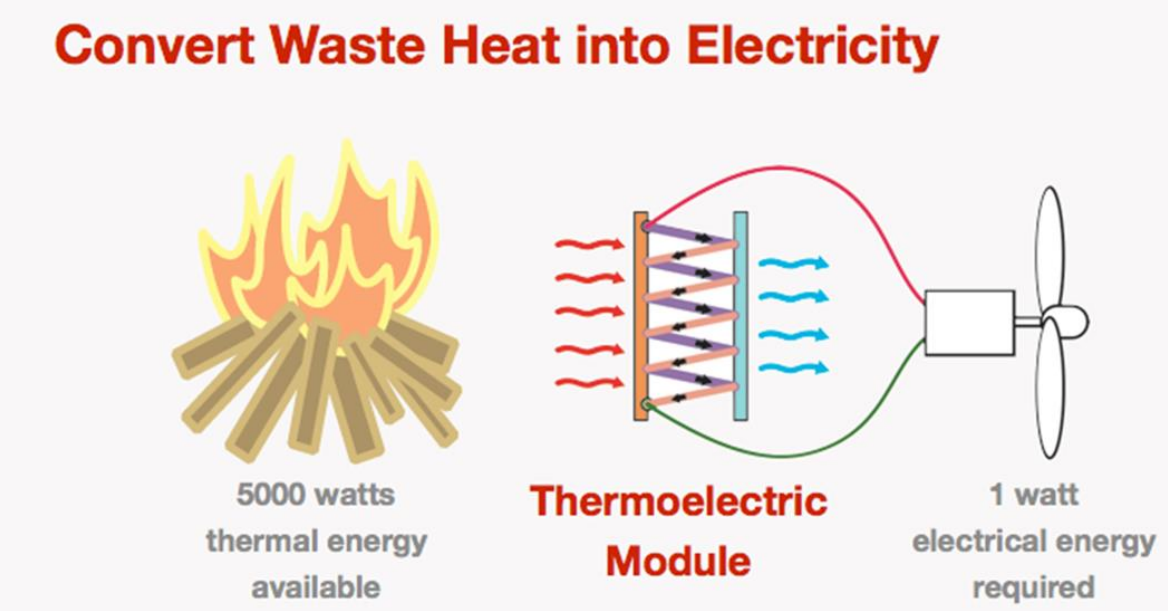
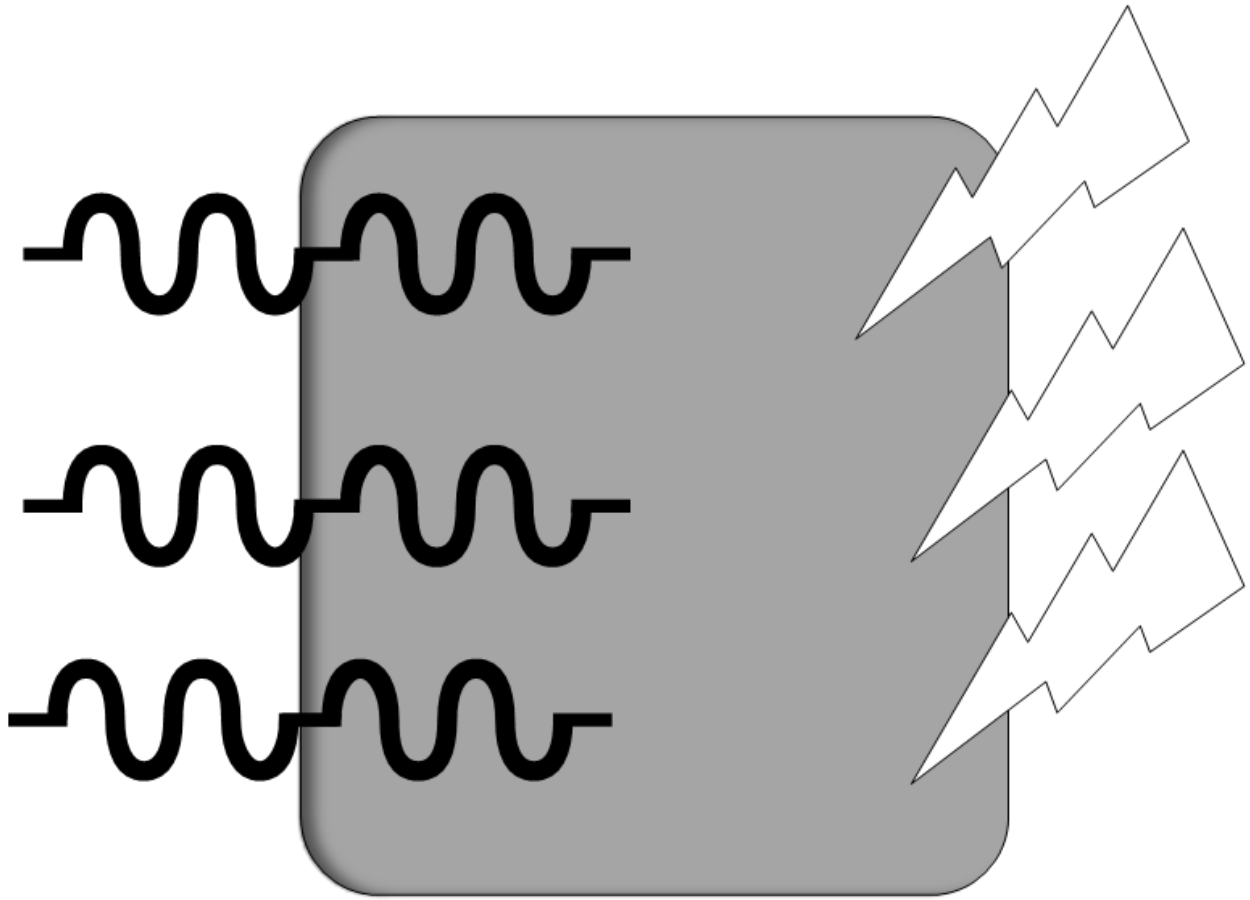
Waste heat recovery for power generation.

