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Farmers' willingness to pay for power in India: conceptual issues, survey results and implications for pricing

Rafiq Dossani[a,*], V. Ranganathan[b,1]

[a] Senior Research Scholar, Asia-Pacific Research Center, Stanford University, 616 Serra Street, Stanford, CA 94305-6055, USA
[b] Professor of Economics and Energy, Indian Institute of Management, Bangalore 560076, India

Abstract

The objective of this paper is to develop strategies useful for raising prices of rural power in India. Such power is currently subsidized and policymakers are eager to make the transition to more efficient prices. The traditionally used measure, willingness to pay (WTP), is shown to have no useful policy implications due to the rationing of power. Using survey data from rural Andhra Pradesh, we show that the utility's cost of power exceeds the income generated by the power. This suggests a political problem—the possibility that low power prices have led to large-scale farming of unproductive land—that will be hard to resolve. Our survey also shows that subsidies are regressive with income. We use measured WTP for higher income groups to propose a discriminatory pricing regime that will raise total revenue by 20%. When combined with removing the causes of motor burnout, such as voltage fluctuations, and eliminating rostering, subsidies can be reduced substantially but probably remain too high to be resolved without political action.

Keywords: Power; Willingness to pay; Subsidy; Efficient pricing

* Corresponding author. Tel.: +1-650-725-4237; fax: +1-650-723-6530.
E-mail addresses: dossani@stanford.edu (R. Dossani), ranga@iimb.ernet.in (V. Ranganathan).
[1] Tel.: +91-80-2699-3155.

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1. Introduction

Electric power for rural pumpset usage is subsidized by all the states in India,[2] the subsidy being estimated at 1.1% of GDP.[3] Users are charged a highly subsidized, flat, annual fee that varies with pumpset size. This fixed charge has encouraged waste and raised subsidies over time. Unwilling to bear these costs any longer, states have proposed a range of strategies, including independent regulation, metering of agricultural pumpsets and raising prices.

This paper seeks to answer the question: By how much may prices be raised? The answer is partly a matter of political acceptability, since raising prices will presumably reduce the affordability of power for marginal farmers, and thus lead to political problems. In theory, however, prices could be raised for everyone to the level that the marginal user of power is willing to pay for the power he consumes—assuming that he is willing to pay more than he does currently. This willingness is termed the marginal willingness to pay (MWTP)[4] and has been extensively measured in India.

However, since power is rationed, MWTP is a theoretically inappropriate measure. Rationing implies the existence of a user whose MWTP equals price. This explains apparently puzzling empirical findings[5] that show that MWTP is equal to the current, subsidized price, despite an average subsidy of more than 85% of costs.

Assuming that subsidy must continue (for political reasons), one possible approach is discriminatory pricing. This may be implemented, for example, by charging higher rates

[2] Under India's federalist constitution, individual states are responsible for ensuring power supply, while the federal (central) government deals with inter-state issues.

[3] This is the figure for rural subsidies only (figures for the fiscal year 2002–2003). Source: Indian Economic Survey (2003), Tables 1.1, p. 2, and 9.4, p. 183. For a discussion of other sources of losses, such as transmission and distribution losses, and theft, see Dossani (2004).

[4] Willingness to pay (WTP) for a product is defined as the maximum price that can be charged without reducing the individual's welfare and utilization of the product. Marginal WTP (MWTP) is the WTP for the marginal user (Gertler and van der Gaag, 1988, p. 25). Note that, if, for example, charging the full cost of power leads to power costs becoming such a high percentage of income as to affect welfare and utilization, then WTP should not be used to guide policymakers. Our survey findings show that some user groups pay as much as a quarter of their income for power (see Table 4).

WTP has been primarily discussed in the public goods literature as an attempt to understand how its usage may be priced—through a usage tax, for example. Since a public good is, by definition, not a rationed commodity, this section does not apply to public goods pricing. For further discussion of WTP for public goods, see Mitchell and Carson (1989).

We focus on conceptual rather than measurement issues. There are several problems with measuring WTP. The most reliable measure is considered to be the contingent valuation method, which asks farmers to estimate additional income they would earn if they had adequate access to power, but this suffers from the problem that the user may not have experience of the effects of additional power on output. There are other methods, such as the recall method (asking farmers how much income they lost as a result of inadequate power supply), and the productivity method (estimating the productivity of land either directly or with alternatives to power such as diesel), which are considered to be even less reliable. For a discussion, see Diamond and Hausman (1994) and TERI (2000).

