5th International Conference on Smart Energy Systems
Copenhagen, 10-11 September 2019
#SESAAU2019

Technical Feasibility Assessment of Solar-Assisted 4th Generation District Heating System in Melbourne

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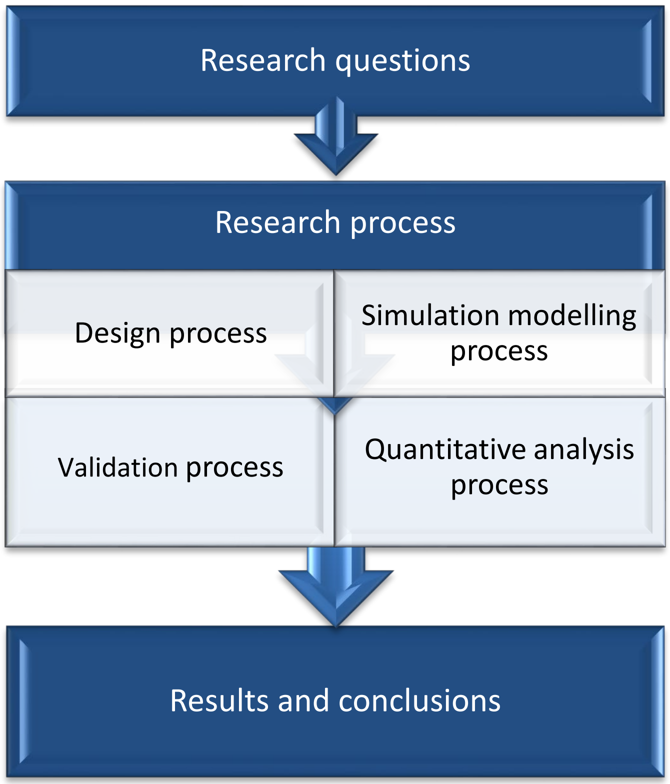
Presentation Content

- **Research questions**
- **Research methodologies and tools**
- **Systems descriptions**
- **Case study definition**
- **Results**
- **Conclusions**
- **Further work**

Research questions

- **Minimum annual energy use of de/centralized DHW system supplied by natural gas?**
- **Differences between centralized and decentralized systems in terms of primary energy consumption?**
- **Primary energy saving by using solar-assisted DHW system?**
- **Primary energy saving by using integrated solar-assisted DHW and space heating (SH) system with seasonal storage?**

Research methodologies and tools



- **Design: supply/return temperatures of the SH (45/25°C) and DHW supply temperature (45°C), assuming homogenous application of buildings (residential purposes), similar type and floor area of residential units**
- **Simulation: DHW and SH systems were designed and simulated using TRNSYS 17.0**
- **Validation: component and system level**
- **Quantitative analysis: pre- and post-simulation analyses including obtaining DHW and SH profiles, thermal and flow losses**

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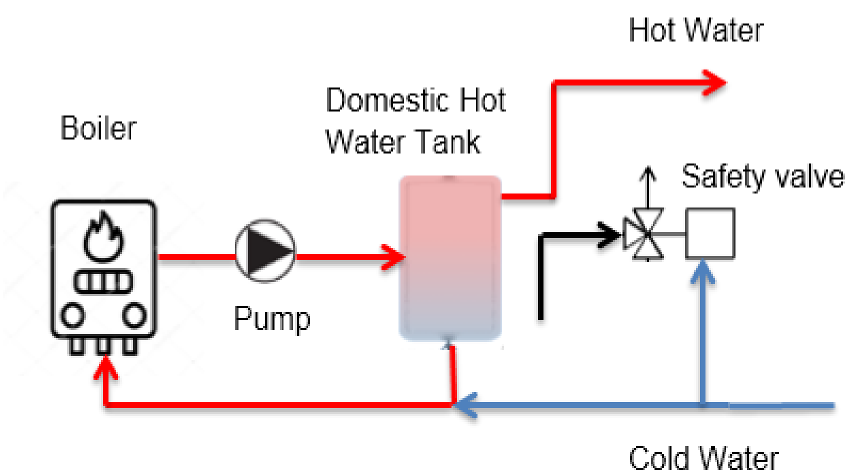
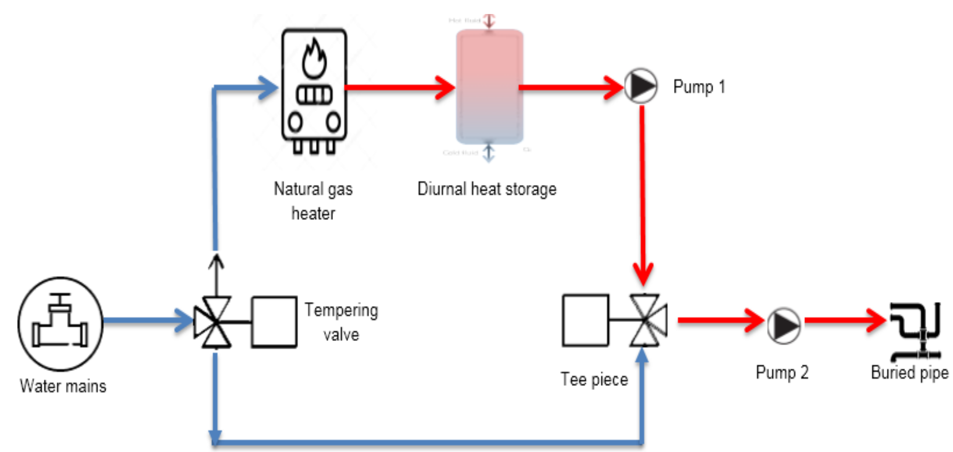
Systems descriptions (non-solar)

