INNOVATION AND RENOVATION IN WATER SUPPLY SYSTEM

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Gamut of innovation and renovation in water supply systems covers the four basis pillars of foundation of any drinking water supply system.

1. Deliverables
2. Sustainability
3. Techno-economics
4. Energy Conservation

1. DELIVERABLES

Deliverables imply to meet with norms stipulated by the authority to supply drinking water quality in desired quantity. Generally, projects executed by authority satisfies the quality norms stipulated by standards. However, desired quantity remains the unresolved issue, since gap between claims by authority on quantity supplied and claims by beneficiaries on quantity received is very big.

Also, the assessment of water demand over design horizon of 30 years has remained grey area requiring significant work to address the complex phenomena of water demand. Need of the hour is to give prime importance to evolve correct design to ensure higher success ratio for delivery of potable water to consumer end for any Water Supply Scheme.

Let us take a classic case of adopting growth rate equivalent to national average growth rate, which is 1.7% per annum. Systems designed on basis of this growth rate experienced -200% (two hundred percent) to +35% (thirty five percent) deficit / surplus over period of only 10-15 years of operation. Hence, it is mandatory to look into advanced analysis for realistic assessment of water demand. In case we wish to assess correct demand for next 30 years, we need to analyze data for last 30 years or more.

For successful performance of any scheme, realistic data based analysis to predict population to be served on design horizon is more important. There are number of approaches, which are described in detail in the CPHEEO Manual published by Government of India. However, Malthusian "S curve theory" proved to be more versatile as compared to other theories. As per practice, we consider uniform growth rate for all villages to be covered in a particular regional scheme. However, growth rate of each village varies, which is governing factor to ensure delivery of desired quantity of water to each village. Correct interpretation of past data on population of each village can yield better performance to match with reality.

2. SUSTAINABILITY

In true sense sustainability demarcates cost sharing between generations, who bear the capital expenditure at present stage and recurring cost over life span of system. In developed countries, it spans over 50 years to 200 years for public utility systems, which is longer for underground utilities. In the Indian context, sustainability conveys that the system should sustain over the design horizon. Hence, in India, sustainability is considered as adequacy of various components of the water supply system over service life of 30 years. However, in reality, life expectancy of pipeline and civil structures is in range of 50-60 years compared to pumping machineries life as 15-20 years. Indian Standards or manuals as well as tenders floated by various authorities also stipulate design life of sump, ESR etc. as 60 years. Any existing water supply system utilizes their sump or ESR for 30 years prior to replacement. Pipelines laid in cities served over 100 years or more since laying of pipeline in urban traffic becomes practically unviable. There are other factors necessitating reconsideration on the design horizon, like availability of land to enhance capacities of existing WTP/ ESR/ sump, increased complication to execute the new structure adjacent to existing structure from stability view-point, laying of parallel pipeline on other side of road posing RoU issues, or in case lines are already existing on both sides of the road and new line is to be laid on similar route or longer route etc. Reliability of source being heart of the system, its' citing and optimization of cost is very crucial and needs careful consideration. Sometimes, source considered fails before the design life of 30 years due to unprecedented activities near source and thus all the related components investment becomes questionable. Mostly all the intake wells are situated near bank with a channel dug upto water stream in main river, probably to save on capital cost. This citing hampers availability of water since water channel gets clogged due to heavy silt in the river, which compels authority to pump water from water channel to intake well by temporary pipeline and then again pump to WTP. Majority of the projects based on such source face this problem. Effectiveness of the investment made to the tune of crores of rupees reduces to a considerable extent due to non-availability of water at Intake well in the desired quantity.

Hence, sustainability of water supply system needs reassessment from policy makers.

3. TECHNO-ECONOMICS

Techno-economics implies that once technical feasibility of two or three options are established, then economic aspects should be addressed. Laying of gravity main pipeline, rising main pipeline, water treatment, sizing of storages like underground sump and ESR, distribution network are governed by thumb-rules instead of time-scale analysis. Rigorous analysis of each component calls for enormous efforts towards technical inputs followed by economical designs to prevent wasteful expenditure of public money.

4. ENERGY CONSERVATION

As per present practice, energy conservation is limited to selection of high efficiency pumps and electro-mechanical equipment and adopting automation for few projects. However, energy conservation is something beyond above few equipment. While exploring rising main, costs based on calculating Internal Rate of Return as 12% and fixed energy charges over a period of 30 years, one arrives at capitalized cost. In this case, it is presumed that we are investing a sum Rs. X today and receive interest @ 12% per year. We withdraw Rs. Y at every year. Then we deduct Y from capital, and add interest @ 12% on X-Y and so on for remaining years till the amount becomes zero over period of 15 years. We have also collected data of MGVCL tariff over last 8 years starting from 2008 to 2015, which is tabulated hereunder.