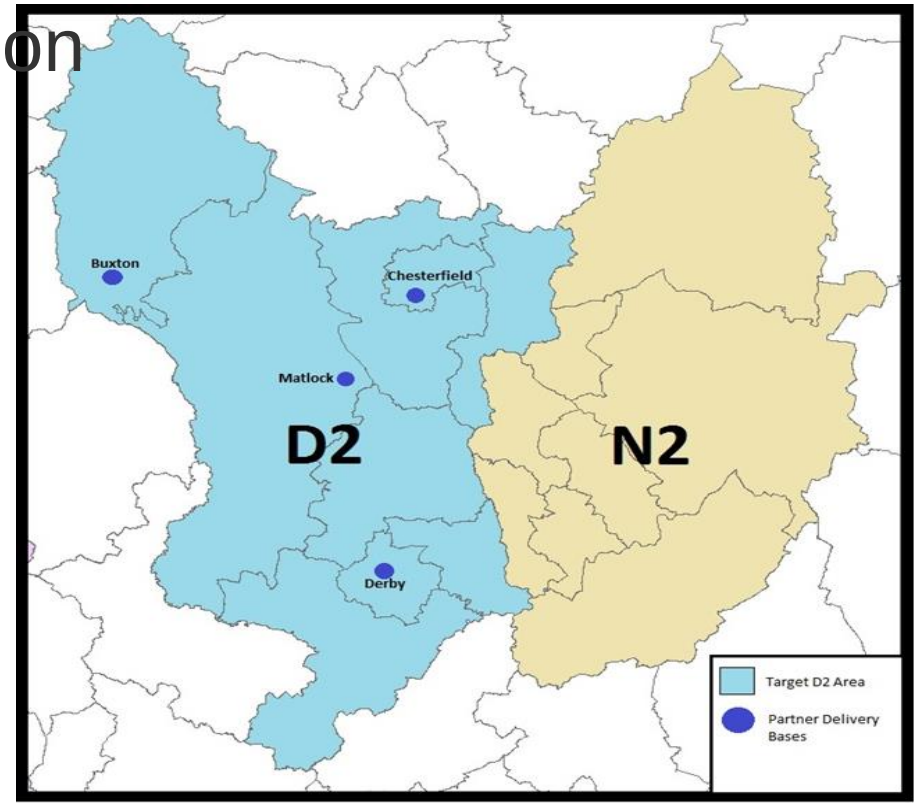




Sarah Odofin

ME

To enable SMEs in the cities of Derby and Nottingham, and the Derbyshire and Nottinghamshire counties, to access funding and expertise to support research and innovation



D2EE (D2 area Energy and Efficiency)

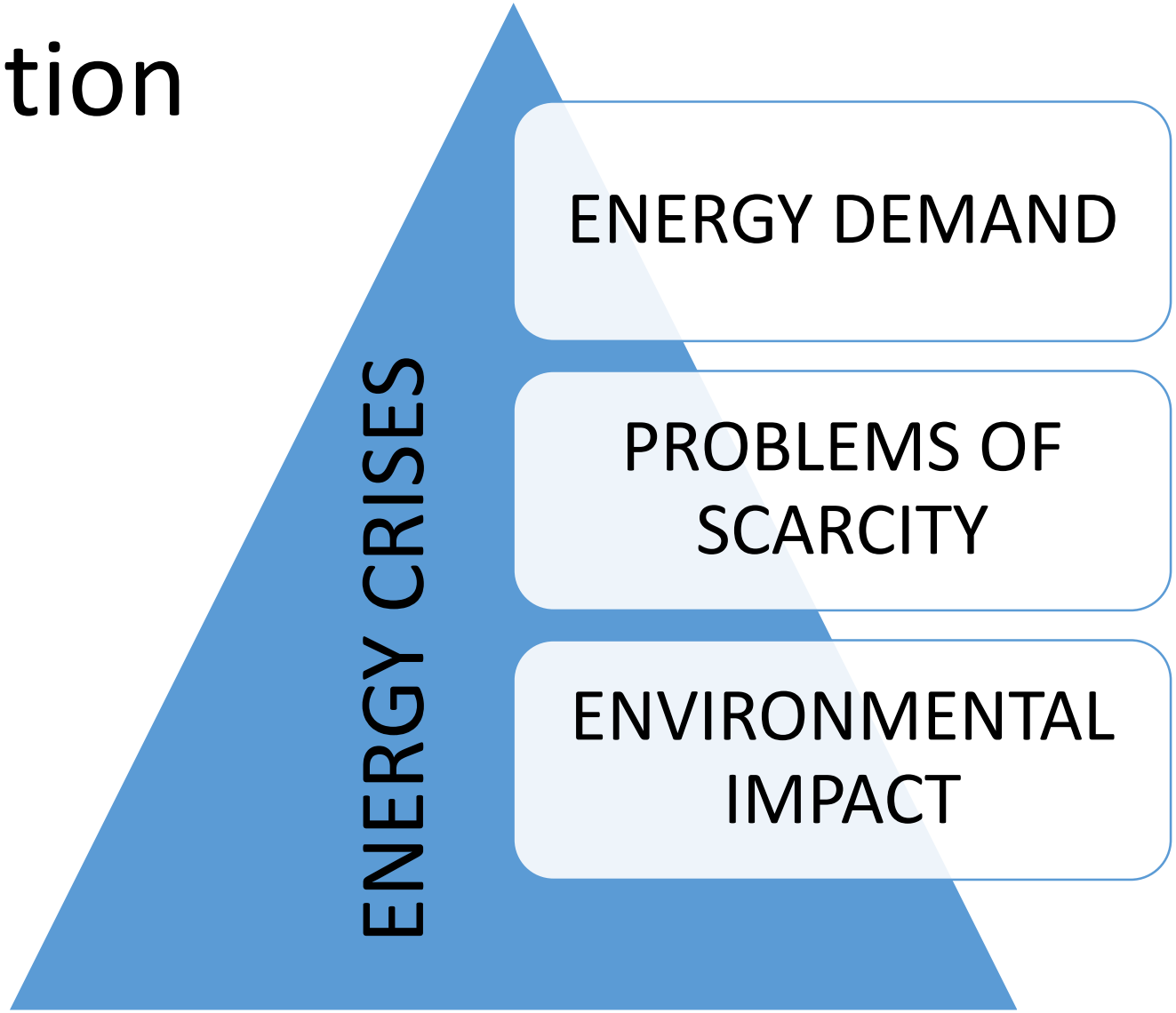
What we do at IISE

- The Institute for Innovation in Sustainable Engineering (IISE) is the University of Derby's latest investment to support advanced manufacturing and engineering companies in our region.
- The Institute is a place where you can access knowledge, funding, expertise and technology to help you to research, develop products and processes, and drive innovation in your business.
- We recognise that companies who want to innovate, and those who can do so with sustainability in mind, are more likely to grow. We want to work with companies who have this ambition.
- Working with industrial partners and supported by Rolls Royce, Toyota and Bombardier, we achieve cutting-edge solutions to challenges SMEs (small and medium-sized enterprises) are facing.

