Model predictive control, MPC
Model predictive control is one of the control methods and is close to the concept of feedforward control. While feedback control determines the control input based on the past information, in MPC, control input is decided based on the future status predicted by the model, so that the object is optimized through a certain period in the future.

Research purpose
The purpose of this study is to compare MPC with conventional rule-based control (RBC) and confirm the effect of MPC application. Artificial neural network was used as prediction model which predicts the behavior of the building in order to reduce the iterative optimization calculation load.

Condition of simulation analysis
Eight-story office building located in Tokyo was assumed. Air conditioning was performed only in the work space, and was modeled as one lumped thermal zone.

Building
- Tool: OpenStudio, EnergyPlus
- U-value: Exterior wall 0.95 W/m²K, Roof 0.49 W/m²K, Slab 0.71 W/m²K, Glazing 2.97 W/m²K
- Occupied hours: 9:00 – 18:00, weekdays
- HVAC: Maintain cooling setpoint temperature 26 °C at occupied hours

System
- Air-cooled chiller
- Stratified chilled water thermal energy storage
- Two fan coil units
- Three fluid to fluid heat exchanger
- Five variable speed pumps

→ Control variables are mass flow rate of five variable speed pumps

ANN prediction model
Total four ANN prediction model was made, and the prediction targets of each ANN are: ① Room temperature, ② Temperature of top and bottom layer inside the TES, ③ Inlet and outlet temperature of chiller, ④ Energy consumption of chiller

Figure 1. Comparison of feedback control and model predictive control

Figure 2. Target building of simulation analysis

Figure 3. Building energy systems of target building
Development of Model Predictive Control Method using ANN and Metaheuristics
Application to Cooling Operation of Building Energy Systems with Thermal Energy Storage (2)

**Optimization problem**

Optimization method: Epsilon constrained differential evolution random jumping (εDE-RJ)

\[
J_S = \sum_{t=1}^{t_H=24} \{(C_{\text{chiller}}^t + C_{\text{pump}}^t) \cdot P^t\}
\]

Minimize \(J_S(m_{p1}, m_{p2}, m_{p3}, m_{p4}, m_{p5})\)

Subject to

- \(T_{\text{zone}} \leq 26^\circ C \text{ at 09:00 ~ 18:00}\)
- \(m_{p1}, m_{p2} \leq 10.86 \text{ (kg/s)}\)
- \(m_{p3}, m_{p4}, m_{p5} \leq 8.22 \text{ (kg/s)}\)

\(C_{\text{pump}}^t \text{ (kWh)} = 0.2555 \cdot m_{pump}^t\)

- \(C_{\text{chiller}}^t \text{ (kWh)} \)
- \(C_{\text{pump}}^t \text{ (kWh)} \)
- \(P^t \text{ (yen/kWh)} \)
- \(m_{pump}^t \text{ (kg/s)}\)

- Room temperature \(T_{\text{zone}}\) \(\text{ (°C)}\)

**Condition of case study**

Case study was conducted to compare RBC and MPC scheme. In RBC scheme, TES is fully charged with 10.86 kg/s at unoccupied hours and discharged with 8.22 kg/s at occupied hours, then chiller operates when charged heat amount of TES is not enough to handle the zone cooling load.