# Replicable Net Zero Water Systems

TH210

Thursday, June 21, 7:30-9:00am

1.5 LUs/HSW/RIBA

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# Acknowledgements/Credits

Grimshaw Architects

Buro Happold Engineering

Sherwood Design Engineers

# Speakers List

- Prentiss Darden, Sherwood Design Engineers
- Denzil Gallagher, Buro Happold
- Aaron Vaden-Youmans, Grimshaw
- Sarah Sachs, Buro Happold

# Course / Learning Objectives

- How to approach water reuse design
- How water supports Better Cities
- Water reuse opportunities + constraints
- No “right answer” to sustainable water strategies

# Background + Site Context

Image Credit: GCD Worldwide

# UAE Water Use

82%

above global average

Image Credit:

# Water Use

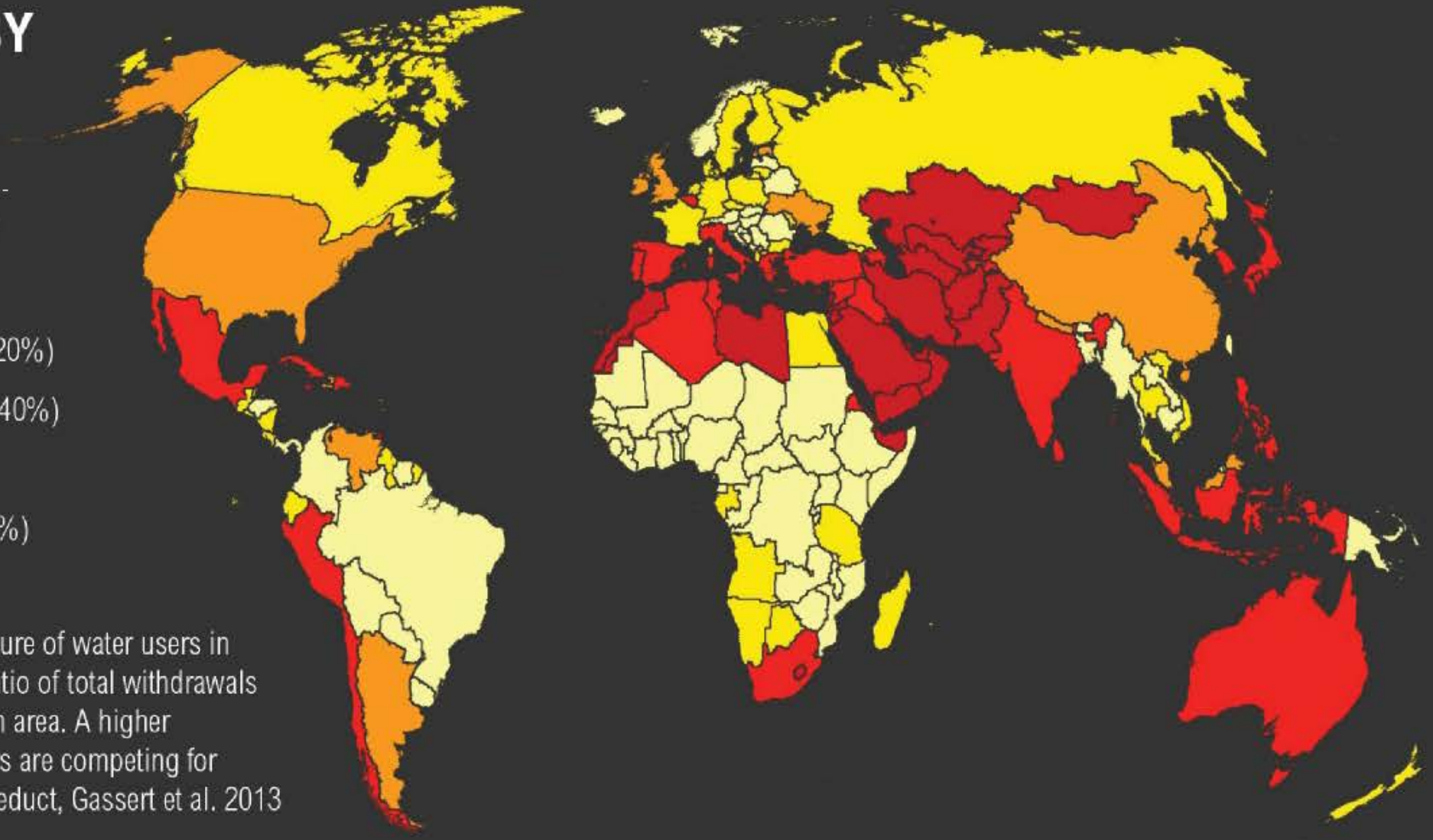
- **Dubai**: 145 gallons/ person/ day
- **New York**: 115 gallons/ person/ day
- **San Francisco**: 50 gallons/ person/ day
- **Cape Town**: 41 to 23 to 13 gallons/ person/ day

Image Credit: National Geographic

# WATER STRESS BY COUNTRY

**ratio of withdrawals to supply**

- Low stress (< 10%)
- Low to medium stress (10-20%)
- Medium to high stress (20-40%)
- High stress (40-80%)
- Extremely high stress (> 80%)



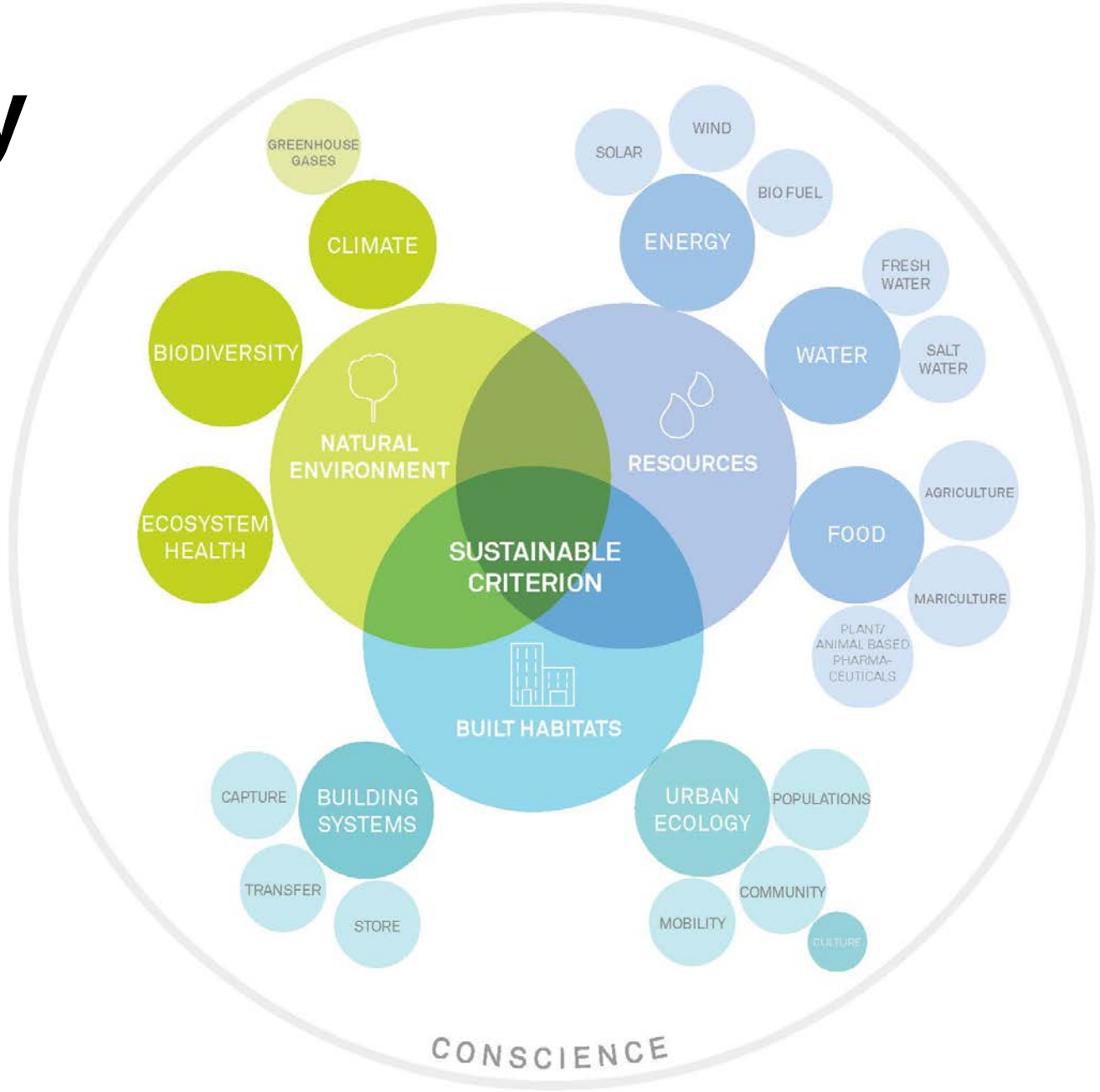
This map shows the average exposure of water users in each country to water stress, the ratio of total withdrawals to total renewable supply in a given area. A higher percentage means more water users are competing for limited supplies. Source: WRI Aqueduct, Gassert et al. 2013

