Atmospheric Water Harvesting in a Harsh Environment (in Qatar)

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Overview & Presentation Agenda

- Problem Definition & Research Questions?
- Objective and Significance
- Solutions
- Environmental Impact
- Methodology and Project Structure
- AWG module with optimized performance and reliability suited for GCC climates
- The benefits of AWH
- Conclusions
- Recommendations
- Annexes

Problem Definition & Research Questions?

- Qatar has a hot and arid climate with low annual rainfall?
- Challenges in providing clean and reliable sources of drinking water?
- What if the desalination plants fails (technical issues or sea water spoiled)?
  - Are there any backup system ?
  - Would it be possible to use high humidity and temperature to generate water from the air ?

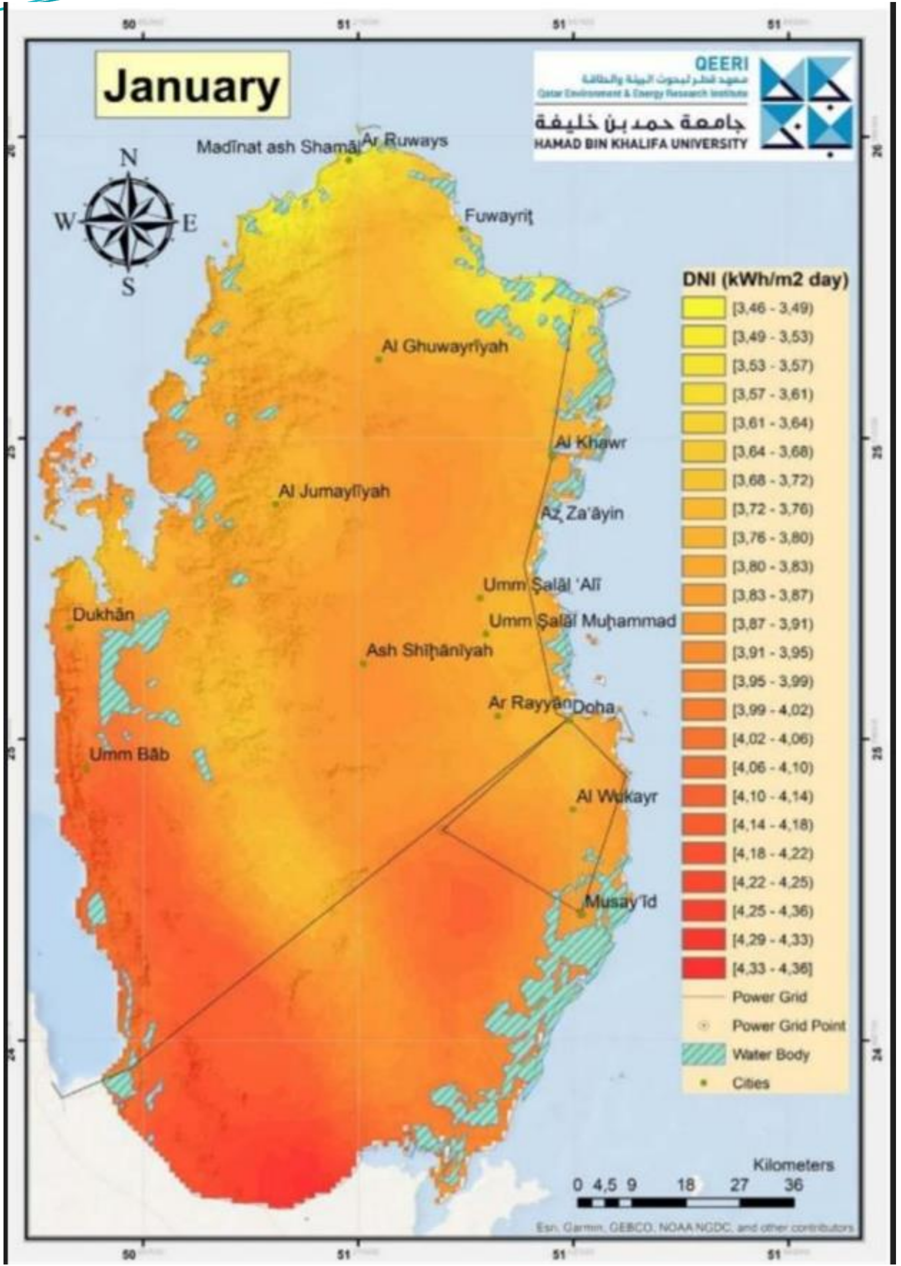
Objectives

- Design a reliable AWH with high water production suited for high RH and temperature
- Benchmark high standard for testing desert AWH systems
- To improve the fabrication of AWH and develop a low-cost, high production and concept that suits GCC conditions.
- To opens new opportunities for further development of the technology and materials for desert-specific AWH in this constellation also after finishing the project (networking).
- Reduce the carbon footprint (Zero Emissions)
- Water is uncompromising on quality, safety, accessibility, and sustainability.
- Reinventing drinking water with technology that keeps both people and planet healthy

Solutions:

- Water from air condensation-based atmospheric water harvesting (AWH) systems powered by solar power could be a potential solution to address water scarcity issues
- The potential of AWH systems in Qatar can be evaluated based on several factors:
  - ✓ Temperature,
  - ✓ humidity,
  - ✓ wind speed,
  - ✓ solar radiation
- The average relative humidity in Qatar is around 60% and in sometimes is 80-85%, which is relatively high and could be favorable for AWH systems
- The average temperature in Qatar is high, around 30°C and in sometimes is 45-50°C
- Solar potential, Qatar has a high level of solar radiation, with an average of around 2,100 kilowatt-hours per square meter per year
- Dew water harvester is available everywhere but requires a cooled condensing surface.

