RECOMMENDATIONS ON WATER SUPPLY SYSTEM DESIGN AND O&M COST REDUCTION

WATER MISSION

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SAM KNOBELOCH, TOM KISUBI, ANDRE MERGENTHALER

(AMERGENTHALER@WATERMISSION.ORG)

Recommendations on Water Supply System Design and O&M Cost Reduction

Outline

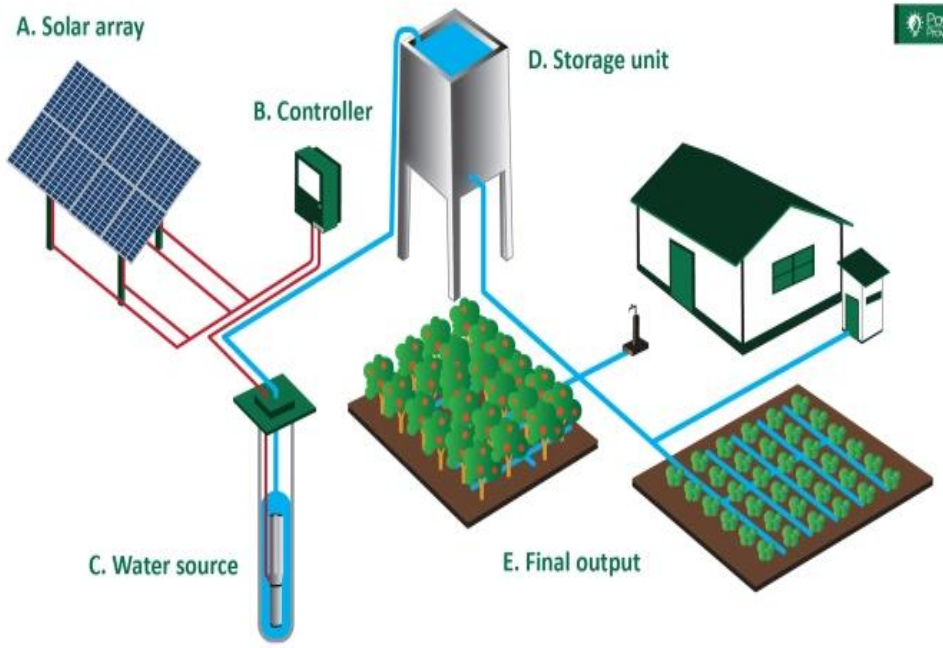
- Common Questions and typical System Design Components Overview
- A - Initial Cost Comparison for 4 Scenarios serving 10k People
- A - 10 Years Cost Comparison for 4 Scenarios serving 10k People
- B - Initial Cost Comparison for 5 Scenarios serving 33k-80k People
- B - 10 Years Cost Comparison for 5 Scenarios serving 33k-80k People
- Summary Table and Answers to Questions

Recommendations on Water Supply System Design and O&M Cost Reduction

Common Questions:

- Can solar really make a difference? Is solar more or less expensive than conventional water supply systems in rural water supply?
- Is it reliable and can it serve a significant population? What needs to be considered?

Recommendations on Water Supply System Design and O&M Cost Reduction



Typical Water System Components – Implications of Generator and Solar Power Supply Only

(Does not consider implications of Hand Pumps or Water Trucking)

- Power Supply => Difference: For Rural Areas and Refugee Settings - Predominantly Generator versus Solar/Hybrids (rarely AC grid)
- Pump Technology => Difference only for Inverter (not pumps) / or small systems solar pumps
- Water Distribution => No Difference
- Water Treatment => No Difference for erosion Chlorination but depend on required technology.
- Water Storage => Considered no difference for this presentation but debatable
- Water Sources

  Surface Water => No difference, solar possible on all motors, this study focuses on BHs

  Boreholes => Limited Solar hours (not energy) may require higher pumping rates and therefore borehole yields. Consider appropriate design and solar-generator-hybrid solutions …

✓ Approach A: Serve a given Population - 10,000 People (15 Liter/Day), consider yield.