[5] For example, the TERI (2000) survey showed that less than 3% of the farmers in their survey were willing to pay more than they were currently paying for power. Similarly, the World Bank Study (1994, pp. 16 and 32) showed that medium and large farmers, who own 60% of total land with electric pumpsets, were unwilling to pay a positive sum for an increase in the quantity of power supplied. Note: small and marginal farmers, i.e., those with landholdings less than 2 ha, were willing to pay up to Rs. 9700 for an additional hour of power supplied per day. The World Bank study was based on the recall method. See also Fu et al., (1999), Nagari Newsletter (1999) and Ranganathan and Ramanayya (1998).

Table 1
Occupation

Secondary	Primary				
	Agriculture	Contract agricultural labor	Trade/ Industry	Government employee	Other
	445	1	1	2	0
Agriculture				2	
Contract labor	1				
Trade/industry	25				
Government employee	2				
Other	1				

for greater usage of power.[6] Other alternatives are to offer better quality power—either for everyone or on a discriminatory basis—and to charge higher rates in return. We focus on two quality-improving approaches that the state might use: doing away with rostering (calibrated, discontinuous supply) and improving the supply parameters that cause motor burnout. An empirical survey is used to show that a combination of the three approaches can reduce subsidies substantially.

2. Survey analysis

The objectives of this section are to analyze survey data on: (1) subsidies in relation to incomes and the costs of supplying power; (2) willingness to pay and additional revenue from discriminatory pricing; (3) costs of rostering and the cost-savings from continuous supply; and (4) costs of burnout due to poor quality supply and cost-savings from better quality supply.

The data come from a survey undertaken by the authors in the year 2000 in Andhra Pradesh, a largely rural state in India. The survey was tendered to landholders who used electric power for pumpsets, in 84 villages in 3 agro-climactic regions: Coastal Krishna-Godavari, Rayalaseema and Telengana. There were 449 complete responses. See Tables 1–3 for a profile. See Appendix A for a comparison of sample with state and national data.

2.1. WTP, subsidies and discriminatory pricing

Tables 4 and 5 present data on the costs paid by farmers in relation to their incomes, the utility's costs of supplying power and the marginal productivity of land.

Tables 4 and 5 imply:

- The subsidy per average farmer, at 88.9% of cost (Table 4, column H), is high and shows perhaps why policymakers need to raise revenue.
- Discriminatory pricing already exists (Table 4, columns C and J).

[6] This assumes both that greater users of power can pay more (not always true) and that practical solutions exist. In the latter case, for example, bidding may be a good way to get users to reveal their preferences, but may be an impractical solution at the retail level in rural areas because of high transaction costs.

Table 2
Landholding

	Rayalaseema	Telengana	Coastal	Total
No. of farmers	123	279	47	449
Average landholding	18.68	11.72	17.85	14.27
Crops per year (median)	2	2	2	2

- The subsidy is regressive, with wealthier farmers receiving a greater absolute subsidy (Table 4, column G). Policymakers, therefore, should focus on (at least) reducing subsidies to wealthier farmers. Over a third of farmers are in the uppermost fee band of Rs. 600/hp (Table 4, column B), so that this should be the target group for raising prices.
- However, the utility's cost/income for the average farmer (Table 4, column K) at 135%, shows that costs exceed income on average. This suggests a political problem—the possibility that low power prices have led to the large-scale farming of unproductive land—that will be hard to resolve without serious political repercussions.
- The problem of unproductive use of land is confirmed in Table 5. The net social benefit of 10 and 15 hp pumpsets is negative and increasing with pumpset size (Table 5, column F) and income/hp declines with larger pumpsets (Table 5, column G). This group of users constitutes over a third of the sample (Table 4, column B).
- Paradoxically (though impracticably, given the fixed costs and political repercussions), therefore, to reduce subsidies, the state could pay those with pumpsets exceeding 5 and up to 15 hp their lost income from switching to a 5 hp pumpset, and allow them to use only a 5 hp pumpset. The net saving of this "solution" is shown in Table 5, column F.
- There may exist a wealthy segment of farmers who use pumpsets with total hp exceeding 15 hp and who may be willing to pay more, perhaps because their landholdings allow for substantial economies of scale.

