SciGRID_gas: Attribute generation heuristics

Jan Diettrich

20.05.2021

Jahrestreffen Forschungsnetzwerks Energiesystemanalyse

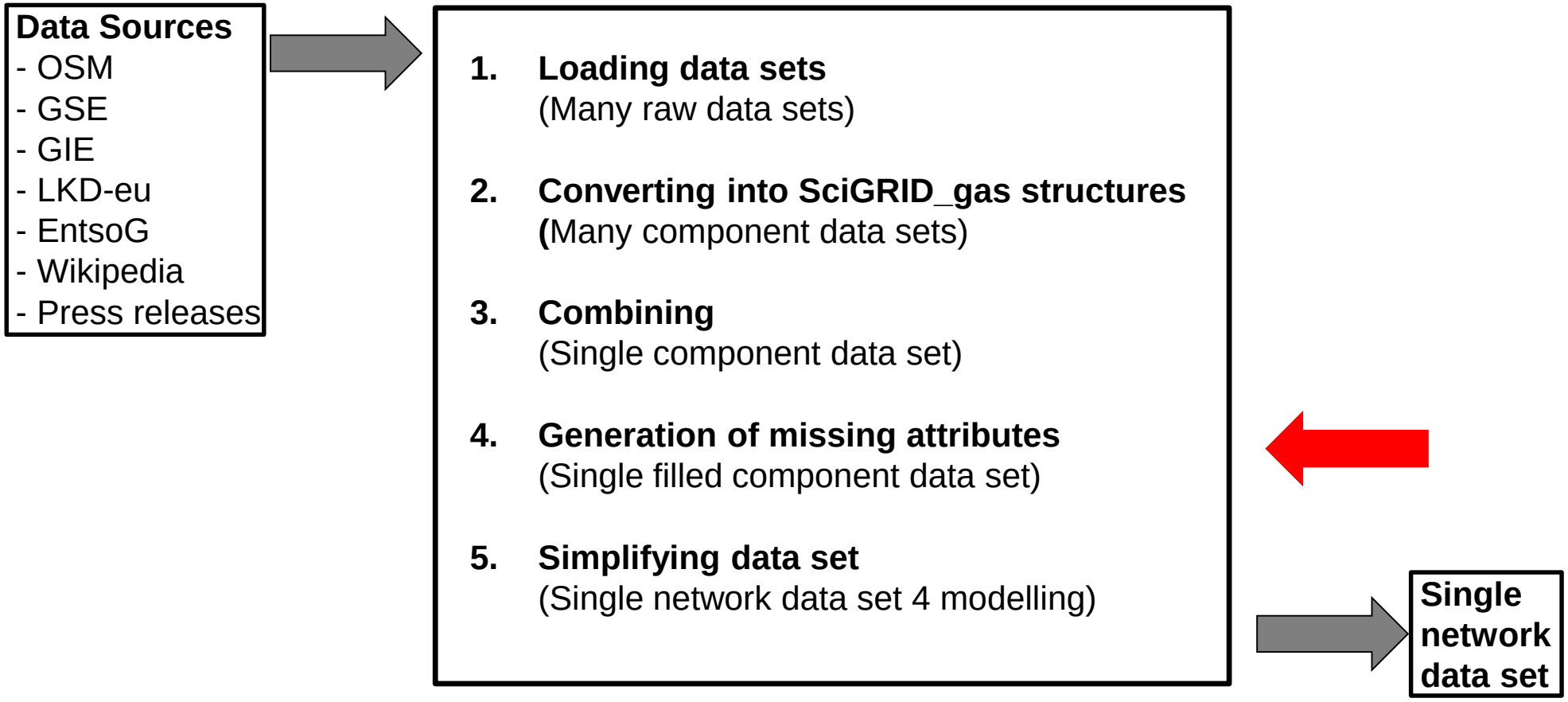
Deutsches Zentrum für Luft- und Raumfahrt e. V. (DLR)
Institute of Networked Energy Systems

Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

Workshop agenda

- Introduction
- Overview and Data Structure
- Input Data
- Merging data sets
- Attribute generation heuristics
- Final Network Model & Data Visualisation
- Users Feedback
- Questions

Pathway


Data Sources
- OSM
- GSE
- GIE
- LKD-eu
- EntsoG
- Wikipedia
- Press releases
1. Loading data sets
(Many raw data sets)
2. Converting into SciGRID_gas structures
(Many component data sets)
3. Combining
(Single component data set)
4. Generation of missing attributes
(Single filled component data set)
5. Simplifying data set
(Single network data set 4 modelling)
Single network data set

Methods of attribute generation

Physical based methods

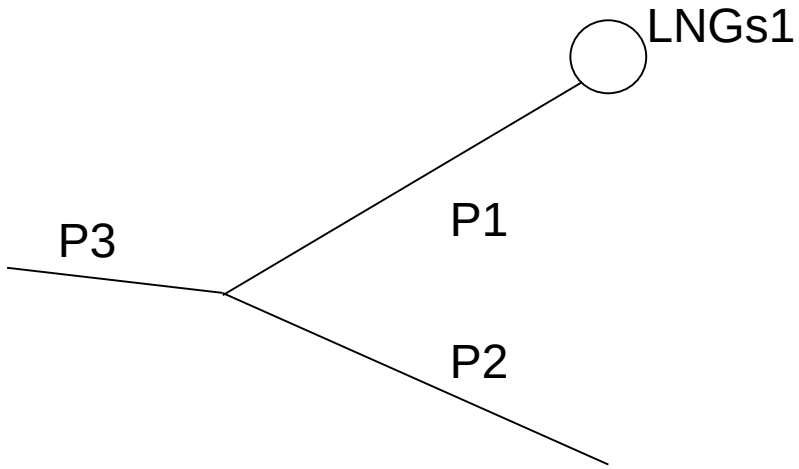
- Pipe capacity ~ diameter^2 * max pressure
- Directionality of gas flow

Statistical based method

- Any parameter can be related to any other parameter (in each element)

