6th International Conference on Smart Energy Systems
6-7 October 2020
#SESAAU2020

Economic Viability of Flexibility Options for Smart Energy Systems With High Share of Renewable Energy

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MOTIVATION

- **Goals:**

1) High RES system
2) Low CO2 emissions
3) Low CEEP (high CF)
4) Low annual cost to current system
5) Limited biomass use

- **These requirements often not aligned**
- **Example: Focus on increasing the share of renewables while CF decreases**
- **Planning can involve optimization of use of various technologies, which is required in each step towards higher share of RES**

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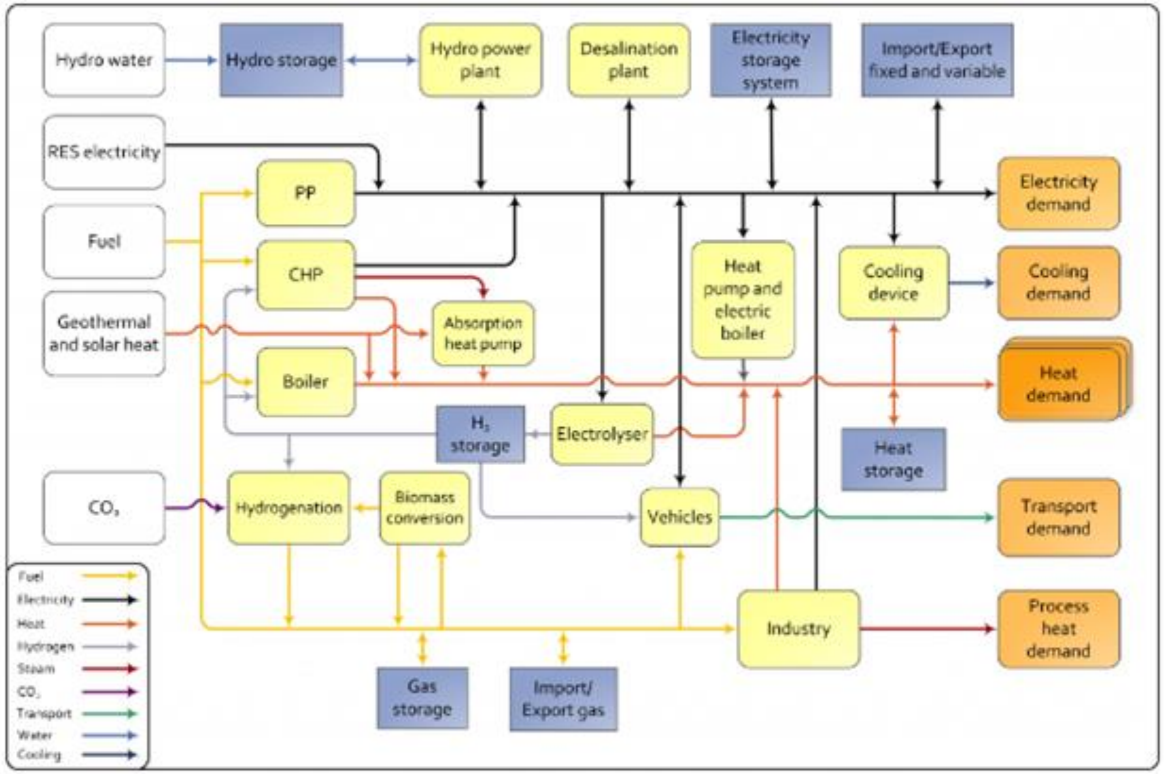
How to increase the share of RES?

- RES generating capacity:
  - Addition of wind, PV and run of river capacity, biomass share in the fuel mix of thermal power plants, solar district heating
- Flexibility options:
  - V2G, P2H, Power plant flexibility, demand flexibility, interconnections, etc.

Method - EnergyPLAN

- Energy system simulation and analysis software
- Required data: installed capacities, demand and distribution curves.
- Deterministic software – measurable influence of each variable variations on output values



EnergyPLAN, Aalborg University, https://www.energyplan.eu/

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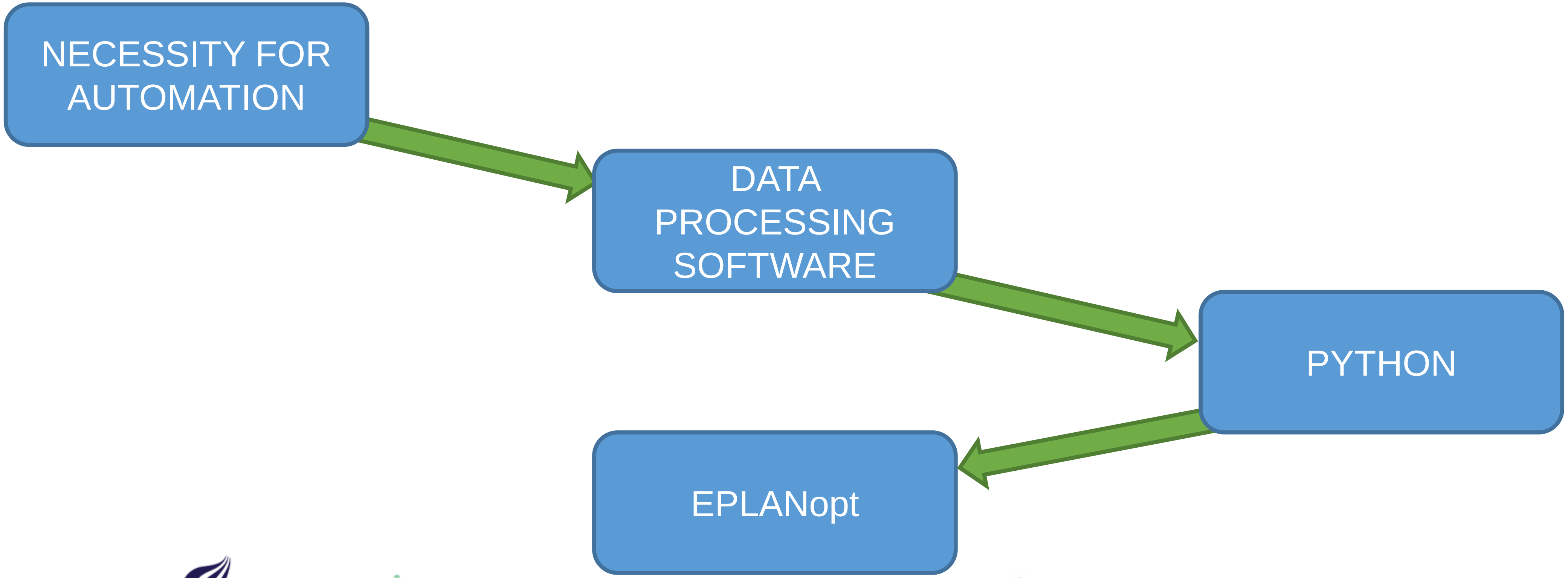
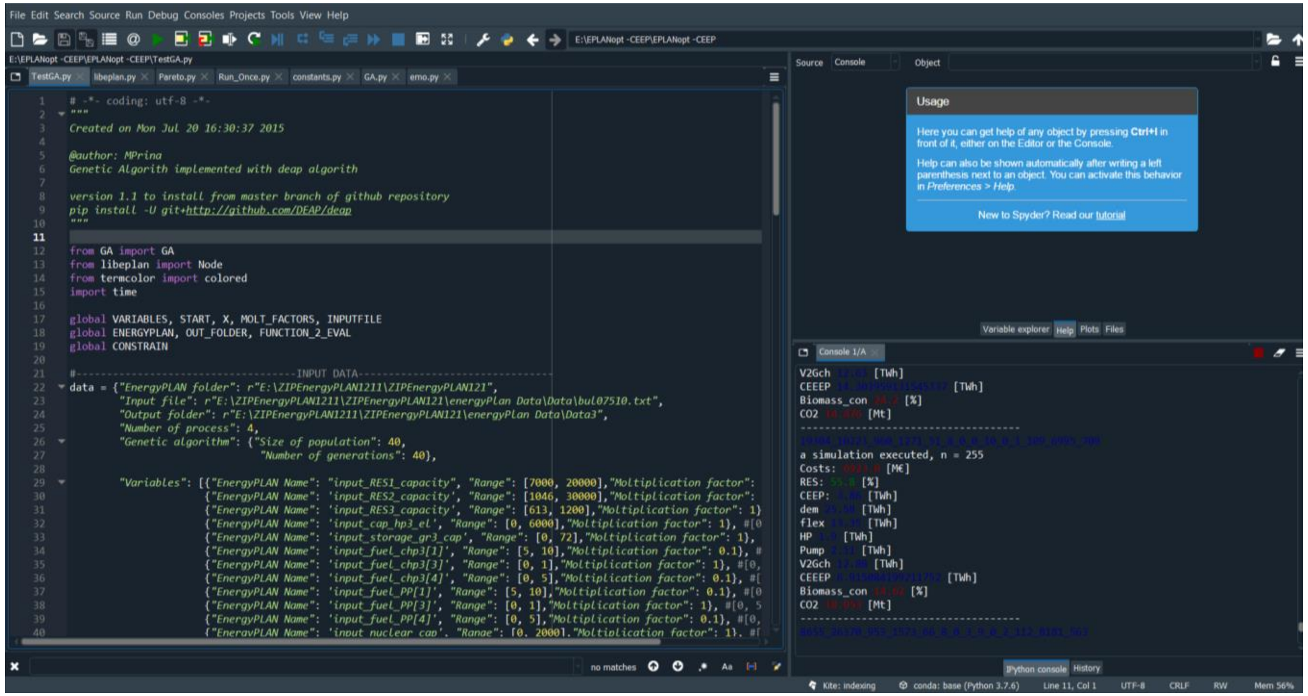
Method

- Necessity to run large number of simulations with slight variations in a short time span – automation



