

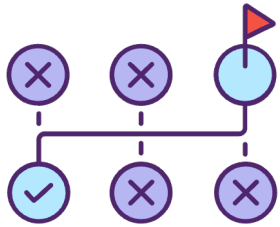
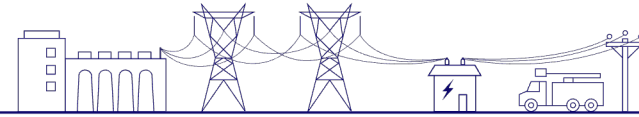


# Varennnes Library within a transactive energy platform

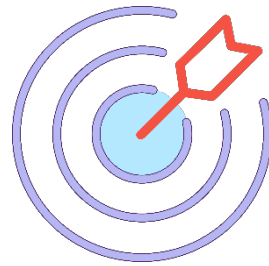
## Case Study

● Presentation ● Discussion ● Information

# Transactive Energy (TE) at Hydro-Québec



Strategic Project



Objectives



What is TE?

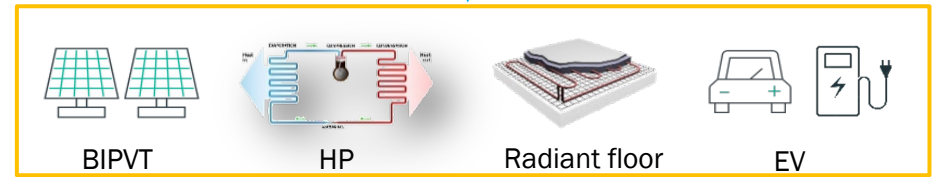
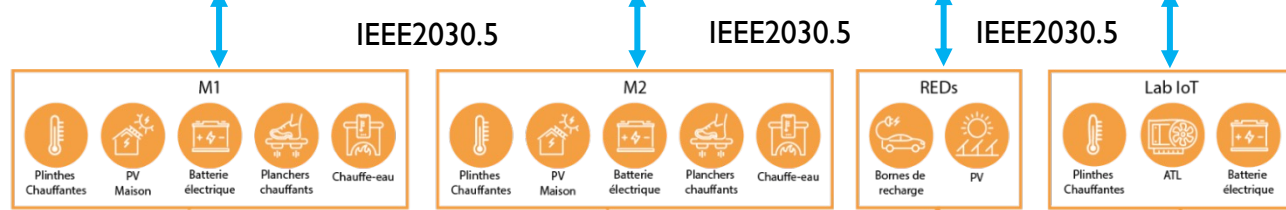
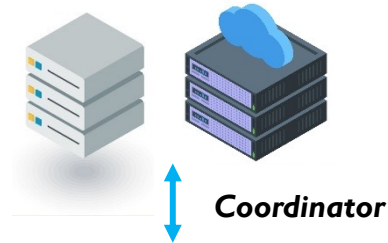


Methodology

A concept that **explore the flexibility of the customers' loads and the DERs through local energy markets** to contribute to the reliable, and equitable operation of the grid, taking into account electricity system constraints.

# TRANSACTIVE ENERGY PLATFORM

Developing Transactive Agents with Customer Preference for Buildings Coordination



- C1  
ATL  
Pompe à chaleur  
PV Maison

- C2  
ATL  
Pompe à chaleur  
PV Maison

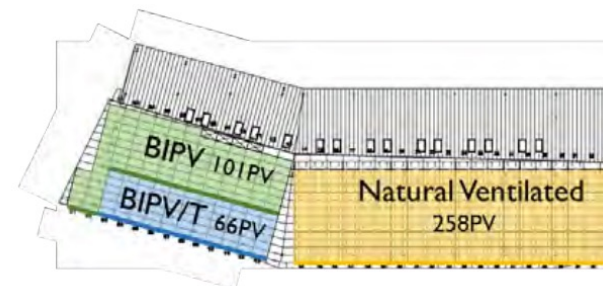
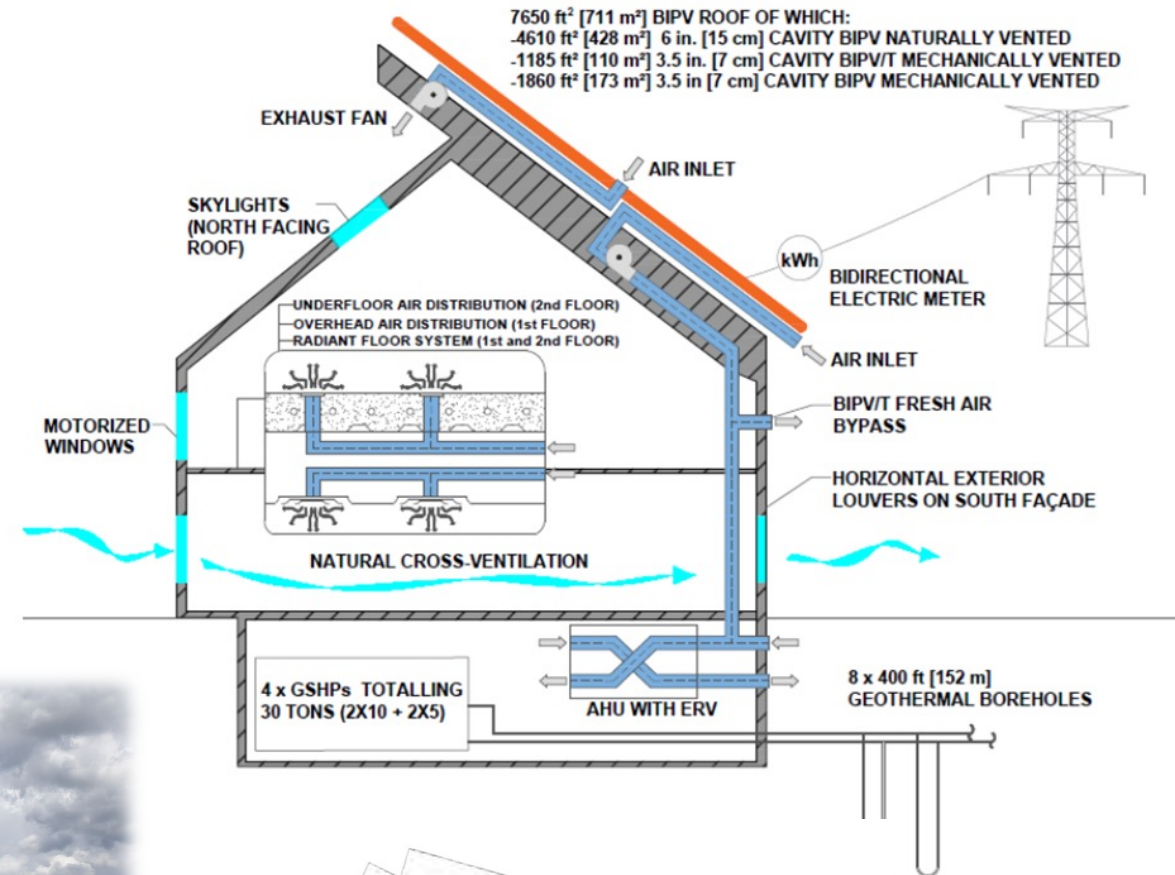




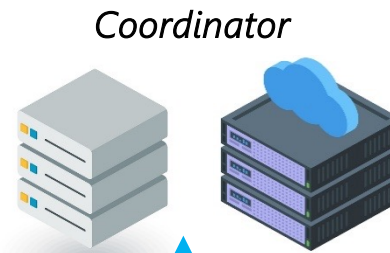
# Case Study: General information

The Varennes Library, first institutional Net Zero Energy Building in Canada.

- ❖ Net floor area: 2100 m<sup>2</sup>,
- ❖ Two floors with large open-space area,
- ❖ 110 kW BIPV system (part BIPV/T),
- ❖ Solar heat recovery (pre-heated fresh air): up to 1142 L/s,
- ❖ 4 ground source heat pumps (8 boreholes of 152 m deep),
- ❖ Dedicated outdoor AHU with ceiling/floor displaced air diffusers,
- ❖ Radiant floor slab heating/cooling,
- ❖ Natural cross-ventilation,
- ❖ Exterior fixed solar shading,
- ❖ EV car charging.



