Cavendish Farms: Heat Recovery

Project Update

ENGN 3720

13 March 2020

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Introduction

- Project Management Update
  - Schedule
  - Budget
    - Materials
    - Labor
  - Risks
- Final Prototype and Plan
  - Methodology (What, Why, How)
- Final Design Definition
  - Requirements Met
  - Design Decisions
- Next Steps

Project Management Update

- Recently completed
  - Mock-up built and ready for testing
  - In house testing
- Current
  - Mock-up data analysis
  - Formulation of conclusions
- Future
  - Local testing at client site
  - Detailed analysis
  - Recommendations to client
  - Semester close-out

Schedule

3.0 Test & Verification Review
3.1 Results of Test and verification activities
Run testing, defined in test plan
math model completed
assess data
rework test plan if necessary
run more testing if necessary
testing for primary requirements completed
Divide work and complete section(s) for report, as outlined
3.2 Final Design
Compile list of specification changes required based on outcome of
Install Insulation wrap
Install Pressure Sensors
Final Testing (Water)
Analyze Test Data (Water)
Final Testing (Steam)
Analyze Test Data (Steam)
Draw Conclusions from Testing
Divide work and complete section(s) for report, as outlined
3.3 Prototype Refinement Plans
Complete requirement analysis to ensure prototype satisfies prima
If primary requirement has not been achieved iterate process
Review time constraints to assess potential to deliver secondary re

4.0 Detailed Design Review & Prototype Release				
4.1 Final design document				
Divide work and complete section(s) for report, as outlined	0%	3-10-20	4-1-20	23
4.2 Demonstration of requirements verification				
set up time with client	0%	3-10-20	3-12-20	3
Compile a list of the fulfilled requirements	100%	3-10-20	3-13-20	4
Deconstruct Mock-up	0%	3-25-20	4-20-20	27
Hand sand & crack fill	0%	3-25-20	4-20-20	27
Paint Mock-up	0%	3-25-20	4-20-20	27
Reconstruct Mock-up	0%	3-25-20	4-20-20	27
Design Labels & Logos	0%	3-25-20	4-20-20	27
Prints/Etch Lables & Logos	0%	3-25-20	4-20-20	27
Set up and trial system	0%	4-20-20	4-22-20	3
troubleshoot system if necessary to ensure proper operation prior to demonstration	0%	4-21-20	4-22-20	2
Prepare Expo presentation	0%	4-20-20	4-22-20	3
practice Expo presentation	0%	4-22-20	4-24-20	3
Physical demonstration to client (video, site visit, mock system)	0%	4-1-20	4-5-20	5
4.3 Operational prototype				
Write report outlining our recommendations for implementation and sale up within the facility	0%	3-20-20	4-1-20	13

Budget: Materials

VANtech Design
General Journal
Term Ending 2020

Date	Account	Ref.	Debit	Credit	Date	Account	Ref.	Debit	Credit
2019									
16-Dec	McMaster Carr: Various Components	27955	$1,252.06		16-Dec	Omega: Various Components	27953	$2,219.34	
	Cash Budget	27955		$1,252.06		Cash Budget	27953		$2,219.34
16-Dec	Diverter Valves	27954	$168.91						
	Cash Budget	27954		$168.91					
2020									
02-Jan	Adjusted: McMaster Carr Various Components	25539	$2,078.55		02-Feb	Adjusted: Plywood	26076	$27.32	
	McMaster Carr: Various Components	27955		$1,252.06		Cash Budget	28562	$1.40	
	Cash Budget	27955		$826.49		Plywood	28562		$28.72
02-Jan	Adjusted: Omega Various Components	25537	$2,177.04		02-Feb	Adjusted: McMaster Carr Various Components	26136	$117.71	
	Cash Budget	27953	$42.30			McMaster Carr Various Components	28562		$57.80
	Omega Various Components	27953		$2,219.34		Cash Budget	28562		$57.80
02-Jan	Adjusted: Diverter Valves	25538	$139.43		12-Feb	Thermocouple Connector	29096	$43.80	
	Cash Budget	27954	$29.48			Cash Budget	29096		$43.80
	Diverter Valves	27954		$168.91	02-Mar	Adjusted: Thermocouple Connector	26617	$96.46	
20-Jan	Plywood	28562	$28.72			Thermocouple Connector	29096		$43.80
	Cash Budget	28562		$28.72		Cash Budget	29096		$52.66
21-Jan	McMaster Carr Various Components	28597	$57.80			**Total Cost of Material**	#####	$3,770.63	
	Cash Budget	28597		$57.80		**Adjusted: Total Cost of Material**	#####	$4,636.51	