Pre-processing of components

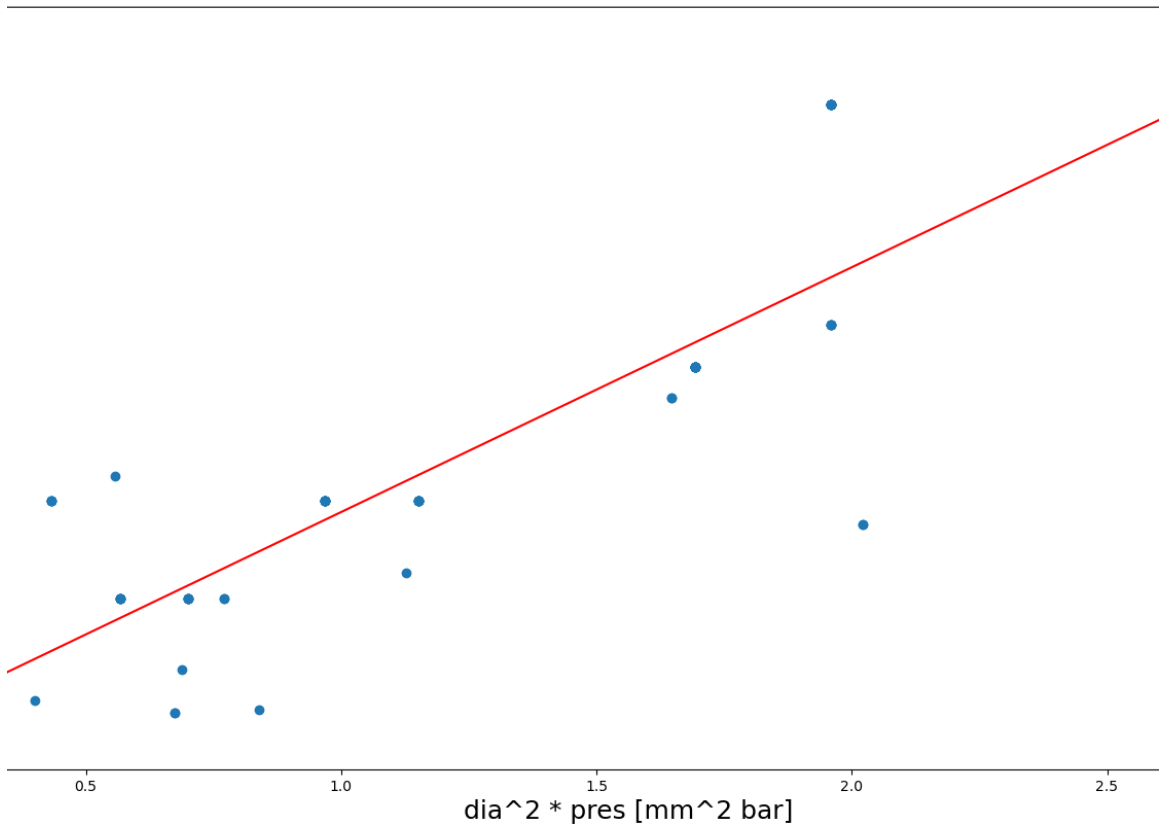
- Copying attributes between elements
  - **Pipe**(pipe_class_Emap) → **compressor**(pipe_class_EMap)
    → Pipe_pipe_class_EMAP
  - **Pipe**(max_cap) → **compressor**(max_cap)
    → Pipe_max_cap
  - **LNG**(max_cap_store2pipe) → **pipe**(max_cap)
    → LNG_max_cap
  - **Compressor**(max_pressure) → **pipe**(max_pressure)
    → Comp_max_pressure



	A	B	C	D	E
1	**Comp_Source**	**Attrib_Source**	**Comp_Destination**	**Attrib_Destination**	**FillMethod**
2	PipeSegments	pipe_class_EMap	Compressors	Pipe_pipe_class_EMap	fill
3	PipeSegments	pipe_class_EMap	Storages	Pipe_pipe_class_EMap	fill
4	PipeSegments	diameter_mm	Consumers	Pipe_diameter_mm	fill
5	PipeSegments	max_pressure_bar	Consumers	Pipe_max_pressure_bar	fill
6	PipeSegments	max_cap_M_m3_per_d	Consumers	Pipe_max_cap_M_m3_per_d	fill
7	PipeSegments	pipe_class_EMap	LNGs	Pipe_pipe_class_EMap	fill
8	Consumers	est_generation_GWh	PipeSegments	Consumers_est_generation_GW	fill
9	Consumers	capacity_E_MW	PipeSegments	Consumers_capacity_E_MW	fill
10	Consumers	capacity_TH_MW	PipeSegments	Consumers_capacity_TH_MW	fill

Physical based heuristics (N = 74)

- Pipe capacity ~ diameter^2 * max pressure
  - r^2 = 0.77
  - Ave (%-diff) = 37%
- Pipe Diameter^2 ~ pipe capacity / max pressure
  - r^2 = 0.63
  - Ave (%-diff) = 29%
- Max pressure ~ pipe capacity / pipe diameter^2
  - r^2 = 0.32
  - Ave (%-diff) = 14%

