2nd International Conference on Smart Energy Systems and 4th Generation District Heating
Aalborg, 27-28 September 2016

Utilizing data center waste heat in district heating – impacts on energy efficiency and prospects for low temperature district heat networks

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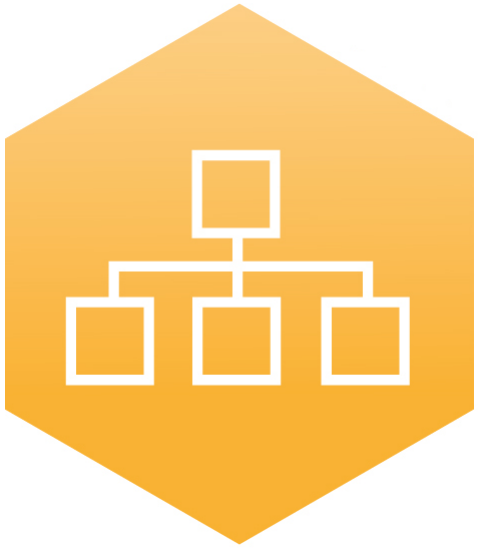

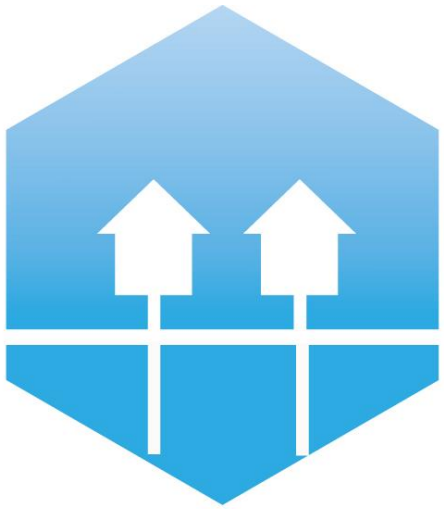

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Data centers in Nordic countries

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- **Why Nordic countries are attracting data centers?**
  - Cold climate
  - Cheap electricity prices and high share of renewable electricity generation
  - High level of information security and know-how on the IT sector
  - Stable political environment

- **What do data centers have to do with district heating?**
  - Almost all of the consumed energy in data centers converts to heat which can be recovered
    - Waste heat temperatures typically low (in air cooled data centers **25-35 ºC**, liquid cooled data centers **50-60 ºC**), but heat pumps can be used to improve temperature
  - Due to high heat demand and diversified heat production portfolio waste heat can easily be utilized in DH and some data centers already supply waste heat to DH

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Aims of the research

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The main **barriers** for data center waste heat utilization are **waste heat quality** (temperature and timing), **profitability** and **business opportunities** for data center operators

We aim to answer following questions based on the main barriers:

- When is waste heat available from data centers?
- How low temperature waste heat could be utilized more efficiently in DH?
- How waste heat utilization would impact heat production in DH network?
- How pricing of waste heat affect its utilization in the network?

