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Towards the decarbonization of urban communities: evaluation of smart and green strategies to reduce gas carbon emissions

«Humanity has the ability to ***make development sustainable*** *to ensure that it meets the* ***needs of the present*** *without compromising the* ***ability of future generations*** *to meet their own needs»*

Energy Sustainability

Introduction of **renewable energy sources**, reduction **of greenhouse gas emissions**, etc.

Environmental Sustainability

Promotion of **biodiversity**, preservation **ecosystems**, reduction of **pollution**, etc.

In order to address the challenges posed by the concept of **sustainability** in the contemporary era, it is necessary to turn to the concept of **smart cities**.

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the smart cities can help in improving the sustainability level of a city and enhance the balance in its assessment

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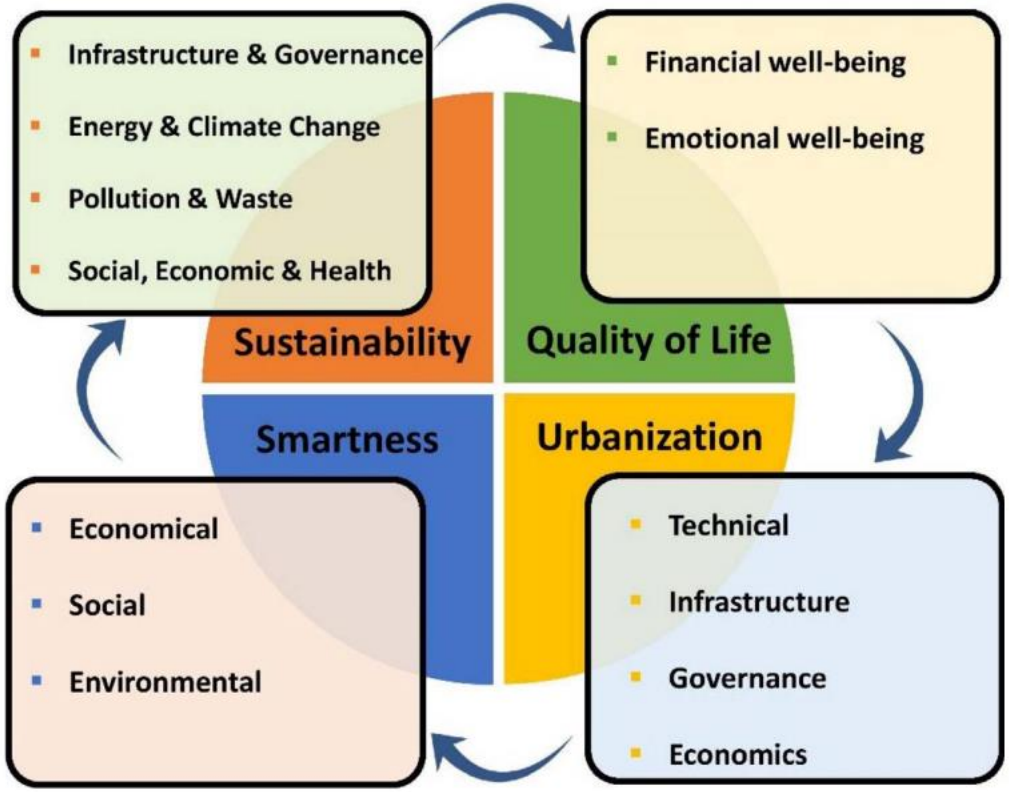
- **Analize data** to assess the **level of sustainability**
- Citizens can **participate in the governance**
- **Priority** to the **sustainable actions**



To **evaluate** the performances its important to collect **Key Performance Indicators.**

They allow to:

Measure the **impact of selected strategies** and **promoting energy sustainability**

Adapt and **optimize ongoing strategies** to ensure **long-term benefits**

The **aim of the work** is to evaluate the **effectiveness** of integrated **smart city initiatives** by defining and monitoring **KPIs.**

