Analysis of Inter-community coordination strategies and the impact on energy communities

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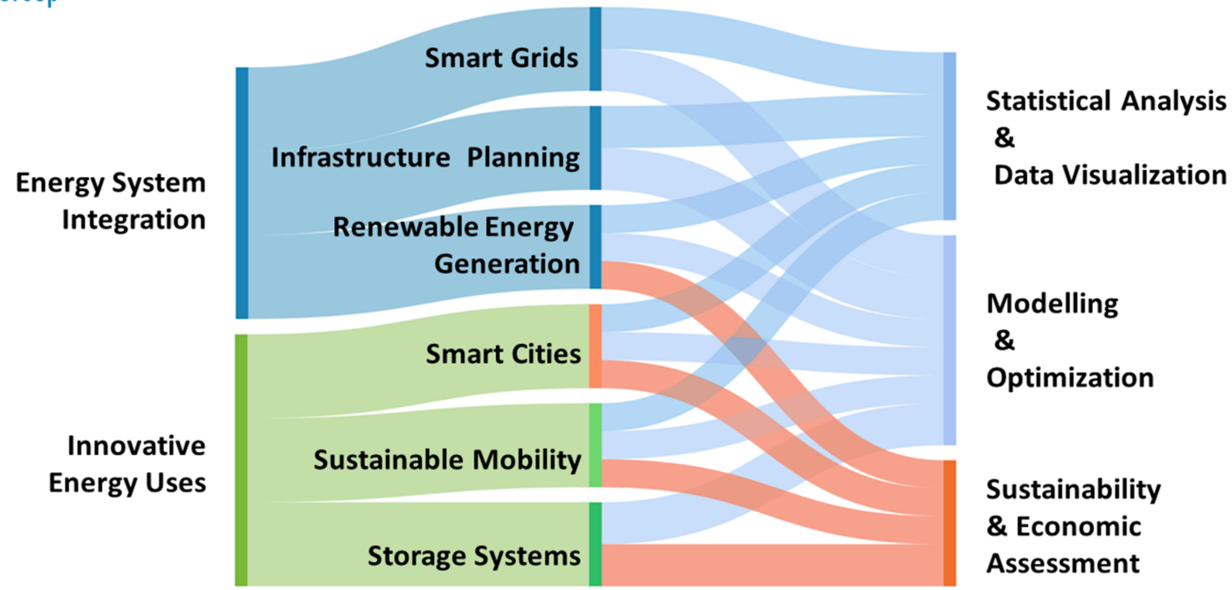
Motivation

- European energy goals seek to **reduce consumption, increase efficiency and increase renewable shares**.
- **Energy communities** can help to address the European goals
- **Clean Energy for All Europeans Package (CEP)** creates a framework for energy communities, amongst other things
- Expansion of **Spanish framework** for energy communities and **incentives**
  - RD 477/2021: €1.12 billion for self-consumption and storage
- Limited literature comparing community coordination strategies including **Collective Self-Consumption** (CSC) in Spain
- Current literature does not include recent **updates to CSC rules** in Spain
  - Hourly variable distribution coefficient

