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POLITECNICO DI TORINO
Dipartimento Energia ''Galileo Ferraris''

Environmental protocol for Energy Communities

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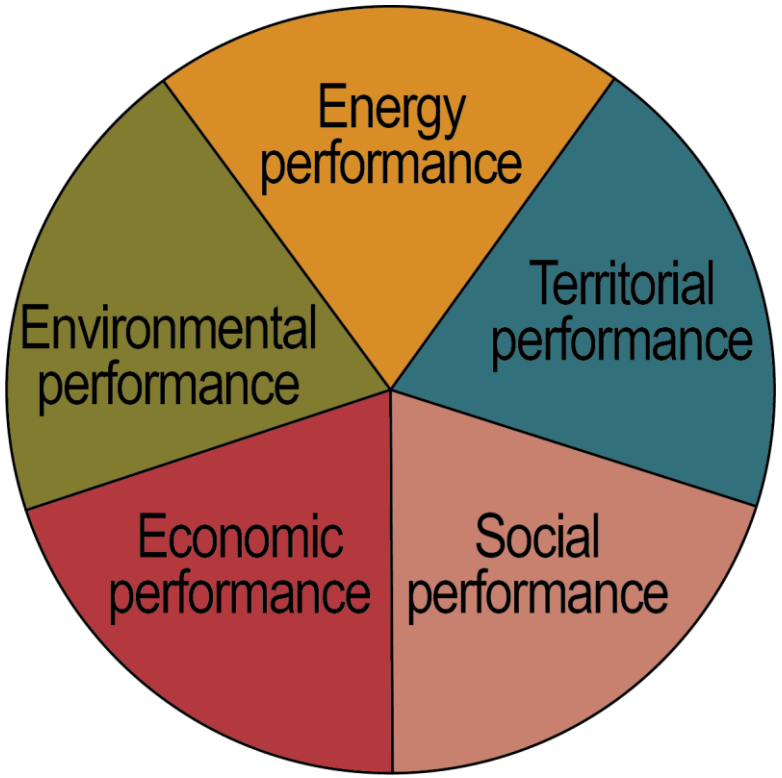
Aim of the work

The proposal for a protocol to measure the sustainability of Energy Communities (EC) pursues a holistic approach and addresses the need to provide a multidisciplinary assessment of the sustainability of the project.

The protocol must be able to describe not only the energy, but also the territorial, environmental, economic, and social performance of an EC, to establish if it can bring benefits to all those involved.



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Introduction FROM INTERNATIONAL AGREEMENTS TO THE NATIONAL REFERENCE FRAMEWORK

UN, Sustainable development goals of Agenda 2030

In the perspective of international agreement on climate, energy and environment, the European policies for the energy transition towards sustainable development have recently led to the implementation of the United Nations Agenda 2030.

The *European strategy for economic and territorial development* promotes a model of smart, sustainable, inclusive growth, and underlines the importance of actions in the field of energy, integrated with the economic and territorial ones.

The *Clean Energy Package for All Europeans* define the actions to guarantee adequate infrastructure for the existing-future energy demand and the integration of the available renewable sources, ensuring security of supply and an economically competitive energy transition for all countries.

Member States are invited to implement the Integrated National Energy and Climate Plan (NECP) for the period 2021-2030, to identify specific actions for each context.

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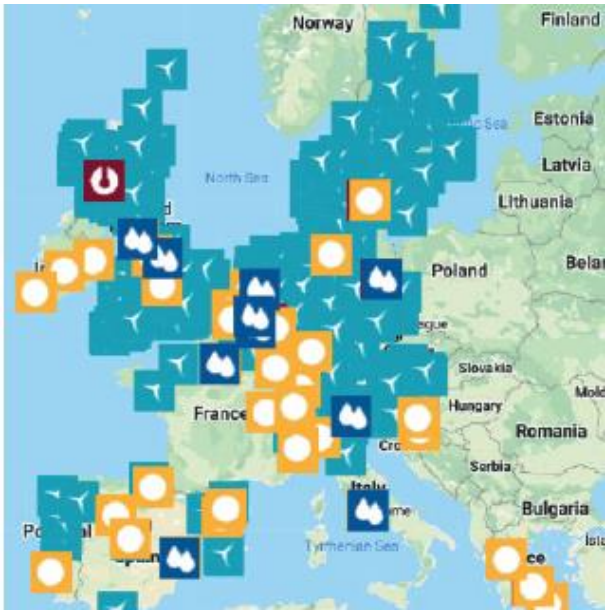
Introduction