Decentralized conventional DHW system



Centralized conventional DHW system



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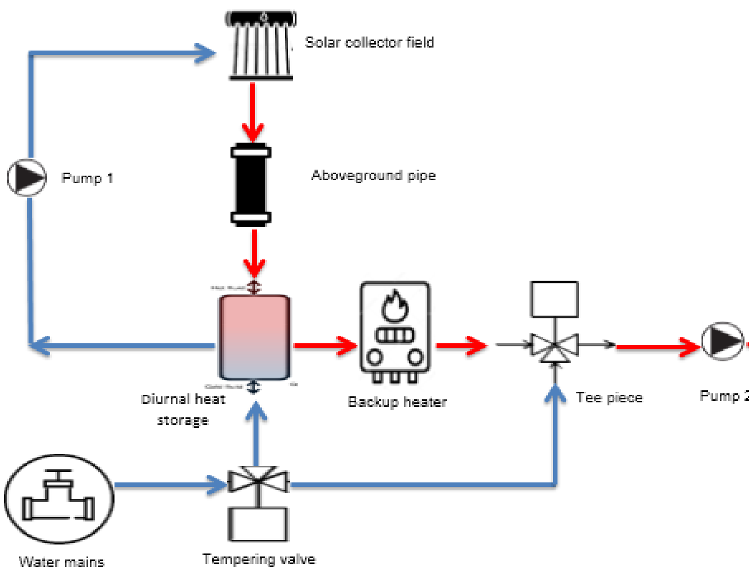
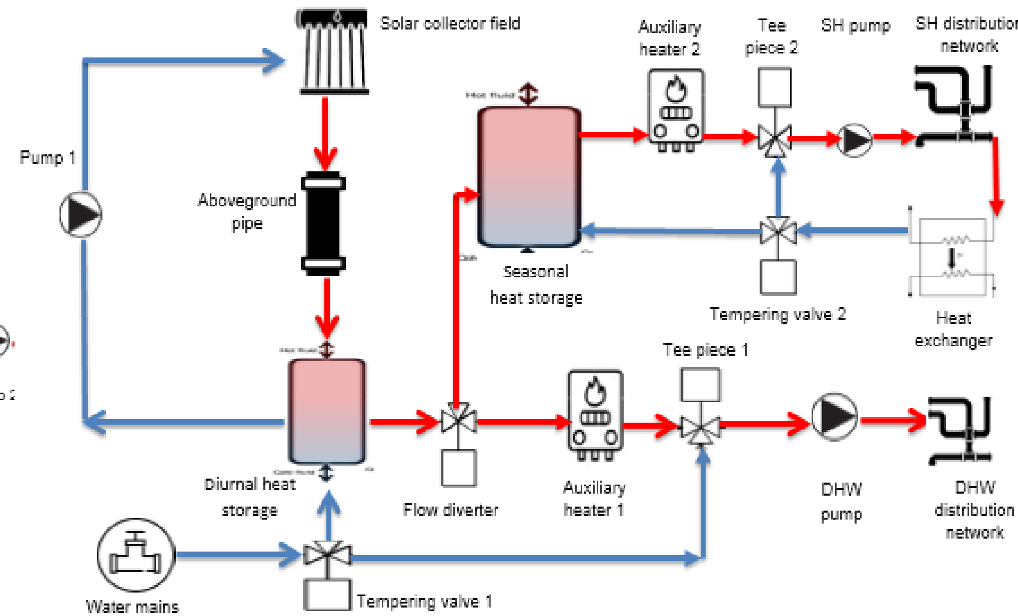
Systems descriptions (solar-assisted)