To examine the last-noted possibility, we present data on WTP in the Table 6 below. Table 6 implies:

- The maximum acceptable price rise is 100% (rows A and B), thus indicating a large gap with the price rise needed to cover costs (Table 4, column J).
- The MWTP is zero, as predicted in the introduction (rows A and B).
- The acceptable price rise does not bear a monotonic relationship to income (rows A and D), implying that a simple discriminatory pricing strategy of raising prices according to income will not work. This is confirmed by the low coefficient of determination (7.3%).
- However, 19.1% of respondents are willing to pay at least 51% more. This is the wealthiest segment (see row D). The sample data shows that those with pumpset ratings

Table 3
Sample profile (continued)

Average annual expenditure (Rs.)	32,460
Average landholding (acres)	14.27
Average hours pumpset used per day	7.22
Average days used per annum	273.85
Average pumpset rating (horsepower)	5.32
Average pumpsets per farmer	2.19

Table 4
Costs, incomes and subsidies

A (hp)	B (%)	C (Rs.)	D (kwh)	E = C/D (Rs.)	F (Rs.)	G = F − C (Rs.)	H = G/F (%)	I (Rs.)	J = C/I (%)	K = F/I (%)	L = K − J (%)
Pumpset rating upper band	Users within each fee band	User fees per annum at upper limit	Power used per annum	User cost per kW h	Utility cost	Subsidy per annum	Subsidy/utility cost	Farmer income per annum	User cost/income	Utility cost/farmer income	Subsidy/farmer income
3	10.8	750	4294.5	0.17	11,036.8	10,286.8	93.2	22,920	3.3	48.2	44.9
5	21.0	2000	7197.2	0.28	18,496.9	16,496.9	89.2	29,490	6.8	62.7	55.9
10	33.9	5000	14,590.1	0.35	37,496.4	32,496.4	86.7	34,360	14.6	109.1	94.5
15	34.3	9000	22,171.4	0.41	56,980.6	47,980.6	84.2	37,060	24.3	153.8	129.5
11.66		4849.3	17,060.1	0.28	43,844.3	38,995.0	88.9	32,460	14.9	135.0	120.1

1. Columns A and C: pumpsets are levied fees in bands, depending on their horsepower (hp): Rs. 250/hp up to (i.e., up to and including) 3 hp, Rs. 400/hp up to 5 hp, Rs. 500/hp up to 10 hp and Rs. 600/hp thereafter. Data source: APERC (2001), Table 96, p. 253. In practice, up to 5 hp, pumpset sizes are invariably either 3 or 5 hp. Above 5 hp, pumpset sizes differ from their limits of 10 and 15 hp (averages are 8.22 and 17.89 hp, respectively). Note that, in addition to fees paid to the utility, farmers bear additional costs, such as interest costs, repairs and maintenance, and bribes paid (90.1% of respondents paid bribes to get connected).
2. Column B: sample data for respondents within each fee band, except for the final cell, i.e., 10.8 % have pumpsets with rating up to 3 hp, 21.0% have pumpsets up to 5 hp, 33.9% have pumpsets up to 10 hp. However, 34.3% have pumpsets over 10 hp, with an average of 17.89 hp, as noted above.
3. Column D: annual power consumed is based on separate regressions of hours of usage per day on the pumpset hp and number of days of usage each year on the pumpset hp owned by the farmer. The regression equations are:

$$Y = 6.88 + 0.03X$$
$$t = (32.12)(2.24)$$

where Y = hours of usage per day and X = the pumpset rating.

$$Y = 278.8 - .42X$$
$$t = (66.55)(1.67)$$

where Y = number of days used per year and X = pumpset rating. Pumpset rating for calculating entries in column C is obtained from column A.
4. Column F: data source for utility's cost to serve (Rs. 2.57/kW h): APERC (2001), p. 243.
5. Column I: annual income figures are proxied by sample data on personal expenditure (this excludes crop-related expenditure, such as power costs). The first four entries in column G refer to point measures, i.e., those with pumpset ratings of 3, 5, 10 and 15 hp. Hence, it will not be fully consistent with the average estimate in the last row.
6. Figures in the last row are for the average farmer.

