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Energy Pricing in Developing Countries: Lessons from the Egypt Study

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ENERGY PRICING

IN DEVELOPING COUNTRIES:

LESSONS FROM THE EGYPT STUDY

DeAnne Julius, EGY

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Energy Department
World Bank
1818 H Street, N.W.
Washington, D.C. 20433, USA

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INTRODUCTION

The first comprehensive study financed by the Bank on the effects of energy price changes in a developing country was completed in September 1981 for Egypt.1/ Although the data and model used in the study are clearly specific to Egypt, the study provides insight into the mechanisms through which energy prices affect other prices in the economy and, therefore, the incomes of rich and poor consumers, the profitability of key industries, the balance of payments, and the government budget. Because some of the energy price scenarios tested for Egypt involved large and sustained increases (e.g., an eight-fold increase over 10 years), the resulting impacts on producers and consumers are probably greater than those one would expect in a developing country with more typical (i.e., much higher) domestic energy prices.

This note is not a summary of the Egypt study; for that, the final report of the study itself is recommended. Rather, the first section below is organized around a series of empirical questions about energy pricing and use in developing countries; it summarizes the evidence from Egypt. The second section brings together this evidence to formulate a set of policy recommendations that can be derived from the pricing study.

I. STUDY RESULTS

Price Impacts

1. How significant is the total effect of energy price increases on the prices of other goods and services in the economy?

> With the exception of a small number of industries (see Question 5), the effect even of large and continuing energy price increases is surprisingly small. Using a price scenario where all petroleum products prices were increased by 31% per year (23% in real terms) from 1980 through 1990 in order to reach world prices over that period, and assuming zero price elasticity of demand, 25 of the 33 sectors in the economy experienced price increases of less than 5% per year. The unweighted average of the price increases of the 33 sectors was 3.8% per year.

2. How is the total effect broken down between direct and indirect price effects?

> The Egypt study used an input-output framework so that it is possible to separate the direct or first-round price effects (e.g., the increase in transport costs due to higher fuel prices) from the indirect or second-round effects (e.g., the increase in food prices caused by higher

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1/ See Petroleum Products Pricing Study, by the Pearce-Whiteman-PEIDA Consortium, September 1981, commissioned by the Egyptian General Petroleum Corporation.

fertilizer costs resulting from increased fuel oil and gas prices). An unweighted average across sectors shows that the direct effects were responsible for slightly more than half of the total price increase, with the indirect effects accounting for the remainder.

In terms of the 8 most affected sectors, however, more than three-quarters of the price increase was from direct effects. Conversely, for those sectors with small total effects, the indirect effect often outweighed the direct. As shown in Table 1, the size of direct effects ranged from zero to 12.2%. The range of indirect effects was much smaller from 0.1% to 4.2%. If we exclude aluminum, whose large indirect effect results entirely from electricity price increases, the highest indirect effect is 3.0% per year.

3. What does this set of sectoral price changes mean in terms of the overall producer and consumer price indeces?

The value of the petroleum product price index (PPPI), the producer price index (PPI) and the consumer price index (CPI) are shown below:

	PPPI	PPI	CPI
1980	100	100	100
1985	386	133	109
1990	1488	261	144
Ave. Ann. increase	31%	10.1%	3.7%

The CPI is calculated using sectoral consumption expenditures as weights, while the PPI uses base year domestic output values as weights. The PPI is affected by the prices of many sectors and commodities that are not directly used by final consumers and therefore affect the CPI only indirectly and with a lag. Some of these commodities, such as fertilizer and cement, are the hardest hit by petroleum product price increases. Consequently the PPI is more sensitive than the CPI to energy price changes.

4. How sensitive are these results to the price elasticity of demand?

The results noted above were based on the assumption of no behavioral response to price changes (i.e., constant input-output (I/O) co-efficients). The base case in the Egypt study used a more realistic assumption which allowed for modest consumer price elasticities on petroleum products (higher for gasoline than for kerosene or LPG) and a gradual movement by producers from existing I/O coefficients toward "technically efficient" coefficients. This movement was assumed to be more rapid for the energy intensive industries. No

TABLE 1: Average Annual Percentage increase in Sector Prices Resulting from a 31% Average Annual Increase in all Petroleum Product Prices.

