

WP4.4 Pilot Case Studies indicators database for MCA

Structure of Cordon decisional tree

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Summary

SHORT DESCRIPTION

This document intends to describe the structure of the SESAMO trees projects and the MCA application to the Pilot Case Study of Cordon stream.

Document Control

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Summary

The report summarizes the general methodological approach, the criteria and the indicators used to test the multi criteria analysis (MCA) on the Rio Cordon pilot case study. The report highlights the progression of MCA model development. The main analyzed aspects are:

- Focus on MCA application.
- Criteria, sub-criteria, & Indicators evaluation and
- Layout of the decision tree.

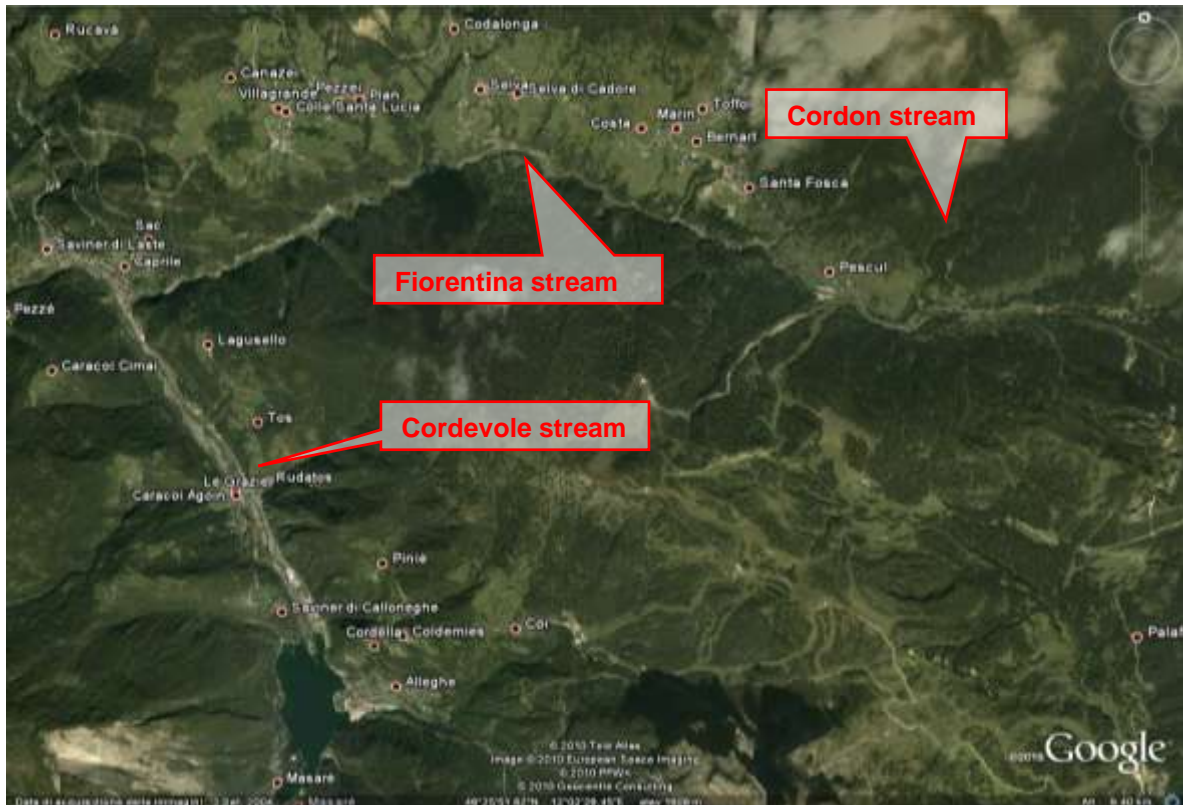
This report is devoted to an explanation and the justification for each of the branches of the Cordon decisional tree model, until its leaves. We identified potential indicators useful to evaluate the chosen management alternatives.

Structure of Cordon decisional tree

The Cordevole river basin is almost completely included in the upper part of the Belluno Province. The territory is mainly mountainous (Dolomites region), and an important hydroelectric exploitation of the water resource began in the early 1900 with the construction of large dams and the creation of big reservoirs along the Cordevole main stream. The recent HP industry development has touched the minor tributaries, with the increasing construction of small and mini HP plants.

Regarding the Cordevole pilot case study, the MCA has been applied to one of this mini HP plants, installed on a little torrent named Cordon.

The Cordon stream is a tributary of the Fiorentina torrent, which is one of the main tributaries of the Cordevole stream. The Cordon hydrographic basin is about 7 km². The altitude ranges from 2748 m a.s.l. and 1763 m a.s.l., with a medium value of 2200 m a.s.l..



Overview of Cordon stream connection with Fiorentina stream

On the Cordon stream there is a mini hydropower plant, installed and managed by Consorzio BIM GSP S.p.A., which is a subsidiary company created by 67 Municipalities of the Belluno Province. The withdrawal point is placed at the altitude of 1638.7 m a.s.l., while the HP power plant is located at 1468 m a.s.l.. The difference in height at disposal for energy production is 170.7 m. The maximum discharge that can be withdrawn is 0.195 m³/s, the medium is 0.115 m³/s. Consequently, the maximum plant power is 238 kW, and the medium is 191 kW. The annual production potential is 1150000 kWh.

This mini hydropower plant is not the only structure present on the Cordon stream. A few hundreds meters upstream, in fact, there is a solid discharge measuring station managed by ARPAV. This station is represented by a big concrete structure in which the solid transport stops and can be quantified. Beside solid discharge, also water discharge and several physical-chemical parameters are monitored. This monitoring station is located at the altitude of 1763 m a.s.l.



BIM HP plant intake. The water abstraction work is made of a grid placed on the top of the check dam



BIM HP plant intake: detail of the grid on the top of the check dam



BIM HP plant located at 1468 m a.s.l.



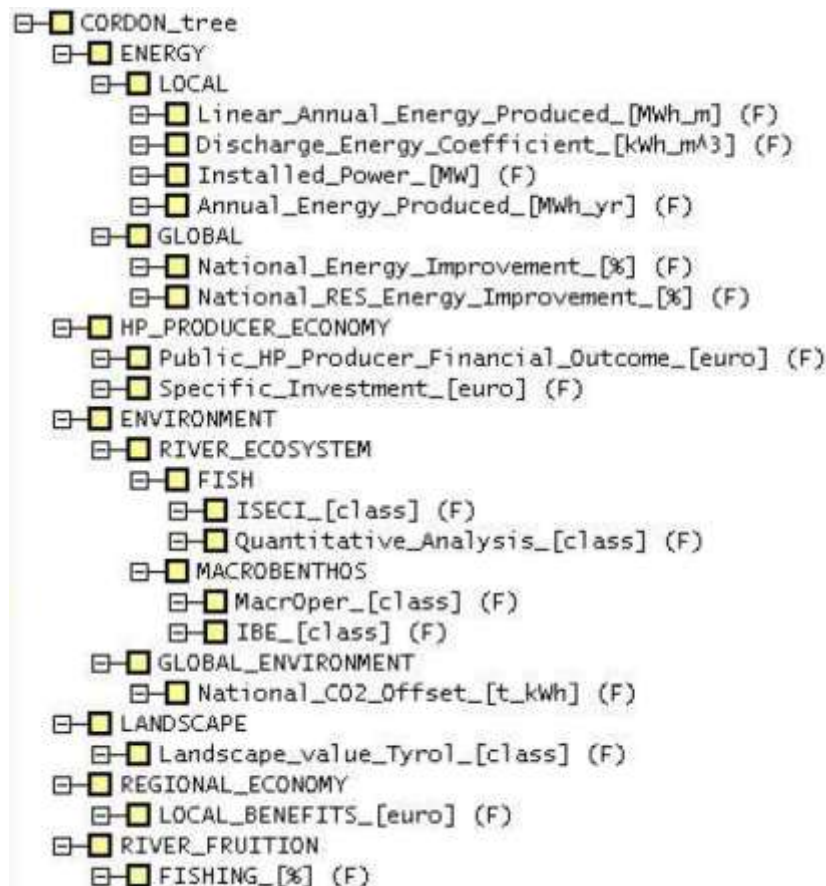
ARPAV's solid discharge measuring station

Alternatives description

The MCA has been applied to different hypothesis of energy production improvement on the upper reach of Cordon stream. Starting from the consideration that the ARPAV's monitoring station represents a remarkable discontinuity for the river longitudinal development, one can consider the exploitation of this structure for energy production. Three hypothesis about the use of this existent barrage have been considered, and are described as follows:

1. **ALTERNATIVE 0:** Current BIM HP plant configuration
2. **ALTERNATIVE 1:** Dismantling of the existent HP plant intake and construction of a new one immediately downstream the ARPAV's measuring station, in order to exploit an increased difference on height (124.3 m + 170.7 m = 295 m). The withdrawn discharge should however be consequently reduced. This alternative is named "new HP plant", and is based on the idea that in the upper zones of the mountainous basins withdrawing a smaller discharge with an increased difference in height will bring more or less the same energy production, but the environment could be less damaged, since the presence of lateral small water contributions from hills and mountains slopes.
3. **ALTERNATIVE 2:** Keeping the existing HP plant, but building a new HP plant with the intake immediately downstream the ARPAV's measuring station, and the release just upstream the existent power plant. This alternative is named "two in line HP plants", and considers an improvement on energy production, with the employment of a new stream reach which currently is not concerned by water withdrawal. However, this reach is included between two artificial structures which represent remarkable stream discontinuities for biological communities. The basic idea is the possibility of gaining energy production without worsening the current situation which is already noticeably influenced by the presence of the existing structures.