AQUEDUCT

WORLD RESOURCES INSTITUTE

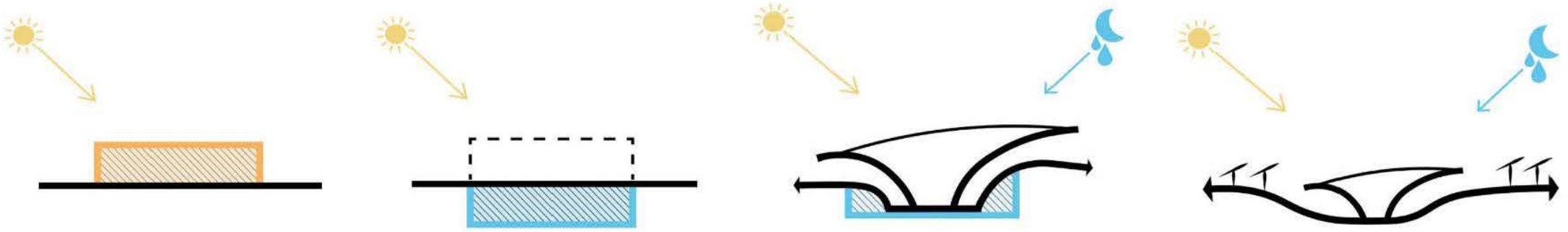
# Initial Design

# Sustainability Pavilion Vision



# Vision

# Design Ideas: Energy + Water Collection



**TYPICAL**
*BUILDING ABOVE GROUND EXPOSED TO HARSH ENVIORNMENTAL CONDITIONS*

**BUILDING ACCOMMODATION**
*BY SUBMERGING SPACE, EARTH PROVIDES INSULATION REDUCING CLIMATE CONTROL LOADS.*

**CANOPY STRUCTURE**
*SHIELDS BUILDING FROM SUNLIGHT*

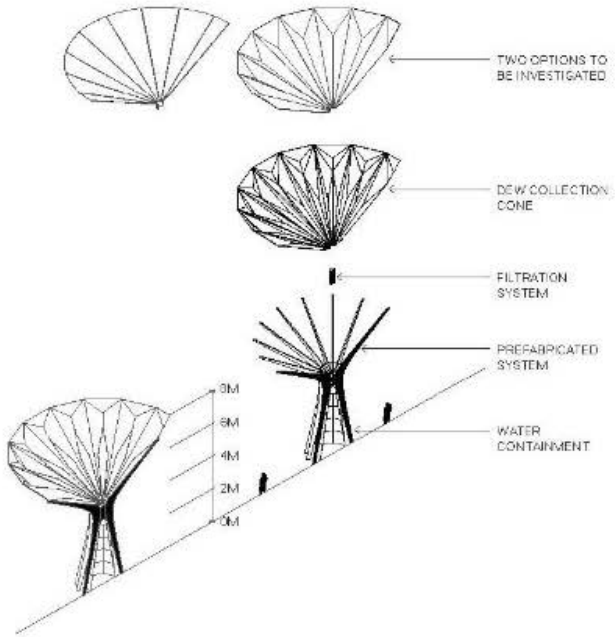
**LANDSCAPE CANOPIES**
*ADDITIONAL SHADE PROVIDES PEDESTRIAN CONFORT WITH THE MAIN CANOPY, PROVIDES SOLAR ENERAGY AND ATMOSPHERIC WATER GENERATION*

