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# Principles for saving energy with dynamic thermal storage

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# Agenda

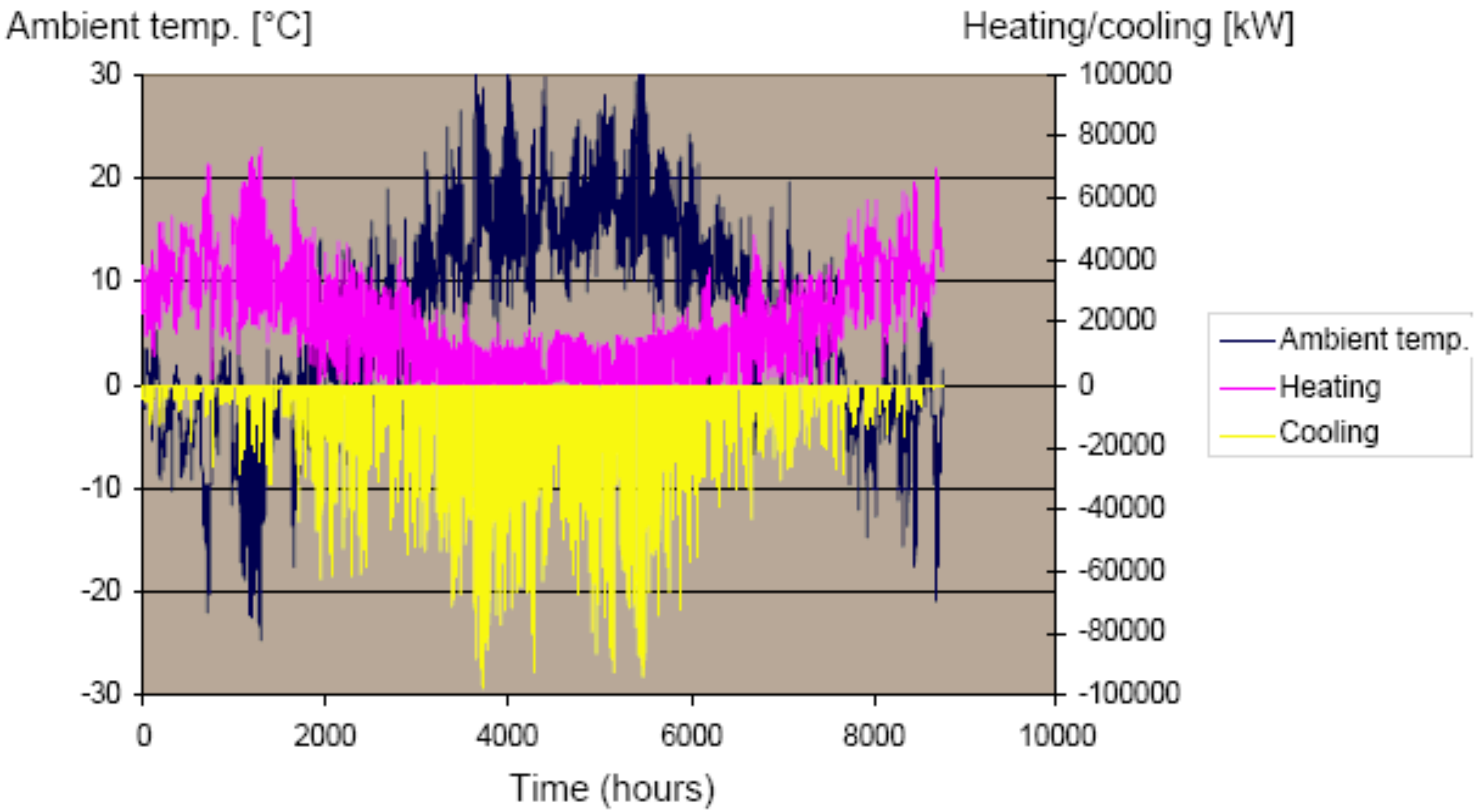
- Not Used Energy (NUE) or Negawatts
- Energy from variation in temperature
- A systems approach
  - Transfer and storage of heat and cold
  - Dynamic thermal storage (DTES)
  - Synergy with borehole thermal storage (BTES)
- Saving energy
  - Saving when available for use when needed
  - Getting rid of excess heat at night
- Economic savings (from off-peak electric tariffs)

