HCC 2026
Initial Testing Results

Team

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DESIGN REQUIREMENTS SUMMARY

Customer Requirements
CR1 - Reliable Power Supply
CR2 - Structural Integrity
CR3 - Competitive Cost
CR4 - Low Environmental Impact
CR5 - Long Life Expectancy
CR6 - Regulatory Compliance

Engineering Requirements
ER1 - Generation Capacity(1-10MW)
ER2 - LCOE ($.08/kWh± $ .03/kWh)
ER3 - Flow Availability (>40m^3/s)
ER4 - Flow Diversion Ratio (10-25%)
ER5 - Grid Connection (<2km)
ER6 - Capacity Factor (40-80)%

TOP-LEVEL TESTING SUMMARY

Experiment/Test	Relevant DRs	Equipment Needed	Other Resources
Part 1 - Turbine spin/Speed test	-Turbine same model as actual -Turbine fits for experiment -Turbine spins	-Hydraulic bench -Turbine w/ all parts -Tachometer -Force gauge	-Access to Thermal Fluids lab -4 teammates for testing
Part 2 - Prony brake/weight test	-Shaft spins smoothly -Drum collects energy efficiently -Doesn’t fall apart	-Prony brake made by: shaft, drum, wood parts, bearings, 3D print, & rope	-Crafting equipment -Excel spreadsheet to place results
Part 3 - Energy collection	-Transmitter work -Generator collect energy -Batter save and read energy	-Transmitter -Generator -Battery	-Electrical Engineering subteam
Part 4 - Translation to actual analysis	-The turbine behaves in an expected way	-Turbine -Prony brake -Hydraulic bench	-Real world data

TOP-LEVEL TESTING SUMMARY

Procedure:

1. Measure static length values like turbine and inlet radius
2. Set up Prony brake and turbine to hydraulic bench
3. Shoot out water at first speed and collect its speed data
4. Set up first dead weight to get tension
5. Shoot water through turbine and collect rotational speed and force
6. Repeat steps 4-6 for all speeds/weight
7. Use collected data to measure power and efficiency
8. Graph collected data to find ideal tension in the system

The torque output from the turbine was calculated using the net force output measured by the Prony brake multiplied by the radius of the turbine. By multiplying this output torque with the angular velocity of the turbine, a power output (W_0) can be found as seen in equation 4 below.

$$W_0 = T \cdot \omega \tag{4}$$

Prony Brakes

Weights: [g]	Main (N)	Dead Weight (N)	force (N)	rmp	w (rad/s)	U Speed m/s	Torque	W (power)	Efficiency
0	0	0	0	3000	314.159	7.8539816	0	0	0
50	1	0.4905	0.5095	2500	261.799	6.5449847	0.01274	3.334669702	0.005276452
100	2	0.981	1.019	1500	157.08	3.9269908	0.02548	4.001603643	0.006331743
200	4	1.962	2.038	1000	104.72	2.6179939	0.05095	5.335471523	0.008442324
300	6	2.943	3.057	500	52.3599	1.3089969	0.07643	4.001603643	0.006331743
400	8	3.924	4.076	250	26.1799	0.6544985	0.1019	2.667735762	0.004221162
500	10	4.905	5.095	100	10.472	0.2617994	0.12738	1.333867881	0.002110581

d(pony break)	
d(turbine) [m]	0.05
radius(turbine) [m]	0.025
Jet Velocity [m/s]	1.591549431
Tube rad. [m]	0.01
Mass flow rate	0.499
Tube Area [m^2]	0.000314159

deltaP (Pa)	1266.51
Wi	631.991
Density [kg/m^3]	1000

TOP-LEVEL TESTING SUMMARY

Measured Variables:

- Speed of water: **0.1 L/s** - max output (**~1.0 L/s**)
- Force 1 - Dead weight (tension): **0 g - 500 g**
- Force 2 - Force gauge: **0 N - 10 N** (expected)
- Rotational speed (tachometer): **0 rpm - 3000 rpm** (expected)

Calculations

- Power will be calculated by multiplying net force by angular velocity and rudder radius
- This **0 - 6 Watts** will be compared to power in, determined by velocity, to find efficiency

With this being an optional part of the competition and having a real scale prototype unfeasable the requirements are little and possibilities open. We will use a scaled down turbine in the fluids lab to collect potential power outputs. What we stand to gain from this experiment is to understand when a turbine is most efficient, when it provides maximum power output, and how it acts under different water conditions.

