SUMMER SCHOOL “ENABLING DRES TO OFFER ANCILLARY SERVICES” 20TH – 24TH SEPTEMBER 2021

Software Tool for Evaluation of AS

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Objectives and KPIs

	Objective	KPI
1	Increase the robustness of the power system to abrupt frequency changes using virtual inertia and damping in DRES	Increase the average overall system inertia by at least 1.5% for every 10% increase in DRES penetration
2	Contribute to the stability of the grid by providing frequency-dependent active power	For every 3 MW of DRES entering the system more than 2.5 MW of conventional reserves will be decommissioned. The rest of 0.5 MW or less will appear as reduction of the power of conventional base load units.
3	Increase the renewable energy penetration levels at both LV and MV level, while avoiding investments for grid reinforcement	The relative increase in DRES with EASY-RES is higher than with conventional approach
4	Make the RES more grid-friendly by i) reducing the short-term electric power fluctuations at both DRES and HV/MV substation level and ii) introducing active harmonics filtering to each DRES converter	i) Power smoothing functionality reduces power fluctuations maxΔP/minute <30% of DRES rated power and maxΔP/minute <10% of HV/MV (MV/LV) transformer rating ii) THD is kept within the limit of EN50160 standard (<8%) even with 100% penetration of DRES
5	Preserve the long-term grid security	The additional DRES penetration due to developed functionality that does not violate existing fault-protection means in MV and LV (symmetrical and non-symmetrical)

Tool idea

- To speed up simulation.
- Enable fast simulation of thousands of scenarios.
- Give an access for easy parameter setting.

- Solution: setting Python with DigSILENT PowerFactory (PF)

Setting up the stage – Python installation

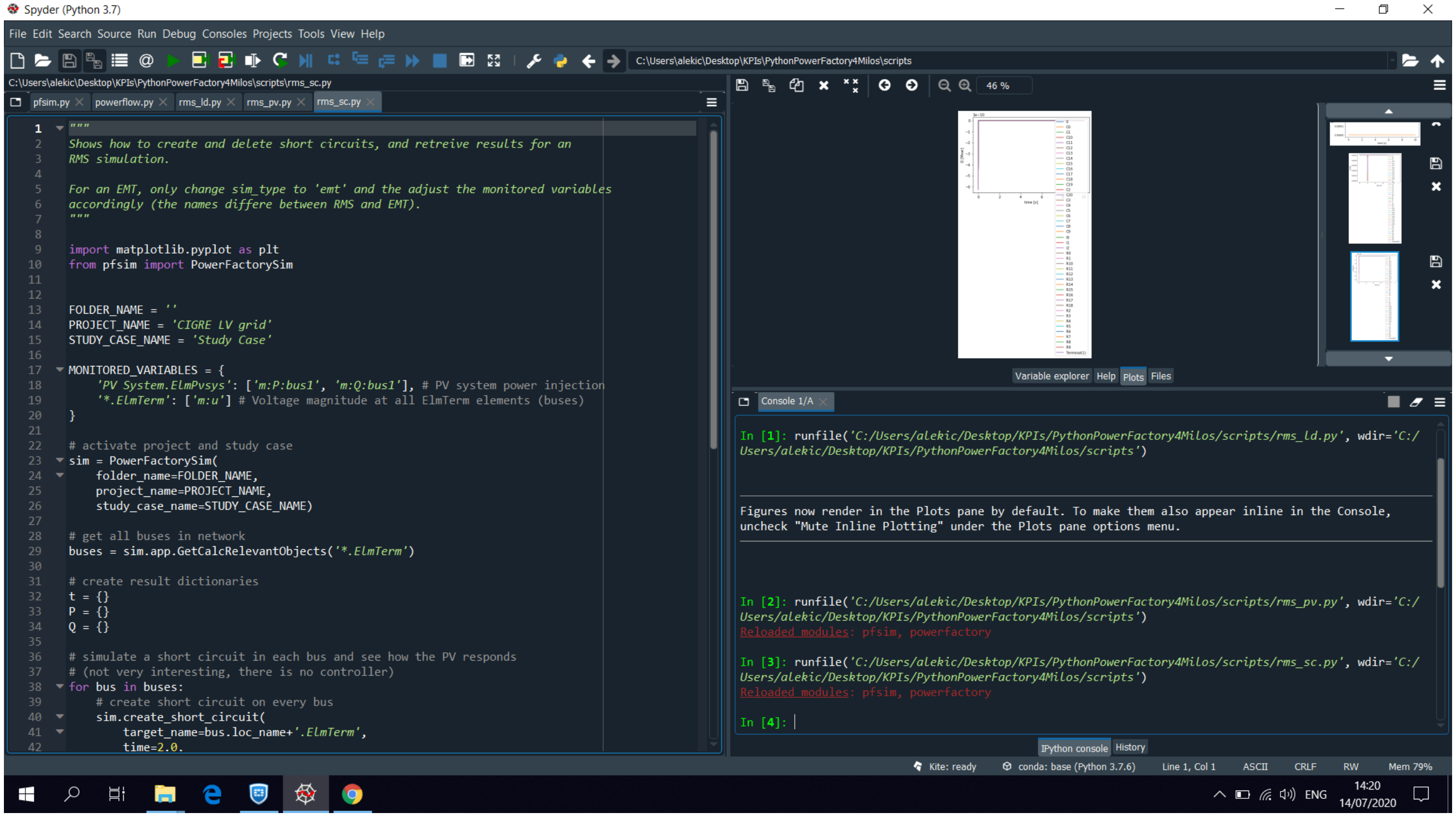
- Anaconda chosen – good GUI named Spyder
- Package installation?
    - Inside Anaconda: open Anaconda prompt

