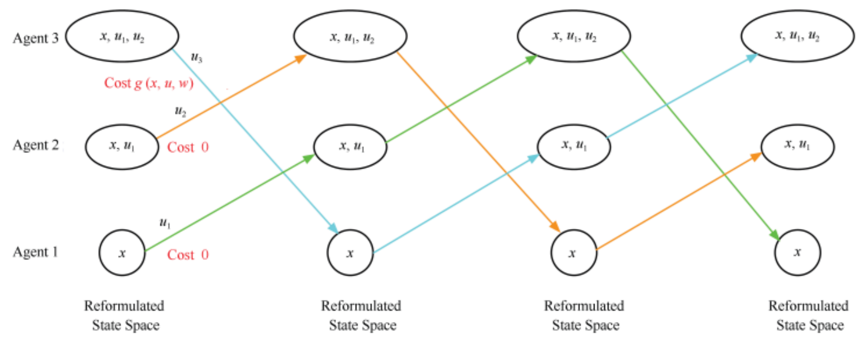
# MS Thesis Project Opportunity

Carrier Corporation

## *Distributed Reinforcement Learning for Building Energy Optimization*

**Problem Description:**




Buildings account for 40% of energy consumption globally, and saving energy in building operation is therefore an important element of advancing towards a more sustainable energy landscape. Buildings are complex due to heterogeneous physical domains (thermodynamics, electrical, mechanical), of large scale (100s of sensors and actuators) and span a large range of time constants (from seconds to years). Commissioning and tuning of high-performance controls to reach energy-efficient operation is feasible but is time consuming and require skilled experts. Reinforcement learning is a promising approach since it has the potential of adaptively and autonomously optimize energy consumption during operation. However, scaling of RL to complex systems is non-trivial. ***In this project, distributed reinforcement learning methods will be explored to apply RL to energy optimization in buildings.***

**Project Description:**

The key objective of this thesis is to understand how distributed RL methods can be used to tune regulatory control loops in buildings to optimize building energy efficiency. Examples of targets include commercial buildings, data centers and residential buildings. While different in scale and load patterns, they all share the challenge of controlling energy flows from sources to sinks, and to maximally use storage (e.g., car batteries or ice storage) to reduce cost, energy consumption and carbon footprint. Key questions of interest in this thesis project are:

- How to apply a distributed computation model for reinforcement learning to separate out building control loops, including compressor speed, valves, dampers, use of storage etc?
- How much data is needed to train distributed RL algorithms?
- How much energy can be saved compared to traditional building control systems.

The project will also include to use and refine dynamic Modelica building models constructed from the open-source Buildings Library developed by Lawrence Berkeley National Laboratory, as well as regulatory control systems that are common in building system operation. Numerical experiments (Python, Julia, Jupyter notebooks) will be used to carry out the mathematical analysis to assess the scaling potential distributed reinforcement learning.

A stretch goal is to understand and carry out Software in the Loop (SIL) methods using distributed RL methodology with Carrier Automated Logic building control software.

The student(s) will work closely with Carrier engineers that are experts in chiller systems and chiller systems modeling.

**Student profile:**

Skilled students with interest in machine learning, automatic control, physics of energy equipment, optimization, and programming. Experience with thermofluid systems, Python programming, and numerical methods for optimal control will be beneficial.

**Supporting team:**

- Johan Åkesson (lead Carrier advisor and point of contact)
- Clas Jacobson (Carrier Senior Fellow Systems and Controls)
- Bo Bernhardsson (lead LTH point of contact)
- Liang Chang (Group Leader, Controls at Carrier)
- Carl Laird (CMU Professor — optimization and ML/AI)

Carrier has recently opened an office in Lund and is interested in hiring students from successful MS Thesis projects.

**References:**

[Ber20] D. Bertsekas. Rollout, Policy Iteration, and Distributed Reinforcement Learning. Lecture Notes ASU. Feb. 2020.

[Ber23] D. Bertsekas. A Course In Reinforcement Learning. http://www.mit. edu / ~dimitrib / RLbook.html. Athena Press, 2023.

[CMM22] Flora Charbonnier, Thomas Morstyn and Malcolm D. McCulloch. 'Scalable multi-agent reinforcement learning for distributed control ofresidential energy flexibility'. In: Applied Energy (2022)