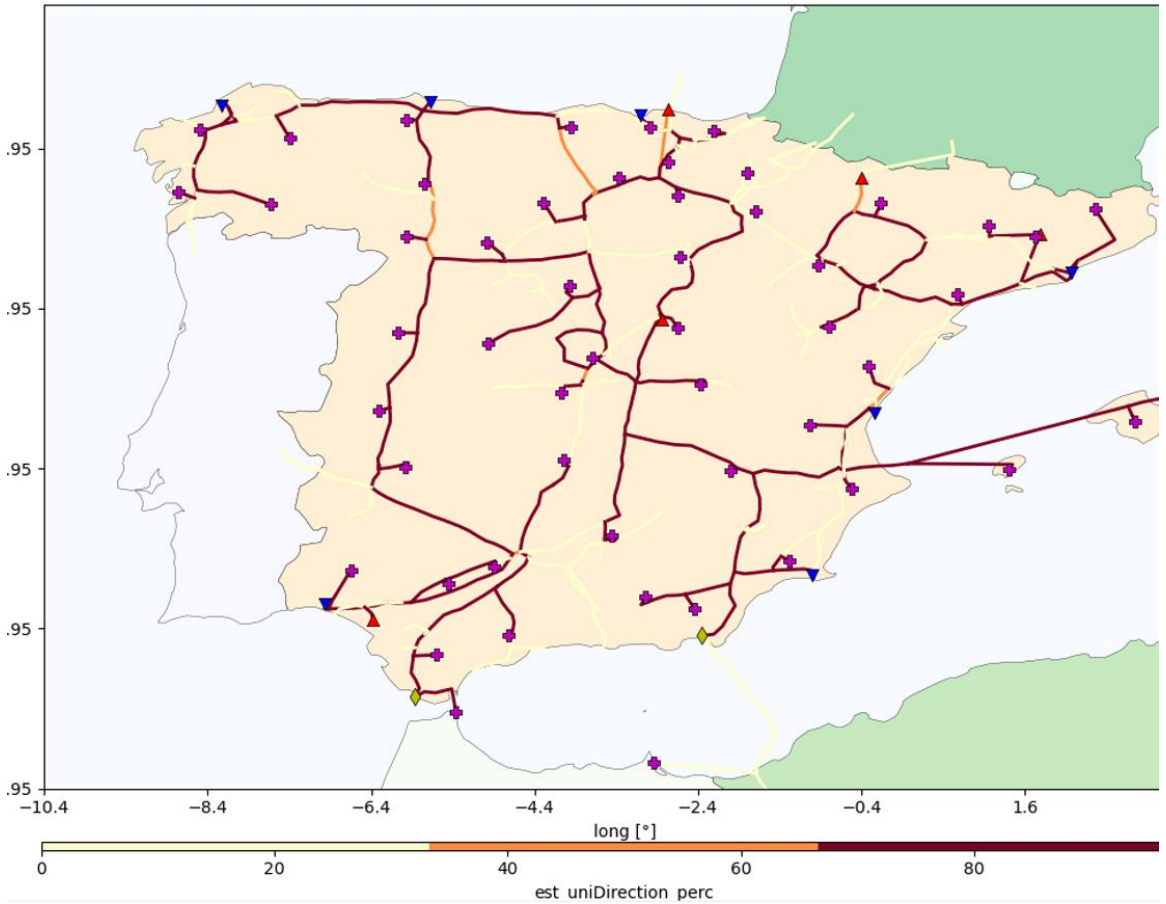


Physical based heuristics

- Pipeline flow direction
  - Sinks
    - Consumers
  - Source
    - LNGs
    - Productions
  - Sink & Source
    - Storages

  - Pipeline capacity
  - LNG/storages/border point capacities

  - Summer/winter simulation
  - Shortest path



Statistical based heuristics

Approach

- Selection which attribute to be independent
- Selection which attribute to be estimated

