The Emcoin project: knowing the energy contained in products for conscious consumption

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Abstract: The paper aims to illustrate the Emcoin project (project co-financed by the 8 x 1000 funds of the Waldensian Church, by the Polytechnic of Turin, by the Resconda and Sequs Associations) , which focuses on the development of the Emcoin (Emergy as a Coin) App, a practical and user friendly tool that, by quantifying the energy incorporated into products available on the market (under a LCA approach) and by providing an energy expendable budget to the users, aims at making consumers aware of the impact of their purchase choices, so that they can decide how - and to what extent - to contribute to the ecological transition, on the basis of each one's individual preferences and possibilities.

Keywords: CED (cumulated energy demand); Emergy; conscious consumption; App; Sustainability; LCA

1. Introduction

Currently, the state of health of the Earth's biosphere is very worrying and despite the fact that even in the general media - such as TV and print - there is a lot of information about "ecological transition", the 2030 agenda and "stringent climate objectives" to be achieved in the coming decades, the concrete actions of the States aimed at combating the climate change appear to be ineffective (Richardson, Steffen, Rockstrom et al., 2023). Notwithstanding a massive and pervasive presence of this topic on the media and political agenda, there is a evident lack of awareness of which actions should be undertaken and their effectiveness to this purpose: people receive generic and sometimes even contradictory information, of a predominantly qualitative nature, which do not allow to make a comparative evaluation of the actions and/or behaviors to be undertaken. The qualitative approach also does not allow people to define measurable objectives around their actions, preventing real individual responsibility and commitment on the issue of sustainability.

In our socio-economic model, based on industrial production and the consumption of goods and services, there is a direct and biunivocal relationship between energy consumption and environmental impact. The foundation of this relationship lies in the circumstance that almost all the forms that the environmental impact takes depend - to a large extent - on the use of the main fossil sources of energy: oil, natural gas, coal. In this context, when energy consumption per capita increases - all things being equal - the environmental impact at a systemic level also increases. Where energy consumption decreases, the environmental impact is reduced. This relationship is mitigated if part of the energy consumed is used to reduce the environmental impact in question, an objective that can be pursued by creating functional systems characterized by reduced impact or by removing and/or reducing the environmental impact produced. In any case, the significance of this relationship allows us to consider the energy consumed by people as a primary indicator - certainly capable of providing quantifiable and directionally correct data - of the environmental impact.

Assuming that every product/service exchanged has an environmental cost, since resources are used for its creation and provision, environmental sustainability can only derive from a reduction in the consumption of limited physical resources: raw materials, soil, air, water, energy (Slesser 1989). Among these resources, one is common and always present in all products/services traded commercially and that is energy. In our opinion, the reduction of energy consumption constitutes the fundamental and primary condition in the fight against climate change and the reduction of the human impact on the ecosystem. Furthermore, it is functional for the transition towards a renewable sources based energy production model, which currently cannot guarantee the same performance as the current system based on fossil fuels.

There are numerous guidelines and systems aimed at monitoring and improving environmental performances on the part of companies (including the UNI EN ISO 14064, 14067 and UNI EN ISO 50001 standards, as well as a large number of other sectoral "guidelines"). These rules are essentially aimed at allowing companies to present themselves on the market as attentive to environmental sustainability, but do not allow (or only partially allow) the consumer to know the environmental and energy cost of a specific product. On the consumer side, there are suggestions and numerous behavioral indications considered consistent with a sustainable lifestyle, but almost all of them are limited to providing generic suggestions, without providing any quantitative dimension that would allow people to assess the difference between what they do and what they should do. The objective of the Emcoin project, currently being implemented, is therefore to provide consumers with a quantitative and easy-to-use tool, which can, through the development of an App, allow everyone to know the energy incorporated in the purchased products / services available on the market.

2. Materials and Methods

From what has been illustrated above it emerges that, in general:

- Reducing energy consumption leads to a reduction in environmental impact;

- All consumer goods (raw materials, manufactured goods, industrial products, services) contain a certain amount of energy;

- It is possible to determine an overall total of the energy used by a person - in a given period of time - corresponding to the total Cumulated Energy Demand (CED) contained in the goods and services consumed by the person;

- By knowing the CED of the goods or services you intend to consume, it is possible to make choices between these aimed at reducing your environmental impact.