Cordon MCA tree



Indicators description – Cordon stream PCS

The following section contains the metadata of every indicator used in the Cordon stream reach example directly related to MCA model Sesamo software.

The structure of the decision tree for the pilot case of Cordon stream considers 4 main branches, similarly to the Astico River case:

1. **Energy;**
2. **HP Producer Economy;**
3. **Regional Economy;**
4. **Environment;**
5. **Social criteria (Tourism, Landscape, etc.)**

• The first branch called **ENERGY** includes local and global criteria on the hydropower production. It is divided into 2 sub-criteria:

LOCAL: this sub-criteria is evaluated through energy indicators such as:

- **Annual energy produced**
- **Linear annual energy produced**
- **Discharge energy coefficient**
- **Installed power**

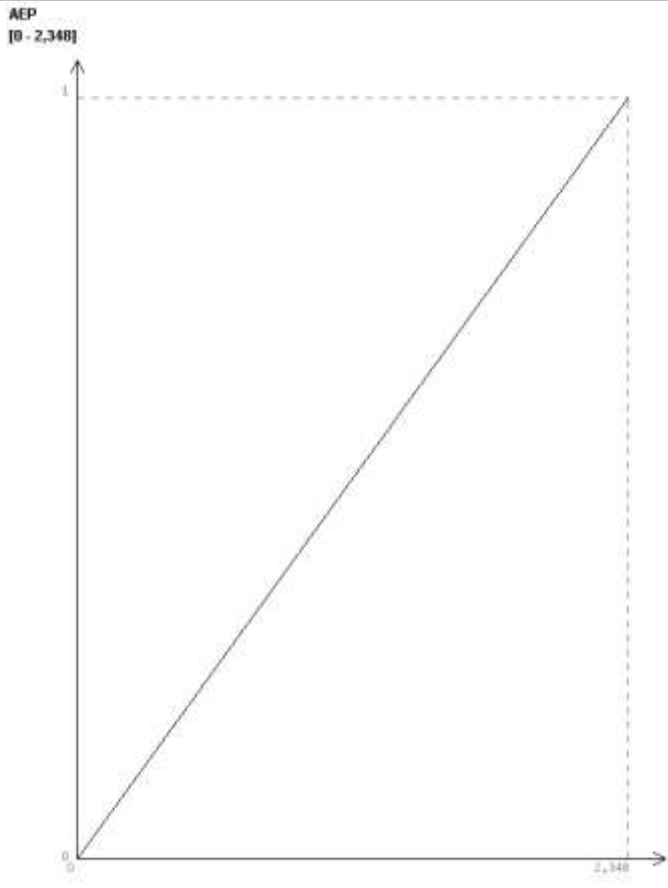
GLOBAL: sub-criteria evaluated through energy indicators such as

- **National energy improvement**
- **National RES energy improvement**

The following charts are more simplified respect to those of Astico River, for those indicators common to the 2 MCA decisional trees and already described.

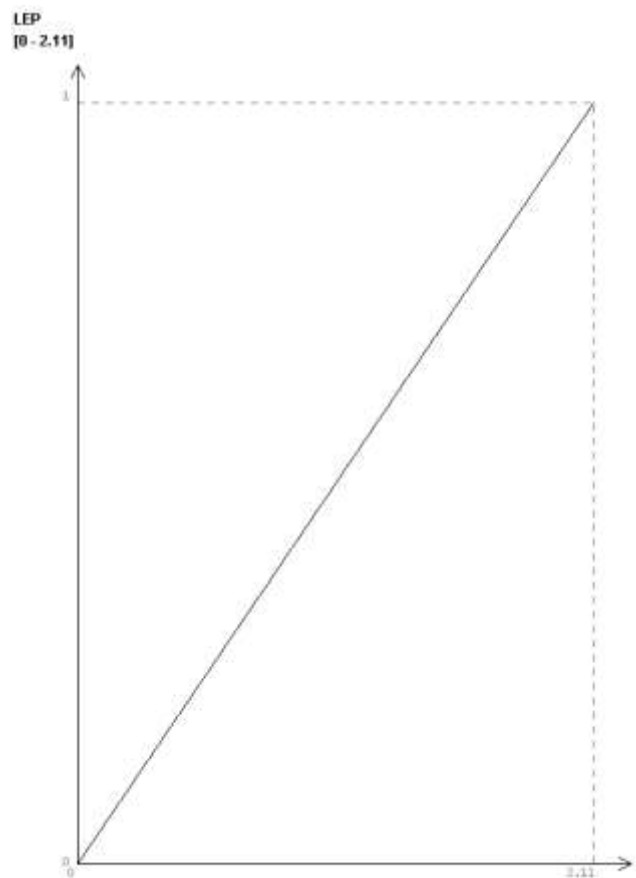
Cordon tree | ENERGY | Annual energy produced

FIELD	DESCRIPTION																								
INDICATOR NAME	evaluation of the annual plant energy production (<i>GWh/year</i>) assessed (for proposed plants not already realised) or measured (for existing plants)																								
ACRONYM	<i>AEP</i>																								
FIELD	METHODS AND MONITORING STANDARDS																								
EVALUATION	<p>The main parameters considered and evaluated for the Cordon stream BIM SHP plant are:</p> <table border="1"> <tbody> <tr> <td>DH</td> <td>170.70</td> <td>m</td> </tr> <tr> <td>Qconc max</td> <td>0.195</td> <td>m³/s</td> </tr> <tr> <td>Qconc med</td> <td>0.115</td> <td>m³/s</td> </tr> <tr> <td>Installed power</td> <td>0.238</td> <td>MW</td> </tr> <tr> <td>MIF actual</td> <td>0.035</td> <td>m³/s</td> </tr> </tbody> </table> <p>The AEP for the different alternatives of the Cordon stream BIM SHP plant correspond to:</p> <table border="1"> <tbody> <tr> <td>ALT 0</td> <td>1346</td> <td>MWh/yr</td> </tr> <tr> <td>ALT 1</td> <td>1796</td> <td>MWh/yr</td> </tr> <tr> <td>ALT 2</td> <td>2348</td> <td>MWh/yr</td> </tr> </tbody> </table>	DH	170.70	m	Qconc max	0.195	m ³ /s	Qconc med	0.115	m ³ /s	Installed power	0.238	MW	MIF actual	0.035	m ³ /s	ALT 0	1346	MWh/yr	ALT 1	1796	MWh/yr	ALT 2	2348	MWh/yr
DH	170.70	m																							
Qconc max	0.195	m ³ /s																							
Qconc med	0.115	m ³ /s																							
Installed power	0.238	MW																							
MIF actual	0.035	m ³ /s																							
ALT 0	1346	MWh/yr																							
ALT 1	1796	MWh/yr																							
ALT 2	2348	MWh/yr																							
AVAILABLE UF	YES																								
UF	The Utility Function adopted is LINEAR growing (0 – 2348 MWh/yr)																								

	
SHARE RELATED IND.	Linear annual power produced
FIELD	DATASOURCES
NUT III CODE	ITD33
SHARE PILOT CASE STUDY	Cordon

Cordon tree | ENERGY | Linear annual energy produced

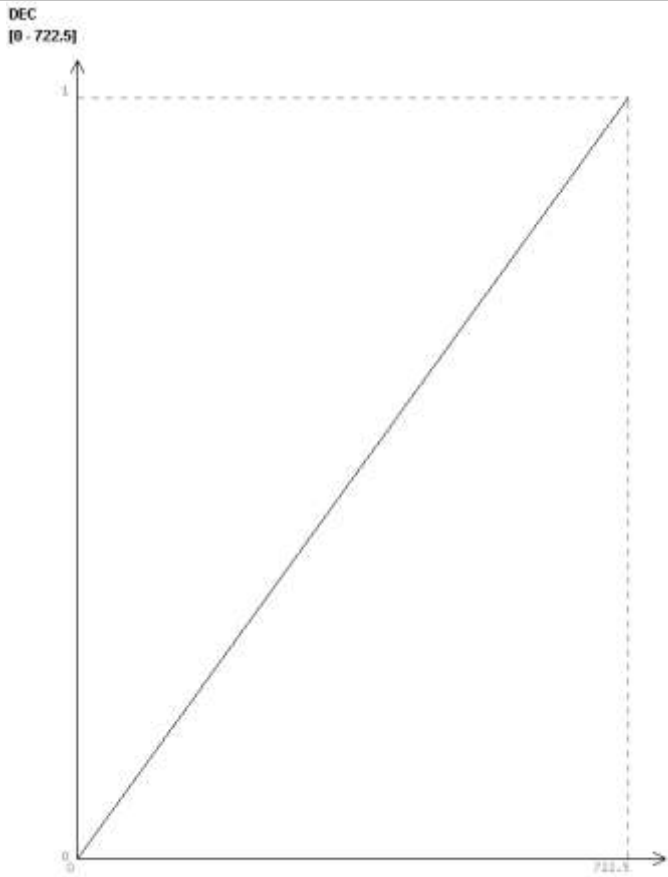
FIELD	DESCRIPTION
INDICATOR NAME	evaluation of the annual plant energy production (<i>GWh/year</i>) assessed (for proposed plants not already realised) or measured (for existing plants), relative to the unit diverted channel reach length
ACRONYM	<i>LAEP</i>
DPSIR	D (Driving Forces)
DESCRIPTION	This indicator furnishes an evaluation of the annual plant energy production, relative to one length unit of river and to each liter turbined, assessed (for proposed plants not already realised) or measured (for existing plants). The indicator becomes significant when there is two or more alternatives to be appraised in which the points of withdrawal or restitution of the diverted flow are different (where is different therefore the stretch withdrawn) or, in other way, where is set to comparison the productivities of different plants in relation to the unity length of derived river stretch