Centralized solar-assisted DHW system



Centralized solar-assisted DH system



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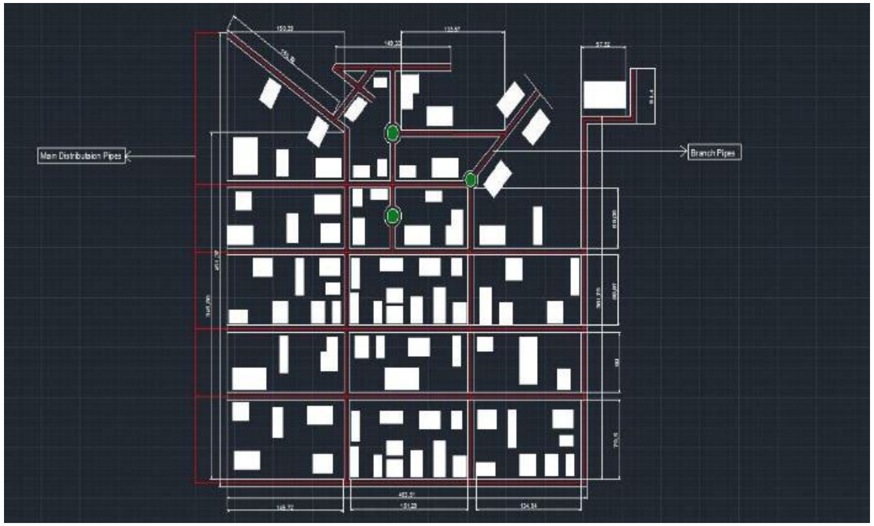
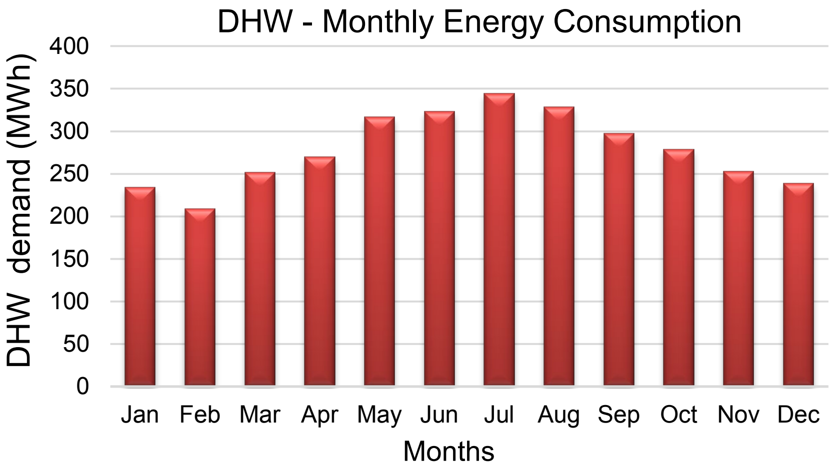
Case study definition

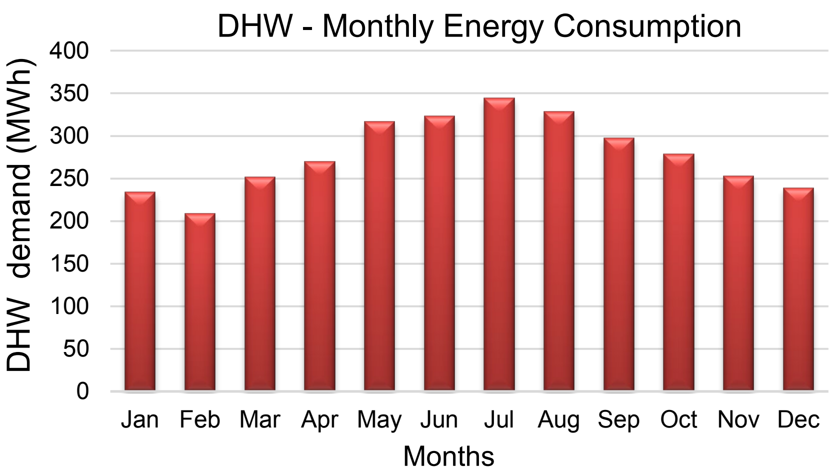
- **Melbourne – 1,000 residential units – population of almost 3,000 people**
- **Average floor area of 60 m^2 for each unit**
- **Hypothetical heating grid modelling**

