

SciGRID: Transmission Network Modeling Using Open Source Data

Wided Medjroubi
Energy System Analysis

NEXT ENERGY

EWE-Forschungszentrum für
Energietechnologie e.V.

Next Energy & System Modelling Group

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EWE-Forschungszentrum für
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- | Non-profit organisation whose objective is to carry out application-oriented and interdisciplinary research, thus playing an active role in the transformation of our energy system
- | Founded in 2007 as an affiliate institute of the University of Oldenburg by the energy supplier EWE AG, the University of Oldenburg and the Federal State of Lower Saxony
- | Financed by the industry and the public sector



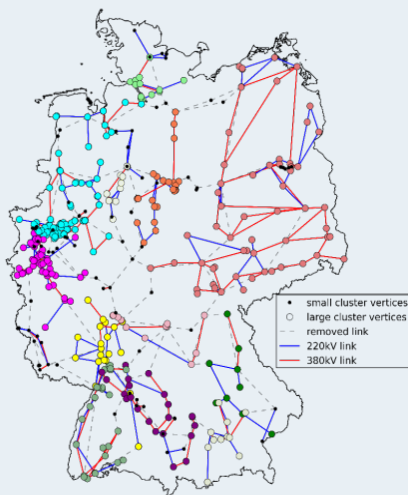
System Modellig – Thematic Focuses

Projekts Overview

SciGRID open_eGo



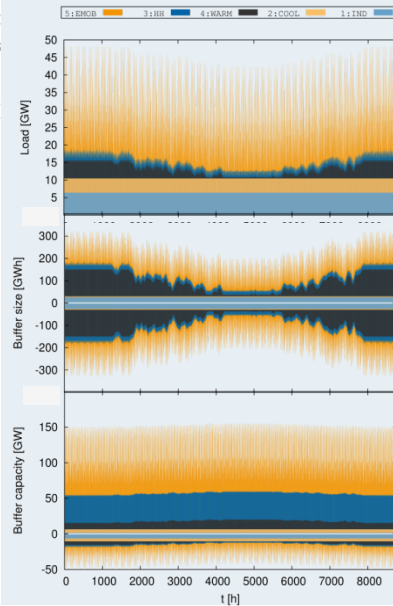
Power Network Modeling & Analysis



RESTORE 2050



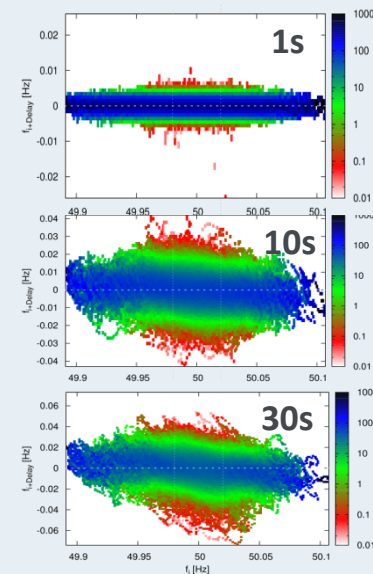
Storage & DSM Potential Estimation



DYNAMOS



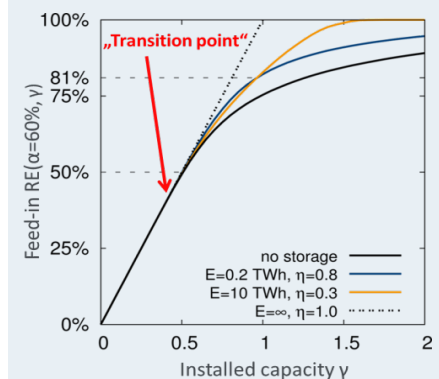
Systematic Dynamic Effects



SYSMOD



Generation Portfolios Optimization



SciGRID: An Open Source Reference Model for the European Transmission Network

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STROMNETZE

Forschungsinitiative der Bundesregierung

Transmission Network Data

Which data is needed?



Electrical parameters

- Voltage levels
- Status: active/inactive in planning
- Resistance and Reactance
- Thermal limits



Geo-locations

- Exact geo-locations
- Electrical connections
- Power plants locations



other

- Possibility of integration of development plans
- Possibility of combination of other datasets
- Reliability
- Validation

Available Transmission Network Data

	ENTSO-E map	BNetzA	TSO's	OpenStreetMap	SciGRID	GridKit
extent	Europe Russia, MENA	Germany	TSO supply region	Europe, America, Asia*, Africa*	Europe, America, Asia*, Africa*	Europe, America, Asia*, Africa*
vol. levels	220 kV - 750 kV	220 kV - 750 kV	220 kV - 380 kV	all voltage levels available	220 kV - 380 kV	all voltage levels available
elect. Info	circuits nb, voltage levels	impedances voltage levels	impedances voltage levels	wires, cables, (circuits*) nb voltage levels	OSM data +impedances	OSM data +impedances
geo. loc.	no geo-locations	no geo-locations	no geo-locations	geo-locations	geo-locations	geo-locations
license	copyright ENTSO-E	Datenlizenz Namensnennung Deutschland V2.0	copyright/no specifications	Open Database License V1.0	Open Database License V1.0	Open Database License V1.0