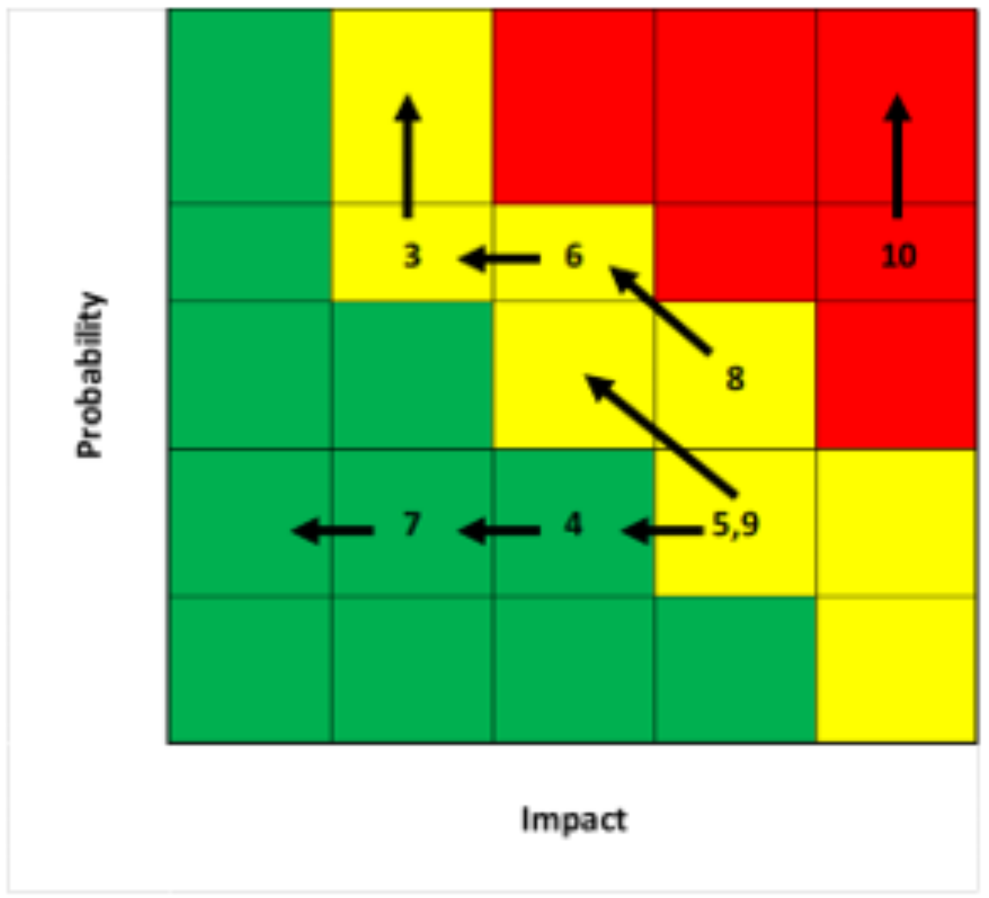
Budget: Labor

Labour Cost Breakdown			
Employee	Wages	Labour hrs	Total Cost
Engineering Consultants	$100 CAD/hr	$ 773.50	$ 77,350.00
UPEI Technical Consultants	$175 CAD/hr	$ 5.00	$ 875.00
UPEI Technologist	$75 CAD/hr	$ 10.00	$ 750.00
			$ 78,975.00

Project Cost as of March 12, 2020		
Adjusted: Total Material Cost	$ 4,636.51	6%
Labour Cost	$ 78,975.00	94%
Total Project Cost	$ 83,611.51	100%

Risks

Trend Definitions	
-	No change
↔	Change in consequence
↕	Change in likelihood
New	New risk added
Retired	Risk retired