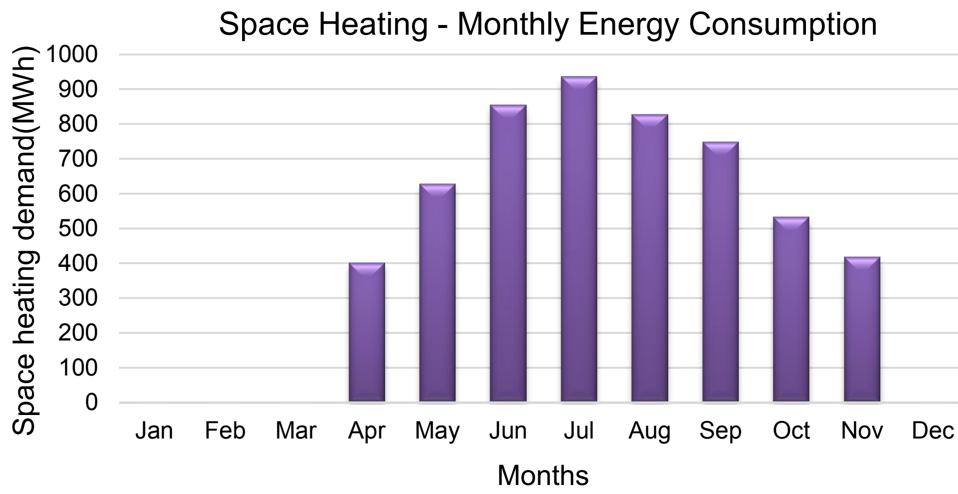


Results


DHW - Monthly Energy Consumption
DHW demand (MWh)
400
350
300
250
200
150
100
50
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Months