METHODOLOGY OVERVIEW

Comprehensive **analysis of the case study**

↓

Individuation of the **actions** proposed and **simulations**

↓

Definition of the **KPIs**

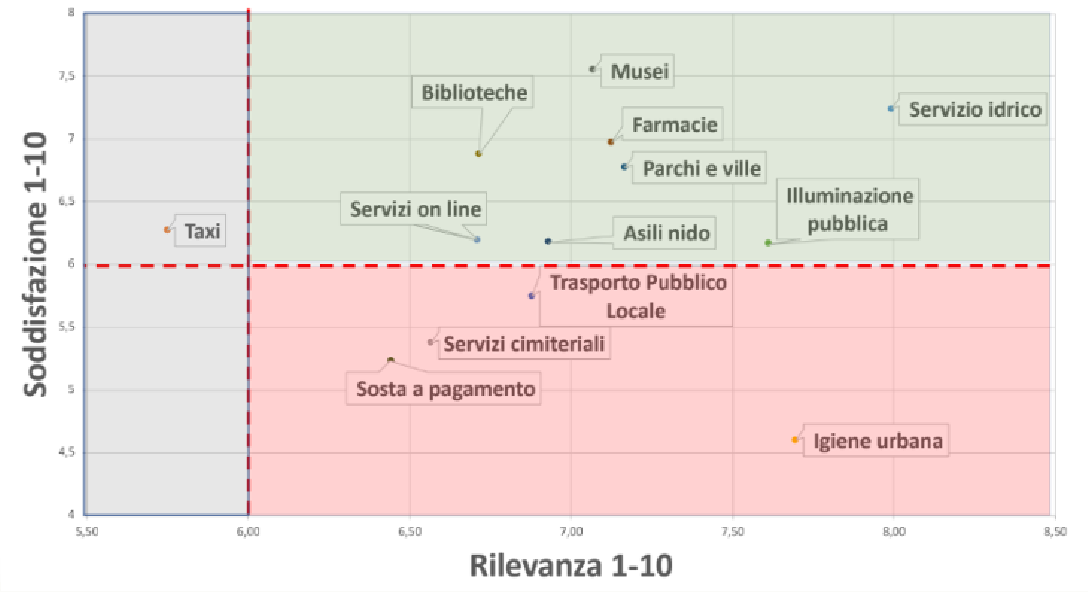
↓

Ranking of the solutions

CASE STUDY

The case study is located within the **third municipality of Rome**, with a total extension of 97.82 km2

In order to ensure collective participation in the planning and management of the city, general **satisfaction ratings** of the inhabitants of the areas concerned:



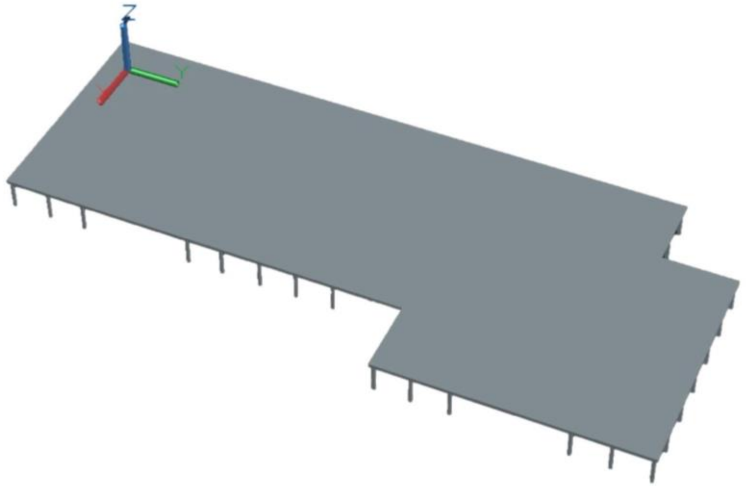
Photovoltaic Plant Simulations

Action:

Redevelopment of the former landfill site and conversion of the principal structure into a **depot for electric buses**, with a **photovoltaic system** installed on the roof

Softwares:

AutoCAD 3D, PVsyst



Action technical sheet	
Surface PV plant [m^2]	5397
PV panel model	Trinasolar TSM-DE15M-(II)-400
Power [Wp]	400
Power PV plant [kWp]	1062
Inverter	Emerson SPV 1800
Annual producibility [kWh/kW/yr]	1422
Electrical buses	Mercedes eCitaro 3-doors

Intelligent Traffic Lights Simulations

Action:

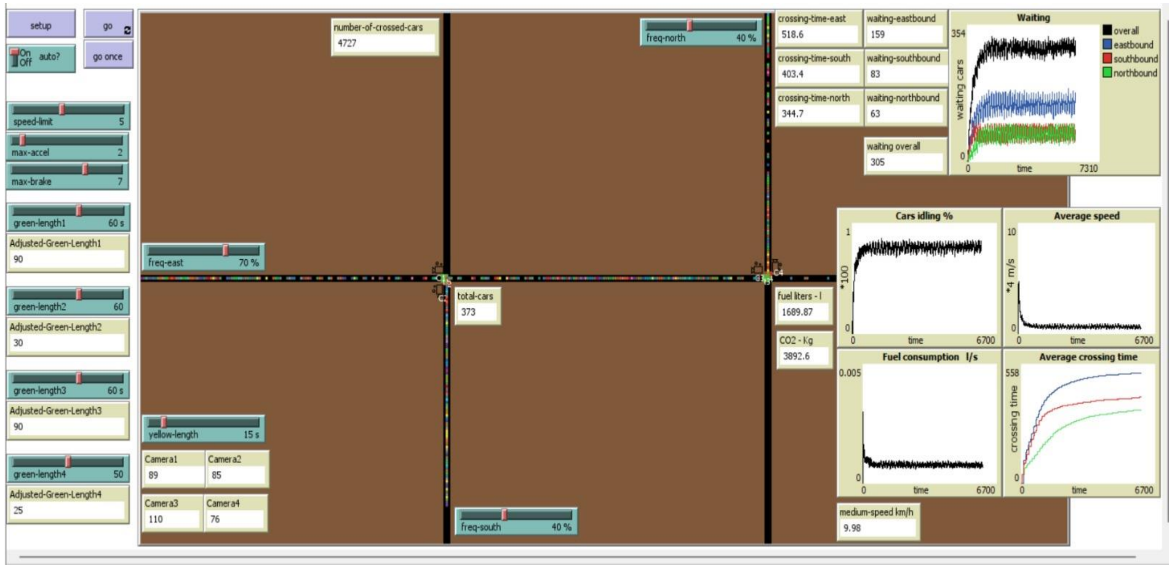
Introduction of **smart traffic lights** to **reduce traffic congestion** and **CO_2 emissions**

Software:

NetLogo, an agent-based modelling platform used for simulating and studying complex systems

The model depicts a principal road intersecting with two perpendicular side roads.

Action technical sheet	
Tiles dimensions	4 x 4 meters
Model spatial domain	400 x 200 tiles
Probability cars	70%
Green lights sliders	50 (prim) and 60 (sec)
Real road section	2.5 km, 8 traffic lights
Estimated vehicles	8000 vehicles in 4 h
Days of traffic	200



Incidence matrix

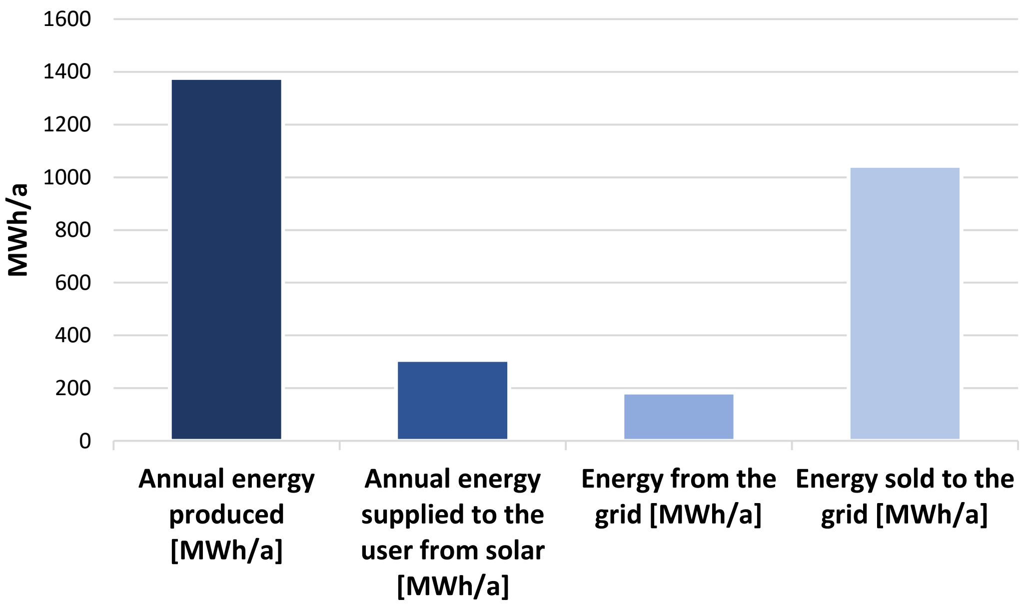
Quantitative analysis of the proposed strategies

