THE PRODUCTIVITY OF LABOUR IN INDUSTRY AND THE ECONOMICS IN ENERGY

By

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There exists a manifold and complicated interrelation in the increase in productivity of labour, the volume of production and consumption of the sources of energy, the proportions of the different sources of energy, the efficiency of energy transformation as well as the development of energy demand of the industrial production as a whole, or the production of various branches or single products of industry. These interrelations may be regarded as distinct manifestations of the widespread process of technological development. Technological evolution is most comprehensively characterized by the increase in the productivity of labour. Technological evolution at the same time is also accompanied by significant changes in the production and consumption of energy.

As a result of mechanization and automation, the productivity of labour increases on the one hand, and the demand for energy per worker increases on the other — in the first place and to the highest degree that for electric energy. Mechanization and the accompanying growth of the demand for electric energy are important *factors* of the increase in the productivity of labour. When speaking in the foregoing about the productivity of labour we were thinking only of the utilization of live labour, i. e. the labour applied in a given working process. In this relation, namely regarding the utilization of live labour, the productivity of industrial labour is influenced by the changes in the productivity of the branches producing sources of energy and of those transforming energy, as the development of productivity in these branches deviates from the all industrial average. (As we shall see, in these branches the productivity of labour generally increases much slowler than in the whole of industry.)

Examining the development of the productivity of labour at the level of national economy or at all — industrial level, the changes in the utilization of *stored-up labour* must also be taken into account. (This problem is quite well known in the analysis of labour productivity, where changes in stored-up labour — used e. g. in the form of raw materials — is not taken into account mostly.) An analysis of productivity however, which neglects the changes in the utilization of stored-up labour gives a more or less distorted picture of the real changes in productivity. It is obvious, that e. g. electric energy consumed in production process also contains labour, and thus, if we neglect the increase in the consumption of electric energy and consider only the decrease in the utilization of live labour, we do not get an adequate picture of the effective change in productivity.

Energy is precisely that factor of the total labour input necessary for production which — as compared to other elements of stored-up labour — is exposed to relatively quick changes. In some branches and in some cases, naturally, the material consumption may also change quickly. It occurs in engineering industry that by constructions technically more perfect, or with the help of high quality metals, material can be saved. The development of the chemical industry and especially that of synthetic materials enables in several cases of the use other materials and considerably less material than in the past. The general tendency, however, is, that material consumption and especially that of basic materials as compared to production changes rather slowly. In many branches of industry — e. g. in metallurgy, in the textile industry — there are but little opportunity for saving material or for the substitution of other materials.

With energy consumption the case is quite different. One may witness a two-way change of double character and which in addition is, a rather quick-rate change, too. As already mentioned, the rise in the productivity of labour is accompanied by a quick-rate growth in the consumption of electric energy per worker. In a sense, this phenomenon means substitution: mechanical work and the energy necessary for driving the machines, substitute — indirectly — human labour. (In fact, is no substitution really occurs, but the increase in energy consumption enables the increase of the efficiency of human labour.)

As regards the consumption of energy, we also found a change of another kind and of no less importance, especially in the last decade. The point is, that the total energy consumption of single countries, the demand for energy of industry as a whole, or of some branches of industry grows more slowly than the gross national product, the national income or industrial production. Let us mention some examples:

Average yearly increment of national income and of energy consumption from 1950 to 1959[1] *(per cent)*

	German Dem. Rep.	Czechoslovakie	USSR
National income	9.8	7.5	10.5
Energy consumption	5.0	5.4	8.0

[1] Statistisches Jahrbuch der DDR, 1957, 1959, 1960.
Statisticka Rocenka CSSR, 1957, 1958, 1959, 1960.
Narodnoe Hozyaystwo SSSR, 1956, 1958, 1959.

In England, the gross national product rose from 1950 to 1959 by 23 per cent, industrial production by 28 and the total consumption of energy only by 7 per cent. The relative decrease of demand for energy is still sharper when compared to 1956. From 1956 to 1959, the rise of the gross national product was 8 per cent, that of industrial production 7 per cent and the total energy consumption dropped by 5 per cent.[2]

In the German Federal Republic the gross national product expanded from 1950 to 1959 by 75 per cent, industrial production by 63 and the consumption of energy by only 35 per cent. Here too, the relative decrease of energy consumption appears especially sharply from 1956 on: from 1956 to 1959 the gross national product rose by 14 per cent, the rise of industrial production was 13 per cent, while the consumption of energy remained invariable.[3]

In the German Federal Republic, the specific consumption of all energy dropped between 1950 and 1958 by 30 per cent in the whole industry, by 19 in ferrous metallurgy, by 40 in the chemical industry and by 41 in the production of fine ceramics. (The specific consumption means the energy consumption expressed (and summarized) in calories per volume-unit of production; its index is given by the quotient of the volume indices of production and of energy consumption.)[4]

In Austria, the specific energy consumption of industry decreased by 24 per cent from 1948 to 1959.[5] *The decrease of specific energy consumption naturally means that a smaller amount of labour is needed to produce the same volume of use-value, i. e. productivity is growing.* Such an indirect way of increasing the productivity of labour by a more rational utilization of energy is conceating further considerable reserves, as the calorific efficiency of energy utilization is still very low in many processes; much lower than e. g. the specific utilization of materials with most working processes. Besides, in the economics of energy there is a wide range of substitution possibilities; we can, therefore, find a means of substituting certain sources of energy for one another, in such a manner that after all it results in increasing the national productivity of labour.

