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OpSim – a smart grid co-simulation environment

F. Marten, J.-C. Toebermann

Fraunhofer IWES

This work presents selected results from the project "OpSim" (FKZ 0325593A,B), supported by the Federal Ministry for Economic Affairs and Energy, based on a decision of the Parliament of the Federal Republic of Germany.

Federal Ministry for Economic Affairs and Energy

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Fraunhofer Institute for Wind Energy and Energy System Technology (IWES)

www.iwes.fraunhofer.de
www.herkulesprojekt.de

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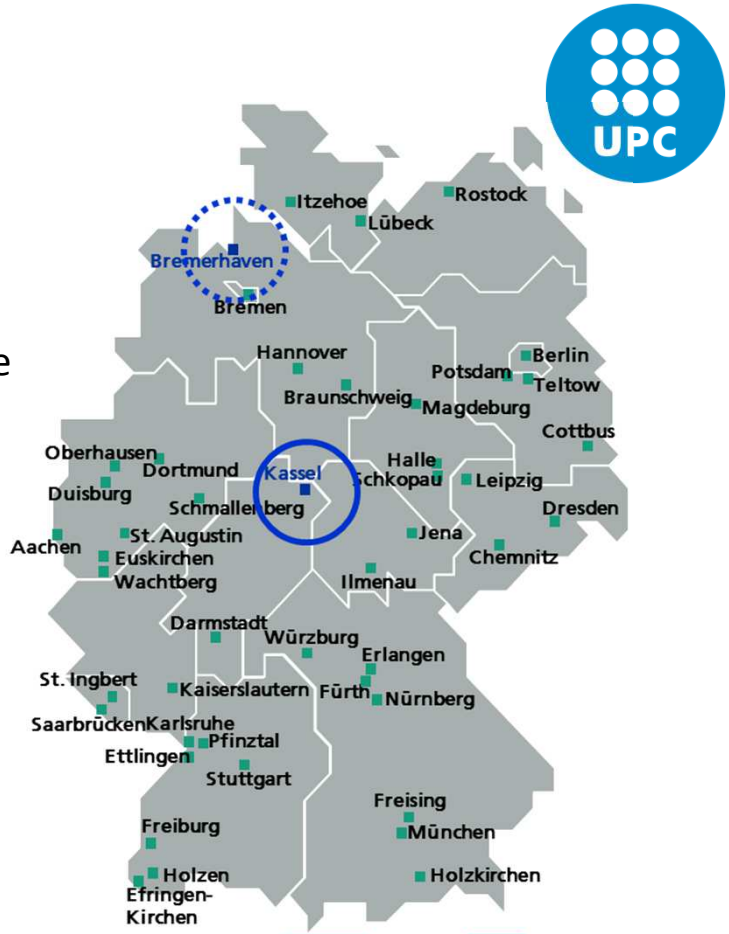
Fraunhofer-Gesellschaft, founded 1949 and nowadays the largest organization for applied research in Europe with more than 80 research units in Germany and more worldwide

Fraunhofer Institute for Wind Energy and Energy System Technology (IWES)

- Bremerhaven: (Offshore) Wind Energy
- **Kassel: Energy System Technology**
- Annual budget: approx. 32 Mio. Euro
- Staff: approx. 480
- Directors: Prof. Dr. Andreas Reuter, Prof. Dr. Clemens Hoffmann



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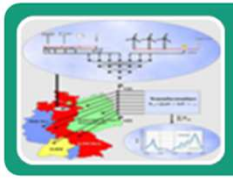
Renewable energy and grid integration: concept and feasibility studies



Modeling, simulation and optimization of energy systems

Competence center Smart Grid

Laboratory testing and field tests

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IWES Department “Distribution System Operation“

Head of Department and Professor at University of Kassel: Prof. Dr.-Ing. Martin Braun

- Application-oriented solutions for an optimal integration of generators, storages and consumers into distribution grids
- Technical and cost-optimal methods for grid planning, optimal layout and control of distributed technologies & assets
- Combining grid planning algorithms with simulation tools, for a holistic evaluation of present and future grid operation strategies

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Introduction to the OpSim-project