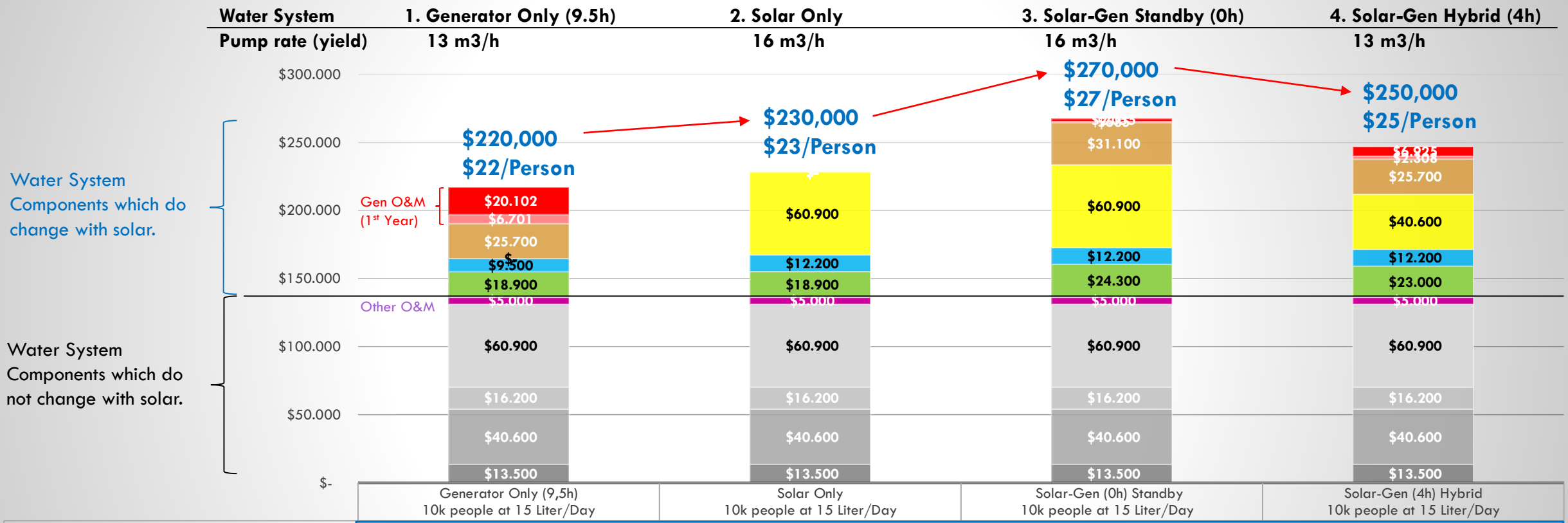
✓ Approach B: Serve a maximum Population through increasing pumping hours using solar-hybrid systems.

as in following slides …

- Total Project Cost: CapEx+O&M 1st Year
- Inclusive Logistics and Implementation
- Inclusive G&A, PM, Contingency (~30%)
- Based on a real projects in northern Uganda (Bidibidi)
- Exclusive Drilling
- Figures rounded

Approach A: Serve a given Population - 10,000 People (15 Liter/Day), consider yield.

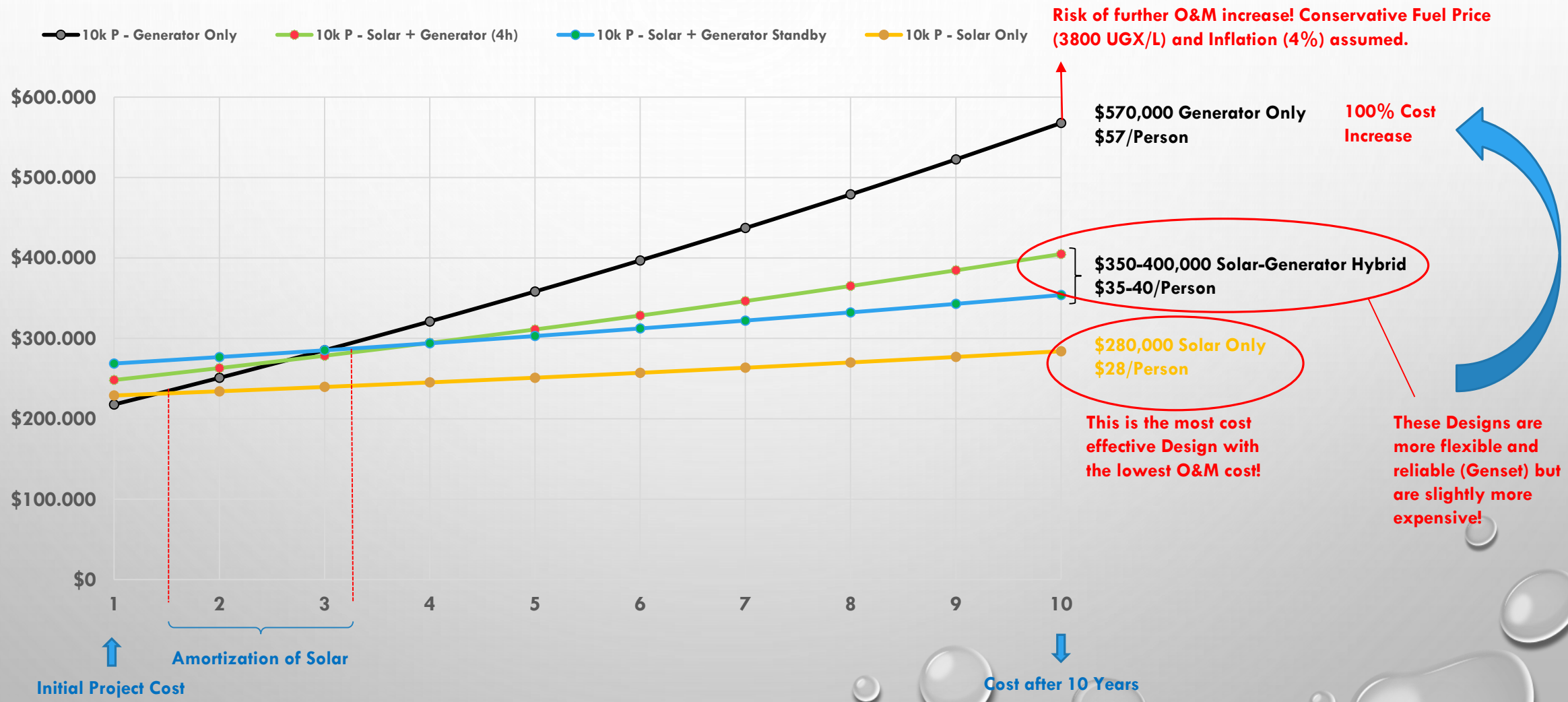
Initial Cost Comparison of Water Systems and Components (in USD)



