Solar District Heating in Scotland (!?)

Borehole Thermal Energy Storage Modelling in Energy Systems Optimisation

3RD INTERNATIONAL CONFERENCE ON SMART ENERGY SYSTEMS AND
4TH GENERATION DISTRICT HEATING

COPENHAGEN, 12–13 SEPTEMBER 2017

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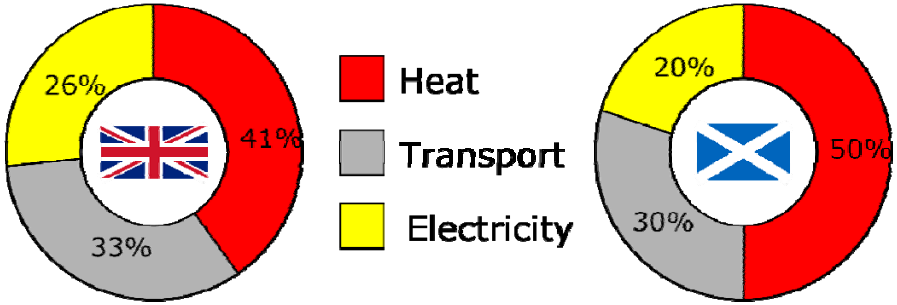
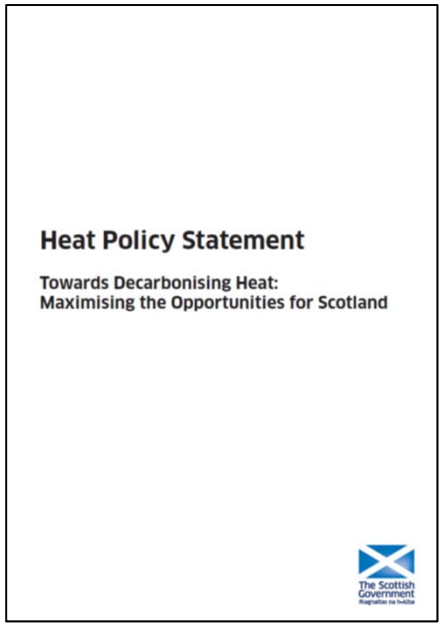
Background

- End-use energy consumption





- Heat decarbonisation
  - Demand reduction
  - Efficient supply & distribution
    - District heating
    - Gas grid
    - Storage
  - Low carbon & renewable heat