# Not Used Energy (NUE) / Negawatts

- Advantages:
  - Reduced $CO_2$ or increased utility through ”rebound”
  - Energy available to others
  - Elimination of all upstream losses
  - Free energy (for ever) once facilities are paid for
- Innovation:
  - Macroeconomic gain relative to power plants and burning of fuels
  - Convertible to saleable commodity through societal measures similar to $CO_2$-quota systems

# Measured Heating and Cooling Demands

*Example – Heating and Cooling of a Hotel (Oslo)*

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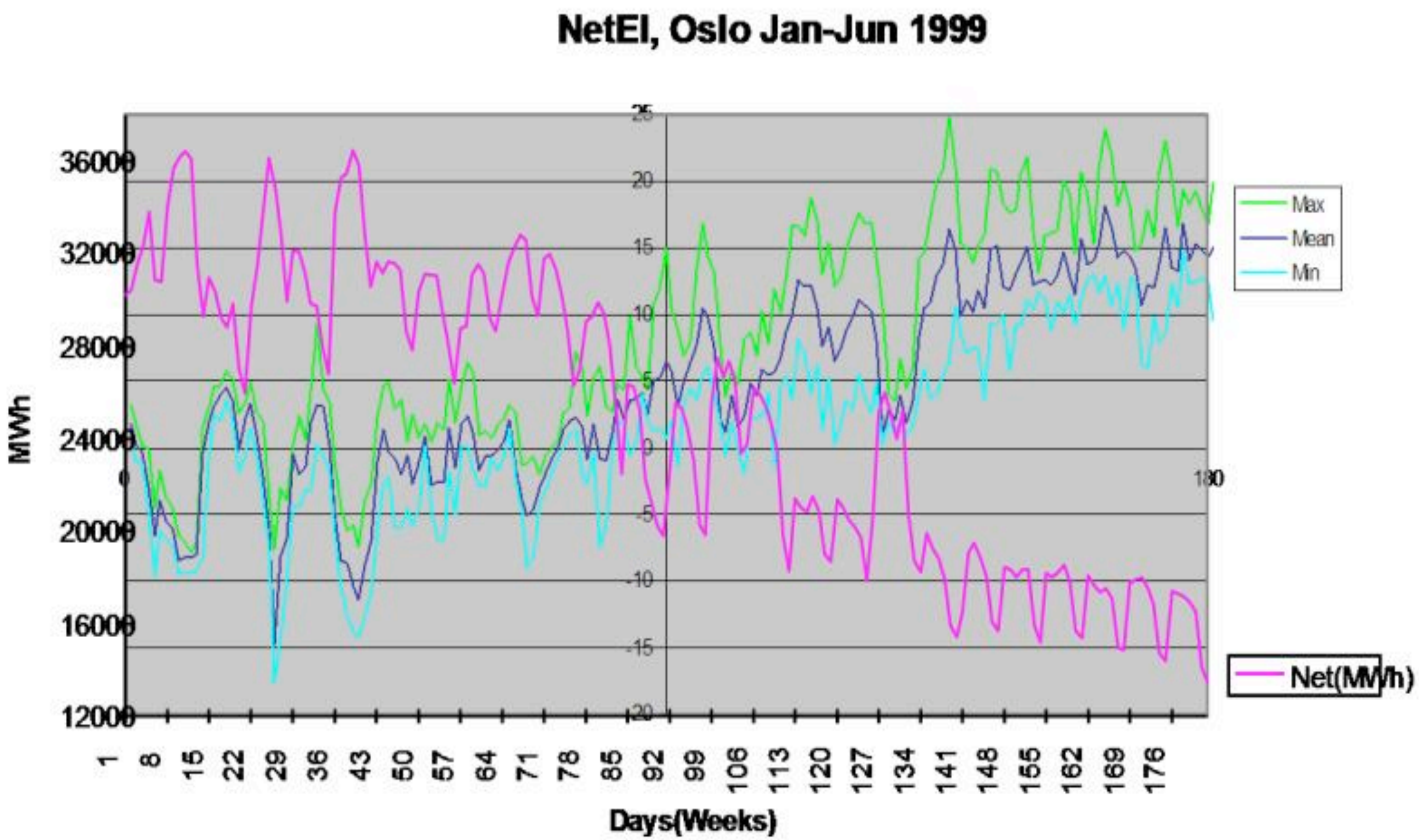
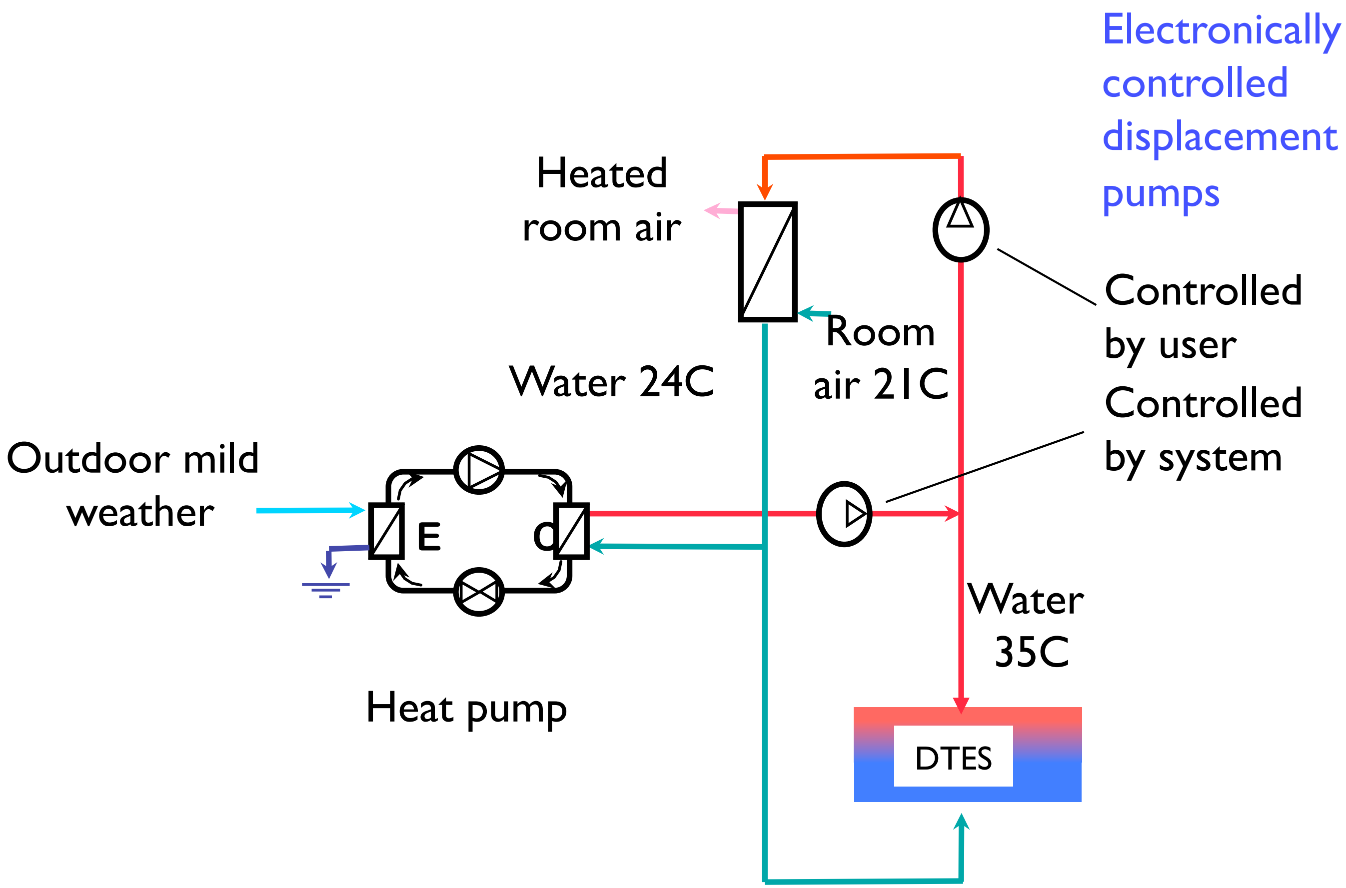
# Temperature variation and demand for electric power