- Generator Fuel (1st Year)
- Generator Maintenance (1st Year)
- Generator Set
- Solar Array and Rack
- Pump and Inverter
- Structures and Fencing
- Other O&M Costs (1st Year)
- Water Storage
- Supply Piping, Water Treatment, Miscellaneous/Other
- Distribution System
- Assmt, Design, Supervision

Generator Only (9,5h) 10k people at 15 Liter/Day	Solar Only 10k people at 15 Liter/Day	Solar-Gen (0h) Standby 10k people at 15 Liter/Day	Solar-Gen (4h) Hybrid 10k people at 15 Liter/Day
• Low CapEx.	• Low CapEx.	• Slightly Higher CapEx.	• Low CapEx.
• Far highest O&M.	• Lowest O&M.	• Low O&M.	• Higher O&M.
• Maximum service if O&M can be met.	• Great service level/ resilience.	• Maximum service level/resilience (Gen)	• Maximum service level/resillience (Gen)
• Low borehole yield required.	• Slightly higher borehole yield required.	• Slightly higher borehole yield required.	• Low borehole yield required.

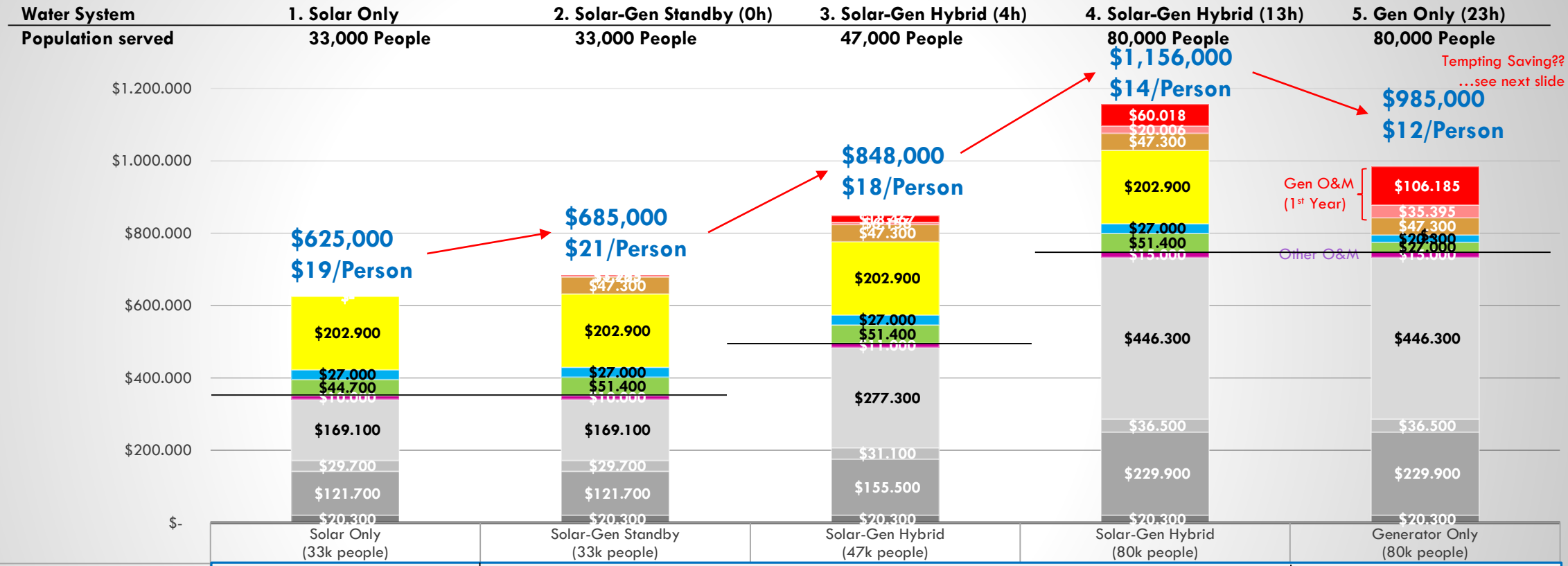
Approach A: Serve a given Population - 10,000 People (15 Liter/Day), consider yield. Cumulative Cost of Water Systems over 10 Years (in USD).