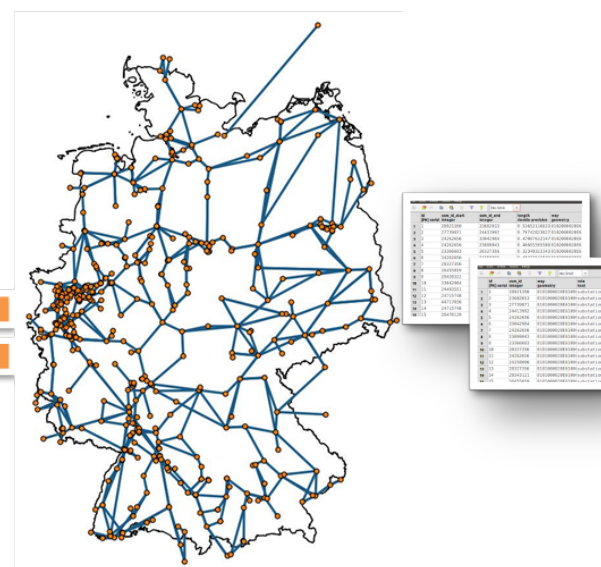
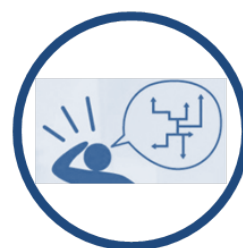
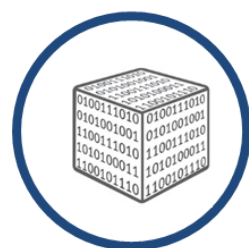
Introduction to SciGRID

- | **SciGRID** is an open source transmission network model
- | **SciGRID** is not only a model, it is also data
- | **SciGRID** is based on **OpenStreetMap** “power” data
- | **SciGRID** uses **open source tools and software**
- | **SciGRID** output is a **topological network** model



Introduction to SciGRID

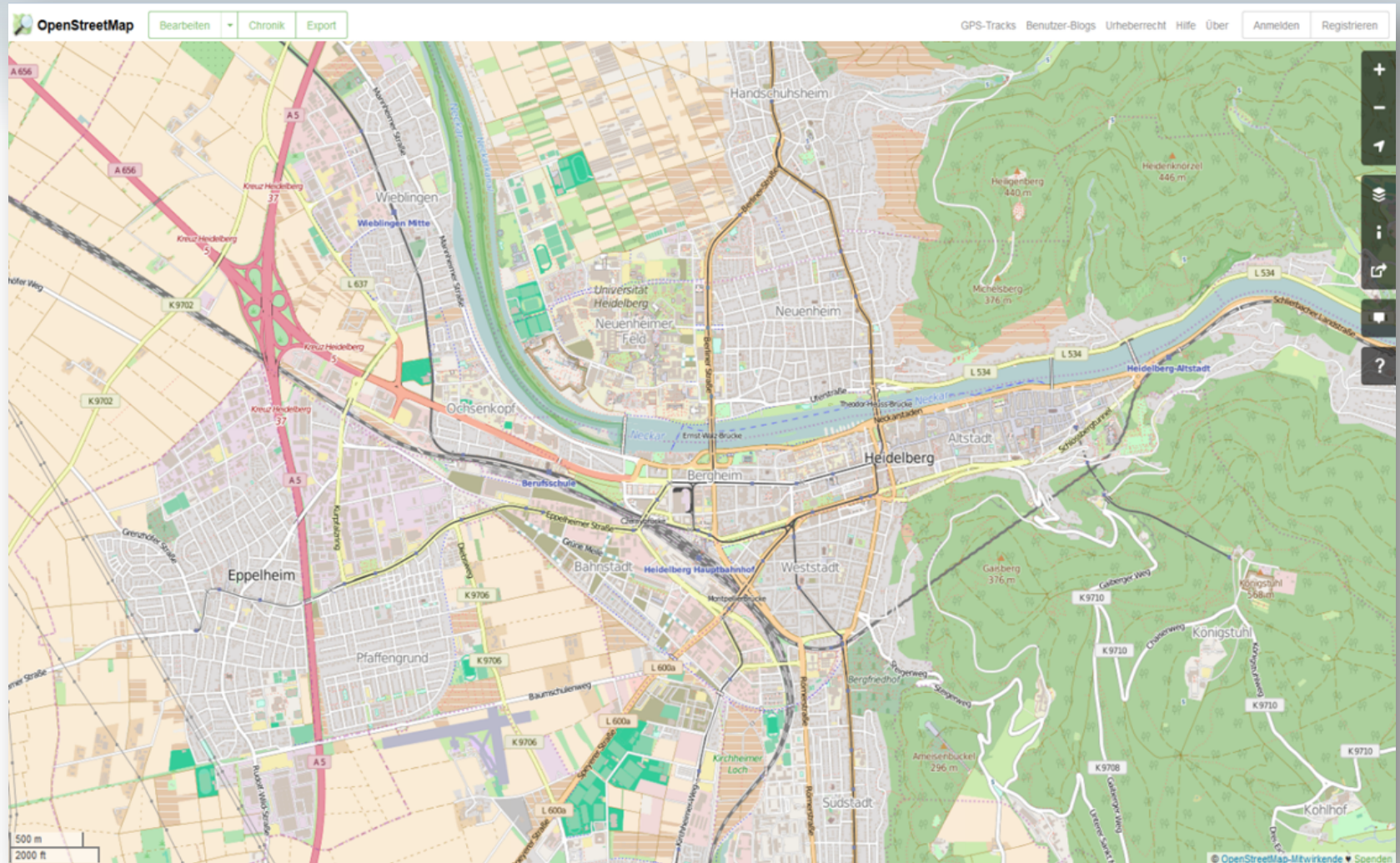
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SciGRID: Data Source and Structure