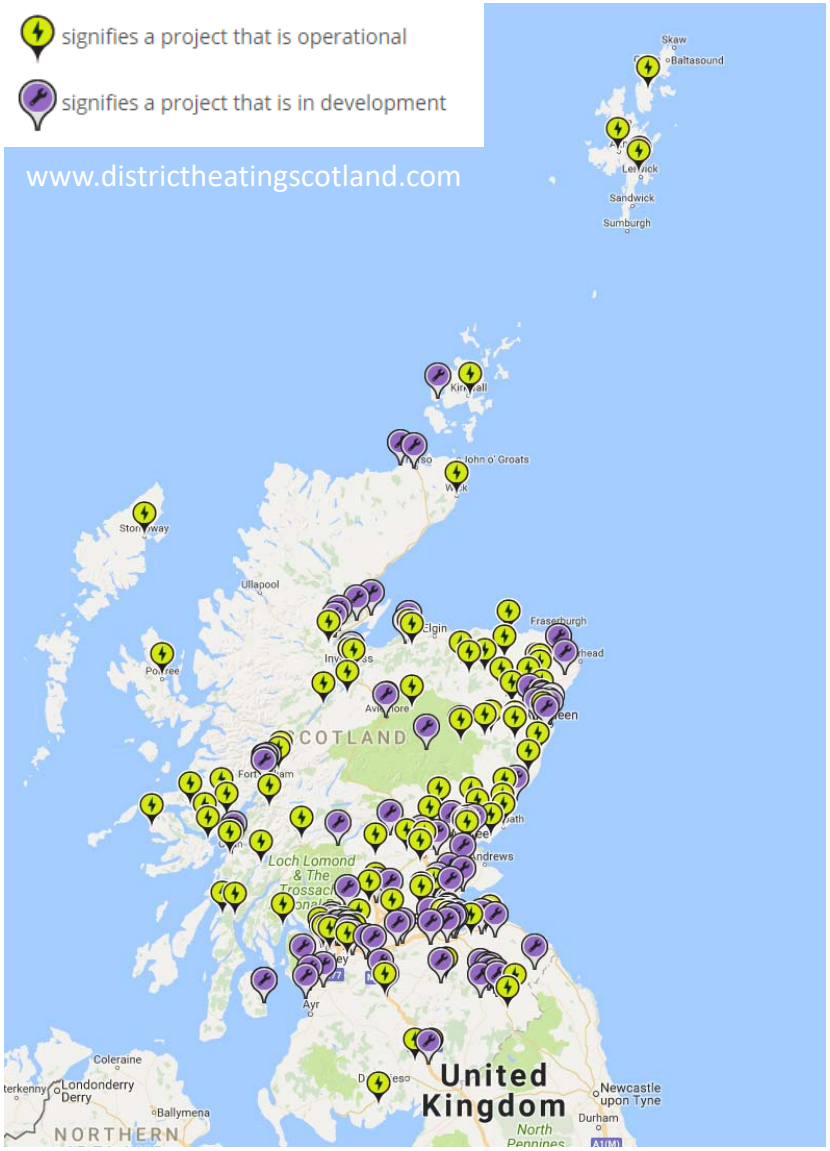
DH in Scotland

SUPPORT

- HNP Local Authority District Heating Strategy
- HNP Local Authority District Heating Strategy Sessions 1
- HNP Local Authority District Heating Strategy Sessions 2
- Heat Network Partnership Workshop Presentations
- Documents and tools
- Best practice from Denmark

Main technology:

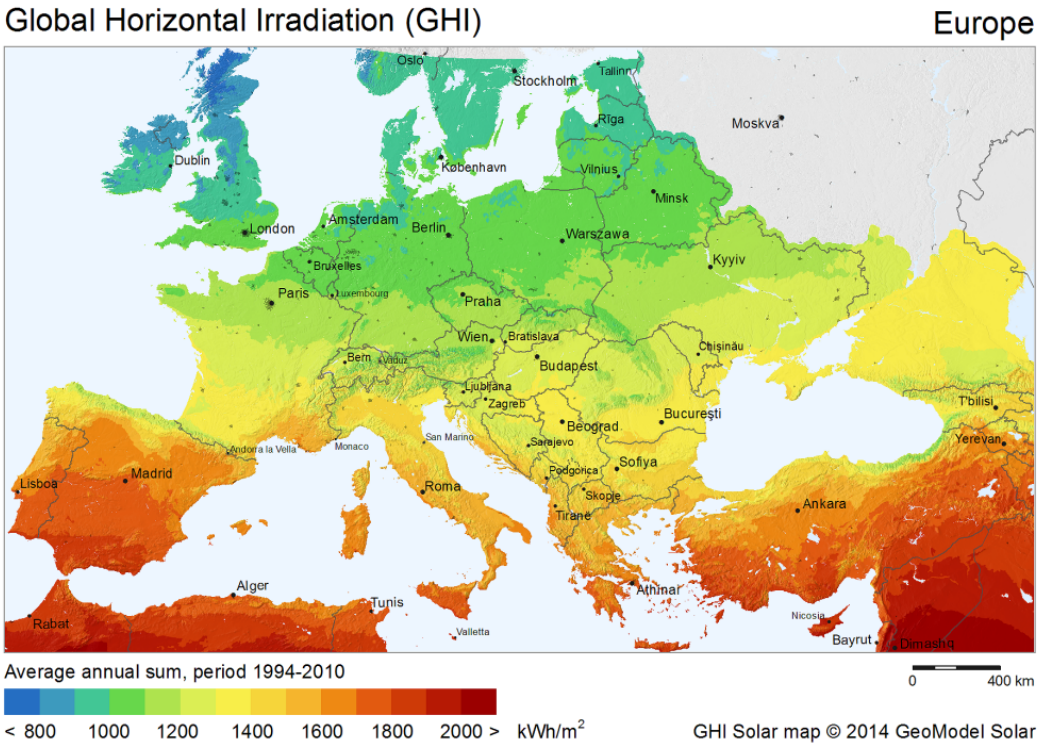
- Boiler (Gas & Biomass)
- CHP
- Ground Source Heat Pump
- Buffer storage tank

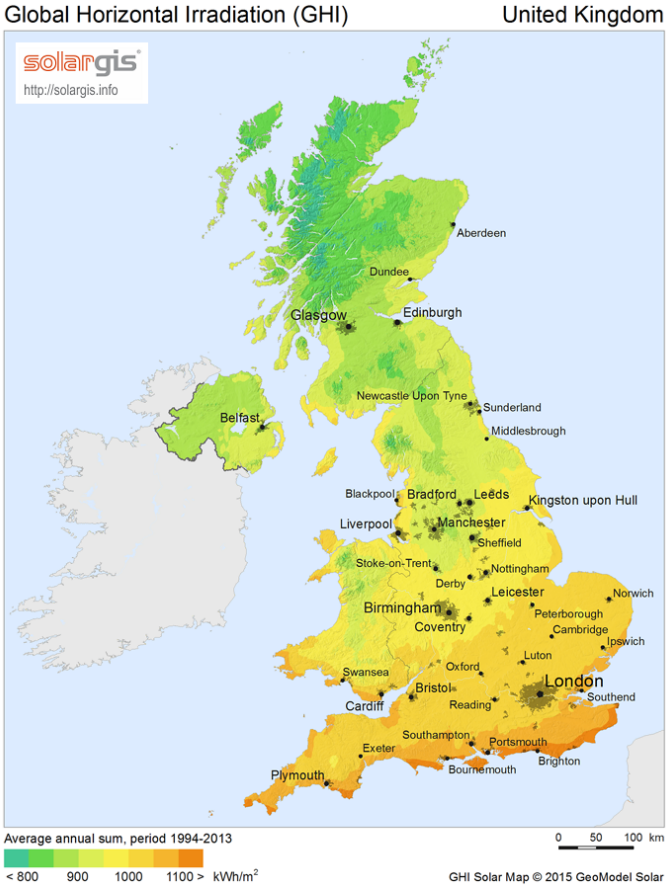


What about solar ?