As, on the one hand, the demand for energy — mainly as a result of mechanization — is increasing and this increase may be considered an important factor in raising productivity and, on the other hand, there is a possibility for reducing the specific consumption of energy and thus for raising productivity measured at the level of the national economy — the interrelations between

[2] National Institute, Economic Review, September, 1960.
[3] OEEC Statistical Bulletin, General Statistics, 1960.
[4] Wirtschaftskonjunktur, 1960. No. 1.
[5] Monatsberichte des Österreichischen Institutes für Wirtschaftsforschung. October 1960.

the economics of energy and that of productivity of labour need a thorough analysis.

In the following we are going to examine more closely the interrelations mentioned and will try to quantify them.

The productivity of labour and the consumption of electric energy

The connection between the utilization of energy and productivity is a subject treated in the literature, mostly from the point of view of the dynamics of the productivity of labour and that of the electric energy consumption per head. A more or less close connection is established between the electric energy consumption per head (or per hour) and the production per head (or per hour), i. e. productivity. Thus e. g. Stepankow states: "There is an almost directly proportionate connection between the productivity of labour and its energy supply."[6] This connection is supported by Stepankow by several examples. In the Soviet Union the energy supply and the productivity of labour increased at the following rate: (1950 = 100)

	1955	1956	1957	1958	1959
Labour's energy supply	146	155	160	169	179
Productivity of labour	144	154	165	174	184

He finds a similar close connection with the international comparison of the productivity of labour by branches of industry. Comparing the productivity of labour and the energy consumption per worker in the industries of the United States and of the Soviet Union, the article quoted above discloses the following proportions:

The industry of the United States = 100

Branch of industry	Energy consumption	Production
	per worker in the industry of the USSR	
Ferrous metallurgy	44.3	49.1
Machine-tool production	66.7	74.4
Paper industry	43.2	42.1

[6] On the rate of development and the organization of the economics of electric energy, by A. Stepankow. Voprosy Ekonomiki, 1961. No. 5. p. 21.

Certain data on the Hungarian industry also show similar relations. As compared to 1950, the index of electric energy consumption per worker in 1955 was 117 per cent, that of the productivity of labour was 118; in 1959 both indexes stood at 133 per cent. In 1958, the level of productivity in Czechoslovakia was by 60 per cent higher than in the Hungarian industry when weighted with the pattern (labour input) of the Czechoslovak industry and by 75 per cent when weighted with that of the Hungarian industry. The electric energy consumption per industrial worker, however, was by 77 per cent higher — after eliminating the differences in the pattern of industry.[7]

It is obvious that here we have a very important connection. If, namely, the productivity and the electric energy consumption per head or per hour are really directly proportionate to one another, then from this relation we may deduct important conclusions from the point of view of economic analysis and of economic planning.

We may write the connections of production, number of workers and energy consumption also as follows:

$$\text{productivity} = \frac{T}{L} = \frac{E}{L} \cdot \frac{T}{E} \quad ; \text{ where:}$$

T = production
L = number of workers
E = energy consumption
$\frac{T}{E}$ = "specific" demand for energy (electric energy consumption necessary to produce one unit of production)
$\frac{E}{L}$ = labour's energy supply (energy consumption per worker)

It may be seen that the productivity $\left(\frac{T}{L}\right)$ and the supply with energy $\left(\frac{E}{L}\right)$ can change proportionately when and only when the specific demand of production for energy remains unchanged. In so far as such a relation really exists, it enables among others the planning of the demand of industry for (electric energy, moreover, as the proportion of industry within the total electric) *energy* consumption — established by empirical figures — is fairly constant, also the planning of the entire demand for electric energy.

The above relation also makes possible, that for an analysis of the connection between electric energy consumption and productivity it suffice to examine the indicator of specific electric energy consumption. If, namely,

[7] A comparison of the productivity of the Czechoslovak and the Hungarian industries by Zoltán Román. Közgazdasági Szemle, July—August, 1961.

the quotient $\frac{T}{E}$ increases, it means that productivity $\frac{T}{L}$ rises faster than the supply with energy $\left(\frac{E}{L}\right)$ or the supply with energy rises more slowly than productivity. With dynamic comparisons and when comparing the industries of different countries (or their branches), productivity and supply with energy are proportionate and have the same value only when the specific demand of production for energy remains unchanged.