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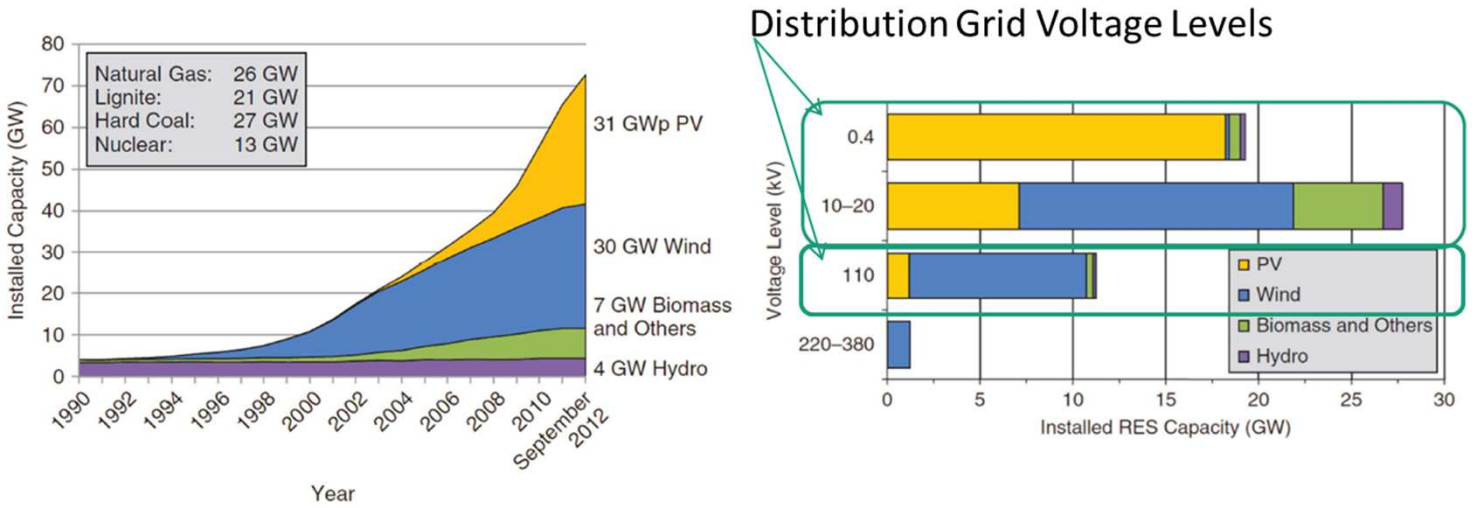
Motivation 1

Increased installments of decentralized renewable generators in German distribution grids



Sources: BMU or energymap.info according to J. Appen, M. Braun, T. Stetz, K. Diwold, D. Geibel, "Time in the Sun", IEEE Power & Energy Mag., vol.11, pp.55-64, March 2013

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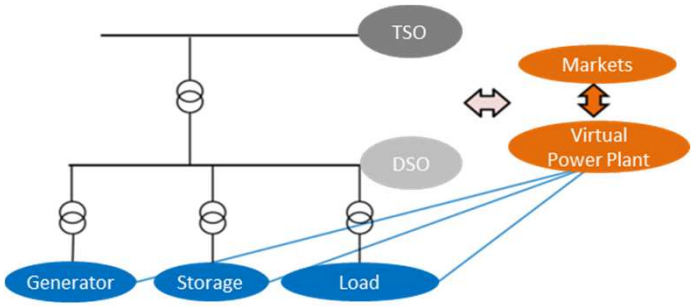
Motivation 2

In reality, many parallel actors (TSOs, DSOs, VPPs, …) control generators, storages, loads and compensator equipment in power grids

Common practice in many studies on this topic (often due to simulation tool inflexibility):

- just one grid voltage level is considered for grid optimization/simulation
- just one grid topology, weather data set or plant type is applied per investigation
- VPP control strategies neglect the grid topology altogether



