PIACER
Piattaforma Progettazione Gestione
Comunità Energetiche Rinnovabili

Evento Finale

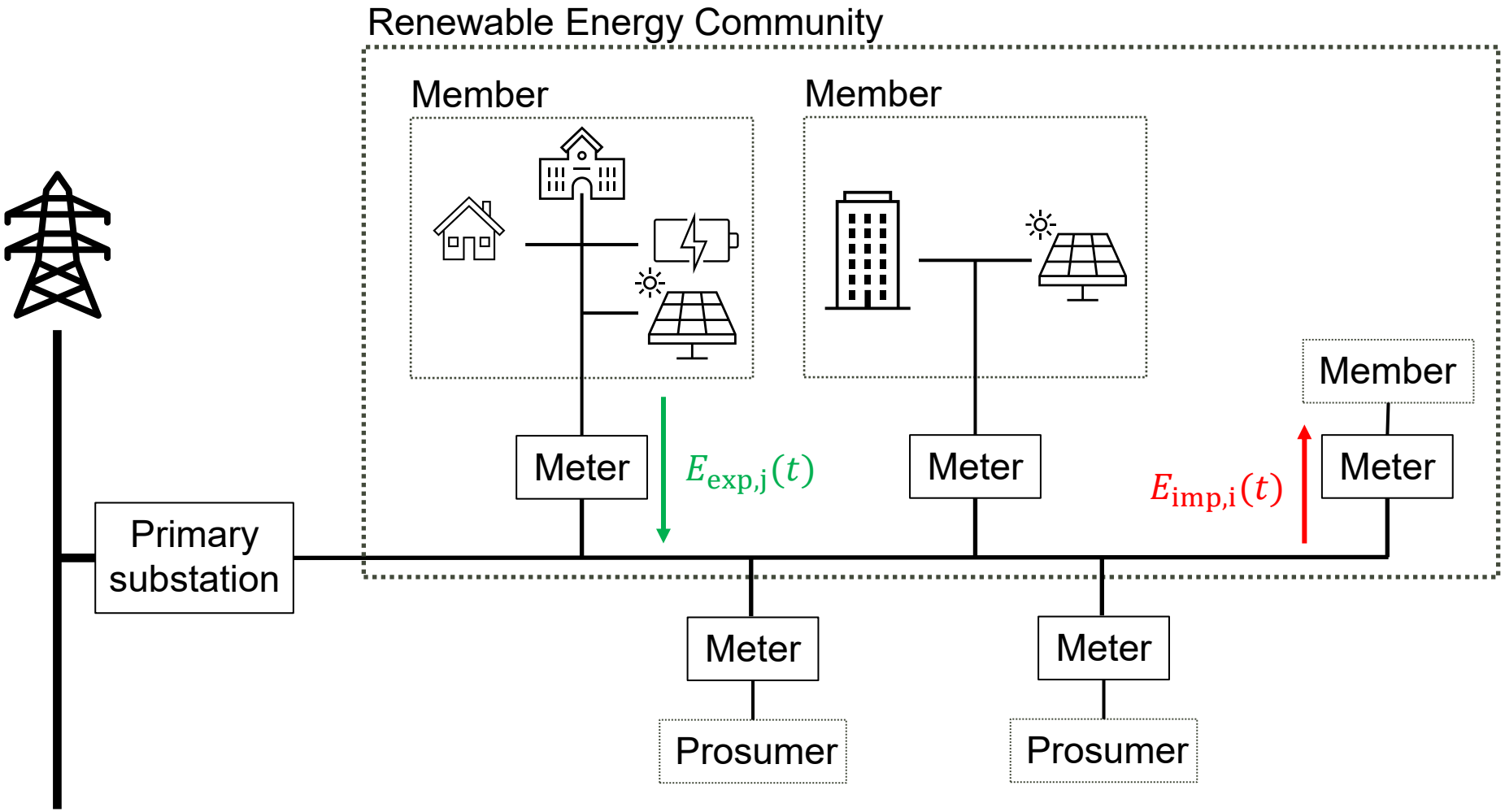
Tecnopolo di Reggio Emilia

Optimal sizing

25/11/2026

Mirko Morini – CIDEA Università di Parma

The economic incentive in a Renewable Energy Community is generated by shared renewable energy and rewards collective participation in the community