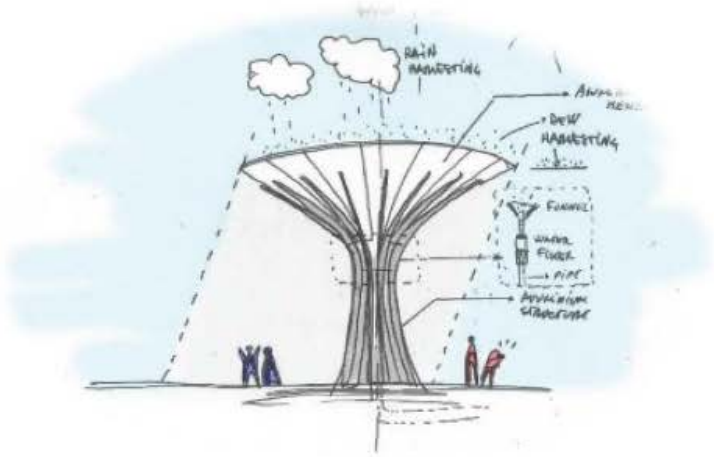




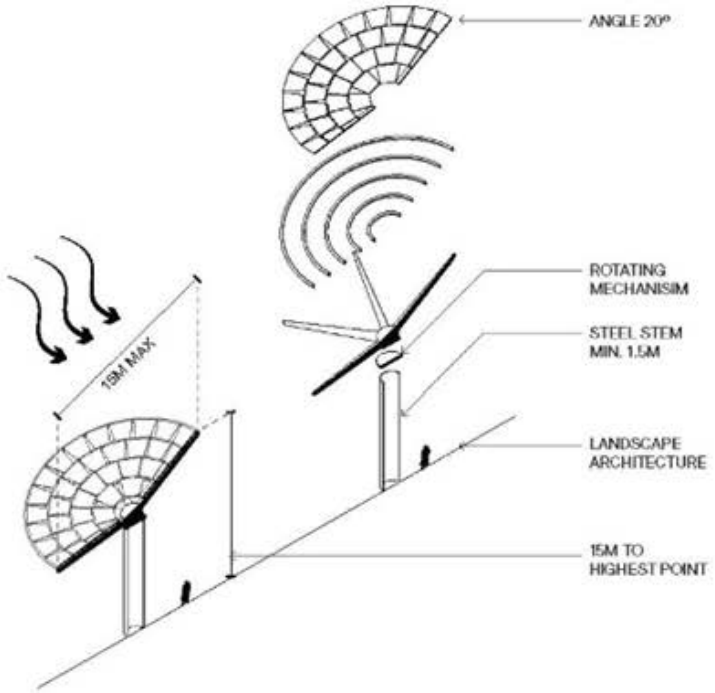


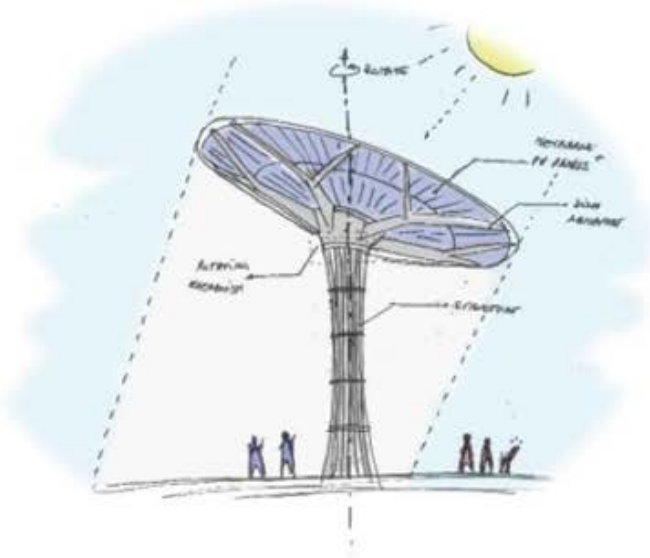
# Design Ideas: Dew Harvesting Trees

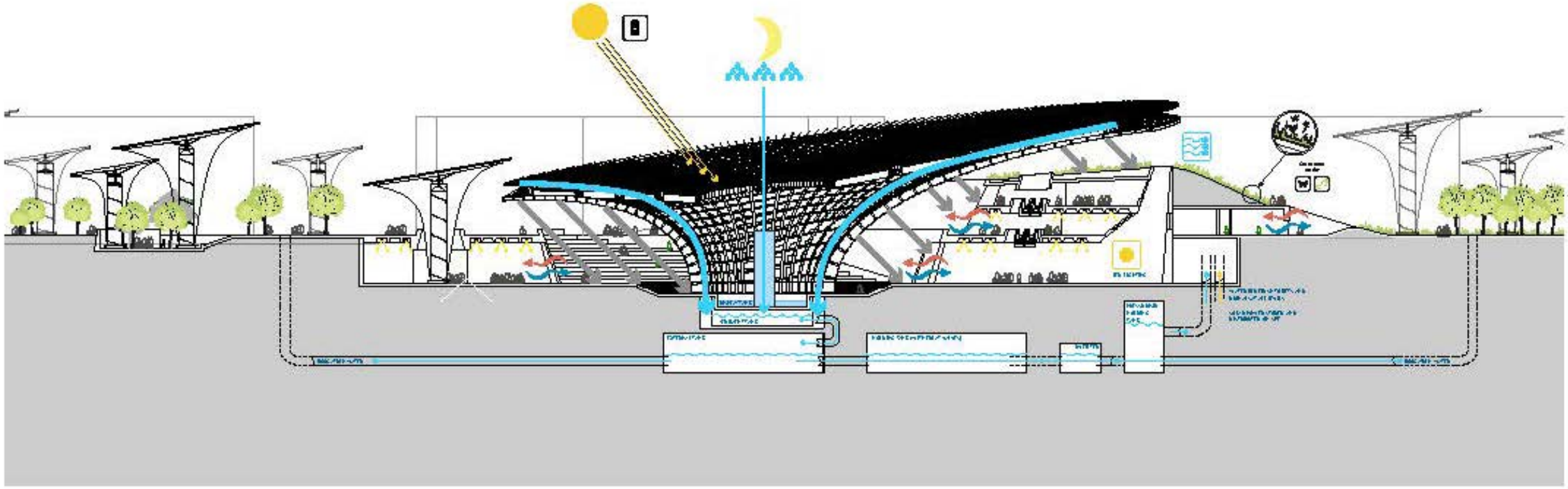


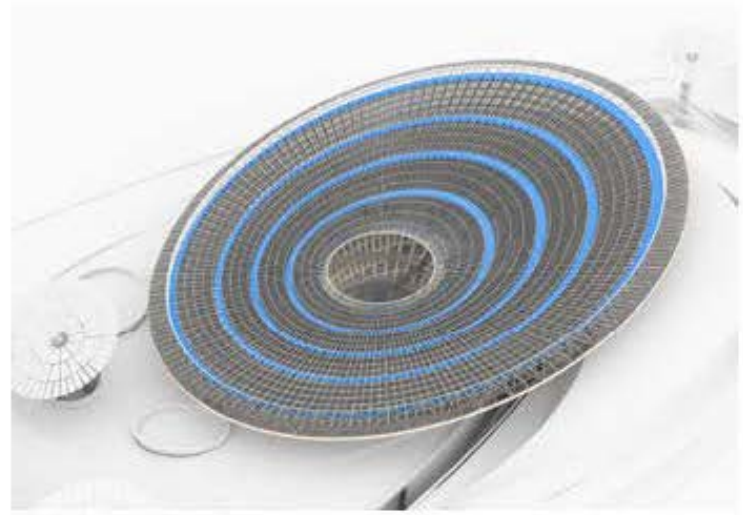
# Design Ideas: Solar Energy Trees



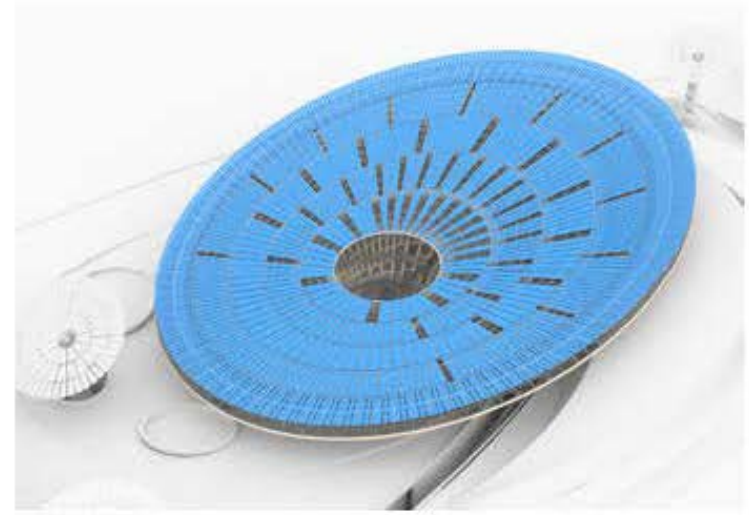





CIRCULATION SPIRAL RAMP

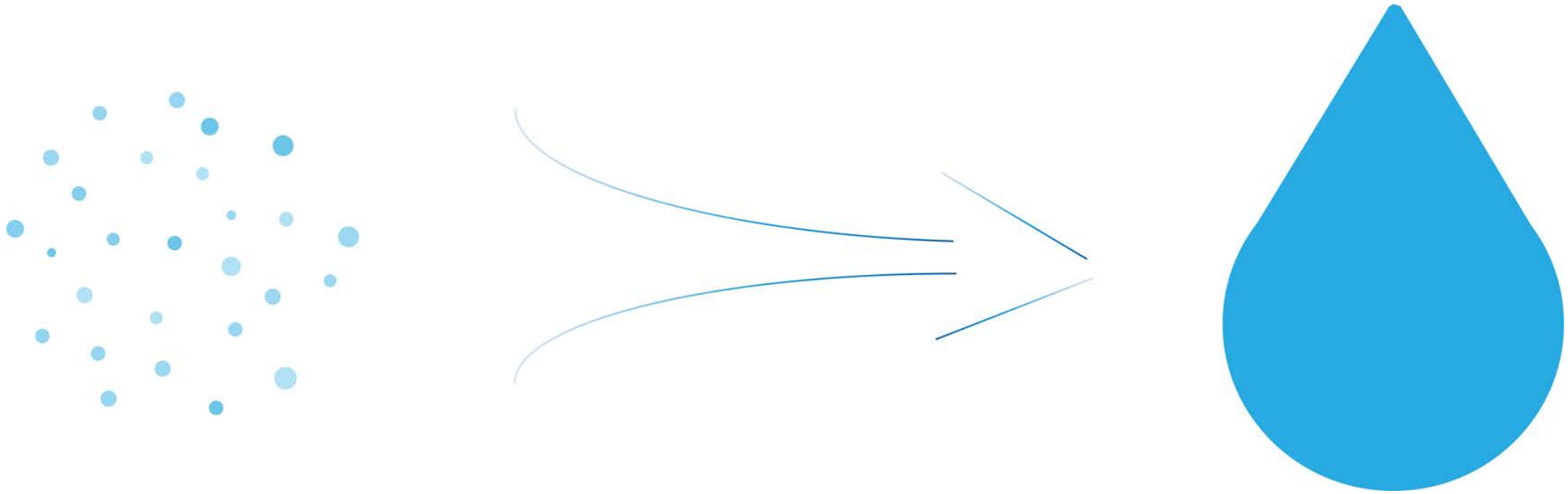


WATER CAPTURE STRUCUTRE



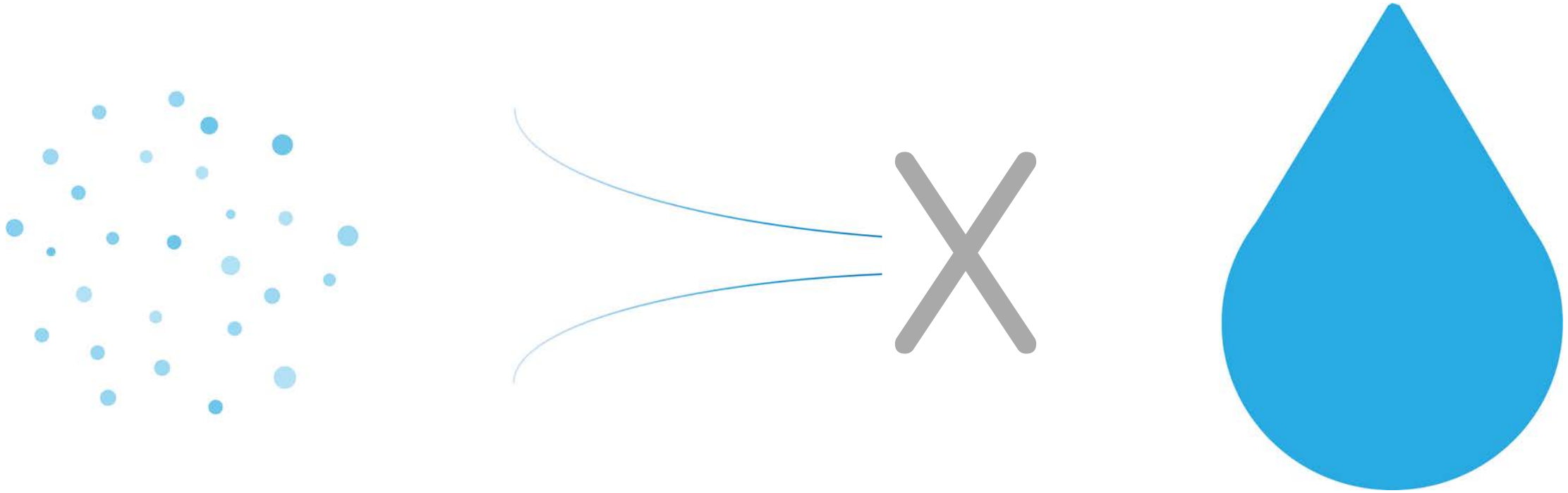
SOLAR PANELS

