FREE GREEN NATURE

LCA screening analysis for an alternative treatment system to antifungal products in viticulture

Final report_rev01

Study carried out by Spinlife s.r.l. (spin-off dell'Università di Padova)
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SPIN-OFF DELL'UNIVERSITÀ DI PADOVA

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The project objectives

The project's mission is **quantification potential reductions in environmental impacts** relating to the adoption of a treatment system innovative for the protection of vine plants compared to those of traditional techniques.

The Life Cycle Assessment approach is then used to compare the impacts of two processes with the same purposes, but with consumption and different methods

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General Settings

- Treatments in comparison

- **UVC rays**: innovative technique based on the use of a hybrid robot equipped with UVC lamps. The rays emitted hit the vine leaves and damage the DNA of the pathogenic microorganisms. The number of treatments is established by a sensor station for humidity, temperature etc..
- **Traditional**: consists in the distribution of pesticides diluted in water on the surface foliar of the plants, through the use of a diesel tractor with barrel towing.

Objective of the study:

Assessment of the potential reduction of environmental Impacts, from a life cycle perspective, associated with UVC treatment compared to the environmental impacts of traditional treatment

Functional unit

All values within the study are referring to the set of treatments carried out in a single production season

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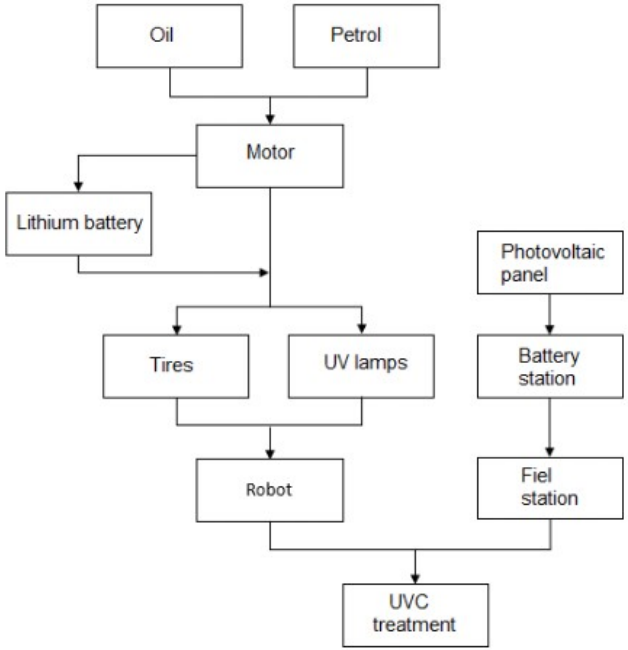
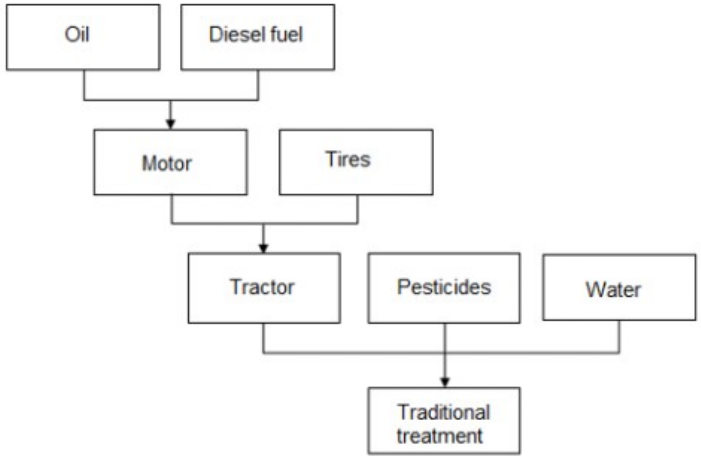
The boundaries of the system



UVC treatment diagram



Traditional treatment diagram

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Inventory analysis - traditional treatment

The inventory phase was conducted by preparing a data collection sheet with the aim of reporting the consumption of mass and energy and emissions in the various environmental sectors

List of units subject to maintenance / replacement and consumption related to treatment traditional, used in the modeling phase

