CHAPTER 5 THE POTENTIAL OF PUMPED STORAGE HYDROPOWER PLANT IN MAHARASHTRA

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CHAPTER 5 THE POTENTIAL OF PUMPED STORAGE HYDROPOWER PLANT IN MAHARASHTRA

5.1 Prospect of Assured Pumped-Storage Resource

The pumping resource was calculated based on the demand projection and the power development projects acquired from MSEB, and the daily load curve on the highest load day and lowest load day acquired from Western Region Central Load Dispatching Office.

The base load supplied to the pumped storage hydro power plant from the thermal power generation facilities and the nuclear power generation facilities were calculated for each section of 1995, 2000, 2005 and 2010. The plant factor for the thermal and nuclear install capacity in Maharashtra State and its shares was 0.8. **Fig. 4.1-1** shows the relation between the max. demand, total install capacity, total install thermal capacity and estimated base power.

The difference between the daily load curve produced for the future demand projection in Chapter 3.3.7 and the base load during the night was sorted according to the time unit and evaluated as the pumping resource. The pumping resource in each projection year and back data are described in **Table 5.1-1 and Table 5.1-2.**

Table 5.1-1 Pump Resources and Generating Energy in Maharashtra Power System from 1993 to 2010

Year	Pumping Resource	Pump Time	Total Pump	Generating Energy
1995	700 MW	5.5 h	3,850 MWh	2,503 MWh
2000	1,900 MW	6.0 h	10,900 MWh	7,085 MWh
2005	900 MW	5.5 h	4,750 MWh	3,088 MWh
2010	1200 MW	5.3 h	6,400 MWh	4,160 MWh

Table 5.1-2 Calculation of the Pumping Resauses in Maharashtra Power System 1993 - 2010

(Unit: MWh)

	1993		1995		2000		2005		2010	
Time	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.
1	5,600	3,875	6,658	4,607	9,321	6,450	12,591	8,713	16,253	11,247
2	5,475	3,750	6,510	4,459	9,113	6,242	12,310	8,432	15,891	10,884
3	5,270	3,687	6,266	4,384	8,772	6,137	11,849	8,290	15,296	10,701
4	5,330	3,753	6,337	4,462	8,872	6,247	11,984	8,438	15,470	10,893
5	5,600	3,878	6,658	4,611	9,321	6,455	12,591	8,719	16,253	11,255
6	5,900	4,214	7,015	510	9,820	7,014	13,266	9,475	17,124	12,231
7	6,453	5,000	7,673	5,945	10,741	8,322	14,509	11,242	18,729	14,512
8	6,689	5,218	7,953	6,204	11,134	8,685	15,040	11,732	19,414	15,145
9	6,900	5,245	8,204	6,236	11,485	8,730	15,514	11,793	20,027	15,223
10	6,981	5,380	8,300	6,397	11,620	8,955	15,696	12,097	20,262	15,615
11	6,980	5,450	8,299	6,480	11,618	9,071	15,694	12,254	20,259	15,818
12	6,633	5,180	7,887	6,159	11,040	8,622	14,914	11,647	19,252	15,034
13	6,525	5,028	7,758	5,978	10,861	8,369	14,671	11,305	18,938	14,593
14	6,485	5,025	7,711	5,975	10,794	8,364	14,581	11,298	18,822	14,585
15	6,523	5,025	7,756	5,975	10,857	8,364	14,667	11,298	18,932	14,585
16	6,525	5,125	7,758	6,094	1,861	8,530	14,671	11,523	18,938	14,875
17	6,855	5,125	8,151	6,094	11,410	8,530	15,413	11,523	19,896	14,875
18	7,000	4,975	8,323	5,915	11,651	8,281	15,739	11,186	20,317	14,439
19	7,233	5,550	8,600	6,599	12,039	9,238	16,263	12,479	20,993	16,108
20	7,230	5,923	8,596	7,042	12,034	9,859	16,256	13,318	20,984	17,191
21	7,175	5,783	8,531	6,876	11,942	9,626	16,133	13,003	20,825	16,785
22	6,853	5,475	8,148	6,510	11,407	9,113	15,409	12,310	19,890	15,891
23	6,400	5,000	7,610	5,945	10,653	8,322	14,390	11,242	18,575	14,512
24	6,163	4,625	7,328	5,499	10,258	7,698	13,857	10,399	17,887	13,424
MAX.	7,233	5,923	8,600	7,042	12,039	9,859	16,263	13,318	20,993	17,191
MIN.	5,270	3,750	6,266	4,459	8,772	6,242	11,849	8,432	15,296	10,884

1995 Pump Energy			2000 Pump Energy			2005 Pump Energy			2010 Pump Energy		
Base	Peek-Base	Resauce	Base	Peek-Base	Resauce	Base	Peek-Base	Resauce	Base	Peek-Base	Resauce
7,400	742	700	11,300	1,979	1,900	13,500	909	900	17,500	1,247	1,200
7,400	890	700	11,300	2,187	1,900	13,500	1,190	900	17,500	1,609	1,200
7,400	1,134	700	11,300	2,528	1,900	13,500	1,651	900	17,500	2,204	1,200
7,400	1,063	700	11,300	2,428	1,900	13,500	1,516	900	17,500	2,030	1,200
7,400	742	700	11,300	1,979	1,900	13,500	909	900	17,500	1,247	1,200
7,400	385	350	11,300	1,480	1,900	13,500	234	250	17,500	376	400
7,400	-273		11,300	559	500	13,500	-1,009		17,500	-1,229	
7,400	-553		11,300	166		13,500	-1,540		17,500	-1,914	
7,400	-804		11,300	-185		13,500	-2,014		17,500	-2,527	
7,400	-900		11,300	-320		13,500	-2,196		17,500	-2,762	
7,400	-899		11,300	-318		13,500	-2,194		17,500	-2,759	
7,400	-487		11,300	260		13,500	-1,414		17,500	-1,752	
7,400	-358		11,300	439		13,500	-1,171		17,500	-1,438	
7,400	-311		11,300	506		13,500	-1,081		17,500	-1,322	
7,400	-356		11,300	443		13,500	-1,167		17,500	-1,432	
7,400	-358		11,300	439		13,500	-1,171		17,500	-1,438	
7,400	-751		11,300	-110		13,500	-1,913		17,500	-2,396	
7,400	-923		11,300	-351		13,500	-2,239		17,500	-2,817	
7,400	-1,200		11,300	-739		13,500	-2,763		17,500	-3,493	
7,400	-1,196		11,300	-734		13,500	-2,756		17,500	-3,484	
7,400	-1,131		11,300	-642		13,500	-2,633		17,500	-3,325	
7,400	-748		11,300	-107		13,500	-1,909		17,500	-2,390	
7,400	-210		11,300	647		13,500	-890		17,500	-1,075	
7,400	72		11,300	1,042		13,500	-357		17,500	-387	
	4,955	3,850		12,582	10,900		6,408	4,750		8,713	6,400
	-11,385	2,503		997	7,085		-30,418	3,088		-37,940	4,160
		5.5			6.0			5.3			5.3

5.2 Confirmation of the Power System Stability

The generator constants of the power generation facility in Maharashtra State was already acquired from MSEB. The power flow calculation and the simulation of power system stability were carried out using the power system constants of the transmission line and substation facility and the impedance model in Fig. 5.2-1. All the recommended sites for pumped storage power generation facilities were confirmed to present no problems regarding power system stability.

(1) Power Flow Calculation

As a basic case, the power flow was confirmed with the 1995 power system. Regarding the sections of 2000, 2005 and 2010, the power flow was assumed under the following conditions. The power flow in each section of 1995, 2000, 2005 and 2010 is shown in Fig 5.2-2 through Fig. 5.2-4.

Also in the study of flow during the pumping operation, the proportion between the peak value and the load during the pumping operation in the night was acquired from the daily load curve in 1993. The flow was then calculated by multiplying the following constants and the load.

1995 Projection Pmin ÷ Pmax = 6,266 MW ÷ 8,600 MW
= 0.729

- Regarding the power system load in 2000, 2005 and 2010, the load in the future power system was assumed as in the study of pumping resource by multiplying the growth ratio described in the Max. Demand Projection in Fig. 3.3-6.

- Regarding the power facilities up until 2003, the existing power development projects were applied. Due to a lack of data after 2003, the power system was formed by assuming a reinforcement of the existing thermal facilities and the flow application of the pumped storage power generation facility in this Master Plan. The power flow was calculated accordingly.

- Regarding the constants of the assumed power generation facility, the data in India was applied when the similar data was available. When unavailable, the standard value in Japan was applied.

- Regarding the transmission facility, the existing projects were also applied for the period up to 2003. After 2003, however, the existing transmission lines were reinforced where heavy power flow was expected, so that the flow calculation did not deviate from the allowable range. No new transmission line route was particularly assumed.

- Regarding the HVDC Transmission facility (±500kV, 1,500MW) between Chandrapur and Padge, operation is planned to start in 1997. The flow calculation was applied from the 2000 section and simply simulated with the load and power source.

- The voltage values were specified for the power flow calculation convergence, but the appropriate amount of reactive power compensators were provided irrespective of these values. The compensators were installed to the substation at the load side in the primary system (400 kV) as a basic concept. Transformer taps were applied when the volume was estimated as being small.

- The standard transformer taps in Japan were applied.

- The voltage allowable range of the power system was assumed at 400 kV = ±5%, and 230 kV = ±10%.

(2) Power System Stability Calculation

Regarding the 3 sections of 2000, 2005 and 2010, stability of the power system at the selected pumped storage power development sites was calculated under the following conditions and system stability was confirmed accordingly.

Fault type	:	3LG
Trip duration	:	6 cycle

Maharashtra Power System Diagram (1995 Base)

R+jX(Y/2) [% at 100 MVA Base]

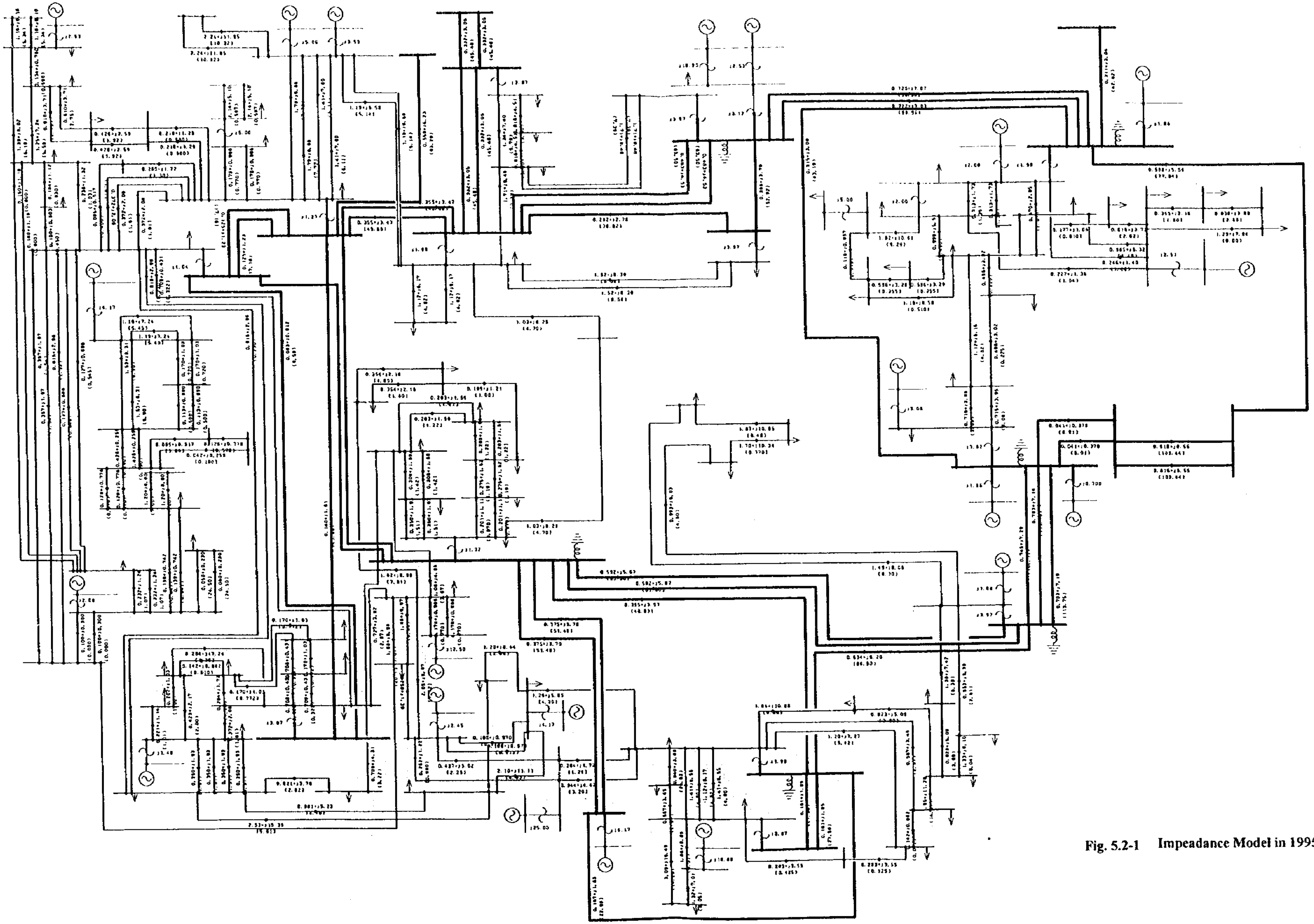

Fig. 5.2-1 Impeadance Model in 1995

Maharashtra Power System Diagram (1995 Base)