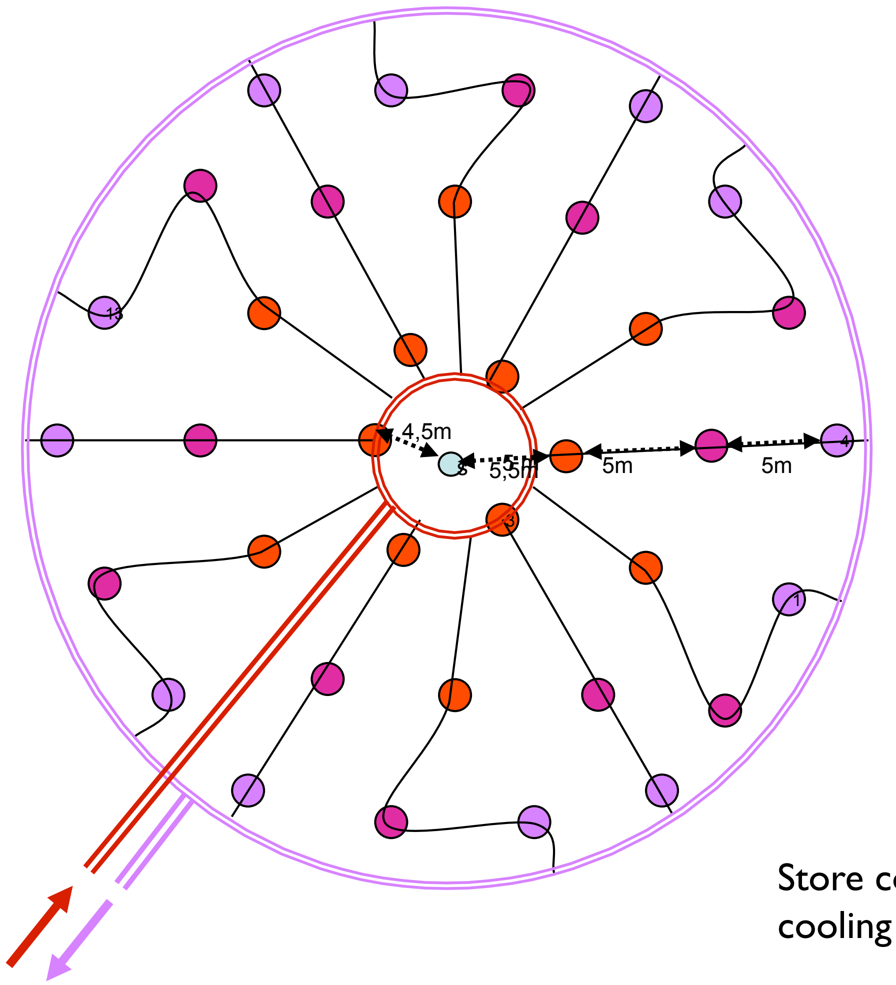
## Oslo, January – June



# Principal integration of dynamic thermal storage (DTES) into buildings



# Borehole thermal storage (BTES) for large capacity and regeneration




Store cold in centre for cooling in warm climates

Reverse direction of flow for retrieval of heat

# Transfer of heat/cold

The importance of efficient heat exchange - with heat pumps we pay for every degree

