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Generating DHW load profiles of buildings with realistic simultaneity for DH system simulations using DHWcalc and TRNSYS

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Motivation

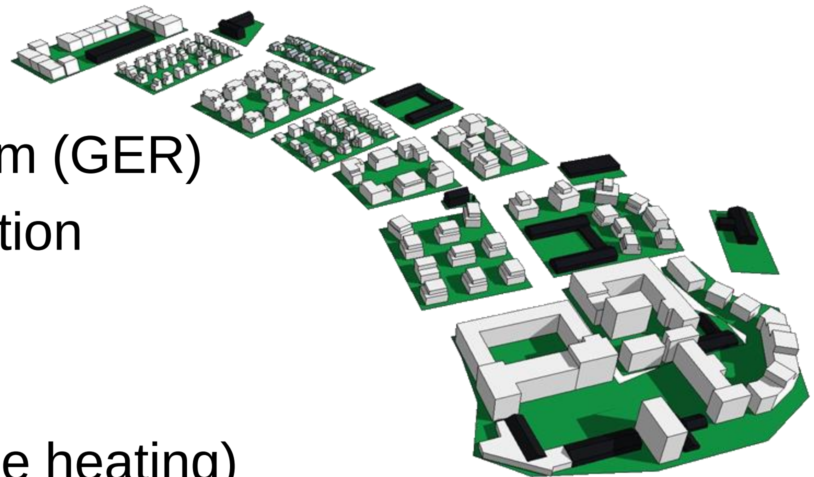

Image by:
Young Jae Yu (Fraunhofer IEE)

Sullivan District:

- Part of former US-Military base in Mannheim (GER)
- Mix of SFH and MFH, mainly new construction
- Approx. 100.000 m² living area total

Target: Dynamic simulations of DH-System

→ **load profiles for DHW** (and space heating)

Approach:

DHWcalc:
DHW draw-off profiles → Substation Models (TRNSYS) → DHW load profiles (end-energy)

Research subjects:

- Storage and distribution losses
- Return temperatures
- Simultaneity of superposed load profiles

DHW Draw-Off Profiles: DHWcalc

- Free access tool developed in scope of IEA SHC Task-26

- User sets reference conditions:
  – Mean daily draw-off volume
  – Flow rates and draw-off durations
  – Probability distributions (during day, week, year)

- Generates DHW draw-off profiles in 3 steps:
  1. Generate list of draw-off incidents
  2. Calculate probability distribution over the year
  3. Distribute draw-off incidents through random operator

DHWcalc is available for download at www.solar.uni-kassel.de

Defining Building Types

- DHWcalc originally developed for single building profiles
- New version will allow generation of profiles for districts
- Example: 5 unique building types, 20 buildings of each type
  → 100 unique draw-off profiles

- 11 building types were defined:
  – 4 single family houses (SFH)
  – 7 multi family houses (MFH)
- Building types differ in floor area, no. of living units and inhabitants, draw-off volume, distribution pipe lengths, storage volume

- Draw-off profiles were generated for each building type and fed into **substation models**

