HCC 2026
Final Testing Results

Team

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DESIGN REQUIREMENTS SUMMARY

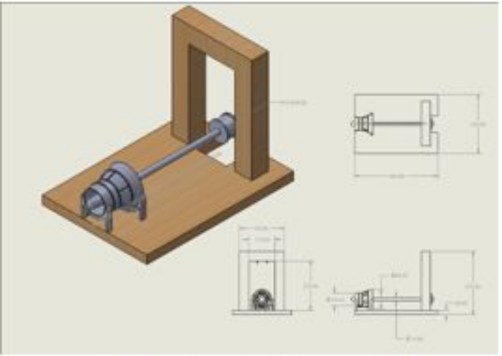
Customer Requirements
CR1 - Reliable Power Supply
CR2 - Structural Integrity
CR3 - Competitive Cost
CR4 - Low Environmental Impact
CR5 - Long Life Expectancy
CR6 - Regulatory Compliance

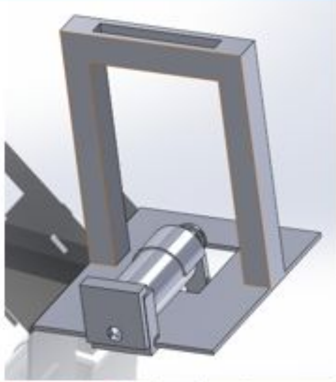
Engineering Requirements
ER1 - Generation Capacity(1-10MW)
ER2 - LCOE ($.08/kWh± $ .03/kWh)
ER3 - Flow Availability (>50m^3/s)
ER4 - Flow Diversion Ratio (10-25%)
ER5 - Grid Connection (<2km)
ER6 - Capacity Factor (40-80)%

TOP-LEVEL TESTING SUMMARY

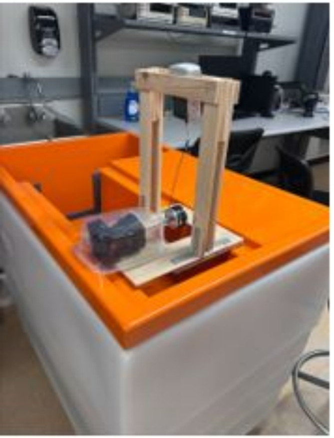
Experiment/Test	Relevant DRs	Equipment Needed	Other Resources
Part 1 - Turbine spin/Speed test	-Turbine same model as actual -Turbine fits for experiment -Turbine spins	-Hydraulic bench -Turbine w/ all parts -Tachometer -Force gauge	-Access to Thermal Fluids lab -4 teammates for testing
Part 2 - Prony 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

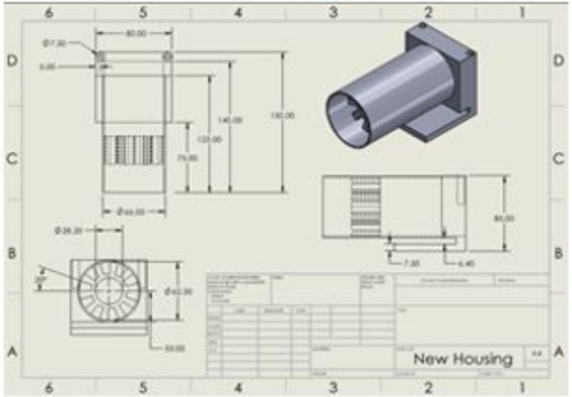
DESIGN ITERATIONS





The design went through 4 total design iterations with the biggest change being the housing for the turbine





WHAT WE LEARNED

Weights: [g]	Main (N)	Dead Weight (N)	force (N)	rpm	ω (rad/s)	Torque	W (power)	Efficiency	Volume(L)	Time (s)	flow rate(L/s)
0	0	0	0	4000	418.9	0	0	0%	5	5.47	0.914
20	0.65	0.196	0.454	3500	366.5	0.015	5.41	24%	5	5.48	0.912
40	1.5	0.392	1.108	1000	104.7	0.036	3.77	17%	5	5.85	0.855
										Average L/s	0.894

Weights: [g]	Main (N)	Dead Weight (N)	force (N)	rpm	ω (rad/s)	Torque	W (power)	Efficiency	Volume(L)	Time (s)	flow rate(L/s)
0	0	0	0	2400	251.3	0	0	0%	5	8.49	0.589
20	0.45	0.196	0.254	1500	157.1	0.00825	1.30	21%	5	8.81	0.568
40	0.6	0.392	0.208	0	0.0	0.00675	0	0%	5	8.54	0.585
										Average L/s	0.581

