Final Presentation

Hydro-Sol, Team 1

Problem Definition

Our Purpose:

- The project will meet the needs of residents that will be living in Accessory Dwelling Unit
- Meet the requirements of the OCC Fair Sustainability Decathlon

The following problems are to be addressed:

- The amount of water that is wasted waiting for it to be heated
- Creating a reduction in the amount of energy that is spent on heating the water
- Affordability of the system (cost in the long run)
- If possible, try to make the water arrive at the faucet more quickly as a way of water conservation

Jiahao

Design Attributes and Requirements

Attributes

- Sustainable
  - Water efficient
  - Energy Efficient
- Affordable
- Low maintenance
- Long life
- Easy to install and use
- Only shower and sinks will need hot water
  - Laundry & dishwasher will create their own hot water

Requirements

- No combustion
- ADU tank regulations (ie, standing tanks cannot be openly outside)
- Roof should support 265-926 lbs if a roof tank is installed; shed should be 10 ft x 10 ft if a heat pump tank is installed
- Off the shelf parts
- Provide enough hot water for a 4 person household size
- Meets minimum temperature of 120 ℉ and avoids scalding

Chiara

Key Design Decisions and Justification

- Hot Water Capacity
  - For 3 to 4 people: 50-60 gallons
- Hot Water Outlets
  - Kitchen sink
    - Hot water needed for proper washing of dishes (cdc.gov)
  - Washer/Laundry
    - Hot water not needed to wash clothes
    - For food and medicine fields, washer should have sanitize setting to internally heat water
- Cost Analysis
  - Initial cost
  - Hourly cost to run
  - Estimated cost per year
    - Estimated with temperature conditions and/or average household use of 5 hours a day

Everything Considered Thus Far/Existing Solutions

- Tankless
  - Not sustainable, takes up a lot of electrical power
- Recirculation
  - Constantly running, made more surface area for heat to escape
- Active vs Passive Solar Tank
- Electric vs Heat pump
- Evacuated Tubes vs Flat Plates
- POU
- DWHR

Chiara

Key Components and Rationale

- **Electric vs Heat Pump Back Up:**
  - Accounts for the hot water that the Passive Solar Tank cannot provide in winter(Nov-Mar)
  - Heat pumps have a higher first hour rating (how much hot water you get in the first hour of use) compared to electric tank
    - For example, 50 gallon Rheem electric tank provides 63 gallons of hot water and Rheem heat pump electric tank provides 65 gallons
  - Heat pumps have a lower estimated yearly energy cost
    - $104/yr for electric heat pump tank vs $424/yr for electric tank
  - Heat pumps have a lower yearly energy use
    - 855 kWh for electric heat pump tank vs 3531 kWh for electric tank

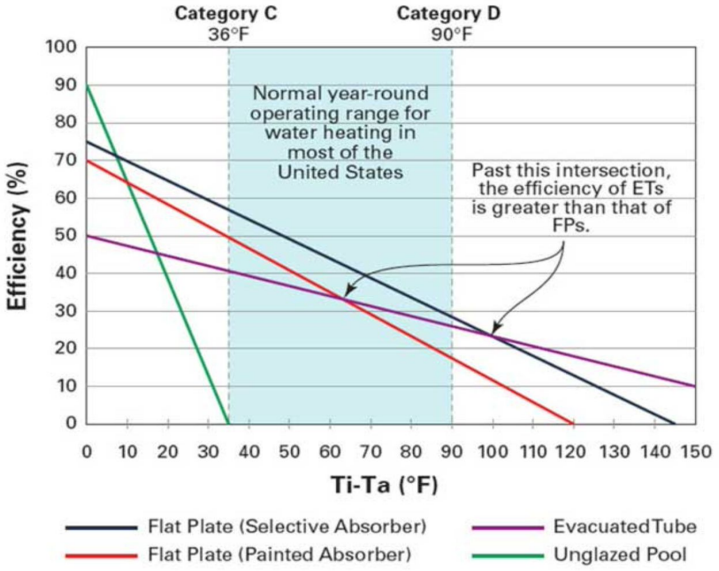
Heat Pump Electric Tank:

Electric Tank:

Chiara

Key Components and Rationale

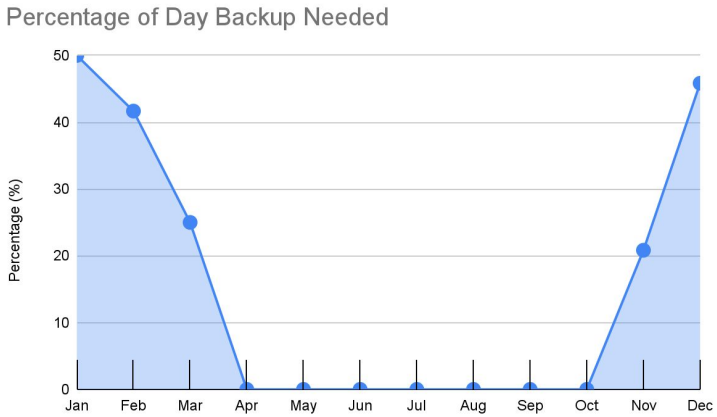
- **Evacuated Tubes vs Flat Plates:**
  - Evacuated Tubes heat water quickly than Flat Plates
  - Evacuated Tubes work better in cloudy and rainy days because they can absorb sunlight efficiently from a wide range of directions due to their shape while flat plate collectors are more sensitive to the incoming radiation.
  - Installation of flat plate collectors is difficult. Evacuated Tubes are lightweight individual tubes which are easier to assemble.
  - If an Evacuated Tube gets damaged, individual tubes can be replaced but if a flat plate collector gets damaged, whole plate needs to be replaced.
  - Flat Plates heat water up to 180℉ while Evacuated Tubes can heat upto 250℉ so Evacuated Tubes can overheat but the overheating can be prevented using a controller and oversizing the tank.



Mahnoor

Key Components and Rationale

- **Passive Solar Tank:**
  - Heat water(120 ℉ or more) to reduce risk of bacterial growth
  - Can reliably provide 120 ℉ (or more) water for a large majority of the year(Apr-Oct)
- **Temperature Analysis:**
  - Local weather data and estimated backup needs with solar systems
  - ΔT of +60°F

