Advanced peak demand forcast and battery dispatch algorithms to integrate storage-based demand response with BAS

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INTRODUCTION

- Buildings contribute up to **40%** of all greenhouse gas emission and up to **73%** of the electricity usage in the US.
- There exist mature technologies in large-scale CPS applications such as modern commercial buildings with BAS-based DR and electricity storages, which can ***potentially*** enable substantive energy savings (or sustainable usage)
- However, these technologies are underutilized because of the lack of a comprehensive building automation framework.

OBJECTIVE

We envision that, "***Demand peaks and associated grid stress, electricity unit cost, and carbon emissions can be effectively reduced, by investigating a novel CPS framework that integrates the battery storage within the advanced Building Automation Systems***".

APPROACH & INTELLECTUAL MERIT

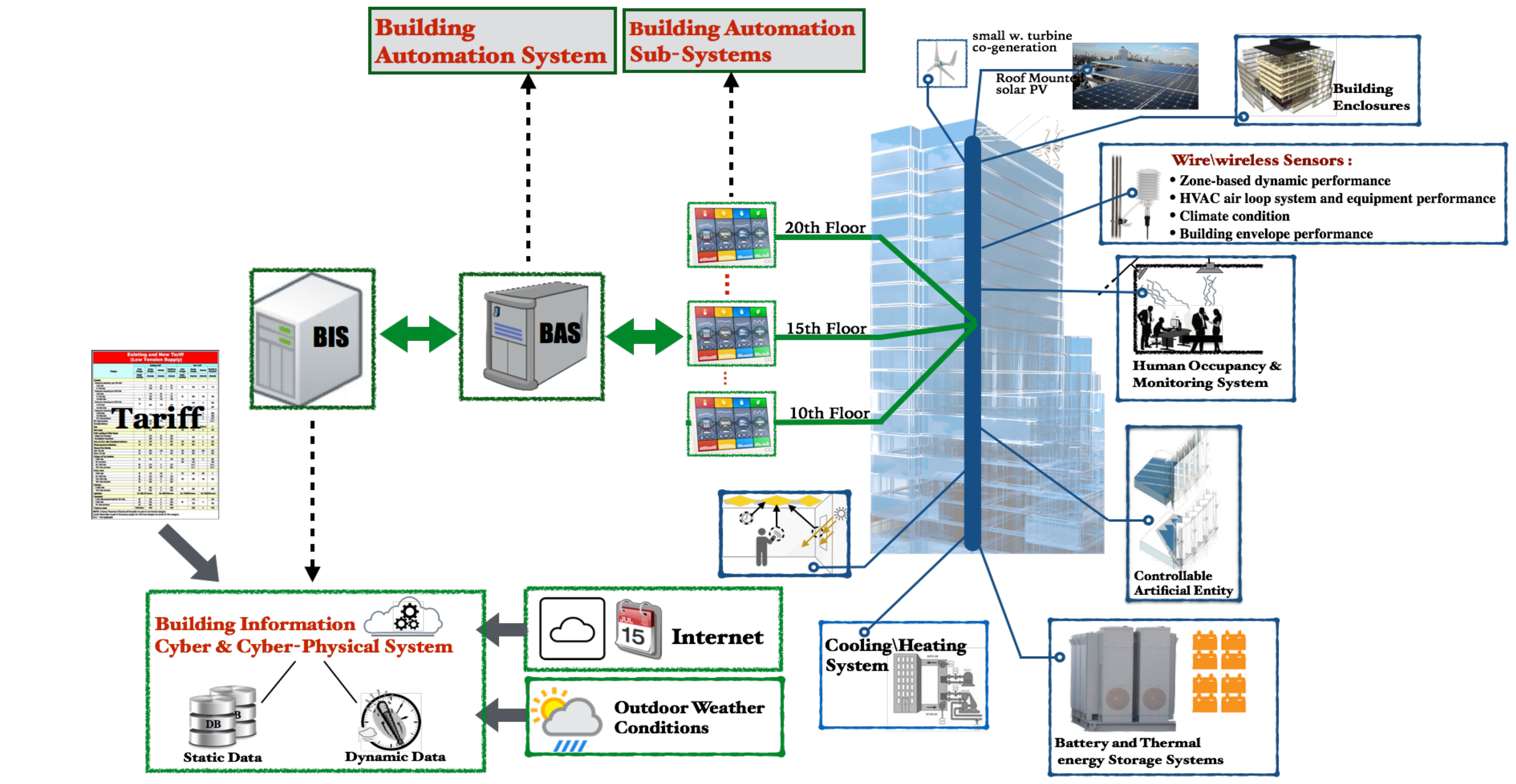
To address this fundamental objective, we proposed a novel three-step CPS framework called: **A.I.R.**, i.e., **A**ssess, **I**nterpret, and **R**espond.