Traditional treatment - consumption				
Voices	**value**	**u.m.**	**Note**	**Source**
Diesel fuel	6	L/ha	The tractor consumes 6 L/ora	agency
Water	400	L/ha	Per season	agency
Pesticide	50	Kg/ha	Per season, with an average di 4,16 kg/treatment	agency
oil	1	L/season		agency
Total treatments per season: 12				

Traditional treatment - maintenance					
Voices	**amount**	**Average life [years]**	**Note**	**Source amount**	**Source years of life**
motor	1	10		agency	literature
battery	1	10		agency	literature

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Inventory analysis - UVC treatment

List of units subject to maintenance / replacement and consumption related to X-ray treatment UVC, used in the modeling phase

UVC treatment - consum			
Voices	**value**	**u.m.**	**Note**
petrol	0,543	L/ha	It takes into account the total hectares treated (motorized at 63.5% of power + battery only)
Oil change	1,5	L/season	
Total treatments per season: three usage scenarios were considered with a variable number of outlets and power used			

UVC treatment - maintenance			
Voices	**amount**	**Average life [years]**	**Note**
photovoltaic panel	1	30	175W, 24V panel; average life: given Ecoinvent
battery station	1	10	
lithium battery	1	12	
motor	1	12	
UVC emitters	8	8,5	Average life from 7 to 10 years, based on use

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Modeling phase - estimates

Traditional treatment	
Phases	**Recruitments**
tractor production	A dataset was used that considers the consumption and emissions related to the production of a tractor with an average life equal to 7,000 h and weight of 3,000 kg
water	The impacts of well water extraction in Italy were considered
pesticides	A dataset was used that calculates emissions and impacts due to the production of pesticides
impacts of tractor with trailer	A dataset was used to calculate the emissions into the air and into the soil and the production of heat deriving from the work of a tractor with trailer. It does not consider the transport of goods. The diesel consumption data provided was used by the company.
processing operation	Simulates the treatment using the data entered on the tractor, water, pesticides and the distance traveled per hectare. The Emissions consider those of the tractor with trailer (see above) plus those of pesticides, which have been estimated considering a fictitious pesticide containing 3 antifungal active ingredients against downy mildew, powdery mildew and botrytis (respectively metiram, sulfur and cyprodinil).

UVC treatment	
Phases	**Recruitments**
Robot movement	A dataset was used on the impacts of an electric car with a lithium battery
Engine combustion	A dataset on emissions and impacts due to the combustion of a gasoline engine was considered. The power and consumption data provided by the company..
Field station	Two datasets were used: one for the lithium battery that powers the sensors and one for the photovoltaic panel. Both return the impacts due to the production and use of the two elements and have been modified to be aligned with the data provided by the company
Processing operation	Combine the two datasets described above

The model for the assessment of environmental impacts

12 impact categories are assessed (1/2):

1. **Climate change:** Climate change can have negative effects on the health of people ecosystems, human health and material well-being. Climate change is related to greenhouse gas emissions into the air, for example related to fuel consumption and activities agricultural;

2. **Ozone depletion:** This category concerns the depletion of stratospheric ozone, which it can have harmful effects on human health, animal health, terrestrial and aquatic ecosystems, on biochemical and material cycles. The geographic scope of this indicator is on a global scale;

3. **Ionizing radiation (kgBq U235 eq):** the characterization model used is the one reported in Frischknecht et al, 2000, and represents the potential impact of ionizing radiation on population, in relation to Uranium 235;

4. **Photochemical ozone formation:** Photo-oxidant formation is the formation of reactive substances (mainly ozone) which are harmful to human health and ecosystems and which can too damage crops. This problem is also referred to as "summer smog". Winter smog does not fall under this category.

