WATER AND ENERGY

SYNERGIC MULTI-PURPOSE DEVELOPMENT OF SURFACE WATER RESOURCES

By

Riaz Nazir Tarar[1]

1. Perspective

At present, Pakistan is facing an acute energy crisis. At the same time even sustainability of irrigated agriculture is in jeopardy due to substantial sedimentation of on-line reservoirs. Simultaneously, the country is on the threshold of entering 'Severe Water Shortage' according to international standard of per capita availability. Ironically, at the same time about 35 MAF of river water is escaping unutilized into the sea. Therefore, it is need of the hour to concentrate on synergic multi-purpose development of our surface water resources.

Water and energy nexus is in existence almost since creation of the mankind. It started with the invention of water wheel to convert potential into kinetic energy. Even today this basic principle is applicable to the turbines for hydropower generation. In the present context of serious environmental pollution caused by burning of fossil fuels for energy production, hydro also offers a friendly option. Therefore, the nations blessed by this God given bounty, are focusing on maximum energy generation through hydropower.

Fortunately, Pakistan is blessed with a very large hydropower potential of over 55,000 MW on Indus River System in the North (refer Annex-01). Location Map of Identified Hydropower Sites in Upper Indus and Jhelum River Basins is shown in Annex-02. Against this, Pakistan has so far developed only 6750 MW (refer Annex-03) representing only about 12% of the hydropower potential.

2. National Energy Scenario

2.1. Short Term Energy Demand

It has been assessed that even on suppressed basis the national peak energy demand during 2013-14 is about 18,000 MW. Against total installed capacity of 20,400 GWh, availability of dependable generation is 15,900 MW in summer and 13,400 MW in winter (refer Annex-04). Thus, a perpetual load-shedding between 2000-4000 MW is being experienced. This has been caused by a combination of constraints comprising: no dependable system spare capacity, de-rating of existing thermal units, non-availability of gas for thermal power stations, and seasonal reduction in hydropower capability due to drawdown of reservoirs.

Even assuming a stunted load growth of about 4% per year, peak energy demand over the five year period of 2014-18 is expected to raise up from 18,000 to 21,100 MW (refer

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1. Associate NDC & Project Manager, Diamer Basha Consultants, WAPDA, Lahore.

Annex-05). Against this, the ongoing hydropower projects likely to be commissioned over this period would aggregate to 2507 MW comprising: 22 MW Rehabilitation of Jabban (2014), 106 MW Golen Gol (2016), 969 MW (Neelum-Jhelum (2016), and 1410 MW Tarbela 4th Extension (2017). On the thermal side also, additional capacity of 2507 MW is expected comprising: 425 MW Nandipur (2014), 245 MW Rehabilitation of GENCOs (2015), 163 MW Grange Holding (2014), 134 MW Star Thermal (2016), 1200 MW imported coal, and 340 MW CHASHNUPP IC (2017). Even if all these additional installations of about 5000 MW materialize in the short term scenario of next 5 years (2014-18), the System could still be facing substantial load shedding.

2.2. Prevailing Thermal-Hydro Mix and Generation Costs

Prevailing thermal-hydro mix within the dependable / derated installed capacity of about 19,000 MW is 65:35. Considering energy generation this mix is 70:30. Against this, the past (1990's) mix was 30:70. Due to reversal of thermal-hydro mix over the last two decades, the power tariffs have gone very high. This is due to excessive thermal generation costs varying between Rs. 6 / kWh for gas to Rs. 26 / kWh for diesel operated plants. On the other hand, overall generation cost of WAPDA's system is Rs. 3.50 per kWh as per details in Annex-06. It covers: operative hydropower stations (Rs.1.07), under 'Commissioning / Implementation Projects' (Rs. 4.67), and 'Ready for Implementation Projects' (Rs. 4.76).

3. Medium Term Electricity Demand

3.1. Projection upto 2025

It is gathered that the Planning Commission of Government of Pakistan (GoP) is now in the process of developing a medium term national development plan titled 'Vision 2025 Programme'. Regarding electricity, even on the basis of very low annual growth rate of 4%, the peak demand of 18,000 MW in 2013-14 is expected to go upto 27,700 MW (refer Annex-05).