Method - EPLANopt

- Python and EnergyPLAN integration software
- Based on DEAP genetic algorithm
- Create set of inputs
- Set optimization targets for each of the variables (maximize or minimize)



EPLANopt, EURAC, https://gitlab.inf.unibz.it/URS/EPLANopt

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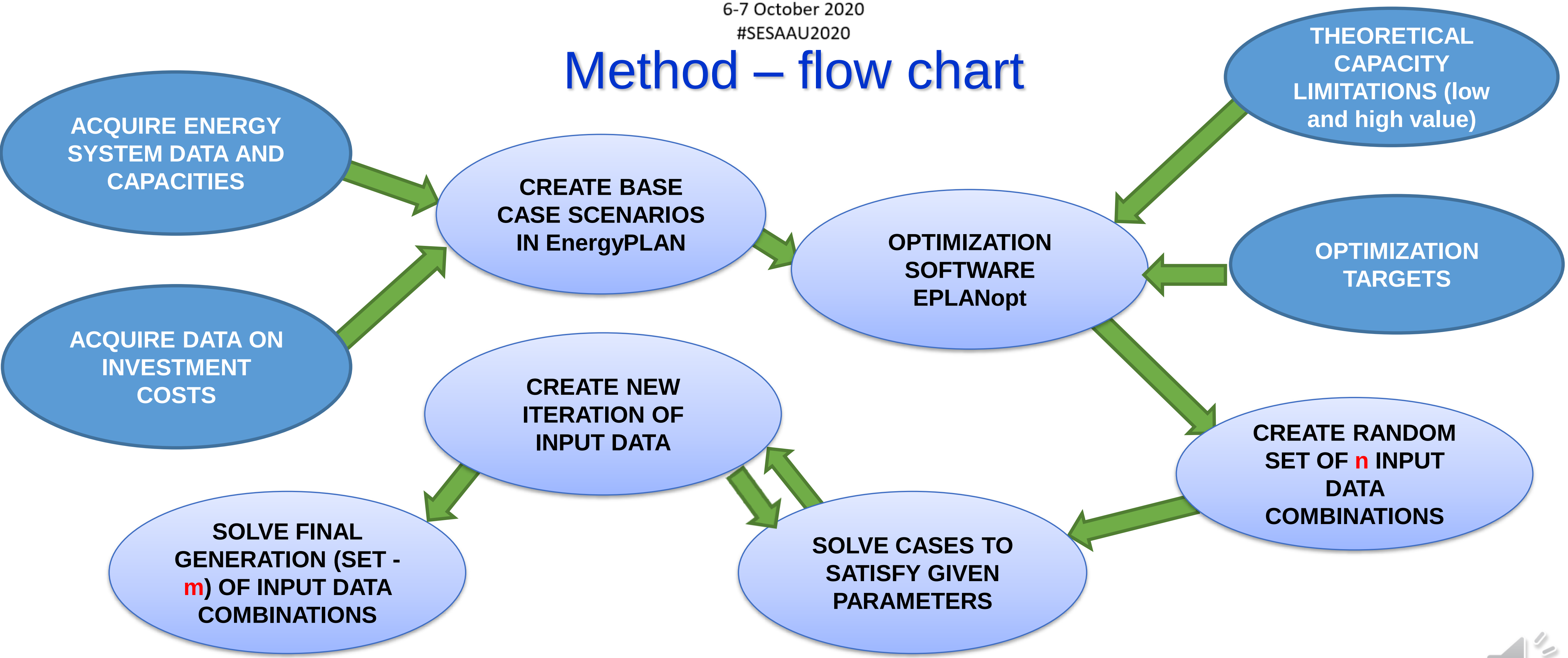
Method – flow chart



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Case study

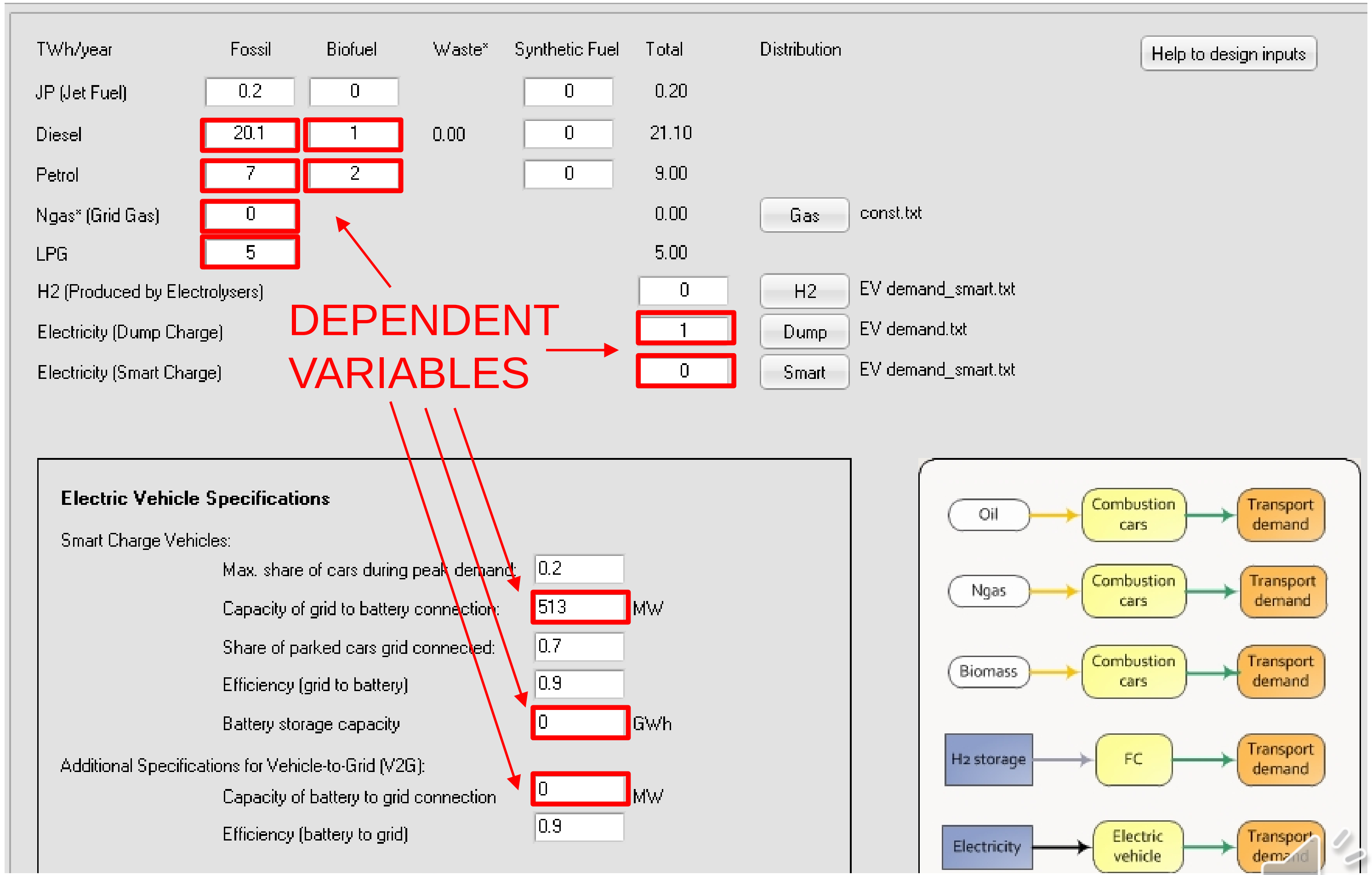
- Case of Bulgarian energy system model
- Proof of concept
- Available data for detail energy model in EnergyPLAN
- 2030 NECP

Considered technologies

- Electricity generating technologies
- Industry electrification
- Heat generating technologies
- Flexibility options

Modeling other variables

- No single value defining variable
- Combination of manually predefined cases and EPLANopt
- V2G, demand flexibility, industry electrification



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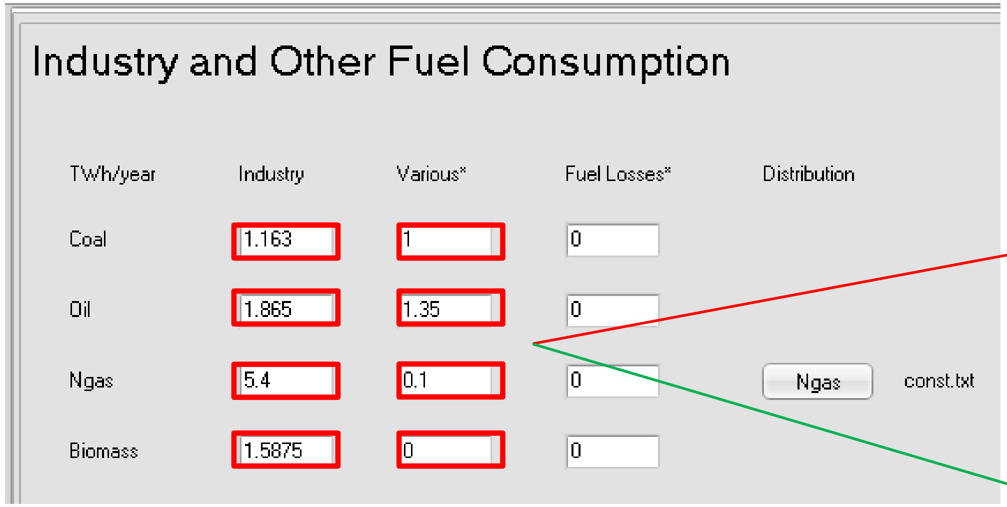

