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Optimum Integration of Heat Pump System into Commercial Buildings

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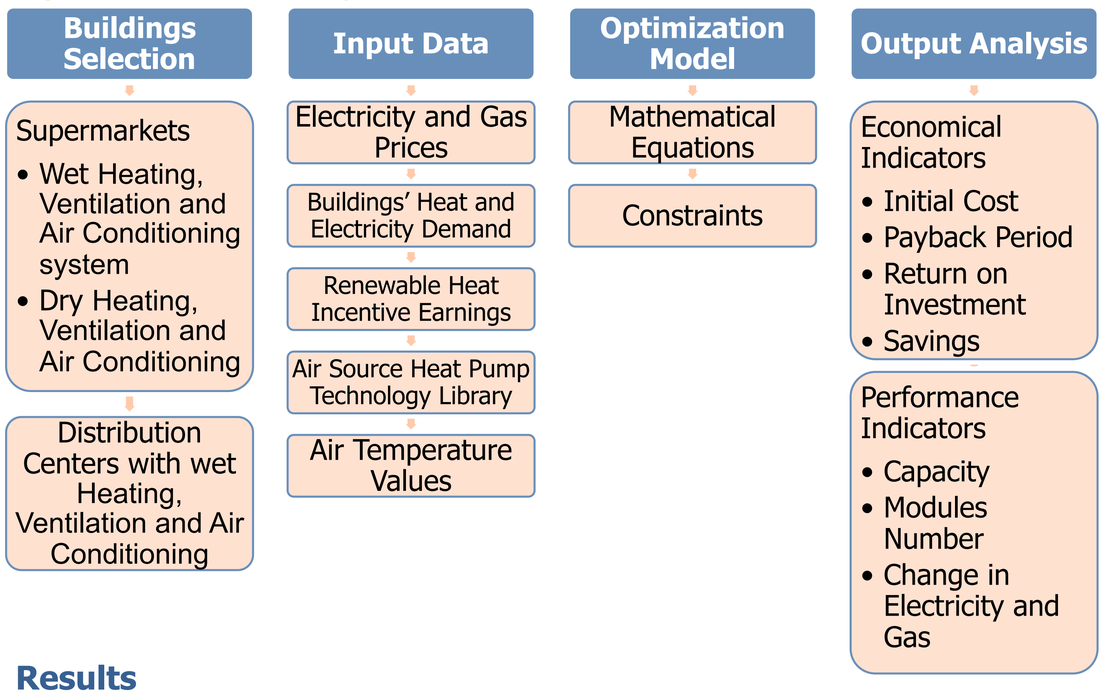
Research Motivation and Aim

The motivation of this research is based on the pressing need to shift towards more renewable energy sources, and to reduce the emission of greenhouse gases such as carbon dioxide.

This research aims to put together a better model which can address the gaps in the existing air source heat pump tools and models using the Technology Selection and Operation (TSO) model. The developed model during this research, aims to provide an understanding, and better representation with more accurate analysis when the air source heat pump system was added to Sainsbury's commercial buildings. Thus, it will be helping Sainsbury's in achieving greater savings, and at the same time minimizing carbon emissions.

In order to include the air source heat pump technology, several steps were conducted to accomplish this research:

Figure 1 shows the steps that were used conduct the research



Results

This section provides part of the outcomes results of one of the supermarkets; Dawlish. It is located in the south coast of Devon in England. The parameters of this building are as follows:

- ID: 2196
- Size: 23 k ft^2
- Annual Heat Demand: 1,231,145
- Peak Heat Demand: 292

Table 1 shows the selected heat pump system and its capacity with the change on the amount of imported gas and electricity

Parameter	Result
Heat Pump Unit	Ecodan Heat Pump
Capacity	170.4
Number of Modules	4
Changes in Imported Gas (+/-) %	-91.84
Changes in Imported Electricity (+/-) %	+8.81