3.2. Coping Strategy

It is understood that to cope with the above Medium Term Electricity Demand, GoP is focusing on power development as per following priorities:-

i. Bringing the old de-rated thermal plants of WAPDA to design capacity including switch over from costly fossil fuels to coal.

ii. Adding coal based thermal generation on account of short term gestation and low running costs as compared to oil based stations.

iii. Developing run-of-river hydropower facilities with somewhat shorter gestation period as compared to multi-purpose storage projects.

iv. Tapping of un-conventional source of wind for an aggregate capacity of about 2200 MW by the private sector through Alternate Energy Development Board (AEDB) of GoP (refer Annex-07).

Above strategy to cope with Medium Term Electricity Demand notably ignores synergic multi-purpose development of surface water needed not only for cheap renewable energy but direly needed storage water for sustenance of irrigated agriculture.

4. Prirotized Development of Hydropower

In the medium as well as long term, it is essential to give high priority to hydropower development in order to: harness the large unutilized potential, and generate cheap electricity to keep power tariffs within affordable limits. In this regard, focus should not be only on run-of-river (RoR) projects but multi-purpose storages also. This will enable firming up of generation capacity of RoR projects as well enhance their energy output at the downstream locations through cascading effect of storage water releases.

In pursuit of the above strategy, 'Proposed WAPDA's High Priority Hydropower Projects (Phase I)' aggregating to about 18,000 MW installed capacity and aggregate live storage of 8.9 MAF are listed in Annex-08. These also include Diamer Basha Dam Project which, besides adding 4500 MW of power, will provide the direly needed 6.4 MAF of storage to sustain irrigated agriculture in the Indus Basin.

Under Phase II, an aggregate capacity of about 2200 MW is proposed to be developed during 2015-18 through WAPDA, SHYDO and PPIB (refer Annex-09).

Additionally, through Independent Power Producers (IPPs), 17 hydropower projects of 3835 MW are under process with PPIB (refer Annex-10). These comprise: 1490 MW under tariff negotiations, and 2345 MW under processing with Private Power Infrastructure Board (PPIB).

5. Role of Large Multi-Purpose Storages

5.1. Need

Though a number of RoR type projects are now under implementation or planning, their energy output during low flows will reduce to about 35%. Therefore, this will need to be firmed up through construction of large storages, wherever feasible. In addition, Pakistan has compulsion for construction of large dams due to the following reasons:-

i. Need for maximum conservation of unutilized water on the verge of becoming a 'Water Scarce Country' as per global per capita availability criteria.

ii. Rapidly increasing population with enhancing need of food and fiber to be provided by agriculture sector through timely / additional availability of water.

iii. Rapidly depleting on-line storages.

iv. Optimal river regulation and integration of existing irrigation system.

v. Flood regulation, particularly for super events like 2010, to avoid extensive loss of life and property in the Indus Plains.

5.2. Minimum Additional Storage Requirement by 2025

To sustain the agricultural economy as well as ensure national food autarky through increased agriculture outputs, the main reliance has to be placed on the Indus River Basin Irrigation System (IBIS). An estimate has been made of the minimum additional storage requirement of 18 MAF by 2025 over and above 2.9 MAF of Raised Mangla (refer Annex-11).

5.3. Status of Five Dams Identified During 2005 for Priority Implementation

5.3.1. List of Dams

In 2005 the Federal Cabinet took policy initiative to construct five dams on priority basis. This was also conveyed to the nation through the Presidential Pronouncement. These five dams comprised: Kalabagh, Diamer Basha, Akhroi, Munda, and Kurram Tangi. As a sequel to the above policy decision of GoP, engineering studies were pursued by WAPDA, particularly of the large dams to store Indus river surplus flows.

5.3.2. Current Engineering Preparedness Status of Dams

For the above mentioned five dams, the current status is as below:-

i. Kalabagh Dam with live storage of 6.1 MAF and installed capacity of 3600 MW, though ready for implementation since 1987, is in suspended animation due to lack of national consensus.

ii. Diamer Basha, after completion of engineering design, tenders and approval of PC-I in 2009, is under implementation through construction of 'Preliminary Works' and land acquisition. However, to develop live storage of 6.4 MAF and installed capacity of 4500 MW, launching of the core construction is awaiting commitment of the needed foreign financing.

iii. Feasibility Study of Akhori Dam has been completed and go ahead for tender design is awaited.

iv. Updation of feasibility and engineering design of Munda Dam Project, with 0.7 MAF live storage and installed capacity of 740 MW, is in hand through consultants.

v. Engineering of Kurram Tangi Dam Project with 0.9 MAF live storage and installed capacity of 83 MW is complete. USAID has committed necessary funding and it is due for entering the construction stage shortly.

