What energy solutions matter at city level in the long run?

Energy systems analyses in Friendly Sam

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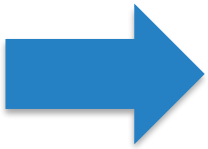
What we wanted to do:

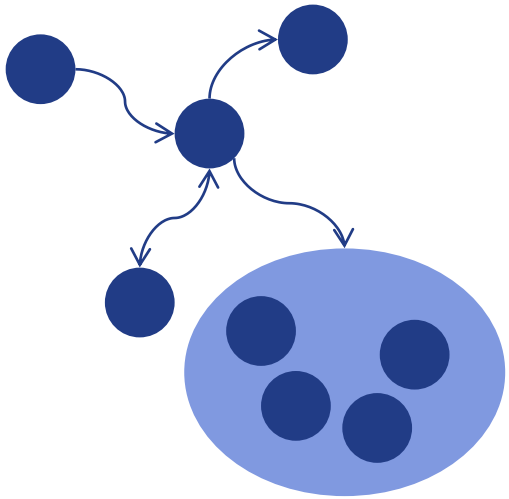
- Evaluate and compare the total system costs and CO_2 effects when scaling the SINFONIA solutions within the city
- Compare the SINFONIA solutions in terms of impact and economic performance for different energy price scenarios for 2030 and 2050
- Analyse what solutions have the greatest potential and whether there are barriers to scaling



We needed an optimization tool

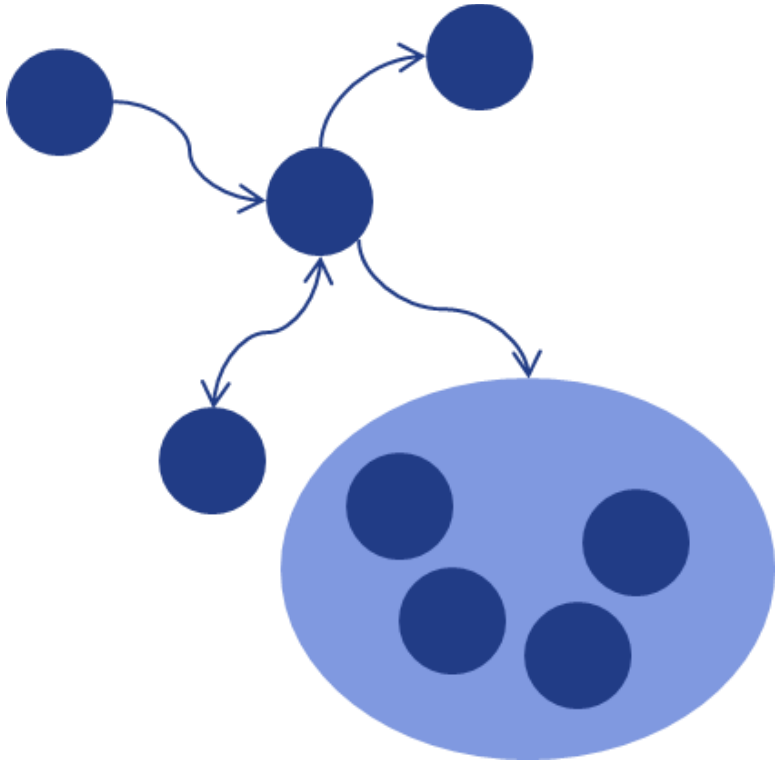
Friendly Sam is a toolbox

- Optimization based
  - Customized objective function (cost, CO_2, combinations)
- Core concept:
  - Resources flow between nodes
  - Nodes process and alter flows
- Nodes are instances of predefined archetypes
  - Power plants
  - Consumers
  - Customized by user



Sinfonia

Energy system structure and connections



- Customized system structure through connections and clusters.
  - Enables flexibility in model complexity.
  - Possibility for more detailed modeling of critical parts of the system.
- Clustering of parts of the system (no transfer limitations considered within clusters).
- Connections between nodes/clusters with e.g. limited transfer capacities.