AIM	It furnishes an evaluation of the energy production relative to one length unit of river to allow the evaluation of the intrinsically power of each river stretch and allows the comparison between different plants									
KEY MESSAGE	The river energy production related to bypassed river length evaluates the energy river capacity linked to the withdrawal									
MEASURE UNIT	<i>GWh/m</i>									
REFERENCES	–									
FIELD	METHODS AND MONITORING STANDARDS									
INDICATOR ELABORATION	The indicator is calculated as the ratio between annual energy produced and river length bypassed by HP									
INDICATOR LIMITS	----									
EVALUATION	<p>The LAEP for the different alternatives of Cordon stream correspond to:</p> <table border="1" style="background-color: #ffccff;"> <tr> <td>ALT 0</td> <td>1.13</td> <td>MWh/m</td> </tr> <tr> <td>ALT 1</td> <td>0.81</td> <td>MWh/m</td> </tr> <tr> <td>ALT 2</td> <td>2.11</td> <td>MWh/m</td> </tr> </table>	ALT 0	1.13	MWh/m	ALT 1	0.81	MWh/m	ALT 2	2.11	MWh/m
ALT 0	1.13	MWh/m								
ALT 1	0.81	MWh/m								
ALT 2	2.11	MWh/m								
AVAILABLE UF	YES									
UF	<p>The Utility Function adopted is LINEAR growing (0 – 2.11 MWh/m)</p> 									

SHARE IND.	RELATED	Annual power produced
COUNTRY CODE		IT
WFD HER		INNER ALPS SOUTH
FIELD	DATASOURCES	
DATA SOURCE		HP producer
TIME COVER		~ 10 ÷ 1
UPDATE FREQUENCY		annual
NUT III CODE		ITD33
NORMATIVE REFERENCE		LOCAL
NORMATIVE RELEVANCE		----
SHARE PILOT CASE STUDY		Cordon

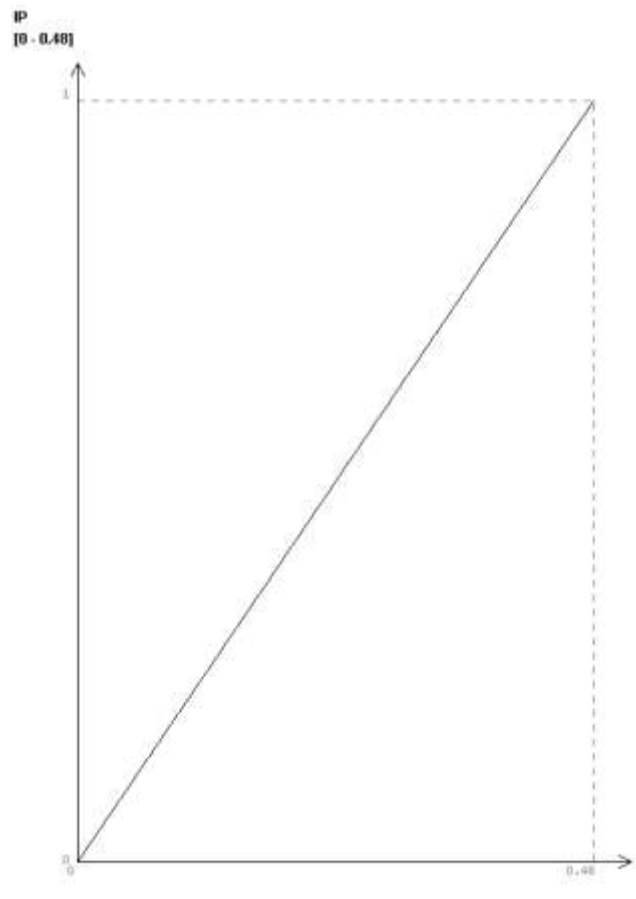
Cordon tree | ENERGY | Discharge energy coefficient

FIELD	DESCRIPTION			
INDICATOR NAME	Annual energy produced in relation to the annual mean and released MIF discharges ratio			
ACRONYM	DEC			
FIELD	METHODS AND MONITORING STANDARDS			
EVALUATION	The DEC values for the different alternatives of Astico river at Leda dam correspond to:			
	ALT 0	DEC	409.7	kWh/m³
	ALT 1	DEC	722.5	kWh/m³
	ALT 2	DEC	714.5	kWh/m³
AVAILABLE UF	YES			
UF	The Utility Function adopted is LINEAR growing (0 - 722.5 kWh/m ³)			

	
FIELD	DATASOURCES
NUT III CODE	ITD33
SHARE PILOT CASE STUDY	Cordon

Cordon tree | ENERGY | Installed power

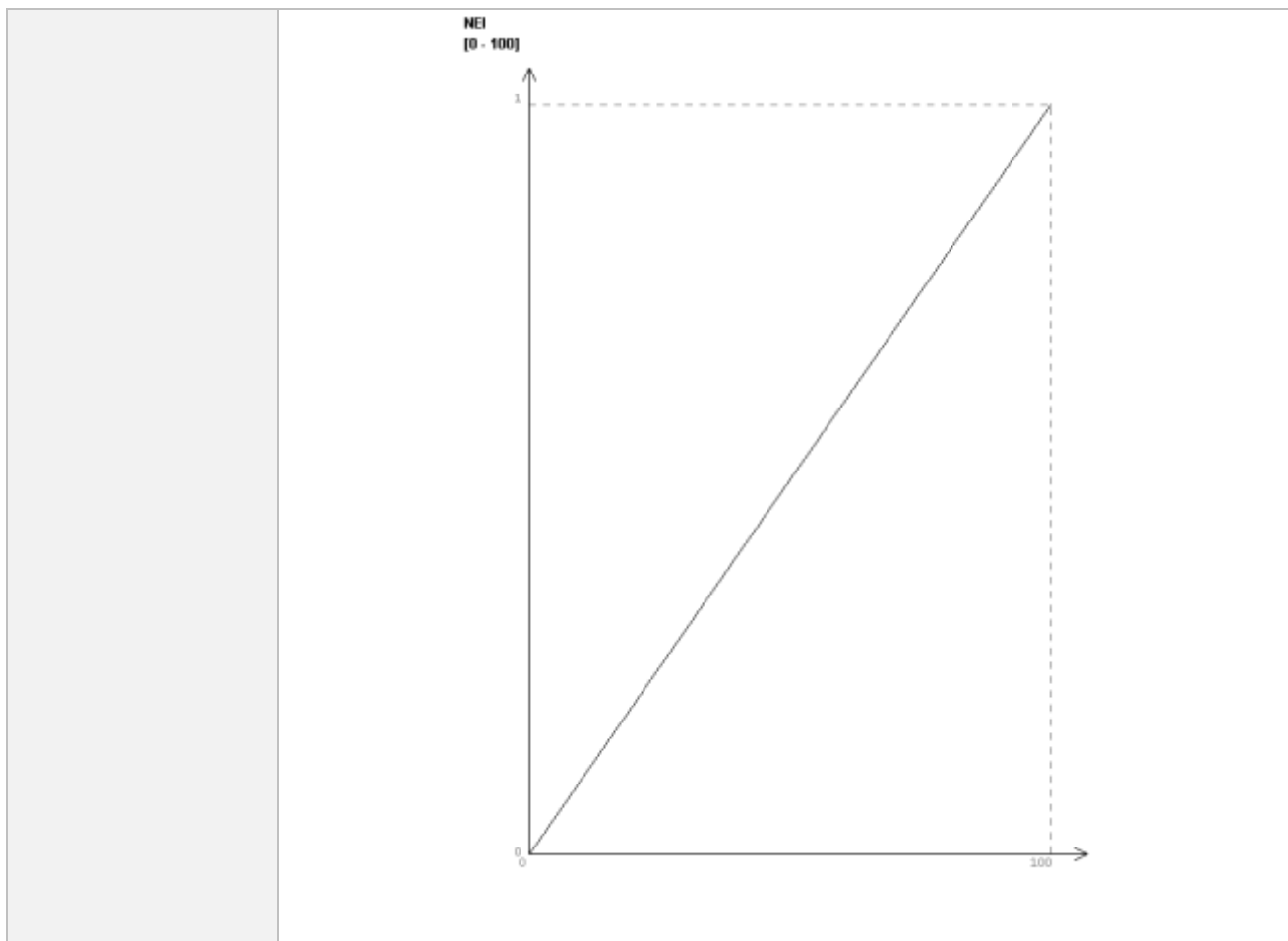
FIELD	DESCRIPTION
INDICATOR NAME	Power energy installed by the HP plant
ACRONYM	<i>IP</i>
DPSIR	----
DESCRIPTION	This indicators depends on the HP plant installed power, which can be assumed as an indicator of the plant value
AIM	It furnishes an evaluation of the HP plant value and potential

KEY MESSAGE	The more is the HPP installed power, the more is the economic value and the potential of the plant									
MEASURE UNIT	MW									
REFERENCES	–									
FIELD	METHODS AND MONITORING STANDARDS									
INDICATOR ELABORATION	It does not need elaborations									
INDICATOR LIMITS	----									
EVALUATION	<p>The IP for the different alternatives of Cordon stream are:</p> <table border="1" style="background-color: #ffccff;"> <tr> <td>ALT 0</td> <td>0.24</td> <td>MW</td> </tr> <tr> <td>ALT 1</td> <td>0.24</td> <td>MW</td> </tr> <tr> <td>ALT 2</td> <td>0.48</td> <td>MW</td> </tr> </table>	ALT 0	0.24	MW	ALT 1	0.24	MW	ALT 2	0.48	MW
ALT 0	0.24	MW								
ALT 1	0.24	MW								
ALT 2	0.48	MW								
AVAILABLE UF	YES									
UF	<p>The Utility Function adopted is LINEAR growing (0 – 0.48 MW)</p> 									
SHARE RELATED IND.	----									
COUNTRY CODE	IT									
WFD HER	INNER ALPS SOUTH									