- Total Project Cost: CapEx+O&M 1st Year
- Inclusive Logistics and Implementation
- Inclusive G&A, PM, Contingency (~30%)
- Based on real projects design
- Components change with System Size
- Exclusive Drilling
- Figures rounded

Approach B: Serve a maximum Population through increasing pumping hours. (Pump Rate 55m3/h)

Initial Cost Comparison of Water Systems and Components (in USD)



- Generator Fuel (1st Year)
- Generator Maintenance (1st Year)
- Generator Set
- Solar Array & Rack
- Pump and Inverter
- Structures and Fencing
- Other O&M Costs (1st Year)
- Water Storage
- Supply Piping, Water Treatment, Miscellaneous/Other
- Distribution System
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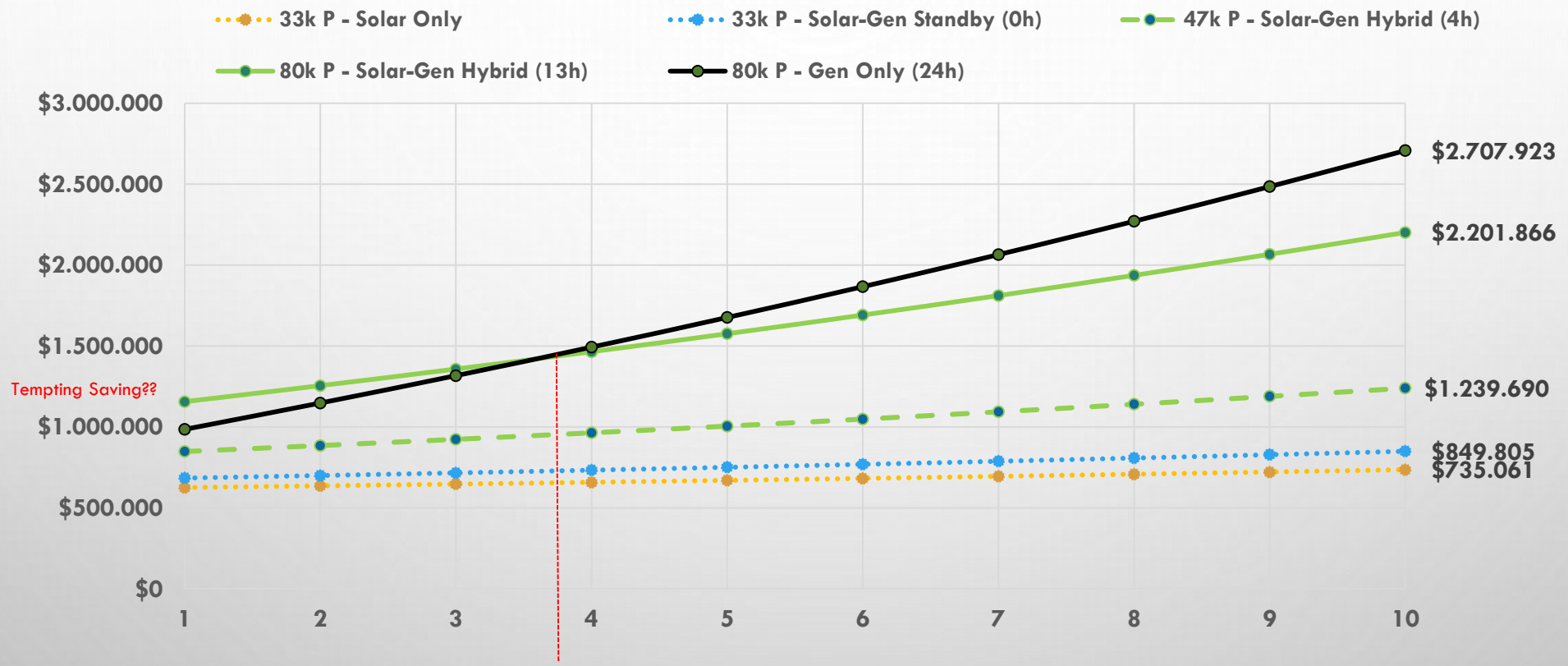
- **Low CapEx.**
- **Lowest O&M.**
- **Great service level/ resilience.**

- **More People being served with increasing Generator pumping time**
- **Solar maximized to day light hours and yield**
- **Gen O&M minimized compared to Gen Only**

- **Low CapEx.**
- **Far highest O&M.**

Approach B: Serve a maximum Population through increasing pumping hours. (Pump Rate 55m3/h)

Cumulative Cost of Water Systems over 10 Years (in USD)



