WORKING GROUP FOR ENERGY DEMOCRACY

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RESEARCH PAPER

THE REAL COST OF ELECTRICITY PRODUCED FROM RENEWABLE ENERGIES

A model for photovoltaic energy IPPs in Tunisia

CONTENT

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In the context of promoting and publicizing renewable energies by international financial institutions and official governmental bodies, it is often repeated that the cost of electricity produced through renewable energies is lower than that produced through traditional means (steam or gas turbines, combined cycle).

Although this justification has some truth and is based on objective data, it hides other facts that some avoid discussing because the comparison is often irrelevant and does not rely on the same principles, thus falling into what is called "comparing the incomparable," especially since the justifiers often adopt this type of comparison not to justify investment in renewable energies but mainly to justify private investments against public investments that can be made by national companies in the field.

Therefore, the Working Group for Energy Democracy submits this paper in order to delve deeper into the topic by examining the Tunisian example in the field.

1-Legislative framework for private production of electricity through renewable energies

Before diving into the details of the cost of production, it is necessary to address the legal formula that allows the private sector to access renewable electricity production in Tunisia.

The 2015 law for the production of electricity through renewable energies[1] is the legal framework that detailed the areas and limits of private sector intervention. This law includes four regimes:

- The self-production regime is mainly for companies wishing to invest in renewable energies in order to meet their needs and reduce their electricity bill. This regime includes some incentives such as the possibility of selling surpluses.

The chapters regulating this regime were amended in 2019[2] to allow the establishment of companies (called Self-Production Companies) whose mission is limited to producing electricity from renewable energies and selling it exclusively to companies wishing to do so according to specific conditions, most notably the contribution of capital.

- The authorization regime for local (national) consumption is the legal framework for small plants and was introduced to encourage the local private sector to contribute to the production of electricity from renewable energies (according to the official view). Legislatively, this regime covers plants whose nominal capacity does not exceed:

*10 megawatts for photovoltaic energy

*30 megawatts for wind power.

Initially (i.e. since 2015, when the law on the production of electricity from renewable energies was approved), projects under this regime were selected after the publication of requests for proposals that included the required capacity and were ranked on the basis of the lowest selling price. This formula was changed in 2024 after a ministerial decree fixed the electricity sales prices for PV plants as follows[3]:

*1 MW projects: 7.2 cUSD/kWh

*2 MW projects: 7 cUSD/kWh

[1] https://www.anme.tn/beta2/arrete/files/Loi2015_12Arabe%20(5).pdf

[2] https://igppp.tn/sites/default/files/loi201947arabe-190623163526_0.pdf

[3] https://www.energiemines.gov.tn/cadre règlementaire

*10 megawatt projects: 4.7 cUSD/kWh

This means that there is no competition as the selection of projects is linked to the date of submission of applications, which is another issue!!!

- The concession regime for local (national) production is of large-scale projects for the production of electricity through renewable energies. The projects included in it are identified after an international request for proposals (RFP) is announced and the lowest bid is selected according to the legislation of concessions.

Through the previous requests for proposals launched by the supervisory authority (Ministry of industry, energy and mines) in previous years, we note the dominance of foreign investors in this type of projects.

- The export regime within the framework of concessions in purpose and its main objective is to attract foreign investments in the field (according to the official view) and to respond to European needs by exporting renewable energies (according to our view as a working group).

This regime is completely independent of the previous regimes, which means that it is possible to install plants to export electricity produced from renewable energies regardless of the country's need for it.

Note: As for the authorization and concession regimes, the public structure (Tunisian Electricity and Gas Company) is obliged to buy all the electricity produced through contracts with the project owners.

2-The cost of producing electricity in Tunisia through the public structure (Tunisian Electricity and Gas Company)

In this section, we will try to calculate the cost of producing electricity through public power plants of various types: Conventional or renewable energies, based on the assumptions used to calculate this cost, and we will also address some aspects that may enlighten the reader in this field by analyzing the data and drawing conclusions.

