1st Nordic Conference on
Zero Emission and Plus Energy Buildings
Towards carbon neutral built environments

Monitoring of Passive House and Near Zero Energy Buildings with Advanced Thermal Energy Systems Exchanging Excess Heat with Adjacent Buildings

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Ms Marie Garen Aaberg – Ingenia AS, Norway
Ms Anja Meisler – NTNU, Norway


Photo – Koteng Eiendom AS

Photo – Øystein Thommesen AS

Illustration – SiT

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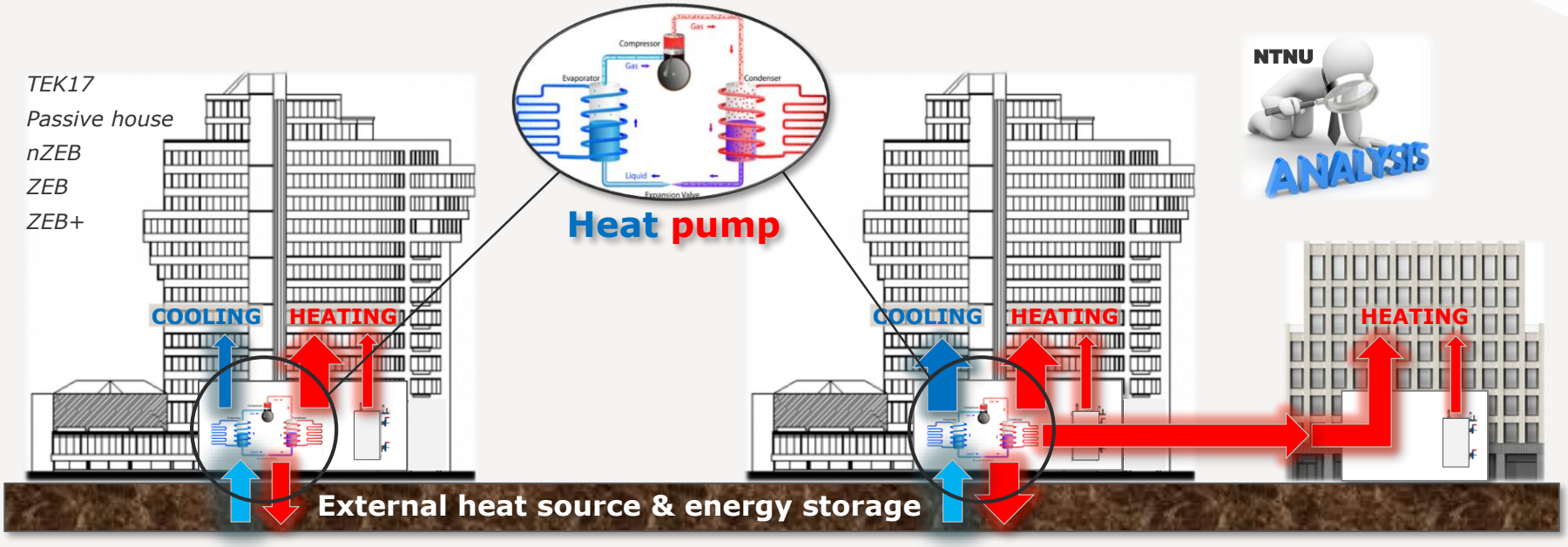
Individual Bldgs. vs. Interaction Between Groups of Bldgs.



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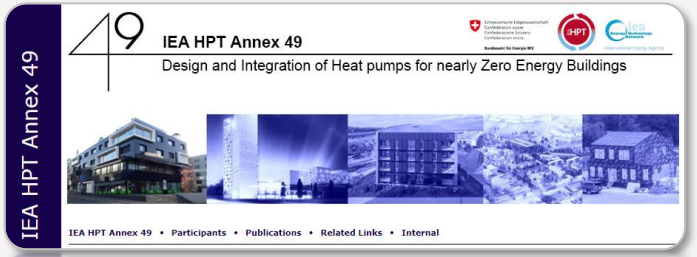
NTNU Field Measurements – Activity Implemented in:

- NTNU-SINTEF FME «Zero Emission Buildings» and «Zero Emission Neighbourhoods in Smart Cities», **FME ZEB/ZEN** (2010/16 – 2017/24)
  - http://www.zeb.no
  - https://fmezen.no

- IEA Heat Pumping Technologies **Annex 40/49** – «Heat Pumps in nZEB» (2012/15 & 2016/20)
  - https://www.annex49.net



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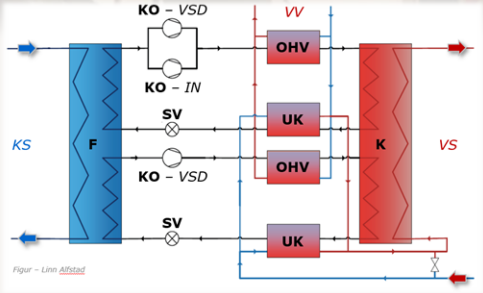
Case 1) Otto Nielsens vei 12 E – Office Bldg., Trondheim



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Case 1) Buildings – Thermal Demands and Supply

- The building (ONV12 E) – completed in 2017
  - 9100 m^2 – passive house standard + Breeam-Nor Excellent
  - Process cooling is the dominant building load (kWh/a)
- Ground-source heat pump system – heating/cooling
  - 290 kW high-efficiency heat pump unit
    - High-temperature design (max. 70 °C)
    - Designed according to the maximum cooling demand
  - BTES* – 25 x 260 m boreholes in bedrock under the building
- External heat supply to old. bldg. ONV12 A-B-C-D
  - Heat exchanger + 200 m pipeline system
  - Reduces the demand for district heating

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BTES – Borehole Thermal Energy Storage (vertical boreholes in bedrock)

