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Conference of Environmental and Climate technologies

Differential evolution optimization advantages in transition to energy communities. System dynamic model for multi-family buildings

Presenter: Dr.sc.ing Ruta Vanaga

Project team: Ģirts Bohvalovs, Ritvars Freimanis, Vita Brakovska, Andra Blumberga

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Climate goals

- *The average rate of renovation should be increased to at least 3% per year to ensure the renovation of the full building stock by mid-century.*
- *Renovation practice needs to be scaled up to industrial levels. A focus on deep renovation will reduce energy demand in buildings and will replace existing heating systems with more efficient and renewables-based systems.*
- *Member States should rigorously follow the NZEB principle for all new buildings. As of 1 January 2021, all new buildings in the EU must be NZEBs, combining very high energy performance with significant renewable energy supply. No new fossil fuel heating system should be installed in new construction from 2021 onwards. Any new installation of fossil fuels-based heating systems locks in CO2 emissions for the next two decades.*
- *A strategic effort to decarbonise heating and cooling energy supply and to invest in low temperature renewable heat supply infrastructure is needed.*
- *The use of fossil fuels for heating and hot water in buildings should drastically decrease in the next decade. Considering that the average lifetime of heating equipment is in the range of 15-20 years, policies to discourage installation of new fossil-fuel based systems should be implemented.*
- *To achieve faster and deep renovations, mandatory minimum energy performance requirements can be an effective policy, as indicated in the Renovation Wave. These should be tailored to specific segments of the building stock and ownership tenures and coupled with financing and targeted advice.*

On the way to a climate-neutral Europe – Contributions from the building sector to a strengthened 2030 climate target. Buildings Performance Institute Europe 2020

Revise current praxis

Renovation of multiapartament buildings
Energy community

Lower the energy demand

Increase Renewable energy

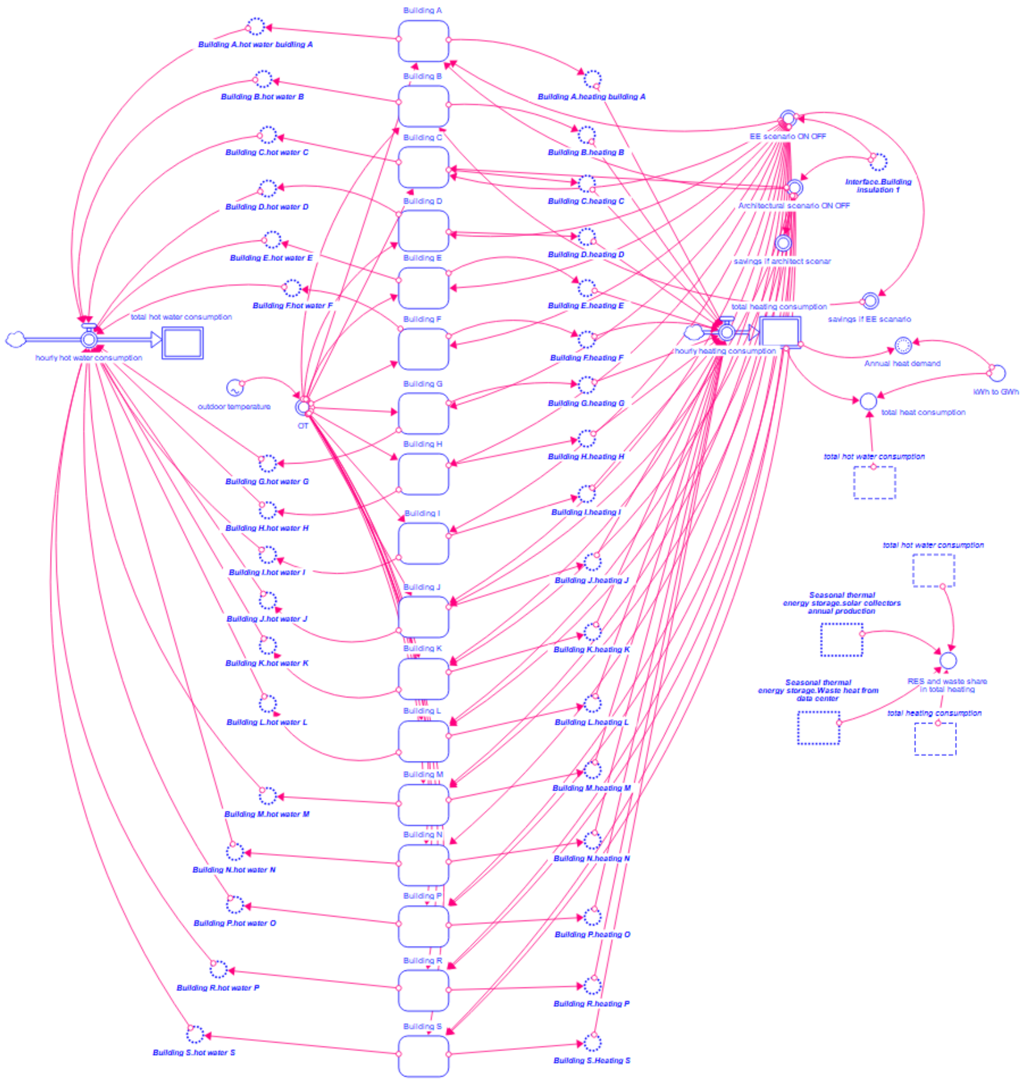
Energy community. Multi apparment buildings

