The social energy

4E - A method for the global assessment of useful energy.

1. Energy is a fundamental element of nature: it permeates the universe and perpetuates plant and animal life. Since its appearance on Earth, humanity has benefited from intaking energy as food to grow and to generate heat and movement. With the discovery of fire humanity has made the first voluntary conversion of energy for its own welfare. Today energy is employed in progress, well-being and fun activities, for peace and for war.

The energy quality can be assessed in different ways: by the source (fossil, renewable), the availability and programmability, the use, the density, the carrier. In addition, the conversion efficiency can be assessed in terms of performance or according to its characteristics: physical, chemical, thermodynamic, logistic, economic, etc. Finally, the quality and value of energy cannot be divorced from the environmental context (pollution, greenhouse effect) and the social context (employment, cultural progress, awareness).

It is not uncommon to find the word "energy" associated with the words "economy" and "environment" to provide evaluation schemes and so-called "sustainable development" models. However, these macro aggregates do not always put in the right evidence some important aspects - such as the regional typicality, the degree of energy demand satisfaction or the employment increase determined by the useful energy production technology[1] – that instead must be the basis of energetic governmental policies (incentives for installation and production, models of development and of management of distribution networks, etc.).

2. The proposed method is a modest contribution to the debate through a quantitative approach to the overall assessment of energy useful to planning that is attentive to social needs and environmentally friendly. The quantitative approach is based on the identification of determinant factors and characteristic indicators, on the fixation of objective criteria and on the collection and analysis of technical, economic, environmental and social data. It should be noted that the method does not provide absolute results but is a tool of comparison between various technological configurations (source + conversion technology) for the production of useful energy.

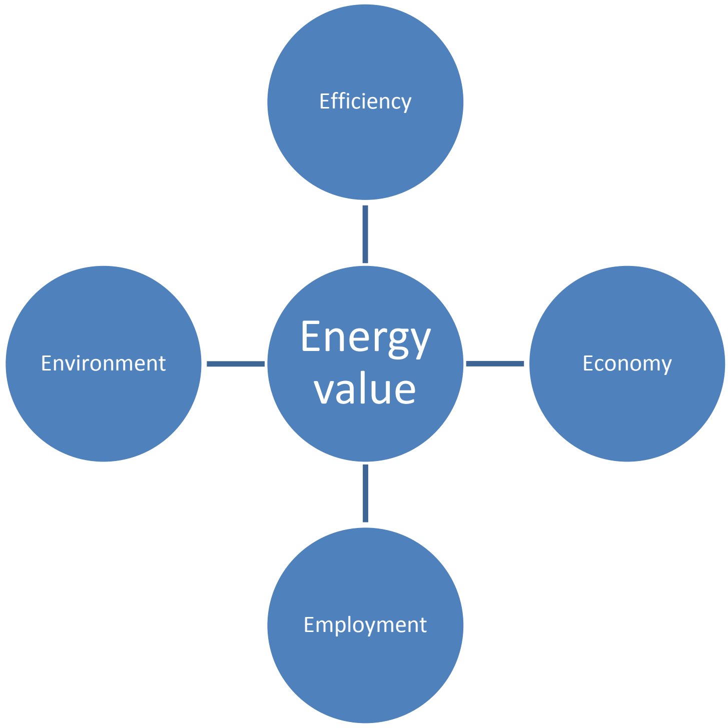
For the quantification of the total value of the useful energy V_E (Energy value), produced with a particular technological configuration, its four factors are considered: Efficiency, Economy, Employment and Environment[2]. These elements can be evaluated by a series of characteristic indicators, to which are attributed values based on defined criteria and available statistical data.

[1] Useful energy means the energy already transformed in the type required for usage.
[2] The protection of health is not taken into account because it is taken for granted in every place and human activity, including the production of useful energy.

Further considering the matter, it can be assumed that the overall value of the useful energy, V_E, is given by the product[3]:

$$V_E = E_f \times E_c \times E_n \times E_m \qquad (1)$$

where E_f = Efficiency, E_c = Economy, E_n = Environment, E_m = Employment.



