# Hydropower of Pico: Sustainable Future Development in Remote India

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***Abstract*:** Rural growth is one of the most significant fields in developing countries such as India. In rural areas of 121 Indians, there are about 83.3 crore people while in metropolitan areas there are just 37.7 crore people and industrial areas 68.84%. A vast number of people sleep in rural or remote areas without grid wattage, primarily because large-scale manufacturing plants are used for industrial facilities while transmitting is very costly. Taking into account the quality of the energy generation and its transmitting value and delivery in the country the significance of electricity supply in remote areas is determined. It is known that India abounds tremendously in water sources and that we can use water flows to produce massive quantities of energy. There are many big hydro plants and irrigation systems installed to provide electricity. There are, however, several villages in India that are disconnected from the power grid. These settlements are situated at high altitudes in the rugged countryside and have numerous small sources of the sea including river channels, ponds and waterways. Nonetheless, high altitudes make it challenging for most of these populations. When there is still a minimal water source the same elevated level will be of help. Many resources are big enough and have enough potential to extend the multi-purpose Pico hydropower plant. It can be done at reasonably low expense, with practically no environmental or social implications, by way of Pico Hydro, a water network with less than 5 kW of electricity.

***Keywords*:** Hydropower of Pico, Renewable energy, Hydropower, Rural development

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## 1. INTRODUCTION

Power connection has been viewed as associated with rural electrification by the expansion of the grid[1] in increasingly remote regions. Rural energy in the countryside is afflicted by problems of high transmission and distribution losses; regular failures in delivery of power to the system, logistical difficulties and the financial disadvantage of system extension to distant and inaccessible areas; scattered communities in small villages resulting in low high peak loads, bad financial conditions of state energy boards, etc.[4]

The National electricity policy(NEP) for India declared in February 2005 mentions rural electrification[5] in its national electricity strategy. It mentions rural electrical resources. NEP stipulates the Government of India's pledge to ensure that all households can access electricity by 2010, through rural electrification. For this reason, localized power production with a local distribution network should be provided anywhere grid access could not be affordable. Even before the 2005 NEP declaration, a remote village electrification system for delivering electric power to remote villages where the energy grid expansion could not be feasible in the immediate future was initiated in 2001-2002 by the Government of India's Ministry of non-conventional sources of power (MNES)[6]. In rural villages electricity supply from cooperative generation choices based on renewable energy is suggested, for example, small hydropower, biomass gasifiers, PVs, wind turbines, hybrid systems, etc.

Any usable hydroelectric capacity worldwide can be classed as big hydroelectric power. The hydropower plant can be categorized by the energy capacity, as seen in table 1.

:1

| Power | Class |
|---|---|
| > 10 MW | Large |
| < 10 MW | Small |
| < 1 MW | Mini |
| < 100 kW | Micro |
| < 5 kW | Pico(PHP) |

Table -1 Classification of Hydropower[7-11]

More analysts accept, though, that hydropower above 1 MW is not sustainable. This is because of influences in many years that necessary its efficiency. A water tank or lake also contributes to ecosystem destruction and the rooting of humans. While the micro and Pico hydropower groups may be small, they have played a major role in remote and off-grid settlements.

This small hydropower provides ample power at night to enlighten the group. Instead, the machine uses a run-of-river operation from a penstock to supply the turbine with head and flow levels. Over the last 30 years, Pico hydropower has proved as a low-cost, efficient and effective tool for electricity generation and mechanical energy development for off-grid applications and is going soon to be of major significance in rural electrification.[2]

By 2012 the Indian Government had planned to provide electricity to all rural villages in India, but this rural electrification plan could not be achieved. Komalikudi is a village once situated in the hills of the Western Ghats in the Idukki district of Kerala, 20 km from Munnar town. Their rate of literacy is far below the national level of literacy. In this area, however, main energy sources such as firewood and kerosene are used in the household for their operations. Electricity accessibility divides them into higher and lower groups [2]. The energy infrequent impact can be calculated by the form of fuel used, the volume of energy used and its availability, etc. Someone who can afford energy is luxurious while the other lives in darkness. This all adds to neighbourhood conflicts among the residents.[3]

The key emphasis of this paper is the state, operation and turbine technology of the Pico hydro turbine. This article aims to examine the impact on the power efficiency of Pico-hydraulic power systems of certain physical parameters, such as head and flow levels. This research aims also to identify possibilities for the generation of electrical power in rural or remote areas including mountains, hills and others and to estimate the amount of electricity generated. The chosen spectrum of head and flow spectrum would be evaluated for a general and generalized theoretical conceptual model of a Pico Hydropower network. The analysis indicates that the viability and scope for further development and future work are important in the proposed system as an alternate electricity production network.