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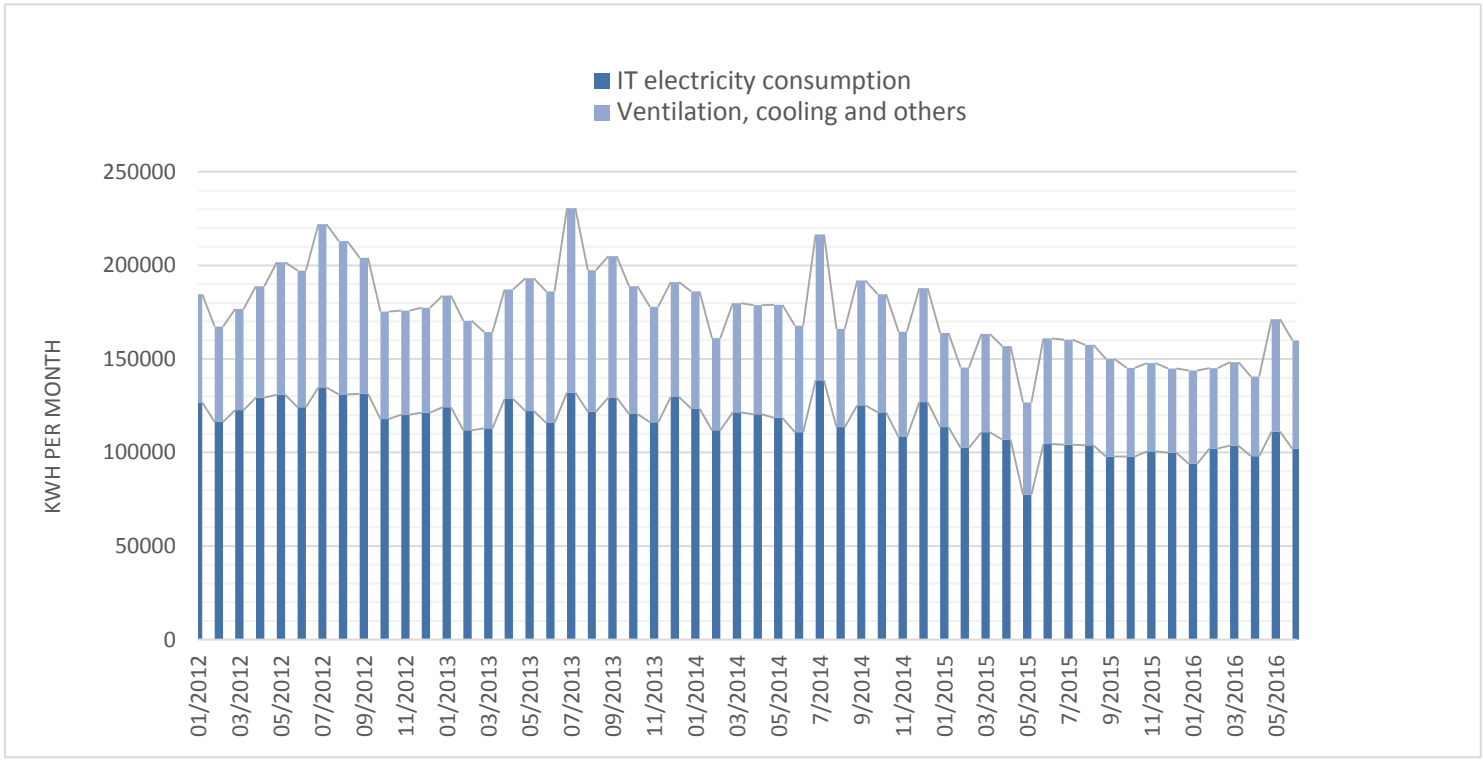
Monthly electricity consumption in a commercial data center



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Production in a non-commercial data center

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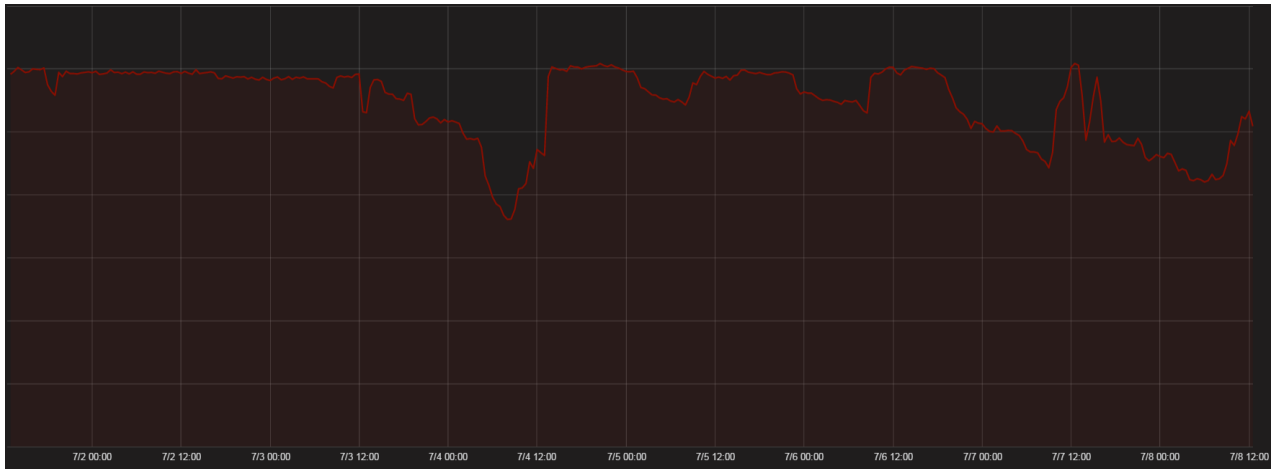
1 year production

