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Motivation

- Detailed models of the power grid are inaccessible for the security community. However, power lines, substations and plants appear to be well documented by OpenStreetMap.
- ls open geodata a reliable source of information? Does open geodata provide worthwhile insights for adversaries?
- In this work, we **model** the Austrian power grid based on OpenStreetMap Data.

Processing the data in GIS

- ► Import data for each state where "power" is the key attribute and "line", "minor line", and "substation" are the values. Clipping all vector layers, as the data are not linked to each other.
- ► Generate geometric measurements based on a selected CRS.
- Calculate a buffer of 1km for all substation objects to find out which lines might be connected to them.
- Clipping all lines with the municipalities where they run through.

Terms & Definition

Geographic Information System (GIS)

- Computer-aided system
- Model and process spatial data

Geodata

- Describe an object, either directly (by coordinates) or indirectly (e.g., by postal code), a landscape or by its position in space
- Can be linked to each other in order to create detailed queries and analyses

OpenStreetMap

Built by a community of mappers that contribute and maintain open data about objects on the earth's surface

QGIS

- Open source GIS for viewing, editing, and capturing spatial data
- OSM plugin allows the access to up-to-date OSM data, and simple export to an easy-to-use Shapefile or SQLite database

Maps & Tables

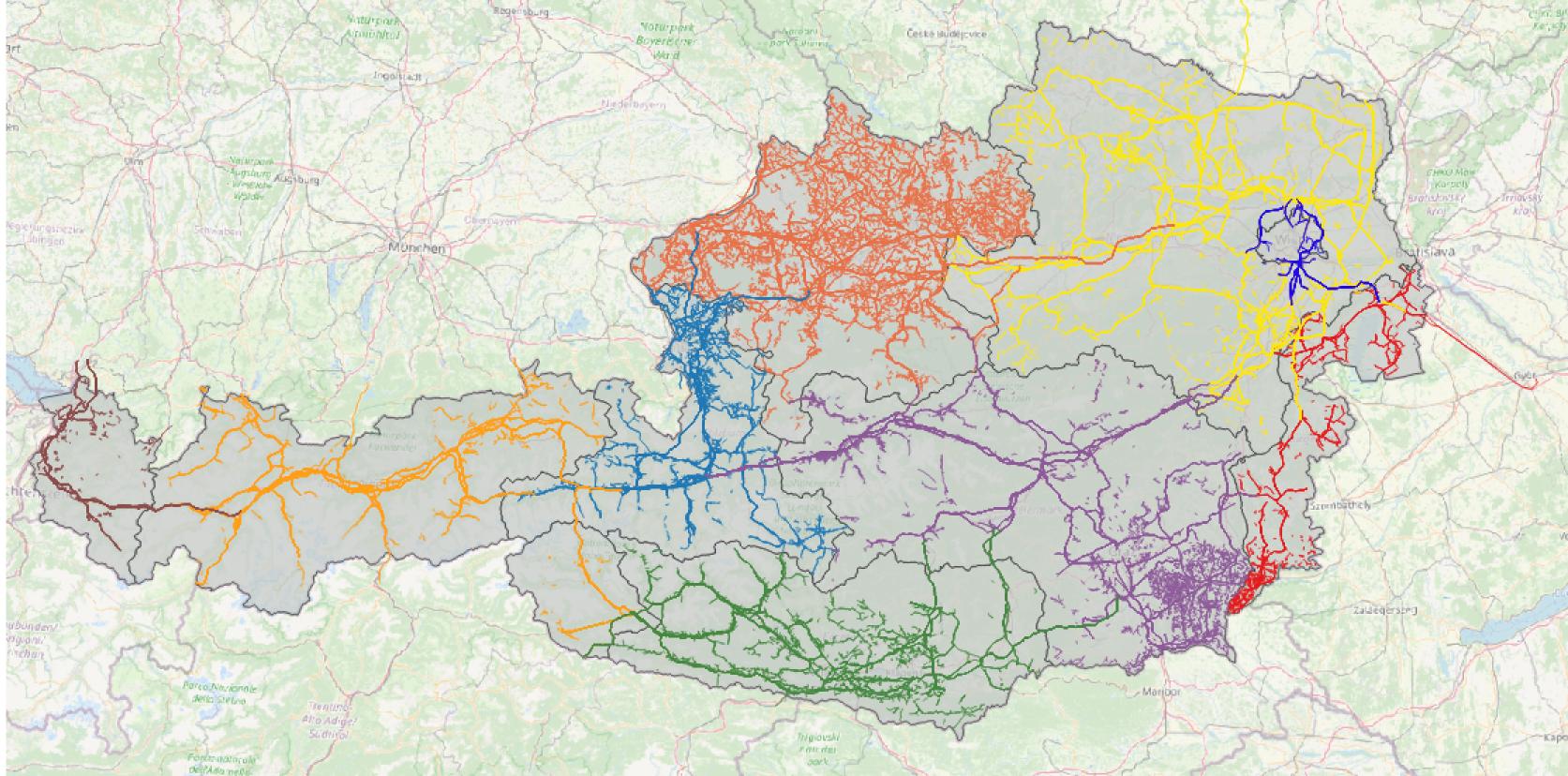


Figure 1: OpenStreetMap power lines Austria

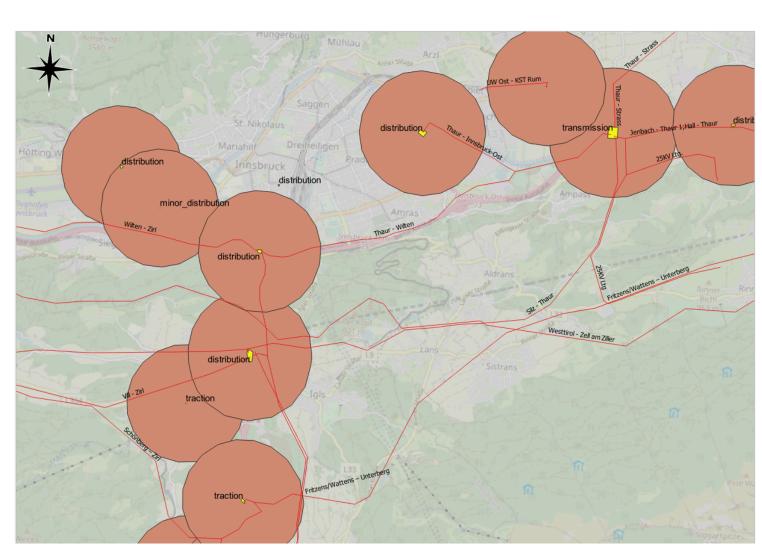


Figure 2: Buffer around substations

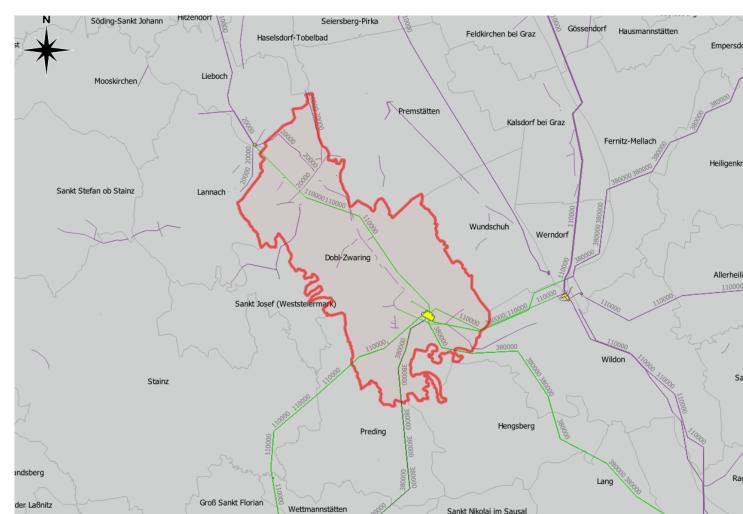


Figure 3: Power lines clipped with municipalities