This paper should focus on the state, operation and turbine technology of Pico hydro turbines. The goal of this paper is the study of the impact on power generation in the Pico-hydro power systems of certain physical parameters, such as head and water flow rate. The purpose of this research is also to evaluate the possibilities of electrical energy production in a rural or remote region including trees, hills, etc. and to estimate the amount of electricity generated. The chosen spectrum of head and water flow rate is evaluated and built into a general and condensed Theory of the Pico-hydro power system mathematical model. Our results demonstrate that the viability of the proposed program as an alternative energy solution is relevant and provides new possibilities to develop more and to conduct the study.

## I. 2. *Material and Methods:*

***2.1.Principle Operation:*** Hydroelectricity provides the available energy over the variations in height from the surface. The energy in water is transformed into mechanical energy which can be used directly or electrically by a turbine. The term head, H, is water pressure calculation. The actual difference in height in the water is mentioned. Power, P, is the energy that is converted overtime or work rate.

The power P, which can be derived from a stream of water; is $P = \eta Q H \rho g$

Where;¨ η is device efficiency, Q the overall volumetric movement, H the head, ρ is water density, and g is gravitational constancy (9.81 m/s²).[12]

*2.2. Components Used In Pico-Hydro System:* Hydro-power(HP) is an ecologically friendly and sustainable power source that converts the water's potential gravitational energy into electricity. Water supplies for irrigation and other uses[38] are then provided by electricity. The basic theory of HP is that the generated potential energy should be used to do the work by channeling water from higher to lower rate. In the hydraulic tube, the water head rotates, converts the potential energy into kinetic energy and drives the water engine, which then produces electricity[13]. Schematic design and core components of a standard PHP framework

*2.2.1. Forebay Or Upstream Source:* The pressure or forward supply (forebay) includes a holding tank, the trash rack, the gate or entrance, leak, etc. Forebay or upstream supply. The intake/gate separates the water flow from the central river or dam. The intake in the main water stream must always resist inconsistency. Similarly, low-cost controllers should be used to balance the intake of water flow.

In general, the intake in PHP systems is the highest.

*2.2.2. Water Head And Flow:* Basar et al. [14] found that the water head and the water movement are the two main variables in a PHP framework. The head corresponds to the water pressure or may be interpreted as a vertical decrease in water bodies. The Head is typically seen as a vertical gap (H) or pressure (N / m2).

Water flow or flow rate relates to water volume. For smaller water sources, the HP generator is the easiest way to calculate water flow levels [15]. The dispersed water is gathered during this method into a bucket or tub, and the time (t) is taken to fill the bottle. Thus, the rate of water flow, Q (m3/s or L / s) is determined simply as follows:

$$Q = V / t$$

*2.2.3. Penstock:* The penstock is a conduit that guides the water from the dam or reservoir to the gas turbine. It is important to decide the size, weight, internal diameter and penstock configuration as these aspects have a significant effect on the capital cost and overall efficiency of PHP. The penstock accelerates and enhances the water movement to transform the water turbine's impeller. The duration and diameter of the penstock must be that because the device is costly. The primary guidelines for optimizing penstock settings for PHP systems are contained in Fraenkel et al.[16], Maher and Smith[17], and Alexander and Giddens[18]. The findings of the study indicate that the setup in the gross head form with less than 10% of head losses would possibly provide consumers with useful choices. The penstock must usually be continuously fixed to the floor, or air bulbs may be shaped and water turbines and pipelines destroyed.

*2.2.4. Turbine***:** Numerous forms of impulse Turbines (IT) including Turgo, Cross-Flow Turbines and Pelton are available. The architecture of it is easy and low-cost[19] is worth noting. In high and medium heights of water, it is commonly used[20]. Throughout recent years ITs for lower headings and micro-locations have also been employed and it is a popular option around the world, as they have shown high performance. One or two jets have a Pelton turbine (PT). Because of its high efficiency[20], PTs are widely used in the PHP framework.