P+jQ [% at 100 MVA Base] V/θ [%/deg]
TOTAL PLOSS 252.10 QLOSS-1344.37

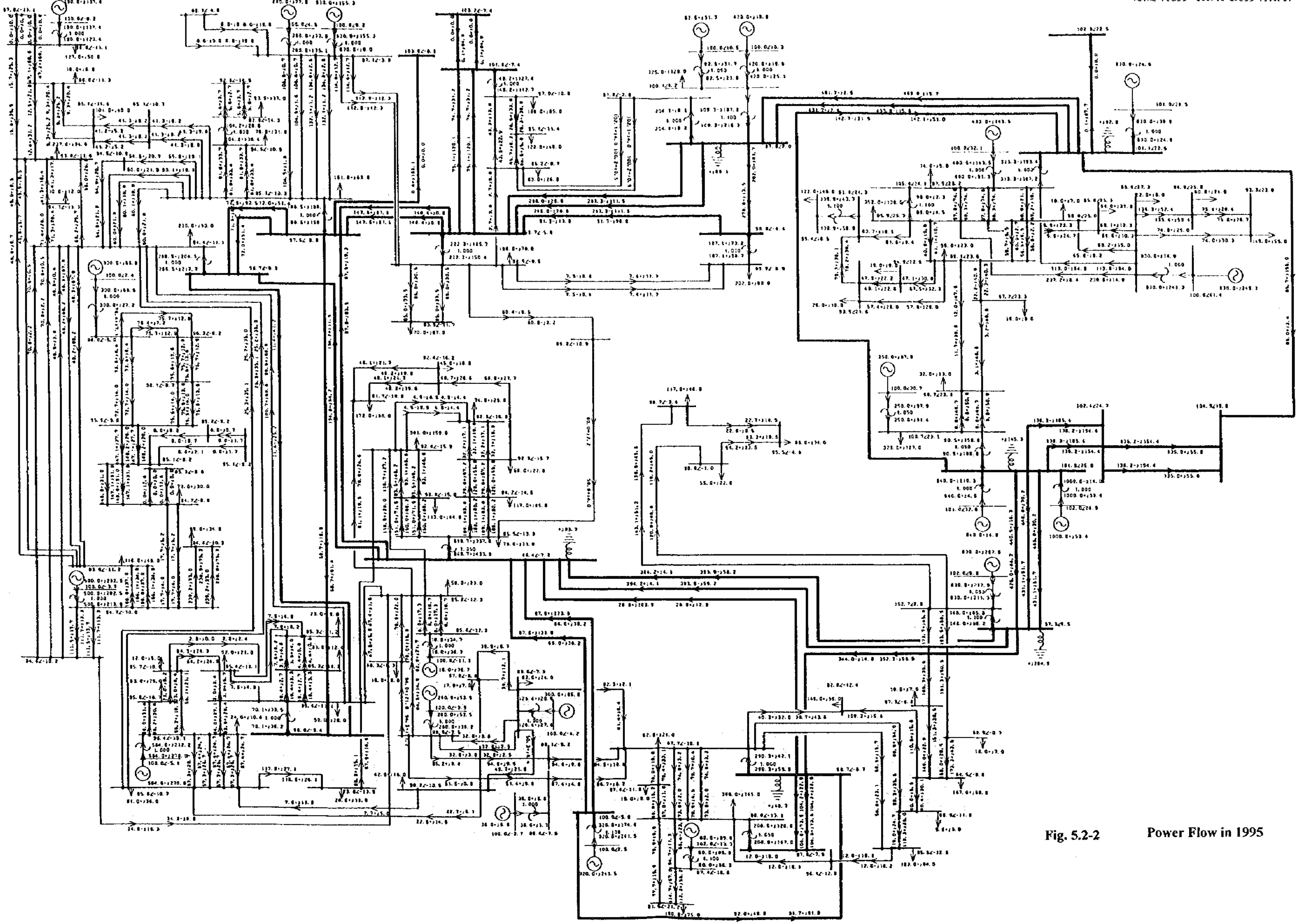

Fig. 5.2-2 **Power Flow in 1995**

Maharashtra Power System Diagram (2000 Base)

P+jQ (% at 100 MVA Base) V∠θ (%∠deg)
TOTAL PLOSS 364.65 QLOSS 346.18

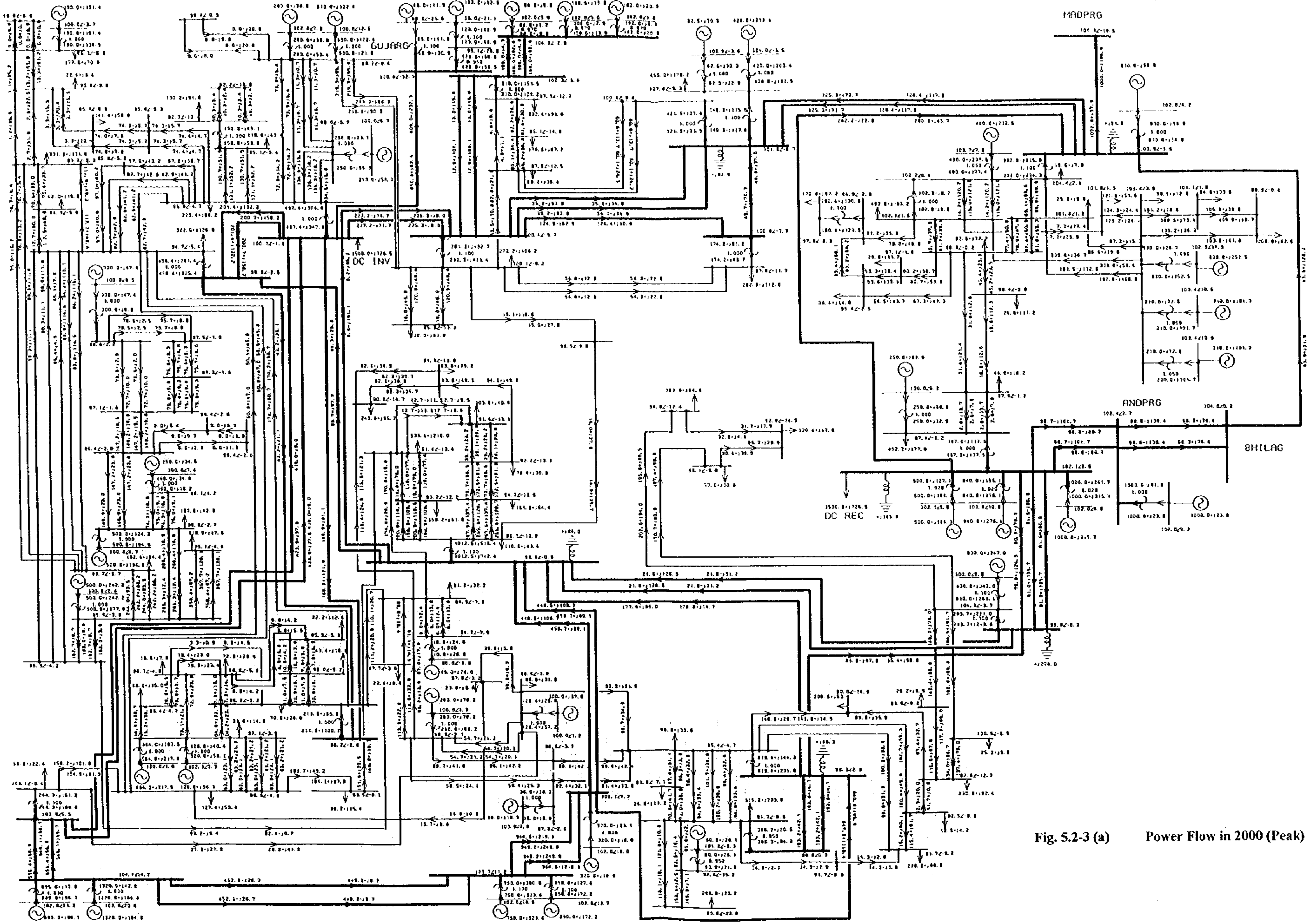

Fig. 5.2-3 (a) Power Flow in 2000 (Peak)

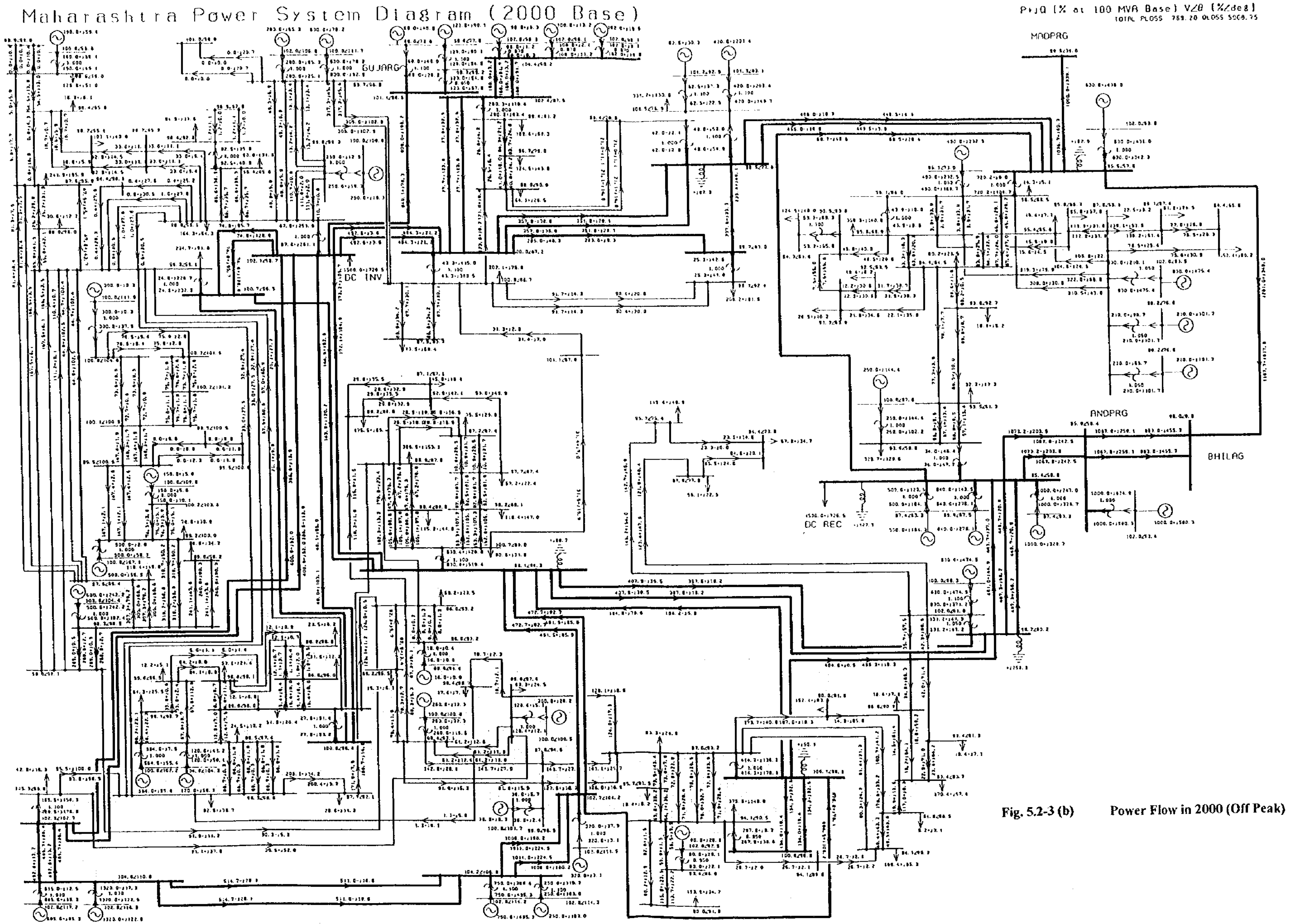

Fig. 5.2-3 (b) Power Flow in 2000 (Off Peak)

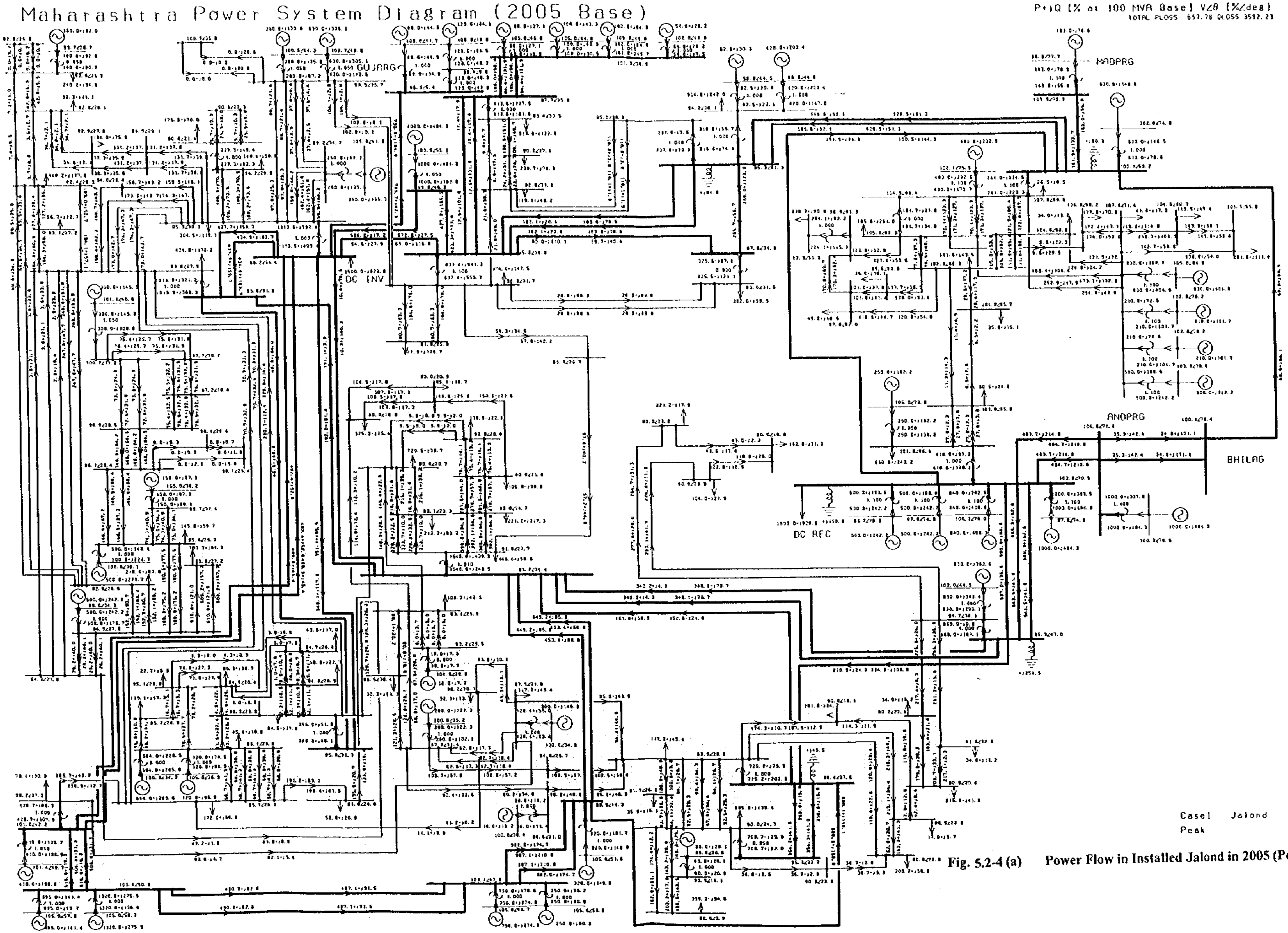

Fig. 5.2-4 (a) Power Flow in Installed Jalond in 2005 (Peak)