In the Hungarian industry and in some of its branches the industrial electric energy consumption per unit of net production value $\left(\frac{T}{E}\right)$ and the industrial electric energy consumption per worker $\left(\frac{L}{E}\right)$, as compared to 1950, were in 1955 and 1959 as follows:

	A		B[8]	
	1955	1959	1955	1959
Mining	108	120	99	109
Metallurgy	123	129	135	152
Engineering industry	108	84	134	140
Building material industry	122	118	145	181
Chemical industry	85	83	108	136
Rubber and synthetic material processing	70	89	88	118
Heavy industry, total	109	100	124	137
Wood industry	98	118	135	170
Paper industry	92	88	119	128
Printing	98	105	151	184
Textile industry	101	107	120	120
Leather and fur industry	119	138	122	125
Clothing industry	113	206	130	229
Light industry, total	83	84	96	97
Foodstuffs, drinks, tobacco industry	80	124	98	162
State industry, total	103	101	118	133

The foregoing table shows that the development of the specific consumption of energy is somewhat different in the various branches of industry and

[8] A = Index of industrial electric energy consumption per net production value in the years 1955 and 1959, per cent, 1950 = 100.

B = Index of industrial electric energy consumption per head of workers for the years 1955 and 1959, per cent, 1950 = 100.

that the equal development of productivity and of electric energy consumption per worker for the whole of industry, or in other words the stability of the quotient $\frac{T}{E}$ for the whole industry took shape from changes of differing direction and size in the branches of industry.

Neither do we find proportionate changes — at least as regards the branches of industry — between productivity and electric energy consumption in the Czechoslovakian industry. The data for 1958 are the following (1950 = = 100):

Groups of industry	Index of		
	gross production	electric energy consumption	specific electric energy consumption T/E
	per worker in industry in 1958		
I. Electric energy	185	199 [9]	93
II. Fuel industry	151	148	102
III. Ferrous metallurgy	183	203	90
IV. Non-ferrous metallurgy	191	376	51
V. Engineering industry	218	125	174
VI. Chemical and rubber ind.	216	121	178
VII. Building material ind.	262	139	188
VIII. Wood industry	206	139	148
IX. Paper industry	139	122	114
X. Glass and ceramics ind.	182	168	108
XI. Textile industry	166	137	121
XII. Clothing industry	182	200	91
XIII. Leather and shoe ind.	181	153	118
XIV. Printing	159	150	106
XV. Food industry	171	150	114

The above figures prove that the specific electric energy consumption changes in the different branches of industry at differing rates and in divergent directions. The main tendency is the increase of specific electric energy consumption.

When, making international comparisons, in some branches of industry we compare the ratios of labour productivity and of electric energy consumption per worker in the Hungarian and Czechoslovakian industries, we come to the conclusion that beside those industrial branches where the two ratios are

[9] Including the own consumption of power plants. Source: Statisticka Rocenka ČSSR. 1959.

rather similar — e. g. electric energy production or the paper industry — we also find branches where these ratios considerably differ. We hardly find any closer general relationship than that in the Czechoslovak industry where both the productivity of labour and the electric energy consumption per head are generally higher. (We must remark, however, that while the figures for electric energy consumption per head are quite accurate, the comparison of productivity according to branches is rather doubtful.) In the Czechoslovakian metallurgy, electric energy consumption per worker in 1958 was 57 per cent higher than in the Hungarian industry and productivity by 70 per cent. The corresponding figures are 7 and 25 per cent in the building material industry, 12 and 25 per cent in the textile industry and 86 and 66 per cent in the leather and shoe industries.

The specific consumption of electric energy in industry $\left(\frac{T}{E}\right)$ as an average of the countries belonging to the OEEC and in some other major countries was in 1959 as compared to 1951 the following:[10]

OEEC total	England	German Fed. Rep.	Austria	France	Italy
112.6	121.7	102.4	109.6	111.1	92.4

Thus, — except for Italy — specific consumption of electric energy is increasing, i. e. electric energy consumption per hour is rising faster than productivity.

Accordingly, specific consumption of electric energy developed quite differently by countries and by industrial branches. In the case of Hungary, the stability of the specific consumption of electric energy $\left(\frac{T}{E}\right)$ for 1955 and 1959 is an average which took shape from the changes of different sizes and directions to be found in the various industrial branches. The fact that in various industrial branches the increases and decreases had been levelled up as regards to the whole of industry, may be regarded rather as an accidental phenomenon than a regular one. To consider this levelling up as a regular one, we had to assume there is a regular interrelation in the production increases of the various industrial branches, finally resulting in the levelling up of the specific consumption of electric energy (per unit of production) for the whole of the industry. We have not found, however, such regularity — at least not in the case of such a small country as Hungary — where the

[10] Source: OEEC, Industrial Statistics, 1900—1959.

development of the structure of industry by branches is considerably influenced by foreign trade.