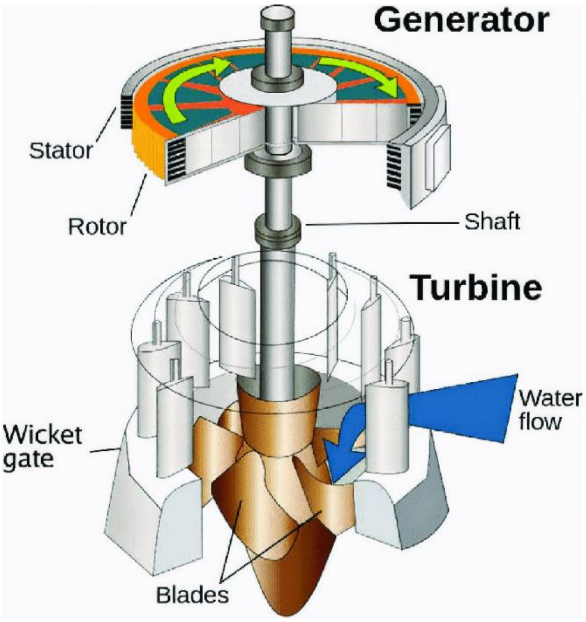


*Fig. 1. Water turbine and electrical generator*

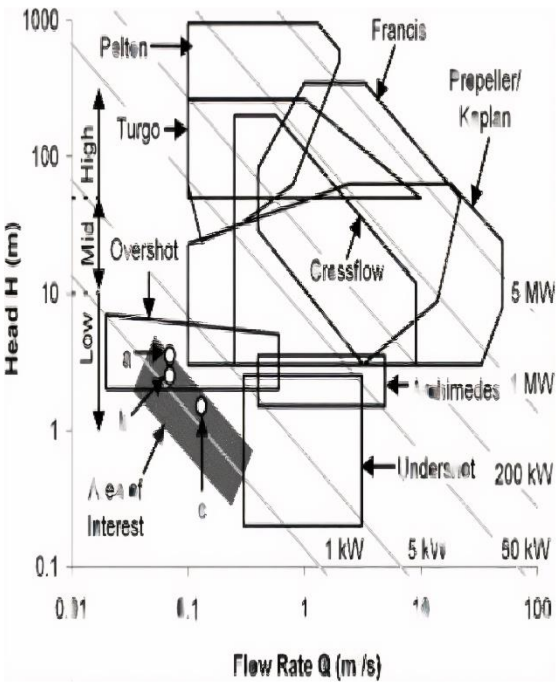


*Fig. 2. The chart of water turbine selection*

The performance of a PT typically is strong at 70–90% [23]. PT can be run at low water flow and can quickly produce power[24]. The free flow of water supplies, however, cannot function on PT. The water must be drawn from a nozzle [21] to produce a high-speed flow in the PT. The water movement is used to generate an upward hydraulic force that rotates the runner's blades by using the reaction turbines (RTs). Compared with ITs, in low and high water flow sites the RTs displayed excellent output [19,22].

The performance of RTs is much higher at slow operating speed than that of ITs[19]. One of the most widely used turbine forms for HP stations is the Francis reaction turbine [54]. This can be used for large, medium or micro HP installations, as their range of work is between 1 m and 900 m [56] and for low-head sites Propeller or Kaplan turbines [54,56] are more fitting and efficient. For lower sites Archimedean screw turbine (AST), its heads can be set as low as 1 m and it is ideal for sites with large flows of water[56], which are now more desirable. As a comparatively revolutionary approach to power generation from a low-lead water supply, West renewable energy [22] and Landustries [55] developed the AST. The high-quality ASTs will generate electricity/power 24 hours a day during the year. Over several years, water wheels (WWs) have been used in low volume as modern hydroelectric generation equipment. While WWs are less powerful than water turbines, in some areas and some conditions, WWs are considered to be economical and realistic alternatives, because it is simple to monitor and also to manage the WWs, they are esthetically advantageous[56].

