Research at OFFIS Energie, Oldenburg, Germany

Nicholas A. Brown
Department of Electrical and Computer Engineering

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Overview

- My simulation needs in a nutshell
- How I identified a person doing relevant work
- How I became a Visiting Researcher
- OFFIS Energie, Univ. of Oldenburg
- My research experience there
- Quick visual tour

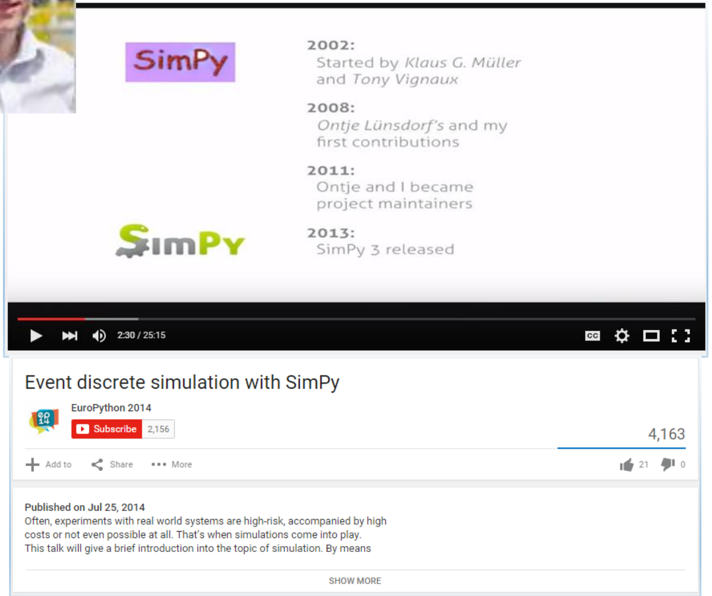
My simulation needs in a nutshell

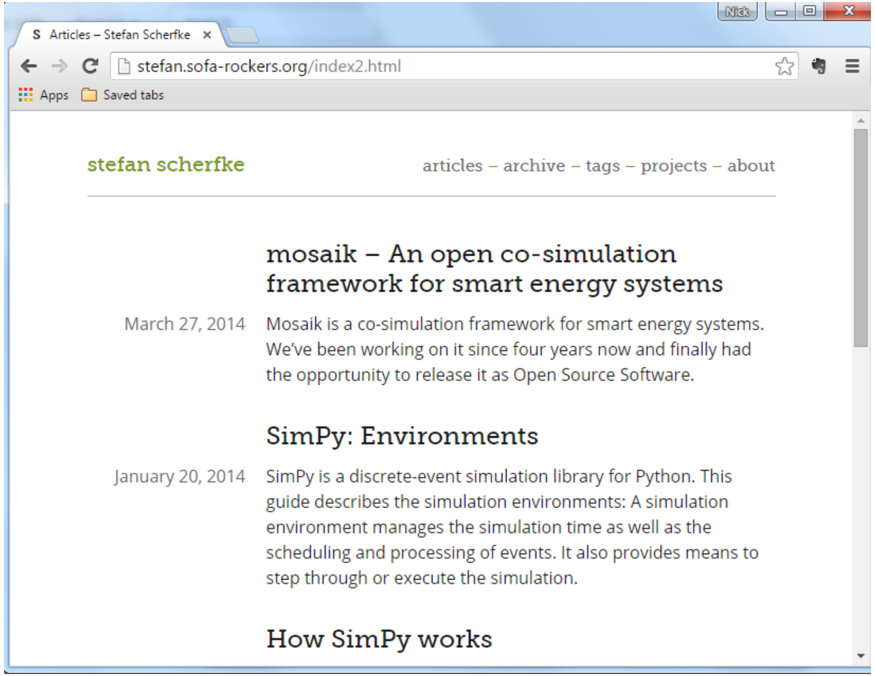
My simulation needs in a nutshell

- Power system models represent high-voltage transmission OR low-voltage grids, not both
- Wanted to address transmission-level needs, given high wind penetration
- Goal: simulate thousands of air conditioners in low-voltage grids responding each day
- Wanted to avoid developing a combined high-voltage/low-voltage model from scratch

How I identified a person doing relevant work

Stefan Scherfke





Searching on "discrete event simulation" -> Video of conference talk on SimPy -> Projects listed on Stefan's homepage

mosaik

- Allows simulations to exchange data
- Stefan Scherfke, S. Schutte were original developers.

