made in the safety analysis of the reactor as a part of the final safety analysis report. The base line data on environment are also established at this stage.

The stage one is within the scope of the work of the site selection committee. The present committee aims to have a preliminary evaluation of the feasibility of a site mainly from safety consideration and ensure that the plant site combination does not constitute an unacceptable risk. However, in view of the fact that some non-safety considerations may affect safety related aspects, such items also have to be studied. It is to be understood that the present committee has evaluated the site from screening considerations. The site related design parameters / bases are to be established at appropriate stages. The review is based on the available information on



population and industrial growth and other proposed facilities at and around the site in addition to safety related aspects like seismo-tectonic environment, geology, hydrology, extreme meteorological phenomenon etc. The site is evaluated from the following consideration.

1. Effect of the region of the site on the plant.
2. Effect of the plant on the region.
3. Population considerations.

While the first of the above factors decide the safety of the plant due to site related natural and man-induced events, the second factor influences the potential radiological impact from the plant on the environment. Population consideration is important for emergency planning.

The acceptability of a site for a particular NPP depends on the existence of engineering solution to site related problems which gives assurance that the proposed plant can be built and operated within acceptably low risk to the population of the region.

IAEA guidelines (1, 2) have been kept in mind for the site evaluation.

## **2. REVIEW FOR THE SUITABILITY OF THE SITE AT KUDANKULAM**

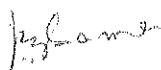
### **2.1. GENERAL CONSIDERATION**

#### **2.1.1. SAFETY-RELATED ASPECTS**

Potential site-specific natural hazards and man-induced events have been evaluated for initial appraisal of their impact on the plant design and the engineerability under the given circumstances. Subsequently, these studies form the design bases.

Among the natural hazards, the following aspects as relevant to site have been studied.

- i. Surface faulting
- ii. Seismicity
- iii. Suitability of subsurface material
- iv. Flood and
- v. Extreme meteorological phenomena (e.g. cyclone)



Because of rocky substrata slope instability, soil liquefaction, surface collapse, subsidence or uplift are not applicable for the present site.

Man-induced events include accidents due to

- i. Air traffic
- ii. Vehicular road traffic
- iii. Industrial and Military activities in the immediate vicinity of the site.

Capability of dispersion in air and water are studied for possible radiological impact on environment. The availability of adequate cooling water supply for the Ultimate Heat Sink is the central safety issue. Feasibility of implementing effective emergency actions has also been considered.

#### 2.1.2. NON-SAFETY CONSIDERATIONS

(Economic, Technical, Environmental and Social Aspects)

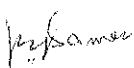
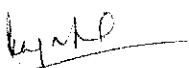
These are primarily related to engineering feasibility. However, some of the factors may indirectly be related to the safety of the NPP.

The factors considered are:

- i. Electricity network
- ii. Availability of cooling water
- iii. Transport routes
- iv. Topography
- v. Industrial support at site
- vi. Non-radiological impact on the environment (e.g. chemical and thermal pollution, industrial growth and its impact etc.)

#### 2.1.3. OBSERVATIONS OF THE COMMITTEE

The committee has studied all site related data submitted by NPC (3,4,5) and has, in accordance with the criteria mentioned above, made a review of the suitability of the Kudankulam site for locating a nuclear power station having two units of 1000 MWe VVER reactor.



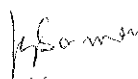

The review findings are presented in Tables I and II.

### 3. ACTIONS TO BE TAKEN

The Committee recommends that the following actions should be taken at appropriate stages.

#### 3.1. Aspects related to site

- 1) ODC committee of NPC to evaluate suitability of transportation of ODC at design stage.
- 2) Maximum Flood Level should be estimated accurately considering IAEA safety Guide 50-SG-S10B. Revised report of CWPRS should be submitted to Design Safety Committee.
- 3) Analysis for the quality of construction water is to be carried out.
- 4) In order to enhance additional reliability for water supply, which is essential for functioning of various safety systems of the reactor, intake well at Pechiparai Dam should be provided at lower elevation than the minimum draw-down level of the reservoir. However, it should be ensured by proper management of water distribution that the water level is maintained above this minimum level.
- 5) Adequate storage of fresh water for prolonged safe shutdown of the reactors is to be provided within plant boundary for safety related systems. Ground water source should be explored.
- 6) Environmental Survey Laboratory should be set up at site and instruments are to be installed at site to collect meteorological data and background radiation.
- 7) Site related design considerations such as seismic aspects, etc. are to be established before submission of PSAR.
- 8) The committee has been informed that detail subsoil investigations have been carried out (12). Bore-hole investigations are to be carried out at the proposed location of various buildings and structures. The report should be forwarded to design group for taking into account at the time of actual design.
- 9) Power evaluation studies particularly that influence the plant grid interaction should be pursued. Feasibility of operation on islanding mode may be studied in collaboration with CEA. In addition availability of a reliable dedicated startup power source of adequate capacity should be examined.