1 week production



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Prospects for low temperature district heat networks (LTDH)

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- Low temperature district heat (LTDH) networks have the possibility of utilizing lower quality heat, which would increase the profitability of waste heat
  - LTDH networks could obtain supply water temperature of under 50 ºC and return water temperature of 20 ºC.
    - In these cases heat pumps might not be necessary to feed waste heat to DH network
  - LTDH networks could be effectively used even in smaller communities and as renewable small-scale heat is integrated to the system
- Thermal storages can be efficiently used to store the excess heat in the summertimes

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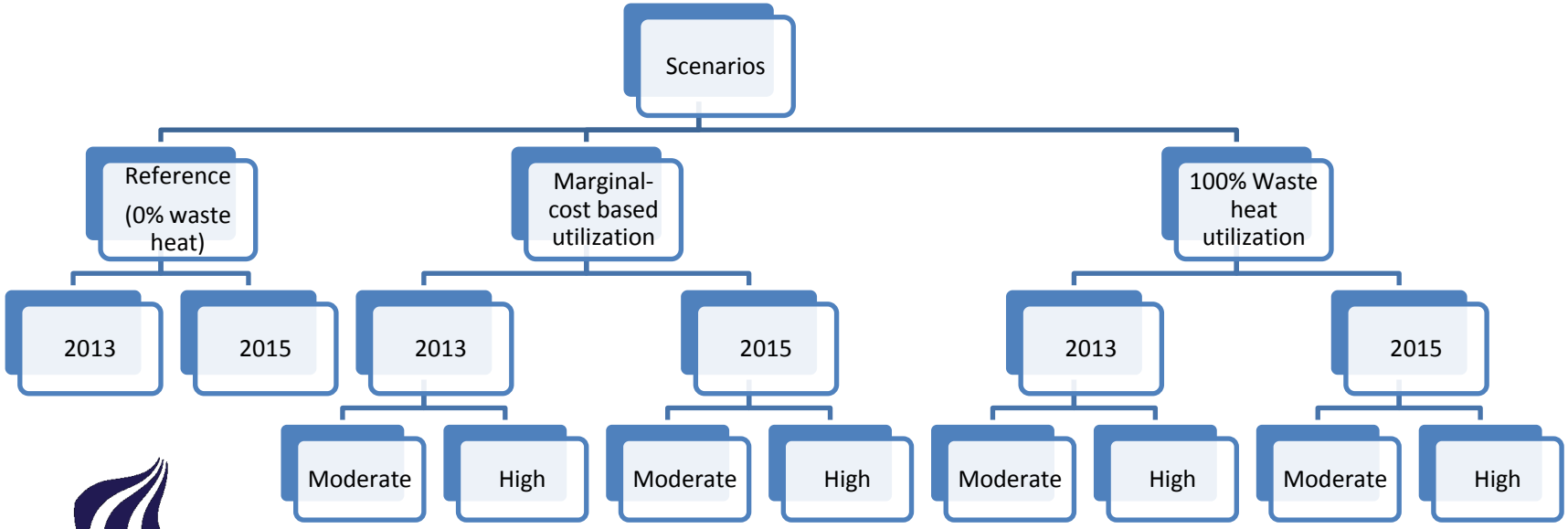
EnergyPro-simulations

