Phased Power Production in Bhakra Nangal

FOR the purpose of development of electrical power. East Punjab, Pepsu, Himachal Pradesh and Delhi and part of Rajasthan have been included in a single unit under the Bhakra Nangal project now in an advanced stage of completion.

With no indigenous source of fuel oil and distant location of collieries', the only source of generation of cheap' power in the North-Western part of India is water. With perennial flow in her rivers, Punjab is happily placed with respect to water power. However, water-power had been scarcely developed for at the time of partition, Uhl river was the only source of hydro-power for the State. The only other large central power station in this area was Delhi.

The Jogindernagar hydro-station (48,000 KW) on Uhl river served the district towns of Kangra, Amritsar, Jullunder, Ludhiana, Ferozpore and a large number of towns and villages in this area. It also served Lahore which continues to obtain electricity from this source by an Indo-Pakistan Agreement, though the supply has been progressively reduced to 5,000 KW this year, The thermal power stations in Delhi have a combined generating capacity of 24,000 KW, The rest of Punjab has been served by small diesel and steam power stations and over the whole area there have been, for past many years, drastic restriction in supply, demand being far in excess.

Under the Bhakra Nangal, project power will be generated in two power houses at Nangal Hydel Channel and one at Bhakra Dam site. Nangal power house on completion of the first stage with installation of 12 units of 24,000 KW in each power house will provide a firm power of 72,000 KW. With provision for installation of one more similar set in each of the power houses, the firm power available will increase to 120,000 KW, for by that time the Nangal Channel, will be assured a perennial How which will enable capacity generation from all the power stations. Bhakra Dam power house has a provision for 8 stations of 90,000 KW each although, as will be discussed later, in the first stage, installation of only one or, two sets is contemplated. The firm capacity of each set in Bhakra Dam power house is expected to be 53,000 KW which will be the output during the lowest water level in the dam. The project thus has provision for an installed capacity of 864,000 KW and a firm capacity of 438,000 KW at the lowest water level. This high power potentiality of Bhakra Nangal, interconnected with Jogindernagar and Delhi power stations, will form the new unit of transmission and sub-transmission lines known as 'the Punjab Transmission System.

To understand the difference between the firm capacity as against installed capacity of an inter-connected system such as of the Uhl-Bhakra Nangal-Delhi grid, one has to take into consideration the periodical shutdown of generators for overhauling. Moreover, for hydro-generators the capacity of generation depends on the availability of water, *ie*, both on the level and flow of water. The Nangal dam would not have enough perennial flow until the Bhakra reservoir is ready in 1960. Therefore, out of 96,000 KW in two Nangal power houses, firm load expectation is not more than 69,000 KW. Similarly in Bhakra, each of the 90,000 KW units will generate 53,000 KW at the lowest working reservoir level, the output increasing with the level of water to the maximum of 90,000 KW.

Moreover, in multipurpose systems, where irrigation is of prime importance, canals are closed for inspection and repairs during off agricultural months when demand for water is lowest. During these periods of closure, shutdown of generators becomes inevitable,

Operational planning, however, enables staggered shutdowns so that of the total number of generators, enough are worked and the maximum capacity so available is the rirm capacity of the system. The firm capacity available from various hydro-electric installations of the Punjab transmission system is given in table below,

Nangal hydro-power station Number I with installed capacity of 48.000 KW is expected to commence regular operation before the end of this year. Number 2 power house at Nangal is expected to be ready by the end of 1955. The Punjab Government Electricity Department has almost completed the wide net work of transmission and sub-transmission lines to cover the territory in all parts of the State for supplying Nangal power. By 1955 Nangal power is expected to be available to these load centres. Pepsu is expected to be ready by then with its distribution system. The Rajasthan Electricity Department is completing its distribution lines to connect load centres in Rajasthan to Nangal power before 1956.

Hydro-power stations at Jogindernagar and Nangal and steam power stations at Delhi will be connected by 132/220 KV "trunk transmission circuit. In view of the large volume of power and long distance over which it is to be transmitted, it has been considered essential to adopt a very high voltage transmission for the operation of this project, the *highest* so far used in India, The total length of transmission lines of 220, 132, 66 and 33 KV is about 1,5125 miles made up of:

222 *KV*	—	200 miles
132 KV	—	110 miles
66 KV	—	176 miles
33 KV	-	747 miles

In addition to these transmission lines the project provides for 800 miles of 11 KV lines and a vast network of 400 volts low tension lines for the distribution to consumers.