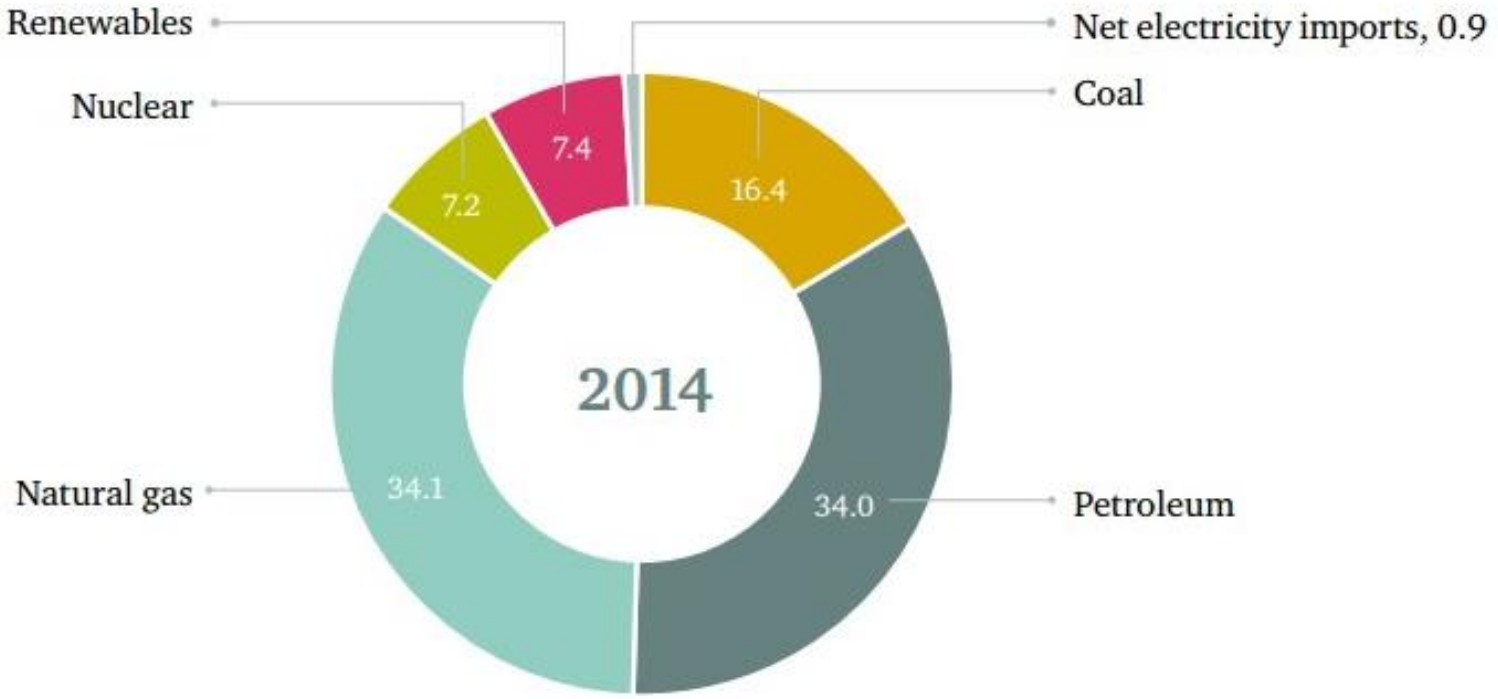
Outline

- Introduction
- Research motivation & Statement of Need
- Overview of the Technology & Applications
- Solutions and Benefits
- Conclusions

Introduction



UK Energy Sector, Current Risks And Future Challenges



UK Inland energy consumption, 2014 (% share)

