An Energy Efficient Upgrade of a Heating System for a 1990's Domestic Dwelling - Kevin McCourt

Dissertation Aim

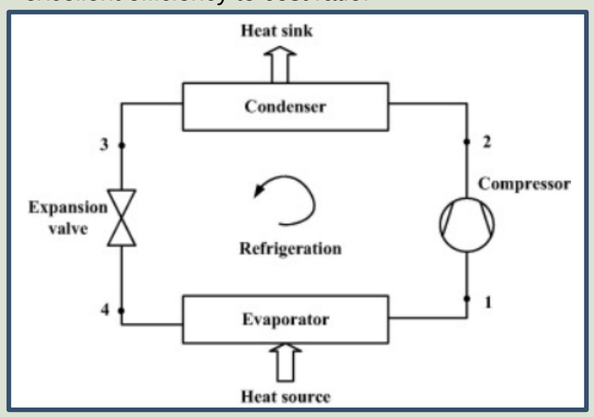
The aim was to carry out a survey and report on an energy efficient heating system upgrade. The upgraded system was to produce fewer carbon emissions and consume less energy.

Objectives

- Research and investigate the current heating system and all other suitable replacements.
- Identify the best heating system that will improve the energy efficiency, reduce carbon emissions and costs.
- Create a model of the property using Revit and determine the required heating loads for the system.
- Report on the process of upgrading the system, include costings and a return on investment.

Literature Review

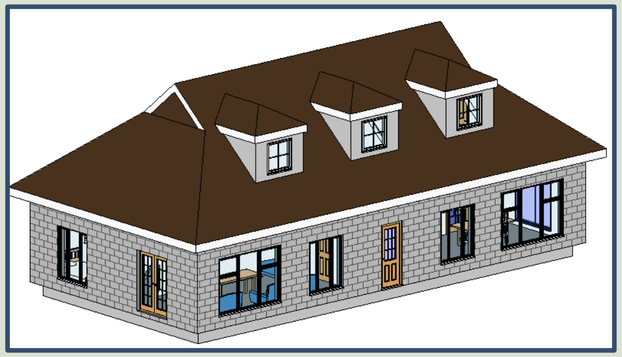
The existing heating system within the dwelling was an oil boiler. Upgrading to a system that had lower running costs and was more environmentally friendly was the goal. A literature review was conducted using primary and secondary research methods to determine the efficiencies, running costs and installation costs of the various popular heating systems on the market today. Research regarding renewable energy systems and building regulations was also carried out. A heat pump system was chosen for the upgrade because of its excellent efficiency to cost ratio.



Heat Pump Cycle

Methodology

Interviews were conducted with registered technical advisors to determine the dwellings suitability for a heat pump upgrade. The existing system running costs were determined from heating oil invoices. The upgraded system running costs were figured out using a combination of Revit software and manual calculations.



Revit Model of Dwelling

A dwelling energy assessment procedure (DEAP) was conducted on the SEAI website for the existing and upgraded heating system to find out the improved energy rating that the upgraded system provided. To gain a further insight into the process and find out if it was worth doing, case studies of homeowners who had already completed a heat pump upgrade on their home were reviewed.

Results

House of Quality				
	Efficiency (%)	Installation Cost (€)	Running Costs per year (€)	System Cost (€)
Oil Boiler	70-80	3,000-5,000	1500-2500	1,500-3,000
Condensing Oil Boiler	90-95	4,000-6,000	1500-2000	2,500-4,500
Natural Gas Boiler	90-95	3,500-5,500	8,00-1,800	1,500-3,000
Biomass Boiler	85-90	10,000-20,000	1,200-2,000	8,000-15,000
Fireplace	15-25	1,000-3,000	200-600	1,000-2,500
Heat Pump (air sourced)	300-400	8,000-14,000	500-1,000	5,000-12,000
Heat Pump (water sourced)	300-400	15,000-20,000	500-1,000	8,000-15,000
Heat Pump (ground sourced)	400-500	20,000-30,000	500-800	10,000-20,000
Infrared Heating	90-95	1,000-3,000	600-1,200	100-500 per panel

House of Quality

The house of quality played a large part in choosing a heat pump system for the upgrade. Shown clearly are the efficiencies and costs of modern popular heating systems, these values were obtained from research. It showed that an air-sourced heat pump has the best efficiency to cost ratio compared to the other systems.

Results

Upgraded System Annual Running Costs						
Peak load of Heat Pump (kW)	Heat Pump running hours per day	Electricity Cost per kW/h (€)	Average Heat Output (kW)	Heat Pump Energy Usage per Day (kW/h)	Heat Pump Energy Usage per Year (kW/h)	Annual Running Cost (€)
5.765	6	0.3288	3.459	5.18	1894	622.75

Heat Pump Running Costs

Analysis was performed on the property using Revit, the software determined that the peak heat pump load was 5.765kW, this meant that a 6-8kW heat pump would suffice for the upgrade. The peak load value was used in the manual calculations along with the cost of electricity per kW/h to determine the estimated annual running costs of the system. This estimated annual running cost was calculated to be €622.75

Existing System Oil Costs	
2024	€1,889
2023	€1,640
2022	€1,567
Average	€1,699

Oil Boiler Running Costs

Heating oil invoices over a 3 year period from 2022-2024 were analysed to work out an annual average cost. The average amount spent annually on oil throughout this period was €1,699, approximately €1,000 more than the calculated annual running cost for the upgraded heat pump system.

BER Result Summary			
	Energy Rating	CO_2 Emissions from Heating System (Kg)	Total CO_2 Emissions from Dwelling (Kg)
Existing System	C3	12,337	12,678
Upgraded System	A3	1,208	1,520

Building Energy Rating (BER) Results

The BER results showed that the energy rating improved from a C3 to an A3 just from upgrading the heating system and sealing up the chimneys and natural air vents throughout the property. This was a massive improvement. The results also showed that the upgraded heating system produced 11,129Kg less CO_2 emissions compared to the existing system. This proved that the upgraded system was an improvement in every aspect. It had cheaper running costs, was more efficient, provided an improved BER and produced significantly less carbon emissions.

Conclusion

- The literature review showed that a heat pump was the most suitable heating system upgrade because of its efficiency to cost ratio. This was further echoed by the technical advisors.
- An annual running cost saving of €1,000 was estimated from the upgrade. This was determined from heating oil invoices, Revit software, and calculations.
- The estimated cost of the upgrade was €19,000 with the government contributing €6,700 of that cost by awarding a grant. The DEAP software showed the upgraded system improved the BER from a C3 to an A3.

Recommendations

- Added upgrades such as replacing the incandescent light fittings with LEDs or installing PV panels could further improve the BER.
- Monitor the annual cost savings of the upgraded system overt the next several years.
- Develop a control system with modern technologies such as smart thermostats and energy management systems.

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