Different incentive-allocation rules reflect different definitions of member contribution, leading to different distributions of benefits within the community

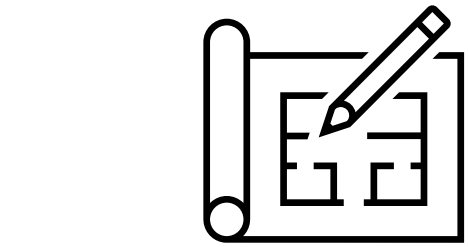
Contribution recognized

		university campus	research institute	supermarket	apartment building
Membership	PC	25,00 %	25,00 %	25,00 %	25,00 %
Consumption	PRHC	85,82 %	7,26 %	6,43 %	0,49 %
	PRAC	86,91 %	7,47 %	5,16 %	0,46 %
	PRHCN	88,11 %	0,02 %	11,02 %	0,85 %
	PRACN	89,81 %	4,33 %	5,38 %	0,48 %
	SEAC	44,84 %	25,05 %	26,98 %	3,13 %
	SEACN	65,28 %	0,02 %	31,53 %	3,17 %
Consumption and production	PRIE	44,10 %	49,96 %	5,51 %	0,43 %
Infrastructures	PRPP	68,67 %	29,65 %	1,49 %	0,20 %

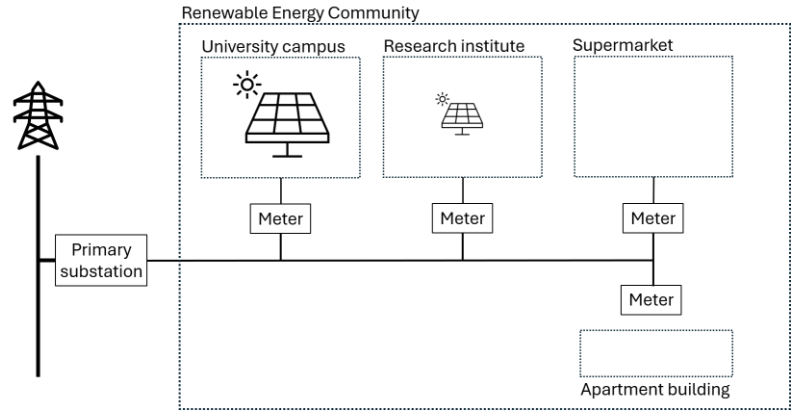
Different distributions of benefits may encourage REC members to adopt different investment strategies, ultimately affecting the design of the community itself

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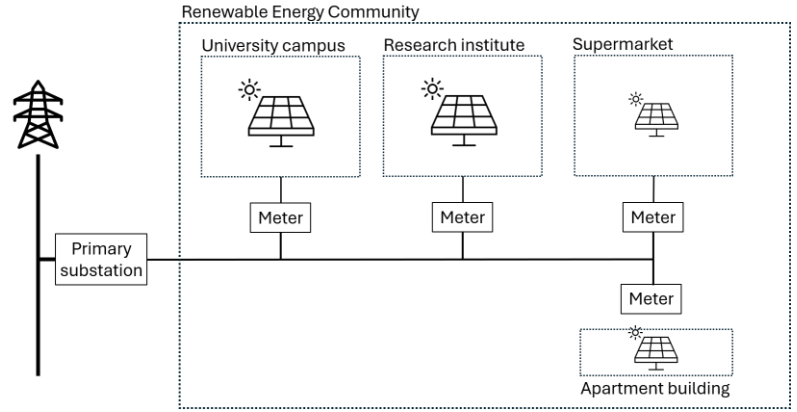
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Method X



Method Y



An MILP tool was developed to optimize REC investments and operation while accounting for renewable-energy tracking, shared energy and incentive calculation

Input

Configurazione of the current REC energy system

Techno-economic data
- Conversion efficiencies
- Plant prices
- Inst. size boundaries

Boundary conditions
- Energy vector prices
- Env. conditions
- Energy demands

MILP Algorithm

Optimization variables
- Plant sizes
- Hourly operation loads
- …

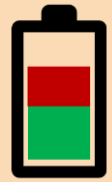
Constraints
- Energy vector balances
- Plant operational limits
- …