ENERGY COMMUNITIES FOR THE GREEN NEW DEAL

Among various measures aimed at improving the safety, sustainability, and competitiveness of local energy systems, Energy Communities are intended as innovative models to promote local energy production and self-consumption, involving directly different local stakeholders and energy end-users, (i.e. municipalities, public and private entities, citizens),



Two European Directives define possible forms of stakeholders' aggregation:

- RENEWABLE DIRECTIVE 2001/2018/EU → Renewable Energy Communities (REC)
  in promoting the use of energy from renewable sources (RES)
- ELECTRICITY DIRECTIVE 2019/944/ EU → Citizens Energy Communities (CEC)
  on the energy market

"autonomous legal entity based on voluntary participation of public and private members whose main objective is to provide environmental, economic, and social benefits through production and sharing of RES energy at community level rather than financial gains."

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Legislative framework

EUROPEAN

- RENEWABLE DIRECTIVE 2001/2018/EU on in promoting the use of energy from renewable sources (RES) → Renewable Energy Communities (REC)
- ELECTRICITY DIRECTIVE 2019/944/ EU on the energy market → Citizens Energy Communities (CEC)

NATIONAL

- Integrated National Energy and Climate Plan - PNIEC 2018
- N.L. 221/2015 - Art. 71 → Oil Free Zone promotion
- D.L. 169/2019 - Art. 42bis → Collective self-consumption and REC
  - New PV plant < 200kW
  - Premium tariff 100-110 €/MWh produced

REGIONAL

- Piedmont R.L. 12/2018 → Promoting of Energy Communities
- D.G.R.18-8520/2019 → Requirements for Energy Communities
- D.D. 547/2019 → Selection notice for public funding

- Puglia R.L. 45/2019
- Sardinia R.L. 47/2019
- Liguria R.L. 13/2020

→ Correspondence of purposes and competences attributed to EC, slightly difference of threshold values of the self-consumption requirement.

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Piedmont Region pilot projects of EC

EC are intended as *non-profit entities, that aim to facilitate the production and exchange of energy generated mainly from RES, in order to overcome the use of oil and its derivatives, as well as forms of efficiency and reduction of energy consumption.*

Regional Environmental Energy Plan (PEAR 2019), EC should :

- affect at least 10% of territory by 2025
- Insist on territories with an "energy vocation" and homogeneous coherent units

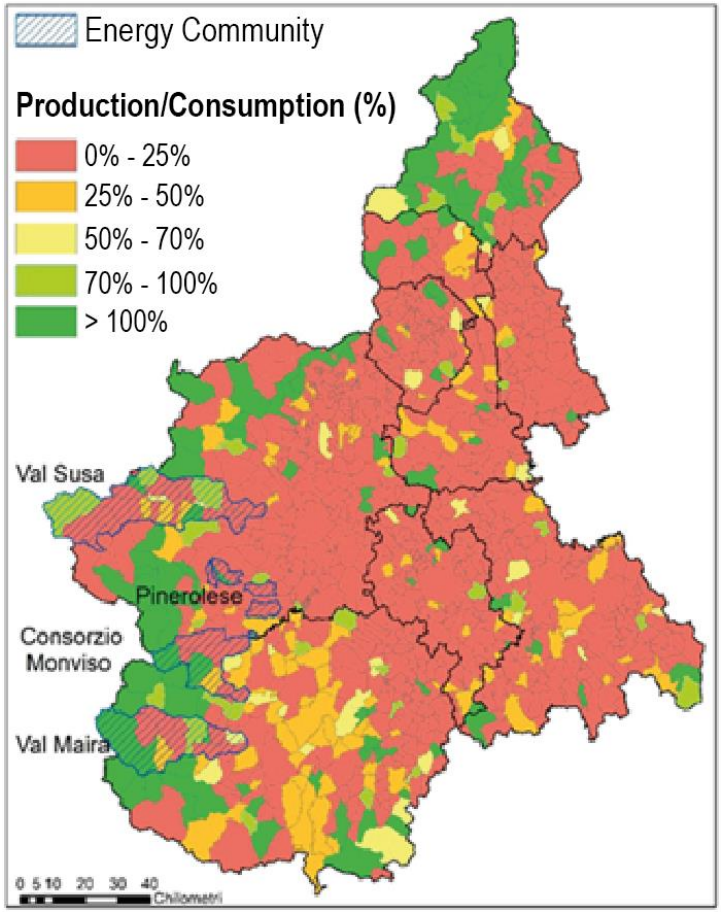
Minimum requirements of EC (LR 12/2018):