	Direct Effects	Indirect Effects	Total Effect
Staple Food	0.4	3.0	3.4
Non-Staple Food	0.7	2.0	2.7
Cotton	0.5	3.4	3.9
Other Agriculture	1.1	1.3	2.4
Mining	2.8	1.2	4.0
Food Processing	0.9	2.4	3.3
Beverages	0.2	1.6	1.8
Cigarettes	0.0	0.6	0.6
Spinning	1.4	2.6	4.0
Ready Cloth	0.9	2.5	3.4
Wood Products	0.0	2.3	2.3
Paper Products	1.4	1.5	2.9
Printing	0.7	1.4	2.1
Leather	0.4	2.1	2.5
Rubber	1.1	1.6	2.7
Chemicals	1.4	1.2	2.6
Fertilizers	10.3	1.6	11.9
Non-metallic products	2.4	3.0	5.4
Cement	7.8	1.5	9.3
Basic Metal	1.6	1.7	3.3
Aluminum	0.9	4.2	5.1
Metal Products	1.5	2.1	3.6
Non-electrical Machinery	4.2	1.8	6.0
Electrical Machinery	1.5	1.6	3.1
Rep. of Trans	0.9	1.9	2.8
Misc. Industries	0.0	2.0	2.0
Electricity	12.2	0.3	12.5
Construction	3.0	2.2	5.2
Transport	6.2	0.1	6.3
Suez Canal	1.4	0.2	1.6
Housing	0.0	0.6	0.6
Tourism	0.0	0.9	0.9
Other Services	0.0	2.7	2.7

Note: Figures assume price elasticity of demand is zero.

changes in the consumers' final purchases of goods other than petroleum products were assumed.

Under this set of price response assumptions, the final price effects were moderated slightly, but not significantly, for most products. The PPI, for example, increased by 9.9% per year rather than 10.1% under the zero elasticity assumption. Although the assumption of price responsiveness had little effect on the increase in other prices, it was important in affecting the quantities of petroleum products consumed (and thus the exportable surplus -- see Question 10).

5. Which sectors are most heavily affected by energy price increases?

The most heavily affected sectors in the Egypt study were fertilizers and electricity, followed by cement, transport, non-electrical machinery, non-metallic products, aluminum, and construction. No other sector showed more than a 5% average annual increase in prices from the 31% per annum energy price increase. The least affected sectors were various services.1/ The Egypt study included plant-level evaluations of the most affected industries. The results of these are discussed in Question 14.

Distributional Effects

6. How is the burden of energy price increases distributed across various income groups?

Although there is not a large difference in the impact on different income groups, the Egypt study indicated that the high income consumers, both urban and rural, were the hardest hit by a uniform increase in all petroleum product prices. The proportion of their income devoted to energy and energy-intensive items is slightly higher than that of the middle or low income groups. The 31% annual increase in petroleum prices (in the scenario discussed above) raised the cost of living for the various income classes by the annual average percentages shown below:

	%
Urban High Income	4.7
Urban Middle Income	2.9
Urban Low Income	2.9
Rural High Income	3.5
Rural Middle Income	2.9
Rural Low Income	3.0

1/ The model contained no wage formation equation to link prices and wages. The latter are controlled in Egypt, but over the long-term some linkage is still likely.

7. Are the poor hit harder by increases in the prices of some petroleum products than others?

The market basket of the poor in Egypt is heavily weighted by food, and therefore the energy products used to produce fertilizer and to transport and cook food products are the most important. In Egypt, where fertilizer is produced with fuel oil and natural gas, price scenarios that involve disproportionately large increases in those products (which are currently subsidized more heavily than other products) result in the rural low income consumers faring marginally worse than any other group.

Conservation Effects

8. What is the scope for energy savings through more efficient use?

In the Egypt study, a set of "technically efficient" input-output coefficients was constructed from information gained from the industry surveys in Egypt and from knowledge of technologies used in other countries. The potential for conservation was therefore represented by the differences between the energy used with existing technologies, and that resulting from the energy efficient technologies. For example, if the "technically efficient" methods were in place, the 1982 level of output could be produced with 19% less oil and 35% less gas than will be needed with current technologies and practices.