# Case Study Analysis



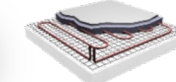
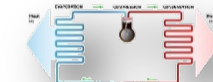
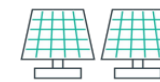
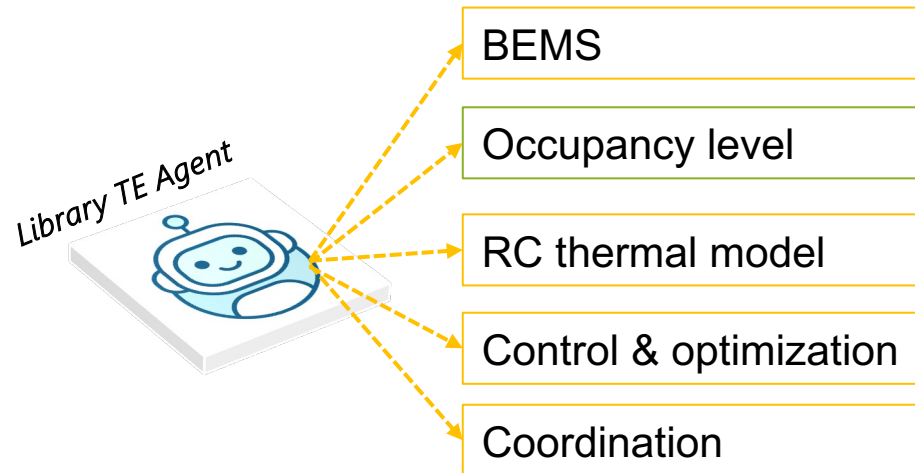
IEEE2030.5

Varennnes Library

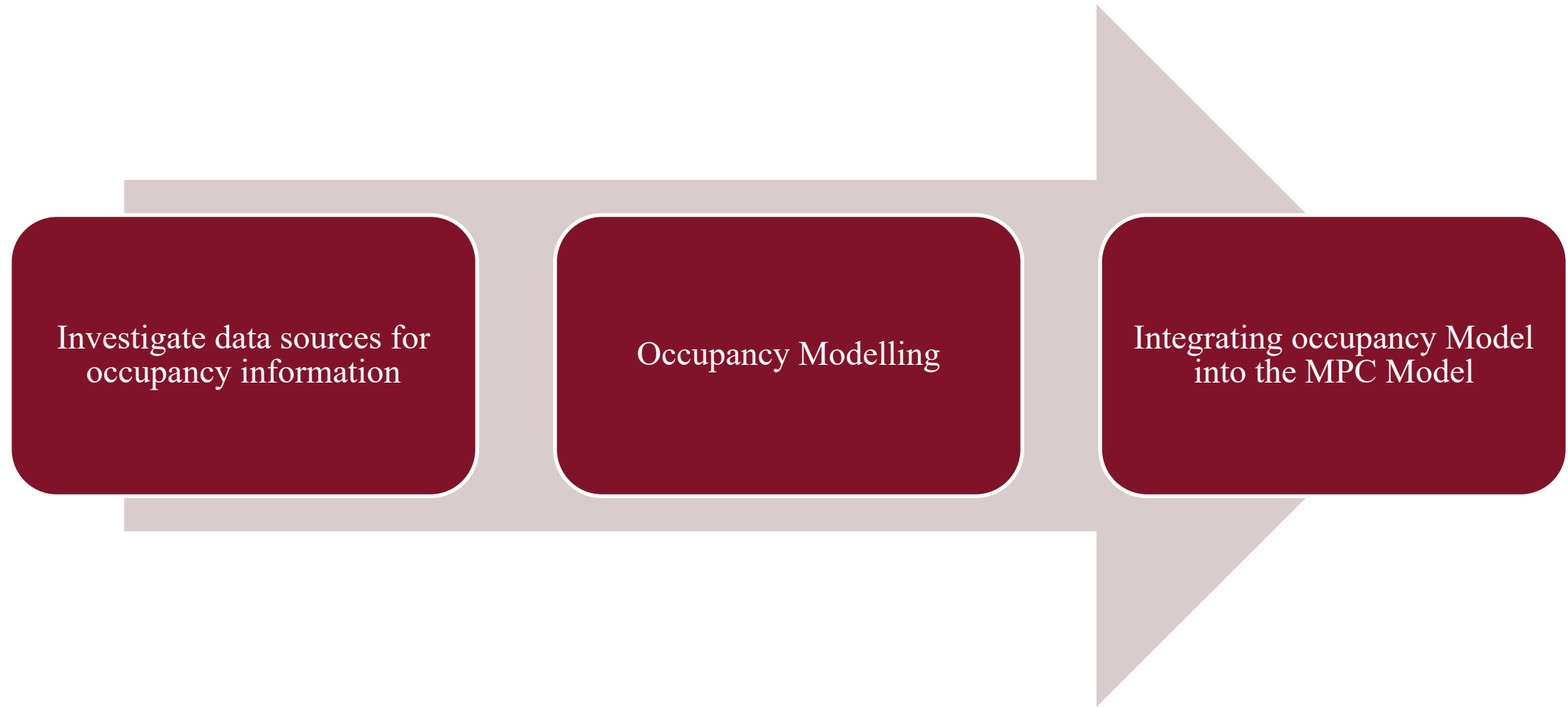


For efficient market coordination:

- ❖ Analyze the impact of the occupancy level and preference.
- ❖ Optimize the operation of the heating, fresh air, air conditioning, fan coils.



# Main Phases



# Phase (1): Investigating Data sources



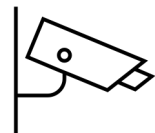
## Open data sources

- Google API
- SafeGraph



## Existing Systems at the Library

- Visitor Count
- Wi-Fi Connection Count



## Adding Occupancy sensor

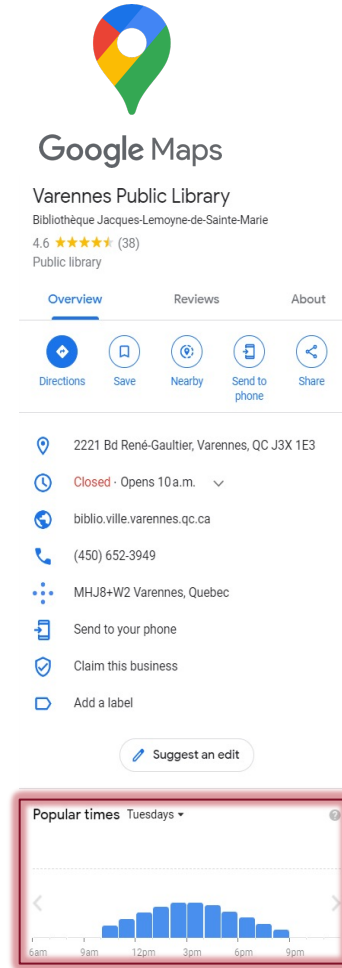
- Camera-based sensor

# Open sources Data-Sets



## ➤ Popular times on Google map

- Google uses aggregated and anonymized data from users who have enabled Google Location History.
- Popular times are based on average occupancy over the last few months.
- They only offer the typical week normalized based on the typical weekly peak.



Google APIs





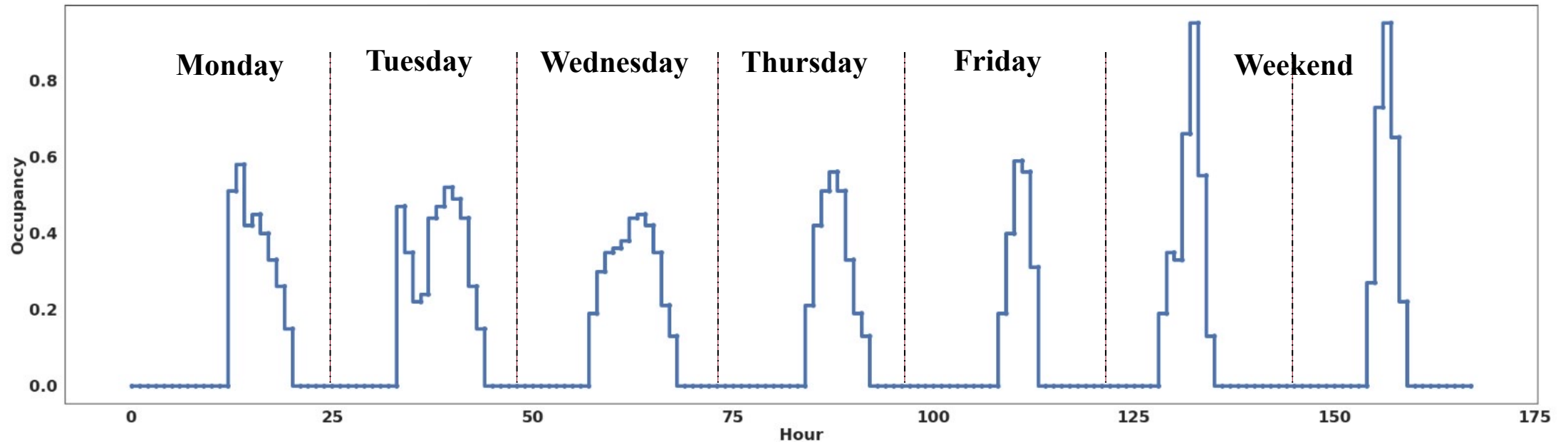
# Open sources Data-Sets



## ➤ Popular times on Google map

- Average occupancy level is 0.12
- The max occupancy is 0.6 during weekdays, and 0.95 during weekends.
- Peak hour is 4 PM on weekdays except for Monday, and 1 PM on Mondays and weekends.