      conda install package-name
    - Python – command line

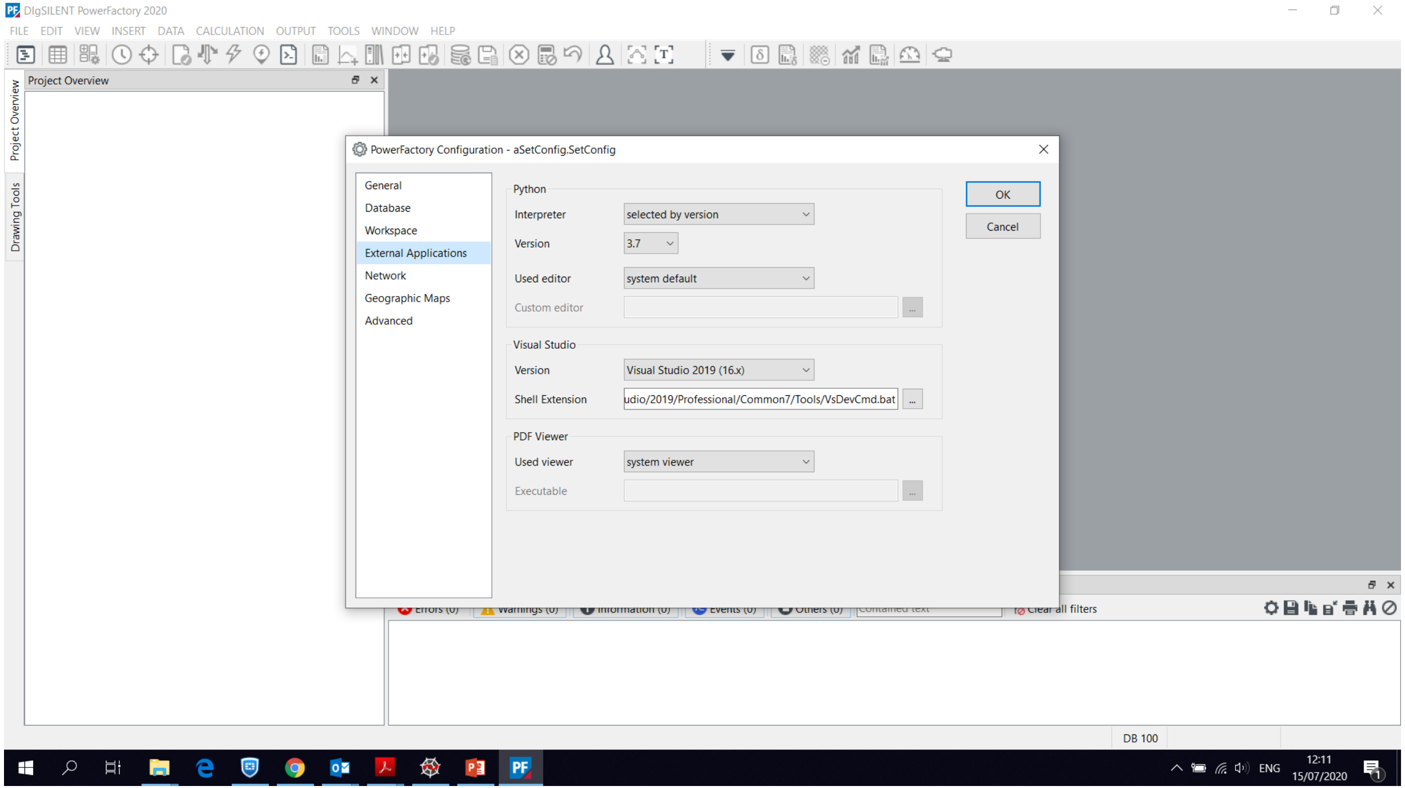
      python -m pip install package_name
    - Python – command line + git