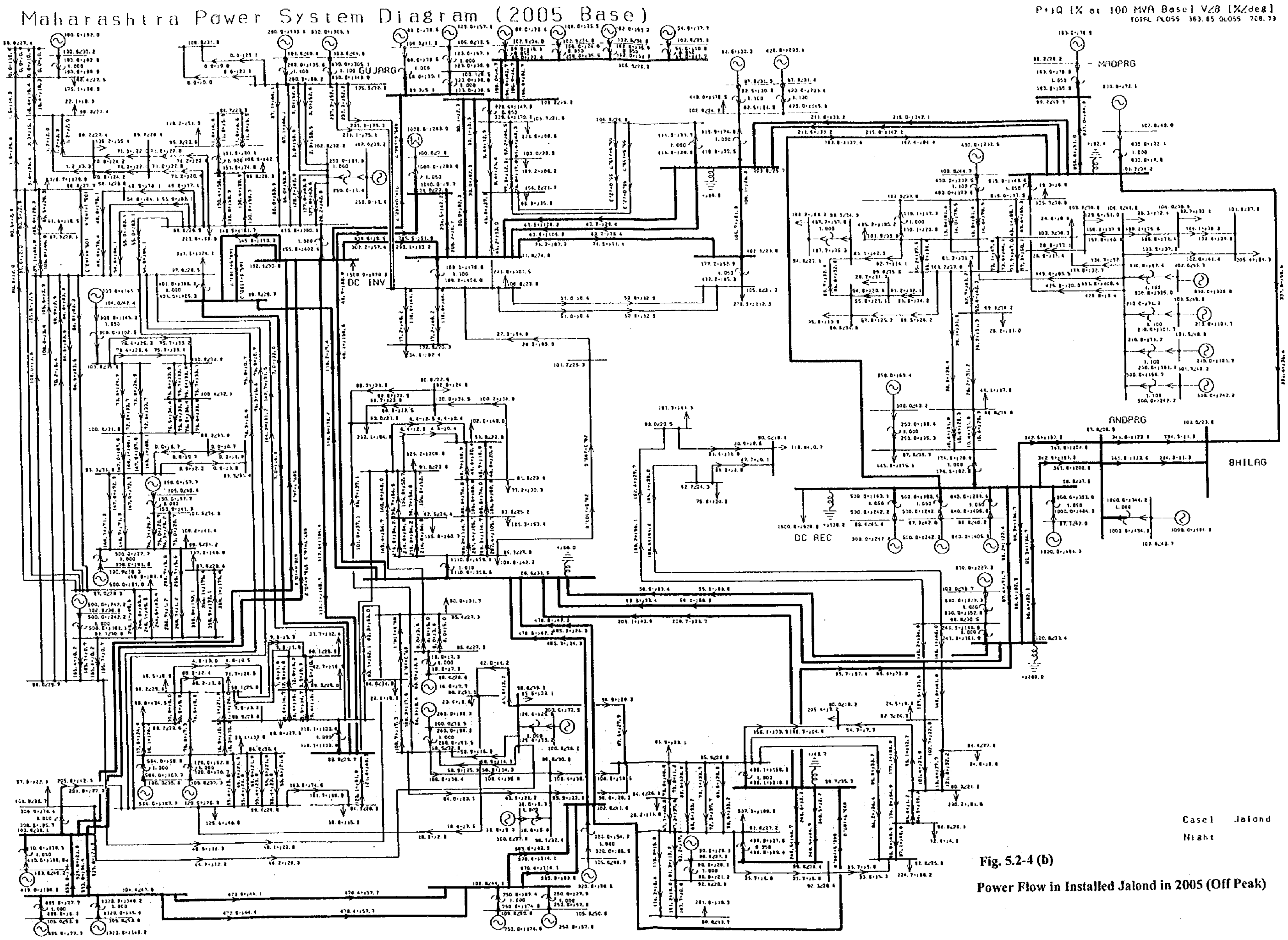

Fig. 5.2-4 (b)

Power Flow in Installed Jalond in 2005 (Off Peak)

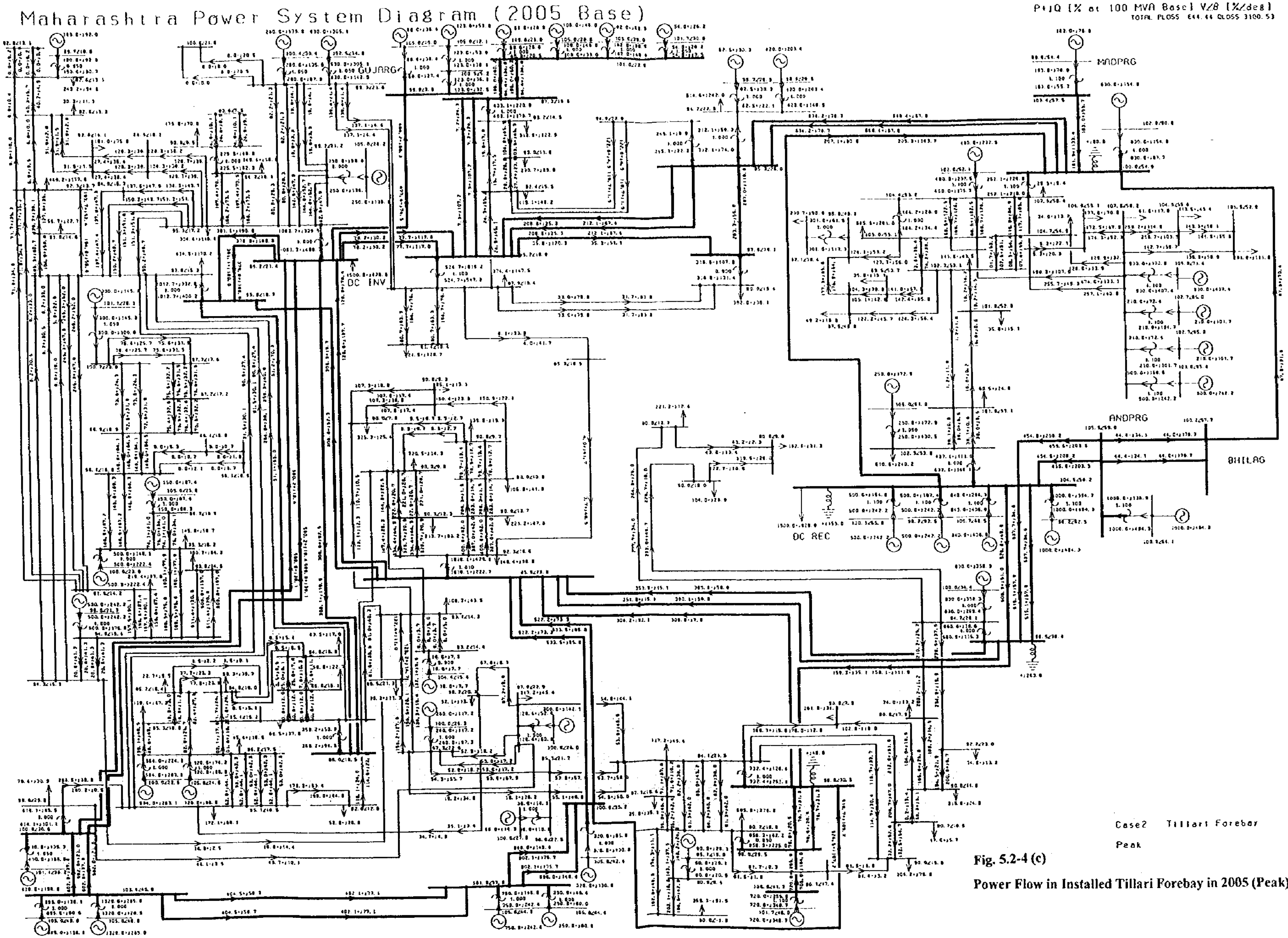

Fig. 5.2-4 (c)

Power Flow in Installed Tillari Forebay in 2005 (Peak)

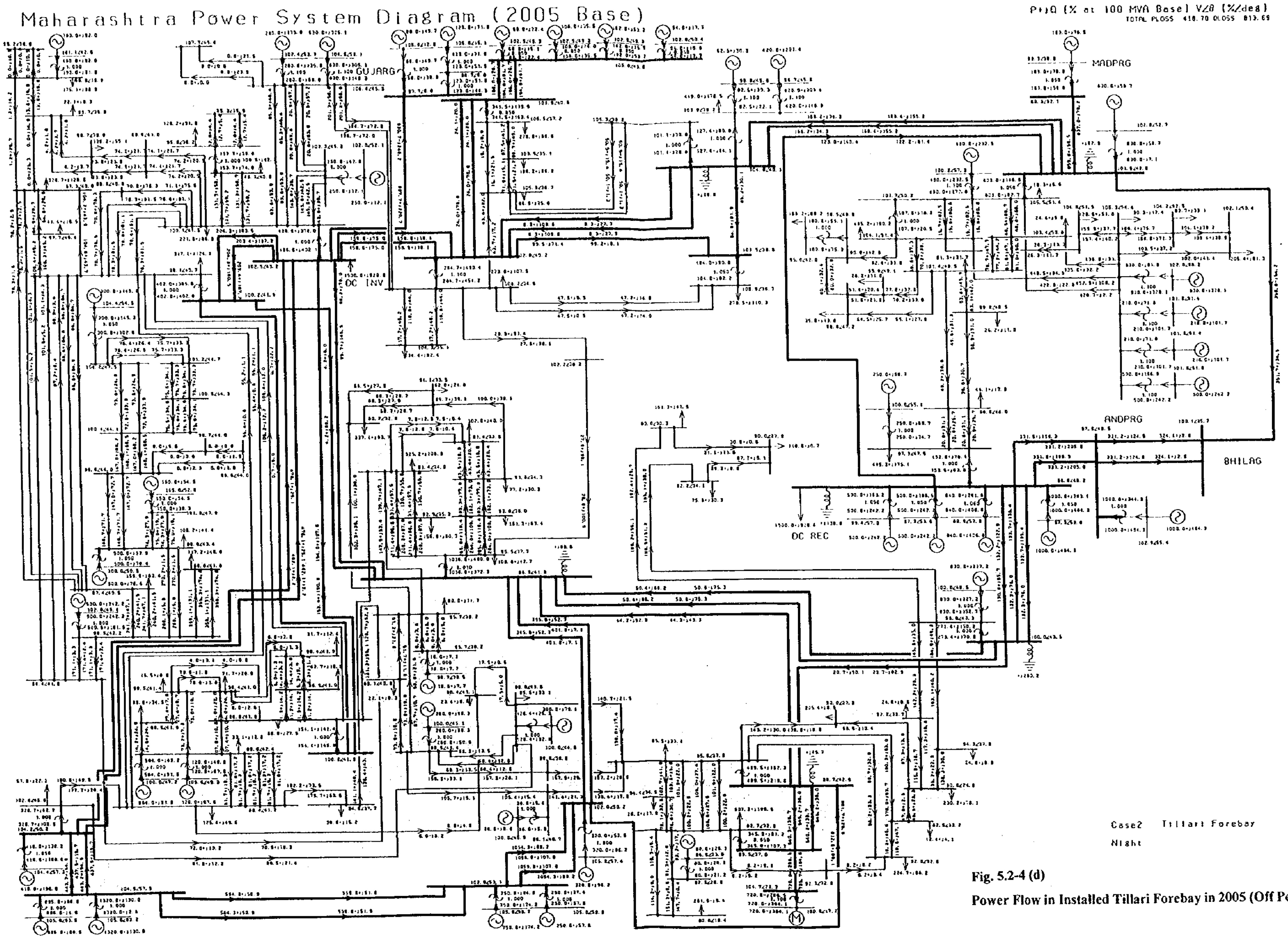

Fig. 5.2-4 (d)

Power Flow in Installed Tillari Forebay in 2005 (Off Peak)