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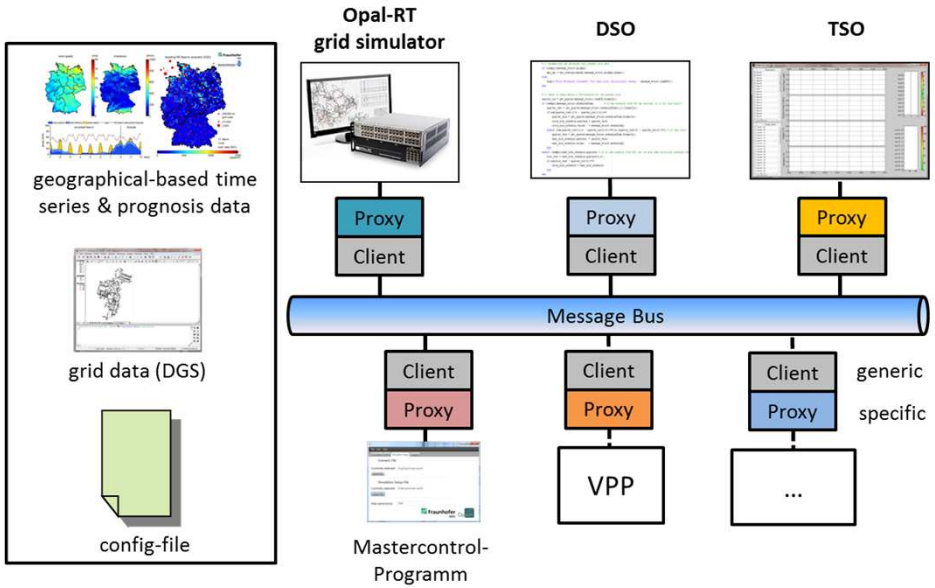
Objective: develop a real-time testing platform for smart grid control strategies

- Simulator for large-scale power networks
- A flexible architecture to connect multiple controllers
- Scenario-data generated by weather databases & forecast tools

The OpSim–project:

- Fraunhofer IWES and University of Kassel
- Industry consortium: 11 known companies from grid operation to energy management
- Governmental funding, 2013-2016



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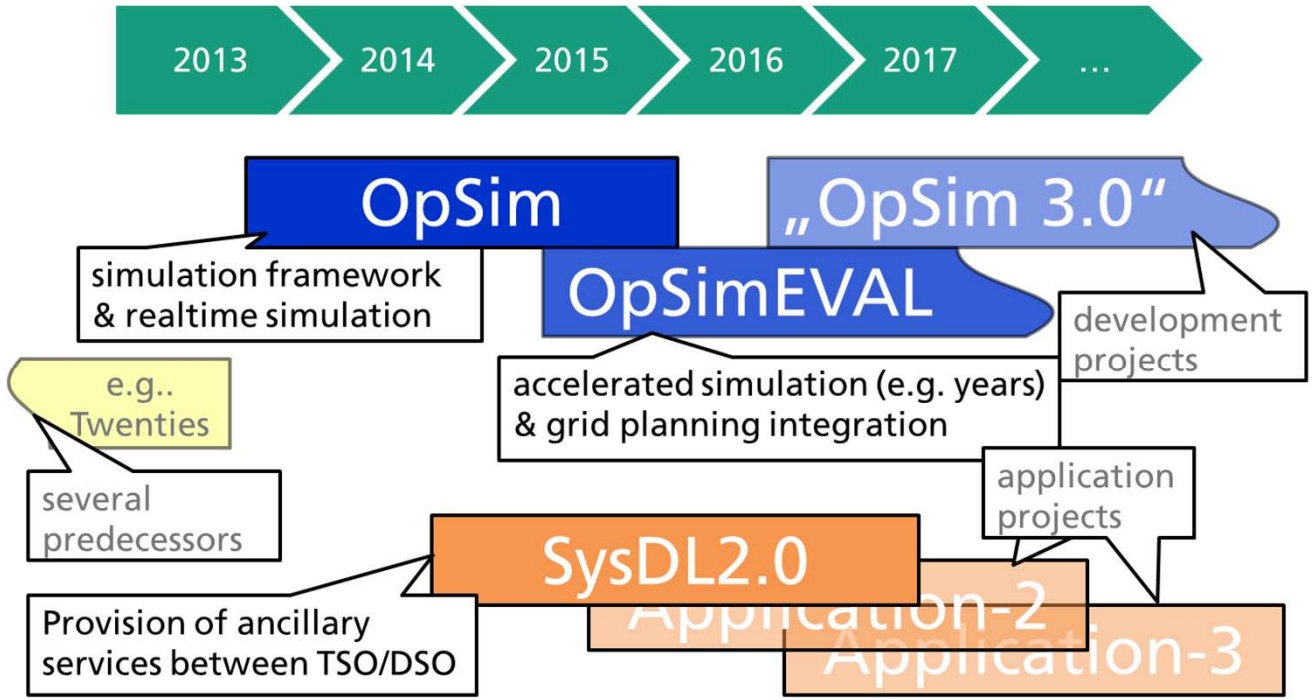
Roadmap of the OpSim-system