If we consider how the increase of industrial electric energy consumption on the one hand, and the increase in productivity on the other, take place, it becomes clear, that these are so complicated and manifold processes that as a result of these we cannot expect a lasting and general direct proportion between productivity and the electric energy consumption per head. In statistics, the electric energy consumption is usually broken down into electric energy used for driving motors, for lighting and for other — mainly technological — purposes. (The breakdown of the electric energy consumption of the Hungarian industry in the average for the years 1950—1959 was: for motor-driving 65 per cent, for lighting 5, and for other purposes 30 per cent. With the development of industry, all three kinds of electric energy are used to an increasing extent in industry. Naturally, in the closest connection with the increase of productivity is the increase of energy used for motor-driving, because this is directly connected with mechanization (and with automation). Electric energy consumption increases when such processes are mechanized as were performed with human labour before e. g. coal cutting in coal mining, transportation in the various industrial branches, etc. With the development of technology, electric energy consumption increases also when manual labour is not entirely mechanized, but only certain operations of manual labour are performed with machines, e. g. in the machine industry some operations in assembling are done with electric screw drivers or other small machines. The demand for electric energy also increases with the intensification of production processes (mostly of mechanical work) e. g. when certain mechanical (cutting) works are performed more expeditious with machines and tools of higher capacity.

In all the mentioned cases the development of technology makes on the one hand the raising of electric energy consumption necessary and, on the other, results in the growth of productivity. From all this, however, it does not follow that there ought to be a direct proportion between the consumption of electric energy and the increase of productivity. In the course of the development of industry the consumption of electric energy for lighting purposes also increases but at a much slower rate than the total consumption of energy. It is beyond question that the increase in the demand for energy used for lighting is an organic part of the process in the course of which better conditions of labour are created, places of work are made more agreeable and these, obviously, contribute to the increase in productivity. But neither here can we assume a direct proportion between the surplus electric energy consumption and the related increase in productivity. Besides, energy used for lighting has — owing to its relatively small share — no important role.

The demand for energy serving technological purposes is significant only in some of the industrial branches; this kind of demand for energy essentially arises in metallurgy and the chemical industry. Just because of this, its changes cannot be directly connected with the changes of productivity, productivity increasing in the whole industry and not only in the branches using technological energy to a considerable extent. We have to remark, however, that the increment of the volume of electric energy serving technological purposes constitutes a rather considerable part of the increment of the total demand for energy.

The relationship between the increase of productivity and that of electric energy consumption per head is, thus, manifold and complex; ot deponds on the rate of mechanization and automation, on the development of energy consumption for technological purposes (limited to a few industrial branches), and, as regards the whole of industry, on the changes in the patters of the structure of industry. The formation of a directly proportionate relationship should be regarded rather as an accident and not as some soil of regularity. The general tendency is rather that the consumption of electric energy increases faster than industrial production. This, however, confirms the principle, followed in the planning of the socialist countries, that the rate of increase of electric energy production should generally outstrip that of the rate of growth of industrial production.

W. Nowak, in his article[11] on "The electric energy consumption of industry and the productivity of labour" comes to a similar conclusion. He establishes that the connection between productivity and electric energy consumption per worker shown there is a relation between two quantities, but there is no close correlation. The general tendency is, also according to Nowak, — that the electric energy supply grows faster than productivity.

Productivity of the branches producing and transforming energy

In the branches producing and transforming energy, the productivity of labour generally develops on an average otherwise than in industry; in this way, it exerts an influence on the formation of the average itself. This influence, naturally, is the greater, the greater the weight of the branch in question in the whole of industry is. Let us for example examine, what influence the branches producing and transforming energy had on the increase of industrial productivity in Hungary. The proportion of these branches calculated by the percentage distribution of workers within the state industry in 1959 was the following:[12]

[11] Gospodarka Planowa, 1961. No. 2.
[12] Az ipar termelése és szerkezete, 1949—1959. Statisztikai Időszaki Közlemények, 1960. p. 111. (Production and pattern of industry. Statistical Periodical Publications.)

Coal mining	11.3 p. c.	briquetting	0.1
crude oil and natural gas production	0.9	electric energy industry	3.3
turf mining	0.1	oil processing	0.4
		town gas production	0.4

thus, a major influence is exercised, in the first place by mining, and in the second, by the electric energy industry for the weight of these is considerable. The effect of the other branches listed above can be neglected — at least as a first approximation.