Easy to work with

- Allows user to focus on model construction
- Compose models with predefined archetypes
- Create new archetypes as needed
- Minimal code repetition

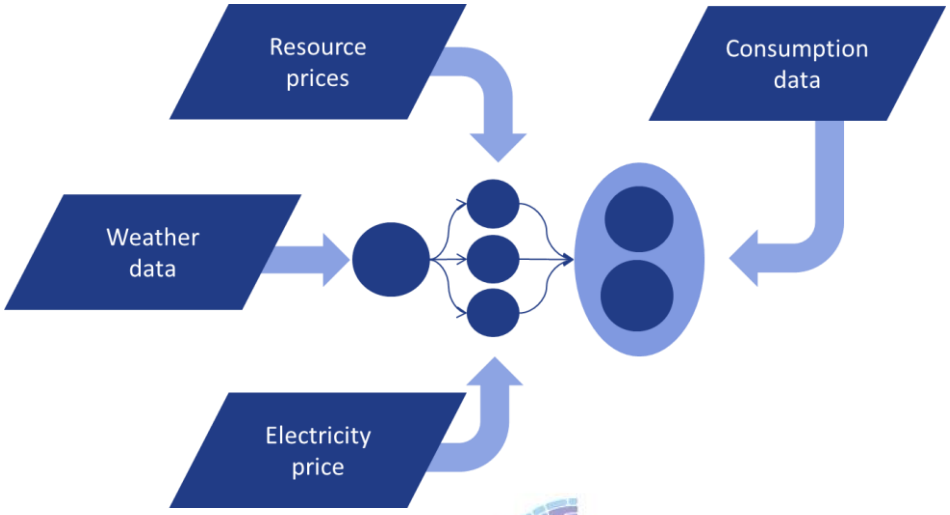
Sinfonia

Flexible and open source

- Solvers: Gurobi or CBC (open source)
- Friendly Sam released under GNU LGP license
- Source code on GitHub
- Complete code transparency

Feeding model data

- Flexible data management
- Easily modified as requirements change
- Data entry limited only by user