ER SPEC SHEET AND TESTING RESULTS

Engineering Requirement	Target	Tolerance	Measured Value	ER Met? (Y/N)	Client Acceptable? (Y/N)
ER1 - Power Output (W)	1 - 6 W	± 0.5 W	Test pending		
ER2 - Efficiency (%)	10 -75 %	± 5 %	Test Pending		
ER3 - Flow Rate (L/s)	.1 - 1 L/s	± .05 L/s	Test Pending		
ER4 - Rotational Speed (RPM)	100-3000 RPM	± 5 %	Test Pending		
ER5 - Torque Ouput (Nm)	.01 - .13 Nm	± 5 %	Test Pending		

CR SITE SPEC SHEET SUMMARY

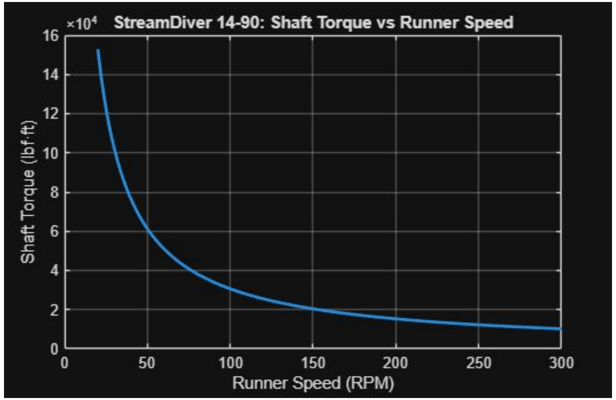
CR's	Evaluation Method	CR Met? (Y/N)	Client Acceptable? (Y/N)
CR1 - Reliable Power Supply	Measured power output vs flow rate	In Progress	
CR2 - Structural Integrity	Assessed through on site concrete review	(Y)	(Y)
CR3 - Competitive Cost	Estimated through LCOE Modeling	(Y)	(Y)
CR4 - Low Environmental Impact	Environmental Impact Study	(Y)	(Y)
CR5 - Long Life Expectancy	Assessed through concrete screening & dam Safety benchmarks	(Y)	(Y)
CR6 - Regulatory Compliance	NEPA,FERC,MNDNR framework implemented in design	(Y)	(Y)

SITE ER SPEC SHEET SUMMARY

ER's	Expected Value	Tolerance	Measure/Calculated	ER Met? (Y/N)	Client Acceptable? (Y/N)
ER1 - Generation Capacity	1-10 MW	none	2.17 MW	(Y)	(Y)
ER2 - LCOE	$.08/ kWh	± $.03/ kWh	.0577 $/kWh	(Y)	(Y)
ER3 - Flow Availability	>50 m^3/s	- 5 m^3/s	Exceeds 90m^3/s 90% of the time	(Y)	(Y)
ER4 - Flow Diversion Ratio	10-25%	None (Licence constraint)	20%	(Y)	(Y)
ER5 - Grid Connection	<2 km	+ .5 km	.6 km	(Y)	(Y)
ER6 - Capacity Factor	40-80%	± 5%	67%	(Y)	(Y)

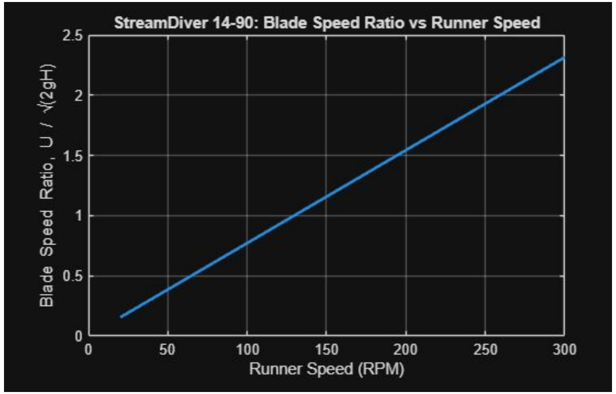
PERFORMANCE MODELING RESULTS

- Power output: ~390 kW per unit
- Optimal speed: ~120 RPM
- Performance driven by site conditions (Q,H)