- Its transformative capability is derived from an integrative ***Systems-of-Systems*** approach, by formulating a bi-level optimization framework.
- It utilizes intelligent technologies and advanced multi-objective and mixed-integer optimization to control Energy Consumption and Cost vs. Occupant's comfort level trade-off.
- It minimizes the human-interaction in building control.
- It uses a powerful model selection approach to select the best statistical learning models to represent the next-day energy consumption (load profile).
- It is compatible with different electricity tariffs.
- It utilizes the adaptive model refinement approach to increase the fidelity of statistical learning models when strategically updated data is available.
- It uses a Data-driven Sensor-based on-line thermal model

SIGNIFICANCE & IMPACT

- Successful outcome of the proposed framework will **promote greater and informed adoption of related/upcoming green technologies (such RE generations, and EVs)** in large scale CPS applications such as modern commercial buildings.
- Successful CPS framework **can pass the ~30% barrier** in load profile reduction reached by Siemens Apogee.
- Developed CPS framework will be implemented to integrate electricity storage with existing BAS
- Performance of the control framework will be calibrated to improve the storage lifetime and the cost of ownership

AUTOMATED DEMAND/RESPONSE FACILITIES



A.I.R. – PASSIVE BUILDING AUTOMATION SYSTEM

A.I.R.-Passive optimization is performed using historical load profile and market price functions to find the Effective Storage Capacity.

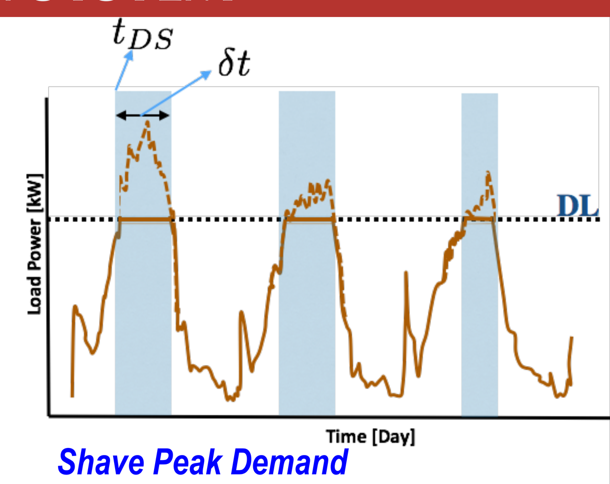
$$t_{DS},\ t_{CS},\ DL,\ \Gamma = \text{Argmin}\left(\sum_{i=1}^{360}\sum_{j=1}^{\beta} S(P({}_j^i t_{DS},\ {}_j^i t_{CS})) + C \times \Gamma\right)$$

$$P(t_{DS},\ t_{CS}) = \begin{cases} E(t) + L(t) & \text{if } t \in \Phi_{DS} \text{ OR } t \in \Phi_{CS} \\ L(t) & \text{Otherwise} \end{cases}$$

$$E(t) = E_t^{+} - E_t^{-}$$
$$\Phi_{DS} = [t_{DS}, t_{DS} + \delta t]$$
$$\Phi_{CS} = [t_{CS}, t_{CS} + \delta t]$$