Modelled Substation Types for DHW Preparation

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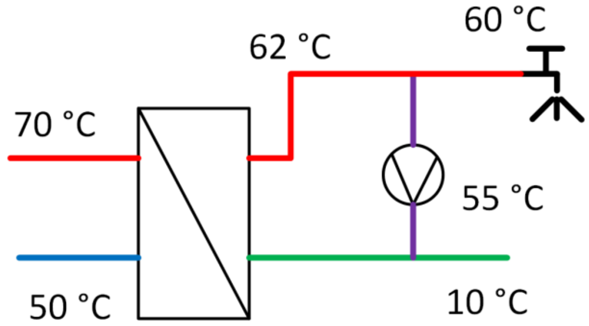
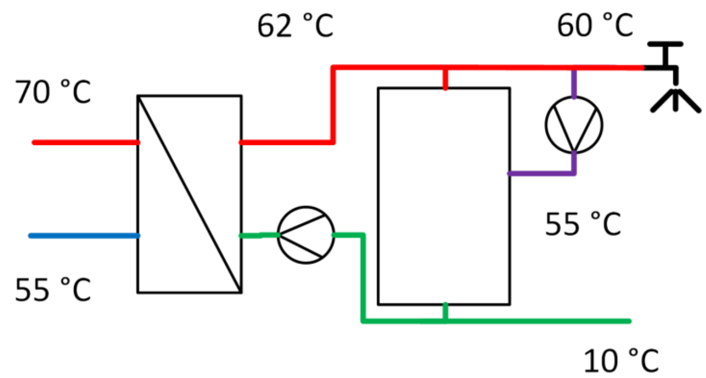
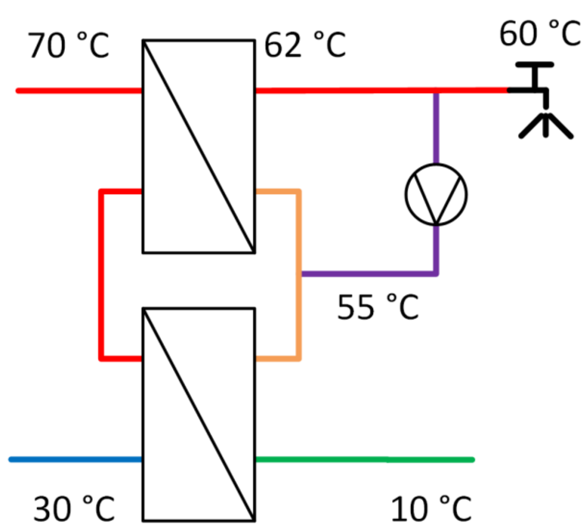
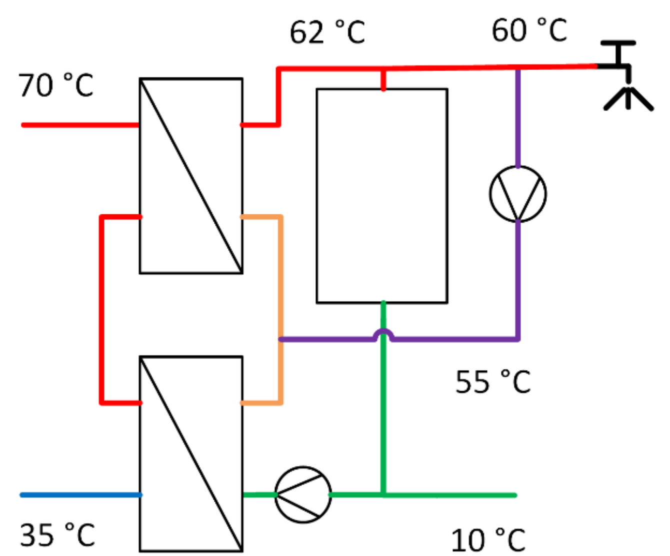
	Instantaneous	Storage
SFH (4 buildings)		
MFH (7 buildings)		