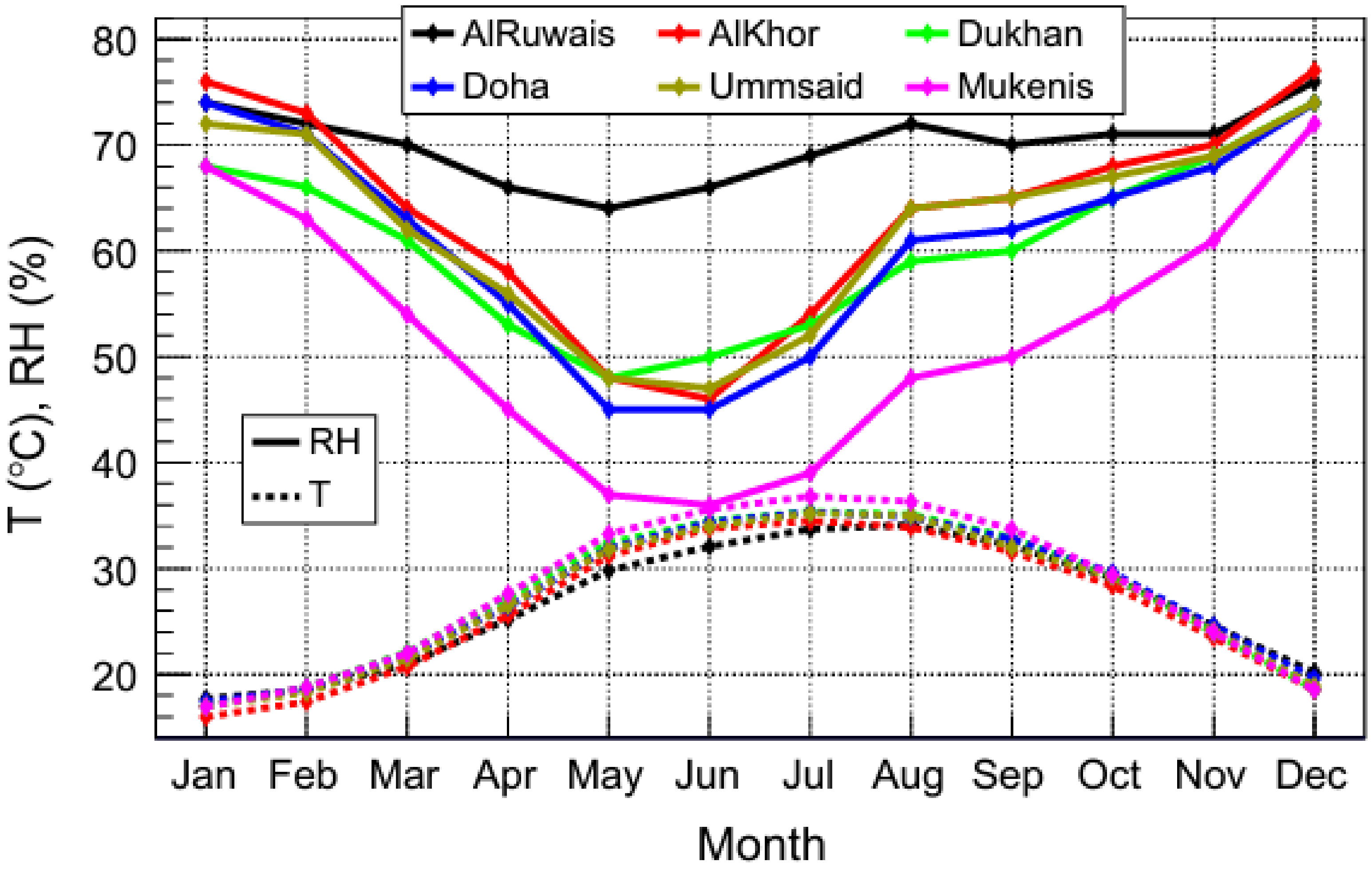
Environment Impact



Qatar Solar Irradiance (kWh/m²/day)

	Surface Tilt (Degrees)			
	T0	T10	T25	T40
Jan	4.1	4.7	5.5	5.9
Feb	5.0	5.5	6.1	6.3
Mar	5.7	6.1	6.3	6.3
Apr	6.3	6.4	6.3	6.0
May	7.2	7.2	6.8	6.1
Jun	7.8	7.7	7.1	6.2
Jul	7.4	7.3	6.8	6.1
Aug	7.1	7.2	7.0	6.4
Sep	6.7	7.0	7.2	7.0
Oct	5.7	6.3	6.8	7.0
Nov	4.4	5.0	5.7	6.1
Dec	4.0	4.7	5.5	5.9
Year	**6.0**	**6.2**	**6.4**	**6.3**

Average Annual Relative Humidity in Qatar



Methodology

AWH Technology

Condensation

- Cooling air to its dew point, temperature at which water vapor in the air condenses into liquid