"It's fine Scottish weather we're having. The rain is falling straight down and kind of to the side like."

Braveheart (1995)





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Case study: Drake Landing Solar Community

SHC 2012

The performance of a high solar fraction seasonal storage district heating system – five years of operation

Bruce Si

Energy 122 (2017) 471–481

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

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Journal of Building Performance Simulation, 2014
http://dx.doi.org/10.1080/19401493.2013.876448

Taylor & Francis
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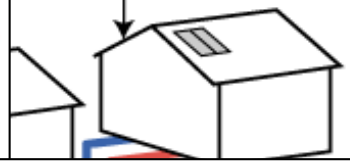
Optin

Department of Mechan

Two-storey single-family homes



Renewable Energy 81 (2015) 377–388

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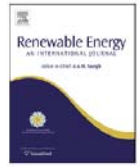

Influence of location and design on the performance of a solar district heating system equipped with borehole seasonal storage

CrossMark

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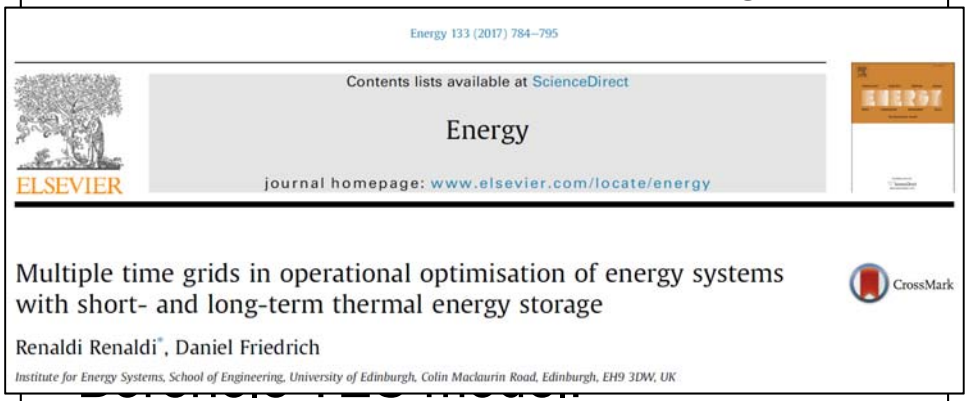
www.dlsc.ca

Methodology: Optimisation & Simulation

Optimisation

- Mixed Integer Linear Programming
- Problem:
  - Temporal properties of storage.



Energy 133 (2017) 784–795

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

Multiple time grids in operational optimisation of energy systems with short- and long-term thermal energy storage

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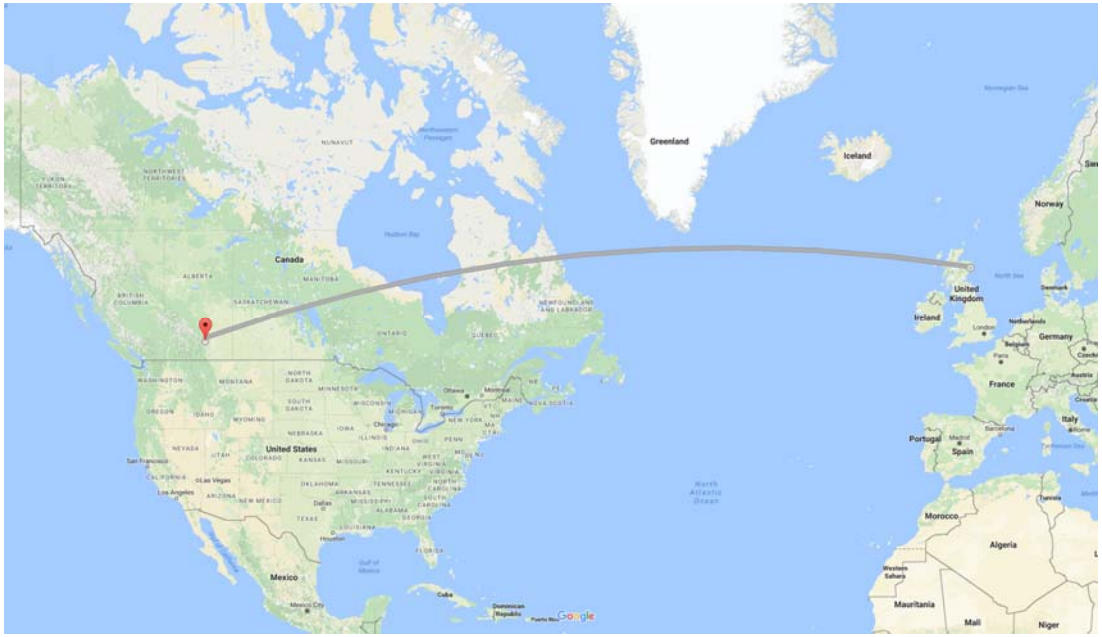
  First-law model.