1.2 Analyzing the data:

Based on the data contained in the official reports of the supervisors of the electricity sector in Tunisia for the year 2023[4], which you will find detailed in the reference section, we find the following:

[4] https://data.industrie\.gov.tn/wp-content/uploads/Conjoncture-energetique-decembre-2023-v_f.pdf
https://www.steg.com.tn/publications

Type	Capacity (MW)	Generation (GWh)	Amount of gas consumed (thousand tons of oil equivalent)	Percentage of total capacity	Percentage of total generation
combined cycle	2528	14924	2656	42.44%	78.17%
steam turbines	660	623	186	11.08%	3.26%
gas turbines	2457	3161	897	41.25%	16.56%
wind power	229	338		3.84%	1.77%
photovoltaic	20	36.5		0.34%	0.19%
hydraulic power	62	9.2		1.04%	0.05%
total	5956	19091.7	3739		

Assuming the following assumptions:

*The cost of purchasing natural gas is equal to 90% of the total cost of electricity production, excluding transportation and distribution costs (i.e. the cost at the production plant border) for conventional production plants

*The purchase price of Algerian gas, which is equal to 441 USD/TOE of oil equivalent in 2023[5]

We drew the following conclusions:

Type	Specific fuel consumption (TOE/GWh)	Load factor	Cost (USD/MWh)
combined cycle	178	67%	87
thermal turbines	299	11%	146
gas turbines	284	15%	139
wind power		17%	
photovoltaic		21%	
hydraulic power		2%	
average	200		98

→ *Specific fuel consumption = amount of gas consumed/energy produced"*

[5] Previous source

*→ Load factor = energy produced/(total nominal capacity*8760 (number of hours per year) " It represents the ratio of the produced energy to the available energy by adopting the nominal capacity of the production plant and if the plant always operates at the same capacity, the load factor represents the number of hours of operation per year "*

*→ Cost = specific fuel consumption*price of natural gas/0.9 " It represents the cost of producing a unit of energy in the currency adopted for the production plant. In our case, we adopted dinars/MWh, which is equal to millimeters/kWh"*

2.2 Conclusions:

- The public structure has a diverse mix of production plants. The main objective of this mix is to provide electricity at all times to consumers: Depending on how consumption varies during the day as well as during the seasons, the utility programs the operation of the necessary plants.

- The combined cycle plants are intended to provide a minimum level of power to meet the national consumption needs, so the necessary capacity is planned by studying the annual and daily loads and taking into account the necessary maintenance periods. These plants represent the backbone of Tunisia's electricity production due to their high efficiency and the possibility of controlling their capacity within certain limits. This type of plant replaced the steam turbines that used to fulfill the same role, but due to their high productivity, they have become the dominant means of production in the electrical grid.

Gas turbines, on the other hand, are limited to meeting peak demand when consumption exceeds the capacity of the combined cycle plants. In other words, gas turbines adjust production to peak demand due to their quick access to nominal capacity and connection to the grid, unlike combined cycle plants, which require a longer response time when switching from idle to operating.

This type of turbines in the public structure includes several types according to the nominal capacity[6]:

*300 megawatt turbines

*120 megawatt turbines

*20-30 megawatts turbines

The mentioned types of turbines represent the minimum change in consumption during each historical period of Tunisia's electrical demand, which makes them perform the task entrusted to them in adjusting it quickly.

- In practice, every national electricity grid must have a total conventional plant capacity equal to or greater than the expected annual peak consumption in order to maintain the safety of the electricity supply because this type of plant can be controlled by the availability of essential resources for its operation.

In the case of Tunisia, the total conventional capacity is equal to 5150 megawatts due to the diminished capacity of gas plants during the summer (the effect of high temperatures). This total

[6] Previous source

capacity can cope with the bulk of the summer peak without forgetting to consider other additional measures (such as load shedding).

- The total cost of electricity for the overall structure is equal to the weighted average cost of all production plants according to their percentage of total production based on this formula:

$$Cug=\sum Cui*Pi*Fchi/\sum Pi*Fchi$$

∑: Sum

Cui : Cost of production of plant i

Pi : The nominal capacity of plant i

Fchi : The load factor of the plant i

Cug : Total cost

Therefore, the cost of 98 USD/MWh is the cost of meeting consumer demand at every moment for a full year (2023), using the average annual natural gas price. It does not in any way reflect the real cost of each individual power plant and does not take into account the operating time and availability of each plant.