The development of productivity is illustrated in the following table:

Index of net production per worker, 1950 = 100[13]

	1955	1958	1959	1960
State industry, total	116	130	135	142
Coal mining	91	107	108	113
Electric energy industry	115	117	122	124

The productivity in coal mining and in the electric energy industry has increased more slowly on an a verage than in industry; these branches, therefore, have slowed down the increase of average industrial productivity. In coal mining, the cause of the slower rise in productivity might be attributed to the gradual deterioration of natural conditions, while in the production of electric energy to the fact that we have here a relatively smaller labour-consuming branch of industry where the raising of productivity requires very large investments, and thus, it is connected mainly with the establishment of new and, as a matter of course, more up-to-date power plants. In the following it can be seen that the technological development which occurred in the production of electric energy caused a considerable rise in the productivity of labour, but this has become visible not in the relative reduction of the labour-force employed in the industry, but in the increase of the efficiency of electric energy production, i. e. in the amount of coal thus saved. As has been mentioned, there is a tendency for the rise in productivity and the increase of electric energy consumption per worker should go hand in hand and even that in these two cases the increase may be considered as proportionate a first and rough approximation. It has also been stated that a surplus consumption of electric energy is equivalent to a greater application of labour i. e. it works in the direction of the lowering of productivity. If a correct result is to be arrive at the index of productivity must be modified with the increase in the consumption of electric energy.

In Hungary, the electric energy industry consumes the greater part of stored-up labour used in the production of electric energy that is in the form of

[13] A munka termelékenysége az iparban, 1958—1960. Statisztikai Időszaki Közlemények, 1960. (The productivity of labour in industry. Statistical Periodical Publications.)

coal. (The case is different in countries where the proportion of hydro-electric plants and other power plants working on other basis than coal is significant.) Though the increase in the consumption of electric energy works in the direction of growing coal consumption, the increasing efficiency of the power plants diminishes this effect. Besides, the changes in the productivity of coal-mining itself must also be taken into account. This can be followed through by the example of the Hungarian industry, shown below:

	1950	1955	1959
a) Electric energy consumption per worker in the Hungarian industry	100	117	133
b) Coal used for one kWh of electric energy	100	92	81[14]
c) Fuel-equivalent of electric energy consumption per worker, in calories (axb)	100	107	108
d) Productivity of labour in coal mining	100	91	108
e) Labour-demand of electric energy consumption per worker	100	119	100

According to the above figures, when properly taken into account, the electric energy consumption would have still lowered the index of productivity in 1955. In 1959, however, the increase in the demand for electric energy per worker was completely counterbalanced in the first place (and to a greater extent) by the improvement of the efficiency of the power plants and in the second (to a lesser extent) by the increase of productivity in coal mining.

The effect of changes in the utilization of energy the total labour input

One kind of relation between the productivity of labour and the consumption of energy is the one already mentioned, namely, that the increase in productivity and that of electric energy consumption per head generally go together. If the efficiency in the production of sources of energy and in their transforming into electric energy remains unchanged, the increase in the consumption of electric energy causes the demand for labour to rise and thus it works towards the lowering of productivity. In an above example it was to be seen that this does not occur in all cases; the increase in the demand for labour might be compensated by the increase of productivity in coal mining and by the improvement in the transforming efficiency of electric power plants.

[14] Fuel used to produce 1 kWh of electric energy in calories: 1950 : 5142, 1955 : 4731, 1959 : 4163. — Statisztikai Évkönyv, 1959. p. 110 and Statisztikai Havi Közlemények 1957. No. 10. p. 23. (Statistical Yearbook and Monthly Bulletin of Statistics.)

There is, however, another no less important relation between the utilization of electric energy and the total demand for labour in production. In the introduction it was mentioned that in recent years the relative decrease of the total energy consumption calculated in calories — as compared to the national income, to the gross national product or to the industrial production — has been a characteristic manifestation of the technological development. Beyond doubt, both the relative savings in calories and the changes in the pattern of the sources of energy change the demand for stored-up labour appearing in the form of energy consumption and are generally reduced in a not insignificant degree. This reduction, however, is not adequately characterized by the savings shown in the balances on energy as expressed in calories, neither do they show what savings in the total labour input are effected by the reduction expressed in calories or what the effect of the changes taking place in the pattern of the balance of energy is.

In the preceding chapter approximative calculations were carried out on how the demand for labour of the electric energy consumption per head has changed in the Hungarian industry, taking into consideration the changes in the efficiency of power plants and in the productivity of coal mining. This kind of calculation, however, though having some illustrative interest, is far from being imperfect. In the calculations the changes of productivity appearing in the energy producing branch of industry itself were neglected, as well as the changes taking place in the productivity of all the other branches of the national economy which, directly or indirectly, also by their production contribute to the production of electric energy. It is also not easy to say what amount of labour input — at a national economic level — is equal to the production of one kWh of electric energy. With the usual methods of accounting and statistics, namely, we are unable to convert the different material and other utilizations of single branches of industry into the corresponding input of live labour. The balance of inter-industry relations (input-output balance) — as is well known — makes the calculation of the so-called total input coefficients possible. The direct and indirect inputs in the whole of the national economy necessary, for the whole or the unit production of single branches might alike be reduced to live labour and to import and amortization inputs. From the balance of interindustry relations we can establish the so-called technological matrix of the technical coefficients containing the direct relations among the branches. With the aid of this, it was possible to work out the so-called inverse matrix which reflects the total already — direct and indirect — interrelations of the branches. The element of the inverse matrix, the inverse coefficients reflect how much input is needed from the other branches for a unit of production to increase the single branches, also taking into account the indirect, farther ringing demands. Hence, these are the coefficients suitable for working out the total inputs. By multiplying the inverse matrix by the vectors of the primary inputs — also determinable, from the balance of inter-industry relations — i. e. by the direct demand of the branches for labour, import and amortization, we get the total labour, import and amortization inputs of the branches.[15]