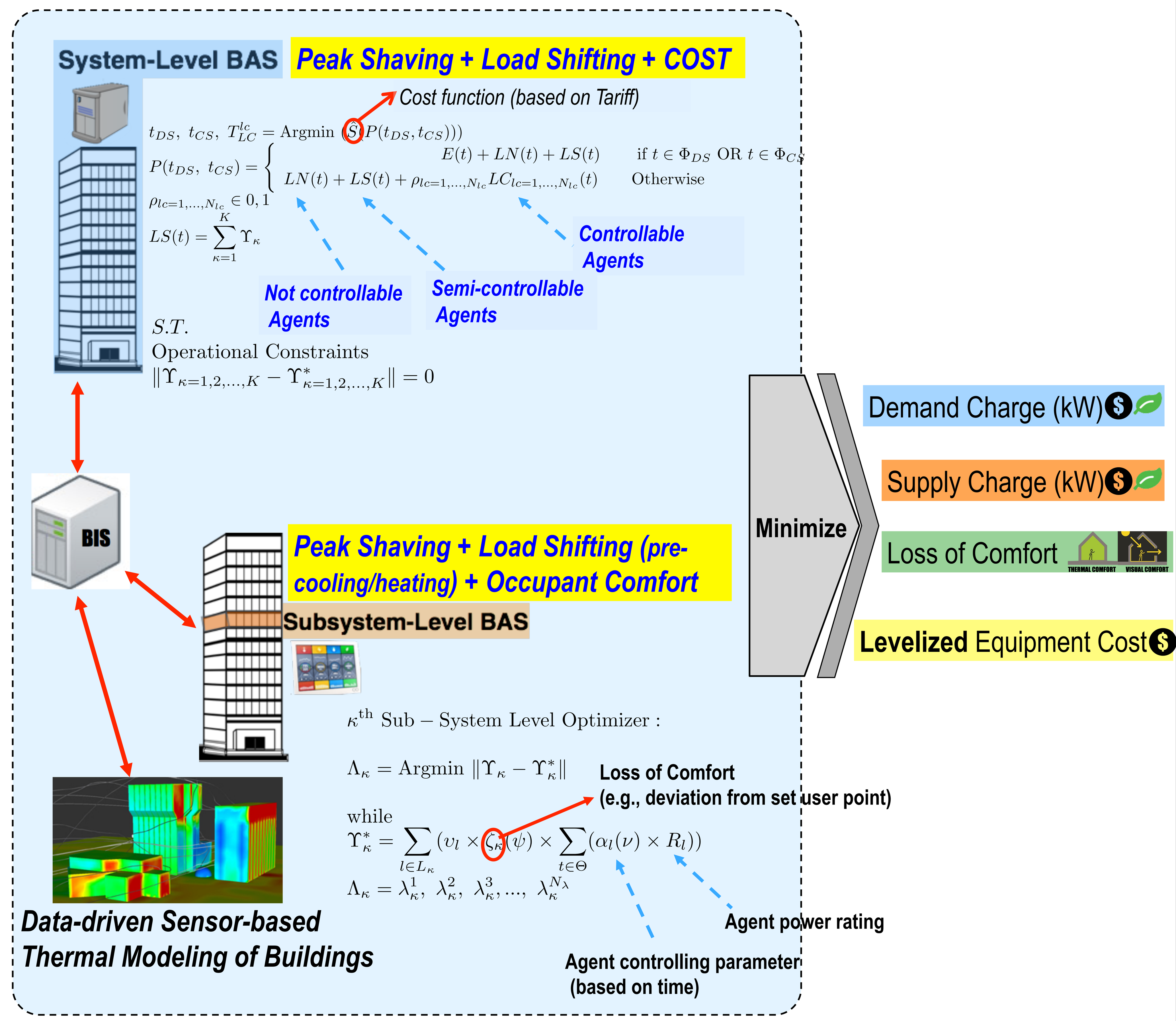
S.T.
Operational Constraints

Recommended Effective Storage Capacity

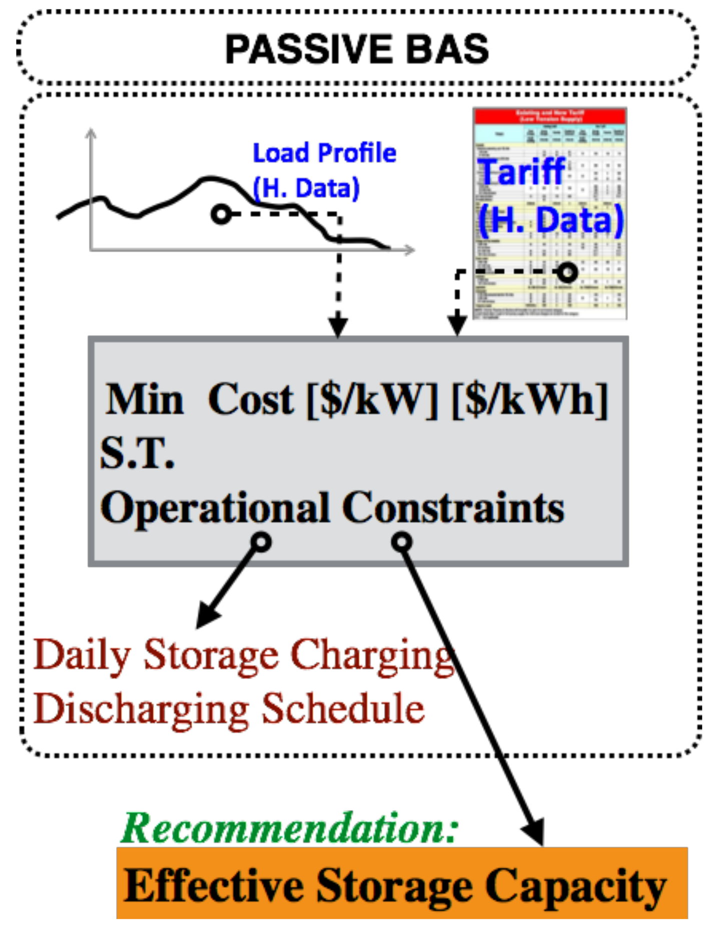