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The OpSim-system

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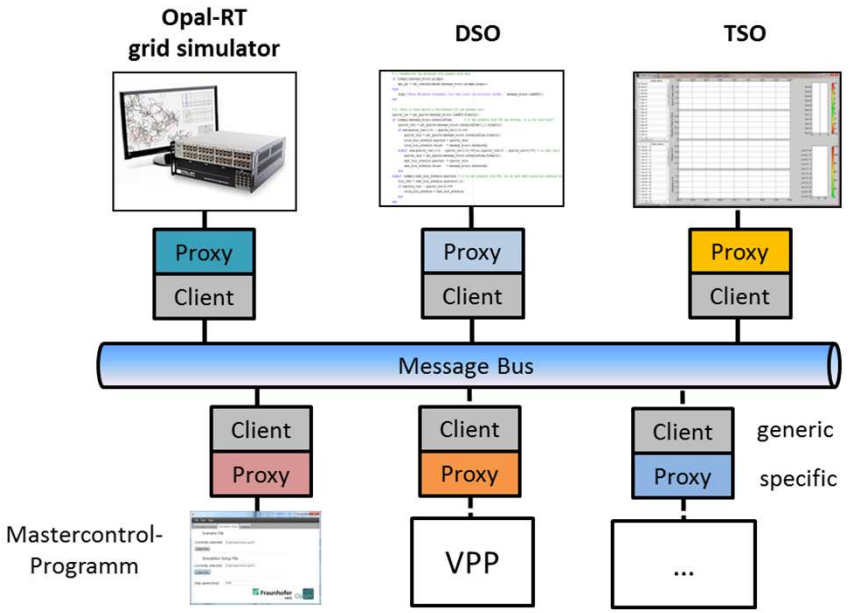
Flexible architecture to connect multiple controllers (motivated by SMB concept*)

- Specific Proxy (Translator)
- Generic Client (Connector)

Clients are written in Java. Currently, we have proxies available for:

- Matlab
- Python
- Java, C



(*) M. Faschang et al., "Rapid Control Prototyping Platform for Networked Smart Grid Systems." IECON, November 2013.

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We employ „ePHASORsim“+ OP5600 Hardware as grid & plant simulator

- Motivation:
  - ✓ Real-time performance
  - ✓ Documented to handle large grid models
  - ✓ Can be expanded at later stage for HIL-tests
  - ✓ Offers interface-templates to external software

- **Was the connection to the OpSim-system easy? Well, no. Why?**

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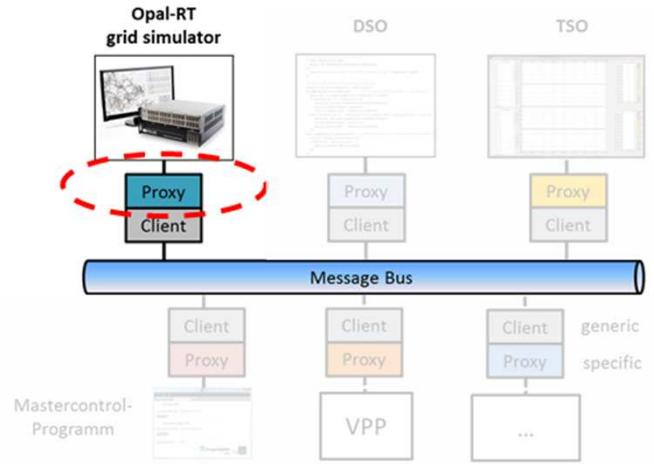
Was the connection to the OpSim-system easy?
Well, no. Why?

- Read/write variables from/to RT-Lab using connectors (pins) in the grid model and RtlabApi.Get
  Not recommended in manual, it is not controllable when the simulation processes incoming signals
- Used the „OpComm“ blocks to export signals from/to the grid model to/from the outside world, as recommended in manual
  Crashed after 20 minutes of simulation, (still) unknown error, no solution yet…
- Use UDP-asynchronous example program, alternative
  Worked! Stable operation up to 10000 floats/second
  Message Bus <-> Client (Java) <-> Proxy (C-Code) <-> ePhasorSim