- Annual electric consumption > 0,5 GWh/y
- 70% of annual self-consumption, half from RES
- Plurality of stakeholders
- Annual energy balance and strategic plan

The first ECs in Piedmont (2019)

EC	*Munic. Nr.*	Pop. Inhab.	Area km²	*Density* inhab/km²	Altitude*	*Consumption* kWh$_{el}$/inhab	Production RES kWh$_{el}$/inhab	RES System
Pinerolese	6	16357	126	129.8	P-H-M	6140	1724	Hydro: 57% PV: 43%
Val Susa	31	73593	832	88.4	H-M	8095	8249	Hydro: 97% PV: 3%
Val Maira	13	11450	567	2.0	M	5793	3737	Hydro: 74% PV: 26%
Monviso	10	20491	347	59.1	H-M	5671	9955	Hydro: 88% PV: 12%

*P=Plain area, H=Hilly area, M=Mountainous area



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Case study

Among the four Energy Communities in Piedmont Region, the Pinerolo EC were chosen as case study.
It is a proactive territory, due to the presence of several entities:

Ambito V Metropolitan Area of Turin

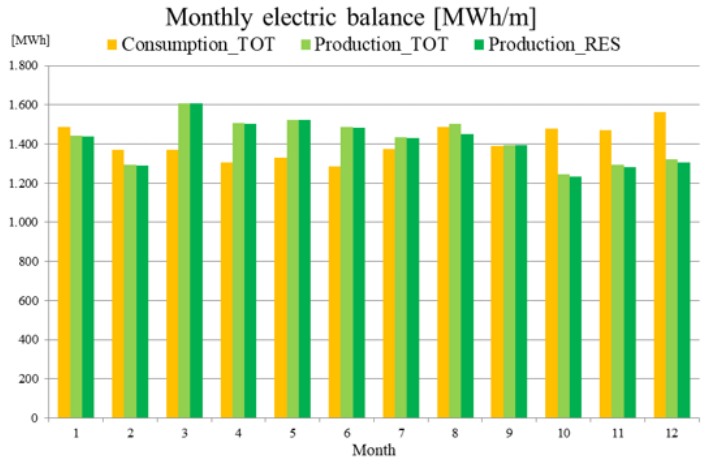
47 Municipalities owner of the energy related multi-utily company ACEA Spa