Authors

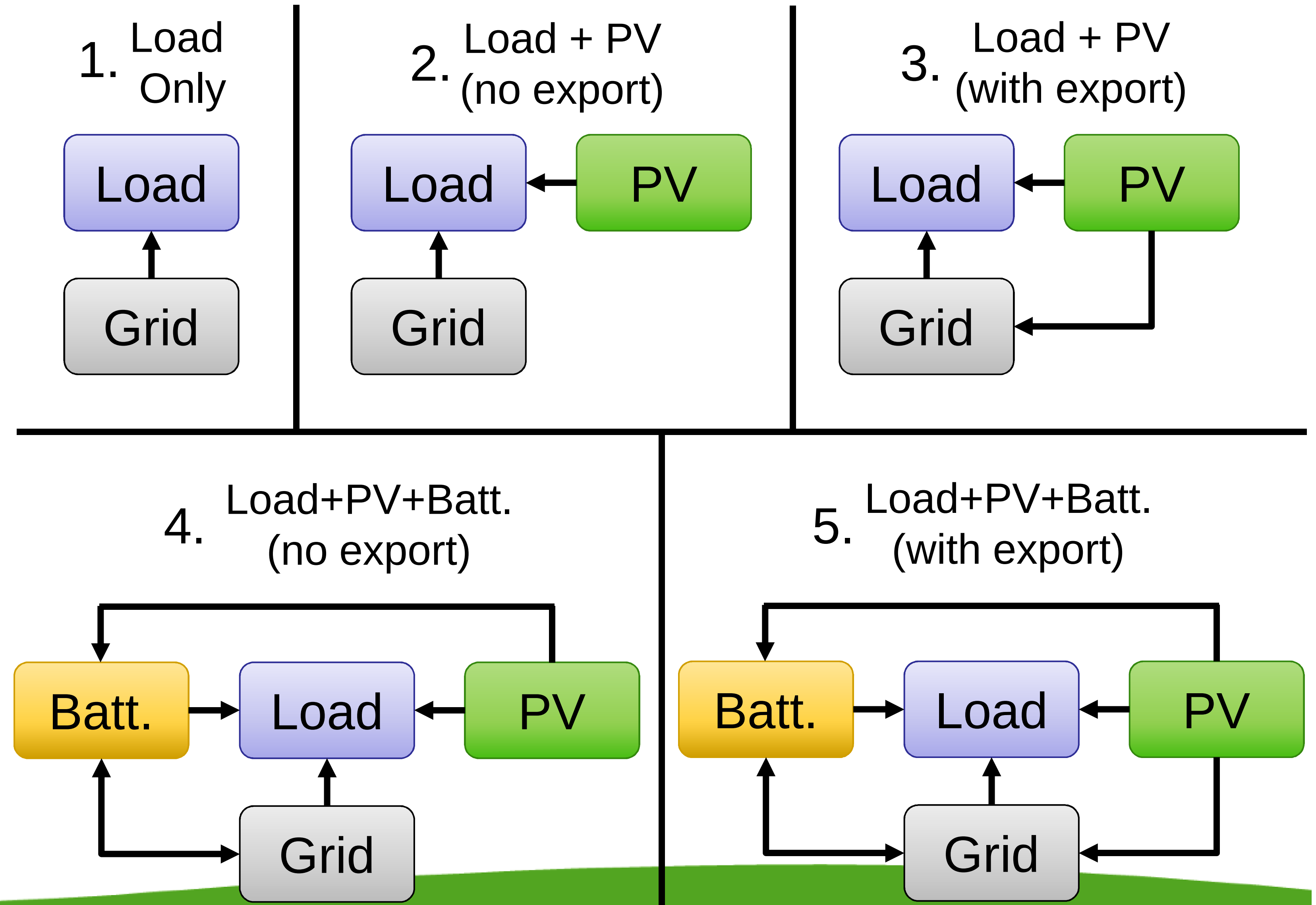
Energy Systems Analytics
Research Group

Energy Systems Analytics is a research group whose areas of expertise are Statistical Analysis & Data Visualization, Modelling & Optimization, and Sustainability & Economic Assessment. Group scientific activity focuses on Energy System Integration and Innovative Energy Uses. Our technological research fields are:



Methodology: Scenario development

1. Load Only
2. Load + Photovoltaic panels (PV)
   (no export)
3. Load + PV
   (with export)
4. Load + PV + Batt.
   (no export)
5. Load + PV + Batt.
   (with export)



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Scenarios include:

- Collective self-consumption (with and w/o)
- Export (with and w/o)
- 5 retail rates (see backup for details)
- 2 equipment distributions (see backup for details)
- 2 sizes (see backup for details)

Scenario combinations

Item	Device configurations	Collective self-consumption	Renewable sales	Retail Rates	Equipment distribution	Size
1	Load only	Yes, No	Yes, No	5	Distributed, centralized	Large, Small
2	Load + PV	Yes, No	Yes, No	5	Distributed, centralized	Large, Small
3	Load + PV + Battery	Yes, No	Yes, No	5	Distributed, centralized	Large, Small