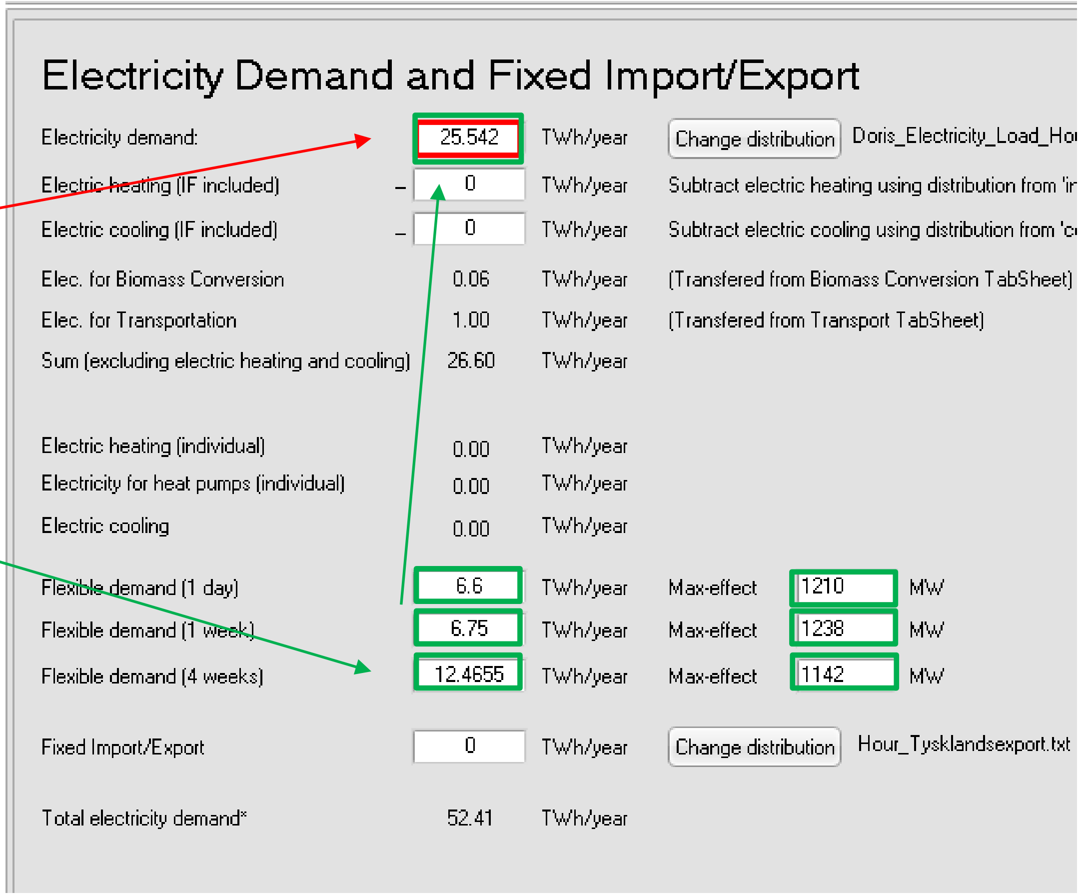

Dependent variables

-Demand flexibility

-Industry electrification

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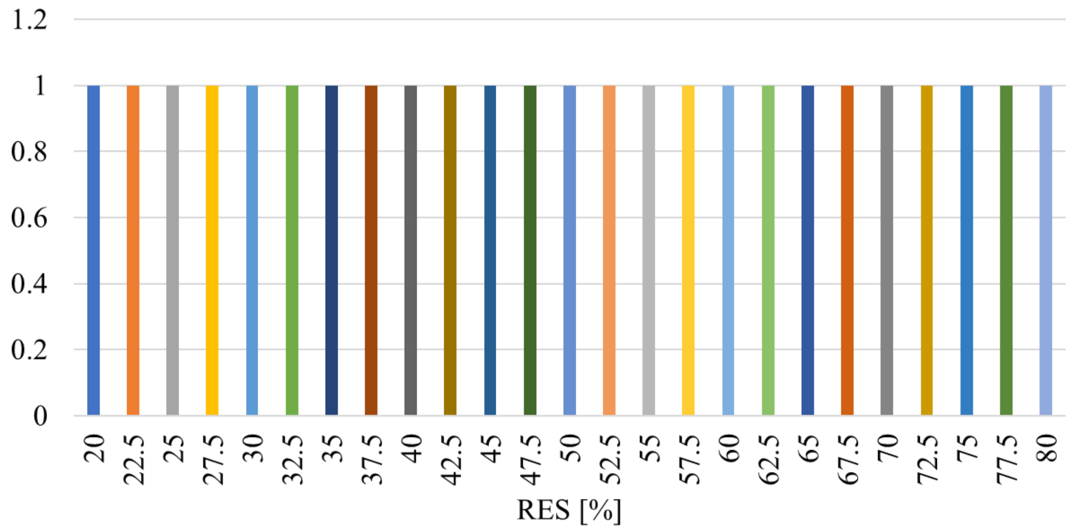
How to determine applicable technology at each RES segment?

- All results in the range from 20 to 80 % RES
- Area divided to 24 segments at 2,5 % range
- Average value for each technology for all segments
- Plot charts



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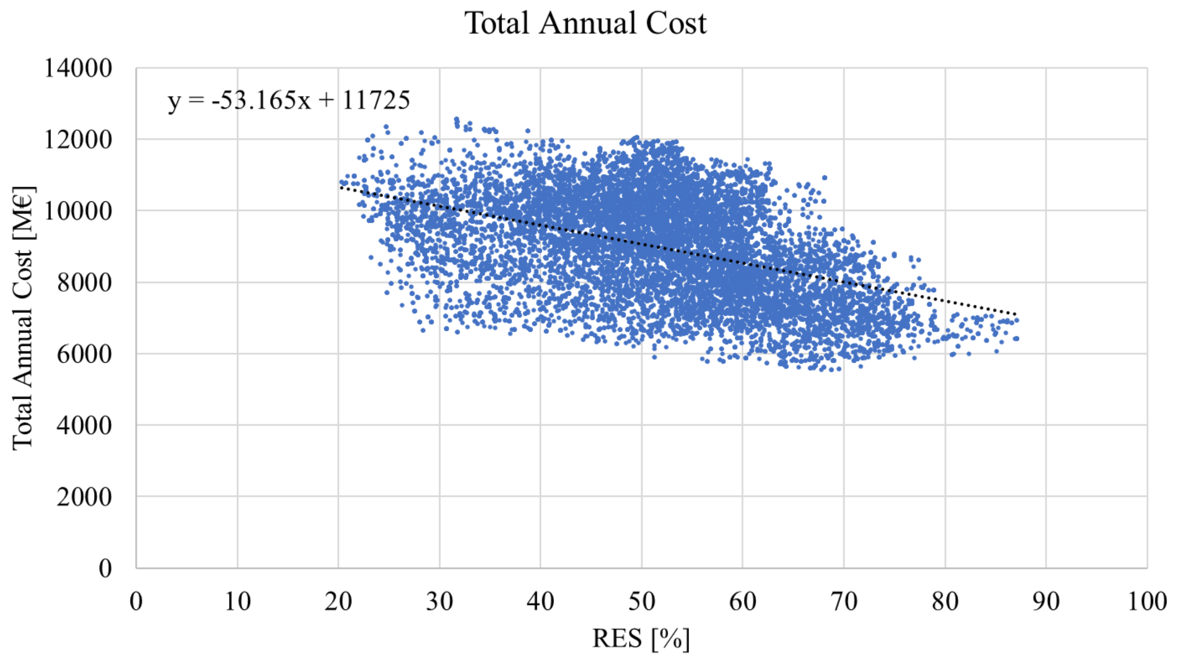
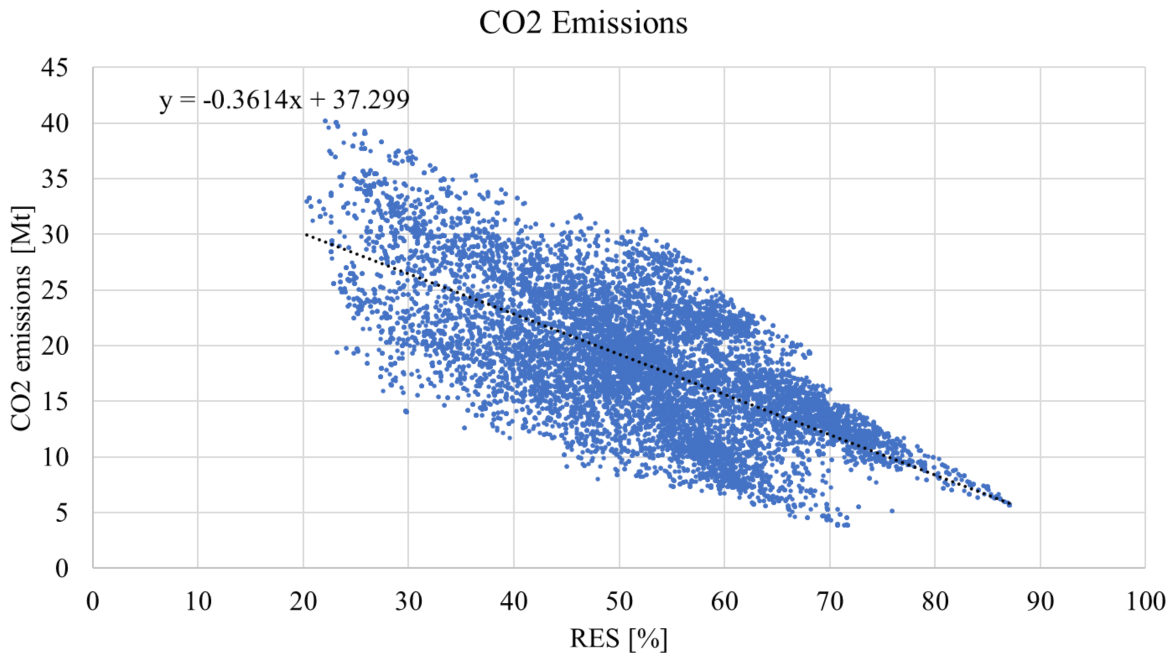
System limitations - EPLANopt