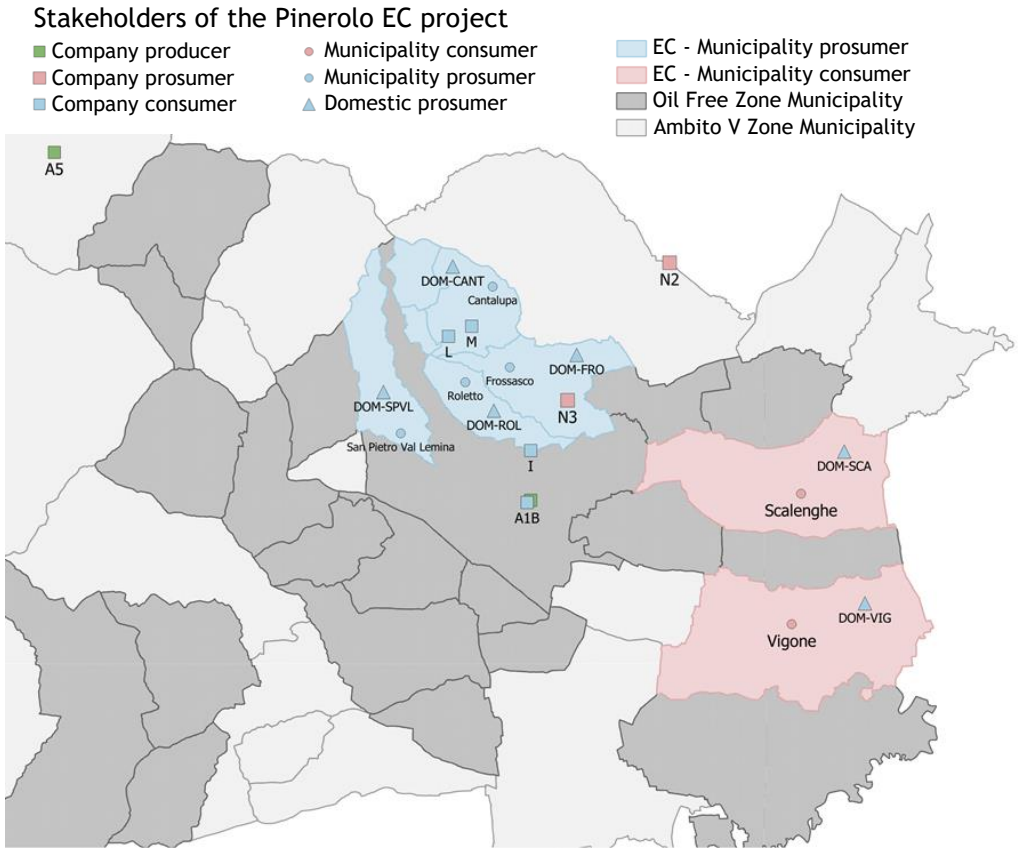
Oil Free Zone

31 Municipalities signatories of the memorandum of understanding (Turin, 2019)

Pinerolo Energy Community

6 Municipalities of the Oil Free Zone
5 Companies
144 Households (2% of residents in each municipality)





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Environmental protocol proposal

Reference to existing protocols

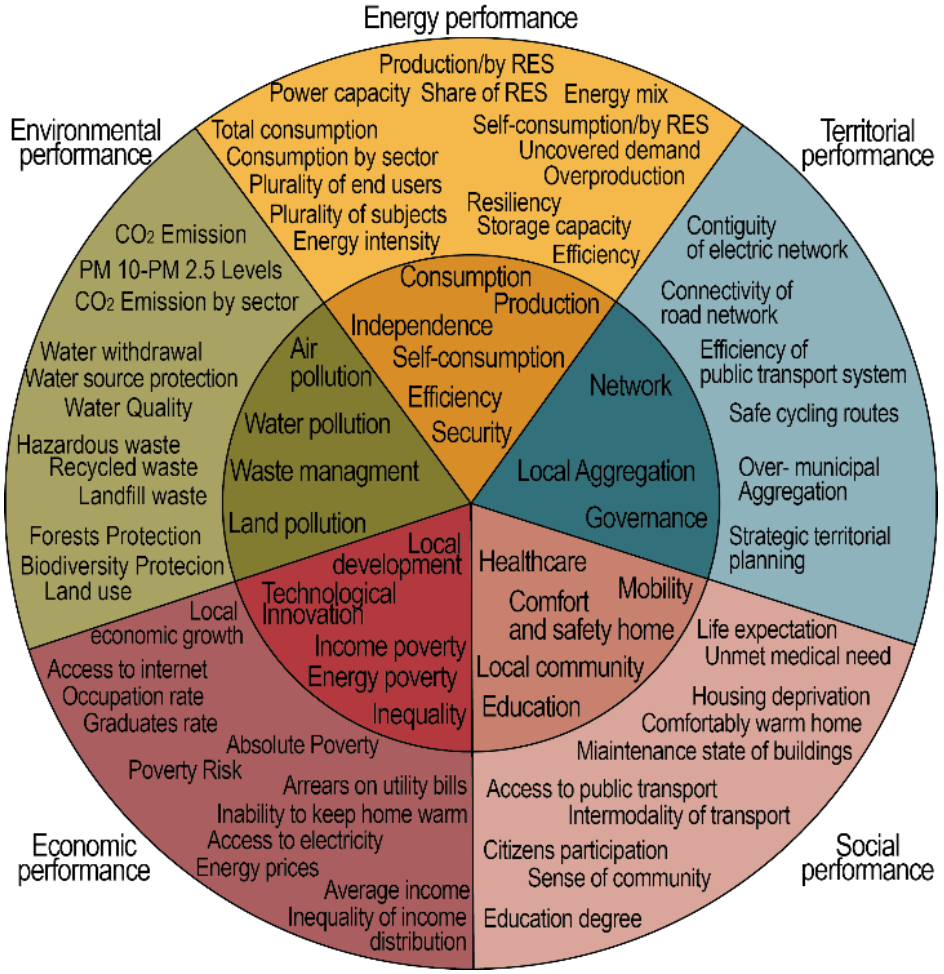
- LEED for neighbourhood development
- ITACA at urban scale
- GBC for district