Objective function
- Single-objective (economic)

REC features

Renewable-energy tracking

Electrical energy vector has been splitted into three vectors: generic, **renewable** and **non-renewable**



Shared energy quantification

$$\mathrm{E_{sh}(t)} = \min(\mathrm{sum}(E_{\mathrm{exp,j}}(t)); \mathrm{sum}(E_{\mathrm{imp,j}}(t)))$$

Non-linearity treated with big-M method

Incentive calculation

$$I_{\mathrm{tot}}(t) = i(t) * E_{\mathrm{sh}}(t)$$

Optimal REC configuration is obtained by maximizing the sum of the differential Net Present Values of REC members with respect to a reference scenario

$$f_{obj} = \max\left\{\sum_{j}(NPV_j - NPV_{reference,j})\right\}$$

$$NPV_j - NPV_{reference,j} \geq 0 \quad \forall j$$

$$NPV_j = \sum_{y=1}^{LT} \frac{\sum_{t=1}^{8760}[-OPEX_j(t) + I_j(t)]}{(1+r)^y} - CAPEX_j$$

$$NPV_{reference,j} = \sum_{y=1}^{LT} \frac{\sum_{t=1}^{8760} -OPEX_j(t)}{(1+r)^y}$$

$$NPV_{reference,j} = \sum_{y=1}^{LT} \frac{\sum_{t=1}^{8760} -OPEX_j(t)}{(1+r)^y} - CAPEX_j$$



Brownfield sizing (existing energy system optimal operation)

Greenfield sizing (individual optimal sizing and operation)



Different incentive-allocation rules were directly embedded into the optimization framework to represent alternative definitions of member contribution

Per Capita (PC)

$$PC_{\mathrm{j}} = \frac{\sum_{t=1}^{8760} I_{\mathrm{tot}}(t)}{n_{\mathrm{m}}}$$

Pro Rata Hourly Consumption (PRHC)

$$PRHC_{\mathrm{j}}(t) = I_{\mathrm{tot}}(t) * \frac{L_{\mathrm{c,j}}(t)}{\sum_{k=1}^{n_{\mathrm{c}}} L_{\mathrm{c,k}}(t)}$$

Pro Rata Annual Consumption (PRAC)

$$PRAC_{\mathrm{j}} = \sum_{t=1}^{8760} I_{\mathrm{tot}}(t) * \frac{\sum_{t=1}^{8760} L_{\mathrm{c,j}}(t)}{\sum_{k=1}^{n_{\mathrm{c}}} \sum_{t=1}^{8760} L_{\mathrm{c,k}}(t)}$$

The analysis was performed on a brownfield REC based on a real case study and including members with markedly different functions and energy demands