Substation Model Specifications

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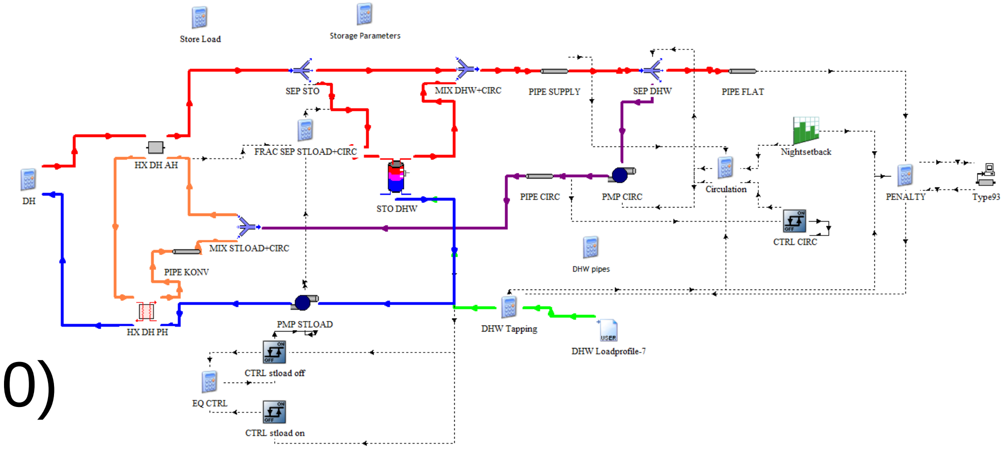
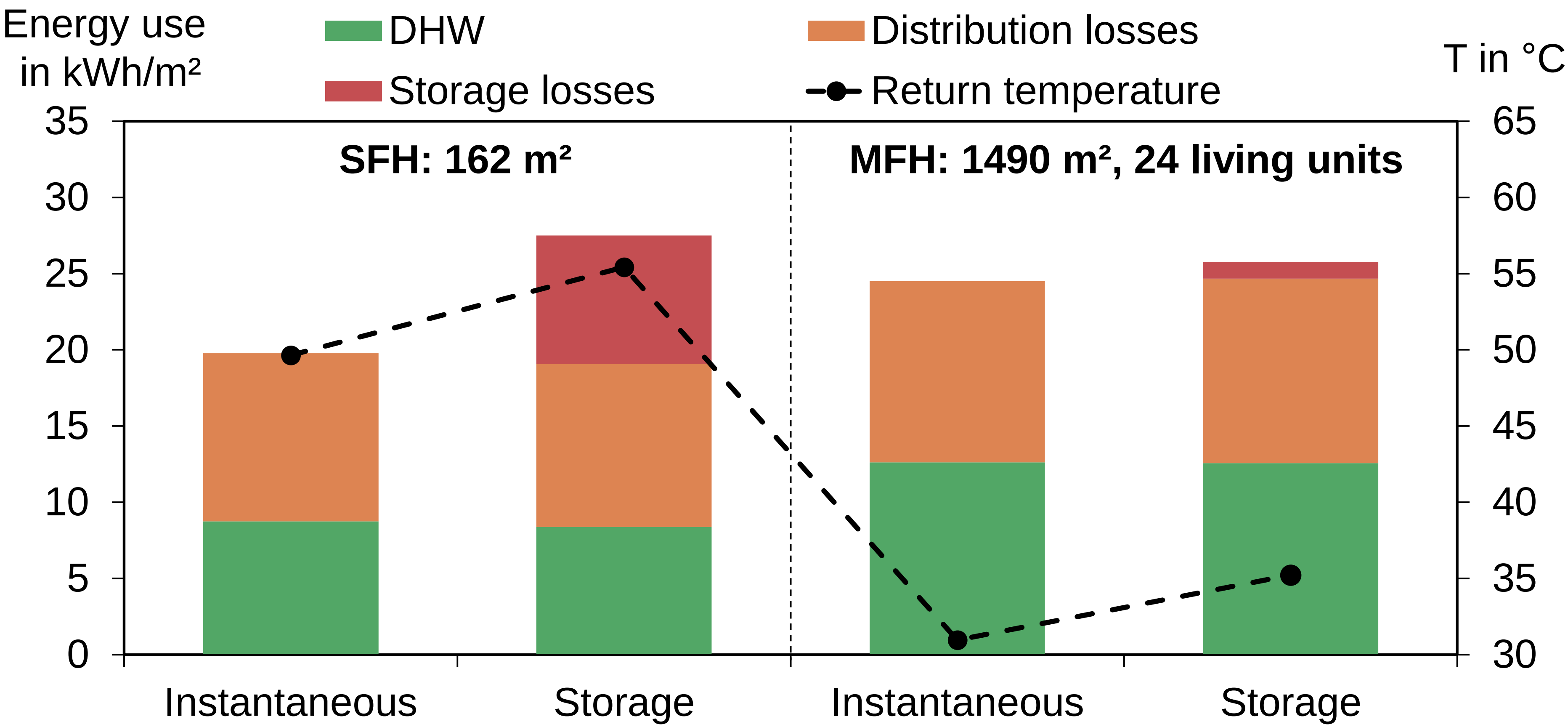
- Simulation in TRNSYS
- Timestep: 3 minutes
- Storage:
  – Stratified model (type 340)
  – Energy efficiency label B
- Pipes:
  – Thermal model for heat losses
  – Insulation according to german building code (EnEV)
- Heat exchanger model calculates DH flow-rate and return temperature
- No circulation during night hours