- 10) Stipulations made by various State and Central authorities in giving clearance. should be met. In addition, plantation in the area under control of the project should be taken up along with site development.
- 11) Tamilnadu legislation to control population growth beyond natural growth within the sterilized zone is to be implemented.
- 12) Termination of the lease in 1994 for lime stone quarry.

### 3.2. Aspects related to design

- 1) Radiological impact should be assessed with proper source terms and relevant dispersion characteristics of the site. Dose limits prescribed should be met at a distance of 1.6 km in the event of greater exclusion radius adopted by NPC.
- 2) Stack height to be checked by Health Physics Division, BARC considering topography and dispersion characteristics.
- 3) Model studies should be taken up for intake and outfall structure for thermal pollution and recirculation.
- 4) Studies on Biofouling and Jelly-Fish etc. that may affect the water supply should be taken up.
- 5) Studies on accretion / erosion rate around the plant site should be carried out. If required, proper protection should be provided.
- 6) Design should be engineered to meet site related design basis events.
- 7) At least two evacuation routes from plant site during an emergency should be provided.

## 4. RECOMMENDATIONS

The committee is of the opinion that Kudankulam site meets the major criteria for siting 2x1000 MWe VVER units. The Committee at the same time recommends that the observations made in the preface and the actions recommended in Section 3 above need to be implemented at appropriate stages.

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## REFERENCES

1. IAEA- Code of Practice on Safety in Nuclear Power Plant Siting. IAEA Safety Series No. 50-C-S International Atomic Energy Agency, Vienna, 1979.
2. Site Survey for Nuclear Power Plants. IAEA Safety Series No.50-SG-S9. International Atomic Energy Agency, Vienna, 1984.
3. Environmental Data on proposed Kudankulam Site for submission to Tamilnadu Pollution Control Board for 2x1000 MWe VVER nuclear power station.
4. Write up on Kudankulam site-DAE.
5. Siting data in AERB standard format. (Received from NPC vide letter NPC/KK/24/1032 dated 7-3-89).
6. Layout of main plant building for 2x1000 MWe VVER project at Kudankulam. Drawing No.KK/10,000/2001/GA/120.
7. CWPRS Pune Report: "Safe Grade Elevation for the Proposed Nuclear Power Station at Kudankulam, Tamilnadu".
8. Draft report on Earthquake Design Basis for Kudankulam Site, DAE, 1988- A.K. Ghosh and D.C. Banerjee.
9. Appendix to Part-I of Site Selection Committee report.
10. Power Transmission System for Kudankulam Atomic Power Project-CEA report.
11. Letter NPC/KK/24 dated 16-3-89 received from NPC.
12. Brief note from NPC on "Geological setup of Kudankulam Site".

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**Table-1**

**SALIENT FEATURES OF KUDNKULAM SITE CONSIDERED DURING SITE EVALUATION**

SR.NO.	SITE CHARACTERISTICS INFLUENCING THE NPP	SPECIFICATIONS/ DESIRABLE CHARACTERISTICS	OBSERVATIONS FOR KUDANKULAM SITE	REMARKS
1	2	3	4	5
1	<b><u>TOPOGRAPHY</u></b>	Plain Topography.	Elevation + 3 m to 45 m above M.S.L. Area measuring 1 km x 2km available.[3] [6]	Terrain suitable Sufficient land available for future expansion.
2	<b><u>ACCESSIBILITY</u></b>			Recommendation for ODC transport:
	i) Nearest Broad gauge rail head.		Kanyakumari (27km), Valliyur (27km)	1)All consignments /equipments with weight <30 ton : USSR-Tuticorin :by ship, Tuticorin --site: by road or on barges by sea route
	ii)Nearest national high way		NH 7 at Kanyakumari 27km, Valliyur (27km)	2)All consignments > 30 tons USSR -- site: by ship and barges. To be unloaded at Jetty within the plant.
	iii)Nearest sea port		Tuticorin (100km)	
	iv)Nearest district road		Coastal road from Kanyakumari (4km)	
3	<b><u>CONSTRUCTION FACILITIES</u></b>			
	i) Construction materials		Coarse aggregates available at Anjagramam(4 km). Sand available at	More sources will be established at construction stage