Results





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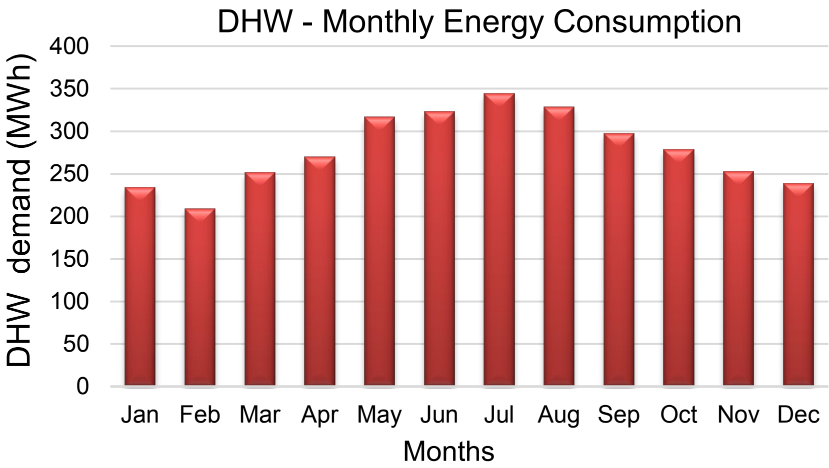
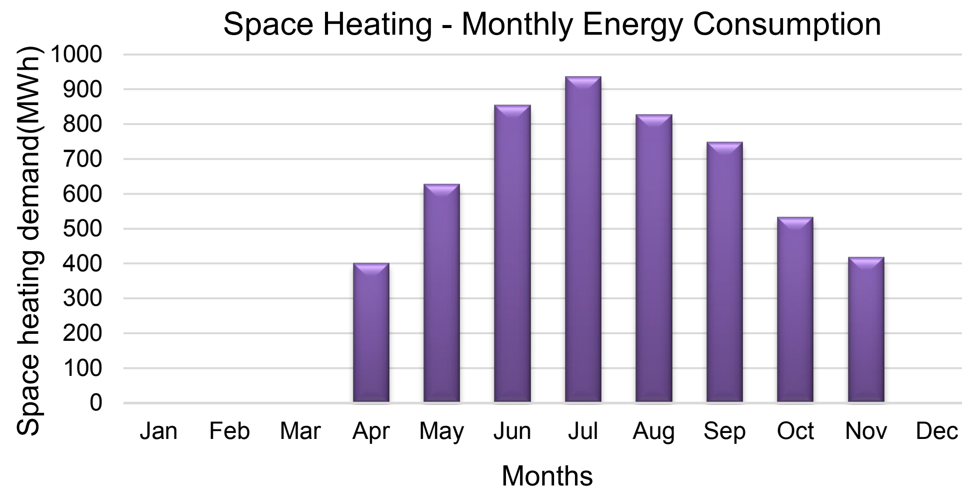
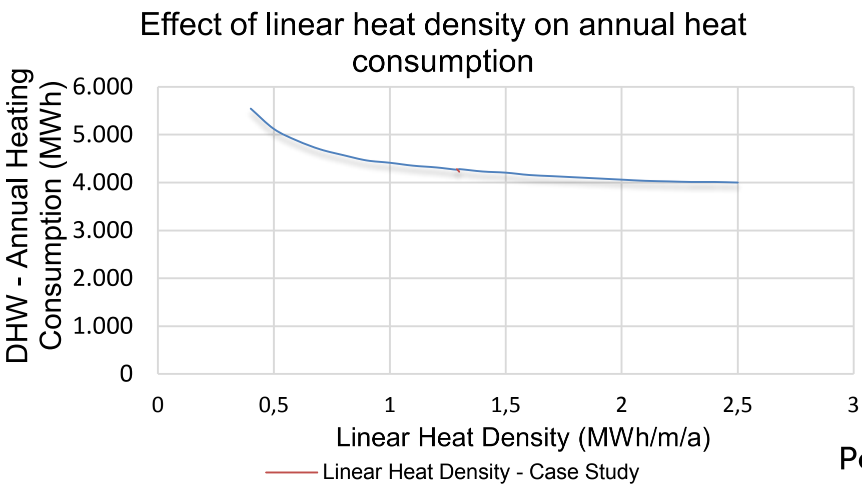
Results