Device assumptions

Parameter	Value
PV capital cost	$1387/kW [1]
PV fixed operation & maintenance cost	$10/kW-year [1]
Storage capital cost	$955/kWh [1]
Storage energy capacity	4 hours at rated discharge power
Storage efficiency	85% AC to AC
Storage self-discharge	1% of stored energy per day [2]

Financial assumptions

Parameter	Value
Euro to dollar	0.89
Study period	20 years
Tax rate	25%
Equity	41.9%
Interest rate on debt	3.125% [3]
Inflation	1.6%
WACC	7%
Depreciation schedule	10% for up to 20 years [4]

1. IRENA, “Renewable Power Generation Costs in 2020,” International Renewable Energy Agency, Abu Dhabi, 2021.
2. E. Redondo-Iglesias, P. Venet, and S. Pelissier, “Measuring Reversible and Irreversible Capacity Losses on Lithium-Ion Batteries,” in 2016 IEEE Vehicle Power and Propulsion Conference (VPPC), Hangzhou, China, Oct. 2016, pp. 1–5. doi: 10.1109/VPPC.2016.7791723.
3. Banco de España, “Table of banks’ lending and borrowing rates.” https://clientebancario.bde.es/pcb/en/menu-horizontal/productosservici/relacionados/tiposinteres/guia-textual/tiposinterespractabla_de_tipos__a0b053c69a40f51.html.
4. infoautónomos, “¿Qué son las amortizaciones? ¿Cómo funcionan? Ejemplo.” https://www.infoautonomos.com/contabilidad/tablas-de-amortizacion-para-los-bienes-de-una-empresa/.

Community description

- The community is comprised of 8 members (see table for more information)
- Location is based on weather data, workday calendar, and PV generation from Barcelona, Spain.
- Data is developed using the LoadProfileGenerator†

† Noah Pflugradt, *LoadProfileGenerator*. 2022. [Online]. https://www.loadprofilegenerator.de/

