STP Guidelines

STP systems should be selected on following basis (based on costs in 2012, which may change over time):

STP Size	Where space is a constraint	Where space is not a constraint
> 1.5 MLD	MBR	MBR
0.5 – 1.5 MLD	MBR	MBBR / SAFF (like systems with tertiary treatment)
< 0.5 MLD	MBBR / SAFF (like systems with tertiary treatment)	Conventional viz. Activated Sludge Process (with extended aeration) with tertiary treatment

Factors to Consider / Learnings:

1. Civil costs form a significant portion of STP costs and to moderate them, it is preferable to locate STP on open ground with only tanks being below ground. If STP cannot be located on open ground, locate in 1st basement or Ground or above Ground, such that partial natural ventilation is feasible.
2. Whenever STP requirement exceeds 1.0 MLD, we will always go for multiples modules as per phasing / occupancy plans and module sizes to be project specific.
3. If STP is installed indoors or commercial/institutes, i.e. at building parking or basement which is accessed, conventional system is not preferred due to hygiene factors.
4. Water processed in MBBR OR MBR based STP can be used for Mechanical Cooling/ Limited Human Touch/ Flushing, as well as for construction purposes.
5. Water processed in Conventional (activated sludge process with extended aeration) system OR SAFF based STP, both with tertiary UV treatment, can be used for Mechanical Cooling/ Limited Human Touch/ Flushing. Further, if RO is added to such system, the output water can be used for construction usage.
6. Assumptions of peak flow rate (residential only): 60% of total STP capacity in 4 hrs (morning 6 AM – 10 AM) to be considered for sizing of collection sump for residential

projects. Remaining plant to be sized as per STP capacity. (Design is for 80% occupancy – hence keeps buffer)

7. Over-ground v/s Under-ground civil cost: Have all the tanks underground & equipment / pump room to be above ground. This arrangement will require less mechanical ventilation. However space required above ground has to be reviewed w.r.t. lost car parks / landscape areas etc. Lowest cost option is if STP can be located away from buildings, then evaluate all tanks and equipment above ground (and surround with landscape) – more applicable in townships.
8. Phasing of capex by staggering procurement of equipment as per occupancy of project (and linked opex e.g. AMC etc):
    a. MBR: For large STPs, having multiple "trains" (consider each train as independent smaller STP, e.g. 6 MLD in Rio designed as 3 trains of 2 MLD each) with equipment such as pumps installed at time of usage. Within each train, cost is further optimized by adding the membrane cassettes as per scale-up (e.g. within each 2 MLD train in Rio, there are 100 cassettes which will be added in a phased manner linked to occupancy). It is important to have equal size trains to increase redundancy of the system (e.g. all pumps).
    b. MBBR/FAB/SBR/SAFF: These STPs have capabilities to operate with min 30% loading. However , the STP can be designed module wise (working in parallel) with common collection sump & sump pumps, partitioned primary & secondary settling tanks, separate bioreactor tanks for each module. Thus each module can be run independent. The raw water & treated water tanks may be kept common. This type of arrangement shall ensure that staggering procurement of equipment as per the occupancy.
9. Distance from sewage source till STP (length of sewage pipes and slope) and location of STP needs to be optimized, specially for township projects
    a. Capacity of sewage pumps increase with higher distance from buildings to STP.
    b. Or else drainage pipes with slope may require a deeper STP due to deeper drainage entry into the STP
    c. For pumping back treated water (non-potable water network), might need to replace uPVC pipes or HDPE or GI pipes which are more expensive.

d. Chances of stagnancy inside lengthy pipelines may affect the effluent BOD/COD parameter and may have varying values between STP discharge and Building Grey water reservoir.