Tariff Comparison for MGVCL from 2008 to 2015

Sr No.	Year	Unit Rate in Rs.			% Increment per Annual		
		Type-I	Type-II	Type-III	Type-I	Type-II	Type-III
1	2015	430	410	320	2.38%	2.50%	3.23%
2	2014	420	400	310	0.00%	0.00%	0.00%
3	2013	420	400	310	6.33%	6.67%	8.77%
4	2012	395	375	285	2.60%	2.74%	3.64%
5	2011	385	365	275	6.94%	7.35%	10.00%
6	2010	360	340	250	2.86%	3.03%	4.17%
7	2009	350	330	240	0.00%	0.00%	0.00%
8	2008	350	330	240	22.86%	24.24%	33.33%
Average increase in % over 7 years (2008-2015)					3.27%	3.46%	4.76%
				Say	3.5%	3.50%	5.0%

Type-I: Water Works & Sewerage pumps operated by other than local Authority

Type-II: Water Works & Sewerage pumps operated by other than local Authority such as municipal corporation. GWSSB located outside Gram Panchyat Area will also attract this tariff

Type-III: Water Works & Sewerage pumps operated by municipalities/ Nagarpalikas or GWSSB for its installations located in Gram Panchyats. As discussed with GWSSB officials, tariff is being charged as per Type-III.Considering data availability, discount is not considered since rate of increase will remain same before or after discount and also for PRV analysis, we consider only rounded figure.

However, actually rate of electricity increases by 5% every year considering current rate of inflation. In case we consider **electricity charge as Rs. 6.00 per unit at present, it will**

be Rs. Rs. 11.88 at 15th year. Techno-economic analysis of pipeline changes drastically with the realistic consideration. It is also important to note that over a period of last 10 years rate of interest has been declining and rate of energy has been increasing. Hence, sensitivity analysis with rate of interest earned as 8% instead of 12% and inflation in energy charges 5%, can yield realistic results.

To explore this aspect, we have taken up case study, wherein, different size of rising main becomes economical than fixed energy. Higher value of energy is realistic than lower value since higher value accounts for increasing energy charges and lower one is based on fixed energy charges. If we had followed fixed energy charges as per conventional practice, result would have been erroneous and far from ground reality and one would have arrived at techno-uneconomical pipe size. Enclosed table clearly shows that there is substantial change in capital investment required at initial stage to meet with ever increasing realistic energy charges. It is fact that presumption of fixed energy charges without any type of increase over a period of 15 years is not true and to account for the realistic energy charges, one shall consider sensitivity of IRR and increase in energy charges. Since IRR and rate of increase in energy is not fixed for long term, average IRR and average increase in energy could be considered. Hence IRR as 8% instead of 12% vis-à-vis 5% increase in energy charges are equated. In absence of realistic analysis, sustainability of project becomes questionable. **This will affect pipe size to a great extent, particularly for lower pipe size, capitalized energy charges plays significant role.**

Table : Capital Investment Required with different IRR and Energy Charges

IRR 12% & As per present practice (without increase in energy charges)					IRR 12% and As per increasing energy charges (increase in energy charges @ 5% per year)				
Year	Capital invested	Interest earned	Amount withdrawn	Balance	Year	Capital invested	Interest earned	Amount withdrawn	Balance
	Balance	12%				Balance	12%	5%	
1	681.086	81.730	100	662.817	1	885.982	106.318	100.000	892.300
2	662.817	79.538	100	642.355	2	892.300	107.076	105.000	894.376
3	642.355	77.083	100	619.437	3	894.376	107.325	110.250	891.451
4	619.437	74.332	100	593.770	4	891.451	106.974	115.763	882.663
5	593.770	71.252	100	565.022	5	882.663	105.920	121.551	867.032
6	565.022	67.803	100	532.825	6	867.032	104.044	127.628	843.447
7	532.825	63.939	100	496.764	7	843.447	101.214	134.010	810.652
8	496.764	59.612	100	456.376	8	810.652	97.278	140.710	767.220
9	456.376	54.765	100	411.141	9	767.220	92.066	147.746	711.541
10	411.141	49.337	100	360.477	10	711.541	85.385	155.133	641.793
11	360.477	43.257	100	303.735	11	641.793	77.015	162.889	555.918
12	303.735	36.448	100	240.183	12	555.918	66.710	171.034	451.594

