Dissemination activity 2

Data analysis for both proposed tariffing methodologies

EIMV | Elektroinštitut Milan Vidmar

Power System Control and Operation Department

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Input data overview

2 sets of data were received:

- ***Aggregated data in 15min resolution*** which was received for each year (for 2018/2019/2021 – partially, 2020)
  - for 5 Slovenian EDPs,
  - TSO data together with:
    - its‘ pump storage hydro power facility (HE Avče) and
    - cross border energy flows
  - for 5 localized distribution areas (ZDS Acroni, ZDS Petrol Ravne, ZDS Petrol Štore, ZDS Talum and ZDS Jesenice)
  - From DSO

- ***Customer load profile data in 15 min resolution*** from all 5 EDPs (for 2018 – partially, 2019-2020, 2021 - partially)

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Aggregated data

Within this dataset we have received:

- ***15min aggregated consumption according to their corresponding customer categories for every year in MWh***

			Aggregated consumption (MWh)											
Timestamp in 15min resolution			HV			MV				LV				
						HV/MV Substation		Network		MV/ LV Transformer		Network		
			T ≥ 6000 h	6000 h > T ≥ 2500 h	T < 2500 h	T ≥ 2500 h	T < 2500 h	T ≥ 2500 h	T < 2500 h	T ≥ 2500 h	T < 2500 h	T ≥ 2500 h	T < 2500 h	without power metering
hh	mm	ss	…	…	…	…	…	…	…	…	…	…	…	…

Households and small business consumers (included in the group “without power metering”) represent over 98% of all consumers in Slovenia

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Aggregated data

- ***Customer categories capacity for every year (2020)***

Voltage level	Connection method	Load factor (operating hours)	# of customers connected	Aggregated measured or contracted capacity (kW) at the end of the year
HV	network	T ≥ 6000 h	3	246,100
		6000 h > T ≥ 2500 h	3	168,337
		T < 2500 h	2	29,088
MV	Substation feeder	T ≥ 2500 h	24	197,235
		T < 2500 h	6	18,198
	network	T ≥ 2500 h	1,000	1,128,478
		T < 2500 h	626	536,843
LV	Substation feeder	T ≥ 2500 h	619	142,717
		T < 2500 h	644	145,166
	network	T ≥ 2500 h	3,654	404,476
		T < 2500 h	7,713	670,798
		without power metering	95,726	1,484,284
		Households	852,345	5,682,061

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Aggregated data

- ***15min consumption, generation, energy flows, losses and cross border energy flows for every year in MWh***

Timestamp in 15min resolution			Consumption connected to voltage level (MWh)					Generation connected to voltage level (MWh)						Energy flows (MWh)				
			HV	HV/MV substation	MV	MV/LV transformer	LV	HV	new HV (calculated)	HV/MV substation	MV	MV/LV substation	LV	From HV to HV/MV substation (measured)	From HV to HV/MV substation (calculated)	From HV/MV substation to MV (calculated)	From MV to MV/LV transformer (calculated)	From MV/LV transformer to LV (calculated)
hh	mm	ss	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…

Timestamp in 15min resolution			[CALCULATED] Losses (MWh)					
			HV	HV/MV substation	MV	MV/LV substation	LV	Cross border energy flows from TSO
hh	mm	ss	…	…	…	…	…	…

- **A justified estimation of losses on all 5 voltage levels had to be made**
- **Energy flows were recalculated on all levels from corresponding losses**
- **Cross border flows from the TSO on HV had to be accounted for**
- **New HV generation was calculated to account for errors in loss estimation**

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Aggregated data

- ***Aggregated data processing:*** A summation of data for all 12 provided source entities
- ***Checksum mechanisms which were used:***
  - *Calculating 15min and overall **yearly losses** within energy flows – they had to conform with the ones which were received by the Agency,*
  - *Aggregating consumptions on a yearly basis for every customer category and comparing them with the ones which were officially reported to the Agency – they had to match to within 5%,*
  - *Customer category capacities and numbers had to match those which were officially reported to the Agency,*
  - *Consumptions and productions at every voltage level had to match,*
- ***Improving data was an iterative process during which many entities were asked to re-submit their aggregated data***

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Aggregated data

- ***Recognized costs and income***
- ***3 and 10 year future estimations based on official long-term plans***

3 years future estimations table:

Expected growth for future years (in % per year) - PESIMISTIC (slow post COVID recovery)	HV	HV/MV substation	MV	MV/LV substation	LV	Total
Measured or calculated capacity growth (obračunska moč)	0.877%	0.128%	0.242%	0.177%	0.196%	**0.212%**
Energy consumption growth	0.933%	0.503%	1.115%	0.970%	0.633%	**0.822%**
Peak growth (Konica EES) - under "Scenarij 2"	0.224%	1.535%	0.812%	1.110%	1.003%	**0.927%**
TSO and DSO network costs	3.64%	4.88%	4.88%	2.55%	1.34%	3.43%

Expected growth for future years (in % per year) - **REGULAR** (normal post COVID recovery)	HV	HV/MV substation	MV	MV/LV substation	LV	Total
Measured or calculated capacity growth (obračunska moč)	8.078%	1.410%	1.035%	0.929%	1.000%	**1.155%**
Energy consumption growth	8.065%	2.240%	2.094%	2.073%	1.788%	**2.747%**
Peak growth (Konica EES) - under "Scenarij 3"	0.188%	1.076%	1.466%	1.634%	1.518%	**1.314%**
TSO and DSO network costs	1.08%	1.95%	5.28%	6.70%	6.07%	4.04%

Data source for growth of energy consumption, measured capacity:	Source: data received from DSO and CDS's, May 2021 on request of AGEN-RS (April 2021)
	Location of data: Količine\Pregled količin 2021-2024_po nivojih.xlsx
Data source for growth of system peak:	Source: RAZVOJNI NAČRT PRENOSNEGA SISTEMA REPUBLIKE SLOVENIJE ZA OBDOBJE 20
	Link: https://www.eles.si/Portals/0/Documents/SLO/20210126-RNPS2021-2030.pdf?ver=2021-02-02

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Customer group definition – step 1

customer category (consumer groups)			2020								
Voltage level	Connection method	Load factor (operating hours)		yearly consumption [kWh]	yearly consumption [kWh]	yearly consumption by group [kWh]	consumption share [%]			numeric share [%]	numeric share [%]
HV		T >= 6000h	3	919,829,234	919,829,234	919,829,234	8.32%	59.22%		1.31%	
		6000h > T >= 2500h	4	387,591,531	387,591,531	387,591,531	3.51%				
		T < 2500h	2	28,800,163	28,800,163	28,800,163	0.26%				
MV	Substation	T >= 2500h	24	631,977,325	631,977,325	631,977,325	5.72%				
		T < 2500h	6	17,080,644	17,080,644	17,080,644	0.15%				
		T >= 2500h	922	2,559,591,753	2,559,591,753	2,559,591,753	23.16%				
		T < 2500h	593	427,620,263	427,620,263	427,620,263	3.87%				
LV	Substation	T >= 2500h	578	322,649,959	322,649,959	322,649,959	2.92%				
		T < 2500h	547	123,311,291	123,311,291	123,311,291	1.12%				
	businesses	T >= 2500h	3,347	679,018,050	679,018,050	679,018,050	6.14%				
		T < 2500h	6,686	447,417,019	447,417,019	447,417,019	4.05%				
		public EV chargers	61	500,243	500,243	500,243	0.00%				
		without power metering	3075	102,534,159	948,931,049	731,912,411	8.59%			4.69%	10.32%
			5762	165,586,703							
			437	10,826,437							
			11940	206,685,936							
			763	10,756,442							
			23823	235,522,734							
			20865	117,359,155		146,032,053				2.77%	
			6036	27,736,093							
			15	108,209							
			97	828,596							
			3197	12,670,458		70,986,585				2.86%	
			215	763,643							
			13114	33,692,289							
			5202	10,333,841							
			6027	13,110,688							
			180	415,666							
	households	households	333	4,747,393	53,039,758	53,039,758	0.48%	0.48%	32.20%	0.36%	88.37%
			334	7,654,605							
			80	1,617,313							
			2386	34,022,054							
			364	4,998,393							
			222,438	1,325,300,979	1,325,300,979	1,325,300,979	11.99%	11.99%		22.78%	
			220,746	1,072,068,283	1,072,068,283	1,566,664,294	9.70%	14.17%		41.06%	
			6,255	20,388,115	20,388,115		0.18%				
			8	29,604	29,604		0.00%				
			6	33,606	33,606		0.00%				
			170,895	465,398,786	465,398,786		4.21%				
			2,980	8,745,900	8,745,900		0.08%				
			188,847	548,418,941	548,418,941	613,836,837	4.96%	5.55%		24.18%	
			28,684	47,092,994	47,092,994		0.43%				
			18,508	18,292,894	18,292,894		0.17%				
			34	32,008	32,008		0.00%				