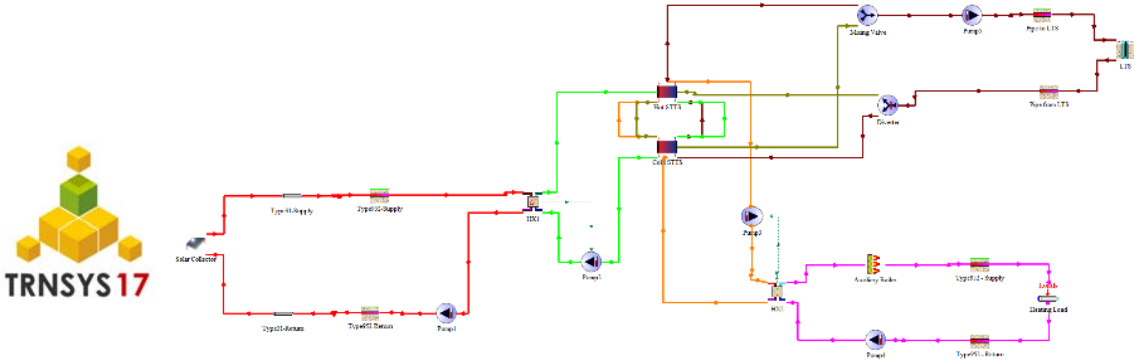
- Lower computational time; accuracy maintained.

Simulation

- TRNSYS
- Problem:
  - Performance in the UK.
  - Parametric study.
- Solution:
  Build a validated TRNSYS model.
- Borehole TES model:
  Type 557 DST
- Thermo-economic analysis.