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The model for the assessment of environmental impacts

12 impact categories are assessed (2/2):

5. **Acidification:** it concerns acidifying substances which cause a wide range of impacts on soil, groundwater, surface water, organisms, ecosystems and materials (buildings).
A typical source of impact are emissions associated with the combustion of coal;

6. **Eutrophication (6. Freshwater, 7. Marine, 8. Terrestrial,):** includes all impacts due to excessive levels of macronutrients in the environment caused by emissions of nutrients in water and soil (e.g. use of fertilizers);

9. **Ecotoxicity Freshwater:** includes all the impacts due to emissions into surface waters of toxic substances for ecosystems. A typical source of impact is linked to the use of pesticides in agriculture;

10. **Water Use**: it is a measure of the consumption of the water resource taking into account the quantity of the resource available in the specific basin. Irrigation processes are the main source of impact in this category;

11. **Resource Use (11. Energy carriers, 12. Minerals and metals):** is a measure of the consumption of non-renewable energy resources. The sources of impact are to be found in the use of fossil fuels

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The representation of environmental impacts

Analysis approach - traditional treatment

12 treatments per season were considered. The impacts were calculated for:

- **«Pesticide production»**: includes all activities related to the production of pesticides;
- **«Water»**: considers all the impacts related to the withdrawal of water resources;
- **«Use of the tractor»:** includes the tractor production and use processes;
- **«Emissions due to pesticides** it consists in the activity of the traditional treatment itself, that is, the distribution of the pesticide diluted in water.

Analysis approach - UVC treatment

The three usage scenarios were considered:

- **Best:** 25 outgo, 50% power
- **Realistic:** 60 outgo, 60% power
- **Worse:** 100 outgo, 100% power

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Environmental impact analysis - traditional treatment

Results of the impacts of traditional treatment relative to 1 ha for an entire production season

Impact category	u.d.m.	Tractor use scenario [1 ha, 1 season]
Climate change	kg CO2 eq	1003
Ozone depletion	kg CFC11 eq	9.96E-04
Ionising radiation, HH	kBq U-235 eq	106
Photochemical ozone formation, HH	kg NMVOC eq	6
Acidification terrestrial and freshwater	mol H+ eq	9
Eutrophication freshwater	kg P eq	4.81E-01
Eutrophication marine	kg N eq	2
Eutrophication terrestrial	mol N eq	20
Ecotoxicity freshwater	CTUe	7635
Water use	m3 eq. depriv.	90
Resource use, energy carriers	MJ	14657
Resource use, mineral and metals	kg Sb eq	6.73E-03

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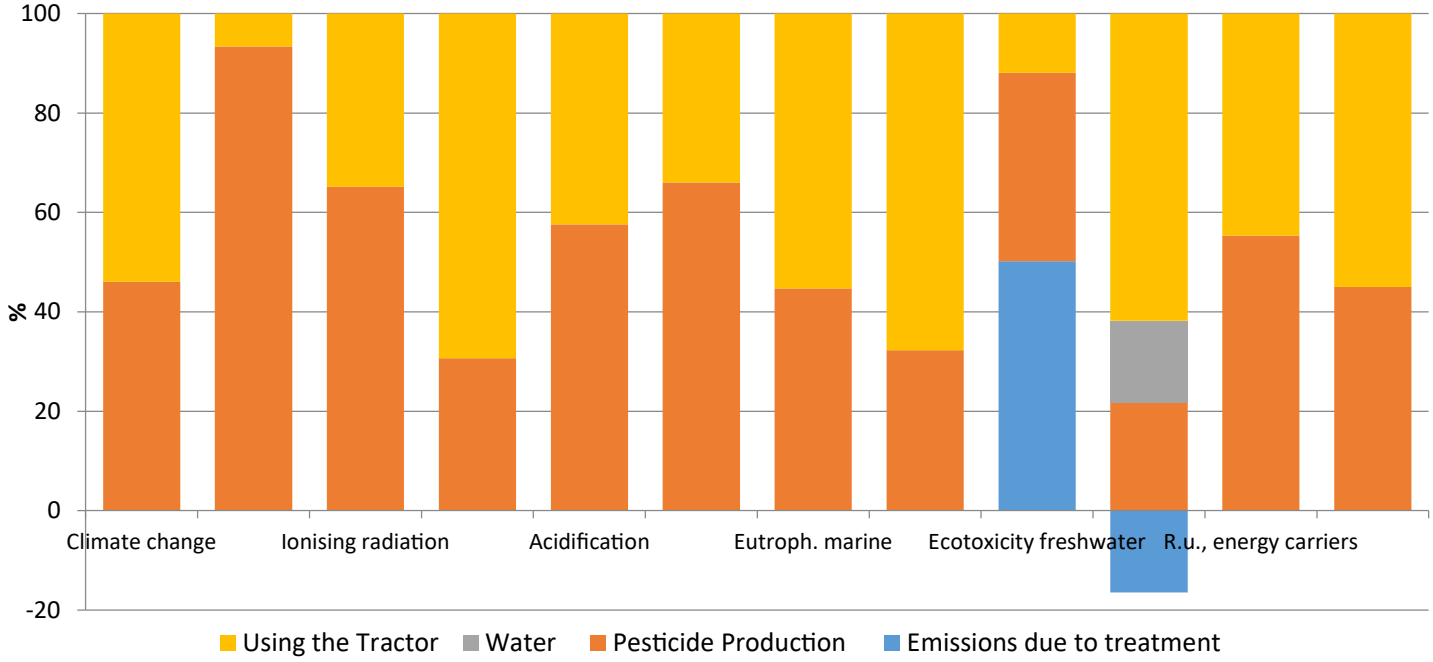
Environmental impact analysis - traditional treatment