Customers without power metering only

customer category (consumer groups)			2020								
Voltage level	Connection method	fuse capacity [A]	contracted power [kW]	number of customers	yearly consumption [kWh]	yearly consumption [kWh]	yearly consumption by group [kWh]	consumption share [%]		numeric share [%]	numeric share [%]
LV	businesses	3x63A	43	3075	102,534,159	948,931,049	731,912,411	8.59%		4.69%	10.32%
		3x50A	35	5762	165,586,703						
		3x40A	28	437	10,826,437						
		3x35A	24	11940	206,685,936						
		3x32A	22	763	10,756,442						
		3x25A	17	23823	235,522,734						
		3x20A	14	20865	117,359,155		146,032,053			2.77%	
		3x16A	11	6036	27,736,093						
		3x10A	11	15	108,209						
		1x50A	11	97	828,596						
		1x35A	8	3197	12,670,458		70,986,585			2.86%	
		1x32A	7	215	763,643						
		1x25A	6	13114	33,692,289						
		1x20A	5	5202	10,333,841						
		1x16A	4	6027	13,110,688						
		1x10A	3	180	415,666						
	households	3x63A	43	333	4,747,393	53,039,758	53,039,758	0.48%	0.48%	0.36%	88.37%
		3x50A	35	334	7,654,605						
		3x40A	28	80	1,617,313						
		3x35A	24	2386	34,022,054						
		3x32A	22	364	4,998,393						
		3x25A	10	222,438	1,325,300,979	1,325,300,979	1,325,300,979	11.99%	11.99%	22.78%	
		3x20A	7	220,746	1,072,068,283	1,072,068,283	1,566,664,294	9.70%	14.17%	41.06%	
		3x16A	7	6,255	20,388,115	20,388,115		0.18%			
		3x10A	7	8	29,604	29,604		0.00%			
		1x50A	11	6	33,606	33,606		0.00%			
		1x35A	7	170,895	465,398,786	465,398,786		4.21%			
		1x32A	7	2,980	8,745,900	8,745,900		0.08%			
		1x25A	6	188,847	548,418,941	548,418,941	613,836,837	4.96%	5.55%	24.18%	
		1x20A	3	28,684	47,092,994	47,092,994		0.43%			
		1x16A	3	18,508	18,292,894	18,292,894		0.17%			
		1x10A	3	34	32,008	32,008		0.00%			

Customer group definition was done based on contracted power (P_{inst}) and annual energy consumption (W_{annual})

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Customer group definition – step 2

Small business customers

fuse capacity [A]	capacity charge [kW]
3x63A	43
3x50A	35
3x40A	28
3x35A	24
3x32A	22
3x25A	17
3x20A	14
3x16A	11
3x10A	11
1x50A	11
1x35A	8
1x32A	7
1x25A	6
1x20A	5
1x16A	4
1x10A	3

Household customers

fuse capacity [A]	capacity charge [kW] [1]
3x63A	43
3x50A	35
3x40A	28
3x35A	24
3x32A	22
3x25A	10
3x20A	7
3x16A	7
3x10A	7
1x50A	11
1x35A	7
1x32A	7
1x25A	6
1x20A	3
1x16A	3
1x10A	3

Group definition based on % share, contracted power and annual energy consumption

No.		< 20 MWh	> 20 < 500 MWh	Total annual consumption (kWh)
1	< 8kW	4.75%		70,986,585
2	8-14kW	0.56%	2.24%	146,032,053
3	17-43kW	0.58%	2.32%	731,912,411

[%] Share definition was determined based on the number of consumers belonging to each group

		1	2	3	4	5	
No.		< 1MWh	> 1 < 2,5MWh	> 2,5 < 5MWh	> 5 < 15 MWh	> 15 MWh	Total annual consumption (kWh)
1	< =6kW	0.73%	2.94%	7.10%	13.72%		613,836,837
2	7-14kW	1.25%	4.99%	12.06%	19.55%	3.74%	1,566,664,294
3	17kW	0.69%	2.77%	6.69%	10.85%	2.08%	1,325,300,979
4	>=22kW	0.36%					53,039,758