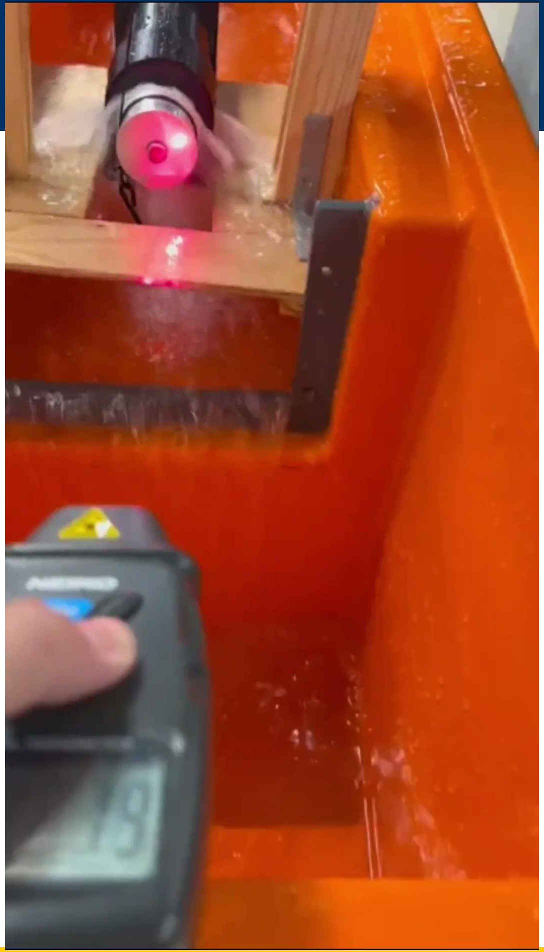
Weights: [g]	Main (N)	Dead Weight (N)	force (N)	rpm	ω (rad/s)	Torque	W (power)	Efficiency	Volume(L)	Time (s)	flow rate(L/s)
0	0	0	0	840	87.96	0	0	0%	5	12.76	0.392
20	0.3	0.196	0.104	200	20.94	0.0034	0.071	4%	5	12.45	0.402
40	0.45	0.392	0.058	0	0	0.0019	0	0%	5	12.58	0.397
										Average L/s	0.397

- Exact efficiency can't be tested for this scaled down a turbine
- Although the more neutral a torque/resistive force there is, the more efficient the system is
- The speed of flow or water has the highest impact on direct output of power
- Having a system that works well together is most important

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	~ 5 W	(Y)	(Y)
ER2 - Efficiency (%)	10 -75 %	± 5 %	1 - 25 %	(Y)	(Y)
ER3 - Flow Rate (L/s)	.1 - 1 L/s	± .05 L/s	~.5 L/s	(Y)	(Y)
ER4 - Rotational Speed (RPM)	100-3000 RPM	± 150 RPM	200 – 3500 RPM	(Y)	(Y)
ER5 - Torque Ouput (Nm)	.01 - .13 Nm	± .0065 Nm	.0035 - .035 Nm	(Y)	(Y)

TESTING



CR SITE SPEC SHEET SUMMARY

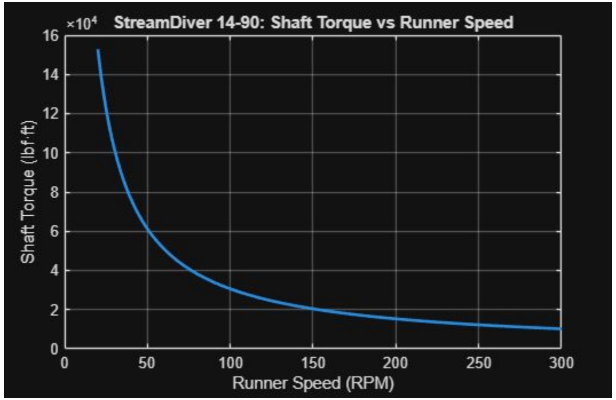
CR's	Evaluation Method	CR Met? (Y/N)	Client Acceptable? (Y/N)
CR1 - Reliable Power Supply	Measured power output vs flow rate	(Y)	(Y)
CR2 - Structural Integrity	Assessed through on site concrete review	(Y)	(Y)
CR3 - Competitive Cost	Estimated through LCOE Modeling	(Y)	(Y)
CR4 - Low Environmental Impact	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	$0.08/ kWh	± $.03/ kWh	$0.0796/ 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)	15%	(Y)	(Y)
ER5 - Grid Connection	<2 km	+ .5 km	.6 km	(Y)	(Y)
ER6 - Capacity Factor	40-80%	± 5%	67%	(Y)	(Y)

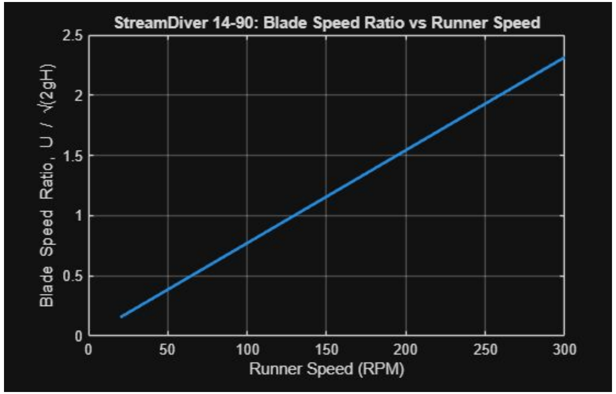
PERFORMANCE MODELING RESULTS

- 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 $P = T^*\omega$
- Blade speed ratio identifies efficient operating range
- Optimal performance occurs near 120 RPM