5.3.3. Proposed Implementing Sequence of Dams

Based on the above 'Current Engineering Preparedness Status', the proposed five storage dams could be implemented through 2025 subject to: availability of funding, and national consensus on Kalabagh. The aggregate live capacity of over 19 MAF to become available from these dams would not only meet the above mentioned minimum additional storage requirement of 18 MAF by 2025, but provide some margin for development. Proposed construction sequencing of the three large dams is: Diamer Basha with live storage of 6.4 MAF and 4500 MW power since approved by GoP (2014-

24), Kalabagh having live storage of 6.1 MAF and 3600 MW power subject to national consensus (2017-24), and Akhori with live storage of 6.9 MAF and 600 MW power (2020-25).

To achieve the objective of constructing above mentioned two large multi-purpose storages of Diamer Basha and Kalabagh, following implementing sequence is suggested:-

i. Priority launching of the core construction of Diamer Basha Dam Project with adequate local / foreign funding commitments from GoP / international donors.

ii. Parallel political efforts to achieve national consensus regarding need of Kalabagh Dam Project, particularly its capability of effective flood regulation to avoid catastrophes like 2010.

iii. Engaging IFIs (WB / ADB) and other potential financial sources (Friends of Democratic Pakistan) in supporting the needed reservoir infrastructure for sustenance of national economy.

6. Diamer Basha Dam Project

6.1. The Project

As mentioned above, Diamer Basha Dam Project (DBDP) is now due to enter its implementation stage through launching of core construction. Project will be located on Indus River about 40 km downstream of Chilas, the district headquarter of Diamer in Gilgit-Baltistan. The dam will be 892 feet (272 m) high roller compacted concrete (RCC) structure with two 2250 MW each underground powerhouses on both sides. It will have a live storage capacity of 6.4 MAF to provide for the direly needed supplemental water for Indus Basin Irrigation System (IBIS). The installed capacity of 4,500 MW would yield an annual at site generation of 18,100 GWh. In addition, its cascading effect would generate extra 2400 GWh at existing downstream hydropower facilities of Tarbela, Ghazi-Barotha and Chashma. By trapping sediments it will also enhance the useful life of Tarbela reservoir by 35 years.

6.2. Current Implementation Status

After approval of PC-I in 2009, the Preliminary Works and land acquisition through PSDP allocations is under way. However, launching of the core construction is pending due to no firm commitment(s) of foreign funding.

Currently, it is being contemplated to defer core implementation of DBDP till completion of Stage I (2160 MW instead of 4320 MW) of Dasu Hydropower Project for which, reportedly, firm financing has since been committed by the World Bank. Stage I of Dasu to be completed in 7 years will be essentially RoR facility with nominal re-regulating storage of 0.9 MAF to be depleted within 10-15 years without Diamer Basha. Further, the estimated annual generation of about 12,000 GWh form Dasu Stage I will get reduced by about 25% due to compulsion of at least one month sediment flushing during high flows with consequential two months stopped generation, in the absence of Diamer

Basha. Therefore, it will not be advisable to defer core implementation of DBDP till Stage I Development of Dasu.

In the absence of committed foreign funding, core construction of DBDP may be launched through Lot 1 (Dam and Appurtenants) from own resources. According to proposed implementation schedule of DBDP, contract award for Lot 2 (Underground Works and Related Structures) will require a lapse of 15 months after Lot 1. Thus, some buffer time will become available for lining up of the respective firm funding for remainder of the Project. It is expected that besides interested IFIs, multi / bilateral sources will come forth for construction of hydropower facilities. Even under the worst case scenario of stand-alone construction of Dam and Appurtenants through Lot 1, the following substantial benefits will accrue:-

i. Availability of 6.4 MAF storage water for the highly stressed irrigated agriculture in IBIS.

ii. Enabling additional energy generation of 2400 GWh at the existing downstream power facilities of Tarbela, Ghazi-Barotha and Chashma.

iii. Extending useful life of Tarbela by 35 years through trapping sediment.

iv. Avoidance of quick sedimentation (estimated within 10-15 years) of Dasu re-regulatory storage of 0.9 MAF.

v. Ensuring Dasu Stage I energy generation of 12,000 GWh.