      python -m pip install git+git_location

Setting up the stage – Spyder interface



Setting up the stage – PF interface for Python



Setting up the stage – PF interface Python

- PF supports Python functions for
    - Change of element parameters
    - Setting up simulation properties
    - Performing simulation and saving results

- Disadvantage of PF+Python
    - Insufficient capabilities for creating power system components in PF from Python

      It is possible, but difficult.

- There is PF support in books and tutorials
    - Manual, PowerFactory User. "DIgSILENT Power Factory." (2017).
    - López, Claudio David, and José Luis Rueda Torres. "Python scripting for DIgSILENT PowerFactory: Leveraging the Python API for scenario manipulation and analysis of large datasets." *Advanced Smart Grid Functionalities Based on PowerFactory*. Springer, Cham, 2018. 19-48.

Python class – Methods for reading/setting values

Nodes voltages

- get_bus_voltages(self)

Loads

- get_all_loads_pq(self)
- set_all_loads_pq(self, p_load, q_load)

•Toggle

- toggle_out_of_service(self, elm_name)
- toggle_switches(self, elm_name)

Python class – Methods for creating short circuits and events

- create_short_circuit(self, target_name, time, duration=None, name='sc')
- delete_short_circuit(self, name='sc')

- create_load_event(self, target_name, time, p_change_percent, q_change_percent, name='lodc', type='step', ramp_duration=0.0)
- delete_load_event(self, name='lodc')

Python class – Methods for power flow simulation

- prepare_loadflow(self, ldf_mode='balanced')
  - Sets up power flow mode (balanced or unbalanced) and connects with PowerFactory simulaton.
- run_loadflow(self)
  - Runs power flow.

Example: powerflow.py

Python class – Methods for dynamic simulation

- prepare_dynamic_sim(self, monitored_variables, sim_type='rms', start_time=0.0, step_size=0.01, end_time=10.0)
  - Sets monitored variables and simulation type to rms or emt.

- run_dynamic_sim(self)
  - Runs dynamical simulation (rms or emt).

- get_dynamic_results(self, elm_name, var_name)
  - Getting simulation results.

Python class

It is made as a package and it can be installed using flit!

```
flit install --symlink
```

