

Distributional Effects of Time of use Tariffs



DEePRED conclusion

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What was the aim?

DEePRED will give an insight on which socio-demographic groups would be affected by introduction of Time-of-Use tariffs.

- What activities contribute to peak demand?
- What clusters of consumers can be identified based on their energy-related activities and their socio-demographic information?
- How would introduction of Time-of-Use tariffs impact consumers?
 - Who could be worse off and who could benefit?
- What historical activities could tell us about the future?



What did we achieve?

UK Time Use Survey 2014-2015

Household demand profiles
LCL and CLNR

Clustering
of
households
by activities

Split households by their demographics

Family
structure (5)

Income (3)

Family
structure (11)

Income (6)

Composites:
Income and location
Income and family
structure

Analysis of activities by peak and non-peak times

Demand modelling by matching
activities and demand profiles

Applied ToU
tariff on **LCL**
control and
intervention
groups

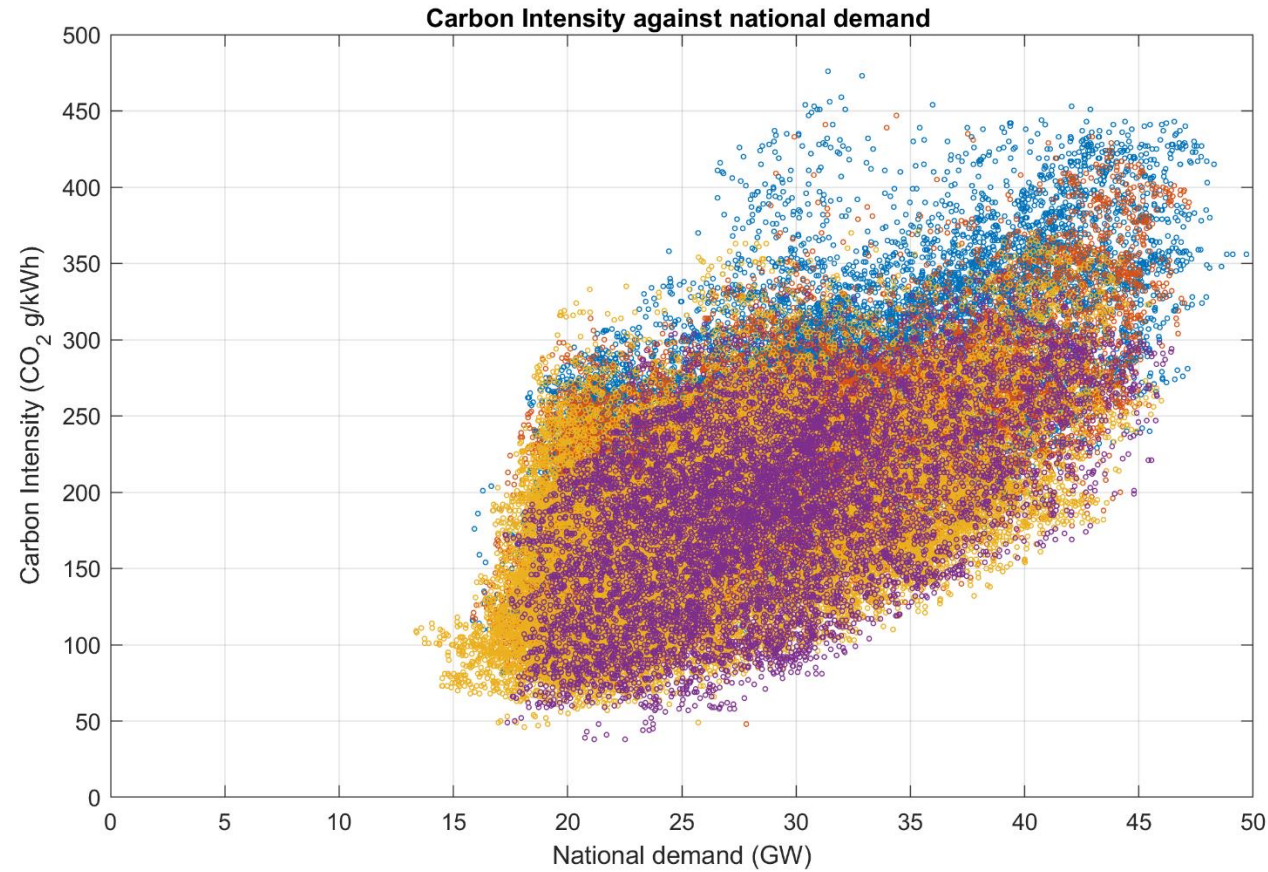
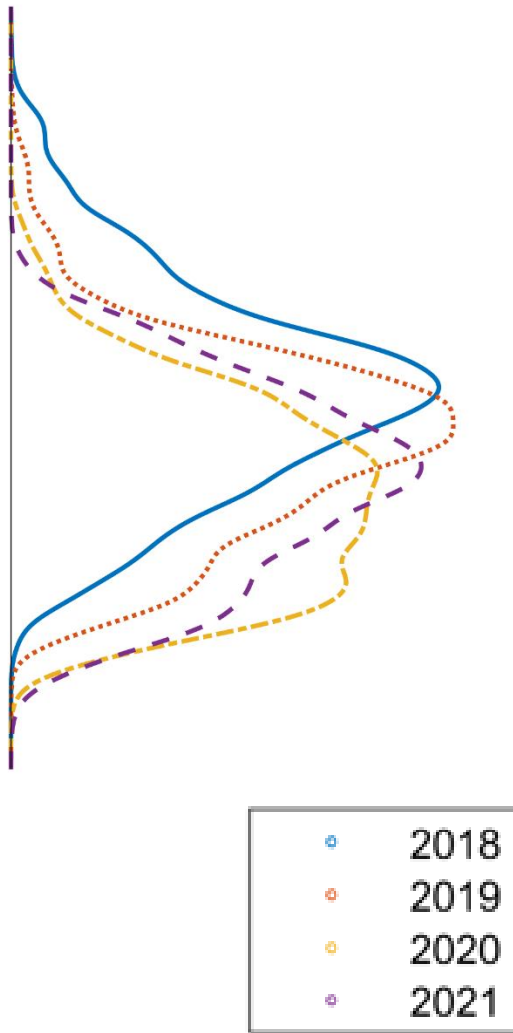
Applied ToU
tariff on **CLNR**
control and
intervention
groups

Distributional impact analysis

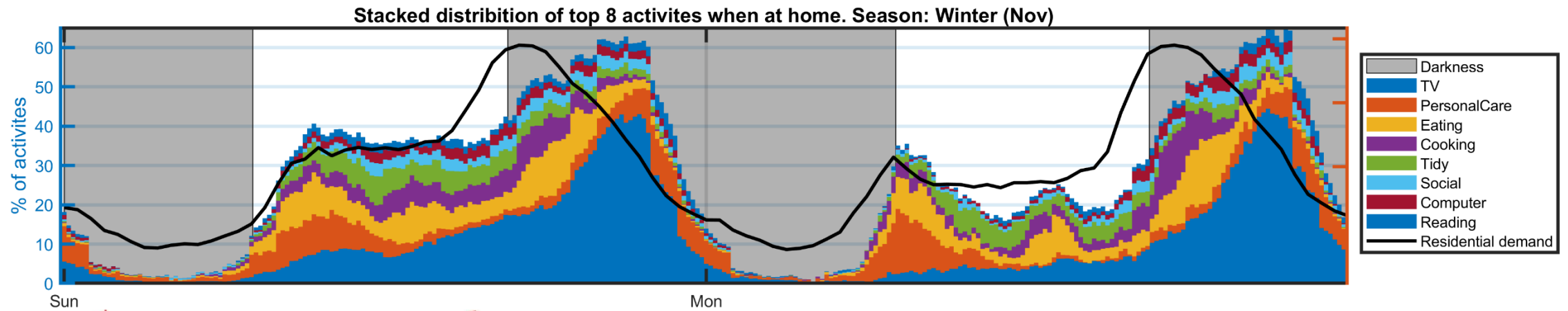
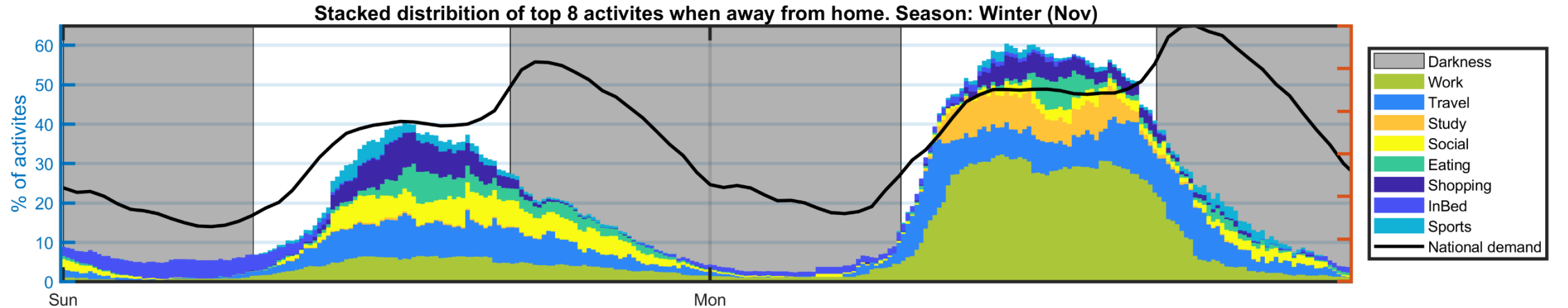
Peak-time activities



Peak demand is problematic...