7. Conclusions and Recommendations

7.1. Conclusions

i. Pakistan, though endowed with hydropower potential of about 55,000 MW on rivers in the North, has so far developed only about 6700 MW (about 12%).

ii. Pakistan is facing one of its worst energy crises with perpetuating peak power shortages between 2000 and 5000 MW despite suppressed demand.

iii. Some short term alleviation measures are contemplated by GoP through additional thermal generation from: restored derated capacity of existing GENCO plants, and switching over from costlier oil based to relatively cheaper coal based generation.

iv. In the medium term upto 2025, even for stunted peak demand annual growth rate of 4%, the main reliance should be placed on cheaper and environmental friendly hydropower generation. This will also enable keeping the power tariffs within affordable level.

v. For development of hydropower, both in public and private sectors, current emphasis is on RoR facilities with much reduced generation in winter. Therefore,

for firming up of this RoR energy, creation of large storage facilities is essential. Similarly, the wind power development of about 2200 MW through private sector will be of discontinuous nature and require firming up through storages.

vi. Large storages, besides providing sizeable energy, are also needed for the purpose of highly stressed irrigated agriculture with an estimated minimum water storage requirement of 18 MAF by 2025.

7.2. Recommendations

i. 'WAPDA's High Priority Hydropower Projects Under Phase I' and aggregating to about 17,200 MW should be taken up during the next 2-3 years to enable their completion by 2025 (refer Annex-08).

ii. Engineering of Phase II hydropower development projects of about 2200 MW should be expedited by the concerned agencies for taking up construction by 2017 (refer Annex-09).

iii. IPPs with aggregate capacity of over 3,800 MW, under tariff negotiations and processing with PPIB, be expedited with aim of their completion by 2025.

iv. Fully engineered and approved Diamer Basha Dam Project should be immediately launched for completion before 2025. Ad interim, due to non-commitment of foreign funding, core project launching be initiated by starting construction of 'Dams and Appurtenants' through own resources. This will convey firm commitment of GoP towards project implementation and attract interested international donors for funding hydropower generation facilities.

8. References

1. Pakistan – Need for Storages for Different Uses, paper presented by Riaz N. Tarar during 71st Annual Session of Pakistan Engineering Congress during July 2011.

2. Diamer Basha Dam Project – Pakistan's Top Ranked Project, paper contributed by Dr. Izhar-ul-Haq and Riaz N. Tarar for 'Conference on Pakistan Energy Options' at Islamabad on 29 & 30 March 2012.

3. Solution to Energy Crises – Bridging Group Between Demand and Power Supply, paper presented by Riaz Ahsan Beg during 72nd Annual Session of Pakistan Engineering Congress held in December 2013.