MOTIVATION

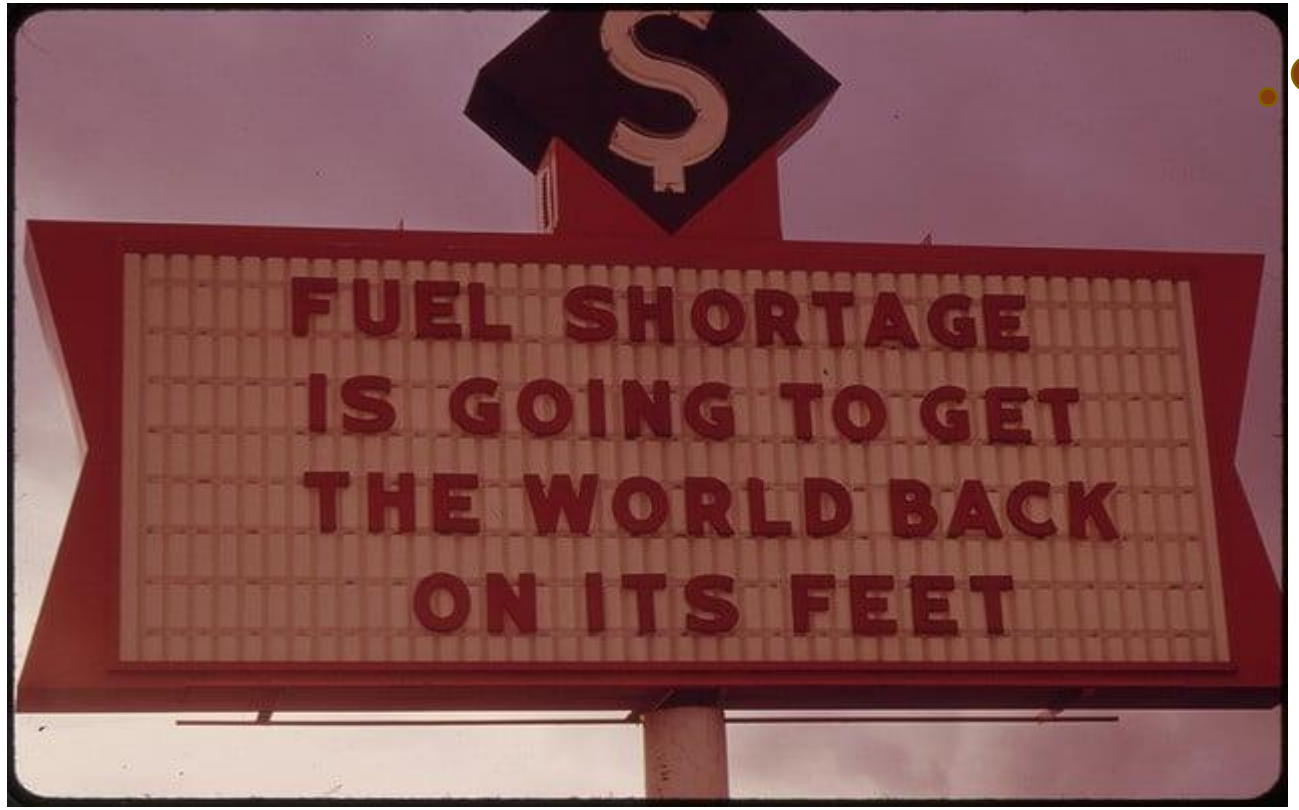
- Energy Sustainability
- To reduce greenhouse gas emissions, reducing and limit the ecological footprint.
- To improve energy efficiency and continuously contribute towards Low carbon green technology and environmental sustainability.
- Solution to greener alternative power production to reduce power crises which meet the demand of daily power requirements.

JUSTIFICATION/ PROBLEM STATEMENT

A major challenge for researchers and industry is how to continuously improve energy efficiency & energy saving.

The Epic challenge of the 21st Century is filling the gap btw energy supply & demand with clean, reliable & inexpensive energy