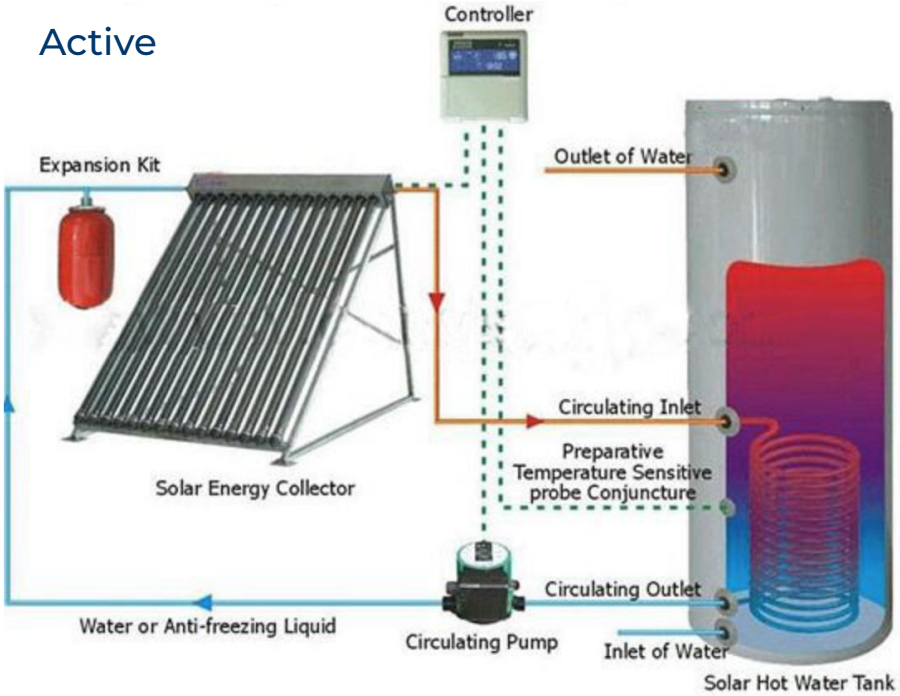


	Ambient Temperature			Solar Water Output Temperature		
Month	High	Average	Low	High	Average	Low
Jan	67.00	57.00	48.00	**143.12**	99.52	60.28
Feb	67.00	58.00	50.00	**143.12**	103.88	69
Mar	69.00	59.00	52.00	**151.84**	108.24	77.72
Apr	71.00	62.00	54.00	**160.56**	**121.32**	86.44
May	73.00	64.00	57.00	**169.28**	**130.04**	99.52
Jun	75.00	67.00	61.00	**178**	**143.12**	116.96
Jul	80.00	71.00	65.00	**199.8**	**160.56**	**134.4**
Aug	81.00	72.00	65.00	**204.16**	**164.92**	**134.4**
Sep	80.00	71.00	64.00	**199.8**	**160.56**	**130.04**
Oct	77.00	67.00	59.00	**186.72**	**143.12**	108.24
Nov	71.00	61.00	52.00	**160.56**	116.96	77.72
Dec	67.00	56.00	48.00	**143.12**	95.16	60.28

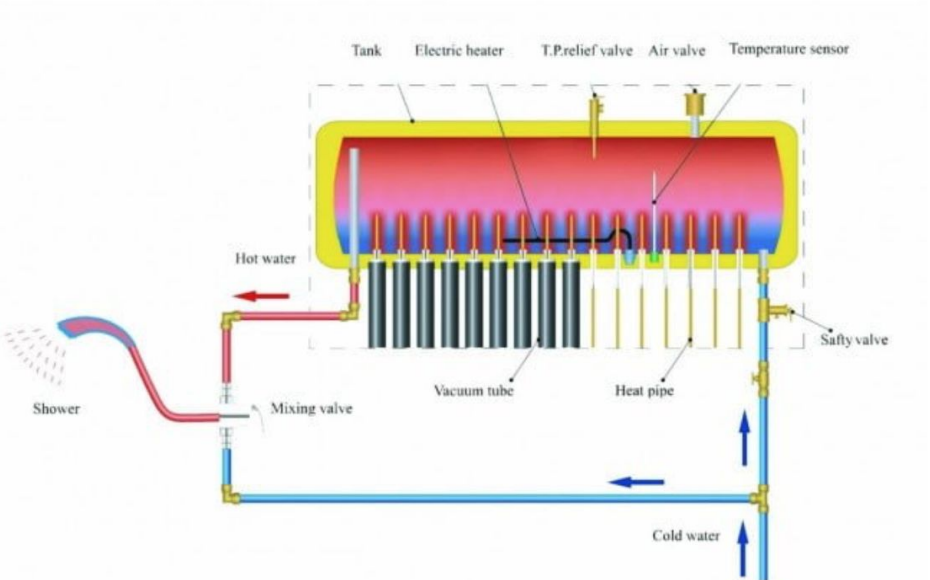
Makala

Active VS Passive Schematics

Active



Passive



Mahnoor

Instant Hot Water - POU

- **Points of Use Heaters:**
  - Provides hot water instantly to the outlets to address waiting for hot water and reduce water waste
  - Can set a temperature limit to reduce water waste with times to reheat
  - Can heat up to 60 ℉ temperature difference
    - Shown in temperature analysis to be minimum needed for solar systems