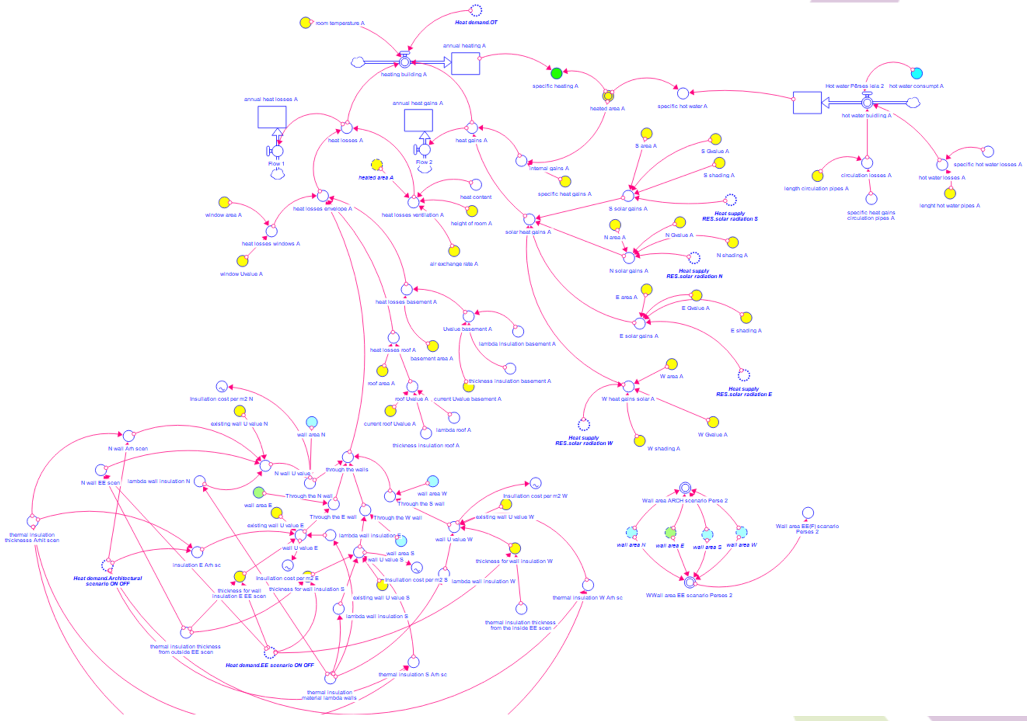
G. Milberga-Zuza

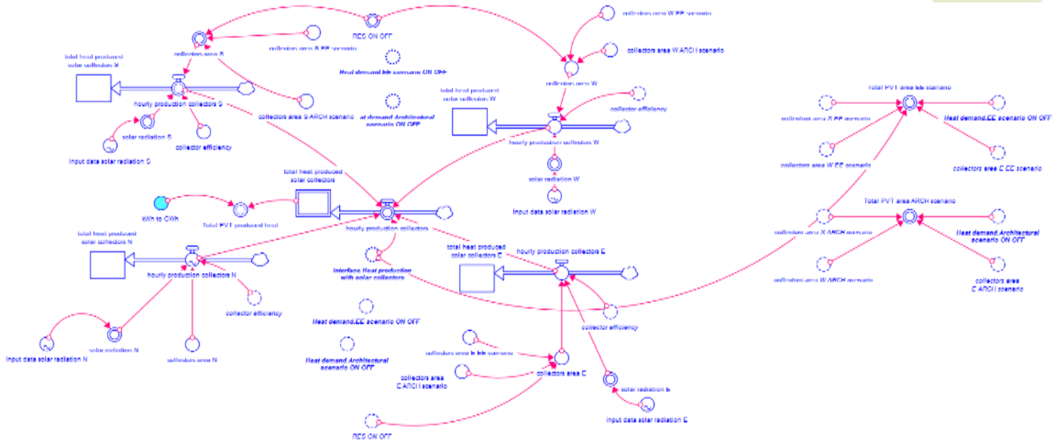
Challenges in modelling neighbourghood level:

- Complexity of composition
- Insulation strategies
- Availability of RES for each building
- Types of RES
- Share of RES vs energy demand reduction
- Energy storage
- Amount of variables in the model

System Dynamic model.