FIELD	DATASOURCES
DATA SOURCE	HP plant owner
TIME COVER	~ 10 ÷ 1
UPDATE FREQUENCY	once
NUT III CODE	ITD33
NORMATIVE REFERENCE	LOCAL
NORMATIVE RELEVANCE	good
SHARE PILOT CASE STUDY	Cordon

Cordon tree | ENERGY | National energy improvement (NEI)

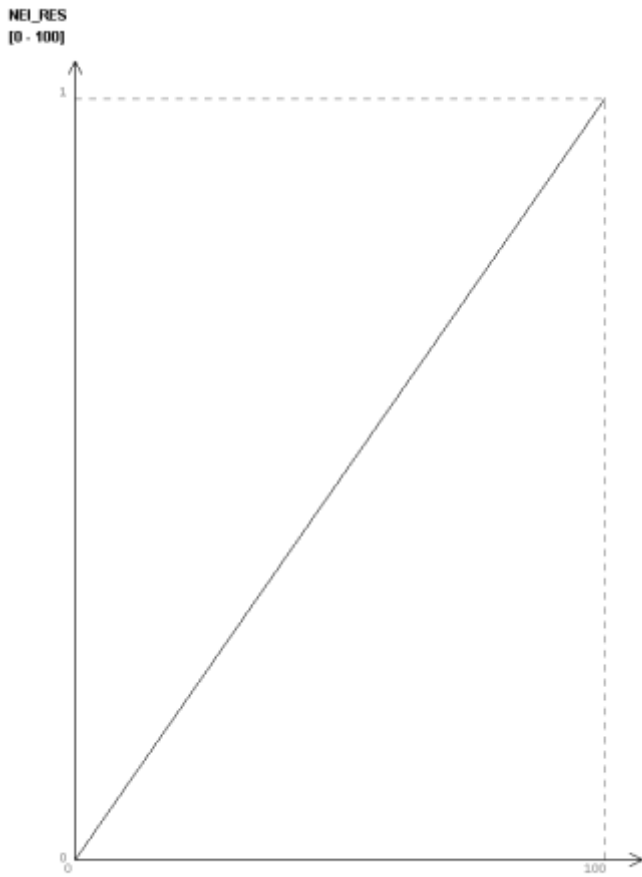
FIELD	DESCRIPTION												
INDICATOR NAME	Contribution of the considered HP if compared to the total national energy production												
ACRONYM	NEI												
FIELD	METHODS AND MONITORING STANDARDS												
EVALUATION	<p>The total NEI in Italy is equal to 288335 GWh (data origin: TERNA). The NEP values for the different alternatives are:</p> <table border="1"> <thead> <tr> <th></th> <th>NEI</th> <th>%</th> </tr> </thead> <tbody> <tr> <td>ALT. 0</td> <td>0.0000047</td> <td>0.0005</td> </tr> <tr> <td>ALT. 1</td> <td>0.0000062</td> <td>0.0006</td> </tr> <tr> <td>ALT. 2</td> <td>0.0000081</td> <td>0.0008</td> </tr> </tbody> </table>		NEI	%	ALT. 0	0.0000047	0.0005	ALT. 1	0.0000062	0.0006	ALT. 2	0.0000081	0.0008
	NEI	%											
ALT. 0	0.0000047	0.0005											
ALT. 1	0.0000062	0.0006											
ALT. 2	0.0000081	0.0008											
AVAILABLE UF	YES												
UF	The Utility Function adopted is LINEAR growing (0 – 100%)												



FIELD	DATASOURCES
NUT III CODE	ITD33
SHARE PILOT CASE STUDY	Cordon

Cordon tree | ENERGY | National RES energy improvement

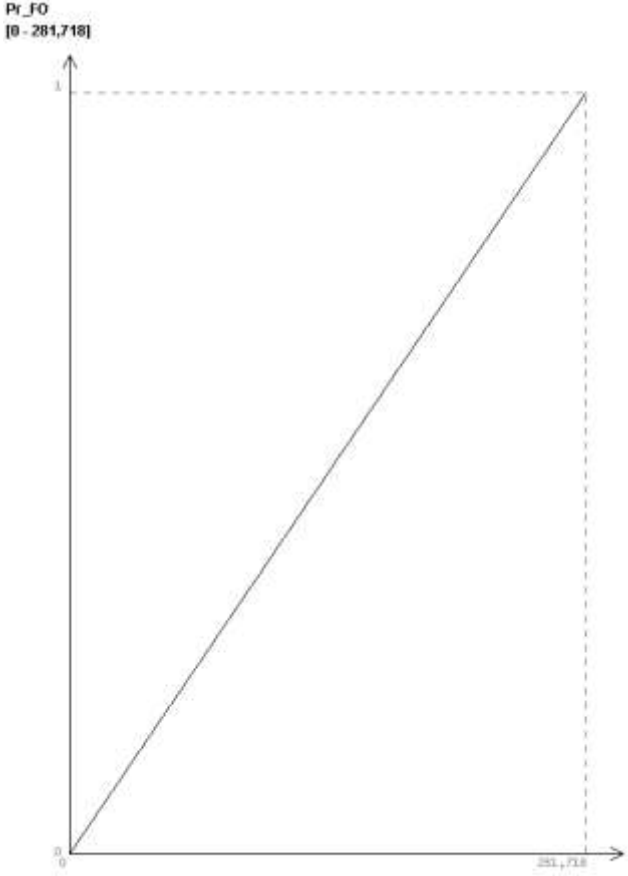
FIELD	DESCRIPTION												
INDICATOR NAME	Contribution of the considered HP if compared to the total national RES energy production												
ACRONYM	<i>NresEI</i>												
FIELD	METHODS AND MONITORING STANDARDS												
EVALUATION	<p>The total NresEI in Italy is equal to 69329 GWh (data origin: TERNA). The NresEI values for the different alternatives are:</p> <table border="1"> <thead> <tr> <th></th> <th>NresEI</th> <th>%</th> </tr> </thead> <tbody> <tr> <td>ALT. 0</td> <td>0.0000194</td> <td>0.0019</td> </tr> <tr> <td>ALT. 1</td> <td>0.0000259</td> <td>0.0026</td> </tr> <tr> <td>ALT. 2</td> <td>0.0000339</td> <td>0.0034</td> </tr> </tbody> </table>		NresEI	%	ALT. 0	0.0000194	0.0019	ALT. 1	0.0000259	0.0026	ALT. 2	0.0000339	0.0034
	NresEI	%											
ALT. 0	0.0000194	0.0019											
ALT. 1	0.0000259	0.0026											
ALT. 2	0.0000339	0.0034											
AVAILABLE UF	YES												

UF	<p>The Utility Function adopted is LINEAR growing (0 – 100%)</p> 
FIELD	DATASOURCES
NUT III CODE	ITD33
SHARE PILOT CASE STUDY	Cordon

- The second criterion called **HP PRODUCER ECONOMY** is here explained by the indicator:
 - Public HP Producer Financial Outcome
 - Specific Investments

Cordon tree | HP PRODUCER ECONOMY | Public HP Producer Financial Outcomes

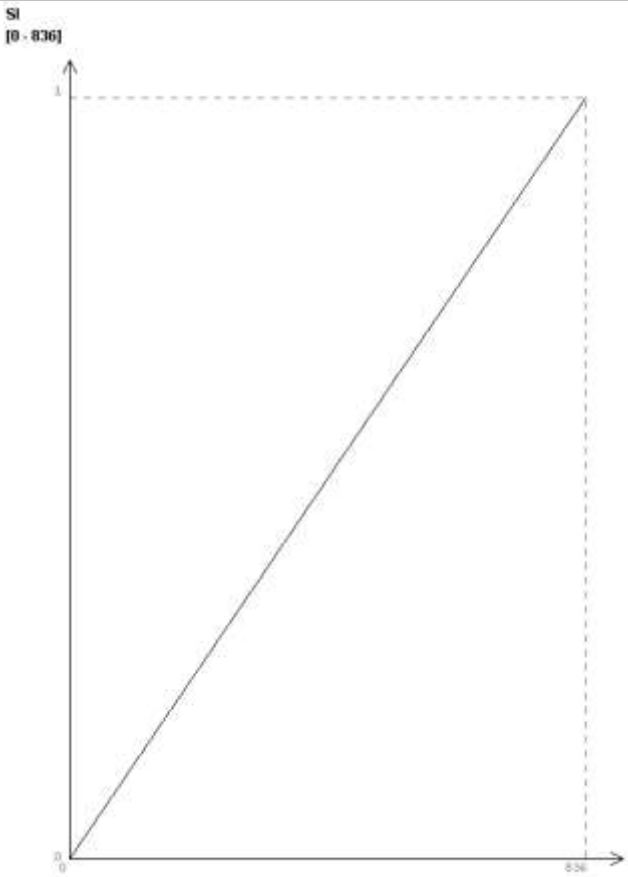
FIELD	DESCRIPTION
INDICATOR NAME	Financial outcomes and degree of satisfaction of publics
ACRONYM	FO
FIELD	METHODS AND MONITORING STANDARDS

