International Conference on Smart Energy Systems and 4th Generation District Heating
Copenhagen, 25-26 August 2015

Smart energy systems applied at urban level: the case of the municipality of Bressanone-Brixen

AALBORG UNIVERSITY
DENMARK

4DH
4th Generation District Heating
Technologies and Systems

Introduction Case study - Bressanone

- North of Italy. Region: Trentino-Alto Adige
- 20,000 inhabitants
- Alpine climate
- Joined Covenant of Mayors in 2013
- Sustainable Energy Action Plan (SEAP) developed by EURAC

Study purpose

- Analyse current energy system including district heating network
- Study solutions to increase overall system efficiency
- Develop future scenarios with high PV penetration
- Compare different peak shaving methods: electric vs thermal storage
- **Best technology mix in terms of emissions and annual costs**

Methodology Reference scenario -assumption

The municipality is handled as a single node

↓

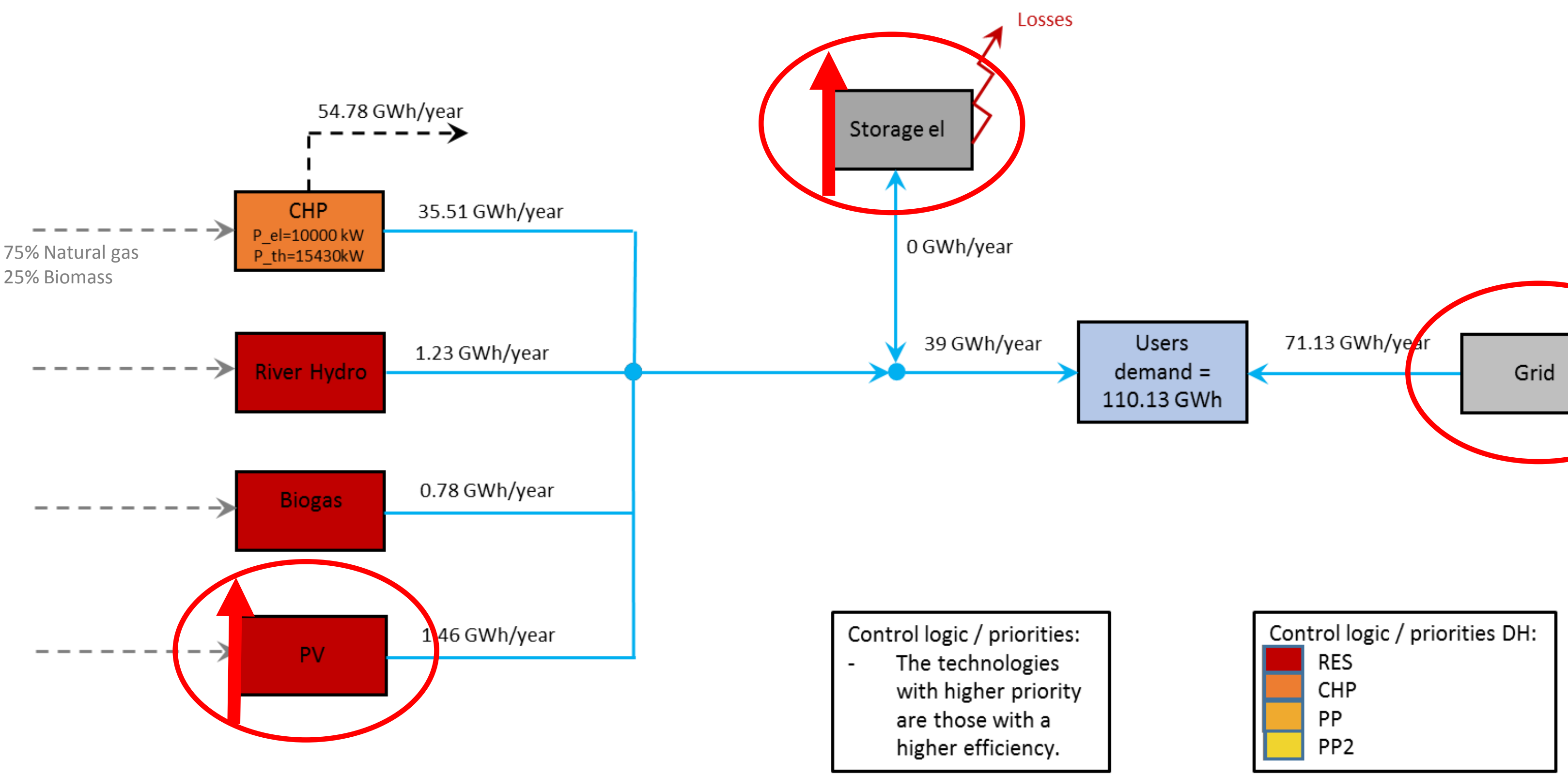
theoretical study

The use of grid balances production surplus and deficits, (hence reducing the need for storage in the future). However, there might be the situation in which the closest regions are in the same condition, with high photovoltaics (PV) electricity production during the central hours of the day

