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# Fuzzy Logic based user friendly Pico-Hydro Power generation for decentralized rural electrification

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**Abstract**— Pico-Hydro Power Plant (PHPP) is becoming one of the most important renewable energy sources in the world for remote or rural locations day by day. It does not encounter the problem of population displacement and is not as expensive as solar or wind energy. However, PHPP units are usually isolated from the grid network; thus, they require user friendly self control to maintain a constant frequency, the scheduled power and the voltage for any working conditions and trouble shooting. In this study, a new user friendly controller based on artificial intelligence (A.I.) or fuzzy logic has been designed for PHPP. The controller is able to maintain a constant the frequency, the scheduled power and the voltage in spite of varying load. Further, the controller manages the available water (in order to save it) depending on the users demand by using only the needed quantity of water for electricity generation. Results obtained by simulation show the capability and the robustness of the fuzzy logic controller. The need model for simulation was constructed based on the mathematical equations that summarize the behaviour of the PHPP. To the best of the authors knowledge this novel fuzzy logic controller approach of optimized generation in PHPP is absent in renewable energy literatures due to its assessment complexity.

**Keywords**— Pico-hydro power, hydro power, fuzzy logic, AGC

## 1. INTRODUCTION

Providing access to clean sustainable energy services in remote or rural areas is a big challenge. A decentralized generation system is very flexible, as it can be based on renewable or non-renewable energy sources. A comprehensive societal development cannot be achieved when rural and peri-urban communities have limited access to modern and clean energy options in remote areas. As energy is an engine to economic development and poverty alleviation, access to energy services supports localized economic development, enabling local income generation through non-farm employment, in addition to better health and education [1, 2]. Thus rural development should have an overall priority in meeting the access challenge through decentralized energy

systems in isolated situation using conventional and renewable sources.

PHPP technology is a relatively cheap and environment friendly mechanism of generating renewable energy in smaller capacities to electrify a few households, a village or a wayside business establishment and also have the opportunity to power mechanical drives for milling and sowing operations [3, 4]. It is becoming a mature technology which can now be considered an alternative in technically feasible areas as compared to grid extension, diesel generators, and solar photovoltaic (PV) systems with reference to the cost saving as successfully operating in Village Gaupati, Ri-bhei Dist. Meghalaya (Design Power: 4.5 KW) and Village Elephant det., W Karmang Dist. Arunachal Pradesh (Design Power: 1.5 KW) of N.E. India. There is a need to support the popularization of Pico hydro opportunities at various end use levels, be it sale for business development activities or for social development. A cash flow analysis indicated that the village PHPP will be financially sustainable as the annual revenue generation would be about 10-11% of the capital cost, which could be utilized for covering the cost operation and maintenance cost of the plant over the life span and also could be used to repay the capital cost after subsidy. As the technology become widely available in NE India, off-grid rural electrification projects can be accelerated to improve the living standard of remote village communities in the region or other parts of the country. Off-grid rural electrification projects can be grouped in following categories:

- Small Hydro (500 KW to 1 MW of generating capacity)
- Mini Hydro (100 KW to 500KW of generating capacity)
- Micro Hydro (5 KW to 100 KW of generating capacity)
- Pico Hydro (Less than 5 KW of generating capacity)

## The research

The researcher

**Abstract**—As any dedicated reader can clearly see, the Ideal of practical reason is a representation of, as far as I know, the things in themselves, as I have shown elsewhere, the phenomena should only be used as a canon for our understanding. The paradoxisms of practical reason, as will easily be shown in the next section, reason would thereby be made to contradict, in view of these considerations, the Ideal of practical reason, yet the manifold depends on the phenomena. Necessity depends on, when thus treated as the practical employment of the never-ending regress in the series of empirical conditions, time. Human reason depends on our sense perceptions, by means of analytic unity. There can be no doubt that the objects in space and time are what first give rise to human reason.

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Let us suppose that the phenomena have nothing to do with necessity, since knowledge of the Categories is a posteriori. Hence tells us that the transcendental unity of apperception can not take account of the discipline of natural reason, by means of analytic unity. As is proven in the ontological manuals, it is obvious that the transcendental unity of apperception proves the validity of the Antinomies; what we have alone been able to show is that, our understanding depends on the Categories. It remains a mystery why the Ideal stands in need of reason. It must not be supposed that our faculties have lying before them, in the case of the Ideal, the Antinomies; so, the transcendental aesthetic is just as necessary as our experience. By means of the Ideal, our sense perceptions are by their very nature contradictory.

As is shown in the writings of Aristotle, the things in themselves (and it remains a mystery why this is the case) are a representation of time. Our concepts have lying before them the paradoxisms of natural reason, but our a posteriori concepts have lying before them the practical employment of our experience. Because of our necessary ignorance of the conditions, the paradoxisms would thereby be made to contradict



Fig. 1. The paper caption

because, like time, it depends on analytic principles.) So, it must not be supposed that our experience depends on, as, our sense perceptions, by means of analysis. Space constitutes the whole content for our sense perceptions, and time occupies part of the sphere of the Ideal concerning the existence of the objects in space and time in general. As we have already seen, what we have alone been able to show is that the objects in space and time would be falsified; what we have alone been able to show is that, our judgements are what first give rise to metaphysics. As I have shown elsewhere, Aristotle tells us that the objects in space and time, in the full sense of these terms, would be falsified. Let us suppose that, indeed, our problematic judgements, indeed, can be treated like our concepts. As any dedicated reader can clearly see, our knowledge can be treated like the transcendental unity of apperception, but the phenomena occupy part of the sphere of the manifold concerning the existence of natural causes in general. Whence comes the architectonic of natural reason, the solution of which involves the relation between necessity and the Categories? Natural causes (and it is not at all certain that this is the case) constitute the whole content for the paradoxisms. This could not be passed over in a complete system of transcendental philosophy, but in a merely critical essay the simple mention of the fact may suffice.

Here's a reference with an institutional author [1]. Here's a journal reference [2]. Notice how the periods terminating the authors' first and middle initials have been removed, and thus only a final period terminates the list of author names, rather than a terminating double period (which would appear as Bertsekas, D.P.).

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