# Design Ideas: Capture water from air



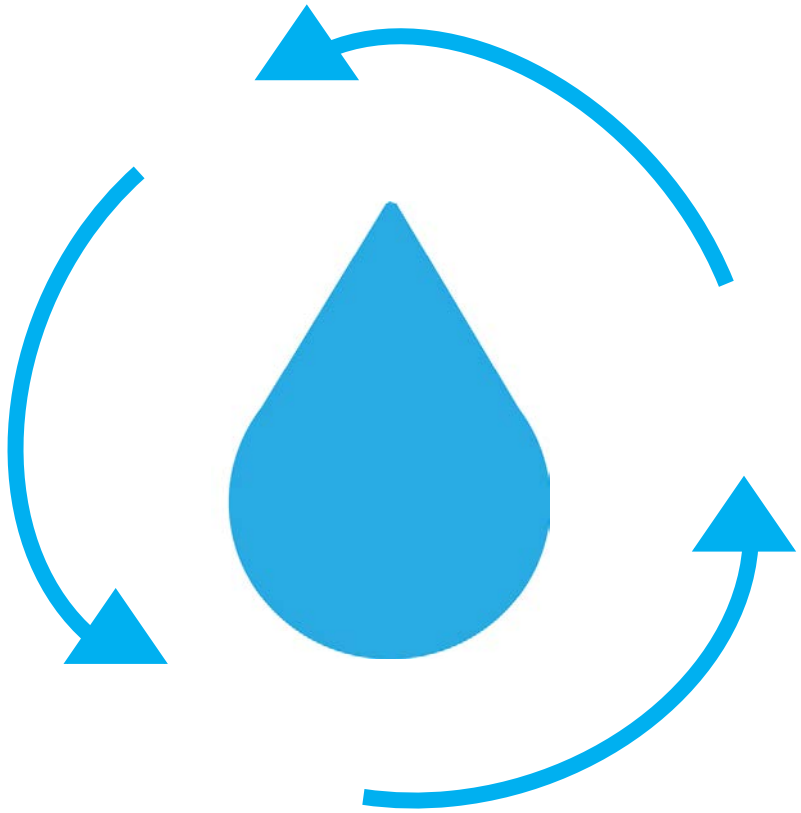
# Obstacles + Redesign

# Met an Obstacle



# Reassess Design Ideas

- Water as a **reusable** resource
- Opened the door for integrated design



# Integrated Water Strategy

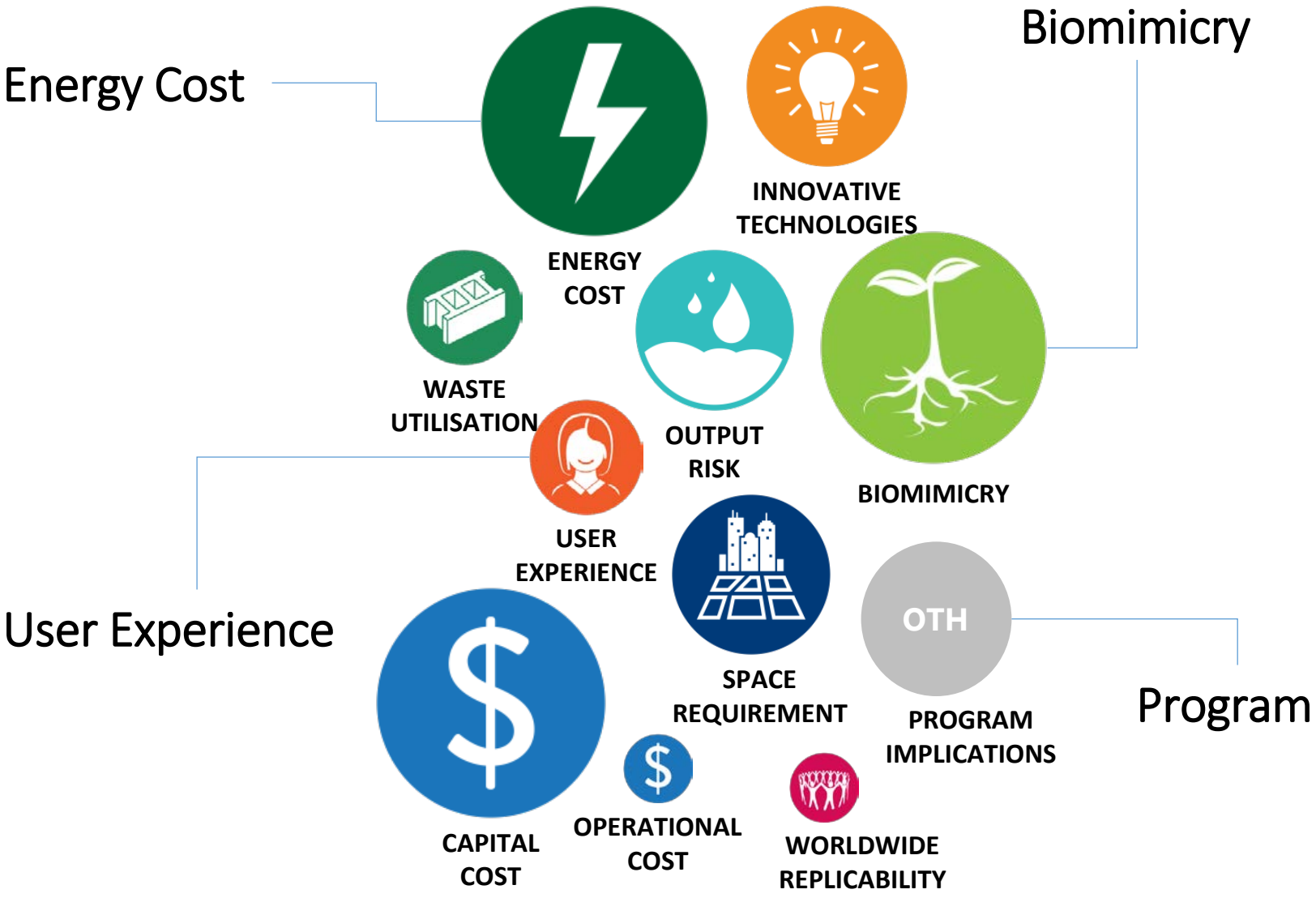
**1** *Reduce Freshwater Demand*

**2** *Reuse "waste"water on-site*

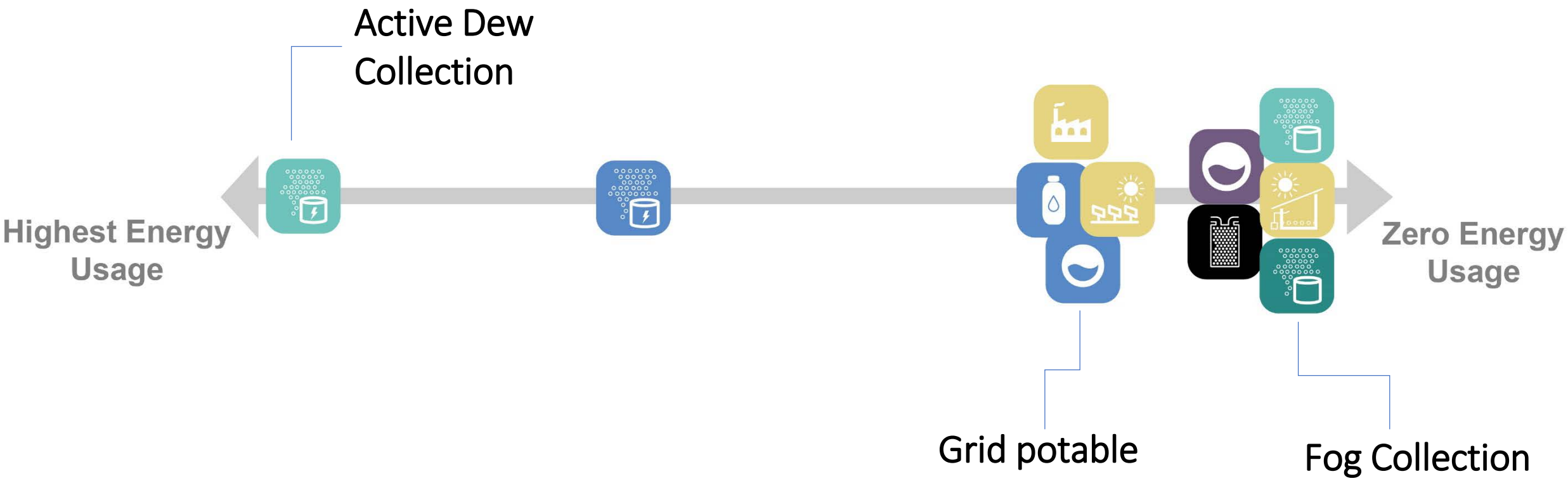
**3** *Integrate water with architecture, landscape, mechanical systems and visitor experience*