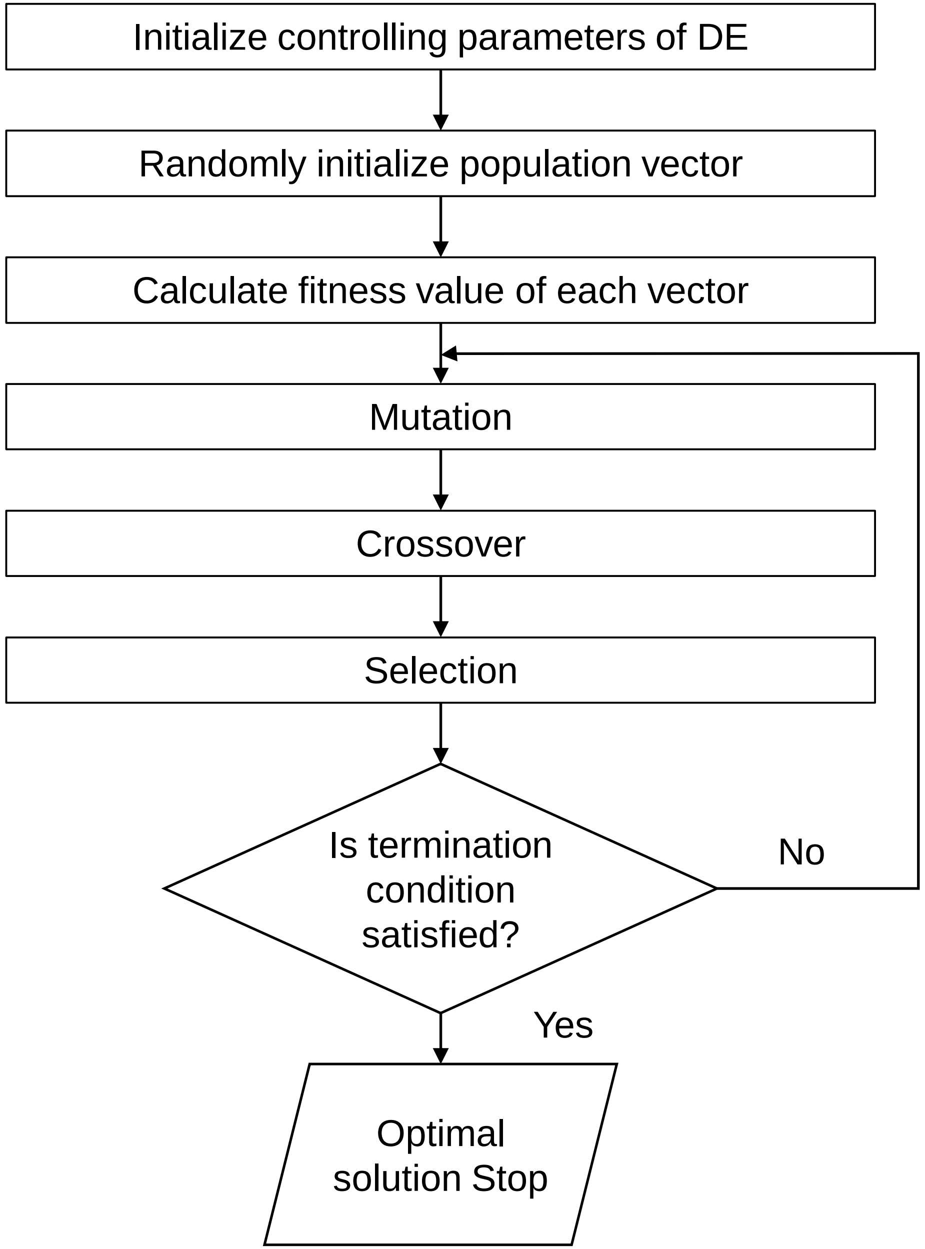




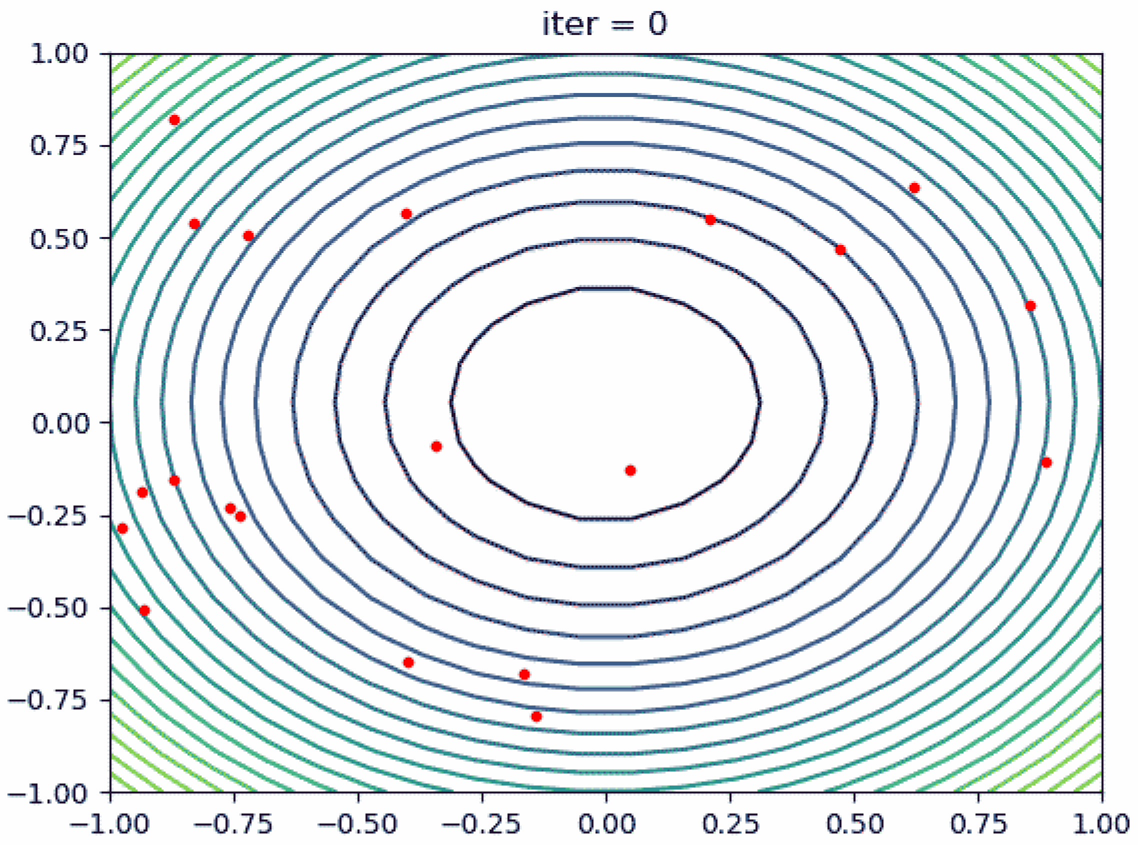
Differential evolution optimisation

Differential evolutionary algorithm is a highly parallel and random search method for objective optimization for multivariable and non-convex problems.