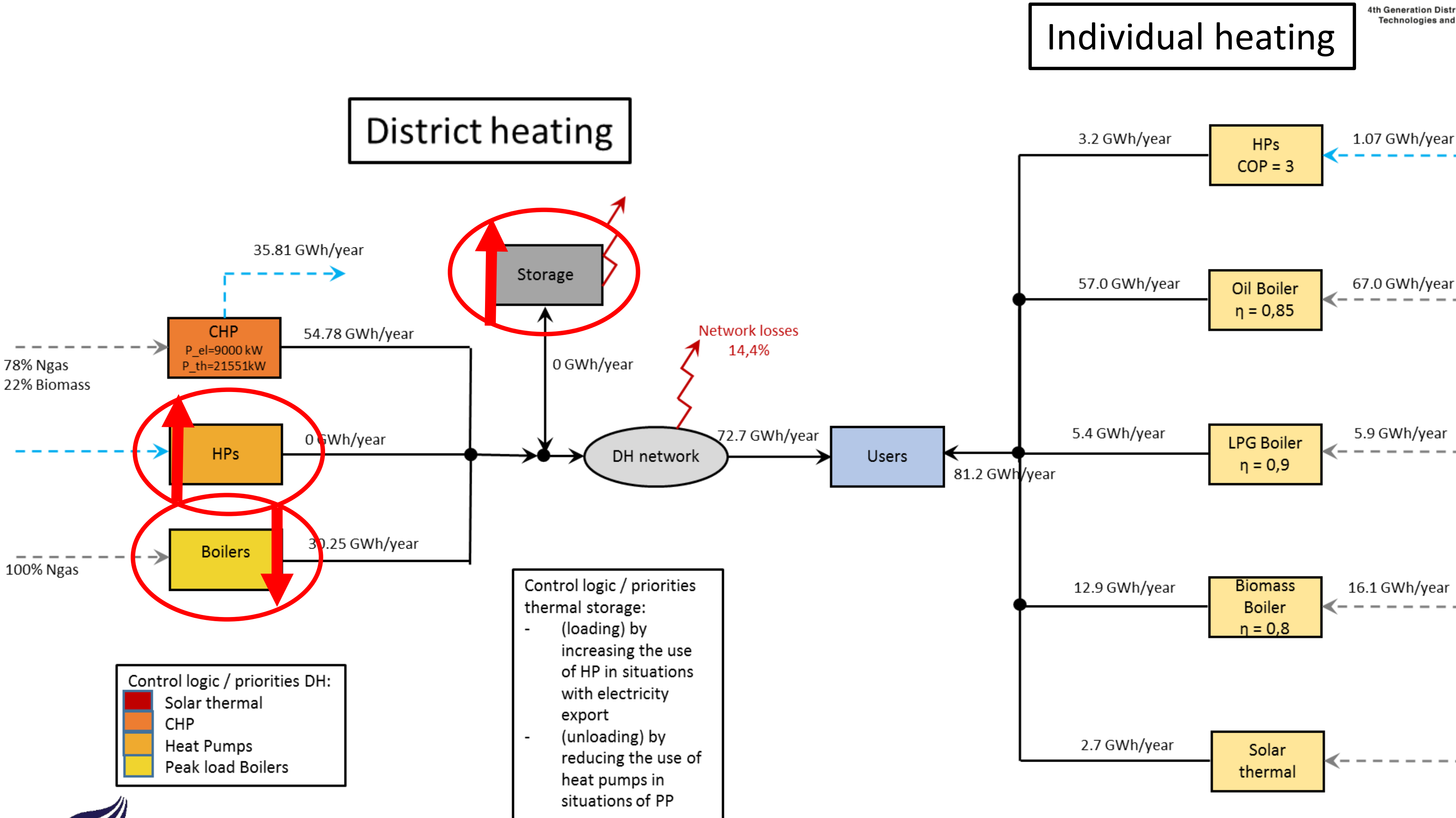
In order to achieve the objectives of the covenant of mayors the single municipalities have to carry out future scenarios studies and practical interventions to be more independent from the import and from the grid.

Storage systems required

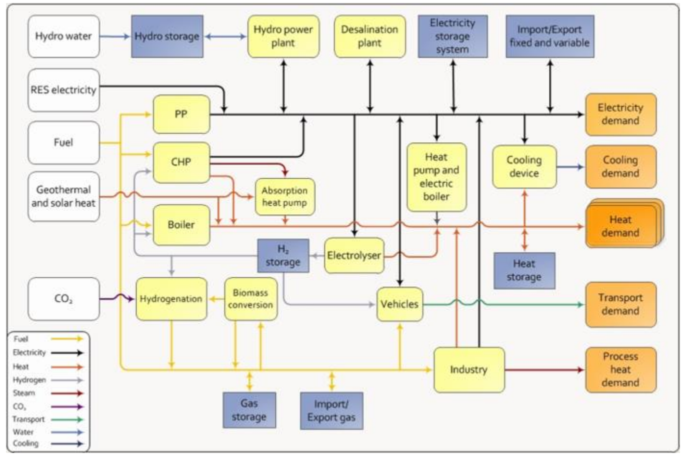
Methodology Reference scenario – electricity baseline