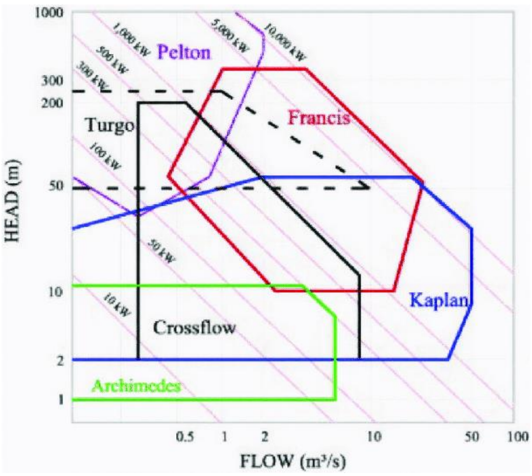


*Fig. 3. A typical water turbine application range*

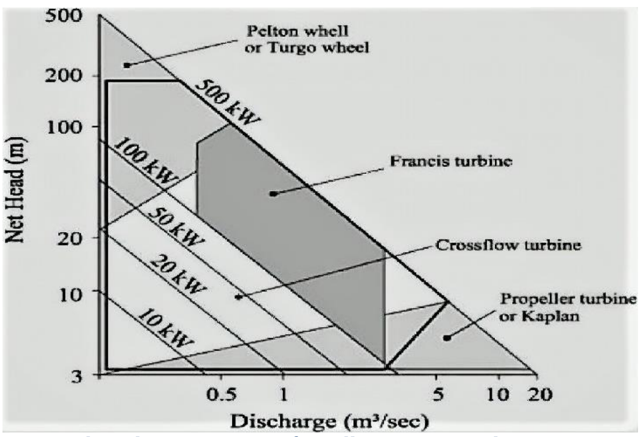


*Fig. 4. The selection ranges of small/micro-HP turbines*

with net heads and water flow rate variations [55,56].

*2.2.5 Selection Of Turbine:* The correct turbines must be chosen as incorrect turbines are the source of most losses. The set of turbine ranges typically differs depending on many criteria, for example, a) net water head(s) (b) Variance of turbine water discharge flow (c) generator speed and turbine rotational speed ratio of less than 3:1, respectively. (d) Cavitation problems such as penstock water quality (e) Turbine rate. In the application of turbines, the net head is the most significant parameter. The accompanying illustration for turbine selection is well known and ideal for larger turbines (Figures. 3 and 4). Williamson et al. have established an innovative method, utilizing qualitative and quantitative analyzes, to find the most effective and economic turbine in low-lead HP plants (Fig. 5). As the Fig can be shown. 5, the power output PHP limit is around 5 kW. There are currently three forms of commercially accessible low-head PHP systems: (a). (PT1-Mk2), (b). Nepal Hydropower and Electric Ltd. [47] (c) ECO-Axial ZD. MHG-1000LH Powerpal [48].

**2**.*2.6. Generator and powerhouse:* The generator is an integral part of HP / PHP that is used to change the electrical control of the generated rotational energy using a water turbine. The shaft produces a magnetic field and, by an electromagnetic field induction, is eventually reshaped into current / electricity in the generator spools. The HP / PHP device generator is selected in the following respects[25]:
(i) the HP / PHP generator's estimated strength.
(ii) the distribution system form and electrical load, e.g. AC or DC.
(iii) Price of a low-priced engine, economically feasible output potential.
(iv) It is a structural or part device that controls the engine, generator and other electrical components.

The powerhouse will be located as small as possible to increase the machine head and power production. Nonetheless, the electricity structures may be above the river or dam level to ensure the health of the flooding of the river or stream.

*2.2.7. Electrical system:* The electronic HP / PHP network comprises an electric generator, a transfer mechanism for power/electricity and electric charges.
In addition, when the system is switched on and off, the electrical switch is connected to the generator. By preventing the increase of voltage, the supply of produced electricity adapts to the electrical loads.
Electronic loads are general names for any electrical equipment utilizing the power supply. The electrical charges related to the PHP device mainly rely on the volume of power/electricity produced.

### *3. Theory:*

*3.1. A hydro system preparation:* To decide the needs of a Pico hydro project for village electrification, a feasibility study must be undertaken in a defined region.
*Overview:* Set up production, payment preparation, local capacity to control the network and the access or expected power grid.