## Google APIs



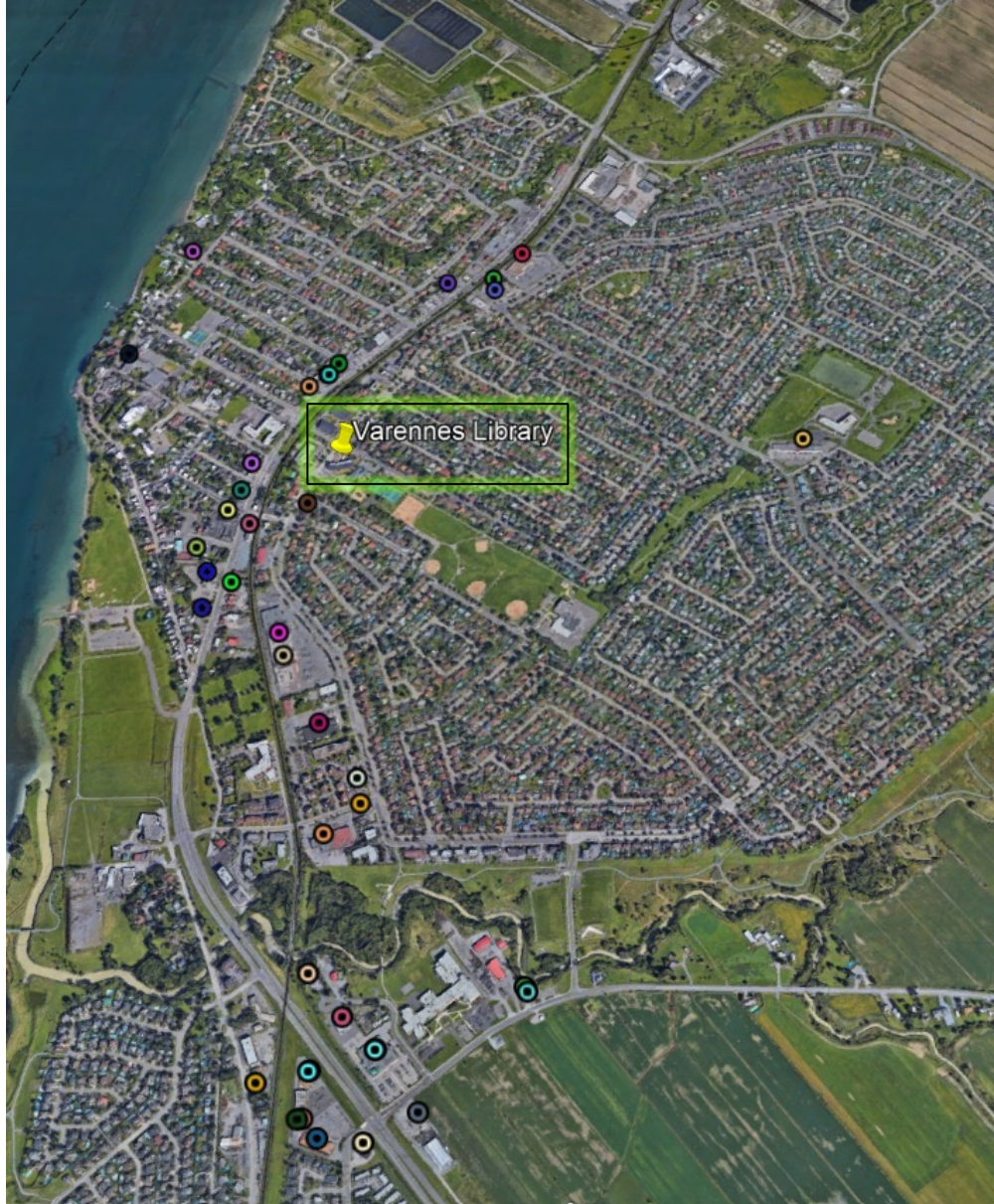
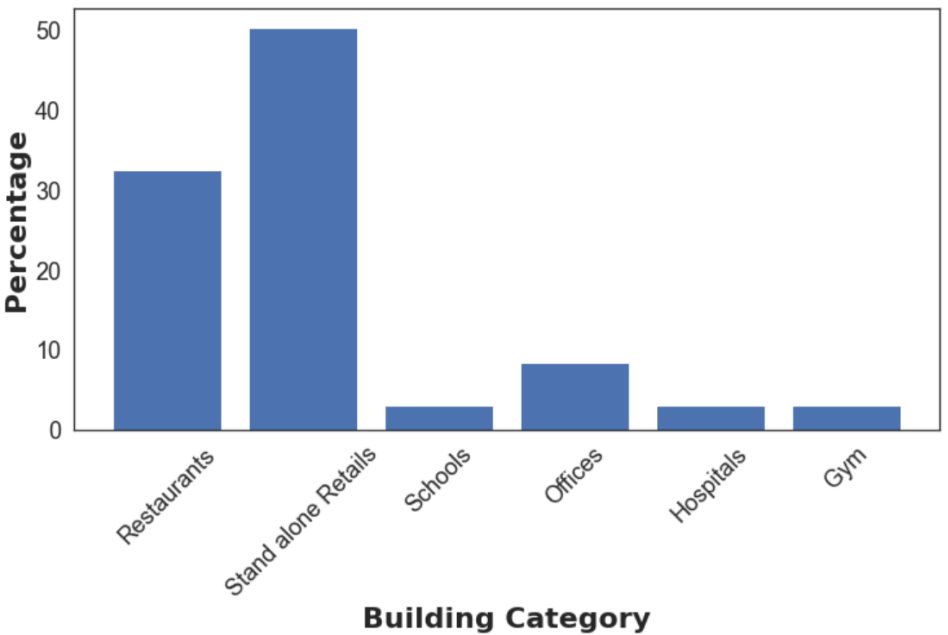


# Occupancy Analysis with the Different Data Sources



## ➤ Varennes city in SafeGraph

- Varennes Library is not covered by Saferaph.



## Phase (1): Investigating Data sources

### Existing Systems



- Visitors Count
- Wi-Fi connections



# Data from Existing Systems



## ➤ Manual Visitors Count

- Manual attendance counting statistics sheet for the years 2018, 2019, 2021, and 2022.
- The count stopped from Jan 2020 till March 2021.

Attribute	min	max	Average
Visitors am	0	357	97
Visitors pm	0	731	184
Visitors evening	0	380	92

### Statistiques de fréquentation 2022



Journée	Date	Visiteurs am	Visiteurs pm	Visiteurs soir	Visiteurs jour	Visiteurs semaine	Visiteurs mois	Visiteurs an
samedi	1 janvier 2022				0	0		83 217
dimanche	2 janvier 2022				0			
lundi	3 janvier 2022				0			
mardi	4 janvier 2022				0			
mercredi	5 janvier 2022				0			
jeudi	6 janvier 2022				0			
vendredi	7 janvier 2022				0			
samedi	8 janvier 2022				0	0		
dimanche	9 janvier 2022				0			
lundi	10 janvier 2022				0			
mardi	11 janvier 2022				0			
mercredi	12 janvier 2022				0			
jeudi	13 janvier 2022				0			
vendredi	14 janvier 2022				0			
samedi	15 janvier 2022				0	0		
dimanche	16 janvier 2022				0			
lundi	17 janvier 2022		22	0	22			
mardi	18 janvier 2022	66	124	47	237			
mercredi	19 janvier 2022	45	18	97	158			
jeudi	20 janvier 2022		98	63	161			
vendredi	21 janvier 2022		84		84			
samedi	22 janvier 2022	96	140		236	898		
dimanche	23 janvier 2022		106		106			
lundi	24 janvier 2022		129	36	165			
mardi	25 janvier 2022	58	120	31	209			
mercredi	26 janvier 2022	62	95	50	207			
jeudi	27 janvier 2022		151	18	169			
vendredi	28 janvier 2022		128		128			
samedi	29 janvier 2022	60	100		160	1 142		
dimanche	30 janvier 2022		157		157			
lundi	31 janvier 2022		125	15	140		2 337	
mardi	1 février 2022	61	102	16	179			
mercredi	2 février 2022	81	114	16	211			
jeudi	3 février 2022		98	24	122			
vendredi	4 février 2022		118		118			
samedi	5 février 2022	65	99		164	1 091		
dimanche	6 février 2022		252		252			

