GLOBAL PST CONSORTIUM

Open-Source Tools for System Operators – Focus on Power Flow Tools

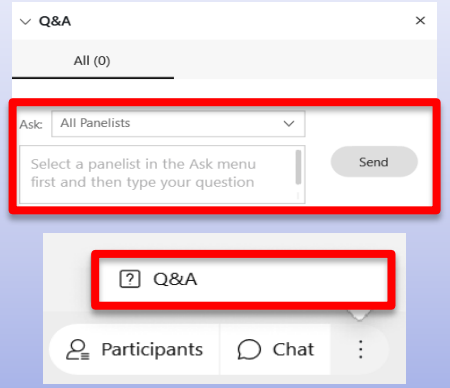
G-PST Consortium Pillar 5

May 27, 2021

Housekeeping & WebEx Tips

During the presentation(s):

- **If you have a question:**
  - **Type it in the Q&A box**
  - **They will be addressed during our Q&A session at the end.**
- **This webinar is being recorded and will be available on the G-PST website.**



Change layout:

- Grid – All videos shown
- Stage – Speaker highlighted, other videos below
- Focus – Only speaker video shown

Audio Issues?

- Check audio outputs and volumes
- If listening by computer, try dialing in by phone
- If listening by phone, try using computer audio

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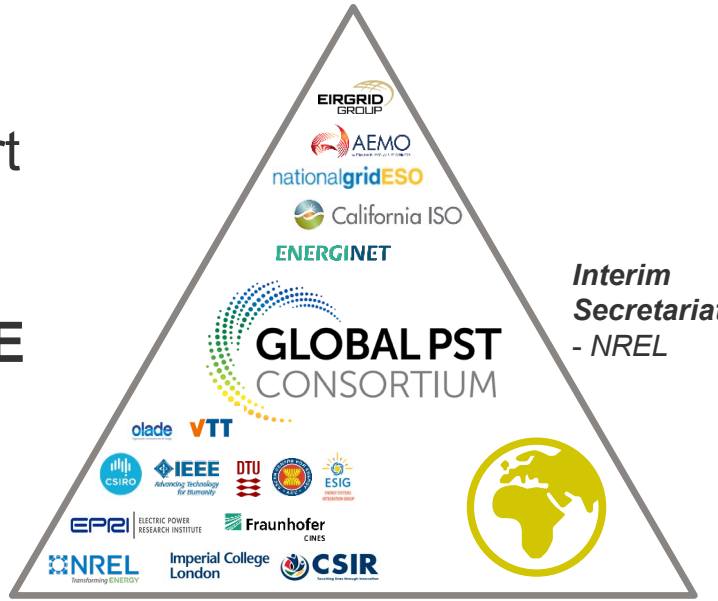
Global Power System Transformation (G-PST) Consortium

What?

A new global **Consortium** focused on support to **power system operators with advanced high RE & other low-emission solutions**

Who?

Founding System Operators



Interim Secretariat *- NREL*

G-PST Core Team Technical Institutes

Developing Country System Operators - *Confirmed partners - Indonesia, Vietnam, India, South Africa, and Peru*

How?

5 Pillars

1. System Operator Research and Peer Learning
2. System Operator Technical Assistance
3. Workforce Development
4. Localized Technology Adoption Support
5. Open Tools and Data

How You Can Engage

- Join our network to receive webinar invitations, our newsletter and other important updates - https://globalpst.org/get-involved/.