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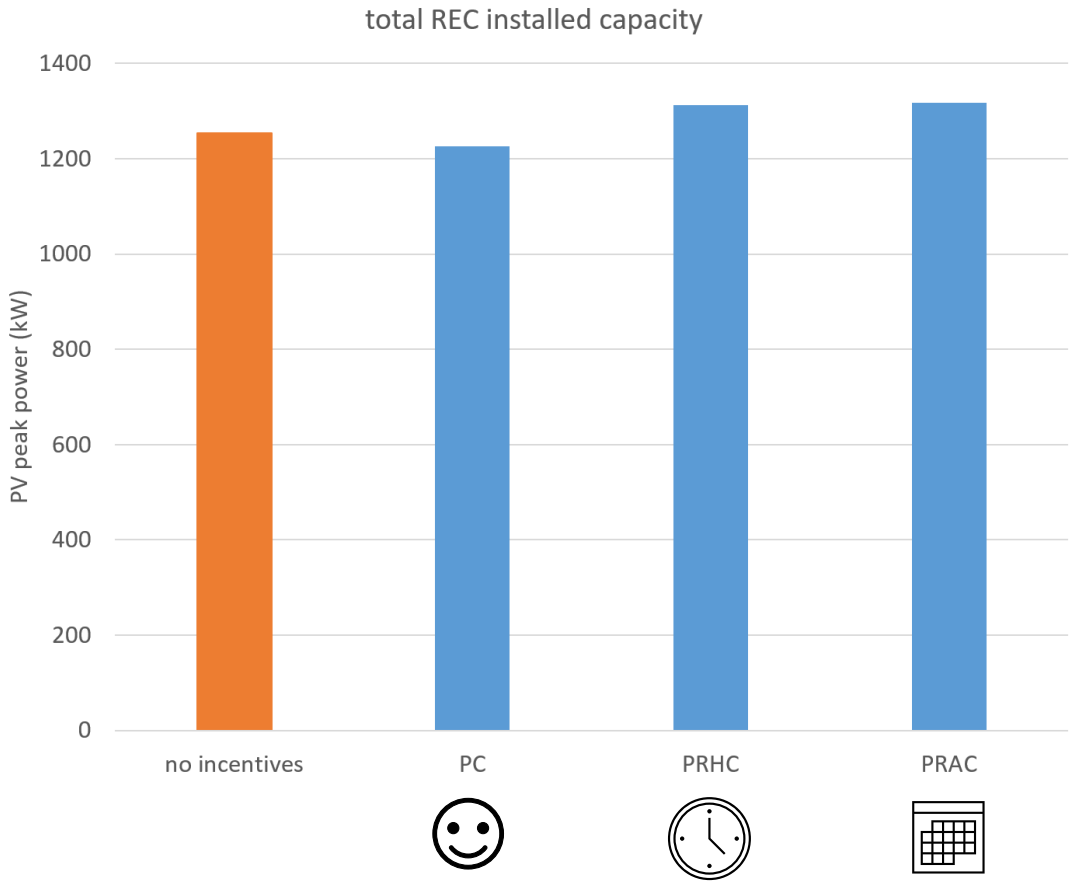
University Campus
demand ≈ 10^4 MWh/yr