Activities and demand

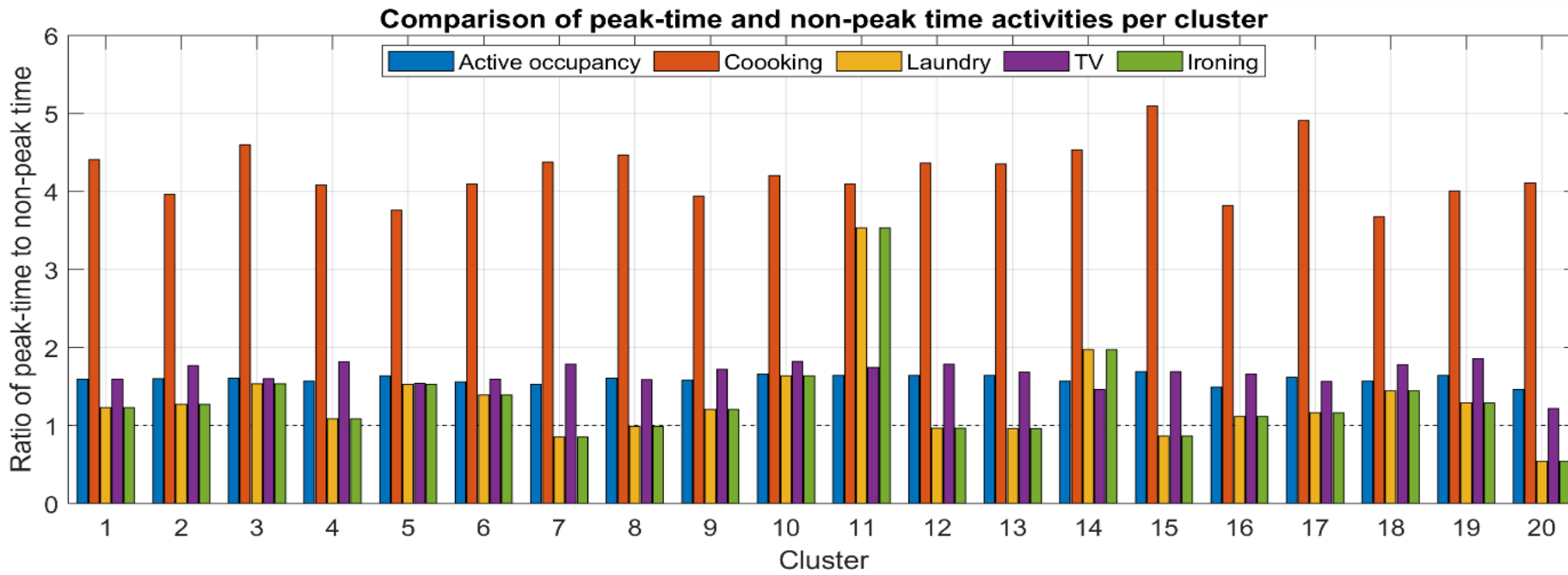
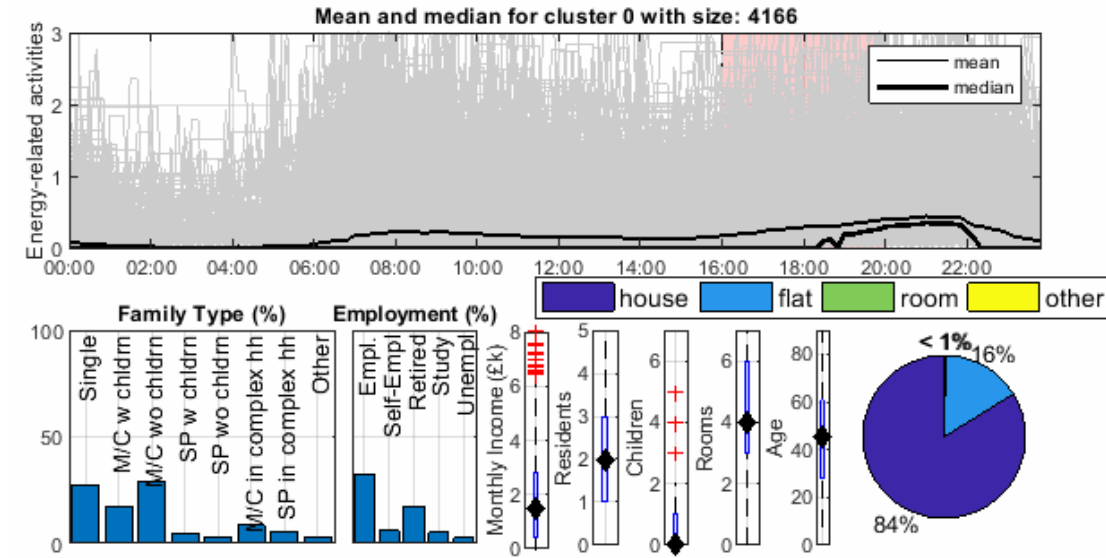


Distributional impacts

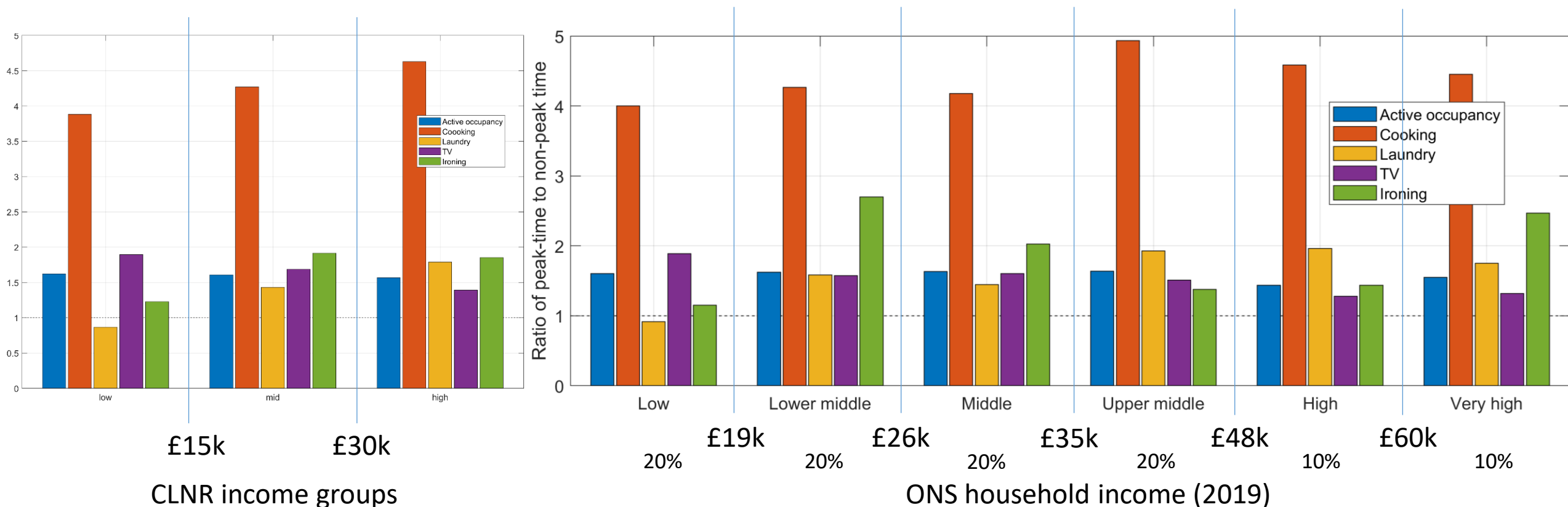
Clustering and split by socio-demographic parameters