3. Having identified the different technological alternatives T for the production of useful energy on the basis of considered regional tyicality[4] (availability of sources, types and technical characteristics and timing of the energy needs, environmental protection, employment requirements, etc.), the issue is then referred to the evaluation of the four determinants factors E_x for each technology T.

At this point choice and objective[5] statistical quantification of the characteristic indicators, $E_{xi,T}$, is made of each determinant factor E_x for the various technologies T. The numerical values assigned can be absolute or relative in reference to alternative technologies chosen (e.g. you can use a scale of 0 to 100 where 100 is the value of better energy technology among those taken into account) and certainly depend on the social and environmental contexts in which the production of useful energy takes place.

[3] The four determinant factors could also be combined in a sum but the use of the multiplication operator amplifies the differences between the various conversion configurations.
[4] A region is a homogeneous territory regarding the characteristic indicators.
[5] For acceptable results, referring to measurable quantities is preferable.

In practice, four matrices of this type are built:

EFFICIENCY E_f	Technology α	Technology β	Technology γ	…
Characteristic indicator 1	$E_{f1,\alpha}$	$E_{f1,\beta}$	$E_{f1,\gamma}$	…
Characteristic indicator 2	$E_{f2,\alpha}$	$E_{f2,\beta}$	$E_{f2,\gamma}$	…
…	…	…	…	…

ECONOMY E_c	Technology α	Technology β	Technology γ	…
Characteristic indicator 1	$E_{c1,\alpha}$	$E_{c1,\beta}$	$E_{c1,\gamma}$	…
Characteristic indicator 2	$E_{c2,\alpha}$	$E_{c2,\beta}$	$E_{c2,\gamma}$	…
…	…	…	…	…

ENVIRONMENT E_n	Technology α	Technology β	Technology γ	…
Characteristic indicator 1	$E_{n1,\alpha}$	$E_{n1,\beta}$	$E_{n1,\gamma}$	…
Characteristic indicator 2	$E_{n2,\alpha}$	$E_{n2,\beta}$	$E_{n2,\gamma}$	…
…	…	…	…	…

EMPLOYMENT E_m	Technology α	Technology β	Technology γ	…
Characteristic indicator 1	$E_{m1,\alpha}$	$E_{m1,\beta}$	$E_{m1,\gamma}$	…
Characteristic indicator 2	$E_{m2,\alpha}$	$E_{m2,\beta}$	$E_{m2,\gamma}$	…
…	…	…	…	…

The following table shows some characteristic indicators[6], $E_{xi,T}$, that can be considered for the quantification of the four factors E_X:

Efficiency:

1. local and time availability of the source
2. programmability of production
3. energy density
4. type of energy (or energy carrier) produced
5. installation restraints
6. production technology[7]
7. production flexibility
8. size of the plants
9. level of energy demand satisfaction
10. complexity of regulation and control
11. power factor

[6] The lists that follow represent an example without any claim to relevance and completeness.
[7] This characteristic indicator may include exergetic analysis.

12. impact of production unavailability

Economy:

1. specific investment (per unit of installed power)
2. unit revenues (per unit of useful energy) from electricity sales
3. unit accessorial revenues (from by-products)
4. unit production costs
5. unit distribution costs
6. unit ordinary and extraordinary maintenance costs
7. specific decommissioning costs
8. payback period

Environment[8]:

1. need of specific sites (waterways)
2. specific use of soil
3. specific dimensions
4. environmental alteration of earth-ocean characteristics
5. materials recycling possibility
6. unitary emissions of greenhouse gases (CH4, H2O, CO2, etc.)
7. unitary emissions of pollutants
8. environmental impacts (visual, acoustic, etc.)
9. risk for fauna, flora and for the particular ecosystem
10. environmental impact from the disposal of waste in operation
11. environmental impact from the disposal of waste in decommissioning
12. dangers and damages in the event of faults

Employment:

1. local expertise availability
2. specific local qualified employment under construction
3. specific local unqualified employment under construction
4. unit local qualified employment during operation
5. unit local unqualified employment during operation
6. specific local qualified employment under decommissioning
7. specific local unqualified employment under decommissioning
8. unit local employment for the production of fuel
9. increase of the local educational level
10. technology osmosis to other industrial sectors.