The CED can be calculated starting from the embodied energy, which measures the energy impact of the product / service considered by analyzing all the phases included in the process. This is the energy that is used to create a product, from the extraction of the raw materials necessary for its creation, transport, manufacturing, assembly, installation, packaging and any other process until the end-of-life phases (Cleveland, C.J., 1992).

At the moment there are various calculation methodologies at an international level and it should be underlined that, to date, even the embodied energy definitions found in the scientific literature refer to different systems and methods (Chen J. et al. 2019). In this regard, the methodology used in the European ECHOES project is of great interest, whose focus concerns the comparative evaluation of European energy lifestyles (Echoes Report, 2019). Aware of the difficulty within the Encoin project of developing a methodology for accounting for embodied energy, it was useful to take a look at the methodologies refined on the Embodied Carbon side as well. In reference to the construction sector (which constitutes a high energy and environmental impact sector) a useful and free tool to assess the emissions incorporated into buildings and construction materials has been launched by the environmental consultancy agency Circular Ecology in 2020 in United Kingdom. The tool is aimed to calculate and compare the embodied emissions of different concrete mixes, by entering the data of the various materials and quantities that you plan to use for a construction (https://circularecology.com/embodied-carbon-footprint-database.html). In the United States, the “Embodied Carbon in Construction Calculator” tool (abbreviated as “EC3”), financed by Skanska and Microsoft, was created, through a collaboration among Skanska USA, the Carbon Leadership Forum of the University of Washington State and representatives from the construction industry. The purpose is to facilitate and disseminate calculations relating to the real climate-changing emissions of buildings, since it could even become secondary how efficiently buildings are managed or improved over time if the emissions produced upstream of the construction process are not significantly cut or even considered. Skanska has teamed up with software developer “C Change Labs” to develop a solution that would allow the construction industry to access and visualize material carbon emissions data easily, allowing to make less impactful choices during the material selection and supply phases. An open-source platform was activated in 2018 to maximize the impact of this tool. There are over 16,000 materials in the database and - in the pilot period of the EC3 tool - development projects are achieving embodied carbon reductions of up to 30%, simply through access to detailed technical information and without significant financial impacts, being in most cases cost-neutral. (Legambiente 2023). In any case, the EmCoin project has developed its own methodology based primarily on careful data collection on a set of categories of goods considered significant in the framework of the standard individual consumption patterns of the Italian population.

In order to determine the CED of products / services, the first phase of the project has been focused on the identification and study of the consumption categories that mostly affect the daily life of an average Italian consumer. Thereafter it has been possible to identify, among the mentioned categories, the ones characterized by the most significant energy consumption, in order to concentrate the available project resources and efforts on the analysis of these categories.

The research was therefore focused on the identification of a pattern that would represent the distribution of the energy consumption attributable to the lifestyle and consumption choices of an average individual and the relative contributions of each individual consumption category.

However, this research did not thoroughly produce the desired results: in the literature, in fact, research works focus on specific areas and sectors, rather than on the average distribution of a person's total energy consumption. The energy consumption categories for which useful data and information are available are essentially electricity and transport.

This highlights the difficulty in making estimates on consumption categories for which data is not available or which appear to be profoundly heterogeneous. As far as the electricity consumption is concerned (domestic users connected to the national grid), estimates provide a range between 2000 and 2700 kWh per year, depending on the number of users per connection (individual, couple or family) and on consumption habits. With respect to transport, the GSE Energy Report in the Transport sector was used, in which the various components of energy consumption in the transport sector in Italy are reported. It emerges that in 2019 energy consumption in the transport sector in Italy amounted to 39.8 Mtoe equal to 462.87 TWh, i.e. 34.5% of the country's overall energy consumption. However, this GSE report includes all transport in Italy for any purpose. This means that this data, including both private, commercial and public transport, cannot be used for our purposes.