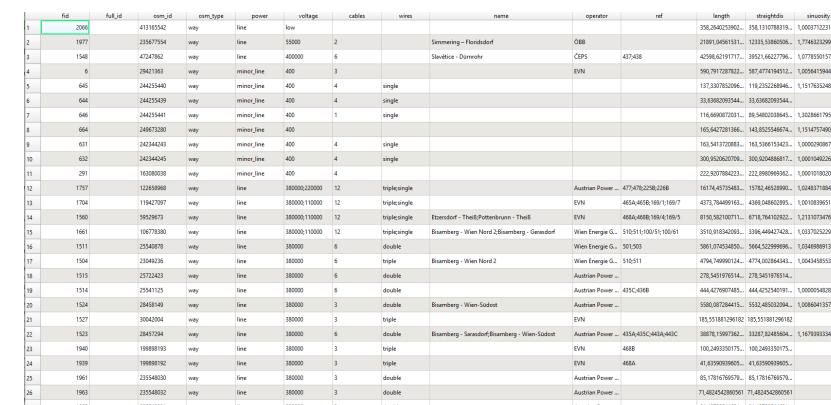


Figure 4: Attribute table QGIS – power lines

4	A	В	С	D	E	F	G	Н	1	J	K	L
wkt_geom		fid	full_id	osm_id	osm_ty	pe power	voltage	cables	wires	operator	circuits	name
LineString (504970.6814358735573478 533	9231.92311365902423859, 505021.49514707631897181 53	206	6	4,13E+08	8 way	line	low					
LineString (604309.91598395421169698 534	46355.29517753422260284, 604323.13761119090486318 5	197	7	2,36E+08	8 way	line	55000)	2	ÖBB		Simmering – Floridsdorf
LineString (579997.4229611688060686 5399	9791.48013689741492271, 580124.00658967474009842 54	154	8	47247862	2 way	line	400000)	6	ČEPS		Slavětice - Dürnrohr
LineString (629612.25007104151882231 535	57145.25849645677953959, 629719.64775378187187016 5		6	29421363	3 way	minor_line	400)	3	EVN		
LineString (498459.10208810964832082 533	80447.11035060230642557, 498427.42268450127448887 5	64	5	2,44E+08	B way	minor_line	400)	4 single			
LineString (498343.97071764222346246 533	80416.63227690476924181, 498332.85533233033493161 5	64	4	2,44E+08	8 way	minor_line	400)	4 single			
LineString (498565.12512885523028672 533	80510.70410469360649586, 498594.48643705825088546 5	64	6	2,44E+08	8 way	minor_line	400)	1 single			
LineString (501484.70631913701072335 533	31062.03503835294395685, 501495.37198201706632972 5	66	4	2,5E+08	8 way	minor_line	400)				
LineString (499468.03266484587220475 533	31518.5985093479976058, 499515.88046249258331954 53	63	1	2,42E+08	8 way	minor_line	400)	4 single			
LineString (499357.33981905784457922 53	81684.93251891899853945, 499375.16228443937143311 5	63	2	2,42E+08	8 way	minor_line	400)	4 single			
LineString (504978.25296382821397856 540	9695.46287153381854296, 504980.58784657577052712 5	29	1	1,63E+08	B way	minor_line	400)	4			
LineString (602538.96548788109794259 53:	15388.24023077730089426, 602522.11641362623777241 5	175	7	1,23E+08	B way	line	380000;220000		12 triple;single	Austrian Power Grid AG		