- Within component relate attributes

- 1, 2, 3,… independent attributes

Regression methods

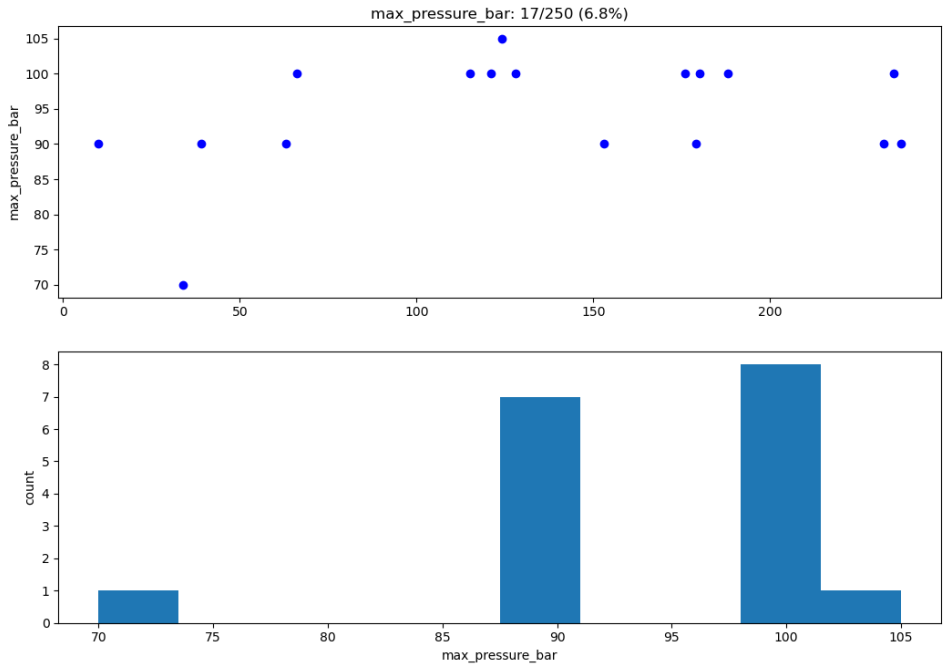
- Linear
- Logistic
- Min
- Max
- Median
- Mean