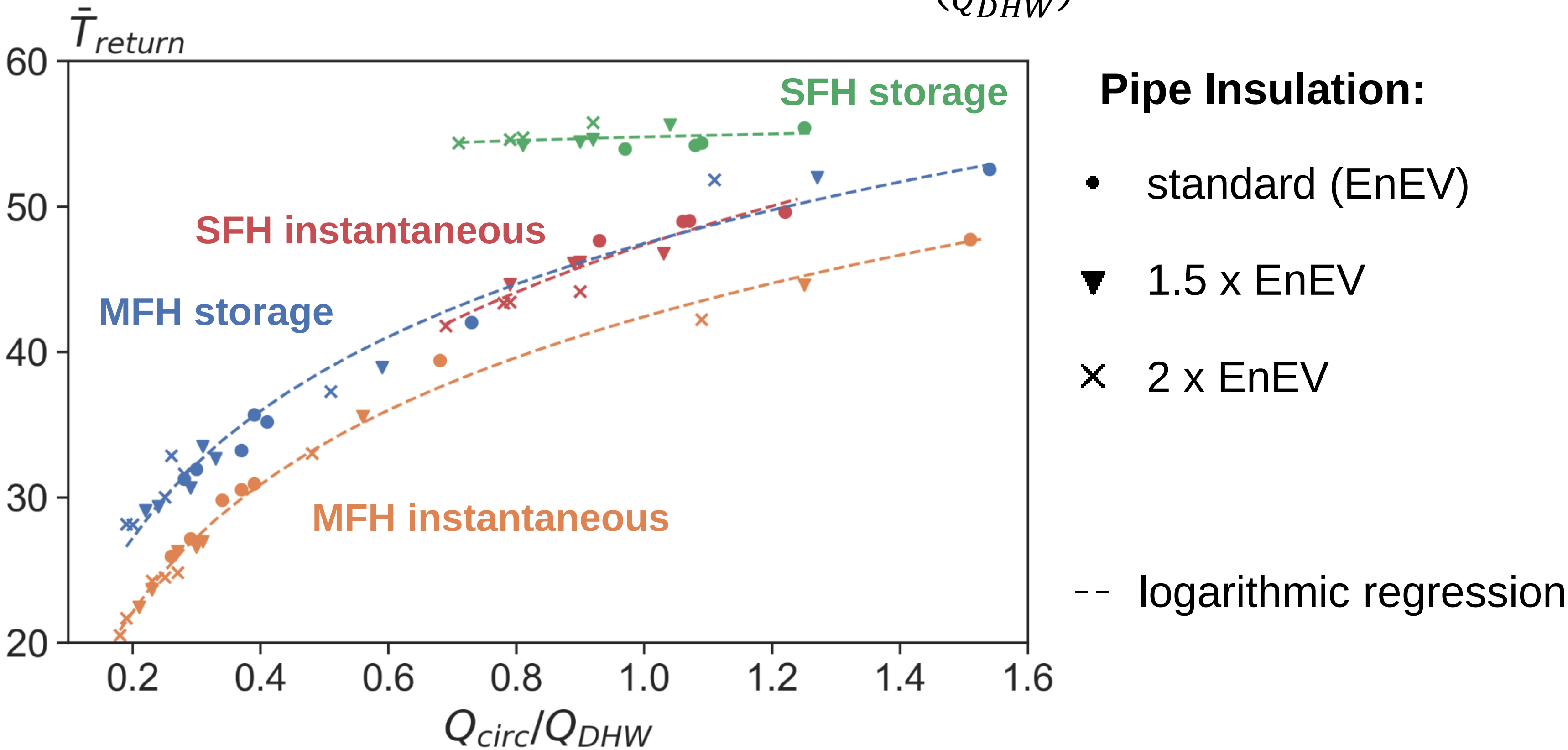
Energy Balance and Return Temperatures of two Exemplary Buildings



- Distribution losses approx. as high as DHW demand
- Storage losses have significant influence in SFH
- Lower return temperatures in MFH and for instantaneous systems