LineString (551477.42309318610932678 534	1781.65423403773456812, 551735.98966267355717719 5	170	4	1,19E+08	B way	line	380000;110000		12 triple;single	EVN		
LineString (552375.73359157063532621 530	50188.48740527778863907, 552649.85519088583532721 5	156	0	5952967	3 way	line	380000;110000		12 triple;single	EVN		Etzersdorf - Theiß;Pottenbrunn - Theiß
LineString (605275.05824665655381978 535	4745.4068492203950882, 605095.93929724290501326 53	166	1	1,07E+08	8 way	line	380000;110000		12 triple;single	Wien Energie GmbH		Bisamberg - Wien Nord 2;Bisamberg - Gerasdorf
LineString (605357.812775471014902 5331:	22.4546509962528944, 605355.5758833586005494 53312	151	1	25540878	8 way	line	380000)	6 double	Wien Energie GmbH		
LineString (605275.05824665655381978 535	4745.4068492203950882, 605230.61842100915964693 53	150	4	23049236	6 way	line	380000)	6 triple	Wien Energie GmbH		2 Bisamberg - Wien Nord 2
LineString (626392.90801528177689761 53	21135.94527863617986441, 626114.81373472383711487 5	151	5	2572242	3 way	line	380000)	6 double	Austrian Power Grid AG		
LineString (605675.9914190664421767 5330	9907.97766620386391878, 605756.07254642306361347 53	151	4	2554112	5 way	line	380000)	6 double	Austrian Power Grid AG		
LineString (625299.69210382853634655 532	26087.18092442583292723, 625132.46412843407597393 5	152	4	28458149	9 way	line	380000)	3 double	Austrian Power Grid AG		Bisamberg - Wien-Südost
LineString (551329.52901536074932665 534	1669.59691657591611147, 551477.42309318610932678 5	152	7	30042004	4 way	line	380000)	3 triple	EVN		
LineString (602206.59503624809440225 535	57232.76452048029750586, 602442.92786331276874989 5	152	3	28457294	4 way	line	380000)	6 double	Austrian Power Grid AG		Bisamberg - Sarasdorf;Bisamberg - Wien-Südost