*Location:* a good geographic location is one with steep rivers which have a year-round flow for a pico-hydro network.
• *Request Survey*: forecast house numbers and citizens able to afford within 1 km of the water source. A length of 1 km is the most conveniently transmissible span of electricity.

• *Power estimates*: the head and flow rate will be determined both for evaluating future energy production and for assisting in equipment selection.

• *Head and Flow*: Decide on an acceptable head-flow combination to obtain the requisite strength. Systems output should be anticipated, but the general performance (water input to electric power) can, if in question, be estimated at 45%.

• *Cost and availability:* determine the generator size to be required to react to the energy demand based on the available equipment's heads, flow and power outputs. The higher the eye, the lower the cost per kilowatt mounted. The spending initially is high, but running costs and repairs are small since no petrol has to be purchased.

• *Profitability:* The contrast of expected annual sales and the cost of capital provides a rough roadmap to financial viability. The investment is not feasible if the total profit is under 10% of the capital expense. It may be likely if it is 10-25% of the system. The system is feasible if total sales are higher than 25%
.
• *Village Council*: Deliver to the board at an open forum the survey findings. Workers will be allowed to engage in the municipal administration.
• *Other measures:* Several other measures, including a comprehensive site assessment, the completion of the extraction of electricity, the development of a chart and the schedule layout and thorough costing, are needed. The scheme will continue until this is completed.

Both supplies, tools and preparation may be ordered.

### *4. Advantages and disadvantages of Pico-Hydropower :*

*4.1. Advantages* **:**
*4.1.1. Sustainability:* Because PHP turbines create alternating current (AC), the produced electricity/power is constant and on-demand. Besides, popular electrical usages such as light bulbs, televisions (TV), radios, and food processing equipment could be directly connected [26,17,20]. PHP is often distinct from other green energy systems, for example, wind / photovoltaic production/electricity fluctuates regularly, with PHP having the least production fluctuation owing to the shifts in

processing capacity during the rainy and dry seasons (20,27).

*4.1.2. Simple to use:* The PHP turbines add a simple, versatile design and cheap technologies for manufacturing. Installing, running and controlling is, therefore, simple [17,28,29].

*4.1.3. Effectiveness:* The PHP method is deemed the most profitable source of electricity/power relative to hydro, wind, hybrid and other fossil-based processes [30]. Some significant considerations render the PHP scheme more favorable: (a) Fewer maintenance and construction prices, recent developments in PHP technologies have given turbines with strong efficiencies that last longer (e.g. 15-20 years), and a decent quality [34,32,31,33] for low-income individuals (30). (b) Fast payback time [35] where the deployment and PHP maintenance of a high performing PHP turbine is effective. As a result, more families with small wages are forced to use PHP [30,35]. (c) Charges for reduced service, replacement and repair. (c) Charges for reduced service, replacement and repair. PHP is a non-fuel device and PHP requires no PV or wind battery [17,20,30]. Maintenance research is not difficult, because the usage of local PHP resources and technology is easy for the owners of PHP[38]. The whole PHP turbine replacement cost is almost the same as the current buying budget[17,20,30]. (d) The PHP device has the lowest tariff at USb 10/kWh to USb 1010/kW h [17,36], which is 15 percent cheaper than the PV (a home solar electric/electricity network) in comparison to other green energy processes [17].

*4.1.4. Impact on the climate:* PHP is an online platform that supports the environment[37]. Thanks to the fact that a dam is not needed for PHP, PHP Turbine has no negative environmental effects. Dams may have a detrimental effect on the natural atmosphere with greenhouse gas (GHG) pollution in the PHP areas. Dams are also adversely influenced by the fish movement, animal ecosystems, natural flows, and consistency, as well as by water-based recreation[32].

*4.1.5. Sharing:* In rural regions, the easiest approach to divide the whole costs of the PHP scheme is by distributing the PHP scheme in the villages. It also reduces PHP's total spending, presenting rural communities with an opportunity to invest in high-efficiency and longer-term PHP units [17,30,39]. Sharing isn't people's free right, but it's their only way to obtain electricity/energy due to the power source inadequacy.

*4.1.6. Rural electrification progress rate:* Most citizens remain without exposure to power owing to poor flows and heads at several places across the planet. PHP provides access to power/electricity for millions of households in remote/rural areas and is adequate to provide electricity/electricity for lighting and other uses [30].