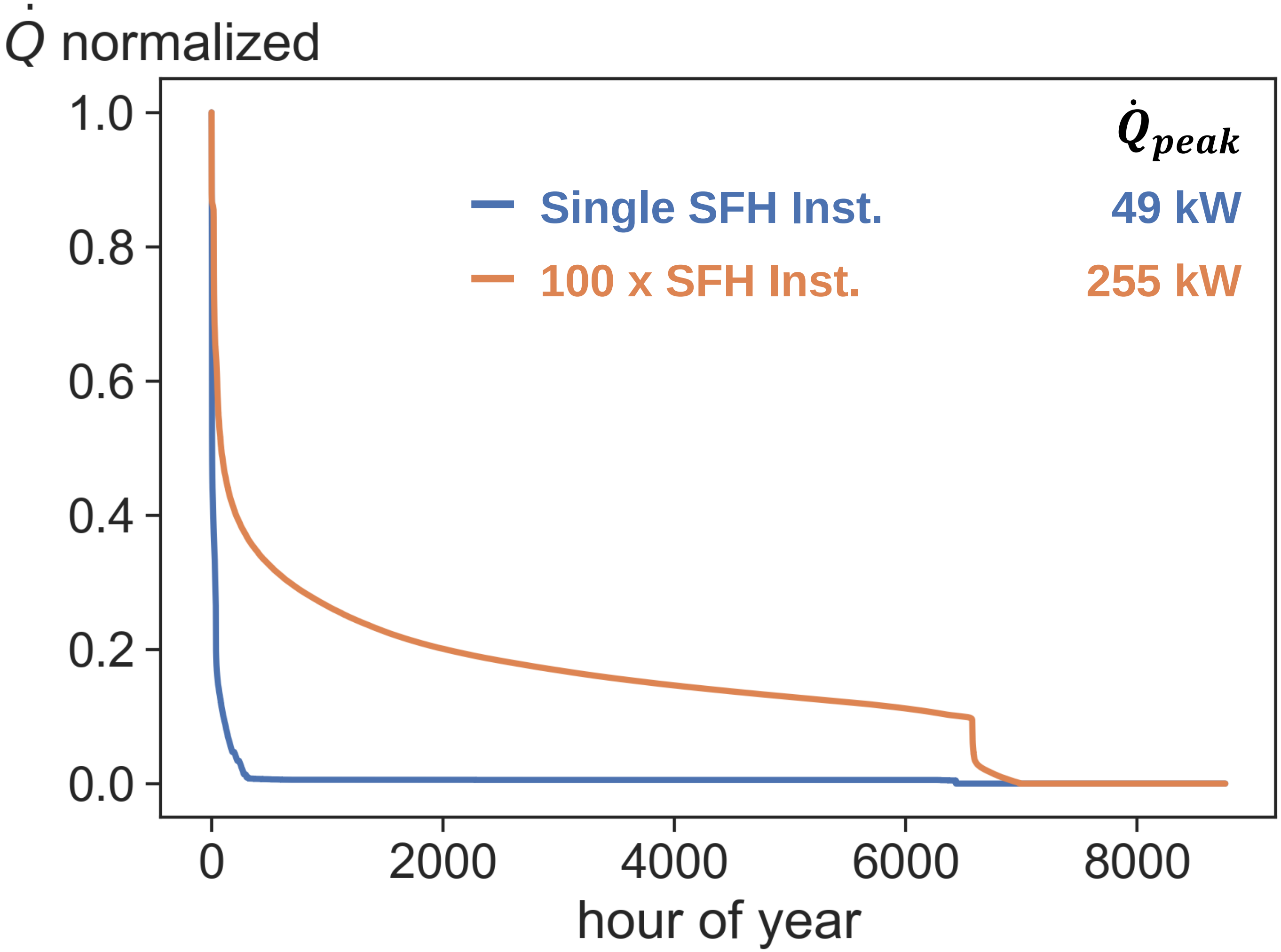
Return Temperature Correlation

Can $\bar{T}_{return}$ be described as $f\left(\frac{Q_{circ}}{Q_{DHW}}\right)$?



- No correlation for storage system in SFH
- Reduced return temperatures for:
  - Instantaneous systems (approx. 6 K)
  - 2-stage systems

