# Reaching Energetic Sustainability through a Self-oriented Battery Charger, Based on Paraconsistent Annotated Evidential Logic E$\tau$

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**Abstract.** The growing demand for simple solutions to the problems faced by people in different situations has led many to an ongoing effort to improve techniques and processes, with a very high tendency to develop self-sustainable devices, aiming to generate reduced environmental impact with optimum results. At this point, there is the supply of electricity on places where this is not available. In these cases, normally the solutions most commonly adopted generate high environmental impact, since working with the burning of fossil fuels, with consequent carbon emissions.
Through the Library and Experimental Research, it was possible to develop the idea which fits within the proposed needs. This article aims to present the idea of a battery charger with solar panel auto-rotatable with working independent of any type of outlet, and provides income support to any charger designed to operate on the grid, with advantage of reduced environmental impact.

**Keywords:** Sustainability, Energy, Battery Charger, Paraconsistent Annotated Evidential Logic Eτ.

## 1 Introduction

In modern times, a growing demand for new technologies is largely visible, plus a great effort on improving techniques and manufacturing processes, disposal and power generation, aiming an environmental impact as low as possible, bringing into account the concept of sustainability, and combining maximum output results with minimum losses to the environment.

In contrast to this scenario of great development, cases of very scarce resources are not rare, particularly in locations distant from urban centers, and therefore devoid of many of the advantages offered by them. One of the most important of these resources is the electricity, often unavailable because of the distance between distribution networks and the locations itself, or even because the great importance of the local ecosystem, causing the impossibility to build any type of network. [1]

The solutions adopted in these cases, normally results in high environmental impact. Generators and combustion engines, or even gas and kerosene lanterns, offers physical risks to those who handle them, in addition to high greenhouse gas emissions. An interesting method for obtaining energy without burning fossil fuels is through the sunlight. Supply only implies in the cost of equipment (and not the power generation itself), and no carbon is liberated during operation.

One important problem is related to the positioning of the solar panel, which is often fixed and does not have the ability to follow the natural movement of the sun throughout the day. There is an option to circumvent this problem by using a timer-controlled servo, which puts the panel on pre-set positions, but this may not match the actual position of the sun.

By using an agent system, and connecting sensors and actuators to the panel, it is possible to obtain a correct positioning of it. This alternative combined with the use of $E\tau$ logic on the decision-making process by the agent, seeks to provide an optimal performance by positioning the panel in an optimized way. The design of the self-sustainable battery charger now proposed is intended to power small devices of everyday use, by charging batteries that can be used in various applications, thus

eliminating the solutions already mentioned and consequently reducing the environmental impact.

## 2 Paraconsistent Logic

### 2.1 Historical Background

The Genesis of Paraconsistent Logic, originated in 1910, by the work of logicians N. A. Vasil'év and J. Łukasiewicz. Although contemporaries, they had no personal contact, developing their research independently. In 1948, Jaskowski, encouraged by his professor Łukasiewicz, discovered Discursive Logic, Vasil'év wrote that "similar to what happened with the axioms of Euclidean geometry, some principles of Aristotelian logic could be revisited, among them the principle of contradiction" [5].

Both logicians, Vasil'év and Łukasiewicz, cared more about a possible exception to the principle of Contradiction, but stopped short of building systems that would take out this possibility. Alongside the works of Jaskowski, the Brazilian logician Newton C. A. Da Costa started in 1954 studies that could lead to construction of logical systems that could deal with inconsistencies.

Going beyond the work of Jaskowski, Da Costa has extended its systems for the treatment of very special cases, having been recognized for it as the introducer of Paraconsistent Logic; Abe [4], also a Brazilian logician, set several other applications of Annotated Systems, specially Logic Eτ, establishing the basic study of model of Model Theory and the Theory of Annotated Sets.

### 2.2 Certainty and Uncertainty Degrees

Founded on the cardinal points, and using the properties of real numbers, is possible to build a mathematical structure with the aim of materializing how to manipulate the mechanical concept of uncertainty, contradiction and paracompleteness, among others, according to figure 1.

Such mechanism will embark, of course, somehow the true and false states treated within the scope of classical logic, with all its consequences. To this end, several concepts are introduced which are considered "intuitive" for the purpose above:

Perfectly defined segment AB: $\mu + \lambda - 1 = 0;\ 0 \leq \mu, \lambda \leq 1$
Perfectly undefined segment DC: $\mu - \lambda = 0;\ 0 \leq \mu, \lambda \leq 1$

The constant annotation $(\mu, \lambda)$ that focus on the segment has completely undefined the relationship $\mu - \lambda = 0$, ie $\mu = \lambda$. Thus, the evidence is identical to the positive evidence to the contrary, which shows that the proposition $p_{(\mu, \lambda)}$ expresses a blurring. It varies continuously from the inconsistency (1, 1) until the paracomplete (0, 0).