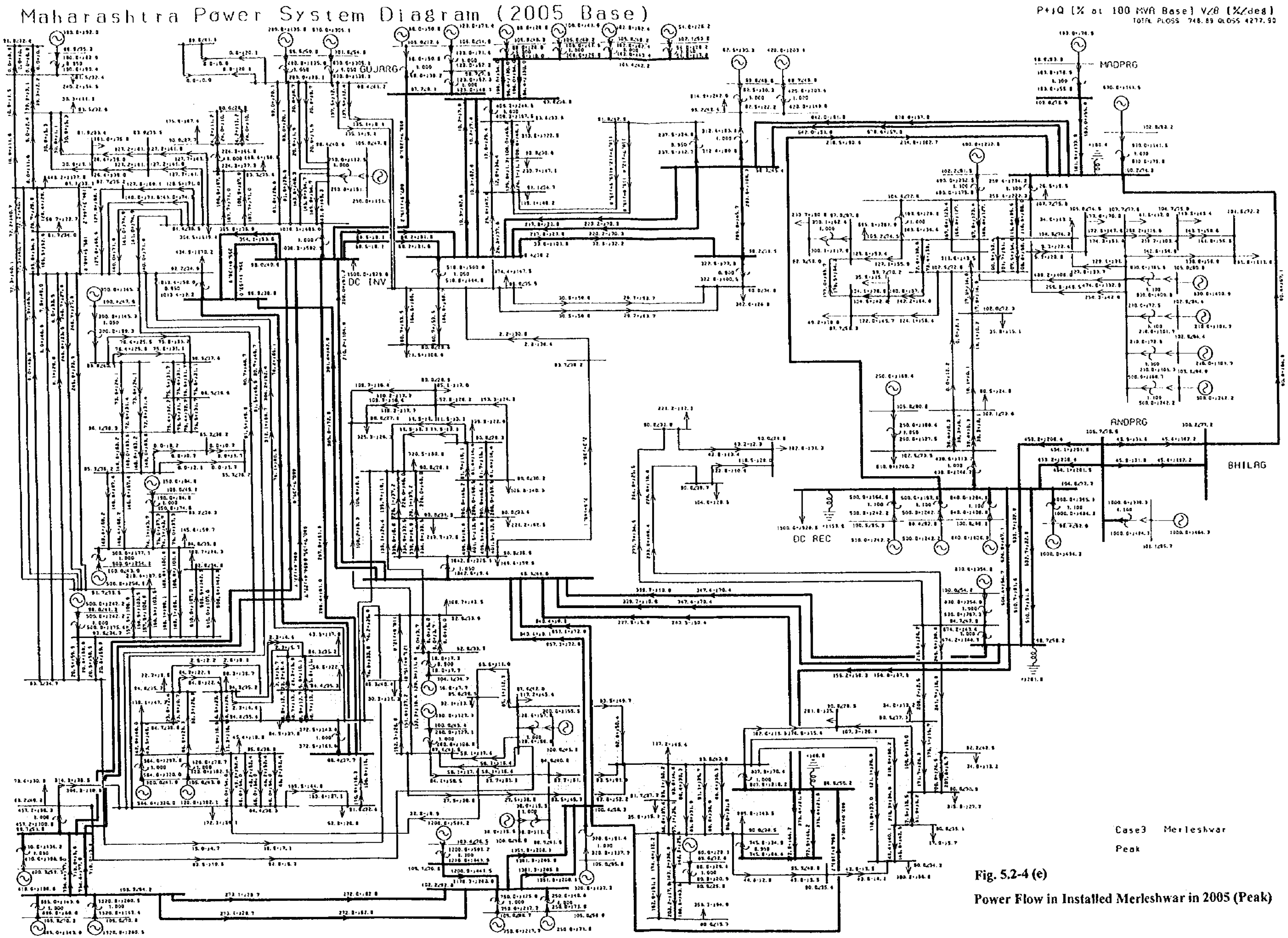

Fig. 5.2-4 (e)

Power Flow in Installed Merleshwar in 2005 (Peak)

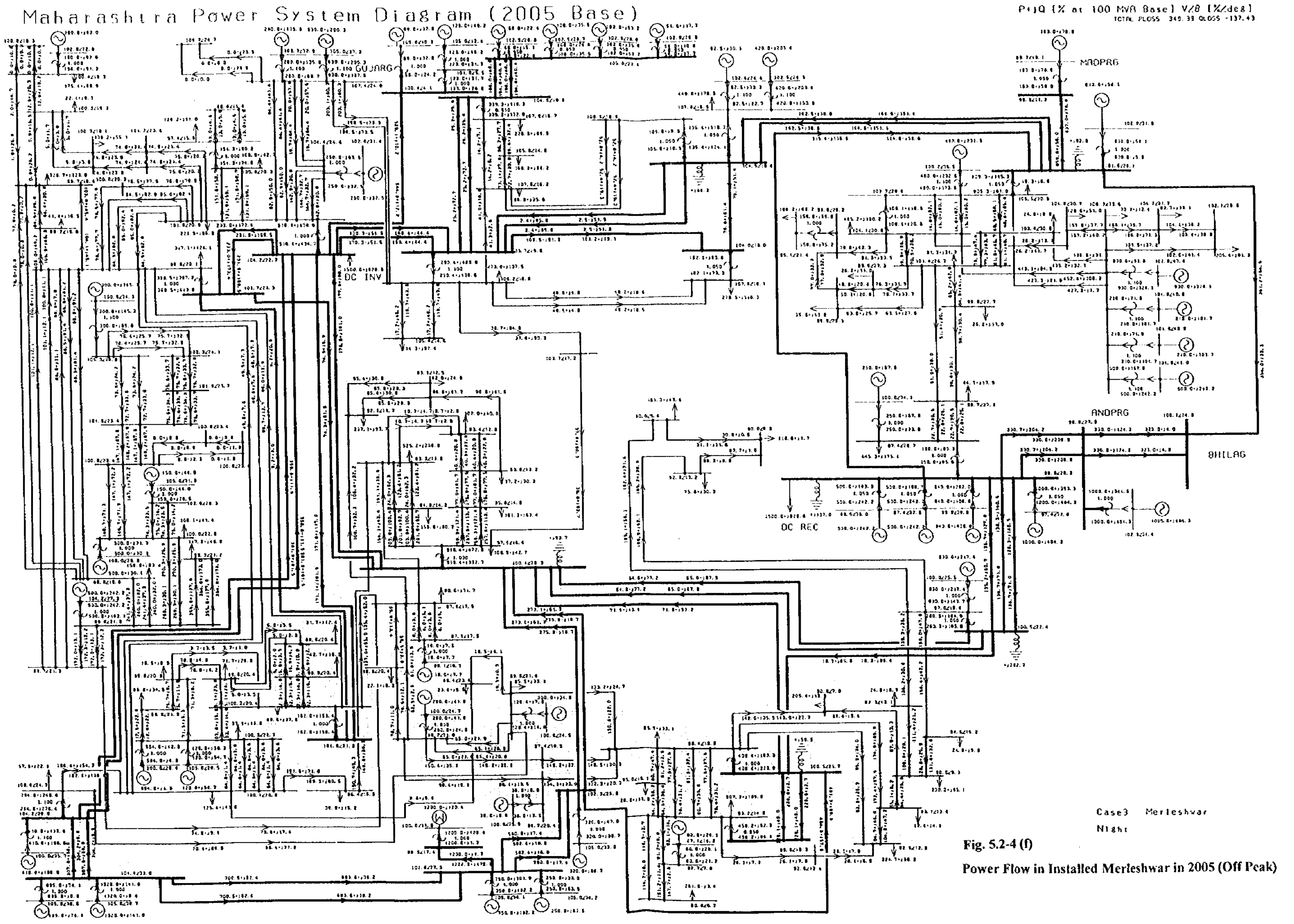

Fig. 5.2-4 (f)

Power Flow in Installed Merleshwar in 2005 (Off Peak)

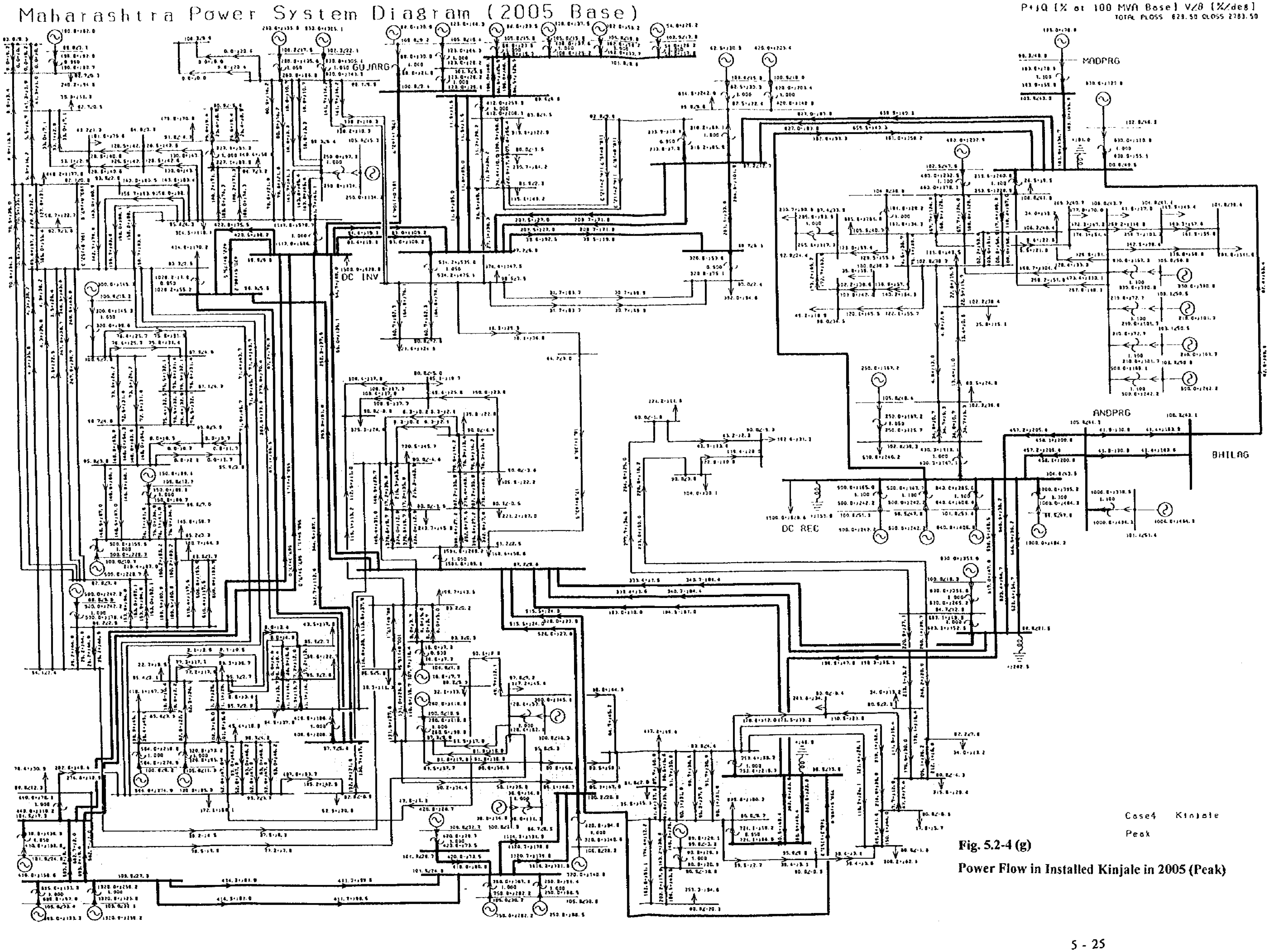

Fig. 5.2-4 (g)

Power Flow in Installed Kinjale in 2005 (Peak)

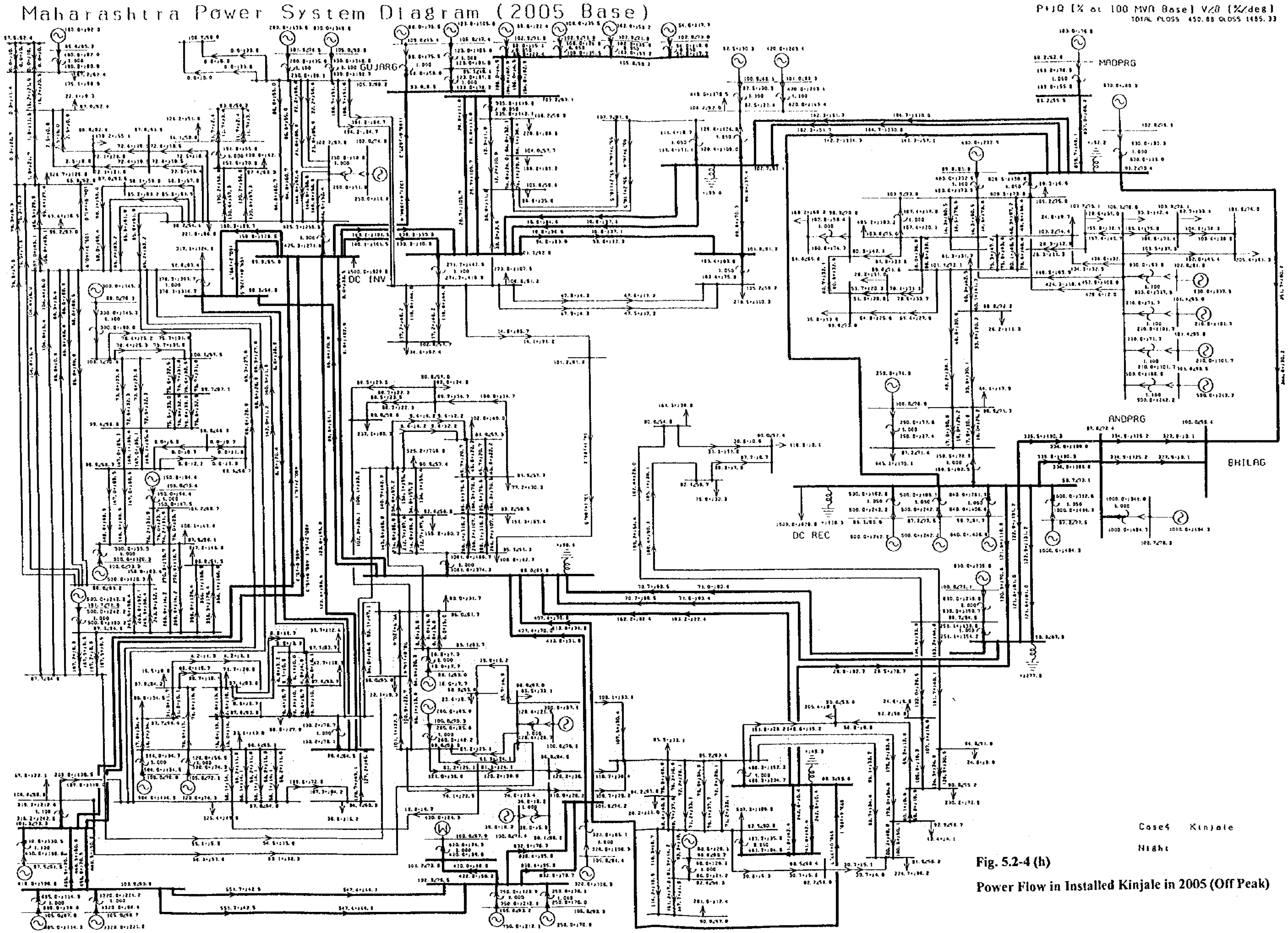

Fig. 5.2-4 (h)

