The development of an Organic Rankine Cycle Heat Engine using a rock thermal battery as the heat source

By:	Jason Christopher Humm
Promoter:	Prof Russell Phillips
Co-Promoter:	Mr Karl Du Preez

Presentation Outline

- Introduction
- How It Works
- Problem Statement
- Sub-Problems
- Hypothesis
- Delimitations
- Significance Of Research
- Advantages over other renewable energy harvesters
- Discussion of components
- Conclusion

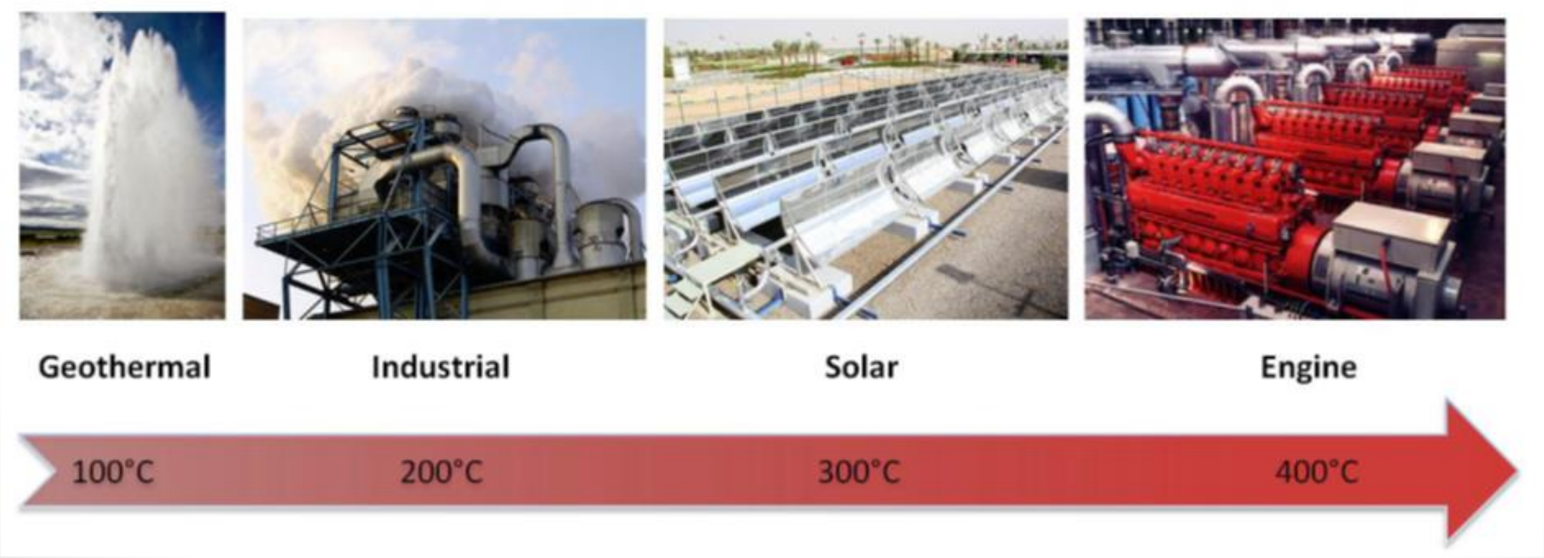
Introduction

- There are many initiatives in South Africa that aim to cut down emissions and power consumption
- By increasing the proportion of energy obtained through renewable sources
- Created an interest in low grade heat recovery
- Solutions to generate electricity from low temperature heat sources have been proposed