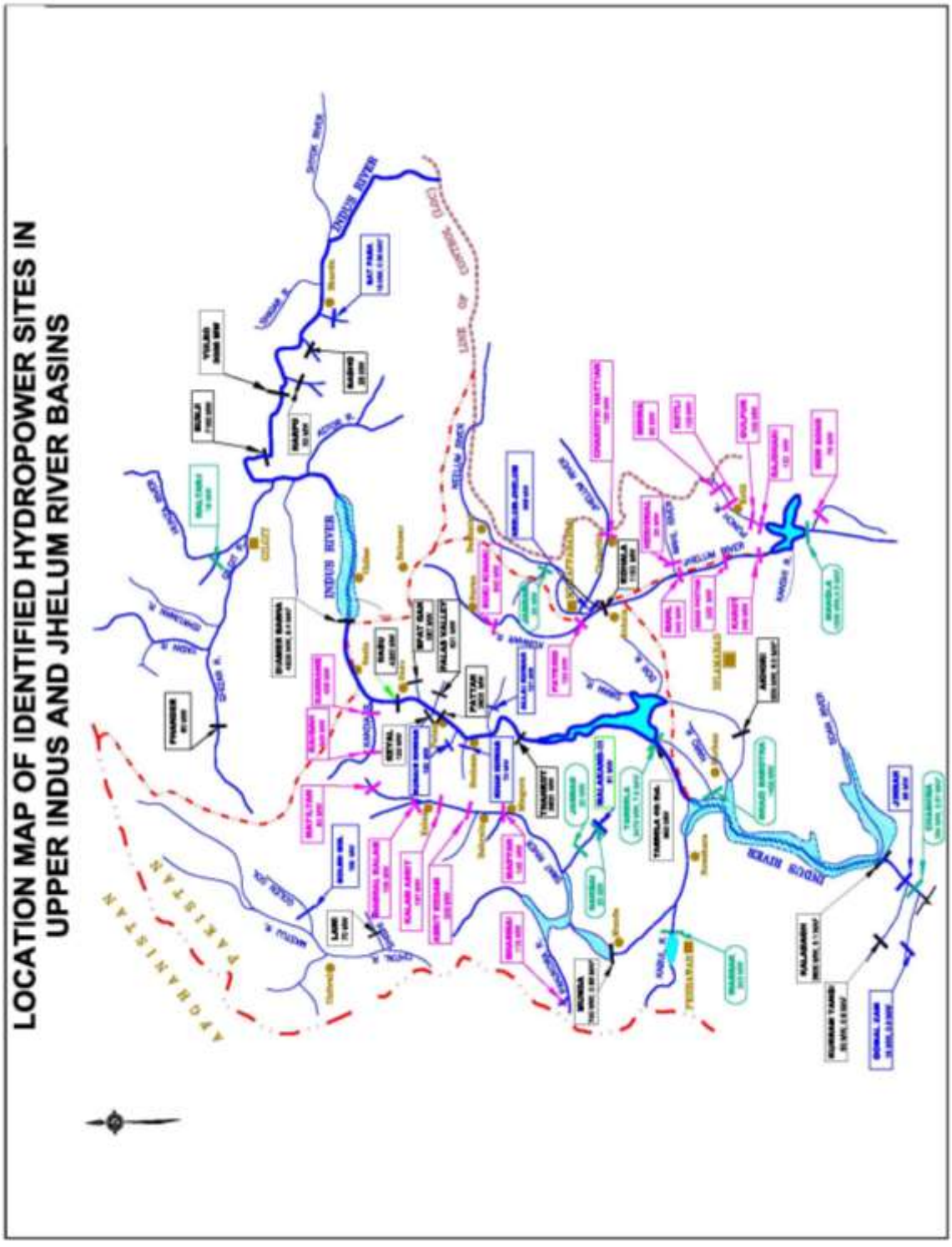
4. Addressing Water and Power Needs of Pakistan Through Construction of Major Storage Dams, paper presented by M/S Muhammad Munir Ch., Zia-ul-Hassan and Dr. Allah Baksh Sufi during 72nd Annual Session of Pakistan Engineering Congress held in December 2013.

ANNEX-01

IDENTIFIED HYDROPOWER POTENTIAL OF UPPER INDUS AND JHELUM RIVER BASINS

Sr. No.	River / Tributary	Capacity (MW)
1	**Indus River and Tributaries**	
i	Indus Main	39,100
ii	Tributaries	8,900
iii	**Sub-total (1)**	**48,000**
2	**Jhelum and Tributaries**	
i	Jhelum River	5,300
ii	Tributaries	1,900
iii	**Sub-total (2)**	**7,200**
3	**Total (1+2)**	**55,200**

ANNEX-02


LOCATION MAP OF IDENTIFIED HYDROPOWER SITES IN
UPPER INDUS AND JHELUM RIVER BASINS
INDUS RIVER
JHELUM RIVER
AFGHANISTAN
PAKISTAN

ANNEX-03

PROGRESSIVE HYDROPOWER DEVELOPMENT IN PAKISTAN
(1925-2013)

Period	Station	Installed Capacity (MW)
Pre-partition (1947)	Renala Khurd (1925)	1
	Jabban / Malakand (1938)	10
1952	Rasul	22
1952	Jabban Extension	10
1952	Dargai	20
1958	Kuram Garhi	1
1959	Chichoki Malian	13
1960	Warsak Dam	230
1961	Shadiwal	14
1963	Nandipur	14
1967-94	Mangla Dam	1000
1975-82	Chitral	1
1967-93	Tarbela Dam	3478
2001	Chashma Barrage	180
2004	Ghazi-Barotha	1450
2010	Khan Khwar	72
2011	Allai Khwar	121
2012	Jinnah	96
2013	Gomal Zam	17
	Total	**6750**