Innovation Drive

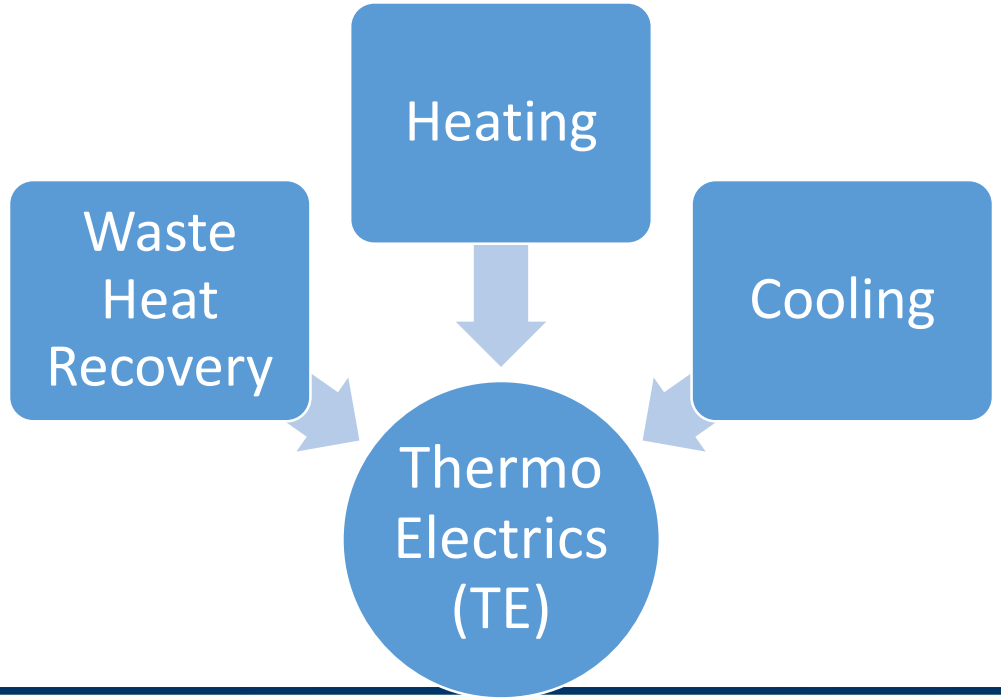


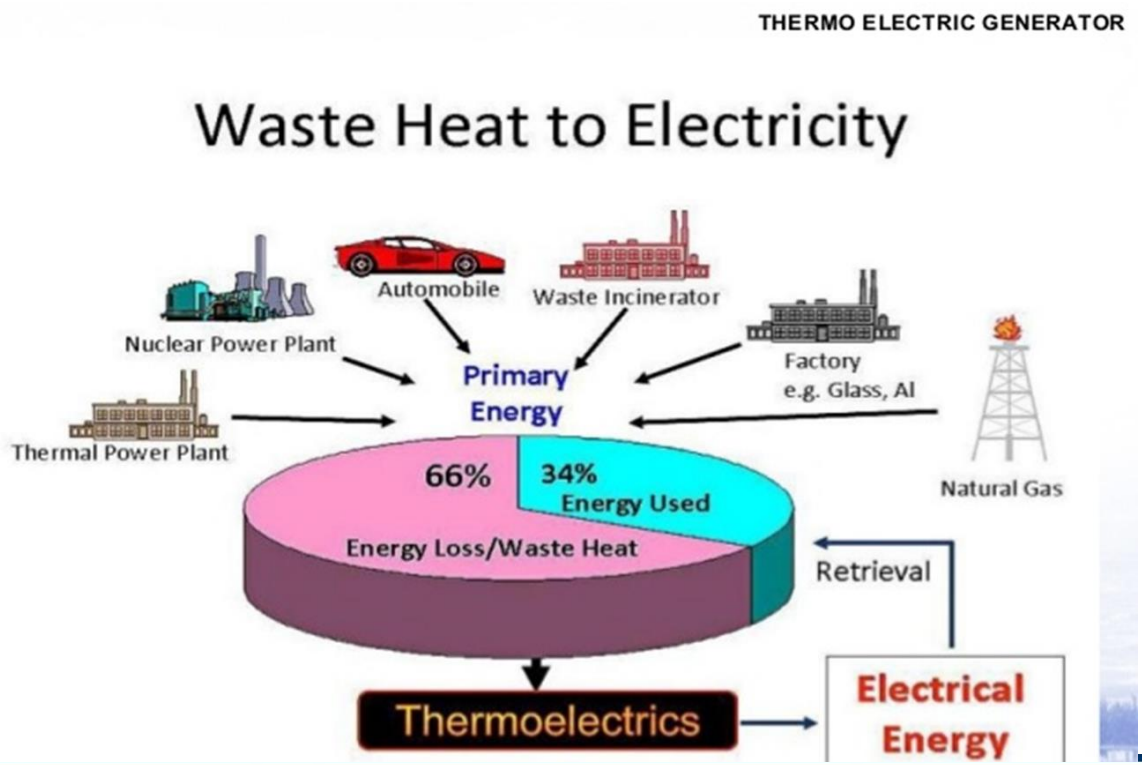
Objectives

- Encouraging growth of alternative energy sources: To review the feasibility of waste heat recovery
- To have a cost-effective power generation.
- To provide more efficient way of recovering waste heat.
- To review the efficiency concern of the innovative technology.

THERMOELECTRIC (TE) APPLICATION

A thermoelectric (TE) module, also called a thermoelectric cooler or **Peltier** cooler, is a semiconductor-based electronic component that functions as a small heat pump, moving heat from one side of the device to the other. Thermoelectric modules are also sometimes used to generate electricity by using a temperature differential between the two sides of the module.





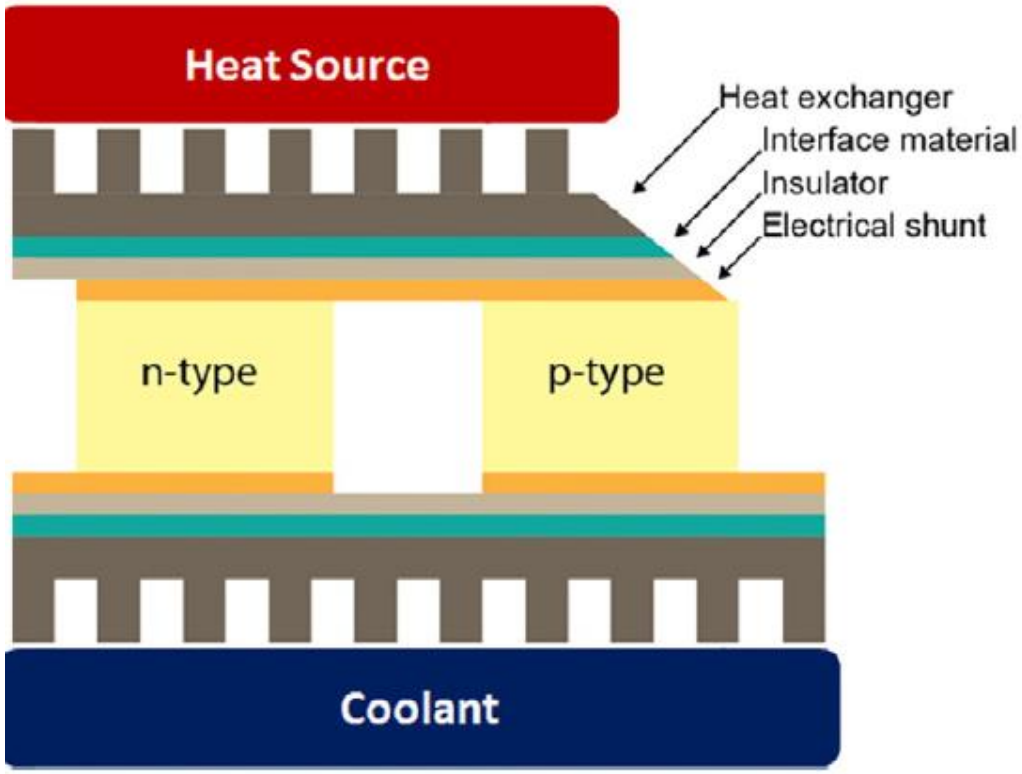
What is TEG?

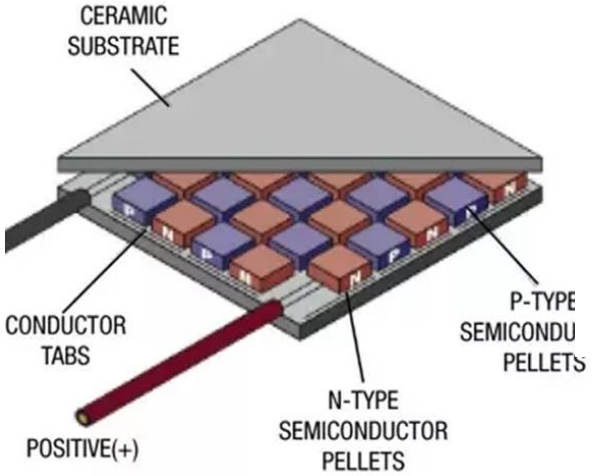
- Devices that converts temperature difference into electrical energy.
- Basic principle- “Seebeck Effect” (power generation).
- Peltier Effect (heating and cooling purposes). TEG module (Peltier Plate)