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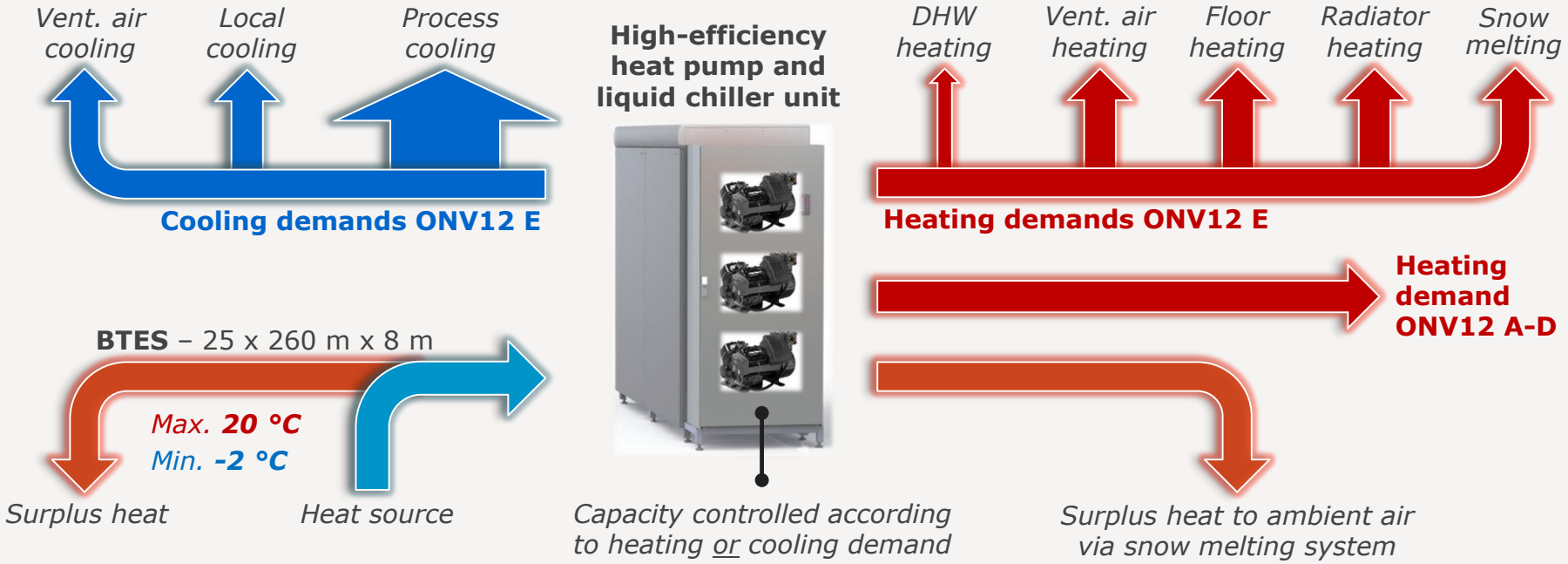
1) Principle Thermal Energy Flow Chart



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1) Transfer of Surplus Heat from ONV12 E to A-B-C-D