- We have used EnergyPro-software to simulate Espoo DH network based on the DH demand in year 2013 and 2015
- We take into account
  - Production costs (fuel prices, start-up costs etc.)
  - Electricity prices
  - Existing plants in 2013 and 2015 (3 CHP units, several HOBs + heat pump)



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EnergyPro-simulations

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Scenario assumptions			
	Reference	*Marginal cost based*	*100% Utilization*
Produced waste heat fed to DH network	0%	Depending on marginal production costs of the system	100%
Cost of waste heat	-	Seasonal pricing (13,8-40,4€/MWh)	0€ (100% will be utilized regardless of the price)
Amount of waste heat	-	*Constant load* 2013 – Moderate: 23,4MW 2013 – High: 58,5MW 2015 – Moderate: 18,7MW 2015 – High: 46,8MW	*Monthly shifting load* 2013 – Moderate: 20-28MW 2013 – High: 50-70MW 2015 – Moderate: 15-20MW 2015 – High: 38-50MW

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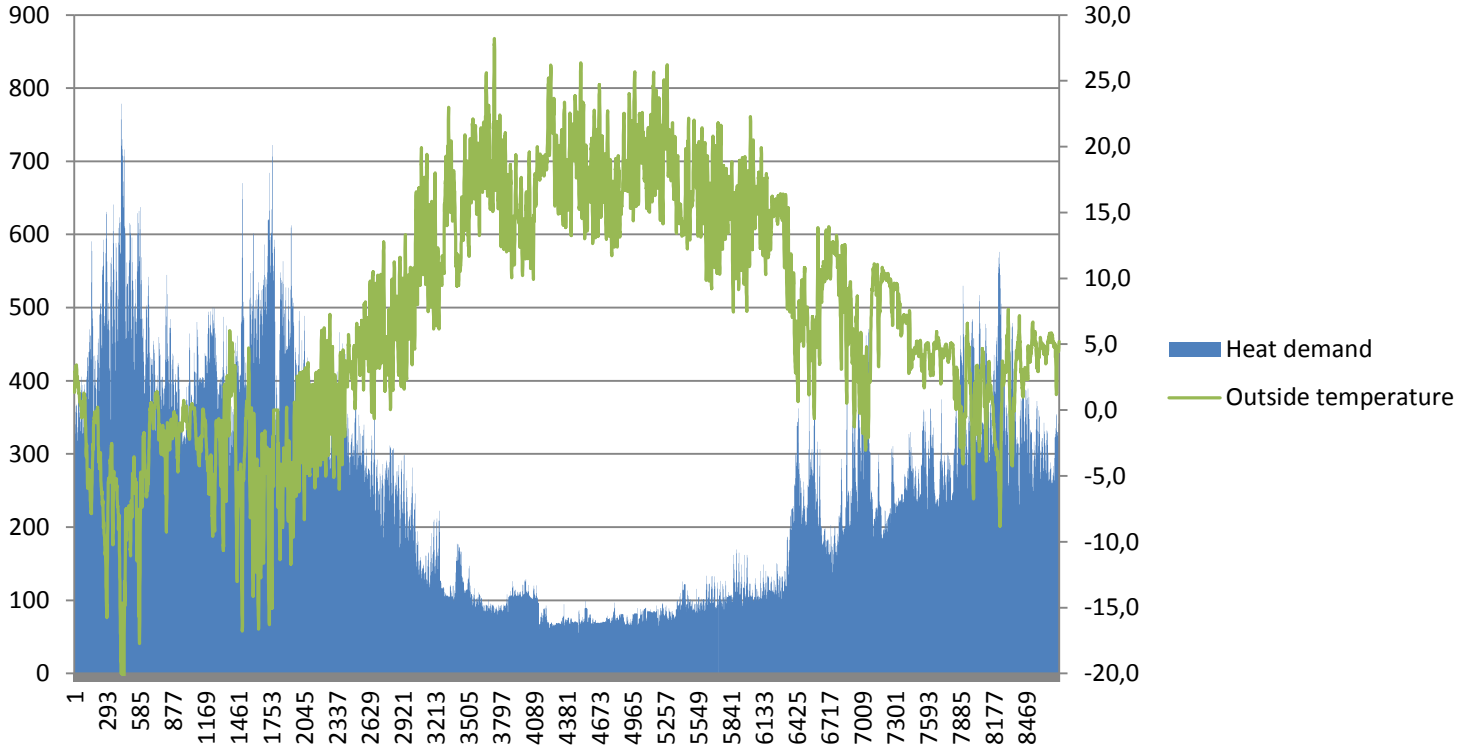
Simulated district heat demand in Espoo network in 2013