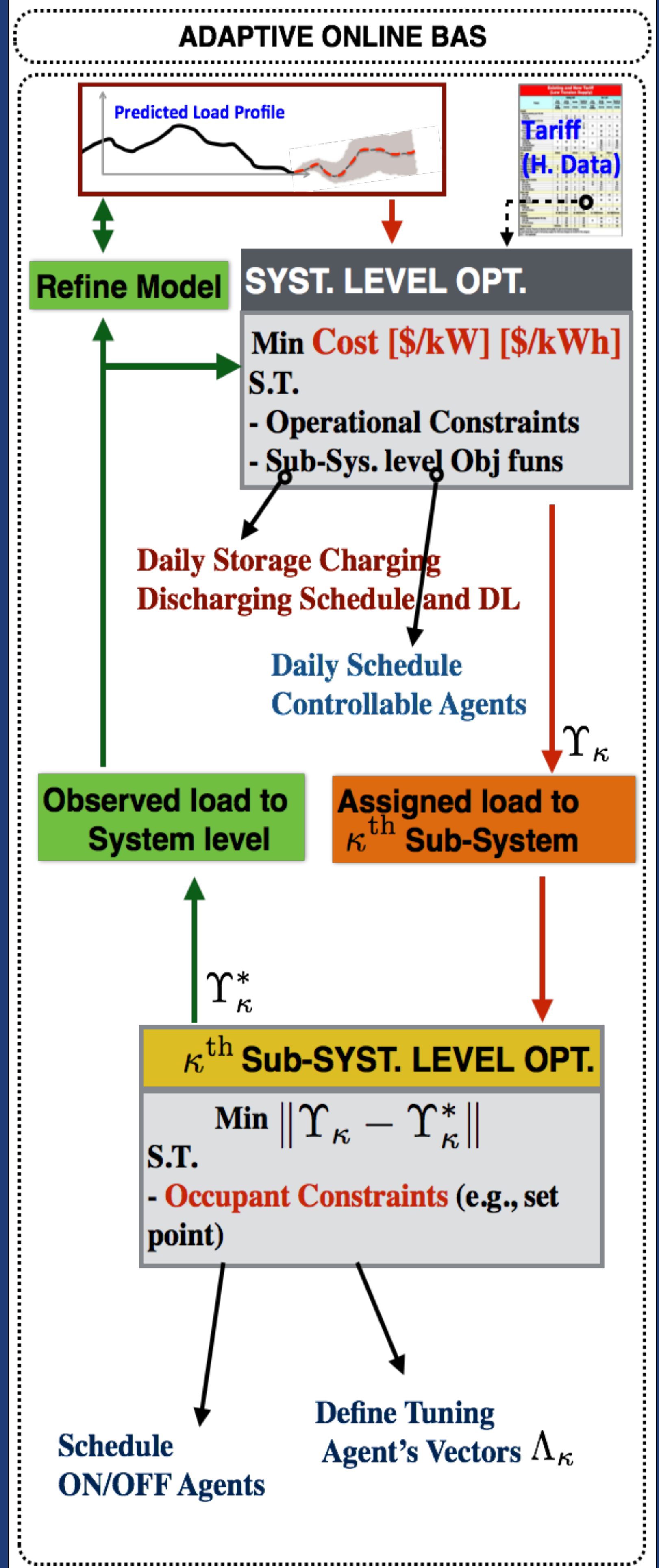
Shave Peak Demand

A.I.R. – ADAPTIVE ON-LINE BUILDING AUTOMATION SYSTEM



A.I.R. ALGORITHM





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