## Transferred heat:

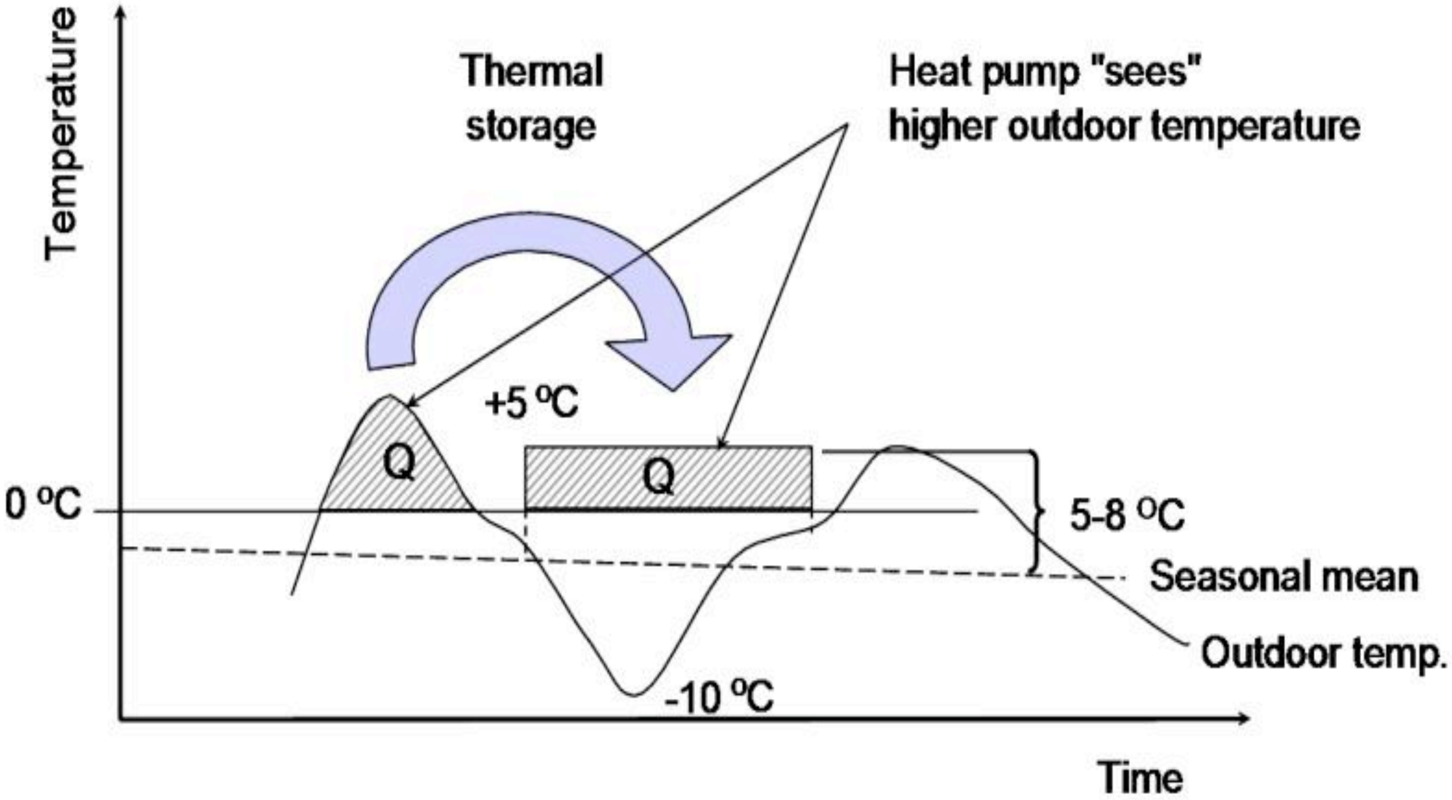
$Q = c_v * m * (t_2 - t_1)$

$c_v$ = spec. heat of transfer medium
m = mass of transfer medium
$(t_2 - t_1)$ = temperature drop in transfer medium from source to delivery.