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Preliminary modelling results

- All scenarios
  - In all of the scenarios **increasing waste heat will decrease utilization of CHP** plants
  - Production in some of the heat-only boilers (HOBs) will increase
  - **Total operational costs will decrease** when more waste heat will be utilized
  - In 2015, electricity prices are lower but heat demand higher
- Marginal cost based scenarios
  - **All of the heat won't be utilized** on current pricing model
  - Waste heat would be "turned off" for short periods
  - In high scenarios waste heat will have less full-load hours

Savings compared to reference scenarios				
Marginal cost based scenarios	*2013*		*2015*	
	MODERATE	HIGH	MODERATE	HIGH
Total production costs	-4,8 %	-9,8 %	-3,3 %	-9,6 %
Profits from sold electricity	-8,1 %	-13,5 %	-5,4 %	-21,0 %
Savings in total	-3,3 %	-8,1 %	-2,9 %	-7,5 %

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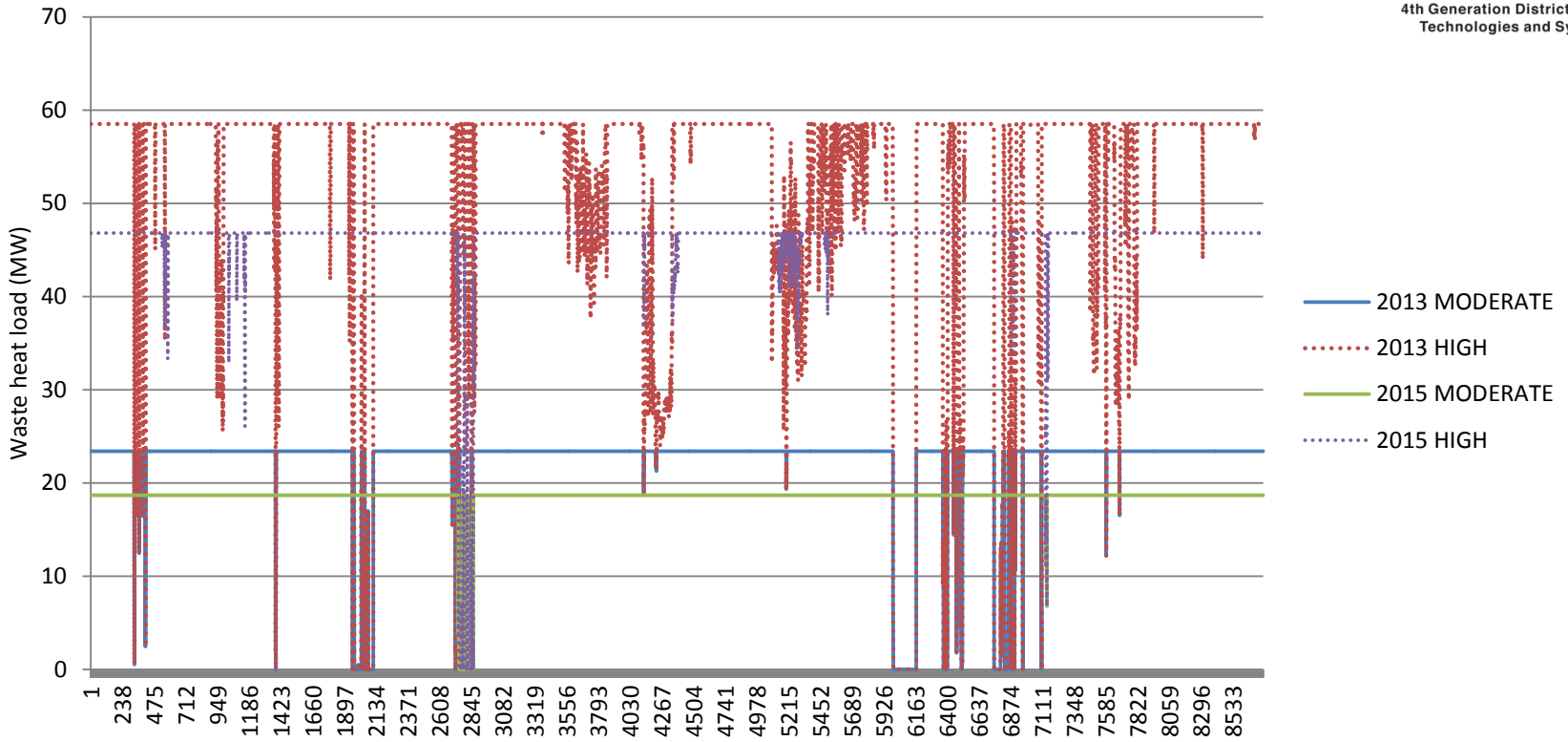
Waste heat utilization in marginal cost based scenarios