The balance of interindustry relations, respectively, its inverse enables us to reduce energy inputs to primary ones. With the use of an approaching method, import-inputs and even amortization can be reduced to live labour. In such a way, the energy inputs, the structural and dynamic changes in the balance of energy can also be reduced to the changes in the live labour inputs. Such a reduction is practical not only because it gives information about the changes in one element of stored-up labour, but also because the usual balances of energy are unable to give information about the changes in the energy-inputs that is in all respects satisfactory. It is evident, that in case of structural changes, the change expressed in calories or in tons of coal-equivalent does not unambiguously and entirely show the real changes in the inputs at the level of national economy: the calorific content of the various primary and secondary sources of energy is, namely, not in proportion to the production costs of the same. — Neither does the measuring by prices of energy consumption give an adequate picture of the changes in the size of inputs *from the point of view of national economy*. This is the situation in socialist as well as in capitalist countries. In socialist countries, the price proportions are often purposefully diverted from the value proportions. This deviation can be of especially great extent with sources of energy, where in the interest of attaining certain goals of economic policy the price proportions of the single sources of energy are sometimes nearer to their utility values and not to the proportions of their production costs. In capitalist countries, however, the price policy of allpowerful trusts interested in the production of sources of energy as well as certain measures of economic policy of governments vigorously divert the price proportions of sources of energy from their cost proportions. Working out, therefore, the total input content, i. e. the reduction of inputs to labour and import inputs and to amortization has — in one opinion — a great significance for planning, for measuring the effects of various measures of economic policy, because in enables us to estimate what labour input, what demand for import and what other *economic* changes there are behind the changes in the volume and structure shown *in calories, i. e. in a technical unit of measurement.* In this paper, however, we intend to deal only with the connections of energy consumption and of the productivity of labour. The usual indexes of productivity neglect the changes in the consumption of stored-up labour *within one branch.* In the following we shall prove through some calculations — naturally only of approximative and illustrative character — that this neglection may

[15] Economic literature has introduced the method for the balance of inter-industry relations in detail. We have assumed therefore, that the basic informations are known and in the above only put some interrelations in mind.

be of such magnitude as regards the whole of industry, and much more so in the case of single branches of industry as already affect the accuracy of the index of productivity.

As is known, the usual indexes of productivity for industrial branches and for the whole of industry are formed from the quotient of the production index and of some index of labour input (the index of the number of workers or of working hours). The production index is considered as a net one; in Hungarian industrial statistics it is actually called the "net index". This production index truly *approaches* the development of net production as the weighting of the elements of the index (mostly series of products) is carried out with the net production proportions of the base-year of the index.

Such indexes of production — contrary to the indexes of gross production — show the development of net production correctly, even when the proportions of the single industrial branches or those of the series of products constituting the single net indexes change. Thus, the distorting effect of structural changes of such character is eliminated. So from this point of view they approach the index of net production correctly. If, however, the consumption of stored-up labour considerably changes, this kind of index is not quite correct, because it does not reflect the changes in net production in connection with the changes in the consumption of stored-up labour. In our introduction we have pointed out the fact, that the specific energy consumption of industry had significantly decreased in the past decade. The following table shows this decrease in the Hungarian state industry as a whole and in some important industrial branches:

Index of specific energy consumption, 1950 = 100
(various sources of energy converted into calories)[16]

	A		B		C	
	1955	1959	1955	1959	1955	1959
State industry, total	94	80	95	86	110	113
Mining	123	95	127	109	117	98
Metallurgy	113	121	116	131	127	155
Engineering ind.	103	66	97	73	120	121
Building material industry	86	74	87	76	104	117
Textile industry	96	84	99	92	117	103
Food industry	67	60	68	64	83	83

[16] *A* = Index of industrial energy consumption per unit of net production in 1955 and 1959; percentages; the electric energy consumption converted into the basic sources of energy by means of actual efficiency of the year in question, 1950 = 100.

B = Index of industrial energy consumption per unit of net production in 1955 and 1959; percentages; the electric energy consumption converted into the basic sources of energy by means of efficiency in 1950, 1950 = 100.