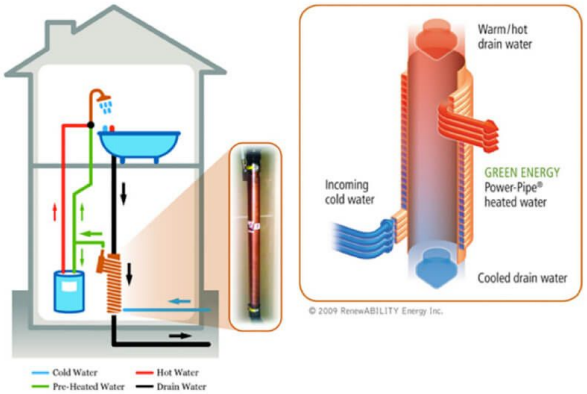
- **Bathrooms (1 each)**
  - ECO MINI 6
  - 1.4 kW, 120 V, 12 A
  - $230
  - $0.45 /hr

- **Kitchen**
  - Rheem 6
  - 6 kW, 220 V, 25 A
  - $220
  - $1.92 /hr
  - 2 GPM flow

Makala

Water Efficiency and Safety- DWHR and Thermostatic Valve

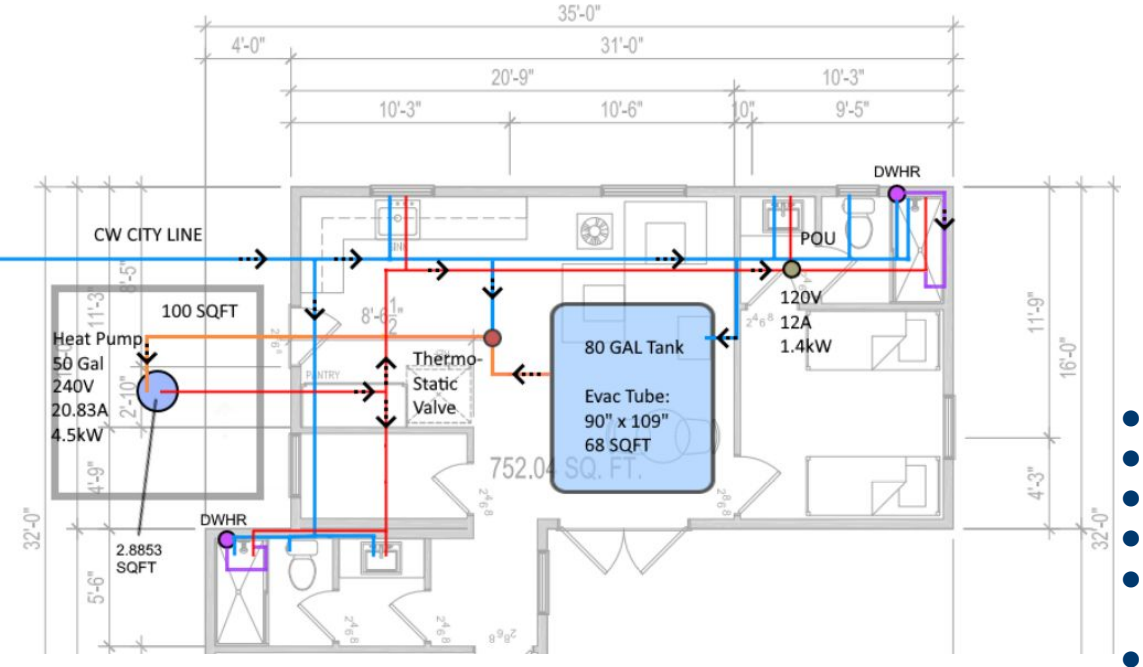
- **Drain Water Heat Recovery Unit:**
  - A completely passive system that requires no maintenance
  - Can recover heat energy and return it back to the water heater so that more energy is not expended to heat otherwise cold water(up to 60% of the heat energy can be recovered)
- **Thermostatic Valve**
  - ASSE 1017 Valve's purpose is to regular the temperature of water coming from the solar tank(could reach 204℉) so it serves as a safety measure within our systems to provide anti-scald protection for the residents



