

# Heat Pump Options

## Performance Comparison

### Background

The Montague Retrofit was carried out using the Passive House PHPP design software. The retrofit was carried out using as much of the existing building as possible from the exterior framing of the first and second floors and the concrete walls in the basement. The result of this work was a home that was comfortable year-around until the summer of 2021 when ambient smoke conditions made it impossible to ventilate the home overnight and interior temperatures became uncomfortable and exceeded the Passive House standards for significant time periods.

The construction work was carried out taking into account the future possibility of installing a heat pump system and perhaps solar panels as well. Penetrations in the existing basement walls for a high efficiency gas furnace were preserved for these purposes.

The PHPP estimates of heating required for the home estimated the peak demand to be 2.2 kW and on this basis a total of 3 kW of baseboard heaters were installed. The first five years of operation have demonstrated that this capacity estimate was reasonable and that the 3 kW was never required.

The PHPP calculations for cooling were based upon the installation of a .....

In the event that the ground-source cooling is unavailable, the requirement for active cooling will increase. Revised PHPP calculations indicate that up to .....

The heating and cooling demands for this home are at the lower end of most of the offerings from the suppliers. The initial targets were 9,000 Btu/hr or 12,000 Btu/hr systems - the lower capacity is likely to be more than adequate to meet our needs while the higher capacity systems offer a wider range of installation options.

Consideration of where and how a split-system ASHP could be installed at Montague, it became apparent that the options available for a "high wall" system are limited and may involve considerable destruction/repair to walls in which they could be installed. A more attractive option would be to install a "floor mounted" system that would be low on the wall and the best location would be a stub-wall between the Dining Room and Living Room on the main floor.

### Selection of Options

Early reviews of cooling options indicated that only a few equipment suppliers were providing equipment appropriate for an environment similar to that of Manitoba. One of them was Mitsubishi so that was our initial benchmark for identifying potential options for the Montague retrofit.

Since that time, many more suppliers have begun to address this market. The recent Canadian Greener Homes program published a list of Cold Climate Air Source Heat Pumps (ccASHP) that

would qualify for grants under that program. This list was used to select systems offered by a number of additional suppliers that could be considered. The initial list includes:

- Carrier - a North American vendor of AC and ASHP equipment
- Daikin - a Japanese company with a large air conditioning presence in North America.
- Fujitsu - a Japanese IT and Communications systems company that has expanded into market of HVAC and related systems
- LG - a Chinese supplier of a wide range of appliances
- Mitsubishi - another Japanese company offering heavy equipment, automobiles, and other products including HVAC systems.

Two systems were selected from each of these suppliers - one would be a “high wall” system and the other would be either a “floor” or “ceiling cassette” system. This may allow trade-offs between convenience, cost and performance during selection a small number of target systems for which quotes could be solicited.

