Complementary between Combined Heat and Power systems, solar PV, and hydropower at district level: Application to the North Eastern Alps

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BACKGROUND

- The advantages of using Combined Heat-Power system (CHP):
  - Able to produce heat and electricity simultaneously
  - Have high-efficiency system
- Heat produced by CHP supplies the heat demand. Thus, **electricity from CHP is driven by heat demand following the variability of seasonal temperature**.
- We investigate **how the electricity from CHP combines with electricity produced by solar photovoltaic (PV) and Run-of-river hydropower (RoR)** that are also driven by weather variables (i.e. solar radiation, temperature, and precipitation).
- The combination of three sources follows the scenario of **100% renewable mix**, which is generation equals demand over the study period, **in several climate gradients from snow-dominated to rain-dominated areas**.

STUDY AREA

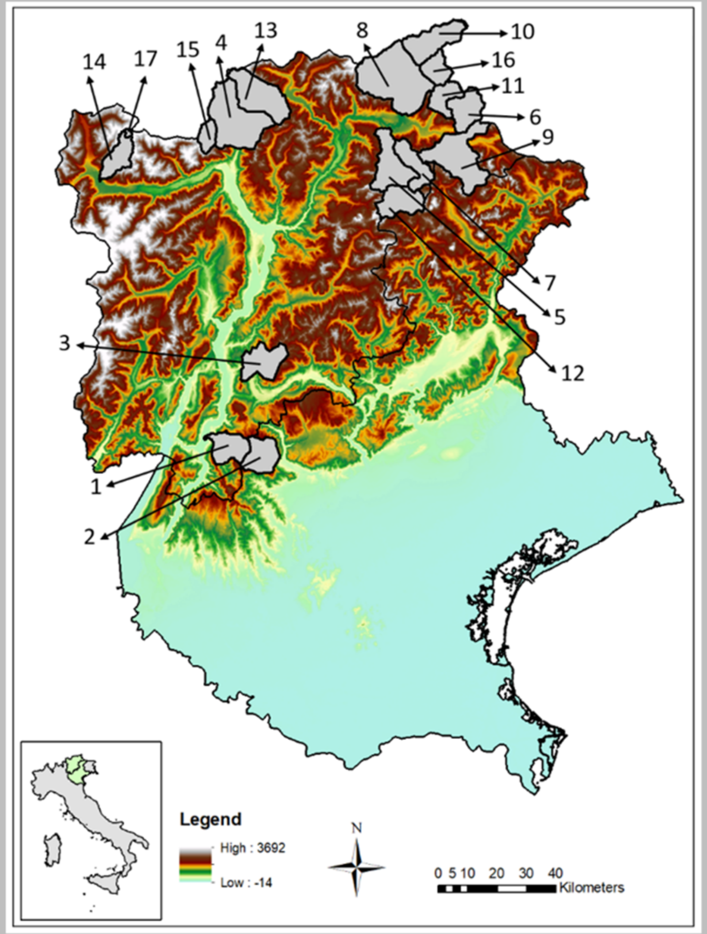


Figure 1. The location of 17 basin in Trentino-Alto Adige and Veneto Region of Italy where we analyze the nexus of PV-RoR-CHP at district level

No	Basin Name	Mean elevation	S/P ratio
1	Leno	1139.5	0.16
2	Posina Stancari	1268.0	0.20
3	Fersina	1373.5	0.21
4	Passirio at Saltusio	1850.5	0.35
5	Gadera at Mantana	1882.5	0.36
6	Casies at Colle	1969.0	0.37
7	San Vigilio at Longega	1990.5	0.37
8	Aurino at San Giorgio	2077.5	0.48
9	Rienza at Monguelfo	2087.5	0.48
10	Aurino at Cadipietra	2156.0	0.52
11	Anterselva at Bagni	2161.5	0.59
12	Rio Gadera	2170.0	0.63
13	Ridanna at Vipiteno	2171.0	0.64
14	Mazia at Adige	2309.5	0.72
15	Plan at Plan	2447.0	0.73
16	Riva at Seghe	2460.0	0.72
17	Mazia Glacierized	3116.0	0.86

Table 1. The detail of mean elevation and snow over precipitation ratio (S/P ratio) of 17 basins ranging from snow-dominated to rain-dominated regime