# Potential Water Strategies

# Evaluation Criteria

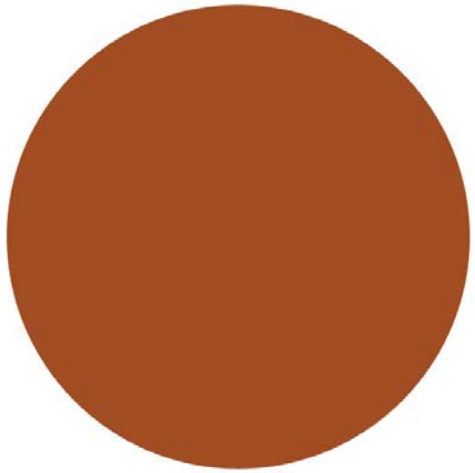


# Energy for Water



# Energy for Water – Seawater Desal

***Municipal Desalination***
*Off-Site*



**Energy Use:**
4.0 kWh/m³

**Salinity**
35,000 mg/L or 3.5%

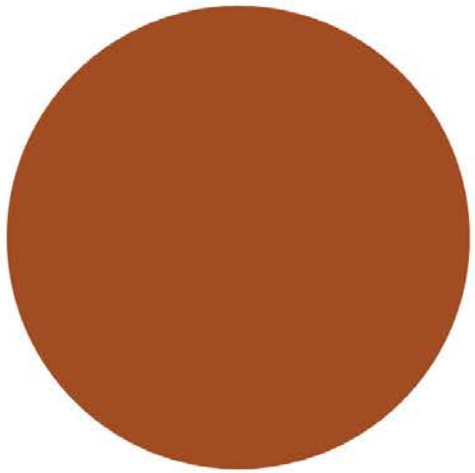
**Energy Source:**
Natural gas

**Water Source:**
Seawater

**Other Concerns:**
- Damaging to aquatic habitat when pulling in water
- Brine byproduct damages aquatic and terrestrial habitat

# Energy for Water – Decentralized Desal

***Municipal Desalination***
*Off-Site*



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**Energy Source:**
Natural gas

**Water Source:**
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**Other Concerns:**
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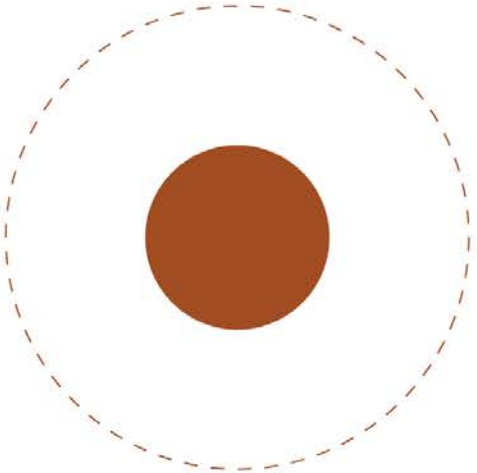
***Decentralized Desalination***
*On-Site*



**Energy Use:**
0.8 kWh/m³

**Salinity:**
750 mg/L or 0.7%

**Energy Source:**
Solar thermal, solar PV, waste heat

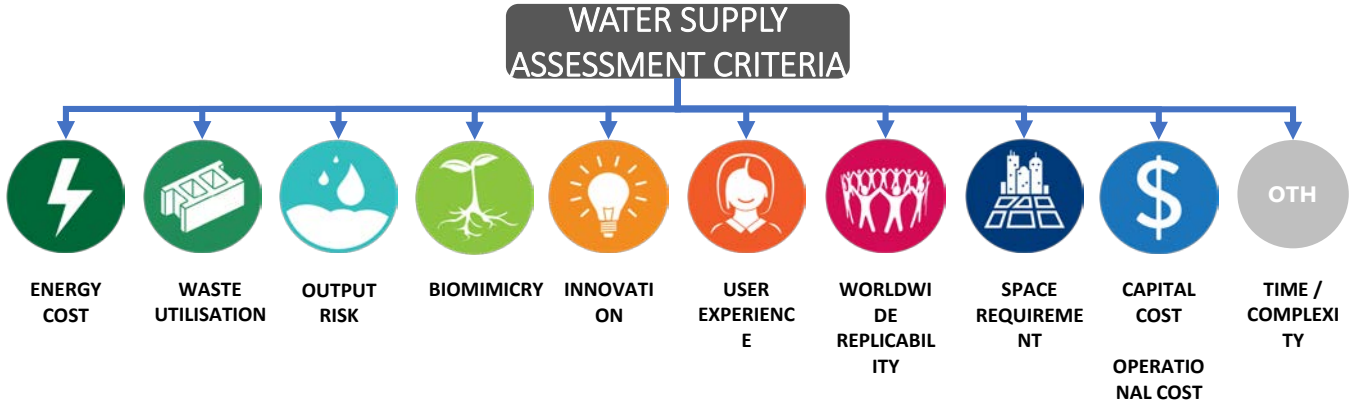
**Water Source:**
Brackish groundwater

**Other Concerns:**
- Use requires replenishment of resources through infiltration
- Opportunity to crystallize brine
- Replicable solution for communities in arid climates

***Desalinating brackish water on-site uses only 20% the energy of municipal seawater desalination.***

Sources: Encyclopedia Britannica; Bloomberg May 1, 2013; Masdar Special Projects

# Evaluation Results




| Supply Option | Weighted Score |
|---|---|
| Living Machine | 74% |
| Condensate Recovery | 71% |
| Grid TSE | 63% |
| Traditional Wastewater Treatment | 61% |
| Rainwater Collection | 57% |
| Ground Water Traditional Desalination | 57% |
| Ground Water Solar Desalination | 57% |
| Groundwater Solar Still | 55% |
| Grid Potable | 51% |
| Bottled Water | 51% |
| Passive Dew Collection | 50% |
| Fog Harvesting | 47% |
| Active AWG (e.g. EcoloBlue) | 37% |
| Active Dew Collection | 33% |