3-The cost of electricity produced from renewable energies through IPP

After addressing the legislative mechanisms for private sector access to renewable energy electricity production in Tunisia in the first section and the cost of electricity production for the public structure in the second section, in the third section we will address the cost of electricity produced from renewable energies through IPP, which is often justified by its lower cost compared to public plants based mainly on the cost of natural gas.

But is the cost of electricity produced from renewable energies through IPP really lower than the cost of electricity produced through the public sector? Is this comparison even valid? And if not, what can be compared?

All these questions will be answered below.

1.3 Analyze the data:

When examining the results of the RFPs related to the production of electricity from renewable energies (we will limit ourselves to the 500 MW RFPs announced in December 2019[7]), we find the following:

[7] https://www.energiemines.gov.tn/energies

Project place	Owner	Capacity (MW)	Sale price (USD/MWh)
Tataouine	SCATEC	200	24
Gafsa	ENGIE-NAREVA	100	27
Kairouan	AMEA POWER	100	33
Sidi Bouzid	SCATEC	50	27
Tozeur	SCATEC	50	27

This means that these projects will produce electricity through the use of photovoltaic energy and sell it to the public structure at the mentioned prices. It is important to note that the energy produced will not be available all the time and the project owner cannot control its flow because it is linked to a natural factor, namely sunlight. Therefore, the number of hours of actual operation will be less than that of conventional power plants, which we expressed in the first section by the load factor, which was equal to 21% for public PV plants, equivalent to 1900 hours of operation at nominal capacity.

This reference is key to understanding the difference between a conventional plant and a photovoltaic plant: While the number of operating hours per year for the former is related to its readiness to convert the potential energy in fuels into electricity, for the latter it will be related to an uncontrolled and intermittent natural factor that fluctuates between a maximum and a minimum state throughout the day. Therefore, comparing the cost is not permissible because in this case the cost of not operating would be overlooked.

This cost is related to the availability of production over the course of a full year: If a conventional plant is ready 90% of the time (after subtracting possible maintenance hours), a PV plant will operate no more than 21% of the time (using the actual load factor of the utility-scale plants) over a full year at nominal capacity, which is its biggest obstacle in keeping up with the pace of conventional plants.

Calculating the cost of photovoltaic plants entails calculating the cost of non-operation: The public structure compensates for the unpreparedness of combined cycle plants (base plants), demand exceeding their capacity or the absence of the contribution of renewable energies by operating gas turbines to intervene so that the electrical needs of the country can be met at every moment and every second, unlike private renewable energy plants that will be hostage to the presence of sunlight to produce electricity and if not, there is no obligation for the private investor to provide electricity. This is precisely what represents for us as a working group the cornerstone of our reservation to the 2015 law because it allows the private sector to benefit only from the positives of photovoltaic energy, while its negative consequences is borne by the public structure.

Based on the above, the true cost of private plants requires taking into account the cost of replacing photovoltaic energy when it is unavailable, in other words, the cost of resorting to another plant to meet demand and ensure the continuity of the flow of electricity to the same extent. Then the comparison with the cost of electricity production in the public structure becomes meaningful because it is based on the same principles, or just comparing the cost of electricity production in private renewable energy plants with the public ones.

Due to the lack of data on the cost of producing electricity from renewable energies through the public structure, we as a working group limited ourselves to calculating the average cost of providing electricity over a full year for private PV plants as shown below:

Project place	Amount of energy produced (GWh)	Amount of energy compensated (GWh)	Cost (USD/MWh)
Tataouine	368	1384	115
Gafsa	184	692	116
Kairouan	184	692	117
Sidi Bouzid	92	346	116
Tozeur	92	346	116

Assumptions:

*The load factor of the plants is 21%

*The amount of compensated energy represents the amount of energy produced via gas turbines when renewable energies are not available

2.3 Conclusions:

Based on the table above, we can see that the real cost of electricity produced by the private sector is higher than that of the public sector based on the same calculation method, which is mainly related to providing electricity at every moment over the course of a whole year. Of course, many will object to this method of calculation and the results using different justifications and explanations. But for us as a working group, the only justification that could be relevant is that the proposed purchase price during the period of operation will be lower than the cost of producing electricity using natural gas during the same period, in other words, the public structure will earn the difference between the cost of purchase and the cost of operation during 1900 hours per year.