Methodology: TRNSYS Simulation





- **Solar Fraction**
- **System Efficiency**
- **LCOE & LCOE$_{SolarThermal}$**

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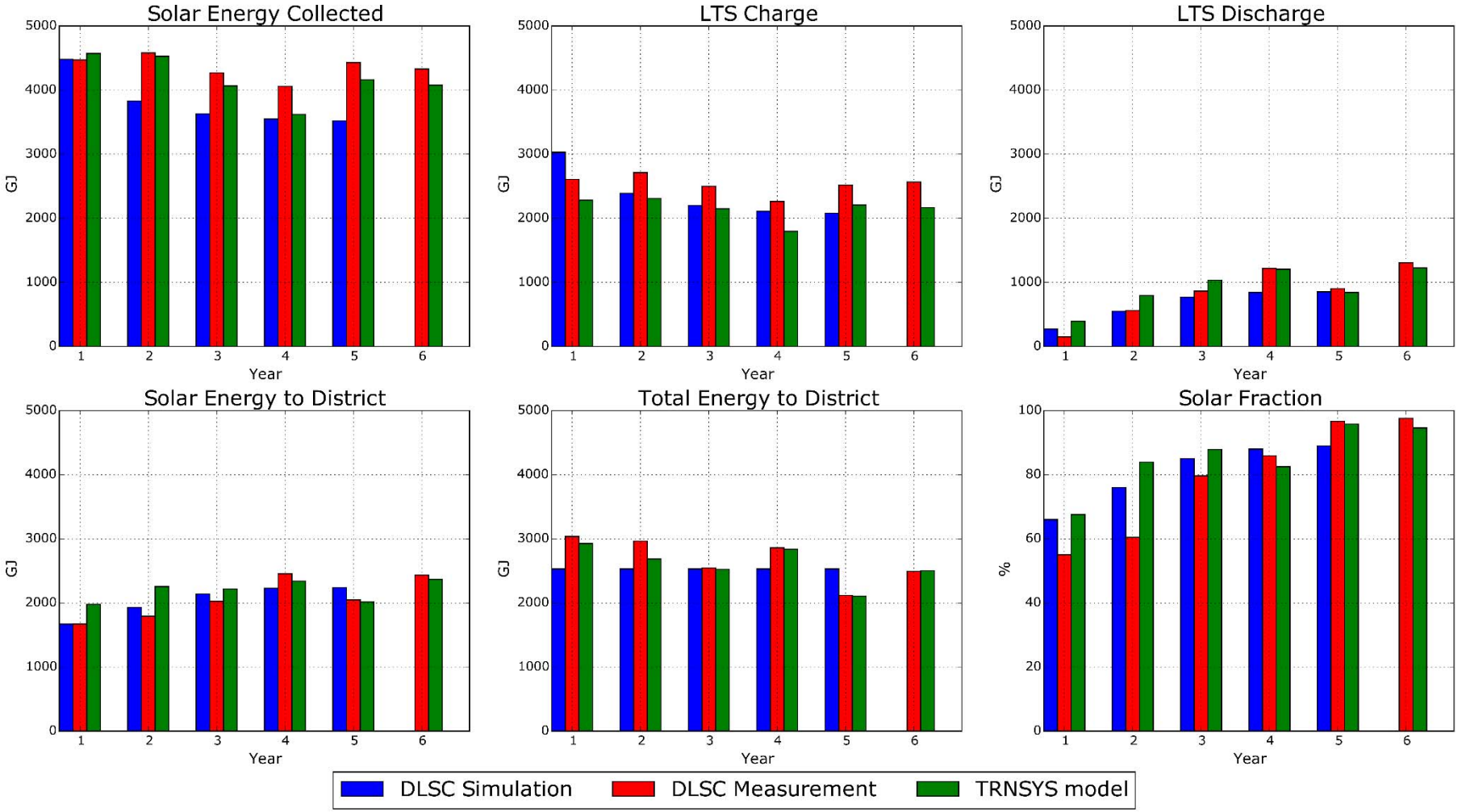
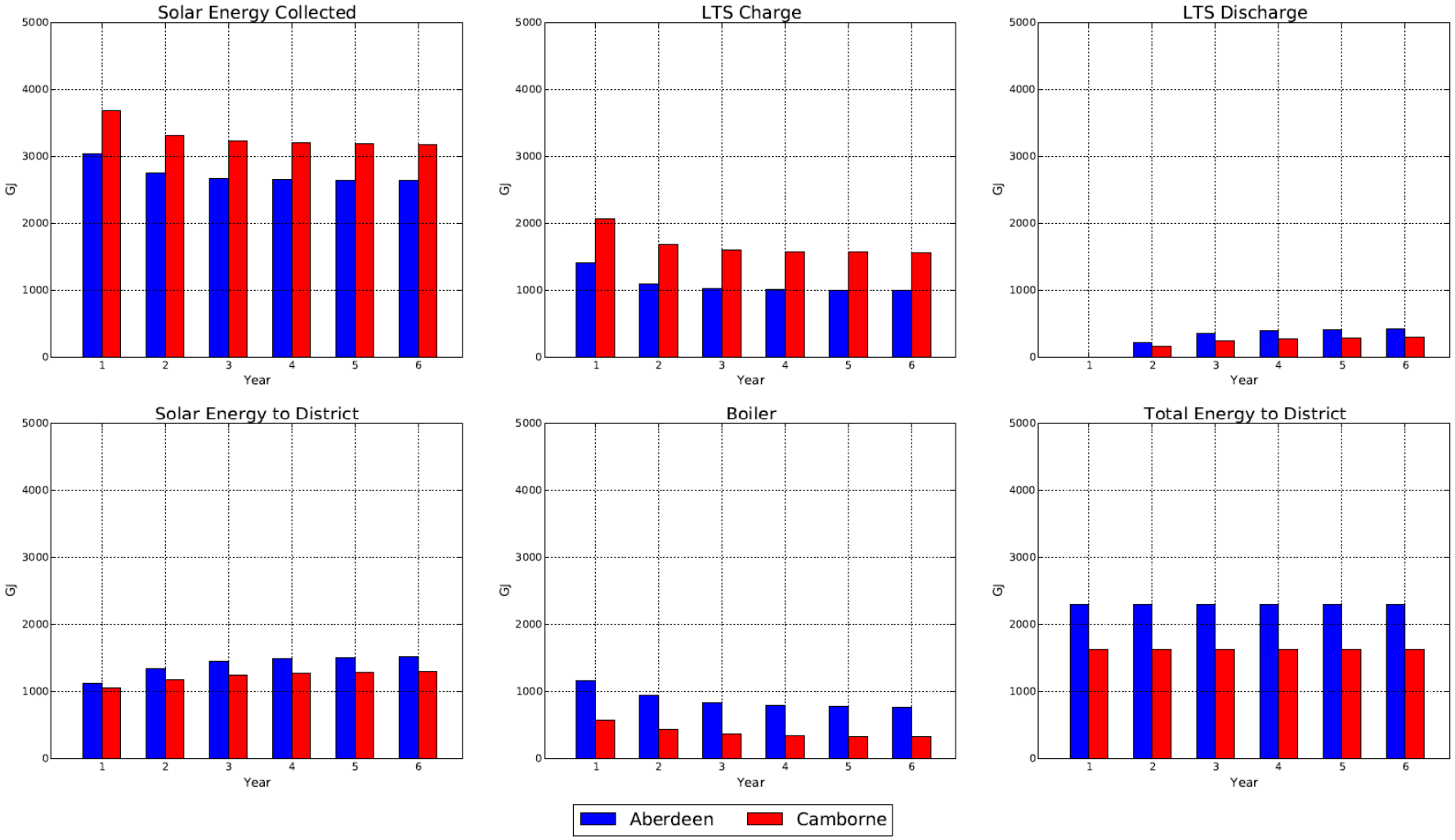
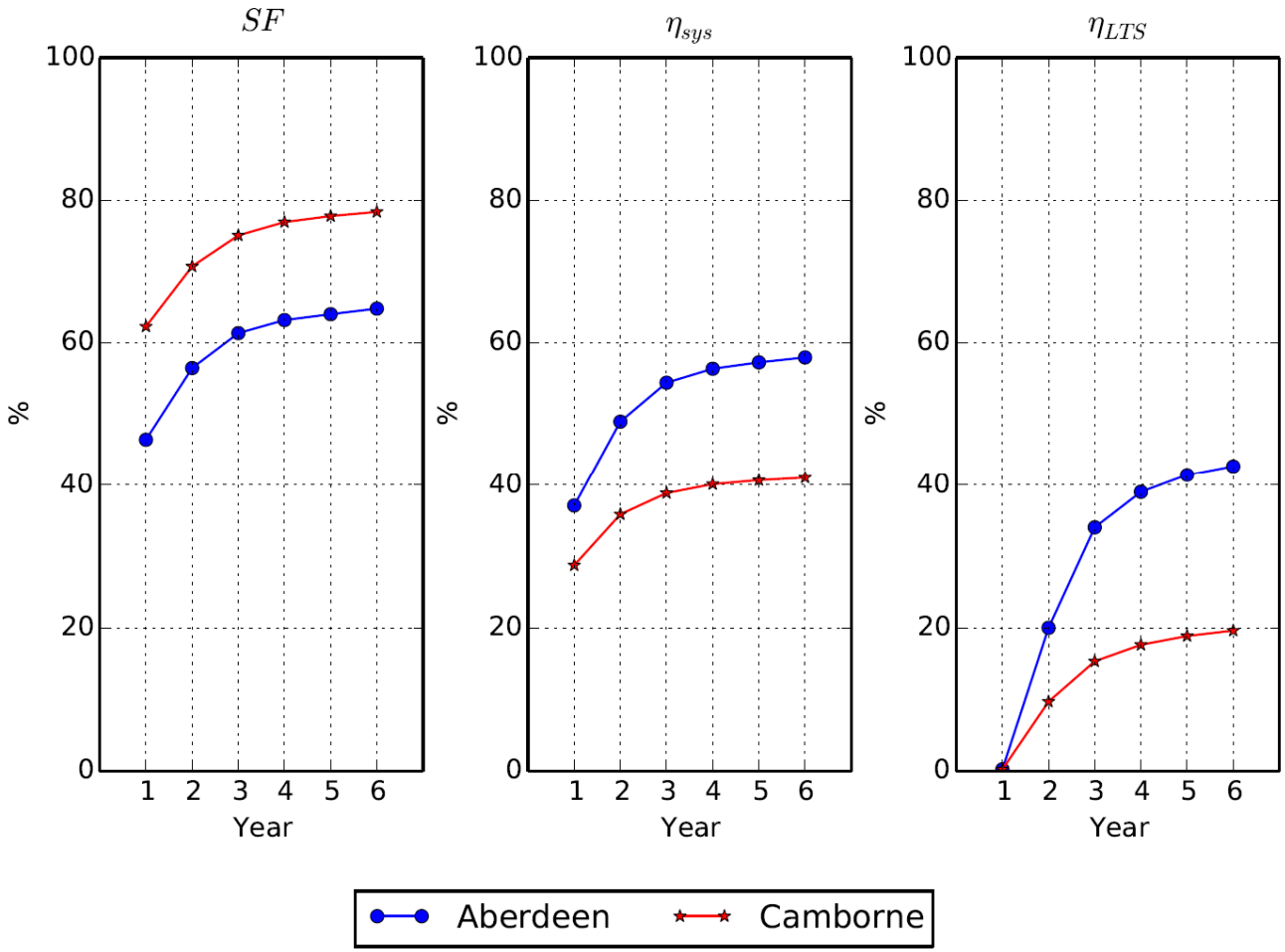
TRNSYS Model Validation