EVALUATION	<p>Starting from the assumption that financial outcomes are of the order of 0.12 Euro/kWh, we obtain:</p> <table border="1" data-bbox="475 297 842 409"> <thead> <tr> <th></th> <th>AEP</th> <th>FO (€)</th> </tr> </thead> <tbody> <tr> <td>ALT. 0</td> <td>1346</td> <td>161 520</td> </tr> <tr> <td>ALT. 1</td> <td>1796</td> <td>215 554</td> </tr> <tr> <td>ALT. 2</td> <td>2348</td> <td>281 718</td> </tr> </tbody> </table>		AEP	FO (€)	ALT. 0	1346	161 520	ALT. 1	1796	215 554	ALT. 2	2348	281 718
	AEP	FO (€)											
ALT. 0	1346	161 520											
ALT. 1	1796	215 554											
ALT. 2	2348	281 718											
AVAILABLE UF	YES												
UF	<p>The Utility Function adopted is LINEAR growing (0 – 281 718 €)</p> 												
FIELD	DATASOURCES												
NUT III CODE	ITD33												
SHARE PILOT CASE STUDY	Cordon												

Cordon tree | HP PRODUCER ECONOMY | Specific Investments

FIELD	DESCRIPTION
INDICATOR NAME	Financial investments for HP plant realization

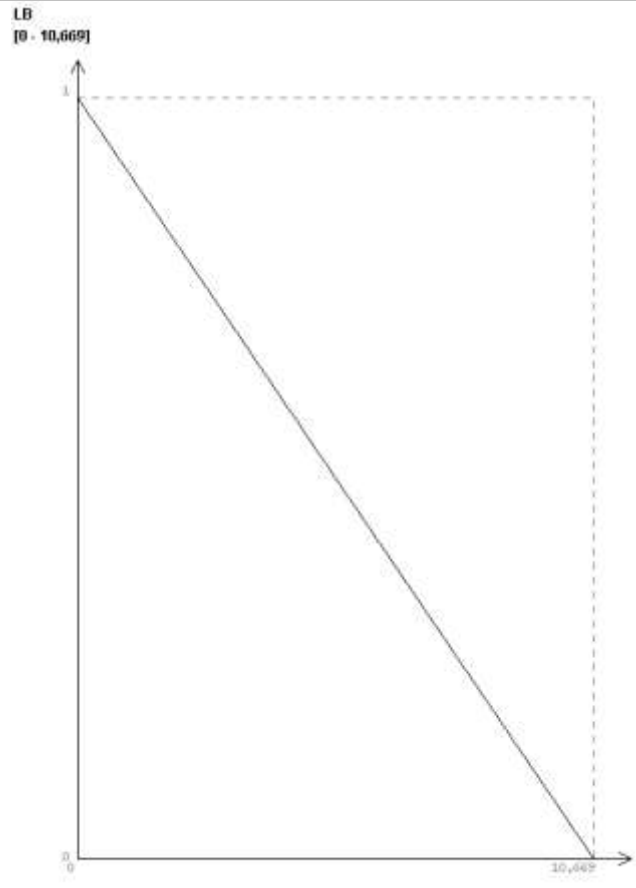
ACRONYM	SI												
DPSIR	----												
DESCRIPTION	This indicator evaluates the investment required for different solutions, related to estimated production												
AIM	It can put in evidence the most convenient projectual solution												
KEY MESSAGE	The same production level can be reached with different costs which have to be evaluated												
MEASURE UNIT	€/MWh												
REFERENCES	–												
FIELD	METHODS AND MONITORING STANDARDS												
INDICATOR ELABORATION	It can be computed as "Investment"/"Estimated annual production"												
INDICATOR LIMITS	The most convenient economical design solution for the HPP is not always the more environmental - friend												
EVALUATION	<p>Starting from the assumption that total financial investments for a SHP on the Cordon stream are of the order of 1 125 000 €, we obtain:</p> <table border="1"> <thead> <tr> <th></th> <th>AEP</th> <th>FO (€/MWh)</th> </tr> </thead> <tbody> <tr> <td>ALT. 0</td> <td>1346</td> <td>836,00</td> </tr> <tr> <td>ALT. 1</td> <td>1796</td> <td>626,00</td> </tr> <tr> <td>ALT. 2</td> <td>2348</td> <td>479,00</td> </tr> </tbody> </table>		AEP	FO (€/MWh)	ALT. 0	1346	836,00	ALT. 1	1796	626,00	ALT. 2	2348	479,00
	AEP	FO (€/MWh)											
ALT. 0	1346	836,00											
ALT. 1	1796	626,00											
ALT. 2	2348	479,00											
AVAILABLE UF	YES												
UF	The Utility Function adopted is LINEAR growing (0 – 836,00 €/MWh)												

	
SHARE RELATED IND.	-----
COUNTRY CODE	IT
WFD HER	INNER ALPS SOUTH
FIELD	DATASOURCES
DATA SOURCE	HP plant owner
TIME COVER	~ 10 ÷ 1
UPDATE FREQUENCY	once
NUT III CODE	ITD33
NORMATIVE REFERENCE	----
NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Cordon

- The third criterion called **REGIONAL ECONOMY** is explained by the indicator:
- **Local Benefits**

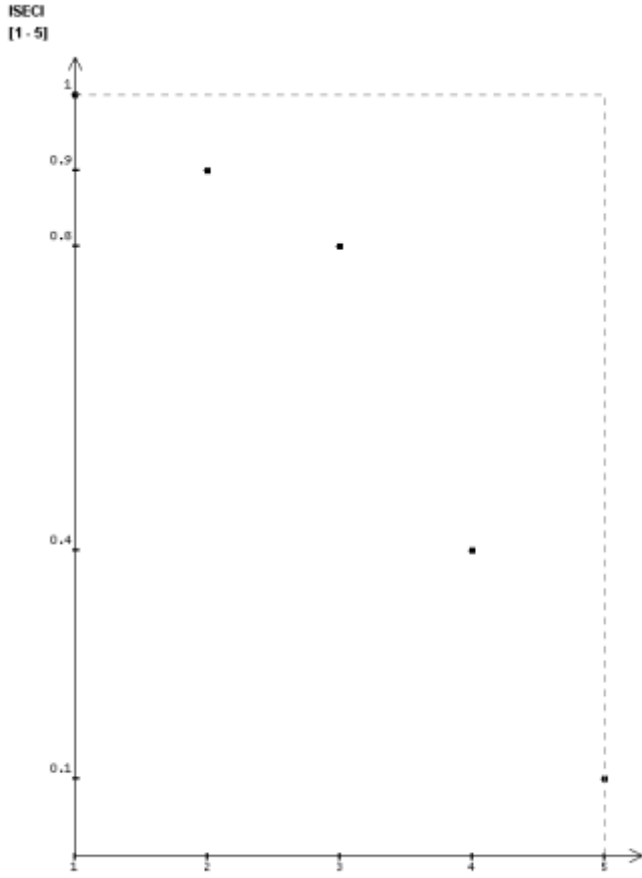
Cordon tree | REGIONAL ECONOMY | Local Benefits

FIELD	DESCRIPTION								
INDICATOR NAME	Evaluation of wider direct economic outcomes on the territories in the same administrative region of HP plant location								
ACRONYM	<i>LB</i>								
DPSIR	R – Response indicator								
DESCRIPTION	This indicator furnishes an evaluation of wider direct economic outcomes on the territories in the same administrative region of HP plant location; it assess the degree of satisfaction of regional administrator related to the different management alternatives considered in the MCA. The direct economic outcomes are represented by the fee of derivation concession. If you compare the fee of a single plant to the administration budget it can represent an exiguous percentage to be appreciated and valued; the utility of this indicator can often be represented in the phase of planning on territorial scale where the whole of the new fees related to the new planned plants can have a meaningful weight on the local administration budgets								
AIM	This indicator directly considers the a aims of the public administrator to maximize the economical benefits for local communities								
KEY MESSAGE	The financial outcomes of HP exploitation could / should have an evaluable economic benefit for local communities strictly related to different management alternatives considered in the MCA								
MEASURE UNIT	€/MWh								
REFERENCES	–								
FIELD	METHODS AND MONITORING STANDARDS								
INDICATOR ELABORATION	The elaboration has to be shaped on a reasonable assessment on real financial outcomes variability								
INDICATOR LIMITS	It's difficult to understand the effective plant economy link with the territory								
EVALUATION	Starting from the assumption that local benefits are of the order of 27.72 €/kWh, and the conceded installed power of BIM SHP is 192.5 kW, we obtain: <table border="1" data-bbox="475 1377 746 1485"> <thead> <tr> <th></th> <th>LB (€/MWh)</th> </tr> </thead> <tbody> <tr> <td>ALT. 0</td> <td>5 335</td> </tr> <tr> <td>ALT. 1</td> <td>5 335</td> </tr> <tr> <td>ALT. 2</td> <td>10 669</td> </tr> </tbody> </table>		LB (€/MWh)	ALT. 0	5 335	ALT. 1	5 335	ALT. 2	10 669
	LB (€/MWh)								
ALT. 0	5 335								
ALT. 1	5 335								
ALT. 2	10 669								
AVAILABLE UF	YES								
UF	The Utility Function adopted is LINEAR decreasing (0 – 10 669 €/MWh)								