LineString (552184.23203747521620244 530	50219.83751661702990532, 552095.72283833811525255 5	194	0	2E+08	8 way	line	380000)	3 triple	EVN		
LineString (552184.23203747521620244 530	60219.83751661702990532, 552183.05699505435768515 5	193	9	2E+08	8 way	line	380000)	3 triple	EVN		
LineString (460782.94309598585823551 533	80021.0000344030559063, 460840.86878388212062418 53	196	1	2,36E+08	B way	line	380000)	3 double	Austrian Power Grid AG		
LineString (460782.94309598585823551 533	80021.0000344030559063, 460815.52887214004294947 53	196	3	2,36E+08	B way	line	380000)	3 double	Austrian Power Grid AG		
LineString (460782.94309598585823551 533	80021.0000344030559063, 460781.66991155385039747 53	196	2	2,36E+08	B way	line	380000)	3 double	Austrian Power Grid AG		
LineString (565679.45710698829498142 53	3081.11007951851934195, 565687.16426982404664159 5	198	3	2,53E+08	8 way	line	380000)	3			
LineString (601844.7234254633076489 535	7071.61508065741509199, 601989.42598777497187257 53	198	5	2,53E+08	8 way	line	380000)	3 double	Austrian Power Grid AG		Bisamberg - Wien-Südost
LineString (565690.57527728646527976 535	3081.23853764310479164, 565687.16426982404664159 5	198	4	2,53E+08	8 way	line	380000)	3			
LineString (565654.49134426366072148 53	3080.33257881831377745, 565687.16426982404664159 5	199	9	2,96E+08	8 way	line	380000)	3 double	Austrian Power Grid AG		
LineString (565294.65782295854296535 535	3390.28624746482819319, 565270.81590147223323584 5	199	8	2,96E+08	B way	line	380000)	3 double	Austrian Power Grid AG		Slavětice - Dürnrohr
LineString (565294.65782295854296535 535	53390.28624746482819319, 565251.97002285136841238 5	199	4	2,96E+08	B way	line	380000)	3 double	Austrian Power Grid AG		Slavětice - Dürnrohr
LineString (565602 27343179797753692 539	3148.43005635775625706, 565602.8690177712123841 53	200	6	2,96E+08	RWW	line	380000		3			

