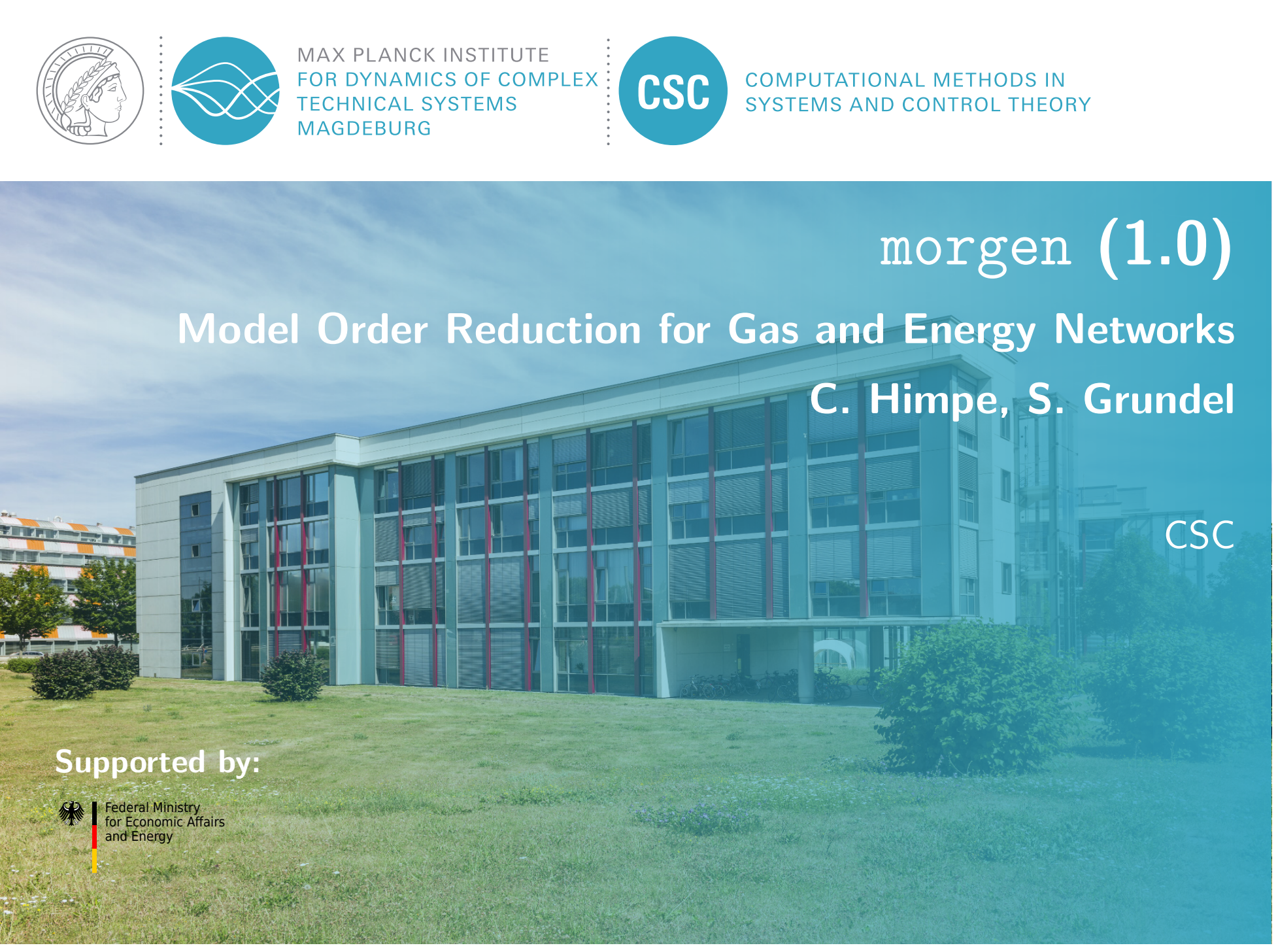
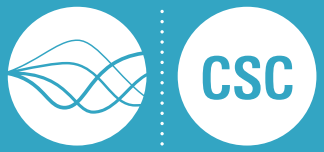
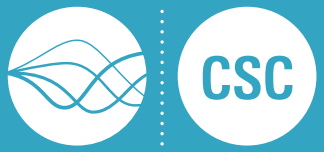

MAX PLANCK INSTITUTE
FOR DYNAMICS OF COMPLEX
TECHNICAL SYSTEMS
MAGDEBURG
CSC
COMPUTATIONAL METHODS IN
SYSTEMS AND CONTROL THEORY
morgen (1.0)
Model Order Reduction for Gas and Energy Networks
C. Himpe, S. Grundel
CSC
Supported by:
Federal Ministry
for Economic Affairs
and Energy



Get morgen

https://git.io/morgen



The Name morgen

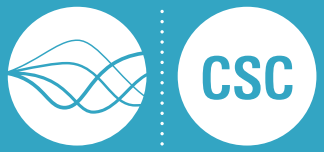
morgen (german for: tomorrow)

- **M**odel
- **O**rder
- **R**eduction

for **G**as

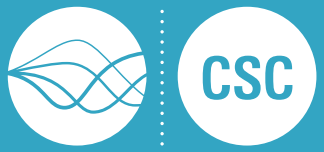
and **E**nergy

- **N**etworks



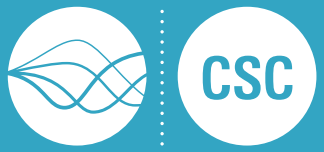
Why morgen

- Testing model-solver-reductor combinations
- Comparing models, solvers, or reductors
- Benchmarking reductors
- Prototyping algorithms
- Uncertainty quantification