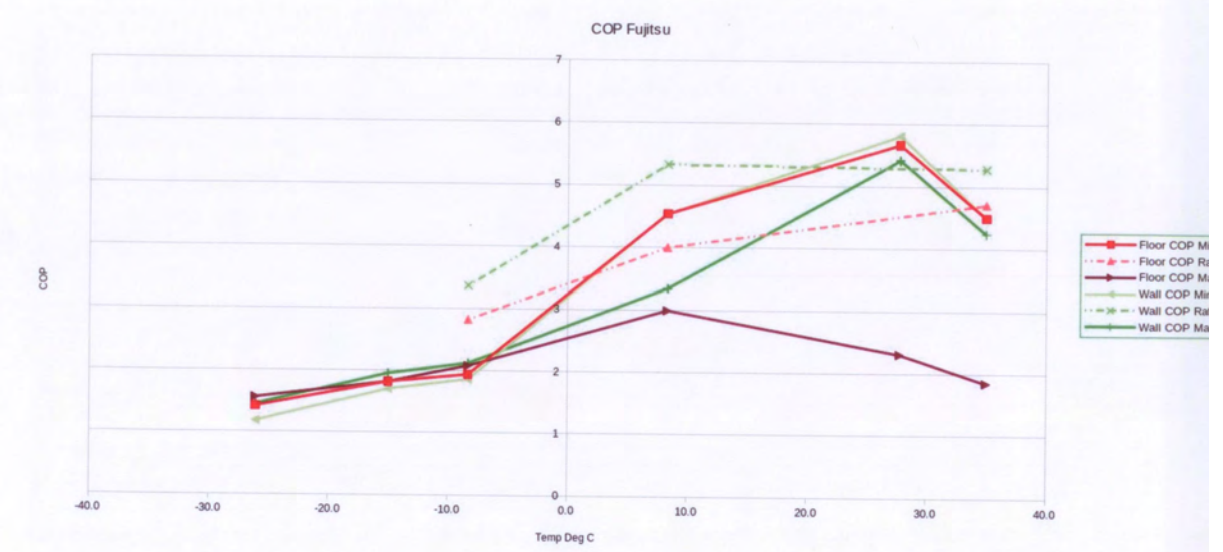
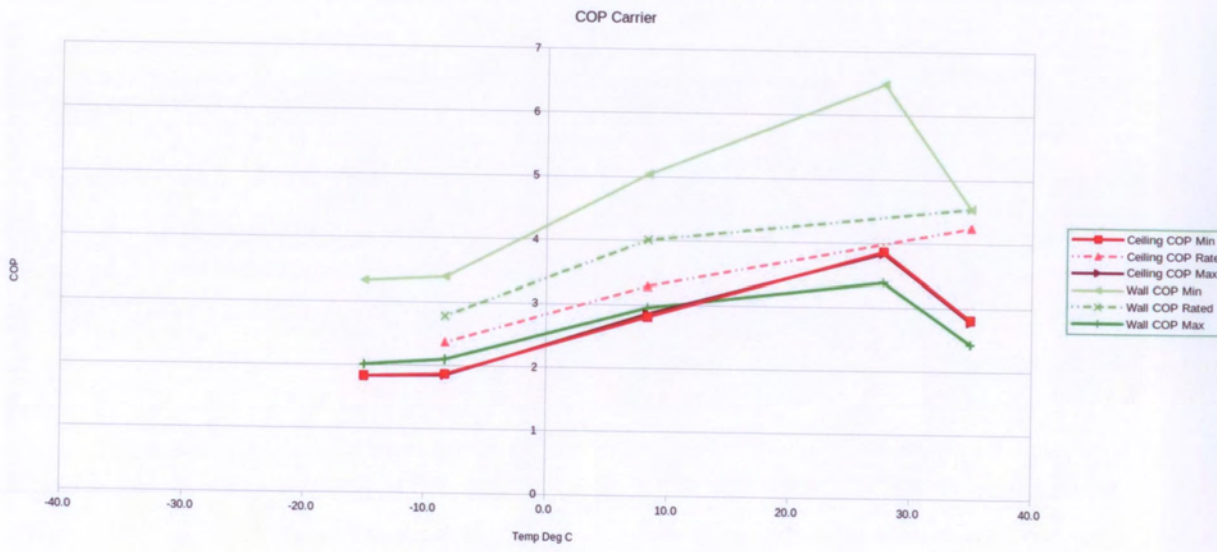
## Performance Evaluation

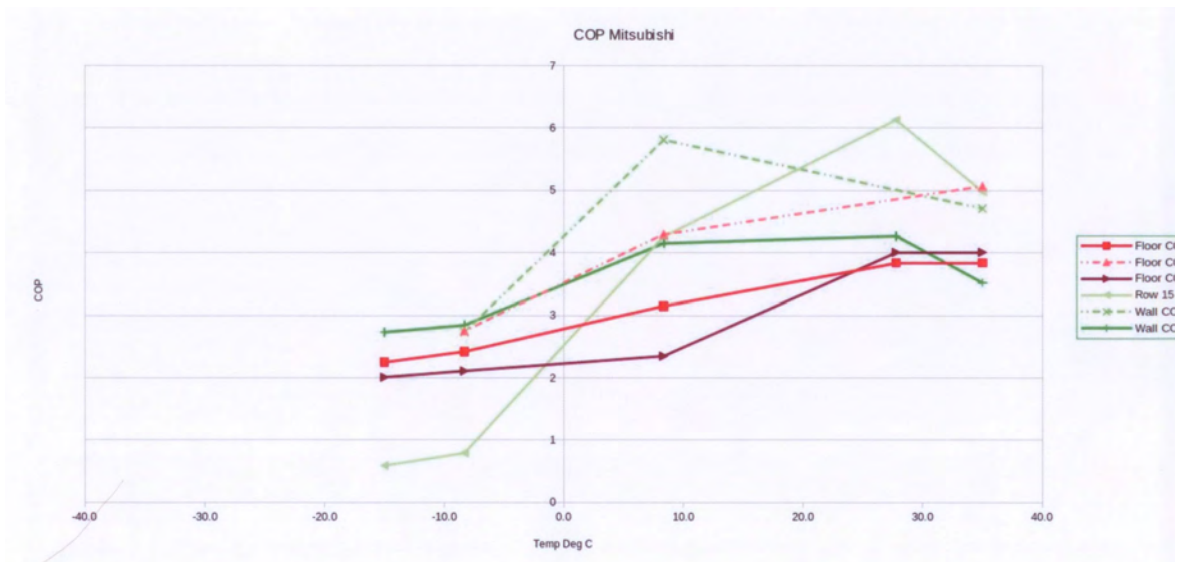
The most readily available relatively consistent source of information on the ASHPs is the site <https://ashp.neep.org> On that site you can use the AHRI system number identified in the Greener Homes data available from their site:

greener-homes-program-eligible-all-ashp-and-cchp-english-revised-final.csv

For each system the performance is shown at several different temperatures for both the heating and cooling cycles. The performance expressed in terms of Btu/hr, input in kW and COP is presented at minimum output , rated output and maximum output for each of the temperatures. In addition, several different measures of overall performance used in the industry are provided.

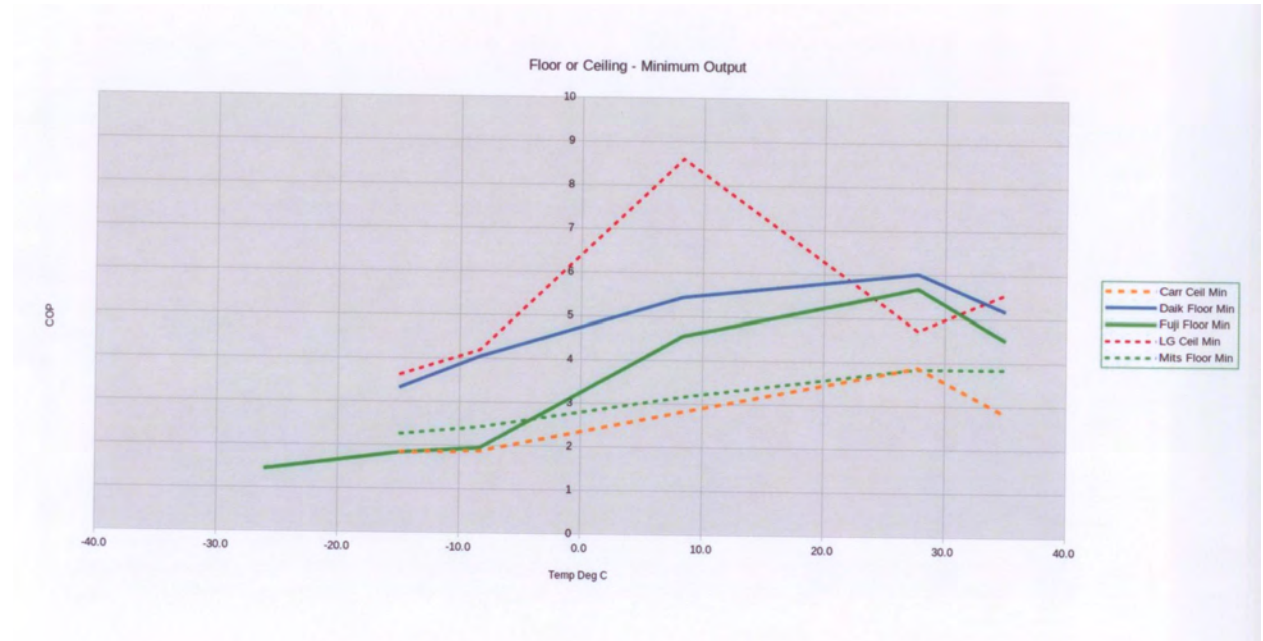
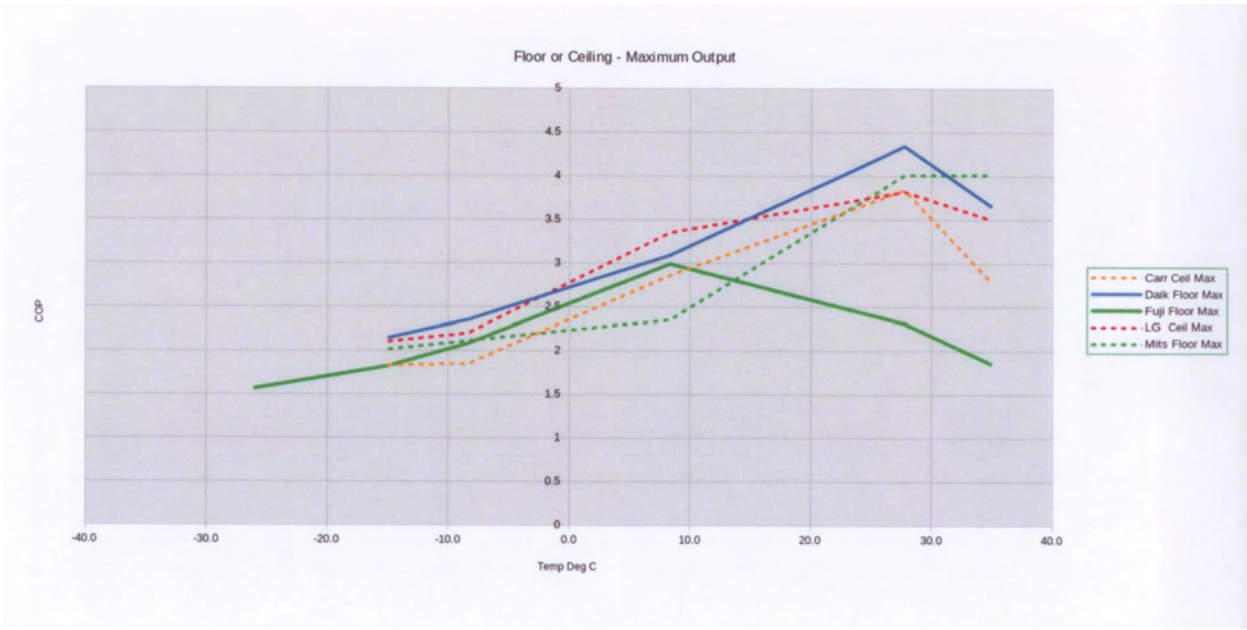
COP will be the best performance measure for Passive Houses as the temperature of the building changes only gradually - usually over many hours or several days. The COP data from the AHRI data was plotted for each unit being considered over the full range of temperatures of interest. It should be noted that the temperatures presented for different machines are often inconsistent in the heating range. The related plots are provided below for each of the suppliers considered.