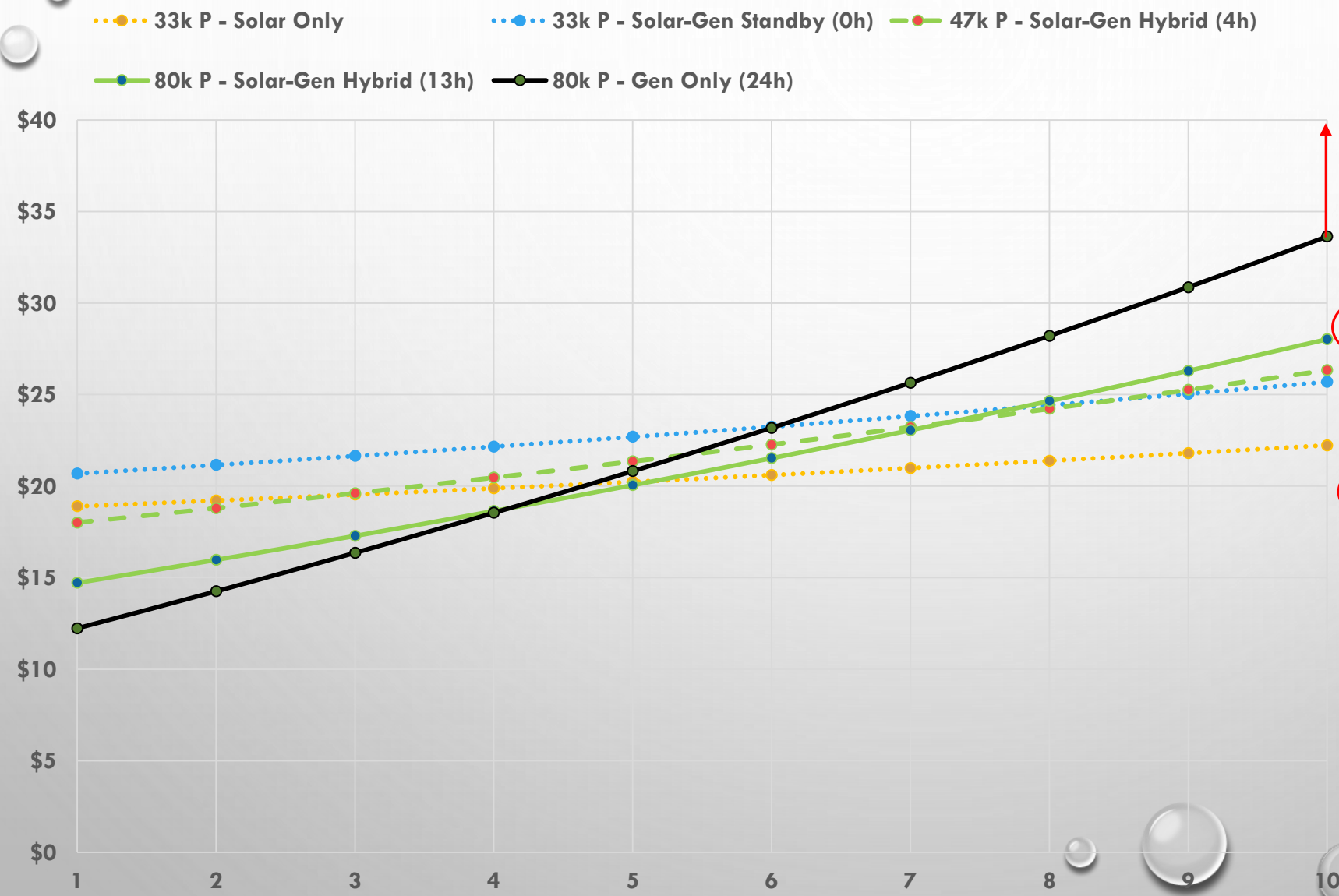
Initial Project Cost

Amortization of Solar <4 years, also with increased Gen runtime (13h) in Hybrid Systems.

Cost after 10 Years

Approach B: Serve a maximum Population through increasing pumping hours. (Pump Rate 55m3/h)

Cumulative Cost per person of Water Systems over 10 Years (in USD/Person).



Risk of further O&M increase! Conservative Fuel Price (3800 UGX/L) and Inflation (4%) assumed.

$34/person, 80k People with Gen Only

$28/Person, 80k People with Solar-Gen Hybrid

This is the most cost effective Design to serve 80,000 people! (Despite running on gen for 13h/day.)

$22/Person, 33k People with Solar Only

This is the most cost effective Design with the lowest O&M cost to serve 33,000 people!