DATA AVAILABILITY

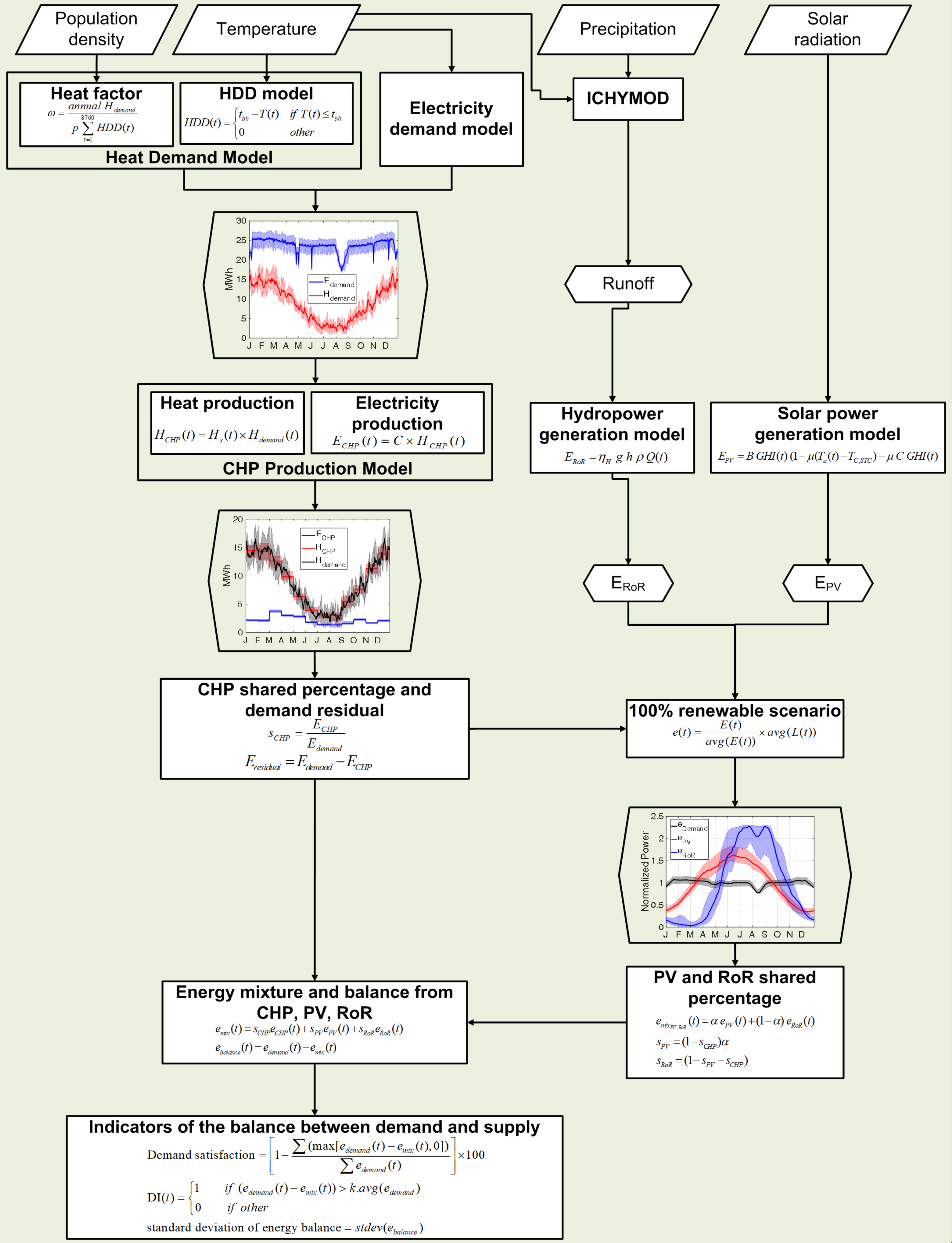
- Temperature and precipitation data on 2000 – 2011 are the observed data from rain gauges of Hydrographic Office of Trentino-Alto Adige and Veneto regions
- Solar radiation data is the Transetto radiation reanalysis data on 1992 – 2008, which is from the archive of EXPRESS-Hydro database
- Thus, **the analyses period in this study is on 2000 – 2008**.

REFERENCE

Ashfaq, A., Kamali, Z. H., Agha, M. H. and Arshid, H. (2017) 'Heat coupling of the pan-European vs. regional electrical grid with excess renewable energy', *Energy*, 122, pp. 363–377. doi: 10.1016/j.energy.2017.01.084.

François, B., Hingray, B., Borga, M., Zoccatelli, D., Brown, C. and Creutin, J.-D. (2018) 'Impact of Climate Change on Combined Solar and Run-of-River Power in Northern Italy', *Energies*. Multidisciplinary Digital Publishing Institute, 11(2), p. 290. doi: 10.3390/en11020290.