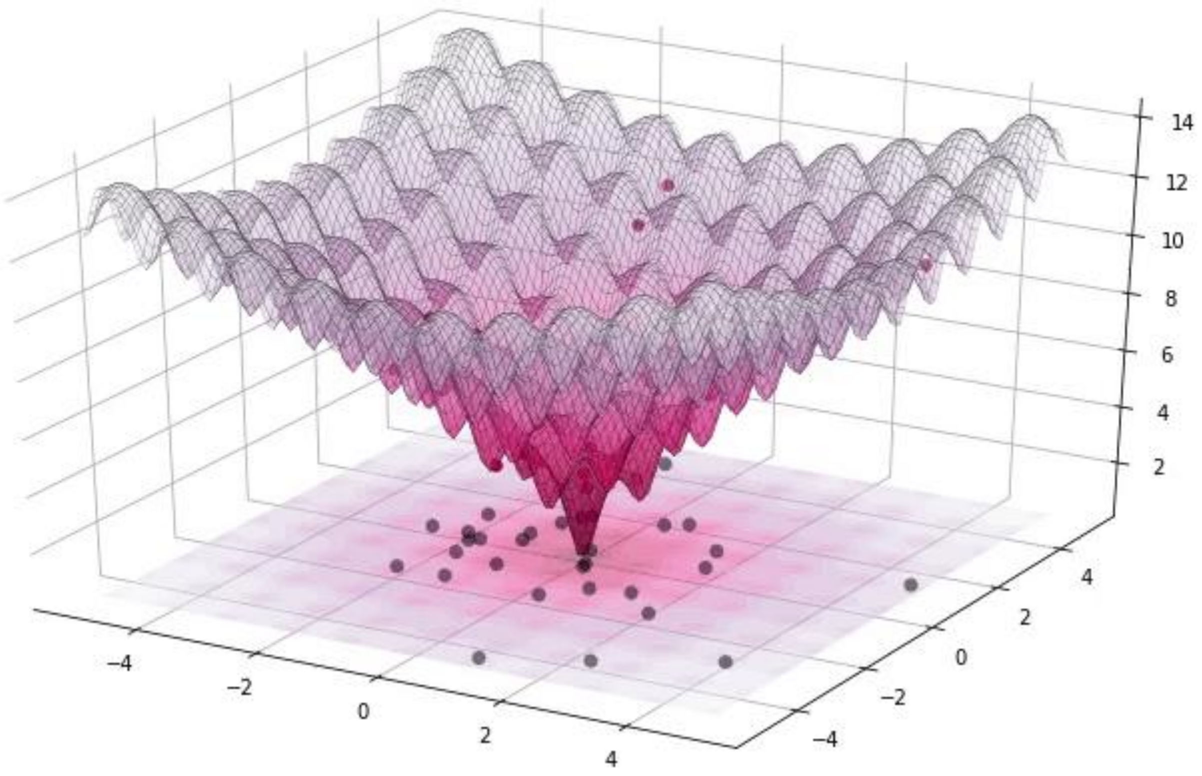
DE algorithm



Population convergence through iterations

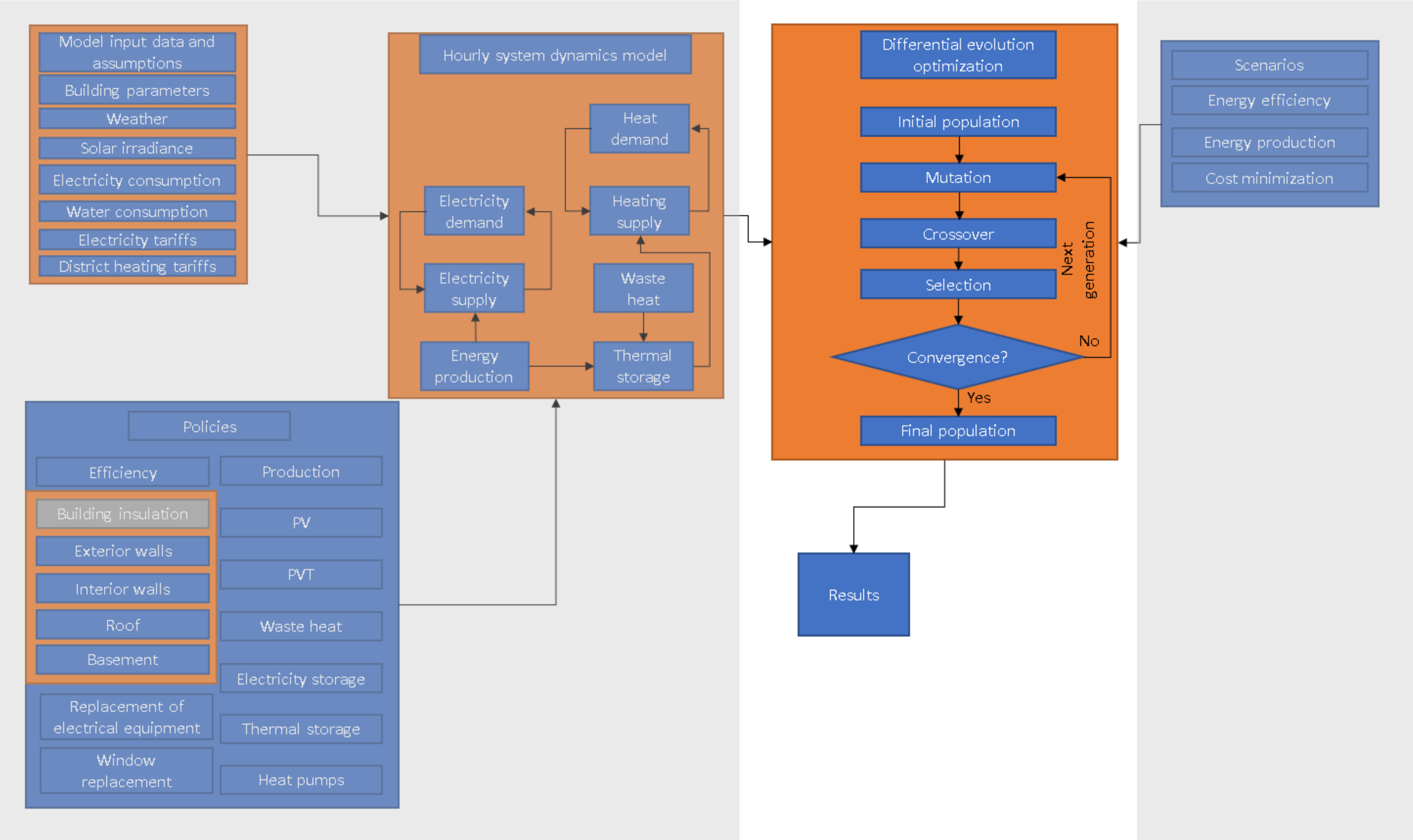


Convergence in 3D graph