ASSE 1017 Valve, Hot and Cold Water Mix and Tempered water is released in the bottom

Miguel

Detailed Design/BOM: Passive Solar with Heat Pump



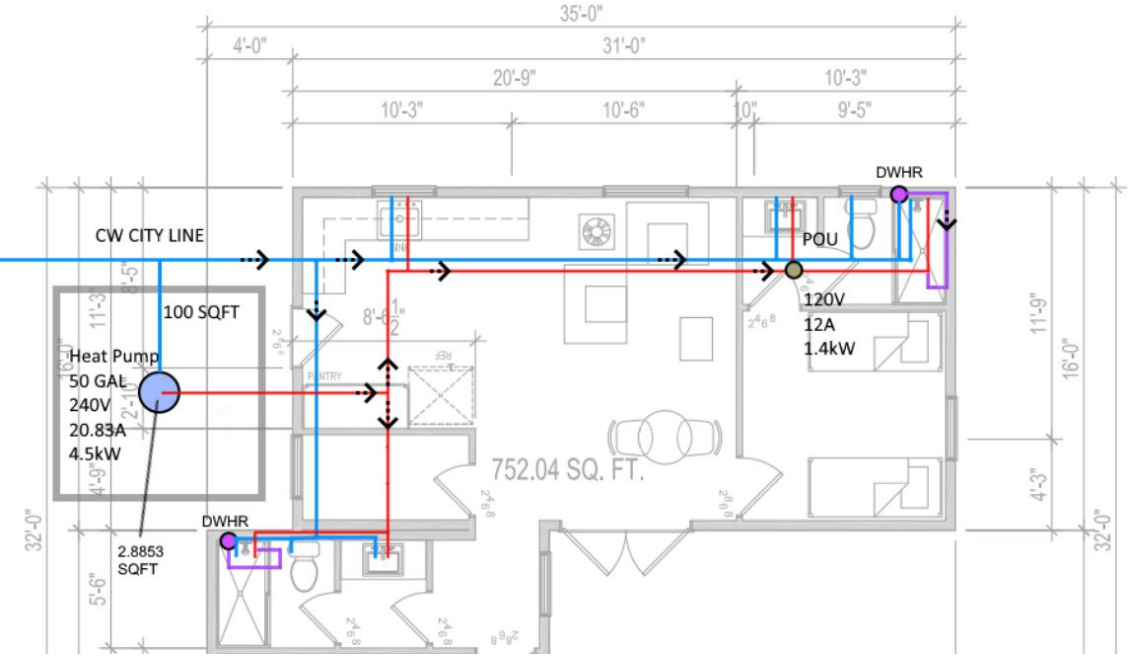
- Cost: $ 4938
- Voltage: 240 V
- Power: 4.5 kW
- Amperage: 20.83 A
- Collector Dimensions: 1 x (90.2 in H x 109 in W)
- Filled weight: 926 lbs

https://www.homedepot.com/p/Rheem-Performance-Platinum-50-Gal-10-Year-Hybrid-High-Efficiency-Smart-Tank-Electric-Water-Heater-XE50T10H45U0/312742081

DIY ThermoPower™ VTS 30 Tube / 80G Thermosyphon Solar Hot Water Kit for Hot Water - SunMaxx Solar