SimPy

- Discrete event simulation.
- S. Scherfke developed SimPy 3
- Supports simulations in mosaik

Projects listed on Stefan Scherfke's homepage -> OFFIS -> Contacted Stefan

How I became a Visiting Researcher

Expressed enthusiasm about common and complementary interests

- Overlapping interest in co-simulation
- OFFIS project: distributed **energy** resources
- Me: distributed **demand** resources
- Stefan put me in touch with group manager of Simulation and Automation for Complex Energy Systems, Dr.-Ing. Sebastian Rohjans
- I noted that I had funding

Articulated my research goals and simulation plans

- Wrote proposal with problem statement, modeling approach, assumptions, and data sources.

Contents

Overview of OFFIS Energie and Energy Research at University of Oldenburg

OFFIS Energie

- Associated institute
- Application-oriented
- ~50 software engineers, PhDs, current PhD students
- Jun.-Prof. Lehnhoff oversees two groups
- Dr. Rohjans leads simulation group

Simulation and Automation of Complex Energy Systems

Systems Analysis and Distributed Optimization

Architecture Engineering and Interoperability

Smart Resource Integration

Energy Research in Oldenburg

OFFIS

- Systems-level simulation
- Information and Communication Technology (ICT)
- Smart Grid, Renewables, Markets, Demand-side, EVs

Image: forwind.de

ForWind

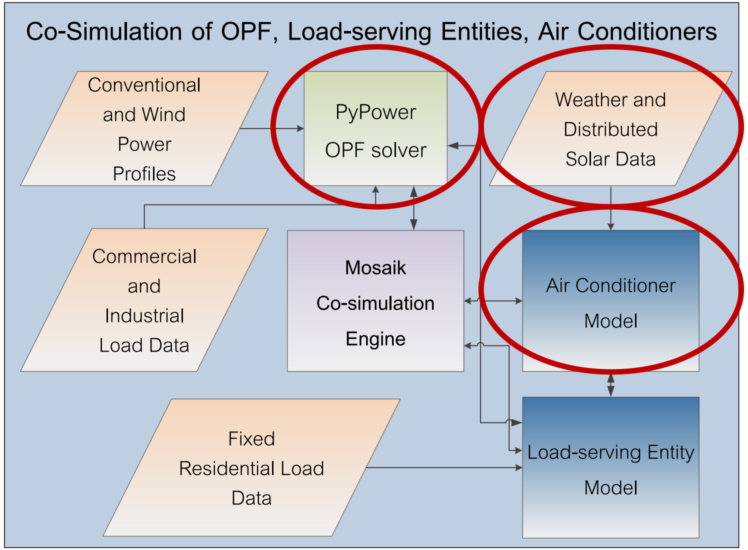
- Aerodynamics, damage detection, power train, structures, numerical simulation, offshore
- Joint center w/ Bremen, Hannover
- Partners: German Aerospace Center, Fraunhofer IWES Nordwest

NextEnergy

- PV, fuel cells, combined heat and power, energy storage
- Founded with EWE

My research experience there

Areas of research



- Item 1: Made high-voltage simulator PyPower run with PV buses and solve for gens' least-cost output
- Item 2: Collected data for air conditioner simulation, system benchmark
- Item 3: Developed equations for air conditioner model entities