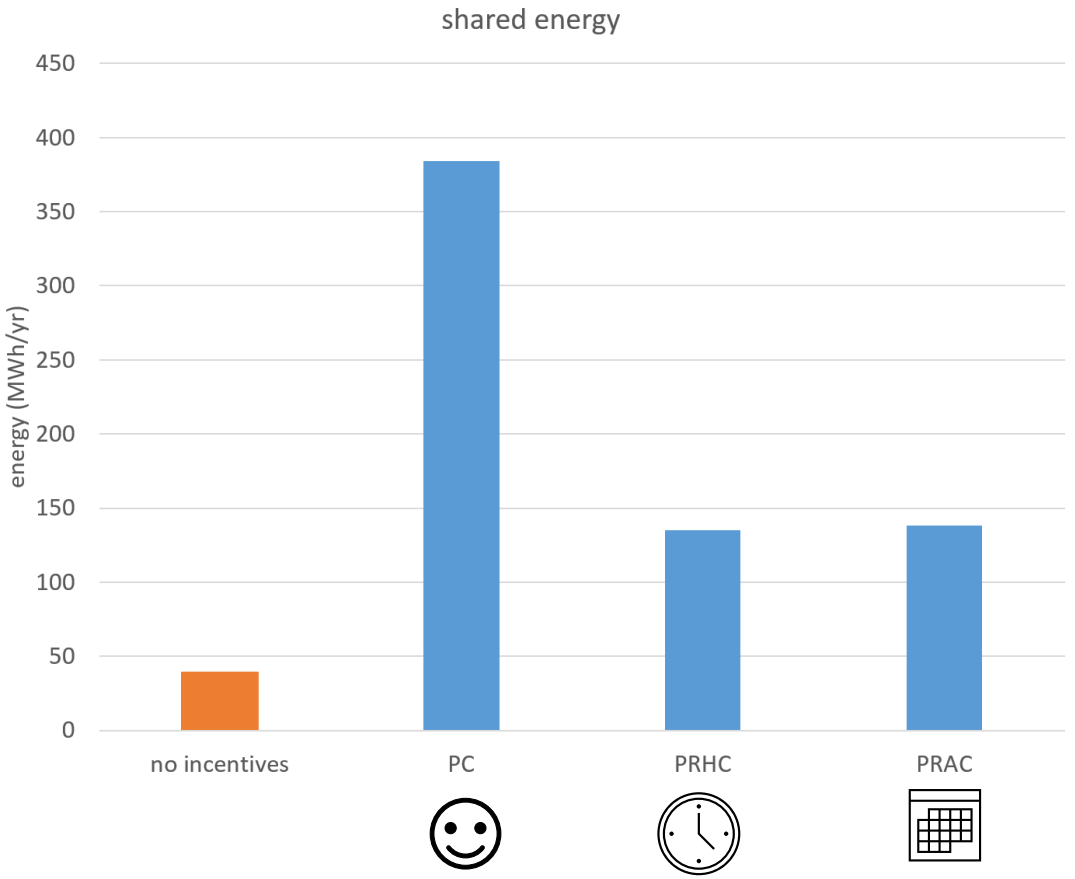


Research Institute
demand ≈ 10^2 MWh/yr

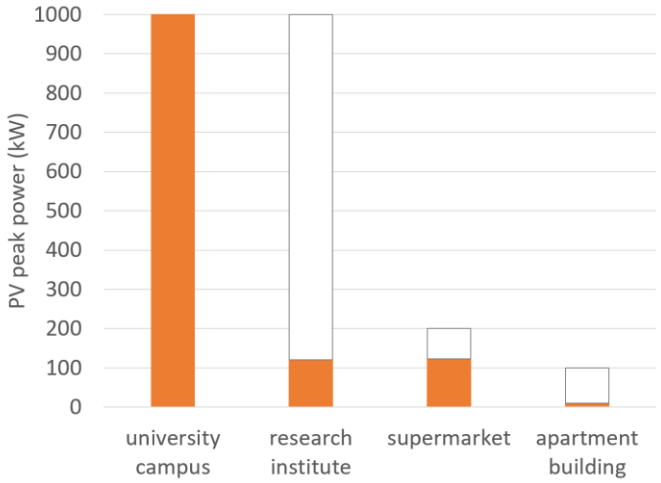
+ Supermarket: demand ≈ 10^2 MWh/yr
+ Apartment Building: demand ≈ 10^1 MWh/yr

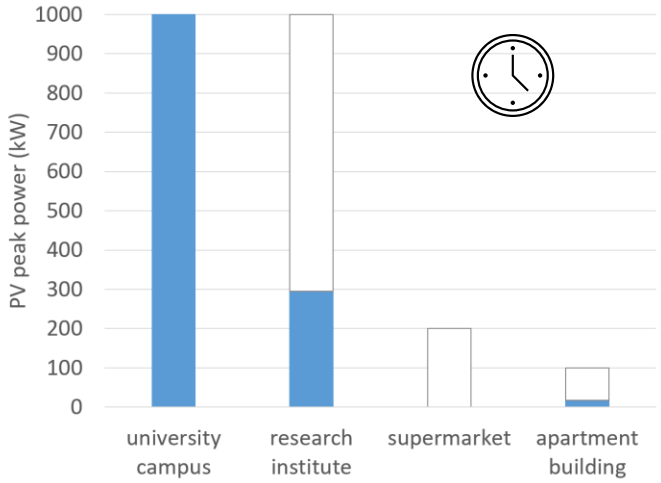
Embedding incentive-allocation rules into the optimization framework leads to different optimal renewable-capacity investments