Contribution of the different phases of traditional treatment to the impact categories considered



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Analyses environmental impacts - traditional treatment

Impacts of traditional treatment related to 1 ha for an entire production season

The results show that the most impacting phases of this type of treatment are:

- **«Using of the tractor»** (maximum 69,4% in Photochemical Ozone formation)
- **«Production of pesticides»** (maximum 93,4% in Ozone depletion)

Which alone are responsible for the impacts of most categories.

The «Water» phase has an impact of 16% in the Water Use category, because it includes the withdrawal of water resources from the environment.l

The phase **«Emissions due to treatment»** has a strong impact on the Ecotoxicity category, freshwater 50 due to chemicals released into the environment.
This phase also leads to a negative value in the Water Use category: this is due to the fact that, during the operation of treatment, the water used for the dilution of chemical products is reintroduced into the environment, making the impact on water resources almost nil.

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Analisi impatti ambientali - trattamento a raggi UVC

Results of the UVC treatment impacts relative to 1 ha for an entire production season, divided into the three usage scenarios

Impact category	u.d.m.	Realistic	Best	Worse
Climate change	kg CO2 eq	70	32	157
Ozone depletion	kg CFC11 eq	1.36E-05	5.29E-06	3.28E-05
Ionising radiation, HH	kBq U-235 eq	5	3	11
Photochemical ozone formation, HH	kg NMVOC eq	1.52E-01	8.91E-02	2.96E-01
Acidification terrestrial and freshwater	mol H+ eq	2.46E-01	1.64E-01	4.35E-01
Eutrophication freshwater	kg P eq	1.88E-02	1.79E-02	2.09E-02
Eutrophication marine	kg N eq	3.39E-02	2.39E-02	5.68E-02
Eutrophication terrestrial	mol N eq	3.61E-01	2.45E-01	6.27E-01
Ecotoxicity freshwater	CTUe	26	21	38
Water use	m3 eq depriv.	17	14	22
Resource use, energy carriers	MJ	960	429	2183
Resource use, mineral and metals	kg Sb eq	6.88E-04	6.82E-04	6.99E-04