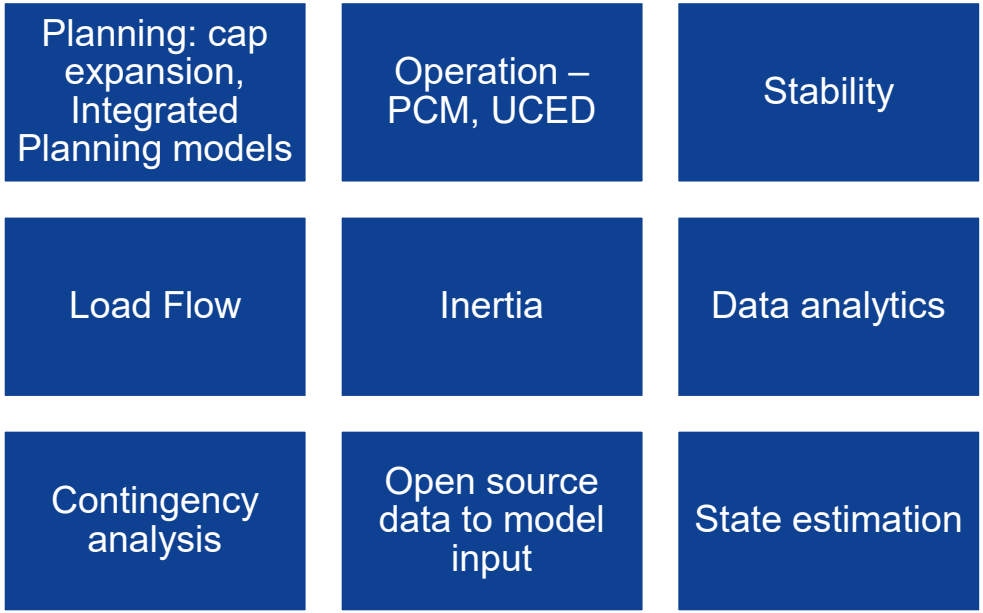
- Engage in our regional peer learning networks and/or pillar groups – submit interest in particular pillars through the website - https://globalpst.org/get-involved/

- Reach out to explore remote light touch technical assistance or with any questions at: **globalpst@nrel.gov**

Pillar 5 Introduction

How to find a useful tool for a specific problem

- High VRE shares call for new capabilities in analysis tools
- Tools are needed both for learning and for analysis
- New tools need to demonstrate capability and they require validation, benchmarking, as well as support



Pillar 5 Open Source Tools & Data - Vision

Portal

- Access to useful tools, for each modelling issue: starting with power flow, inertia, and stability
- Description on the strengths and weaknesses/applicability

Interface

- Model/tool integration (data and workflow management)
- Easy-to-use simple tools (with learning focus) and High fidelity tools (for advanced uses) with same datasets and enabling model linkage

Improvement

- Leverage partner engagements to make tools more accessible and applicable
- From offline, analytical use towards real-time tools

Why open-source?

Advantages:

- Transparency
- Free
- Available source code for customization/extension
- Minimizes duplicate efforts
- Community oriented
- Focus on research

Disadvantages:

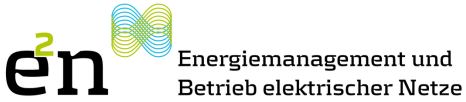
- Maintenance burden
- Ambiguous revenue/funding
- IP protection
- Focus on research

Common concerns:

- Support
- Security
- Validation

pandapower

pandapower



Useful links

Official website:
http://www.pandapower.org/
GitHub repository:
https://github.com/e2nIEE/pandapower
Documentation:
https://pandapower.readthedocs.io

Background: Python ecosystem

- Python is an open-source general purpose interpreted programming language
- Most popular programming language with a large community that provides thousands of packages
- Python supports data analysis and visualization, extensibility, automation and parallelization of workflows

Background: Python ecosystem

Benefits of Python for pandapower:

- Power system analysis can be part of a larger workflow in the same environment
- Parallelization possibilities
- Access to a wide range of libraries to extend standard pandapower capabilities
- Popularity of Python makes it easier to find and hire talent to work with pandapower

Background: pandas

- pandas is an open-source data analysis and manipulation library
- Provides a DataFrame object to store and manipulate tabular data
- Supports different data formats e.g. CSV, Excel, JSON, SQL
- Provides functionality to read, manipulate, visualize and save data

Background: pandas

Benefits of pandas for pandapower:

- Organizing data in a label-based tabular form
- Pre-processing of input data, as well as interpretation and visualization of calculation results
- Familiar to most Python users, which simplifies getting started with pandapower

Background: MATPOWER

- MATPOWER is an open-source package for MATLAB or GNU Octave
- Grid data can be exchanged using the .mat format
- Analysis capabilities:
  - power flow
  - continuation power flow
  - optimal power flow
  - unit commitment

Background: MATPOWER

Implementation gap addressed by pandapower:

- Practical parameters and standard types for elements
- Implementation of switches, 3-winding transformers
- Realistic grid topology
- Control framework
- Open file format
- 3-phase load flow

Why use pandapower?