Methodology Reference scenario – heat baseline



Methodology Reference scenario - energyPLAN



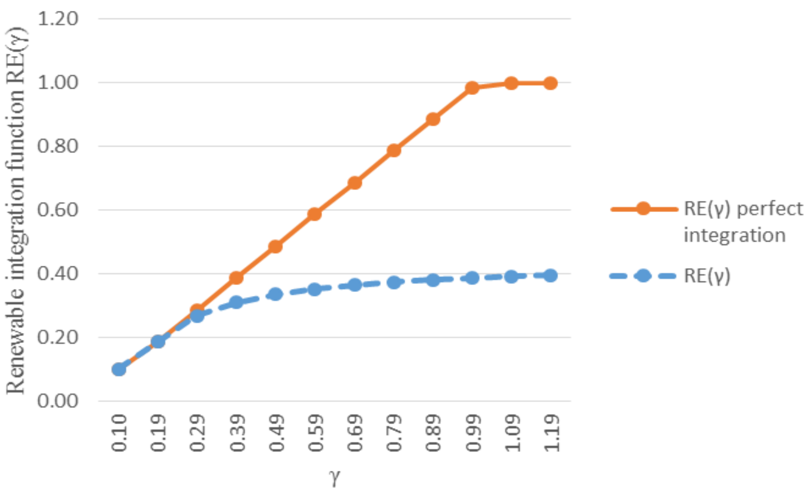
Reference scenario created and **validated** with **energyPLAN**

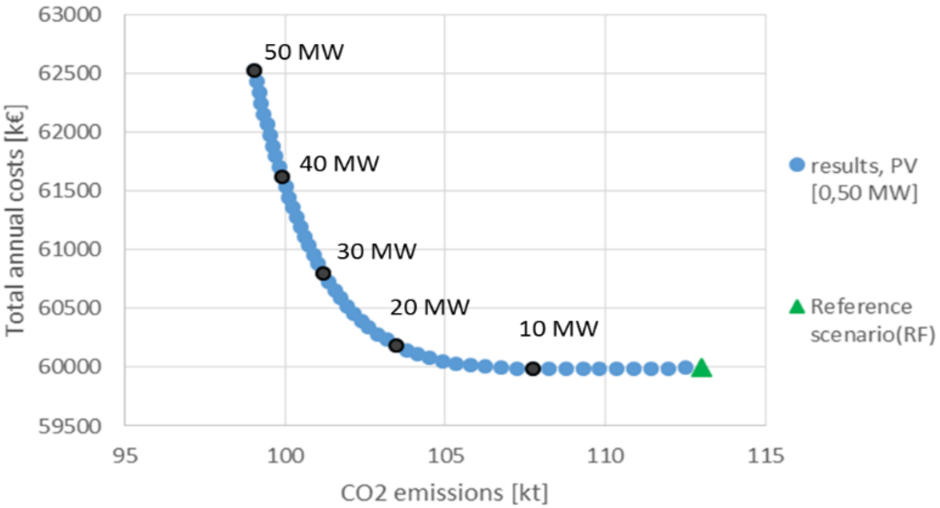
(112.5 kt CO_2 emissions SEAP document)

	Variables		*values*	*Units*
Main input	Electricity total demand		110.13	GWh/year
		Electricity import	71.26	GWh/year
		Electricity export	0	GWh/year
	Heat demand		161.51	GWh/year
		DH demand	85.03	GWh/year
		Individual demand	76.48	GWh/year
Main output	RES electricity prod.		11.06	GWh/year
	RES share of elec. prod.		10	%
	CO2-emission		113	kt
	TOTAL ANNUAL COSTS		60000	k€

Results PV potential and PV scenario

	The PV Potential of South Tyrol: An Intelligent Use of Space (D. Moser, D. Vettorato, R. Vaccaro, M. Del Buono, and W. Sparber)	Solar tirol project
PV potential Brixen	53 MW	55 MW





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Results The model

Why a different model?

To study the impact of additional parameters:

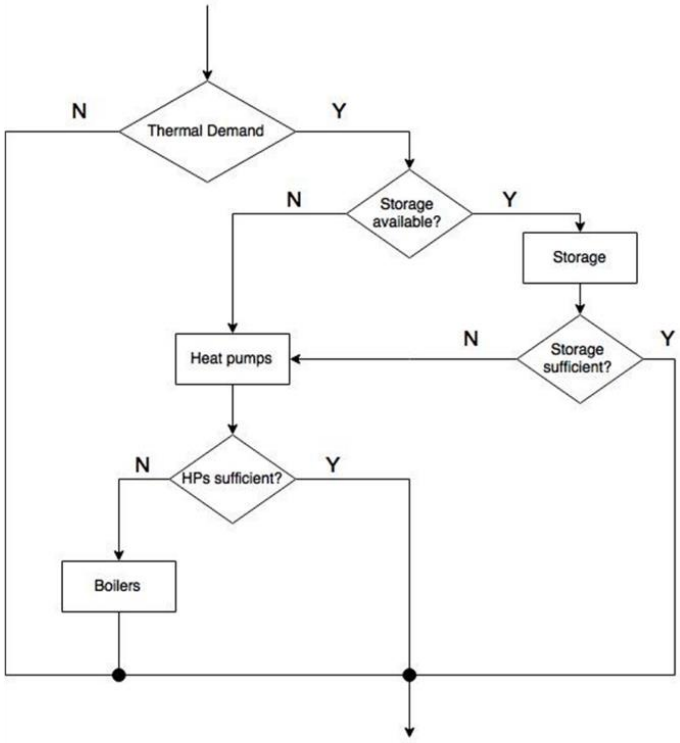
- Initial content of thermal storage ($I_{STO,DH}$)
- Thermal storage losses ($L_{STO,DH}$)
- Charging and discharging power of the thermal storage ($P_{STO,DH}$)

Model is composed by three blocks:

- Thermal demand analysis
- Excess electricity analysis
- Electricity demand analysis