C = Index of energy consumption per head of workers in 1955 and 1959; percentages; the electric energy consumption converted into the basic sources of energy by means of efficiency in 1950, 1950 = 100.

From the figures it can be seen that the decrease of the specific energy consumption in industry as a whole derives from changes of different direction; specific energy consumption increased in metallurgy and decreased in the other branches. If, however, the specific consumption of energy which constitutes a considerable share of stored-up labour decreases to such a measure, it is doubtful whether the usual net production indexes show the development of productivity properly and, whether — at least when we want to present the effect of energy economy on the productivity of labour — it is not justified to correct these indices. In the preceding we have briefly reviewed, how the various inputs — and so also the energy inputs — can be converted into labour inputs with the help of the balance of inter-industry relations, or inversely, respectively. After the conversion into labour input, the correction of the index of productivity may be also performed.

Sources of the data :

a. Energy consumption: from the consumption of fuels and from the balance of energy.

b. Net production value: Statistical Year book, 1959, p. 85. The net indexes for heavy industry and for the total state industry — as they must exclude the net index for the electric energy industry — had been worked out by the Industrial and Investment Department of the Central Statistical Office for our purposes.

c. Number of workers: Statistical Yearbook, 1959, p. 86, excluding the electric energy industry.

In an earlier paper — for the purposes of studying the structure of industry by branches — we had worked out the full input coefficients of the different industrial branches with the help of the balance of inter-industrial relations for 1957 (total labour input, total import content and total amortization). We also worked out the key-numbers for reducing the import content and the amortization to labour-input.[17] With the help of the calculations and indicators presented therein the total labour-inputs of energy inputs can also be worked out. As is well known, these kinds of calculation contain many sources of error, not to be treated here in detail. (They presume e. g. that the different branches are homogeneous as regards their products and the distribution of their products as well, they presume the homogeneity of exports and import from

[17] Cukor György—Román Zoltán: Az ágazati kapcsolatok mérlegének felhasználása az ipar ágazati szerkezetének vizsgálatára és tervezésére. A MTA Közgazdaságtudományi Intézetének Közleményei, 9. sz. Közgazdasági és Jogi Könyvkiadó, 1960. (The utilization of the balance of inter-industry relations for analysing and planning the structure of industry, by George Cukor and Zoltán Román. Publications of the Institute of Economics of the Hungarian Academy of Sciences, No. 9. Publishing House for Economics and Law, 1960.)

the point of view of their countervalue in foreign exchange, etc. The calculations in question, besides, contain also such errors as can be attributed to the special character of the Hungarian table for 1957; partly to the fact, namely, that this was the first table prepared, and the statistics required were not available in many respects, and also partly to the year 1957 being an exceptional one for the Hungarian national economy in many relations; the various proportions in the national economy departed, more or less, from these in the previous and also from those in later years. (With the help of the total input coefficients published in the mentioned paper we worked out the primary inputs per one billion calories of the major sources of energy. This calculation, owing to the errors and distortions mentioned above, is rather of an illustrative character. Still, it demonstrates certain tendencies properly.

Primary inputs of 1 billion kg-calories in 1957

	Number of workers per year	Imports 1000 foreign exchange forints	Amortization 1000 Ft	Number of workers incl. imports	Amortization converted into number of workers	Total input converted into number of workers per year
1	2	3	4	5	6	7 (5 + 6)
Coal	1.85	2.94	8.45	2.20	0.47	2.67
Coke	—	50.93	—	6.04	—	6.04
Electric energy	2.35	13.78	25.79	3.98	1.44	5.42
Fuel oil	0.52	9.71	8.32	1.67	0.47	2.14
Petrol + gas oil	0.52	9.71	8.32	1.67	0.47	2.14
Natural gas	0.81	1.57	19.07	1.00	1.07	2.07

In the above table we have adopted some simplifications, which may also jeopardize the accuracy of the calculations. We have neglected the home production of coke and have considered the total consumption of coke as derived from import. We have divided the inputs of fuel oil, petrol and gas oil according to their calorific content. The inputs of home produced natural gas and of home produced crude oil have also been divided according to their calorific content.

The simplifications mentioned were permissible because — as has already been mentioned — our calculations are to serve only illustrative purposes and the presentation of tendencies; more accurate calculations would have required much more effort.

The table in question anyhow shows that the inputs of fuel oil and natural gas, calculated for the same amount of calories, are much lower than in the case of coal. (We have to remark, however, that the exceptional circumstances of the year 1957 distort the figures disadvantageously for fuel oil and natural gas; in other years these would present a picture still more favourable.)

The most uncertain part of the calculations — both as regards the reliability of the basic figures and the economic interpretation of the results arrived at — is the conversion of amortization into labour input. Further on, therefore, we shall make only such calculations, where only *current expenditure* is converted into total labour inputs, amortization will thus be disregarded.