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					Hanumanathyovari Road (7km). Bricks available at Panagudi(27km)	
	ii) Construction Power	26 MVA + 2 MVA for township			Panagudi sub-station (27km)-110 KV line exists. 110 KV line from Kodyar Power Station is also being considered.	Required power will be made available.
	iii) Construction water	3.5 Cu. sec (350cu.m per hour)			Initially limited supply to be tapped from ground water sources. Subsequently the demand will be met from Pechiparai dam.	Quality of construction water is likely to be acceptable. Analysis of water will be carried out.
	iv) Infrastructure facilities (e.g. minor workshop etc.)				Nagercoil (30km) and Tuticorin (100km)	
4	<b><u>AVAILABILITY OF POWER SUPPLY AND TRANSMISSION LINES</u></b>					
	i) Start-up power	60 MVA per unit			Available from main state grid and Tuticorin Thermal Power Station (Plant capacity 630 MWe) 220 KV line to be drawn from Tuticorin.	
	ii) Power evacuation scheme				Feasible as per preliminary study conducted by CEA. Detail study is in progress.	Present grid capacity 12832 MWe. Nuclear 470 MWe. Projected capacity in 1995 will be 27541 MWe. Nuclear 1910 MWe.

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5	<u>AVAILABILITY OF WATER</u>			
	i) Condenser cooling	6000 cu. sec (on once-through basis)	Sea water cooling on once-through basis. Silt content:60-100 ppm. Particle size: 75 microns. Temperature:26-29 deg C(5)	No constraint. Titanium tubes will be used. Study on biofouling and jelly fish that may affect the water supply will be taken at design stage. Model study will be taken up for intake and outfall structure(5)
	ii) Fresh water for make-up and domestic use	10 cu. sec	Assured by State Government. One pipe line from Pechiparai dam (at 65 km) to be laid. pH: 7, Dissolved solids: 25 mg/liter, Suspended solids: negligible, Turbidity: 5 mg/liter.(5)	Dam storage 4.45 TMC ft. Dead storage can account for 3 years drought.(5)
6	<u>TOWNSHIP</u>	400 acres	400 acres of land identified near Chettikulam village about 7 km from the site.(3)	

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**TABLE-2**

**SITE CHARACTERISTICS AFFECTING SAFETY OF PLANT**

SR.NO.	SITE CHARACTERISTICS INFLUENCING THE NPP	SPECIFICATIONS/ DESIRABLE CHARACTERISTICS	OBSERVATIONS FOR KUDANKULAM SITE	REMARKS
1	2	3	4	5
1	GEOLOGY			
	i) Foundation conditions depths of bed rock and type		Bed rock at 5- 16 m below ground. Biotite granite gneiss with lenticular bodies of charnockites or quartzites	
	ii) Strength	Maximum intensity of loading 6 kg/sq.cm at RB.	Dry strength:650 kg/sq.cm Wet strength:450 kg/sq.cm.(5)	
	iii) Ground water	Below > 1m	5-8m below ground-gradient towards Sea.(5)	
2	NATURAL EVENTS			
	i) Coastal erosion		Erosion insignificant with respect to life of station. Nearest main plant structure from shore about 120 m away from the sea base line.	Layout for the main plant still under consideration. figure of 120 m estimate on the basis of 7 m as the ground elevation at main plant building.
	ii) Flood		Maximum flood level considering tidal range wave run-up and maximum storm surge 5.9 m above chart datum of 0.0. Exposed structures placed well above this level.(7)	Grade level around Reactor Building will be above 7 m from M.S.L. Revised report on MFL from CWPRS awaited. Grade elevation will be charged if necessary.
	iii) Tsunami		Not significant as per preliminary report of CWPRS.	1m height of wave considered due to tsunami effect.
	iv) Wind, storm, cyclone		Maximum speed of storm: 112	Engineering capability to design