Another way to measure the conservation potential is to calculate the energy/output coefficient of the economy. This coefficient, which is sometimes mistakenly called an income elasticity, is calculated by dividing the growth rate of total energy demand by the GNP growth rate over a particular period. For 1980-1990, the energy/output coefficients for Egypt under different energy price assumptions are shown below:

	Energy/Output Coefficient
No price change (falling real prices)	1.04
Constant real prices	0.74
World prices by 1990	0.37

It is interesting to note that the income elasticity implied by the second figure above (i.e., when real energy prices are held constant) is less than unity for Egypt. Since the energy demand projection behind that figure is derived using constant I/O coefficients (i.e., an income elasticity of one for individual sectors), it implies that the structure of the Egyptian economy is projected to move toward less energy-intensive activities.

9. How effective are increases in energy prices in inducing more efficient energy use?

This depends on the price elasticities of producers and consumers, parameters which were assumed rather than estimated[1/] in the Egypt study. As noted in Question 14, because of the dominance of public sector firms among the large energy consumers in Egypt, energy price changes alone are unlikely to bring about the efficient level of energy use.

Balance of Payments Effects

10. How do energy price increases affect the balance of payments?

There are two opposing effects. First, the resulting increases in domestic commodity prices will reduce the country's export competitiveness and stimulate imports of competing foreign goods. Second, for an oil exporting country such as Egypt, the domestic conservation of energy brought about by price increases will free more of the oil products for export. The overall impact on the balance of trade will depend on the relative strengths of these two factors.

Given the elasticity assumptions in the Egypt study, the positive conservation effect far outweighed the negative effect on Egypt's non-oil trade. The non-oil trade deficit by 1990 would be 4% larger under the scenario that assumes average annual energy price increases of 31% compared with that assuming no change in energy prices. However, the net oil exports by 1990 would be more than twice as large with the energy price increases than without them. The overall balance of payments deficit under the price increase scenario would be about 60% as large as that resulting from no price increase.

11. Do price changes for different energy products affect the balance of payments differently?

One of the interesting implications of the Egypt study is the importance of the structure of energy prices in determining overall effects. It is possible to compare, for example, two scenarios that reach the same level of energy prices by 1990, but with different sets of product prices. In the first scenario, each petroleum product price is equal to its border price. In the second scenario, the average price of the reconstituted barrel equals the border price, but there are cross-subsidies among products. Gasoline is

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1/ In the Egyptian context, where energy prices have remained virtually constant for the past 20 years, it was not considered possible to estimate meaningful elasticities from historical data.

priced above world levels while fuel oil and natural gas are priced below their opportunity costs.[1] The balance of payments deficit resulting from the first "world price" scenario (WP) is 8% larger than that from the "world price average" scenario (WPAV). This is the result of two factors. First, the WPAV scenario affects the service sectors relatively more than the directly traded sectors. Services -- such as transport, construction, etc. -- are not subject to foreign competition and, therefore, increases in their costs do not directly affect the balance of trade.[2]

The second difference is through the exportable surplus of oil, which is 7% larger under the WPAV scenario than under the WP scenario. This also results from two factors: (1) the price elasticity of demand is larger for gasoline than for fuel oil or gas, and (2) the unit value of the gasoline "conserved" is higher than that of the "conserved" fuel oil or gas.

<u>Budgetary Effect</u>

12. How significant are the effects of energy price increases on the government budget?

For Egypt, the effects would be very significant. Increases in oil revenue from both domestic (due to higher prices) and foreign (due to larger quantities) sales far outweigh the somewhat higher government expenditures resulting from the pass-through effects on non-oil prices. For example, under the WP scenario, the non-oil deficit would be about three percent larger by 1990 than with no energy price increases, while the oil revenues would increase more than 20-fold. This means that without energy price changes the overall 1990 budget would run a deficit of over $7 billion, compared with a nominal surplus under the WP scenario. Part of this net revenue increase could be used, of course, to alleviate the effects of higher energy prices on low income groups. These figures also demonstrate the significant potential for resource mobilization through the energy sector for a country that can produce energy (either for export or for import substitution) at a lower cost than the internationally determined price.