This reasoning is not entirely correct because the cost of production of the public structure plants varies according to the yield and is related to the fluctuations of natural gas prices according to

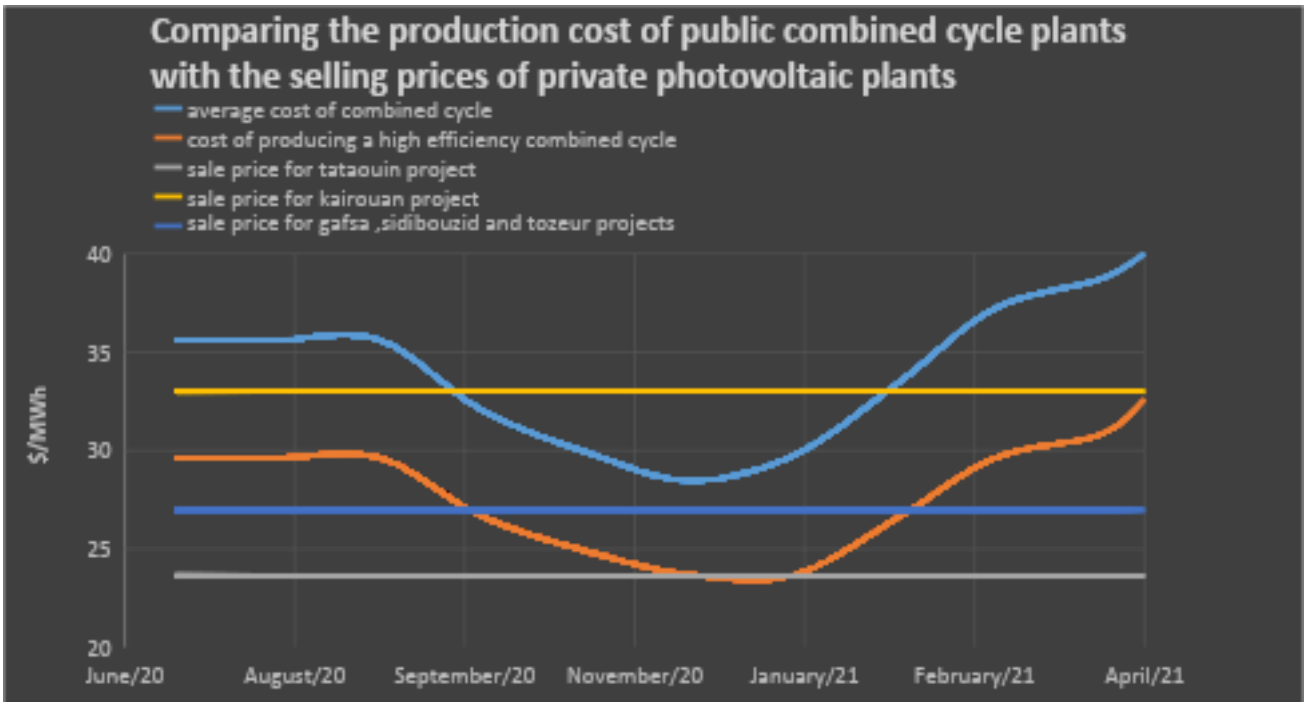
the periods, if we compare this cost with the selling prices of the above-mentioned private projects during the period from July 2020 to May 2021[8] based on:

* Calculating the average cost of all combined cycle plants of the public structure for the period in question

* Calculating the cost of the combined cycle plant with the highest efficiency for the public structure, which represents 50% of the installed capacity of combined cycle plants and 25% of the total installed capacity of the public entity (efficiency is approximately 54%)[9]

*Based on the Algerian gas supply prices during this period and included in the reports of the supervisory authority[10]

We derive the following graph:



From the figure above, we can see that the cost of producing electricity for the public sector through combined cycle plants using natural gas have fallen below prices of purchasing electricity produced from renewable energies through the private sector during the mentioned period. Thus, the argument of absolute minimum cost can be completely refuted and is subject to natural gas price fluctuations: The economic viability of renewable energies is highly correlated with fuel markets.