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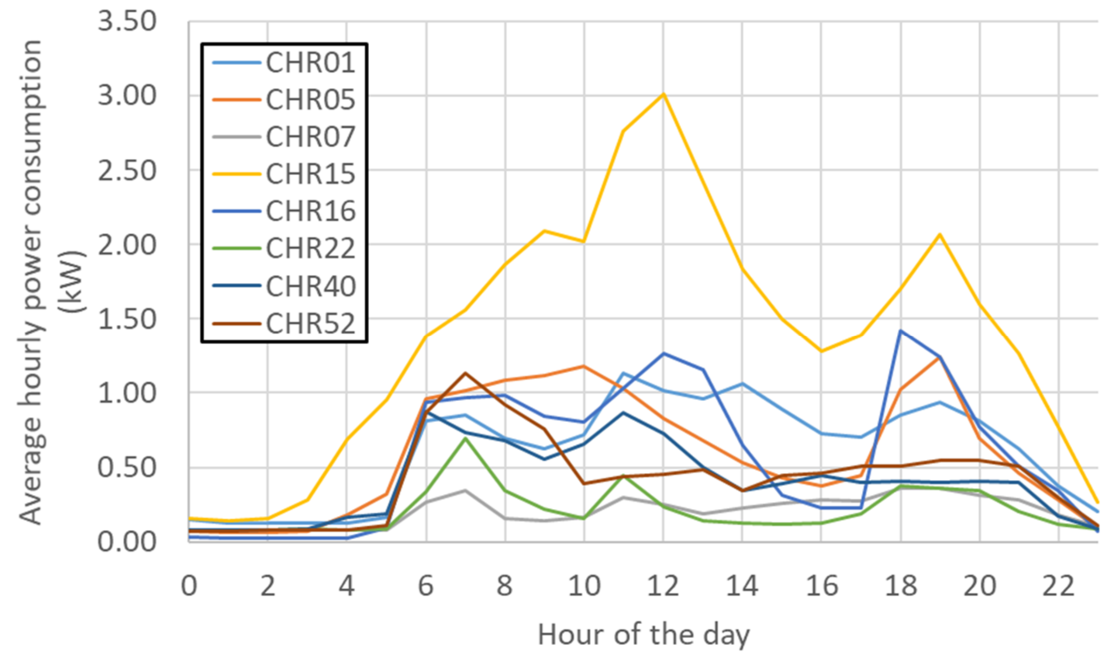
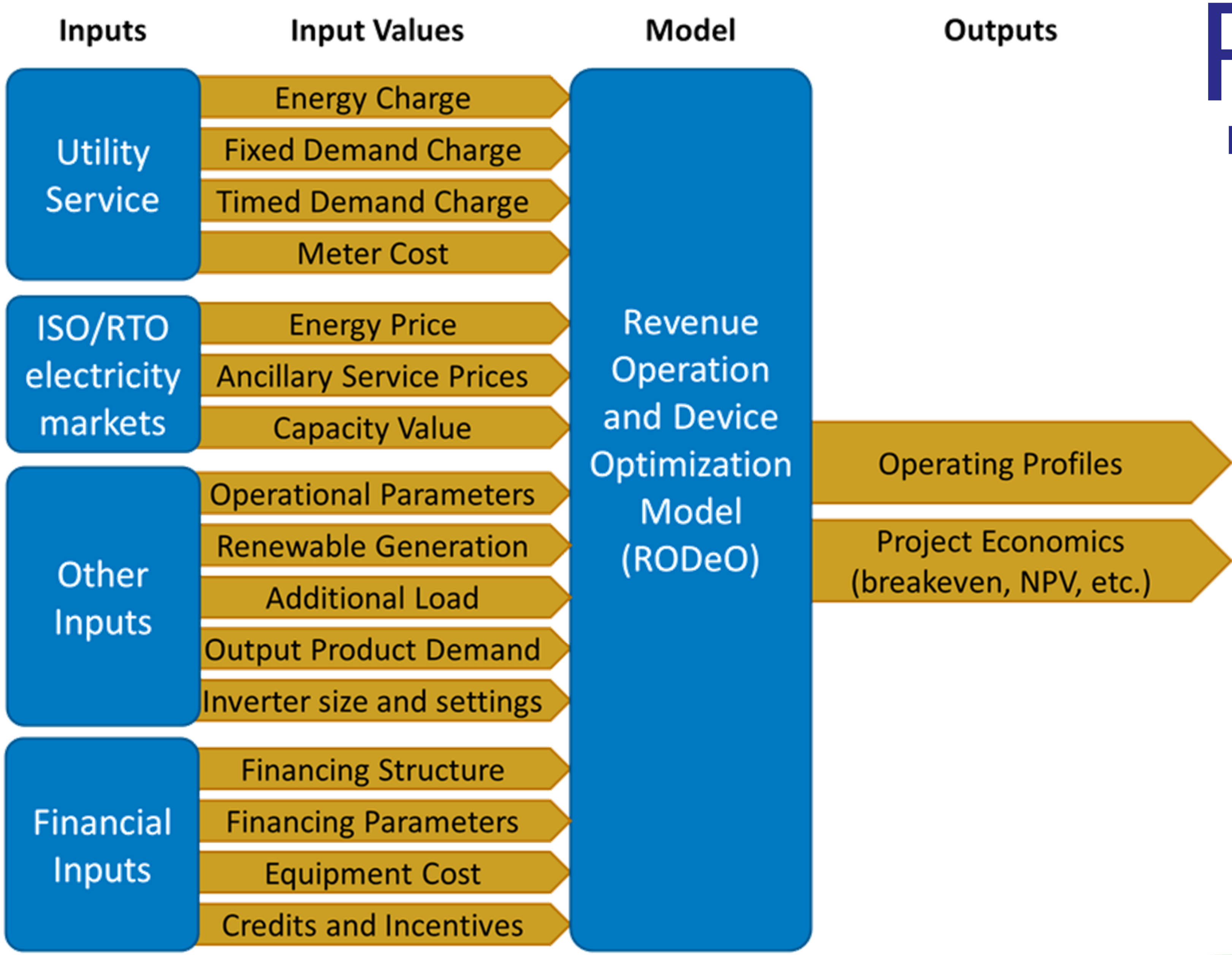


