Making houses energy independent through energy generating walls

1. Background

Electricity is essential to humanity. Unfortunately, many of the electricity production methods of today are damaging to our environment. In the United States alone, 89%[1] of all energy is produced through non-renewable electricity generation methods.

2. Purpose

What we hoped to achieve was to bring a *concrete contribution* toward *addressing the problems* facing humanity. From the start, we set some specific goals:

- Finding a renewable source of electricity
- Energy production method that can be used in large scale and can have a significant impact
- Generation of electricity right where it is consumed (avoid transportation of electricity)
- Take advantage of naturally existing properties or phenomena

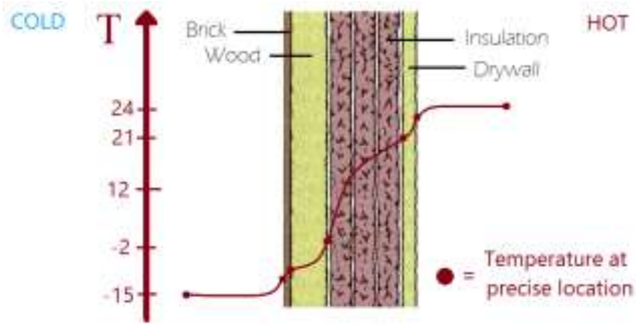
The project is all about devising a practical solution to accomplish the goals listed above. These are the steps we followed from fundamental research to the invention:

1. We have observed that there is considerable heat exchange in the house.[12]
2. Had the idea that maybe we can harness the existing heat exchanges.
3. We then started looking for ways of generating electricity at the level of the houses by somehow harnessing the heat exchanges existing using an existing method
4. Identified thermoelectric generation. Did fundamental research and experimentation.
5. Came up with an innovative approach for building walls that generate electricity through thermoelectric effect just by harnessing existing heat exchanges.

3. Research & Experiments

- Investigating temperature distribution in different parts of the wall.

We wanted to investigate the heat loss and temperature distribution in a typical house. We firstly used a thermal camera to identify the areas of a house with the greatest heat loss. We noticed that insulated surfaces minimized heat loss, resulting in a greater temperature difference between the inside and outside of the wall.



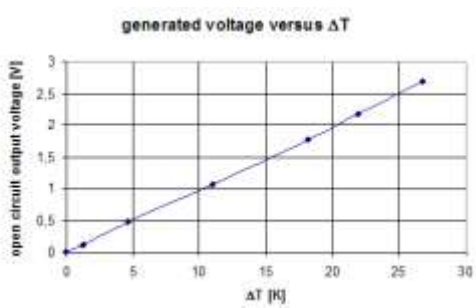
Heat loss in a house

The temperature distribution inside the wall

In order to help us devise a practical solution for harnessing the difference in temperature, we needed to measure the temperature distribution *inside* the wall.

We then conducted an experiment, by exposing the exterior wall to -15°C and the other side to 24°C and recording the temperature at each layer. The results obtained are shown above.

- Exploring the potential of thermoelectrics



Voltage vs temp. difference for one TEG.[2]

We also needed to find a way to put to use the temperature difference existing between the layers of the wall. Thermoelectric generators (TEGs) allow us to do just that, using the *Seebeck Effect*.[13]

4. Procedure

4.1 Principles of the invention

We have applied our findings to create our invention: a wall that uses the difference in temperature between the inside and outside of a building to produce electricity.

This is accomplished through an innovative design that embeds thermoelectric elements throughout the structure of the wall and takes advantage of a multitude of physical phenomena.

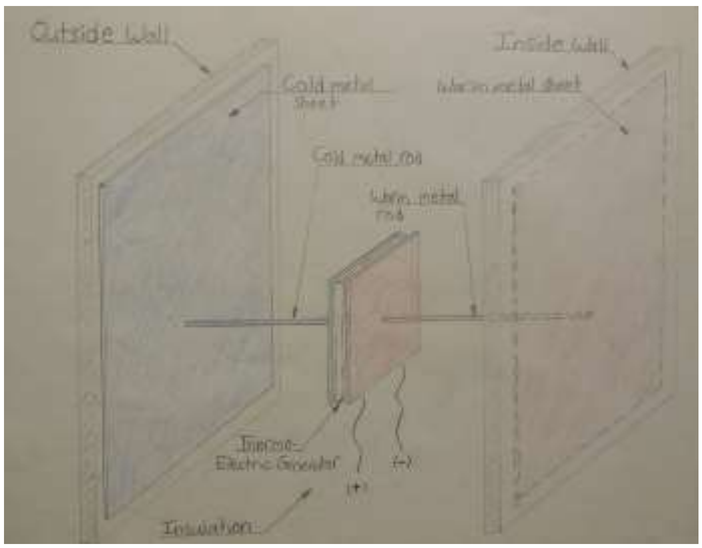


Diagram illustrating the principles of the invention

How it works:

- There is always a temperature difference between the wall's different layers
- Metal sheets on opposite sides of the wall absorb the temperature at both ends
- The heat is conducted through insulated metals rods connected to the metal sheets
- It is then transferred to the metal plates found in the center of the wall
- The two metal plates are in close contact with both sides of TEGs
- Due to the difference in temperature in the metal plates, the TEGs turn the difference in temperature into electricity, which is then harnessed

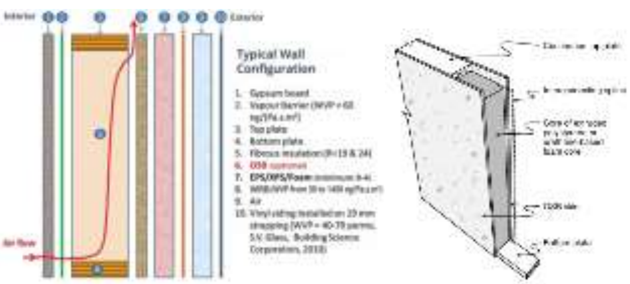
4.2. Implementation

We thought about two possible practical methods of implementation of the invention.

The invention can be implemented within typical walls made of multiple components: studs, joists, insulation, vapor and air barrier, interior drywall, and exterior sheathing.

However, the invention can also be implemented within *structural insulated panels* (SIP), which consist of an insulating layer sandwiched between two layers of structural board.[14]

We created a prototype of our invention (for a typical wall) and experimented with it.



Comparison between typical walls[3] and SIP[4]

Invention prototype for typical wall

Comparison of implementation options - Why SIP boards are a better implementation option:

- The foam core of SIPs is continuous throughout the wall, reducing temperature loss from the rods, so the TEG surfaces will have temperatures close to the internal/external surfaces.
- SIP boards are thinner, with shorter distance between the metal surfaces
- The exterior surfaces can be made of metal, so the original metal sheets are redundant.
- Manufacturing at industrial scale is possible. The electricity generation system is setup at manufacturing time inside the boards, not at building time when the wall is constructed.
- The density of TEGS per square feet can be dramatically increased.

5. Observations & Calculations

The calculations below provide a concrete estimate of the electricity produced by our invention. Firstly, we researched key facts relating to our needed calculations. (For Canada)

- Average outside temperature: 4ºC,[5] average household temperature: 21ºC[6]
- Average house exterior square footage: 2100,[7] number of houses: 13.3 Million[8]
- 225 TEGs are needed to produce 12 Watts at a temperature difference of 17ºC.[9]
- In our invention, 25 TEGs can be fit into one square foot

Therefore, 9 sq ft. are needed to produce 12 W → With 2100 sq ft. per house, 2800 W per house can be produced → In one year, 24,528 kWh can be produced per house → All 13.3 million houses in Canada could produce 326,222,400 MWh yearly.

As a comparison, one house consumes around 12,000 kWh yearly.[10] Thus, this invention could produce double the amount consumed by one house. In addition, Canadian households consume 395,884,722 MWh yearly,[11] meaning our invention could almost match this consumption.

Along with the resulting energy production, there are many other advantages:

- Constant production of electricity – doesn't depend extensively on any external factors
- Potential for mass generation of electricity, and no maintenance needed
- Complements solar energy (Solar energy is optimal during the summer, while our invention works best in the winter)

6. Conclusion

Applying the results of our interdisciplinary research, we created an innovative approach to electricity generation. Our calculations show that this invention could have a very significant impact on the energy balance of Canada.

8. Acknowledgements

I would like to recognize the dedication of the science teachers at Broadview Avenue Public School for providing me with this opportunity, as well as the support of my parents.

9. References

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