Again, from the methodological point of view, it was decided to make a significant distinction on the energy source used in the CED of a product or service, distinguishing between renewable sources and non-renewable sources. In fact, the environmental impact of the former, although not equal to zero, is substantially lower (even up to two orders of magnitude) compared to the average impact of fossil fuels. It follows that, wanting to provide a useful tool for reducing environmental impact, it cannot neglect the sources of CED and must indeed define them according to their belonging to the "renewable" or "non-renewable" group.

For this purpose, the classification proposed by the European Environment Agency (EEA 2023) was adopted: renewable sources include solar, geothermal, wind, water and biomass energy, while non-renewable sources include fuels fossils (including oil, coal and natural gas) and uranium for nuclear energy. In the construction of the database of the analyzed categories, the total value of the CED is therefore reported, accompanied by the distinction between the two groups of energy sources. In this first phase of work, it was decided to refer to the average national shares of electricity production from renewable sources, applying them transversally to the goods and services considered, without prejudice to cases of availability of specific data, detected in some product categories. In the subsequent and more in-depth research phase, these indicators will be detailed by referring to the data provided by the producers of the good or service, in relation to the choice of the electricity supplier or to the circumstance of self-production of electricity (e.g. through photovoltaic).

2.1 Categories definition and data base building

Given the difficulties encountered in the data collection activity aimed at defining a standard model of individual energy consumption, the expenditure categories were analyzed assuming a direct and significant correlation between the driver of economic expenditure - the usual and widespread way of analyzing individual consumptions - and that of energy consumption. The categories with the greatest weight (economic values) were thus assumed the ones from which to begin the analysis. This assumption is to be furtherly validated.

The categories were identified using the ISTAT 2022 basket data presented here in decreasing order with respect to the contribution of household spending (in euros):

1. Food products and non-alcoholic drinks 18.5%

2. Transport 14.5%

3. Housing, water, electricity and fuel 11.0%

4. Accommodation and catering services 9.6%

5. Other goods and services 9.3%

6. Health services and health 9.0%

7. Furniture, household items and services 7.9%

8. Recreation, shows and culture 6.8%

9. Clothing and footwear 6.3%

10. Alcoholic drinks and tobacco 3.4%

11. Communications 2.6%

12. Education 1.1%

Among the 12 macro categories above listed, those to be considered the subject of analysis (complete or partial) for this phase of the project were identified. This decision was adopted based on the following parameters:

1. Relative % economic weight of the category;

2. Likely level of correlation between monetary expenditure (as reported by ISTAT) and energy cost (CED);

3. Availability of data related to the CED;

4. Average frequency of purchase, favoring frequently purchased goods and services over durable ones whose purchase is occasional (such as furniture, household appliances, etc.).

3. Results

The first result of the research work was the structuring of the database with the different categories of goods that will subsequently have to be implemented to achieve the construction of the application (App). Following the definition of the categories referred to in the previous paragraph, the entire structure of the database was therefore built to subsequently facilitate the search and insertion of data, using, with the appropriate reworkings for a better adaptation to the context, the detail of the "ISTAT Basket 2022" in which all the levels and items considered are reported. Below are the levels considered for each of the twelve macro categories of the EmCoin database:

1. Group (X.X);

2. Class (X.X.X);

3. Subclass (X.X.X.X);

4. Segment (X.X.X.X.X);

5. Aggregate and/or product (X.X.X.X.X.X).

Each level has been assigned a progressive and unique numerical code, to be able to reconstruct the previous divisions from which it descends, thus drawing a tree diagram for each level. By way of example, the macro category Food and non-alcoholic drinks (code 01) includes two groups: 01.1 Food products and 01.2 Non-alcoholic drinks. Among the various classes belonging to group 01.1 Food products is that of "Meat" (code 1.1.2) and going down the level there are different subclasses, including that of "Salumi" (code 1.1.2.7). A further division of this subclass is into the segments "packaged cured meats" (code 1.1.2.7.1) and "counter cured meats" (code 1.1.2.7.2). Finally, among packaged cured meats, "Salami" (code 1.1.2.7.1.1), among others, is considered as an aggregate and/or product.