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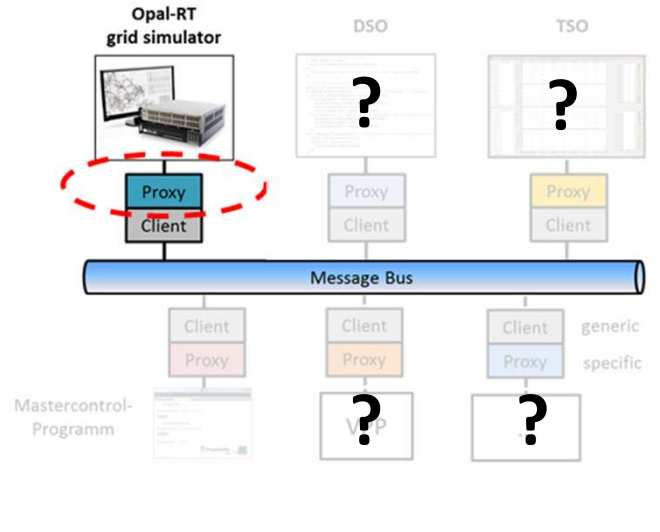
After connecting the grid & plant simulator, which control strategies did we test so far?



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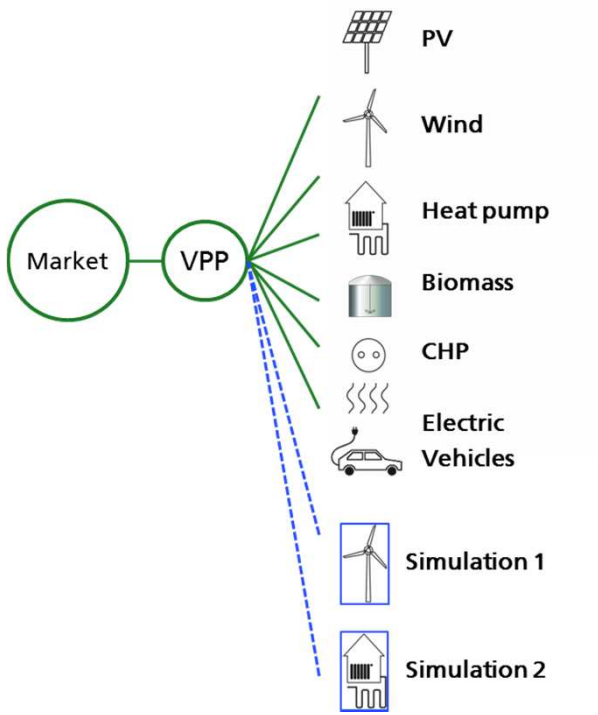
Application 1: VPP software test

Objective: simulate CHP plants to test the VPP software from consortium partner „Bosch Software Innovations“

Test how the VPP software responds to (many) new units.
Requirements for OpSim:

- ✓ Simulation should run in real-time
- ✓ Simulation should represent large amounts of generators, storages and loads (in case of TVPP even a model of the power grid)
- ✓ Should use the same standardized communication interface as real hardware



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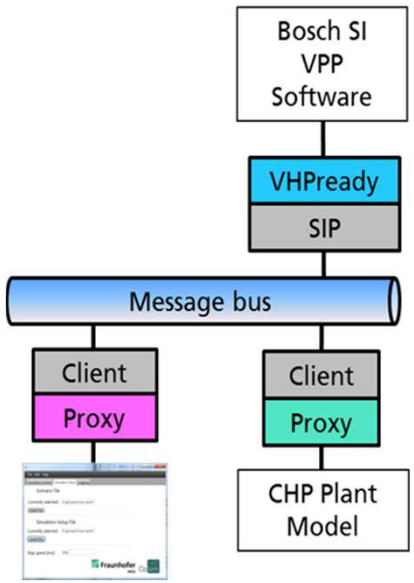
OpSim was configured to connect the VPP Software from Bosch SI to a simulated CHP plant.