Power Flow in Installed Kinjale in 2005 (Off Peak)

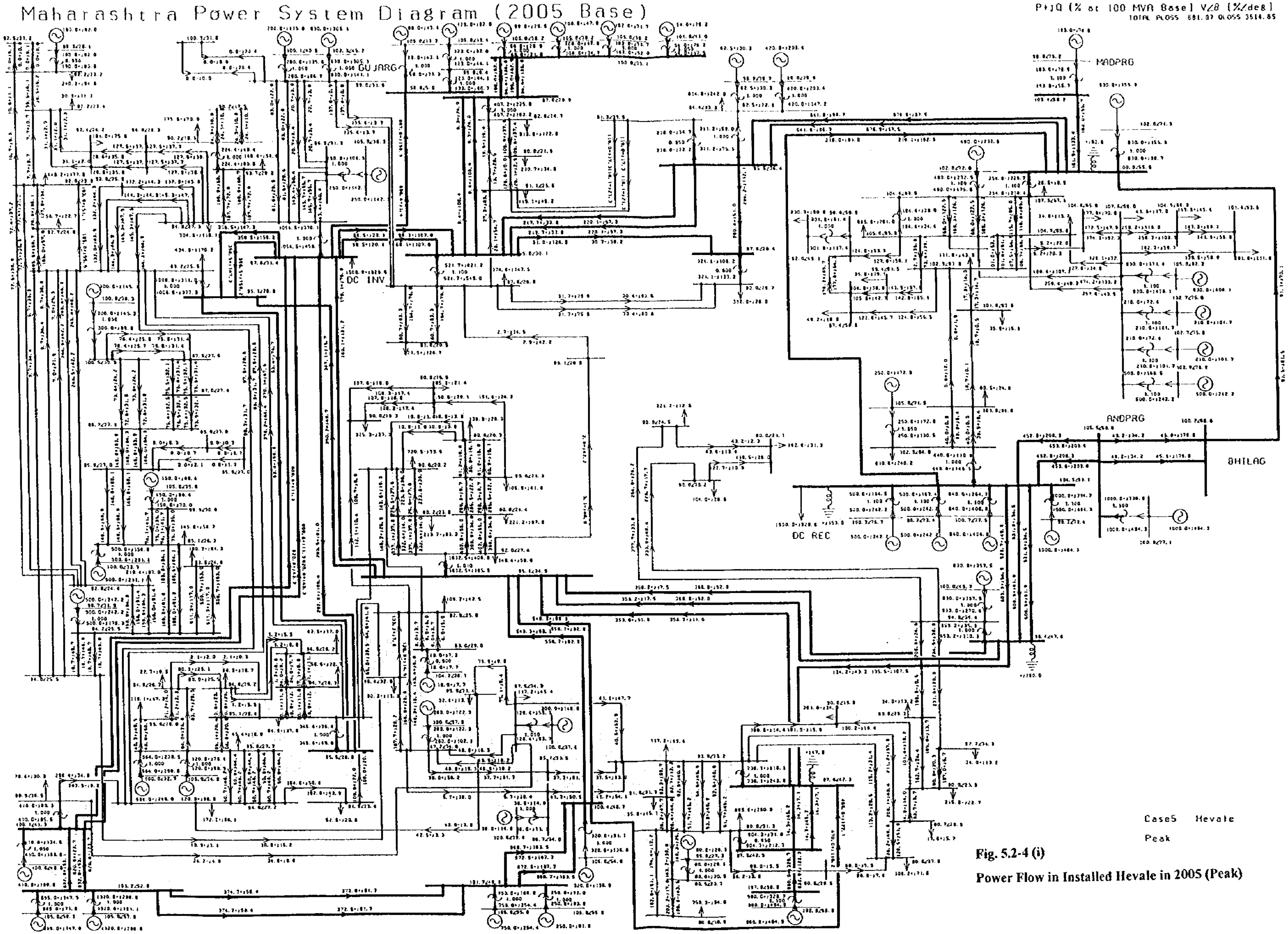

Fig. 5.2-4 (i)

Power Flow in Installed Hevale in 2005 (Peak)

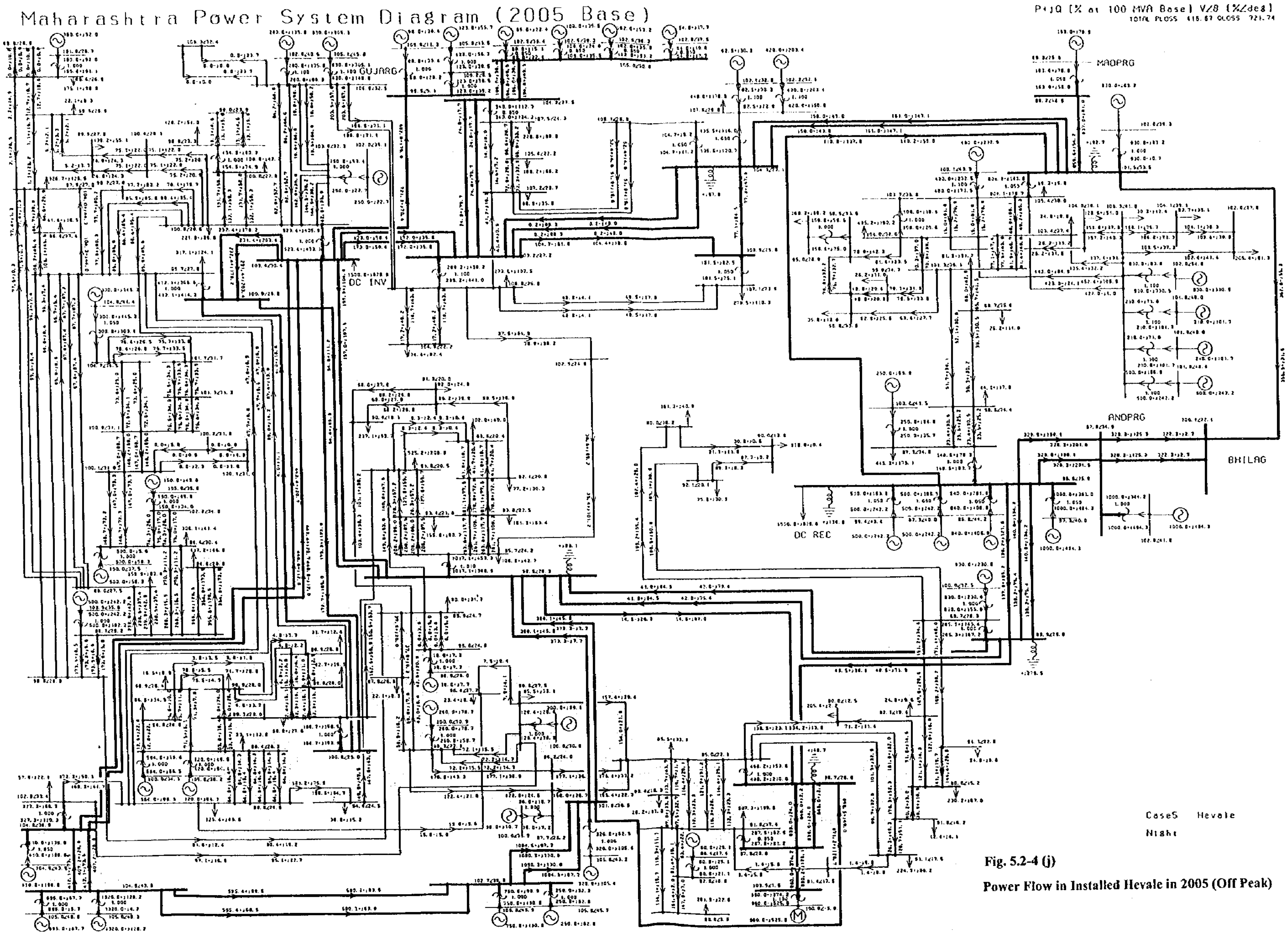

Fig. 5.2-4 (j)

Power Flow in Installed Hevale in 2005 (Off Peak)

CHAPTER 6 SELECTION OF PRIORITY PROJECTS

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CHAPTER 6 SELECTION OF PRIORITY PROJECTS

6.1 Primary Inventory Study

6.1.1 General

The JICA Study Team commenced the primary inventory study after starting the first site survey. The procedure and result of the study are described hereinafter.

6.1.2 Procedure for Formulation of Scheme

The Study Team confirmed the locations of upper and lower dams of 23 schemes which had been identified by GOMID on the topographical sheets with the counter part from GOMID during the first site survey.

The Study Team received the Pre-investigation Study (PIS) Report of 23 schemes prepared by GOMID.

Also the Study Team identified fresh pumped storage power schemes other than 23 schemes identified by GOMID using topographical maps. The Study Team gave his attention on the hill top reservoir type pumped storage scheme which had not been included in 23 schemes, for identification of scheme.

Alternative schemes have been formulated by the following procedure.
Flow chart of procedure is shown in **Fig. 6.1-1.**

(1) The optimum upper/lower reservoir dam axis for the 23 sites identified by GOMID were confirmed on the topo sheets.

Apart from the above 23 sites above, the JICA Study Team selected nine other locations as an alternative scheme without diversion of the river basin.

This includes the hill top reservoir type.

(2) The catchment areas for the upper and lower reservoir dams was measured using a digital planimeter.

(3) The relation between the reservoir capacity and water level of reservoir was determined by measuring the surface area for every 20 m counter of reservoir.

(4) The sedimentation capacity over a hundred years was established from the river bed. Used as a rate of sedimentation was a value of 1.4 acres · ft./sq. miles/year (668 m^3/km^2/year) which was obtained by the hydrological study (Chapter 11)

(5) In view of the structure of the intake from the above (4) sedimentation level, the MDDL was set above 9 - 10 m.

(6) The FRL was determined by taking into consideration the topographical conditions in the reservoir, with the draw-down being less than 30m considering slope stability of reservoir.

(7) The water storage capacity between FRL and MDDL was the effective storage capacity.

(8) An amount was secured above the FRL to provide for a 3 m evaporative water loss, by allowing for an evaporation rate of 5.56 mm/day. In addition to this, a 4 m free board was installed on this. Consequently, the dam's crest level was at 7m above the FRL.

(9) Power generation was operative from Monday through Saturday (6 days). No power generation was operative on Sundays. Pumping-up operations was possible for 5.5 hours both on weekdays and weekends (7 days). Consequently, the water level of the upper reservoir was rise from MDDL to FRL after 11 hours' pumping-up operation in total in the Saturday and Sunday night periods. At the same time, the water level of the lower reservoir was drop from FRL to MDDL. Consequently, the pumped-up discharge could be obtained by dividing the effective water storage capacity by 11 hours.

(10) Based on the results obtained with the pump turbine/motor-generator facilities in the past, the pumped-up discharge was taken as being 85% of the power-generating discharge, and the pumped-up discharge determined in (9) above was divided by 0.85 to obtain the power-generating discharge.

(11) The Standard Intake Level (SIL) and Standard Tailrace Level (STL) was calculated by the formulae below to determine the gross head.

SIL = (FRL (U/R) +1.5 m* - MDDL (U/R)) x 2/3 + MDDL (U/R)

STL = (FRL (L/R) +1.5 m* - MDDL (L/R)) x 2/3 + MDDL (L/R)

Gross head = SIL - STL

*1.5 m = 1/2 x Evaporation loss (3 m)

(12) Based on the results of the past, the effective head was determined by taking the head loss as being 8% of the gross head.

(13) On the basis of the results of the past, the efficiency of the pump turbine/motor-generator facilities was taken as being 85%.

(14) The installed capacity was determined using the following calculation formula.

(15) P = 9.8 x Qp x He x eta = 9.8 x Qp x He x 0.85
eta = Total compounded efficiency of the turbine and power generator.

(16) A unit capacity was taken as being in the range from 200 MW - 250 MW, and the number of units was determined, accordingly. The basic principle was to have an even number of generators.

6.1.3 Concept of Project Layout

(1) Location of Dam

Location of dams of 23 schemes had been already set up based on the 'PIS Report' prepared by GOMID and the Study Team identified 9 project sites on the basis of the topographical maps including the hill top reservoir type schemes.

The Study Team revised the 23 schemes planned by GOMID to make secure as large reservoir capacity as possible taking into consideration of the geographical, geological and environmental conditions at the sites for enlargement of the installed capacity under the experiences and knowledges of the dam planning technology accumulated by the Study Team using the topographical maps.

9 schemes identified by the Study Team were also planned based on the same concept as the above-mentioned manner.

As for type of dam, masonry or rockfill dam type is to be adopted depend upon the site conditions.

(2) Waterway System and Other Structures

The intake and tailrace outlet structures were planned in the vicinity of the dam sites to prevent an affection of sedimentation and in case of the thin overburdern area for the headrace and tailrace tunnels, the morning glory or the inclined type intake and outlet structures were adopted to deepen the overburden for stabilizing the tunnel structures.

The waterway route was layouted strictly considering the geographical features of the topographical map and the location of powerhouse to get as short and smooth as possible in order to make minimize the head loss and to decrease the construction cost. The inclined penstock tunnel was kept at 45° to make fail down smoothly the excavated material. As for the headrace and tailrace surge tanks were generally provided in case of those lengths being more than 1,000 m.

All of the powerhouse was provided in the underground to secure sufficient draft head and located as near as possible to the lower reservoir side considering the layout of the waterway system too for minimizing the construction cost of it and the related underground structures.

The access road length to the project site was assumed looking into the topographical map. The access tunnel to the powerhouse was layouted as short as possible with gradient less than 1:10 and the switchyard was selected at the flat area and connected with the transformer room usually adopting the inclined tunnel

6.1.4 Estimation of Quantities

The method of estimation of quantities of main structures to be erected is shown in **Table 6.1-1.** Essentially, these quantities have been determined by systematically processing the data for the relationship of the construction quantities resulting from pumped storage power projects of the past and the essential parameters (salient features) concerned.

6.1.5 Unit Rate

For the unit rate for the main construction work, we used the rate given by GOMID for civil works. In the calculations we took the indirect costs as being 25% of the direct costs.