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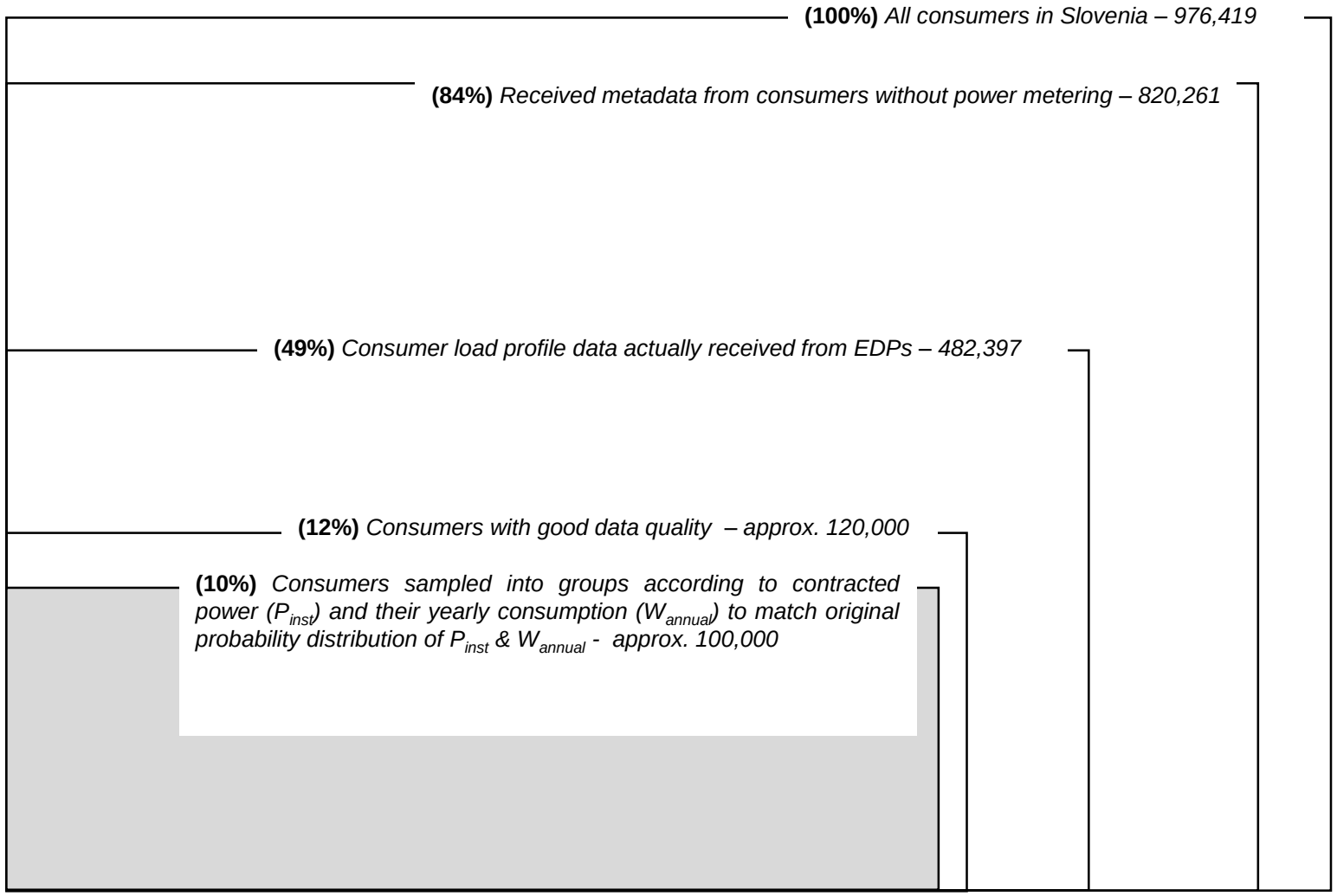
Customer load profile data



Within this dataset we have analyzed:

- ***15min resolution of anonymized consumer raw load profile data***
- ***Metadata files with anonymized consumer IDs from every EDP***