ANNEX-04

GENERATION CAPACITY OF PAKISTAN (2013-14)				
Type of Generation	**Installed Capacity (MW)**	**Dependable / Derated Capacity (MW)**	**Availability (MW)**	
			Summer	**Winter**
WAPDA HYDROS	6,750	6,750	6,550	2,410
WAPDA GENCOs	4,829	3,580	2,780	3,222
IPPs	8,104	7,882	5,867	7,068
Nuclear	692	600	600	600
Rental	62	60	60	60
Total	**20,437**	**18,872**	**15,857**	**13,360**
Say	**20,400**	**18,900**	**15,900**	**13,400**

ANNEX-05

PROJECTED ENERGY GENERATION DEMAND OVER 2014 TO 2025		
Year	**Demand [a] (GWh)**	**Generation [b] (GWh)**
2013-14	18,000	104,200
2014-15	18,700	107,500
2015-16	19,500	110,400
2016-17	20,300	114,100
2017-18	21,100	117,100
2018-19	21,900	120,800
2019-20	22,800	124,500
2020-21	23,700	128,200
2021-22	24,600	131,800
2022-23	25,600	136,100
2023-24	26,600	139,500
2024-25	27,700	144,100

a) Projected from suppressed 18000 MW in 2013-14 to 2024-25 at very low rate of 4% growth per annum

b) At System Load Factor of 70%

ANNEX-06

GENERATION COST OF WAPDA POWER PROJECTS (2011)

Sr.	Project / Power Station	Installed Capacity	Annual Energy Generation	Commercial Operation Date	Generation Cost at Bus-Bars
		(MW)	(GWh)		(Pak Rs./kWh)
I.	**In Operation**				
1	Tarbela	3,478	15,801	1977-93	0.71
2	Ghazi-Barotha	1,450	7,037	2003-04	1.16
3	Mangla	1000	5,443	1967-94	0.52
4	Warsak	243	1,009	1960-81	0.43
5	Chashma	184	959	2001	1.83
6	Rasul	22	63	1952	0.59
7	Dargai	20	162	1952	0.72
8	Nandipur	14	32	1963	1.18
9	Chichoki	13.2	23	1959	1.19
10	Shadiwal	13.5	38	1961	0.81
11	Other Small Hydros	6	29	1925,1975, 1982	2.62
	Sub-total (I)	**6,444**	**30,596**		**1.07 (Avg)**
II.	**Under Commissioning / Implementation**				
12	Khan Khwar	72	306	2010	1.86
13	Allai Khwar	121	463	2012	4.85
14	Duber Khwar	130	595	2014	5.17
15	Jinnah	96	688	2013	3.51
16	Neelum-Jhelum	969	5,150	2016	4.8

17	Golen Gol	106	436	2016	5.05
18	Gomal Zam	17.4	91	2012	7.45
	Sub-total (II)	**1511**	**7729**		**4.67 (Avg)**
III.	**Ready for Implementation**				
19	Diamer Basha	4,500	18,097	-	4.95
20	Kurram Tangi	83	331	-	4.56
	Sub-total (III)	**4,583**	**18,428**		**4.76 (Avg)**
IV.	**Total**	**12,538**	**56,753**		**3.50 (Avg)**

ANNEX-07

PROPOSED WIND POWER DEVELOPMENT IN PRIVATE SECTOR [a)]			
Sr. No.	**Name of Project**	**Capacity (MW)**	**Tentative Commissioning**
1	Sapphire Wind	50	Aug. 2014
2	Metro Power	50	Aug. 2014
3	Gul Ahmed Energy	50	Sep. 2014
4	Wind Eargle Ltd.	50	Oct. 2014
5	Wind Eargle Ltd.	50	Nov. 2014
6	Sachal Energy	50	Nov. 2014
7	Zaphyr Power	50	Dec. 2014
8	Abbas Steel Group	50	Dec. 2014
9	Ismail Industries Ltd.	10	Jan. 2015
10	Pakistan Wind Energy	5	Jan. 2015
11	Titan Energy	10	Feb. 2015
12	China Sunnec Energy	2.4	Mar. 2015
13	Tapal Energy	10	Apr. 2015
14	United Energy	150	Apr. 2015
15	Fenergy Ltd.	50	May. 2015
16	M/S Akhtar Energy	10	Jun. 2015
17	Hartford Alternate Energy	50	Jul. 2015
18	Trident Wind Energy	10	Jul. 2015
19	Tricon Boston Cons	50	Sep. 2015
20	Tricon Boston Cons	50	Nov. 2015

