Appendix: Synthetic Time-Series Load Data via Conditional Generative Adversarial Networks

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***Abstract*—A framework for the generation of synthetic time-series transmission-level load data is presented. Conditional generative adversarial networks are used to learn the patterns of a real dataset of hourly-sampled week-long load profiles and generate unique synthetic profiles on demand, based on the season and type of load required. Extensive testing of the generative model is performed to verify that the synthetic data fully captures the characteristics of real loads and that it can be used for downstream power system and/or machine learning applications.**

I. Load Characteristics

Table I show the percentage load composition of the 12 loads analyzed in terms of commercial, industrial, and residential components. Furthermore, the last column of the table shows the cluster in which each load has been grouped when performing 3-means clustering. When can see that for the top six loads the industrial component is always the smallest, and they are grouped together. The bottom five loads have much more significant industrial component and they are grouped together. Load number 7 is grouped by itself and unfortunately its load composition is not available.

TABLE I
Load composition for the 12 loads and clustering results. The top six are classified as mainly residential/commercial loads and the bottom six are mainly industrial loads.

Load	Composition (%)			Cluster
	Commercial	Industrial	Residential	
1	39	23	38	1
2	35	13	52	1
3	n/a	n/a	n/a	1
4	16	3	81	1
5	17	5	78	1
6	33	4	63	1
7	n/a	n/a	n/a	0
8	12	24	64	2
9	21	39	40	2
10	5	71	24	2
11	31	38	31	2
12	3	78	19	2

II. cGAN for Synthetic Load Profiles

A. Data Generation

To better show the characteristics of the load profiles and their dependence on season and load type, we include more examples of real data. Figure 1 shows four real load profiles for each season (rows), each divided in two mainly residential loads (left two columns) and mainly industrial loads (right two columns).

Moreover, we present further examples of generated data. Figure 2 shows synthetic load profiles, organized in the same way as the previous figure.

III. Evaluation of Synthetic Data

A. Power Spectral Density

Here, the power spectral density is computed over specific subsets of load types. Figure 3 shows the comparison of the power spectral density between real and synthetic summer profiles for mainly residential loads. Figure 4 shows the comparison of the power spectral density between real and synthetic summer profiles for mainly industrial loads. Figure 5 shows the comparison of the power spectral density between real and synthetic winter profiles for mainly residential loads. Figure 6 shows the comparison of the power spectral density between real and synthetic winter profiles for mainly industrial loads.