Figure 5: Exported attribute table – including coordinates

	name	operator	power	ref	voltage	cables	length	sinuosity	straightdis	GKZ	PG	BKZ	PB	BL_KZ	BL
	Hall - Essling		line	151/1A	110000	3	23042,93571076	1,100016397257	. 20947,81111283	61253	Admont	612	Liezen		6 Steiermark
2	Ardning - Hall		line	151/1B	110000	3	9703,041578768	1,053941834436	9206,429863331	61253	Admont	612	Liezen		6 Steiermark
3	Irdning - Haus;Liezen - Haus	Energie Steiermark	line	155/7B;155/8	110000	6	27697,61304643	1,049692531990	26386,40573530	61254	Aich	612	Liezen		6 Steiermark
4	Tauern - Weißenbach	Austrian Power Grid AG	line	221;222	220000	6	84088,1677367147	1,072846677240	78378,5507478401	61254	Aich	612	Liezen		6 Steiermark
5	ÖBB Bahnstromleitung 170, St. Johann im Po	ÖBB	line	170	110000	4	91756,8764763227	1,050307882565	87361,88502380	61254	Aich	612	Liezen		6 Steiermark
6	Liezen - Irdning;Liezen - Haus	STEWEAG-STEG	line	155/7A;155/8	110000	6	15632,23244672	1,155214886137	13531,88279886	61203	Aigen im Ennstal	612	Liezen		6 Steiermark
7	ÖBB Bahnstromleitung 170, St. Johann im Po	ÖBB	line	170	110000	4	91756,8764763227	1,050307882565	87361,88502380	61203	Aigen im Ennstal	612	Liezen		6 Steiermark
8	Graz-Nord - Gleisdorf	STEWEAG	line	136/5;136/6	110000	6	23069,64857951	1,056690567588	21831,98117511	61701	Albersdorf-Prebuch	617	Weiz		6 Steiermark
9	Gleisdorf - Weiz		line	137/3;137/4	110000	6	12606,12136989	1,065158844285	11834,96850026	61701	Albersdorf-Prebuch	617	Weiz		6 Steiermark
10			line	135/9	110000	3	8841,12185921143	1,062673065077	8319,700714878	61001	Allerheiligen bei Wildon	610	Leibnitz		6 Steiermark
11		Energie AG	line	163/6;163/7	110000	6	14138,71124283	1,182479061871	. 11956,83855954	61204	Altaussee	612	Liezen		6 Steiermark
12	Hessenberg - Ternitz	Austrian Power Grid AG	line	225A;226A	220000	6	95364,06781551	1,111236557416	85817,97204115	31801	Altendorf	318	Neunkirchen		3 Niederösterreich
13		Austrian Power Grid AG	line	122/5;122/6	110000	6	37842,90940284	1,152817538235	32826,45184315	31801	Altendorf	318	Neunkirchen		3 Niederösterreich
14	Hall - Essling		line	151/1A	110000	3	23042,93571076	1,100016397257	20947,81111283	61205	Altenmarkt bei Sankt	612	Liezen		6 Steiermark
15			line	150/1;150/4	110000	6	28864,40329210	1,14274847813458	25258,75452420	61205	Altenmarkt bei Sankt	612	Liezen		6 Steiermark
16	Essling - Altenmarkt		line	151/5	110000	3	3770,826062769	1,075291223952	3506,795162809	61205	Altenmarkt bei Sankt	612	Liezen		6 Steiermark
17			line	150/4	110000	3	5,736550785653	1	5,736550785653	61205	Altenmarkt bei Sankt	612	Liezen		6 Steiermark
18	Sattlerstraße		line	150/1;150/8	110000	6	27829,18146104	1,187405328040	23436,96866086	61205	Altenmarkt bei Sankt	612	Liezen		6 Steiermark
19			line	150/8	110000	3	6,434567191043	1	6,434567191043	61205	Altenmarkt bei Sankt	612	Liezen		6 Steiermark
20			line	151/7	110000	3	1166,257318054	1,018907708485	. 1144,615266271	61205	Altenmarkt bei Sankt	612	Liezen		6 Steiermark
21			line	151/1A;151/5	110000	6	63,32825463913	1	63,32825463913	61205	Altenmarkt bei Sankt	612	Liezen		6 Steiermark
22	Tauern - Weißenbach	Austrian Power Grid AG	line	221;222	220000	6	84088,1677367147	1,072846677240	78378,5507478401	50401	Altenmarkt im Pongau	504	Sankt Johann im Pongau		5 Salzburg
23	ÖBB Bahnstromleitung 170, St. Johann im Po	ÖBB	line	170	110000	4	91756,8764763227	1,050307882565	87361,88502380	50401	Altenmarkt im Pongau	504	Sankt Johann im Pongau		5 Salzburg
24	20kV Freileitung		line				940,115070725815	1,038049411826	905,6554148723	61756	Anger	617	Weiz		6 Steiermark
25	20kV Freileitung		line		20000		2274,430399822	1,040783848904	2185,305241060	61756	Anger	617	Weiz		6 Steiermark
26	Weiz - Birkfeld 110kV Freileitung	Estag	line	141/2	110000	3	19566,12806755	1,230324495115	. 15903,22564920	61756	Anger	617	Weiz		6 Steiermark
27	Liezen - Ardning		line	151/1C	110000	3	8819,9413455589	1,203373323911	7329,347568460	61206	Ardning	612	Liezen		6 Steiermark
28	Ardning - Hall		line	151/1B	110000	3	9703,041578768	1 053941834436	9206 429863331	61206	Ardning	612	Liezen		6 Steiermark

Figure 6: Attribute table QGIS – power lines clipped with municipalities

Conclusion & Future Work

- Based on the wide range of accessible geodata, we were able to model the Austrian power grid.
- Based on this model, we plan to investigate attack strategies using network analysis in the future.
- Geodata provides worthwhile insights for the security community and adversaries alike.
- Security-by-obscurity cannot protect large-scale critical infrastructures like the power grid.













