Oemof
Workshop Week

Constraints

Martha Hoffmann

Session 4

RLI, 18.09.2019

Introducing words

Inner workings of oemof:

Linear optimization and constraints

All workshop contents at: https://github.com/smartie2076/oemof_workshop
Todays jupyter notebooks are stored in ./Day_3_Custom_Constraints_for_Oemof

Agenda

- Introduction to linear optimization
- Linear equation systems of oemof models
- In-build oemof constraints
- Introducing own constraints
- Further examples for constraints

Agenda

- Introduction to linear optimization
- Linear equation systems of oemof models
- In-build oemof constraints
- Introducing own constraints
- Further examples for constraints

An introduction to linear optimization

- Example: ./3_LP_general_example.ipynb

- Linear Problem (LP) / Mixed Integer (Linear) Problem (MI(L)P) consists of :
  - a target function
  - a set of constraints and balances
- Solver searches on the edges of the solutions space for the optimal solution
- Available solvers: CBC, GLPK, Gurobi, …
- Time steps adjustable (e.g. 15 mins, hourly)

Agenda

- Introduction to linear optimization
- Linear equation systems of oemof models
- In-build oemof constraints
- Introducing own constraints
- Further examples for constraints

Introducing words

We learnt:

A set of linear equations fully describes an energy system model as a whole

All workshop contents at: https://github.com/smartie2076/oemof_workshop
Todays jupyter notebooks are stored in ./Day_3_Custom_Constraints_for_Oemof

The „lp-file“

- Oemof generates a set of linear equations based on the created model, using Pyomo
- Linear equation system can be stored in „lp-file“
- lp-file transferred to solver for optimization,
  - Recommended solver: coinor-cbc
  - Same file can be optimized with different solvers
  - Lp-file can help to verify and debug your code
  - Includes all necessary data of your energy system

- Example: ./micro_grid_fixed_cap_basic.ipynb

The „lp-file“: Main balance

- The objective value should be minimized:

Image for dispatch problem

Optimizing with oemof – Objective value

- Oemof generates a linear equation system describing the energy system model
- Solves for the minimal objective value (costs)
- Target function:

$$min \sum_i \left(Capex(i) * CRF(i) + Opex_{fix}(i)\right) * P_{inst}(i) + \sum_i \sum_t Opex_{var}(i) * E_{gen}(i,t)$$

$$i \in \{WEA, PV, BHKW, Speicher\}$$

$$t \in \{1 \ldots 8760\}$$

Capex	Capital expenditure	EUR/kW
CRF	Capital recovery factor	-
$Opex_{fix}$	Fixed operational expenditure	EUR/(kW*a)
$Opex_{var}$	Variable operational expenditure	EUR/kWh
P_{inst}	Capacity of component	kW
E_{gen}	Generated electricity per timestep	kWh
i	Index of system components	-
t	Index of time steps	-

The „lp-file“: Objective value

- The objective value should be minimized:

Image for investment problem

The „lp-file“: Bus balances

- Each bus is by default balanced:
  - $\sum inputs = \sum outputs \ \forall \ t$
  - Ie. no energy can be lost or generated from nowhere
  - Can require „shortage“-Source or „excess“-Sink

Image for bus balance easy

The „lp-file“: Bus balances

- Each bus is by default balanced:
  - $\sum inputs = \sum outputs \;\forall\, t$
  - Ie. no energy can be lost or generated from nowhere
  - Can require „shortage“-Source or „excess“-Sink

Image for bus balance easy

The „lp-file“: Bus balances

- Each bus is by default balanced:
  - $\sum inputs = \sum outputs \ \forall \ t$
  - Ie. no energy can be lost or generated from nowhere
  - Can require „shortage“-Source or „excess“-Sink

Image for bus balance transformer

The „lp-file“: Bus balances

- Each bus is by default balanced:
  - $\sum inputs = \sum outputs \; \forall \; t$
  - Ie. no energy can be lost or generated from nowhere
  - Can require „shortage“-Source or „excess“-Sink

Image for bus balance electricity bus

Agenda

- Introduction to linear optimization
- Linear equation systems of oemof models
- In-build oemof constraints
- Introducing own constraints
- Further examples for constraints

In-build bounds of flows

- Bounds limit Flows to an interval
- Decreases search area for valid optimization results
- Examples:
  - Component parameters: `min_storage_capacity`, `max_storage capacity`
  - Flow parameters: `nominal_value`
  - Investment parameters: `maximum`

- Example: ./micro_grid_system_inbuilt_bounds.ipynb

The „lp-file“: Bounds

In-built constraints

- Limit the sum of a Flow: $\sum Flow \cdot variable = const$
- Indirectly decreases search area of optimization, acts like a „exit criterion of a loop“
- Examples:
  - `summed_max`
  - `emission_limit`

- Example: ./micro_grid_fixed_inbuild_sum.ipynb

The „lp-file“: Constraints

Agenda

- Introduction to linear optimization
- Linear equation systems of oemof models
- In-build oemof constraints
- Introducing own constraints
- Further examples for constraints

Guidelines for own constraints

- Rules for own constraints:
  - Linearized behaviour
  - Non-dependent on other decision variables, ie. no „if-then-relation“
- If-then relations can be implemented when accessing a definite timeseries of `actual_value`
- Calling…
  - A Flow of an component with nominal value:
  - A Flow of a component with an investment object
  - A fix parameter of a component

Process of writing constraints

1. Simplify real-world boundary to valid constraint

2. Determine structure of constraint:
   - Does the constraint have to be applied each time step individually?
   - Does the constraint concern Investment objects?

3. Create a constraint with a constraint rule, add directly to the linear model of the energy system using Pyomo

4. Verify your constraint by checking…
   - …the lp-file (for few timesteps)
   - …the results (fow a higher number of timesteps)

Agenda

- Introduction to linear optimization
- Linear equation systems of oemof models
- In-build oemof constraints
- Introducing own constraints
- Further examples for constraints

Renewable share constraint

- Type: Summed minimum constraint
- Based on: Minimum renewable share limit (constant)

Micro grid stability constraint

- Type: Minimum bound per timestep
- Based on: Minimum stability limit (constant)

Intermittantly switching off a component

- Type: Setting flow value in timesteps
- Based on: External boolean timeseries

Forced battery charge

- Type: Setting flow per timestep
- Based on:
  - External boolean timeseries
  - Linerarized formular for value of flow

THANK YOU FOR YOUR ATTENTION !

REINER LEMOINE INSTITUT

How to follow Oemof's activities?

Website: https://oemof.org/
Github: https://github.com/oemof
Or join our mailing list!

Tel: +49 (0)30 1208 434 88
E-Mail: martha.hoffmann@rl-institut.de
Web: http://www.rl-institut.de
Twitter: @rl_institut