Summary Table

Column1	1	2	3	4	5	6	7	8	9
System Design Scenario	Gen Only (9,5h) (10k people)	Solar Only (10k people)	Solar-Gen (0h) Standby (10k people)	Solar-Gen (4h) Hybrid (10k people)	Solar Only (33k people)	Solar-Gen (0h) Standby (33k people)	Solar-Gen (4h) Hybrid (47k people)	Solar-Gen (13h) Hybrid (80k people)	Gen Only (23h) (80k people)
CapEx	$ 186.000	$ 224.000	$ 261.000	$ 234.000	$ 615.000	$ 669.000	$ 812.000	$ 1.061.000	$ 828.000
O&M 1st Year	$ 31.803	$ 5.000	$ 7.741	$ 14.234	$ 10.000	$ 15.059	$ 35.623	$ 95.024	$ 156.581
Total Initial	**$ 217.803**	**$ 229.000**	**$ 268.741**	**$ 248.234**	**$ 625.000**	**$ 684.059**	**$ 847.623**	**$ 1.156.024**	**$ 984.581**
Total after 10 Years	**$ 567.828**	**$ 284.031**	**$ 353.934**	**$ 404.889**	**$ 735.061**	**$ 849.805**	**$ 1.239.690**	**$ 2.201.866**	**$ 2.707.923**
People	10.000 People	10.000 People	10.000 People	10.000 People	33.000 People	33.000 People	47.000 People	80.000 People	80.000 People
$$/People Initial	22 $$/P	23 $$/P	27 $$/P	25 $$/P	19 $$/P	21 $$/P	18 $$/P	14 $$/P	12 $$/P
$$/People/Year	**6 $$/P/Year**	**3 $$/P/Year**	**4 $$/P/Year**	**4 $$/P/Year**	**2,2 $$/P/Year**	**2,6 $$/P/Year**	**2,6 $$/P/Year**	**2,8 $$/P/Year**	**3,4 $$/P/Year**
Cubic Meter / Day	150 m3/Day	150 m3/Day	150 m3/Day	150 m3/Day	495 m3/Day	495 m3/Day	705 m3/Day	1.200 m3/Day	1.200 m3/Day
Cubic Meter in 10 Years	547.500 m3	547.500 m3	547.500 m3	547.500 m3	1.806.750 m3	1.806.750 m3	2.573.250 m3	4.380.000 m3	4.380.000 m3
$$ / Cubic Meter	1,04 $$/m3	0,52 $$/m3	0,65 $$/m3	0,74 $$/m3	0,41 $$/m3	0,47 $$/m3	0,48 $$/m3	0,50 $$/m3	0,62 $$/m3
UGX / Cubic Meter	**3.837 UGX/m3**	**1.919 UGX/m3**	**2.392 UGX/m3**	**2.736 UGX/m3**	**1.505 UGX/m3**	**1.740 UGX/m3**	**1.783 UGX/m3**	**1.860 UGX/m3**	**2.288 UGX/m3**
UGX / 20 Liter	**77 UGX/20L**	**38 UGX/20L**	**48 UGX/20L**	**55 UGX/20L**	**30 UGX/20L**	**35 UGX/20L**	**36 UGX/20L**	**37 UGX/20L**	**46 UGX/20L**
O&M Percentage	**67%**	**21%**	**26%**	**42%**	**16%**	**21%**	**34%**	**52%**	**69%**

Recommendations on Water Supply System Design and O&M Reduction

Common Questions: Answers

- Can solar really make a difference? Is solar more or less expensive than conventional water supply systems in rural water supply?
  - Yes, solar makes a significant difference and is less expensive than a generator powered solution after 1 to 4 years in all Design Scenarios.
  - The bigger the scale the lesser the cost/people.
  - The more solar pumping hours the lesser the cost.
  - O&M costs are significantly reduced. Main reason is the reduction potential of Generator Costs for Fuel and Maintenance.

- Is Solar reliable and can it serve a significant population? What needs to be considered?
  - Yes, solar is more reliable than a generator solution considering down time for repairs and fuel shortages. Solar-Gen-Hybrid can further increase reliability and increase service level.
  - Special attention must be paid to the design being appropriate to its water source and water demand.
  - Any conventional pump can be solar powered and therefore the same population can be served as with conventional water supply systems.
  - Regarding concern about performance of solar during rain season:
    a) The designs shall be based on the most cloudy/rainy month of the year
    b) Any remaining concern can be eliminated through a Standby-Generator at near 0 hours of operation, so that there are no significant Generator Fuel/O&M costs occur.

For any assistance in solar design or implementation needs please contact Water Mission Uganda office.

