SYSTEM INTEGRATION OF LATENT HEAT THERMAL ENERGY STORAGE FOR COMFORT COOLING INTEGRATED IN DISTRICT COOLING NETWORK

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Objectives

- Optimize storage strategy for load shifting to cut down peak hour energy use.
- Perform a case study of an office building load profile optimization located in Stockholm.
- Study economic feasibility of a CTES system upon integration with an existing district cooling network.
- Benchmark against

  -stratified chilled water storage

  -independent auxiliary chiller based cooling units

Model Inputs

- Cooling Load:
  - 120-hour load data
  - peak thermal load 271kW/ average 139kW
- Salt Hydrate PCM, S13:
  - phase change temperature 13°C
  - heat capacity 140kJ/kg (208MJ/m³)
  - 130€/kWh
- Heat Exchanger:
  - extended finned heat exchange model with heat transfer coefficient of 120 W/m².K
- Tank cost: 350€/m³ to 1460€/m³
- Etc.

Model Schematics

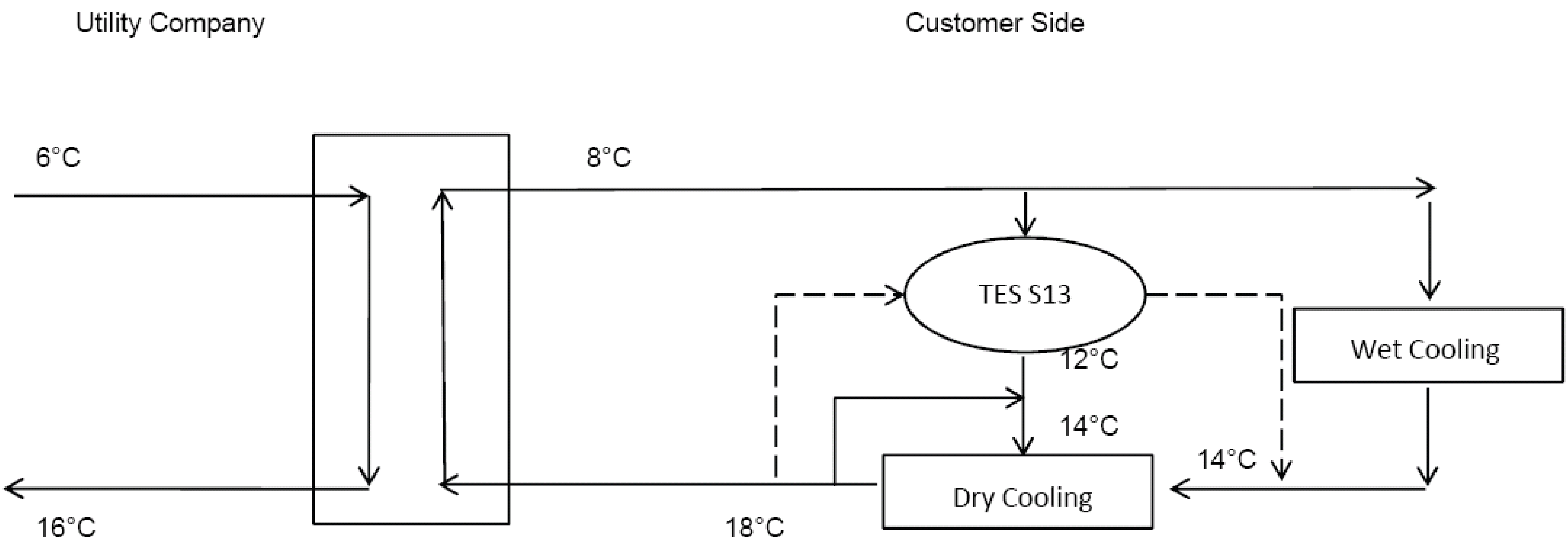

Figure 1 Schematics of TES Charging (continuous line) and Discharging (dashed line)