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			km/hr Storm surge accounted for in flooding. Exceedance probability 5% as per preliminary report from CWPRS	for wind load exists.
	v) Slope instability		Not applicable for rocky substrata	
	vi) Soil liquefaction		Not applicable for rocky substrata	
	vii) Siesmotectonic Environment	No active fault within 5 km of NPP. Engineering capability for stipulated earthquake acceleration should be possible	No active fault within 5 km. Site is in seismic zone II as per IS-1893; 1984. Nearest epicenter at Trivandram (90km). Earthquake in the region; Magnitude 6 at Coimbatore (8Feb, 1900) (300km). Estimated peak horizontal acceleration for SSE is 0.15 g and for OBE is 0.06 g.	Engineering capability to design for such earthquake loads exists. Seismic evaluation report finalized after discussion with GSI and Soviet Specialists. Further ground checks have confirmed the assumptions regarding the nearest lineament.
	viii) Site surface collapse, subsidence or uplift.		Not applicable for rocky substrata	
	ix) Failure of cooling water supply			
	a) Fresh Water pipe rupture		Storage for safety related system will be provided at site for prolonged safe shut down of reactor.[5]	Plant operating procedures and pond capacity will be decided to ensure water requirement for decay heat removal from the two units for a prolonged period. Ground water source will also be explored as standby back-up arrangement.
	b) Failure of upstream dam		Flooding not of consequence as site is far away (50km), and the site is not in the course of the main channel. Intake well at Pechipparai	

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				dam to be provided and supply to be taken from upstream Kodiyar storage for extreme contingency. Site storage is to be provided for safety related systems.	
<b>3</b>	<b><u>MAN-INDUCED EVENTS AFFECTING SAFETY OF THE PLANT</u></b>				
	i) Aircraft impact				
	a) Nearest Airport	SDV 8 km		Trivandrum (90 km)	
	b) Nearest Air Strip	SDV 4 km		-----do-----	
	c) Military Airport	SDV 15 km		-----do-----	
	ii) Toxic gas release	SDV 5 km		No industry using explosives or having potential for explosion within 10 km	
	iii) Chemical explosion	SDV 5 km		No industry using explosion or having potential for explosion within 10 km.	
	iv) Industrial or military accident			No industry or military establishment within 10 km.	
	v) Surface vehicle impact or explosion.			No national highway or railway siding within 10 km. Coastal road from Kanyakumari to Tuticorin is about 4 km from the site	
<b>4</b>	<b><u>METEOROLOGY</u></b>				
	i) Wind speed and direction			Observation at Kanyakumari: Variation of daily average velocity: 6-30 km/hr. Direction: From West (44.5%) and N.E. (16.2%).	
	ii) Rain			Annual average rainfall: 810 mm.	

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	iii) Atmospheric temperature		Monthly average : 23-33 deg C Extreme : 19.2-36.8 deg C	
	iv) Humidity		Monthly average: 65 - 80% R.H. Extreme: 60-85% R.H.	
	v) Atmospheric stability		Environmental survey laboratory Observation will be available for detailed evaluation. Not a constraint during site selection.	Instruments are being installed at site to collect site data.
5	<u>USE OF LAND</u>		<p>Within the exclusion zone: 34 % of area lies in sea.          Remaining 650-750 Ha. of land (no forest), mostly private owned, is barren and unirrigated / poorly cultivable.          Extremely limited agriculture.          Annual yield: 20 Te. of Millet and 2 Te. of Cotton.          Within 10 km radius area: 60% of area lies in sea.          Remaining land is barren or used for agriculture.          Annual yield Paddy 14400 Te, Millet 4300 Te, chilli 3000 Te, Tobacco 380 Te, pulses 850 Te, Cotton 250Te, Oilseeds 70 Te. (4)</p>	<p>A lime stone quarry of about 70 acres falls within the sterilized zone. The lease for this area expires in 1994.          Termination of the lease beyond the period has been requested.</p>
6	<u>USE OF WATER</u>		<p>Ground water, limited in supply, is used for drinking and has a gradient towards the sea.          No salt pans within 5 km.          The degree of development of fisheries is as common as in a coastal belt. In the nearby area. Idinthakarai, Koothapuzh,</p>	