Data Structure: OpenStreetMap



Which power data is available in OSM?

People map in OpenStreetMap what they see!

- » Plants, generators, substations, transformers...



- » 1 towers
 - 6 cables
 - 4 wires



- In a 3 phase system 3 cables define a **circuit** called „**relation**“ in OSM

OSM Data Structure



node



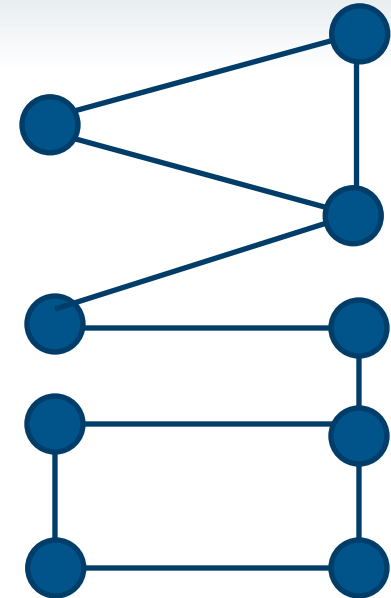
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way



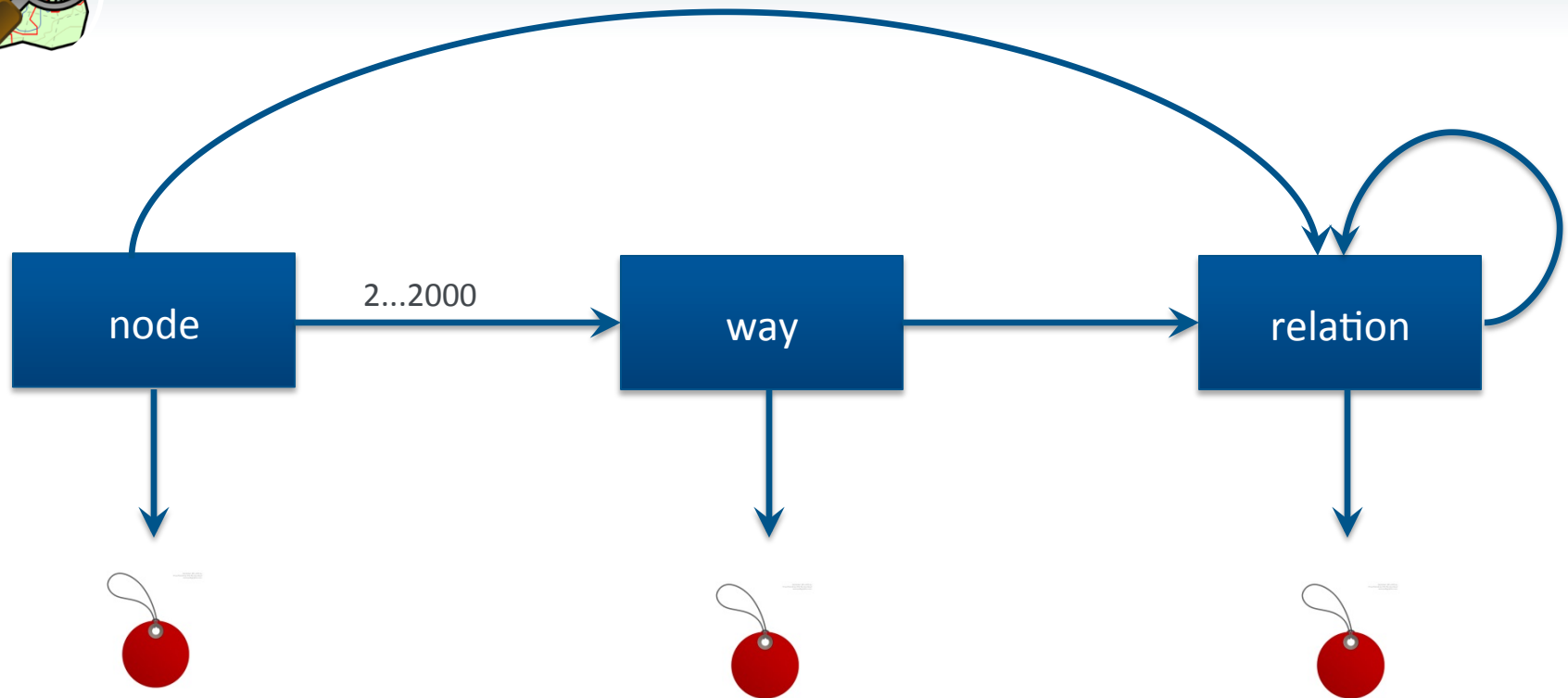
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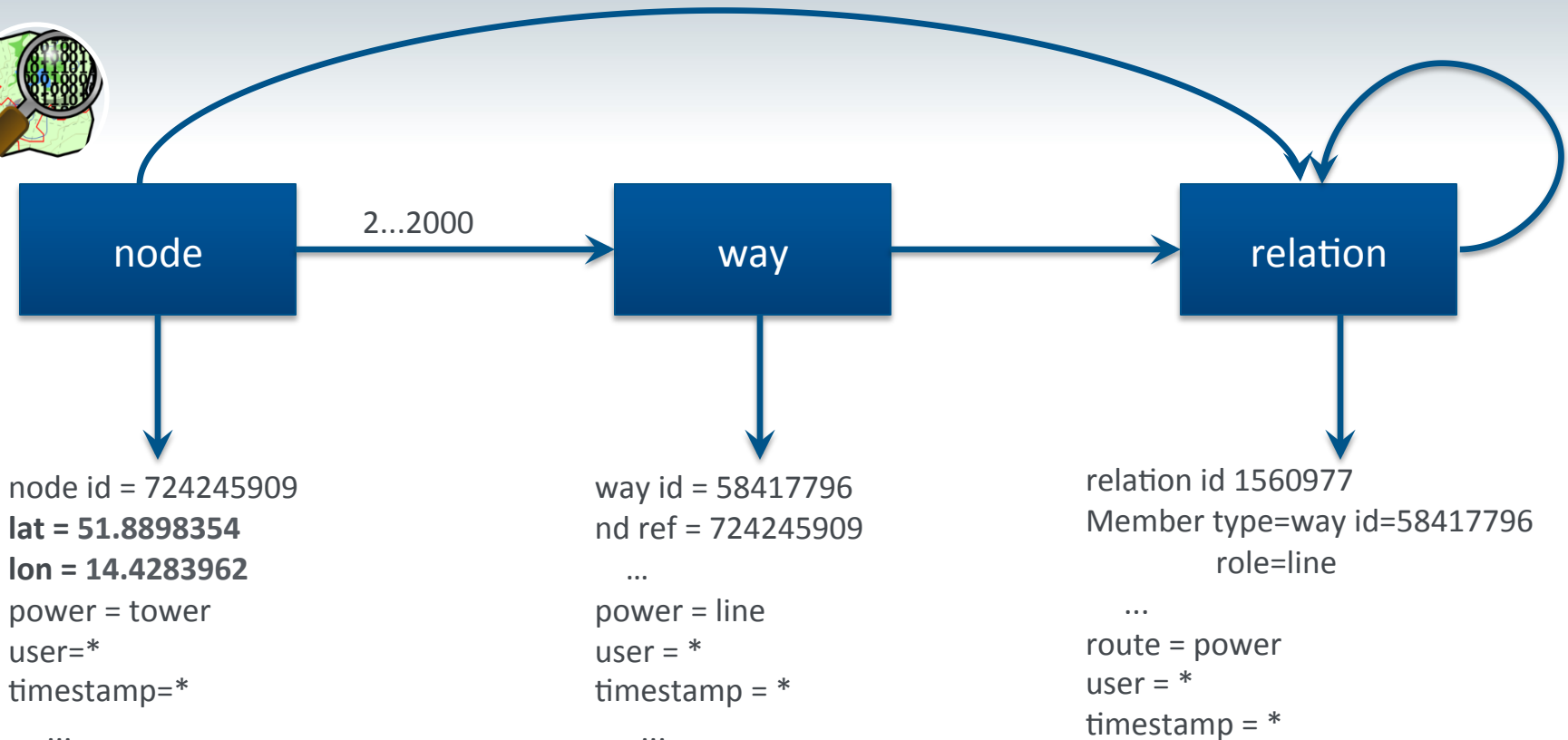
relation