- Automate workflows for power system analysis
  - Access to thousands of useful packages in Python
- No license limitations on parallelization for extensive calculations
  - Can be scaled on a high-performance computing (HPC) cluster
- Broad user base (over 100k downloads and growing) and productive use at Fraunhofer IEE and University of Kassel
  - Linus's law: "given enough eyeballs, all bugs are shallow"
  - Continuous quality improvement and addition of features by the community, Fraunhofer IEE, and the University of Kassel
- pandapower format allows automated screening of the grid data for irregularities, e.g., errors of data input

Types of devices and circuits that can be modeled with pandapower

Node elements:

- Shunt
- Load (incl. ZIP-load)
- Asymmetric load
- Motor
- Static generator
- Asymmetric static generator
- Synchronous generator
- External grid
- Shunt
- Ward
- Extended ward

Branch elements:

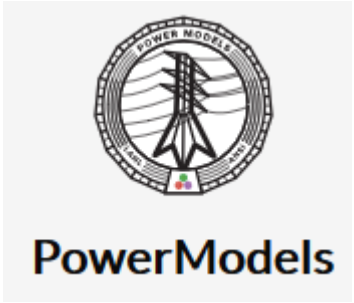
- Switch
- Line
- DC Line
- Impedance
- 2-W transformer
- 3-W transformer

Types of analysis possible using pandapower

- Power Flow
- Optimal Power Flow
- Controller simulation
- Time-series calculation (quasi-static analysis)
- State Estimation
- Short-Circuit Calculation
- Topological Graph Searches
- A customized analysis for a particular purpose

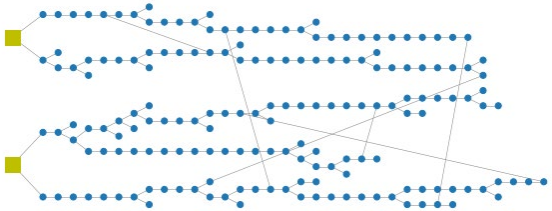
Interfaces with pandapower

- PowerModels.jl
  - Optimal power flow
  - Expansion planning
  - Optimal transmission switching
- pandapipes
  - fluid/gas pipe networks
- MATPOWER converter
- Further interfaces/converters possible by users

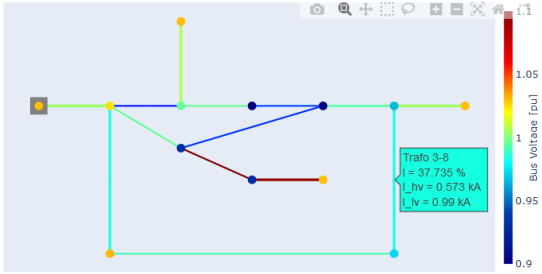


Visualization capabilities

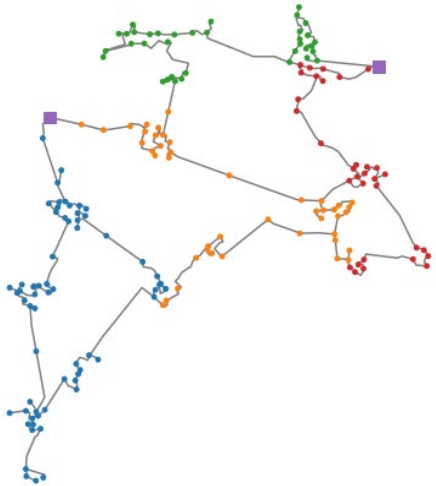
Create schematic coordinates with igraph