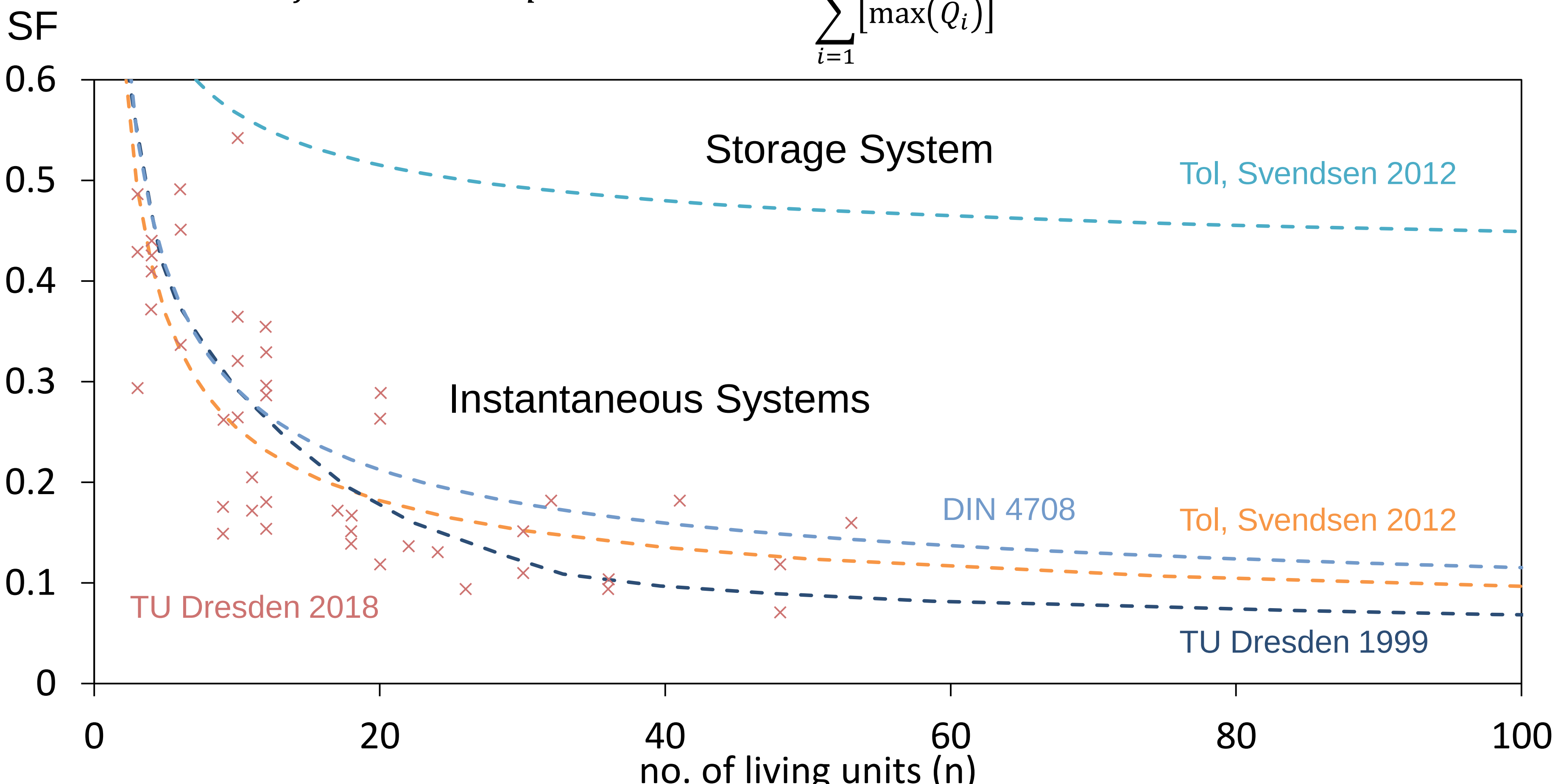
Superposition of Profiles: Duration Curves



→ Superposed profiles show much reduced peak load

Simultaneity Factors (SF)

$$SF = \frac{peak\ load\ of\ building\ group}{sum\ of\ individual\ peak\ loads} = \frac{\max\left[\sum_{i=1}^{n}(\dot{Q}_i)\right]}{\sum_{i=1}^{n}[\max(\dot{Q}_i)]}$$



Literature Values:

Tol, Svendsen 2012: Improving the dimensioning of piping networks and network layouts in low-energy district heating systems connected to low-energy buildings. A case study in Roskilde, Denmark. *Energy* 38, 1, 276–290.

Deutsches Institut für Normung e. V. 1994. *Zentrale Wassererwärmungsanlagen Begriffe und Berechnungsgrundlagen*. Beuth Verlag GmbH, Berlin, 4708 Teil 1.