[8] Some environmental aspects, such as the opportunity to install certain types of plants in certain sites, might be considered introducing further details as e.g. cadastral quality, etc. This method, however, could become too burdensome in the collection and classification of data making it of little help. Moreover, these environmental aspects are generally already taken into account by various national and local specific regulations.

4. To take into account the eventually different importance that might wanted to be assigned to the various characteristic indicators in relation to the social and environmental context in which the production of useful energy takes place, a weight, W_{xi}, absolute or relative can be introduced (in this case you can use a scale of 0 to 100 where 100 is the maximum value of better energy technology among those taken into account). For example, the use of the soil in the desert for the installation of a photovoltaic system has a different weight from the use of land in an area intended for agricultural production; storage of radioactive waste or heavy metals in a strong tourist resort has a different weight compared to storage in uninhabited places or with heavy industrial concentration; in certain contexts unskilled employment may have a different weight than qualified, and so on. Even in this case statistical and objective analysis are necessary, with measurable parameters.

The value of each determinant factor, E_x, for each compared technology, T, then is:

$$E_{x,T} = \sum_{i=1}^{n} E_{xi,T} W_{xi} \quad (2)$$

Therefore, in the matrices of the values, described in step 3, the column of weights will be added:

E_x		**Technology α**	**Technology β**	**Technology γ**	**...**
Characteristic indicator 1	W_{x1}	$E_{x1,\alpha}$	$E_{x1,\beta}$	$E_{x1,\gamma}$	...
Characteristic indicator 2	W_{x2}	$E_{x2,\alpha}$	$E_{x2,\beta}$	$E_{x2,\gamma}$	...
...		...	...	...	...

5. An immediate and effective way to display the comparison between the different energy conversion technologies and the incidence of the four determinant factors may be to represent the values for each $E_{x,T}$ on a radar chart in which the area is proportional to $V_{E,T}$, the value of the useful energy for the given technology T in the given socio-environmental context. This also enables the intuitive and quick assessment of the weaknesses and strengths of each technological configuration.

6. The method also provides that for each compared technology T you can assign another weight L_x to the four determinant factors E_x depending on the particular priority or the boundary conditions (technological, environmental, social). Even in this case you can use a scale, p. eg. from 0 to 10, with 10 corresponding to the value of the most important determinant factor E_x and numbers between 0 and 10 to the values of the other three).

In this way, the value of the useful energy $V_{E,T}$ for the given technology T is given by:

$$V_{E,T} = E_{f,T}L_f + E_{c,T}L_c + E_{m,T}L_m + E_{n,T}L_n \quad (3)$$

With the various factors collected in a table such as the following:

		Technology α	Technology β	Technology γ	…
E_f	L_f	$E_{f,\alpha}$	$E_{f,\beta}$	$E_{f,\gamma}$	…
E_c	L_c	$E_{c,\alpha}$	$E_{c,\beta}$	$E_{c,\gamma}$	…
E_n	L_n	$E_{n,\alpha}$	$E_{n,\beta}$	$E_{n,\gamma}$	…
E_m	L_m	$E_{m,\alpha}$	$E_{m,\beta}$	$E_{m,\gamma}$	…

Since the choice of indicators and criteria for defining characteristic weight ultimately depends on the value of the useful energy obtained, these parameters should be carefully estimated and protected from corporate pressures.

In conclusion, it is desirable that energy policies largely favor the production of useful energy with a greater overall value, making competitive its use, to get the best outcome in terms of efficiency, economy, environment protection and employment.

7.

To complete the illustration of the method an example is shown with the comparison of four useful energy production technologies (T) in a certain context with certain needs and local characteristics. The values are assigned in the range of 0-100 (100 for the best situation). Emphasis is desired on the fact that the parameters chosen, the underlying criteria and the values assigned are only intended to explain the application of the method and are not attributable to any particular useful energy production technology or to any environment and social situation.