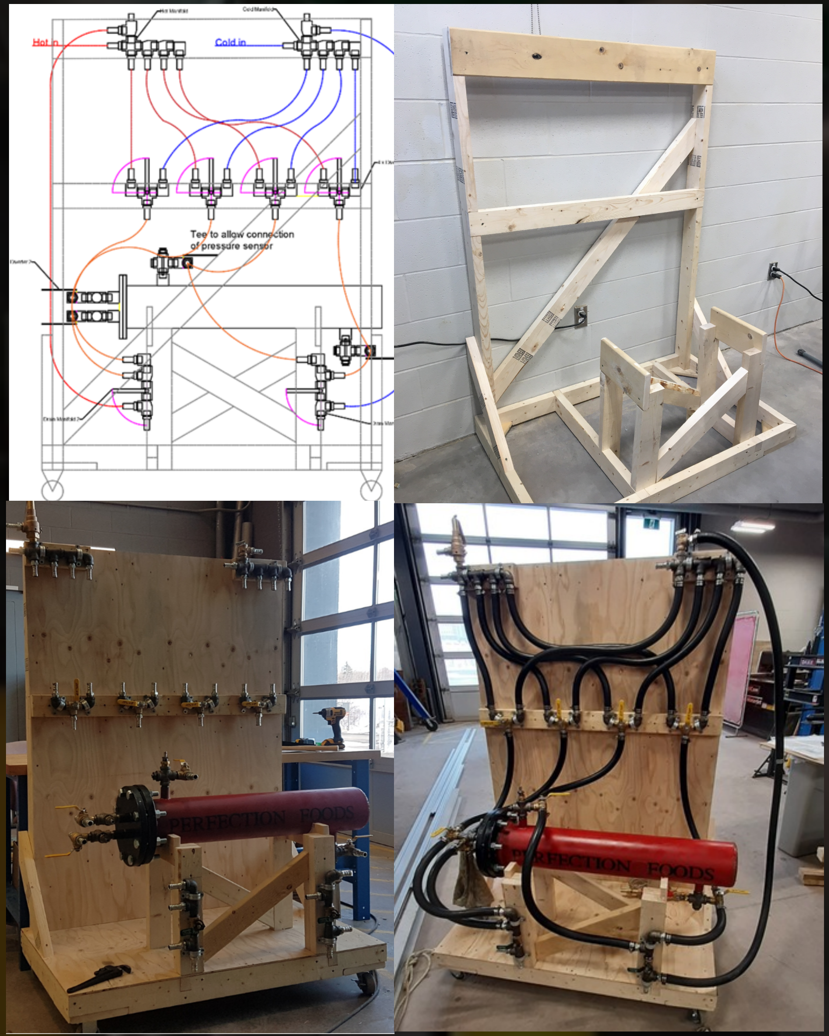


Risk No.	Description	Trend
1	*Not having all materials at the start of the second semester required for building the mock-up has a high probability to push the schedule back.*	Retired
2	*Additional time in building the mockup has moderate probability to push the schedule back.*	Retired
3	*Additional time in necessary testing for calibrating has moderate probability to push the schedule back.*	↑
4	*Component failures that impacts the mockup ability during building or testing has high probability to push the schedule back.*	←
5	*Inaccurate effectiveness values during site testing/analysis has moderate risk of delaying entry into service.*	←
6	*Issues scheduling site visits, meeting and lack of communication has high probability of delaying design.*	←
7	*Component failures that impacts the mockups ability during building or testing requiring new or fixed components has potential to increase the budget by 3 to 5%.*	↓
8	*Complexities in analyzing the mockup resulting in inaccurate data has potential to have a moderate impact the calibration.*	↑←
9	*Inaccurate measurements and calculations of onsite heat exchangers has potential to have a moderate impact the results.*	↑←
10	*Unavailable data for specific heat exchangers and parameters has potential to have a large impact calibration methods.*	↑

Final Prototype and Plan

What and Why?