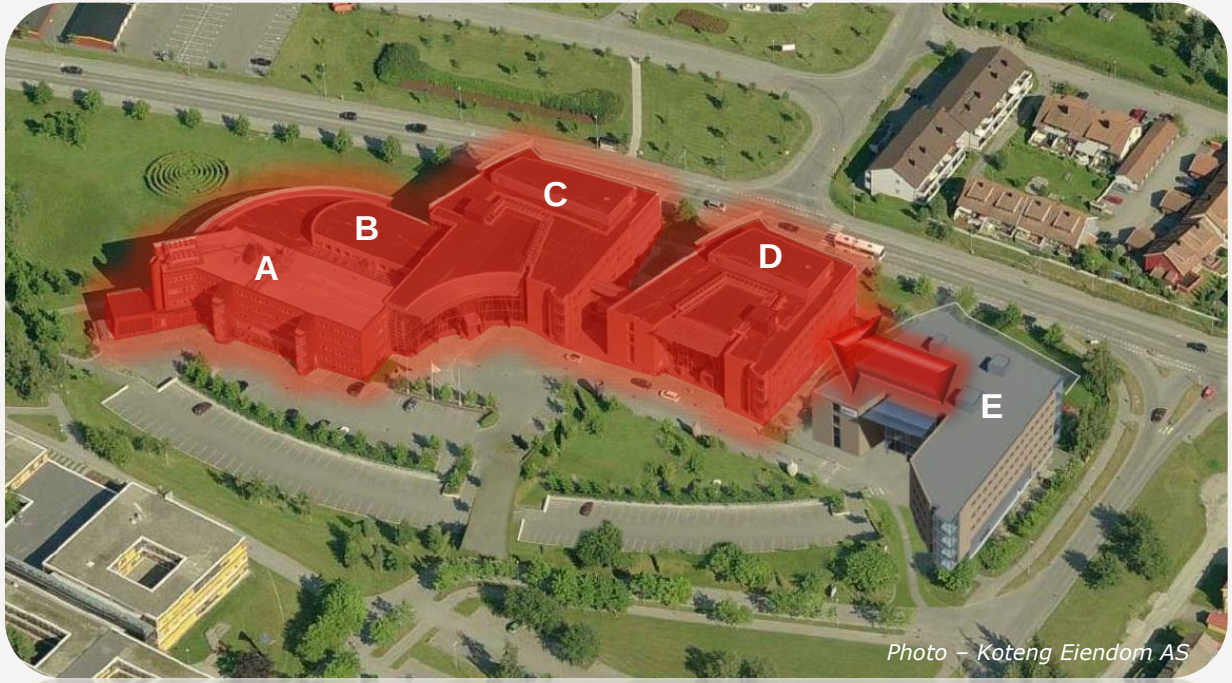

Photo – Koteng Eiendom AS

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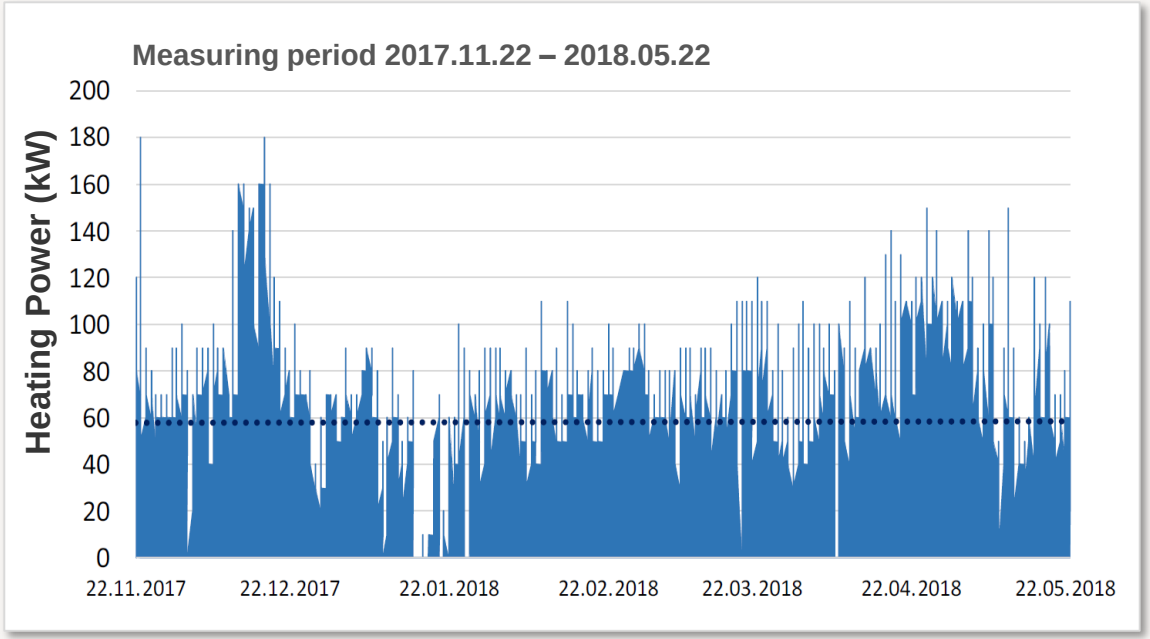
1) Measured Heat Supply to ONV12 A-B-C-D (2017-19)



Measurements – Linn Charlotte Melvik Alfstad

- Heat supply 2017-18
  - 12A-D **220.00 kWh**
- Heat supply 2018-19
  - 12E **230.000 kWh**
  - 12A-D **365.000 kWh**
- 65 % higher heat supply in 2018-19 than that of 2017-18 due to increased process cooling demand

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Case 2) KIWI Dalgård – Supermarket, Trondheim

Photo – Øystein Thommesen AS

Photo – Erik Worsøe Eriksen / Kristian Bye

Photo – Øystein Thommesen AS

2) Buildings – Refrigeration and Heat Pump Systems

- The building – completed in 2017
  - 1250 m^2 – passive house standard
- CO_2 refrigeration system
  - Standard DX system – 10 kW freezing, 59 kW cooling
  - Heat recovery to ventilation air + heat to BTES*
- Ground-source heat pump
  - 2 heat pump units x 38 kW at 4/50 °C (76 kW)
  - **BTES*** – 8 x 260 m in bedrock – thermal charging
    - Heat from refrigeration system during Spring, Summer and Autumn
  - Heating and snow melting at KIWI supermarket
  - External heat supply to 3 block of flats

Refrigeration unit

Heat pump units

BTES – Borehole Thermal Energy Storage (vertical boreholes in bedrock)

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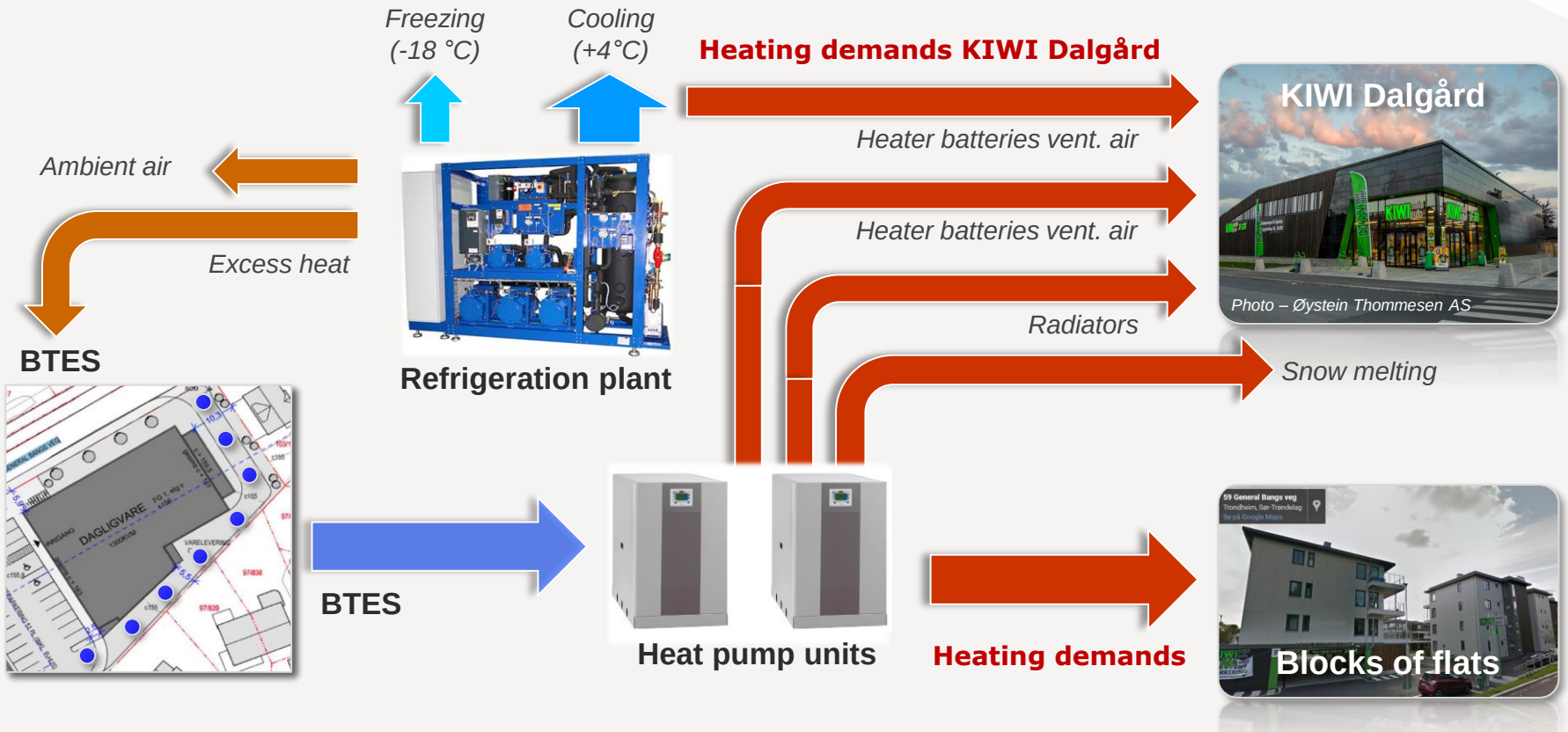
2) Principle Thermal Energy Flow Chart