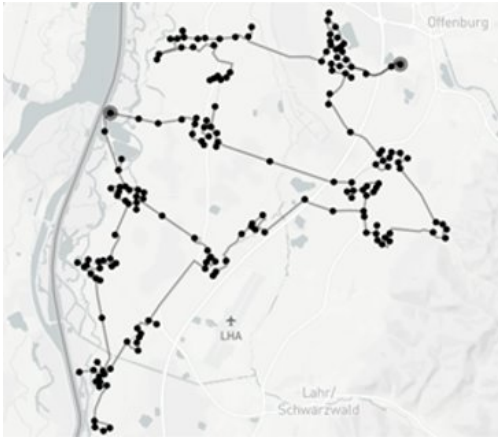
Visualize results with plotly



Identify and highlight topological zones

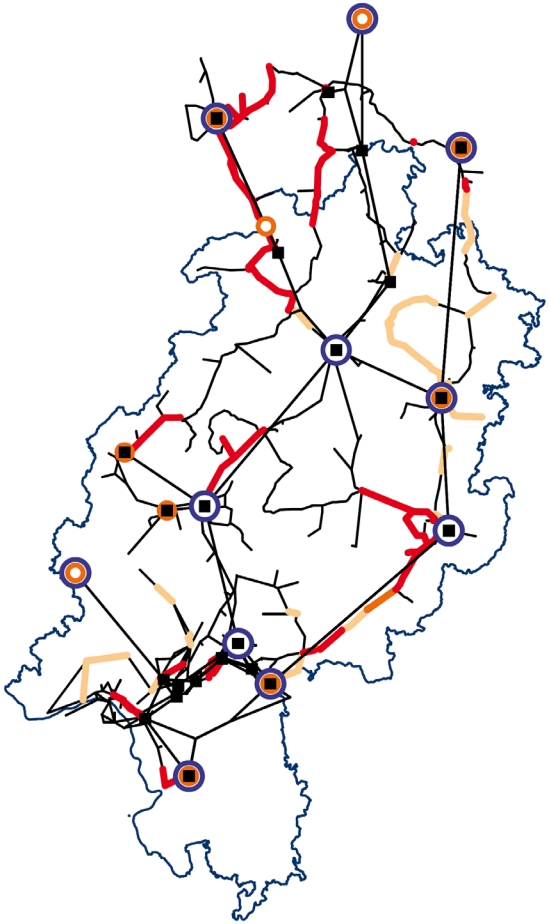


Visualize results with plotly mapbox

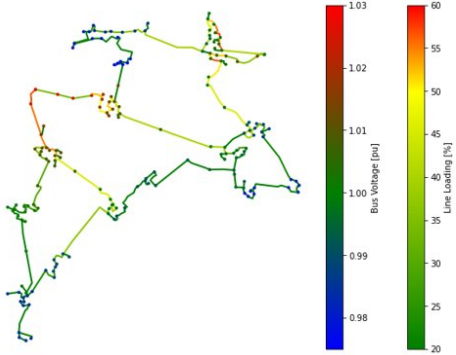


Visualization capabilities

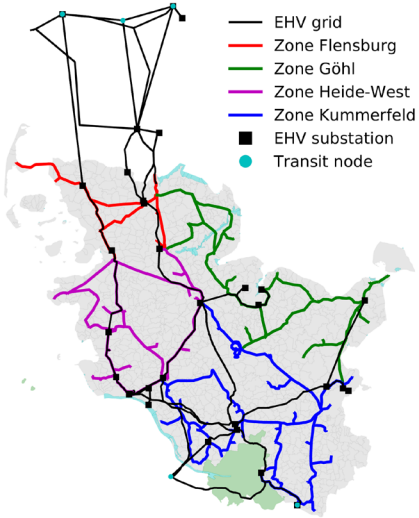
Results of a reinforecement study for HV grids