Miguel

Detailed Design/BOM: Heat Pump

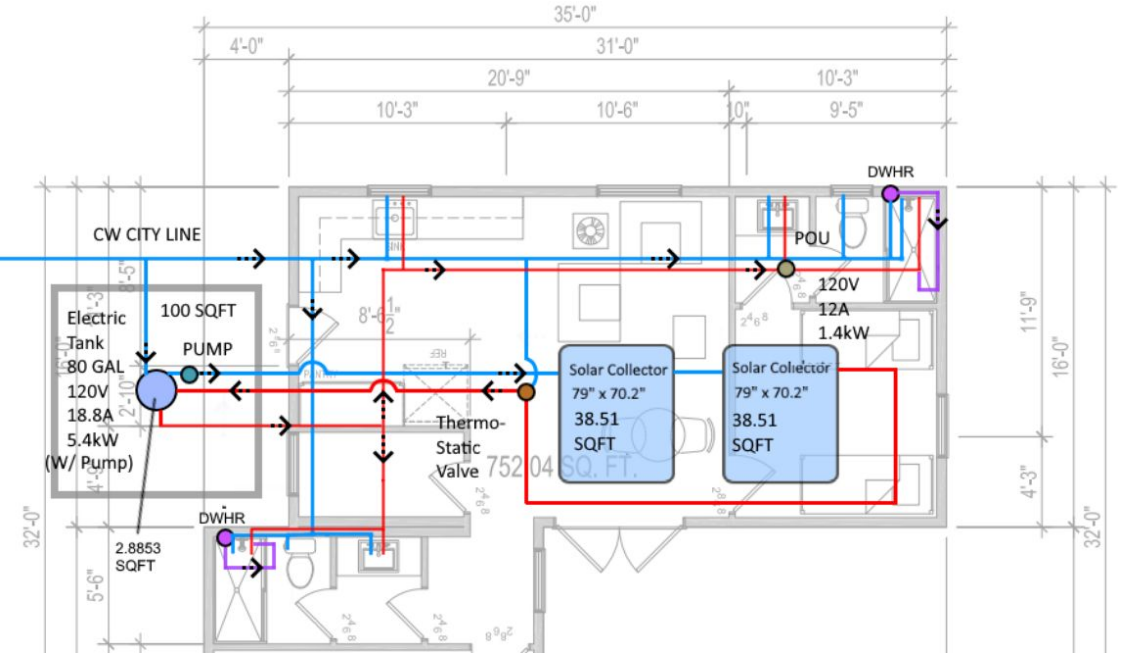


- Total Cost: $2828
- Voltage: 240 V
- Amperage: 20.83
- Dimensions: 48 in H, 22.25 in W, 22.25 in D, 50 gallons

https://www.homedepot.com/p/Rheem-Performance-Platinum-50-Gal-10-Year-Hybrid-High-Efficiency-Smart-Tank-Electric-Water-Heater-XE50T10H45U0/312742081