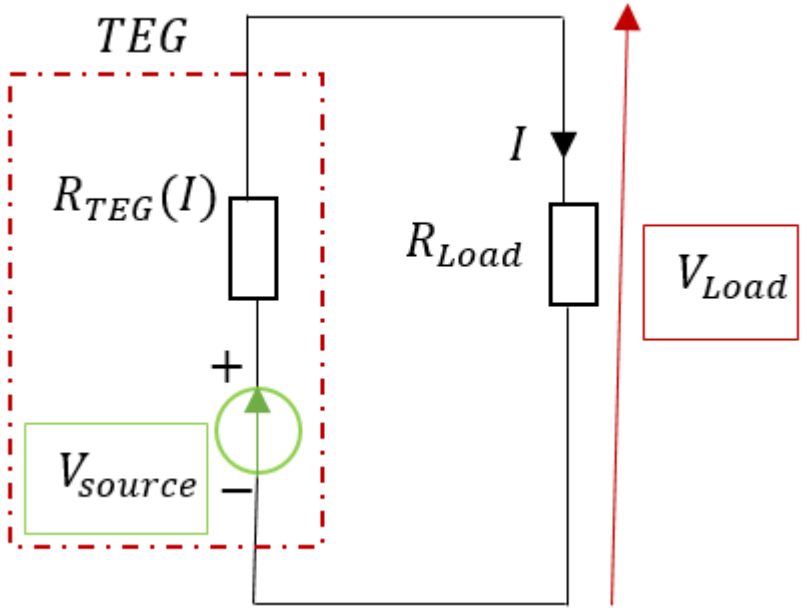
Advantages • Recycles wasted heat energy • Solid state construction, no moving part, no vibration • No noise and low maintenance • Environment friendly • Portable power source • **Disadvantages** • Low energy conversion efficiency rate [5-10%] • Slow technology progression • Requires relatively constant heat source • Lack of customer/industry education

Thermoelectric Generator (TEG) Overview

TEGs draw energy from the temperature difference between the two plates, using Seebeck effect







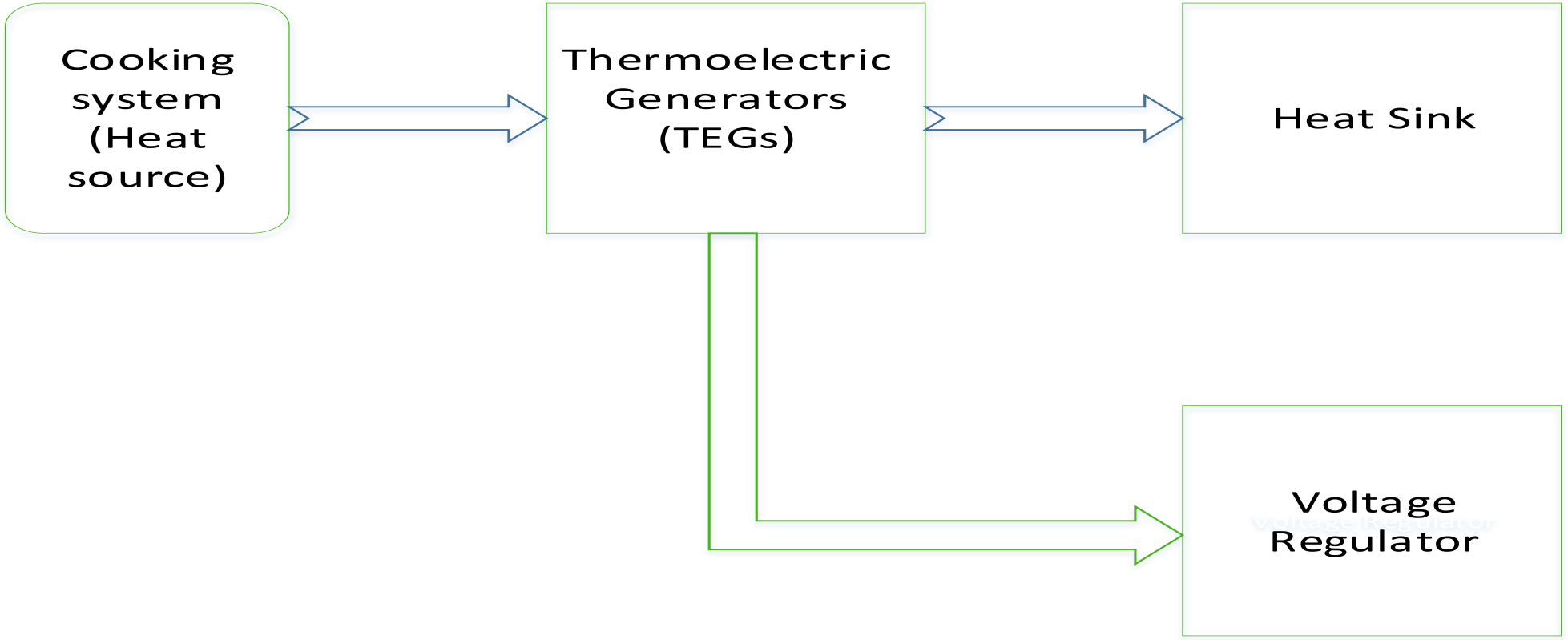
Equivalent Electrical TEG Circuit

How do Thermoelectric Generators work?

TEGs work by exploiting temperature difference between the two sides of the generator.

Occurrence where temperature difference can create a voltage is know as the THERMO ELECTRIC EFFECT.

Practical Applications of TEGs



Block diagram of functional Principle of TEG System using waste heat

Practical Limitations of TEGs

Low Efficiency: There are many challenges in designing a reliable TEG system that operates at high temperatures. Achieving high efficiency in the system requires extensive engineering design in order to balance between the heat flow through the modules and maximizing the temperature gradient across them

This system depends on the temperature difference between the heat source and the heat sink.

Material Types ~ Use Metal Alloys or Nanoparticles (can trap heat)
The system general efficiency is limited based on ZT(figure of merit)

Applications

Vehicles and House
Solar cells on roof
TEGs under the hood/near exhaust
Domestic Application

Powerpot & Automotive-TEG Apps

TEGs to improve car efficiency
For powering car with waste heat

Why the Feasibility Analysis

- For practical demonstration of domestic (Environmentally Friendly / Sustainable Energy Generation) power generation
- Optimisation of Innovative Energy Efficiency performance and application of Low carbon and Energy Efficiency Solutions
- To reduce energy waste, carbon footprint, and improve energy savings and to nurture Innovation
- To contribute to the solutions of global rising demand of energy and support economic benefits.