Model
Efficiency Factors

- Temperature efficiency : penalty on too low temperature returned to the district cooling net.

$$\eta_{temperature} = \frac{12 - 8}{18 - 8} = 40\%$$

- Charging/discharging efficiency : heat transfer limitation between the PCM and the HTF.

$$\eta_{charging/discharging} = 80\%$$

- PCM cost ratio : "the cost of PCM" that would allow the certain TES size to be cost effective as compared to either SCW or chiller units divided by the current market price.

$$PCM\ Cost\ Ratio = \frac{Calculated\ PCM\ Cost\ for\ TES\ to\ Break\ Even}{Market\ PCM\ Cost}$$

Results
Control Strategy

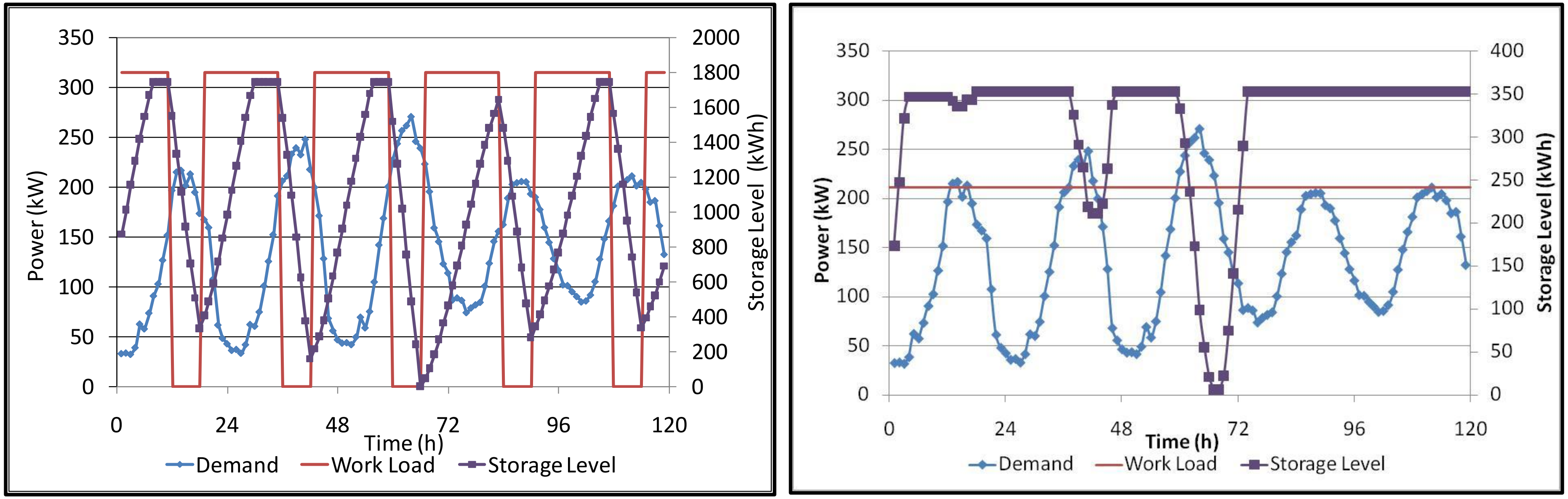

Figure 2 Control Schemes for Office Building: Full Storage (left) and Load Leveling with Peak Power Reduction of 60kW (right)

- The optimum control strategy for alleviating load from district cooling network where opportunity cannot be taken from day/night tariff difference was found to be the load leveling control scheme.