2) Heat Supply to Block of Flats from KIWI Heat Pump

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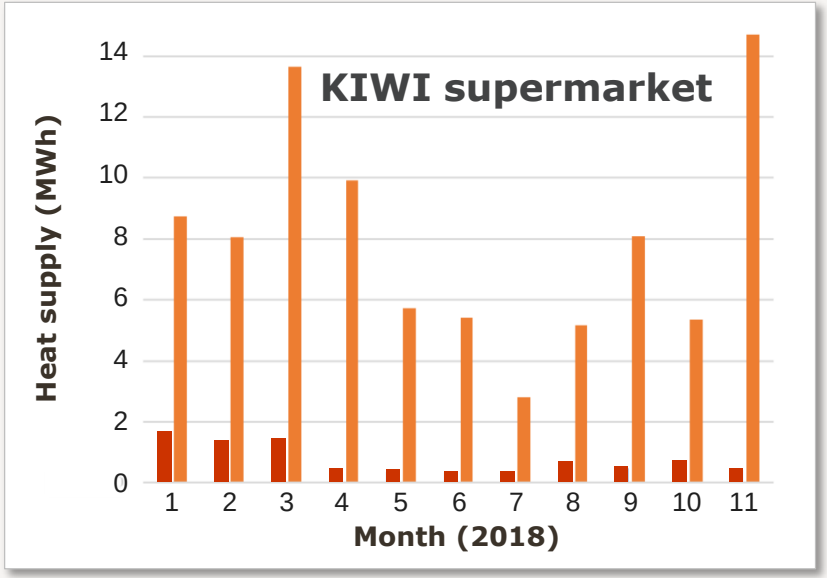
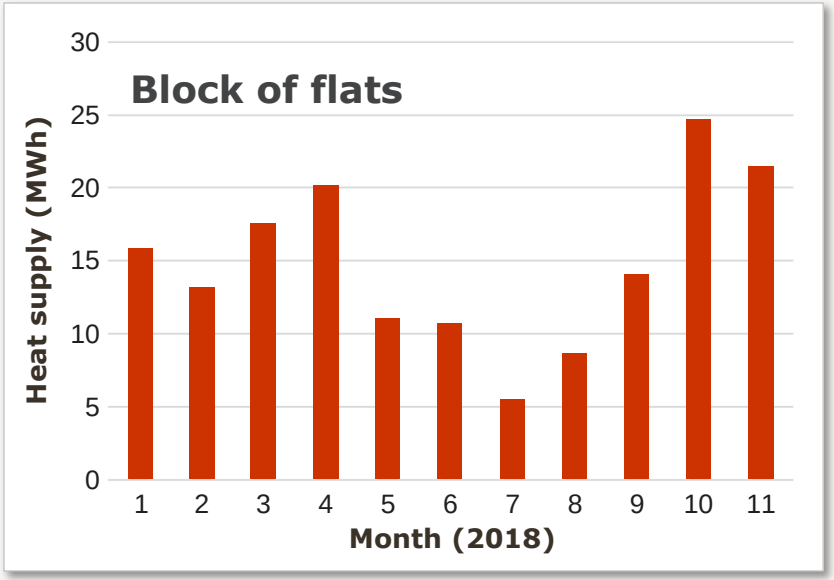
2) Measured Heat Supply to KIWI and Block of Flats