12	303.735	36.448	100	240.183	12	555.918	66.710	171.034	451.594
13	240.183	28.822	100	169.005	13	451.594	54.191	179.586	326.200
14	169.005	20.281	100	89.285	14	326.200	39.144	188.565	176.779
15	89.285	10.714	100	0.000	15	176.779	21.214	197.993	0.000

IRR 8% & As per present practice (without increase in energy charges)					IRR 8% and As per increasing energy charges (increase in energy charges @ 5% per year)				
Year	Capital invested	Interest earned	Amount withdrawn	Balance	Year	Capital invested	Interest earned	Amount withdrawn	Balance
	Balance	8%				Balance	8%	5%	
1	855.948	68.476	100	824.424	1	918.797	73.504	100.000	892.300
2	824.424	65.954	100	790.378	2	892.300	107.076	105.000	894.376
3	790.378	63.230	100	753.608	3	894.376	107.325	110.250	891.451
4	753.608	60.289	100	713.897	4	891.451	106.974	115.763	882.663
5	713.897	57.112	100	671.008	5	882.663	105.920	121.551	867.032
6	671.008	53.681	100	624.689	6	867.032	104.044	127.628	843.448
7	624.689	49.975	100	574.664	7	843.448	101.214	134.010	810.652
8	574.664	45.973	100	520.637	8	810.652	97.278	140.710	767.220
9	520.637	41.651	100	462.288	9	767.220	92.066	147.746	711.541
10	462.288	36.983	100	399.271	10	711.541	85.385	155.133	641.793
11	399.271	31.942	100	331.213	11	641.793	77.015	162.889	555.919
12	331.213	26.497	100	257.710	12	555.919	66.710	171.034	451.595
13	257.710	20.617	100	178.327	13	451.595	54.191	179.586	326.201
14	178.327	14.266	100	92.593	14	326.201	39.144	188.565	176.780
15	92.593	7.407	100	0.000	15	176.780	21.214	197.993	0.000

In few projects we have observed that with a payback period of 5-7 or even 15 years also, huge amount on energy could be saved. Overall approach for selection of pipe size will yield energy saving over lifecycle.

To evaluate the above four aspects, let us look into the case study of three projects, Sankheda Pavi-Jetpur RWSS, Renovation of (Augmentation of) Sankheda Part III RWSS and Umargam RWSS. Cases of Sankheda Pavi-Jetpur and Sankheda III RWSS are striking since villages situated in same taluka have different growth rates and considerable variation in water demand. One can observe that despite the difference in the development pattern pure rural to rurban/ urban, growth rates are very high as compared to average rural growth rate of the district.

a. **Sankheda Pavi-Jetpur is new RWSS** proposed to be evolved to address water supply issues of Narmada Vasahats and nearby villages. This project is envisaged to encompass 70 villages/ vasahats. First innovation in the project pertains to demand assessment. As per overall growth rate of Vadodara district as 0.67% per annum, it would have been 10.04 mld. However, it appears to be 0.94% per annum on average of three decades for all villages covered under the regional scheme (assuming same growth rate of all villages), yielding 10.9 mld. Actual statistical analysis of individual village suggest growth rate of -1.25% to 10.67% over last three decades, yielding 13.2 mld. As per earlier practice of 1.7% per annum, this was to yield 13.4 mld with uniform growth rate for all villages under the RWSS. However, water demand for each village varies as per their individual growth rate. Hence, we observe that in certain RWSS few villages do not have any complaint on water availability and few villages persistently complain on water availability. In case, authority wish to ensure rational water distribution over the design horizon, assessment of water demand for individual village could prove correct approach with higher degree of reliability. In this project, demand assessment is realistic and hence deliverable is assured. Source of the scheme being Bhilodiya Branch Canal emanating from Narmada Main Canal at Ch 32 km, Raw water reservoir is mandatory. Since the source is most reliable, removal of silt prior to entry of flow into pipeline (closed conduit), reduction in capacity in future is eliminated. Techno-economy is also assured by evolving innovative concept instead of adopting conventional practice of providing 20-30% additional capacity to account for evaporation, which could have resulted in higher capacity, calling for larger land area. Based on realistic data and scientific as well as technical analysis, only 1.25% needs to be added to replenish daily evaporation losses. This innovation has resulted in substantial economics. For storages also mass balance analysis is developed on time scale model to arrive at actual requirement. This analysis helped us to provide requisite storage, eliminating surplus/ deficit on the time scale. For the energy conservation, usage of solar panel was discussed, which is being reconsidered by GWSSB. Introduction of increasing energy charges need consent from TSC of GWSSB and hence it is kept in ambience at present stage.