Task

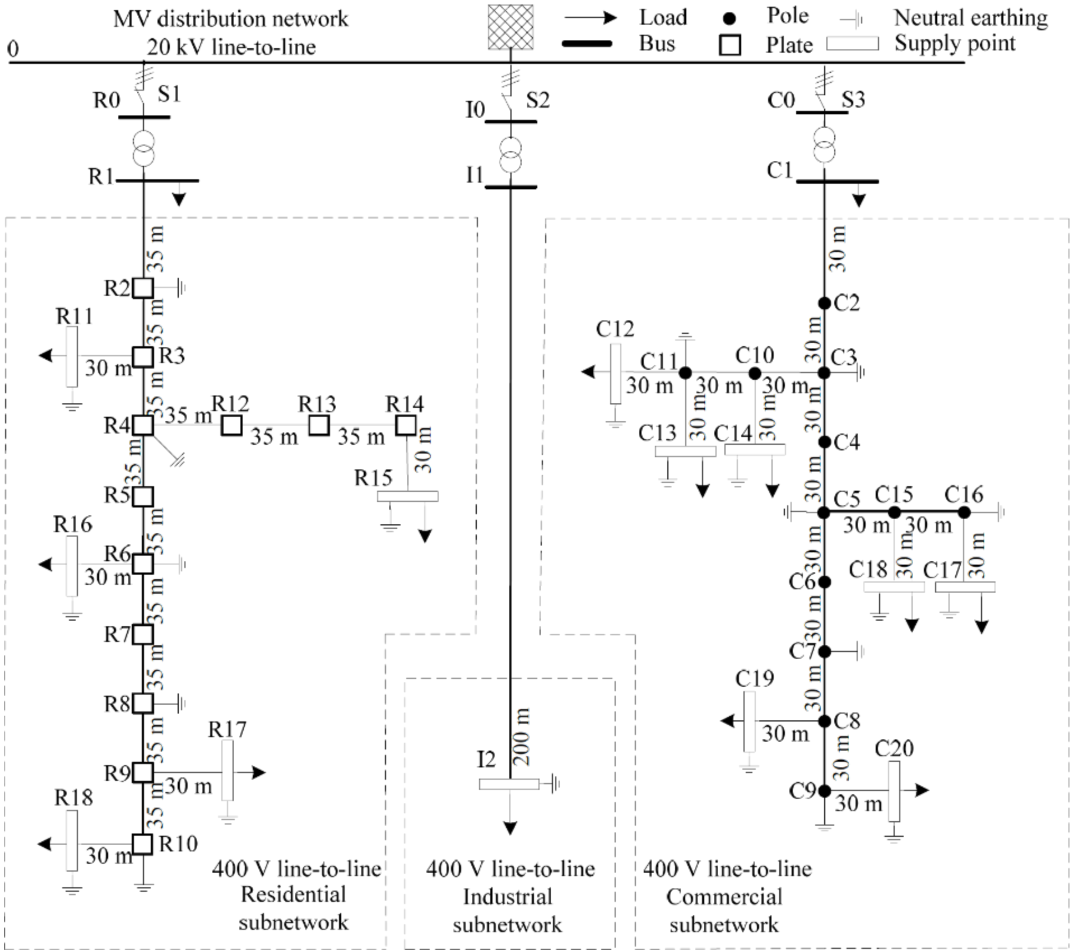
Design a tool for a fast estimation of possible PV penetration

- Enable PV placements on different nodes in distribution grids
- Change active/reactive power of PVs
- Change control of PVs
- Estimate maximum penetration and save results