Since the final objective of the EmCoin project is to put the consumer in a position to be apble compare products basing on their relative CED, compared to the state of the current work phase, it will be necessary in the future to add a further level, following "aggregate and/or product", related to the specific manufacturer of each of the products considered. Returning to the previous example with respect to the last level by product type, a further level of analysis must be added reporting for each product the CED values related to the specific manufacturer (code 1.1.2.7.1.1.X). For each entry the database contains the CED data (in kWh per unit) divided into two components: CED from fossil sources and CED from renewable sources, expressed in absolute and percentage terms. The product unit is normally weight.

The sources used up to now to define the CED values were mainly Ecoinvent [Ecoinvent vers. 3, https://ecoinvent.org/] and Agribalyse [Agribalise 3.1.1, https://doc.agribalyse.fr/]. We chose to refer to two different databases as Agribalyse is more complete and suitable for CED values related to the macro category 01-Food and non-alcoholic drinks and the group 02.1 Alcohol, in fact, in addition to the greater variety of products considered by Agribalyse, analyzes of the product life cycle (specific manufacturing and transformation processes) are included in it which are not considered in Ecoinvent, which is more focused on raw materials and durable goods. The Ecoinvent database can be consulted via specific LCA analysis SW, the most spread being SIMA PRO. As part of the Emcoin project, Open LCA software was used instead, being open source and license free. In Ecoinvent the CED values are expressed in Joules per unit: the unit varies depending on the specific good, although in most cases the adopted unit of measurement is the weight (expressed in grams). In the EmCoin database these values have been converted into kWh/unit. In any case, the values collected and inserted into the EmCoin database require further deep and wide activities of verification in light of the specificities of the products available on the market.

In this phase of the Emcoin project, the most in-depth and represented category is 01-Food products and non-alcoholic drinks. The main CED data source for these products was Agribalyse 3.1.1. Even in this case, however, it was necessary to make some simplifications. On some occasions it has been necessary to identify a representative value for the entire level in which a specific product for which the CED is known is included. In other words, given the availability of a CED value for a single sub-item belonging to a specific level, in the absence of the CED values of the other sub-items belonging to the same level, the value in question was attributed to them associating it with the entire level. This and other simplifications were adopted throughout the project in order to address the lack of specific data relating to one or more products or product categories.

3.1. Project development and next results

As mentioned, the primary objectives of the Emcoin project are:

1.To put the consumer in a position to choose the product with the lowest embodied energy content, among similar products.

2.To make the consumer aware of the energy weight / environmental impact of it's daily purchases and to assess the proportions of the impact as attributable to the different kind of purchased goods.

While, at present stage of the project development, the objective 2. could to a certain extent be reached, in order to be able to achieve the objective 1. reliable and sufficiently comparable data in the database are still missing and required, especially for a proper usage of the final App. As we have seen, the process is carried out in differentiated phases, which are gradually more in-depth and progressively implementable. The refinement of the comparative tool will have to allow the CED of each product to be differentiated based on the manufacturer specifications (manufacturing process, raw material inputs, packaging, logistic, energy self-production and others), an objective that is beyond the real possibilities of implementation in this phase of the project, which is primarily aimed at demonstrating the main functions of the system. To this end, however, we proceeded to carry out - as an example - a first differentiated analysis of the CED for a specific item: UHT pasteurized milk. The CED values of UHT milk were obtained through the Environmental Product Declaration (EPD) available on the EPD International database [https://www.environdec.com/] for some industrial Italian milk producers, available on supermarket shelves (Torquati, B., Taglioni, C., Cavicchi, A., 2015). In fact, the EPDs contain data relating to energy consumption (both from renewable and non-renewable sources) reported under a LCA perspective, as required by the relevant methodology. The products compared were: Mukki PS 100%: Tuscan milk, partially skimmed brand with 100% milk from Tuscany and packaged in 1 liter Tetra Top; Granarolo Bio PS ESL Milk: organic partially skimmed, pasteurized at high temperature ESL and packaged in 1 liter bio-based Tetra Rex®; Accadì Bio Senza Lactose ESL milk: organic lactose-free with 1% fat pasteurized at high temperature ESL and packaged in 1 liter PET bottle; Granarolo Alta Qualità Milk: High Quality Pasteurized fresh milk packaged in 0.5 liter, 1 liter and 1.5 liter PET bottles. In the table hereunder (Table 1) are reported the CED data obtained for each product, accompanied by the reference brand, the type of container used and the percentage of renewable energy contained in the total CED, ending with the average data for the said product.