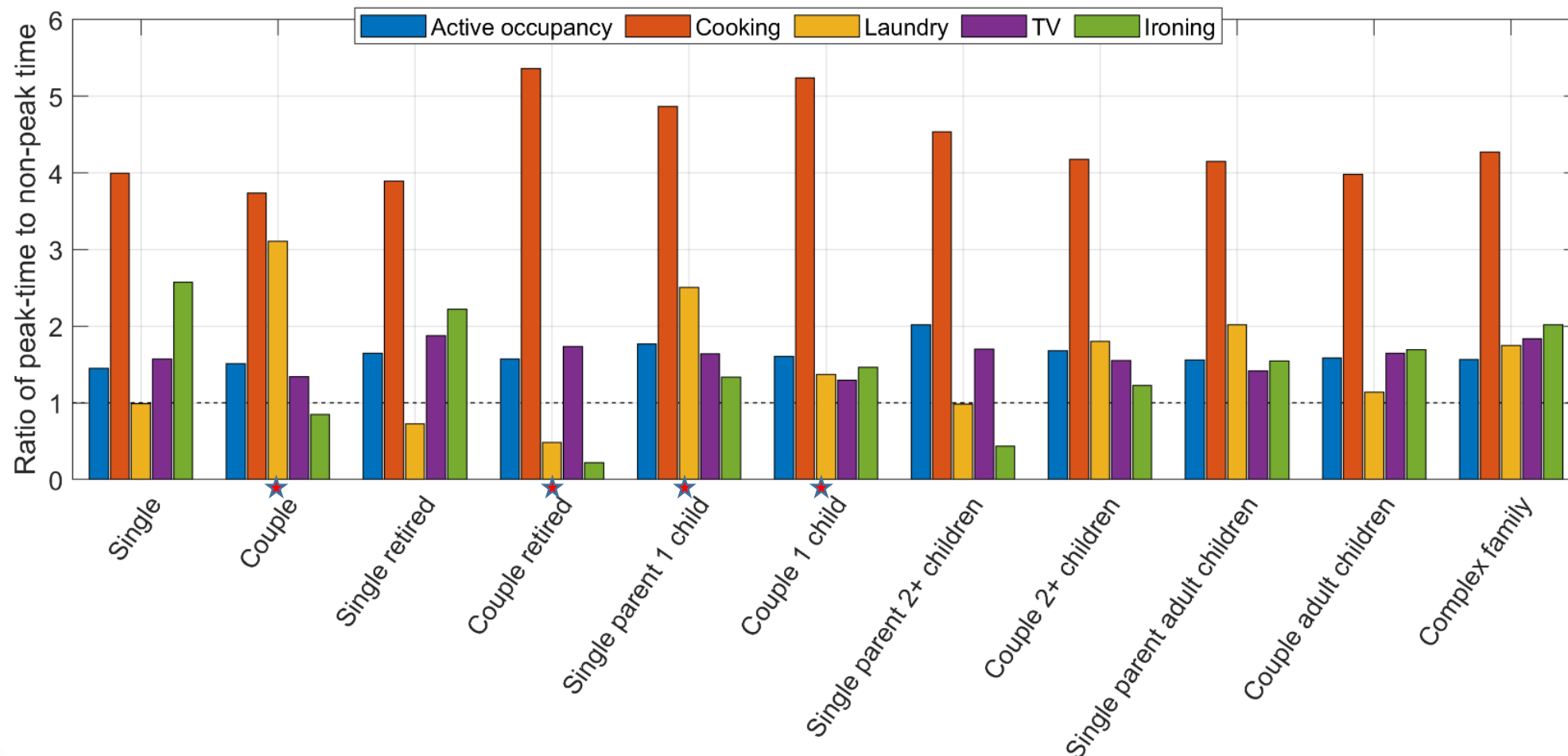
Cluster by activity profiles



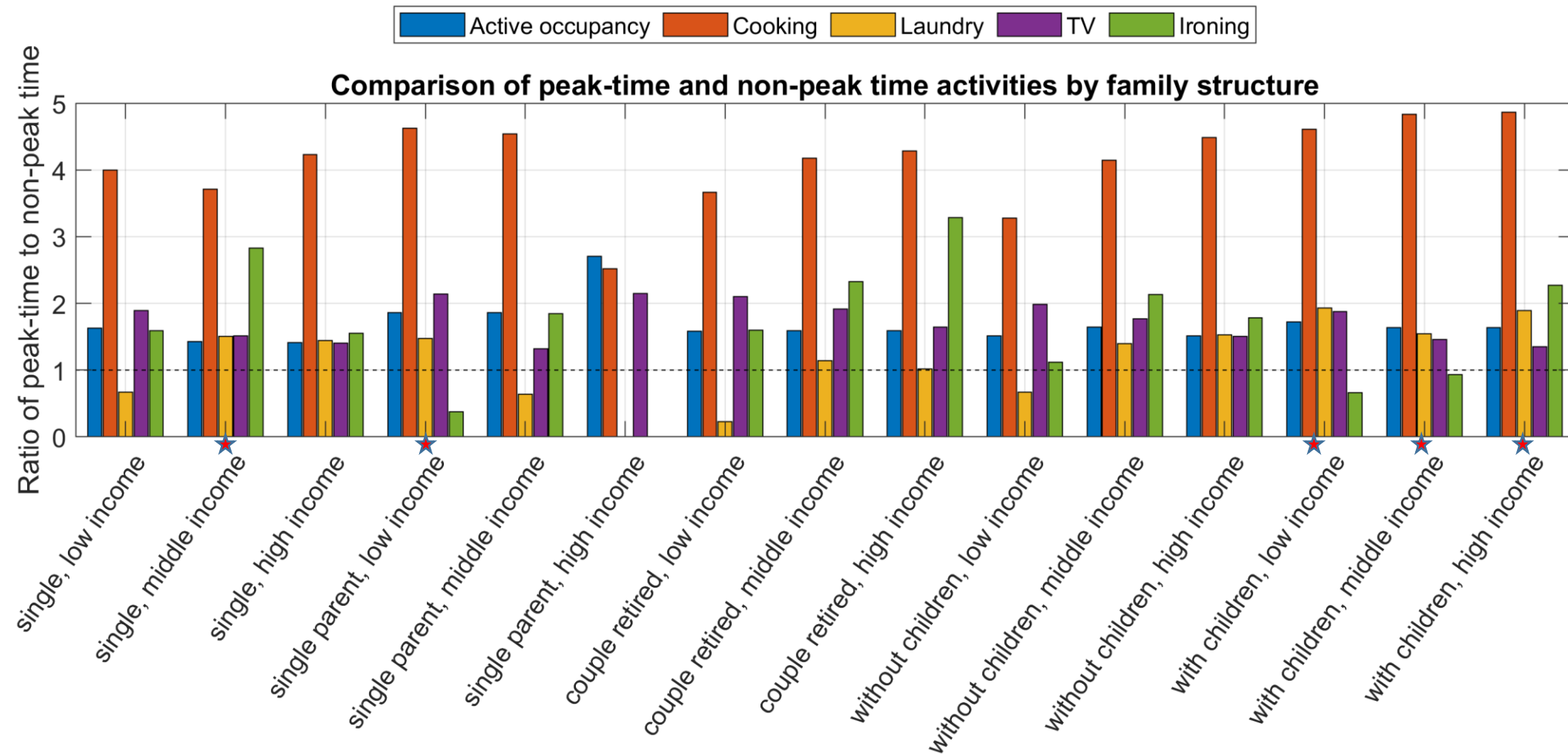
Split by Income



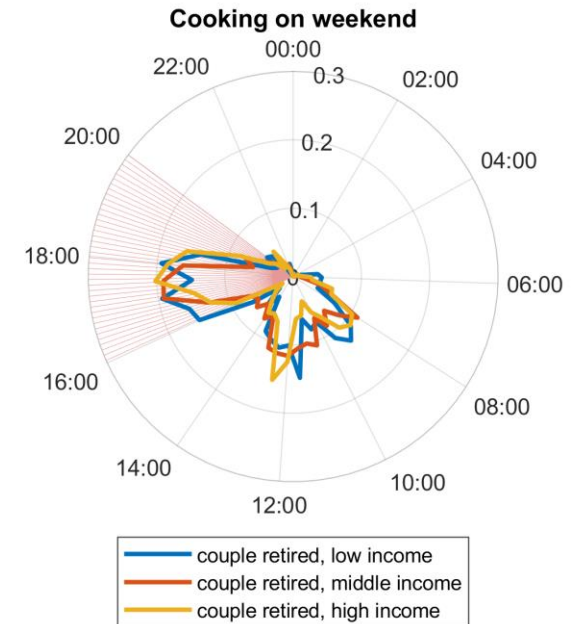
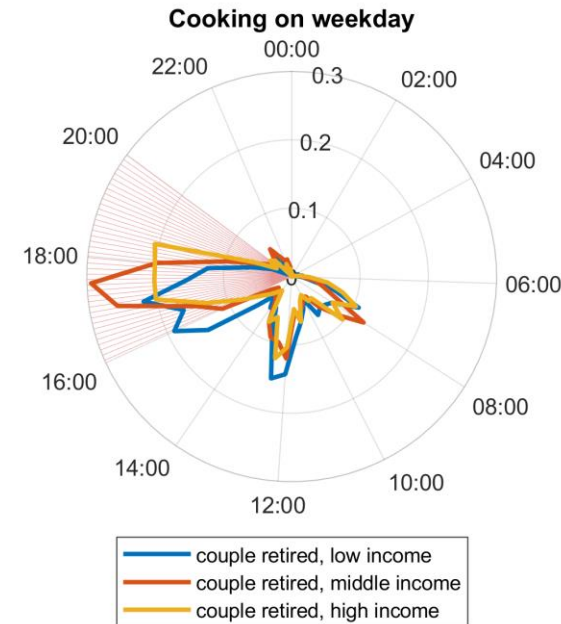
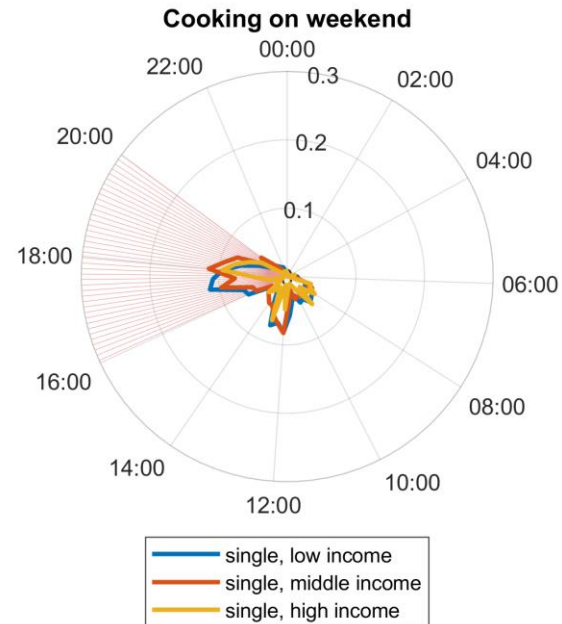
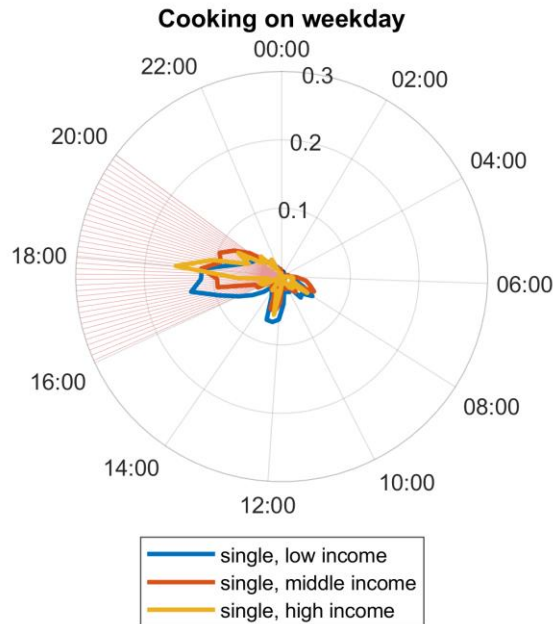
By family structure