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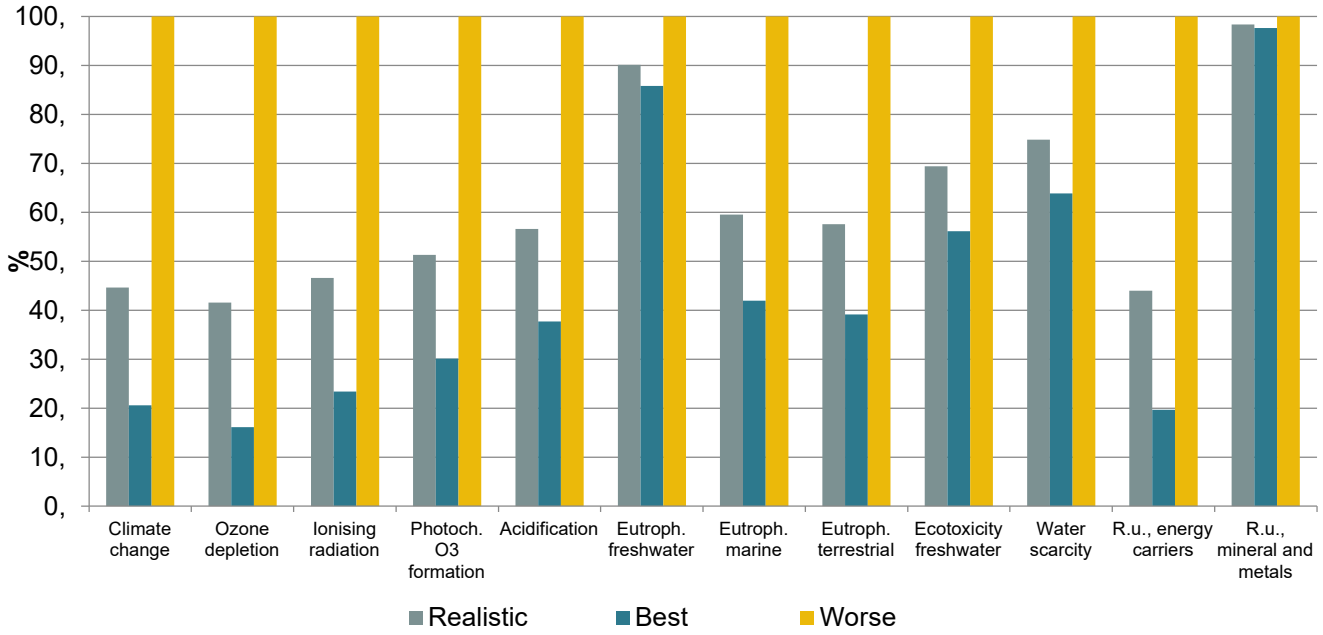
Environmental impact analysis - UVC treatment

Impact changes in the different categories considered, divided into the three usage scenarios.



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Environmental impact analysis - UVC treatmentC

Impacts of UVC treatment related to 1 ha for an entire production season

The modification of the number of treatments and the power used entail considerable variations in impact. In particular, the major differences are highlighted for the categories:

- *Climate Change*
- *Ozone depletion*
- *Ionising radiation*
- *Resource use, energy carriers*

mainly due to the different quantities of fuel consumed.

Some categories - such as *Resource use, minerals and metals - show less marked differences between the three* scenarios: this is due to the fact that these impacts are not related to the processing operations per se, but to the operations of production of the robot components and the field station.

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Comparison between treatments

Impact category	Unit	Tractor	Realistic UVC scenario	Variation %
Climate change	kg CO2 eq	1003	70	-93.0
Ozone depletion	kg CFC11 eq	9.96E-04	1.36E-05	-98.6
Ionising radiation, HH	kBq U-235 eq	106	5	-95.2
Photochemical Ozone formation	kg NMVOC eq	6	1.52E-01	-97.5
Acidification	mol H+ eq	9.47	2.46E-01	-97.4
Eutrophication freshwater	kg P eq	4.81E-01	1.88E-02	-96.1
Eutrophication marine	kg N eq	2.29	3.39E-02	-98.5
Eutrophication terrestrial	mol N eq	20	3.61E-01	-98.2
Ecotoxicity freshwater	CTUe	7635	26	-99.7
Water use	m3 depriv.	90	17	-81.6
Resource use, energy carriers	MJ	14657	960	-93.4
Resource use, mineral and metals	kg Sb eq	6.73E-03	6.88E-04	-89.8

- The UVC treatment involves a reduced use of fuel and the absence of chemicals
- In the **realistic scenario,** all the impact categories studied are ameliorative, with an **average reduction of the impacts** compared to traditional treatment equal to **95%** (minimum 80%)