b. Sankheda III is existing RWSS proposed to be augmented to address water supply issues of Narmada Vasahats and villages already covered under the scheme, but facing acute shortage due to failure of source to yield adequate water (due to sand mining in Orsang River). This project encompass 90 villages/ vasahats. First innovation in the project pertains to demand assessment. As per overall growth rate of Vadodara district as 0.67% per annum, it would have been 9.6 mld. However, it appears to be 1.79% per annum on average of three decades for all villages covered under the regional scheme (assuming same growth rate of all villages), yielding 13.14 mld. Actual statistical analysis of individual village suggest growth rate of -0.8% to 6.13% over last three decades, yielding 13.15 mld. As per earlier practice of 1.7% per annum, this was to yield 12.8 mld with uniform growth rate for all villages under the RWSS. However, water demand for each village varies as per their individual growth rate. Hence, we observe that in certain RWSS few villages do not have any complaint on water availability and few villages persistently complain on water availability. In case, authority wish to ensure rational water distribution over the design horizon, assessment of water demand for individual village could prove correct approach with higher degree of reliability. In this project, demand assessment is realistic and hence deliverable is assured. Source of the scheme being Miyagam Branch Canal emanating from Narmada Main Canal at Ch 62 km, Raw water reservoir is mandatory. Since the source is most reliable, removal of silt prior to entry of flow into pipeline (closed conduit), reduction in capacity in future is eliminated. Techno-economy is also assured by evolving innovative concept instead of adopting conventional practice of providing 20-30% additional capacity to account for evaporation, which could have resulted in higher capacity, calling for larger land area. Based on realistic data and scientific as well as technical analysis, only 1.25% needs to be added to replenish daily evaporation losses. This innovation has resulted in substantial economics. For storages also mass balance analysis is developed on time scale model to arrive at actual requirement. This analysis helped us to provide requisite storage, eliminating surplus/ deficit on the time scale. For the energy conservation, usage of solar panel was discussed, which is being reconsidered by GWSSB. Introduction of increasing energy charges need consent from TSC of GWSSB and hence it is kept in ambience at present stage.

c. Umargam RWSS is existing scheme proposed to be augmented to address water supply issues of villages already covered under the scheme, but facing acute shortage of water. This project encompasses 40 villages and was designed in 2001 with ultimate stage water demand of 19.5 mld at design horizon of 2031. This was commissioned in 2008 and serious complaints on non-availability of water is matter of key concern, since all the designs were prepared strictly in adherence to Technical Committee guidelines and a myth of lowered rural growth rate prevails. While investigating reasons on non-availability of water, we have observed that data on last four decades. First innovation in the project pertains to demand assessment. In case we consider 60 lpcd as per original design, then also water demand would have been 30 mld. Now the scheme is to be augmented due to non-availability of water as a result of very high growth rate, it was planned to assess correct water demand. As per overall growth rate of Valsad district as 0.67% per annum, it should have been 49.4 mld at the design horizon of 2031. However, it is 2.6% per annum on average of three decades for all villages covered under the regional scheme (assuming same growth rate of all villages), yielding 74.2 mld. Actual statistical analysis of individual village suggest growth rate of +0.89% to 9.37% over last three decades, yielding 77 mld. As per earlier practice of 1.7% per annum, this was to yield 61.2 mld with uniform growth rate for all villages under the RWSS. However, water demand for each village varies as per their individual growth rate. Hence, we observe that in certain RWSS few villages do not have any complaint on water availability and few villages persistently complain on water availability. In case, authority wish to ensure rational water distribution over the design horizon, assessment of water demand for individual village could prove correct approach with higher degree of reliability.

Whether one should adopt flow of 49.4 mld as per district average growth rate approach or realistic flow of 77 mld as per growth rate of the villages under consideration is sensible matter since flow varies substantially. In case the scheme is augmented for 49.4 mld, then pipeline could be laid on other side of the road, which is most difficult task from RoU as well as O & M perspective. After 10-15 years, next stage of augmentation will become menace due to the fact that authority can not hamper the existing water supply facility for more than a week and replacement of pipe calls for a period of at least 6 months. Once pipeline is laid on both the sides of the road and laying of third pipeline will not be practicable. This innovation in demand assessment could result in substantial economics. Source strengthening from capacity consideration is another feature to eliminate restriction on drawing raw water since pile foundation based structure will overcome limitation of port size and well dimension from HRT view-point. For storages also mass balance analysis is developed on time scale model to arrive at actual requirement. This analysis helped us to provide requisite storage, eliminating surplus/ deficit on the time scale. Introduction of increasing energy charges need consent from TSC of GWSSB and hence it is kept in ambience at present stage.