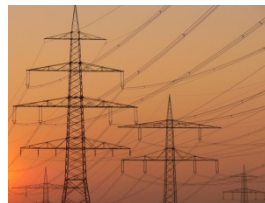
OSM Data Structure



OSM Data Structure: Example



Source: Fotolia / Erwin Wodicka, 2012

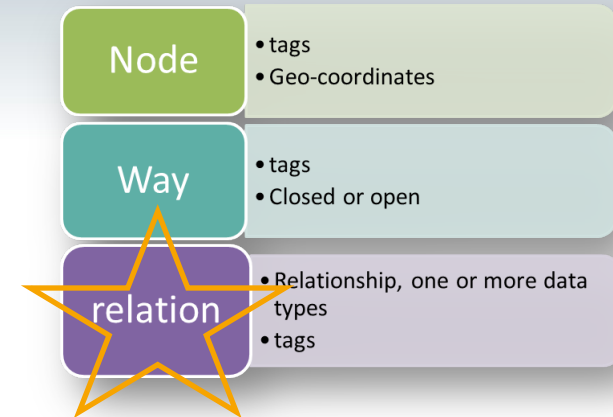
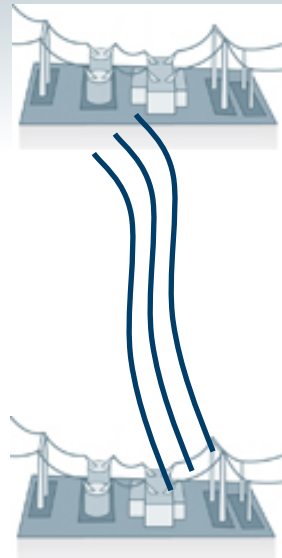
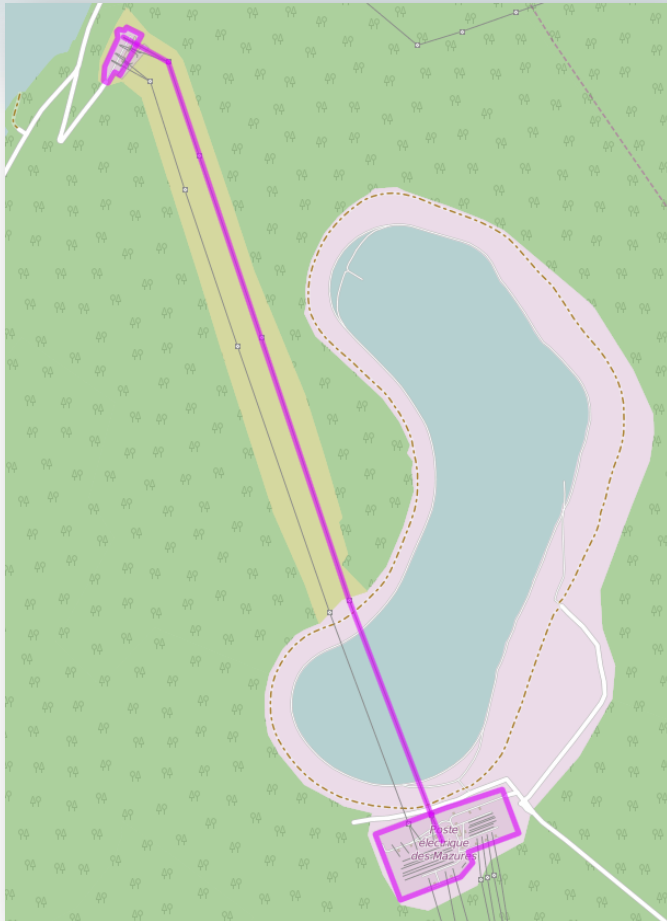


Source: Pitopia / Pehuka, 2013



Source: www.wikipedia.org

OSM Data Structure: Power Relations



```
{
  "type": "relation",
  "id": 5973960,
  "members": [
    {
      "type": "way",
      "ref": 397641668,
      "role": "substation"
    },
    {
      "type": "way",
      "ref": 397641748,
      "role": "line"
    },
    {
      "type": "way",
      "ref": 82949222,
      "role": "line"
    }
  ],
  "tags": {
    "frequency": "50",
    "operator": "RTE",
    "route": "power",
    "type": "route",
    "voltage": "400000"
  }
}
```

SciGRID: Model Derivation



Building the Topological Network

Download planet-latest.osm.pbf (27GB)

Filtering for power data
Osmosis (3-4h, ca. 100MB)

Data Export to database
osm2pgsql (DE, <2min, ca. 500 MB)