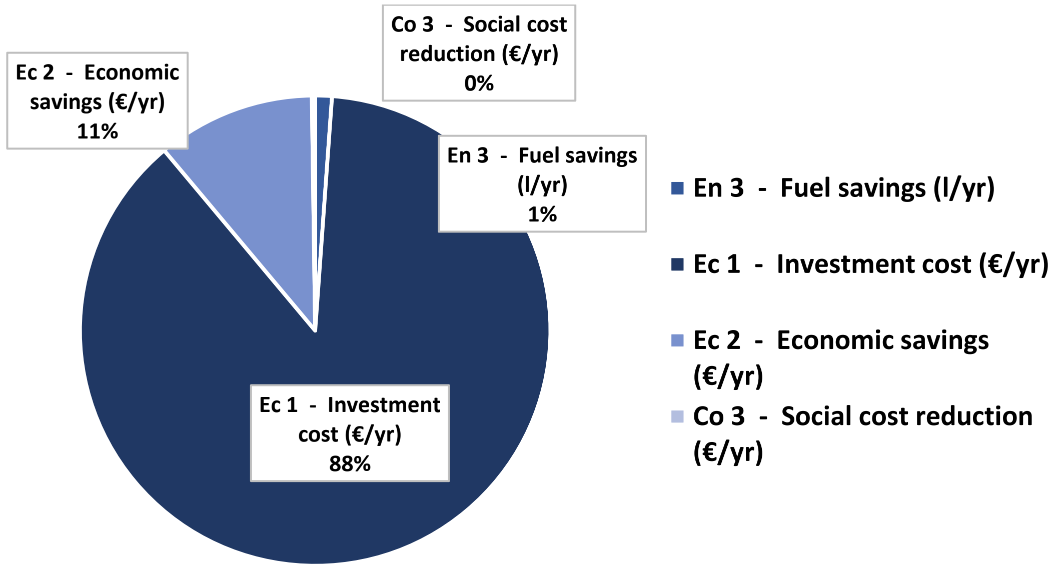
To construct the smart matrix:

- Definition of the **smart axes**
- Definition of the **smart indicators** related to each smart axes
- Calculation of the **correction factor**
- Calculation of the **mean value** for each indicator
- **Scaling procedure** and **attribution of values**
- **Final ranking**

Smart Axes	Key Performance Indicators	units of measurement
Energy	En 1 - Primary non-renewable energy saved	Toe/yr
	En 2 - Renewable primary energy produced	Toe/yr
	En 3 - Fuel savings	l/yr
Economy	Ec 1 - Investment cost	€/yr
	Ec 2 - Economic savings	€/yr
	Ec 3 - Investment payback time	yrs
Community	Co 1 - Satisfaction index	%
	Co 2 - Time saved	min
	Co 3 - Social cost reduction	€/yr
Environment	Ev 1 - Tonnes of CO_2 saved	t CO_2/yr
Mobility	Mo 1 - Travel time reduction	min