Results
Cost Break Down

- At cost breakeven point between SCW TES and PCM TES (13kW)
  - ➢ tank and PCM price on the overall TES economics
  - ➢ impact of space depends on space availability of sites

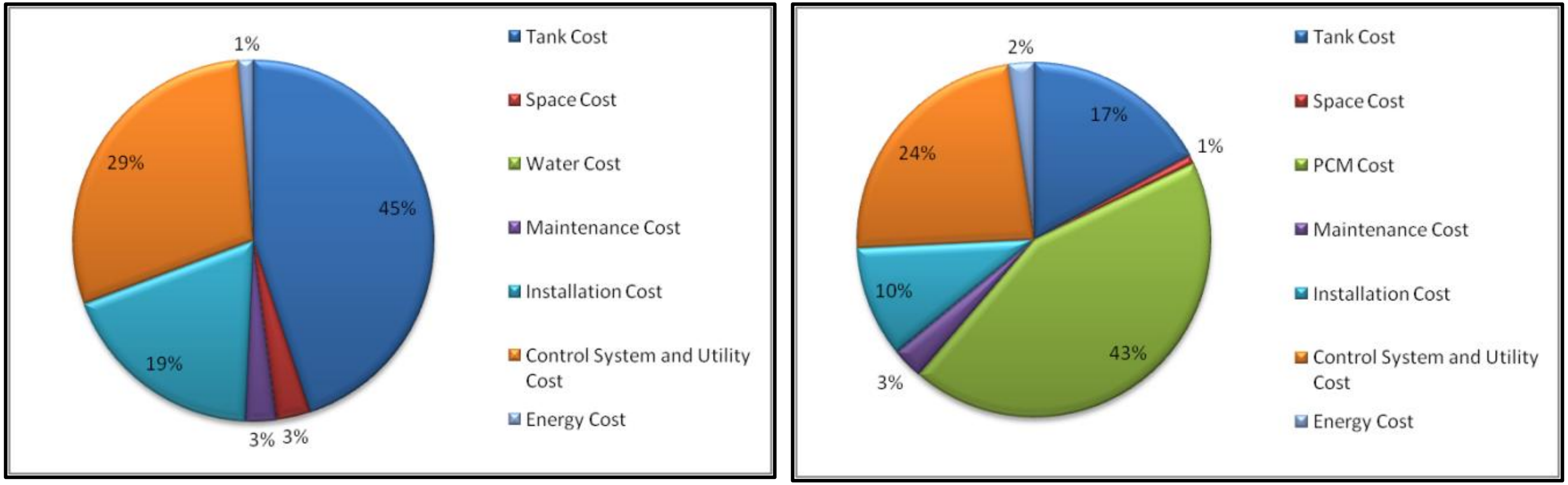

Figure 3 Cost Distribution of SCW TES (left) and PCM TES (right) at Power Reduction Rate of 13kW