Possible statistical methods

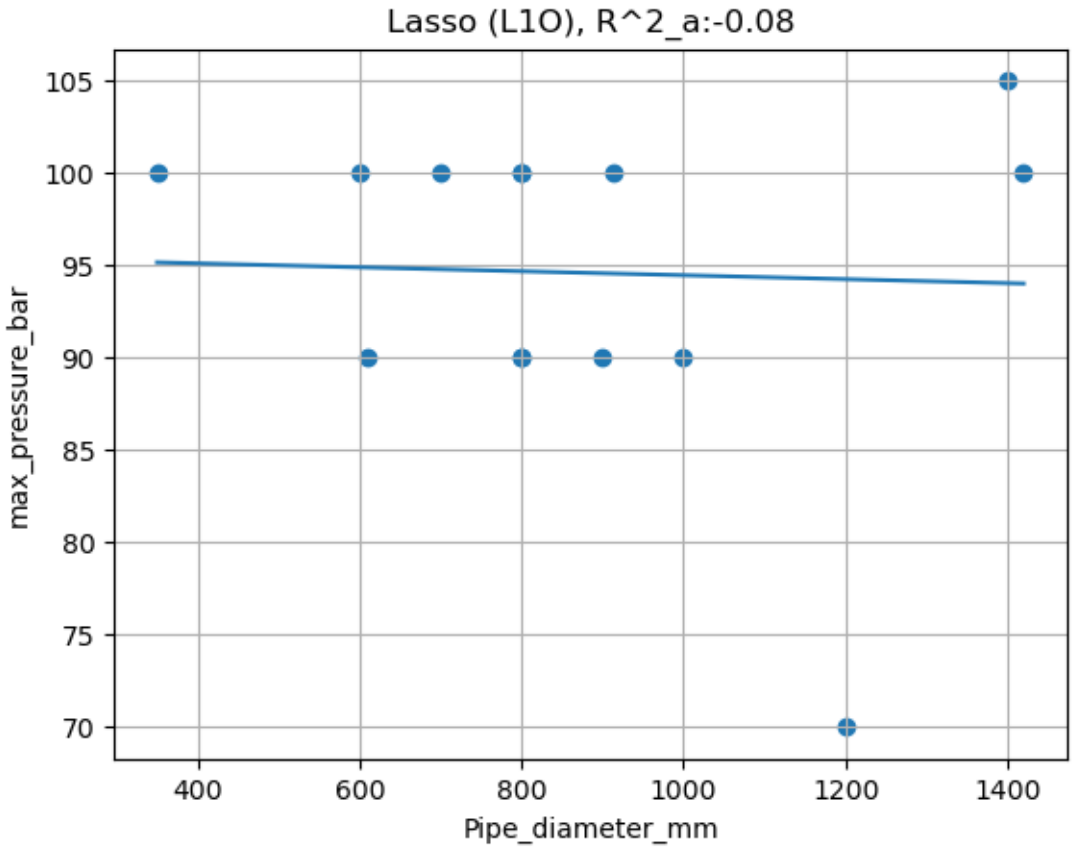
	A	B	C	D	E	F	G	H	I	J	K	L	M
1	CompName	AttribName	NumElemen	ModelName	NumFeatures	FeatureNames	Plots	NumSample	NumFill	BIC	MeanAbsErr	R_2	R_2_adj
2	Compressors	max_cap_M_m3_per_d	250	Lasso	2	["turbine_power_3_MW", "Pipe_diameter_mm"]	../StatsData/	6	28	33.5257237	9.07719747	0.65558074	0.4259679
3	Compressors	max_cap_M_m3_per_d	250	Lasso	2	["max_power_MW", "turbine_power_1_MW"]	../StatsData/	12	50	63.7278772	9.50118089	0.68939559	0.62037239
4	Compressors	max_cap_M_m3_per_d	250	Lasso	2	["max_power_MW", "turbine_power_2_MW"]	../StatsData/	12	48	63.7278772	9.50118089	0.68939559	0.62037239
5	Compressors	max_cap_M_m3_per_d	250	Lasso	2	["max_power_MW", "num_turb"]	../StatsData/	12	50	63.6390845	9.60292992	0.69168539	0.62317104
6	Compressors	max_cap_M_m3_per_d	250	Median	1	["max_cap_M_m3_per_d"]	../StatsData/	18	232	152.793614	39.5306667	-0.12793029	-0.19842593
7													
8	Compressors	max_power_MW	250	Lasso	2	["num_turb", "turbine_power_2_MW"]	../StatsData/	36	0	122.217754	3.06604583	0.95798504	0.95543868
9	Compressors	max_power_MW	250	Lasso	2	["num_turb", "turbine_power_1_MW"]	../StatsData/	37	0	134.882645	3.64405705	0.94783577	0.94476729
10	Compressors	max_power_MW	250	Lasso	2	["num_turb", "turbine_power_3_MW"]	../StatsData/	24	0	92.6994375	3.99098757	0.93391806	0.92762454
11	Compressors	max_power_MW	250	Lasso	2	["num_turb", "turbine_power_4_MW"]	../StatsData/	9	0	38.0651123	4.65099348	0.85722233	0.80962978
12	Compressors	max_power_MW	250	Median	1	["max_power_MW"]	../StatsData/	41	209	322.968678	26.5286734	-0.05904622	-0.08620125
13													
14	Compressors	max_pressure_bar	250	Lasso	2	["max_cap_M_m3_per_d", "Pipe_max_pressure_ba	../StatsData/	8	8	25.2375843	3.37826197	0.40518191	0.16725467
15	Compressors	max_pressure_bar	250	Lasso	2	["max_cap_M_m3_per_d", "Pipe_max_cap_M_m3_p	../StatsData/	8	8	29.0496275	4.57210937	0.04208311	-0.34108365
16	Compressors	max_pressure_bar	250	Lasso	2	["max_cap_M_m3_per_d", "Pipe_diameter_mm"]	../StatsData/	8	8	29.0496275	4.57210937	0.04208311	-0.34108365
17	Compressors	max_pressure_bar	250	Lasso	2	["max_cap_M_m3_per_d", "turbine_power_3_MW"	../StatsData/	8	0	29.2816686	4.65265084	0.01389173	-0.38055158