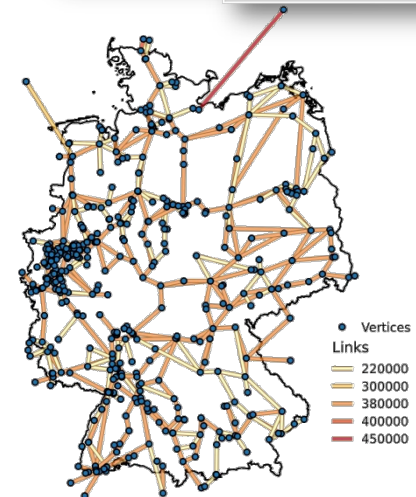
Abstraction to
the Topological Network
python & SQL
(<2min)

Data
Viz.

vertices and links tables, network plots



ID	serial	height	voltage	cables	wires	frequency	length	test
1	1	2	220000	3	2	50	43379	
2	3	4	380000	6	4	50	73686	
3	3	5	6	220000				
4	4	7	5	380000	3			
5	5	8	9	380000	4			
6	6	10	11	220000	3			
7	7	11	12	220000	3			
8	8	10	12	220000	3			
9	9	13	14	220000	6			
10	10	13	15	380000	3			
11	11	16	5	380000	3			
12	12	17	18	380000	3			
13	13	17	12	380000	3			
14	14	13	15	380000	3			
15	15	14	15	220000	10			
16	16	13	19	220000	6			
17	17	20	21	380000	3			
18	18	20	22	380000	3			
19	19	20	23	220000	16			
20	20	23	24	220000	6			
21	21	25	26	380000	6			
22	22	25	22	380000	6			
23	23	27	28	220000	6			
24	24	27	23	220000	6			
25	25	8	21	380000	6			
26	26	9	29	380000	6			



SciGRID Network Data

list of the transmission network vertices and links:

	v_id [PK] bigint	lon double precision	lat double precision	typ text	voltage text	geom geometry
1	1	9.52257596986262	52.3604090557601	substation	220000	0101000020
2	2	9.11321007472722	52.5438533223737	substation	220000	0101000020
3	3	9.38974509624863	52.0263130660355	substation	380000	0101000020
4	4	9.12526485228443	52.5382642243437	substation	380000	0101000020
5	5	10.3662749375017	52.2846467462009	substation	380000	0101000020
6	6	9.91814864613865	52.3799963125719	substation	220000	0101000020
7	7	9.91720008106816	52.2781708137689	substation	380000	0101000020
8	8	10.4149923381504	53.4126068830249	substation	380000	0101000020
9	9	10.3787705903765	53.2197927685849	substation	380000	0101000020
10	10	12.9416466019288	52.3604090557601	substation	380000	0101000020

	l_id [PK] serial	v_id_1 bigint	v_id_2 bigint	voltage integer	cables integer	wires integer	frequency text	length_m integer	r double precision	x double precision	c double precision	l_th_max double precision	geom geometry
1	1	1	2	220000	3	2	50	43379	1.73516	13.88128	498.8585	112.7854	01020000
2	2	3	4	380000	6	4	50	72686	0.22714	18.1715	995.7982	1511.8688	01020000
3	3	5	6	220000	6	2	50	33943	0.67886	10.86176	390.3445	176.5036	01020000
4	4	7	5	380000	3	4	50	33471	0.20919	8.36775	458.5527	348.0984	01020000
5	5	8	9	380000	6	4	50	28163	0.08800	7.04075	385.8331	585.7904	01020000
6	6	10	11	220000	3	2	50	27565	1.1026	8.8208	316.9975	71.669	01020000
7	7	11	12	220000	3	2	50	45809	1.83236	14.65888	526.8035	119.1034	01020000
8	8	10	12	220000	3	2	50	68390	2.7356	21.8848	786.485	177.814	01020000
9	9	13	14	220000	6	2		39497	0.78994	12.63904	454.2155	205.3844	01020000
10	10	13	15	380000	3	2		44323	0.55403	11.08075	607.2251	230.4796	01020000
11	11	16	5	380000	3	4	50	36253	0.22658	9.06325	496.6661	377.0312	01020000
12	12	17	18	380000	3	3	50	200291	1.66909	50.07275	2743.9867	1562.2698	01020000
13	13	17	12	380000	3	3	50	24268	0.20223	6.067	332.4716	189.2904	01020000
14	14	13	15	380000	3	2		44371	0.55463	11.09275	607.8827	230.7292	01020000