Methods to improve energy generation via TEGs

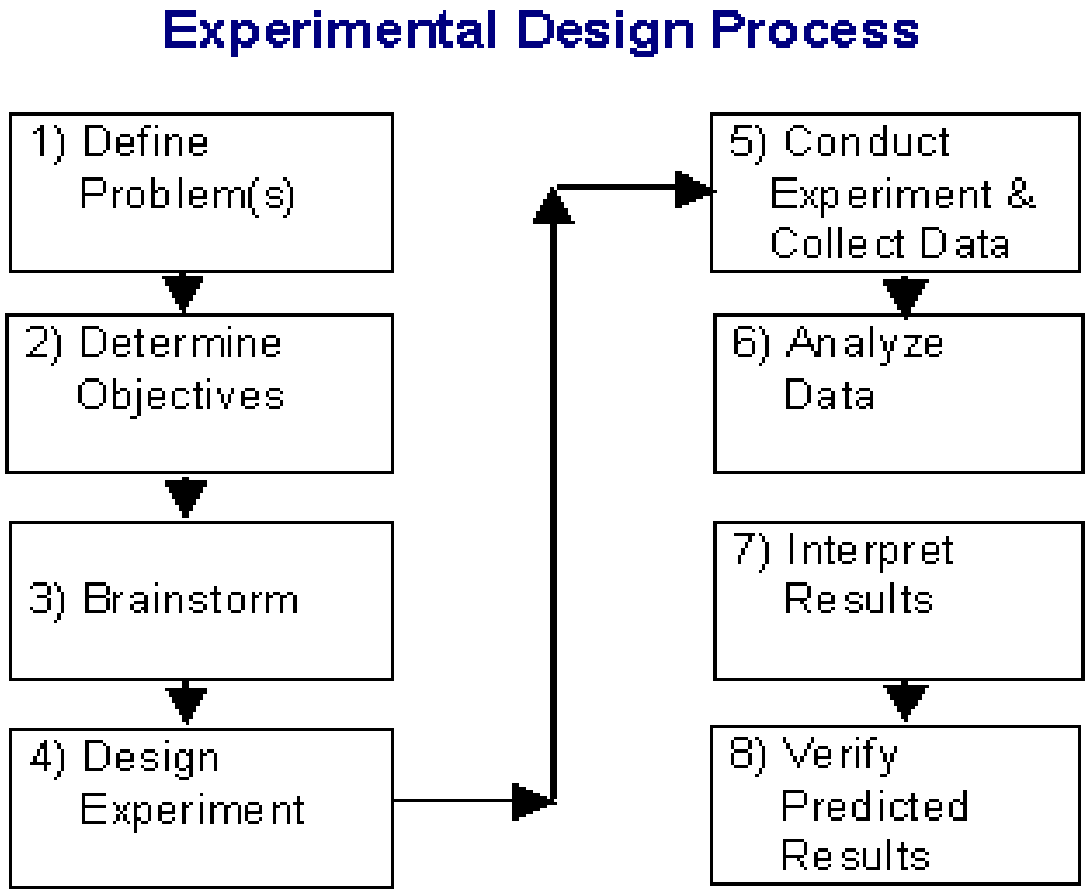
- Effective heat sink choice (heat exchanger), create a higher temperature difference (Low-medium temperature gradient).
- The load resistant & PF should be low.
- Selections of optimized semiconductor material for the TEGs plate
- The figure of merit for the TEG material ***MUST*** be greater than one ($ZT > 1$) to ensure effective operation performance

Recommended TEG Model Specifications

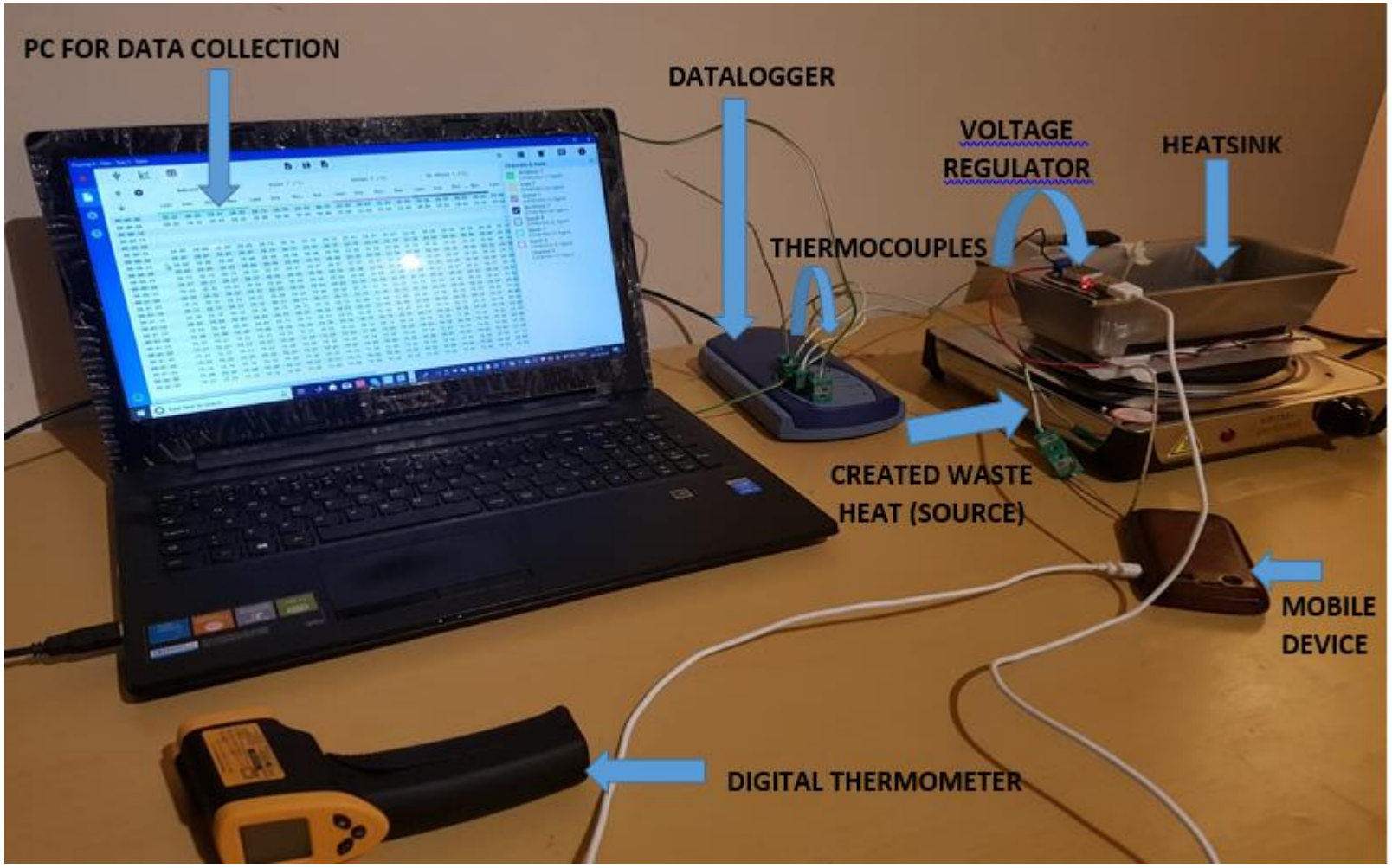
Vdc(V)	5~7
Output power Wattage (W)	>5
Amps (A)	>1
Operating Temperature	>200
Matched Resistance	<1
Size of module plate	40mm x 40mm or 30mm x 30mm
Semiconductor type of materials	Bi2Te3(Bismuth Telluride), PbTe (lead telluride) PbTe-BiTe, Graphites