13. What is the budgetary impact of different <u>relative</u> price scenarios?

Because Egypt is an oil producer, there is a marked difference in the way various sets of relative energy prices affect the budget. As

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1/ This should not necessarily be considered a good structure of cross-subsidies; it merely represents existing relative product prices in Egypt, brought up to an average world price level.

2/ There are indirect effects on trade, of course, which are included in the figures given above.

noted in Question 12, the WP scenario would result in a slight government surplus by 1990. By comparison, the WPAV scenario, which involves taxes on gasoline and "subsidies" (in an economic sense) on fuel oil and natural gas, would generate an $8.6 million budget surplus by 1990 -- about 10 times the size of that under the WP scenario. This is because the "subsidies" on fuel oil and gas are not budgetary items; both would be priced well above their financial costs of production although at only 50-60% of their border prices. For an importing country, of course, this result would not hold.

Effects on Industries

14. In the most affected industries how much scope is there for cost absorption or pass-through without jeopardizing the firm's financial viability or international competitiveness?

The Egypt study included a plant-level analysis of five of the largest energy-consuming industrial sectors: fertilizer, cement, aluminum, textiles, and iron and steel. These case studies reveal an intricate web of public sector policies (tariffs, subsidies on inputs, output price controls, etc.) that affect the firms' net income. A change in the energy subsidy alone is probably not the most efficient route toward improving resource allocation in the broader economic sense.

An analysis of the effect of energy price increases on the five largest industrial consumers of energy must begin with an examination of the current state of those industries in Egypt. All except textiles are heavily dominated by (or exclusively) public sector enterprises. The price at which production can be sold on the local market is controlled in all five cases, although for cement and textiles a portion of the output can be sold at market-clearing prices. In the case of iron and steel, the controlled price is only slightly below border prices; for the other four products it is significantly below. Given existing energy and output prices in Egypt, textiles and iron and steel are marginally profitable; cement and aluminum offset the losses on their domestic sales at controlled prices with other sales (domestic for cement, export for aluminum) at market prices for a modest overall profit. Fertilizer must receive a large subsidy because of very low controlled prices. Table 2 summarizes these findings.

If the subsidy on energy prices were removed, but output prices remained controlled, only textiles would probably show a profit. If output prices were also decontrolled so that these five industries would be operating at border prices for their energy inputs and for their output, only textiles would be internationally competitive given the existing mix of technologies and vintage of machinery in the five industries.

Could this conclusion be altered by better operating procedures and appropriate investments in more efficient technologies? The study does not attempt a full industrial audit so cannot answer this question definitively. However, it does reveal major scope for improving energy efficiency in the four industries. In fertilizer, the energy/output coefficient of the least efficient Egyptian plant is nearly seven times as large as that of the most efficient. In cement this ratio is 1.5, and the introduction of new technology (i.e., dry process kilns) could double the output per unit of fuel input even compared with Egypt's most efficient plant today. A major retrofitting program is already underway in iron and steel, where new technology could produce six times as much output for the same average energy input as today's plants.

In addition to the scope for more efficient production, at least in the case of fertilizers there is probably room for more efficient use. The Egypt study suggests that agricultural output would actually increase if farmers could be induced to reduce their nitrogen/phosphate application ratio. Since it is nitrogenous fertilizer that is primarily affected by energy price changes, an increase in its price relative to that of phosphatic fertilizer might actually improve the farmers' productivity.

Although there is ample scope for increasing the efficiency with which energy is used in these five industrial sectors, the responsiveness of the firms to changes in energy prices must also be considered. In the case of agriculture (fertilizer) and textiles, this responsiveness was judged to be fairly high. For cement it would be lower, and for aluminum and iron and steel, which are almost exclusively in the public sector, and possibly uneconomic at border prices, it would probably be minimal.

The general conclusion to be drawn from the industry studies is that to view the effects of energy price changes in isolation from other price policies may be counter-productive to overall efficiency aims. A broader evaluation of the need for restructuring certain industries, introducing more efficient technologies, changing controlled output prices, and/or retrofitting certain older plants is more appropriate.