About morgen

- Open-source (BSD-2-Clause)
- High-Level (MATLAB and OCTAVE)
- Modular (Six modules)
- Configurable (Three-level configuration)
- Extensible (Contributions welcome)



morgen Modules

1. Models
2. Solvers
3. Reductors
4. Networks
5. Tests
6. Tools

Models

Implemented:

- `ode_mid` – midpoint discretization
- `ode_end` – endpoint discretization (port-Hamiltonian)

```
discrete = model(network,config);
```

`discrete` **Structure:**

- `.E` – Mass matrix function
- `.A` – System matrix
- `.B` – Input matrix
- `.C` – Output matrix
- `.f` – Nonlinear vector field
- `.J` – Vector field Jacobian
- `.x0` – Initial state
- `.nP` – Number of pressure states
- `.nQ` – Number of mass-flux states
- `.nPorts` – Number of ports

Solvers

Implemented:

- `imex1` – 1st Order Implicit-Explicit (Euler-Euler)
- `imex2` – 2nd Order Implicit-Explicit (Runge-Kutta)
- `generic` – 2nd Order Adaptive Rosenbrock (`ode23s`)
- `rk4` – "Classic" 4th Order Explicit Runge-Kutta

```
solution = solver(discrete,scenario,config);
```

`solution` **Structure:**

- `.t` – Time instances
- `.u` – Input time series
- `.y` – Output time series
- `.runtime` – Solver runtime
- `steady_z0` – Mean compressibility
- `steady_error` – Steady-state error
- `steady_iter1` – Algebraic Iterations
- `steady_iter2` – Differential Iterations

Reductors

Implemented:

- `pod_r` – Structured Proper Orthogonal Decomposition
- `eds_ro` , `eds_wx` , `eds_wz` , `eds_ro_l` , `eds_wx_l` , `eds_wz_l` – Structured Dominant Subspaces Variants
- `bpod_ro` , `bpod_ro_l` – Structured Balanced Proper Orthogonal Decomposition
- `ebt_ro` , `eds_wx` , `eds_wz` , `ebt_ro_l` , `eds_wx_l` , `eds_wz_l` – Structured Balanced Truncation Variants
- `gopod_r` – Goal-Oriented Proper Orthogonal Decomposition
- `ebg_ro` , `eds_wx` , `eds_wz` , `ebg_ro_l` , `eds_wx_l` , `eds_wz_l` – Structured Balanced Gains Variants
- `dmd_r` – Dynamic Mode Decomposition Galerkin

```
[proj,name] = reductor(solver,discrete,scenario,config);
```

- `spaces` – Cell array of projectors
- `name` – Full name of reductor

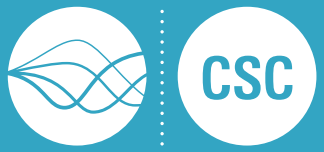
Networks & Tests

Network and scenario data:

- Network data stored as decorated edge list in CSV format (`.net`).
- Scenario data stored as key-vale pairs in INI format (`.ini`).
- Network base name determines associated scenario folder name.
- Each network has minimally a `training.ini` scenario.

Types of tests:

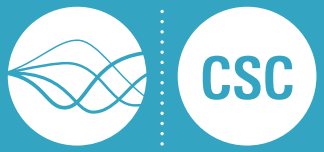
- Prefix `sim_` – Simulate scenario by a model-solver combination.
- Prefix `mor_` – Reduce and test model-solver-reductor combination.



Tools

Available:

- `xml2net` – Convert *GasLib* `.xml` to `morgen .net`
- `json2net` – Convert *MathEnergy* `.json` to `morgen .net`
- `csv2net` – Convert *SciGRID_gas* `.csv` to `morgen .net`
- `vf2kgs` – Convert volume flow to mass flow in kg/s
- `psi2bar` – Convert pressure from psi to bar
- `cmp_friction` – Compare friction factors
- `cmp_compressibility` – Compare compressibility factors
- `randscen` – Generate random scenario from training scenario



Configuration

Available:

- optional arguments (`varargin`)
- configuration file (`morgen.ini`)
- fallback via hard-coded default values

Use morgen

```
R = morgen(network_id,scenario_id,model_id,solver_id,reductor_ids,varargin);
```

{string} `network_id` – Network file (`.net`) base name

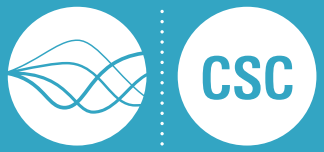
{string} `scenario_id` – Scenario file (`.ini`) base name

{string} `model_id` – Model function name

{string} `solver_id` – Solver function name

{cell} `reductor_ids` – Array of reductor names

{string} `varargin` – Adhoc configuration arguments (‘`key=val`‘)



Notes

- Currently, all reductors use `emgr`: `https://gramian.de`
- A template model, solver and reductor are available.
- This is research software!

Summary

morgen – **M**odel **O**rder **R**eduction for **G**as and **E**nergy **N**etworks

→ https://git.io/morgen ←

C. Himpe, S. Grundel, P. Benner:
Model Order Reduction for Gas and Energy Networks.
arXiv: 2011.12099, 2021. https://arxiv.org/abs/2011.12099

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