Heat supply from refrigeration system
Heat supply from heat pump



Heat supply from heat pump



Measurements – Marie Garen Aaberg

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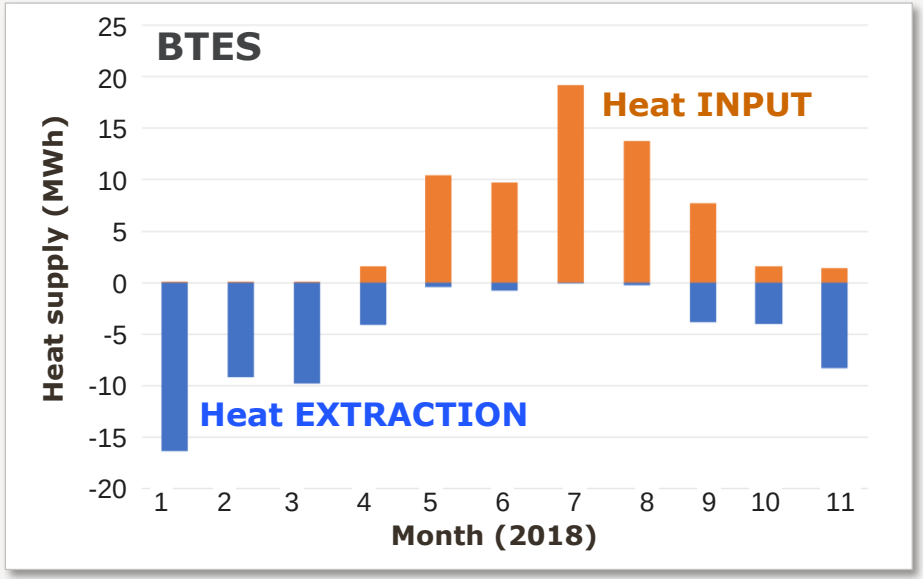
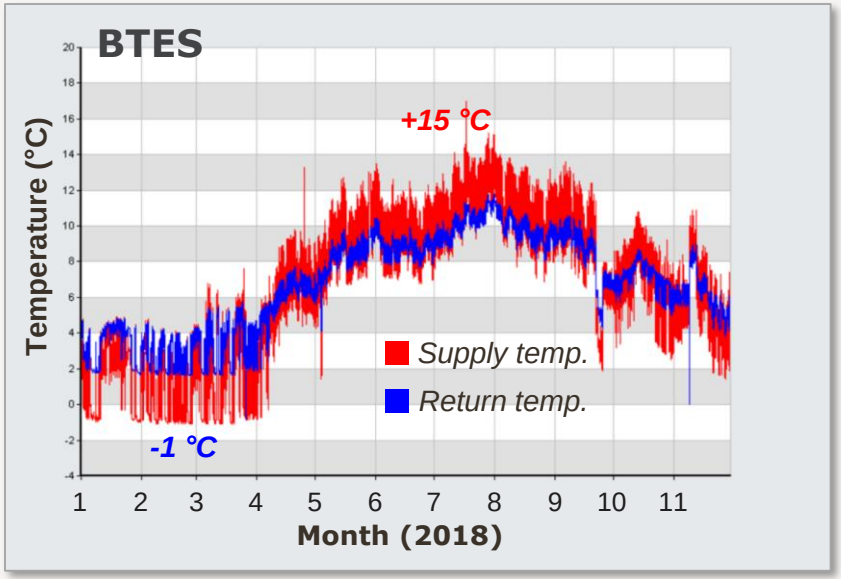
2) BTES – Measured Energy Balance and Temperatures

Heat input from refrigeration system

Heat source for heat pump (heat extraction)



Good annual thermal energy balance in BTES



Measurements – Marie Garen Aaberg

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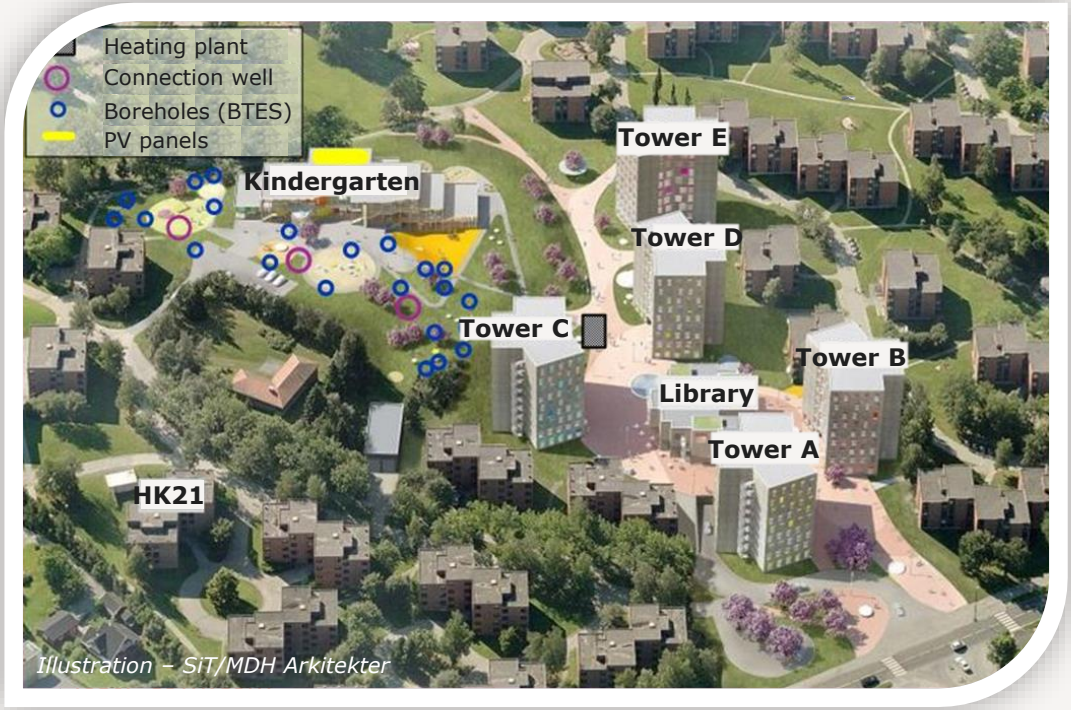
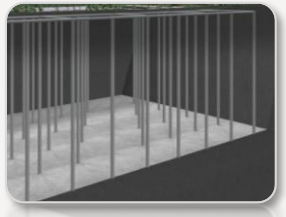
Case 3) Moholt 50|50 – Student Town, Trondheim

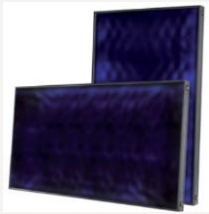


3) Bldgs. – Heat Pump, Heat Recovery and Solar Systems

- The buildings – completed in 2016
  - 632 flats in 5 «towers», kindergarten, library, laudry etc.
  - Passive house standard – buildings in solid wood
  - Space heating covered with electric baseboard heaters



- Centralized heating/cooling system with ground-source heat pump
  - DHW heating (50 °C), heating/cooling of ventilation air and snow melting
  - 3 heat pump units x 84 kW at 4/50 °C (252 kW)
  - Thermal charging of **BTES*** – 23 x 250 m boreholes in bedrock:
    - 72 m^2 solar collector system at Kindergarten
    - 25 m grey water heat recovery heat exchanger
    - Heat from exhaust ventilation air