- Condensed water is then collected and treated for consumption

Absorption

- Using highly absorbent material to absorb water vapor from the air
- The absorbed water is then heated to release the water vapor, which is collected and treated for consumption

Desiccation

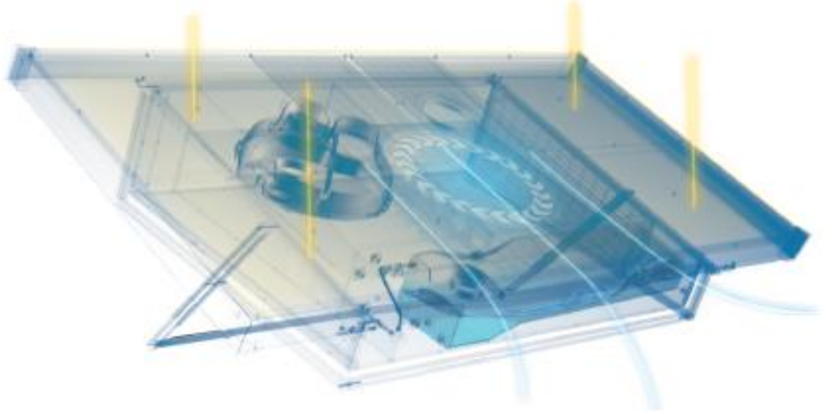
- Using a desiccant material to absorb moisture from the air
- The desiccant material is then heated to release the water vapor, which is collected and treated for consumption

Methodology

HOW DOES IT WORK?