Reference to existing indicators

- Sustainable Development Goal (SDG) of UN Agenda 2030
- Energy Trilemma Index (WEC)
- Eurostat (European)
- EU Energy Poverty observatory
- Istat (Italian statistic institute)
- Ispra (Italian institute for environmental protection)
- Arpa (Regional institute for environmental protection)

Environmental protocol for sustainable ECs

- 5 performances (Energy, territorial, social, economic, environmental)
- 23 selected criteria (inner cycle)
- 58 indicators (external cycle)



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Materials and method

Each SDG objective correspond to one or more *performances*.
Chosen criteria are indicated with their corresponding indicators. For each indicator, are specified the threshold value used in the score sheet and the specific regulatory framework.
The latter can consist of regulatory references enforced in the regional context, national strategic plan or parameters identified in literature.

SDG	*Objectives*	*Performance*	*Criteria*	*Indicators*	*Threshold value*	*Reference*
	End poverty in all its form in the world.	Economic	Income Poverty	Absolute poverty	<5.2% population (R) (family expenses≤ 753.8€/month)	Eurostat
				Poverty Risk	<20.3% population (N) (<60% income$_{median}$)	Eurostat
			Energy Poverty	Arrears on utility bills	<4.5% population (N)	EPOV
				Inability to keep home warm	<14.1% population (N)	EPOV
				Access to electricity	>95.4% population (N)	Istat
				Energy prices	<0.16-0.20 €/kWh (R)	Arera
	Ensure healthy lives and promote well-being for all at all ages.	Social	Healthcare	Life expectation (Oldness index)	<231% population (R)	Eurostat, Istat
				Unmet medical needs	>7.68 doctors /10k inhab. (N)	Eurostat, Istat
	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.	Social	Education	Education degree (% on total population)	University>9% Sr.HS>35% Jr.HS>30%, Primary>26% Total Populatio (R)	Istat
	Ensure availability and sustainable management of water and sanitation for all.	Environmental	Water pollution	Hydroelectric withdrawal	<47% tot withdrawal(R)	Eurostat, Arpa
				Protection of water sources	Good > 39% (R)	Eurostat, Arpa
				Water Quality	>130 aqueducts/600k inhab. (R)	Eurostat, Arpa
	Ensure access to affordable, reliable, sustainable, and modern energy for all.	Energetic	Consumption	Total consumption	> 0.5GWh/yr (R)	R.L.12/2018
				Plurality of end users	Com-Mun-Dom*	R.L.12/2018
				Consumption by sector	-	R.L.12/2018
				Plurality of energy subject	Prod-Cons-Pros**	R.L.12/2018
				Energy Intensity	<107.8 Tep/M€ (N)	Eurostat, PNIEC
			Production	Total production	-	R.L.12/2018
				Energy mix	> 2 RES systems (R)	R.L.12/2018
				RES power capacity	> 6.5kW pro-capta (N)	PNIEC
				Total RES production	> 35% tot Prod. (R)	R.L.12/2018
				Share of RES in public transport	>21.6% tot Cons. (N)	PNIEC
			Self-consumption	Total self-consumption	>70% tot Prod.(R)	R.L.12/2018
				Self-consumption by RES	>70% tot RES Prod. (R)	R.L.12/2018
				Overproduction	<30% Tot Prod. (R)	R.L.12/2018
			Independence	Uncovered demand	<30% Tot Prod. (R)	WEC
			Security	Storage capacity	Yes/No	WEC
				System Resiliency	Yes/No	WEC
			Efficiency	Energy efficiency (Savings rate)	+0.8% a year (N)	Eurostat,PNIEC