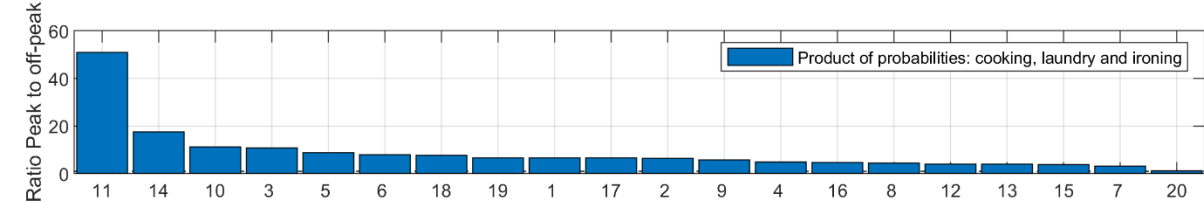
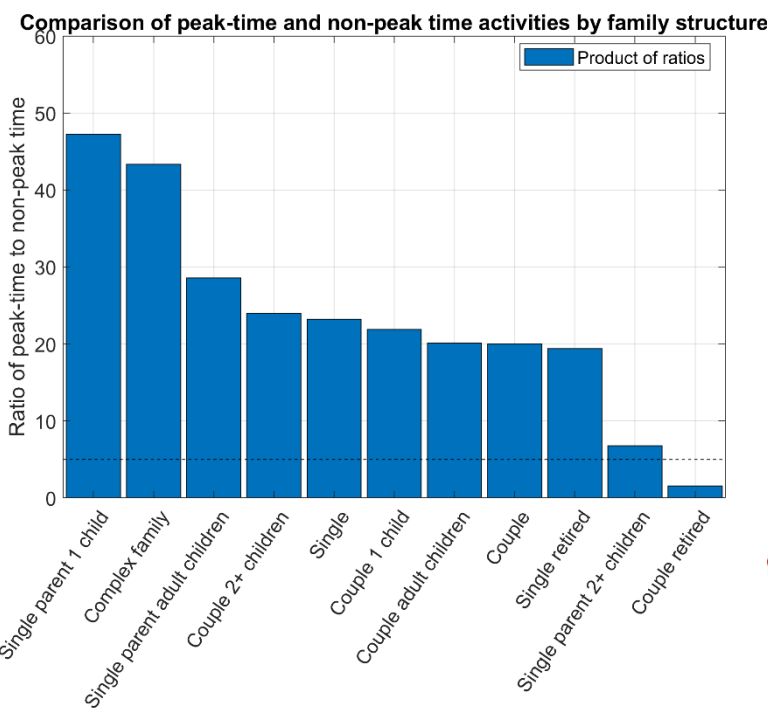
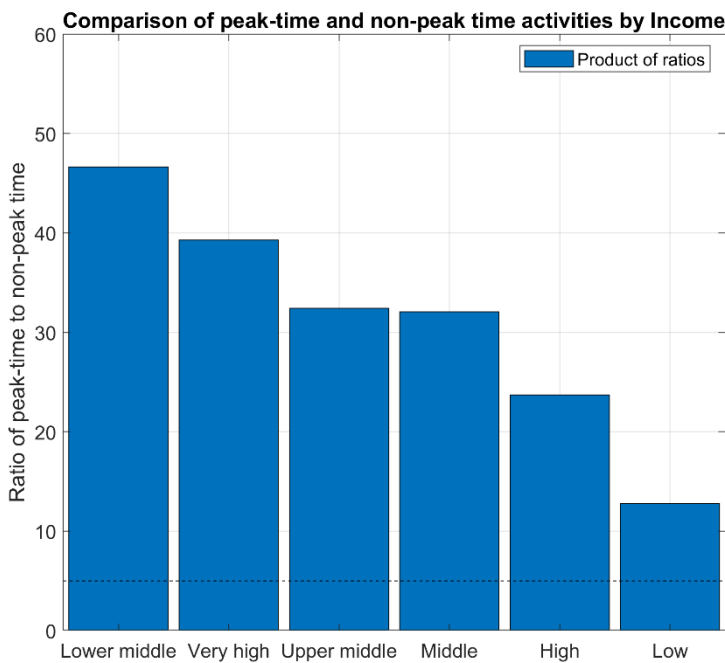


Combined by income and family structure

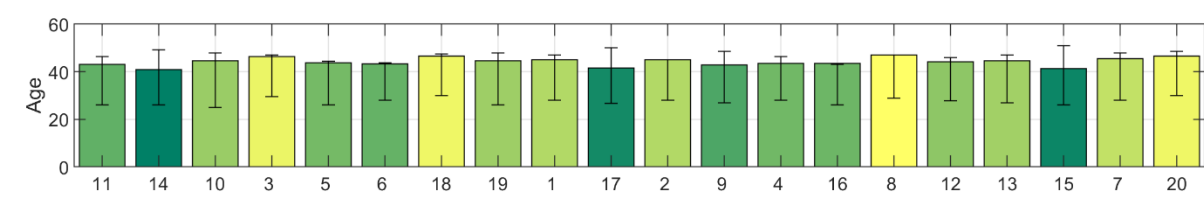


Combined by income and family structure





n/a	19.61	19.35	19.57	22.02	24.64	21.79	17.86	20	22.8	22.92	17.55	20.43	23.72	24.75	25.89	22.7	20.45	23.3	24.27	27.87
Low income	30.07	33.87	25	26.49	17.5	33.46	52.38	47.69	36.14	35.42	28.19	31.18	17.31	30.69	27.92	34.04	39.39	45.63	25.24	39.34
Lower middle income	16.34	14.52	14.67	15.18	15	12.06	9.524	9.231	12.31	8.333	12.23	12.37	12.5	11.88	11.68	12.77	11.36	8.738	15.53	8.197
Middle income	9.804	8.065	14.13	12.8	12.86	12.84	3.571	0	9.715	10.42	10.64	11.83	13.46	7.921	12.18	11.35	8.333	5.825	7.767	6.557
Upper middle income	12.42	8.871	10.87	10.71	15.71	10.51	5.952	13.85	7.383	11.46	14.89	12.37	15.71	10.89	9.645	7.092	9.848	6.796	11.65	8.197
High income	3.922	6.452	4.348	6.548	5.357	2.335	3.571	4.615	4.922	3.125	6.915	5.376	7.051	1.98	3.553	3.546	4.545	2.913	5.825	4.918
Very high income	7.843	8.871	11.41	6.25	8.929	7.004	7.143	4.615	6.736	8.333	9.574	6.452	10.26	11.88	9.137	8.511	6.061	6.796	9.709	4.918



1	22.88	36.29	28.26	13.69	3.214	33.46	53.57	53.85	37.31	43.75	10.37	25.27	8.013	44.55	19.8	46.1	33.33	52.43	22.82	47.54
2	45.1	40.32	37.5	34.52	33.57	43.97	32.14	21.54	28.89	41.67	30.59	33.33	37.18	38.61	35.03	36.88	41.67	35.92	42.72	36.07
3	15.69	10.48	12.5	16.96	23.93	12.84	7.143	16.92	13.99	9.375	16.76	19.35	22.44	11.88	18.78	7.092	15.15	8.738	18.45	14.75
4	13.07	6.452	16.85	26.79	22.86	6.226	4.762	6.154	13.73	4.167	26.06	15.59	20.19	3.96	17.77	9.929	5.303	1.942	12.62	1.639
5+	3.268	6.452	4.891	8.036	16.43	3.502	2.381	1.538	6.088	1.042	16.22	6.452	12.18	0.9901	8.629	0	4.545	0.9709	3.398	0

Rooms	1	1.307	1.613	1.087	0.2976	0	0.7782	2.381	6.154	1.425	4.167	1.064	0.5376	0.641	0.9901	0.5076	1.418	0	1.942	1.456	3.279
	2	11.11	9.677	11.41	5.357	1.786	7.004	17.86	20	9.326	10.42	4.787	5.376	1.923	14.85	5.076	9.22	12.88	15.53	9.223	13.11
	3	14.38	19.35	17.39	14.88	13.93	22.57	25	27.69	19.56	23.96	15.69	23.66	14.1	23.76	15.23	17.73	19.7	24.27	12.62	37.7
	4	24.84	24.19	24.46	25.3	23.21	25.29	26.19	18.46	23.58	26.04	22.34	24.73	26.6	20.79	27.41	29.79	19.7	26.21	23.79	9.836
	5	25.49	25.81	16.3	27.08	21.07	17.9	17.86	15.38	21.11	17.71	27.13	25.27	26.28	20.79	23.35	23.4	28.79	17.48	22.33	24.59
	6	11.76	6.452	13.59	11.61	15	13.23	3.571	7.692	11.92	10.42	13.83	11.29	15.71	9.901	11.68	7.801	10.61	5.825	17.48	6.557
	7	8.497	5.645	9.239	9.226	12.14	6.615	5.952	0	6.347	5.208	9.84	3.763	8.974	4.95	6.599	4.255	6.061	5.825	8.252	3.279
	8+	2.614	7.258	6.522	6.25	12.86	6.615	1.19	4.615	6.736	1.042	5.319	5.376	5.769	3.96	10.15	6.383	2.273	2.913	4.854	1.639
		11	14	10	3	5	6	18	19	1	17	2	9	4	16	8	12	13	15	7	20