As for electromechanical equipment, unit cost per kW of reversible turbine and generator in 1994 in Japan was applied.

Unit rate of civil works is as shown **Table 6.1-2**.

6.1.6 Project Cost

The project cost has been calculated in accordance with the cost calculation method generally adopted in the Master Plan Stage as shown in **Table 6.1-3**.

6.1.7 Preliminary Economic Evaluation

We have calculated the construction costs per kW and classified the results into A, B and C in the order of low-price effectiveness.

A ≤ Rs 25,000,
Rs 25,000 < B ≤ Rs, 30,000,
C > Rs 30,0900

On the whole, the results show that the Kundi location is the most economic one. Among the plans without diversion of the river basin, Marleshwar is the most economical one. The preliminary economic evaluation is shown in **Table 6.1-4**.

6.1.8 Conclusion of Primary Inventory

32 schemes were planned and examined at the primary inventory stage. As for Morwadi scheme, the upper dam site was located at the backwater of the Koyna reservoir. There would not be access rout except using boat to reach the upper dam site. Therefore, it was concluded that the construction of the project would be impossible economical point of view.

As for Tillariwadi scheme prepared by GOMID, the scheme had only 58 m effective head i.e. extremely low head and also 60 Mw i.e. small installed capacity as pumped storage power project. Therefore, it was concluded that this scheme would not be economical project and not contribute an improvement of power network operation of Maharashtra State either.

The Study Team defined 1) Marleshwar, 2) Savitri, 3) Kundi, 4) Valvande and 5) Tillari Forebay, as the targets for site reconnaissance based on the results of Primary Inventory.

However, upper reservoirs of Savitri, Kundi are located in Krishna river basin and lower reservoirs are located in Western flow river basin and will create a water right issues against other states. The other

Site selection (1/50,000 map)

↓

Dam axis (U/D, L/D) selection (1/50,000 map)

↓

Measuring catchment area (1/50,000 map)

↓

Measuring and calculating reservoir capacity

↓

Preserving sedimentation capacity for 100 years from river bed
$668m^3/km^2/year$

↓

Setting up M.D.D.L. (9~10m from Dead Water Level
taking into consideration intake structure/tailrace structure)

↓

Setting up F.R.L (Draw Down ≤ 30 m)

↓

Calculating effective reservoir capacity V_e

↓

Setting up dam crest level
F.R.L. + 3 m (Evaporation) + 4 m (Free board)

↓

Calculating pumping discharge $Q_p = V_e/11$ hrs/3,600 sec.
11 hr - Saterday and Sunday

↓

Calculating generating discharge $Q_g = Q_p/0.85$

↓

Calculating gross head: H_g
(F.R.L, U/R + 1.5 m - M.D.D.L., U/R) x 2/3 + M.D.D.L, U/R] -
{(F.R.L, L/R+ 1.5 m - M.D.D.L) x 2/3 + M.D.D.L, L/R}

↓

Calculating effective head
$H_e = H_g \times 0.92$

↓

Calculating Installed capacity
$P = 9.8 \times 0.85 \times Q_g \times H_e$

Fig. 6.1-1 Formulation of Schemes

Table 6.1-1 Method of Estimation of Quantities (1/3)

Part	Section	Works	Items	Parameter	Method
I. Civil	Dam	Dam	Excavation Masonry	H_d, L H_d, L, B	Diagram Diagram
	Water Way	Intake	Excavation Concrete Reinforcement	H_a, D, n, Q H_a, D, n, Q H_a, D, n, Q	Diagram Diagram Diagram
		HeadraceTunnel	Excavation Concrete Reinforcement		Velocity=5m/se, Lining=D/10. Payline 15 cm Calculation (Theoretical Vol.)x1.40 0.06t/concrete volume
		Penstock	Excavation Concrete		Same as power tunnel Thickness=60 cm
		Surge tank (Headrace Tunnel)	Excavation Concrete Reinforcement	Q, H_a, L_t Q, H_a, L_t Concrete Volume	Diagram Diagram Diagram

H_d: Height of Dam; B: Bottom Length; Q: Discharge; D: Headrace Tunnel Diameter
L: Crest Length; H_a: Drawdown; L_t: Length of Power Tunnel; n: number of T/G

Table 6.1-1 Method of Estimation of Quantities (2/3)

Part	Section	Works	Items	Parameter	Method
		Surge tank (Tailrace)	Excavation Concrete Reinforcement	Q_p, H_s, L_{tt}. Q_p, H_s, L_{tt}. Concrete Volue	Diagram Diagram Diagram
		Tailrace Tunnel	Excavation Concrete Reinforcement	Same as head-race tunnel Same as head-race tunnel Same as head-race tunnel	V=4 m/sec. or 5 m/sec., Lining D/10 Payline 15 cm
		Tailrace Outlet	Excavation Concrete Reinforcement	H_a, D n, Q H_a, D, n, Q H_a, D, n, Q	Diagram Diagram Diagram
	Power House	Foundation	Excavation Concrete Reinforcement	Q, H_c, n Q, H_c, n Concrete Volume	Diagram Diagram Diagram
		Cable Tunnel	Excavation Concrete Reinforcement	D=3.6m, t=40m D=3.6m, t=40m	Calculation Calculation 0.04t/m^3

Q_p: Pumping Discharge L_{tt}: Tailrace Tunnel Length H_s: Draft Head D_t: Tailrace Tunnel Diameter

Table 6.1-1 Method of Estimation of Quantities (3/3)

Part	Section	Works	Items	Parameter	Method
		Access Tunnel	Excavation	D=6.2m, t=50cm	Calculation
			Concrete	D=6.2m, t=50cm	Calculation
			Reinforcement		$0.04 t/m^3$
Preparation Work	Access road		Excavation		Rock Exc.= $45 m^3/m$ Comm. Exc.= $20 m^3/m$
Hydraulic Equipment	Intake	Gate		Q_g D_p H_{ua}	Diagram
		Trashrach		Q_g D_p H_{ua}	Diagram
	Tailrace	Gate		Q_g D_p H_{ua}	Diagram
		Trashrack		Q_g D_p H_{ua}	Diagram
	Draft	Gate		D_d H_s	Diagram
	Penstock	Steel Pipe		Q, H_c L_p n	Diagram

D_d: Draft Tube Diameter

Table 6.1-2 Unit Rate Structure

	Unit	Basic Rate	Indirect Cost	Total
Excavation	Rs/m^3			
Common Excavation	Rs/m^3	35	10	45
Rock Excavation	Rs/m^3	125	45	160
Tunnel Excavation	Rs/m^3	500	130	630
Penstock Excavation	Rs/m^3	900	25	1,125
Under ground	Rs/m^3	450	115	565
Embankment				
Rock Embankment	Rs/m^3	120	30	150
Filter Embankment	Rs/m^3	350	90	440
Core Embankment	Rs/m^3	65	20	85
Concrete				
Mass Concrete	Rs/m^3	1,000	250	1,250
Open Concrete	Rs/m^3	1,200	300	1,500
Lining Concrete	Rs/m^3	1,600	400	2,000
Foundation Concrete	Rs/m^3	900	225	1,125
Plug Concrete in Tunnel	Rs/m^3	1,100	275	1,375
Masonry				
UCR masonry	Rs/m^3	650	165	815
Colg. Masonry	Rs/m^3	1,200	300	1,500
Steel bar reinforcement	Rs/ton	18,00	4,500	22,500
Hydraulic equipment				
Gate	Rs/t	75,000	18,750	93,750
Penstock	Rs/t	70,000	17,500	87,500
Trashrack	Rs/t	65,000	16,250	81,250
Compensation	Rs/ha			60,000

ha: Submergency area

Table 6.1-3 Structure of Project Cost (1/4)

Works	Location	Category	Item	Remarks
I. Civil Works				
	1. Upper Dam	(1) Care of River		(2)x10%
		(2) Dam	(a) Excavation	Rock exc., 70%, Common exc. 30%
			(b) Masonry	
			(c) Others	{(a)+(b)}x20%
		(3) Miscellaneous		{(1)+(2)}x4%
	2. Lower Dam	(1) Care of River		(2)x10%
		(2) Dam	(a) Excavation	Rock exc.: 70%, Common exc. 30%
			(b) Masonry	
			(c) Others	{(a)+(b)}x20%
	3. Waterway	(1) Intake	(a) Excavation	
			(b) Concrete	
			(c) Reinforcement	
			(d) Others	{(a)+(b)+(c)}x25%

Table 6.1-3 Structure of Project Cost (2/4)

Works	Location	Category	Item	Remarks
		(2) Headrace Tunnel	(a) Tunnel Excavation (b) Lining Concrete (c) Reinforcement (d) Others	{(a)+(b)+(c)}x20%
		(3) Surge Tank(H.T.)	(a) Shaft Excavation (b) Lining Concrete (c) Reinforcement (d) Others	{(a)+(b)+(c)}x25%
		(4) Penstock	(a) Penstock Excavation (b) Plug Concrete (c) Others	{(a)+(b)}x20%
		(5) Surge Tank (T.T.)	(a) Shaft Excavation (b) Lining Concrete (c) Reinforcement (d) Others	{(a)+(b)+(c)}x25%
		(6) Tailrace Tunnel	(a) Tunnel Excavation (b) Lining Concrete (c) Reinforcement (d) Others	{(A)+(B)+(c)}x20%

Table 6.1-3 Structure of Project Cost (3/4)

Works	Location	Category	Item	Remarks
		(7) Tailrace outlet	(a) Excavation (b) Concrete (c) Reinforcement (d) Others	{(a)+(b)+(c)}x20%
		(8) Miscellaneous		{(1)+(2)+(3)+(4)+(5)+(6)+(7)}x5%
	4. Powerhouse and Switch Yard	(1) Power house foundation and structure	(a) Underground excavation (b) Lining Concrete (c) Reinforcement (d) Others	{(a)+(b)+(c)}x20%
		(2) Power house building		(1)x30%
		(3) Cable Tunnel		
			(a) Excavation (b) Lining Concrete (c) Reinforcement (d) Others	{(a)+(b)+(c)}x20%
		(4) Access Tunnel	(a) Excavation (b) Lining Concrete (c) Reinforcement (d) Others	{(a)+(b)+(c)}x20%

Table 6.1-3 Structure of Project Cost (4/4)

Works	Location	Category	Item	Remarks
		(5) Miscellaneous		{(1)+(2)+(3)+(4)}x5%
II. Preparation Work				
		(1) Access road	(a) Excavation	
		(2) Preparation Works		(1+2+3+4)x20%
III. Contingency				(I + II)x10%
IV. Hydraulic Equipment				
		(1) Intake Gate		
		(2) Tailrace Gate		
		(3) Draft Gate		
		(4) Penstock		
		(5) Intake Trashrack		
		(6) Tailrace Trashrack		
V. Electromechanical Equipment				
VI. Transmission Line			Transmission Line	
VII. Administration Cost				(I +II+III+IV+V+VI) x15%
VIII. Compensation				
IX. Total				I+II+III+IV+V+VI+VII+VIII

Table 6.1-4 Outline of Project (1/2)

Items		Unit	1 Ulhas	2 Sidgarh	3 Amba	4 Pinjal	5 Kongadi	6 Kalu	7 Jalond	8 Kolman-pada	9 Chornai	10 Savitri	11 Madhali-wadi	12 Vaitarni	13 Morawadi	14 Gadgadi	15 Aruna	16 Kharari
Installed Capacity		MW	600	350	500	30	160	300	1,000	250	480	1,000	500	360		200	440	420
Unit Capacity		MW	150	175	250	30	160	150	250	125	240	250	250	180		100	220	210
Number of Units		unit	4	2	2	1	1	2	4	2	2	4	2	2		2	2	2
Upper	Catchment Area	km^2	6.68	1.00	6.21	2.85	2.45	3.10	20.68	3.38	2.83	5.51	2.68	1.28		0.78	4.78	3.22
Upper	Surface Area	km^2	1.27	0.20	0.47	0.07	0.99	0.54	1.78	0.35	0.85	0.40	0.33	0.25		0.35	0.27	0.52
Upper	Crest Elevation	EL.m	680	906	698	367	590	863	865	828	782	908	683	680		820	882	809
Upper	F.R.L	EL.m	676	902	694	363	586	859	861	824	778	904	679	676		816	878	805
Upper	M.D.D.L	EL.m	670	886	674	349	576	848	850	810	765	874	649	664		786	850	792
Upper	Drawdown	m	6	16	20	14	10	11	11	14	13	30	30	12		30	28	13
Upper	Sedimation Level	EL.m	661	877	665	340	570	839	841	801	756	865	640	655		766	841	783
Upper	Gross Reservoir Capacity	10^6m^3	12.29	2.75	6.65	3.15	5.20	6.09	21.30	4.56	8.50	9.97	6.42	2.52		1.98	5.17	6.11
Upper	Generating Reservoir Capacity	10^6m^3	4.80	2.20	4.28	1.34	2.50	2.50	7.50	2.36	4.55	6.50	4.80	3.36		1.34	3.28	2.94
Upper	Dam Height	m	45	36	58	37	35	48	45	43	32	49	50	35		50	52	37
Upper	Dam Crest Length	m	960	550	320	450	550	550	500	650	600	500	550	450		500	450	450
Lower	Catchment Area	km^2	4.56	0.92	7.99	32.11	5.48	2.71	3.43	3.31	2.48	7.41	6.79	9.61		13.92	2.82	9.12
Lower	Surface Area	km^2	0.26	0.14	0.23	1.04	0.27	0.15	0.55	0.17	0.46	0.47	0.60	0.38		0.49	0.23	0.25
Lower	Crest Elevation	EL.m	142	263	162	237	299	326	297	385	324	278	173	218		182	300	200
Lower	F.R.L	EL.m	138	259	158	233	295	322	293	381	320	274	169	215		178	296	196
Lower	M.D.D.L	EL.m	108	229	128	228	282	292	263	351	302	249	150	195		171	267	174
Lower	Drowdown	m	30	30	30	7	13	30	30	30	18	25	19	20		7	29	22
Lower	Sedimation Level	EL.m	99	220	119	219	273	283	254	342	293	240	141	186		162	258	165
Lower	Gross Reservoir Capacity	10^6m^3	6.35	2.94	6.14	12.75	3.38	3.32	40.74	3.44	6.03	9.52	8.60	5.94		5.85	4.58	4.82
Lower	Generating Reservoir Capacity	10^6m^3	4.80	2.20	4.28	1.34	2.50	2.50	17.50	2.36	4.55	6.50	4.80	3.36		1.34	3.28	2.94
Lower	Dam Height	m	62	38	52	37	39	61	62	40	39	62	45	58		32	50	60
Lower	Dam Crest Length	m	1,000	450	460	400	200	500	550	450	600	600	375	550		400	400	560
Headrace Tunnel Length		m	1,600	450	1,950	1,250	800	0	1,000	500	0	1,850	400	900		3,100	2,250	1,000
Penstock Tunnel Length		m	970	1,100	950	250	700	1,100	1,100	950	1,050	1,200	1,000	1,000		1,200	1,300	850
Tailrace Tunnel Length		m	1,400	1,050	950	1,250	1,600	1,800	1,200	900	1,200	1,800	3,200	1,900		2,000	350	2,400
Standard Intake Water Level		m	675	897	688	359	583	856	858	820	774	895	670	673		807	869	801
Standard Tail Water Level		m	127	248	147	230	290	311	282	370	313	265	162	207		175	285	188
Gross Head		m	548	649	541	129	293	545	576	450	461	630	508	466		632	584	613
Max. Power Discharge		m^3	143	66	127	40	74	74	224	71	135	193	143	100		40	97	87
Transmission Line Length		km	56	57	1	20	1	3	[illegible]	15	60	75	55	35		45	36	105
Economy			B	B	B	C	C	C	A	C	A	A	B	C		C	B	B