Option 1: Passive System (Solar PV)

- Using solar PV, it takes in ambient air via fans and collects water vapor from that air onto a hygroscopic material
- With heat from the sun, it converts water vapor collected into liquid water, made pure
- The water vapor is extracted and passively condenses into liquid
- The pure water is mineralized with magnesium and calcium to achieve an ideal taste profile
- It is fully self-sustained and off-grid.



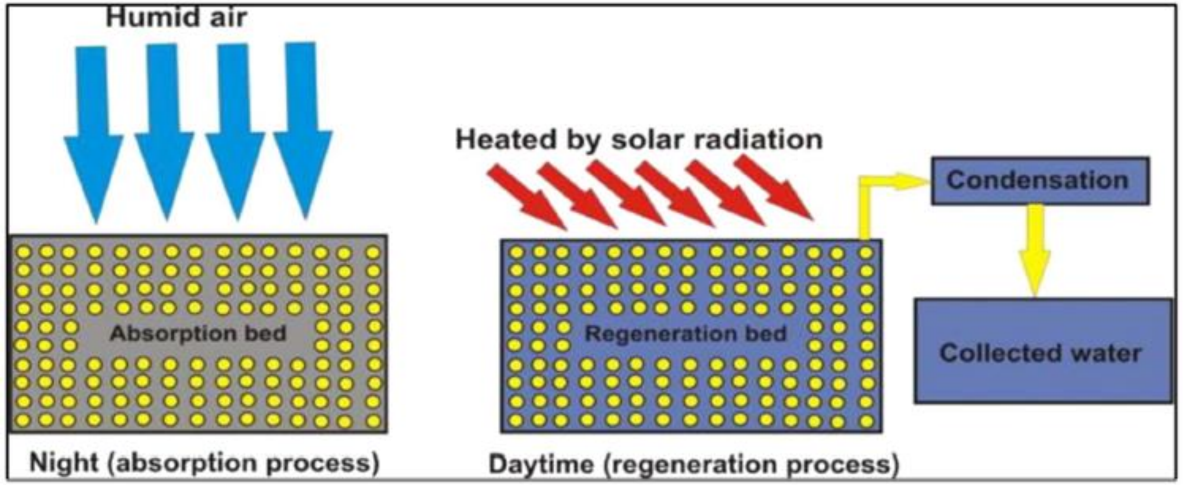
Methodology

The process can be explained as follows:

1. the first stage is water absorption stage at night where the desiccant bed will absorb moisture from humid air.

2. The second stage is water desorption during the day by heating the bed with solar radiation, which will regenerate the desiccant by driving out water vapor.

3. In the third and final stage, the evaporated water will then be condensed into water droplets and collected in a tank.



Solar regenerated desiccant in water harvesting (passive system)

- Dependency parameters, (relative humidity, temperature and topographic cover
- Desiccant materials such as MOF, silica gel, zeolites and CaCl2 are hygroscopic and can absorb moisture through adsorption and absorption process
- The first stage is water absorption stage at night where the desiccant bed will absorb moisture from humid air.
- The second stage is water desorption during the day by heating the bed with solar radiation, which will regenerates the desiccant by driving out water vapour.
- In the third and final stage, the evaporated water will then condensed into water droplets and collected in a tank.
- The advantages of a desiccant system over radiative condensers include the hygroscopic capacity of the desiccant that enables more efficient water collection