Empl.	42.21	44.32	39.48	44.32	41.1	41.78	33.76	44.06	43.26	44.51	37.57	39.77	42.91	38.83	38.99	39.24	44.4	42	39.64	42.86	
Self-Empl	9.74	6.061	8.069	6.08	7.117	9.736	12.1	5.594	7.803	7.143	6.63	9.51	8.277	8.511	6.366	5.903	6.8	8.5	6.218	4.464	
Retired	20.45	15.15	22.19	23.84	20.82	20.08	26.11	18.88	22.18	18.68	25.28	21.61	20.81	21.81	27.32	22.22	20.8	17	23.83	26.79	
Study	7.143	6.061	4.323	5.92	9.431	4.462	7.643	7.692	6.571	6.593	6.215	7.493	5.405	6.915	7.162	6.597	6.8	9	6.218	2.679	
Unempl	2.922	3.788	4.899	3.52	2.135	2.637	1.274	4.895	2.601	1.099	3.729	4.323	1.858	2.66	3.448	2.778	5.2	5.5	4.922	2.679	
MatLeave	0	1.515	1.153	0.8	0.1779	0.2028	0.6369	0	0.6845	1.648	0.4144	0.5764	0.6757	1.064	0.7958	0.6944	1.2	0	0.5181	0	
Homestay	4.221	4.924	5.764	3.36	4.626	6.491	7.643	4.196	4.654	3.846	5.11	4.035	5.405	6.383	3.448	5.556	4.4	4.5	4.145	5.357	
Sick/disabled	1.623	3.03	2.305	2.4	3.915	1.014	2.548	2.098	1.711	1.099	1.934	2.017	1.689	2.128	2.387	2.387	4.861	1.2	3	2.073	1.786
	11	14	10	3	5	6	18	19	1	17	9	9	4	16	8	12	13	15	7	20	

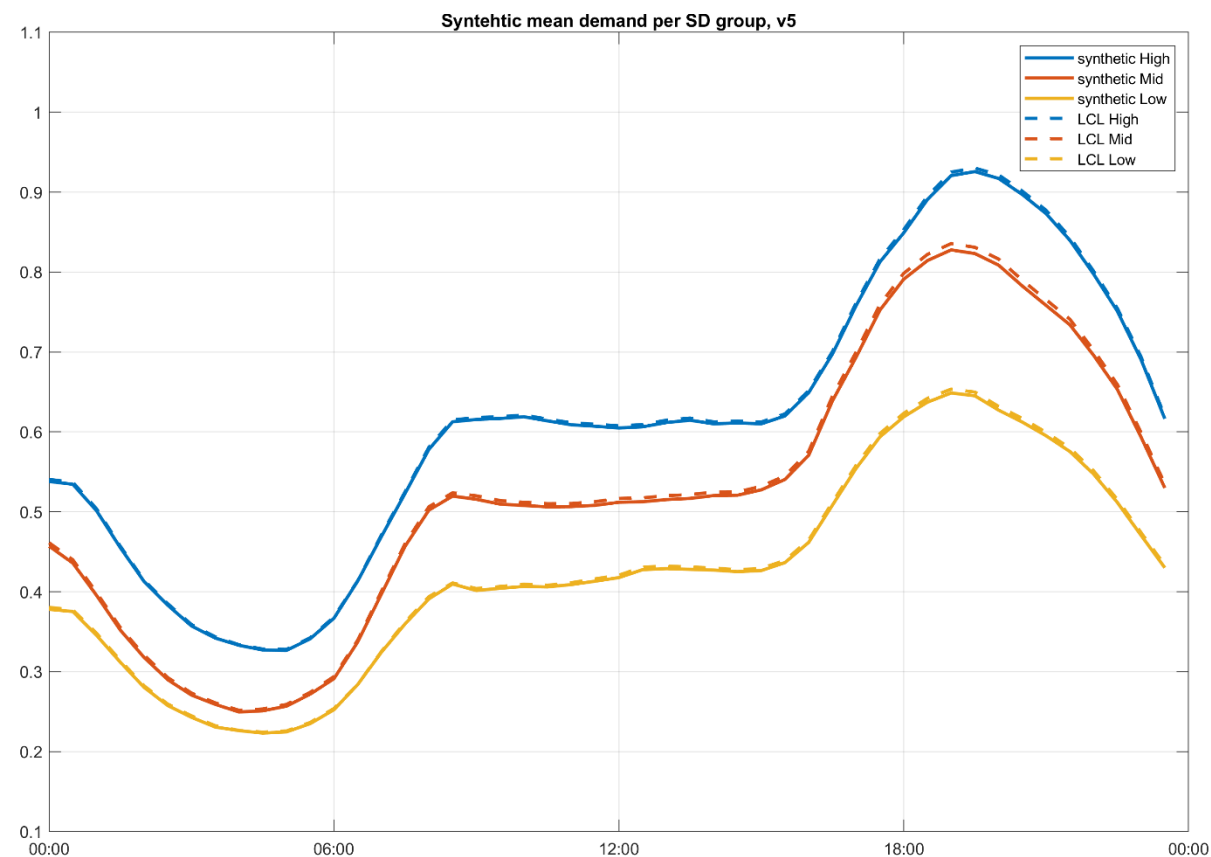
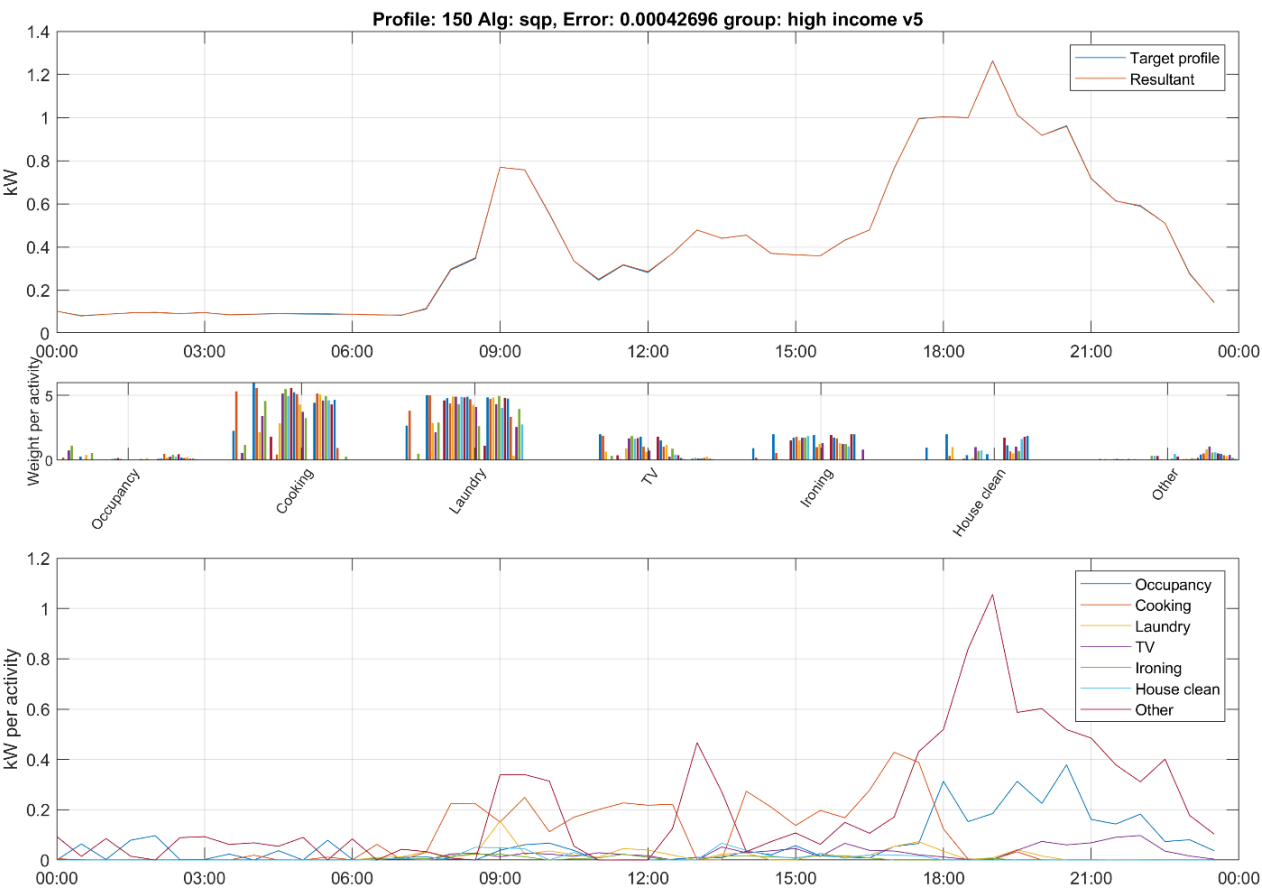
0	75.82	83.87	77.72	57.14	47.14	77.82	95.24	90.77	70.73	90.63	48.67	63.98	57.05	92.08	66.5	87.23	86.36	95.15	77.18	93.44
1	16.34	9.677	10.87	17.26	19.29	13.23	4.762	6.154	11.01	7.292	13.3	18.82	18.59	6.931	14.21	6.383	9.091	4.854	11.65	4.918
2	5.882	5.645	9.239	20.54	21.79	6.615	0	3.077	13.47	2.083	24.73	11.83	19.23	0.9901	13.71	6.383	3.03	0	10.19	1.639
3	1.307	0.8065	1.63	3.869	7.5	1.946	0	0	3.238	0	8.777	3.763	3.846	0	4.569	0	1.515	0	0	0
4+	0.6536	0	0.5435	1.19	4.286	0.3891	0	0	1.554	0	4.521	1.613	1.282	0	1.015	0	0	0	0.9709	0