#	Identifier (CHR)	Description	Max. Power (kW)	Min. Power (kW)	Avg. Power (kW)	StDev of Power (kW)
1	01	Couple both at work	6.59	0.103	0.617	0.792
2	05	Family with 3 children, both parents work	3.76	0.045	0.594	0.589
3	07	Working single person	3.94	0.046	0.205	0.370
4	15	Multigenerational family with 2 working adults, 2 children and 2 seniors	7.82	0.100	1.382	1.233
5	16	Couple over 65 years old	5.49	0.017	0.584	0.795
6	22	Single working woman with 1 child	2.10	0.055	0.213	0.285
7	40	Non-working couple (30-64 years old)	3.00	0.062	0.406	0.439
8	52	Student sharing an apartment	4.08	0.052	0.426	0.489



RODeO™

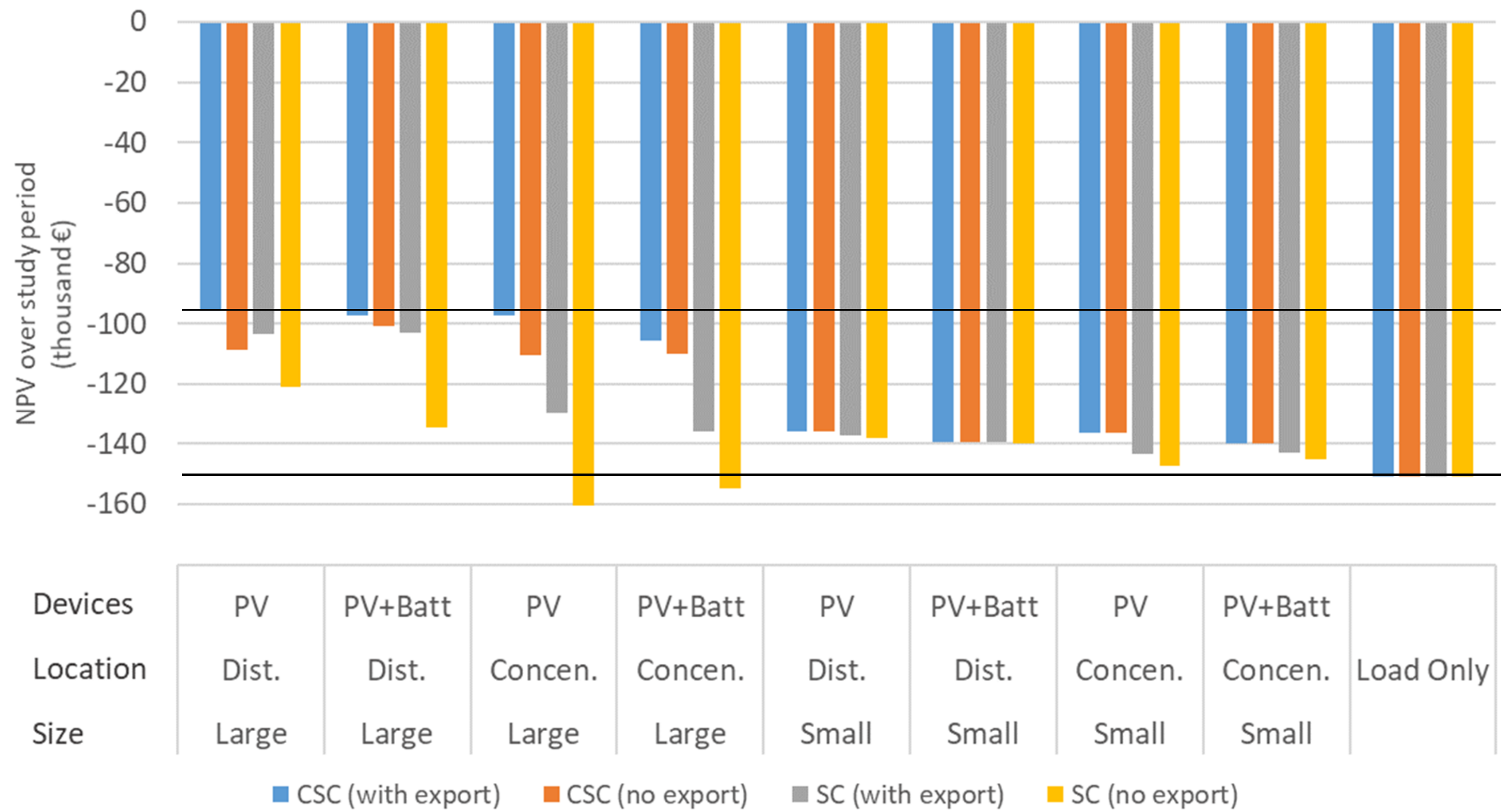
Revenue, Operation, and Device Optimization