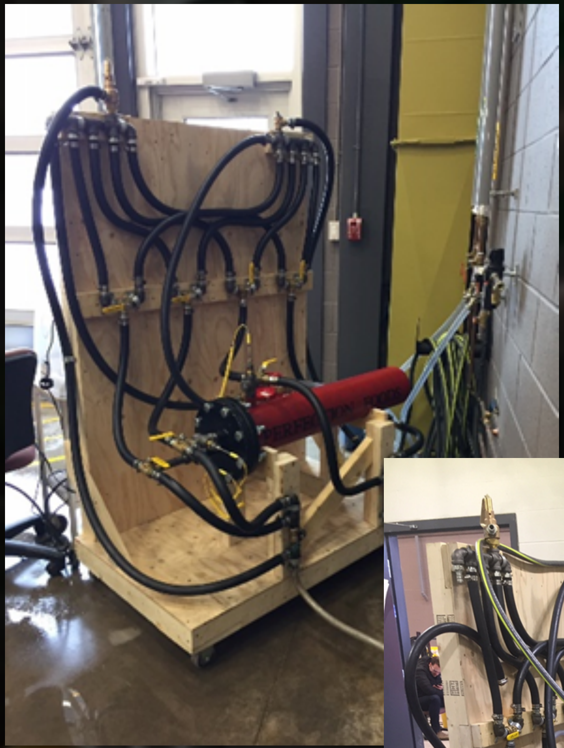
- In house testing
  - Gain a better understanding of heat exchangers
  - Look for uncontrolled outputs and how they affect the system
  - Determine how parameter fluctuations effect the system
  - Prove effectiveness can be logged in real time
- Analysis of collected data using two calculation methods
  - Determine deviation of the calculated result between the two methods
  - Determine which method is more applicable at Cavendish Farms
- On site testing at Cavendish Farms
  - To prove that the chosen method can be readily applied to the clients systems



Final Prototype and Plan

How?

- Constructed a mock-up heat exchanger system for data collection
- Data logged several tests with different parameters adjusted
  - Mass Flowrate
  - Hot side fluid
    - Water
    - steam
- Created excel spread sheets to analyze the data using the LMTD method and the Effectiveness method



Final Prototype and Plan

How?

- Effectiveness Method

$$\varepsilon = \frac{\dot{Q}}{\dot{Q}_{max}} = \frac{\text{Actual heat transfer rate}}{\text{Maximum possible heat transfer rate}}$$

$$\varepsilon = \frac{C_h(T_{h,i} - T_{h,o})}{C_{min}(T_{h,i} - T_{c,i})}$$

- LMTD Method

$$LMTD = \frac{(\Delta T)_1 - (\Delta T)_2}{\ln(\frac{\Delta T_1}{\Delta T_2})}$$

$$\dot{Q} = UA_s \Delta T_{lm}$$

Final Prototype and Plan

Effectiveness Method

Test 1: Trial 2

Parameters			
Measurements	Variables	Control	Value
Cold side mass flow rate	m_c	Needle valve	20
Cold side fluid type	-	Domestic Water Supply	Cold Water
Hot side mass flow rate	m_h	Needle Valve	20
Hot side fluid type	-	Domestic Water Supply	Warm Water

Specific Heat				
Tube/shell	Fluid	State	Pavg, in	Specific Heat, c
Tube	Cold Water	Liquid		4186
Shell	Warm Water	Liquid		4186

$$\varepsilon = \frac{C_h(T_{h,i} - T_{h,o})}{C_{min}(T_{h,i} - T_{c,i})}$$

Data:

No.	$T_{c,in}$	$T_{c,out}$	M_c	C, c	M_h	C, h	C, min	$T_{h,in}$	$T_{h,out}$
1	18.80	32.41	0.1419529	594.2148394	0.3816957	1597.7782	594.2148394	61.64	56.35
2	17.92	32.47	0.1419529	594.2148394	0.3816957	1597.7782	594.2148394	60.66	56.66
3	17.79	33.90	0.1419529	594.2148394	0.3816957	1597.7782	594.2148394	61.39	55.56
4	18.04	33.47	0.1419529	594.2148394	0.3816957	1597.7782	594.2148394	61.52	56.66
5	18.74	32.35	0.1419529	594.2148394	0.3816957	1597.7782	594.2148394	60.72	55.43
6	18.11	33.15	0.1419529	594.2148394	0.3816957	1597.7782	594.2148394	61.09	55.25
7	18.36	31.98	0.1419529	594.2148394	0.3816957	1597.7782	594.2148394	60.54	56.66
8	18.30	32.97	0.1419529	594.2148394	0.3816957	1597.7782	594.2148394	60.66	55.37

Calculations:

Current Rate of Heat Transfer, Q_{now}	*Current Max Rate of Heat Transfer, Qmax*	*Method 1: Effectiveness*	*Method 2: Q (Leslie)*
8448.539834	25456.22908	33.19%	1738.2
6386.3674	25396.35005	25.15%	1744.1
9322.364731	25907.83236	35.98%	1678.4
7759.513963	25830.75675	30.04%	1727.5
8443.778455	24946.94537	33.85%	1690.8
9324.042398	25539.00321	36.51%	1680
6191.93377	25062.06855	24.71%	1747.5
8444.209855	25172.32512	33.55%	1676.6

Final Prototype and Plan

LMTD Method

					Hot Flow					
Trial	Cold Inlet	Cold Outlet	Hot Inlet	Hot Outlet	Gallons/min	Volumetric flowrate (m^3/s)	Reynolds	Prandtl	Nusselt	h
1	PD1_A02	PD1_A03	PD1_A01	PD1_A04	9.4	5.93E-04	#VALUE!	#VALUE!	#VALUE!	#VALUE!
2	°C	°C	°C	°C	9.4	5.93E-04	#VALUE!	#VALUE!	#VALUE!	#VALUE!
3	11	45	61.6	50	0.5	3.15E-05	667.2	3.0	5.8	30.1
4	11.3	33.3	60.7	55.6	9.4	5.93E-04	12543.4	3.0	69.0	355.4
5	11.3	33.7	61.7	55.7	9.4	5.93E-04	12543.4	3.0	69.0	355.4
6	11.4	34.2	62.3	55	9.4	5.93E-04	12543.4	3.0	69.0	355.4