10. Supplementing operational power cost with solar: Since electricity cost of the STP is a considerable portion of the opex, should consider supplementing it with solar panel based systems. Since solar power production and peak operations of the STP both occur during the daytime, load profiles would match to considerable extent. Also, if STP is outdoor type and has "rooftop space" (e.g. CBG, Casa Rio), panels can be accommodated on it and other rooftop spaces available on nearby structures (thumb-rule of within 150-200 metres to reduce LT cable costs). Solar power landed tariff to be compared against available grid tariff before taking decision.
11. Strategic partnerships are critical since technology changes and VE options require equipment manufacturer input (even more than MEP consultant). Based on break-even costs, ideally, we should have strategic tie-ups (master agreements on per KLD basis) with 1-2 vendors broken by the following ranges.
    a. > 1.5 MLD
    b. >0.5-1.5 MLD
    c. <0.5 MLD

    This is critical, since allows design team to directly work with strategic partner during master-planning of the site and space provisioning which cannot be done at a later stage.

12. Operating costs of the STPs are significant – recycled water could cost almost 3-4 p / litre (pipeline water is 2.5 p / litre) driven by electricity, opex and AMC costs.
    a. Long-term operating contracts with equipment vendor in addition to AMC.
    b. Special attention to be given to max operating costs to be included in the contracts.
13. Space requirements for a MBR STP:
    a. Of total, ~70% of floor area towards tanks, of which 10% requires full (~ 9 m) height. These spaces can deal with significant column presence. All tanks need to have their bottom at the same/similar level.
    b. Balance ~30% of floor area towards mechanical machinery, which require flexible spaces with limited column restrictions.

14. Cost evaluation of STP technology options: Five key cost levers need to be considered while comparing the total cost of the technologies:-
    a. Civil costs
    b. Equipment costs
    c. Loss of parking space (because of difference in footprint of plants)
    d. Operating expenses (Including manpower and chemicals)
    e. Power costs

Comment [Y1]: Revision 1

Appendix

STP Technologies

Summary of technologies and commonly used vendors listed below:

1. **Membrane based Technologies**: Equipment cost is highest for these technologies; but quality of output water is significantly better along with savings in terms of space for parking or other commercial value (STP footprint)
    - **a.** Membrane Bio-Reactor (MBR) – e.g. GE is the manufacturer of the membranes but can be implemented by any other vendor as well.
2. **Bio-reactor Technologies**: Equipment cost is higher than conventional but lower than MBR but requires more horizontal space; quality of output water is comparable to MBR
    - **a.** MBBR – Safetreat, Eureka Forbes, etc
3. **Conventional Technologies**: Equipment cost is lowest for these; but quality often not up to usable standards; takes up much more footprint and thus space for parking or other commercial value is lost. Some of the players in STP technologies listed below:
    a. Conventional with extended aeration: Safetreat, Seamak
    b. SAFF: Seamak, Tasla, Pollucon, Katech, Wapp, Safetreat
    c. RMBR: Naik Enviro (patented technology and single small player)
    d. Fluidized Aerobic Bio-reactor (FAB): Thermax (Patented technology)
4. **Conventional Technologies with Tertiary Treatment**: Slight increased Equipment cost over Conventional systems by introducing UF or UV as tertiary treatment; increases space requirement than Conventional systems. This will enable the usage of water for horticulture purpose.
    a. Same vendors as Conventional, but with tertiary treatment
5. **Eco-friendly STPs** – These are non-mechanical type STPs which primarily use soil filters and bacteria for treating water and needs to be clubbed with landscape. Generally, used for small capacity applications / low water quality and ample space is available constraints (typically university, hotels in low cost areas, etc). Advantage of virtually zero loading and low opex. (output water is only usable for plantations)
    a. SBF – IIT patented technology
    b. SIBF

Detailed comparison of technologies is given in Annexure 2.

The parameters (e.g. capex, opex, footprint or space required) for various technologies summarized below:

	Capacity range	**Equipment costs (Rs / KLD)***	**Civil costs (Rs / KLD)***	**Total Capex (Rs / KLD)***	**Opex (Rs / KLD / year)**	**Approx. space requirement (sqm/ MLD)**
Membrane based systems						
Membrane Bio-Reactor (MBR) Recommended size: > 1.5 MLD	1 to 1.5 MLD	~19,000	~21,000	~40,000	3000 - 4000	700 – 800
	2 to 3 MLD	~17,800	~19,000	~34,000		
	6 + MLD	~16,400	~15,500	~32,000		
Bio-reactor technologies						
Sequential Batch Reactor (SBR) or **MBBR** (similar to SBR) (water quality is good equivalent to MBR) Recommended size: < 1.5 MLD	0.5 to 1.5 MLD	~16,000	~21,000	~37,000	3000	1,000 – 1,200
Conventional systems						
Submerged Aerobic Fixed-film (SAFF) Recommended size: < 1.5 MLD	0.2 to 1.5 MLD	~14,000 (with tertiary UV)	~21,000	~35,000	TBC	1500
Conventional activated sludge process (Extended aeration) Recommended size: < 0.5 MLD	0.2 to 0.5 MLD	~11,000	Minimal – specifics TBC	~17,000 estimated	TBC	4000
Fluidized Aerobic Bio Reactor (FAB) with ultra-filtration Recommended size: 0.5 – 2 MLD	1 to 1.5 MLD	~18,000	~20,000	~38,000	3700 - 5200	1000 – 1200
	2 to 3 MLD	~18,400	~22,000	~40,000		
	6 + MLD	~18,200	~22,000	~40,000		

- Costs – completely dependent on size; higher the size, lower the equipment, civil, opex / KLD
- For STPs installed indoors or commercial / institutes, i.e. at building parking or basement which is accessed, conventional system is not preferred due to hygiene factors.

Total Cost of Ownership for STPs

1. **Equipment costs** – can vary from 60-70% of the total STP cost in case of membrane technology vs. 40-45% of total STP costs in case of conventional systems.
    a. Membrane equipment costs reduce with increasing size and achieve break-even with conventional (with tertiary) at 2-3MLD.
    b. However, combined with civil costs, membrane based technologies can break-even at ~1-1.5 MLD.
    c. Scalability provision is available only with MBR system as per demands.
2. **Civil costs –** These are driven primarily by design decisions (underground vs. Over-ground) and the space requirements. Typically, membrane based technologies have 30-40% lower space requirements.
    a. All STP's need to be designed as "over-ground" i.e. tanks for sewage holding and treatment will be underground as per the sewage network outflow levels, but rest of equipment needs to be hosted above ground. Total underground systems increase cost of excavation, civil and water-proofing.
    b. Membrane based technologies have lower Processing Time (3-7 hours) compared to conventional technologies (10-20 hours), which reduces volume requirement of the holding tanks significantly. Hence, civil and water-proofing costs are lower for membrane based technologies.
    c. In case of MBR, the entire STP can be provisioned over-ground (including equalization tanks) – further the tank can be RMC or steel. Civil cost in this case comes to ~ Rs 12,500 / KLD
3. **Space costs** – In projects, where space is at premium (lack of space or alternative commercial usage such as parking needs to be accommodated), better to go for membrane based systems which require lesser space on per KLD basis
4. **Phasing of capex** – Detailed in design implications section

5. **Opex** – Membrane based systems are high on chemical and electricity costs; which can be moderated by utilizing solar or other renewable sources with lower tariff than grid. Detailed in design implications section
    a. MBR/MBBR: ~Rs 4200/KLD per year for Casa Bella Gold STP (GE estimate)
    b. FAB: ~Rs 4300/KLD per year for Casa Bella Gold STP (Thermax estimate)
    c. Conventional system or SAFF: TBC (less than Membrane based systems, since processing time is longer and less power requirement)

Additional Implications for Lodha Design

1. **Getting vendor on board at the time of master-planning** – decisions on phasing, space allocation etc. can be best provided by vendor.

Additional Implications for Lodha Procurement

1. Taxes and duties: For imported items (e.g. bio-reactor membranes in MBR) in large (>3 MLD) installations, discounted customs duty might be applicable, if treated water is used for "industrial purposes" (e.g. future construction). *Being explored currently with Taxation teams*

2. Financing model, BOOT models: Some equipment vendors may be willing to provide equipment financing and/or converting the Design-Build into a BOOT model. *Being explored with GE*