Results

Model layout



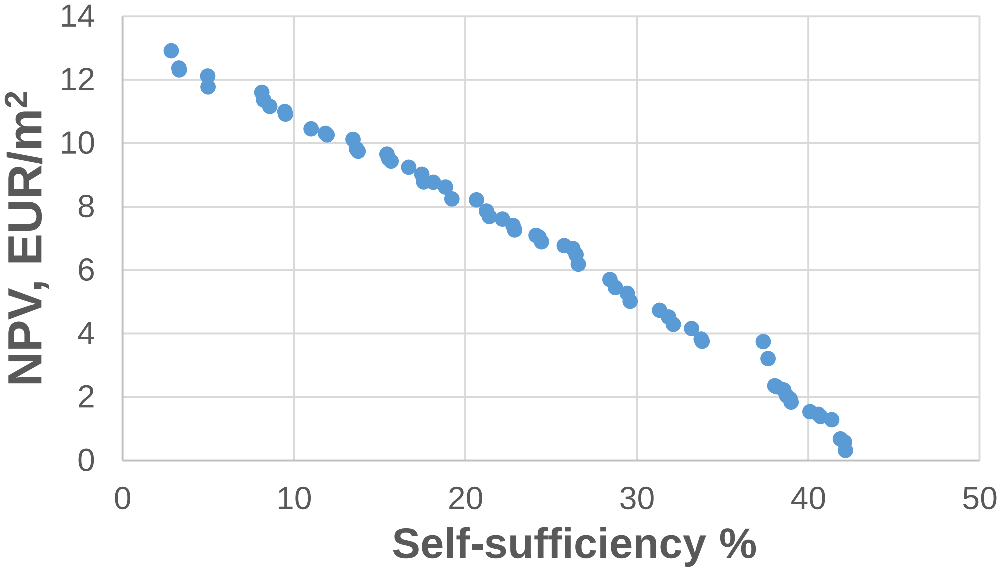
Initialization

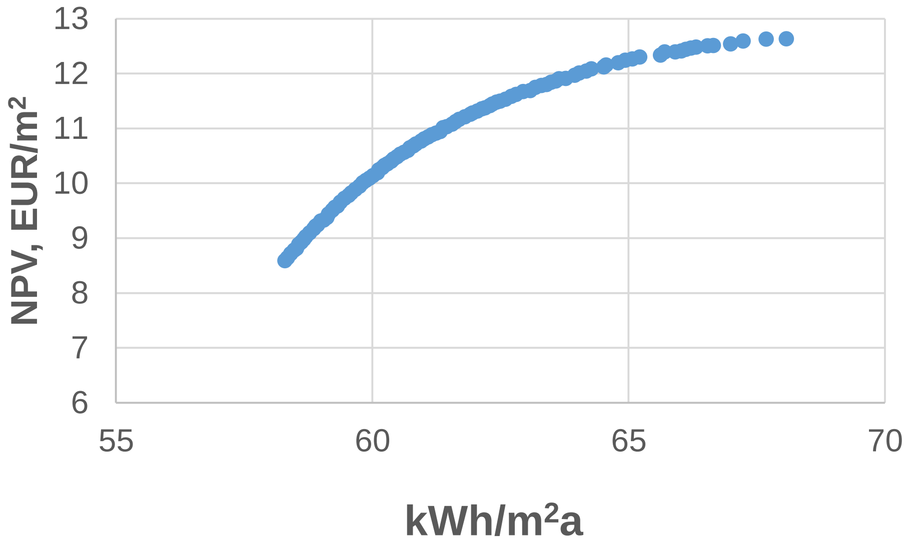
Payoff:	Net present value	Self-sufficiency
Action	maximize	maximize
Kind	Outcome Optimization	Outcome Optimization
Element	Net present value	Self sufficiency
Weight	1	1
Time Range	Final value	Final value