Priority:
1) Thermal storage
2) Heat Pump
3) Boiler

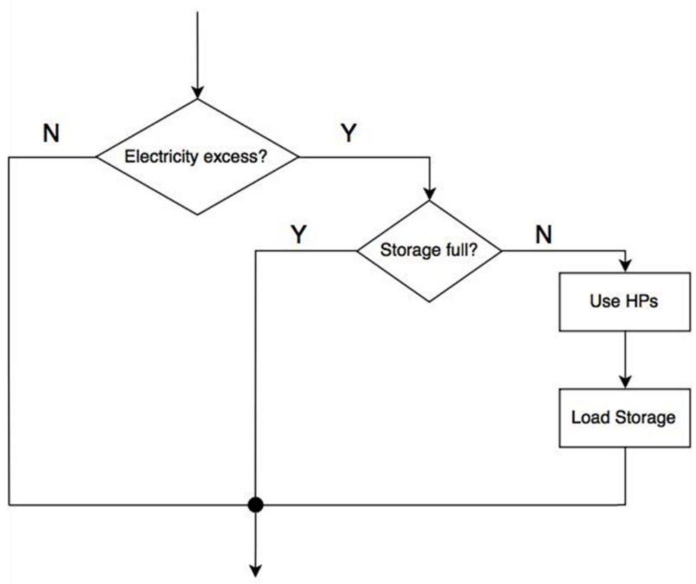
Thermal demand analysis



Results The model

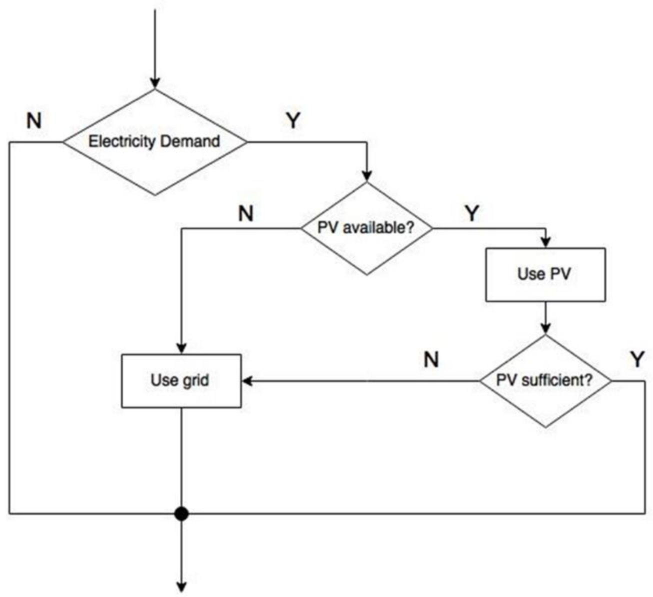
Excess electricity analysis

Priority:
1) Heat pump

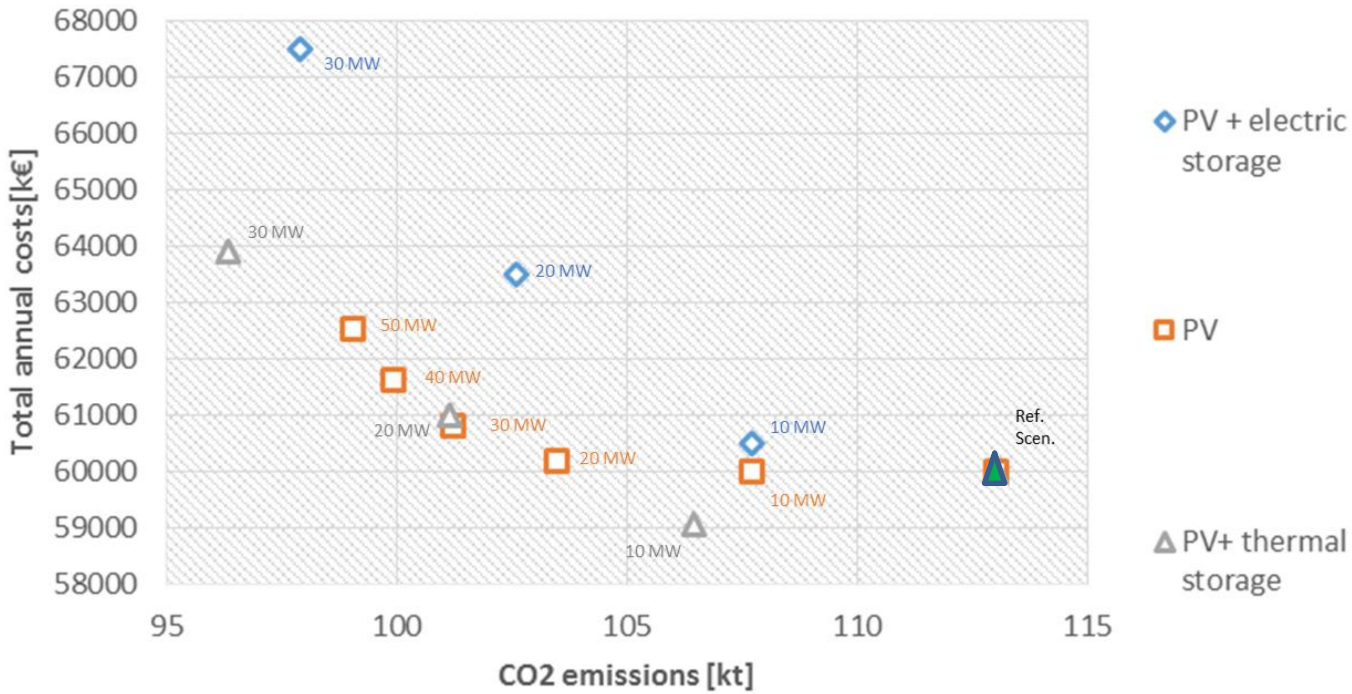


Electricity demand analysis

Priority:
1) PV
2) Grid



Results The deterministic approach



- C_{PV} is the only parameter that varies. The value of C_{HPs}, C_{STO}, C_p, C_t, $C_{STO,el}$ depends on the value of the EEP_{PV} excess electricity production.
- The three scenarios are 3 extreme cases that don‘t consider neither a different type of variables‘ sizing nor hybrid solution with integration of electric and thermal storage

		Electric storage			*Thermal storage*		
C_{PV}	EEP_{PV} [GWh/year]	C_p [kW]	C_t [kw]	$C_{STO,el}$ [kwh]	C_{HPs} [kW]	$C_{STO,DH}$ [kWh]	$V_{STO,DH}$ [m^3]
0	0	0	0	0	0	0	0
10	0.06	2043	3866	8431	2161	8200	131
20	2.17	9386	10240	58406	9504	416554	6665
30	8.40	17452	13400	122826	17512	10991626	175866