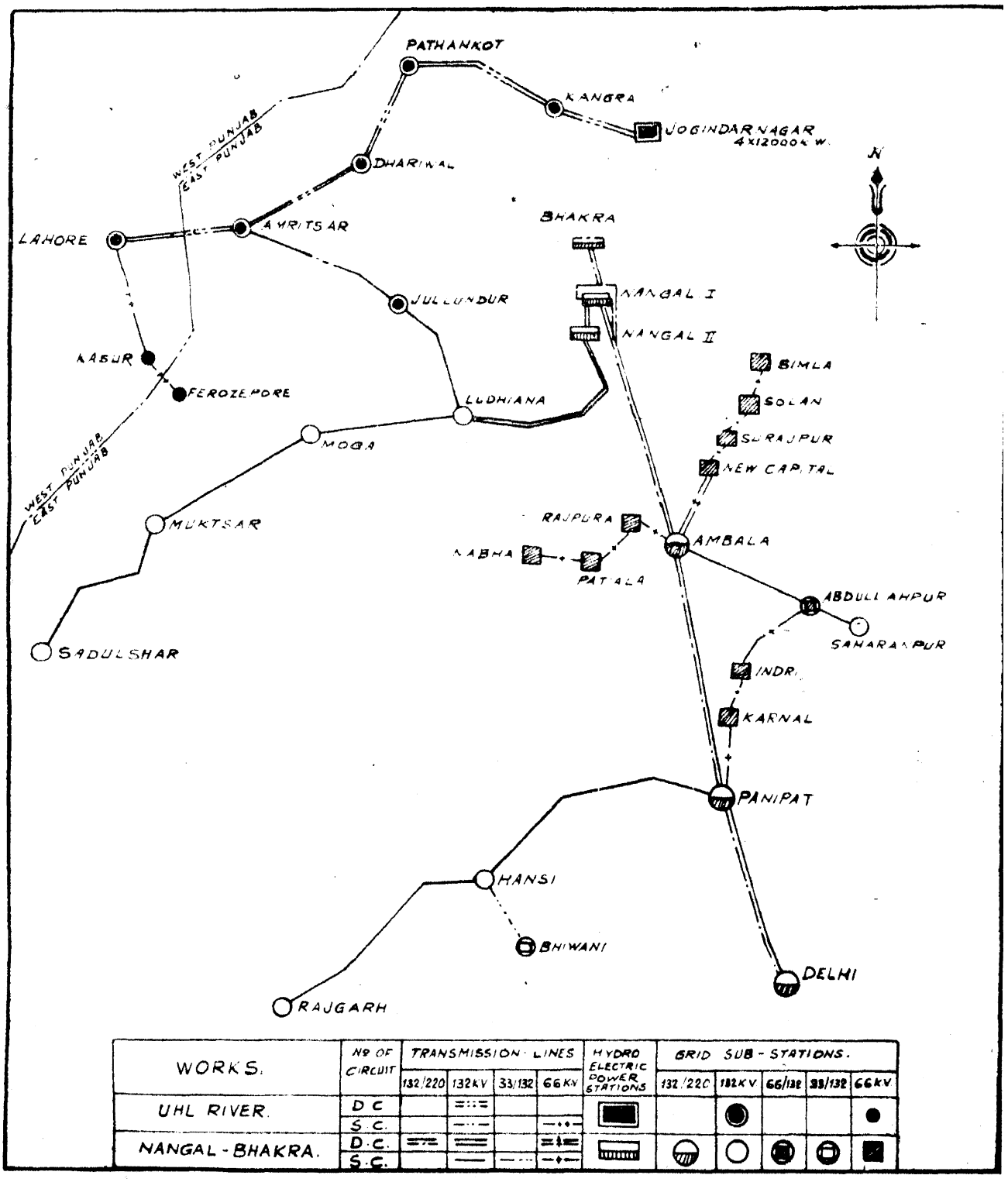
The inter-connected power stations will be linked by Carrier telephone communication which will enable operation of all the power stations under one central control. This ensures maximum economy by increased use of hydro-power and elevation of firm capacity of the system. Though the steam capacity at Delhi is restrained, total generation from this station will be only a fraction of what it is now, as hydro-capacity increases, resulting in considerable saving in the cost of fuel.