BTES – Borehole Thermal Energy Storage (vertical boreholes in bedrock)

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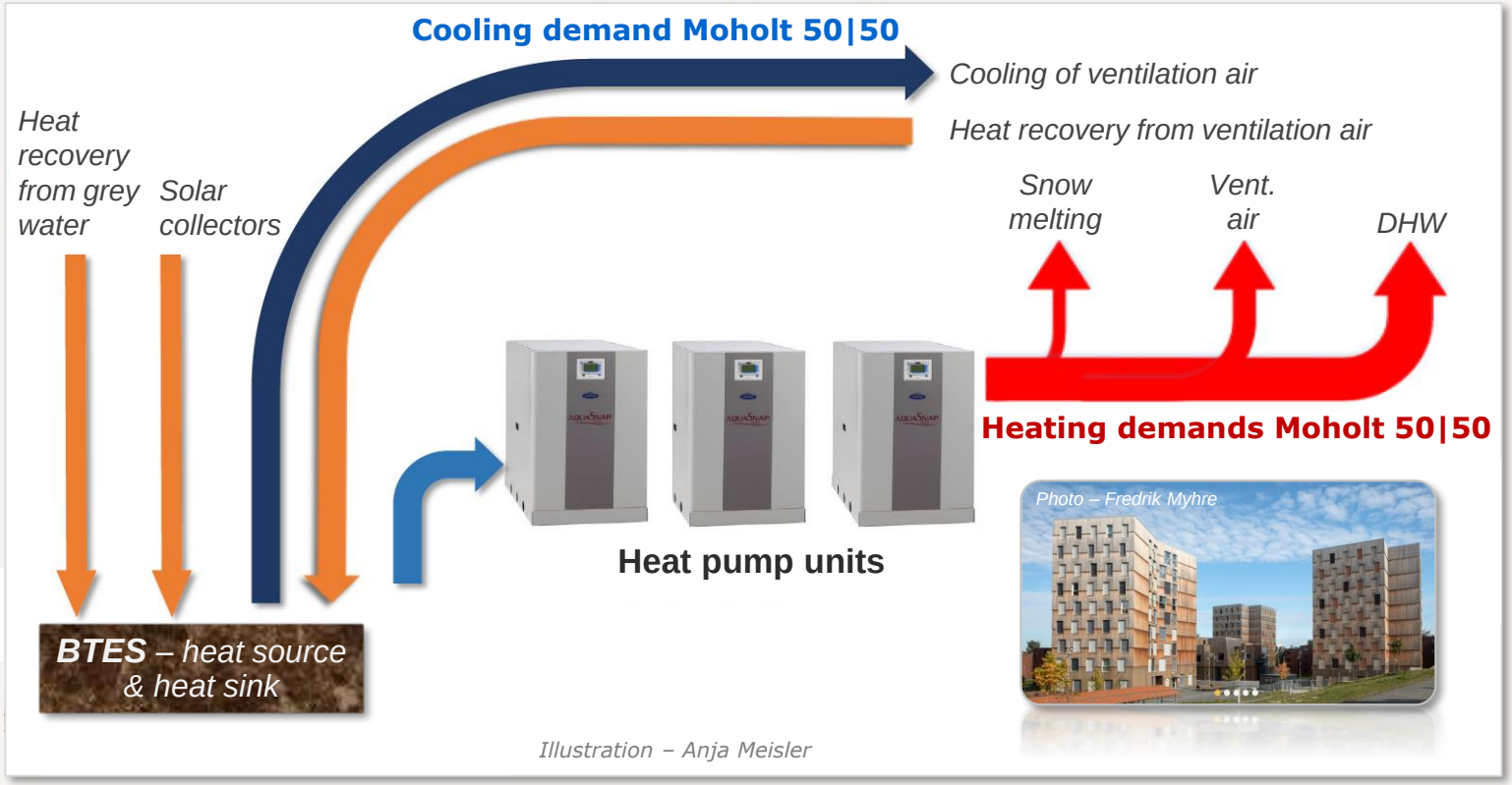
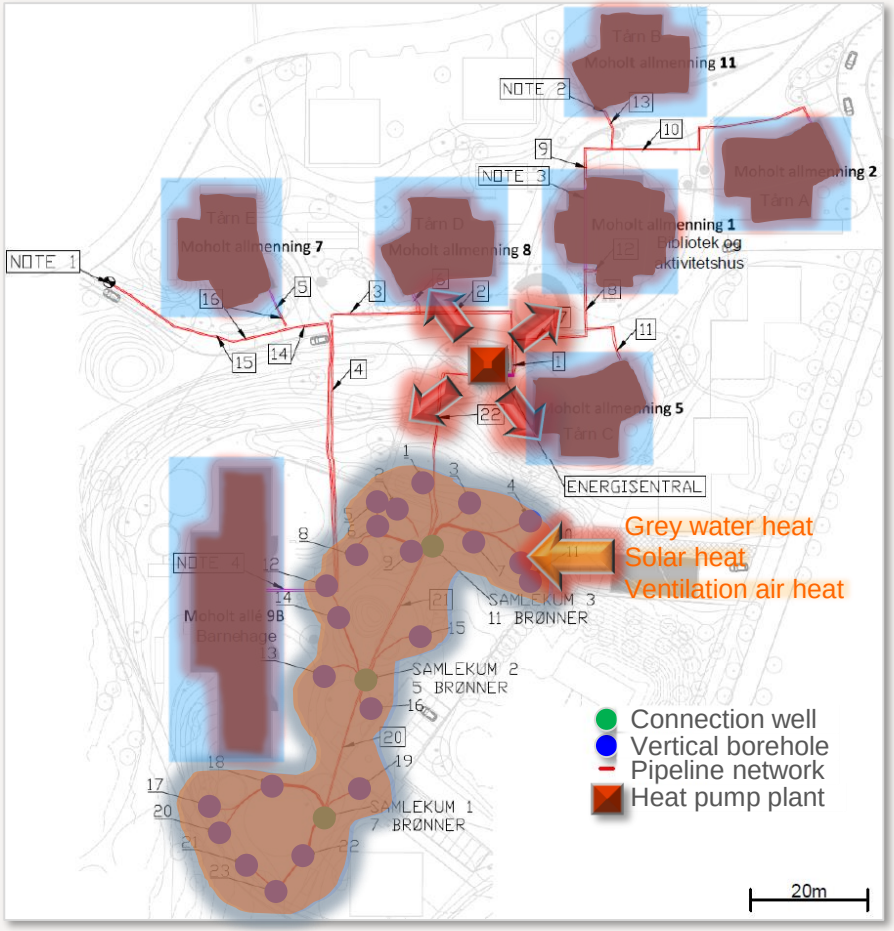
3) Principle Thermal Energy Flow Chart