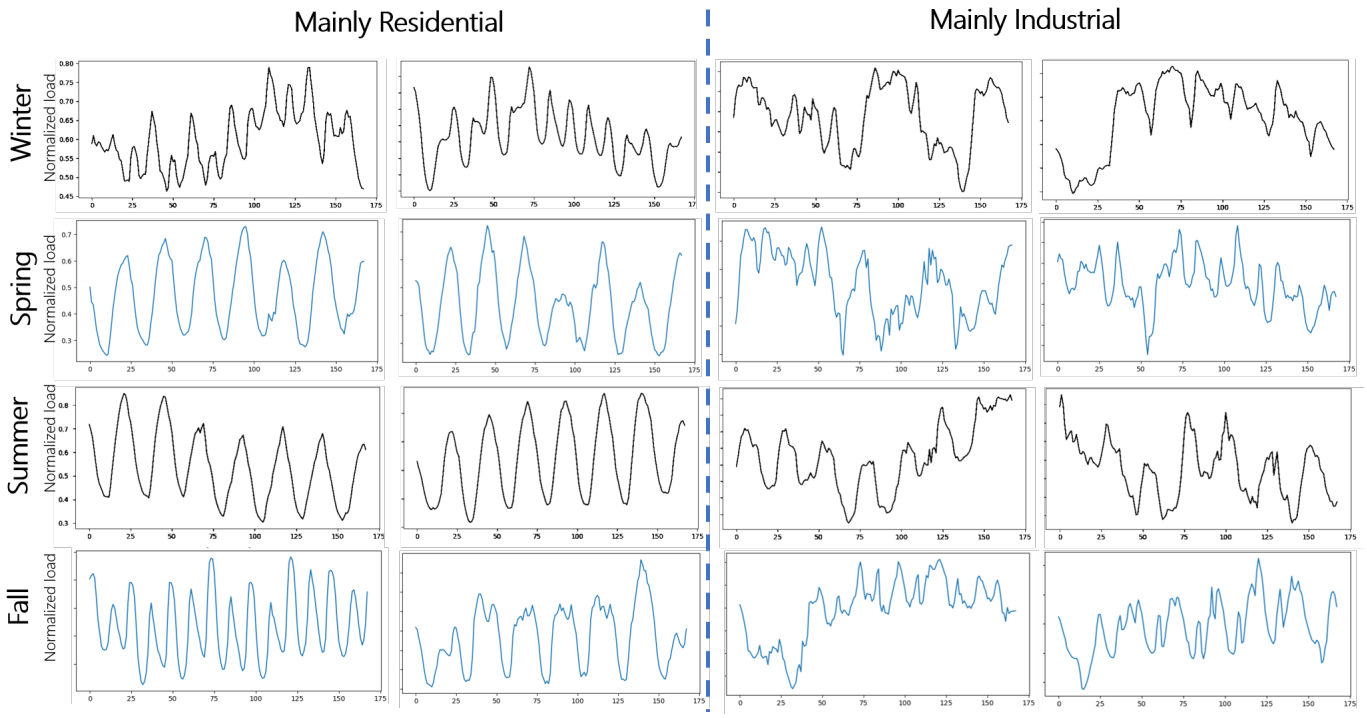

Fig. 1. Examples of real profiles for each season and load type. Left two columns: mainly residential loads; right two columns: mainly industrial loads. First row: winter profiles. Second row: spring profiles. Third row: summer profiles. Fourth row: fall profiles.

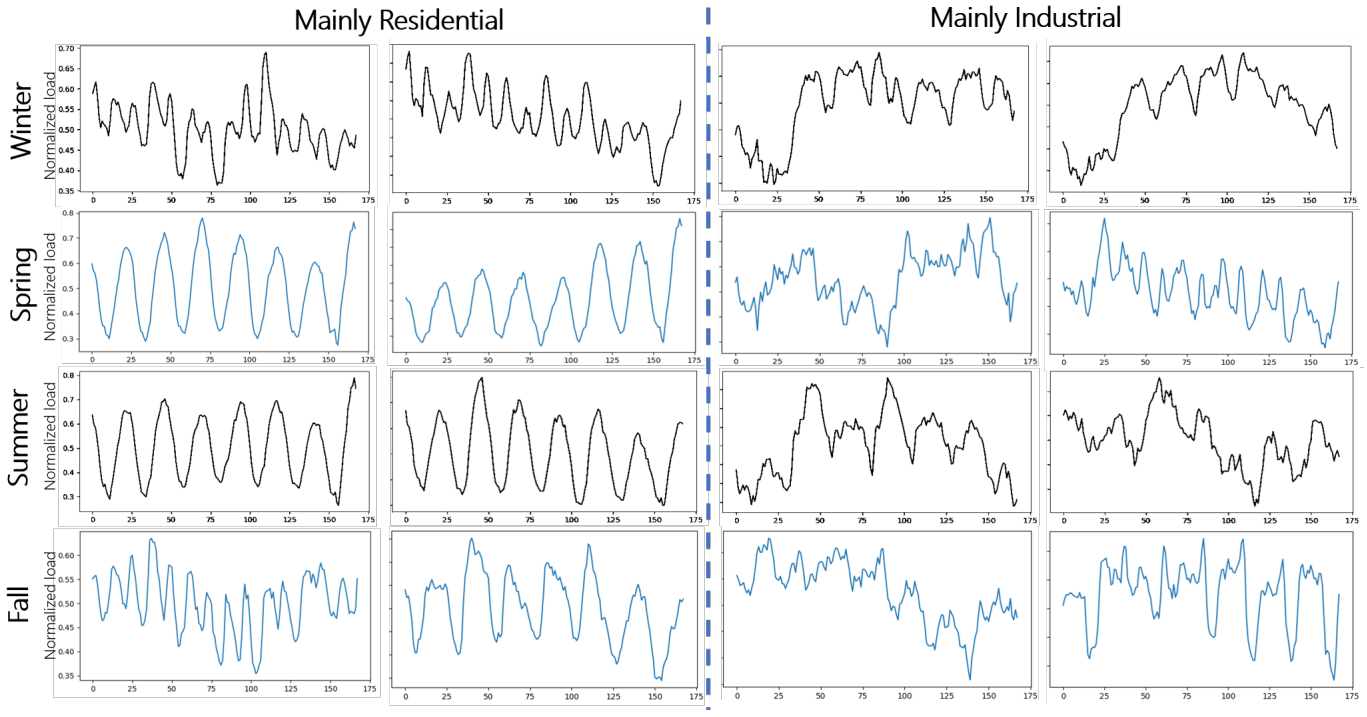

Fig. 2. Examples of generated profiles for each season and load type. Left two columns: mainly residential loads; right two columns: mainly industrial loads. First row: winter profiles. Second row: spring profiles. Third row: summer profiles. Fourth row: fall profiles.