7	10.8	34	61.1	56.1	9.4	5.93E-04	12543.4	3.0	69.0	355.4
8	11.4	33.2	60.9	56.5	9.4	5.93E-04	12543.4	3.0	69.0	355.4

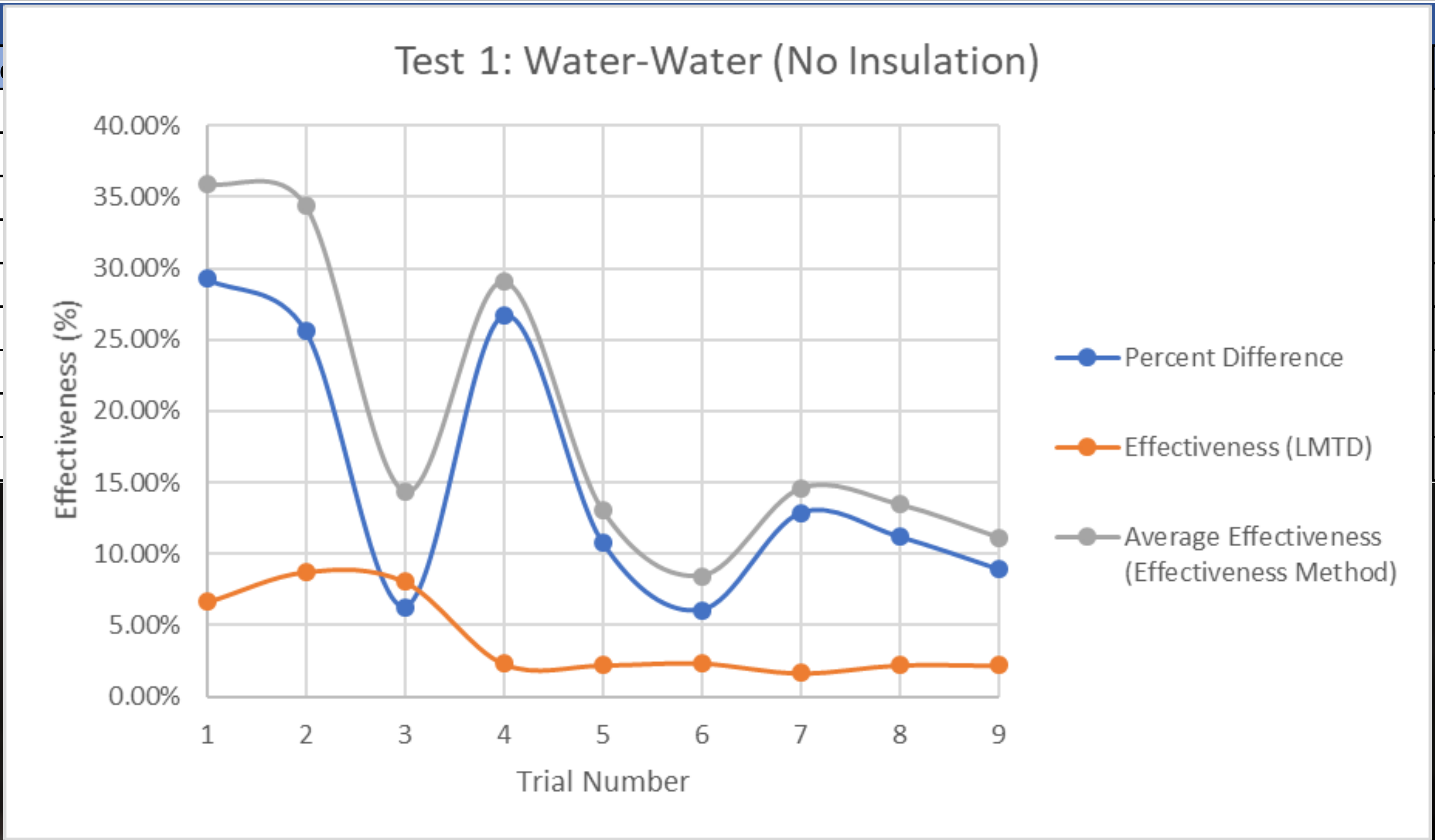
Cold Flow						Effectiveness							
Gallons/min	Volumetric flowrate (m^3/s)	Reynolds	Prandtl	Nusselt	h	U	LMTD	NTU	C, cold	C, hot	C	E	Q
9.35	5.90E-04	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
9.35	5.90E-04	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
9.35	5.90E-04	14321.0	9.5	115.6	5010.6	30.1	19.7	0.053	2473.852	129.737	0.1	0.0261	136.6
9.35	5.90E-04	14321.0	9.5	115.6	5010.6	347.2	34.1	0.033	2473.852	2439.060	1.0	0.0136	2729.2
9.35	5.90E-04	14321.0	9.5	115.6	5010.6	347.2	34.3	0.033	2473.852	2439.060	1.0	0.0136	2744.3
9.35	5.90E-04	14321.0	9.5	115.6	5010.6	347.2	33.6	0.033	2473.852	2439.060	1.0	0.0136	2694.2
9.35	5.90E-04	14321.0	9.5	115.6	5010.6	347.2	34.3	0.033	2473.852	2439.060	1.0	0.0136	2746.6
9.35	5.90E-04	14321.0	9.5	115.6	5010.6	347.2	34.8	0.033	2473.852	2439.060	1.0	0.0136	2785.1

