

Urban networks with high share of variable generation

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Optimal demand side management (DSM) and power-to-heat (P2H) in cities with wind and PV

Variable renewable energy (VRE) is a potential provider of carbon-free energy to urban areas, which consume $\frac{2}{3}$ of primary energy worldwide.

Optimal load-VRE match and cost-optimal spot trading with urban demand flexibility: P2H to district heating (DH) and DSM.

Case study with hourly data (2013–2015) in Helsinki (>90% of DH), with new data on shiftable loads.

P2H absorbs all surplus VRE when it provides 50% of electricity through self-consumption.

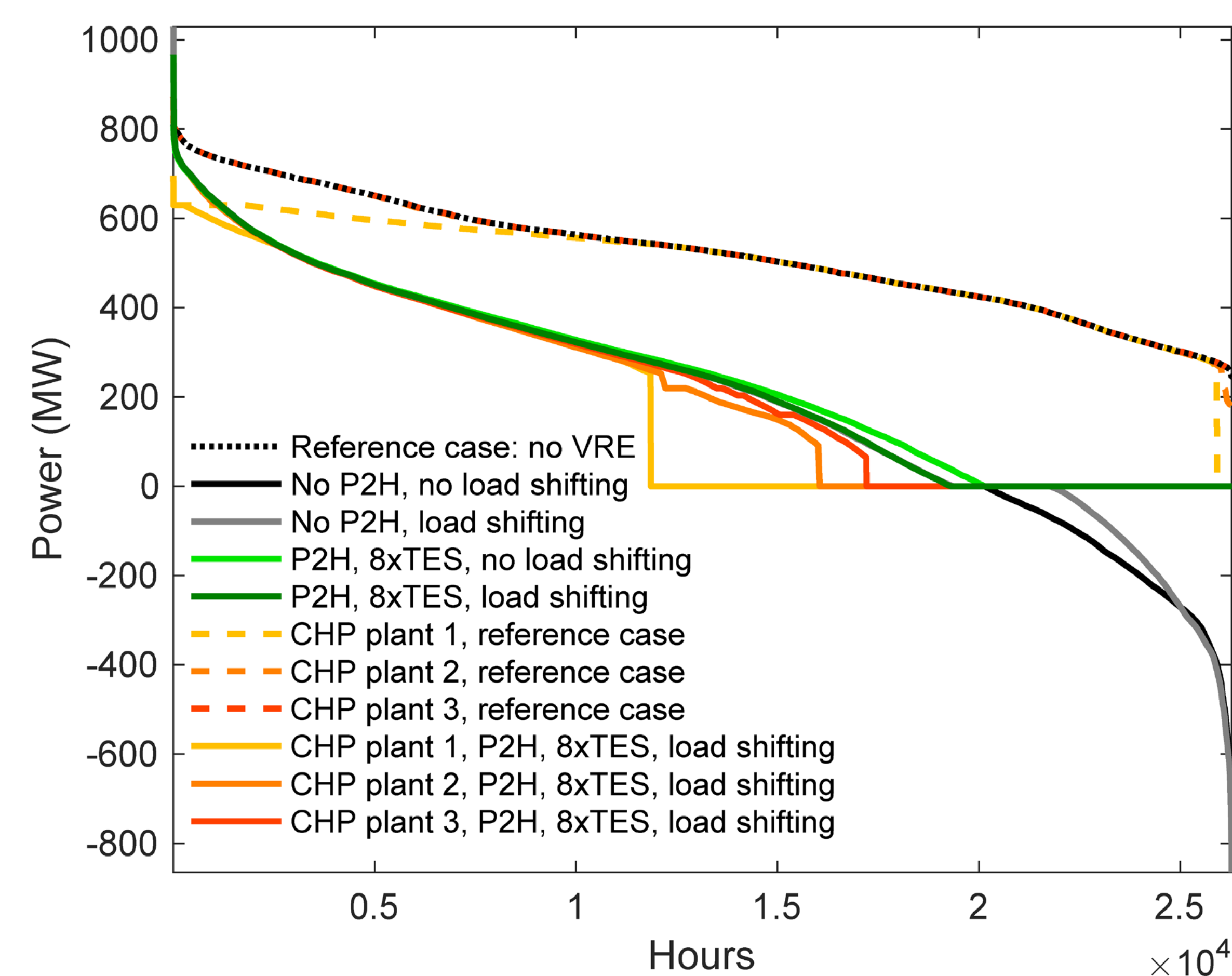


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Positive net present value for P2H with thermal storage (TES) and load shifting with electric heating and commercial refrigeration.

Salpakari J, Mikkola J, Lund PD. Improved flexibility with large-scale variable renewable power in cities through optimal demand side management and power-to-heat conversion. *Energy Conversion and Management* 2016;126:649–61. doi:10.1016/j.enconman.2016.08.041.