Another major economy that will be derived from operating Jogindernagar, Nangal and Delhi power-stations in an inter-connected system is the increase of firm load carrying

Project	Installed capacity	Firm capacity
1. Uhl river (Jogindernagar) —4 units	48,000 KW	33,000 KW
2. Nangal—4 units (Pre-Bhakra)	96,000 KW	69,000 KW
3. Nangal—4 units (Post-Bhakra)	96,000 KW	72,000 KW
4. Bhakra each unit	90,000 KW	53,000 KW

Punjab Transmission System — I

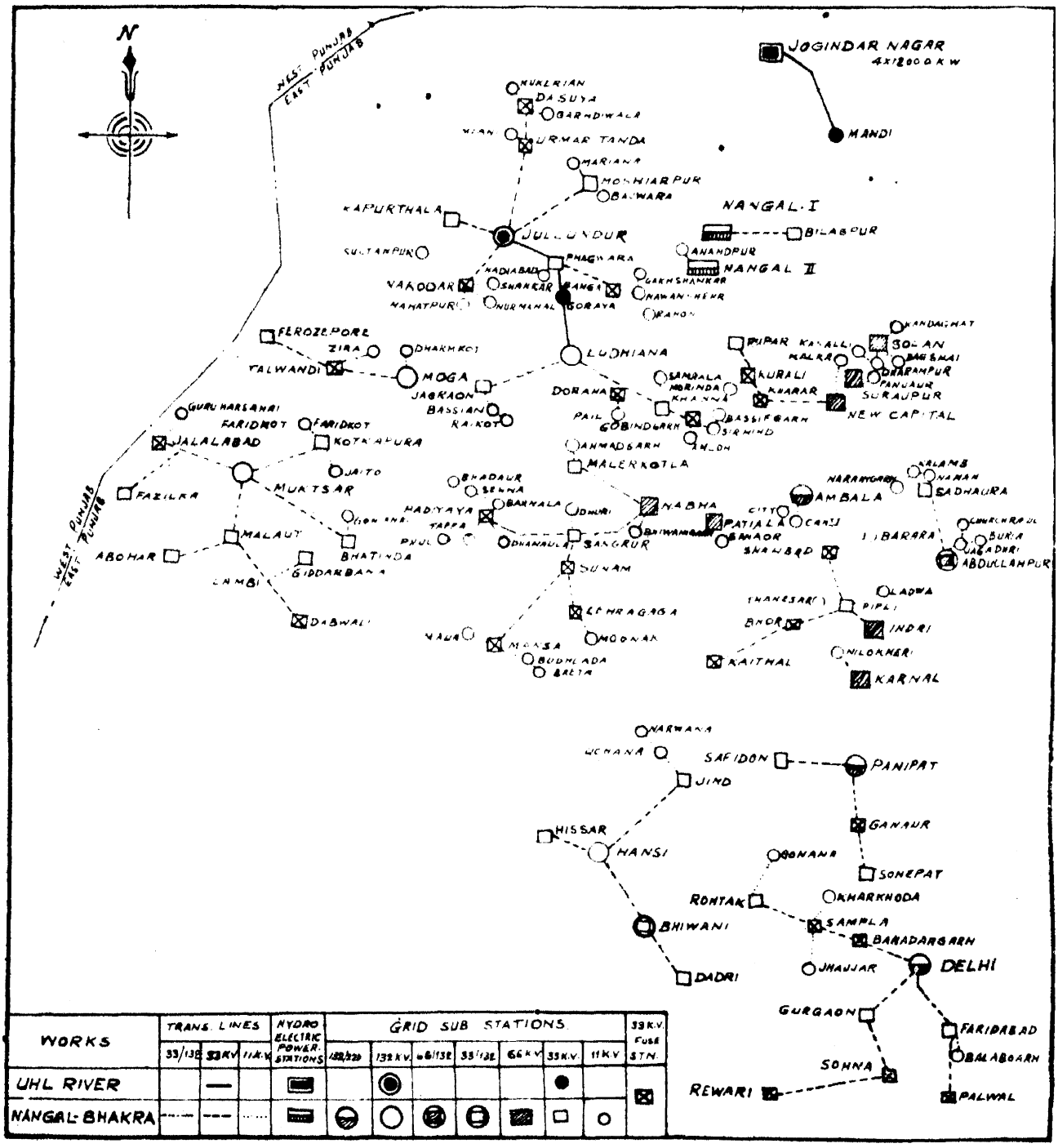
230/132 KV Transmission



Data for Lines on page 902

Punjab Transmission System—II

33/11 KV Transmission



Data for Lines on page 902

DATA FOR PUNJAB TRANSMISSION SYSTEM —1

Section	Mileage	Voltage	Maximum demand at destination in KW
Bhakra-Nangal I	23	132/220	—
Hansi-Rajgarh	60	132	9,785
Nangal I—Nangal II	6	132	—
Nangal I—Ambala	69	132/220	41,761
Ambala—Panipat	75	132/220	28,018
Panipat—Delhi	53	132/220	36,208
Nangal II—Ludhiana	68	132	10,055
Ludhiana—Jullundur	36	132	6,730
Ludhiana—Moga	44	132	3,862
Moga—Muktsar	51	132	6,310
Muktsar—Sadulshar	55	132	3,932
Ambala—Saharanpur	56	132	10,000
Panipat—Hansi	68	132	612
Ambala—New Capital	23	66	7,155
New Capital—Surajpur	7	66	6,233
Surajpur—Kalka	4	66	—
Kalka—Solan	12	66	877
Solan—Simla	20	66	1,600
Ambala—Rajpura	15	66	965
Rajpura—Patiala	15	66	2,275
Patiala—Nabha	15	66	8,804
Panipat—Karnal	22	66	2,264
Karnal—Indri	14	66	2,611
Indri—Abdullahpur	28	66	11,485
Hansi—Bhiwani	24	33/132	6,345

DATA FOR PUNJAB TRANSMISSION SYSTEM — II

Section	Mileage	Voltage	Maximum demand at destination in KW
Nangal I—Bilaspur	20	33	900
Ludhiana—Doraha	17	33	742
Doraha—Khanna	12	33	1,669
Khanna—Gobindgarh	6	33	1,869
Phagwara—Banga	14	33	1,021
