SES4DH - 2017 - Copenhagen

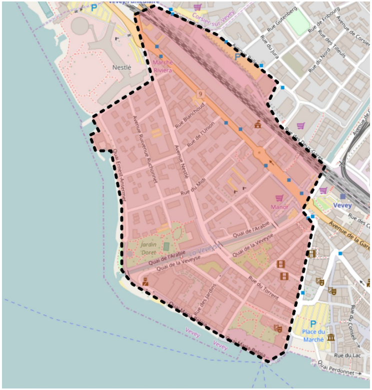
Implementation of distributed co-simulation for urban energy systems

Pablo Puerto

September 2017

Challenges and opportunities

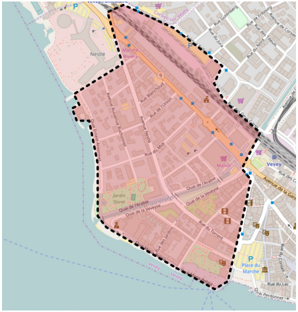
Neighbourhood in Switzerland



- New district heating and cooling network project
- Strong political will to increase energy efficiency
- Energy utilities: electricity, thermal and natural gas

Energy Status Quo

Mapping the needs - yearly values



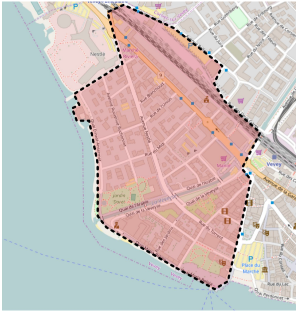
- Heating and hot water
- Cooling
- Electrical services

PlanETer
Planification Énergétique Territoriale

http://www.ncsa.ch/planeter/

Energy system planning

Mapping the future needs



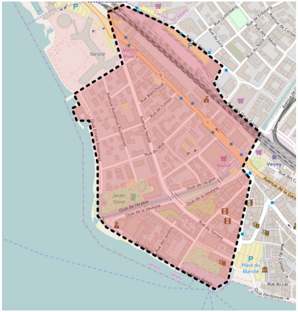
- Scenario of demand evolution
- Refurbishment rates
- New projects

PlanETer
Planification Energétique Territoriale

http://www.ncsa.ch/planeter/

Energy system planning

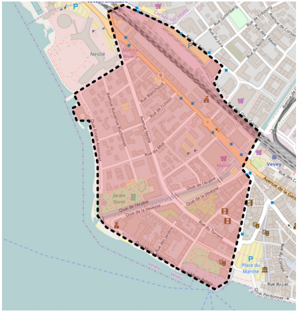
Existing energy infrastructure: Power grid



- 20 feeders (MV to LV)
- 300 spot-load
  (full zone: 464)
- $\approx$ 250 buildings

Energy system planning

Existing energy infrastructure: Natural gas



- Fully developed natural gas network
- Covering 50% of heating and hot water demand
- Integration of renewable bio-gas production
  (goal: 30% for 2030)

Objectives

Local authority

- KPIs and objectives based on 2009s Energy Planning (will be updated after PlanETer study)
- 2000W society compatible energy system
- Use the lake as energy resource
- Increase resilience and self-consumption
- Gather all energy utilities on the new energy project
- **Robust design of urban scale multi-energy system ?**

Optimal design of distributed energy systems

Pinch analysis

J. Rager, F. Maréchal (Dir.). Urban Energy System Design from the Heat Perspective using mathematical Programming including thermal Storage. Thèse EPFL, no. 6731 (2015)

SMOSE

IPESE
Industrial Process and Energy Systems Engineering

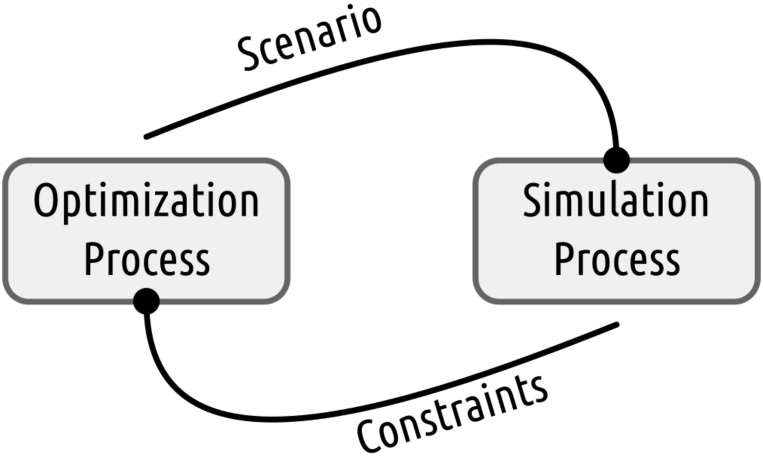
Superstructures

N. Duić, G. Krajačić, and M. da Graça Carvalho. RenewIslands methodology for sustainable energy and resource planning for islands. Renewable and Sustainable Energy Reviews, May 2008