Results: UK Locations



Results: Techno-economic metrics

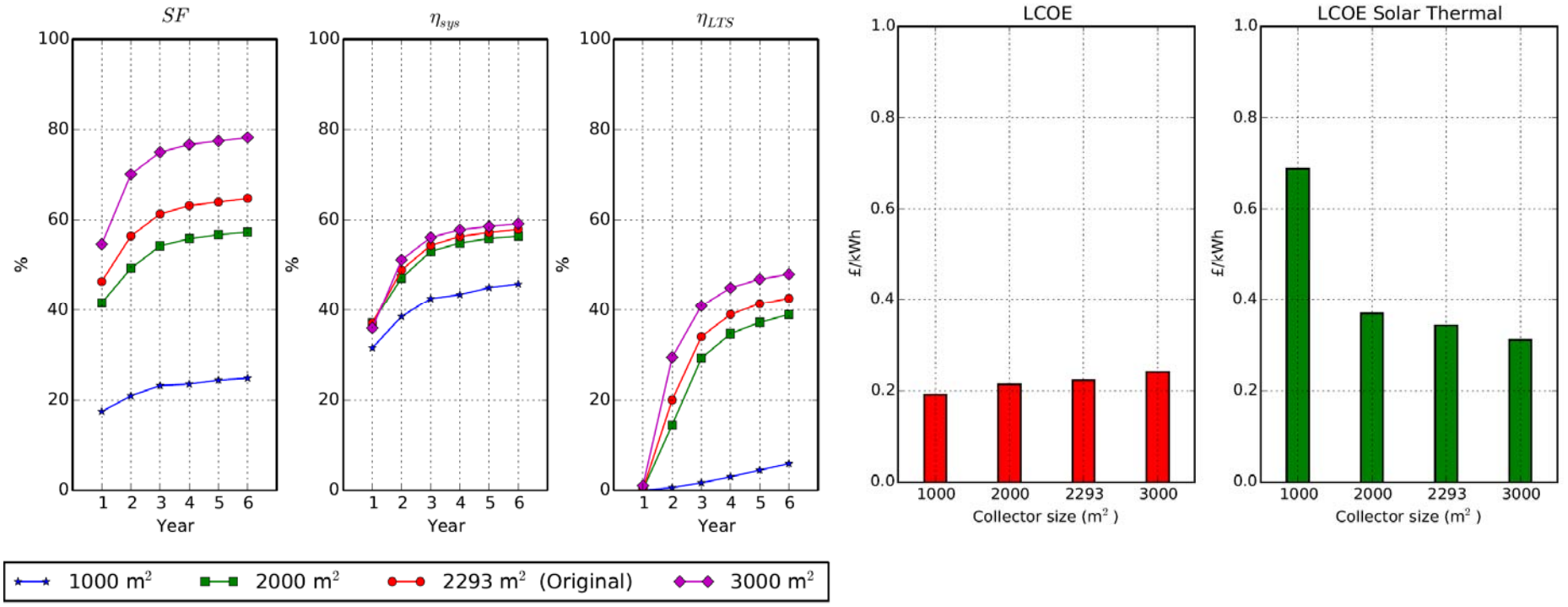


LCOE (£/kWh)
Aberdeen: 0.22
Camborne: 0.30

$LCOE_{ST}$ (£/kWh)
Aberdeen: 0.34
Camborne: 0.39

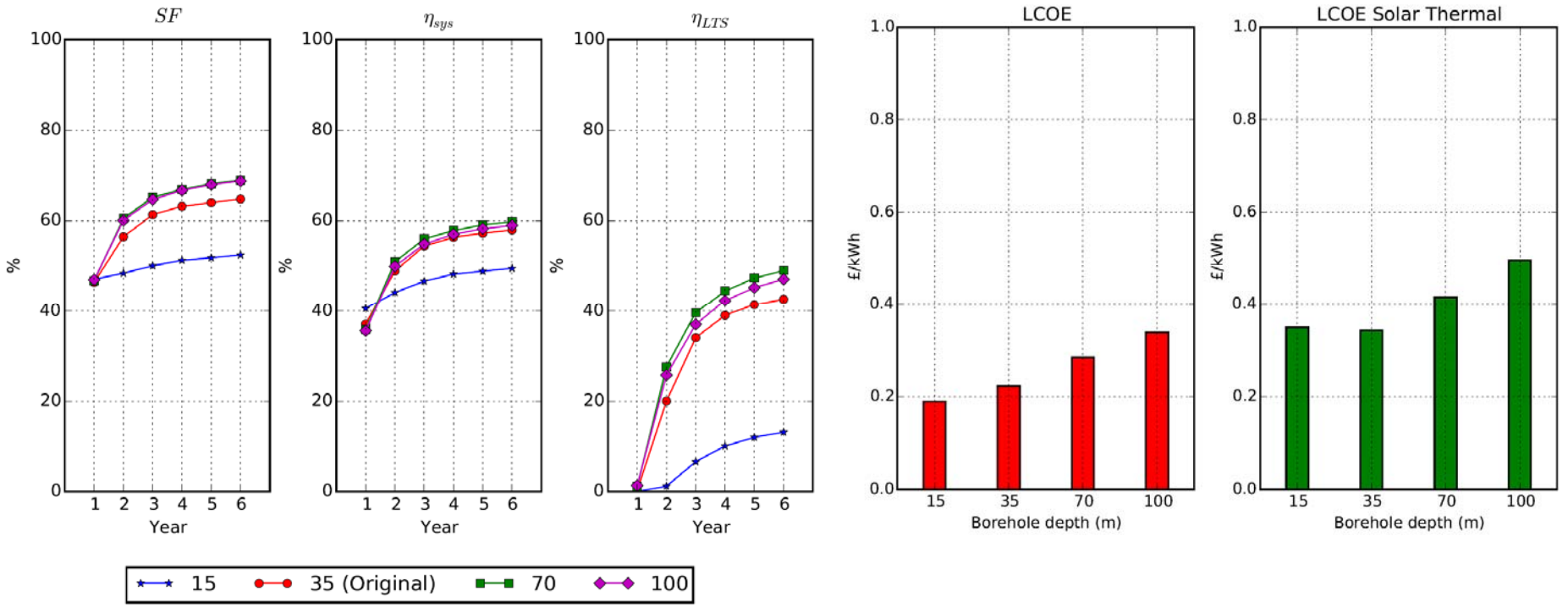
Parametric Study: Solar Collector

- Collector size: 1000, 2000, and 3000 m^2



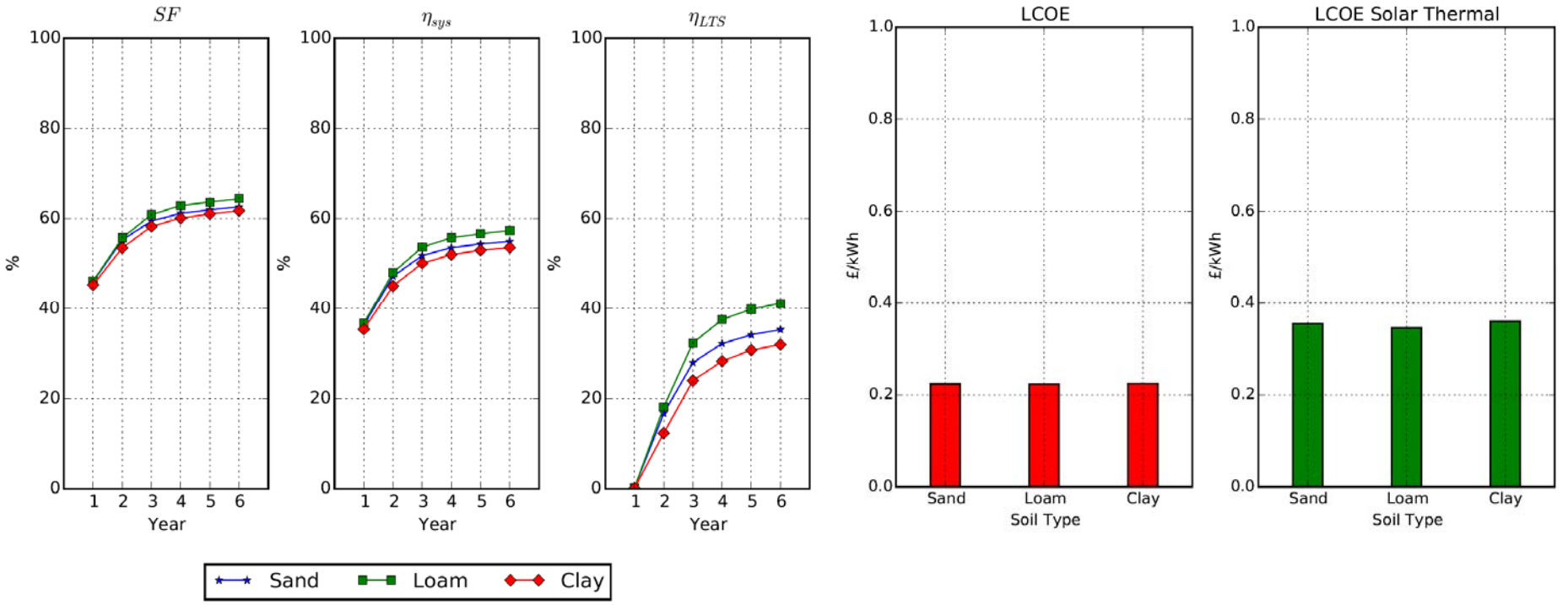
Parametric Study: Borehole depth

- Depth: 15, 35, 70, and 100 m.



Parametric Study: Soil Types

- Typical soil type: Sand, loam, and clay (median values).



Conclusions

- Validated TRNSYS model of DLSC.
- UK installations: Lower solar fraction, high LCOE.
- Aberdeen: ↓ solar fraction, ↑ system efficiency, ↓ LCOE.
- Camborne: ↓ storage efficiency due to high soil thermal diffusivity.
- Parametric studies:
  - Solar collector: Undersizing will grossly increase $LCOE_{ST}$.
  - Borehole: Optimal depth exists from LCOE viewpoint.
  - Soil: Loam-type is more suitable for borehole storage.

Future work

- Techno-economic optimisation.
- Other renewables, e.g. biomass, waste heat, heat pump.
- Potential financial incentives (e.g. Renewable Heat Incentive, District Heating Loan).

Thank you !

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