[8] https://www.energiemines.gov.tn/fileadmin/docsu1/Conjoncture_%C3%A9nerg%C3%A9tique_d%C3%A9cembre_2021_Fr.pdf
[9] https://openjicareport.jica.go.jp/pdf/12342291.pdf
[10] https://www.energiemines.gov.tn/fileadmin/docsu1/Conjoncture_%C3%A9nerg%C3%A9tique_d%C3%A9cembre_2021_Fr.pdf

It is this same economic viability that has kept these private projects from going into production until 2025. According to statements made by some members of the Energy Committee of the Tunisian Parliament[11], as well as a statement signed by several MPs on energy transition issues, it turns out that the owners of the 500 megawatt concessions stipulated that in order to complete their projects, they would enjoy privileges that would increase their economic profitability, which they considered weak based on the announced prices.

These privileges are in addition to the hidden costs of electricity produced from renewable energies through IPP, which are withheld in favor of the lowest cost, which will be discussed in the next section.

4-The hidden cost of producing electricity from renewable energies through IPP

The hidden cost is the total cost borne by the public structure or public finances as a result of private investments to produce electricity from renewable energies. This cost can be summarized in the total number of privileges and incentives received by private investors, as well as in the total additional costs that the public structure may bear through the type of projects that the private sector can carry out within the legislative framework we discussed above, such as fixing the sale prices of electricity produced by projects under the authorization regime.

1.4 privileges and incentives:

These privileges are mainly represented in:

- Extending the term of concessions from 20 years to 30 years[12] means adding new revenues to the project owners and transferring them to the public structure that would have benefited from them, since at the end of the term, the ownership of these plants will revert to it. These additional revenues are equal to 50% of the total revenues resulting from 20 years of exploitation, as shown in the following table:

Project place	20 years of exploitation	30 years of exploitation	Difference
Tataouine	180	270	**90**
Gafsa	100	150	**50**
Kairouan	123	184	**61**
Sidi Bouzid	50	75	**25**
Tozeur	50	75	**25**
Total	**503**	**754**	**251**

Million of USD

[11] https://www.babnet.net/rttdetail-313328.asp
[12] Previous source

- Waiving the credit carbon owned by the public structure[13] (as stipulated in PPA) to the state, which will provide them to Japan, which in return will commit to financing part of the mentioned projects and giving them grants for the purpose. These grants, which the public structure could have used to finance its projects, amounted to about 27 million dollars for the Sidi Bouzid and Tozeur projects, according to the official website of the Embassy of Japan in Tunisia[14] (dated March 24, 2025).

All of above data shows that the prices proposed during the RFP are unrealistic, which is why the highest-priced Kairouan project of all these projects is the only one under construction and has the least amount of downtime. As for the rest of the projects:

* ENGIE-NAREVA abandoned the Gafsa project, so the next bidder was VOLTALIA[15].

*The Sidi Bouzid and Tozeur projects started after ensuring economic viability as a result of the above-mentioned grants from Japan (After waiving carbon credit)

*As for the Tataouine project, SCATEC abandoned the project, and as of this writing, there is no additional information regarding the replacement company

For reference, the difficulties found by the owners of these projects are not related to the photovoltaic panel markets and the economic conditions after the Corona pandemic, as some are promoting. If we look at the evolution of the cost of installing PV plants from 2019 to 2023, we find that it has decreased by 35% (from 1161 USD/kW to 758 USD/kW), according to the Cost of Renewable Energy Production 2023 report[16] published by the International Renewable Energy Agency (IRENA).

The issue is mainly related to the level of profits that the owners of these projects want to make, which seems to have fallen short of their expectations, causing some of them to back out of some projects, as discussed above.

2.4 Fixing electricity sales prices for projects under the authorization regime:

In the above, we have limited ourselves to addressing large private photovoltaic projects (concession regime) and their cost compared to the production of electricity through the public structure, but we should not neglect the exposure to small projects by the private sector (authorization regime).

These projects, whose capacity does not exceed 10 megawatts, can be a heavy burden on the budgets of the public structure, which is obliged to buy all the electricity produced at a fixed price according to the proposed capacity, regardless of the objectives that the legislator wanted to achieve by approving this type of projects within the 2015 law.

The October 2024 decision to fixing sales prices, which is part of the incentive for small private investments in photovoltaic energy, allows the generation of stable and predictable returns

[13] Previous source
[14] https://www.tn.emb-japan.go.jp/itpr_ja/11_000001_00569.html
[15] https://www.voltalia.com/fr/news-release-details/voltalia-remporte-son-second-projet-en-tunisie
[16] https://www.irena.org//media/Files/IRENA/Agency/Publication/2024/Sep/IRENA_Renewable_power_generation_costs_in_2023.pdf

without the risk of competition and regardless of the decline in the price of photovoltaic installations, which (as mentioned above) is decreasing significantly from one year to the next.