Payoff:	Net present value	Specific heat consumption
Action	maximize	minimize
Kind	Outcome Optimization	Outcome Optimization
Element	Net present value	Heat per area
Weight	1	1
Time Range	Final value	Final value

Parameter:	Insulation thickness [Walls]	Insulation thickness [Roof]	Insulation thickness [Basem.]	En.ef. appl.	Heat pump electric power	Energy production	Storage Volume [High T]	Storage Volume [Low T]	Inverter capacity	Window change	Production shares [PV]	Production shares [Collector]	Production shares [PVT]
min_value	0	0	0	0	0	0	0	0	0	0	0	0	0
max_value	0,25	0,4	0,15	100	200	100	500	100	250	100	100	100	100
increment	0,01	0,01	0,01	1	1	1	1	1	1	1	1	1	1

Results


NPV, EUR/m²
14
12
10
8
6
4
2
0
0
10
20
30
40
50
Self-sufficiency %


NPV, EUR/m²
13
12
11
10
9
8
7
6
55
60
65
70
kWh/m²a

Results

Column1	Insulation thickness[Walls]	Insulation thickness[Roof]	Insulation thickness[Basement]	Energy efficiency in buildings	Heat pump electric power	Energy production	Storage Volume[High T]	Storage Volume[Low T]	Inverter capacity	Window change	Production shares[Photovoltaics]	Production shares[Solar collector]	Production shares[PV Thermal Hybrid]	Net present value	Specific heat consumption
Non-dominated solution 69	0,18	0,23	0,15(max)	100(max)	0(min)	0(min)	5	42	0(min)	40	37	44	19	468 796	68
Non-dominated solution 72	0,19	0,23	0,15(max)	100(max)	0(min)	0(min)	5	0(min)	0(min)	40	37	44	19	468 547	68
Non-dominated solution 45	0,19	0,24	0,15(max)	100(max)	0(min)	0(min)	0(min)	1	0(min)	42	37	44	19	467 296	67
Non-dominated solution 35	0,21	0,23	0,15(max)	100(max)	0(min)	0(min)	1	18	0(min)	40	37	44	19	465 330	67
Non-dominated solution 67	0,19	0,25	0,15(max)	100(max)	0(min)	0(min)	16	1	0(min)	45	14	19	67	464 338	67
Non-dominated solution 25	0,21	0,24	0,15(max)	100(max)	0(min)	0(min)	3	1	0(min)	42	37	44	19	464 059	67
Non-dominated solution 74	0,21	0,26	0,15(max)	100(max)	0(min)	0(min)	1	3	0(min)	42	37	44	19	463 160	66
Non-dominated solution 59	0,21	0,27	0,15(max)	100(max)	0(min)	0(min)	0(min)	0(min)	0(min)	42	37	44	19	462 493	66
Non-dominated solution 60	0,21	0,28	0,15(max)	100(max)	0(min)	0(min)	1	3	0(min)	42	37	44	19	461 602	66

Conclusions

1. Differential evolution optimisation provides efficient multivariable optimisation in complex energy community level modeling
2. Gained results provide rich insights in to the convergence process, the pathway that leeds to te optimum based on selected criteria
3. In case study it is found that at ~40% of self-sufficenty NPV =0, but proposed insulation scenarios provides NPV>0
4. Other simulations can be performed seeking the optimum in CO_2 emmissions, LCA emmissions, RES share ect

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Ruta.Vanaga@rtu.lv

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