# Evaluation Results

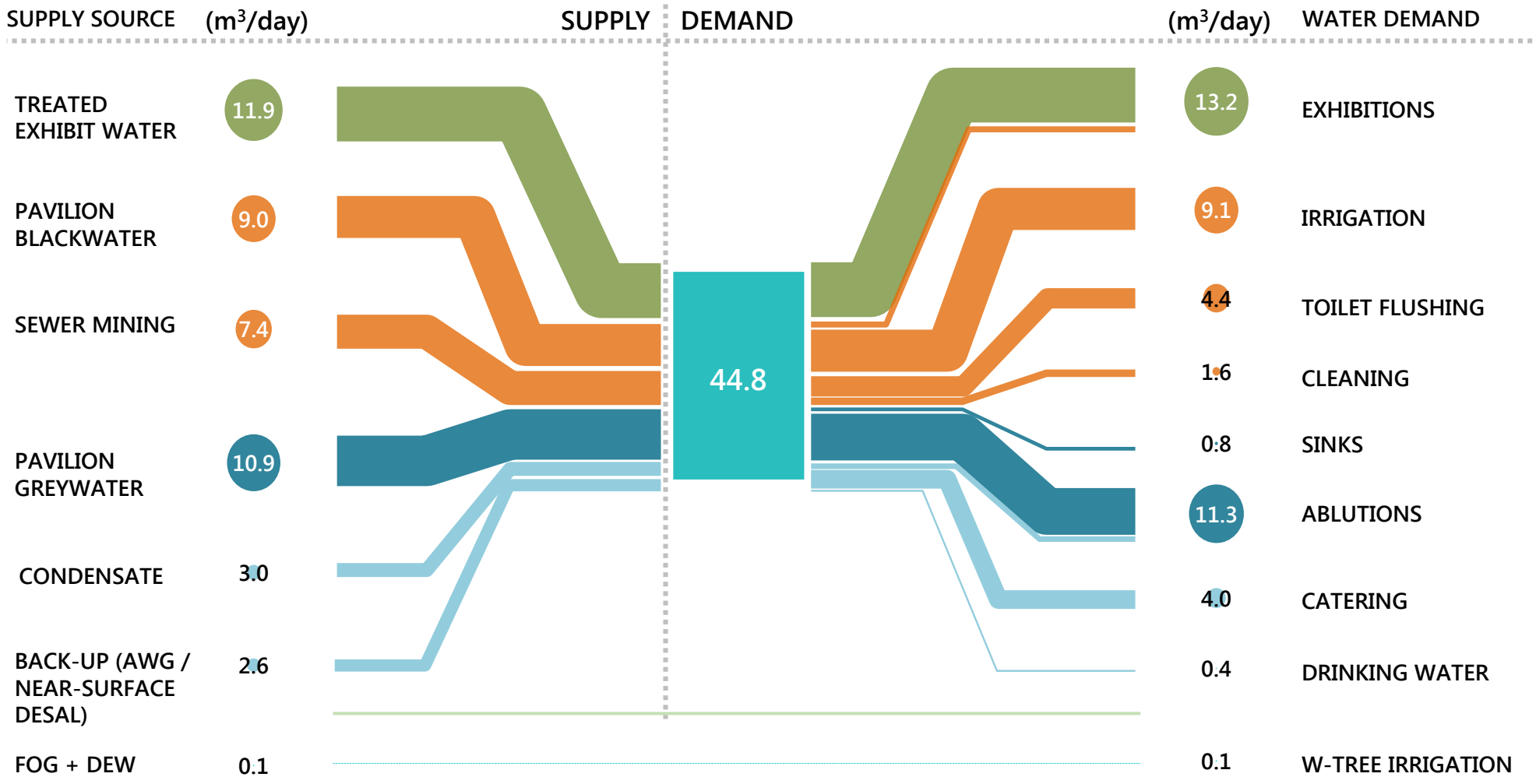
Active Dew Collection

Brackish desalination

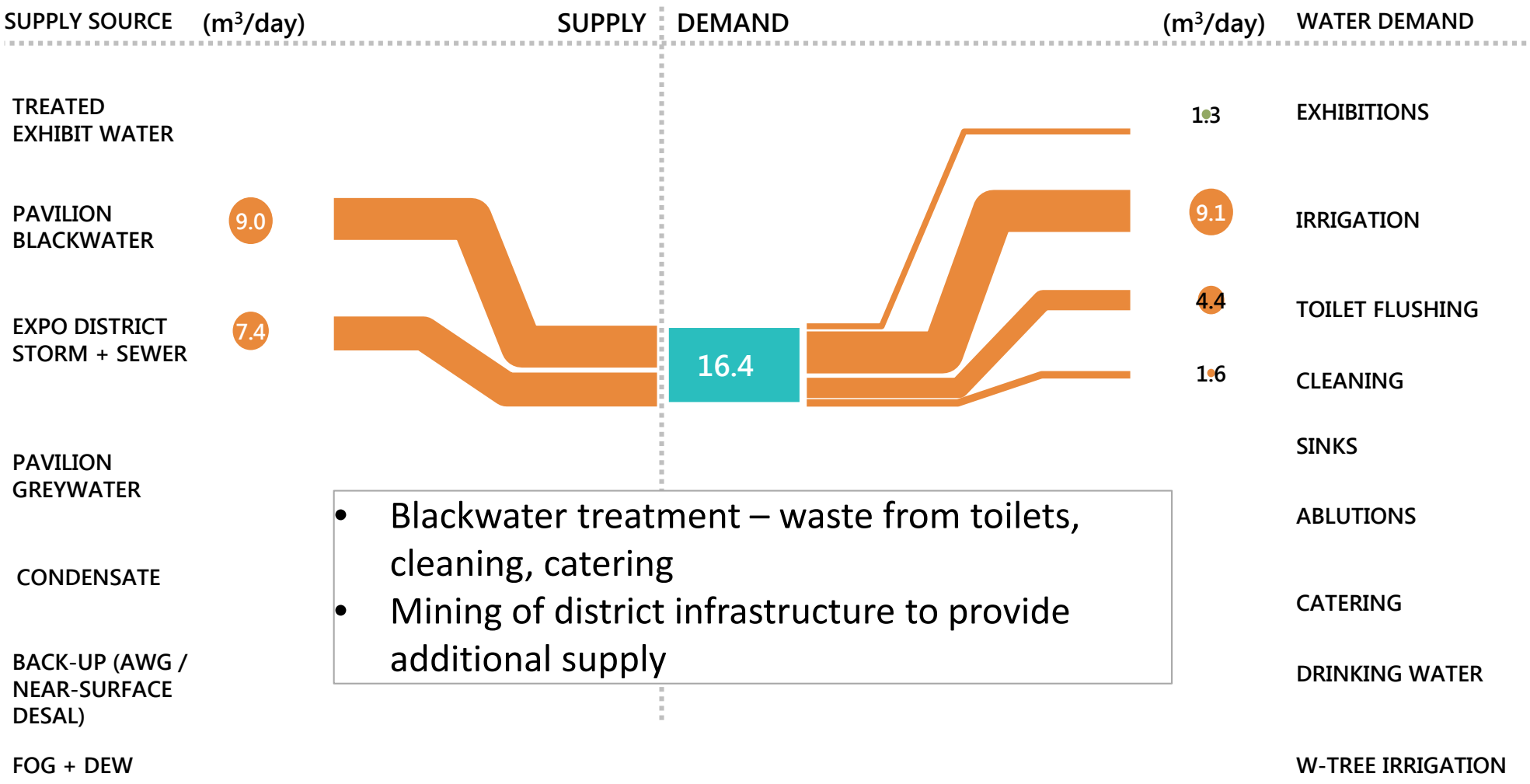

Grid potable

Wetland wastewater treatment

# Water Balance: Supply & Demand

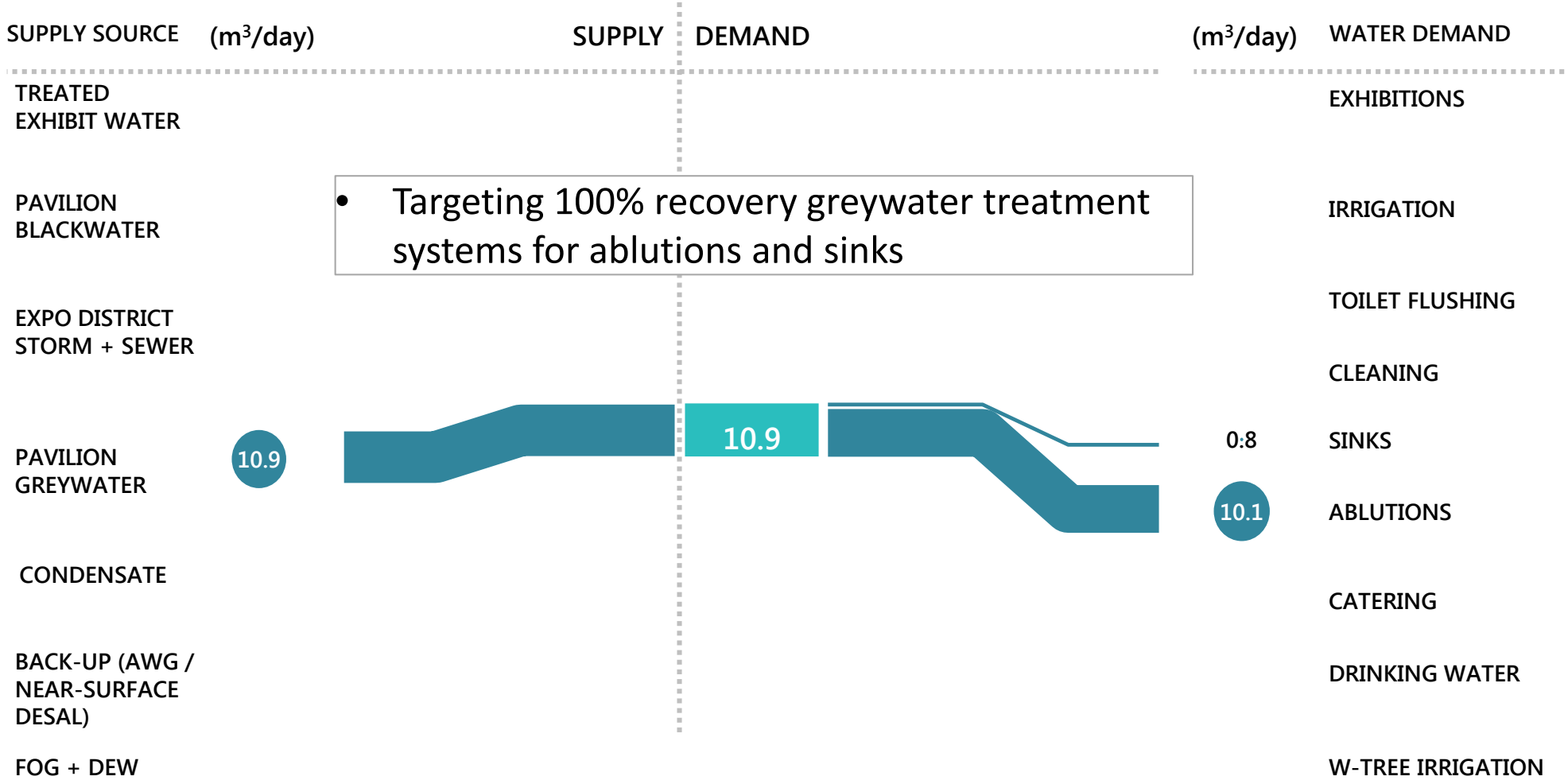


# Water Balance: Supply & Demand




- Blackwater treatment – waste from toilets, cleaning, catering
- Mining of district infrastructure to provide additional supply