Table of relative values					
Efficiency	**W**	**T1**	**T2**	**T3**	**T4**
local and time availability of the source	90	50	40	100	100
programmability of production	80	90	50	100	100
installation restraints	80	60	20	100	100
production flexibility	80	60	60	80	100
size of the plants	80	100	100	40	90
level of energetic satisfaction	90	60	60	100	100
complexity of regulation end control	60	100	100	90	90
powre factor	70	20	20	100	100
impact of production unavailability	80	100	70	60	100
TOTAL (/100)		501,0	404,0	608,0	696,0

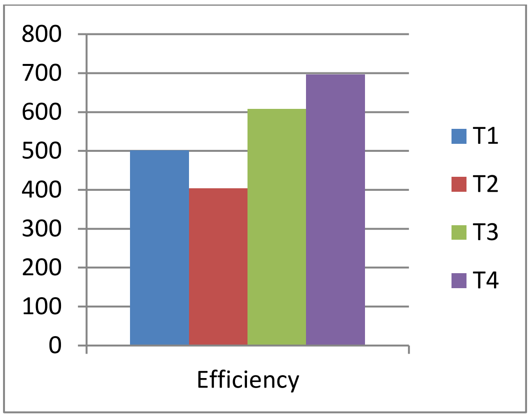


Table of relative values					
Economy	**W**	**T1**	**T2**	**T3**	**T4**
specific investment (per unit of installed power)	100	100,0	90,0	80,0	80,0
unit revenues (per unit of useful energy) from electricity sales	100	100,0	100,0	100,0	100,0
accessories unit revenues	100	0,0	0,0	90,0	100,0
unit production costs	100	100,0	100,0	40,0	50,0
unit distribution costs	100	90,0	60,0	80,0	100,0
unit costs of ordinary and extraordinary maintenance	100	100,0	90,0	70,0	70,0
specific costs of decommissioning	100	70,0	70,0	90,0	100,0
return time of investments	100	100,0	100,0	100,0	100,0
TOTAL (/100)		660,0	610,0	650,0	700,0

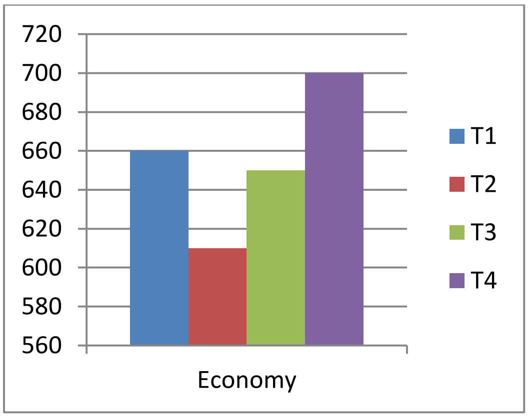


Table of relative values					
Environment	**W**	**T1**	**T2**	**T3**	**T4**
specific use of soil	70	60,0	80,0	50,0	100,0
specific dimension	80	50,0	70,0	80,0	100,0
possibility of recycling materials	80	30,0	30,0	80,0	90,0
unitary emission of greenhouse gases	100	100,0	100,0	90,0	90,0
environmental impact (visual, acoustic, etc.)	80	60,0	60,0	80,0	100,0
risk fauna, flora and for the particular ecosystem	80	90,0	80,0	100,0	100,0
environmental impact for the disposal of waste in operation	100	100,0	100,0	90,0	80,0
environment impact of the disposal of waste in decommissioning	100	70,0	70,0	90,0	100,0
TOTAL (/100)		496,0	518,0	577,0	652,0

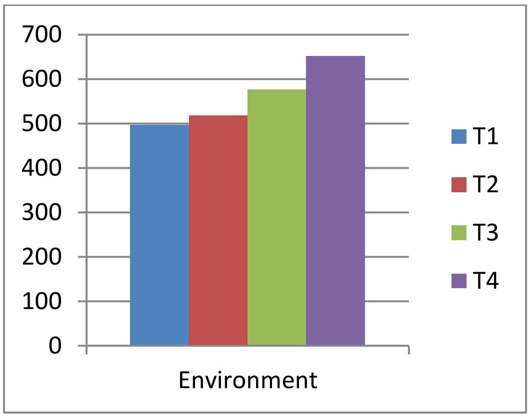
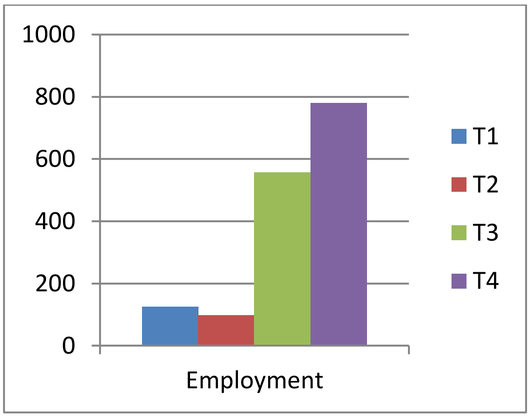