Cost-optimal space heating and plug-in electric vehicle (PEV) charging in net zero energy houses

PEVs and space heating with heat pumps can provide energy efficiency, electrification and flexibility.

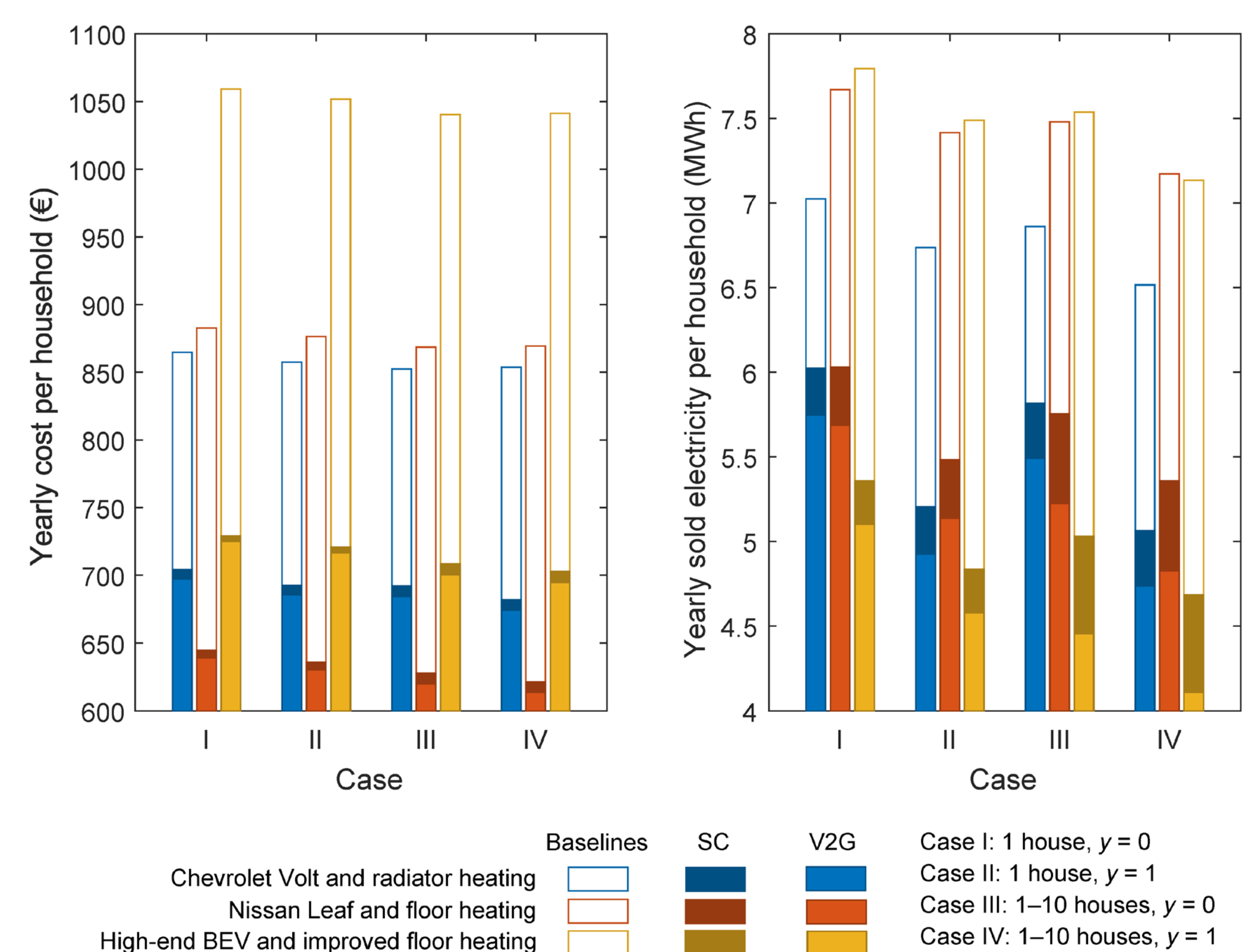
Cost-optimal control of heat pumps and PEV charging. Smart charging (SC) and vehicle-to-grid (V2G). Reference minimizes energy consumption.

Battery degradation and thermal dynamics of buildings and PEVs included in the model.

Case study: 1–10 net zero energy houses with PV in Sweden. Hourly data from Sept 2005 – Aug 2006. PV transfer to workplace for day charging on/off ($y=1/0$).

8–33% cost savings compared to reference.

V2G provides limited added value compared to SC.



Battery degradation significantly decreases the added value of V2G.

Salpakari J, Rasku T, Lindgren J, Lund PD. Flexibility of electric vehicles and space heating in net zero energy houses: an optimal control model with thermal dynamics and battery degradation. Submitted to *Applied Energy* on 19.8.2016.