(shaded box) Selected Project for the Secondary Inventory Study

Table 6.1-4 Outline of Project (1/2)

	Items	Unit	1 Ulhas	2 Sidgarh	3 Amba	4 Pinjal	5 Kengadi	6 Kalu	7 Jalond	8 Kolman-pada	9 Chornai	10 Savitri	11 Madhali-wadi	12 Vaitarni	13 Morawadi	14 Gadgadi	15 Aruna	16 Kharari
Installed Capacity		MW	600	350	500	30	160	300	1,000	250	480	1,000	500	360		200	440	420
Unit Capacity		MW	150	175	250	30	160	150	250	125	240	250	250	180		100	220	210
Number of Units		unit	4	2	2	1	1	2	4	2	2	4	2	2		2	2	2
Upper	Catchment Area	km^2	6.68	1.00	6.21	2.85	2.45	3.10	20.68	3.38	2.83	5.51	2.68	1.28		0.78	4.78	3.22
	Surface Area	km^2	1.27	0.20	0.47	0.07	0.99	0.54	1.78	0.35	0.85	0.40	0.33	0.25		0.35	0.27	0.52
	Crest Elevation	EL.m	680	906	698	367	590	863	865	828	782	908	683	680		820	882	809
	F.R.L	EL.m	676	902	694	363	586	859	861	824	778	904	679	676		816	878	805
	M.D.D.L	EL.m	670	886	674	349	576	848	850	810	765	874	649	664		786	850	792
	Drowdown	m	6	16	20	14	10	11	11	14	13	30	30	12		30	28	13
	Sedimation Level	EL.m	661	877	665	340	570	839	841	801	756	865	640	655		766	841	783
	Gross Reservoir Capacity	10^6m^3	12.29	2.75	6.65	3.15	5.20	6.09	21.30	4.56	8.50	9.97	6.42	2.52		1.98	5.17	6.11
	Generating Reservoir Capacity	10^6m^3	4.80	2.20	4.28	1.34	2.50	2.50	7.50	2.36	4.55	6.50	4.80	3.36		1.34	3.28	2.94
	Dam Height	m	45	36	58	37	35	48	45	43	32	49	50	35		50	52	37
	Dam Crest Length	m	960	550	320	450	550	550	500	650	600	500	550	450		500	450	450
Lower	Catchment Area	km^2	4.56	0.92	7.99	32.11	5.48	2.71	3.43	3.31	2.48	7.41	6.79	9.61		13.92	2.82	9.12
	Surface Area	km^2	0.26	0.14	0.23	1.04	0.27	0.15	0.55	0.17	0.46	0.47	0.60	0.38		0.49	0.23	0.25
	Crest Elevation	EL.m	142	263	162	237	299	326	297	385	324	278	173	218		182	300	200
	F.R.L	EL.m	138	259	158	233	295	322	293	381	320	274	169	215		178	296	196
	M.D.D.L	EL.m	108	229	128	228	282	292	263	351	302	249	150	195		171	267	174
	Drowdown	m	30	30	30	7	13	30	30	30	18	25	19	20		7	29	22
	Sedimation Level	EL.m	99	220	119	219	273	283	254	342	293	240	141	186		162	258	165
	Gross Reservoir Capacity	10^6m^3	6.35	2.94	6.14	12.75	3.38	3.32	10.74	3.44	6.03	9.52	8.60	5.94		5.85	4.58	4.82
	Generating Reservoir Capacity	10^6m^3	4.80	2.20	4.28	1.34	2.50	2.50	7.50	2.36	4.55	6.50	4.80	3.36		1.34	3.28	2.94
	Dam Height	m	62	38	52	37	39	61	62	40	39	62	45	58		32	50	60
	Dam Crest Length	m	1,000	450	460	400	200	500	550	450	600	600	375	550		400	400	560
Headrace Tunnel Length		m	1,600	450	1,950	1,250	800	0	1,000	500	0	1,850	400	900		3,100	2,250	1,000
Penstock Tunnel Length		m	970	1,100	950	250	700	1,100	1,100	950	1,050	1,200	1,000	1,000		1,200	1,300	850
Tailrace Tunnel Length		m	1,400	1,050	950	1,250	1,600	1,800	1,200	900	1,200	1,800	3,200	1,900		2,000	350	2,400
Standard Intake Water Level		m	675	897	688	359	583	856	858	820	774	895	670	673		807	869	801
Standard Tail Water Level		m	127	248	147	230	290	311	282	370	313	265	162	207		175	285	188
Gross Head		m	548	649	541	129	293	545	576	450	461	630	508	466		632	584	613
Max. Power Discharge		m^3	143	66	127	40	74	74	224	71	135	193	143	100		40	97	87
Transmission Line Length		km	56	57	1	20	1	3	1	15	60	75	55	35		45	36	105
Economy			B	B	B	C	C	C	A	C	A	A	B	C		C	B	B

[ ] Selected Project for the Secondary Inventory Study

Table 6.1-4 Outline of Project (2/2)

	Items	Unit	17 Kundi	18 Jalware	19 Tillari -wadi	20 Tillari -Forebay	21 Marlesh -war	22 Valvand	23 Shemi	24 Kudan -budrak	25 Kaudoshi	26 Kumb- havde	27 Mundi -richi	28 Virdi	29 Bamnoli	30 Kinjale	31 Khakhar -wadi	32 Hevale
Installed Capacity		MW	1,200	440		720	1,200	1,200	60	450	400	630	750	660	1,320	420	660	960
Unit Capacity		MW	200	220		180	200	200	60	225	200	210	250	220	220	210	220	240
Number of Units		unit	6	2		4	6	6	1	2	2	3	3	3	6	2	3	4
Upper	Catchment Area	km^2	1.67	2.47		3.22	8.15	2.68	47.00	4.20	4.88	4.32	—	—	—	—	—	—
Upper	Surface Area	km^2	0.63	0.34		0.52	1.57	0.78	0.59	0.33	0.30	0.98	0.21	0.17	0.56	0.23	0.24	0.32
Upper	Crest Elevation	EL. m	880	767		740	861	660	382	679	621	820	825	823	887	843	766	747
Upper	F.R.L	EL. m	876	763		756	857	656	378	675	617	816	823	821	885	841	764	745
Upper	M.D.D.L	EL. m	846	748		711	846	626	371	645	590	797	793	791	855	811	734	716
Upper	Drowdown	m	30	15		25	11	30	7	30	27	19	30	30	30	30	30	30
Upper	Sedimation Level	EL. m	837	738		702	837	599	362	636	581	788	—	—	—	—	—	—
Upper	Gross Reservoir Capacity	10^6m^3	11.80	5.12		8.14	19.87	14.04	9.55	7.54	5.70	9.94	6.43	5.12	11.23	3.76	7.29	9.81
Upper	Generating Reservoir Capacity	10^6m^3	8.92	3.57		5.83	8.68	9.36	1.6	5.53	3.95	7.60	5.00	4.00	8.70	2.93	5.67	7.64
Upper	Dam Height	m	50	42		※50	76	70	27	54	61	50	26	23	27	23	26	27
Upper	Dam Crest Length	m	400	400		※500	500	600	300	340	140	300	1,908	1,910	2,460	1,500	2,020	2,310
Lower	Catchment Area	km^2	9.90	9.41		22.46	23.20	6.40	10.57	12.60	14.76	15.53	9.83	7.46	18.31	4.81	5.95	22.48
Lower	Surface Area	km^2	0.69	0.28		0.45	0.75	0.84	0.22	0.34	0.47	0.86	0.85	0.54	0.55	0.28	0.35	0.50
Lower	Crest Elevation	EL. m	280	220		189	201	117	200	327	183	458	167	106	229	205	265	200
Lower	F.R.L	EL. m	276	216		185	197	113	196	323	179	454	163	102	225	201	261	196
Lower	M.D.D.L	EL. m	251	192		166	176	92	185	293	149	435	143	84	195	171	231	166
Lower	Drowdown	m	25	24		19	21	21	11	30	30	19	20	18	30	30	30	30
Lower	Sedimation Level	EL. m	242	182		157	167	82	176	284	140	426	134	75	186	162	202	157
Lower	Gross Reservoir Capacity	10^6m^3	13.08	5.93		7.71	13.54	15.51	3.23	8.37	7.84	11.82	14.85	8.90	13.19	4.42	10.19	11.72
Lower	Generating Reservoir Capacity	10^6m^3	8.92	3.57		5.83	8.68	9.36	1.60	5.53	3.95	7.60	5.00	4.00	8.70	2.93	5.67	7.63
Lower	Dam Height	m	50	50		44	56	47	45	62	63	48	47	46	59	55	80	72
Lower	Dam Crest Length	m	500	600		650	500	1,250	300	400	440	600	400	320	380	320	420	600
Headrace Tunnel Length		m	450	2,800		0	1,900	400	1,600	1,000	2,000	1,500	0	0	0	0	0	0
Penstock Tunnel Length		m	1,200	1,100		1,100	1,150	1,050	500	620	700	520	1,270	1,100	1,160	1,250	1,010	1,070
Tailrace Tunnel Length		m	1,300	1,400		1,350	1,150	700	1,100	850	1,600	1,200	2,000	2,600	1,600	2,200	1,550	1,450
Standard Intake Water Level		m	867	759		728	854	647	376	666	609	810	814	812	876	832	755	736
Standard Tail Water Level		m	267	207		178	189	105	191	312	168	447	155	95	214	190	250	185
Gross Head		m	600	552		550	665	546	185	354	448	363	659	717	62	642	505	551
Max. Power Discharge		m^3	265	106		173	258	278	47	164	118	294	149	119	259	87	168	227
Transmission Line Length		km	55	100		95	60	60	110	70	55	100	120	125	61	45	55	100
Economy			A	A		A	A	A	C	B	B	B	A	A	A	B	C	B

(Shaded) Selected Project for the Secondary Inventory Study

Table 6.1-4 Outline of Project (2/2)

	Items	Unit	17 Kundi	18 Jalware	19 Tillari-wadi	20 Tillari-Forebay	21 Marlosh-war	22 Valvand	23 Shemi	24 Kudan-budrak	25 Kaudoshi	26 Kumb-havde	27 Mundi-richi	28 Virdi	29 Bamnoli	30 Kinjale	31 Khakhar-wadi	32 Hovale
Installed Capacity		MW	1,200	440		720	1,200	1,200	60	450	400	630	750	660	1,320	420	660	960
Unit Capacity		MW	200	220		180	200	200	60	225	200	210	250	220	220	210	220	240
Number of Units		unit	6	2		4	6	6	1	2	2	3	3	3	6	2	3	4
Upper	Catchment Area	km^2	1.67	2.47		3.22	8.15	2.68	47.00	4.20	4.88	4.32	----	----	----	----	--	----
	Surface Area	km^2	0.63	0.34		0.52	1.57	0.78	0.59	0.33	0.30	0.98	0.21	0.17	0.56	0.23	0.24	0.32
	Crest Elevation	EL. m	880	767		740	861	660	382	679	621	820	825	823	887	843	766	747
	F.R.L	EL. m	876	763		736	857	656	378	675	617	816	823	821	885	841	764	745
	M.D.D.L	EL. m	846	748		711	846	626	371	645	590	797	793	791	855	811	734	715
	Drawdown	m	30	15		25	11	30	7	30	27	19	30	30	30	30	30	30
	Sedimation Level	EL. m	837	738		702	837	599	362	636	581	788	---	---	---	---	---	---
	Gross Reservoir Capacity	10^6m^3	11.80	5.12		8.14	19.87	14.01	9.55	7.54	5.70	9.94	6.43	5.12	11.23	3.76	7.29	9.81
	Generating Reservoir Capacity	10^6m^3	8.92	3.57		5.83	8.68	9.36	1.6	5.53	3.95	7.60	5.00	4.00	8.70	2.93	5.67	7.64
	Dam Height	m	50	42		※ 50	76	70	27	54	61	50	26	23	27	23	26	27
	Dam Crest Length	m	400	400		※ 500	500	600	300	340	140	300	1,908	1,910	2,460	1,500	2,020	2,310
Lower	Catchment Area	km^2	9.90	9.41		22.46	23.20	6.40	10.57	12.60	14.76	15.53	9.83	7.46	18.31	4.81	5.95	22.46
	Surface Area	km^2	0.69	0.28		0.45	0.75	0.84	0.22	0.34	0.47	0.86	0.85	0.54	0.55	0.28	0.35	0.50
	Crest Elevation	EL. m	280	220		189	201	117	200	327	183	458	167	106	229	205	265	200
	F.R.L	EL. m	276	216		185	197	113	196	323	179	454	163	102	225	201	261	196
	M.D.D.L	EL. m	251	192		166	176	92	185	293	149	435	143	84	195	171	231	166
	Drawdown	m	25	24		19	21	21	11	30	30	19	20	18	30	30	30	30
	Sedimation Level	EL. m	242	182		157	167	82	176	284	140	426	134	75	186	162	202	157
	Gross Reservoir Capacity	10^6m^3	13.08	5.93		7.71	13.54	15.51	3.23	8.37	7.84	11.82	14.85	8.90	13.19	4.42	10.19	11.72
	Generating Reservoir Capacity	10^6m^3	8.92	3.57		5.83	8.68	9.36	1.60	5.53	3.95	7.60	5.00	4.00	8.70	2.93	5.67	7.63
	Dam Height	m	50	50		44	56	47	45	62	63	48	47	46	59	55	80	72
	Dam Crest Length	m	500	600		650	500	1,250	300	400	440	600	400	320	380	320	420	600
Headrace Tunnel Length		m	450	2,800		0	1,900	400	1,600	1,000	2,000	1,500	0	0	0	0	0	0
Penstock Tunnel Length		m	1,200	1,100		1,100	1,150	1,050	500	620	700	520	1,270	1,100	1,160	1,250	1,010	1,070
Tailrace Tunnel Length		m	1,300	1,400		1,350	1,150	700	1,100	850	1,600	1,200	2,000	2,600	1,600	2,200	1,550	1,450
Standard Intake Water Level		m	867	759		728	854	647	376	666	609	810	814	812	876	832	755	736
Standard Tail Water Level		m	267	207		178	189	105	191	312	168	447	155	95	214	190	250	185
Gross Head		m	600	552		550	665	546	185	354	448	363	659	717	62	642	505	551
Max Power Discharge		m^3	265	106		173	258	278	47	164	118	294	149	119	259	87	168	227
Transmission Line Length		km	55	100		95	60	60	110	70	55	100	120	125	61	45	55	100
Economy			A	A		A	A	A	C	B	B	B	A	A	A	B	C	B