Jullundur—Phagwara	16	33	2,621
Jullundur—Kapurthala	15	33	1,291
Jullundur—Hoshiarpur	24	33	795
Jullundur—Urmartanda	25	33	227
Urmartanda—Dasuya	10	33	618
Jullundur—Nakodar	15	33	1,047
Ludhiana—Jagraon	23	33	925
Moga—Talwandi	15	33	380
Muktsar—Kotkapura	20	33	1,595
Muktsar—Jalalabad	19	33	518
Jalalabad—Fazilka	20	33	830
Muktsar—Malaut	22	33	541
Malaut—Lambi-Dabwali	20	33	339
Lambi—Giddarbaha	11	33	476
Malaut—Abohar	14	33	1,036
Muktsar—Bhatinda	32	33	975
Nabha—Malerkotla	20	33	2,288
Nabha—Sangrur	22	33	1,650
Sangrur—Hadiyaya	20	33	1,799
Sangrur—Sunam	8	33	690
Sunam—Lehragaga	15	33	370
Sunam—Mansa	27	33	1,297
New Capital—Kharar	14	33	328
Kharar—Kurali	6	33	379
Kurali—Rupar	9	33	262
Indri—Pipli	11	33	900
Pipli—Shahabad	13	33	256
Abdullahpur—Sadhaura	19	33	500
Pipli—Bhor—Kaithal	36	33	765
Panipat—Safidon	20	33	715
Panipat—Sonipat	28	33	2,177
Hansi—Bhiwani	24	33/132	2,898
Bhiwani—Dadri	15	33	3,470
Hansi—Hissar	14	33	2,755
Hansi—Jind	28	33	872
Delhi—Bahadargarh	13	33	328
Bahadargarh—Sampla	10	33	399
Sampla—Rohtak	13	33	1,147
Delhi—Gurgaon	19	33	584
Gurgaon—Sohna	16	33	71
Sohna—Rewari	28	33	722
Delhi—Faridabad	23	33	2,427
Faridabad—Palwal	20	33	530
Talwandi—Ferozepore	20	33	3,357

capacity, with the same total installed generating capacity. If the stations were not inter-connected, the shutdown of the largest generating unit in each station for several weeks for annual overhaul would reduce the effective capacity of the stations to 33,000, 72,000 and 38,000 KW respectively. Working in the same grid, the largest unit shutdown would still leave 164,000 KW in the, system or 21,000 KW more than when the units are operated independently.