*4.1.7. PHP's disadvantages/drawback:* PHP is the low price option for rural electrification, while PHP is a minor nuisance, for the explanation that PHP is a site-specific technology[13,48] with seasonal fluctuations [32,41,42], which involves a restricting of HP outlets, a shortage of feasible areas and difficulty replacement [32,40].

In addition, research and special machinery for surveying PHP schemes are needed for PHP programs, increasing the budget for the system as a whole[17,27]. Moreover, strong rainy seasons are painful, because the PHP scheme may be weakened and washed out by flooding during the strong rainy season[40]. Overall, PHP users are still fearful that PHP could be hacked when it is not being used [20,30].

*4.2. Hydro Power-plant economic significance:*

• Remote areas in countries with significant grid electrification are mostly energy free. Owing to the comparatively low use of electricity, the grid association of small communities persists, amid strong demand for electrification.

• Pico hydro needs only a minimal flow of water, such that multiple acceptable locations can be identified. There is always ample water from a tiny stream or river.

• Portable and lightweight hydro Pico gear. The pieces will conveniently be shipped to isolated locations that are unavailable.

•The number of homes linked to each structure is limited, usually below 100. The required money is thus simpler to obtain and the management and receipt of profits handled.

• The Pico hydro systems are deliberately built to cost less per kilowatt than wind or solar electricity. Initially cheaper but diesel generator systems have a higher cost per kilowatt in existence owing to the rising fuel prices.

• It is important to develop local goods. It is quick to know the design concepts and produce. In a comparison of local incomes, this prevents certain maintenance prices.

• Deals on possession, revenues, processes, management and water resources are simpler to establish and retain, as electricity supply for limited numbers of households is given by units.

## *5. Discussion:*

*5.1. Case studies:*

*5.1.1. For India a few moves:* Two pilot units with 200-watt peak hydroelectricity have been constructed at Mankulam, an isolated village in Kerala, an INFORSE member of the Malanadu Creation Society. For the last year, the plant has functioned well. Based on this MDS, 30 units for 30 affluent and prosperous households in the village were suggested. The beneficiaries offered to make a modest donation to the scheme planned.

In Karnataka, there are many rural zones, especially in Malnad hilly regions and Udupi, Dakshina and Kannada coastal areas. The factors on the ground render grid electricity untrustworthy. Such regions, however, provide suitable locations for small Pico hydro systems. After the installation of Pico Hydro projects in Karnataka in the past 4 years, the energy situation has changed significantly. Pico Hydro projects up to 5 kW are specially targeted to provide access to small streams and rivulets for rural communities. These projects are built in the UK and about 400 Pico Hydro Plants have been constructed since 2007, with the numbers gradually rising.[43]

*5.1.2.District of Kirinyaga, Kenya:* In Kathamba, Kirinyaga County, Kenya, a traditional Pico hydropower plant has been built. This research was conducted as part of the Pico Hydro Engineering in Sub Saharan Africa initiative initiated by the Micro Hydro Center in Nottingham Trent University. The project funders (European Committee) covered the expenses of the penstock, turbine and generator equipment and the remaining expense was compensated for by the 65 households that now provide the network with electricity.

In this case study, a Pico hydropower plant with a Pelton turbine is defined, directly coupled with a 1.1 kW electric output induction motor. The plumb has a length of 158 m and a diameter of 110 mm PVC tubing. The 1.1 kW electric output correlates to the efficiency of the turbine generator of 48%. The source of water is a tiny spring with a supply of about 90 per cent of the year which has never been completely dried.[44]

## 6. Conclusion:

The need for energy and its use has gradually risen. Moreover, gasoline fuel as a principal energy market demand has to trend to rise day by day for most factory and vehicle engines. The Ministry of Power proposed ambitious preparation and growth for green energies and an efficient usage of natural capital, such as electricity, hydropower, solar energy, biogas, and farm waste. The energy is effectively used to produce a stream of water with a small flow rate relative to its head in the machine mounted. In the domestic network, rainwater should be used. Places with larger water supplies and challenging regions, if this scheme is carried out on a greater scale, will benefit from the water supply, power and income-generating activities. This project is very appropriate and feasible in India and obviously has certain benefits over other clean energy and rural development ventures. This project is very productive and feasible.

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