Modelling demand from activities

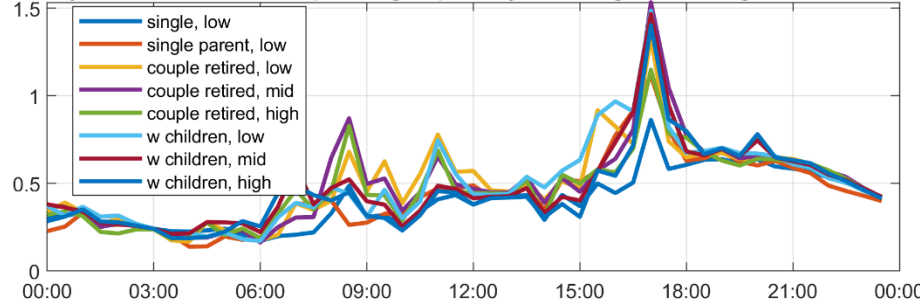


Matching to real demand

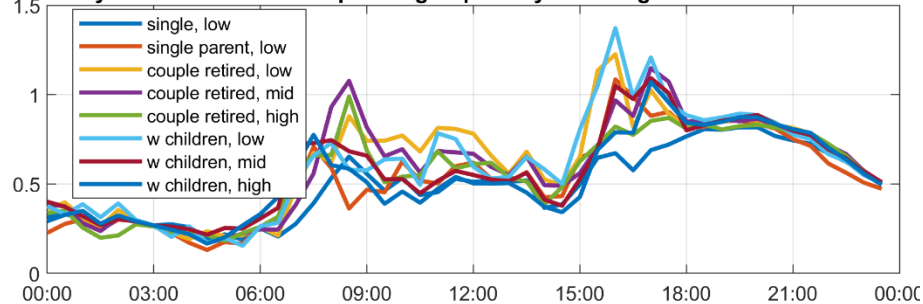


Synthetic demand

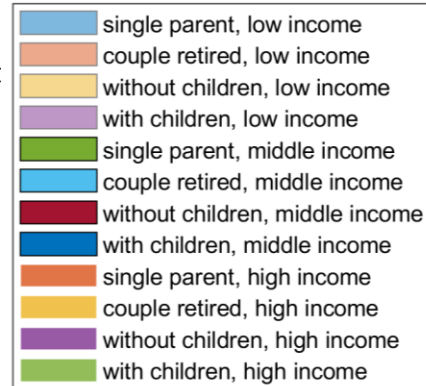
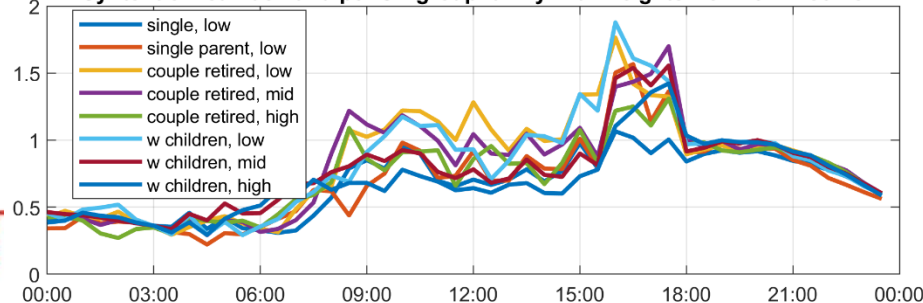
Synthetic mean demand per SD group family with weights from high income - v5



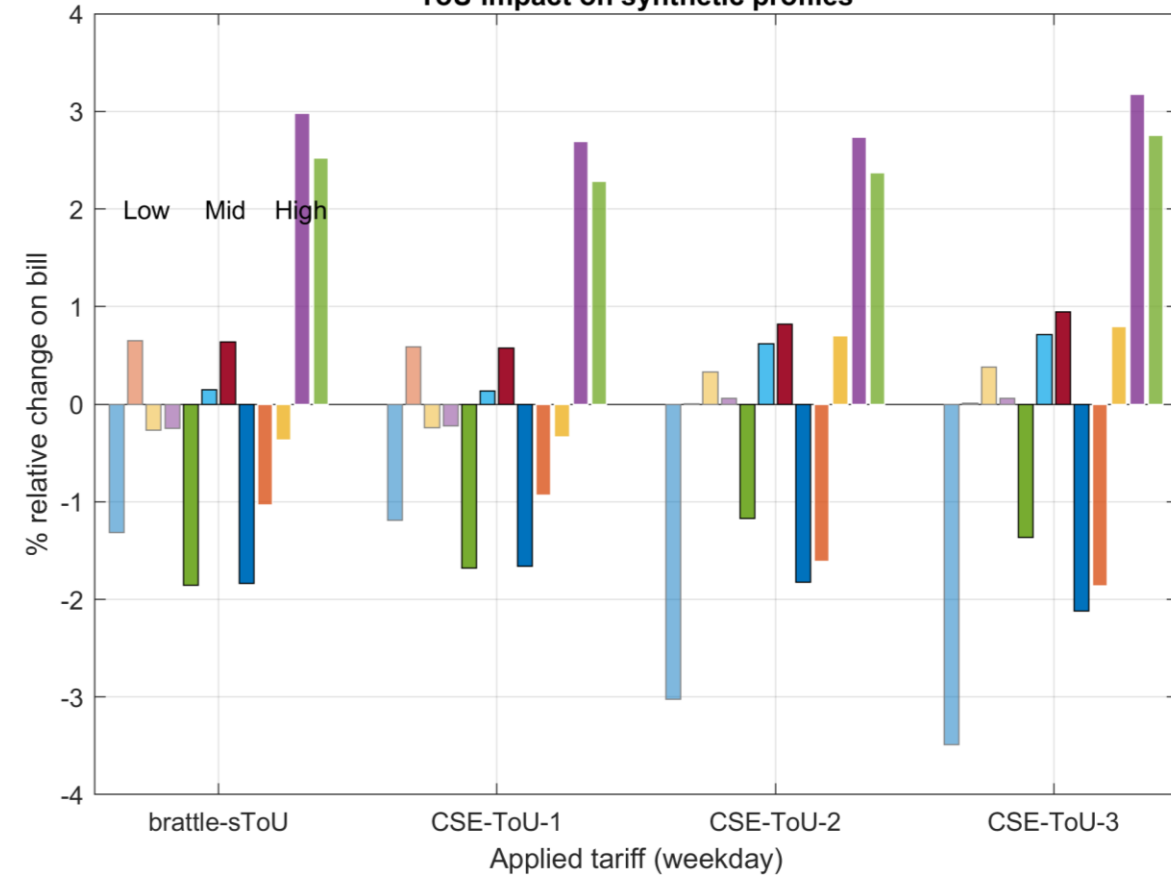
Synthetic mean demand per SD group family with weights from mid income