Visualize results with matplotlib

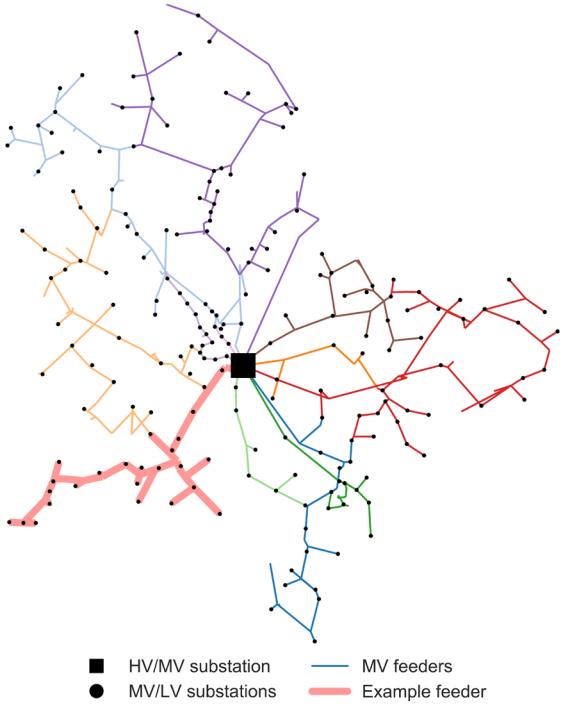


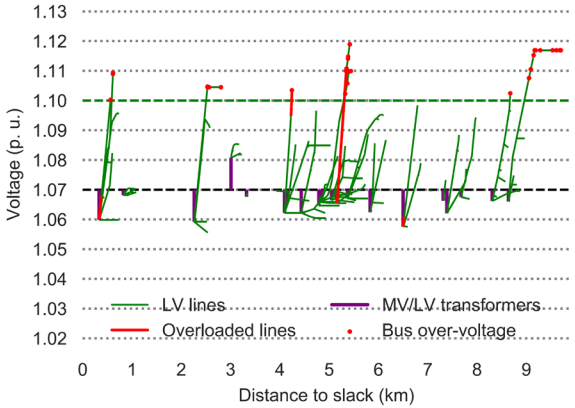
A grid with multiple voltage levels

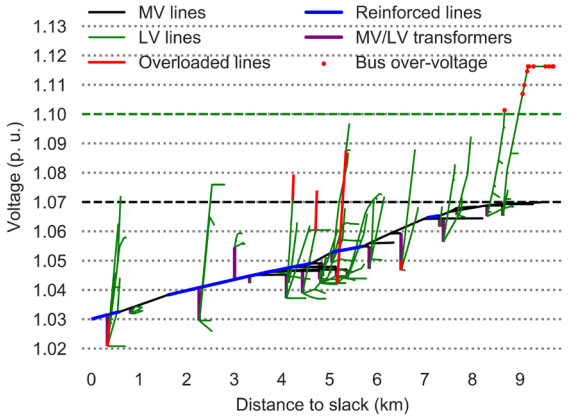


Visualization capabilities

Results of a reinforecement study for HV grids

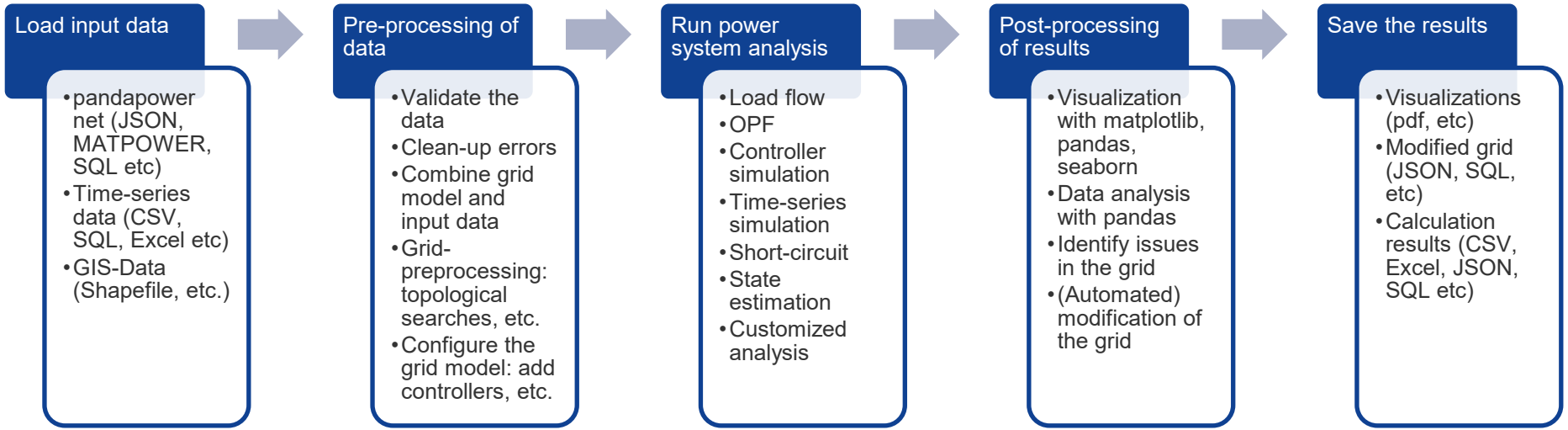




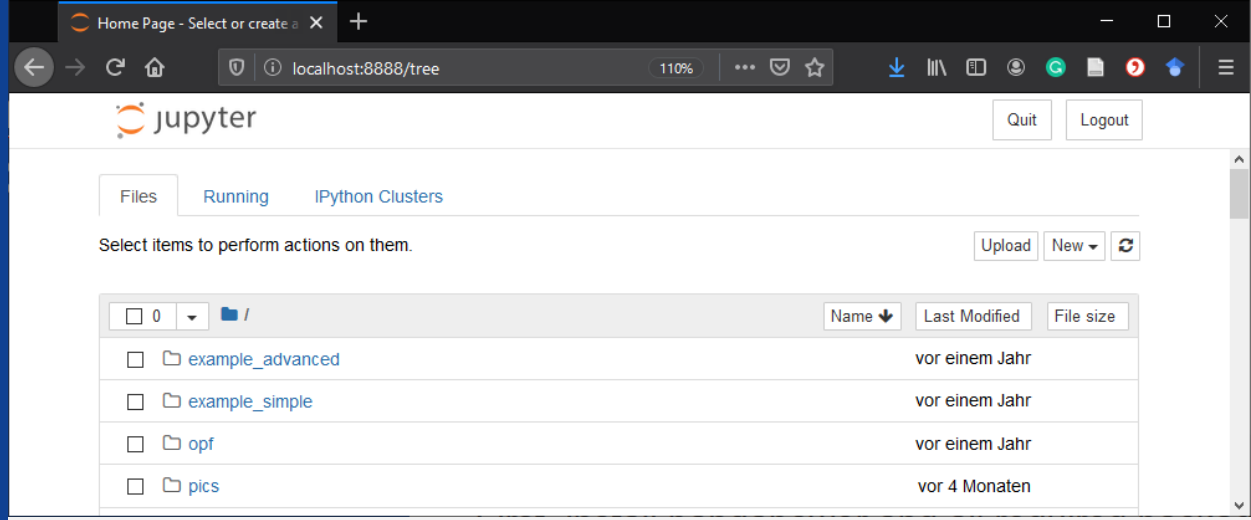


Python – pandapower
Demo

Workflow using pandapower



pandapower tutorials



- We run examples with Jupyter Notebook: jupyter.org
- First, install pandapower and all required packages.
- Start command prompt.
- Navigate to the directory pandapower/tutorials.
- Run the command "jupyter notebook":

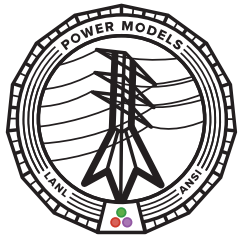
```
C:\>
C:\>cd pandapower\tutorials
C:\pandapower\tutorials>jupyter notebook
```

Next Steps

Please suggest future events!

Possible future webinars to showcase other tools:

- Julia:
  - PowerModels.jl
  - PowerSystems.jl & PowerSimulations.jl



PowerSystems.jl
PowerSimulations.jl

- Python:
  - PyPSA
  - Andes

Q&A

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