Table 5
The social costs and benefits of power

A (hp)	B (Rs.)	C (Rs.)	D (Rs.)	E (Rs.)	F = E − D (Rs.)	G = C/A (Rs.)
Pumpset rating	Social cost	Social income	Incremental social cost of larger pumpset	Incremental revenue of larger pumpset	Net social benefit of using larger pumpset	Average income per hp
3	11,036.8	23,670				7890
5	18,496.9	31,490	7460.1	7820	359.9	6298
10	37,496.4	39,360	18,999.5	7870	− 11,129.5	3936
15	56,980.6	46,060	19,484.2	6700	− 12,784.2	3071

1. Column B is the utility's cost (from column F in Table 4).
2. Column C: social income includes cost paid by farmer to the state for the pumpset, i.e., sum of columns C and I in Table 4. It ought to include other crop-related expenditure, but we have no data for this. However, the effect of such inclusion would be to strengthen the results of Table 5.
3. Column D: incremental cost is the increase in social cost from moving to the upper limit of the next pumpset band, i.e., the difference between successive cells in column B.
4. Column E: incremental revenue is the increase in social revenue from moving to the next pumpset band, i.e., the difference between successive cells in column C.

exceeding 15 hp are willing to pay 45.4% more on average, implying a close match with this segment.

This is the group with the largest contribution to revenue, as shown in Table 7 below. Tables 6 and 7 imply that it is possible to raise prices by 50% (the WTP for the highest group) for those respondents who use pumpsets in excess of 15 hp. Since this group contributes 40.6% of total revenue, the effect will be to raise the state's revenue by 20.3%. We return to the effect of this on subsidies below (Table 8).

2.2. Rostering

It has been noted in the literature that managerial inefficiency, motor burnouts and transformer burnouts raise power costs.[7] The practice of rostering (i.e., supplying power in intervals rather than continuously) attracts less attention. In AP, rural power is supplied in two blocks of 6 and 3 h during the day for pumpset use, totaling 9 hours a day.[8] This practice is not favored by at least some farmers, as is evident from regulatory commission hearings.[9]

[7] APERC (2001) estimates are that most of the system's T&D losses of 33.9% are due to "operational inefficiencies rather than (as claimed by Aptransco) due to factors beyond the licensee's control." (pp. 39 and 42). This is supported by Rao's (2000) finding that the line losses for distribution under cooperative management were lower, and ranged from 18.5% to 24.13%. See also Ministry of Power (1991), MERC (2000) and Sinha (2001) for more on power losses.

[8] World Bank (1994, p. 8).

[9] APERC (2001, p. 25) notes: "During the public hearing. . .it was also submitted that since the Licensees are making available 9 h supply in two blocks of 6 and 3 hours each either during the day or during the night, many farmers are using automatic starters and are also incurring high labour costs, etc. The truncated power supplied to the farmers thus caused undue hardship requiring the farmer to stay awake during the nights. It was requested that supply of power be provided continuously for 9 h at least for one batch from 3 a.m. in the morning to 12 noon and the two batches maybe alternated over weekly intervals."

Table 6
Acceptable increase in price over current price[a]

A (%)	(WTP-price)/current price	0%	1–10%	11–20%	21–50%	51–100%	>100%	Total
B (%)	Respondents	15.9	8.9	16.3	39.4	19.1	0.0	100
C (%)	Average acceptable price rise							32.4%
D	Average income	30,610	31,900	22,880	27,450	38,560	N/A	32,460

R^2 (income, (WTP-price)) = 7.3%.

1. Row A: this is the maximum percentage increase over the current price that respondents were willing to pay without reducing their use of power.
2. Row C: the average acceptable price rise is weighted by hp, i.e., it is calculated by weighting acceptable price rise ((WTP-price)/price) by the total pumpset hp used by the respondent.
3. Row D: this is the average income of those with responses as in row A.

[a] The method used is contingent valuation: respondents were asked to state the maximum that they would pay without reducing their consumption of power, but with no change in the physical conditions of supply.