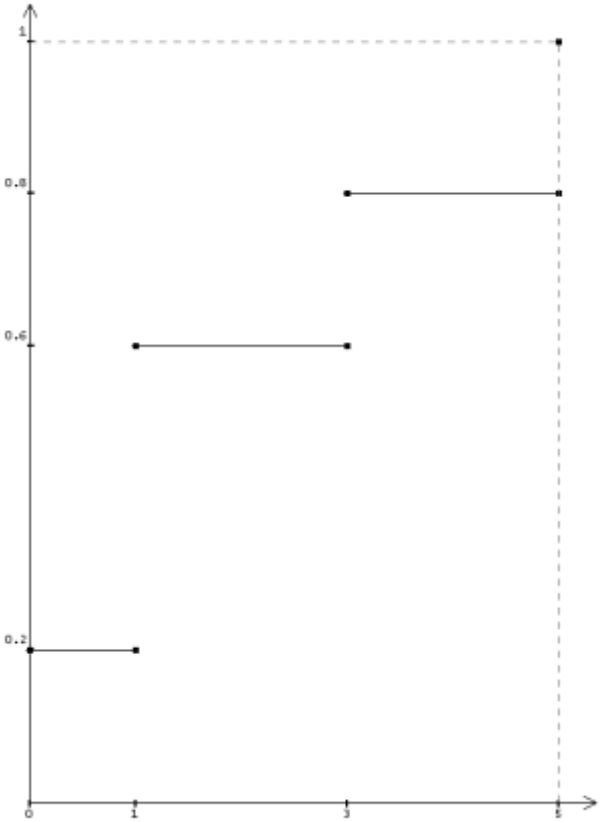
	
SHARE RELATED IND.	-----
COUNTRY CODE	IT
WFD HER	INNER ALPS SOUTH
FIELD	DATASOURCES
DATA SOURCE	HP producer
TIME COVER	~ 10 ÷ 1
UPDATE FREQUENCY	annual
NUT III CODE	ITD33
NORMATIVE REFERENCE	REGIONAL
NORMATIVE RELEVANCE	----
SHARE PILOT CASE STUDY	Cordon

- The fourth criterion is **ENVIRONMENT**, divided into 2 sub-criteria:
 - RIVER ECOSYSTEM**: this sub-criterion is evaluated through indicators such as:
 - **Fish (ISECI, Quantitative Analysis)**
 - **Macrobenthos (IBE, MacOper)**
 - GLOBAL ENVIRONMENT**: sub-criterion evaluated through the indicator:
 - **National CO2 offset**

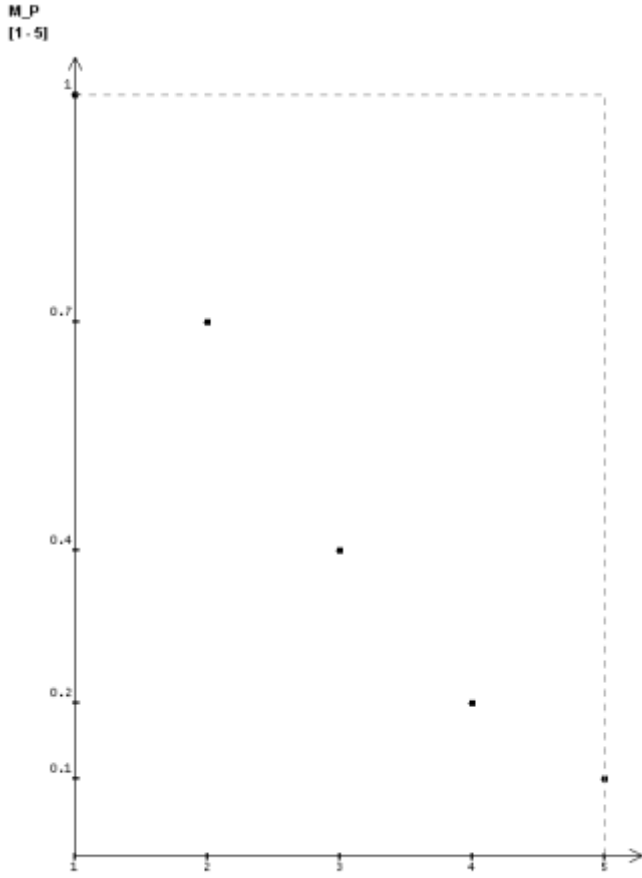
Cordon tree | ENVIRONMENT – RIVER ECOSYSTEM | Fish - ISECI

FIELD	DESCRIPTION												
INDICATOR NAME	Index of Ecological Status of Fish Communities												
ACRONYM	<i>ISECI</i>												
FIELD	METHODS AND MONITORING STANDARDS												
EVALUATION	<p>The class values of ISECI for the different alternatives were defined starting from direct field surveys during summer and autumn 2011:</p> <table border="1" data-bbox="534 616 1407 694"> <thead> <tr> <th></th> <th>Alt_0_Present_Plant_Configuration</th> <th>Alt_1_New_single_HP_plant</th> <th>Alt_2_Two_in_line_plants</th> </tr> </thead> <tbody> <tr> <td>ISECI</td> <td>3</td> <td>4</td> <td>4</td> </tr> </tbody> </table>		Alt_0_Present_Plant_Configuration	Alt_1_New_single_HP_plant	Alt_2_Two_in_line_plants	ISECI	3	4	4				
	Alt_0_Present_Plant_Configuration	Alt_1_New_single_HP_plant	Alt_2_Two_in_line_plants										
ISECI	3	4	4										
AVAILABLE UF	YES												
UF	<p>The utility function (UF) for the values normalization is SINGLE POINTS (1 - 5) decreasing</p>  <table border="1" data-bbox="635 862 1279 1736"> <caption>Utility Function Data</caption> <thead> <tr> <th>ISECI Value</th> <th>Utility (UF)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1.0</td> </tr> <tr> <td>2</td> <td>0.9</td> </tr> <tr> <td>3</td> <td>0.8</td> </tr> <tr> <td>4</td> <td>0.4</td> </tr> <tr> <td>5</td> <td>0.1</td> </tr> </tbody> </table>	ISECI Value	Utility (UF)	1	1.0	2	0.9	3	0.8	4	0.4	5	0.1
ISECI Value	Utility (UF)												
1	1.0												
2	0.9												
3	0.8												
4	0.4												
5	0.1												
FIELD	DATASOURCES												
NUT III CODE	ITD33												
SHARE PILOT CASE STUDY	Cordon												

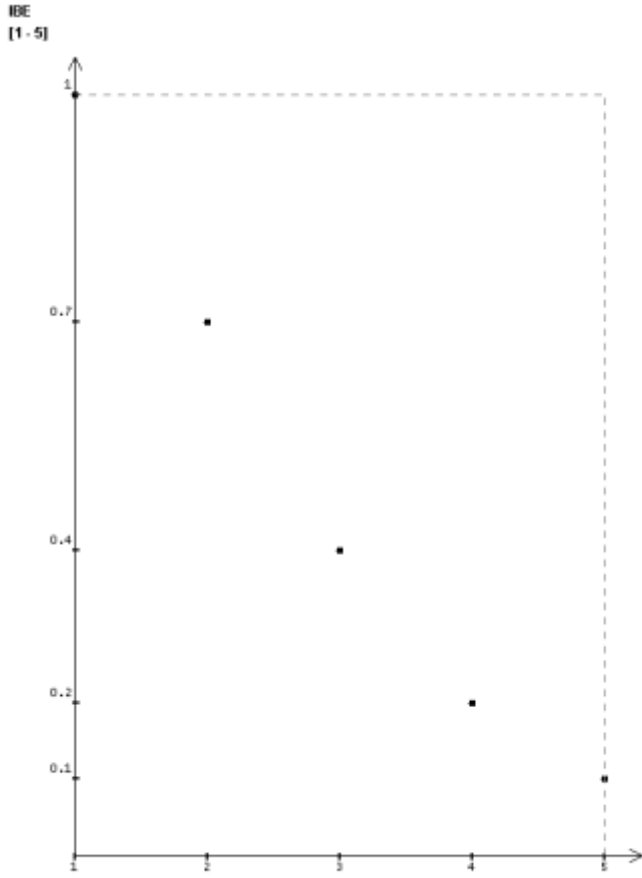
Cordon tree | ENVIRONMENT – RIVER ECOSYSTEM | Fish – Quantitative Analysis

FIELD	DESCRIPTION								
INDICATOR NAME	Index of Ecological Status of Fish Communities								
ACRONYM	Q_An								
FIELD	METHODS AND MONITORING STANDARDS								
EVALUATION	<p>The class values for the different alternatives were defined starting from direct field surveys during summer and autumn 2011</p> <table border="1"> <thead> <tr> <th></th> <th>Alt_0_Present_Plant_Configuration</th> <th>Alt_1_New_single_HP_plant</th> <th>Alt_2_Two_in_line_plants</th> </tr> </thead> <tbody> <tr> <td>Quantitative_Analysis</td> <td>0.5</td> <td>0</td> <td>0</td> </tr> </tbody> </table>		Alt_0_Present_Plant_Configuration	Alt_1_New_single_HP_plant	Alt_2_Two_in_line_plants	Quantitative_Analysis	0.5	0	0
	Alt_0_Present_Plant_Configuration	Alt_1_New_single_HP_plant	Alt_2_Two_in_line_plants						
Quantitative_Analysis	0.5	0	0						
AVAILABLE UF	YES								
UF	<p>The utility function (UF) for the values normalization is STEP (0 - 5) growing</p> <p>Q_An [0 - 5]</p> 								
FIELD	DATASOURCES								
NUT III CODE	ITD33								
SHARE PILOT CASE STUDY	Cordon								