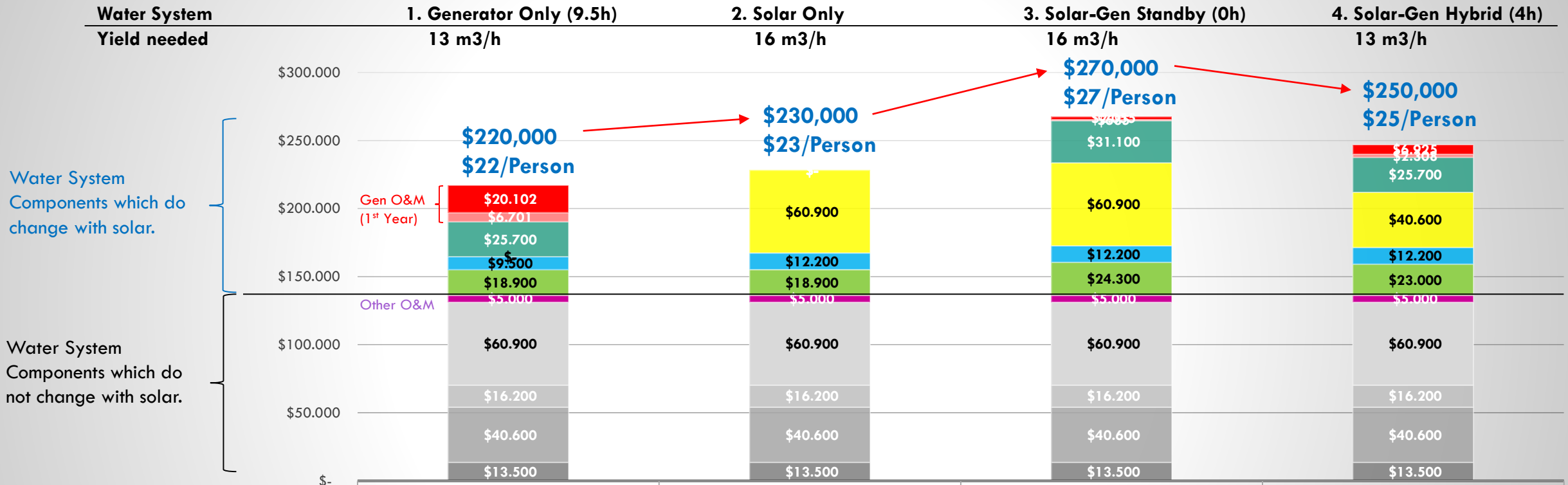
Thank you.

Background Info / Assumptions

No.	Subject	Assumption
1	Water System Design	All 14 scenarios repreasent hypothetical water systems for Rhino Camp Zone 6, with a recently tested 55 m3/hr borehole as the system's water source
2	Water System Design	Scenarios 1-5 (Top Table) represent water systems designed to serve 10,000 eople at 15 L/person/day
3	Water System Design	Scenarios 6-14 (bottom Table) represent different water system options designed to maximize the flowrate from a borehole of 55 m3/hr yield
4	Water System Design	Tanks sizes based on daily water production only, regardless of power supply method
5	Solar Design	Solar Array Size for each scenario was determined using the average daily irradiation in the lowest solar irradiation month of the year
6	Water System Capacity	Population Served by each system determined based on average daily water production, using 15 Liters per capita per day
7	Capital Costs	Capital Costs for a Solar-Gen Hybrid Water System serving 10,000 people (Scenario 4) were taken from the PBE for Bidibidi Settlement project (00.182.34)
8	Capital Costs	Capital Costs for other water systems serving 10,000 people were estimatd by modifying the cost estimate of the Solar-Gen Hybrid system according to all cost differences that are affected by the relative power supply method
9	Capital Costs	Capital Costs for the maximized Solar-Gen Hybrid System serving ~ 47,000 people (Scenario 10) were estimated by designing the water system to be implemetned at Rhino Cmap Zone 6 and using a PBE to estimate
10	Capital Costs	Capital Costs for all other maximized water systems were estimatd by modifying the cost estimate of the Solar-Gen Hybrid system according to all cost differences that are affected by the relative power supply method
11	Capital Costs	Solar Array costs of $1.50 per watt for materials and installation, +Overhead, Project Management, Contingency
12	Capital Costs	Capital Costs shown are the total installed costs for each project component, including labor including Overhead, Project Management, Contingeny
13	Capital Costs	Overhead, Project Management, Contingency about 30% of total Cap+O&M, except Generator O&M.
14	Capital Costs	Costs for Borehole drilling not included
15	O&M Costs	Generator fuel consumption per hour was estimated using the chart in the "Generator Data" tab, from DieselServiceandSupply.com
16	O&M Costs	Cost of diesel fuel is assumed to be UGX 3,800 per liter. Diesel fuel without Overhead, Project Management, Contingency.
17	O&M Costs	Generator O&M costs assumed to be 1/3 of fuel costs per hour of operation. Generator O&M without Overhead, Project Management, Contingency. Cost range in literatur goes up to 100% of fuel costs.
18	O&M Costs	Exchange rate of UGX 3,700 per 1 USD
19	O&M Costs	Conservative Inflation rate of 4% per year (conservative based on inflation rates over the last 5 years) https://tradingeconomics.com/uganda/inflation-cpi

Approach A: Serve a given Population with a given borehole - 10,000 People (15 Liter/Day)