Results
PCM LHTES System Analysis

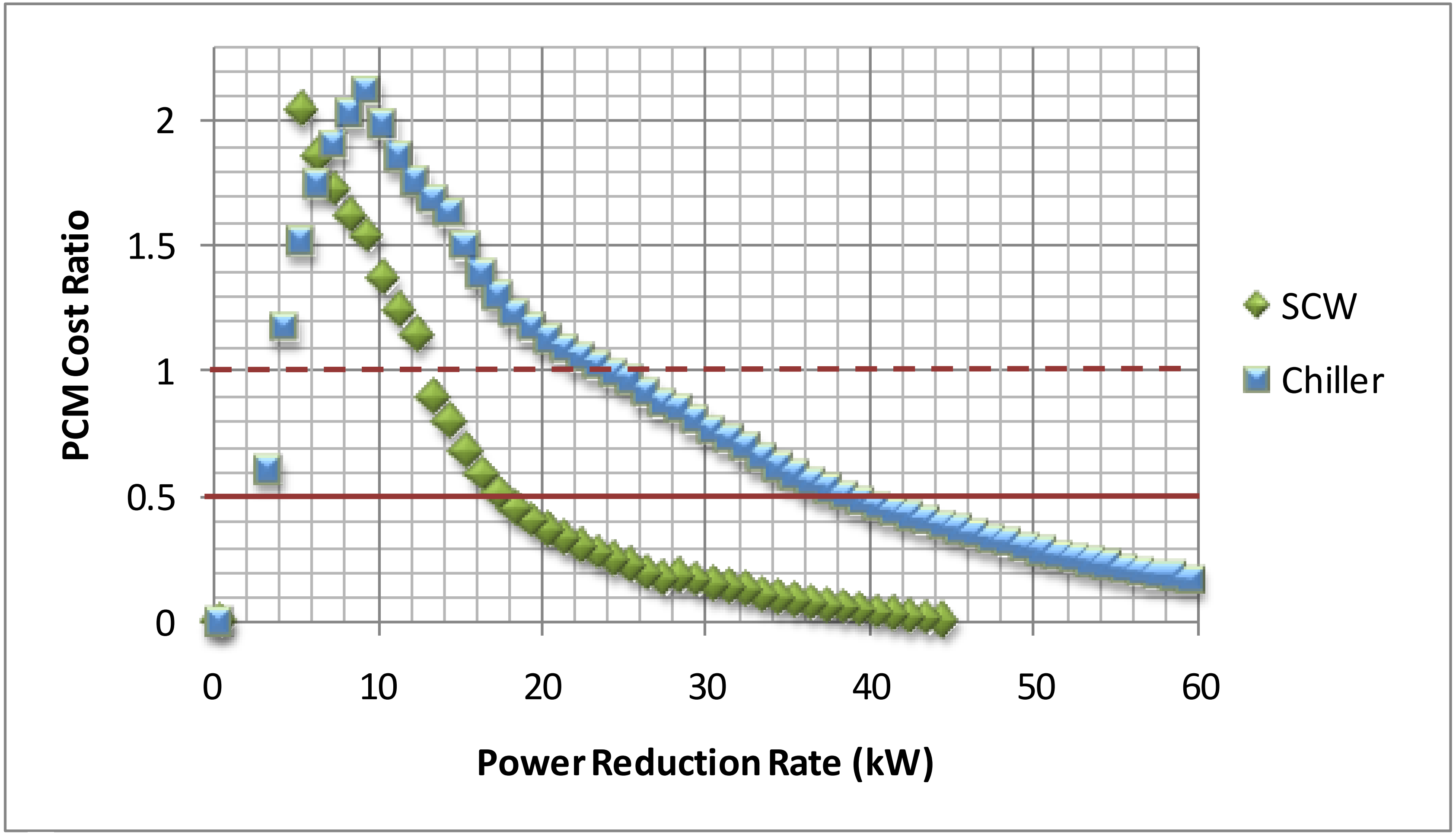

Figure 4 Profitability Analysis with Low Return Temperature Penalty

Results
PCM LHTES System Analysis

•PCM based TES breaks even with SCW at power reduction rate of 13kW which corresponds to 5% peak power rate and it is economically competent against chiller units in the range of 4kW to 24kW (1% to 9%) peak power reduction.

Table 1 Cost Effective Peak Power Reduction

	Peak Power Reduction Absolute Value		Peak Power Reduction Percentage	
	SCW	Chiller	SCW	Chiller
Penalty/ No Cost Reduction	<13kW	4kW-24kW	<5%	1%-9%
Penalty/ 50% Cost Reduction	<18kW	4kW-39kW	<7%	1%-14%
No Penalty/ No Cost Reduction	<24kW	4kW-31kW	<9%	1%-11%
No Penalty/ 50% Cost Reduction	<81kW	4kW-59kW	<30%	1%-22%

Conclusions

- ✓ Load leveling control scheme is the most appropriate for fixed tariff district cooling network.
- ✓ Full storage is economically feasible only if off-peak energy cost saving justifies the investment cost.
- ✓ Breakthroughs are required in material development to further minimize subcooling.
- ✓ Eliminate of low return temperature penalty.
- ✓ Lower PCM cost.

→ 22% to 30% peak load power reduction may be achieved economically.

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Thank you