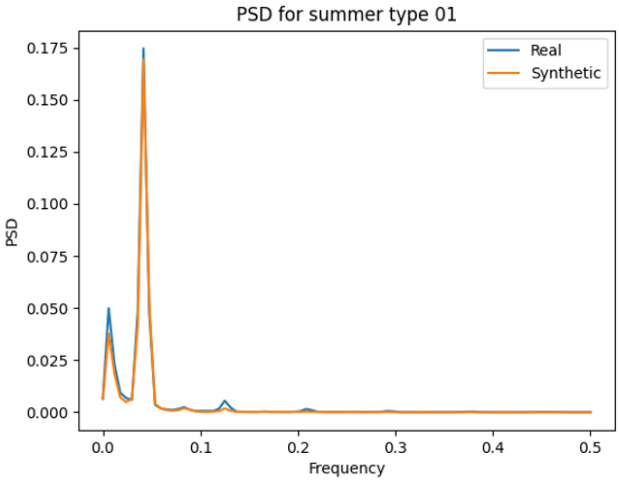

Fig. 3. Comparison between the power spectral density of real data (blue) and generated data (orange) for summer, mainly residential profiles.

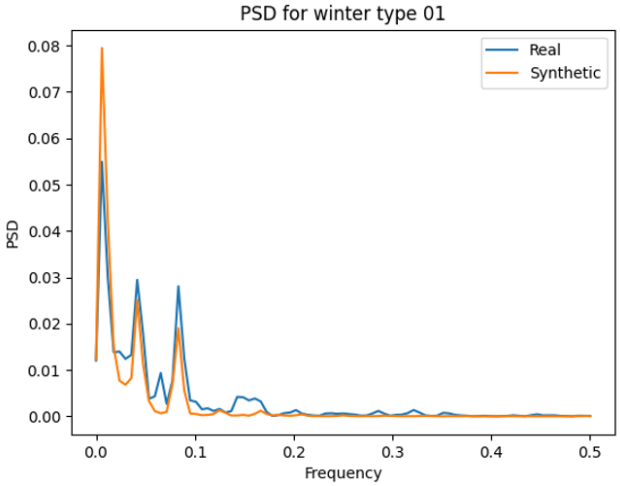

Fig. 5. Comparison between the power spectral density of real data (blue) and generated data (orange) for winter, mainly residential profiles.

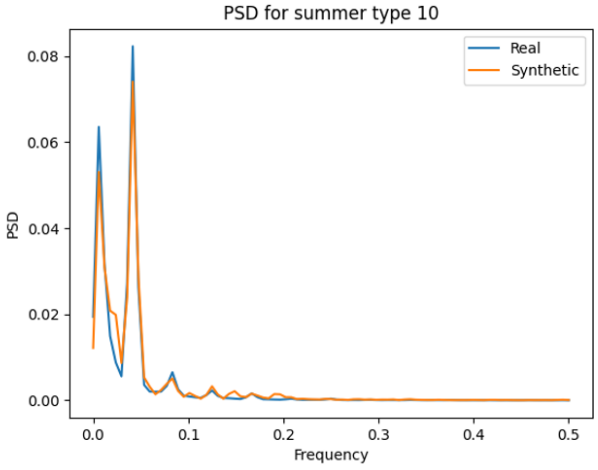

Fig. 4. Comparison between the power spectral density of real data (blue) and generated data (orange) for summer, mainly industrial profiles.

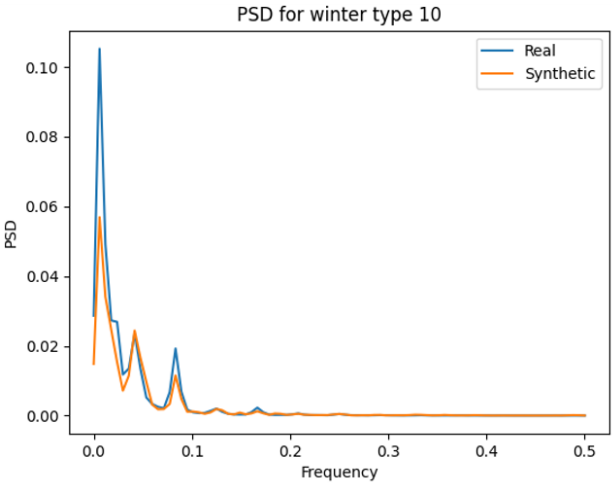

Fig. 6. Comparison between the power spectral density of real data (blue) and generated data (orange) for winter, mainly industrial profiles.