Product	Packaging	CED (kWh/liter)	% RES based CED
Mukki PS	Tetra top 1 l	5,13	12,53
Granarolo Bio PS	Tetra Rex® Bio-based 1 l	7,78	10,18
Accadì Bio SL	PET 1 l	6,04	2,55
Granarolo Alta Qualità	PET 0,5 l	4,52	2,27
	PET 1 L	3,99	1,9
	PET 1,5 L	4,27	1,78
Generic milk (Average from EDP data)	1L	5,29	5,20

Table 1. CED values for some UHT pasteurized milk available on the Italian market

Another problem taken into consideration for the determination of the total CED of a product is related to the inclusion in the calculation of the type of packaging used. The choice of material and different packaging, in fact, can determine a difference in the CED of the same product made by different companies, in particular within the food and beverage categories (Nikolić, S. et al. 2015). In the first instance, the data related to the materials mostly used for packaging were searched through the Ecoinvent 3.1.1 database (see Table 2). The value obtained for amorphous granulated PET acts as a general value for products (e.g. food trays) made of this material, but it lacks the energy content due to the specific industrial process aimed to give the desired shape to the package, so it must be subject to revision in the subsequent phases of the project.

3.2. Conclusions

As we have seen, the EmCoin project, once this first phase of data analysis and definition of the database structure underlying the development of the App tool has been completed, requires revisions, in-depth analysis and implementations validated by numerous tests. As already mentioned above, the EmCoin application aims to provide a tool for quantifying the CED of daily consumer goods and services to ensure consumers have a higher level of awareness regarding the environmental impact of their consumption choices. However, these values would be devoid of real significance if they could not be understood in the context of a defined quantity of energy "spendable" by the consumer himself, as a sort of individual available “energy budget” that defines the limits within which the consumer has the possibility of Act. In other words, it involves hypothesizing a budget that has, with respect to one's (environmental) energy expenditure, the same function that a monetary budget (economic spending capacity) normally has with respect to purchasing decisions. In the absence of this reference, the consumer would not be held responsible and would not have a precise objective to pursue in making his purchasing choices.

It is therefore necessary to identify a range of individual energy budgets that represent the maximum availability, in terms of CED (expressed in kWh), to be spent in a given time frame. This phase is under development.

The subsequent phases of the project involve refining and defining the missing data, firstly food products (various types not considered yet), detergents and household products, hygiene and body care products. Furthermore, other types of energy consumption that are significant in terms of impact/relevance will be refined, in particular with respect to mobility, household consumptions, IT data traffic. Another element of great significance will be the verification and analysis of the data collected with companies. Various in-depth analyzes of the results, verification of consistency and investigation of the causes of any inconsistencies will be necessary. The final tool, the application, currently at the first prototype stage, once refined and validated by an adequate number of tests carried out by volunteers, will be placed on the Android and IOS platforms and made available to users.

Material / Item	CED (kWh/unit)	Unit
Glass, white	4,963	kg
Glass, green	4,962	kg
Glass, brown	4,965	kg
LDPE film	26,371	kg
Cardboard container for liquids	23,663	kg
Kraft paper (for food bags)	16,499	kg
PLA bottle 0,5	0,351	1bottle
PET bottle 0,5	0,389	1 bottle
PET (granulate, amorphous)	21,534	kg
Aluminum can	91,421	kg
Cardboard box	6,663	kg
Polystyrene (PS)	24,784	kg

Table 2 - CED values of different packaging materials and shapes

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