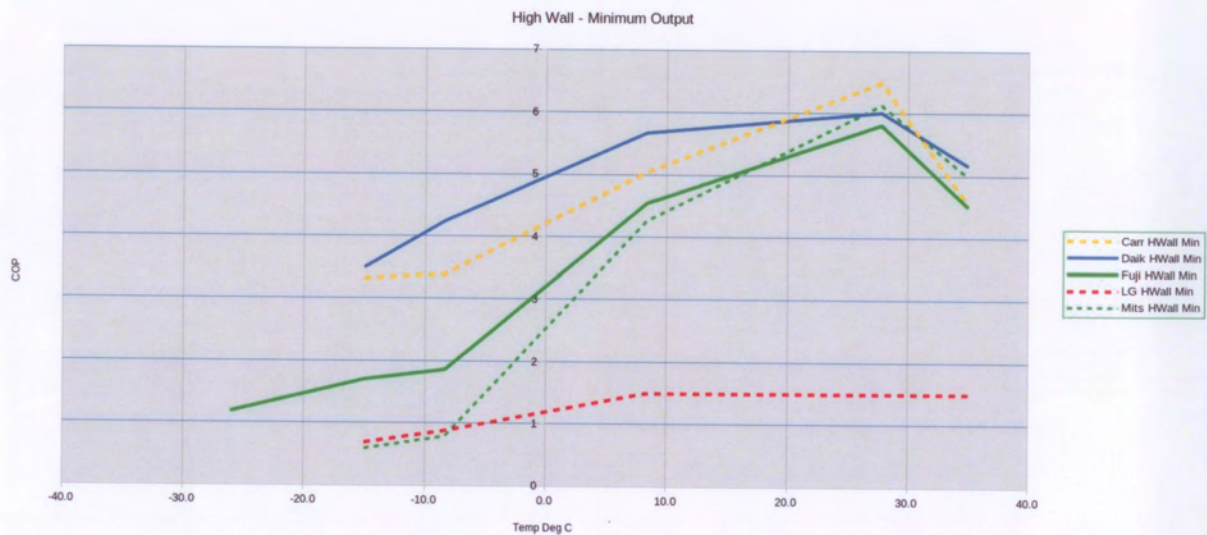
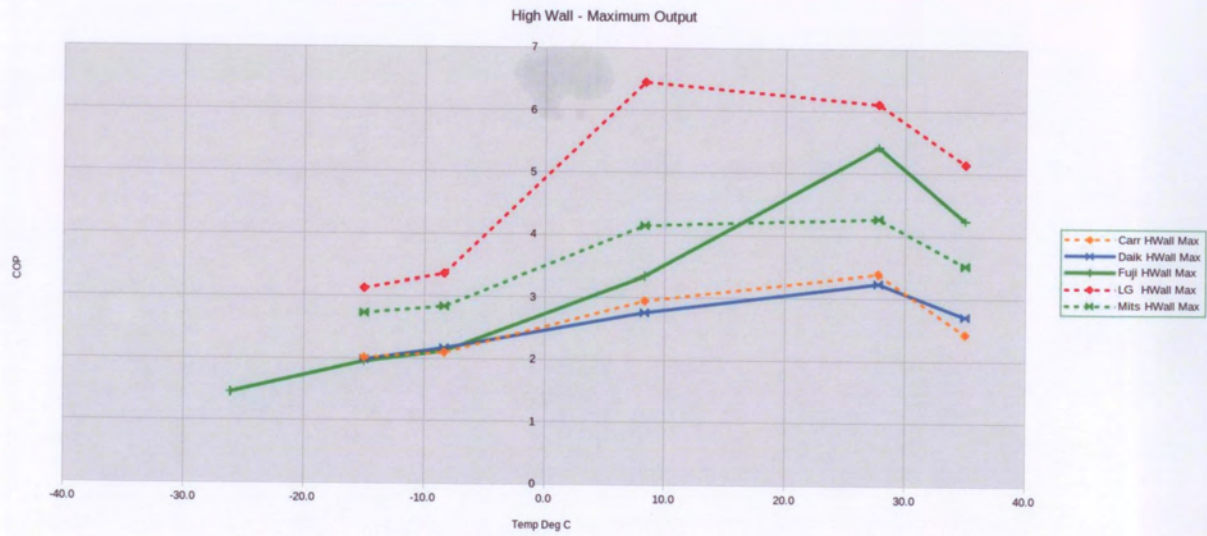
These figures show indicate some relationships that are difficult to rationalize. In general at maximum capacity the COP is typically lower than the design values. For minimum capacity operation the COP is in some cases much better than the design values (Carrier Wall) and in others much worse (Fujitsu Floor) - perhaps either the indoor unit or the outdoor unit limits performance in these cases. Some data appears quite irrational (LG - unrealistic peak in heating at 10 degrees and flat COP in the cooling range). It is much easier to rationalize the performance of others (Daikin Wall and Floor) where the COP increases as the demand on the system is decreased at any given temperature - this likely indicates a well designed physical system operated by well tuned controls.

Review of the foregoing figures suggested future focus upon Daikin, Fujitsu and perhaps Carrier. Further consideration of LG was judged to perhaps be misleading. One more check was performed by comparing all of the systems against each other on a single plot for each of maximum and minimum operation and separating the high-wall units from the ceiling and floor based units. These plots follow:



For the Floor / Ceiling units it is quite clear that the Daikin system outperforms the others (except for perhaps the questionable LG system).

For the case of the Montague situation, where the system is oversized for much of the demand, the overall performance of the Daikin system will be most attractive.



For the Wall systems, the Fujitsu appears to outperform the Daikin at maximum output during the cooling cycle. The Daikin (and Carrier) system outperform the others at minimum output.

For the Montague situation, where heating demands are expected to exceed cooling demands, the Daikin system would be the most attractive performer. In any situation where cooling is relatively more important the Fujitsu system may perform the best.

## **Cost Considerations**

## **Ranking**