Methodology

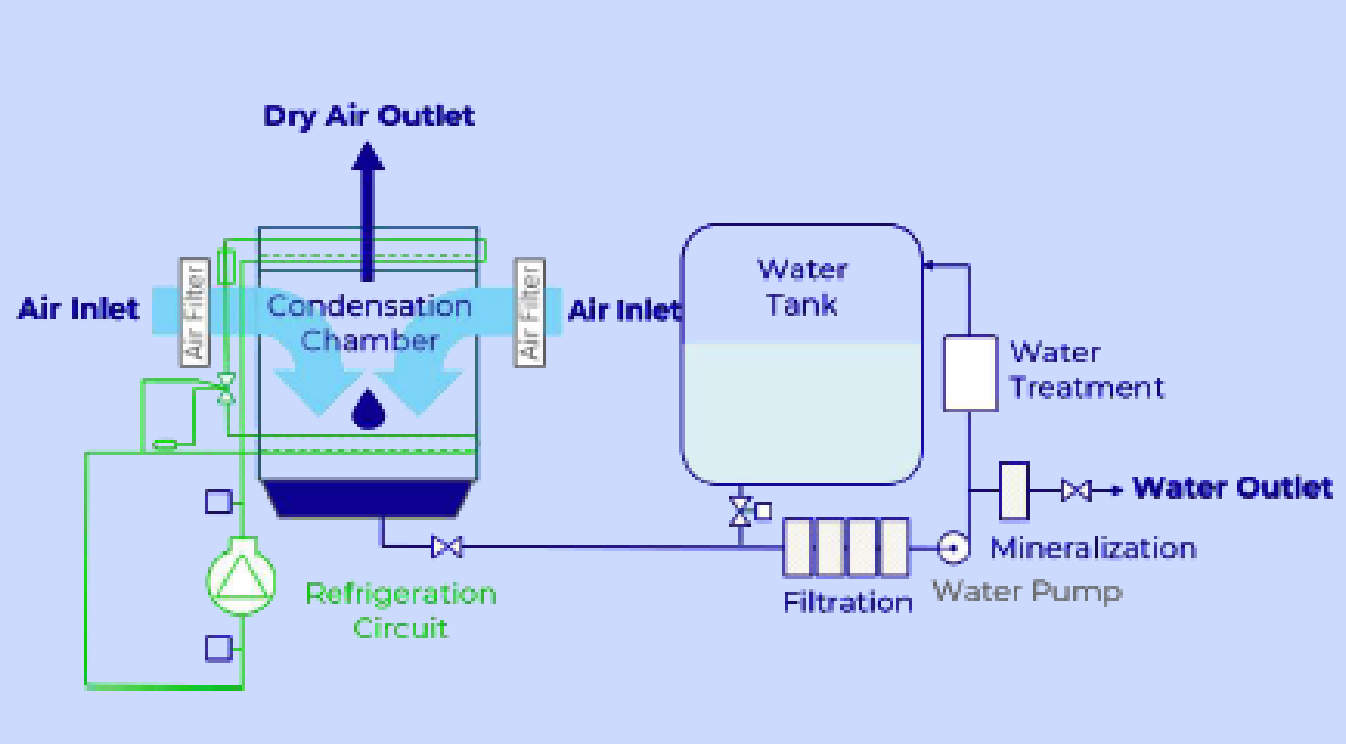
Sunlight + Air = Water

Option 2: Condensation based method

Atmospheric Water Generation (AWG)