Sinfonia

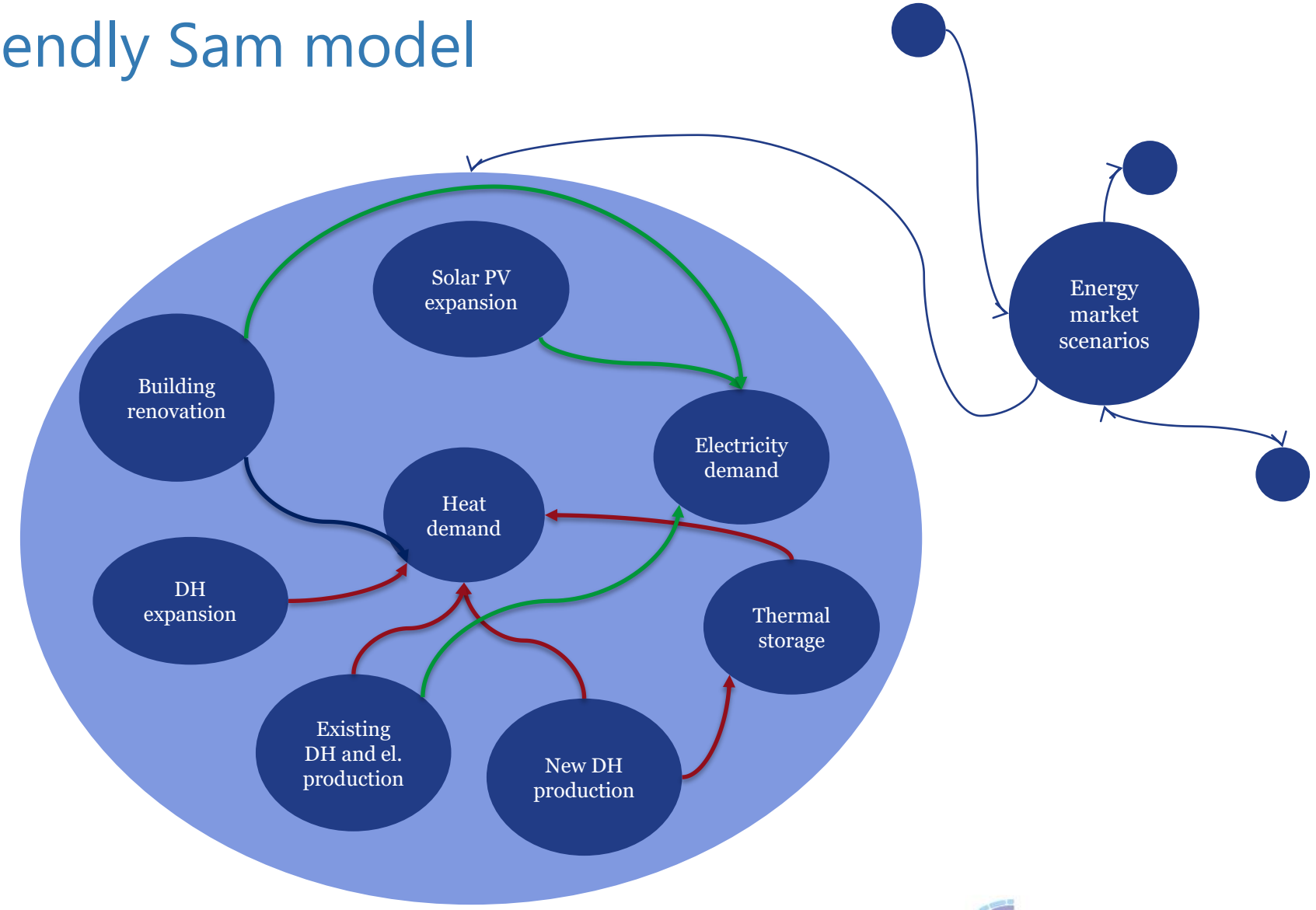
Open source available for use:

- https://friendly-sam.readthedocs.io/en/latest/

Sinfonia

EXAMPLE FROM BOLZANO

Friendly Sam model

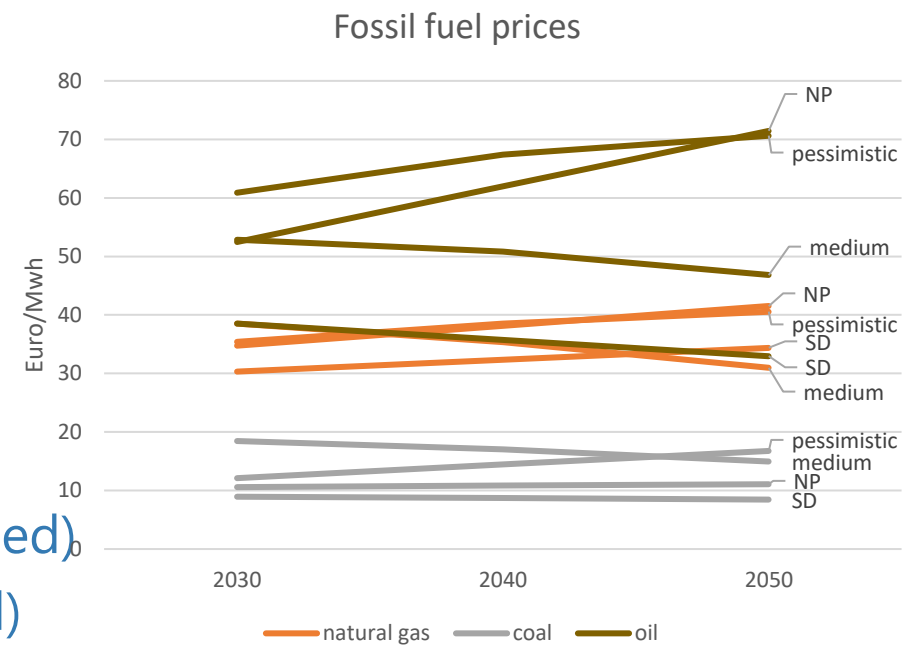


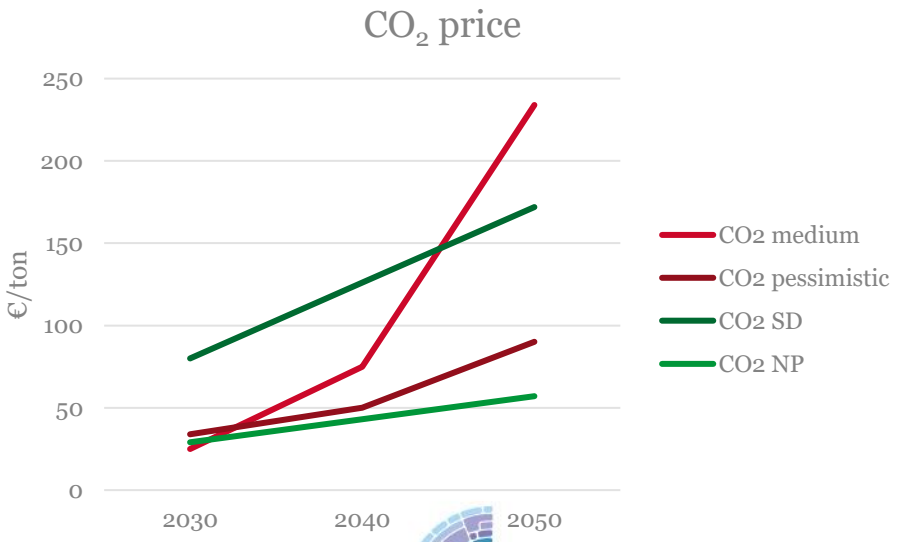
	BAU	Max RES	Max DH	Max retrofit	Optimal trade-off
Solar PV production	Trend	Max capacity	Trend	Trend	Cost-optimal
Heat storage capacity	Trend	Trend	Optimal	Trend	Cost-optimal
DH grid expansion	Trend	Trend	Max	Trend	Cost-optimal
DH production	Trend	Trend	Optimized based on grid	Trend	Cost-optimal
Extent of renovation	Trend	Trend	Trend	High	Cost-optimal

Scenarios

Several price scenarios are used

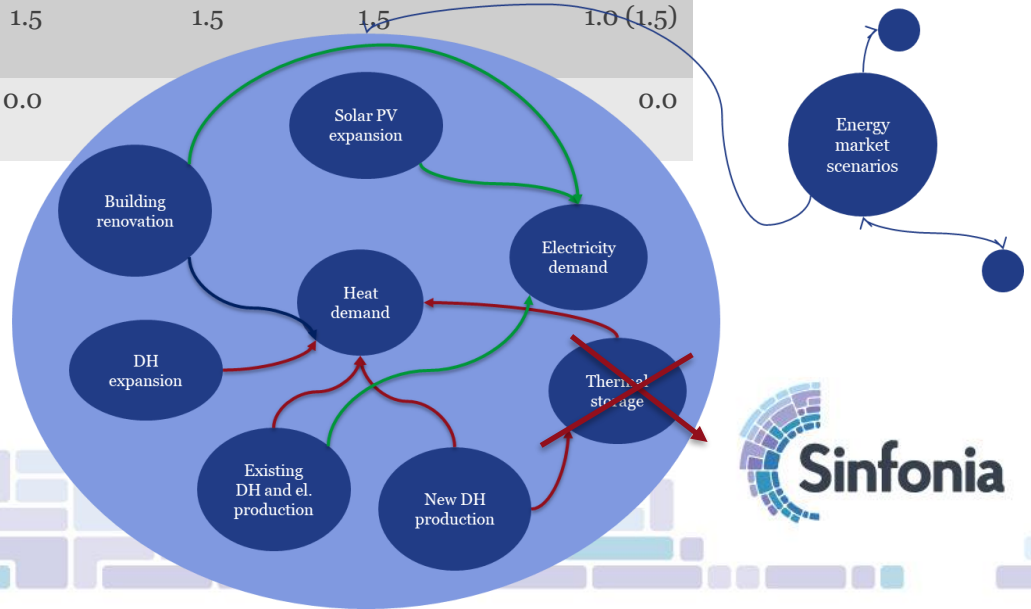
- Pessimistic scenario (T9.1 PRIMES based)
- Medium scenario (T9.1 PRIMES based)
- New Policies (ENPAC)
- Sustainable Development (ENPAC)