EraNET Smart Cities
http://integrcity.epfl.ch/
March 2016 à February 2019 – 3.5M€

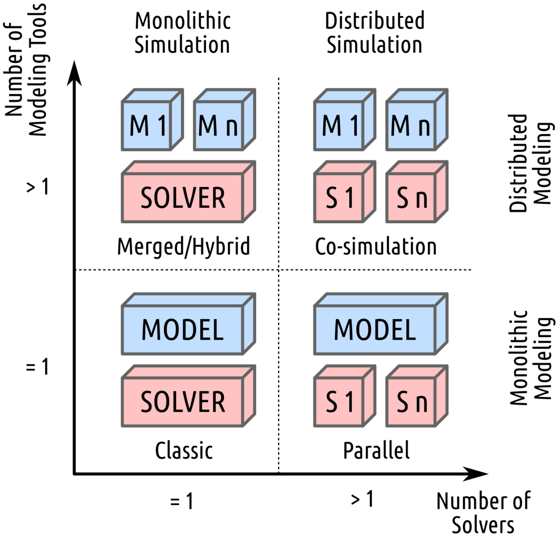
Project principle

Simulation based validation and feedback to optimal design process



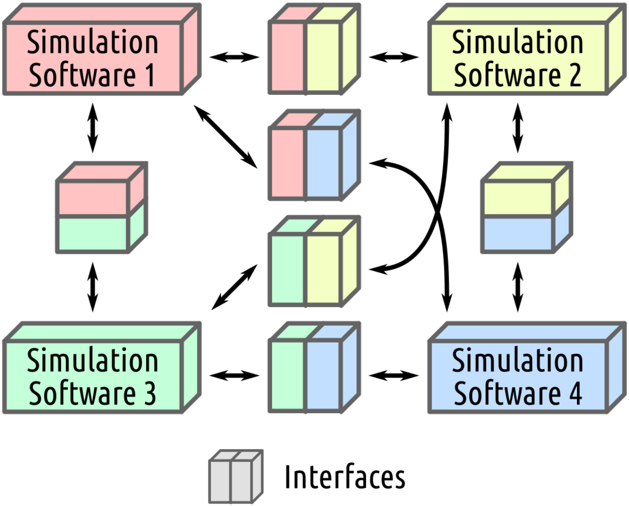
Simulation

Classification of methods



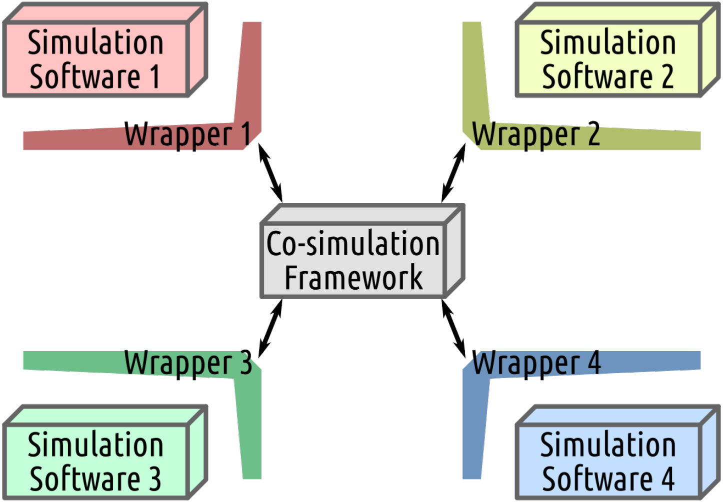
Co-simulation

Specific method



Co-simulation

Generic method



Docker

Virtualization concept

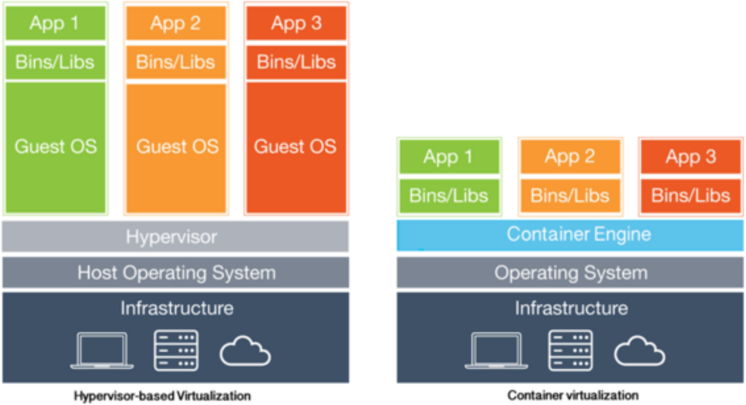
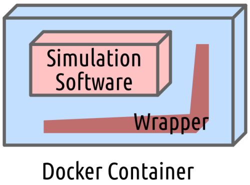