Since the constant annotation $(\mu, \lambda)$ that focus on the segment has clearly defined the relationship $\mu + \lambda - 1 = 0$, ie $\mu = 1 - \lambda$, or $\lambda = 1 - \mu$. Therefore, in the first case, the favorable evidence is the Boolean complement of contrary evidence and, second, the contrary evidence is the Boolean complement of favorable evidence, which shows that the evidence, both favorable and contrary 'behave' as if classic. It varies continuously from the deceit (0, 1) to the truth (1, 0).

The applications are introduced as follows:
$G_{ic}:[0, 1]\times[0, 1] \rightarrow [0, 1]$, $G_{pa}:[0, 1]\times[0, 1] \rightarrow [-1, 0]$, $G_{ve}:[0, 1]\times[0, 1] \rightarrow [0, 1]$, $G_{fa}:[0, 1]\times[0, 1] \rightarrow [-1, 0]$.

Defined by:
Inconsistency Degree: $G_{ic}(\mu, \lambda) = \mu + \lambda - 1$, since $\mu + \lambda - 1 \geq 0$
Paracompleteness Degree: $G_{pa}(\mu, \lambda) = \mu + \lambda - 1$, since $\mu + \lambda - 1 \leq 0$
Truth Degree: $G_{ve}(\mu, \lambda) = \mu - \lambda$, since $\mu - \lambda \geq 0$
Falsehood Degree: $G_{fa}(\mu, \lambda) = \mu - \lambda$, since $\mu - \lambda \leq 0$

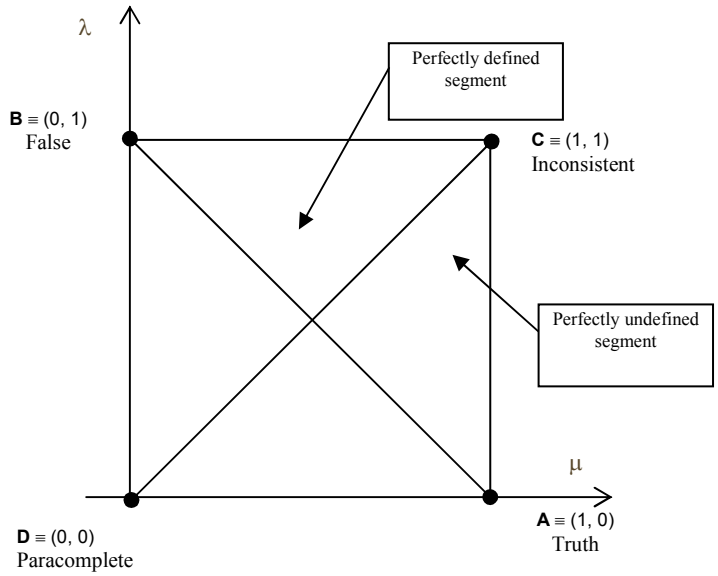


**Fig. 1.** τ Reticulate [3]

It is seen that the Accuracy Degree "measures" how an annotation (μ, λ) "distances" from the segment perfectly defined and how to "approach" of the state, and the true degree of Falsehood "measures" how an annotation (μ, λ) "distances" from the segment perfectly defined, and how to "approach" the false state.

Similarly, the inconsistency degree "measures" how an annotation (μ, λ) "distances" from the segment undefined and how "close" it is from the inconsistent state, and degree of Paracompleteness "measures" how an annotation (μ, λ) "distances" of the segment undefined, and how "close" it is from paracomplete. Is called $G_{in}$ uncertainty degree (μ, λ) from an entry (μ, λ) to any of the degree of inconsistency or paracompleteness. For example, the maximum degree of uncertainty is in an inconsistent state, ie $G_{ic}$ (1, 1) = 1.

It is called the Certainty Degree $G_{ce}$ (μ, λ) of an annotation (μ, λ) to any of the degrees of truth or falsity.

## 2.3 Decision States: Extreme and Not-Extreme

With the concepts shown above, it is possible to work with "truth-bands" rather than the "truth" as an inflexible concept. Perhaps more well said that truth is a range of certainty with respect to a certain proposition. The values serve as a guide when such a proposition is considered; for example, "true" in order to make a decision positively, and so on. The extreme states are represented by Truth (V), False (F), Inconsistent (⊤) and Paracomplete (⊥); and the not-extreme logical states by the intermediate areas between the states. The areas bounded by not-extreme values depend on each project.