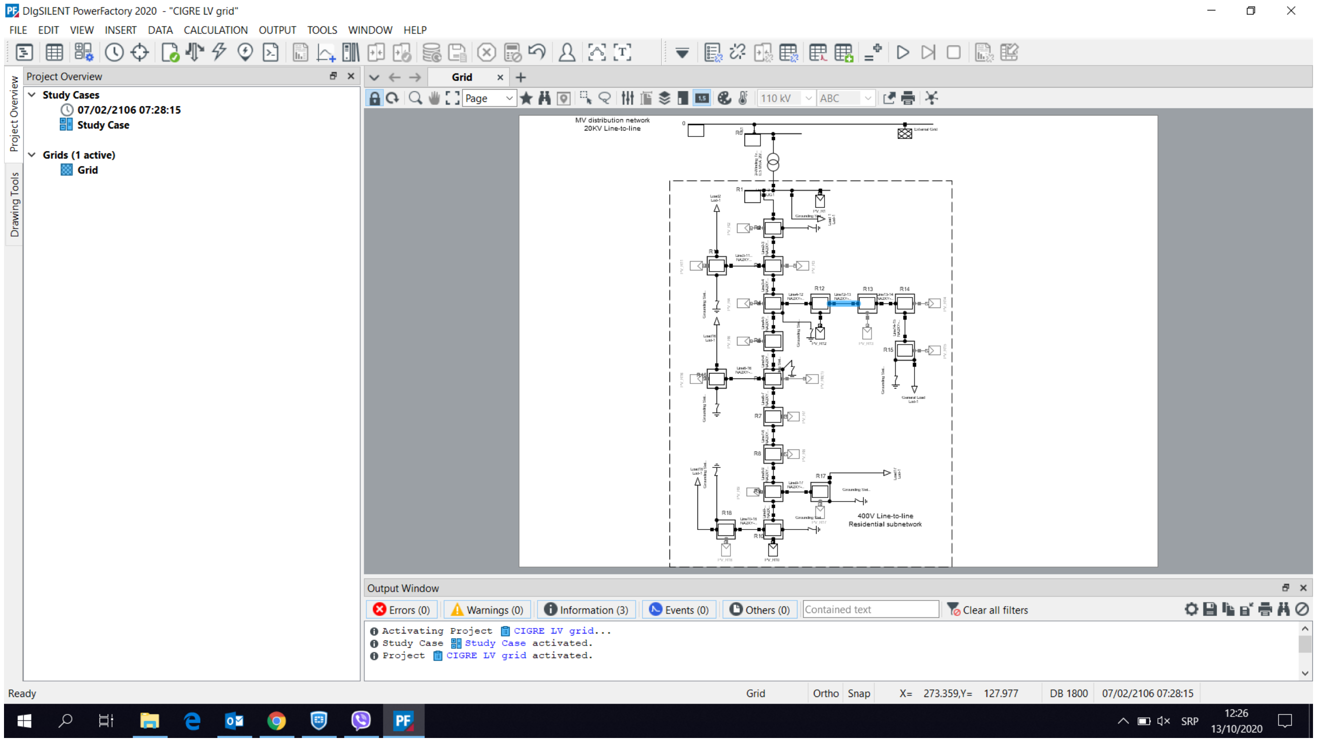
PV placements in the tool – PF

- Create distribution power grid (LV CIGRE on the right) in PF
- Name nodes with numbers
- Create PVs for all nodes in the distribution system and name them *PV_nodenumber.*

Now we can switch to Python!



PV placements in the tool – PF

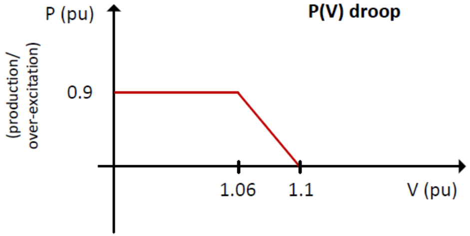


Developed tool in Python
Class in Python properties

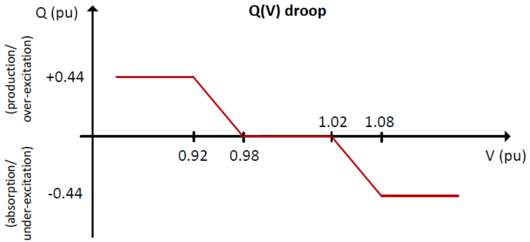
- Functions for intancing – used to start simulation in PF and get an access to PF settings/functions
- Get pointers to buses and the solutions of power flow/RMS/EMT
- Prepare power flow/RMS/EMT simulation settings
- Create and clear faults
- Change properties of PVs
    - Active/inactive
    - Power
    - Control principle

Developed tool in Python
PV penetretation simulation procedure

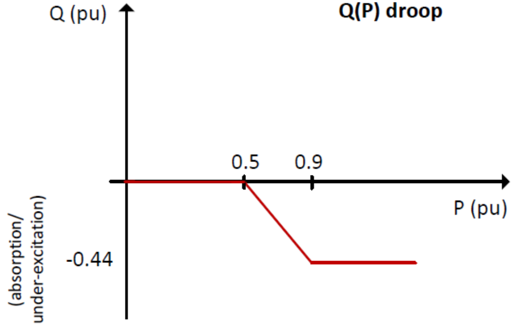
- **Add number of newly installed DRESs equipped with one of the examined voltage control scheme:**
  - P(V) denoted as constq in PF



  - Q(V) is denoted as qvchar control



- cos(ϕ)(P) is denoted as cpchar
- cos(ϕ) = 1 is denoted as constc
- Q(P) is defined using QP curve and desired active power (pgini)