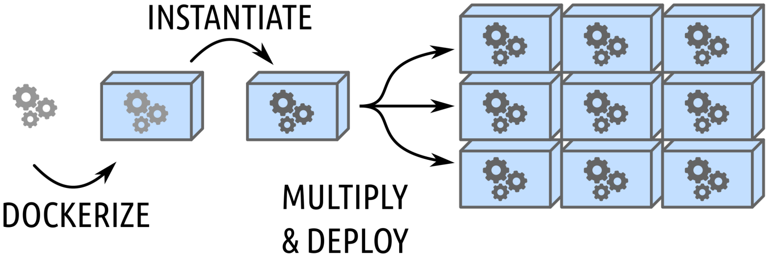
Figure: Docker structure, credit to crmtrilogix.com

Co-simulation

Encapsulation and deployment

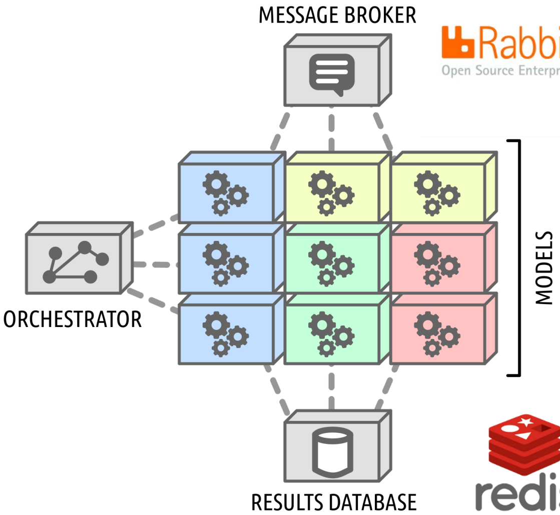


- Dedicated and isolated environment
- Dependencies and library
- Easy deployment
  (Docker SDK for Python)
  `http://docker-py.readthedocs.io/`