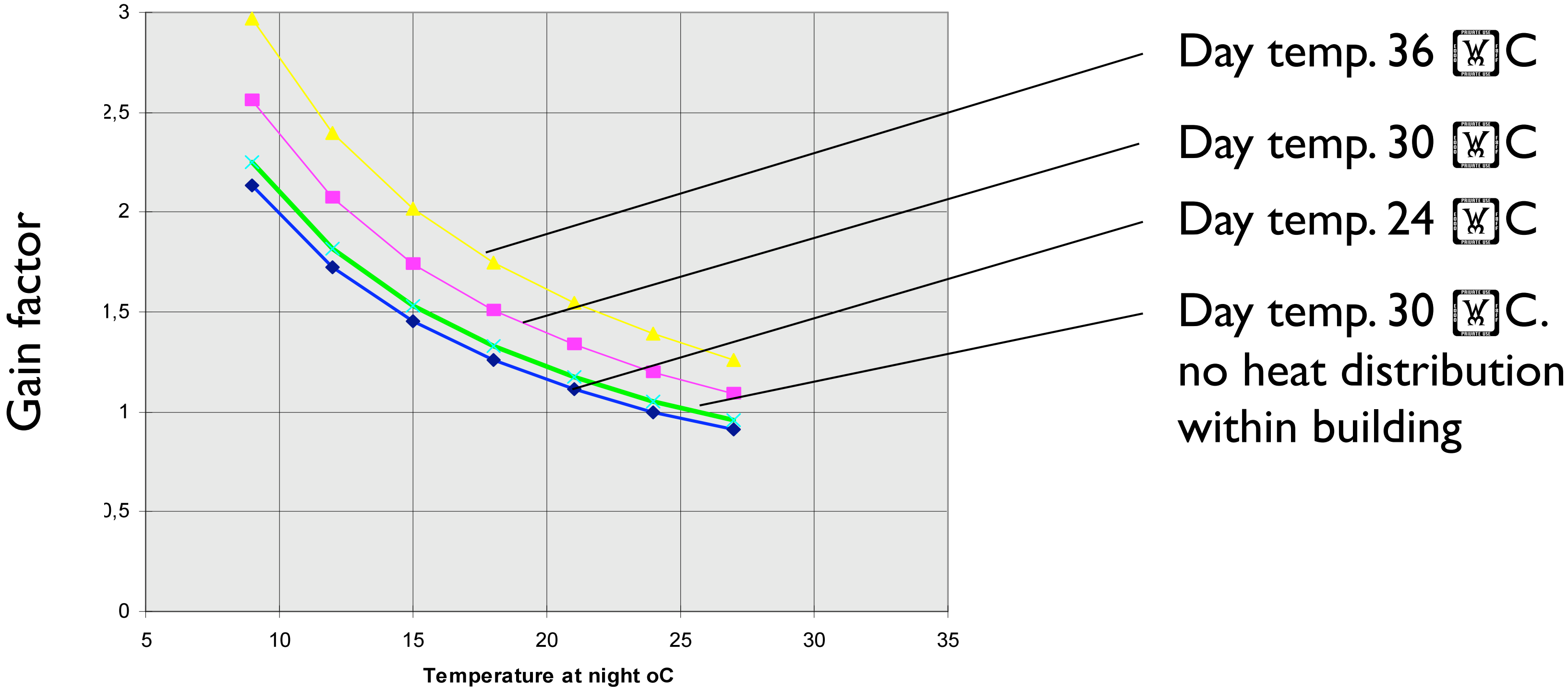
## Energy lost in transfer:

There is a temperature drop in the heat exchanger from source to transfer medium, and a second drop from transfer medium to receiving medium. These drops should be kept low relatively to $(t_2 – t_1)$