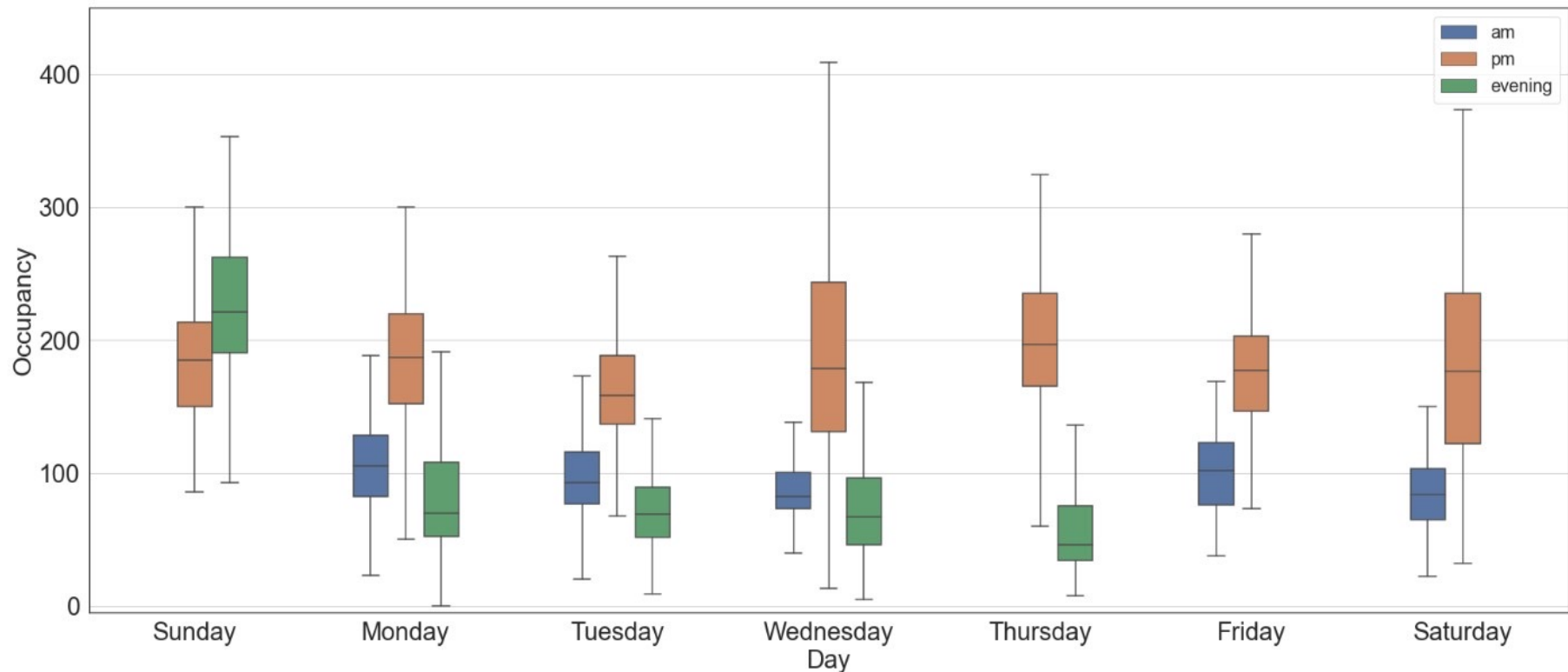
# Data from Existing Systems



VARENNES

## ➤ Limitation of using Manual Count

- Data aggregation is not suitable for day-ahead planning with 15 resolution.
- Data collection is subjected to human error.
- However, it can be used for pre modelling analysis

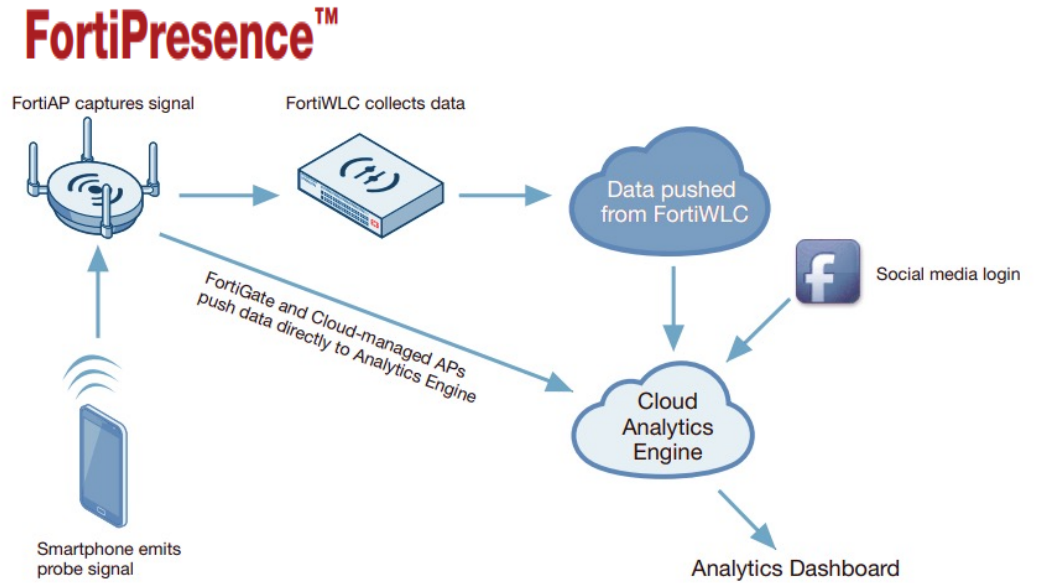


# Data from Existing Systems



## ➤ Wi-Fi connection count

- The Wi-Fi data records the number of connected devices for each hour of the day.
- Data was accessible since May 2<sup>nd</sup> , till September 14<sup>th</sup>.



# Occupancy Analysis with the Different Data Sources



## ➤ Limitation of Wi-Fi connection count



The occupancy schedule will be under the assumption of one device via occupant.



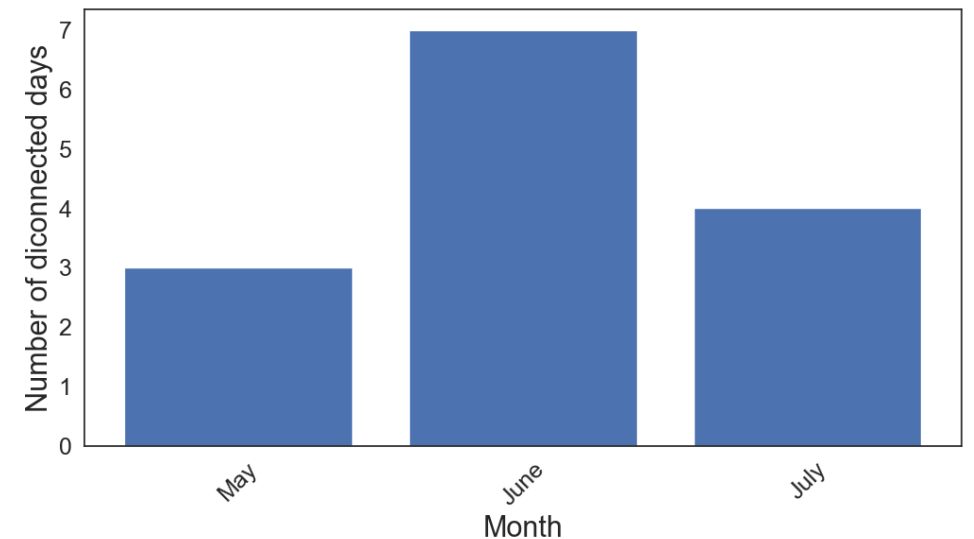
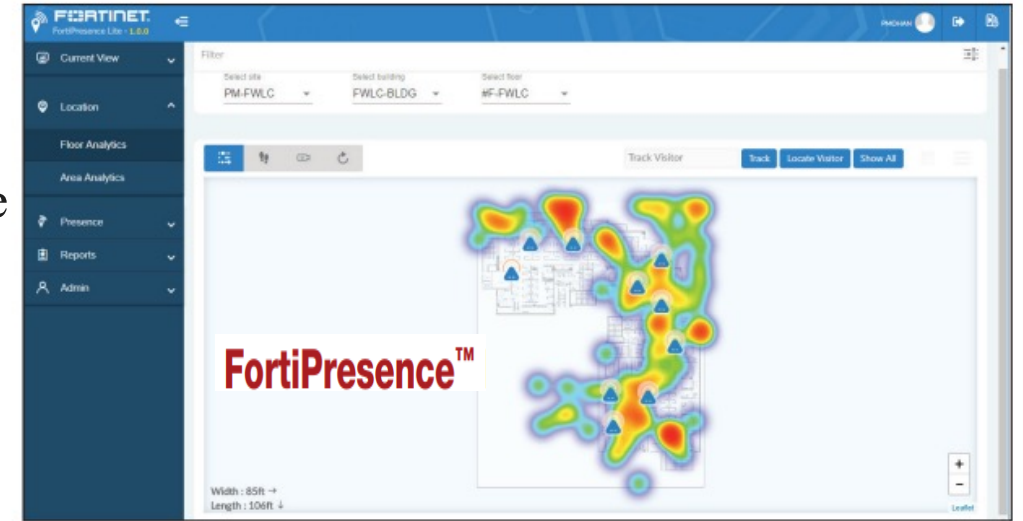
The system does not provide 15-minute aggregated data



The Wi-fi connection is accessible by neighbors.



The system is not reliable.



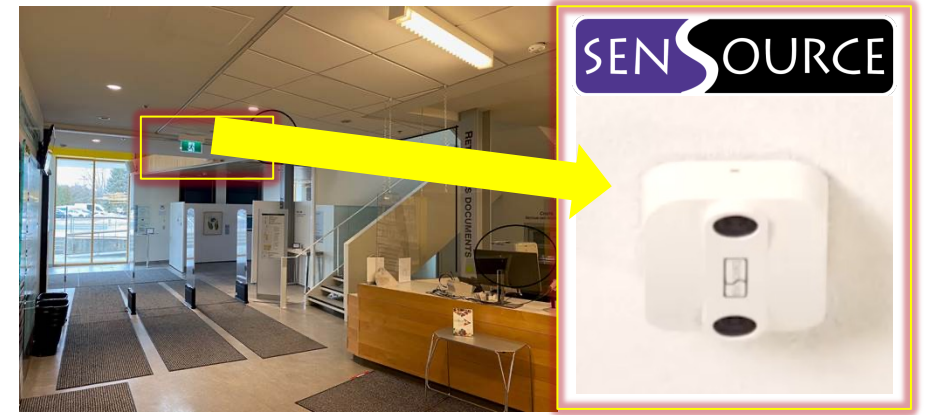


# Occupancy Sensor



## ➤ Vea SenSource

- The Sensor was installed Friday, April 18.
- Data is recorded since Saturday, April 19.