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Conclusions

- Utilizing waste heat will have significant effects on the DH system
  - In a DH system with CHP and HOB, paying for waste heat **may reduce CHP full-load hours**
  - **At high electricity prices CHP will be in full use** and waste heat will not always be taken into the system

- We didn't consider how waste heat will affect the DH system temperatures
  - **Priming of heat could be required** depending on the waste heat temperature
  - If data center waste heat is lower quality it should be taken account in pricing structure and on the network system level

- Results indicate that utilization of **waste heat is beneficial for the system**, however business cases between data center operator and DH network operator need to be addressed.
  - Mutually good business models seems to be feasible, but **pricing structure is highly important**
  - Pricing structure on data center waste heat needs to be determined to fully exploit the benefits

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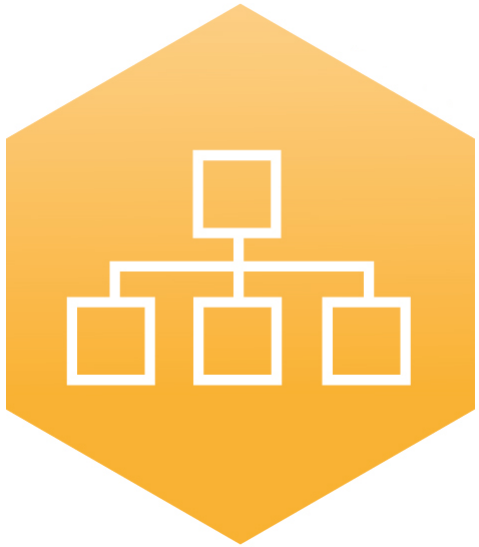
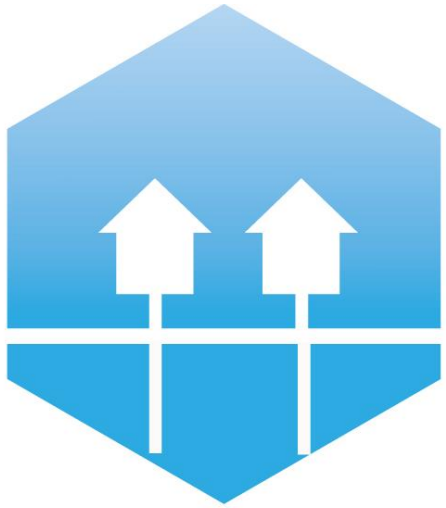
Thank you for your attention!





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