METHODOLOGY



RESULTS

1. How is the demand satisfaction when there is CHP?

Basin number	Demand satisfaction from 75% RoR and 25% PV	Demand satisfaction from the combination of CHP, PV, and RoR
2	73.62	75.84
5	71.54	74.50
14	63.49	68.53

Table 2. The change of demand satisfaction when CHP is included in the energy system compared to the system that has only 25% PV and 75% RoR

2. How are the changes of indicators and PV and RoR shared in all considered basins?

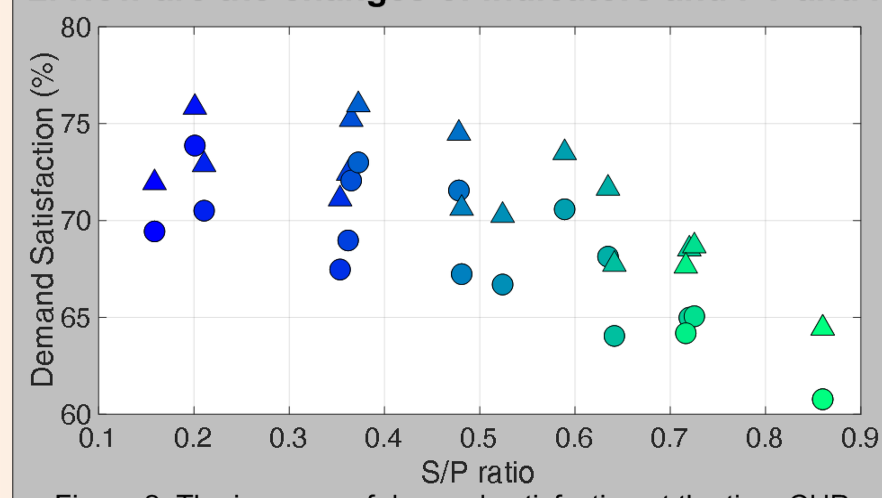


Figure 2. The increase of demand satisfaction at the time CHP that is able to supply 100% H_{demand} is available

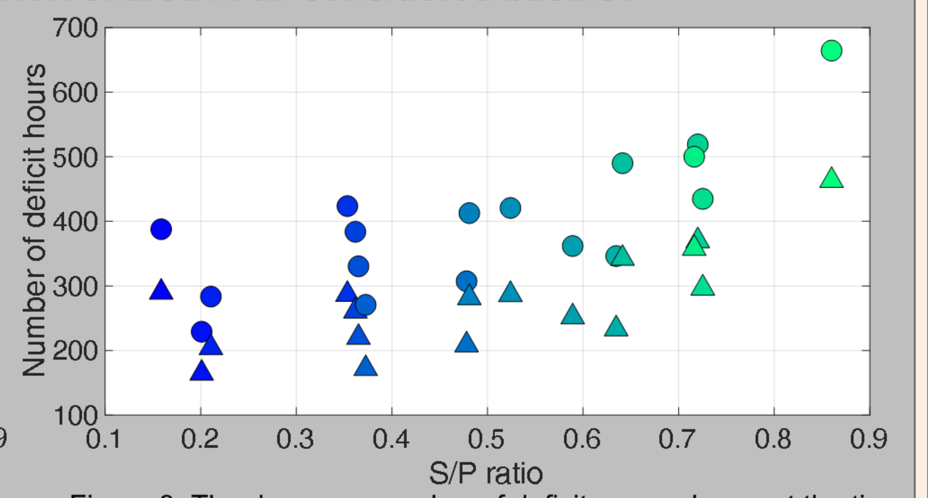


Figure 3. The decrease number of deficit energy hours at the time CHP that is able to supply 100% H_{demand} is available

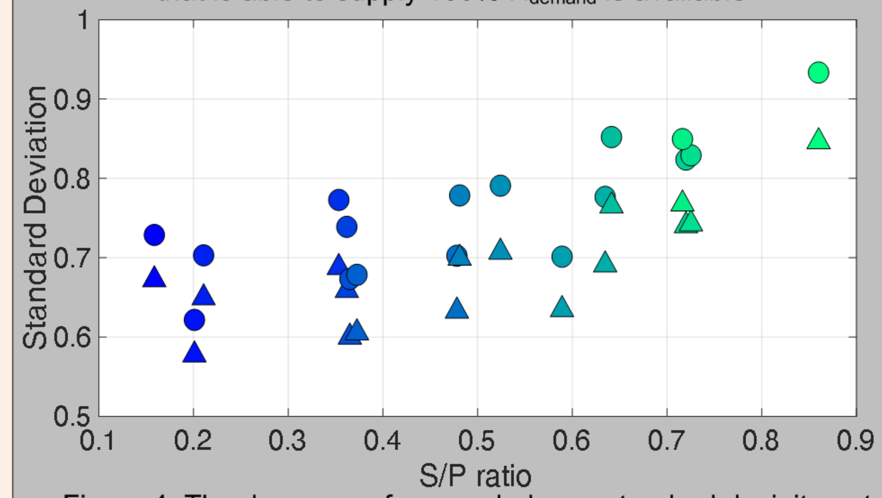


Figure 4. The decrease of energy balance standard deviaiton at the time CHP that is able to supply 100% H_{demand} is available