21	Tricon Boston Cons	50	Dec. 2015
22	Hawa Holding Ltd.	50	Feb. 2016
23	NBT Wind Power	250	Apr. 2016
24	NBT Wind Power	250	Jan. 2017
25	Burj Wind Energy	15	Mar. 2017
26	System Wind Energy	150	Jan. 2018
27	China Sunnec Energy	50	Jan. 2018
28	Hydro China Xiebi	100	Feb. 2018
29	Hydro China Xiebi	100	Feb. 2018
30	Hydro China Xiebi	100	Mar. 2018
31	Associated Technologies	100	Mar. 2018
32	Anadolu Wind Energy	200	Apr. 2018
	Total	**2222.4**	
a) Through Alternate Energy Development Board (AEDB) of GoP			

ANNEX-08

WAPDA'S HIGH PRIORITY HYDROPOWER PROJECTS (Phase I)

Sr.	Project	River	Location	Installed Capacity (MW)	Storage in MAF (Gross/live)	Earliest Initiation	Tentative Project Commissioning
1	Dasu (Stage I)	Indus	KPK	2,160	1.15/0.9	2014	2021
2	Kurram Tangi	Kurram	FATA / KPK	83	1.2/0.9	2014	2019
3	Golen Gol	Chitral	KPK	106	RoR	2011	2016
4	Tarbela 4th Extension	Indus	KPK	1,410	Existing Tarbela Storage	2013	2017
5	Munda	Swat	FATA/ KPK	740	1.3/0.7	2015	2021
6	Kohala	Jhelum	AJK	1,100	RoR	2016	2022
7	Bunji	Indus	GB	7,100	RoR	2018	2025
8	Diamer Basha	Indus	GB	4,500	8.1/6.4	2015	2024
Total				**17,199**	**11.75/8.9**		

ANNEX-09

PHASE II HYDROPOWER PROJECTS IN PIPELINE

Sr.	Hydropower Project	Implementing Agency	Capacity (MW)	Tentative Commissioning
1	Patrind	IPP	147	Apr. 2017
2	Phandar	WAPDA	80	May. 2017
3	Harpo	WAPDA	35	May. 2017
4	Shushghai-Zendoli	SHYDO	144	Nov. 2017
5	Sharmai	SHYDO	150	Nov. 2017
6	Matlitan	SHYDO	84	Dec. 2017
7	Shogo-sin	SHYDO	132	Dec. 2017
8	Gulpur (Poonch River)	PPIB	100	Dec. 2017
9	Keyal Khwar	WAPDA	122	May. 2018
10	Lower Palas Valley	WAPDA	665	May. 2018
11	Basho	WAPDA	28	May. 2018
12	Lower Spat Gah	WAPDA	496	Jun. 2018
13	**Total (1 to 12)**		**2183**	

ANNEX-10

PRIVATE SECTOR HYDROPOWER PROJECTS UNDER TARIFF NEGOTIATIONS AND PROCESSING

Sr. No.	Hydropower Project	Capacity (MW)
I	**Under Tariff Negotiations**	
1	New Bong Escape	84
2	Rajdhani	132
3	Matlitan	84
4	Kotli	100
5	Gulpur	100
6	Patrind	150
7	Suki Kinari	840
8	**Sub-total (I)**	**1,490**
II	**Under Processing**	
1	Gabral-Kalam	101
2	Asrit-Kedam	209
3	Kalam-Asrit	197
4	Madyan	148
5	Azad Pattan	222
6	Karot	240
7	Sehra	65
8	Sharmai	115
9	Chakothi Hattian	500
10	Kaigha	548
11	**Sub-total (II)**	**2,345**
III	**Total (I+II)**	**3,835**

ANNEX-11

ESTIMATED MINIMUM ADDITIONAL STORAGE REQUIREMENT [a] BY 2025		
		MAF
1	Replacement of On-line Live Storage Loss	6
2	Meeting shortfall between projected demand and anticipated canal withdrawals of 2025:-	
i.	Demand	125
ii.	Anticipated Withdrawals With Online Storages (Including 2.9 MAF from Raised Mangla)	105
iii.	Short fall (i-ii)	20
iv.	Corresponding Storage Requirement @ 60% of Shortfall	12
3	Additional Storage Requirement [1+2(iv)]	18
a)	Corresponding to WAPDA's Vision 2025 Programme (2000) and ADB's Water Strategy Study (2002)	