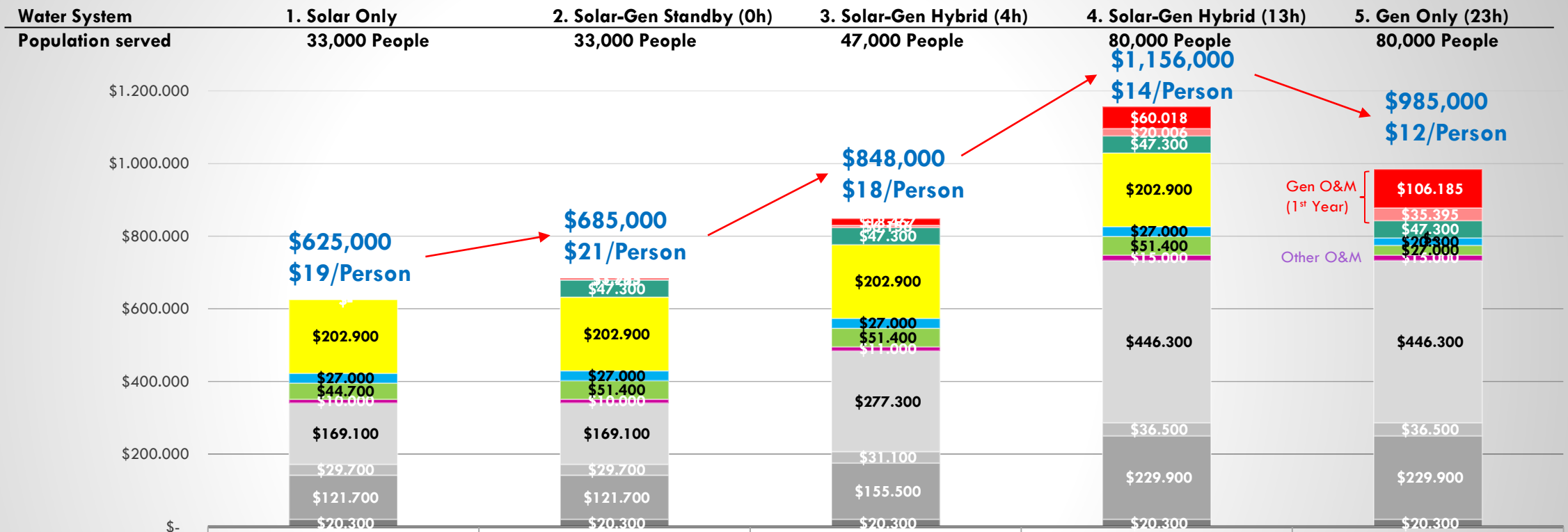
Cost Comparison of Water Systems and Components (in USD)



	Generator Only (9,5h) 10k people at 15 Liter/Day	Solar Only 10k people at 15 Liter/Day	Solar-Gen (0h) Standby 10k people at 15 Liter/Day	Solar-Gen (4h) Hybrid 10k people at 15 Liter/Day
Generator Fuel (1st Year)	$20.102	$-	$2.055	$6.925
Generator Maintenance (1st Year)	$6.701	$-	$685	$2.308
Generator Set	$25.700	$-	$31.100	$25.700
Solar Array and Rack	$-	$60.900	$60.900	$40.600
Pump and Inverter	$9.500	$12.200	$12.200	$12.200
Structures and Fencing	$18.900	$18.900	$24.300	$23.000
Other O&M Costs (1st Year)	$5.000	$5.000	$5.000	$5.000
Water Storage	$60.900	$60.900	$60.900	$60.900
Supply Piping, Water Treatment, Miscellaneous/Other	$16.200	$16.200	$16.200	$16.200
Distribution System	$40.600	$40.600	$40.600	$40.600
Assmt, Design, Supervision	$13.500	$13.500	$13.500	$13.500

Approach B: Serve a Maximum Population with a given borehole (Yield 55m3/h)

Cost Comparison of Water Systems and Components (in USD)



	Solar Only (33k people)	Solar-Gen Standby (33k people)	Solar-Gen Hybrid (47k people)	Solar-Gen Hybrid (80k people)	Generator Only (80k people)
Generator Fuel (1st Year)	$-	$3.795	$18.467	$60.018	$106.185
Generator Maintenance (1st Year)	$-	$1.265	$6.156	$20.006	$35.395
Generator Set	$-	$47.300	$47.300	$47.300	$47.300
Solar Array & Rack	$202.900	$202.900	$202.900	$202.900	$-
Pump and Inverter	$27.000	$27.000	$27.000	$27.000	$20.300
Structures and Fencing	$44.700	$51.400	$51.400	$51.400	$27.000
Other O&M Costs (1st Year)	$10.000	$10.000	$11.000	$15.000	$15.000
Water Storage	$169.100	$169.100	$277.300	$446.300	$446.300
Supply Piping, Water Treatment, Miscellaneous/Other	$29.700	$29.700	$31.100	$36.500	$36.500
Distribution System	$121.700	$121.700	$155.500	$229.900	$229.900
Assmt, Design, Supervision	$20.300	$20.300	$20.300	$20.300	$20.300