Synthetic mean demand per SD group family with weights from low income



ToU impact on synthetic profiles

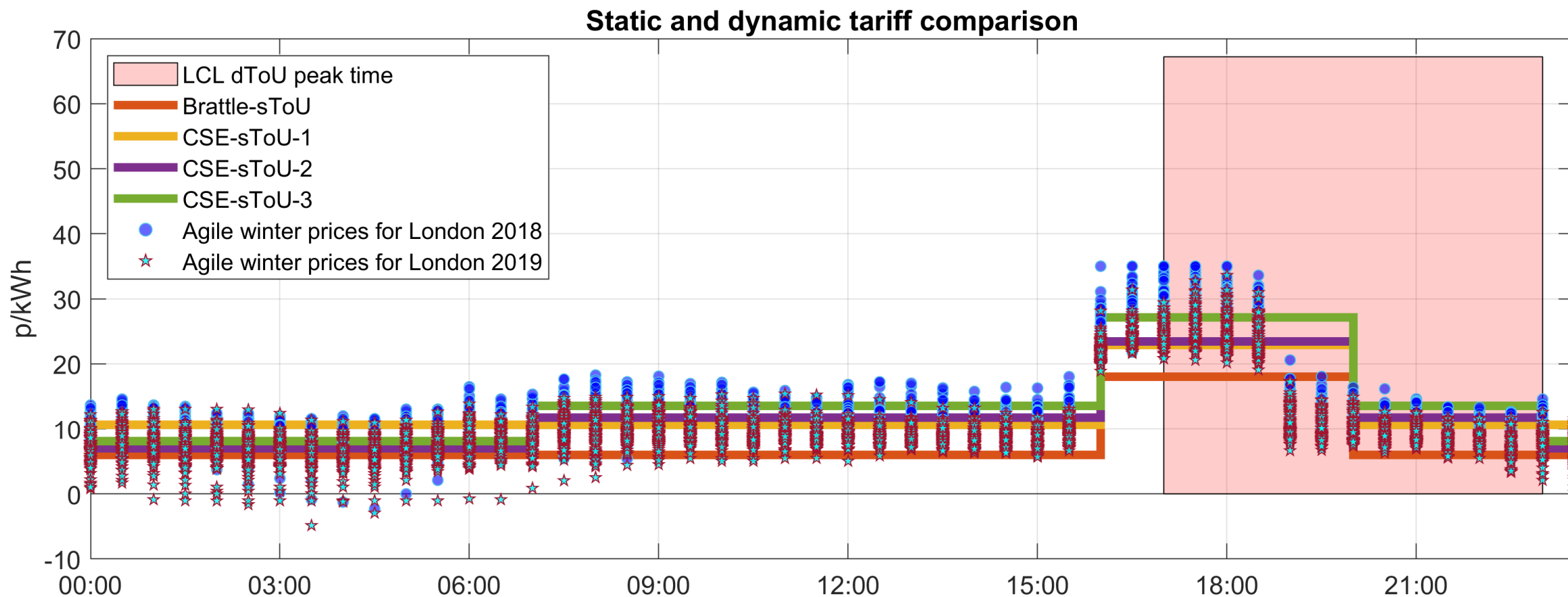


Analysis on smart meter data

Applying Agile tariff on demand profiles

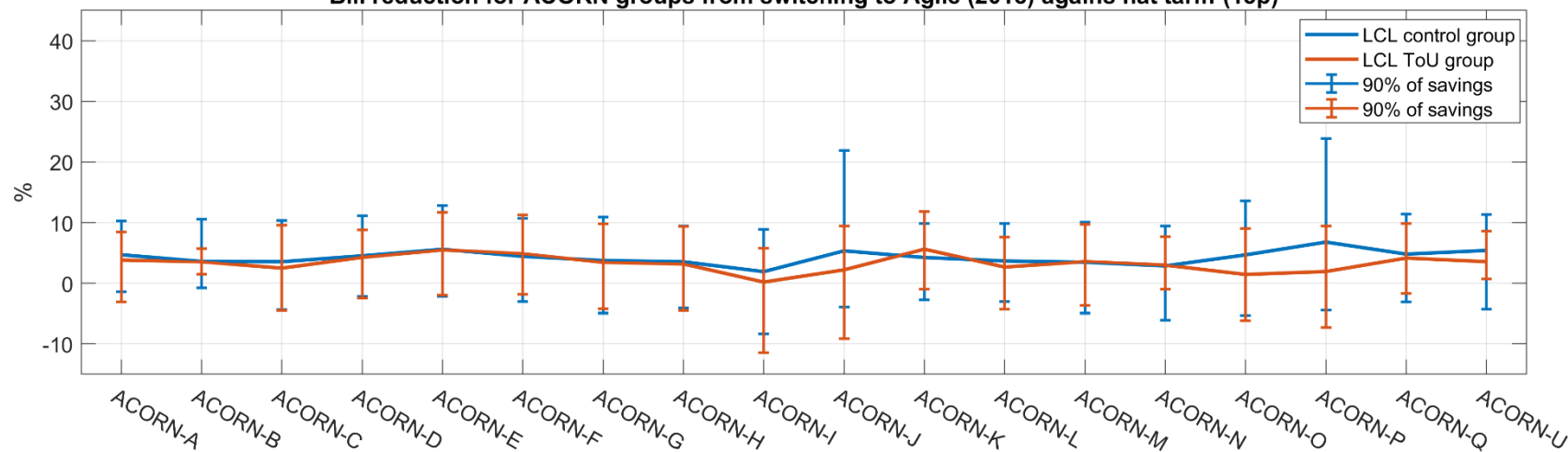


Agile Tariff

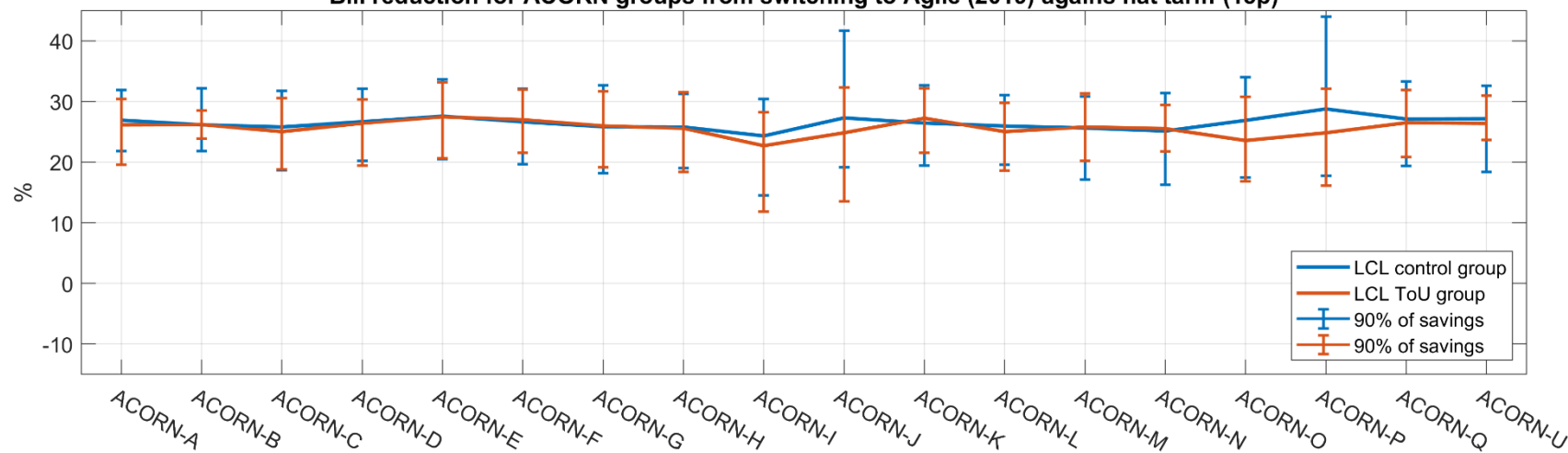


LCL trial participants

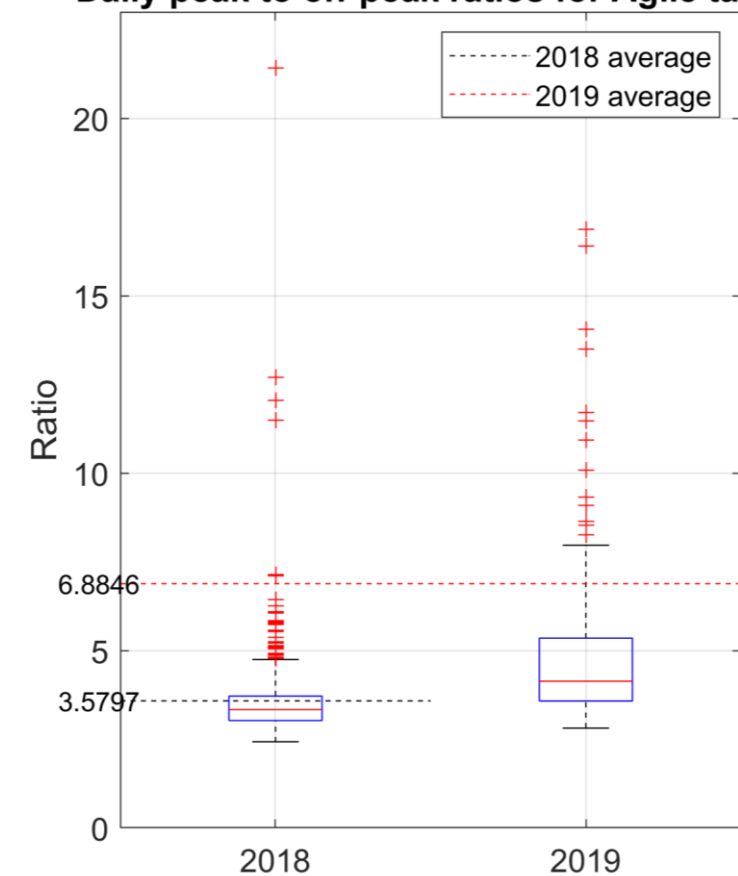
Bill reduction for ACORN groups from switching to Agile (2018) against flat tariff (15p)