3) System Overview

- Pipeline network x 2
  - Hot water distribution (50 °C)
  - BTES brine distribution (1 to 10 °C)
- DHW + heating/cooling of vent. air
- BTES – 3 systems for thermal charging
  - Grey water heat recovery
  - Solar collectors
  - Heat from exhaust ventilation air



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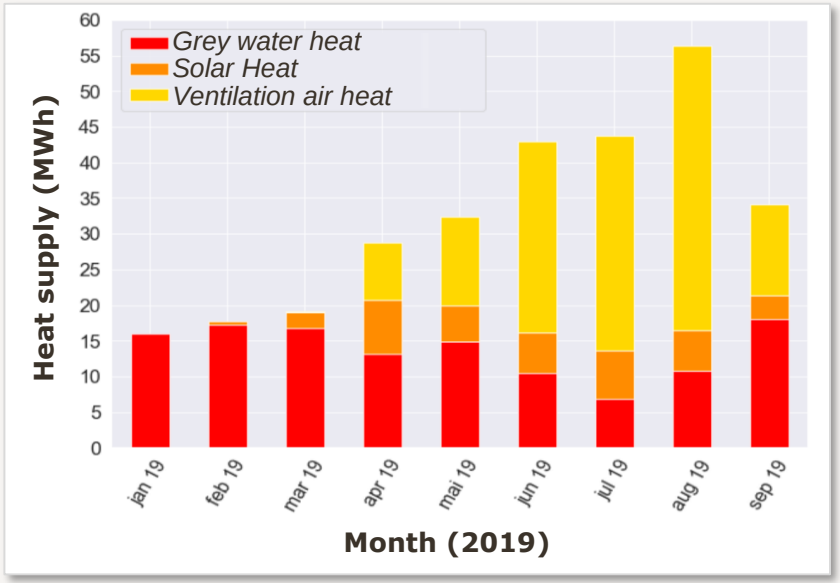
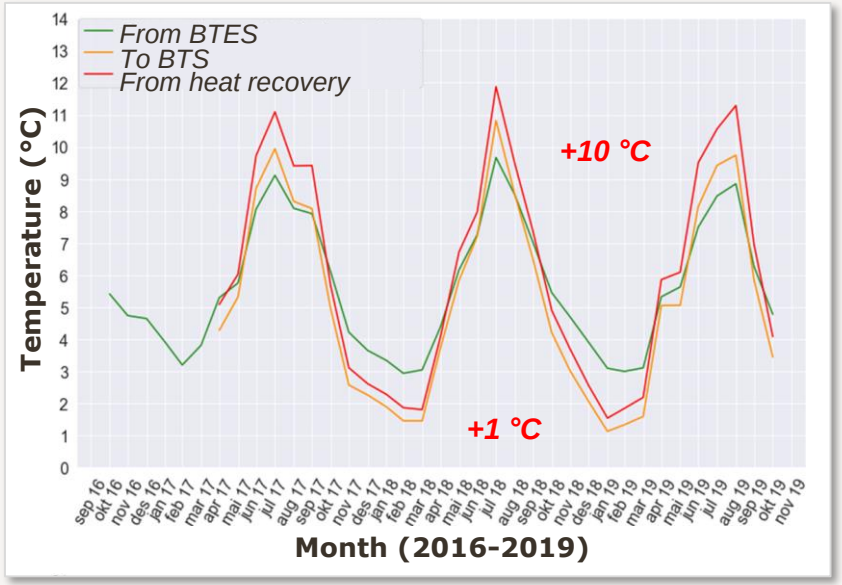
3) BTES – Measured Energy Balance and Temperatures

Thermal charging of BTES from different sources



Good annual thermal energy balance in BTES



Measurements – Anja Meisler

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Field Measurements – Project (P) and Master (M) Theses

NTNU – Department of Energy and Process Engineering (EPT), Trondheim

- **Analysis of the Thermal Energy System at Otto N. vei 12E**
  - Project thesis (EPT-**P**-2017-25) and Master Thesis (EPT-**M**-2018-04)
    - Ms Linn Charlotte Melvik Alfstad
- **Analysis of the Thermal Energy System at KIWI Dalgård**
  - Project thesis (EPT-**P**-2018-32)
    - Ms Marie Garen Aaberg
- **Analysis of the Thermal Energy System at Moholt 50|50**
  - Project thesis EPT-**P**-2018-32)
  - Master thesis – to be completed December 2019 (EPT-**M**-2019)
    - Ms Anja Meisler

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Thank you for your attention!