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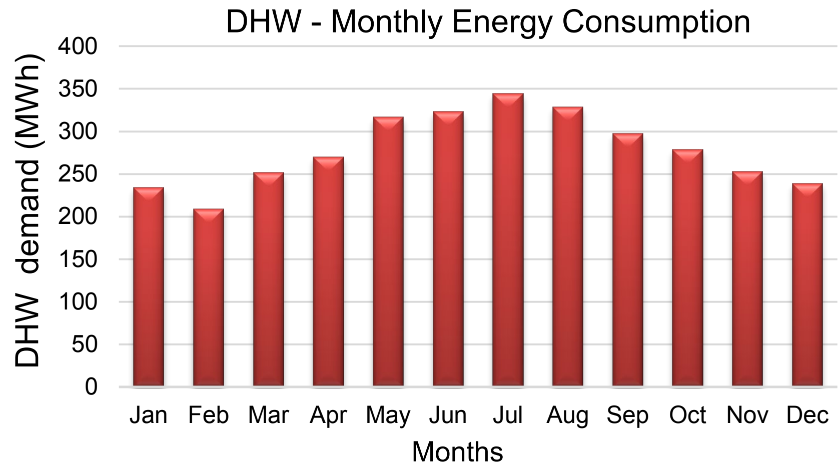
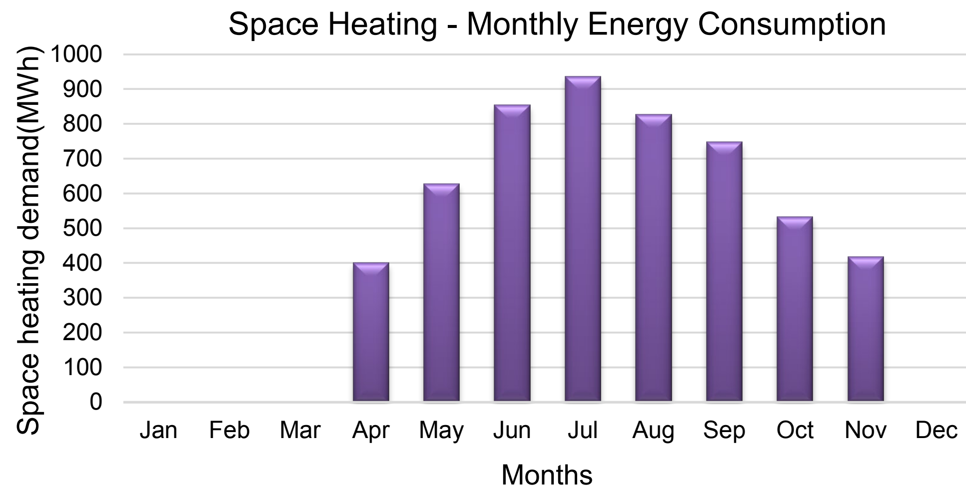
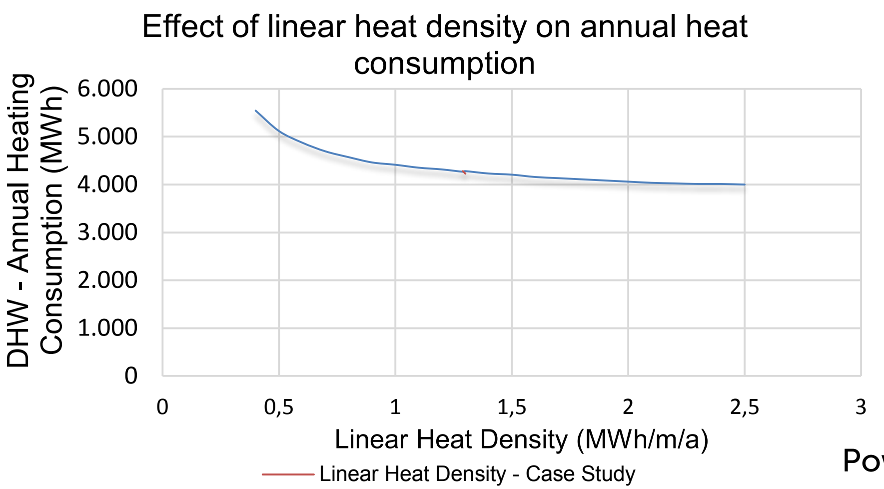
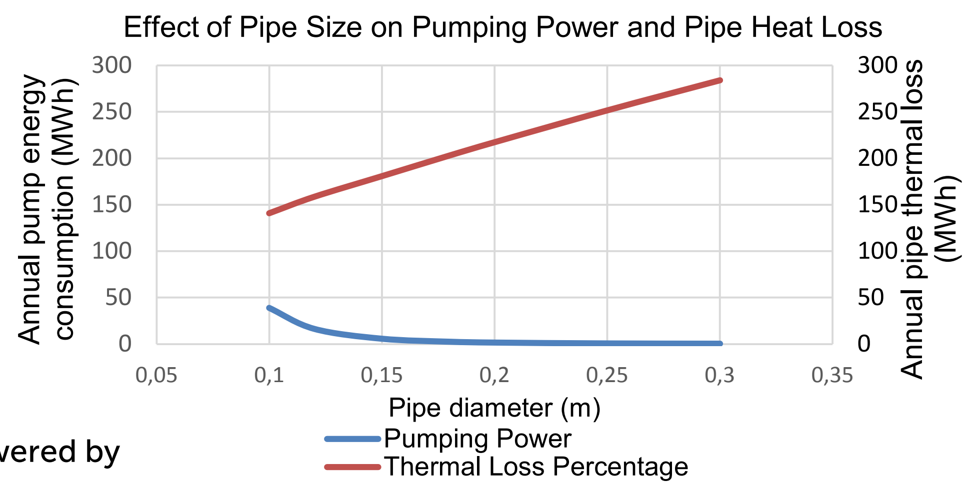
Results