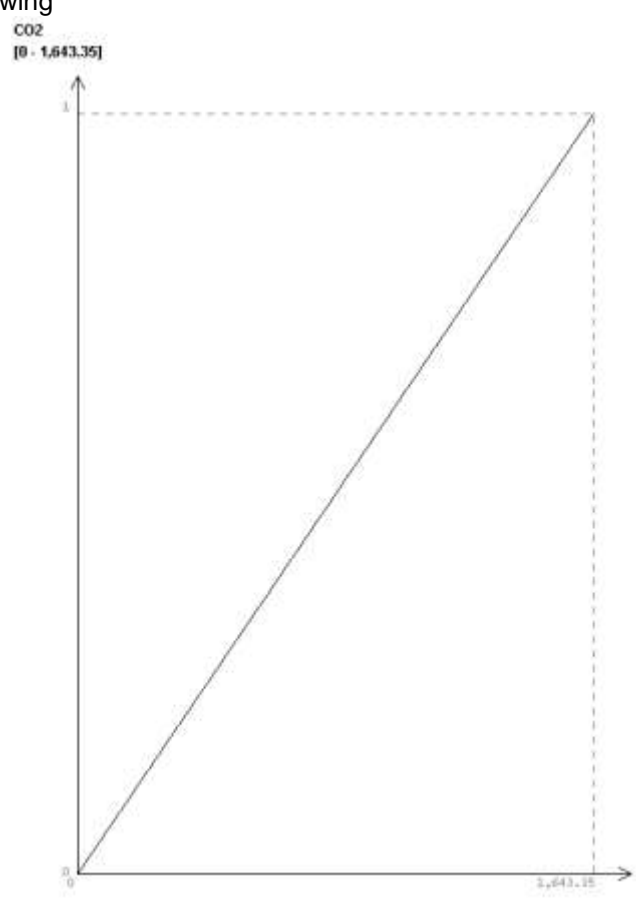
Cordon tree | ENVIRONMENT – RIVER ECOSYSTEM | Macrobenthos – MacrOper

FIELD	DESCRIPTION								
INDICATOR NAME	Index of abundance of fish communities								
ACRONYM	<i>MacrOper</i>								
FIELD	METHODS AND MONITORING STANDARDS								
EVALUATION	<p>class values of MacrOper for the different alternatives were defined starting from direct field surveys during summer and autumn 2011.</p> <table border="1"> <thead> <tr> <th></th> <th>Alt_0_Present_Plant_Configuration</th> <th>Alt_1_New_single_HP_plant</th> <th>Alt_2_Two_in_line_plants</th> </tr> </thead> <tbody> <tr> <td>MacrOper</td> <td>1</td> <td>1</td> <td>1</td> </tr> </tbody> </table>		Alt_0_Present_Plant_Configuration	Alt_1_New_single_HP_plant	Alt_2_Two_in_line_plants	MacrOper	1	1	1
	Alt_0_Present_Plant_Configuration	Alt_1_New_single_HP_plant	Alt_2_Two_in_line_plants						
MacrOper	1	1	1						
AVAILABLE UF	YES								
UF	<p>The utility function (UF) for the values normalization is SINGLE POINTS (1 - 5) decreasing</p> 								
FIELD	DATASOURCES								
NUT III CODE	ITD33								
SHARE PILOT CASE STUDY	Cordon								

Cordon tree | ENVIRONMENT – RIVER ECOSYSTEM | Macrobenthos – IBE

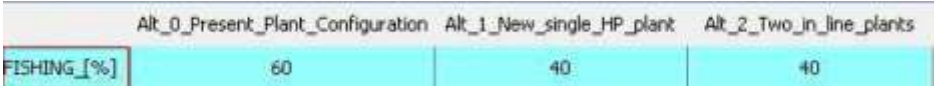
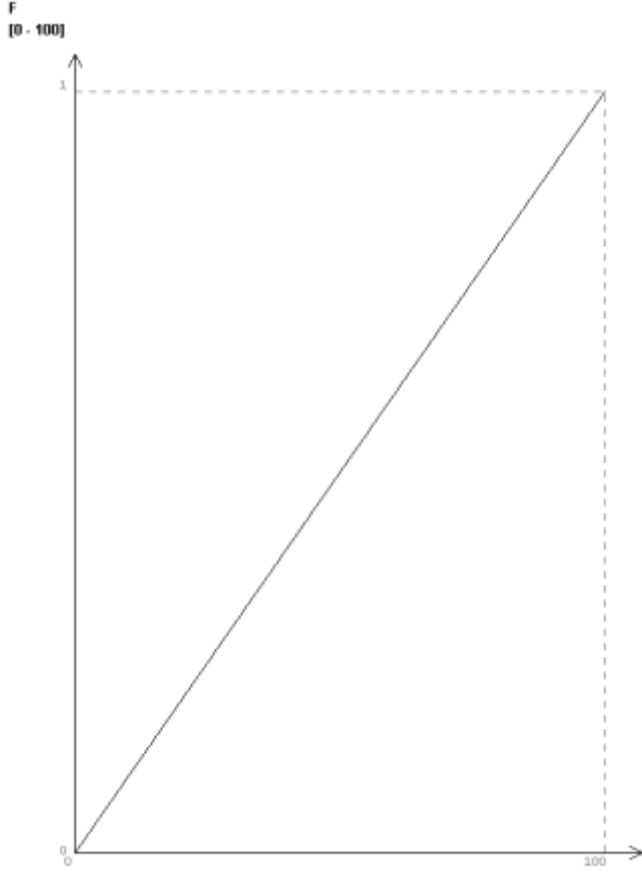
FIELD	DESCRIPTION								
INDICATOR NAME	Index of abundance of fish communities								
ACRONYM	IBE								
FIELD	METHODS AND MONITORING STANDARDS								
EVALUATION	<p>The class values of IBE for the different alternatives were defined starting from direct field surveys during summer and autumn 2011.</p> <table border="1"> <thead> <tr> <th></th> <th>Alt_0_Present_Plant_Configuration</th> <th>Alt_1_New_single_HP_plant</th> <th>Alt_2_Two_in_line_plants</th> </tr> </thead> <tbody> <tr> <td>IBE</td> <td>1</td> <td>1</td> <td>1</td> </tr> </tbody> </table>		Alt_0_Present_Plant_Configuration	Alt_1_New_single_HP_plant	Alt_2_Two_in_line_plants	IBE	1	1	1
	Alt_0_Present_Plant_Configuration	Alt_1_New_single_HP_plant	Alt_2_Two_in_line_plants						
IBE	1	1	1						
AVAILABLE UF	YES								
UF	<p>The utility function (UF) for the values normalization is SINGLE POINTS (1 - 5) decreasing</p> 								
FIELD	DATASOURCES								
NUT III CODE	ITD33								
SHARE PILOT CASE STUDY	Cordon								

Cordon tree | ENVIRONMENT – GLOBAL ENVIRONMENT | National CO2 offset

FIELD	DESCRIPTION																				
INDICATOR NAME	Index of CO2 emissions reduction																				
ACRONYM	CO2																				
FIELD	METHODS AND MONITORING STANDARDS																				
EVALUATION	<table border="1"> <thead> <tr> <th></th> <th>AEP</th> <th></th> <th>CO2 reduction (g/kWh)</th> <th>CO2 tot red (tonn/kWh)</th> </tr> </thead> <tbody> <tr> <td>ALT. 0</td> <td>1346</td> <td>MWh/yr</td> <td>700</td> <td>942.20</td> </tr> <tr> <td>ALT. 1</td> <td>1796</td> <td>MWh/yr</td> <td>700</td> <td>1257.40</td> </tr> <tr> <td>ALT. 2</td> <td>2348</td> <td>MWh/yr</td> <td>700</td> <td>1643.35</td> </tr> </tbody> </table>		AEP		CO2 reduction (g/kWh)	CO2 tot red (tonn/kWh)	ALT. 0	1346	MWh/yr	700	942.20	ALT. 1	1796	MWh/yr	700	1257.40	ALT. 2	2348	MWh/yr	700	1643.35
	AEP		CO2 reduction (g/kWh)	CO2 tot red (tonn/kWh)																	
ALT. 0	1346	MWh/yr	700	942.20																	
ALT. 1	1796	MWh/yr	700	1257.40																	
ALT. 2	2348	MWh/yr	700	1643.35																	
AVAILABLE UF	YES																				
UF	<p>The utility function (UF) for the values normalization is LINEAR (0 – 1643.35 tonn/kWh) growing</p> 																				
FIELD	DATASOURCES																				
NUT III CODE	ITD33																				
SHARE PILOT CASE STUDY	Cordon																				

- The fifth criterion called ‘**SOCIAL CRITERIA**’, is divided in:
 - **RIVER FRUITION**, evaluated through the indicator:
 - **Fishing**
 - **LANDSCAPE**, evaluated through the indicator:
 - **Landscape value Tyrol**

Cordon tree | RIVER FRUITION | Fishing

FIELD	DESCRIPTION
INDICATOR NAME	Fishing river activity
ACRONYM	F
FIELD	METHODS AND MONITORING STANDARDS
EVALUATION	
AVAILABLE UF	YES
UF	<p>The utility function (UF) for the values normalization is LINEAR (0 – 100%) growing</p> 
FIELD	DATASOURCES
NUT III CODE	ITD33

SHARE PILOT CASE STUDY	Cordon
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Cordon tree | LANDSCAPE | Landscape value Tyrol

A Landscape evaluation was proposed by the ‘Bewertung der Wasserkraft in Tirol’, as reported in the following charts.