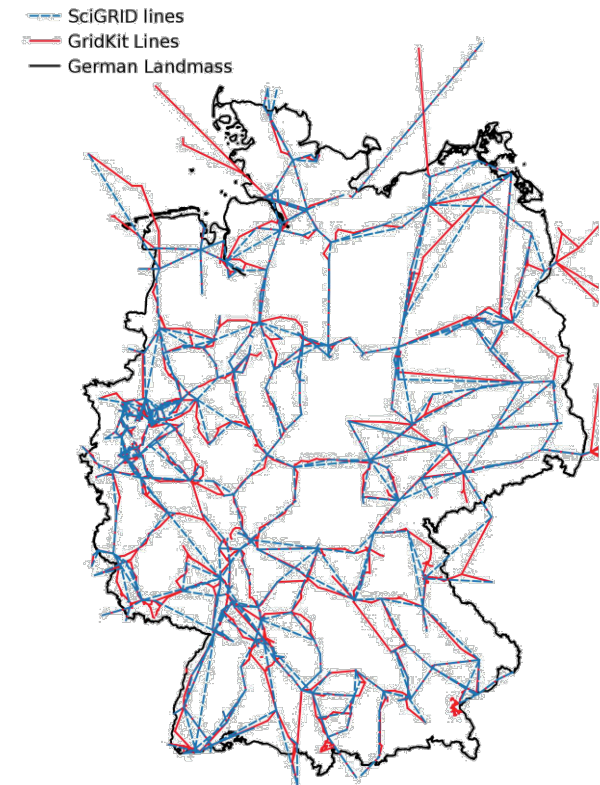
Milestones and Progress

- | Project webpage: www.scigrid.de, mailing-lists
- | First SciGRID workshop 20.04.2015
- | First release 15.06.2015
- | Second release 20.11.2016
- | Heuristic version GridKit release 11.03.2016
- | Converter tool to PyPower
- | Scientific communications (poster, paper, presentations)

- | **Third release mid July 2016**
- | **Comparison & validation**
- | **Scientific conference 30.-31. March 2017**

GridKit Extension of SciGRID

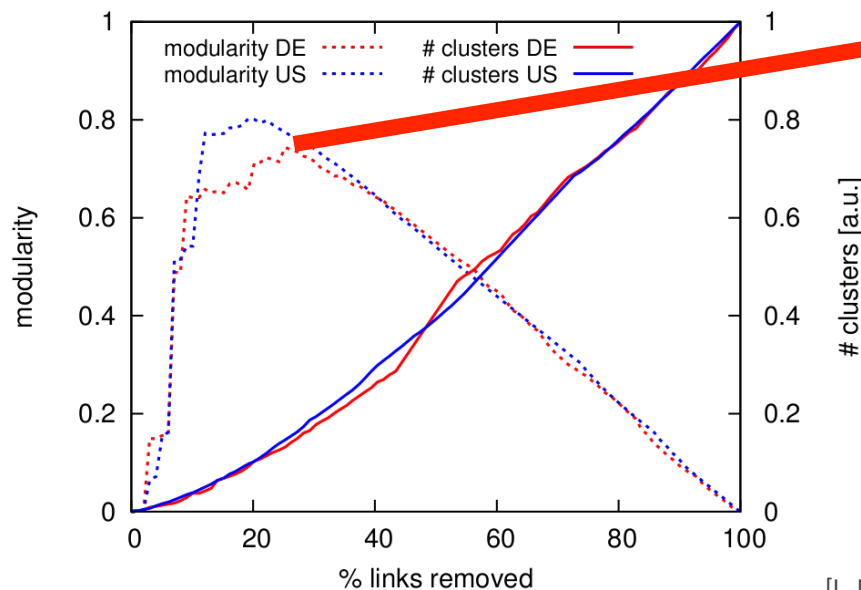
- Developed in the context of the SciGRID project
- GridKit uses spatial and topological analysis
- Implemented as a series of SQL scripts
- Uses heuristic analysis



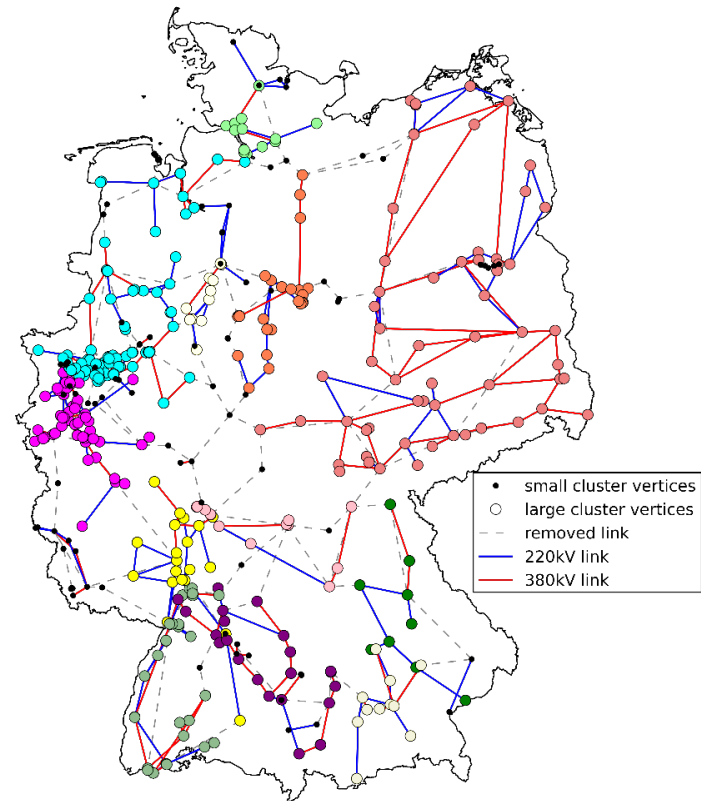
[B Wiegmanns, 2016, Master Thesis]