Item 1: Made high-voltage simulator minimize cost

Before

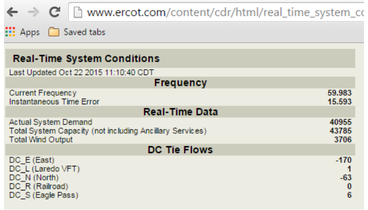
- When using mosaik to run PyPower, PyPower ran power flow for distributed generation
- When using mosaik to run PyPower, mosaik accepted **Excel and JSON text formats as inputs**

After

- When using mosaik to run PyPower, PyPower runs high-voltage **optimal** power flow (**least cost**)
- When using mosaik to run PyPower, mosaik accepts **Excel, JSON and standard PyPower case format**

Item 2: Web-scraped public power system (ERCOT) and weather through automation

- Benchmarking: Total ERCOT demand, system capacity, total wind (every 5 mins.)
- Benchmarking: Online generation capacity, controllable load (every 5 mins.)
- Input to air conditioner simulation by Texas region: temp., wind, cloud cover (hourly)



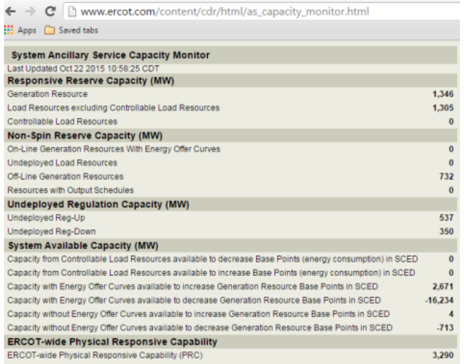
www.ercot.com/content/cdr/html/real_time_system_co
Apps Saved tabs

Real-Time System Conditions

Last Updated Oct 22 2015 11:10:40 CDT

Frequency	
Current Frequency	59.983
Instantaneous Time Error	15.593
Real-Time Data	
Actual System Demand	40955
Total System Capacity (not including Ancillary Services)	43785
Total Wind Output	3706
DC Tie Flows	
DC_E (East)	-170
DC_L (Laredo VFT)	1
DC_N (North)	-63
DC_R (Railroad)	0
DC_S (Eagle Pass)	6

Energy



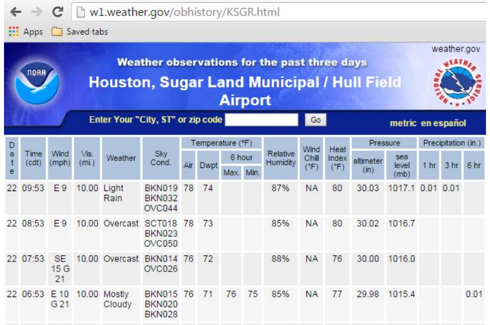
www.ercot.com/content/cdr/html/as_capacity_monitor.html
Apps Saved tabs

System Ancillary Service Capacity Monitor

Last Updated Oct 22 2015 10:58:25 CDT

Responsive Reserve Capacity (MW)	
Generation Resource	1,346
Load Resources excluding Controllable Load Resources	1,305
Controllable Load Resources	0
Non-Spin Reserve Capacity (MW)	
On-Line Generation Resources With Energy Offer Curves	0
Undeployed Load Resources	0
Off-Line Generation Resources	732
Resources with Output Schedules	0
Undeployed Regulation Capacity (MW)	
Undeployed Reg-Up	537
Undeployed Reg-Down	350
System Available Capacity (MW)	
Capacity from Controllable Load Resources available to decrease Base Points (energy consumption) in SCED	0
Capacity from Controllable Load Resources available to increase Base Points (energy consumption) in SCED	0
Capacity with Energy Offer Curves available to increase Generation Resource Base Points in SCED	2,671
Capacity with Energy Offer Curves available to decrease Generation Resource Base Points in SCED	-16,234
Capacity without Energy Offer Curves available to increase Generation Resource Base Points in SCED	4
Capacity without Energy Offer Curves available to decrease Generation Resource Base Points in SCED	-713
ERCOT-wide Physical Responsive Capability	
ERCOT-wide Physical Responsive Capability (PRC)	3,290