Name	Lower limit value	Higher limit value	Unit
Wind capacity	7000	20000	MW
PV capacity	1046	30000	MW
River capacity	613	1200	MW
P2H generating capacity	0	6000	MW
P2H storage capacity	0	72	GWh
Thermal power plant minimum operating power	0	800	MW
Coal in CHP	0.5	1	-
Natural gas in CHP	0	1	-
Biomass in CHP	0	0.5	-
Coal in PP	0.5	1	-
Natural gas in PP	0	1	-
Biomass in PP	0	0.5	-
Import/export capacity	3000	10000	MW
Industrial excess heat in DH	0	5	TWh
Solar energy in DH	0	5	TWh
Solar energy in individual heating	0	5	TWh

Results





Decrease from 11 B€ to 7 B€
Bulgaria 2019 - 10,2 B€

Decrease from 30 Mt to 5 Mt
Bulgaria 2018 – 58,6 Mt CO_2
(eurostat)

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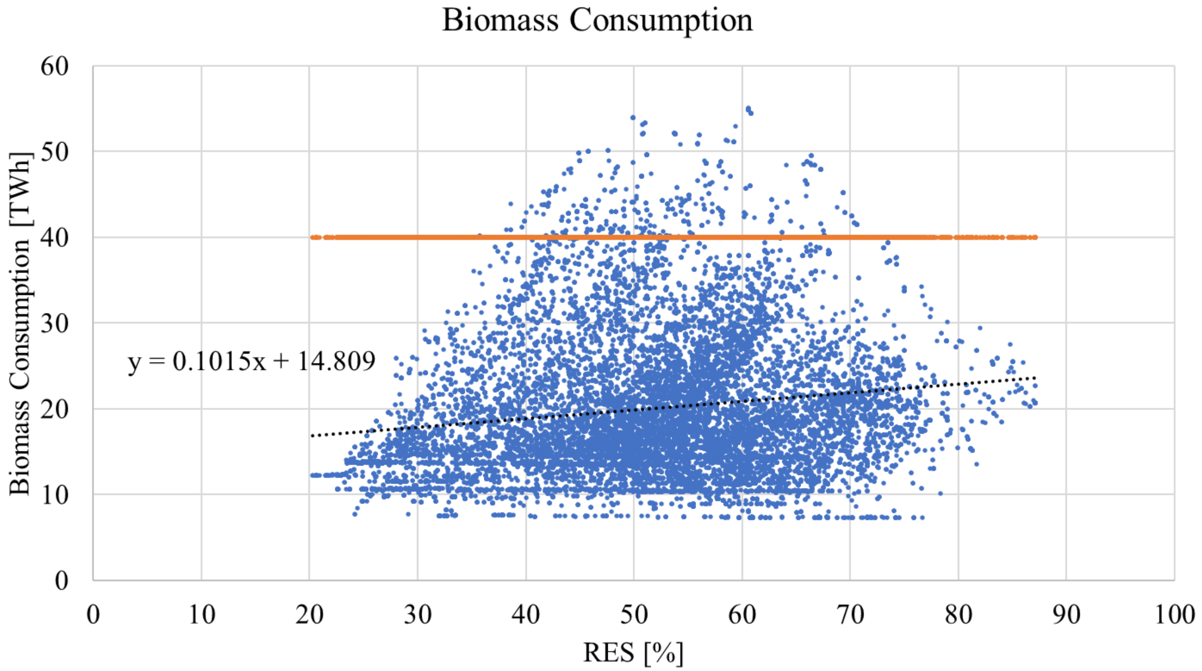
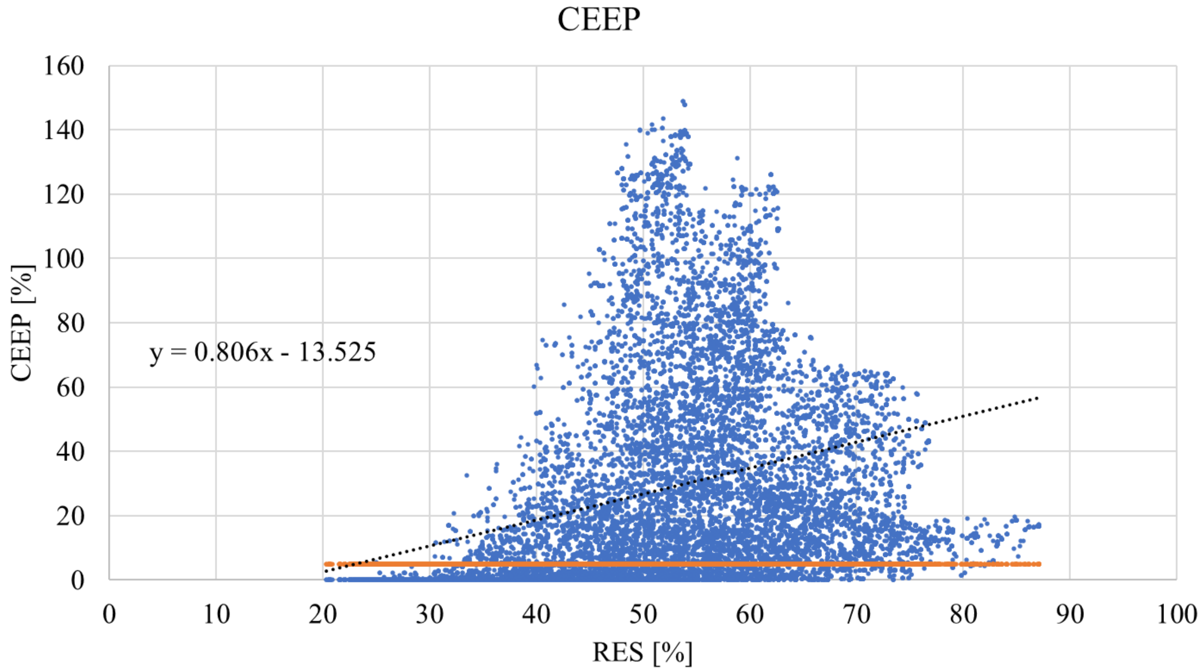
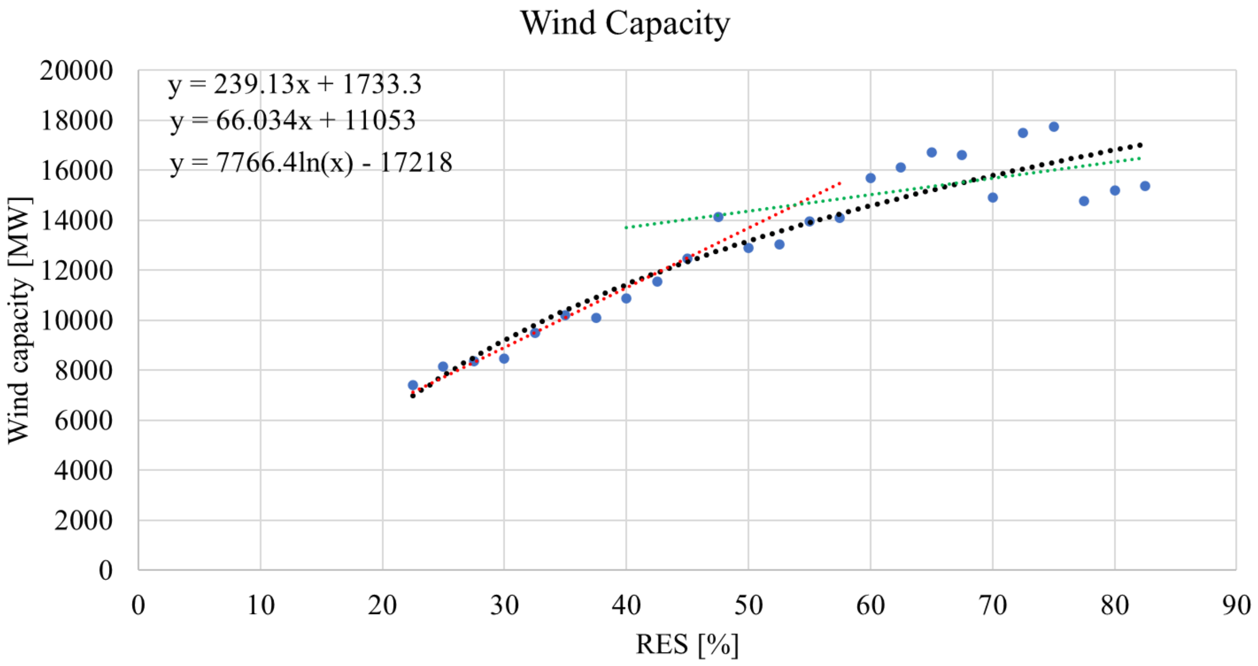