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Results (continue)

Optimal design of central DHW gas heating system

Parameter	Value (Unit)	Parameter	Value (Unit)
Network length	2.6 km	Piping thermal losses	0.41 GWh
Linear heat density	1.29 MWh/m	Tank thermal losses	0.18 GWh
Net DHW energy demand	3.35 GWh	Total energy penalty	0.61 GWh
Pump energy consumption	0.02 GWh	**Total annual energy use of centralized conventional DHW system**	**3.96 GWh**

However, the total annual energy use of decentralized conventional DHW system is 3.35 GWh.

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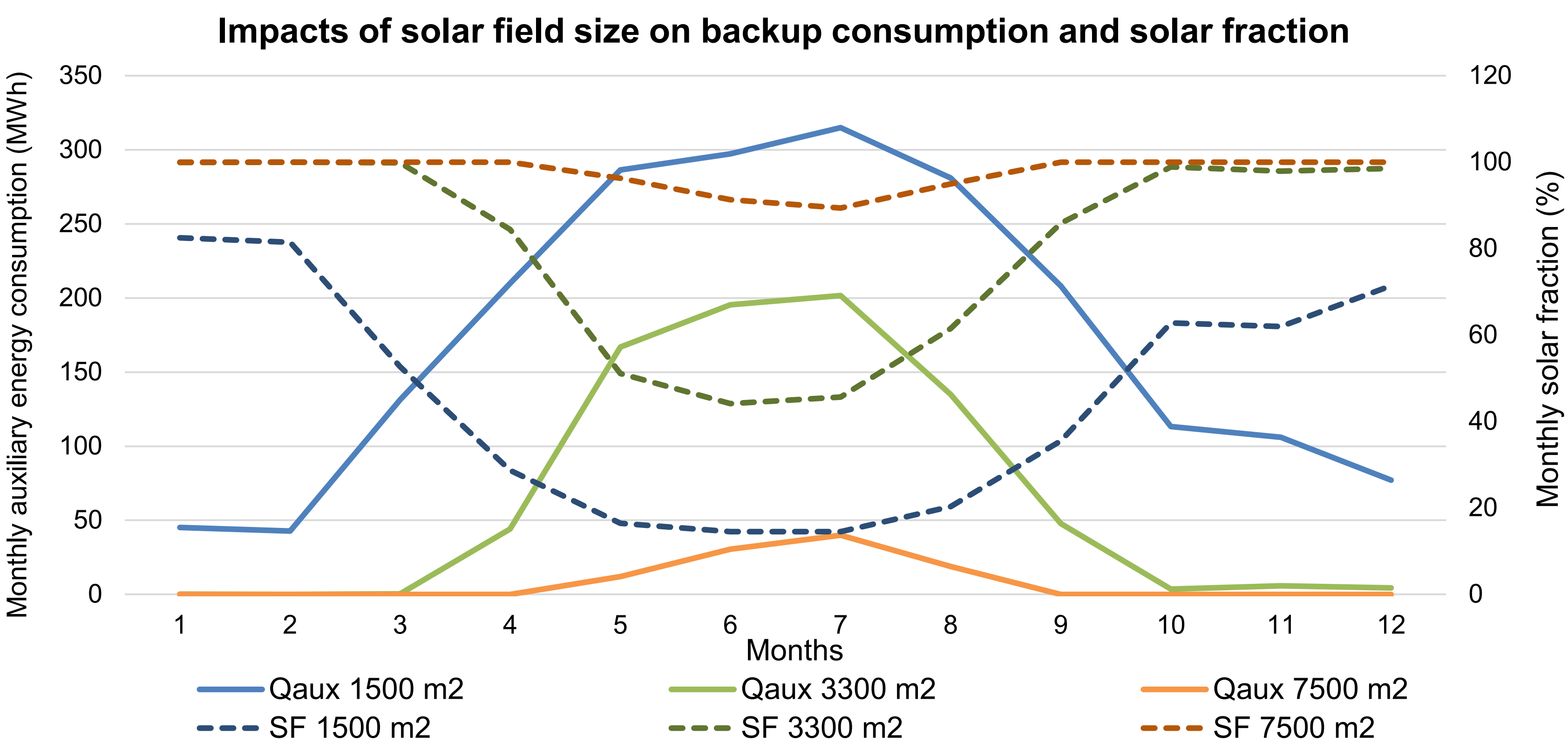
Results (continue)