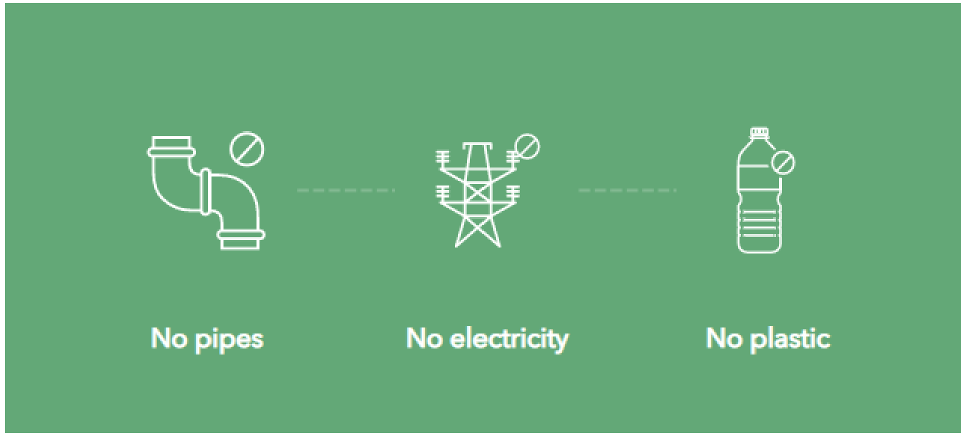
- Replicates the natural process of rain
- Condenses water from humidity in the air
- Uses refrigeration technology
- Just air and a source of energy needed

- 2-stage air filtration
- Condensation chamber materials
- Efficient refrigeration and heat exchangers
- Mineralization and water purification



The Benefits of AWG System

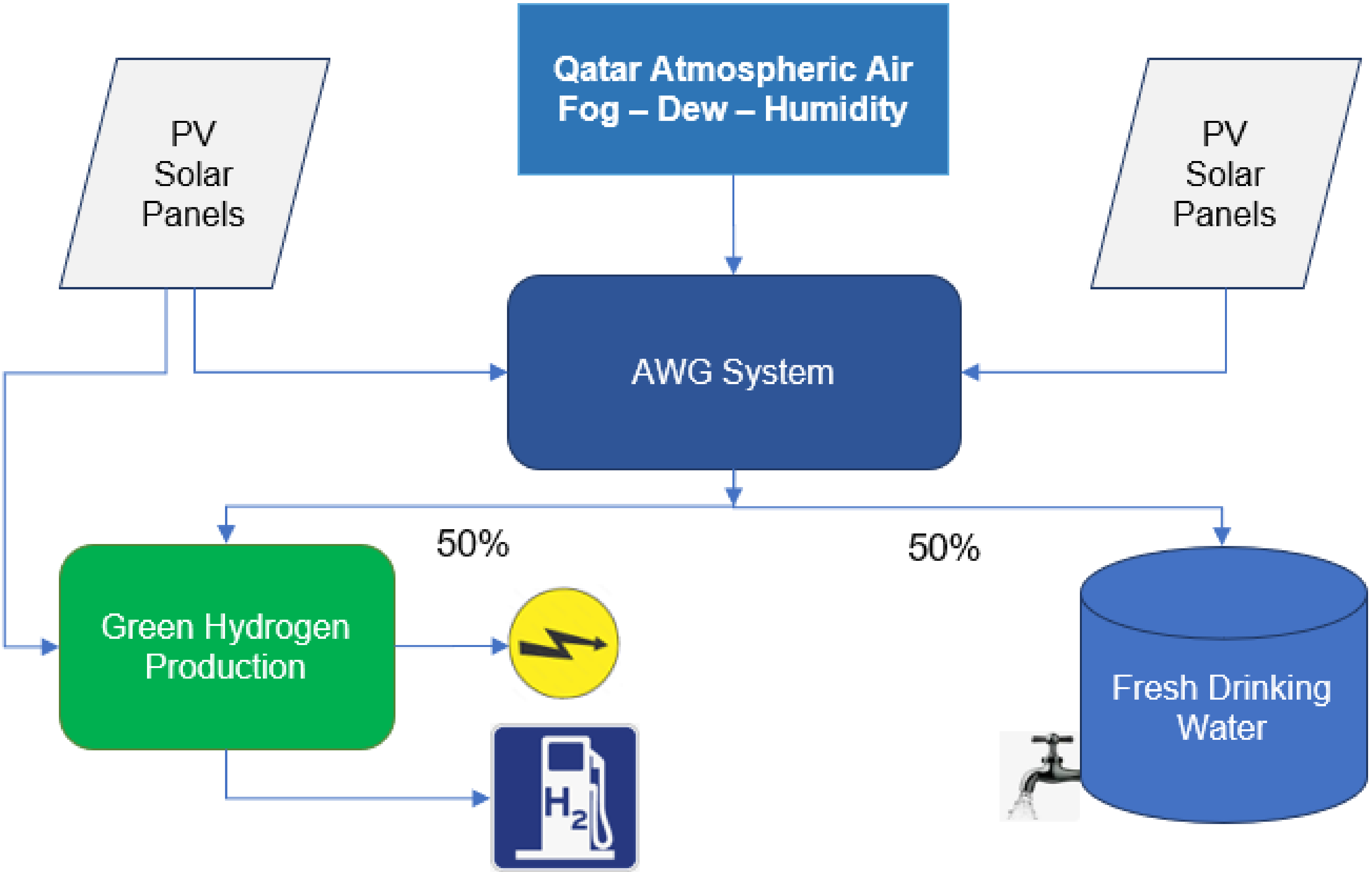
- Zero emissions
- Sustainable.
- Aligns with Qatar Vision 2030’s pillars
- Overcoming the challenges on long-distance transport or delivery of potable water in rural areas.