We define continuity of supply as the highest percentage of total number of hours supplied per day that was received in a single block. For example, if a farmer received 9 hours of power per day in two blocks of 6 and 3 hours, the continuity is 66.7% (6/9).

From the sample data, it was observed that, on average, farmers used 5.2 hours out of the first block and 2.02 hours out of the second block, for an average sample continuity of 72.01%.

We estimated the regression

$$y = 10.14 - 4.04x$$

$$S.E.\ (0.46)(0.60)$$

$$t\ (22.26)(-6.70)$$

$$R\colon -0.31$$

where y = hours of usage of power and x = continuity of supply.

The regression shows that rostering significantly increases the usage of power. Continuous supply will reduce average usage to 6.1 hours—a reduction of 1.12 hours below current average usage of 7.22 hours—thus saving the utility 15.5% of energy used.

Of course, there may be costs to supplying power in a continuous block, especially if the supply crosses peak hours. However, the 9-hours block can conceptually be provided

Table 7
Respondents WTP and contribution to revenue

A (hp)	B (Rs.)	C (%)	D (%)
Pumpset rating	Cost per user	Respondents	Revenue share
3	750	10.8	1.4
5	2000	21.0	7.1
10	5000	33.9	28.8
11–15	8220	15.8	22.1
>15	12,900	18.5	40.6

1. The average pumpset used in the 11–15 hp range is 13.7 hp.
2. The average pumpset used in the 15+ hp range is 21.5 hp.

Table 8
The average effect on the subsidy gap

A	B	C	D = A + B + C	E	F	G	H=[1 − (D/(E − F))]	I = B + C + F
User fees	Burnout	WTP revenue	Total fees paid by average user	Utility's old cost	Savings related to rostering	Current subsidy/cost	Subsidy after changes/cost	Social benefit of changes per household
Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	%	%	Rs.
4849.3	3826.6	984.4	9660.3	43,844.3	6795.9	88.9	73.9	11,606.9

1. Column A: from column C in Table 4.
2. Column B: burnout is the average burnout repair cost (Rs. 3826.64) as estimated from the survey.
3. Column C: the WTP adjustment is calculated as the effect of a 20.3% price increase on existing user fees (see Table 7) obtained by raising charges by 50% on pumpsets larger than 15 hp.
4. Column E: from Table 4, column F.
5. Column F: savings calculated as 15.5% of average usage of 17,060.1 kW h per annum (Table 4, column D) and cost at Rs. 2.57/kW h (Table 4, note 4).
6. Column G: see Table 4, column H.

fully in off-peak hours, between say, 10 p.m. to 7 a.m., and we shall assume for purposes of analysis that continuous supply for 9 hours is possible.

There are many reasons why discontinuous supply may lead to wastage of power. First, facing rostered supply, the farmer may need to re-water the piece of land closest to his borewell twice, so that the water supply may reach the outer limits of his land. Of course, he can partially avoid such re-watering by channeling the water away from already-watered areas.

Since power is often supplied in off-peak hours (sometimes in the middle of the night) and is unmetered, the incentive to save power by rechanneling water is low. The typical response of the farmer is to leave the pump on at all times. This not only wastes power by using it to water already-watered areas, but also leads to waste of groundwater.

Another response to rostering might be to have multiple pumpsets, which would raise the farmer's fixed costs. The survey showed that most farmers have two or more pumpsets, with an ideal-typical layout as follows (Fig. 1).

Initially, assume that the farmer has a pumpset installed at borewell 1. If the original supply of power was insufficient to allow the water to reach subchannel 3, the farmer may choose to restart the pump when power returns, partly re-water subchannels 1 and 2 and thus take the water to subchannel 3. Alternatively, he may choose to install a second borewell (and pumpset), borewell 2, at the other end of his land.

Another response to rostering is that the farmer might install an extra large pumpset. An extra large pumpset might allow him to withdraw more water than he immediately needs,

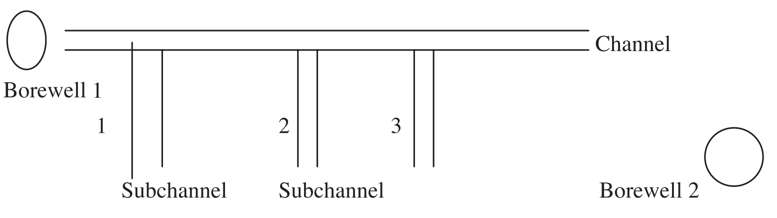

Fig. 1. Layout of Pumpsets.

which he might store at a cost until he needs it (e.g., during a time when power is not available), or simply overwater the plants when power is available and provide no watering otherwise.