Successful demo of approx. 1 week runtime! Results were shown at:

- E-World SmartER Europe 2015
- VDE Fachtagung „Von Smart Grids zu Smart Markets“ 2015

Papers can be obtained from:
frank.marten@iwes.fraunhofer.de



- Virtual Power Plant of Bosch Software Innovations, *Bosch SI: data center*
- TCP/IP connection to server which maps simulation to IEC 60870-5-104 protocol (VHPready 3.0) *Fraunhofer IWES: Backend-server*
- RabbitMQ message bus *IWES backend-server*
- Simulation of 50 kW_{el} CHP plant model *University of Kassel : Opal-RT simulator*

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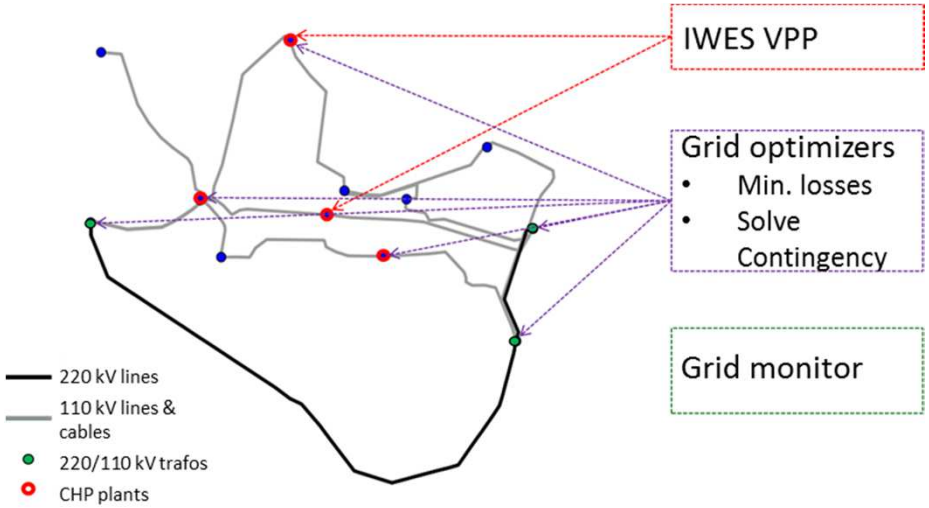
Application 2: grid simulation demo

Objective: analyze the interaction between grid operators and a VPP in real-time

- How do grid operation strategies respond to a VPP control action (say, frequency reserve calls?)
- How to coordinate the interactions in future?



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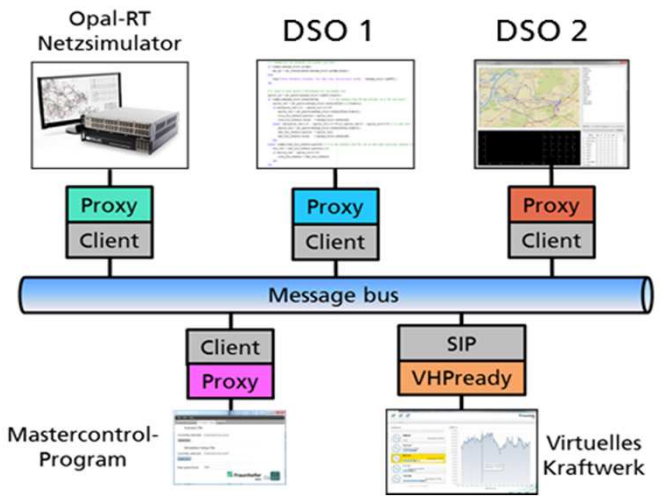
In this demo, four control strategies (DSO1, DSO2, TSO, VPP,…) will be connected to a simulated grid in the OpSim-System. Results will be shown in:

- OpSim Industry Consortium
  16 June, Kassel, Germany
  Additional participants are welcome!
  Email to frank.marten@iwes.fraunhofer.de
- PowerTech 2015
  29 June, Eindhoven, Holland
  Talk by Mike Vogt



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Summary

- OpSim: a flexible and versatile co-simulation environment for smart grids
- Presently designed for real-time simulations. Accelerated simulations for annual studies are developed in follow-up project “OpSimEval”
- Standardized interfaces for coupling „external“ control systems to large real-time grid simulations, to allow systematic testing: reproducible, safe & cost-effective
- First applications completed, next industry consortium on 16 June in Kassel.
  New participants are welcome!

Thank you very much for your attention

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OpSim project homepage

www.opsim.net

Fraunhofer IWES (Kassel) website:

http://www.energiesystemtechnik.iwes.fraunhofer.de/

Fraunhofer IWES – Department Distribution System Operation

Research Focus:

- application-oriented solutions for an optimal integration of generators, storages and consumers into distribution grids
- technical and cost-optimal methods for grid planning, optimal layout and control of distributed technologies & assets
- Combining grid planning algorithms with simulation tools, for a holistic evaluation of present and future grid operation strategies

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