Occupancy ▾ Last Week ▾ Minute ▾ 15 Space ▾ Space  All Zones ▾ All Zones ▾

Set options above and click Refresh

Drag a column header and drop it here to group by that column

Space Name	Location Name	Record Date	Max. Occupancy	Avg. Occupancy	Ins	Outs
Varenes Public Library	Varenes Public Library	2023-04-18 14:00	70.00	64.6	9	32
Varenes Public Library	Varenes Public Library	2023-04-18 13:45	67.00	65.3	16	16
Varenes Public Library	Varenes Public Library	2023-04-18 13:30	66.00	64.3	8	4
Varenes Public Library	Varenes Public Library	2023-04-18 13:15	62.00	40.1	55	5
Varenes Public Library	Varenes Public Library	2023-04-19 13:45	51.00	47.7	9	11
Varenes Public Library	Varenes Public Library	2023-04-19 13:30	50.00	46.7	9	3
Varenes Public Library	Varenes Public Library	2023-04-19 14:15	49.00	45.9	11	10

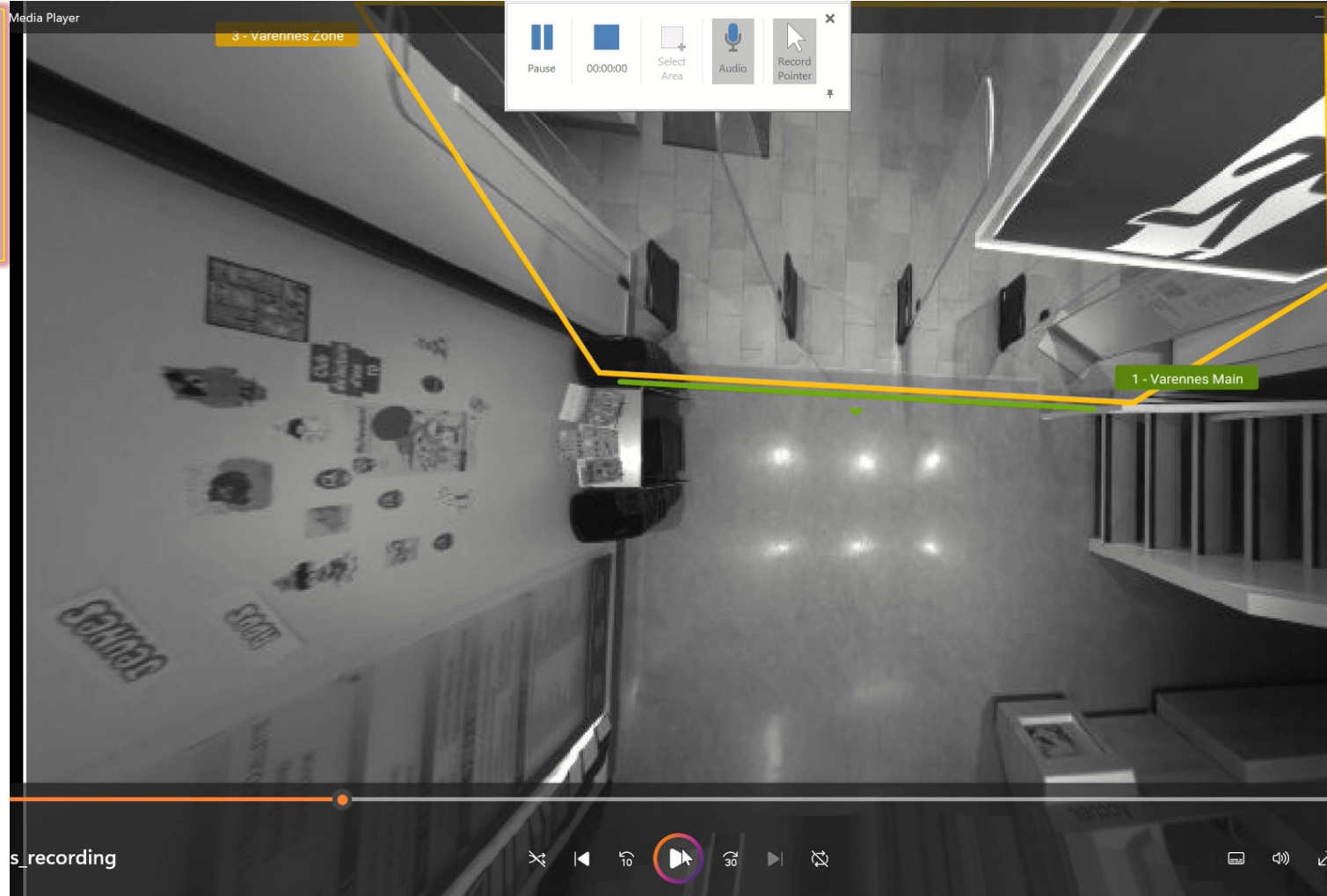
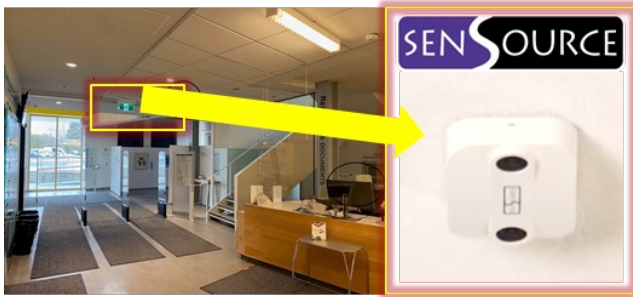
## The Data record:

- Number of people in and out at each timestep.
- Max Occupancy within the timestep.
- Average Occupancy for each timestep.

