NSERC Smart Net-Zero Energy Buildings Strategic Research Network

Réseau de recherche stratégique du CRSNG sur les bâtiments intelligents à consommation énergétique nette zéro

Optimized Control Strategies For Solar District Heating

NSERC CRSNG

Project 4.3: Smart operating strategies for net-zero energy solar communities

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OBJECTIVES

- Develop new control strategies for solar communities by using Model Predictive Control (MPC) in order to increase the energy efficiency and the economical and environmental performance
- Assess impact of optimizing controls during the design phase

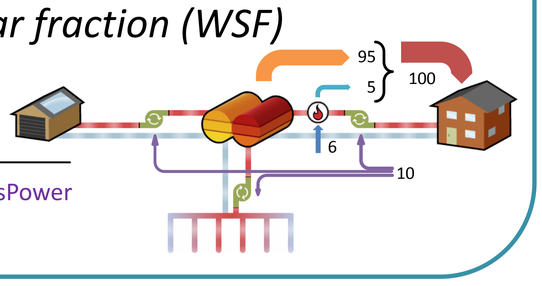
RESEARCH QUESTIONS

- Can MPC increase the solar fraction of a given system?
- Can the MPC potential be realized using simplified models and available weather forecasts?
- Can improved controls still increase the solar fraction by anticipating cold / cloudy spells?

METHODOLOGY

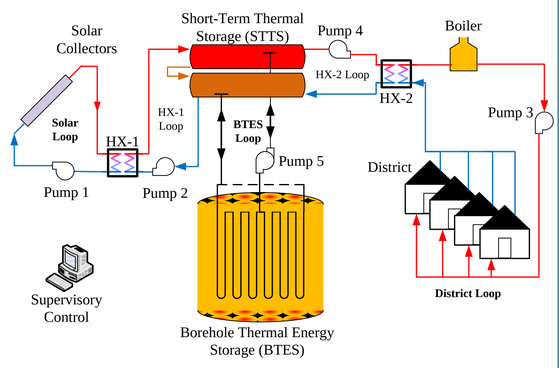
- Calibrate a detailed TRNSYS model of the existing system
- Compare standard and MPC based control strategies using the simulation model
- Take into account electricity consumption for the calculation of a *Weighted solar fraction (WSF)*

$$WSF = \frac{\text{SolarEnergyToDistrict}}{\text{SolarEnergyToDistrict} + \text{Gas} + 3*\text{PumpsPower}}$$

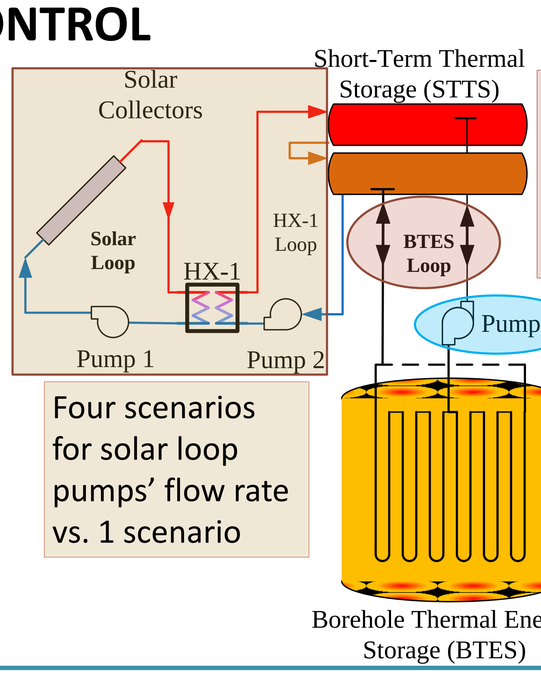


CASE STUDY: Drake Landing Solar Community (DLSC)

- Centralized space heating for 52 homes
- 2290 m^2 of solar collectors, 240 m^3 of short-term thermal storage (STTS), Borehole Thermal Energy Storage (BTES): 144 35m-deep boreholes as *seasonal* storage



PROPOSED CONTROL vs. STANDARD (STD) CONTROL



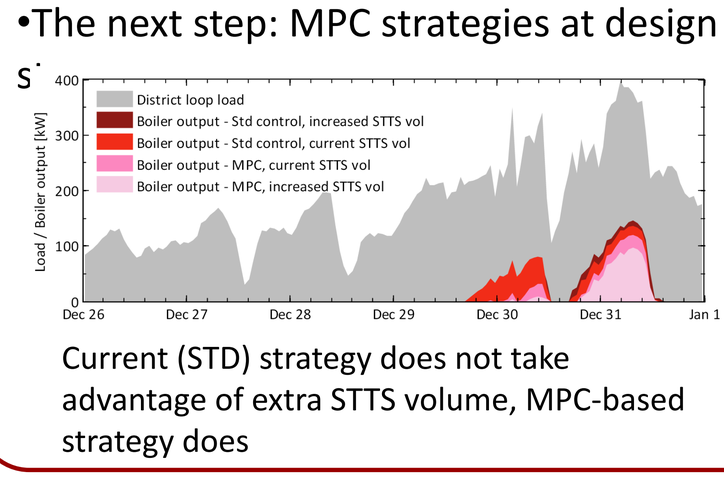
Force BTES discharge based on weather forecast s vs. BTES discharge= f(STTS charge level, STTS charge required)

Four scenarios for solar loop pumps' flow rate vs. 1 scenario

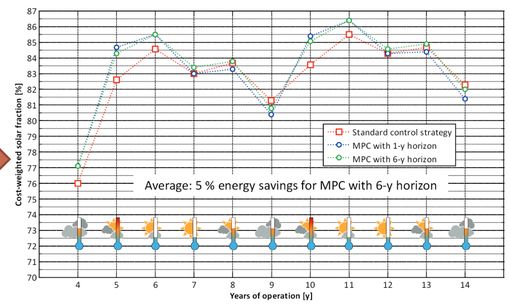
Modulate BTES loop pump flow rate based on weather forecasts vs. Manual/constant flow rate

RESULTS

- Comparing Standard (STD) strategy to Proposed MPC strategies for the period: Feb 4th - 7th, 2011



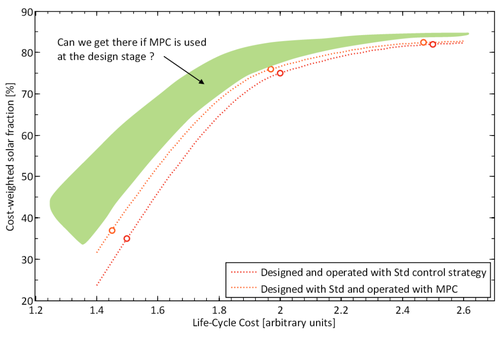
Weighted Solar Fraction over the optimization period



Average annual energy savings close to 5% with weighted (3x) electricity consumption!

- The next step: MPC strategies at design s

Current (STD) strategy does not take advantage of extra STTS volume, MPC-based strategy does



CONCLUSIONS

- Calibrated TRNSYS model is accurate enough to test and analyze the impact of the proposed MPC control strategies
- Advantage of having a detailed, component-based model: new designs can be optimized
- Practical approach based on look-up tables adds to existing rules but does not replace them
- Modest primary energy savings (5 %), but reference strategy builds on expertise gained over 5 years of operation

FURTHER WORK

- Develop simpler and faster models for applying online MPC to solar district heating systems
- Determine if more cost-efficient configurations can be obtained if optimized controls are included during the design simulation

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