Final Prototype and Plan

Comparison

Test 1 Results:

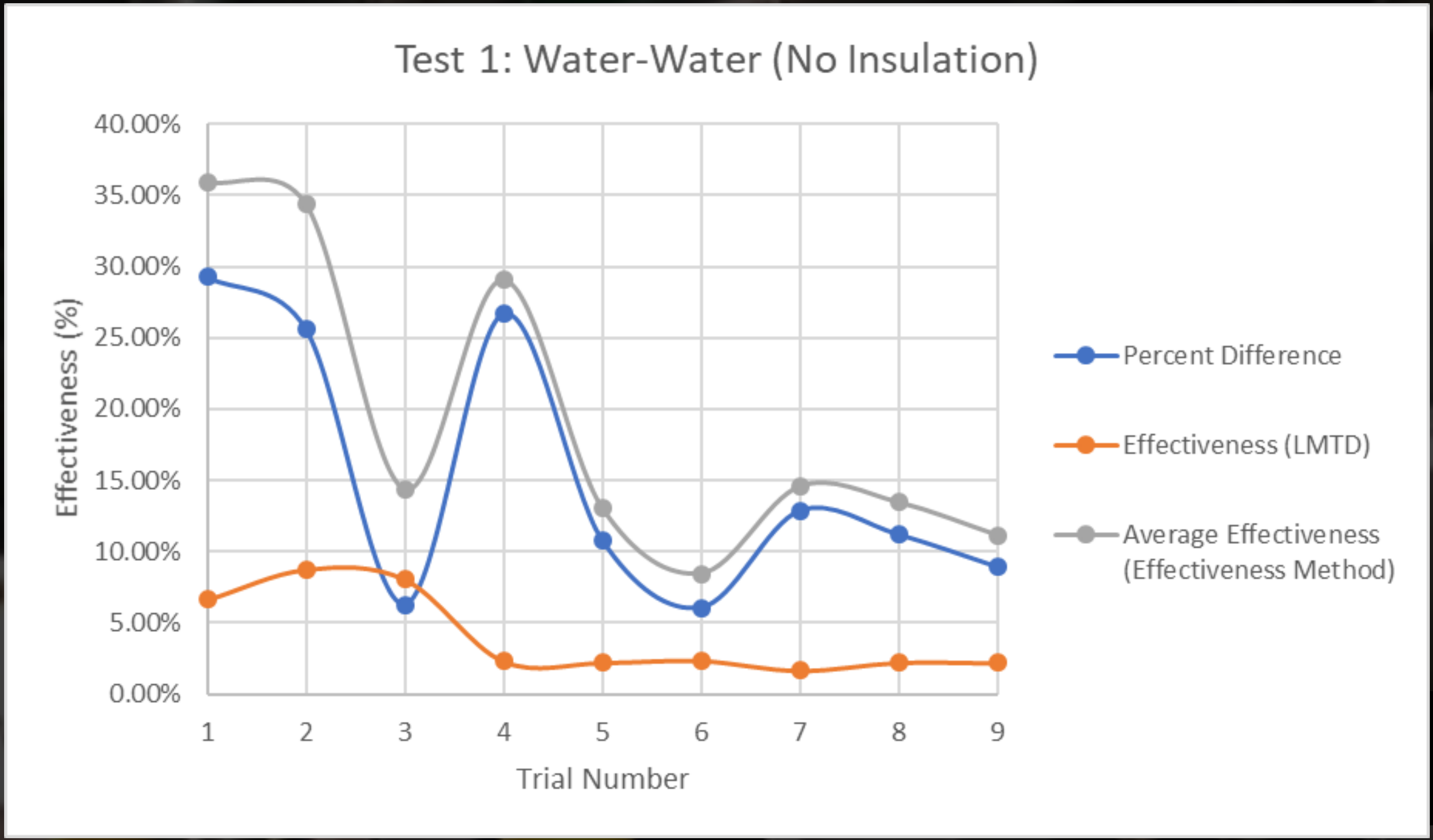
Trial	Valve (	Percent Difference
1		29.29%
2		25.64%
3		6.29%
4		26.72%
5		10.81%
6		6.07%
7		12.87%
8		11.20%
9		8.92%



Project Management Update | Final Prototype and Plan | Final Design Definition | Next Steps

Final Design Definition

Design Decisions



- Through the first test, many design decisions were made based on the results. These involved:

1) **Calculation method:**

- LMTD vs. Effectiveness.

2) Sensory data:

- Critical parameters needed to calculate effectiveness.

3) Efficiency vs. Effectiveness.

$$efficiency = \frac{current\ effectiveness}{maximum\ effectiveness}$$

Final Design Definition

Requirements Met

Business objectives		Requirements		How will we do this	Confirmation Technique			
		User	System					
Why the project is needed?		What do users need the system to do?	What does the system need to do?		Analysis	Inspection	Demonstrate	Test
Identify areas of concern. Where is energy lost?	1	Real time monitoring		Data logging			X	X
Save money	2	Measure heat exchanger properties and calculate efficiency		Logged data will be fed into the calibrated mathematical model			X	
Save Energy	3	Compares actual efficiency to rated efficiency to determine effectiveness		Logged data will be fed into the calibrated mathematical model			X	
	4	Ability to interface with users system		Confirm components with client		X		
	5	Identify all heat exchangers with locations and type		Identify all heat exchangers types, ratings and fluids through site visits and documents provided by the client. Compile information into one document.		X		
	6		Get data from heat exchangers	Client to install monitoring equipment	X			
	7		System analysis. Use parameters to calculate efficiency and effectiveness	Create mathematical model to compute data	X			X
	8		Provide accurate data	Calibrate system using data logging to fine tune mathematical model.	X			X
	9		Able to operate within the physical environment	Spec electonics for the locations they will be utilized.	X	X		

Next Steps

Roadmap

- Onsite testing at Cavendish Farms (Monday, 16th March)
- Final analysis and comparison of results
- Finalize conclusions and recommendations for the client
- Finalize documentation
- Prepare for final presentation
- Prepare mock-up for the expo

Project Management Update → Final Prototype and Plan → Final Design Definition → Next Steps

Questions?