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Customer load profile data – data quality filtering

Relevant facts:

- ***only data of good quality could be accepted with small amounts of invalid values for consumers that were active through the whole years 2019 or 2020,***
- ***only load profiles of consumers with data for the whole year were taken,***
- ***Percentage of invalid values for the whole year must be less than 1 % per consumer,***
- ***Consumers are allowed to have the longest missing data gap interval of one hour.***

In this process the P_{inst} (contracted power) and W_{annual} (annual energy) distribution is not always the same as in the whole population of input data

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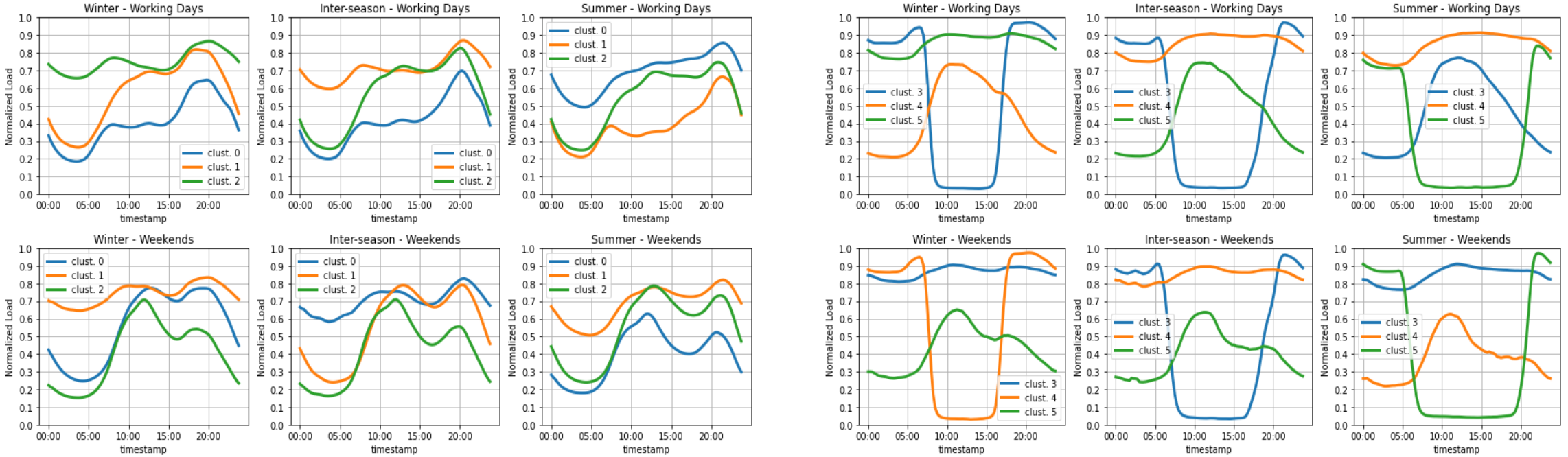
Customer load profile data – data processing

- ***Clustering was done on customer groups based on:***
  - ***their contracted power (P_{inst}) and their yearly consumption (W_{annual})***
  - ***each consumer's time series was grouped according to season (winter, inter-season, summer) and day type (working days and weekends/holidays) for households (clusters 0,1,2) and for small business consumers (clusters 3,4,5)***



- ***According to the GDPR directive, load profiles for households were not registered prior to approx. Q4 2019***
- ***The only complete year for which we have received data was 2020 which in many ways is not optimal as this year has been severely affected by the COVID-19 epidemic***

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Conclusions

- ***20 customer groups were composed for customer load profile data processing (i.e. clustering),***
- ***The purpose of these groups was to categorize particular load profiles in order to create a representative consumer for comparing the effect of the new tariff methodology (1 or 2) on a particular representative consumer,***
- ***Aggregated and load profile data analysis was done for 2019 and 2020,***
- ***Load profile data analysis for 2019 was done on business customers,***
- ***Input data format must be standardized to allow for efficient future data analysis,***
- ***In the future input data will be obtained much faster due to experience gained in this project,***
- ***Future years will be more representative due to no COVID-19 effects so such analyses will become more and more important and representative.***

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EIMV | Elektroinštitut Milan Vidmar
Hajdrihova 2, SI-1000 Ljubljana, Slovenia