Annexure 1 - Key Terminology

1. STP – Sewage Treatment Plant
2. RO – Reverse Osmosis Plant
3. UF – Ultra-filtration
4. UV – Ultra Violet treatment
5. MBR – Membrane Bio Reactor
6. FAB – Fluidized Aerobic Bio Reactor
7. SBR – Sequential Batch Reactor
8. MBBR – Moving Bed Biofilm Reactor
9. SAFF – Submerged Aerobic Fixed-film
10. BOD – Bio-chemical Oxygen Demand
11. COD – Chemical Oxygen Demand
12. TSS – Total Suspended Solids
13. TDS – Total Dissolved Solids

Annexure 2 - STP Technology comparison

Technology	**Primary treatment**	**Secondary treatment**	**Tertiary treatment**	**Output water quality (key parameters)**	**Pros**	**Cons**
Membrane Based systems						
Membrane Bio-Reactor (MBR)	Screening, grit removal, oil and grease removal and flow equalisation	Aeration tank and membrane as media (Process time 5-7 hrs)	included part of the system	BOD: 3-5 ppm COD: <10 ppm TSS: 0 Ph : 6 -8	• Excellent output water quality • Smaller footprint • Lesser maintenance issues due to absence of PVC media inside tank • Sludge production is lower • Low chemical requirement • Low energy consumption • Ideal for retrofitting Scalability	• Costlier than conventional systems • Membrane life is maximum 5 years • Fewer vendors • Required min. 8 m head room above bio reactor. Other STPs require 5 m head room

Sequential Batch Reactor (SBR) or MBBR (similar to SBR)	Screening, grit removal, oil and grease removal and flow equalisation	Sequential batch reactor where aeration and secondary settling process take place in same reactor (Process time 4-6 hours)	Included as part of the system.	BOD: < 5 ppm COD: <30 ppm TSS: <5 ppm Ph – 6 -8	• Smaller footprint and power requirement (~50%) than conventional system • Highly suitable for small & medium installations • Proven technology • Low capital and operation costs	• Dependency on overseas suppliers of decanting equipment for operations and maintenance
Conventional systems						
Submerged Aerobic Fixed- film (SAFF)	Screening, grit removal, oil and grease removal and flow equalisation, Primary settling	Aeration tank using fixed PVC media rested on support structure (Process time 10-14 hrs) followed by secondary settling	Disinfection, pressure sand filter, activated carbon filter to be added as per water utilization demands.	BOD: < 30 ppm COD: <100 ppm TSS: <30 ppm	• High reliability for treatment of biodegradable wastes. BOD removal efficiency of 90% • Requires 40% smaller bioreactor tank than conventional activated sludge process. • Less power requirement and less sludge generation than conventional technique • Multiple vendors	• Water quality not as good as MBR / MBBR • Requires more area than MBR • Requires heavy support structure for holding PVC SAFF media inside bioreactor tank. • Suitable for developments in which treated water usage is restricted for flushing / irrigation needs only.
Fluidized Aerobic Bio Reactor (FAB) with ultrafiltrati	Screening, grit removal, oil and grease removal	Aeration tank using floating PVC media	Disinfection, ultrafiltration is required for better	BOD: < 20 ppm COD: <100 ppm TSS: <10 ppm	• Lesser retention time, small footprint and less energy consumption	• Tertiary treatment (UF) is required. • Suitable for outdoor application / for

on	and flow equalisation, Primary settling	(Process time 3-5 hours), secondary settling	water quality		• Less sludge generation)	smaller capacities.
Conventional activated sludge process (Extended aeration)	Screening, grit removal, oil and grease removal and flow equalisation, Primary settling	Aeration tank using activated sludge process (Process time 18-22 hours), secondary settling and activated sludge recycle	Disinfection, removal trace organics using chemical oxidation, pressure sand filter, activated carbon filter	BOD: < 30 ppm COD: <100 ppm TSS: <20 ppm	• Proven and readily available technology • High reliability for treatment of biodegradable wastes. BOD removal efficiency of 90%	• High area requirement • Output water barely meets discharge criteria • High sludge generation • Water quality is not consistent Not suitable for indoor installations, commercial, institutional buildings

Note: The above mentioned STP's do not remove hardness in water, for which further RO processing or demineralization plant might be required.