Chiara

Detailed Design/BOM: Direct Solar with Electric

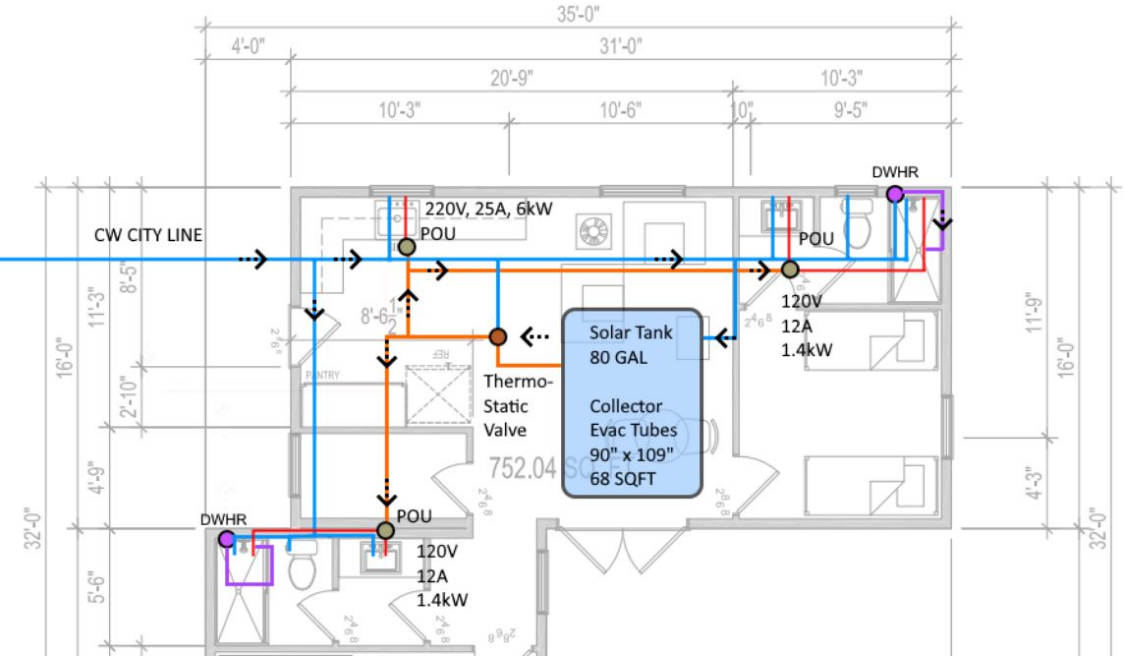


- Cost: $5400
- Voltage: 120 V
- Power: 5400 W
- Amperage: 18.8 A
- Tank Dimensions: 22.5in x 69in (D x H)
- Collector Dimensions: 2 x (79 in H x 70.2 in W)

Mahnoor

https://www.sunmaxxsolar.com/product/heliomaxx-80g-glycol-solar-hot-water-evacuated-tube-collector-kit/

Detailed Design/BOM: Passive Solar



- Cost: $3,239.94
- Voltage: N/A
- Amperage: N/A
- Dimensions: 90 in H x 109 in W

Mahnoor

https://www.sunmaxxsolar.com/product/thermopower-vts-30-tube-80g-thermosyphon-solar-hot-water-kit-with-heat-pipes/

Comparison/Analysis

	Passive + Heat Pump	Heat Pump	Direct Solar + Electric	Passive Solar
Cost*	$6,068	$2,828	$6,529	$4,829
Power (kW)**	N/A + 4.5 + 1.44	4.5 + 1.44	4.5 + 1.44	N/A + 1.44 + 6
Storage	Shed + Roof	Shed	Shed + Roof	Roof
Total POU	1 - ECOMINI6	1 - ECOMINI6	1 - ECOMINI6	2 - ECOMINI6 1 - RHEEM 6
Hourly Cost***	$1.90	$1.90	$1.90	$3.82
Yearly Cost****	$956.86	$2628	$956.86	$902.31

*Including POU and DWHR cost

**System + POU

***Everything on for 1 hour

****Yearly Cost estimated with 1/2 backup needs per day

****Yearly Cost estimated with 5 hrs a day of hot water use

****Yearly Cost estimated with 1/2 backup needs per day

Makala

Which Design to Choose?

- Passive Solar Water System
  - Temperature data in Irvine is suitable for solar systems
  - Estimated yearly cost is lowest
    - Affordable system
  - No additional planar space required
    - Spatial consideration to maximize house layout capacity
  - Has minimal electrical usage
    - No pump or electric components in tank
    - Only needs POUs when Solar temperature not sufficient
      - Only 33.3% of year needed for more than 25% of daily water usage

Risks/Concerns

- Risks
  - Will the roof support the tank on the roof?
  - Cost of installation varies, it may be high depending on the vendor.
  - Passive relies on the weather/the sun
    - If there's a string of cloudy days, the system will rely on POU, which will be costly.
- Concerns
  - High upfront cost for the model.
  - Architecture may have a problem with the tank on the roof.
  - Materials.
  - Regular maintenance.

Jiahao

Future Recommendations

- To find a way to implement DWHR into the passive system
  - We want to utilize the heat from the drain water
- Perhaps collaborate with the sustainability team and find appliances that will limit hot water flow once 120 ℉ is reached
  - It will help with the hot water consumption/waste
- Strong steel makes more protection during years.(the quality make sense)
- Unsure what to do, don’t hesitate to ask a professional.

Jiahao