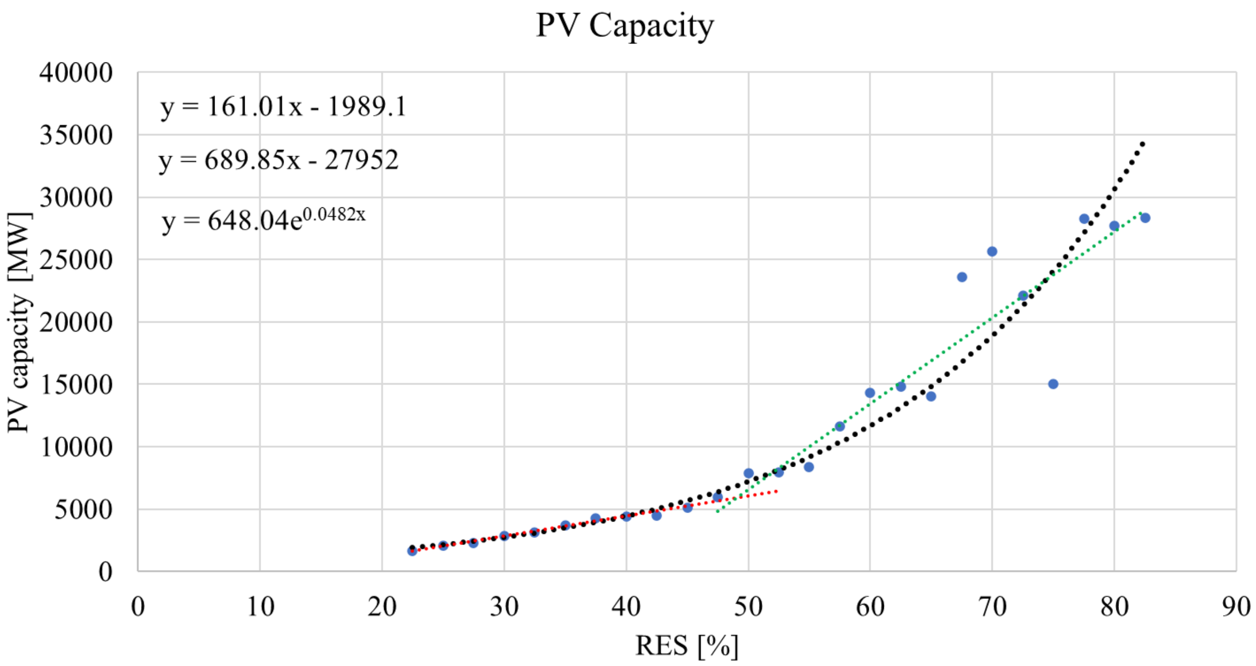


Limit biomass consumption < 40 TWh
7445 out of 8191 cases

Consider cases with CEEP < 5 %
8191 out of 24000 cases (34%)

Power generating technologies





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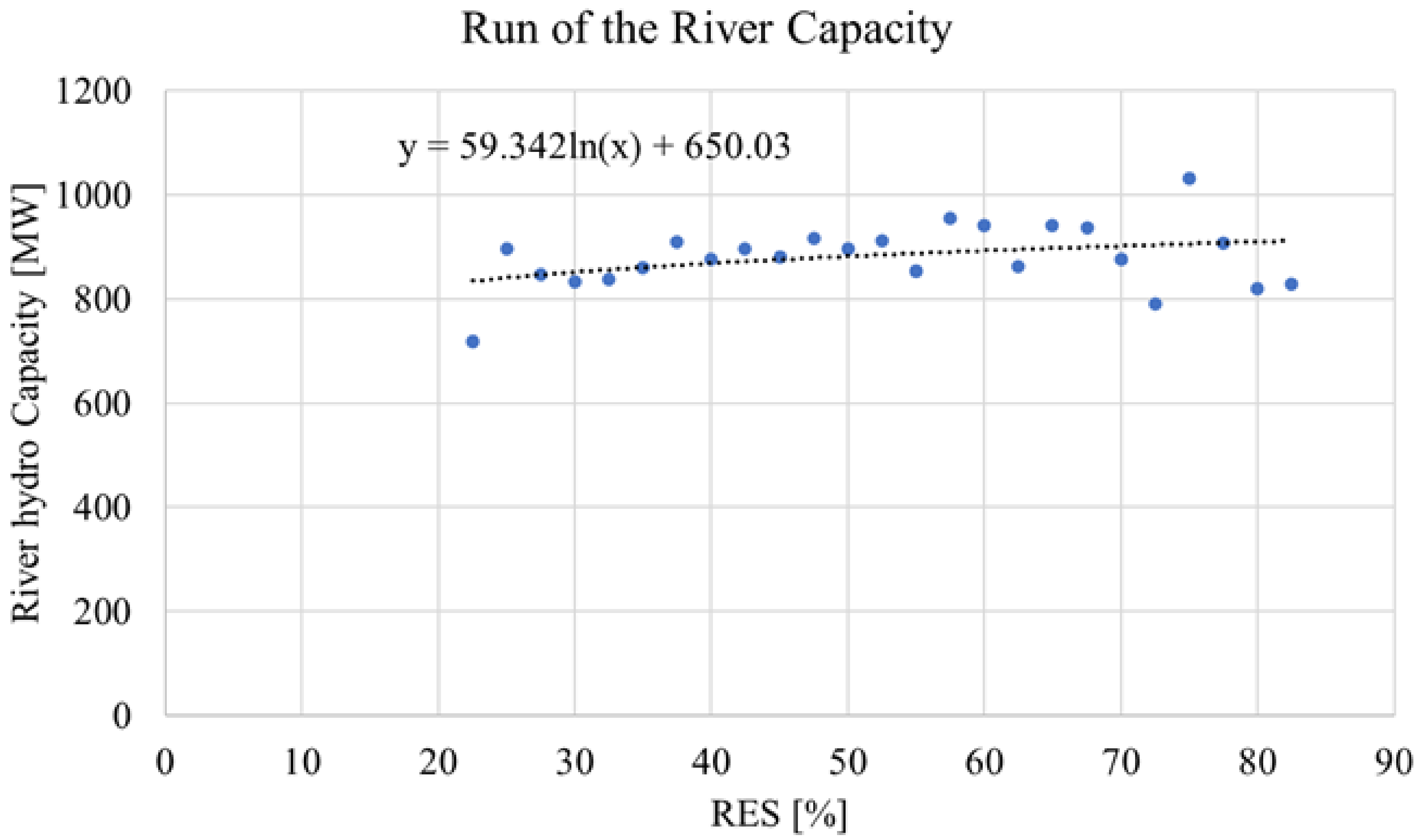
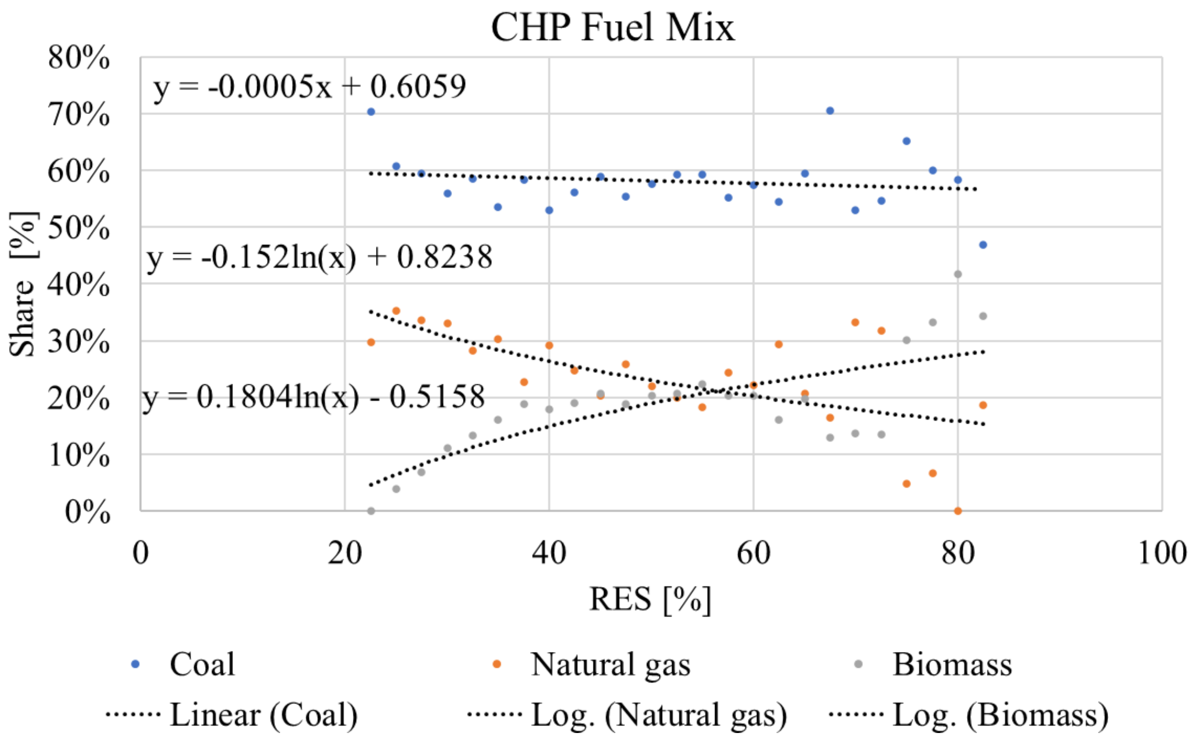
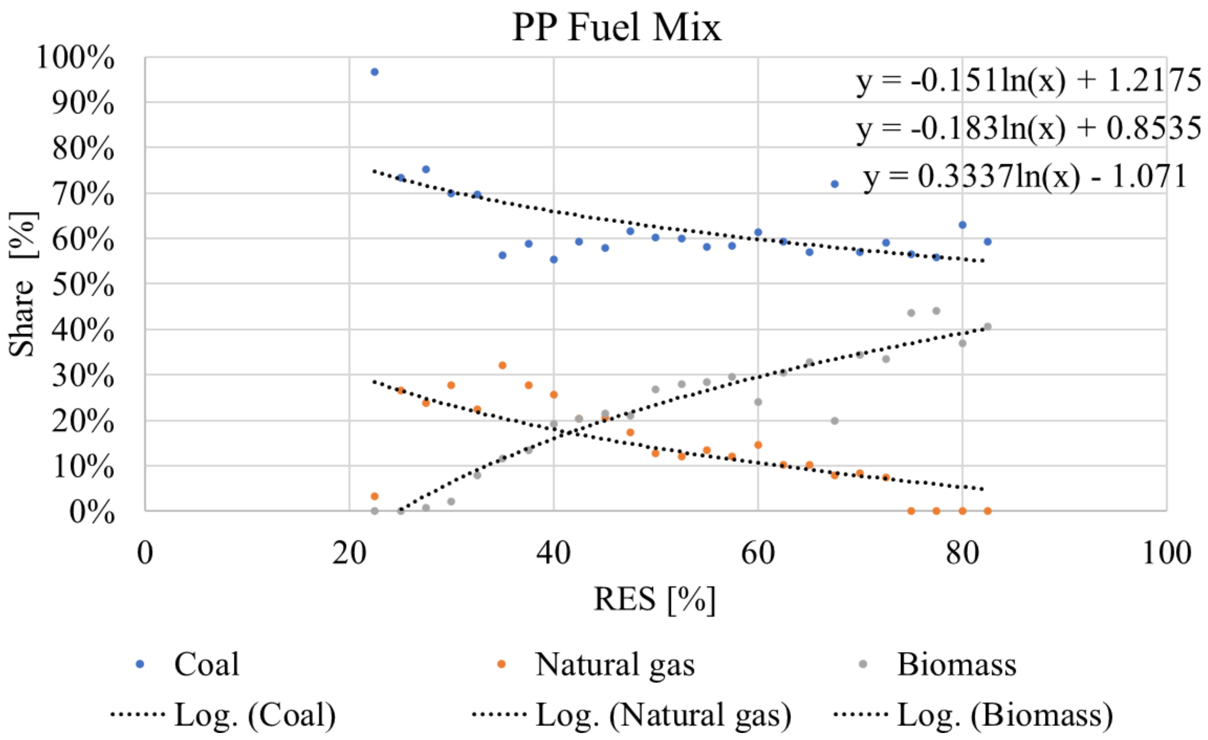