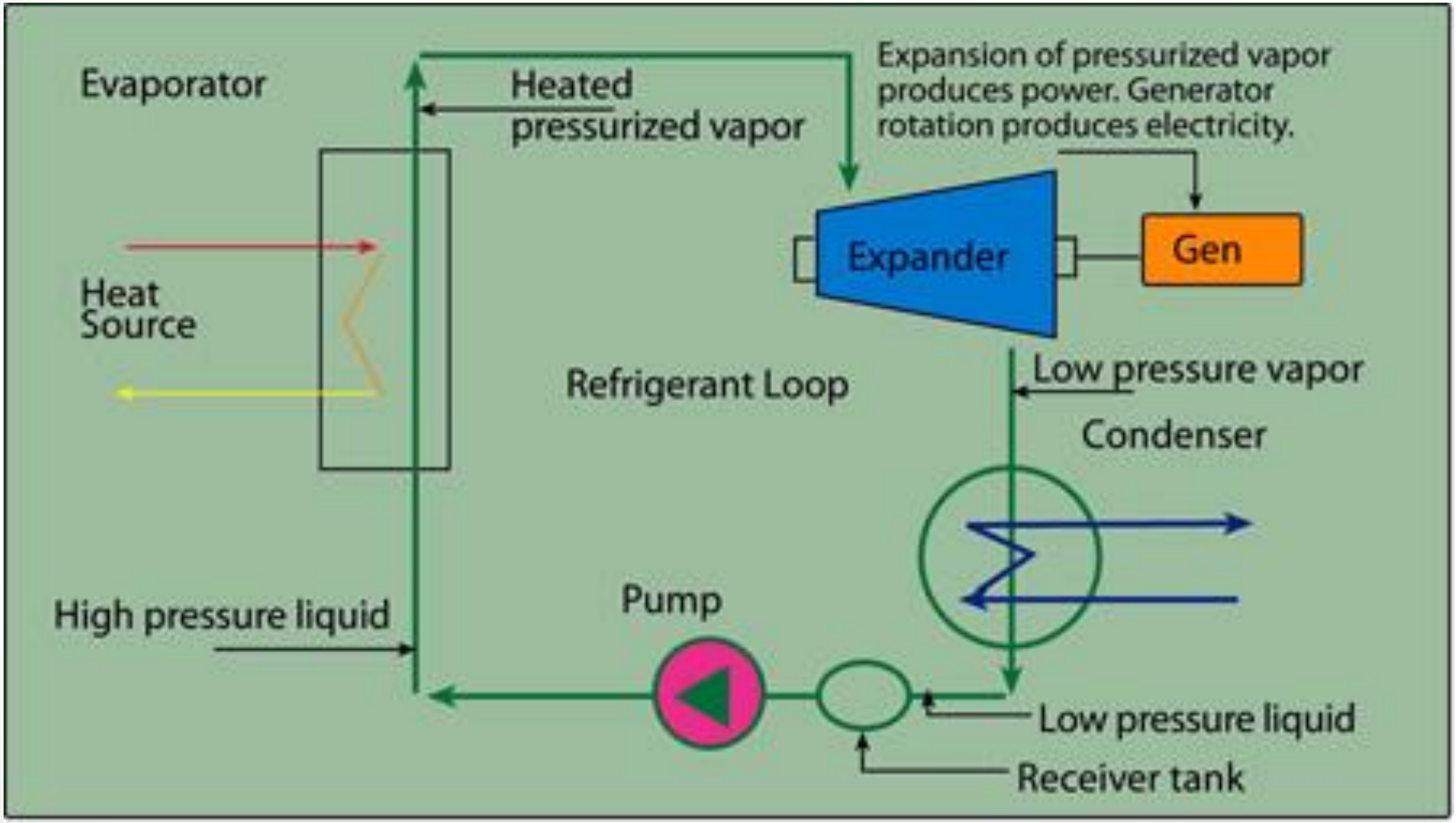
Introduction

- The Organic Rankine Cycle (ORC) uses working fluid that has a lower boiling temperature than water, this allows reduced evaporating temperatures