# Occupancy sensor



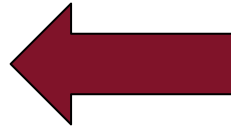
➤ **Vea SenSource**



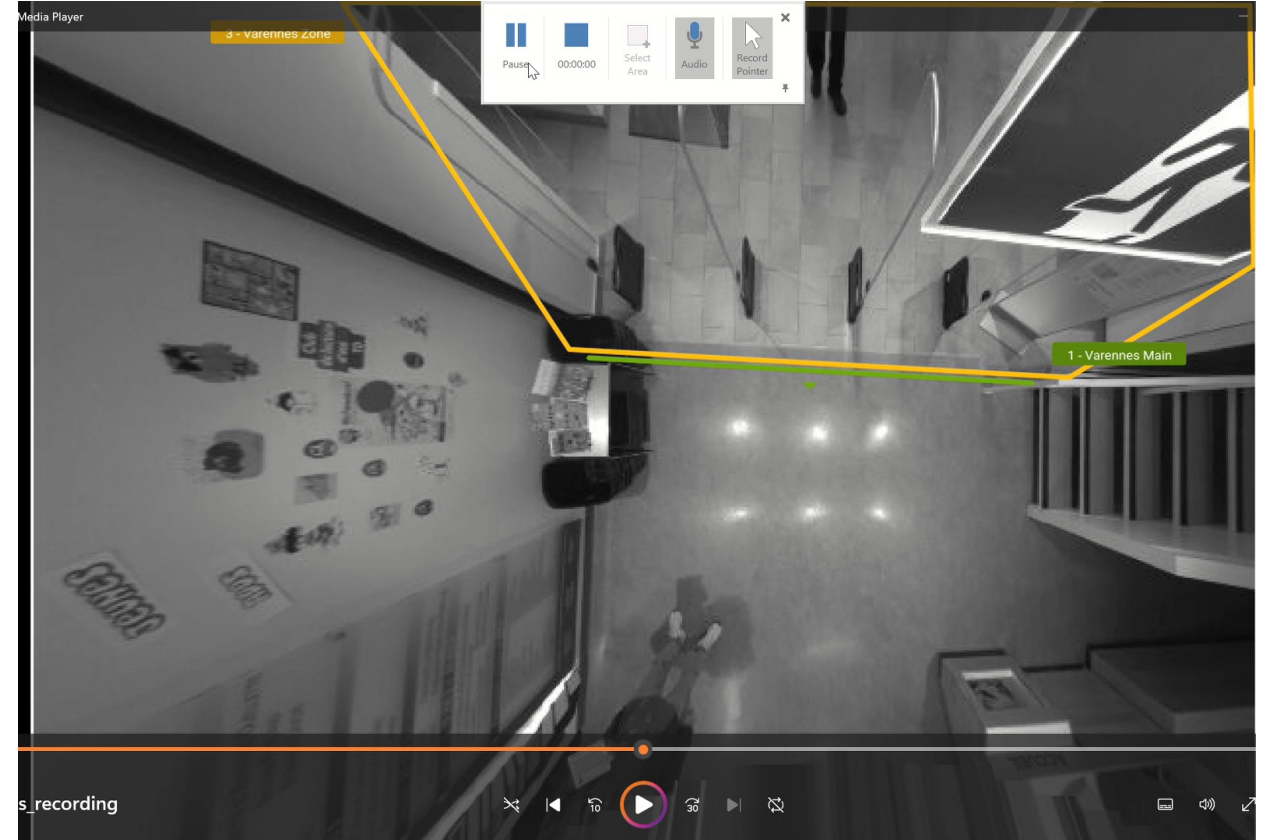
# Occupancy sensor



➤ **Vea SenSource**



Example of a counting error



# Occupancy Analysis with the Different Data Sources



## ➤ Vea SenSource

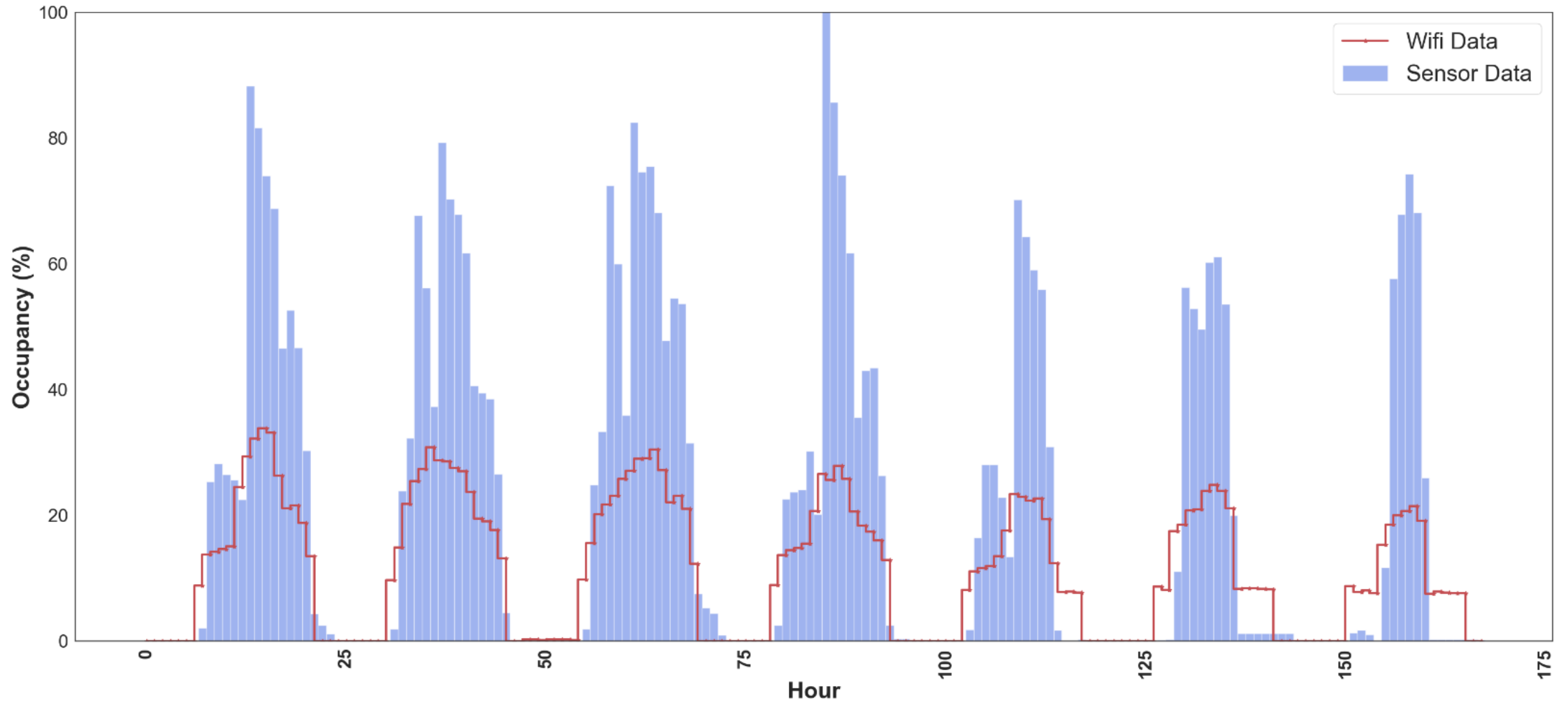
- Data collected at 15 min resolution from April 19<sup>th</sup> till October 24<sup>th</sup>

$$\text{Number of people inside}_t = (\text{People in}_t + \text{people inside}_{t-1}) - \text{people out}_t^*$$

<b>Descriptive Statistics</b>	<b>people Inside</b>
Resolution	15 minutes
Median	13
Average	15
Max	76