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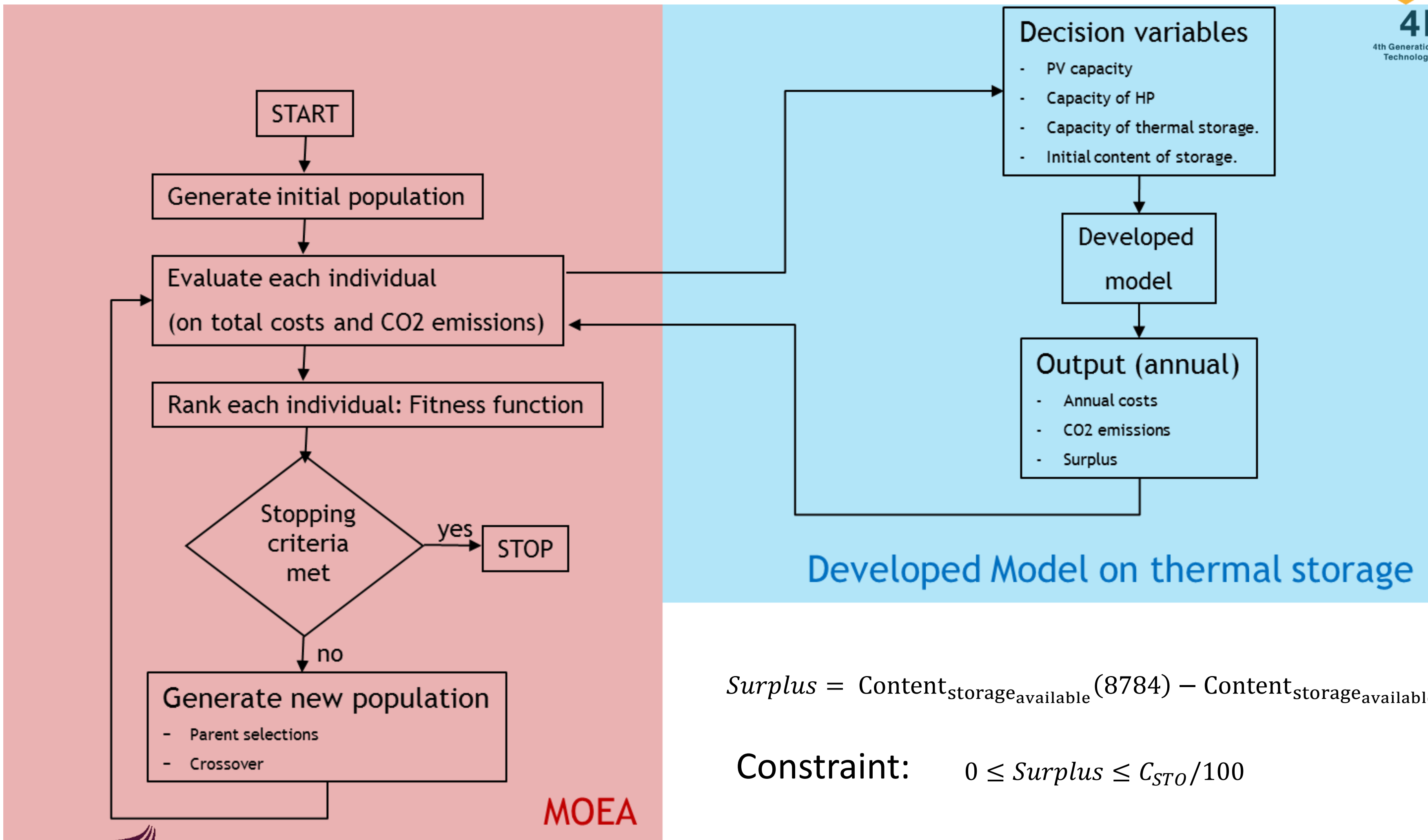
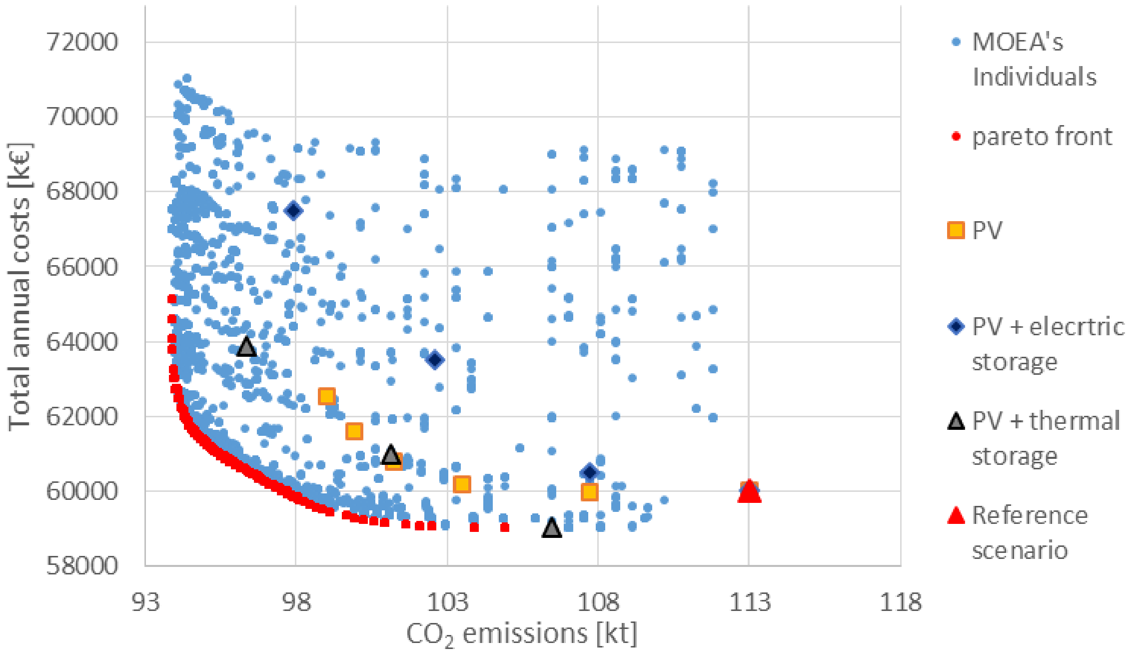
Results
The optimization approach