- ORC system can be used with various heat sources with little modifications

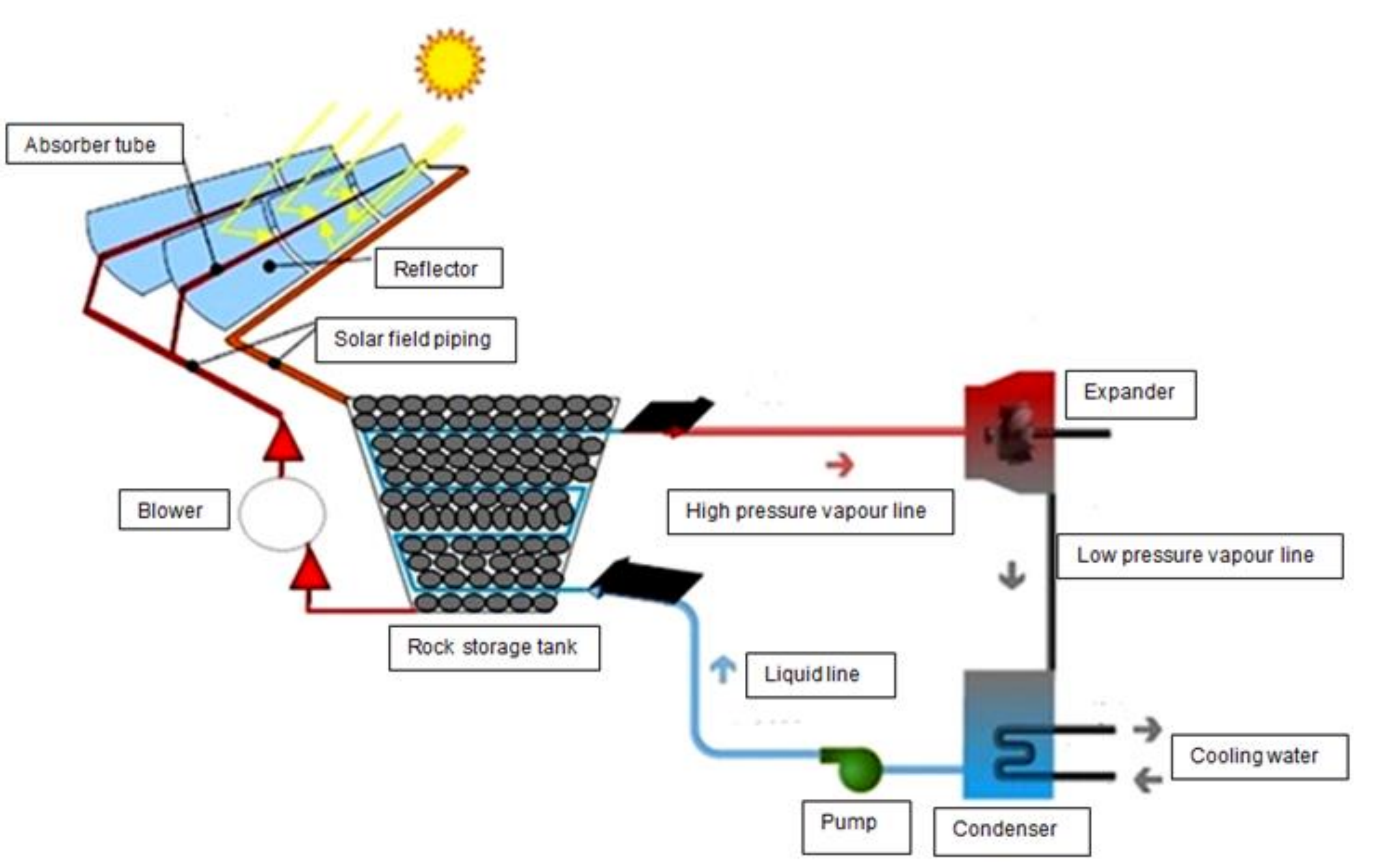


How It Works



Evaporator
Heated pressurized vapor
Expansion of pressurized vapor produces power. Generator rotation produces electricity.
Expander
Gen
Heat Source
Refrigerant Loop
Low pressure vapor
Condenser
High pressure liquid
Pump
Low pressure liquid
Receiver tank

How It Works



Absorber tube
Reflector
Solar field piping
Expander
High pressure vapour line
Blower
Low pressure vapour line
Rock storage tank
Liquid line
Cooling water
Pump
Condenser

Problem Statement

- To design, build and analyse a small scale Organic Rankine Cycle that will transform stored heat energy into shaft power.

Sub-Problems

- Investigate and select the working fluid. Considering thermal stability, toxicity, flammability and cost.
- Establish a practical means of extracting heat from the rock

Sub-Problems

- Evaluate and select
  - Expander
  - Condenser
  - Working fluid pump

Hypothesis

- It is envisaged that a domestic scale Organic Rankine Cycle Heat Engine can be developed that will be able to run off a rock thermal battery and provide the user with electricity during the day and for a number of hours into the night.