To summarize, the effect of rostering is the excess usage of power by 15.5% on average. It may also lead to higher fixed costs, due to the need to have a larger pumpset or multiple pumpsets, while leading to wastage of groundwater.

2.3. Motor burnout

This problem, too, has been widely noted,[10] arising from poor quality supply, such as voltage fluctuations. The respondents reported an average of 1.59 pumpset burnouts a year attributable to voltage and other fluctuations, with an average repair cost of Rs. 3826.64. This raises the average annual cost of power to the farmer significantly, from Rs. 4849.32 to 8675.96.[11]

Table 8 shows the effects on subsidies if: (1) burnout is eliminated through better quality supply; (2) prices are raised by 50% for those with pumpsets exceeding 15 hp; and (3) rostering is eliminated. We assume that (1) savings on burnout costs can be recovered fully through higher prices and (2) there will be no effect on number of pumpsets owned or on the size of pumpsets owned.

Column I, the social benefit from the changes considered, is large. While all the policy changes count, the easiest to implement is changing the pricing regime (column C above), followed by continuous supply and improving quality.

3. Conclusion

The objective of this paper was to develop strategies useful for raising prices of rural power in India, using survey data from Andhra Pradesh. Such power is currently subsidized and policymakers are eager to make the transition to more efficient prices. The paper shows that a traditional measure, MWTP, has no useful policy implications due to the rationing of power.

Data from a survey undertaken by the authors in rural Andhra Pradesh in 2000 show that, on average, the utility's cost of power is 135% of the income generated by the power. This suggests a political problem—the possibility that low power prices have led to large-scale farming of unproductive land—that will be hard to resolve.

However, our survey also shows that subsidies are regressive with income. We used measured WTP for higher income groups to propose a discriminatory pricing regime that will raise total revenue by 20%. We also showed that the effect of removing the causes of

[10] In regulatory hearings, it was stated that "During the public hearing, many objectors complained about the quality of supply to the agriculture sector. They mentioned that because of high voltage fluctuations, the motors are getting burnt." (APERC, 2001, p. 25).

[11] Of course, the burnout cost is undoubtedly partly influenced by the initial quality of the pump purchased, but it appears—given that burnout is a high percentage of pumpsets owned (72.6 percent)—poor quality of power supply is the most significant reason. We shall assume that all the burnout costs may be saved if power quality improves adequately.

motor burnout, such as voltage fluctuations, is also positive. A surprising and potentially important finding is that doing away with the practice of rostering will lead farmers to use 15.5% less power, thus substantially reducing the states' subsidy burden. Improving the quality of power so as to remove the causes of motor burnout, eliminating rostering and installing the proposed discriminatory pricing regime will reduce subsidies substantially from 88.9% of the utility's cost to 73.9%, but remains too high to be resolved without political action.

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Appendix A. Sample data reliability

Representativeness of the sample data of the rural population of AP.

Notes: 1. Population average landholding based on AP aggregate data on rural population (51.65 m), average size per rural household (5), landholder percentage (40.4%), total cropped area (12.78 m ha or 31.57 m acres) and percentage of cropped to total area (46%). Therefore, average landholding=$(31.57/0.46)/[(51.65/5) \times 0.404] = 16.43$. Data source: AP Statistical Abstract (1995), Tables 1.11, p. 23, 1.9, p. 20, and 4.1, p. 68.

2. Population average expenditure for sample landholding of 14.27 acres is based on AP aggregate data on annual yield of rice/acre (1.03 t/acre), cropped area (46%), support price for rice (Rs. 5.1/kg). Therefore, average annual income=$(5.1 \times 14.27 \times 0.46 \times 1.03) =$ Rs. 34,425. Data source: AP Statistical Abstract (1995), Tables 4.1, p. 68, and 4.5, p. 74; Indian Economic Survey 2000–2001 (2001, p. 96).

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