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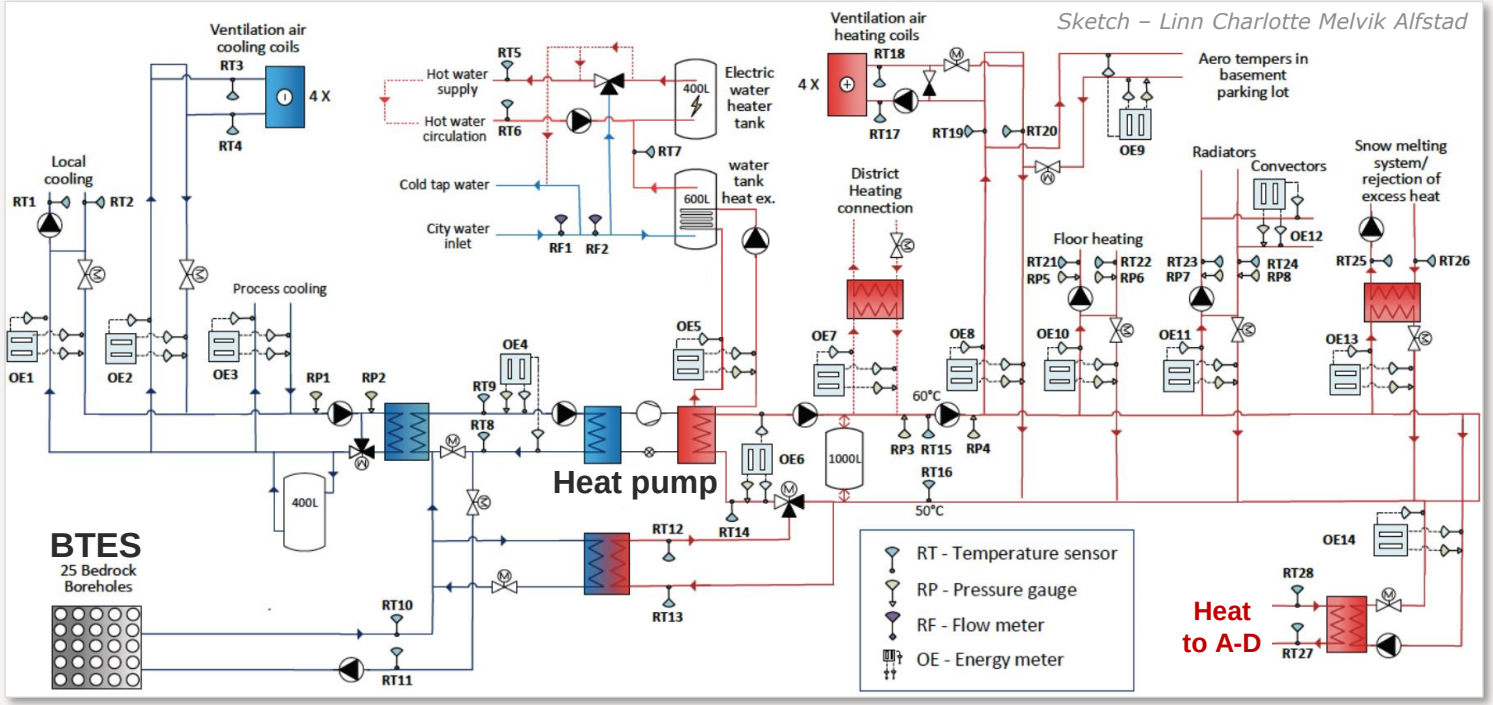
1) Principle Thermal Energy System with Instrumentation



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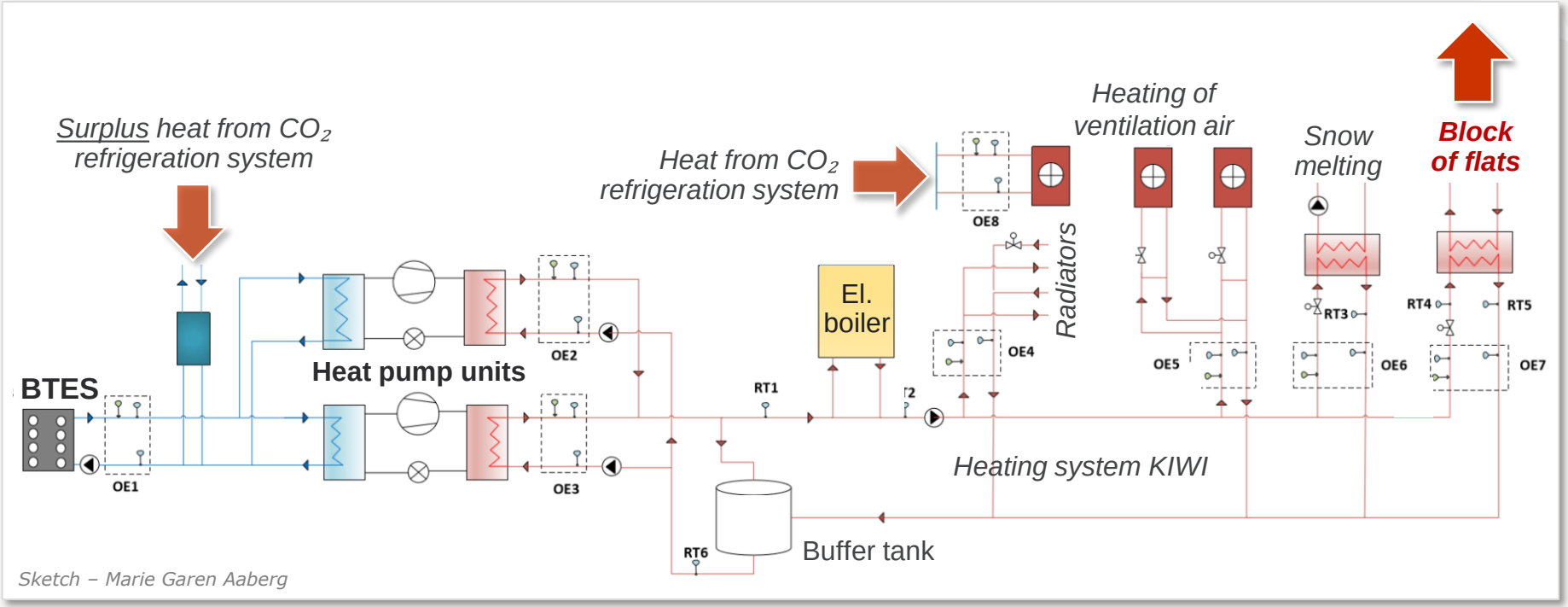
2) Principle Thermal Energy System with Instrumentation



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3) Principle Thermal Energy System