Delimitations

- For the purpose of this research the heat source is restricted to a hot rock thermal battery with rock mass less than 2000 Kg.
- The research aims to use an existing expander and condenser and will not focus on the design or optimisation thereof.

Significance of the research

- Price of fossil fuels increasing
- Concerns about climate change casting a shadow over the future of coal
- Individuals realising they can make a difference
- Manufactured in South Africa

Advantages Over Other Renewable Energy Harvesters

- Storage system
- Automatic and will operate continuously
- Does not rely on weather
- Simple to setup and maintain

Thermodynamic Model

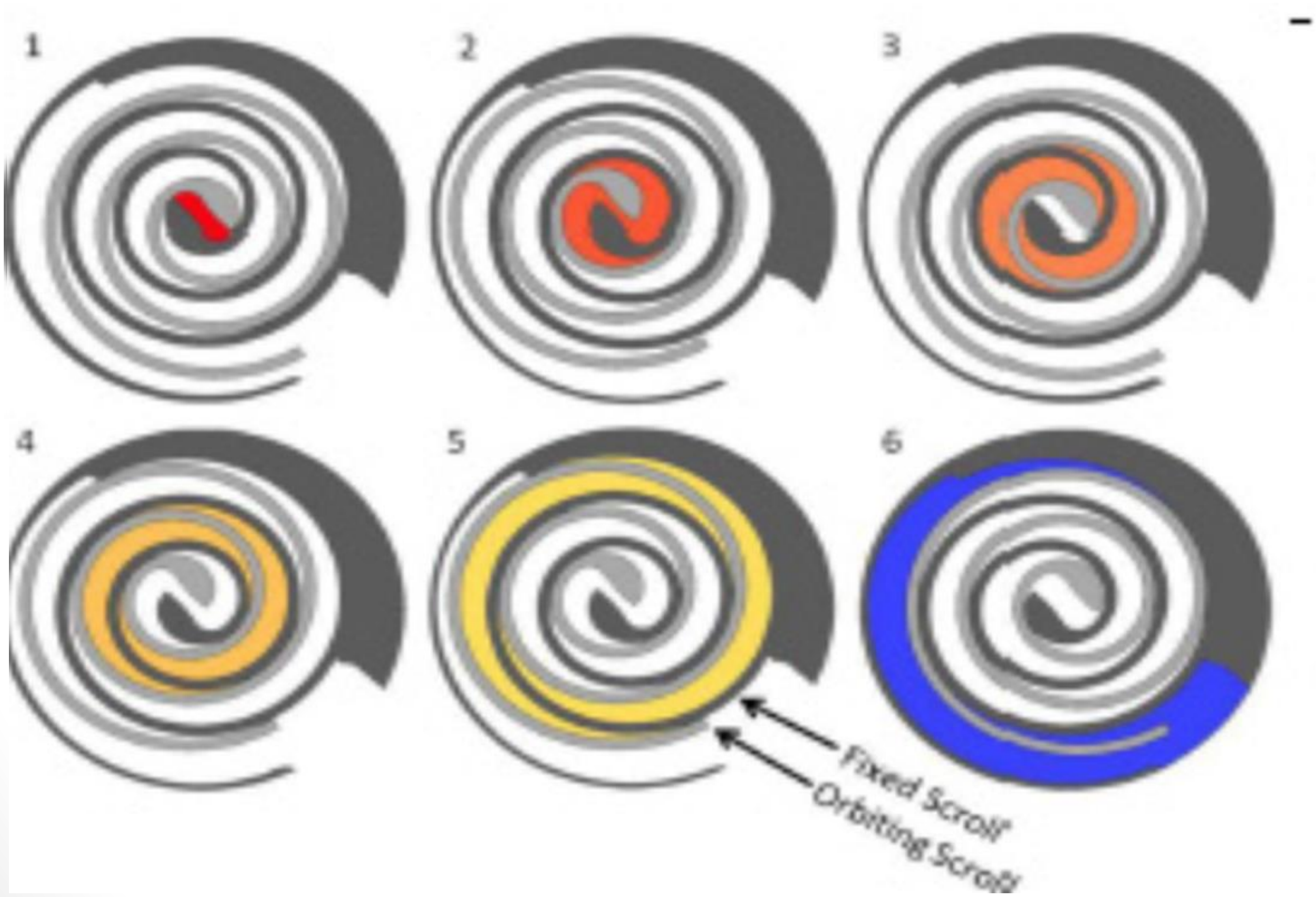
- Have set up the thermodynamic model in excel