Conclusions

- This project aims to adapt (AWH) system design and material,
- To ensure excellent performance and reliability of AWH in harsh conditions
- Development of passive system, high efficiency solar cell technologies
- Provide valuable information on the feasibility of atmospheric water harvesting in desert environments
- Identify the factors that influence the ability to collect water from the air and determine the most promising locations for further study

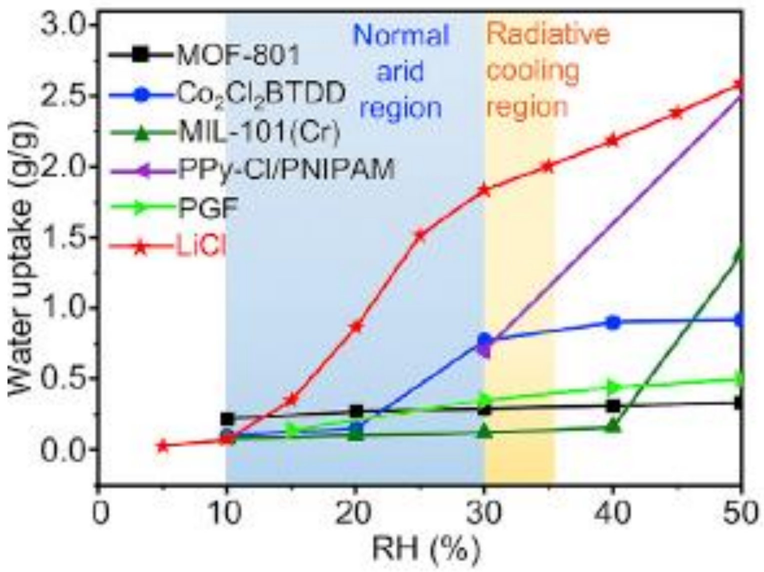
Recommendation:
Integrated System (PV-AWG-H2)



Annexes:

Materials Selection

- Efficient AWH approach that achieves an excellent water harvesting capacity of 2.62 g/g even in arid conditions by designing devices consisting of a superhydrophilic inside matrix for efficient water adsorption, superhydrophobic and elastic fibrous skin for adaptative expansion, and water leakage prevention.
- AWH based on three key components: deliquescent sorbent, superhydrophilic porous matrix, and superhydrophobic skin
- Ideal deliquescent sorbent should possess high moisture-sorption capacity, a fast sorption/desorption rate, and low desorption temperature
- Lithium chloride (LiCl).
- MOF
- MIL-101(Cr) is a MOF having remarkable water stability



Annexes:

Material Selection Criteria

- Essential properties of moisture harvesters for AWH. The ideal moisture harvesters should have high sorption capacity, low regeneration energy demand, fast sorption/desorption, and long-term cycling stability.