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Comparison between treatments

Impact category	Unit	Tractor	UVC worst case scenario	Variation %
Climate change	kg CO2 eq	1003	157	-84.4
Ozone depletion	kg CFC11 eq	9.96E-04	3.28E-05	-96.7
Ionising radiation, HH	kBq U-235 eq	106	11	-89.8
Photochemical Ozone formation	kg NMVOC eq	6	2.96E-01	-95.1
Acidification	mol H+ eq	9.47	4.35E-01	-95.4
Eutrophication freshwater	kg P eq	4.81E-01	2.09E-02	-95.6
Eutrophication marine	kg N eq	2.29	5.68E-02	-97.5
Eutrophication terrestrial	mol N eq	20	1	-96.9
Ecotoxicity freshwater	CTUe	7635	38	-99.5
Water use	m3 depriv.	90	22	-75.4
Resource use, energy carriers	MJ	14657	2183	-85.1
Resource use, mineral and metals	kg Sb eq	6.73E-03	6.99E-04	-89.6

- Even considering the **worst case scenario**, all the impact categories studied are ameliorative, with one **average reduction in impacts** compared to traditional treatment equal to **91%** (minimum 75%).

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The new variants of ICARO

- **Variant of ICARO A:**

the petrol engine is eliminated as a **HATZ 1B50 Diesel engine** is installed, but the **endothermic engine always works to power the 6.8 kWh battery** which acts as storage. In in this case the specific fuel consumption was estimated at 807.9 g / ha

- **Variant of ICARO B:**

the petrol engine is always eliminated as a function of a **Diesel HATZ 1B50 engine, but it comes also eliminated the storage battery.** In this case the specific fuel consumption was estimated in 816 g/ha.

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The comparison between the variants of ICARO

Both variants were simulated in the worst case, therefore considering 100 passes per season

Impact category	Unit	Traditional tractor	Worst UVC scenario (hybrid petrol)	Variant A (hybrid Diesel)	Variant B (only Diesel)
Climate change	kg CO2 eq	1.00E+03	1.57E+02	3.66E+02	3.70E+02
Ozone depletion	kg CFC11 eq	9.96E-04	3.28E-05	6.73E-05	6.79E-05
Ionising radiation, HH	kBq U-235 eq	1.06E+02	1.08E+01	2.69E+01	2.72E+01
Photochemical Ozone formation	kg NMVOC eq	6.02E+00	2.96E-01	1.77E+00	1.79E+00
Acidification	mol H+ eq	9.47E+00	4.35E-01	1.98E+00	2.00E+00
Eutrophication freshwater	kg P eq	4.81E-01	2.09E-02	9.39E-02	9.47E-02
Eutrophication marine	kg N eq	2.29E+00	5.68E-02	5.74E-01	5.80E-01
Eutrophication terrestrial	mol N eq	2.04E+01	6.27E-01	6.26E+00	6.32E+00
Ecotoxicity freshwater	CTUe	7.63E+03	3.82E+01	9.38E+02	9.47E+02
Water use	m3 depriv.	9.03E+01	2.22E+01	6.17E+01	6.22E+01
Resource use, energy carriers	MJ	1.47E+04	2.18E+03	5.10E+03	5.15E+03
Resource use, mineral and metals	kg Sb eq	6.73E-03	6.99E-04	5.23E-03	5.28E-03

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Conclusions

- In traditional treatment, the most significant contributions are associated with the use of diesel and pesticides, with significant impacts in all the environmental categories analyzed;
- In UVC treatment, the use of a hybrid petrol engine, the absence of pesticides and the reduction of the use of water resources lead to a significant decrease in the impact on the environment;
- The analysis of different usage scenarios for UVC treatment highlights how, even in the scenario of worst use 100 outings / season at 100 power), the reduction of impacts compared to traditional treatment is net;
- The change from a hybrid petrol engine to a diesel engine results in an increase of the impacts especially in the categories Climate change and Resource Use energy carriers, due to the variation in the type of fuel used;
- Variant B (diesel only) has only slight increases in impact compared to variant A (hybrid diesel).

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