## 2.4 Applying the Logic Eτ to the Agent System

Starting from the principles shown above, the agent system works based on the readings of a photoresistor, which works as a lightening sensor, attached to the solar panel and providing to the controller board the light values as voltage levels between zero and 5 volts, corresponding to each position. To work with such values by using the Logic Eτ, the agent system uses a "Para-Analyzer" algorithm, developed by Brazilian logician Newton C. A. da Costa, which is able to express the paraconsistent analysis by treating the favorable and contrary evidence degrees, providing a 12-digit binary word where a single active digit, which represents the logical state of the resulting analysis, plus an analog output, represents the certainty and contradiction values.

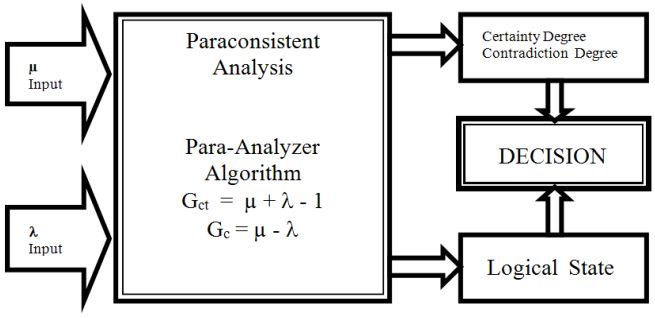


**Fig. 2.** Schematic of "Para-Analyzer" algorithm. [4]

The operation of the algorithm is detailed in Figure 2. In order to obtain from the sensor the input values of favorable and contrary evidence, it

was determined experimentally that reading values below 2.5V will represent the contrary evidence, and above it, favorable.

The system works as follows in the activity diagram of figure 3, which shows the steps performed by the software in its operation:

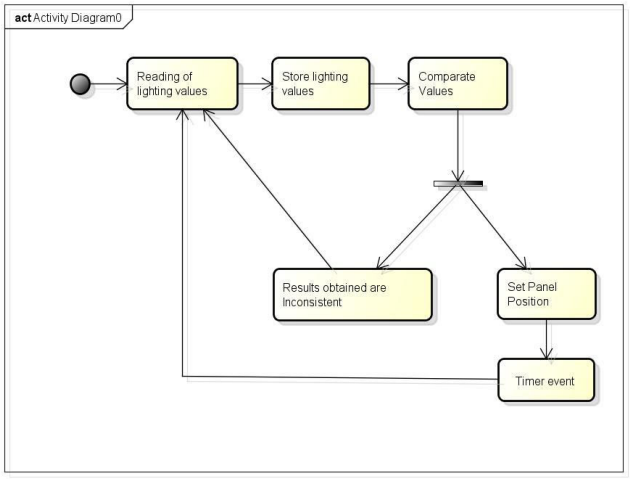


**Fig.** 3**.** Activity diagram, showing the work of the Agent system.

## 3 Controller Board and Electronic Circuit

The solar module used is capable of supplying a voltage of 17.5 V with maximum current of 286mA. With relatively small dimensions (338mm x 315mm x 18mm), it provides an effective charge to the battery, optimized by the self-orientation system. For the section of the controller board, responsible for the embedded software, was chosen the Arduino Duemilanove model, based on the ATMEGA168, a simple and versatile microcontroller.

The sensor is positioned next to the solar panel, and provides an idea of the position of the sun to the controller board. As actuator, a low cost servo motor has been chosen, connected mechanically to the solar panel through a pair of tipper gears. An analog regulator provides adjustment of the load current, adapting it to the battery used, a small 12V sealed lead acid (SLA), operating under cyclic charge. A second battery, maintained under continuous charge, provides the energy for operating the positioning system. The use of lead acid type batteries is providen-

tial, as most readily available and low cost rechargeable types.

## 4 Conclusion

In times of a growing technologies and optimized systems, there are still situations of extremely scarce resources, especially in distant places. One of these important resources is the electricity, often not available due to reasons like great distances and importance of local ecosystem. Normally, solutions adopted in these cases are not self-sustainable.

This paper aims to propose a low-environmental impact alternative for powering small devices in places where the electricity is not available. The proposed charger is capable to work without consuming any fuel, thus without release of carbon. The use of Paraconsistent Annotated Evidential Logic Eτ in the decision-making process by agent system, seeks to provide an optimal performance by positioning the panel in an optimized way, extracting maximum performance of a relatively small solar panel.

It is not intended a comparison between the model here proposed with any other similar solutions, based on different systems or even in Classical Logic, since that constitutes object for new iterations, following the present paper on the future.

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