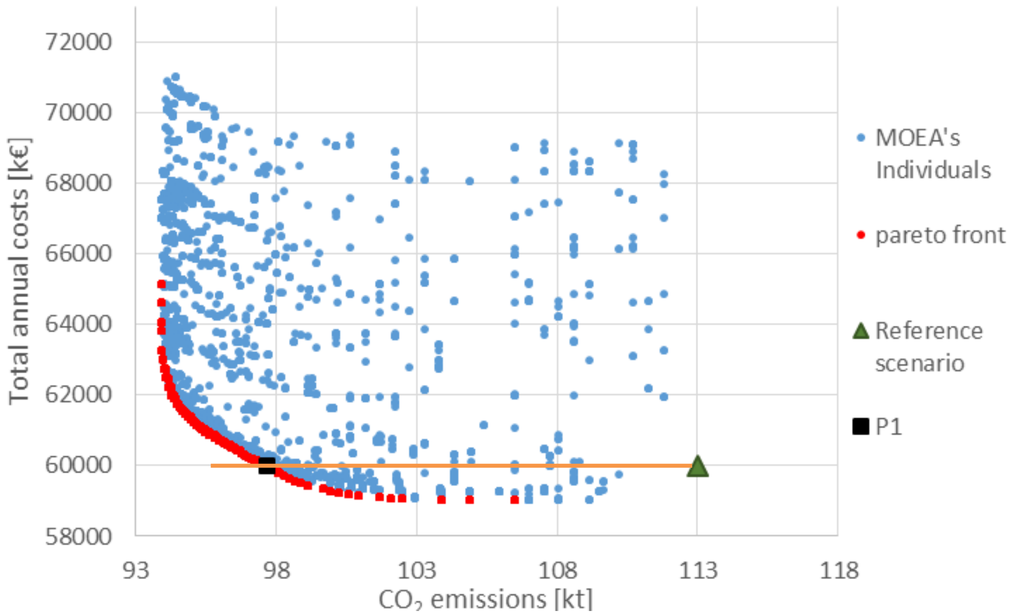
$$Surplus = \text{Content}_{\text{storage}_{\text{available}}}(8784) - \text{Content}_{\text{storage}_{\text{available}}}(0)$$