Solar-assisted DHW system



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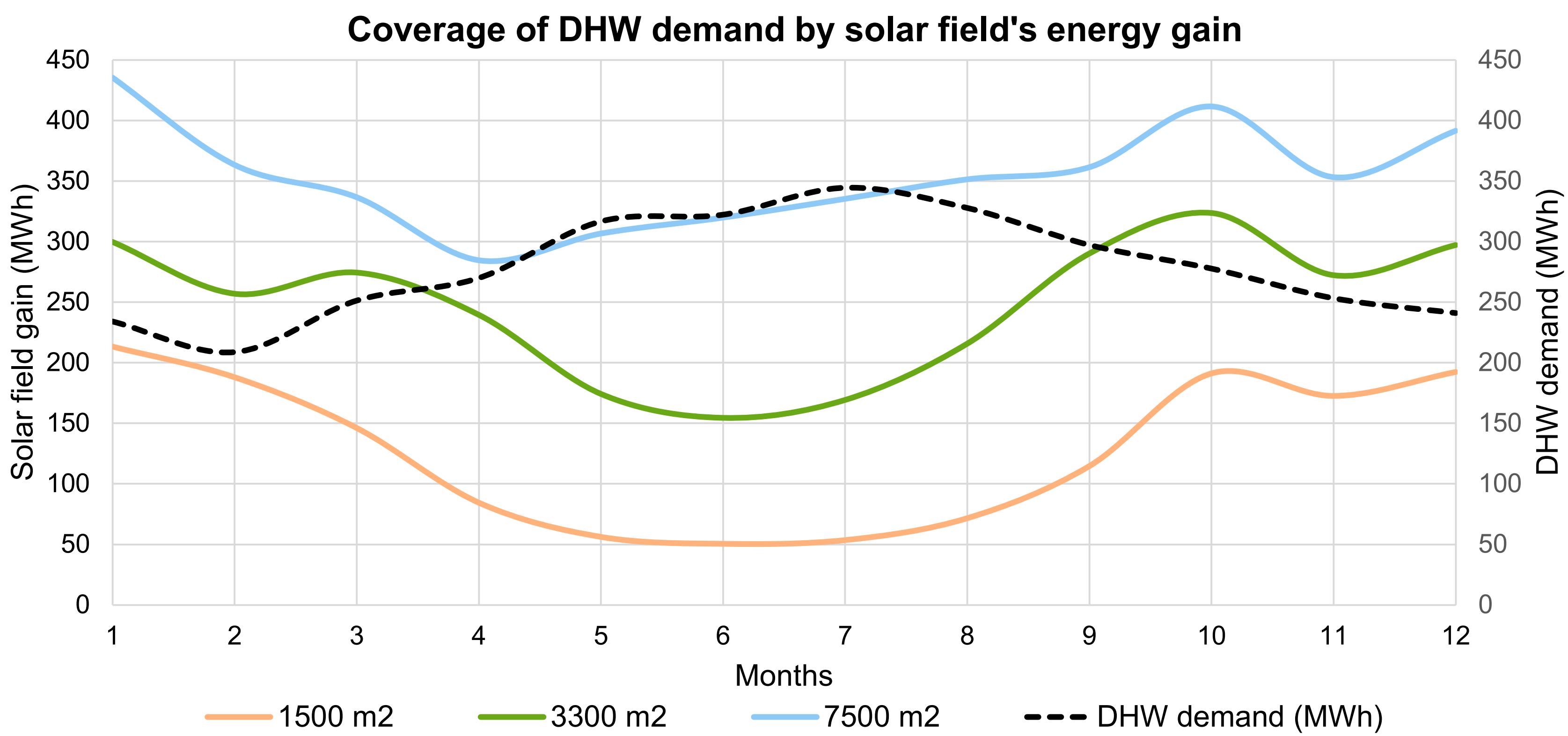
Results (continue)

Solar-assisted DHW system



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Results (continue)

Solar-assisted district heating system

Energy performance analysis of different solar field sizes in supplying district heating systems

Solar field area (m^2)	Size of required seasonal heat tank (m^3)	Increase in solar field gain during charging cycle (MWh)	Saving in backup use of SH network (MWh)	Coverage of SH demand by solar heat (%)
4,000	4,000	483	215.2	3.5
5,000	15,000	681	594.5	13.1
7,500	30,000	1,456	1,512.2	24.6

- **Higher useful energy gain due to higher mass flow rate**
- **Lower primary energy consumption**

Conclusions

- **Annual energy losses of the centralized DHW system supplied by natural gas is 0.61 GWh. Hence, its minimum annual energy use is 3.96 GWh.**
- **Minimum annual primary energy usage of decentralized conventional DHW system is 3.35 GWh.**
- **Enlarging solar field from 1,500 to 7,500 m^2 increased annual primary energy saving from 37% to 97% compared to conventional DHW system.**
- **Three solar fields with 4,000, 5,000 and 7,500 m^2 resulted in 4%, 13% and 25% reduction in the primary energy consumption of the SH network compared to the case without additional flow, while the seasonal tank losses increased due to the increase in storage size.**

Further work

- **Techno-economic analysis of the system in more densely populated areas of Melbourne to achieve lower heat losses and pumping power for a larger demand with comparable length of network**
- **Integration of the other sources of renewable energy such as geothermal and biomass as well as waste heat**
- **Integration of the other types of seasonal heat storage such as borehole thermal energy storage**

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Questions and Answers

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