Experiment Design Process

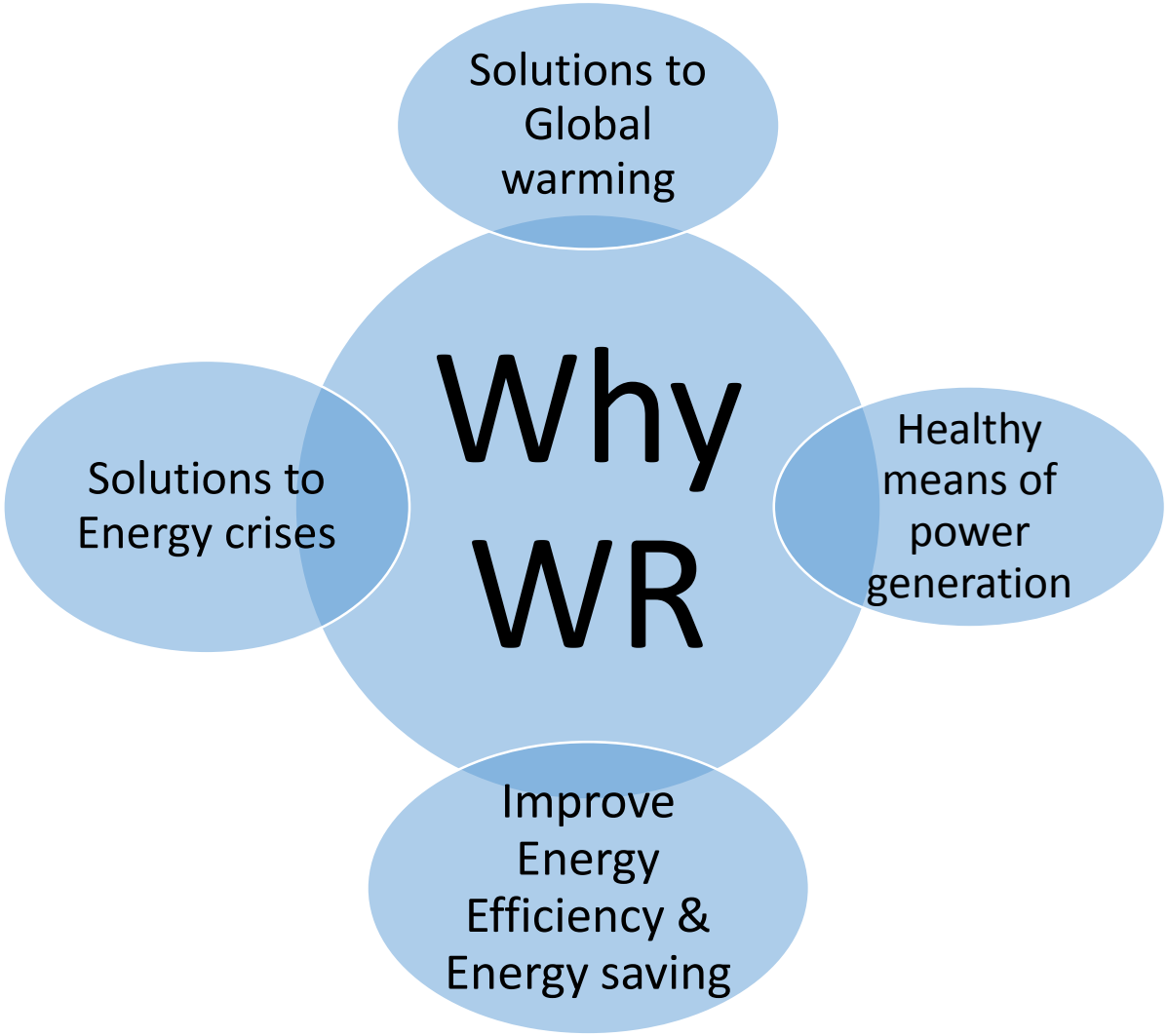
The flow chart below illustrates the experiment design process:



Experiment Set-Up



Why use waste heat for power generation



Solutions & Benefits

1. Innovating green solutions
2. Clean, reliable & sustainable energy
3. Increase energy saving & energy efficiency
4. Idea renewable Energy Solution
5. Comply with environmental laws

Conclusions & Future Work

- To collect (ambient temperature, heatsink temperature, surface temperature & hot side temperature) for data analysis
- To estimate maximum power point tracking (MPPT)
- Comparison between heat exchanger and fan as heat sink medium
- Voltage and current analysis

Thanks for the attention!

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