Constraint: $0 \leq Surplus \leq C_{STO}/100$

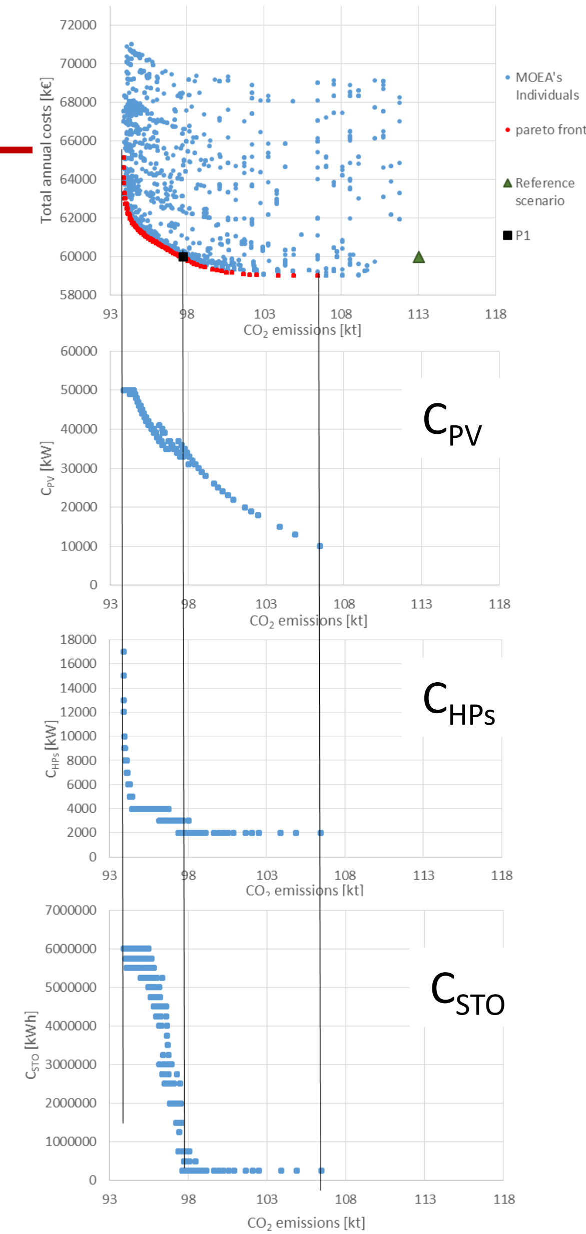
Results The optimization approach



Results The optimization approach

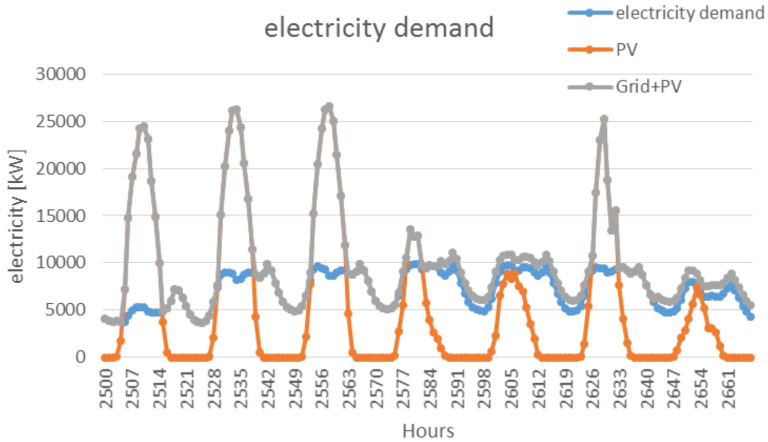


P1 C_{PV} = 33000 kW
C_{HPs} = 3000 kW
C_{STO} = 750000 kWh
$I_{STO,DH}$ = 0 kWh

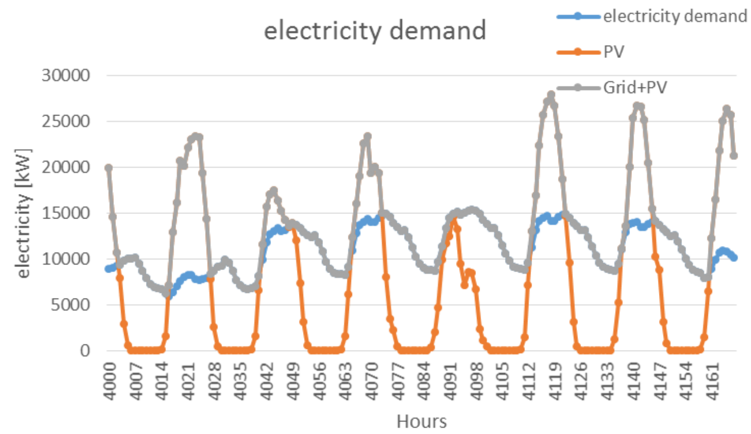


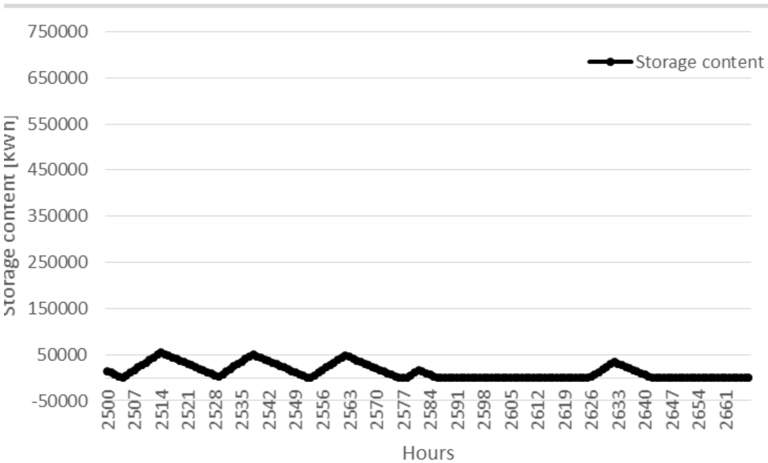
Results
The optimization approach: P1

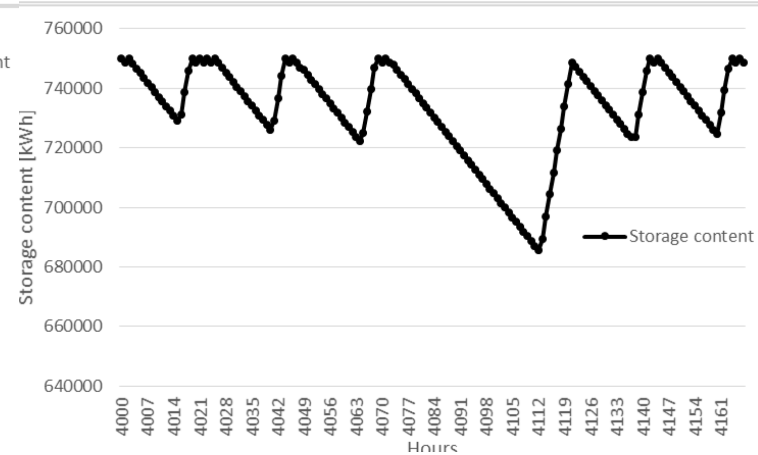
Spring week



Summer week







Conclusions

- The case study of Bressanone-Brixen has been analysed starting from the creation of the **reference scenario** in energyPLAN.
- A **model** to describe the **interactions** between **PV**, **large heat pumps** and **seasonal thermal storage** has been developed.
- A **deterministic approach** has been used **to compare** different **peak shaving solutions**: thermal (analysed with the created model) and electric storage (inspected with energyPLAN). The two scenarios have been created varying only the installed capacity of PV and calculating the size of the others variables in order to cover the entire excess electricity production without exchanges with the grid. For this reason the two scenarios describe the **extreme cases**.
- A **Multi Objective Evolutionary Algorithm** has been used to study the best intermediate solutions of the "PV + thermal storage" scenario, finding out the pareto front of best technology mix.
- A solution on the pareto front (P1) has been chosen as solution that permits to save more annual CO_2 emissions without increasing the annual costs of the energy system compared to the reference scenario.
- Futher studies could focus on the analysis of the best hybrid solutions between electric and thermal storage systems.

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Thanks for the attention!

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