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Material and methods

8	Promote inclusive, and sustainable economic growth, full and productive employment, and decent work for all.	Economic	Local development	Occupation rate	>42.5% population (N)	Istat
				Local economic growth	+0.4% a year (N)	Istat
				Graduates rate	> 9.2% population (R)	Istat
9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.	Economic	Technological innovation	Access to internet	> 75.1% population (N)	Eurostat, Istat
		Territorial	Network	Contiguity of electric network	Yes/No	R.L.12/2018
				Connectivity of the road network	-	Istat
				Efficiency of public transport	<12 min waiting (R)	Istat
				Availability of safe cycling routes	>1.5m/inhab (N)	Fiab
10	Reduce inequality within and among countries	Economic	Economic inequality	Average income (of families)	31,608€/yr/family (R)	Eurostat, Istat
				Inequality income distribution	< 6.3% population (N)	Eurostat, Istat
11	Make cities and human settlements inclusive, safe, resilient, and sustainable.	Social	Comfort and safety home	Comfortably warm/cool home	>85/76% dwellers (N)	EPOV
				Maintenance state of buildings	Good >84.6% (R)	Istat
				Housing deprivation	>49.6 m²/occupant (R)	Istat
			Mobility	Access to public transport	< 33.5% population (N)	Istat
				Intermodality of transport system	-	Eurostat
13	Take urgent action to combat climate change and its impacts.	Environmental	Air pollution	Total GHGs emissions	<41.6kton/yr (N)	Ispra, PNIEC
				GHGs emission by sector	-40% /10yr (N)	PNIEC
				Annual level of PM10-2.5	40/25 µg/m³ (R)	Eurostat
15	Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	Environmental	Land pollution	Land use	<6.9% tot area (R)	Arpa, Ispra
				Forest protection	>38.5% tot area (R)	Arpa, Ispra
				Biodiversity protection	>17.8% tot (R)	Arpa, Ispra
			Waste management	Special Hazardous waste	<152.6ton/yr (R)	Arpa, Ispra
				Recycling rate	>61.3% tot waste (R)	Arpa, Ispra
				Land fill waste rate	<9.8% tot waste (R)	Arpa, Ispra
16	Promote peaceful and inclusive societies, provide access to justice for all and build effective, accountable, and inclusive institutions at all levels.	Social	Local community	Sense of community	>24.6/100 inhab. (N)	Istat
				Citizen participation	>23.8/100 inhab. (N)	Istat
		Territorial	Local aggregation	Territorial/municipal aggregation	Yes/No	-
			Governance	Strategic territorial plans	Yes/No	-

*Com=companies, Mun=Municipalities, Dom=Domestic; **Prod=Producer, Cons=Consumer, Pros=Prosumer; (N) National data; (R) Regional data

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Material and methods (for Pinerolo and Susa Valley)

- The assessment of the sustainability for ~~of~~ each of the five identified performances was conducted by assessing the compliance of each criterion with the reference threshold values.
- For the two-case studies, two score sheets were drawn up separately. For each of the five performances the number of indicators satisfied by the EC was calculated; firstly in reference to the number of indicators that can be calculated, and then in reference to the number of the total indicators classified in the protocol.

Performance		Indicator	Treshold values	Unit	Pinerolo EC		Unit	Score
Energyc	1	Annual total consumption EC	0,50	GWh/year	EC	16,96	GWh/year	yes
	1.1	Plurality of end user	30	%	Company user	3%	%	yes
					Municipality user	4%		
					Domestic users	93%		
	1.2	Consumtion by sector	30	%	Company user	85%	%	yes
					Municipality user	13%		
					Domestic users	2%		
	1.3	Plurality of energy subjects	30	%	Consumotion	10%	%	yes
					Prosumer + producer	92%		
	1.4	Energy Intensity	107,80	Tep/mln€	EC	1816,1	Tep/mln€	no
	2	Annual total production EC			EC	17,04		yes
	2.1	Energy mix	30	% (circa)	Biogas	80%	% (circa)	yes
					Hydroelectric	16%		
					Pv	3%		
					Cog (NO RES)	10%		
	3	Annual RES production EC	5,964	GWh/year	EC	16,94	GWh/year	yes
	3.1	Self-consumption	70	%	EC	100%	%	yes
	3.2	RES Self-consumption	70	%	EC	99,9%	%	yes
	3.3	Energy dependency	<30	%	EC	5,5	%	yes
	3.4	Overproduction	<30	%	EC	5,5	%	yes
	3.5	Installed capacity	\	kW/procapite	EC	6,5	kW/procapite	yes
	4	Storage system	yes/no	\	EC	no	\	no
	5	Energy system resiliency	\	\	EC	\	\	\
	6	Energy efficiency	-0,8	%	EC	\	%	\
	7	Share of RES in transport system	21,6	%	EC	\	%	\
TOT							Calculable	12/14
TOT							totali	12/17