Inspection of heuristic process

Histogram plots

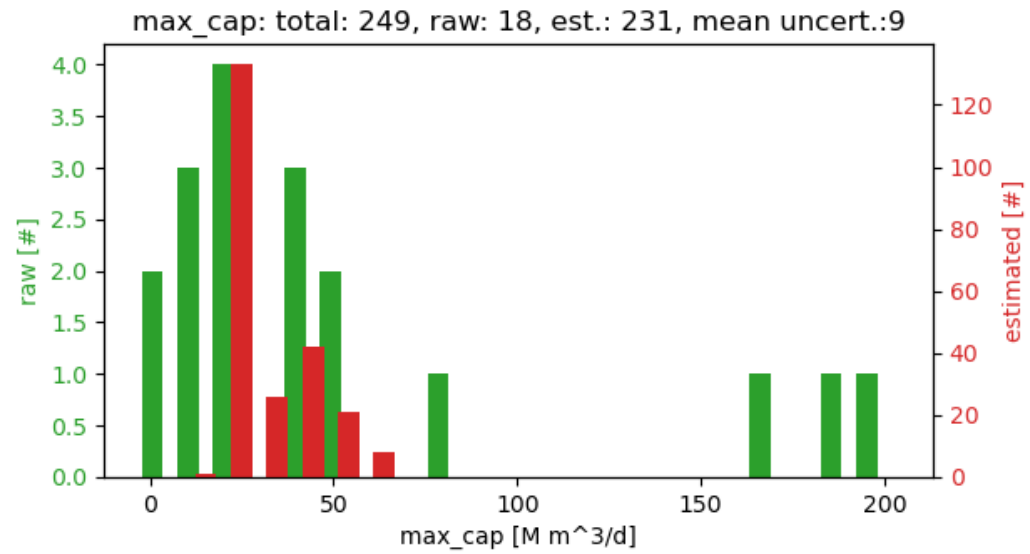


Attribute relation plots



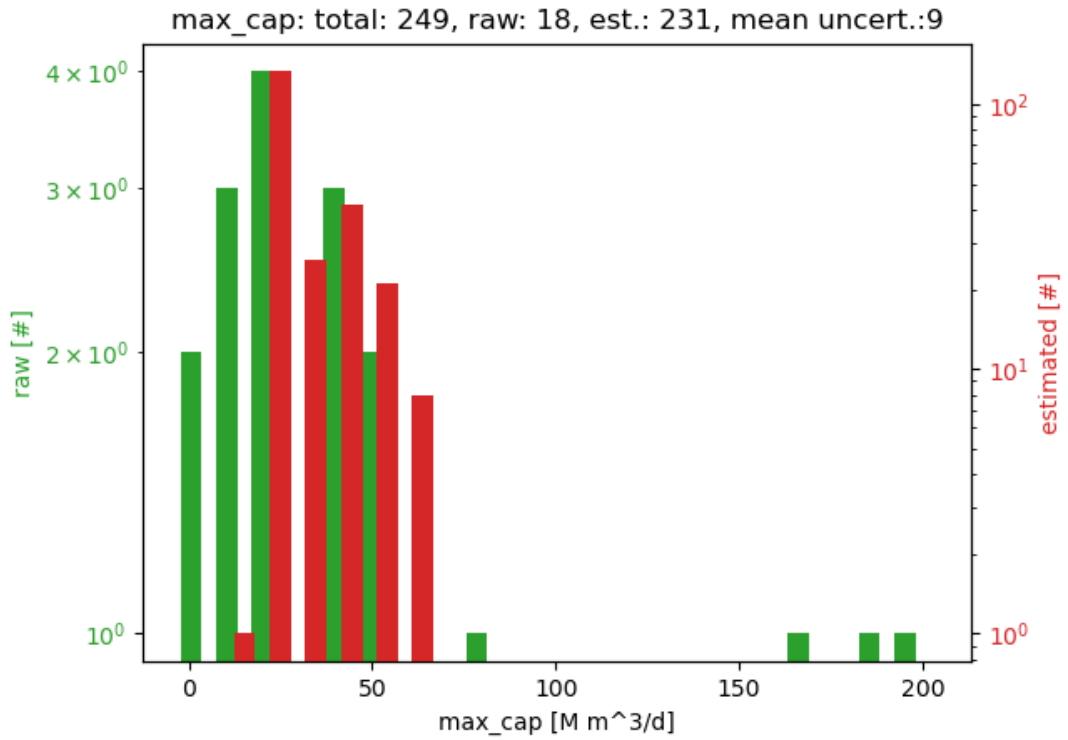
Inspection of heuristic process

Distribution of Raw and estimated values



Lasso(turbine_power_3_MW, Pipe_diameter_mm): 99 (mean uncert.: 9)
Lasso(max_power_MW, turbine_power_1_MW): 132 (mean uncert.: 10)
min(raw):5.52, max(raw):199.99, min(est):11.0, max(est):64.25

Log representation



Checking generated attribute values

- Compressor:
  - 70 < max_press_bar < 200
    - Replacing value with min or max
    - Setting new uncertainty value

- LNGs
  - 1 < max_workingGas_M_m3 < 1000
    - Replacing value with min or max
    - Setting new uncertainty value

	CompName	AttribName	MinVal	MaxVal	UncVal
2	Compressors	max_pressure_bar	70	200	50
3	Compressors	turbine_power_1_MW	0	50	25
4	Compressors	turbine_power_2_MW	0	50	25
5	Compressors	turbine_power_3_MW	0	50	25
6	Compressors	turbine_power_4_MW	0	50	25
7	Compressors	max_cap_M_m3_per_d	5	200	50
8	Compressors	max_power_MW	2	300	100