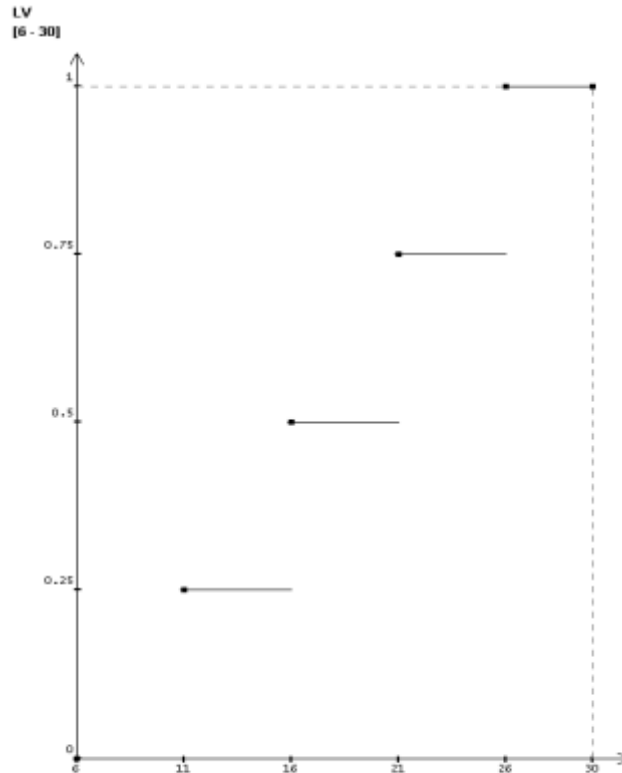
Criteria	Indicator	Analytical in a model	Assessment	
			Scores	Interval definition
Landscape Scenery/Recreational Value The landscape scenery and the recreational value are protected (natural) resources regarding the Tyrolean Nature Conservation Act 2005. The assessment conducted on the qualitative parameters.	Visibility Diversity/ Uniqueness/ Beauty for: - Origin of the landscape elements - Uniqueness - Representativity - Recreational Value	No	sum of the subcriteria (parameter) Visibility, Origin of the landscape elements, Uniqueness, Representativity, Recreational Value	
			1	6 to 10
			2	11 to 15
			3	16 to 20
			4	21 to 25
5	26 to 30			

Landscape Scenery/Recreational Value		View of point		
		long-distance effect (including close-up effect)	just close-up effect	no effect
Visibility		1	3	5
Diversity/ Uniqueness/ Beauty		Disturbance		
		strong	medium	low
Origin of the landscape elements	natural / traditional cultural	1	2	4
	near natural / partly traditional cultural	2	3	5
	anthropogenic influenced	4	5	5
Uniqueness	high	1	2	4
	medium	2	3	5
	low	4	5	5
Representativity	typical element and typical dominant	1	2	4
	partly typical element / not dominant	2	3	5
	untypical element / non-resident	4	5	5
Recreational Value	high	2	4	8
	medium	3	6	10
	low	8	10	10

The indicators evaluations varies with the Alternatives proposed for the Cordon stream, giving the results:

Landscape scenery / indicators	Alt. 0	Alt. 1	Alt. 2
Visibility	3	3	3
Origin of landscape elements	4	2	2
Uniqueness	4	2	2
Representativity	4	2	2
Recreational value	8	4	4
Total	23	13	13
Class (value)	4	2	2

The utility function assumes the following form:



Weights assignment

The weights (W) assigned to the different criteria analyzed for the Cordon stream are shown in the following table.

CORDON TREE	CRITERIA	W	SUB-CRITERIA	W	INDICATORS	W	SUB-INDIC	W
	ENERGY	0.20	LOCAL	0.8	Linear annual en. produced	0.3		
					Annual en. produced	0.3		
					Discharge en. coefficient	0.2		
					Installed power	0.2		
			GLOBAL	0.2	National en. improvement	0.4		
					National RES en. improvement	0.6		
	HP PRODUCER ECONOMY	0.15			HP producer Financial Outcomes	0.6		
					Specific Investments	0.4		
	REGIONAL ECONOMY	0.15			Local Benefits	1.0		
	ENVIRONMENT	0.40	RIVER ECOSYSTEM	0.8	Fish	0.4	<i>ISECI</i>	0.7
							<i>Quant. An.</i>	0.3
					Macrobenthos	0.4	<i>MacrOper</i>	0.4
							<i>IBE</i>	0.6

			GLOBAL ENVIRONMENT	0.2	National CO2 offset			1.0
	RIVER FRUITION	0.08			Fishing	1.0		
	LANDSCAPE	0.02			Landscape value Tyrol	1.0		

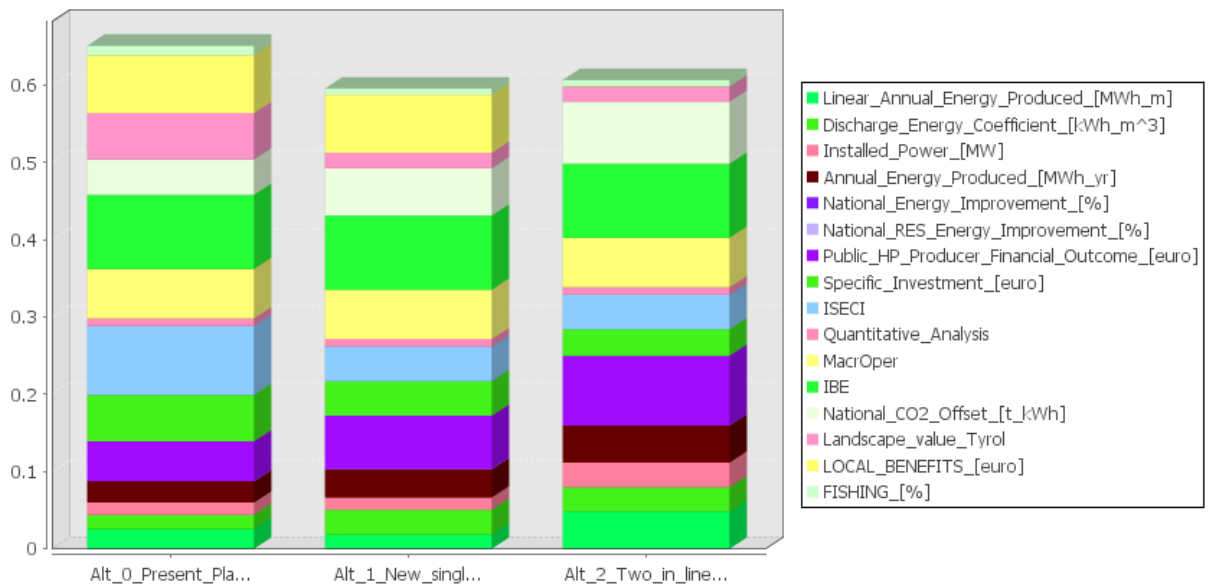
The value of 0.4 for the Environment Criterion weight was chosen according to the actual morphological river reach quality status calculated applying the ISPRA methodology. The morphological status can be considered as ‘Status Indicator’ because affect the weight of the Environmental criterion. The canal reach upstream the withdrawal point is characterized by a good naturality, with the exception of the small zone limited to the ARPAV monitoring station. Along Reach 1 there are no transversal and longitudinal hydraulic works, so the sediment transport and natural channel adjustments driven by formative discharges are assured. The morphological channel bed quality of reaches 1 and 2 can be assumed elevate. Downstream the withdrawal point (reaches 3 and 4), the presence of check dams and of longitudinal hydraulic works (< 33% of total banks length), reduce the natural stream longitudinal and lateral continuity, thus affecting the natural sediment transport trend and the channel section adjustment processes. So, these reaches are basically characterized by a moderate/sufficient natural status, according to IDRAIM (2011) method for rivers morphological quality evaluation. River ecosystem sub-criterion is the most important (0.8) inside the Environment criterion, and is explained by fish fauna and macroinvertebrates indicators. Energy crietrium weighs the 20% of the whole tree, being the local energy more relevant (0.8) than global energy sub-criterion (0.2).

River fruition and Landscape criteria have a lower importance in the MCA, being the sum equal to 0.10. This is due to the characteristics of the river reach, poor of direct river fruitions and fishing activity; the same is for Landscape, explained by landforms, which is not appreciable with the alternatives variations.

Evaluation of alternatives performance

Calculations have been made for three different Alternatives regarding SHP planning. The weights (importance) of the indicators for the Alternatives explanation are showed in the following graph and chart.

INDICATORS	ALT. 0 Present HP config.	ALT. 1 New single HP plant	ALT. 2 Two in line HP plants
Linear_Annual_Energy_Produced_[MWh/m]	0.048	0.039	0.058
Discharge_Energy_Coefficient_[kWh/m^3]	0.032	0.062	0.041
Installed_Power_[MW]	0.032	0.033	0.043
Annual_Energy_Produced_[MWh/yr]	0.048	0.062	0.058
National_Energy_Improvement_[%]	0.016	0.016	0.016
National_RES_Energy_Improvement_[%]	0.024	0.025	0.024
Public_HP_Producer_Financial_Outcome_[euro]	0.090	0.105	0.010
Specific_Investment_[euro]	0.060	0.044	0.051
LOCAL_BENEFITS_[euro]	0.150	0.153	0.140
ISECI	0.112	0.087	0.104
Quantitative_Analysis	0.048	0.049	0.048
MacrOper	0.064	0.065	0.064
IBE	0.096	0.098	0.097
National_CO2_Offset_[t_kWh]	0.080	0.095	0.090
Landscape_value_Tyrol	0.080	0.048	0.070
FISHING_[%]	0.020	0.007	0.016



The Alternatives performance gives a higher value (0.65) to the Alternative 0 (present configuration and management), followed by the Alternative 2 (two in-line SHP plants). The lowest value, that is, the worst alternative, is that of Alternative 1 (0.59), characterized by a new single SHP plant.

Alt_0_Present_Plant_Configuration	0.651
Alt_2_Two_in_line_plants	0.607
Alt_1_New_single_HP_plant	0.596