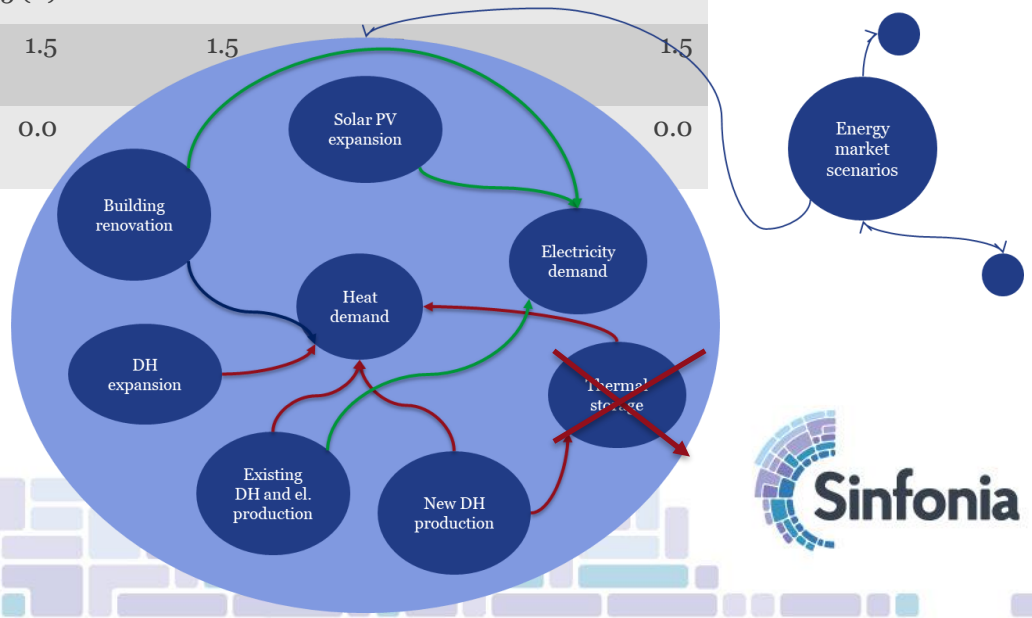
Results – optimized investments 2030

2030 Trade off investments				
Measure	Italy medium	Italy pessimistic	New policies	Sustainable development
Solar photovoltaics [MW_{el}]	30	30	30	30
Accumulator [MWh]	0	0	0	0
Grid expansion [GWh]	183	183 (182)	182 (181)	180 (182)
Natural gas CHP [MW_{th}]	35	31 (21)	0	0
Biomass CHP [MW_{th}]	0	0	0	0
Yearly deep renovations [%]	1.5	1.5	1.5	1.0 (1.5)
Yearly shallow renovations [%]	0.0			0.0

