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Forecasting district heating consumption based on customer measurements

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- In Helsinki 90 / 90 / 90 philosophy in district heating (DH)

Picture from: wiki.aalto.fi

Target of the paper

- To develop a **forecasting model** for DH consumption
- **Hourly heat consumption data from individual customers** is used as a source

- More accurate consumption data is now available
  - Remote meter readings

Benefits for

DH producer

- Better production **planning** and **optimization**
  - Optimizing the use of **heat storages**
- **Customer profiles** for different customer types
- Customer and area specific forecasts

DH customer

- Allow **planning their own heat consumption** and possible local production (smart DH systems)

Data used

- Initially data from 14 customers (block buildings)
  - Nine customers were included
- Hourly heat consumption data
- The full year 2011
- T_{out} from Helsinki

Methods

- Linear regression is used

$$y_t = a_0 + a_1 x_t$$

- Social component is included

$$y_t = a_0 + a_{h(t)} + a_1 x_t$$

Factors taken into account

- Outdoor temperature
- Social component
  - Four different ways

=> Five different models were developed

T, T168, T72, T168H, T72H

Model T - outdoor temperature

- Outdoor temperature data is used in the linear regression model

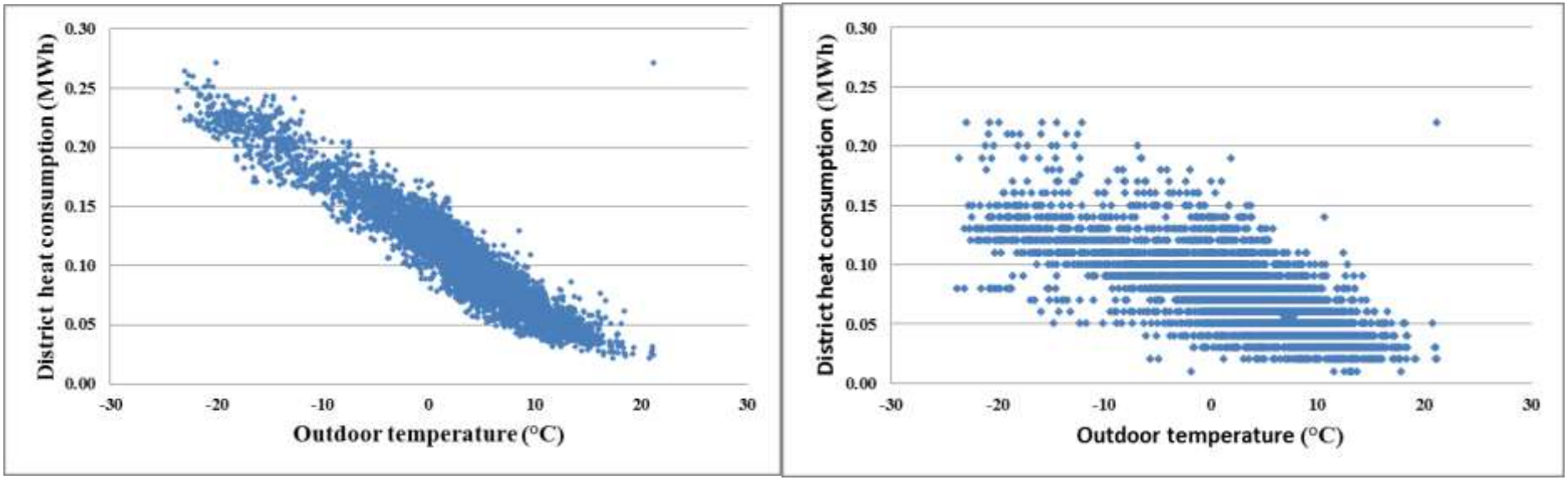
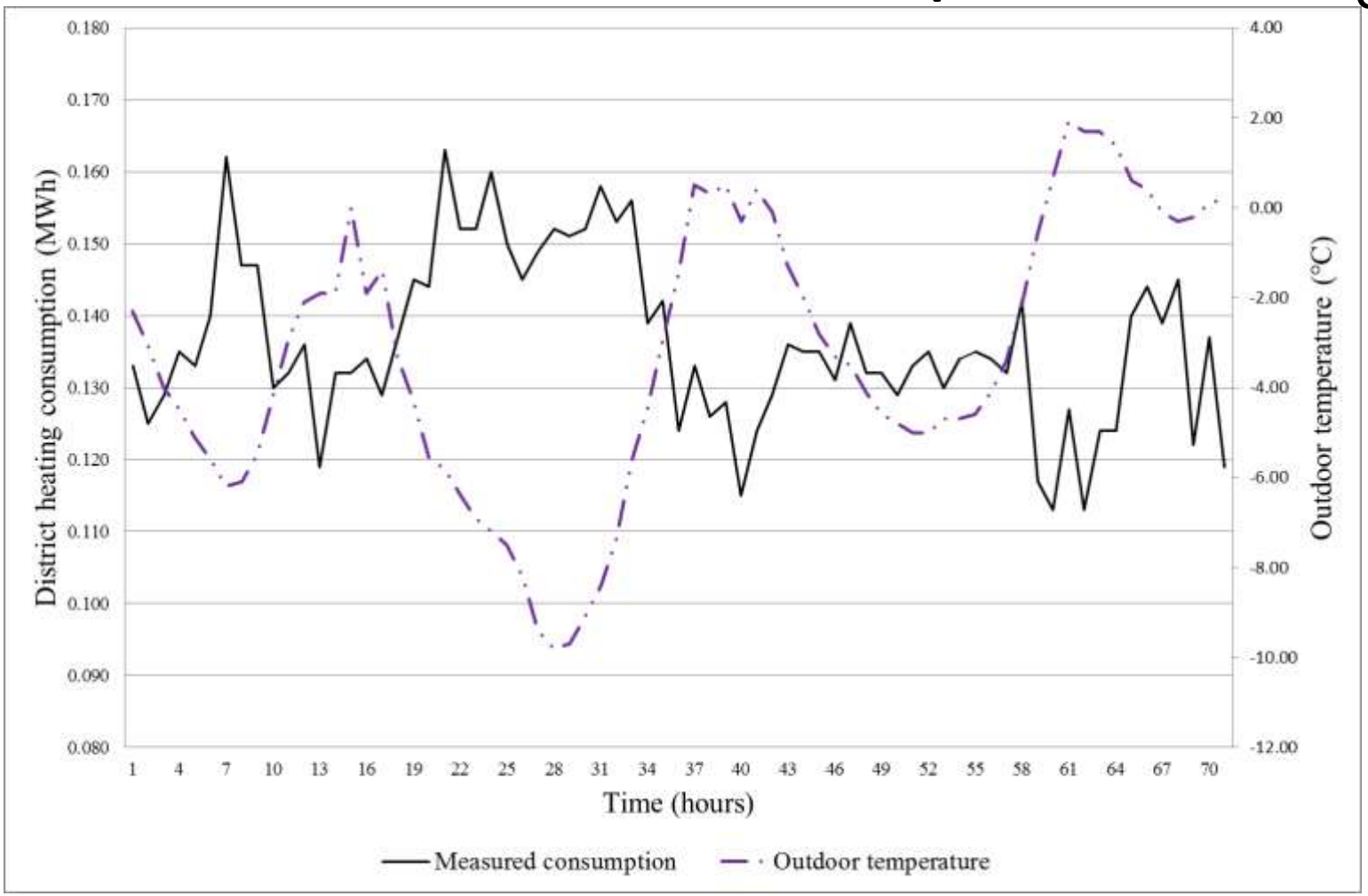
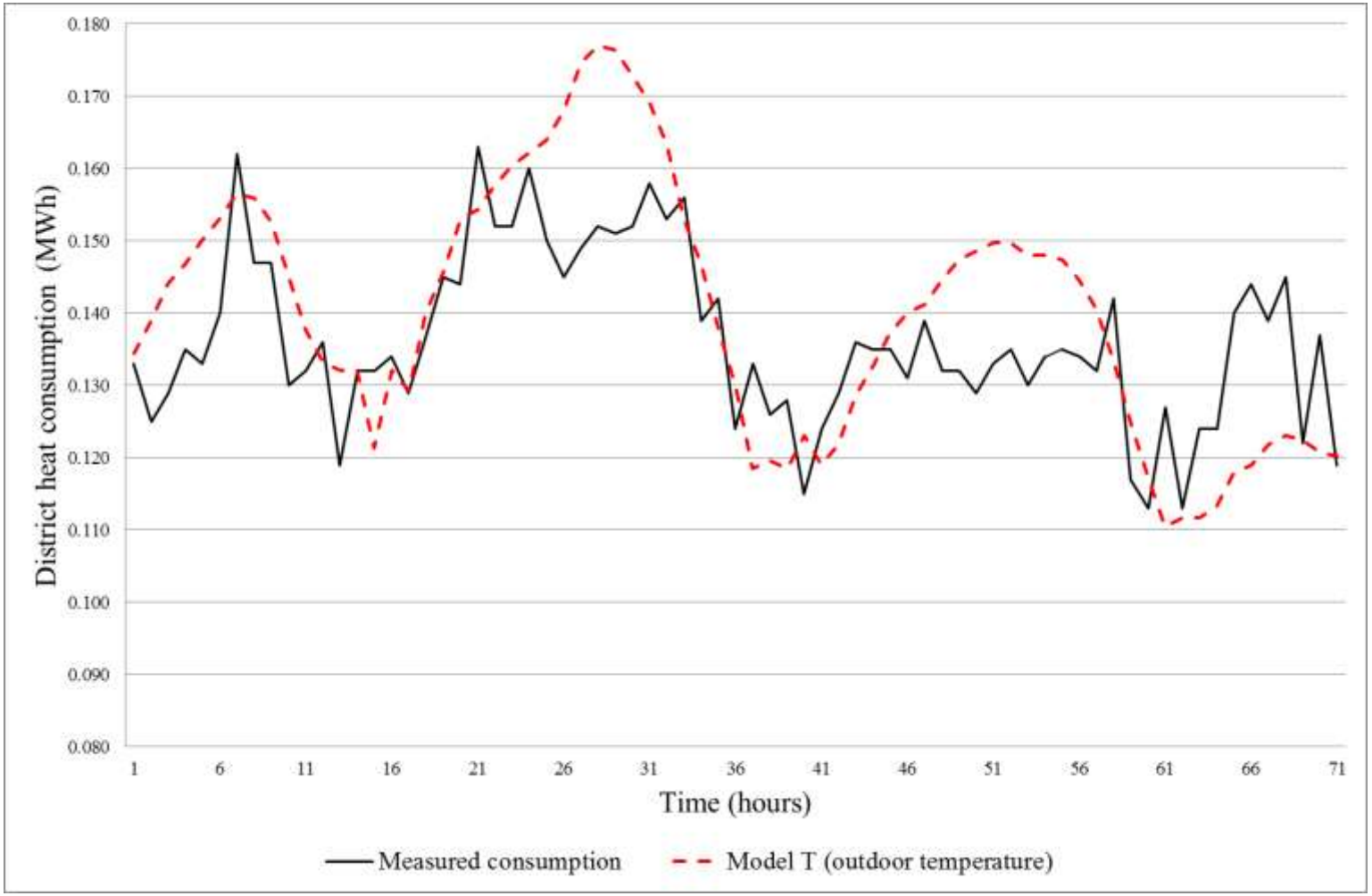