Key Insights

- Torque decreases with RPM due to P = T*ω
- Blade speed ratio identifies efficient operating range
- Optimal performance occurs near 120 RPM

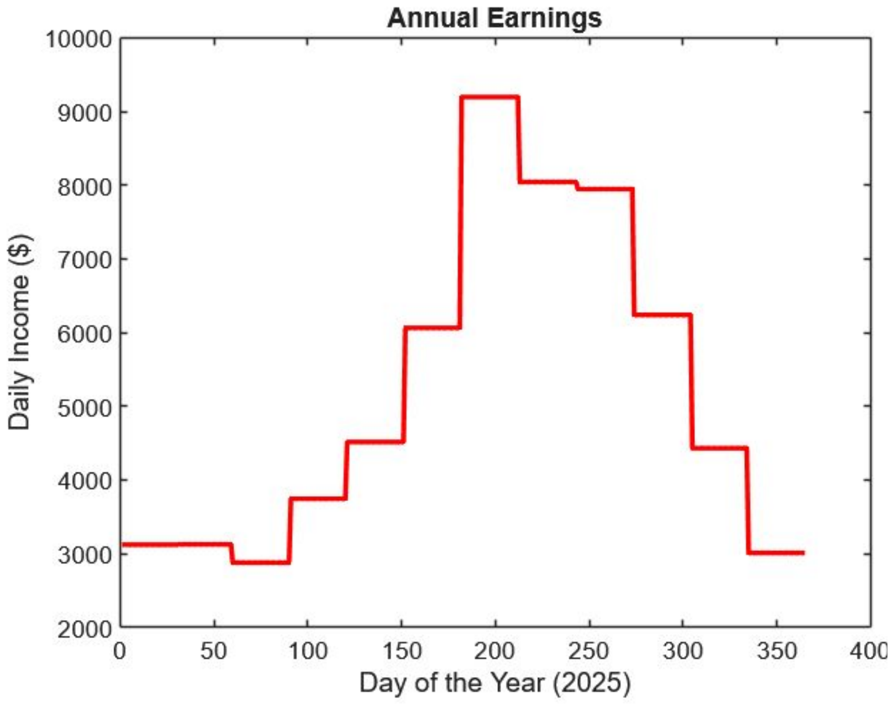


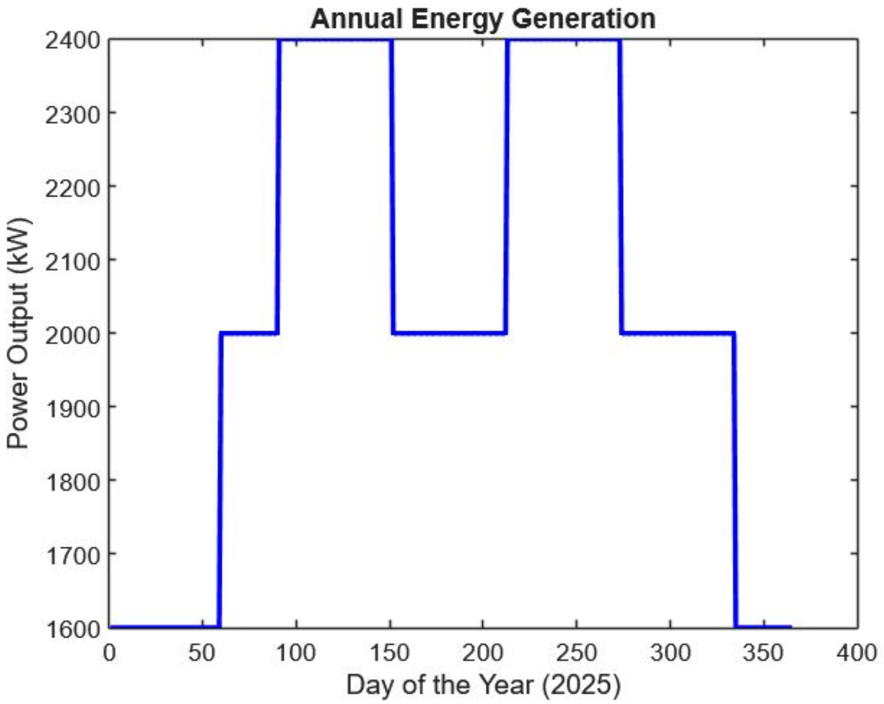
VIRTUAL PROTOTYPE

Test Summary:

- How much energy & income does the design produce?
- Procedure:
  - **Collect real-world water and LCOE data**
  - **Plug into created program**
- Looking for:
  - **1-10 MW Nameplate Capacity & Mean Output**
  - **Atleast $1 million Income**
- Results
  - **2.4 MW Capacity**
  - **2.04 MW Mean**
  - **$1.9 Million/Year**

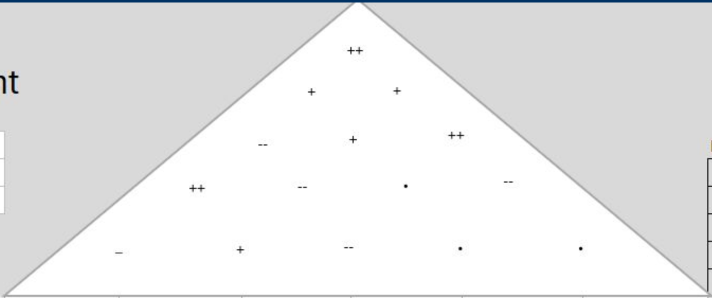
VIRTUAL PROTOTYPE





Quality Function Deployment

Project title: **HydroJacks**
Project leader: **Karsten Jones**
Date: **3/21/2026**



Legend

++	Strong Positive
+	Positive
.	No Correlation
-	Negative
--	Strong Negative

		Desired direction of improvement (↑,0,↓)	↑	↓	↑	↓	↓	↑
	1: low, 5: high	Technical Requirements →						
	Customer importance rating	Customer Requirements ↓	Generation Capacity (1-10MW)	LCOE ($/kWh)	Available Flow Rate (m^3/s)	Flow Diversion Ratio (%)	Grid Connection (km)	Capacity Factor (%)