Over the course of four rounds for proposals, the average price of electricity sold to the public structure dropped from 71 USD/MWh to around 60 USD/MWh for 1 MW projects and from 54 USD/MWh to 40 USD/MWh for 10 MW projects[17]. This means that in each round, given the competition between bidders, the prices gradually decreased, which enabled the burden on the financial budgets of the public structure to be reduced. However, due to the fixation of sales prices, all these efforts to reduce prices were in vain and the public structure was required to purchase electricity during the fifth round issued on October 17, 2024 at a price equal to 73 USD/MWh for 1 megawatt projects and 48 USD/MWh for 10 megawatt projects.

If we calculate the difference between the cost of purchasing electricity by the public structure considering the fourth round price rate[18] and that considering the decision to stabilize selling prices for the capacity required during the fifth round (the required capacity is equal to 200 MW), and based on the type of projects that can meet it (a load factor of 21%), we get the following:

Type of projects	**1 MW projects**	**10 MW projects**
Annual cost considering the fourth round	23	15
Annual cost considering the fixation of sales price	28	18
Difference	**5**	**3**

Million of USD

As for the cost difference between using small projects and adopting large projects, we calculated the annual cost to the public structure of 200 megawatts (required during the fifth round of the authorization regime) by 20 projects in the 10 megawatt format and compared it to the cost of a project from the concession regime (we will adopt the sale price of the Kairouan project), as shown in the following table:

	20 projects at 10 megawatts each	**200 megawatt project**
Annual cost	18	13
Difference	**5**	

Million of USD

We note that the annual cost difference is equal to about the revenues of the 100 MW project using the sale price of the Kairouan plant, which means that the public structure could have paid

[17] https://www.energiemines.gov.tn/energies renouvelables/projets et programme/régime des autorisations
[18] Previous source

the amounts required to purchase electricity from 20 projects with a total capacity of 200 MW in favor of a large plant with a total capacity of 300 MW. This cost will further burden its financial budgets to finance investor profits that could have been avoided if it (public structure) had completed these projects.

In addition to the above-mentioned privileges and incentives, there are a number of investment incentives that we did not take into account in the cost calculation, such as exemption from paying taxes during the first years and others that increase the economic viability of the projects, which will translate for investors as profits, most of which will be sent abroad (in hard currency), and for the public structure and the public finance, costs and burdens that will be deducted from taxpayers and electricity consumers in the country.

5-Conclusion: Public investment in renewable energies is a viable alternative

In the midst of the conclusions and findings reached after analyzing the data contained in the approved reports and documents, which you will find detailed in the references section, we identify the limits of private investment in renewable energies in Tunisia. This investment is only interested in making profits and more profits, not only through the exploitation of renewable energies, but also by adapting legislation and seizing every opportunity to increase its income through measures and incentives without being willing to make some compromises by sharing risks and profits between it and the state alike.

For us as the Working Group for Energy Democracy, and based on the findings of this research paper and all the articles and studies it has published over the past years, we emphasize that the only alternative solution for renewable energies to have the desired feasibility and profitability that reduces the burden of exploiting conventional plants is to push and encourage public investments in the field in addition to citizen initiatives aimed at involving electricity consumers in general in the production activity and not limiting them to the passive role of paying the bill only.

Public investment in renewable energies contributes to reducing their cost by eliminating the profit margins resulting from private investment and benefiting from the preference given to public loans. It also opens the way for people's sovereignty over their resources instead of the monopolization of this type of project by large corporations, which is proven by facts at the local and global level: More than half of the 500 megawatts mentioned above were awarded to a single company, which refutes the argument of competition and non-monopolization that some have always justified the use of the private sector and the reduction of the activity of public companies.

Therefore, what is needed nationally is to rehabilitate the public structure represented by the Tunisian Electricity and Gas Company and give it the green light to expand its investments in renewable energies, which will complement the rest of the conventional plants it owns, which will truly contribute to reducing the total cost of production, which will reflect positively on the burden of consumption.

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