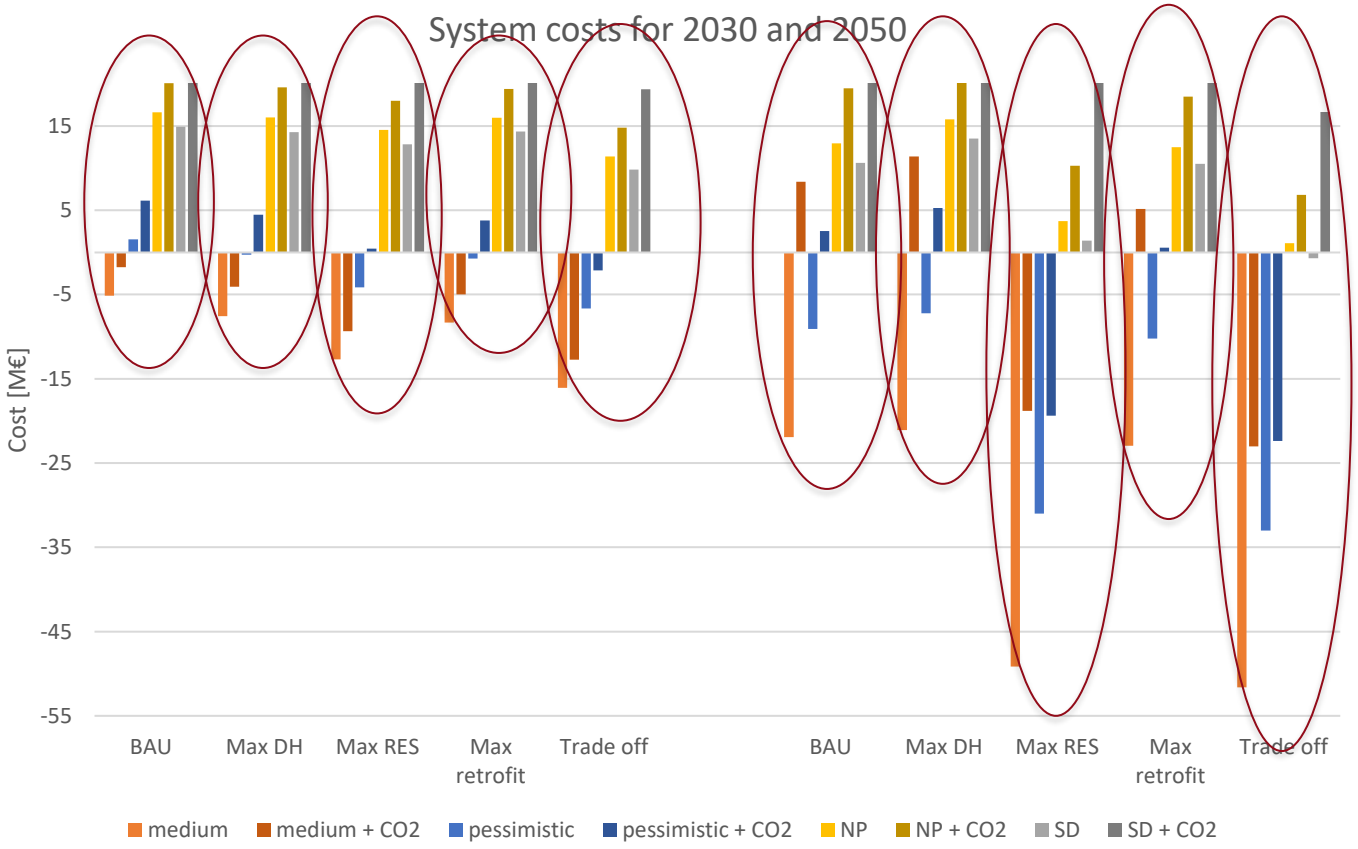


Results – optimized investments 2050

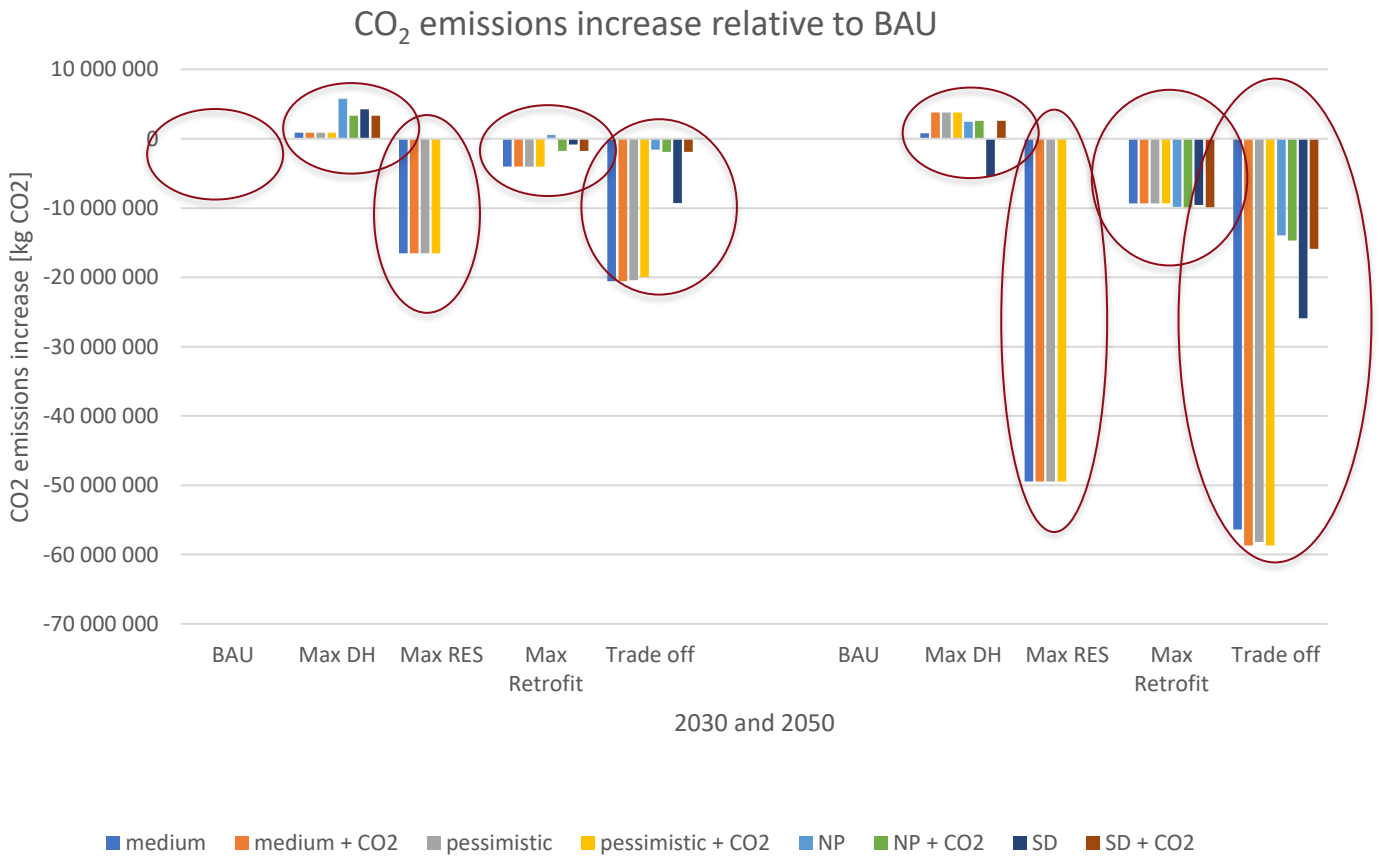
2050 Trade off investments				
Measure	Italy medium	Italy pessimistic	New policies	Sustainable development
Solar photovoltaics [MW_{el}]	60	60	60	60
Accumulator [MWh]	0	0	0	0
Grid expansion [GWh]	223	223	188	188 (179)
Natural gas CHP [MW_{th}]	35 (22)	35 (22)	0	0
Biomass CHP [MW_{th}]	25 (0)	0	0	0
Yearly deep renovations [%]	1.5	1.5		1.5
Yearly shallow renovations [%]	0.0			0.0



Results – total system costs



Results – system CO_2 emissions effects



Conclusions

- Renovations are economically efficient at reducing CO_2 emissions
- Expanding the district heating grid is economically beneficial, emissions decrease depends on what heat source is replaced
- Solar PV:s are an efficient way of reducing emissions, although grid effects have not been analysed

Thank you

Friendly Sam
https://friendly-sam.readthedocs.io/en/latest/

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