# Water Balance: Supply & Demand




- Targeting 100% recovery greywater treatment systems for ablutions and sinks

# Challenges

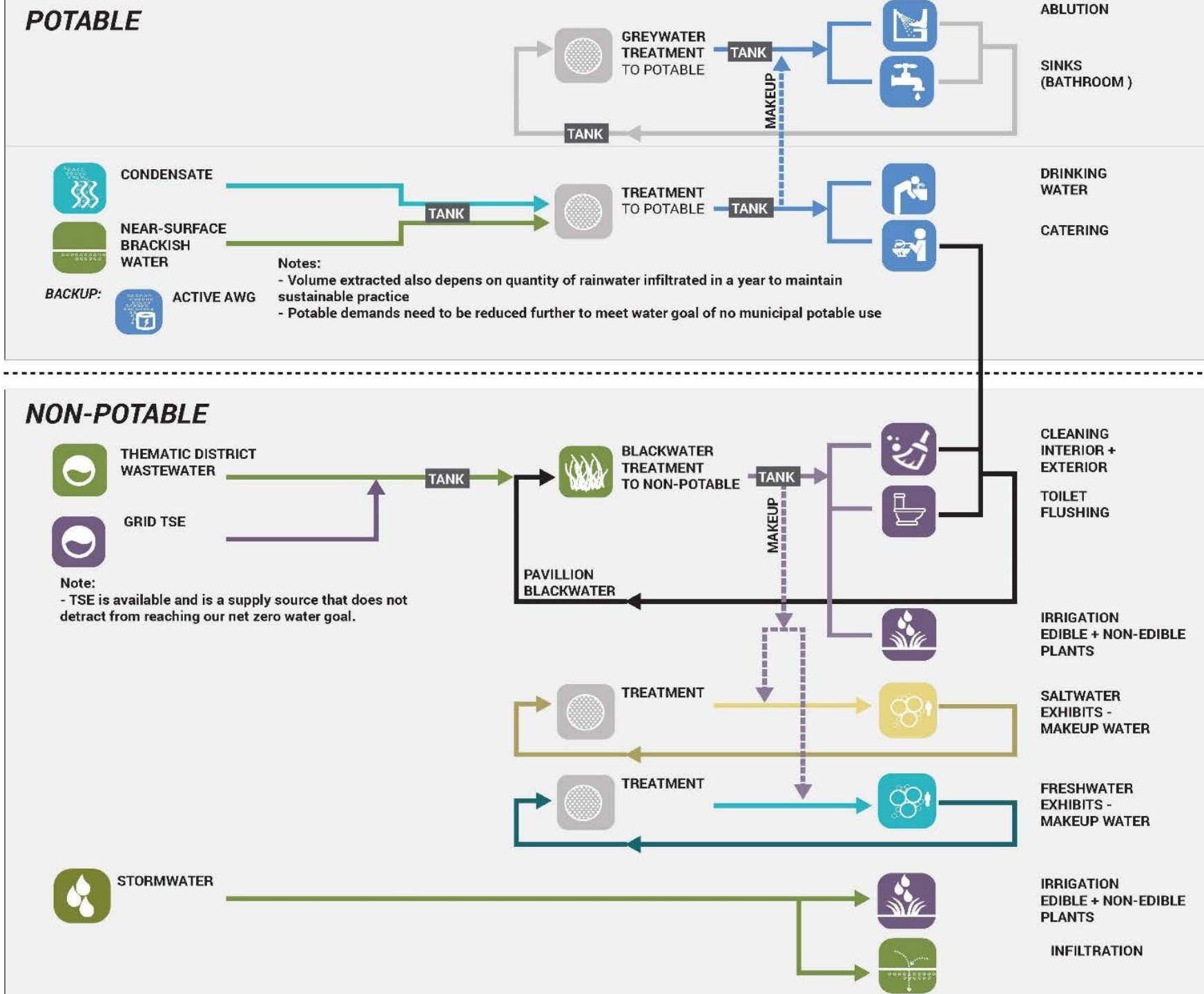
- Modeling water demands
- Energy use of water systems
- Barriers to implementation

# District Scale Water Reuse

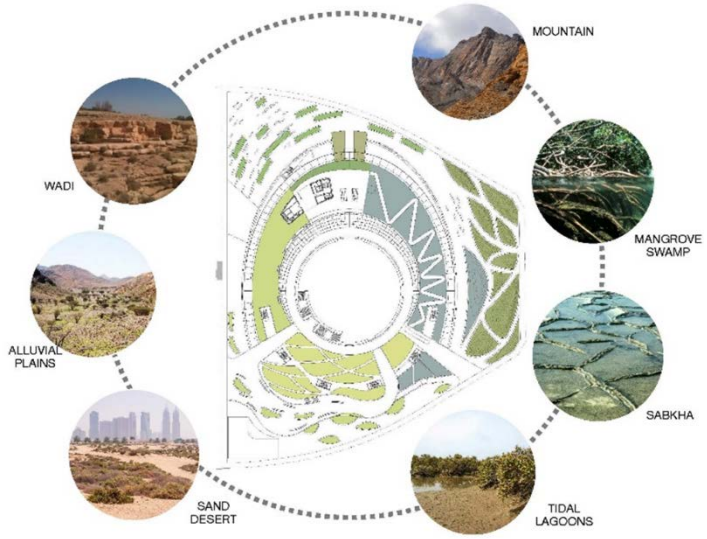
- Sustainability Pavilion: Site within a larger city
- Existing infrastructure: Coordination with neighbors
- Looking to connect: What worked, what didn’t

# Final Design Solutions

# Basis of Design



# Landscape + Water




**mountains**
no soil
well drained rock forms
channeled water flow
WATER COLLECTION / CONVEYANCE

**wadi**
crops+ medicinal plant cultivation
largest range of plants
dates line waterbodies
AGRICULTURE

**cultivated terraces**
crops+ medicinal plant cultivation
AGRICULTURE

**alluvial plains**
floodplain remnants
gravel desert
acacia trees
halophytes
WATER COLLECTION / CONVEYANCE

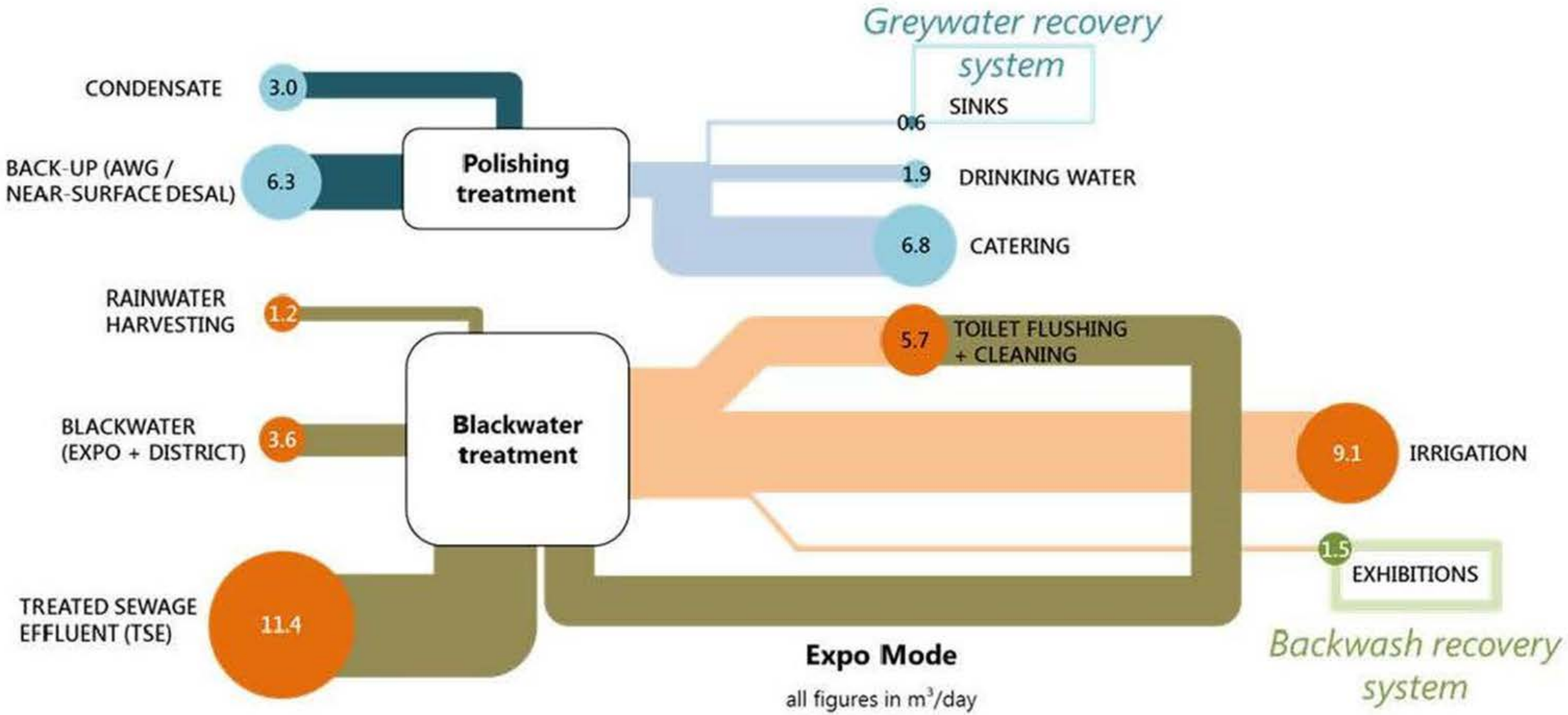
**sand desert**
tamarisk trees
ghaf trees
filtration
infiltration
connect to aquifer
SHALLOW INFILTRATION
AQUIFER RECHARGE