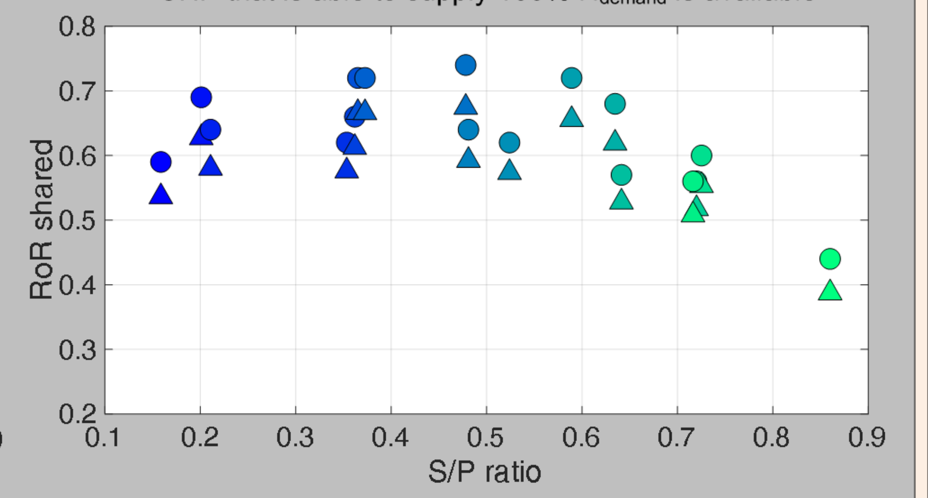


Figure 5. The change of of RoR shared at the time CHP that is able to supply 100% H_{demand} is available

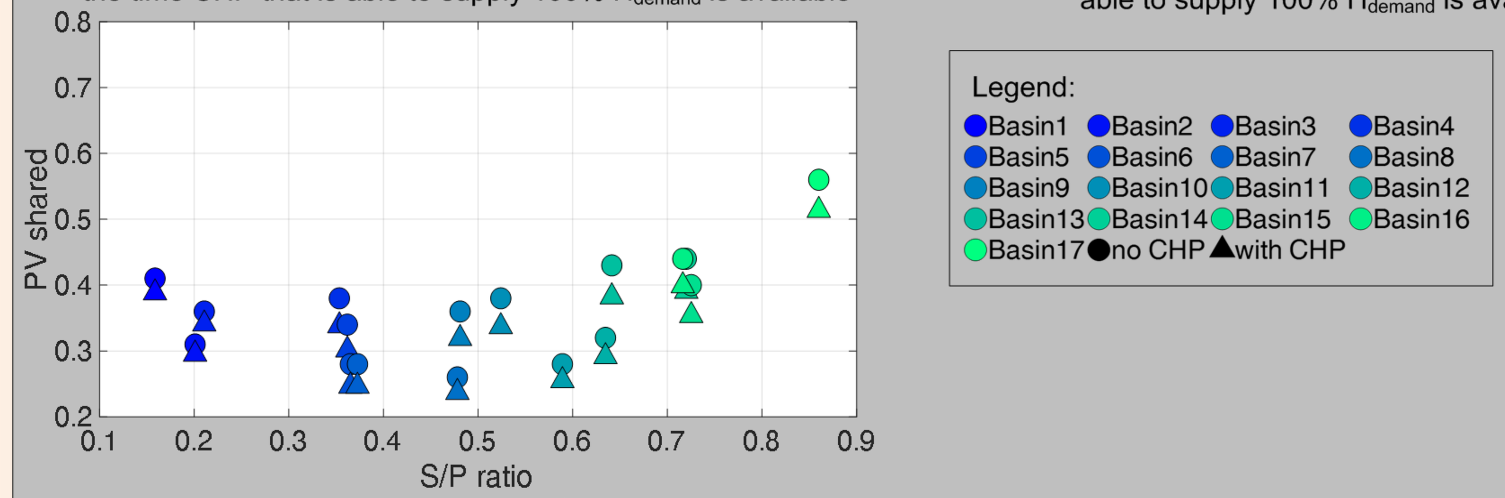


Figure 6. The change of of PV shared at the time CHP that is able to supply 100% H_{demand} is available

CONCLUSION

- Energy mixes that include CHP, in the system that has already had PV and RoR have **higher demand satisfaction, lower number of hours with extreme low generation, and lower variability of generation to supply the demand**
- The availability of CHP in the energy mix **modifies the optimal share between PV and RoR power generation**
- The changes in indicators and PV and RoR shared values caused by the availability of CHP in the energy system are **consistent in all hydro-climatic regimes**