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	Koothankuzhi and Purumanal are the fishing villages within 20 km and annual fish produce of about 4000 Te in the area is reported. About 3900 fisherman in these villages are engaged in fishing as per information furnished in 1982. At Chinnamuttam near Kanyakumari, a fishing harbour is being developed.(4)		
7	<b><u>DISPOSAL OF RADIOACTIVE WASTE FROM THE NPP</u></b>		
	i) Solid Waste	Low level solid waste to be buried- within exclusion zone in leak-proof RCC Vaults/trenches/tile Holes. 160-180 m.cu per year of cemented waste including spent absorption materials, 40 m cu/yr of compacted waste and 5 m cu/yr of cemented ash will be generated from one reactor.(5)	Bore wells surrounding the solid waste burial area will be provided for monitoring migration of activities.
	ii) Liquid waste	Most of the radioactivity in the liquid is removed in the Ion Exchange resin and as evaporator concentrate. After above processing the liquid effluent from two units is estimated as 6000 m Cu/year with activity levels lesser or equal to 10E-9 Ci/l. This will be further diluted by condenser cooling water to meet the limits	6000 cu secs of sea water available for dilution while sea water less than 1 cu sec required to achieve the specified limits.

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	iii) Gas release		<p>allowed by AERB.</p> <p>Stack height is 100 m.</p> <p>Use of high efficiency (0.3 micron) particulate absolute filter will help to comply with authorized limits for particulate activity.</p> <p>The estimated gaseous discharges from two units as following:</p> <p>Nuclides : Average daily release Ci/day</p> <p>Noble gases : 2200</p> <p>I-131 : 30x10E-4</p> <p>Long life : 0.012</p> <p>Nuclides</p> <p>Short life : 0.26</p> <p>Nuclides</p>	<p>It is understood that specific detailed information regarding waste and radioactive released will be available along with PSAR for review.</p>
8	<b><u>RADIOLOGICAL IMPACT</u></b>			
	i) During normal operation	AERB prescribed limits	<p>Based on releases vide para 7, preliminary estimates indicate very low dose rates 11.24 mrem/yr. to the individual at 1.6 km exclusion radius. Both the water and air routes have been considered in the above estimates.</p>	
	ii) During design basis accident conditions	<p>10 rem: for whole body,</p> <p>50 rem: for child thyroid at exclusion radius</p>	<p>For all design basis accidents adequate engineering safety features shall be provided to meet the specified requirements</p>	<p>DBA calculations will be carried out at the design stage.</p>
9	<b><u>THERMAL POLLUTION</u></b>			<p>Model studies will be carried out at CWPRS Pune. The requirements of Tamil Nadu</p>

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10	<b><u>STORAGE AND TRANSPORTATION OF FRESH AND SPENT FUEL</u></b>	sea will avoid thermal pollution.	Pollution Control Board should be met. 50 Ton of spent fuel will be discharged annually from the two reactors. After adequate cooling inside the pool, it will be shipped to Soviet Union by sea route in hermetically sealed casks. Special jetty provided within the plant area will be used for transfer of cask to the Soviet ships so that spent fuel remains within plant boundary at all stages during the process of shipment of irradiated fuel.
11	<b><u>FUEL REPROCESSING FACILITY</u></b>	Reprocessing not planned at this site	
12	<b><u>POPULATION CONSIDERATIONS</u></b>		
	i) Population within 2 km radius exclusion zone	No habitation	No resident population
	ii) Population within 5 km radius sterilized zone	Less than 20,000 population density < 2/3 state average	Total population: 15,000 3 villages in this area Kudankulam, Idinthakarai and Erukkanthorai
	iii) Population within 10 km radius zone	No centre > 10,000	No population centre with more than 10,000 people. Total population 40,842 (1981 census). Population density: 130 persons / sq.km
	iv) Population within 30 km radius zone	No centre > 1,00,000	No population centre with more than 1 lakh people. 11 centers have

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			population more than 10,000 . Nagercoil (at 30 km) has a population of 1,71,641.	
	v) Population within 50 km radius zone		33 population centers with population more than 10,000.[4]	
13	<u>EMERGENCY – PREPAREDNESS CONSIDERATIONS</u>		3 routes – for possible evacuation. Schools and other public buildings exist for adequate temporary shelter. Nagercoil (30 km), Tirunelveli(100 km) and Tuticorin (100km) can provide communication medical facilities and administrative support.	Draft proposal on off site emergency preparedness plans already submitted to AERB.
14	<u>ADDITIONAL STATUTORY REQUIREMENTS OF THE CENTRAL AND STATE GOVERNMENT</u>		Clearance for the following has been obtained: Tamilnadu Pollution Control Board, Shore Protection Committee of T.N. Government, State Committee on Environment, Ministry of Environment, Ministry of Environment and Forests [Government of India]	Stipulation made in the clearance documents should be adhered to.

“This is the retyped version of original report.”

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