topography
ecology

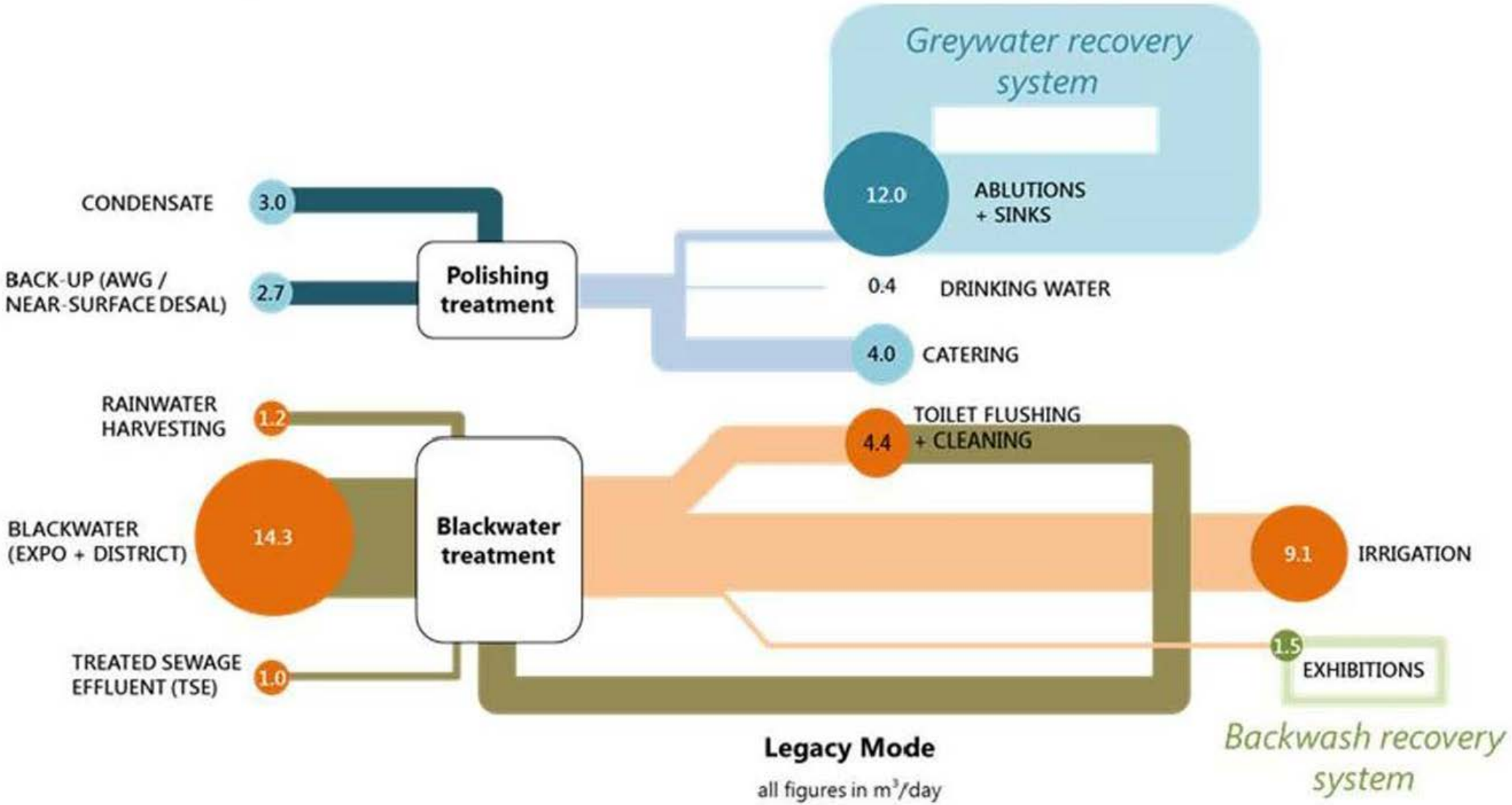
**coastal mangroves**
rich ecosystem
nutrient (N+P) removal
MANGROVES
WASTEWATER TREATMENT
LIVING LAB I WASTEWATER PLANTERS
LIVING LAB II WASTEWATER PHOTOBIOREACTORS

**sabkha / salt flats**
impermeable ground
inundated during storms or high tides
evaporation
salts + minerals
algae mats
SOLAR STILL

# Water Balance: Expo Mode

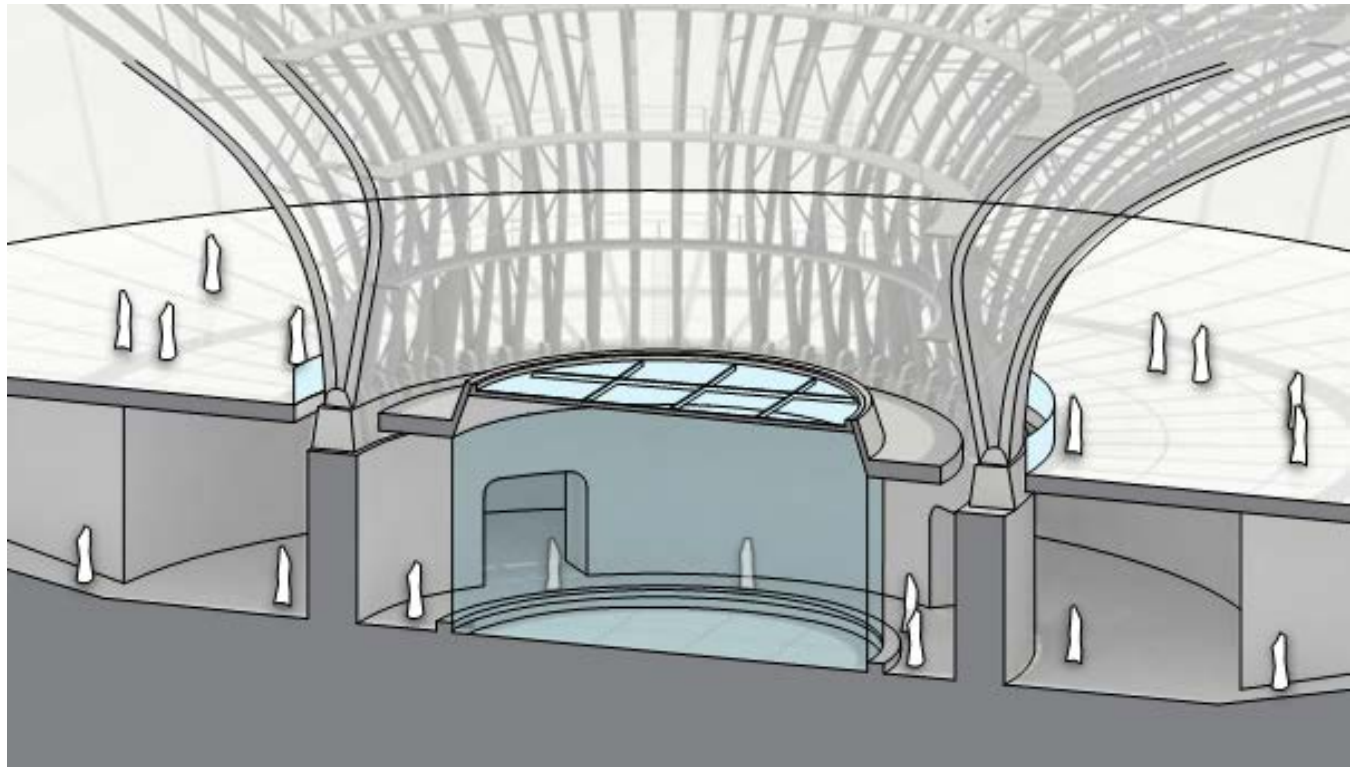


# Water Balance: Legacy Mode



# Innovation: Water Reuse

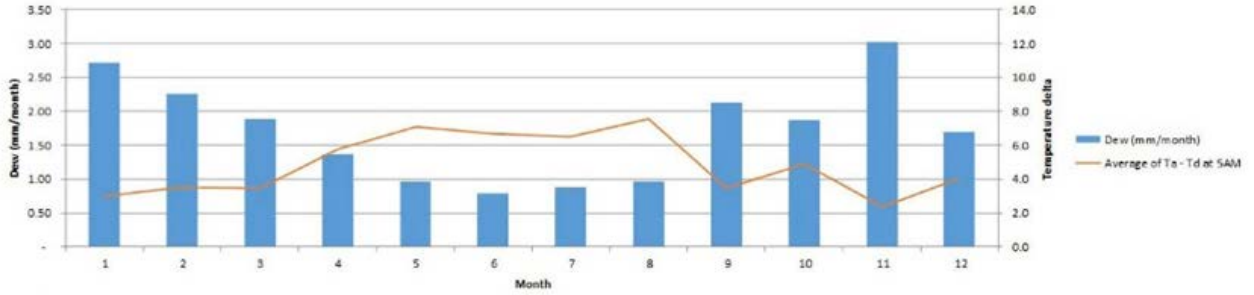
- Low Flow Fixtures
- Greywater Reuse
- Blackwater Reuse
- Condensate Reuse
- Stormwater Reuse
- Exhibition Backwash Reuse
- Low energy water systems
- Integrate visitor experience

# Innovation: Water Tech + Design

- Demonstrate to replicate
- Innovation Gallery
- Technologies
  - Sewer mining
  - Passive water desalination
  - Renewable powered desalination
  - Metal organic framework
  - Dew capture

Water Tree




Dew Collection Monthly Variations

# Innovation: Water Policy

- Dubai's progressive building code
- Progressing even more
- Role in shaping policy



Image Credit: Dubai Municipality

# Conclusion

# Questions?

# THANK YOU