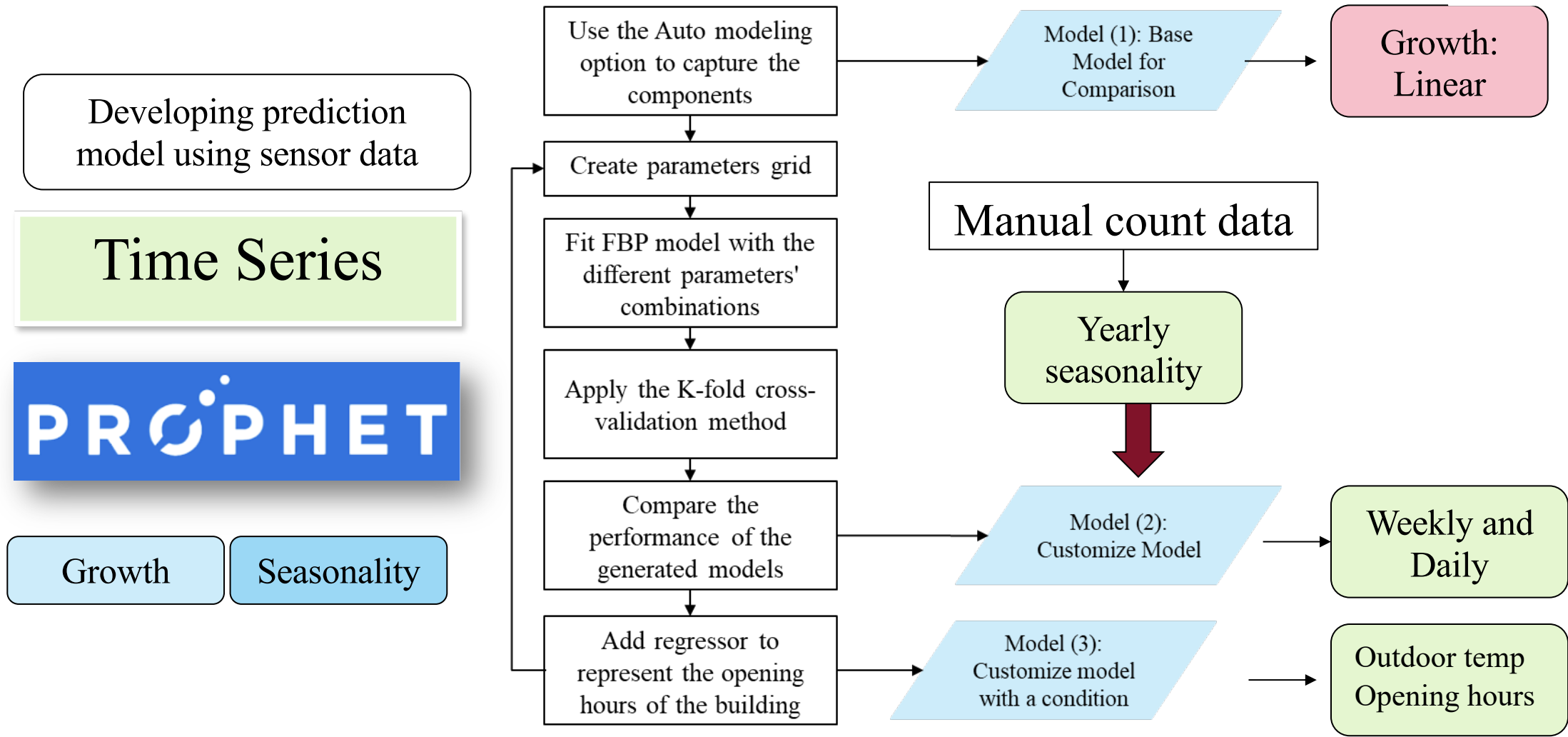


# Correlation between Wifi and Sensor data



## **Phase (2): Prediction Model**

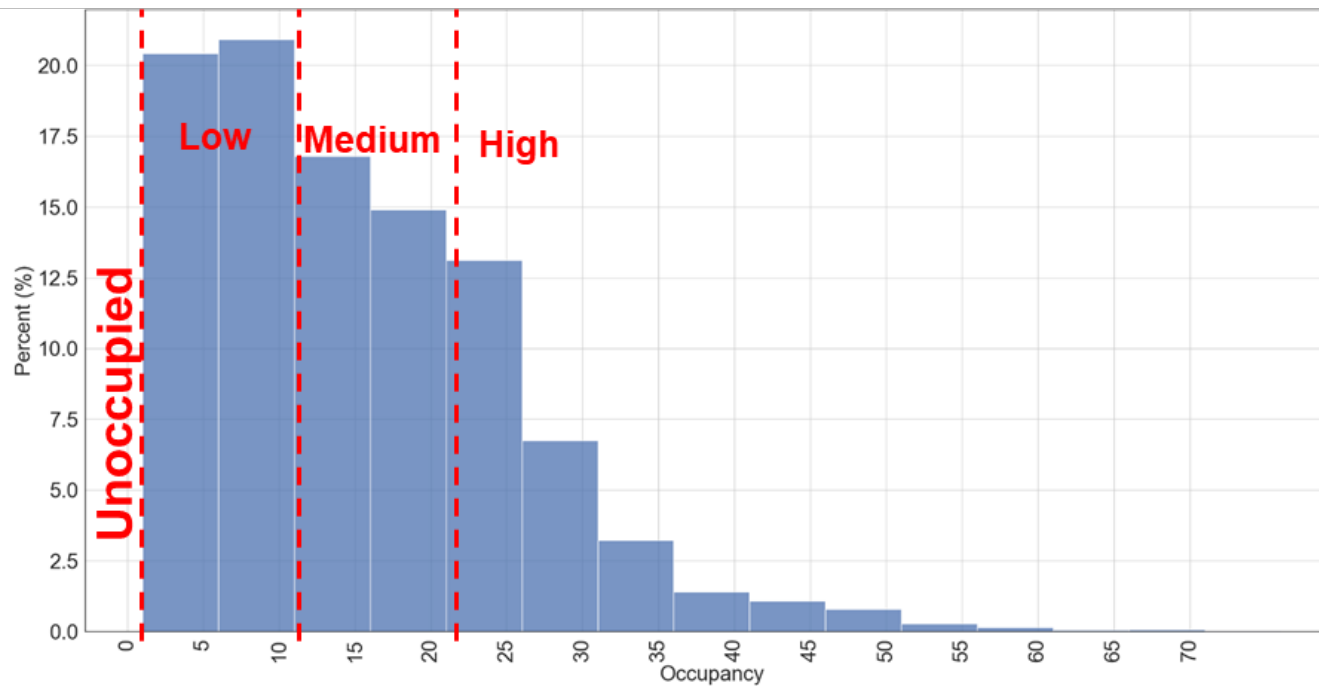
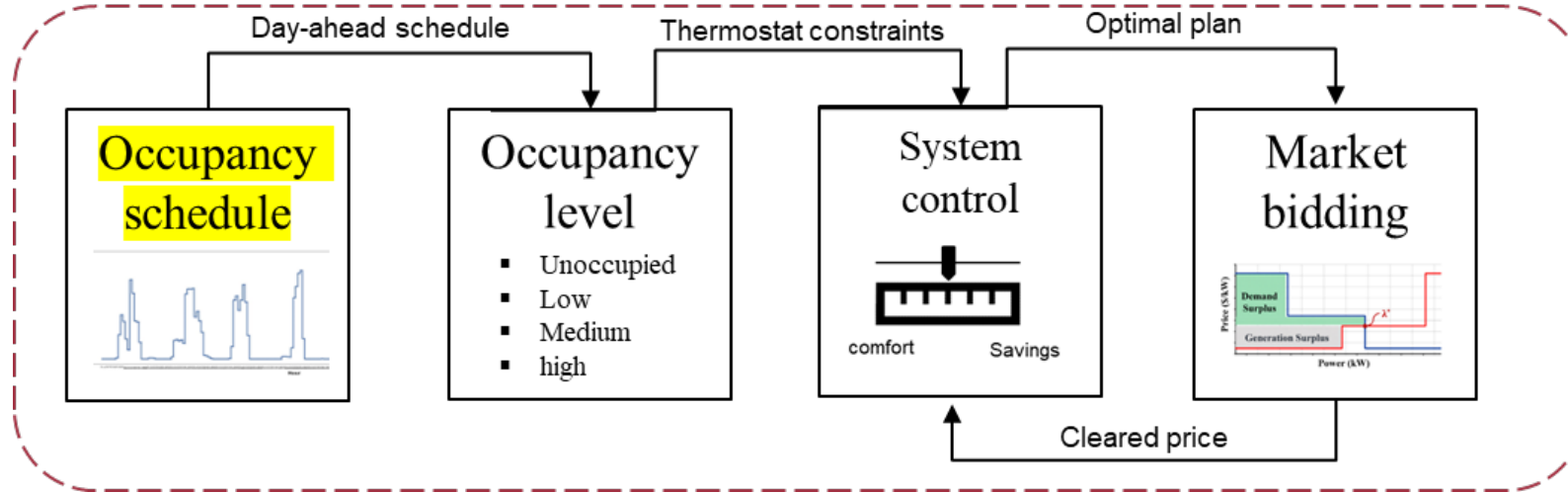
# Developing Occupancy Prediction Model



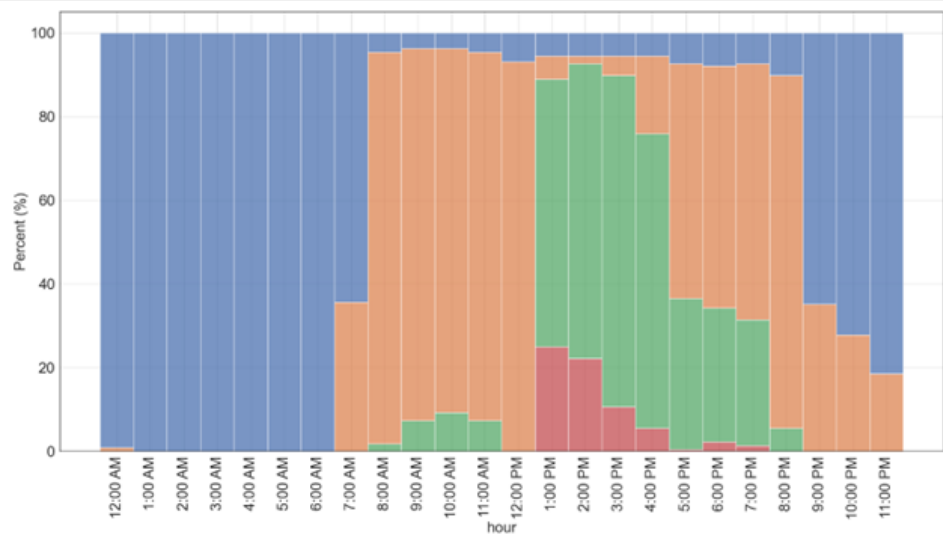
**Phase (3): Integrating  
Occupancy model into MPC**



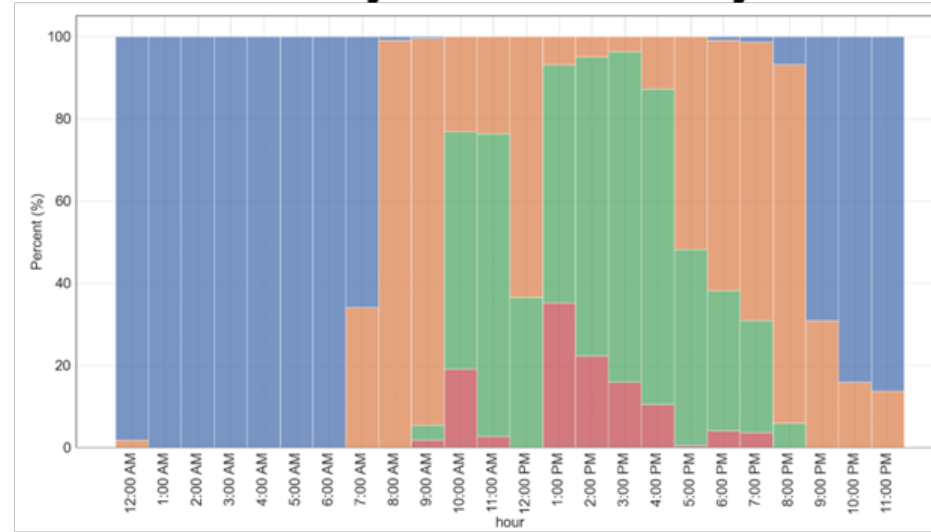
# Transactive Agent for Varennes Library