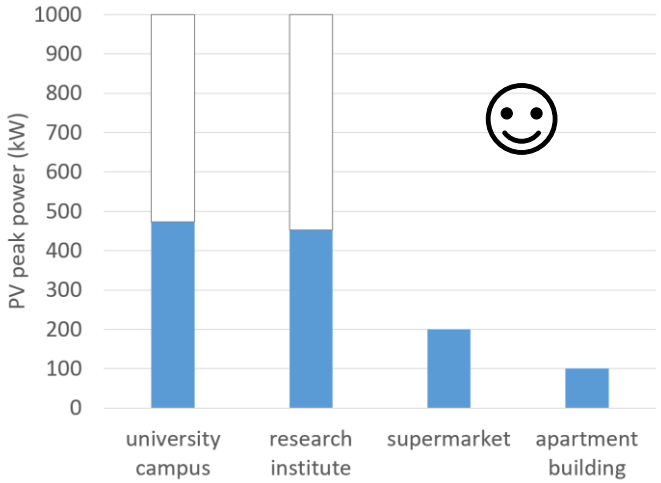


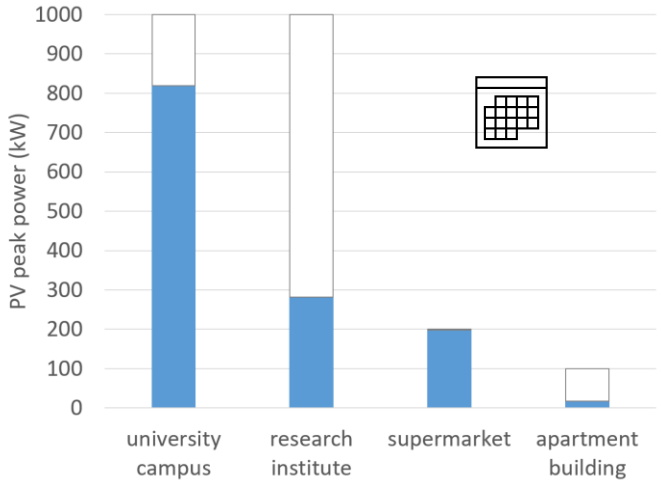


Incentive-allocation rules affect not only the amount of installed renewable capacity, but also how investments are distributed among REC members









Different allocation rules modify the motivation to create shared energy, resulting in different investment patterns among REC members

No incentives

Individual self-consumption

No shared-energy incentive

PV sized mainly for individual self-consumption

Limited shared energy



Cooperative value creation

All members receive the same benefit

Smaller members are encouraged to install additional capacity

Campus absorbs their surplus and creates shared energy



Concentrated benefit allocation

Most benefits are allocated to the campus

Smaller members have less interest in creating surplus energy

Investments return towards self-consumption



Shared-energy specialization

Benefits are further concentrated on the campus

Shared energy becomes more profitable than the last unit of campus PV

PV capacity shifted to members suited to generate shared energy

Incentive-allocation rules should not be viewed solely as ex-post benefit-sharing mechanisms, as they may also influence REC design decisions

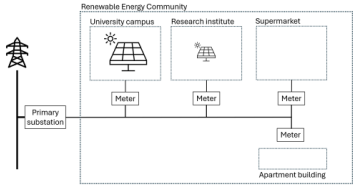
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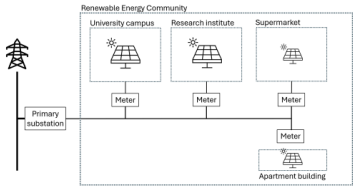
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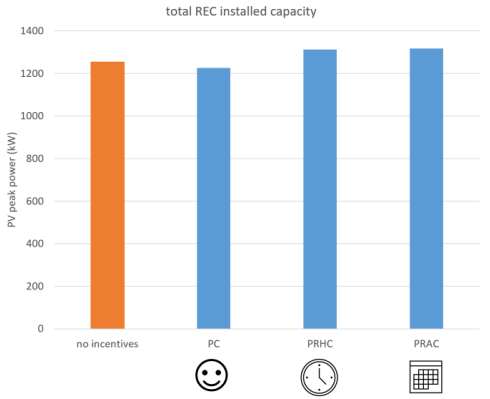
Method X

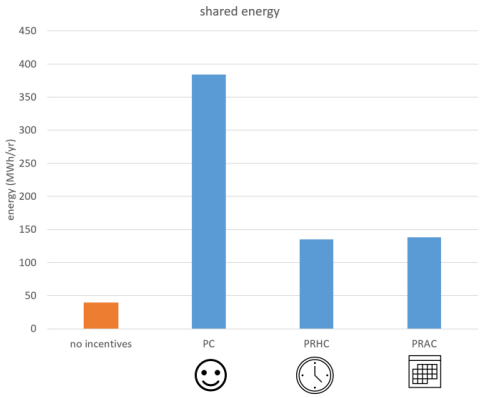


Method Y



Embedding incentive-allocation rules into the optimization framework leads to different optimal renewable-capacity investments





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