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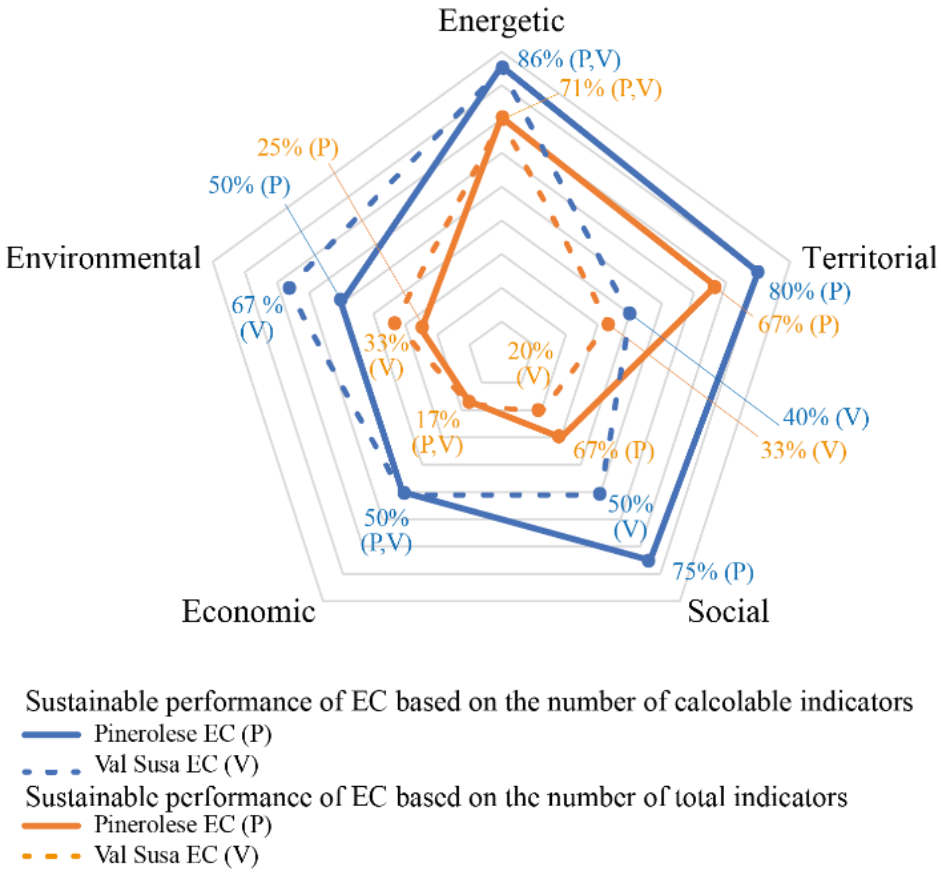
Results

In both cases, it was possible to determine only 34 of the 58 indicators.

The number of total indicators for social, economic, and environmental benefits is approximately the same. In all cases the number of calculable indicators is limited, due to the lack of data relating exclusively to the case studies' territory.

	Performance	Indicator				
		Satisfied	Calculable		Total	
Pinerolo EC	Energetic	12	14	86%	17	71%
	Territorial	4	5	80%	6	67%
	Social	3	4	75%	10	30%
	Economic	2	4	50%	12	17%
	Environmental	3	6	50%	12	25%
Valsusa EC	Energetic	12	14	86%	17	71%
	Territorial	2	5	40%	6	33%
	Social	2	4	50%	10	20%
	Economic	2	4	50%	12	17%
	Environmental	4	6	67%	12	33%

For each of the 5 performances of sustainability in the Pinerolo and Val Susa EC, the maximum degree of satisfaction (100%) is placed at the top of the pentagon; the lowest degree of fulfilment of the criteria is located in the center of the figure (0%).



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Conclusion

- This methodology is very **flexible and transferable** because it sets criteria while the threshold values can change with the introduction of new rules and objectives that can be adapted to each specific territorial context.
- The protocol proposed in this article could become a **supporting tool** to measure and evaluate the progress of the territorial energy plans.
- The monitoring of energy data, functional to the ordinary management of the EC, could be associated with the monitoring of other parameters, such as levels of environmental pollution and data on local mobility.
- EC can offer opportunities to the territory and to the community itself, questioning the methods of management and sharing of local resources, whether they are natural or anthropogenic.
- The acquisition of information at the business-as-usual scenario is essential for the definition of possible scenarios of intervention, as well as useful for assessing the degree of initial sustainability of the EC and for identifying the main critical issues to which allocating resources.
- Future research. While in this study the assessment was pertinent only to the electric energy, the same indicators can be used in assessments regarding thermal energy, or other forms of energy, if appropriately modified as appropriate.