Run of the River Capacity
y = 59.342ln(x) + 650.03
River hydro Capacity [MW]
RES [%]
0
200
400
600
800
1000
1200
0
10
20
30
40
50
60
70
80
90

Thermal power plant fuel mix





Coal
Natural gas

Biomass

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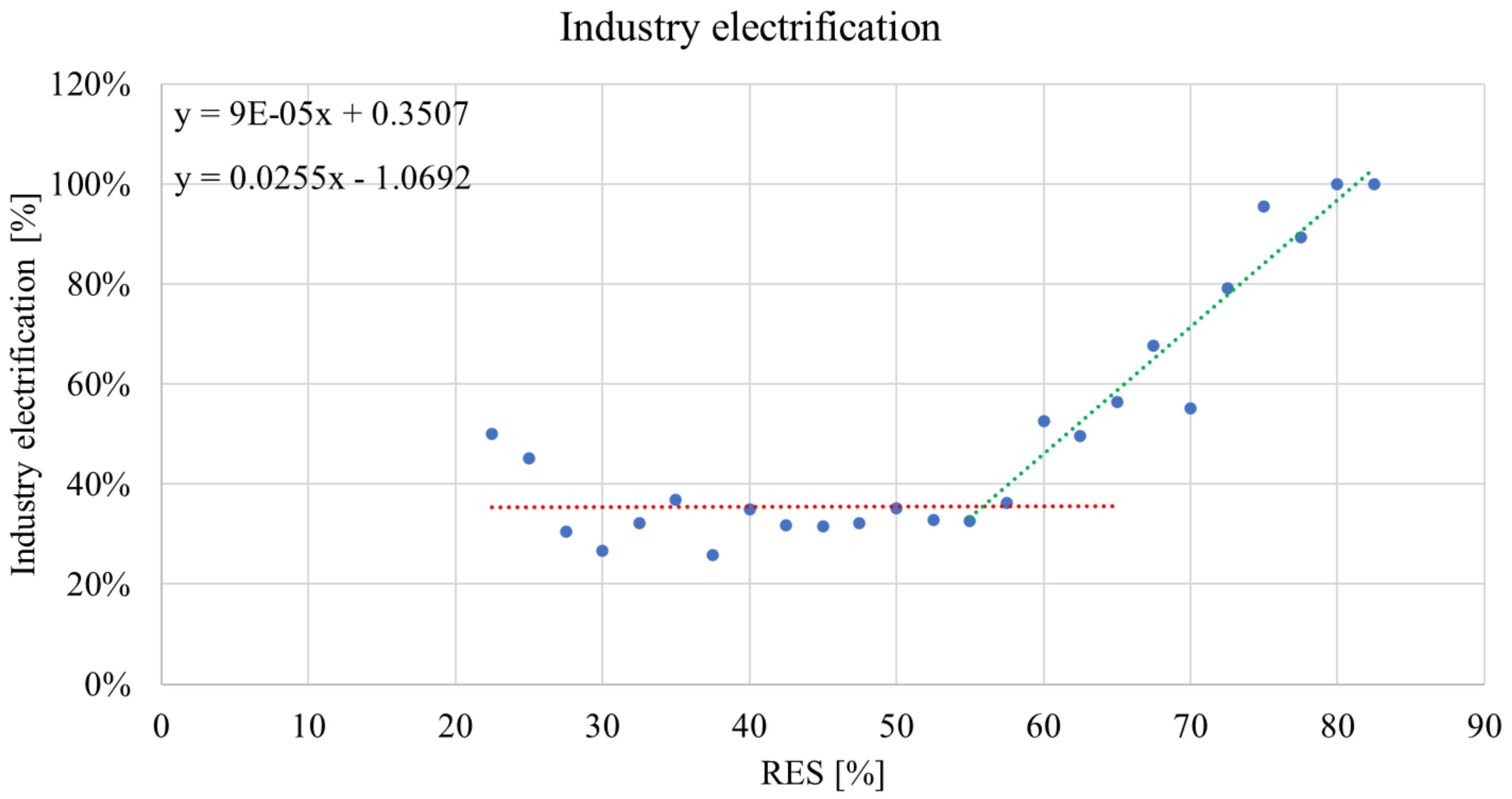
Industry electrification



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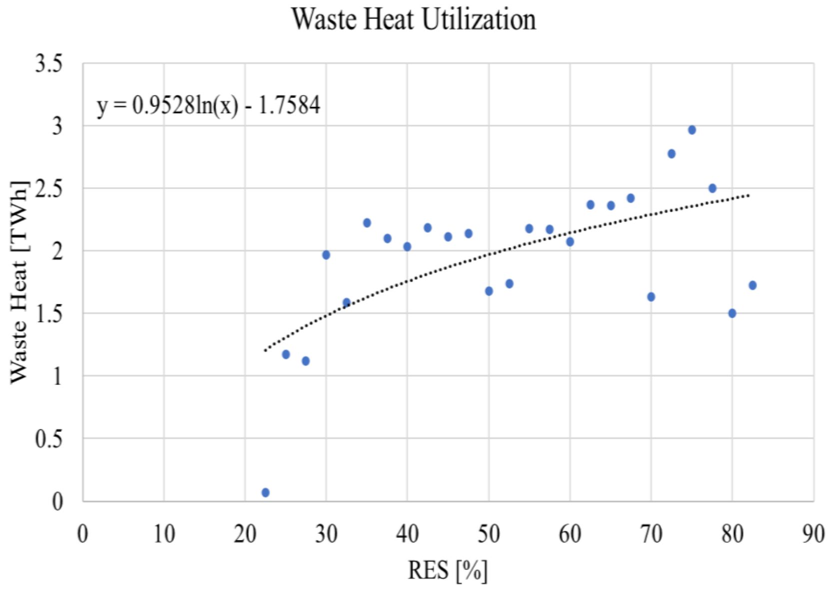
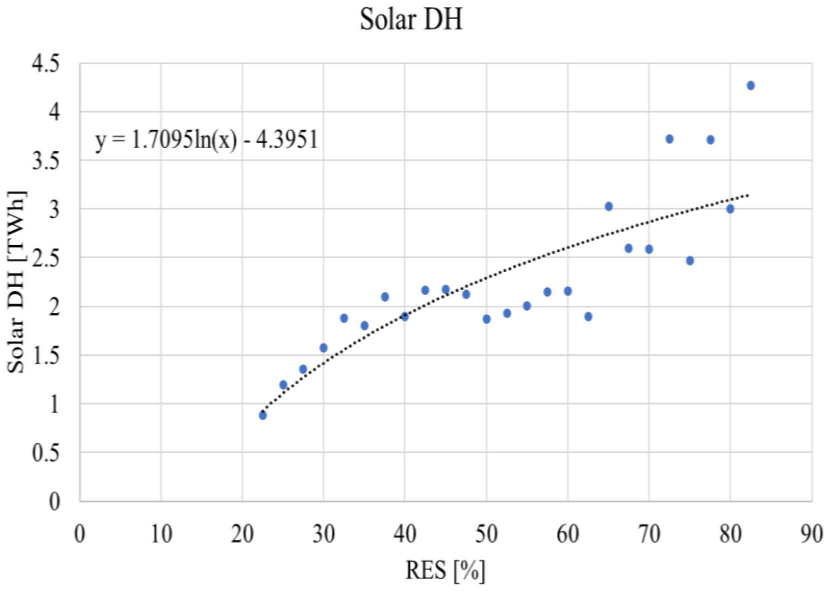
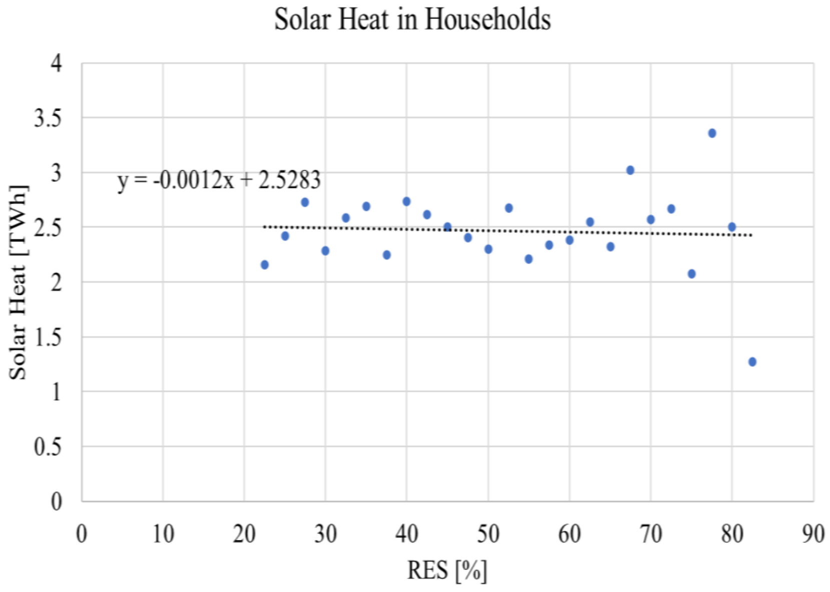
Heat generation