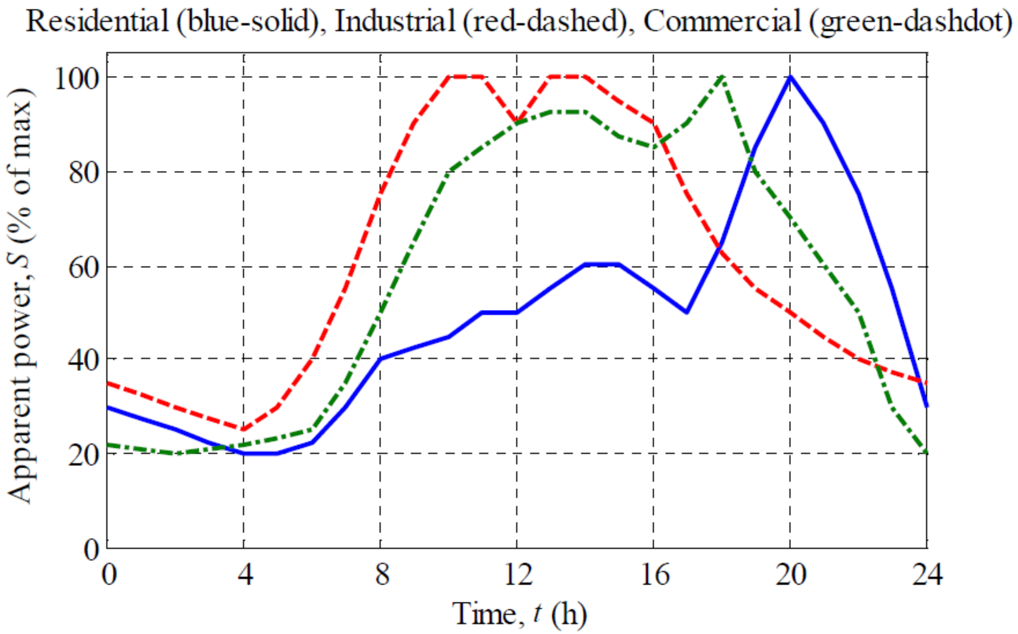


Developed tool in Python
PV penetretation simulation procedure

- Add number of newly installed DRESs (equipped with one of the examined voltage control scheme).
- Randomly select PV location and make it active or inactive.
- Change DRES installed capacity.
- Set voltage type control. It is set using local controller property in PF.
- Statistical analysis of the obtained results:
    - Voltage deviations from the nominal value. It reports voltage violation if for any bus voltage appears to be outside the set [Vmin, Vmax].
    - Load violation in any circuit component.
    - Produce summary of the results.

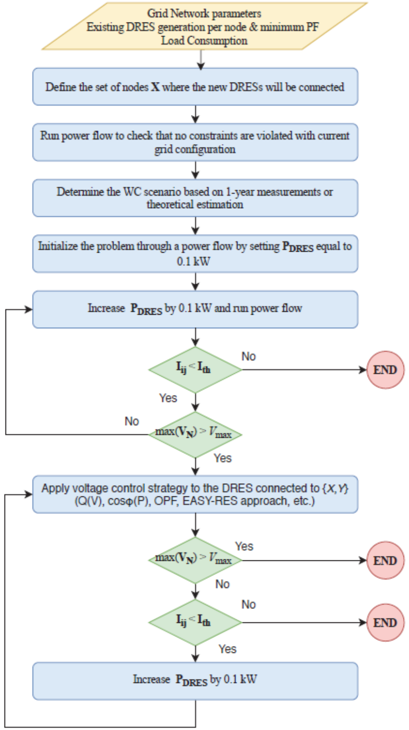
Developed tool in Python
PV penetretation simulation procedure

- Change load profiles to enable daily simulation



Developed tool in Python
PV penetretation simulation procedure

- Enable comparison with Easy-RES static control
  - Selection of P(V) scenario
  - Simulate for one time instance
  - Run simulation for one day



Developed tool in Python
Result interpretation

Results in csv file:

1. Marked bus voltage in p.u.
2. Given DRES power
3. Resulting losses
4. Given external grid power

File named

*“gridtype_*PV*_controltype_X_PVlocations*.csv”

0	1	10	11	12	13	14	15	16	17	18	2	3	4	5	6	7	8	9	DRES power [kW]	Ploss [MW]	External grid power [MW]
1.05	1.020643	0.691813	1.000382	0.72108	0.71829	0.715255	0.712655	0.705576	0.692848	0.689385	1.010841	1.000901	0.723219	0.715784	0.708354	0.704168	0.699583	0.694647	63	0.065986	0.386498776
1.05	1.02266	0.738081	1.004976	0.765205	0.762903	0.760044	0.757594	0.750608	0.739051	0.735802	1.01425	1.005562	0.766901	0.76006	0.753223	0.74944	0.745374	0.740741	72	0.049733	0.361447428
1.05	1.020213	0.677441	1.000213	0.709228	0.706844	0.703761	0.70112	0.692054	0.678497	0.674963	1.010522	1.000342	0.710972	0.702924	0.694883	0.69015	0.685368	0.680332	68	0.07118	0.386577916
1.05	1.02287	0.736123	1.005954	0.763815	0.761508	0.758644	0.75619	0.749068	0.737096	0.733838	1.014843	1.006328	0.765594	0.758639	0.751688	0.747798	0.743435	0.73879	82	0.050237	0.351945096
1.05	1.021347	0.704376	1.001842	0.733451	0.730854	0.72787	0.725314	0.718101	0.705392	0.70199	1.012098	1.00243	0.735347	0.728086	0.720831	0.716766	0.712011	0.707161	70	0.061244	0.374832807

The Consortium

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Thank you!

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