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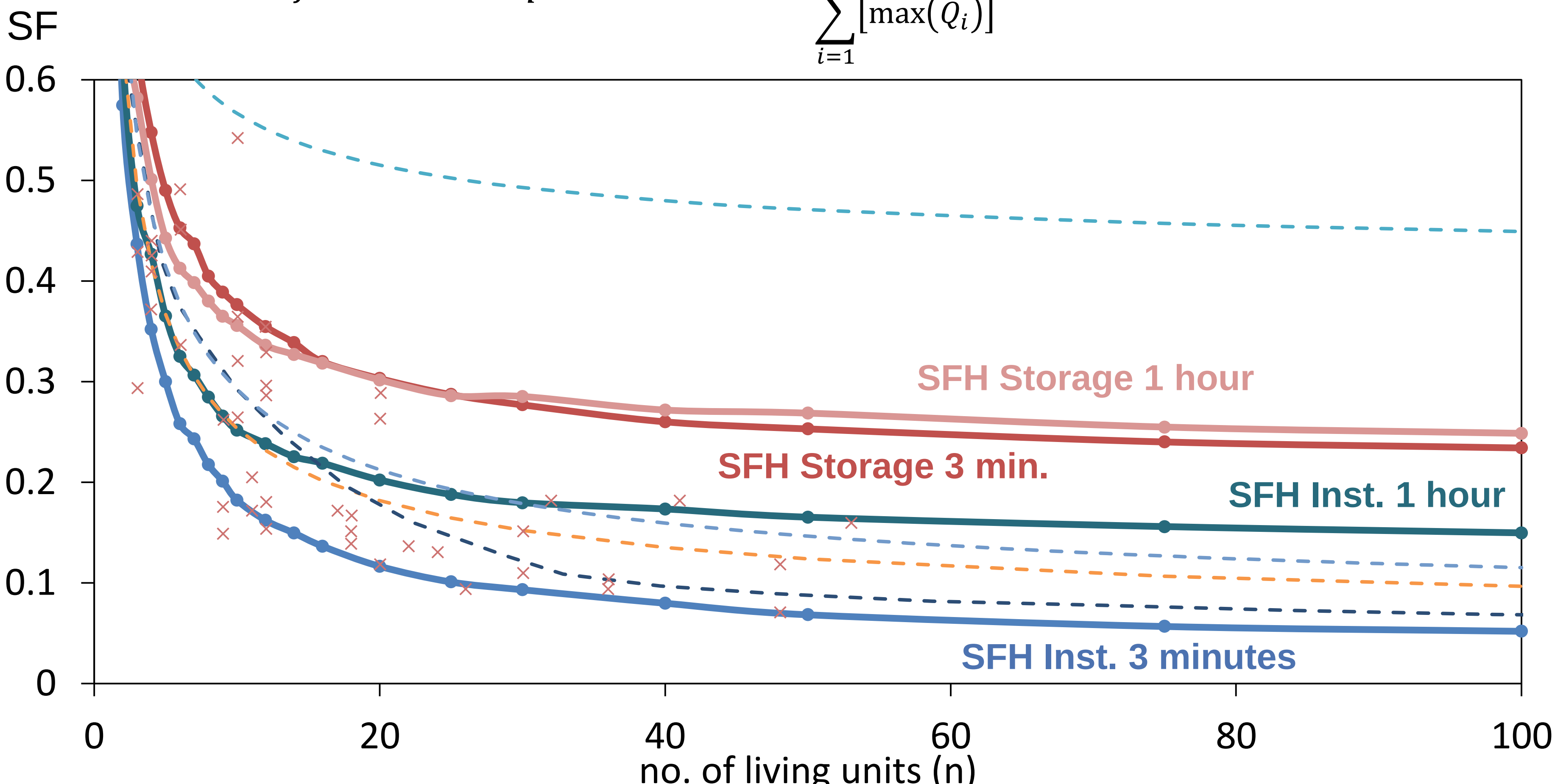

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Summary

- Combination of DHWcalc draw-off profiles and substation models result in realistic end-energy load profiles for DHW preparation
- Distribution losses account for approx. 50 % of end-energy demand for DHW preparation
- Compared to storage systems, instantaneous systems result in
  - reduced heat demand (especially in SFH)
  - lower return temperatures (approx. 6 K for MFH)
  - higher peak loads
- Superposition of load profiles based on DHWcalc results in plausible peak loads and simultaneity
- Further observations of impact on DH-systems:

  → Presentation by **Isabelle Best** (Session 30)

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Thank you for your attention! **solar@uni-kassel.de**