1	3	Reliable Power Supply	9	3	9	1	9	9
2	7	Structural Integrity	1	1	3	1	1	1
3	5	Competitive cost	9	9	3	1	3	9
4	4	Recreational & Aestetic Preservation	1	1	3	9	1	1
5	2	Low Enviromental Impact	1	3	3	9	3	1
6	6	Long Life Expectancy	3	3	3	3	1	3
7	1	Regulatory Compliance	1	1	3	9	3	1
		Technical importance score	104	90	102	96	68	104
		Importance %	18%	16%	18%	17%	12%	18%
		Priorities rank	1	5	3	4	6	1

KEY QFD RESULTS

Top Drivers:

- Generation Capacity(18%)
- Capacity Factor(18%)
- Flow Availability(18%)
- Flow Diversion(17%)

Design is driven primarily by power production and flow conditions

ER Results

- Generation capacity - 2.17 MW Nameplate
- LCOE - 0.0577 $/kWh
- Flow - 90 m^3/s at 90% Exceedance
- Diversion - 20% Cap
- Capacity Factor - 67%
- Grid connection - .6km

All Engineering Requirements were met.

QFD CR → ER CORRELATION

Reliable Power → Capacity+Flow+CF
Competitive Cost →LCOE
Environmental Impact →Diversion
Regulatory Compliance →Diversion+Capacity
Structural Integrity →Flow+Capacity+Site Assessment
Long Life Expectancy →Flow
Recreational Preservation →Flow+Diversion

APPENDIX

THANK YOU!

NORTHERN ARIZONA UNIVERSITY