Co-simulation

Components structure

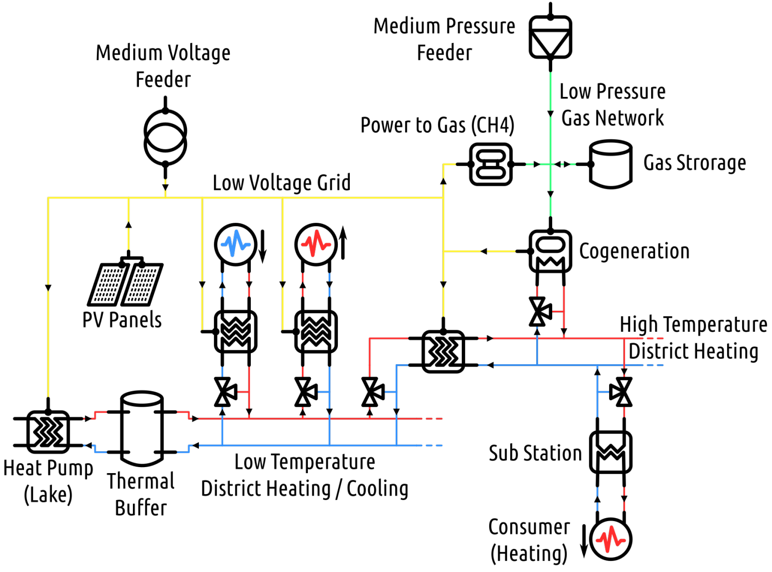


RabbitMQ
Open Source Enterprise Messaging

redis

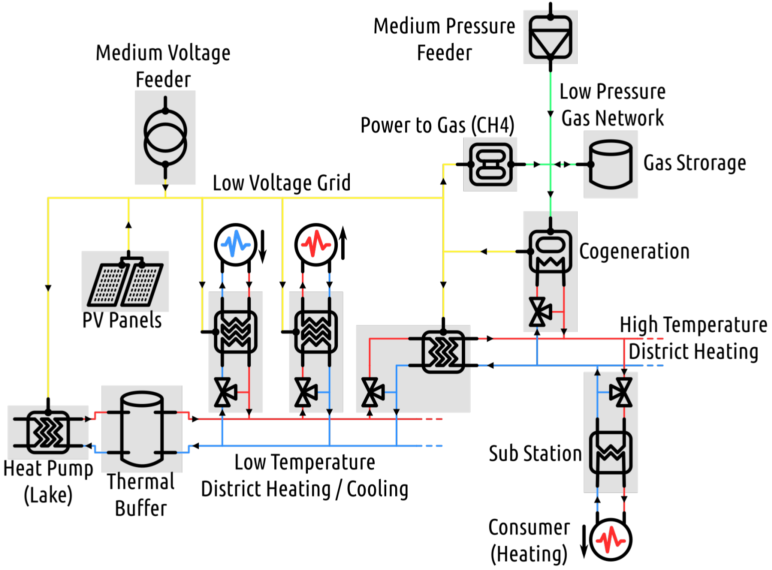
Co-simulation

Studied system



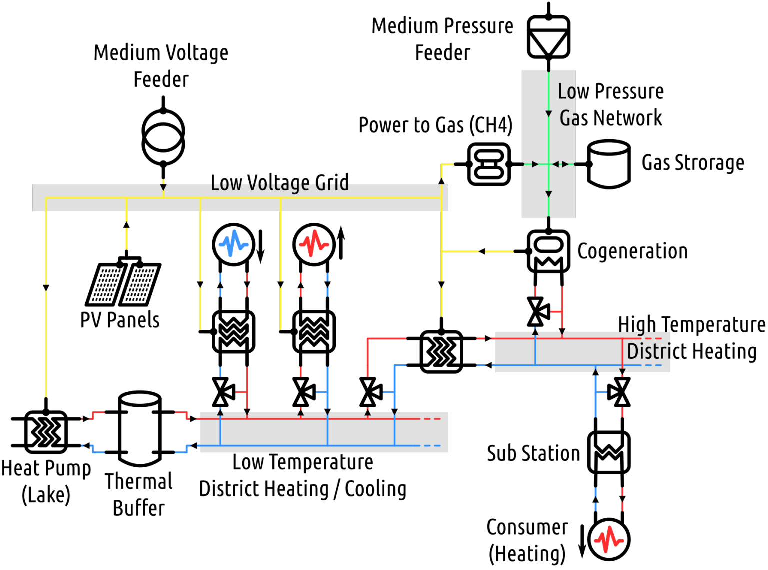
Co-simulation

Studied system



Co-simulation

Studied system



Co-simulation

Drawbacks and benefits

- Implementation of wrappers
- Impact of model partition
- Influence of sampling time

- Distributed computation (native Docker Swarm tool)
- Integration of commercial software with academic models
- Automatic models creation and deployment from database

Development

Open Source - Apache License 2.0

IntegrCiTy project on GitHub
`https://github.com/IntegrCiTy`

OBvious Node Link - OBNL
`https://github.com/IntegrCiTy/obnl`

Dedicated images on Docker Cloud
`https://cloud.docker.com/swarm/integrcity`

Thanks !

- Centre RAPSODEE - CNRS UMR 5302
  Mines Albi - Université de Toulouse, FRANCE
- Centre de Recherches Énergétiques et Municipales
  CREM - Martigny, SWITZERLAND
  pablo.puerto@crem.ch
- Haute École Spécialisée de Suisse Occidentale
  HES-SO - Sion, SWITZERLAND
  pablo.puerto@hevs.ch

Co-simulation

Performance - Small scale

- **RabbitMQ performance**: $\approx$ 40000 msg / s
- **Redis performance**: $\approx$ 75000 req / s
- **Docker extra network layer latency**: $\approx$ 100 μs / msg

- **Final time**: 1 day
- **Sampling time**: 1 min
- **Nbr. of periods**: 30x24x7 $=$ 1440

- **nbr. of profiles (buildings)**: 2
- **nbr. of nodes**: 7
- **nbr. of links**: 13

- **Total simulation time**: 1 min 20 s

Co-simulation

Performance - Full scale

- **RabbitMQ performance**: $\approx$ 40000 msg / s
- **Redis performance**: $\approx$ 75000 req / s
- **Docker extra network layer latency**: $\approx$ 100 μs / msg

- **Final time**: 1 week
- **Sampling time**: 5 min
- **Nbr. of periods**: 30x24x7 $=$ 5040

- **nbr. of profiles (buildings)**: 250
- **nbr. of nodes**: 261
- **nbr. of links**: $+$800

- **Total simulation time**: 135 min