With the help of the total coefficients of the sources of energy we have reduced the structure of the balance of energy for 1957 to labour inputs — expressed in number of workers — by main sources of energy. As a result of the calculations, we obtain the following proportions:

	Percentage distribution	
	by kg-calories	according to production and import inputs, in number of workers
Coal	40.1	29.8
Coke	14.5	28.6
Electric energy	31.2	34.3
Fuel oil	9.9	5.4
Natural gas	3.1	1.3
Petrol + gas oil	1.2	0.6
Total	100.0	100.0

Even the reduction of the pattern of energy consumption for one year only, enables us to draw some interesting conclusions. As expected, the proportions of fuel oil and of natural gas are smaller by labour input than by calory utilization. The growing proportions of these sources of energy, therefore — and their proportion increased considerably in the past decades — brings about an important saving in itself. It is worth mentioning that the consumption of the coke, proportion of which makes out only 14,5 per cent calculated by calories, is the double of that when calculated by labour input, its weight is thus much greater from the point of view of labour consumption than from that of calory utilization. From the table preceding the above one it may be seen that the decrease in the consumption of coke means a saving three times as big as that of coal with regard to economizing labour, i. e. raising productivity— when calculated for the same amount of calories. In general, it is perceptible that coke is the "most expensive" source of energy. The total input coefficients employed may be used not only for analysing the structure of the balance of energy but also for examining its changes in time. The total labour input of energy consumption could be arrived at, if — similarly to the year 1957 — we carried out the same conversion for other years also. Since, however, the balance of inter-industry relations and its inverse are available only for the year 1957 (the inversion of the balance for 1959 is now in process), this idea had to be abandoned.

We have converted, however, the energy consumption in the years 1950, 1957 and 1959 into their total labour content, on basis of the total input coefficients for 1957. The result obtained is not the total demand for labour for the productivity of labour (and the coefficients of the balance of inter-industry relations) changed between 1950 and 1959. The results of the calculations, however, show how large the savings in labour input in industry achieved through the changes in energy consumption and in the structure of the balance of energy would have been in case the input coefficients and the structural relations of the year 1957 had remained unchanged — apart from the changes having taken place in the consumption of energy. In the following calculations we have taken into account the electric energy consumption with an unchanged calorific content (with that in 1950) and so we have disregarded the improvement in the transforming efficiency of electric energy production. This seemed expedient for examining the savings achieved in the various branches of industry by themselves.

	1950	1957	1959
Index of industrial production	100	181	228
Index of energy consumption in industry converted into labour	100	166	206
Relative savings, expressed in manpower thousands	—	14	26
as percentage of the manpower in industry	—	1.8	3.0

The savings achieved are partly a result of the decrease in the total consumption of energy and partly of the changes in the structure of energy consumption. As can be seen, in the relation of the whole of industry this is a quantity not to be entirely neglected any longer, though it would not essentially change the index of net production or that of productivity.

The case is somewhat different if we make the same calculations not for the whole of industry, but for some industrial branches. Here we may already find that the change in energy consumption results in a change of the total labour input to such a degree as to make the accuracy of the index of productivity doubtful. In metallurgy, for instance, energy consumption in calories and also when converted into total labour input, had risen from 1950 to 1957 to a greater measure than production. The increase in manpower calculated in this manner is 1000 workers for 1955, nearly 19,000 for 1957 and 17,000 for 1959. Since the total number of workers in metallurgy was 59,600 in 1959, the effect of the increase in energy consumption amounted to 29 per cent of the manpower in metallurgy — thus it is very significant. — Naturally, the increase in question cannot be entirely attributed to the increase in the specific energy consumption of metallurgy, it is an outcome mainly from the changes in the pattern of products within metallurgy.

We may discover changes of opposite direction in the building material industry where the decrease of specific energy consumption from 1950 to 1959, converted into total labour input, means more than 5,000 people, i. e. ten per cent of the manpower in the building material industry in 1959. Here, therefore, the rise of the index for productivity should be corrected upwards. The situation is similar in the textile industry where we also find savings. The extent of the latter is smaller though: about two per cent of the manpower in 1959.

The increase in the transforming efficiency of electric energy production can also be converted into total labour input. The saving in calories and in total manpower utilization is the following:

	Savings in billions of calories	Savings in labour input, heads	Savings as percentage of the manpower in industry
1951	641	2.551	0.5
1952	387	1.540	0.2
1953	444	1.767	0.3
1954	1.407	5.600	0.8
1955	2.076	8.262	1.2
1956	3.042	12.107	1.7
1957	4.197	16.704	2.3
1958	5.590	22.248	2.9
1959	7.481	29.774	3.1

From the above calculations one can see that the changes in the volume and in the pattern of energy consumption may result in a considerable change in the utilization of stored-up labour both in regard to the whole of industry and various industrial branches. Therefore it is practical, to take the effects of energy economics into account when analysing productivity.