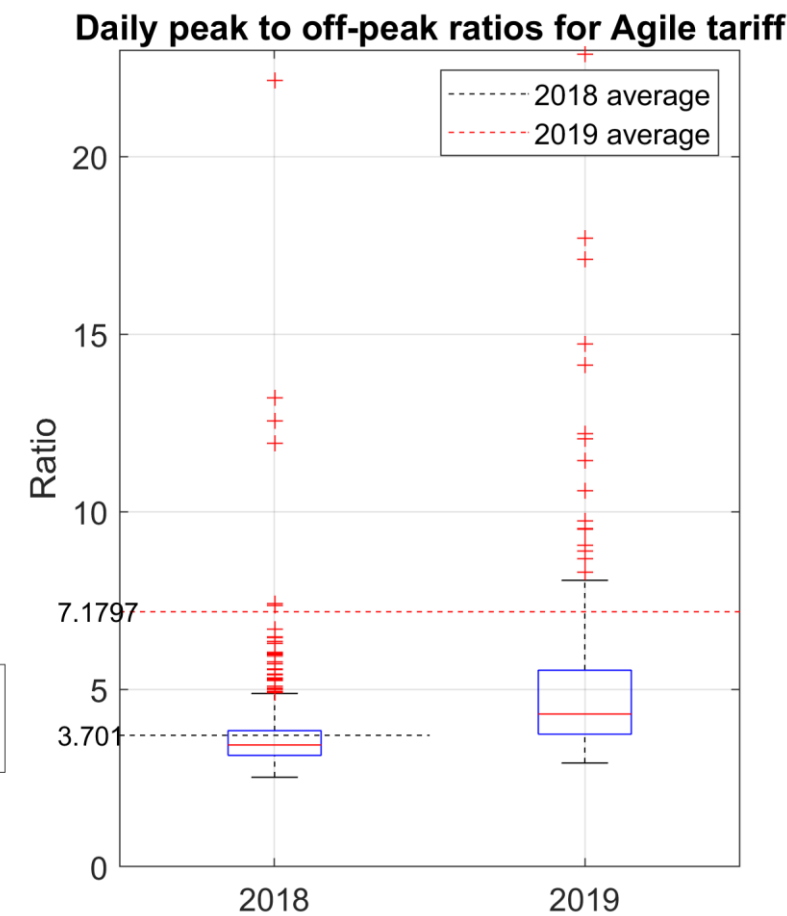
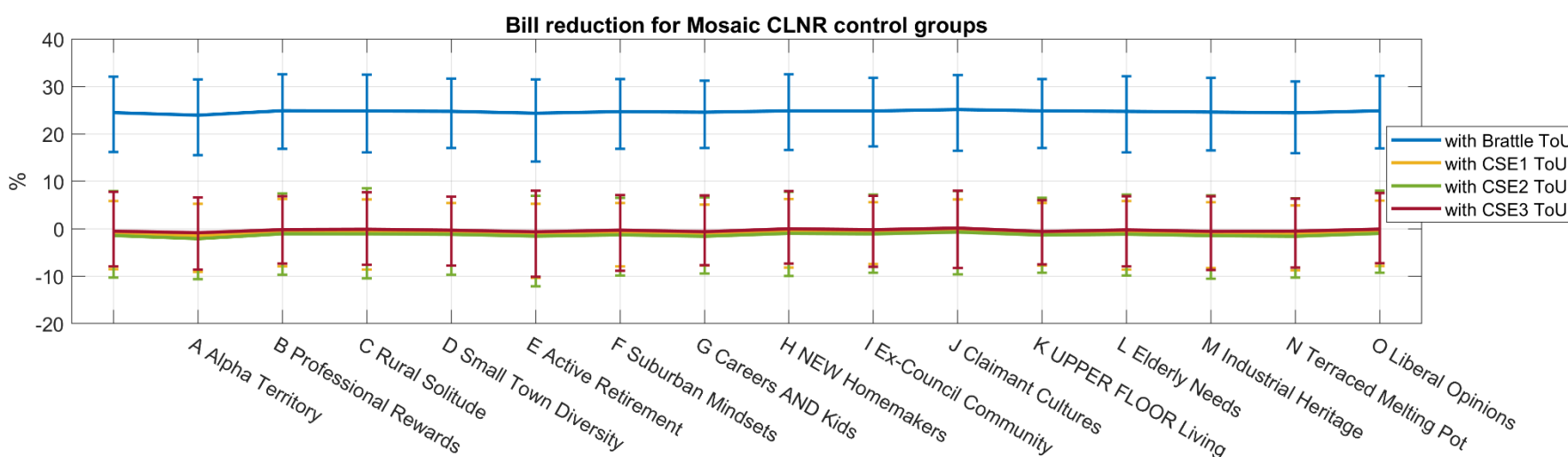
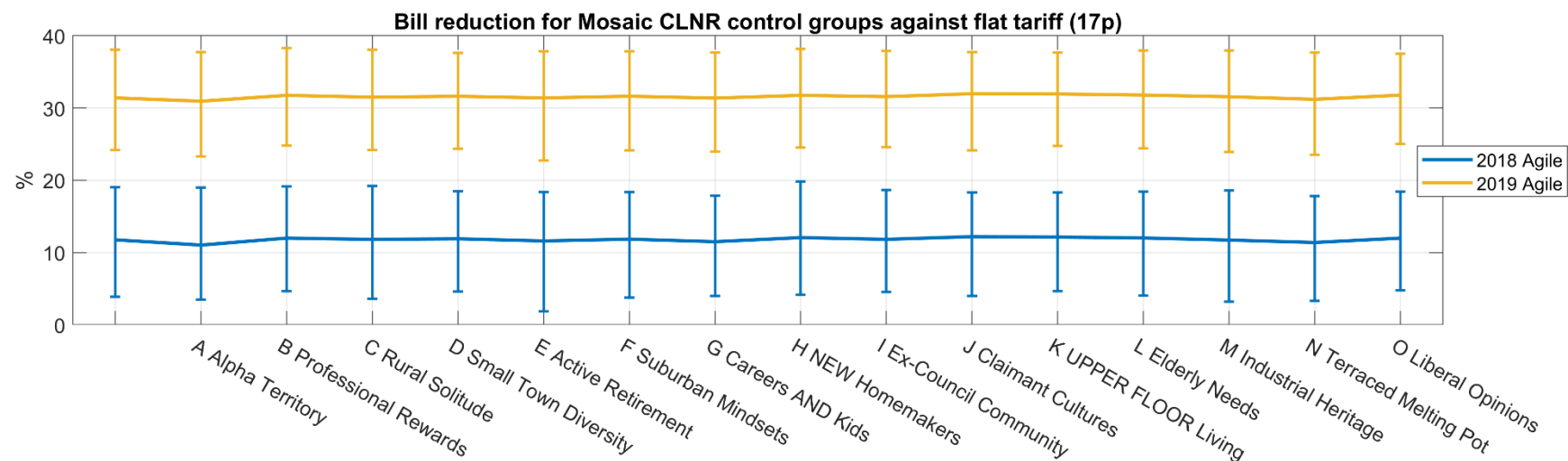
Bill reduction for ACORN groups from switching to Agile (2019) against flat tariff (15p)



Daily peak to off-peak ratios for Agile tariff

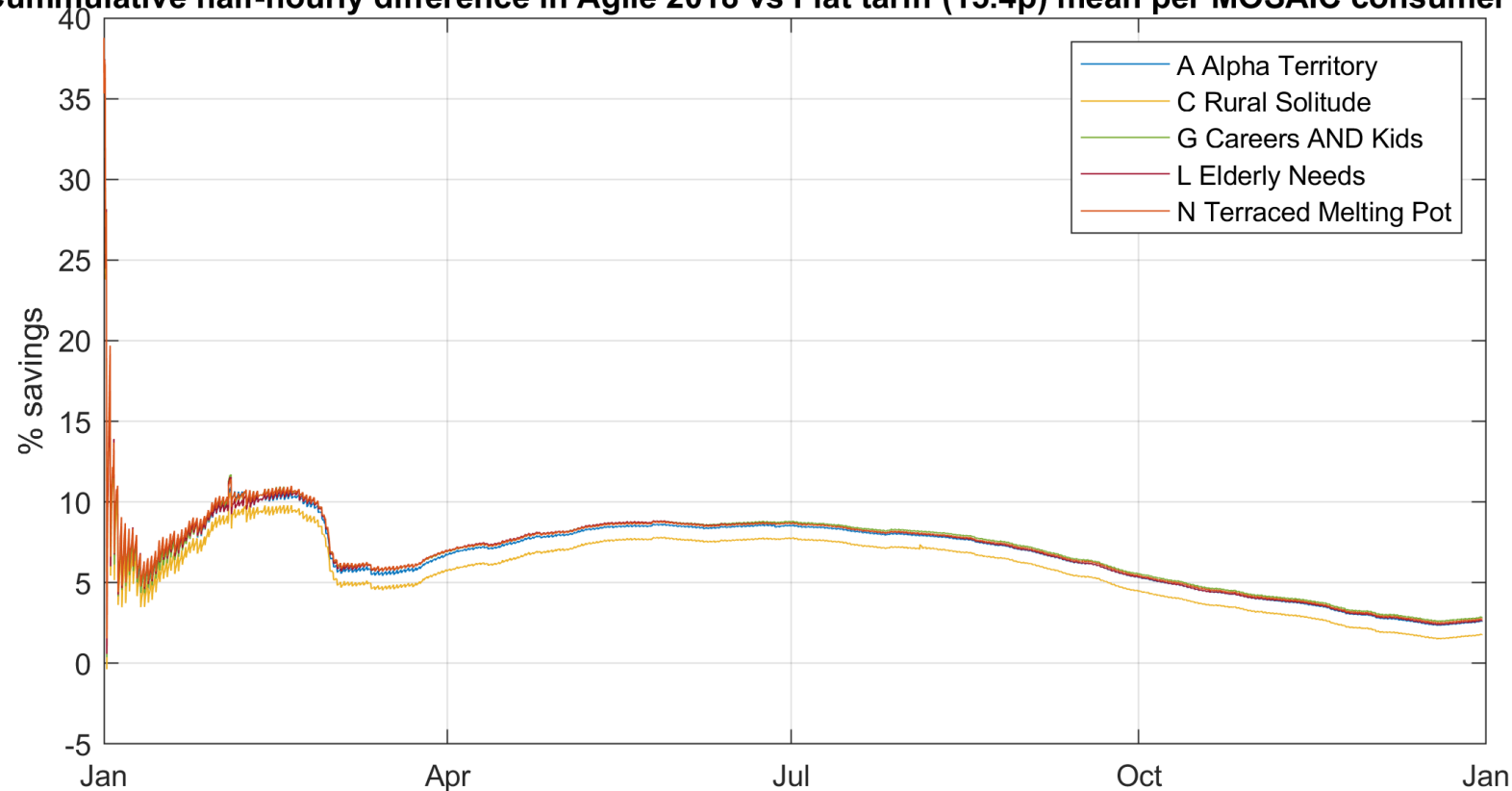


CLNR trial participants



Impact over a year

Cummulative half-hourly difference in Agile 2018 vs Flat tariff (15.4p) mean per MOSAIC consumer group



Key findings

1. Most peak-time activities are broadly synchronised and locked in
 - Core activities are driven by rhythms of practices
 - Often irrespective of the socio-demographic parameters
 - “Flexible” activities still occur at peak time – but why? Time scarcity could be the reason.
2. Presence of children impacts the intensity of peak-time activities
 - Children and high peak to non-peak ratio come in hand
3. Ratio of peak and non-peak levels determine the overall effect
 - It shows the likelihood of activity occurring in peak-time
 - Occupancy could be used as a proxy for flexibility or use of LCTs (e.g. EV charging)
4. Grouping has trade-offs
 - Granularity and combining multiple parameters
 - Bottom-clustering shows a cluster of those who will be worse-off.
 - Top-down is less powerful than activity-based clustering, but easier to implement.

Looking to the future

- Need smart meter data with diverse social data (even better with activities)
 - To fully understand the distributional impact from ToU and impact from the transition to NetZero
- Cooking is the most prominent peak time activity
 - Electrification of cooking may disadvantage retired couples, couples with one child and single parents with one child if exposed to ToU
- Its not all about energy, but also time scarcity
 - Day-time occupancy offers an opportunity to be flexible
 - Future working patterns and changes to demographics



Thank you!

Related publications:

J. Torriti, T. Yunusov, *It's only a matter of time: Flexibility, activities and time of use tariffs in the United Kingdom*, Energy Research & Social Science, Volume 69, 2020.

<https://doi.org/10.1016/j.erss.2020.101697>

<http://centaur.reading.ac.uk/92146/>

T. Yunusov, J. Torriti, Distributional effects of Time of Use tariffs based on electricity demand and time use, Energy Policy, Volume 156, 2021.

<https://doi.org/10.1016/j.enpol.2021.112412>