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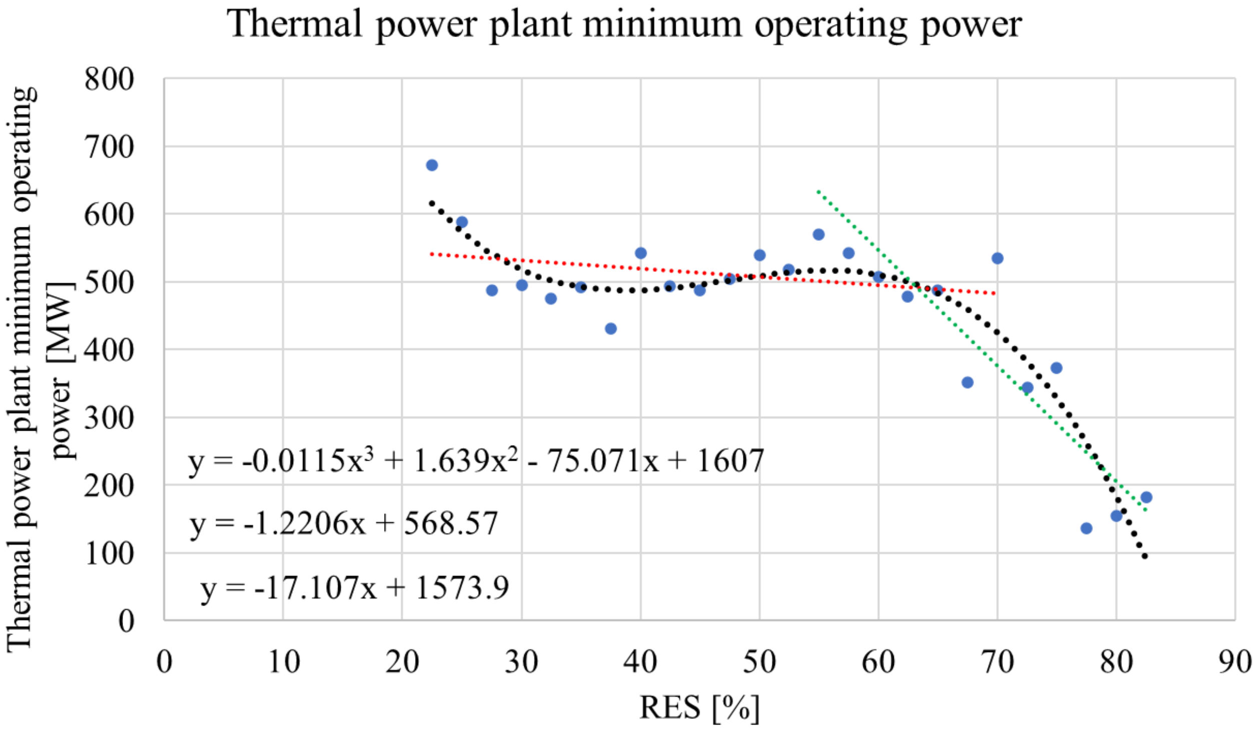
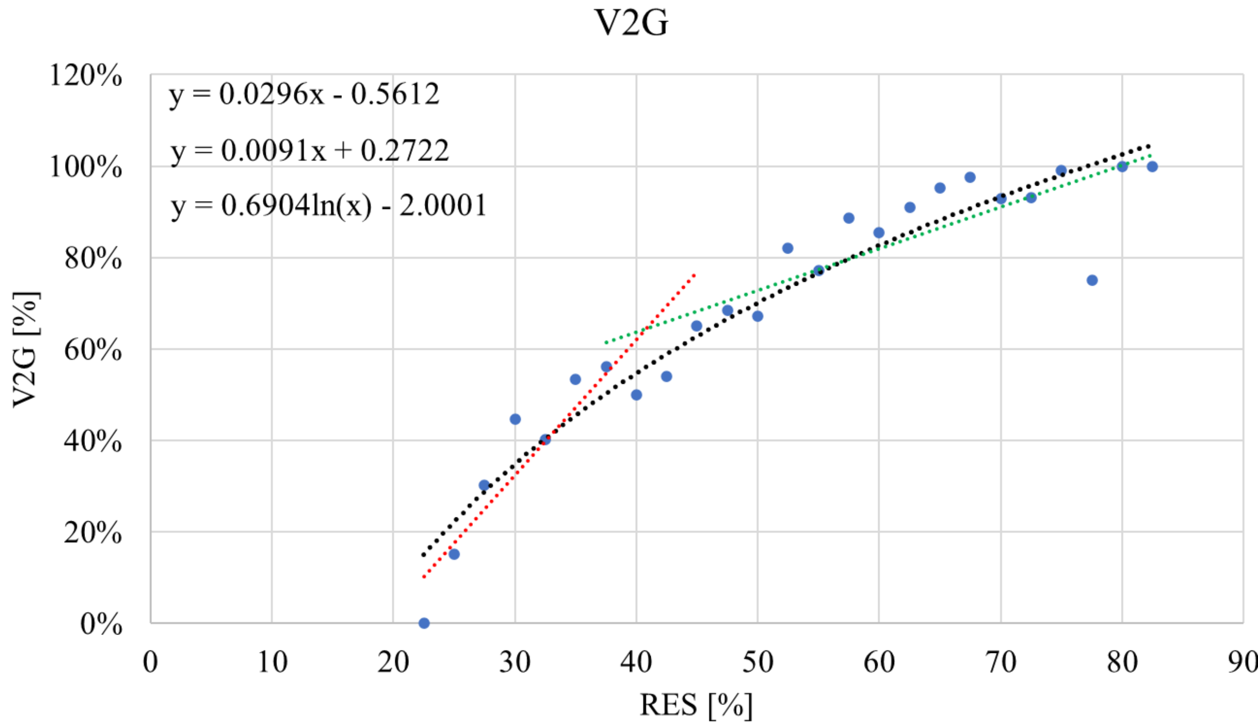
Flexibility options





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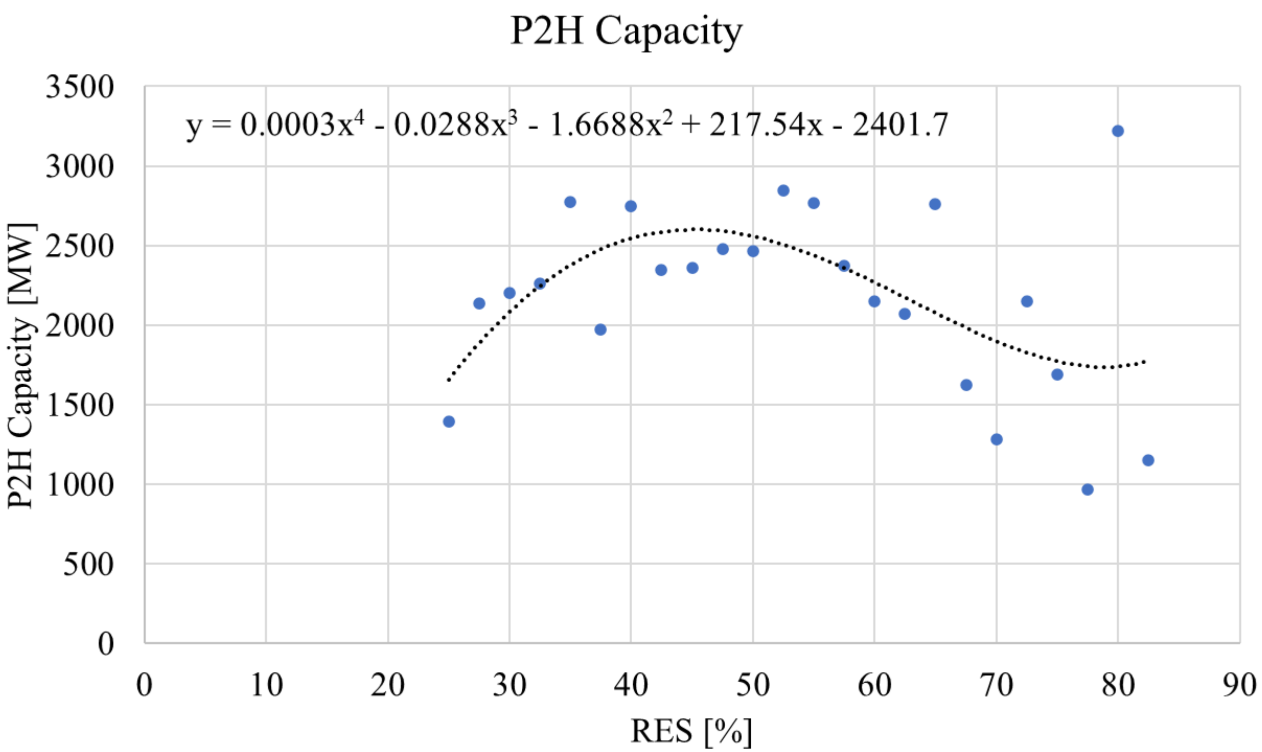