Table 2. Summary of Industry Studies

Existing Situation	Fertilizer	Cement	Aluminum	Textiles	Iron/Steel
Local price set below border price?	yes	yes-2 tier	yes	yes-2 tier	yes but close
Profitable under existing energy and output prices	no	yes on average	yes on average	yes	marginal
Ratio of energy/output coefficients in least efficient to most efficient plant	6.8	1.5	-	-	1.9
Ratio with new technologies	-	2.9	-	1.2	6.4
Increased Energy Prices					
Effect of 100% energy price increase on cost	35%	10%	5%	1%	5%
Profitable under existing output prices	no	no	no	yes?	no
Profitable at border output prices	no	no	no	yes?	no
Scope for more efficient production	for some plants	very large	no?	little	yes
Scope for more efficient use	yes	no	no	no	no
Responsiveness to price changes	high	moderate	low	high	low

II. POLICY IMPLICATIONS

The overriding reason for raising energy prices in Egypt would be to increase the efficiency with which energy is used in the economy. By focusing on that objective, rather than on energy prices per se, one is led to recommend a package of measures, only some of which deal specifically with prices. The five recommendations presented below are listed in order of their probable impact on energy savings for Egypt.

(1) The economic desirability of producing aluminum in Egypt should be examined afresh. The existing plant was built during the days of surplus hydropower, and still accounts for 15% of the total electricity consumption in Egypt. If that electricity is valued at its marginal supply cost (i.e., thermal generation), the plant appears, prima facie, to be a net economic loss. Since half of the aluminum production is exported, it appears that Egypt is, in effect, subsidizing the consumption of its trading partners. The case is not quite this simple, however. A study needs to be undertaken to define the costs of transmitting the power used at the plant (located in upper Egypt) to other users, and to determine the marginal impact on the power system of alternative assumptions of availability of that energy. In addition, the regional development objectives of Egypt need to be taken into account. Given the very large potential savings of electricity, however, the continued justification for aluminum production needs to be examined urgently.

(2) The second striking misuse of energy resources that the study demonstrates is the operation of a major fertilizer complex based on the electrolysis process. That energy-intensive plant (again built during the days of surplus hydropower) consumes about 12% of Egypt's electricity. It and the aluminum plant are responsible for almost 30% of the total consumption of electricity in Egypt; they pay less than one-fifth of the long-run marginal cost of electricity supply. Yet even with these large energy subsidies, both plants operate at a loss on the output they sell at government-controlled prices. It is unlikely that energy prices (including power tariff) changes alone would have much effect on their consumption.

The costs and benefits from a hypothetical project to convert the electrolysis plant to a process based on natural gas have been calculated by the consultants. Even attributing the full costs of a new gas pipeline to such a conversion, the net present value at 10% would be nearly $400 million. As the study points out, however, while such a conversion would be an improvement over the current situation, it would not be the most economic solution. A new plant, of an appropriate size, probably located near gas fields, should be considered as a replacement for the existing complex.

(3) The proper pricing of electricity is the key to controlling the growth of oil and gas demand in Egypt. The power sector is

the largest single consumer of hydrocarbons; in 1980 it accounted for 35% of the country's fuel oil use, 33% of its gas consumption, about 15% of gas oil and all domestic sales of naptha. The government's projections show that by 1985 these percentages would increase to 52%, 48%, and 22%, respectively, of fuel oil, gas, and gas oil (three fuels which, together, make up 70% of Egypt's hydrocarbon consumption). Yet the power sector's demand for fuel is clearly a derived demand based on the economy's demand for electricity. The latter, of course, is a function of the power tariff rather than petroleum product prices, and the current average electricity tariff is less than one-fifth of its long-run marginal cost. At least partly as a result of this very low tariff, the growth of electricity demand has been high -- over 15% per year. Not only do low tariffs accelerate demand growth, they also deprive the utility of the financial resources to fund needed increments in investment. Thus for financial as well as economic reasons, and certainly from the vantage point of the overall energy sector, the importance of proper pricing of electricity is paramount.