Results: Photovoltaic systems

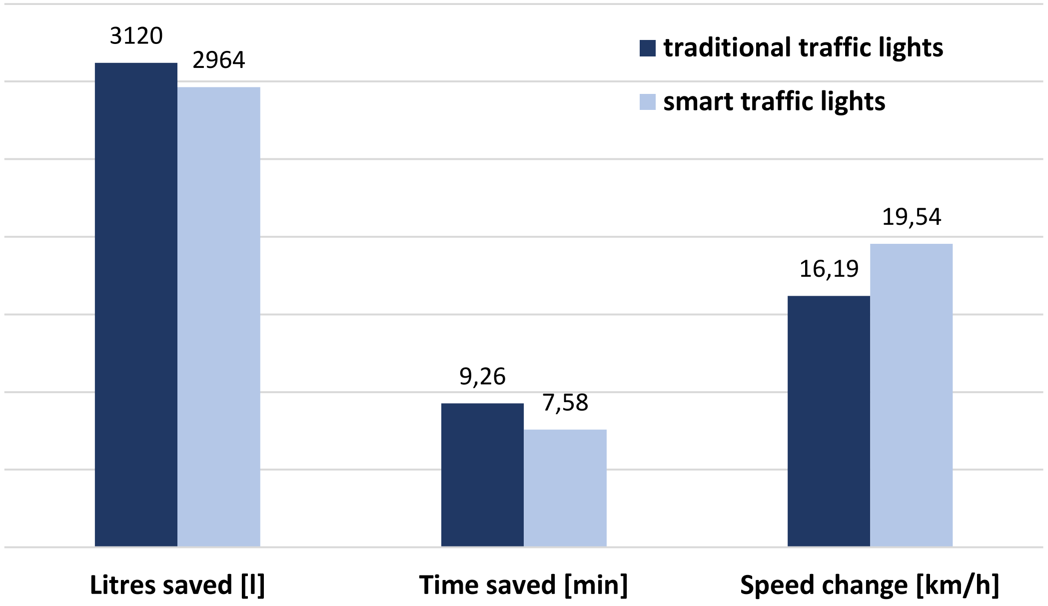


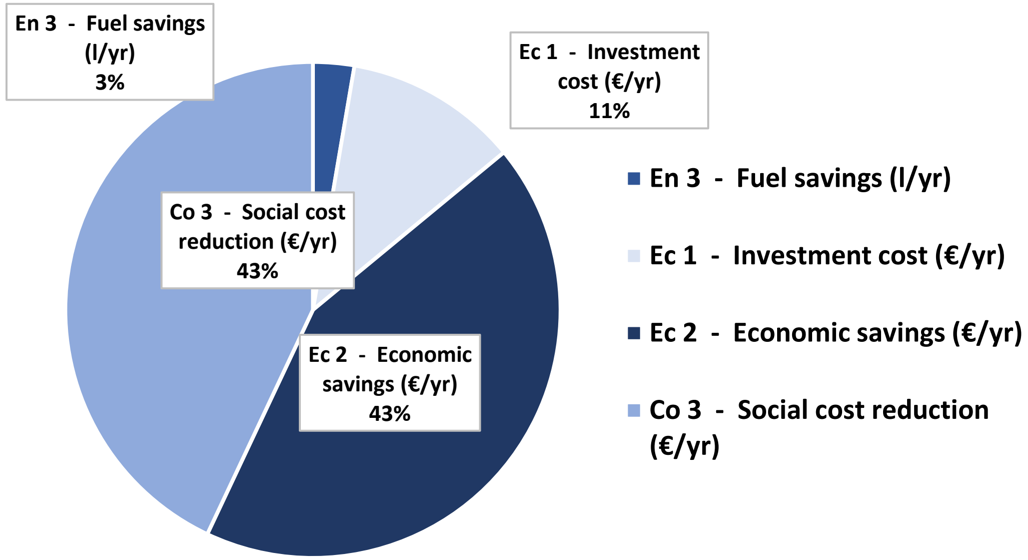


- Reduction of **CO_2 emissions** is 36 tonnes per year
- Total **non-renewable primary energy saved** is then equal to 2 Toe/y

- The **investment** amounts to €2,601,000, with an estimated **economic saving** of €276,298 per year
- The investment is projected to yield a **19-year payback period**

Results: Smart Traffic Lights





- Intelligent traffic lights can result in a **5% reduction** in **fuel consumption** and **CO_2 emissions**
- **Reduced crossing time** and **increased average vehicle speed**

- The annual economic savings amount to € 498,484, guaranteed by the **reduction in social costs** associated with **CO_2 emissions** and **traffic congestion** and **fuel savings**

Results: Matrix Ranking

		Scenari			
Axes	**Indicator**	**Smart traffic lights**	**Landfill**	**Library**	**Smart streetlights**
Energy	[En]1	5.00	-3.25	0.00	-3.30
	[En]2	0.00	5.00	0.00	0.00
	[En]3	4.03	5.00	0.00	0.00
Economy	[Ec]1	2.92	-5.00	5.00	5.00
	[Ec]2	5.00	1.98	0.00	-3.23
	[Ec]3	3.82	-5.00	0.00	-0.05
Community	[Co]1	-2.87	1.13	5.00	-5.00
	[Co]2	5.00	0.00	0.00	0.00
	[Co]3	5.00	-3.66	0.00	-5.00
Environment	[Ev]1	5.00	0.94	0.00	-3.87
Mobility	[Mo]1	5.00	0.00	0.00	0.00
Economic feasability		0.908	0.000	0.998	0.998
Time feasability		0.833	0.000	0.972	0.917
Somma		**39.64**	**-2.87**	**11.97**	**-13.53**

CONCLUSIONS

Two scenarios for the **integration of renewable energy sources** into urban infrastructure were proposed:

Installation of a photovoltaic (PV) field on the roof of an abandoned building to power an electric bus line

Deployment of smart traffic lights

Both were **analyzed through KPIs** deemed useful for the characterisation

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Both resulted in a **significant reduction of CO_2 emission**, significantly contributing to the **decarbonisation objectives of European sustainability programmes** and the development of **energy districts**

The first scenario also increased the **share of renewable energy produced and self-consumed** on site

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