Qin	11477.66675	w
	11.47766675	Kw
Wout	1.2253956	Kw
efficiency turbine	80	%
efficiency pump	75	%
Actual Wout	0.98031648	Kw
Work pump	0.043585661	Kw
Efficiency thermal	8.161334866	%

Expander

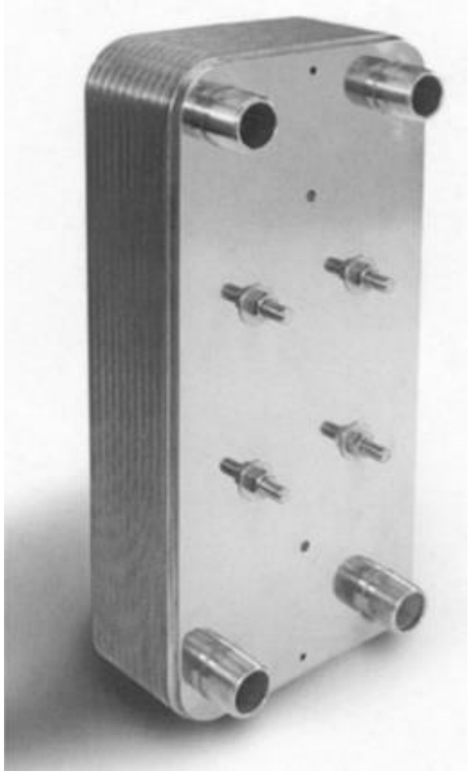
- Selected 1 kW Scroll expander from Air Squared

Expander



Condenser

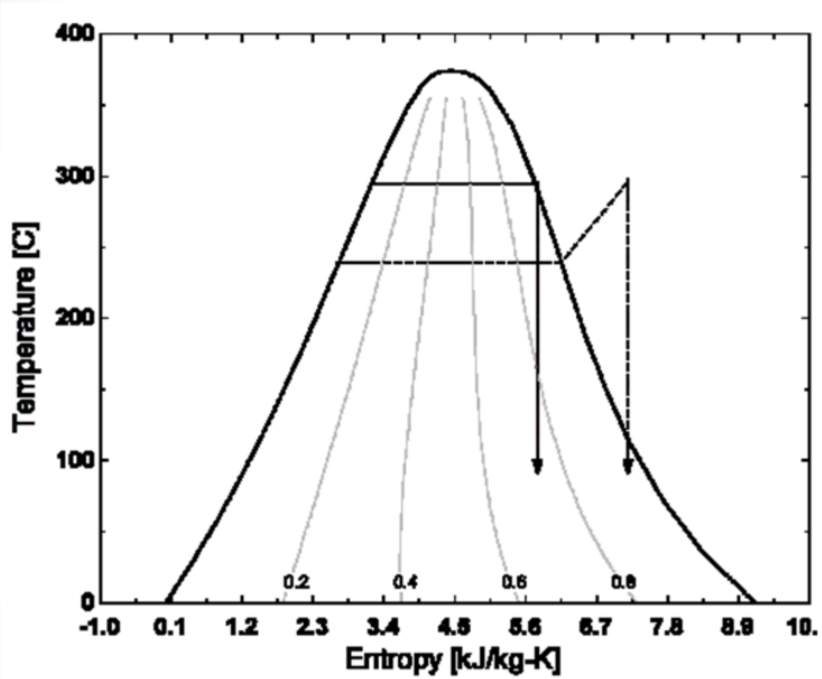
- Condenser selected is a brazed plate heat exchanger