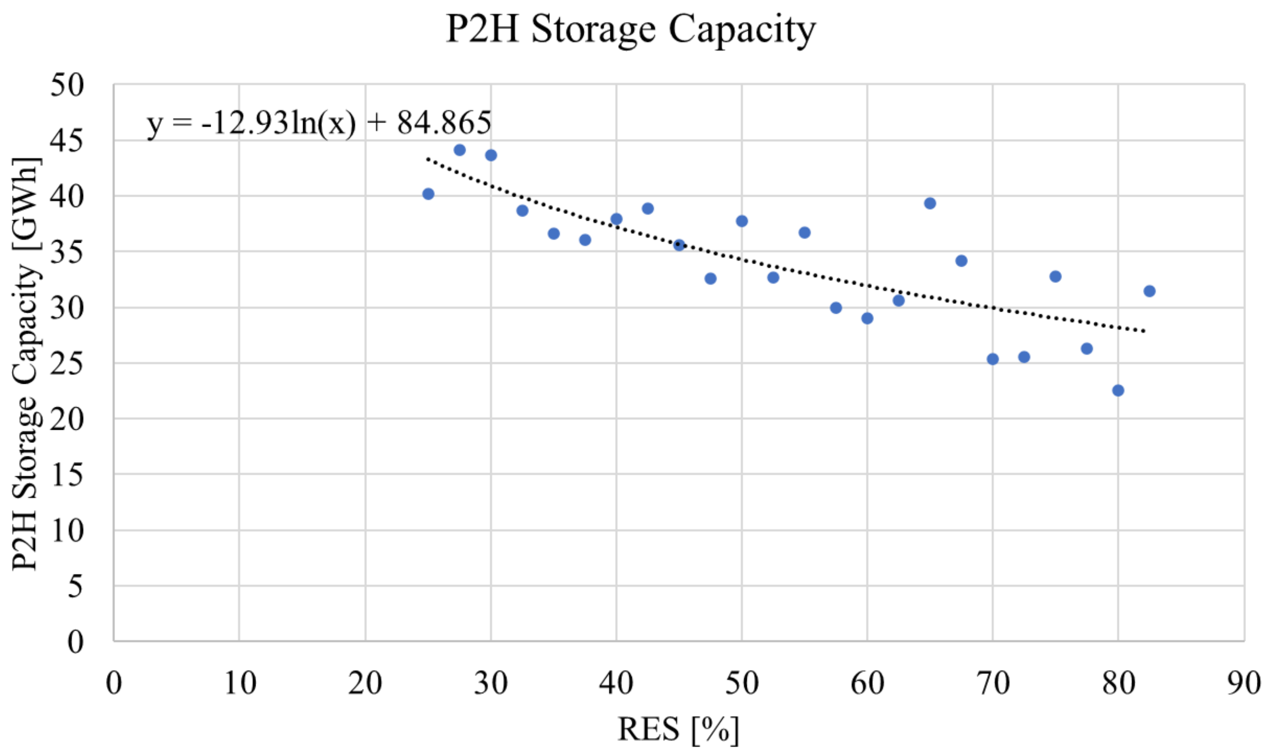

- Better at lower RES shares
- Competition with industrial excess heat and solar DH

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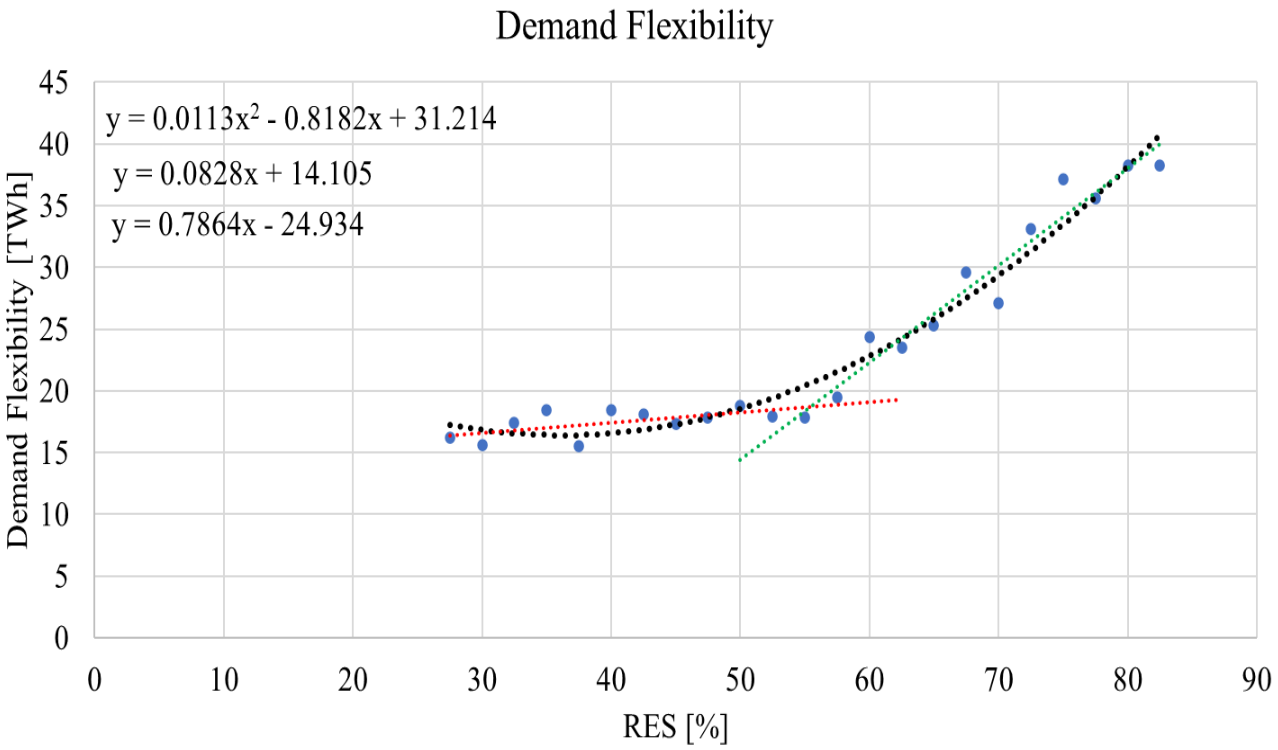

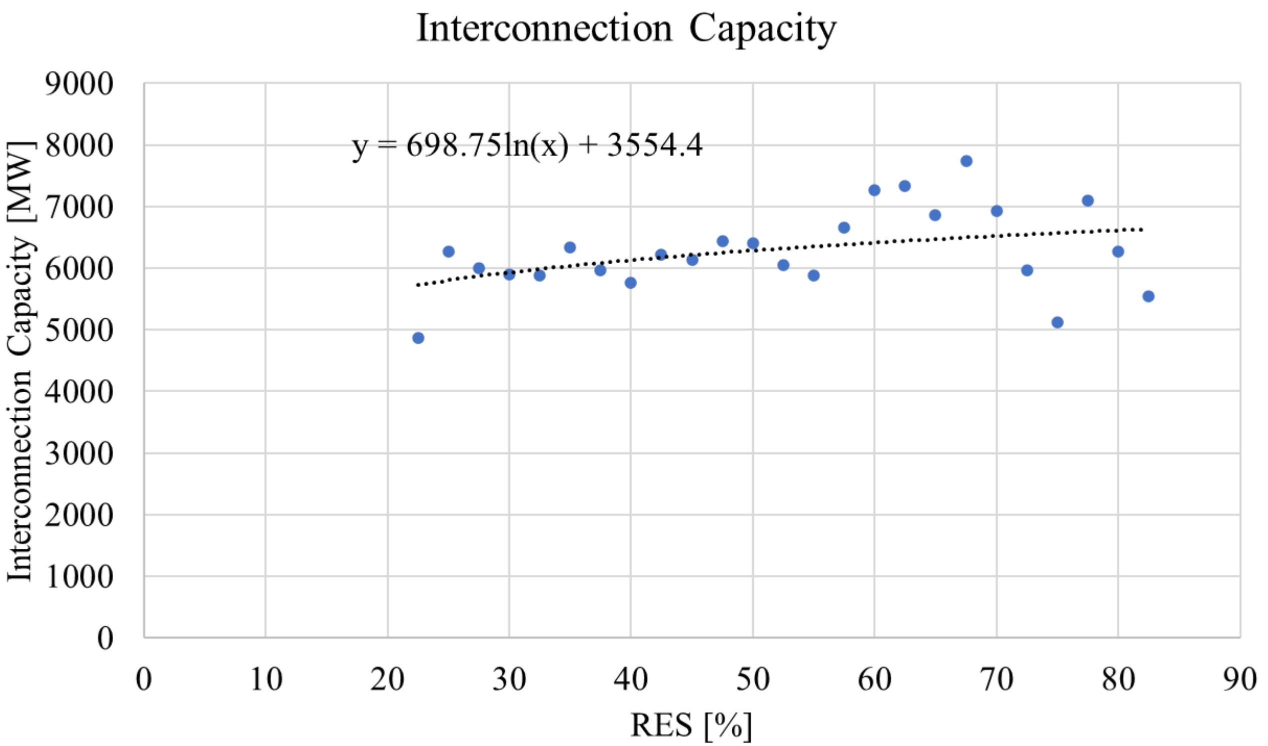

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Conclusions

- Significant reduction in Total annual cost with application of optimization
- Reduction of CO_2 emissions
- Minimization of CEEP
- Best results – V2G and PPmin for the whole RES range
- Industry electrification and demand flexibility effective at high RES share
- Further work:
  - implement linking of dependent variables
  - more detail analysis at higher RES shares
  - include other features (synthetic fuels, hydrogen)

LOCOMOTION

Low-carbon society:
An enhanced modelling tool for the transition to sustainability

Thank you very much for your attention!

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