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Research Questions

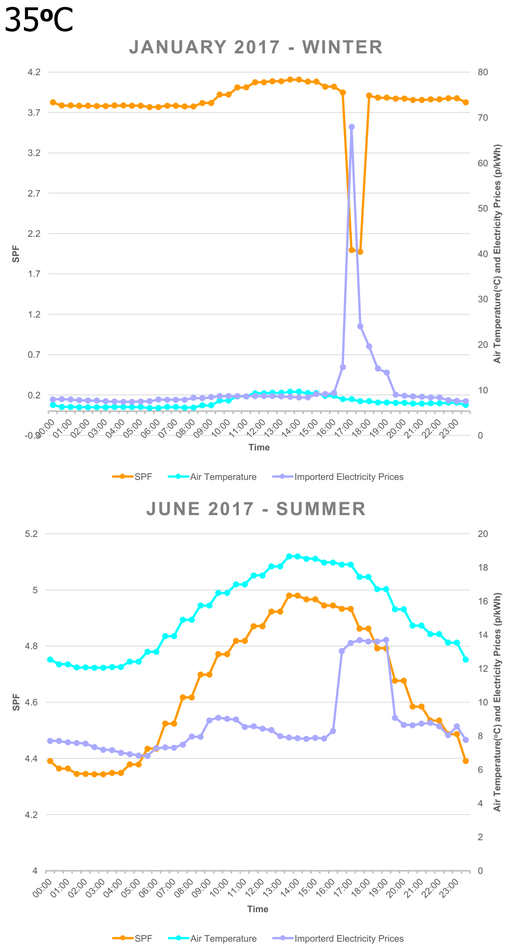
1. What are the impacts of using air source heat pump on the commercial buildings' heat and electricity profile?
2. Are there medium-large sites where heat pump is more attractive than CHP?
3. What are the different economic indicators to evaluate a project?
4. What are the impacts of the changing of technology, electricity and gas prices on the performance of air source heat pumps?
5. How the renewable heat incentive (RHI) does affect the air source heat pumps results in addition to the outlet water flow temperature?

Economics Indicators

Table 2 shows the economics benefits of integrating the heat pumps are shown below.

Indicator	Value
Initial Cost (£)	£260,684
Payback Period (years)	3.16
Return on Investment (%)	318
Profitability Index	5.76
Savings (£)	179,902

Figure 2 shows the variation of SPF and electricity prices with different temperatures of a Summer and Winter month using a flow temperature of 35ºC



As the operation of the heat pump system is effected by the air temperature, it was found that during the summer the operation of the heat pump is better than during winter. This is because, the higher the air temperature is, the higher the seasonal performance factor. The average seasonal performance factor (SPF) over the months of January (winter) versus June (summer) is shown.

it is noticeable that the heat pump outcome increases and decreases in parallel with the increase and decrease of the air temperature.

Also, the operation of the heat pump system is effected as well with the electricity prices. The average electricity prices during the winter are higher than during the summer. The Figure as well demonstrate the half hourly operation of the heat pump based on the half hourly average electricity prices over the months of January and June.

Key Findings

The results of the buildings differed based on their type. It was found that for wet buildings the main factor dominating the selection of the heat pump system is the heating demand of the buildings. On the other hand, for dry buildings, in addition to the heating demand of the building, the size of the building has a great effect on the selection as more initial cost will be required. The wet buildings are more attractive for investment as the payback period ranges between 3-4 years while for the dry buildings the payback period ranges from 4-6 years. The capacity of the heat pump depends mainly on the heat demand of the building regardless of its size. It is possible to have large buildings, but their heating demand can be low because they do not require a large amount of heat. For instance, depending of the building type and its functionality, the heating demand can vary, in which supermarkets comparing to distribution centres require more heating. Additionally, the electricity and gas prices have an effect on the outcome results. Finally, without the RHI earnings, the integration of air source heat pumps would not result any benefit.