Applications

- Multi-market optimization
- Hydrogen business case assessment
- Wholesale market revenue comparison
- Retail rate optimization
- Solar PV + Storage
- Real-time optimization control of electrolyzer
- Vehicle fleet optimization

Results

- Collective self-consumption (CSC) with export is the least cost
- Generally, collective self-consumption (no export) is better than self-consumption (SC) with export.
- Large systems were preferred
- Distributed systems have lower operating cost than concentrated systems



CSC: Collective self-consumption
SC: Individual self-consumption

Dist.: Distributed
Cocen.: Concentrated

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Results

- Allowing export is the most effective way to reduce curtailment
- For collective self-consumption without export there can be a tradeoff between net present value and curtailment

Collective self-consumption		Yes	Yes	No	No
Sale of renewables		Yes	No	Yes	No
Net present value (thousand €)	PV	-116	-123	-129	-142
	PV + Battery	-121	-122	-130	-144
Curtailment (MWh)	PV	0.0	5.7	0.0	11.1
	PV + Battery	0.0	1.3	0.0	6.4

PV = photovoltaic panels

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Next steps

- Demonstrate the ability to control real CSC systems
- Expand the load scenarios to characterize more types of communities.
- Explore the impact of optimization under uncertainty (PV forecasting, energy limited storage, etc.)

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Thank you for your attention

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ACCIÓ

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Device and Financial assumptions

Device assumptions

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Storage energy capacity	4 hours at rated discharge power
Storage efficiency	85% AC to AC
Storage self-discharge	1% of stored energy per day [2]
Retail electricity rates	Sale price based on wholesale market price [3] Endesa (One Luz and One Luz 3 period) [4,5] Hola Luz (Classic and Fair rate) [6] Pepe Energy (ECO) [7]

Financial assumptions

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Sizing and location breakdown

- PV size for small systems is based on 75% of average load at site
- PV size for large systems is based on 50% of max. load at site
- Storage size for small systems is based on 20% of average load
- Storage size for large systems is based on 20% of max load at site

PV sizing and location

Location	Size	Consumer							
		1	2	3	4	5	6	7	8
Distributed	Small	0.5	0.4	0.2	1.0	0.4	0.2	0.3	0.3
Concentrated	Small		1.6	1.7					
Distributed	Large	3.3	1.9	2.0	3.9	2.7	1.1	1.5	2.0
Concentrated	Large		9.0	9.4					

Storage sizing and location

Location	Size	Consumer							
		1	2	3	4	5	6	7	8
Distributed	Small	0.12	0.1	0.0	0.28	0.12	0.04	0.08	0.09
Concentrated	Small		0.4	0.5					
Distributed	Large	1.3	0.8	0.8	1.6	1.1	0.4	0.6	0.8
Concentrated	Large		3.6	3.8					

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