9	Consumers	capacity_E_MW	2	5000	1000
10	Consumers	capacity_TH_MW	12	2600	1000
11	Consumers	est_generation_GWh	5	26000	10000
12	LNGs	max_cap_store2pipe_M_m3	1	100	50
13	LNGs	max_workingGas_M_m3	2	1000	400
14	LNGs	median_cap_store2pipe_M_	2	100	50
15	PipeSegments	diameter_mm	60	1600	500
16	PipeSegments	max_cap_M_m3_per_d	2	200	50
17	PipeSegments	max_pressure_bar	10	220	100
18	Productions	max_supply_M_m3_per_d	1	4000	1000
19	Storages	max_cushionGas_M_m3	1	60000	20000
20	Storages	max_power_MW	1	500	100
21	Storages	max_storage_pressure_bar	12	600	200
22	Storages	min_storage_pressure_bar	1	600	200
23	Storages	num_storage_wells	1	1800	500
24	Storages	max_cap_pipe2store_M_m3	1	270	100
25	Storages	max_cap_store2pipe_M_m3	1	270	100
26	Storages	max_workingGas_M_m3	10	50000	10000

Results of heuristic processes

PipeSegments

Attrib Name	N(R)	N(E)	Mean	Med	P(10)	P(90)	MAE(E)	|Z|
diameter_mm	768	1291	980.92	964.55	800	1219	132	0.84
max_cap_M_m3_per_d	310	1749	48	42	15	79	22	3.62
max_pressure_bar	557	1502	77	75	70	83	6.15	0.95
is_bothDirection	194	1865	0.0563	0	0	0	0.5	17