(4) The prices of petroleum products and gas should be set to promote the optimal choice of fuel by consumers and to discourage waste. This does not necessarily imply simple equivalence to border prices. Indeed, one of the most interesting findings of the pricing study is the widely different effects of pricing scenarios with the same average level, but with different structures of product prices. As discussed in Questions 11 and 13 above, the WPAV scenario has a smaller effect on poorer consumers, yields a lower balance of payments deficit, and a smaller government budgetary deficit than the WP scenario. These are only indicative results, and one could probably devise better weighted average price scenarios than the WPAV, but they do indicate that simple "first-best" solutions to petroleum product pricing may not be the best in an economy beset by other distortions. They also suggest that one should not be wedded to a particular set of "optimal" energy prices; there are probably many good sets. Instead of focusing on specific prices, one should develop criteria that the set of prices should meet. For the case of Egypt, these criteria might be as follows:

(a) The set of energy prices should encourage the substitution of gas for liquid fuels. This means that the prices of fuel oil and gas oil, in particular, should be above that of natural gas. Indeed, since Egypt's aim should be to replace the bulk of the "black oil" use with gas, the major pricing focus should be on gas rather than fuel oil, and the major investment focus should be directed toward accelerating that substitution.

(b) Gas should not be valued below its resource cost to the economy. It is not yet clear whether Egypt's gas reserves are large enough to reduce the marginal opportunity cost of gas to its resource cost, or whether it will still replace fuel oil at the margin. In either case, because gas is a depletable resource, Egypt certainly should not use its gas in ways where its return would be less than the expected appreciation of gas left in the ground. If recent estimates for the Abu Qir fields are used, this resource cost (including an allowance for depletion) would be around $1.10/mcf, or about four times current gas prices in Egypt.

(c) The "economic subsidy" on petroleum products should be eliminated. This means that the weighted average price of all petroleum products should be increased at least to the weighted average of their border prices. Within this weighted average, there may be justification for cross-subsidies based on Egypt's broader socioeconomic objectives. However, subsidies should be confined to those energy products which are final consumption items (i.e., rather than intermediate inputs). The obvious candidates are kerosene and LPG.1/

1/ With increased natural gas substitution, the Egyptian "reconstituted barrel" by, say, 1990 could look much different from that of 1980, as shown below. The dominance of the fuel oil price in the weighted average would be greatly reduced, while kerosene and LPG (which are used almost exclusively for household cooking and lighting) would assume greater importance. Thus, their cross-subsidy via higher gasoline prices, for example, would be somewhat limited by the relative sizes of the two markets.

Percentage Consumption of Petroleum Products

	1980	1990*
LPG and Kerosene	18	40
Gasoline	11	15
Gas Oil and Diesel	23	25
Fuel Oil	48	20
Total	100	100

* Estimates based on Table 4A of PEIDA Report to World Bank, October 1981. They are from the WPAV scenario with maximum natural gas substitution.

Within these long-term objectives, short-term constraints on the relative prices of certain fuels would have to be observed in order to avoid uneconomic substitutions. For example, the domestic prices of gas oil and diesel should be kept at least 50% higher than the energy equivalent of domestic fuel oil prices to reflect their relative border value. (At present the gas oil/fuel oil domestic price ratio is over 4:1.) If the price differential between kerosene and diesel widens, the government should closely monitor any evidence of kerosene use for transport purposes. The bottom block of the gas tariff for residential households should remain in line with the LPG price, on an energy-equivalent basis. Once a course of energy price increases has been decided on, a unit within the government could be charged with the responsibility of monitoring these relative price relationships.

(5) Along with increases in petroleum product prices will come the need for changes in other prices in the Egyptian economy. Electricity tariffs have already been discussed. The pricing study shows that, provided power tariffs are also increased, the most affected sectors would be fertilizer, cement, aluminum, and iron and steel. There is considerable scope for cost absorption through increases in the efficiency of energy use in each of these industries. Fertilizer and aluminum have been discussed above. A major rehabilitation effort is already underway in iron and steel. In cement a shift from wet process to dry process production has begun, and should be accelerated. However, all of these industries are already incurring losses at the existing government-controlled prices for their output. A full analysis of the effect of these low controlled prices for fertilizer, cement, aluminum and iron and steel on the rest of the Egyptian economy was clearly beyond the scope of the pricing study. One may conclude, therefore, that the obvious examples of misuse of energy should be tackled directly (i.e., fertilizer and aluminum) while the need for changes in the controlled prices of fertilizer, iron and steel, etc. should be handled as part of the government's continuing economic and sector work in agriculture, industry, etc.