Cluster Analysis and Decomposition

- Evaluation of „betweenness centrality“
- Successive removal of most prominent links
- Universal „small world“ property:



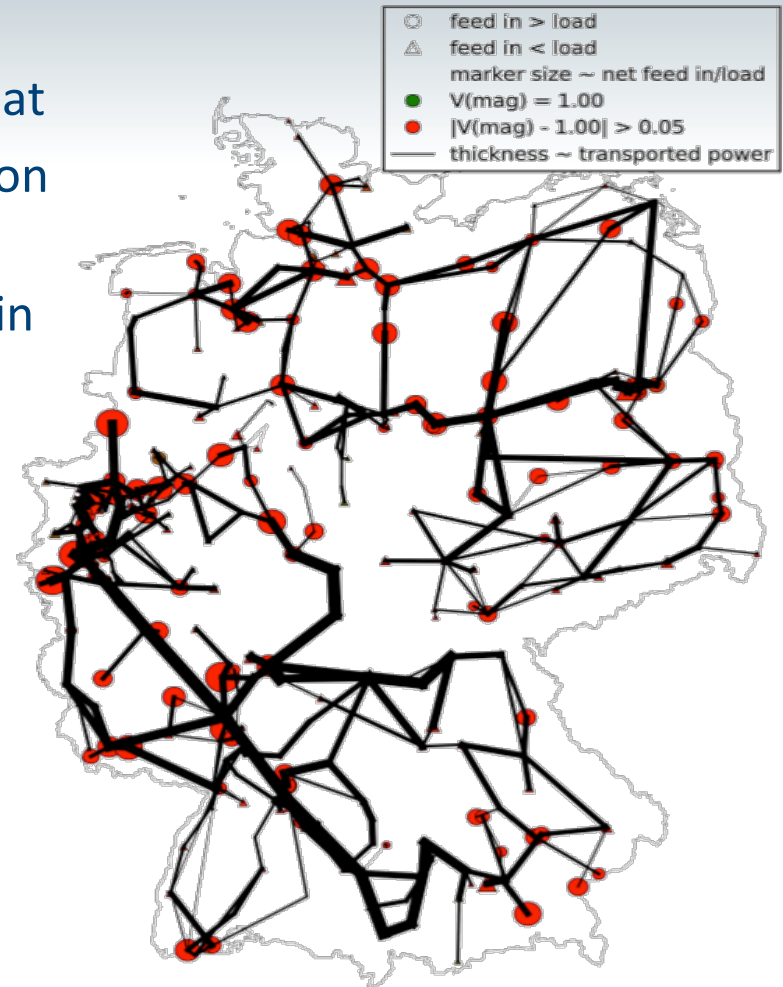
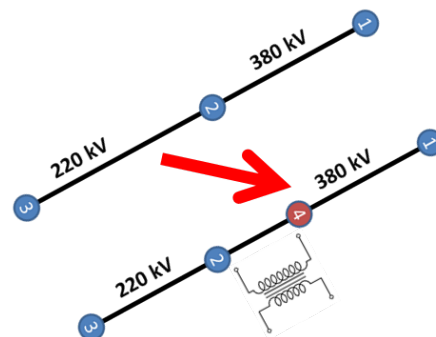
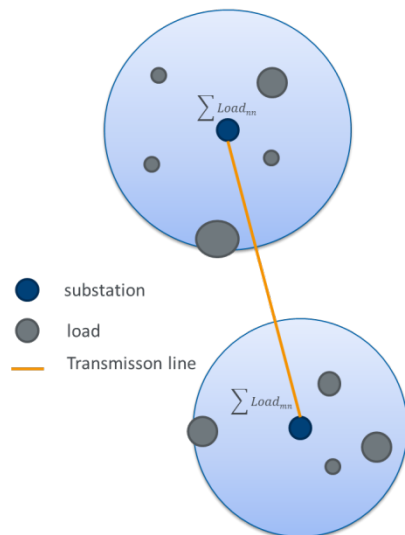
Resulting clustered network:



[L. Matke et al., submitted to Advances in Energy System Optimization, available on request]

Power Flow Simulations

- Export of SciGRID data to pypower format
- Derivation of data for power consumption and generation
- Power flow simulations on sub-clusters in Germany



[S Schroedter, 2016, Master Thesis]

Summary

- | New challenges for the energy sector due to increasing share of RES
- | Energy modeling and analysis are necessary
- | Increasing importance of modeling transmission networks
- | Models and data of transmission networks needed **BUT** access to existing data and models is restricted
- | **SciGRID**: based on open data, free, offers new possibilities
- | **GridKit**: heuristics are necessary

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