Reserves



w1.weather.gov/obhistory/KSGR.html
Apps Saved tabs
weather.gov
Weather observations for the past three days
Houston, Sugar Land Municipal / Hull Field Airport
Enter Your "City, ST" or zip code Go
metric en español

Date	Time (cdt)	Wind (mph)	Vis. (mi.)	Weather	Sky Cond.	Temperature (°F) Air	Dwpt	6 hour Max.	6 hour Min.	Relative Humidity	Wind Chill (°F)	Heat Index (°F)	Pressure altimeter (in)	sea level (mb)	Precipitation (in.) 1 hr	3 hr	6 hr
22	09:53	E 9	10.00	Light Rain	BKN019 BKN032 OVC044	78	74			87%	NA	80	30.03	1017.1	0.01	0.01	
22	08:53	E 9	10.00	Overcast	SCT018 BKN023 OVC050	78	73			85%	NA	80	30.02	1016.7			
22	07:53	SE 15 G 21	10.00	Overcast	BKN014 OVC026	76	72			88%	NA	76	30.00	1016.0			
22	06:53	E 10 G 21	10.00	Mostly Cloudy	BKN015 BKN020 BKN028	76	71	76	75	85%	NA	77	29.98	1015.4			0.01

Weather

Item 3: Derived temperature equation for air conditioner model entities

- Temperature as a function of time

The following functions have been derived, beginning with a solution to the differential equation 13 from Ihara and Schweppe.

τ Thermal constant for building
T_f Ambient (outdoor) temperature
w Air conditioner on (1), off (0)
Tg Heat gain for air conditioner (< 0)

$$\frac{dT}{dt} = -\frac{1}{\tau}(T - T_f - wT_g)$$

Solution:

$$T(t) = T_f + wT_g + \frac{T(0) - T_f - wT_g}{\exp\left(\frac{t}{\tau}\right)}$$

Item 3: Derived cycle duration equation for air conditioner model entities

- Time as function of starting, ending temperatures

The derivation begins with the formula for $T(t)$ previously derived. The constant c is again based on $T(0) - T_f - T_g$.

T_{end} is the ending temperature and represents $T(t)$, while t is the duration of temperature change.

$$T_{end} = T_f + wT_g + \frac{c}{\exp(\frac{t}{\tau})}$$

Solution:

$$t = \tau \, ln \left(\frac{T(0) - T_f - wT_g}{T_{end} - T_f - wT_g} \right)$$

Ongoing discussion and support

Quick visual tour

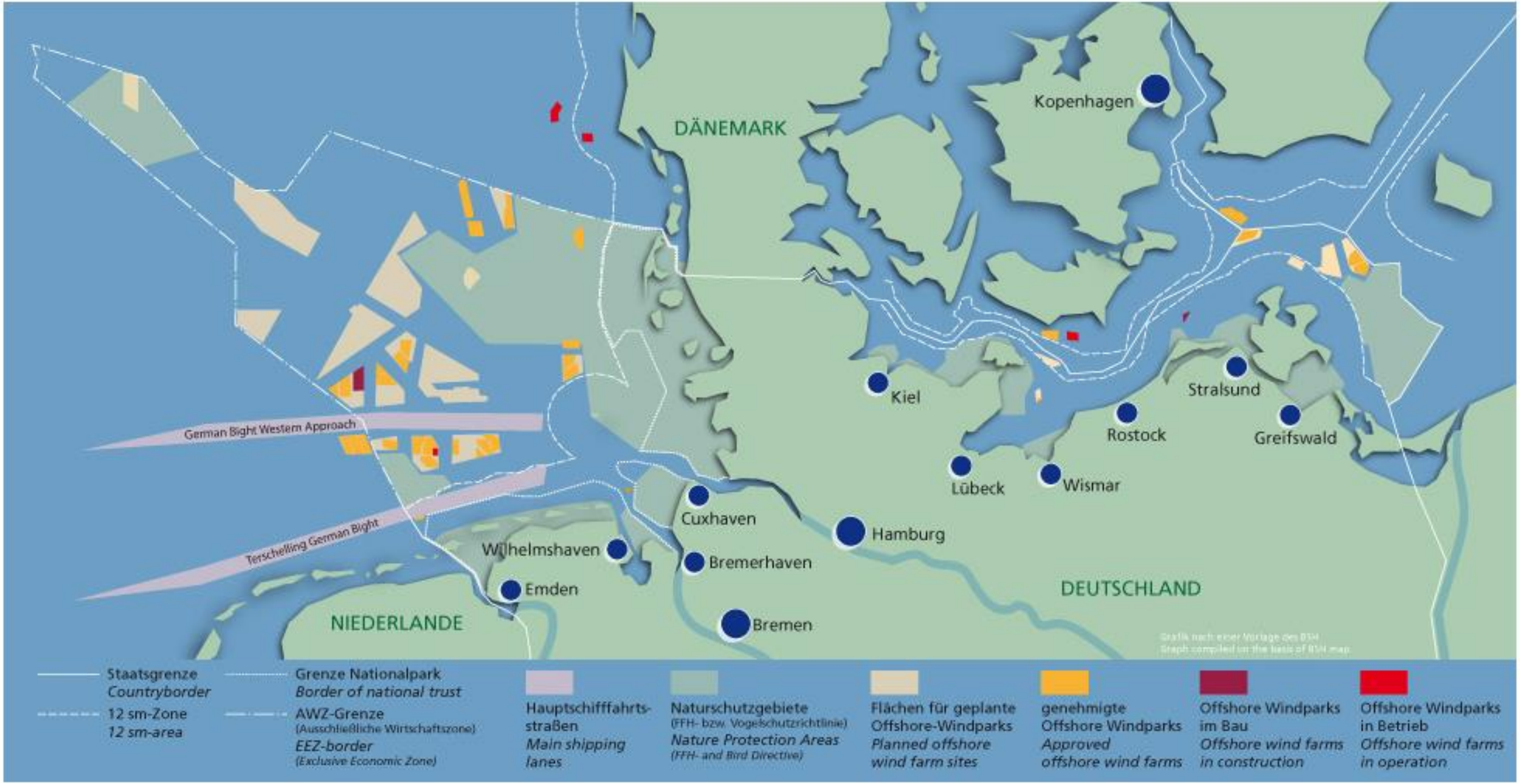
Next to Campus Haarentor

Wheels


Campus Wechloy
Carl von Ossietzky Universität Oldenburg


Lüneburg


Panasonic
RENATA
Hinweise laut BattG
Pb
Vorsicht
Stufe
FUTURE
XCell
Bitte kein
Fahrrad anstellen
Bitte keine Fahrräder
vor dem Schaufenster
abstellen!!!
BATTERIE-CENTER



DÄNEMARK
Kopenhagen
German Bight Western Approach
Terschelling German Bight
Kiel
Stralsund
Rostock
Greifswald
Lübeck
Wismar
Cuxhaven
Hamburg
Wilhelmshaven
Bremerhaven
Emden
DEUTSCHLAND
NIEDERLANDE
Bremen
Grafik nach einer Vorlage des BSH
Graph compiled on the basis of BSH map
Staatsgrenze
Countryborder
12 sm-Zone
12 sm-area
Grenze Nationalpark
Border of national trust
AWZ-Grenze
(Ausschließliche Wirtschaftszone)
EEZ-border
(Exclusive Economic Zone)
Hauptschifffahrts-straßen
Main shipping lanes
Naturschutzgebiete
(FFH- bzw. Vogelschutzrichtlinie)
Nature Protection Areas
(FFH- and Bird Directive)
Flächen für geplante Offshore-Windparks
Planned offshore wind farm sites
genehmigte Offshore Windparks
Approved offshore wind farms
Offshore Windparks im Bau
Offshore wind farms in construction
Offshore Windparks in Betrieb
Offshore wind farms in operation


Danke (thank you)!