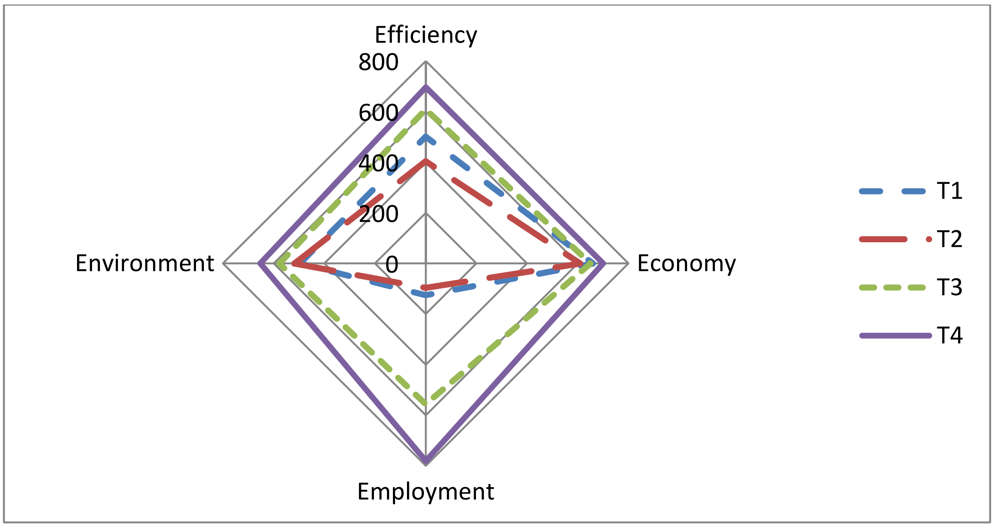
Table of relative values					
Employment	**W**	**T1**	**T2**	**T3**	**T4**
local availability of expertise	100	30,0	40,0	100,0	100,0
specific local qualified employment under construction	90	30,0	20,0	70,0	100,0
specific local unqualified employment under construction	100	30,0	20,0	90,0	100,0
unit local qualified employment during operation	90	20,0	10,0	70,0	100,0
unit local unqualified employment during operation	100	20,0	10,0	90,0	100,0
unit local employment for the production of fuel	100	0,0	0,0	90,0	100,0
increase of the local educational level	100	0,0	0,0	30,0	100,0
technology osmosis to other industrial sectors	100	0,0	0,0	30,0	100,0
TOTAL (/100)		125,0	97,0	556,0	780,0



In summary:

Table of relative values	T1	T2	T3	T4
Efficiency	501	404	608	696
Economy	660	610	650	700
Environment	496	518	577	652
Employment	125	97	556	780
TOTALE (/100)	1782	1629	2391	2828
	63%	58%	85%	100%

and in graphical form:



In case of application of a weight L_X for the different determinant factors $E_{X,T}$ of each technology T, the values of $V_{E,T}$ change into the following:

Table of relative values	L	T1	T2	T3	T4
Efficiency	80	400,8	323,2	486,4	556,8
Economy	80	528,0	488,0	520,0	560,0
Environment	100	496,0	518,0	577,0	652,0
Employment	100	125,0	97,0	556,0	780,0
TOTALE (/100)		1549,8	1426,2	2139,4	2548,8
		61%	56%	84%	100%

Therefore, the useful energy with the highest value in the context in exam is produced with the technology T_4 and, with respect to this measure, the useful energy produced with the other three technologies considered has the values in percentage indicated above.

8. The production of useful energy is a major activity of man and his intelligence has allowed him to find countless ways to obtain it. However, these methods are not always respectful of the best welfare interests and environment protection but are determined by other drives. A serious

commitment of everyone is required so that choices regarding energy are compatible with human needs and sustainable, especially to hand to future generations a better environment and models of progress.

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