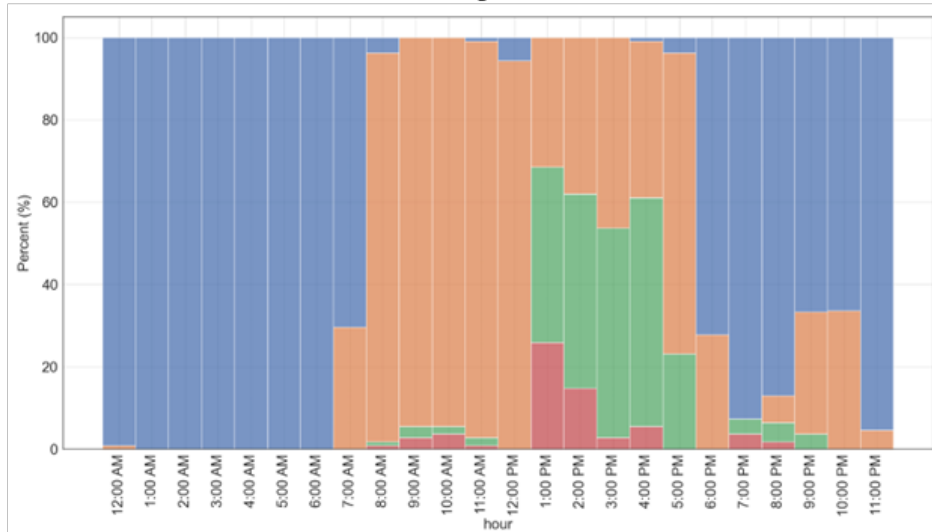
## Mondays and Thursdays



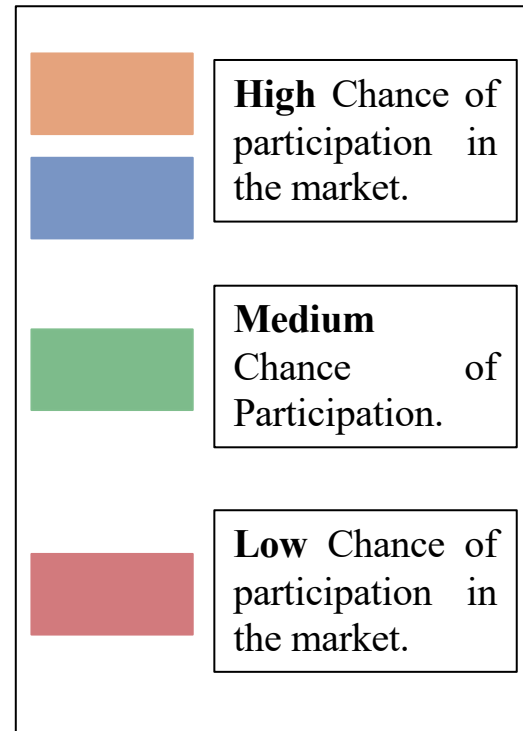
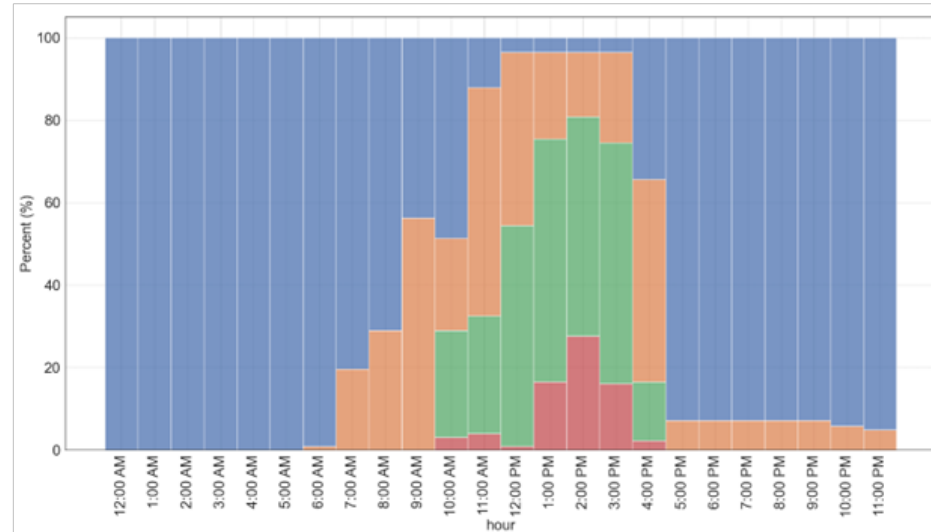
## Tuesdays and Wednesdays



## Fridays



## Weekends



TE Agent



BEMS

Occupancy level

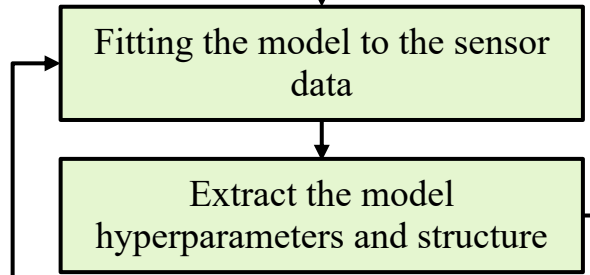
RC thermal model

Control & optimization

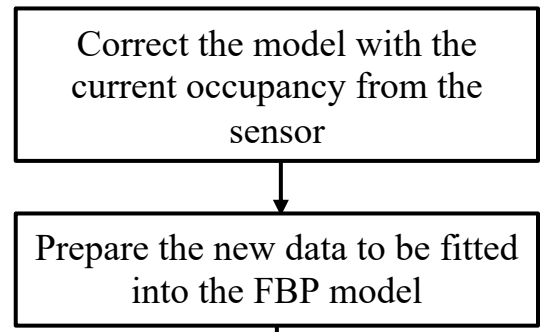
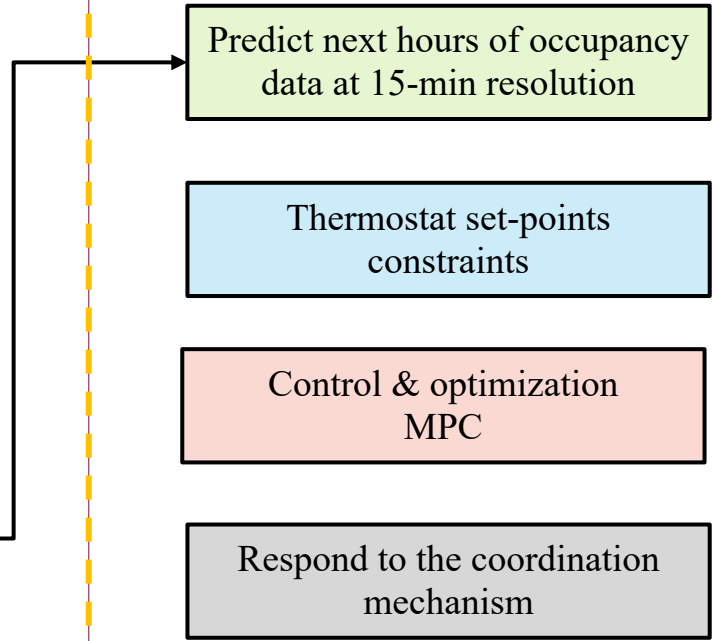
Coordination

Includes camera-based occupant count measurements as well as proxy virtual sensing from the Wi-Fi-connected devices

### Open data sources



*Before coordination mechanism*

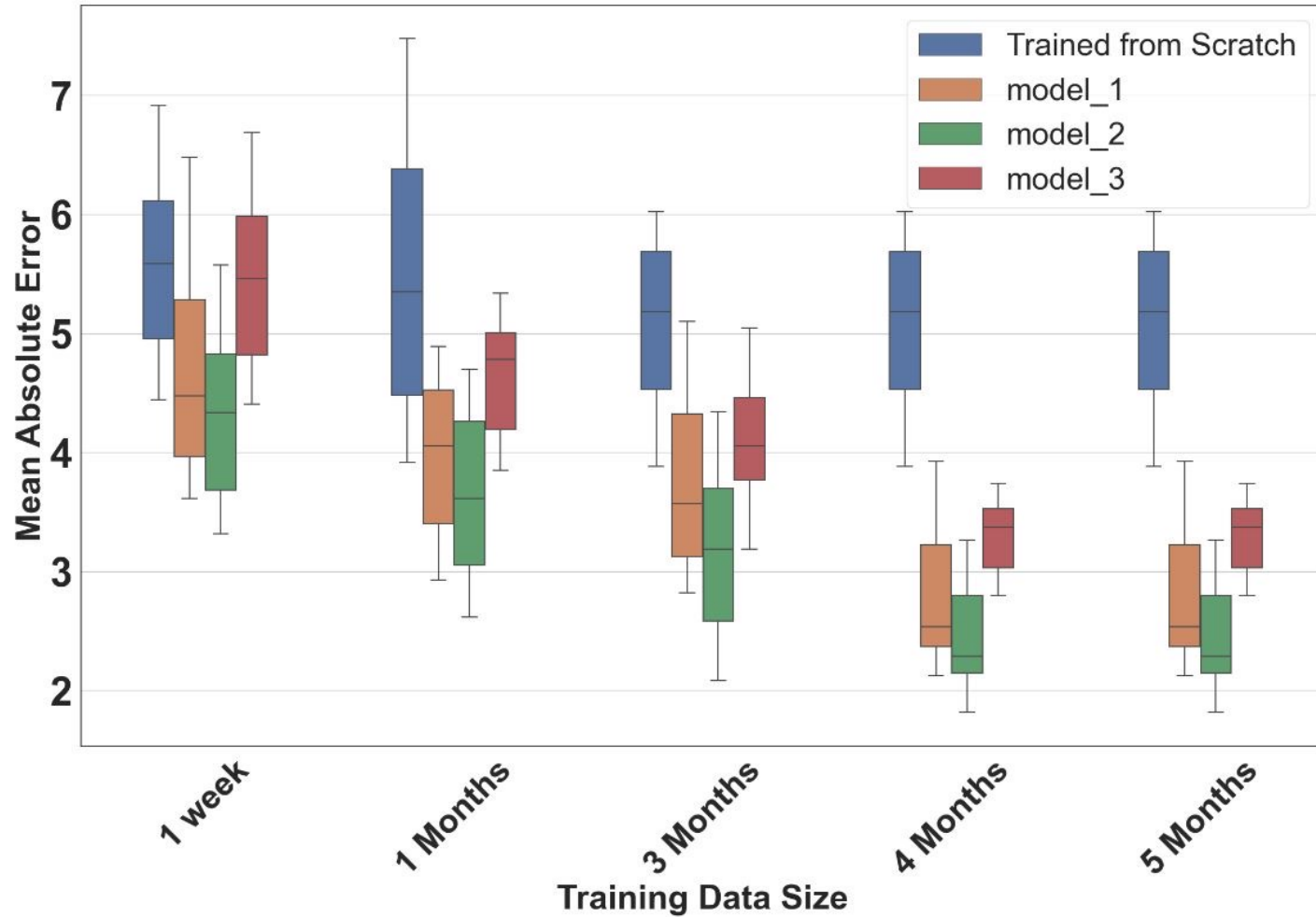


*After coordination mechanism*

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# Questions

# Performance of the prediction model



- Trained from scratch Model using only sensor data.
- Model (1): using only time as predictor.
- Model (2): adding a predictor to represent the opening hours.
- Model (3): adding outdoor temperature.

$$MAE = \frac{1}{n} \sum_{t=1}^n |F_t - A_t|$$