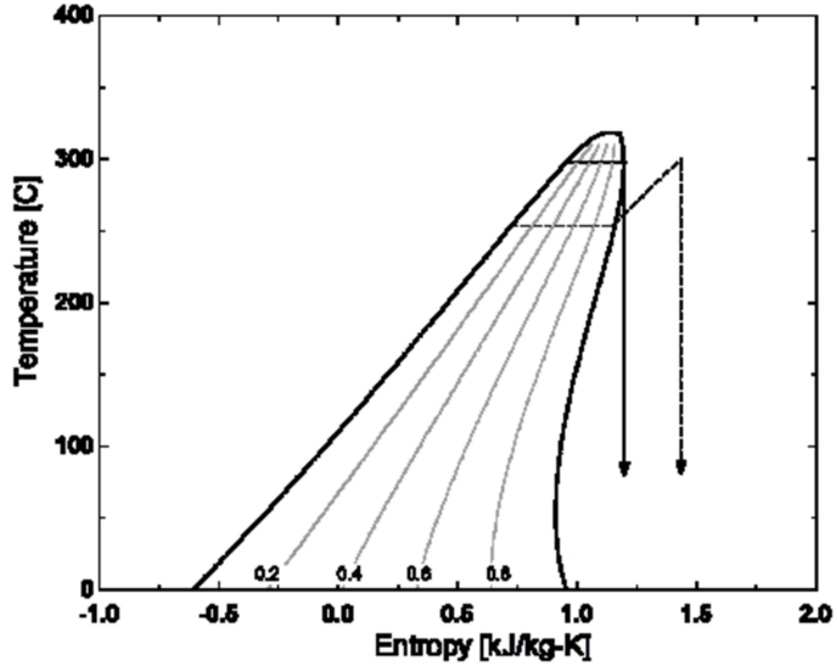


Working Fluid Pump

- The pump selected is a Hydra-cell G20 pump 0.55kw
- Plunger pump
- Pulsation dampener

Fluid

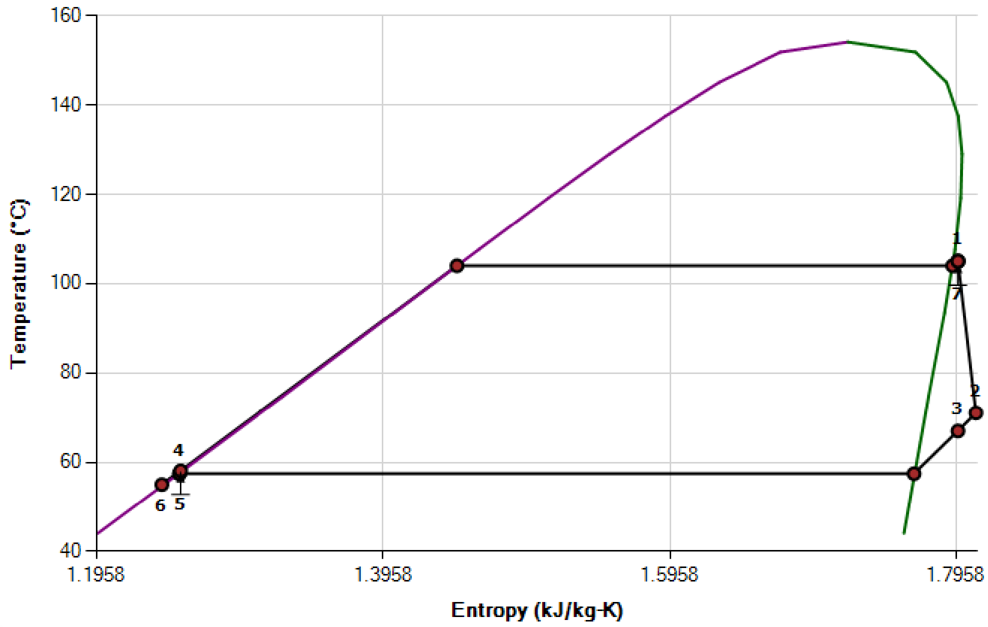




- The fluid selected is R245fa

Genetron Simulation

Refrigerant	R245FA		**Thermal Eff.**	-	0.0834
GWP	1030		**Turb. Exit Quality**	-	1
Mass Flow	kg/s	0.05714	**Turb. Exit Superheat**	°C	13.57
Boiler Heat Input	W	11687.72	**Boiler Temp.**	°C	103.98
Turbine Output	W	980	**Condensation Temp.**	°C	57.46
Heat Rejection Cond.	kW	10.273	**Pump Power**	kW	0.058



Conclusion

- Not a new technology
- Potential for domestic user
- Need to lower cost
- Plan for testing in October/November

Thank you

- Contact details

- Jason Humm
- s209001426@nmmu.ac.za