Central Water and Power Cornmission carried out load surveys from 1951 to 1953 in Punjab, Pepsu, Rajasthan and Delhi, that is in all the areas which will he served by the Punjab Transmission System. The present load of the region served by Jogindernagar and Delhi power stations and forecast of the demand on the inter-connected system till the end of 1964 has been shown in the table below.

The public electric supply power-stations in the areas to be served has today a demand of 71.000 KW. The load of prime mover installations consisting of SMALL diesel engines or steam engines serving different industries is 30.000 KW. As power from the Punjab Transmission system would be cheaper than fuel costs, they are expected to changeover to the hydro-power. Starting with the estimated power supply of about 66 KW in 1952, with the relief in shortage provided by Nangal first stage the load is expected to increase from 85,000 KW in 1955 to 174,000 KW in 1964.

As the two power stations at Nangal go into operation in 1955. the Punjab Transmission System will have surplus power for several years. The Technical Committee that was appointed by the Planning Commission to go into the question of Bhakra power is of the opinion that when the Bhakra dam is ready, the firm capacity of the system will be 152,000 KW, which will be adequate for the capacity load increase till 1961.

In designing the Nangal Power House, space has been provided for one additional 24,000 KW unit in cadi station. Similarly at Bhakra, the construction of the dam would include civil work for part of the power house. Therefore in both cases, of her constructions to complete installations of the generating units can be carried our at any time later on. This design feature would enable extension of the capacity of the system in economical stages until the lull potential capacity of two additional units of 24,000 KW and ten Bhakra 90.000 KW units is utilised. The cost of such extension, it is estimated, will be much lower than the cost of installation of steam stations, or that of undertaking new projects. This will naturally mean lower cost of generation also.

To what extent the power requirement of the area to he served by the Bhakra-Nangal Project would be met in the forseeable future can best be appreciated from the estimate that has been made that addition of only two units at Bhakia would be more than adequate upto 1972, while the design provides for 8 more units.

To meet the increase in estimated load after 1961, the 'Technical Committee has considered two alternative programmes:

(1) Installation of two 24,000 KW units, one at each power house, at Nangal followed by the first 90,000 KW unit at Bhakra.
(2) Installation of first and second 90,000 KW units at Bhakra.

The expansion would increase installed capacity of the system which, will be 188,000 KW at the end of 1955, after completion of the second station at Nangal, to nearly 300.000 KW in both cases. Either programme is expected to be adequate to meet requirements through next 12 to 15 years and the Committee is of the opinion that it is not necessary to decide immediately which capacity expansion programme should be adopted. To keep up with the expansion of load, additional installed capacity should be available by 1961 and therefore the Committee has recommended that decision regarding increased generating capacity may be postponed till the beginning of 1957.

In the meantime with the completion of the two power stations at Nangal the Punjab Transmission System will be in the happy position of not only having adequate installed capacity to meet demand from the area it has been planned to serve, there would still be surplus power available. The present agreement with Pakistan for supply of load to Lahore may therefore be retained, on an yearly renewal basis. The Punjab Transmission System may also be usefully linked up with the Ganges Canal Transmission System in UP. The UP System includes thermal stations at. Hardwaganj and Chandausi, and both these can be closed during the period when surplus hydro-power is available, thereby saving consumption of fuel.

Actual and Estimated Simultaneous Maximum Demand on Uhl Bakra Nangal Delhi Power System ('000)

	1953		1955		1958		1960		1964	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
Punjab	35.0	31.8	42.70	35.7	66.60	53.00	71.20	55.90	87.80	68.70
Pepsu	9.0	8.20	10.90	9.10	22.00	18.40	24.80	20.20	30.00	24.30
Rajasthan	4.2	3.80	7.10	6.50	11.20	10.20	12.10	11.10	13.90	12.80
Himachal	0.25	0.37	0.40	0.60	0.60	0.90	0.70	1.10	0.80	1.40
Delhi	30.0	33.6	33.0	37.00	42.00	46.00	48.50	52.50	58.50	62.50
Aggregate	78.45	77.77	94.0	88.90	142.40	128.50	157.30	140.80	191.00	169.70
With diversity factor of 1.10 ..	71.2	706.	85.5	80.80	129.20	117.00	143.00	128.00	174.00	154.00