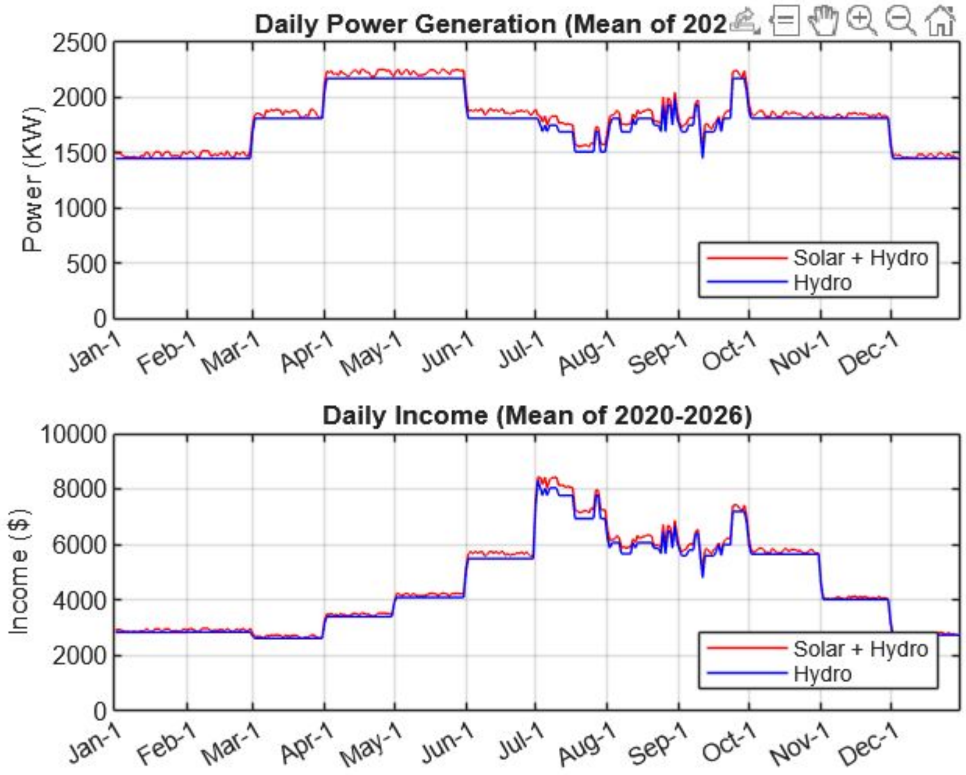
VIRTUAL PROTOTYPE

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
  - **2.17 MW Capacity**
  - **$1.4 Million/Year**

MATLAB

VIRTUAL PROTOTYPE



ENERGY PRODUCTION & RESIDENTIAL IMPACT

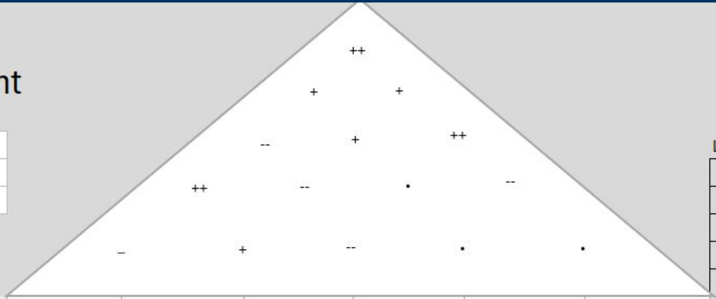
Parameter	Installed Capacity (MW)	Capacity Factor (%)	Annual Energy Production (MWh/yr)	Annual Energy Production (kWh/yr)	Avg. MN Household Consumption (kWh/yr)	Equivalent homes Powered
Hydro	2.17	67	12,699	12,699,000	8,544	1,490
Solar	.25	15.5	480	480,000	8,544	56
Hybrid	2.42	61.9	13,479	13,479,000	8,544	1,546

- Annual generation of 13,479 MWh was compared to the average residential electricity consumption in Minnesota.
- Based on average household usage of 712 kWh per month (8,544 kWh annually), the proposed hydropower system is capable of supplying energy to approximately 1,550 homes per year as shown.

QUALITY FUNCTION

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,↓)		↑	↓	↑	↓	↓	↑
	Customer importance rating (1: low, 5: high)	Technical Requirements → / 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 - 0.0796 \$/kWh, 1,780 homes powered
- Flow - 90 m^3/s at 90% Exceedance
- Diversion - 15% Cap
- Capacity Factor - 67%
- Grid connection - .6km

All Engineering Requirements were met.

APPENDIX

THANK YOU!

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