Figure: Regression lines for customer 1 (left, good accuracy) and customer 6 (right, bad accuracy)

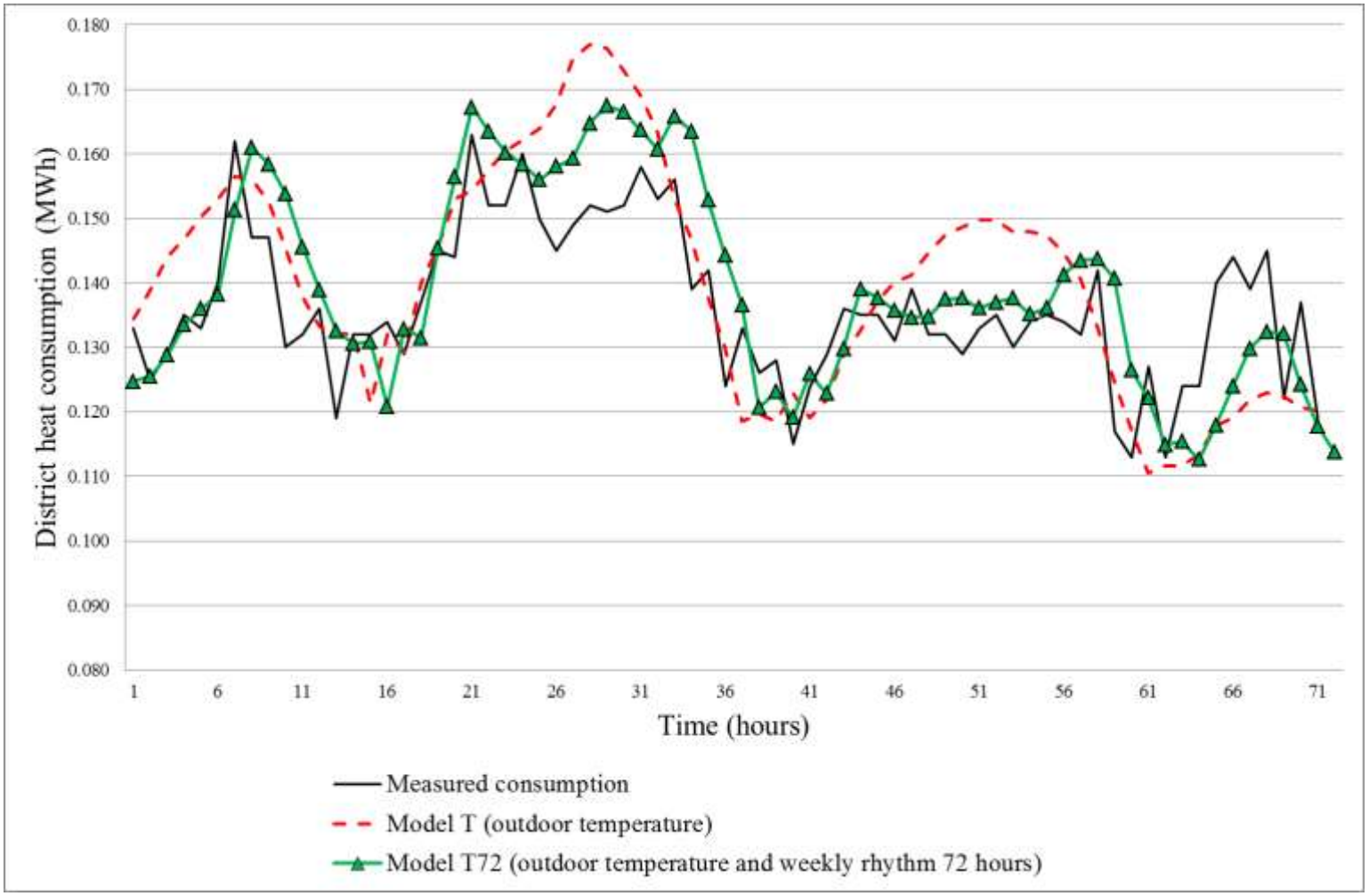
DH consumption and T_{out}



DH consumption and model T



DH consumption and models T and T72



Conclusions and future work

- Accuracy of the forecasting models varies depending on the customer
  - More accurate for bigger customers and aggregated groups of customers
- In the best cases a rather simple model was shown to predict the heat consumption with good accuracy

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Thank you!

Appendix 1. Different models used

- Five different models

T	Only outdoor temperature (T_{out}) was considered
T168	T_{out} together with a 168 hour weekly rhythm was used
T72	T_{out} together with a 72 hour weekly rhythm (working days, Saturdays, Sundays) was used
T168H	Same as the T168 model, but midweek holidays were classified as Saturdays or Sundays
T72H	Same as the T72 model, but midweek holidays were classified as Saturdays or Sundays

Appendix 2. Results

	Errors of different forecasting models (A – E)									
	Relative error (%)					Absolute error (MWh)				
	T	T168	T72	T168H	T72H	T	T168	T72	T168H	T72H
Customer										
1	**9.50**	**7.69**	**7.15**	7.76	7.17	0.0097	0.0076	0.0073	0.0078	0.0074
2	10.62	7.53	7.66	7.50	7.63	0.0078	0.0060	0.0061	0.0061	0.0061
5	20.81	14.90	15.42	14.99	15.47	0.0081	0.0056	0.0057	0.0056	0.0057
6	26.74	24.46	24.32	24.19	24.06	0.0164	0.0135	0.0135	0.0134	0.0134
7	14.42	8.09	7.51	8.13	7.53	0.0196	0.0109	0.0102	0.0109	0.0102
8	10.40	6.77	6.25	6.74	6.26	0.0107	0.0074	0.0071	0.0074	0.0072
11	11.61	7.88	7.58	7.89	7.59	0.0160	0.0104	0.0102	0.0104	0.0102
12	12.87	8.45	8.32	8.39	8.24	0.0154	0.0105	0.0105	0.0105	0.0104
13	**21.65**	**15.52**	**15.82**	15.51	15.81	0.0141	0.0111	0.0112	0.0110	0.0112
Customer pairs										
1 + 2	9.13	6.69	6.43	6.71	6.41	0.0162	0.0122	0.0119	0.0123	0.0120
5 + 6	19.83	16.04	16.12	15.86	15.94	0.0204	0.0148	0.0148	0.0147	0.0146
7 + 8	12.05	6.51	5.80	6.52	5.81	0.0297	0.0153	0.0143	0.0154	0.0144
11 + 12	11.29	6.41	6.41	6.37	6.36	0.0291	0.0166	0.0167	0.0165	0.0165
All customers	10.67	5.34	5.28	5.33	5.25	0.0872	0.0421	0.0424	0.0420	0.0423