[ ] Selected Project for the Secondary Inventory Study

hand, Maharashtra state has a right to utilize the water resource in the upper stream basin from Paithan dam on Godavari river even with diversion water scheme.

And a private power utility company is proposing Maharashtra State Government to implement Valvande project utilizing Private Sector participation policy.

Taking into consideration the above circumstance, GOMID and the Study Team had a conclusion that Jalond, Kinjale Marleshwar, Tillari Forebay and Hevale were taken up for the site reconnaissance instead of Savitri, Kundi and Volvande in order to avoid the water right issues and disturbing privatization movement in power sector

6.2 Secondary Inventory Study

6.2.1 General

After conducting the site reconnaissance at Joland, Morleshwal, Kinjale, Tillari Forebay and Hevale sites, the preliminary inventory was revised based on the results of site reconnaissance for the secondary inventory study. The result of the study is indicated in **Table 6.2-1**. General layout and water way profile are indicated in **Fig. 6.2-1 to Fig. 6.2-10.**

6.2.2 Jalond P.S.S.

(1) Reservoir Capacity

(a) Upper Reservoir

Dam axis of upper dam which had been planned on the topographical maps at the primary inventory study wereconfirmed at the site to construct a masonry dam without difficulty in terms of civil engineering technology. Therefore, the reservoir capacity of upper dam was not required to be reviewed. However, the configuration of upper reservoir was a narrow gorge, the reservoir capacity would be reviewed based on the toposheet with 1:10,000 scale to be prepared by the topographical survey in the next stage.

(b) Lower Reservoir

It was confirmed by the site reconnaissance that the lower dam could be constructed at the site which had been identified at the primary inventory study. It was not required to review the reservoir capacity, either.

(2) Planning an Outline of Pumped Storage Power Operation

Basic conditions for pumped storage power operation such as pumping up hours were confirmed by Hydroelectric Power Circle of GOMID and MSEB. Therefore, the same concept as the primary inventory study was adopted in this stage.

(3) Conceptual Design of Major Structure

(a) Upper Dam

Upper dam was located at N19°26'25" and E73°43'41". The dam type would be masonry or concrete gravity type.

According to the site reconnaissance the dam crest length measured 300 m in length by a range finder instead of 500 m estimated in the primary inventory study using topographical map.

(b) Lower Dam

Lower dam was located at N19°24'41" and E73°42'44". The dam type would be rockfill type due to its configuration of dam site. However, availability of soil material was not confirmed yet, a masonry dam type is adopted at this stage.

(c) Water conducting System

The intake structure is located at the heal of upper dam and two headrace tunnels in number with 1,000 m in length and 5.3 m in diameter are led from the intake to the penstock tunnels. Four penstock inclined tunnels in number with 1,100 m in length and 3.8 m to 2.6 m in diameter are to be constructed. The powerhouse is located in the underground to install 4 units × 250 MW reversible turbine and generator. From the powerhouse, two tailrace tunnel with 1200 m in length and 5.3 m in diameter will be constructed and be connected to the outlet which is planned at the right abutment near the lower dam.

(4) Economic Evaluation

Preliminary cost estimation was made by the same methodology as in the primary inventory study. The economic reliability of Jalond project is ranked at A.

6.2.3 Tillari Forebay P.S.S.

(1) General

The JICA study team planned at increasing height of Tillari Forebay Dam to create additional reservoir capacity for pumped storage scheme at the primary inventory study stage. However, from the results of site reconnaissance, Tillari Forebay reservoir and Tillari Main reservoir connected by a open cannal with 15 km in length and a gradient of 1:3,000.

It came out that the increasing dam height was impossible without a large scale open cannal modification.

(2) Reservoir Capacity

(a) Upper Reservoir

The existing Forebay reservoir had an excess capacity of $1.26 \times 10^6 m^3$ which could be utilized for pumped storage scheme other than the conventional hydropower project.

The excess storage capacity was used in this study without any modification of existing facility.

(b) Lower Reservoir

Lower dam axis was shifted toward the up-stream about 300 m from planned dam axis at the primary inventory study stage to avoid influence on the existing powerhouse.

A reservoir capacity of lower reservoir was to be set up corresponding to the upper reservoir capacity.

(3) Planning on Outline of Pumped Storage Power Operation

Basic conditions for pumped storage power operation such as pumping up hours were the same concept as in the primary inventory study.

(4) Conceptual Design of Major Structure

(a) Upper Dam

The existing Forebay dam was to be utilized as a upper dam of pumped storage power scheme.

(b) Lower Dam

Lower dam was located at N15°03'40" and E73° 49'41". The dam type would be rockfill type due to the configuration of dam site. However, availability of soil material was not been confirmed yet, masonry dam type was adopted at this stage.

(c) Water Conducting System

An intake structure was located at the upstream of existing intake. A single penstock inclined tunnel with 1,150 m in length and 2.8 m diameter was planned.

The powerhouse was located in the underground to accommodate a reversible turbine and generator with 125 MW output. A tailrace tunnel with 1,150 m in length and 3.1 in diameter led from powerhouse to the outlet.

The outlet structure was to be constructed at a just upstream of lower dam in left bank.

(5) Economic Evaluation

Based on the actual condition i.e. utilizing existing Forebay dam as a upper dam without any heightening dam, it was impossible to plan a large scale pumped storage power project and enjoy a scale merit even no investment for upper dam. Economic ranking therefore was turned into C.

6.2.4 Marleshwar P.S.S.

(1) Reservoir Capacity

(a) Upper Reservoir

Dam axis of upper dam which had been planned on the toposheet at the primary inventory was confirmed at the site. There was no difficulty to construct a masonry dam or concrete gravity dam in terms of civil engineering technology.

The reservoir capacity as the same as in the primary inventory study stage was adopted in the secondary inventory study.

(b) Lower Reservoir

According to the results of site reconnaissance, it was confirmed that a dam could be constructed where the dam axis was planned during the primary inventory study study.

Therefore, the same reservoir capacity as the Primary Inventory study was applied in this stage too.

(2) Planning Outline of Pumped Storage Power Operation

Outline of pumped storage power operation was the same concept as in the primary inventory study.

(3) Conceptual Design of Major Structure

(a) Upper Dam

Upper dam was located at N17°05'02" and E73°43'41". The dam type would be masonry or concrete gravity type. According to the site reconnaissance, the dam crest length measured 350 m instead of 500 m estimated in the primary inventory study using topographical map.

(b) Lower Dam

Lower dam was located at N19°24'41" and E73°42'44".

According to the site reconnaissance, the dam crest length measured 550 m instead of 500 m in the primary inventory study due to the thick overburden.

The dam type would be rockfill type due to its configuration. However, availability of soil material was not confirmed yet, a masonry dam type was adopted at this stage.

(c) Water Conducting System

The intake structure was located at the heal of upper dam in the left bank, and two headrace tunnels with 1,750 m in length and 5.7 m in diameter each were led from the intake to the penstock tunnel. Six penstock inclined tunnels with 1,000 m in length and 3.3 m to 2.3 m in diameter respectively were planned in this inventory study.

The powerhouse was located in the underground to accommodate six reversible turbine and generator with 200 MW output respectively. Two tailrace tunnels with 1,400 m in length and 5.7 m in diameter were planned. The tailrace outlet was to be located at the right bank of the upstream of the dam.

(4) Economic Evaluation

Preliminary cost estimation was made by the same methodology as in the primary inventory. The economic reliability of this project was ranked at A.

6.2.5 Kinjale P.S.S.

It came out that the upper reservoir river basin was belong to the eastern river basin (Krishna Basin) by the site reconnaissance. Therefore, this project had little opportunity to realize the plan. The salient feature was the same as in the primary inventory study.

6.2.6 Hevale P.S.S.

(1) Reservoir Capacity

Location of lower dam was the same one as the Tillari Forebay P.S.S lower one. Reservoir capacity at the primary inventory study stage was reviewed and planned an effective storage capacity with $6.49 \times 10^6 m^3$ between FRL (EL 210 m) and MDDL (EL 180 m).

The same effective storage capacity as the lower reservoir was planned at the upper reservoir of an excavated and embanked hill-top type.

(2) Planning Outline of Pumped Storage Operation

Based on the revised reservoir capacity, the installed capacity was recalculated 800 MW instead of 960 MW at the primary inventory stage. The other power operation parameter such as pumping up hours and efficiency were the same as in the primary inventory stage.

(3) Conceptual Design of Major Structure

(a) Upper Dam

A hill-top type reservoir created by concrete facing fill dam was designed at upper reservoir. Location of the dam was N15°49'52" and E74°09'24".

(b) Lower Dam

Location of the lower dam was N15°03'40" and E73°49'41". A masonry type was applied at this stage, but rockfill type dam would be examined taking into consideration availability of fill materials.

(c) Water Conducting System

A morning glory type intake would be constructed in the hill-top type reservoir. Four lines of inclined penstock tunnels with 1,070 m each were to be provided and connected to the underground powerhouse. The powerhouse would accommodate 4 units x 200 MW reversible turbines and generators. Two lines of tailrace tunnel with 1,450 m in length and 5.0 m in diameter would be constructed from the power house to the lower reservoir. The tailrace out let would be established on the right bank of the lower reservoir.

(4) Economic Evaluation

Preliminary cost estimation was made by the same methodology as in the primary inventory. The economic reliability of this project was ranked at B considerably closed to A.

6.2.7 Conclusion of the Secondary Inventory

Based on the secondary inventory study, Marleshwar, Jalond and Hevale projects should be taken up and the detailed site investigations should be conducted for the above said projects in the next stage.

Table 6.2-1 The Secondary Inventory

Item		7		20		21		30		32	
		Joland		Tillari Forebay		Marleshwar		Kinjale		Hevale	
Installed Capacity	MW	1,000		125		1,200		420		800	
Unit Capacity	MW	250		125		200		210		200	
Number of Unit	Unit	4		1		6		2		4	
		Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Catchment Area	Km^2	20.68	3.43	2.22	1,992	8.15	23.20	-	4.81	-	19.92
Surface Area	Km^2	1.78	0.55	0.22	0.22	1.57	0.75	0.23	0.28	0.32	0.50
Crest Elevation	m	865	297	729.044	192	861	201	843	205	747	214
F.R.L.	m	861	293	726.314	188	857	197	841	201	745	210
M.D.D.L.	m	850	263	720.59	180	846	176	811	171	715	180
Drawdown		11	30	5.72	8	11	21	30	30	30	30
Sedimentation Level	m	841	254	715.67	170	837	167	-	162	-	170
Gross Reservoir Capacity	10^6m^3	21.30	10.74	2.12	4.02	19.87	13.54	3.76	4.42	9.81	9.810
Generating Reservoir Capacity	10^6m^3	7.50	7.50	1.024	1.024	8.68	8.68	2.93	2.93	6.49	6.49
Type of Dam		Masonry	Masonry	Masonry	Masonry	Masonry	Masonry	C.F.R.F.	Masonry	C.F.R.F	Masonry
Dam Height	m	45	62	23.24	60	76	56	23	55	27	80
Dam Crest Length	m	300	550	350.00	600	350	550	1,500	320	2,310	700

Item		7 Length	7 Number of Tunnels	7 Diameter (m)	20 Length	20 Number of Tunnels	20 Diameter (m)	21 Length	21 Number of Tunnels	21 Diameter (m)	30 Length	30 Number of Tunnels	30 Diameter (m)	32 Length	32 Number of Tunnels	32 Diameter (m)
Headrace Tunnel	m	1,000	2	5.3	-	-	-	1,750	2	5.7	-	-	-	-	-	-
Penstock Tunnel	m	1,100	4	3.8~2.6	1,150	1	2.8~2.0	1,000	6	3.3~2.3	1,250	4	3.3~2.8	1,070	4	3.5~2.5
Tailrace Tunnel	m	1,200	2	5.3	1,150	1	3.1	1,400	2	5.7	2,200			1,450	2	5.0
Standard Intake Water Level	m	858			723			854			832			736		
Standard Tail Water Level	m	282			184			189			190			197		
Gross head	m	576			539			665			642			537		
Max Power Discharge	m^3	224			30			258			87			193		
Economy	-	A			C			A			B			B		

C.F.R.F.: Concrete Facing Rock Fill Dam