# Using mild weather when cold

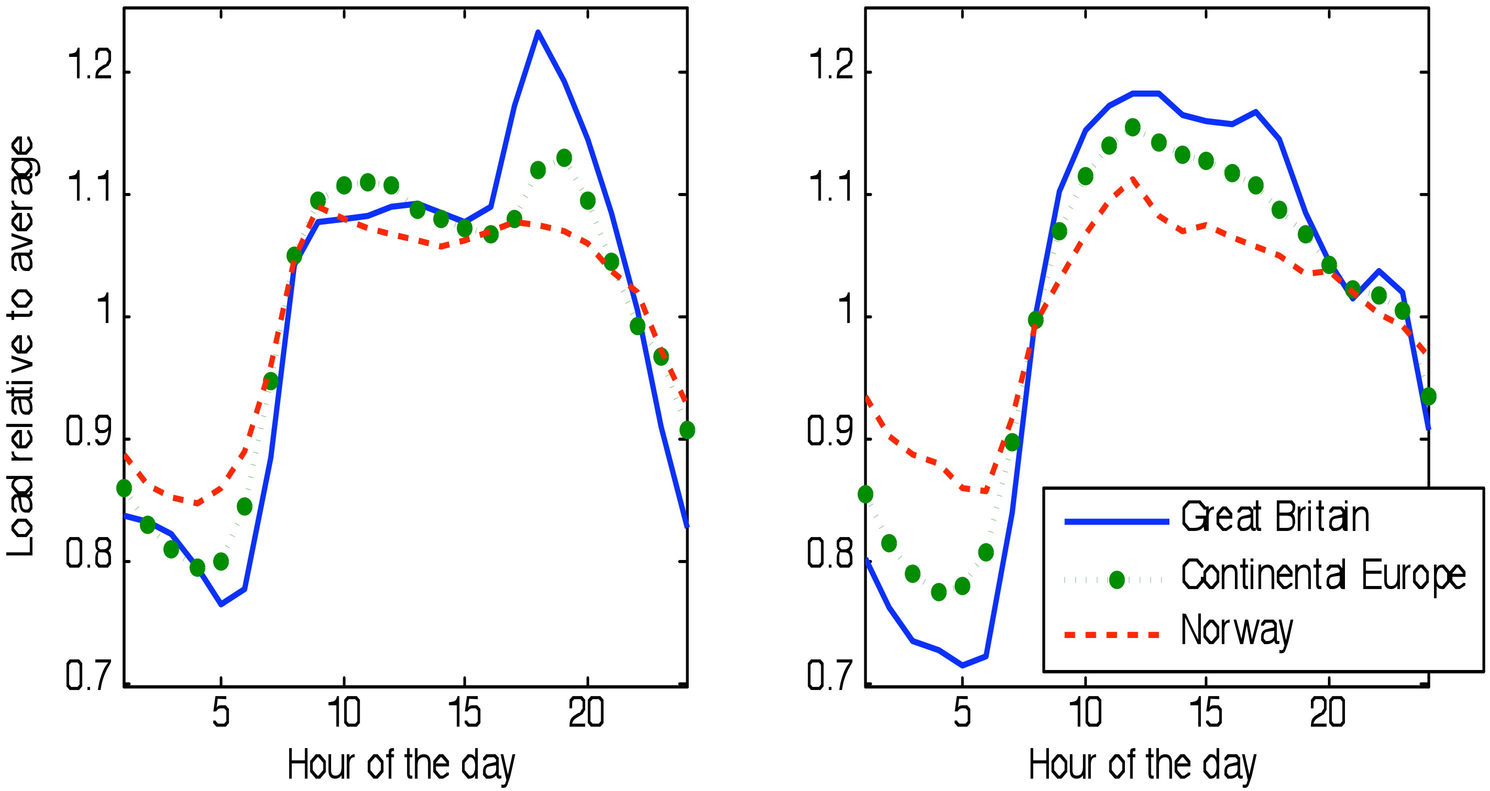


# Cooling at night for more efficient air-conditioning

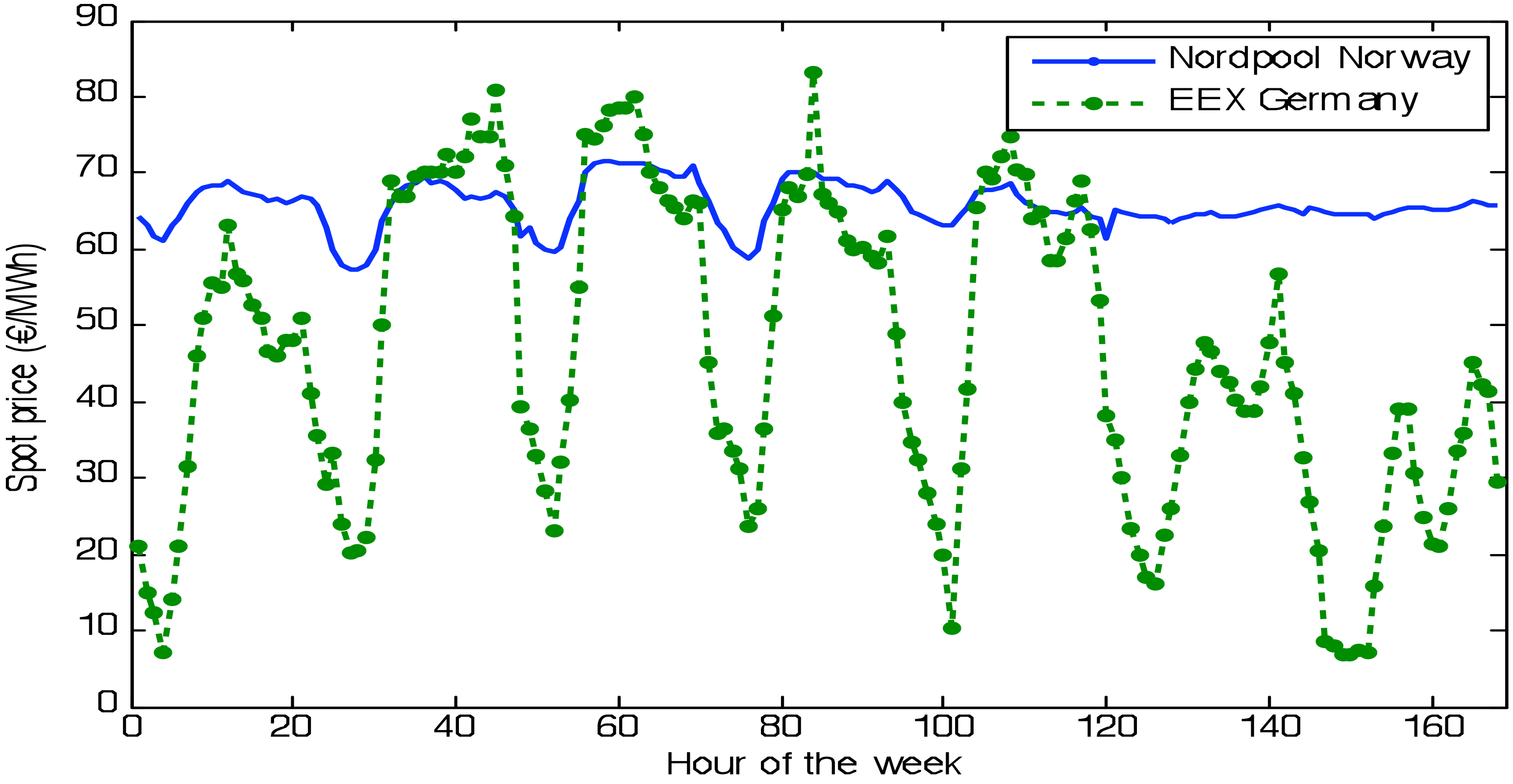



Temperature at night

# Traditional diurnal pattern of consumption of electric power



# Economic gains from using electric power at low tariffs



# Practical implementation

- Laboratory experiments confirm stable, low-loss separation of warm and cold heat transfer medium in DTES storage.
- Installation costs are presently under evaluation.
- Modelling indicates about twice the efficiency of ordinary heat pump technology.
- Ability to use night tariffs for electricity creates runtime economics of about six times that of traditional air conditioning.

# Thank you for your attention

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