Energy Externalities Evaluation: Implementation of the ExternE Methodology, Tunisian case.

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Development for Sustainability") Project. The overall objective of the NEEDS Project is to evaluate the full costs and benefits (i.e. direct and indirect) of energy policies and of future energy systems, both at the level of individual countries and for the enlarged EU as a whole. Within NEEDS, extension of the research has been made for few Mediterranean Partner countries (Egypt, Morocco and Tunisia). The paper summarises the main results obtained for Tunisia.

1. Tunisian Energy and Electricity Context

1.1. Main challenges of the Tunisian energy situation

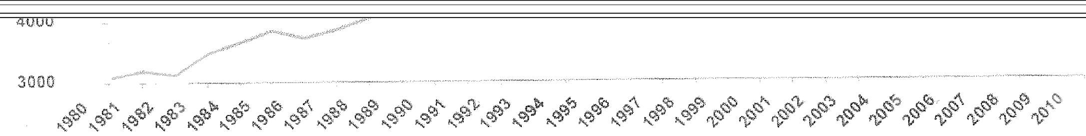
Tunisian energy context has some specific features. The major fact is the unbalance between national demand and supply of energy the country is facing since 2001. Indeed, after a long period of surplus that benefited to the welfare of the Tunisian economy, the country is facing a growing deficit since 2001 (presently around 13-15 % of final energy demand). With a fast increasing demand, growing at an estimated annual rate of 7% and except new resources discoveries, the gap between domestic supply and local demand is to widen up in the coming years. In addition to this growing deficit, the increase of oil prices constitutes a burden to the national economy.

In order to address this challenge, the Tunisian authorities have engaged an energy policy, compatible with the sustainable development, and which is based on two main pillars: the determined seek for energy efficiency and the deployment of renewable energies which are targeted to reach about 10 % of total supply in 2011.

In addition, the energy policy has been encouraging for many years the natural gas use in substitution to other fossil fuels as the country is gas producer and benefits from in kind resources as a fee from the gas pipe-line crossing the country.

Figure 1-1: Energy Resources and Demand

[1] More details on the NEEDS Project are available at: www.needs-project.org



Source: National Agency for Energy Conservation (ANME), Energy Conservation in Tunisia, horizon 2030, Tunis 2006

1.2. The Tunisian electricity sector

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Equipment	MW	%
Gas turbine	1165	36,4
Thermal	1090	34
Combined cycle	862	27
Hydro	62	2
Wind	20	0,6
Total	3199	100

Source: Société Tunisienne d'électricité et du Gaz (STEG), Annual Report, 2006

In 2006, the national electricity production reached 12,600 GWh, with 9,600 GWh public and 3,000 GWh private; hydro production was about 100 GWh and wind production almost 40 GWh[3] (see table 1-2).

Table 1-2: Electricity production by technology (2006)

Combined cycle	45.5%
Thermal	41.4%
Gas turbine	12.1%
Hydraulic and Wind	1%

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[2] Société Tunisienne d'électricité et du Gaz (STEG), Annual Report, 2006
[3] Directorate General for Energy, Ministry of Industry and Energy, Tunisia, and Société Tunisienne d'Electricité et du Gaz (STEG), Annual Report, 2006

Source: Société Tunisienne d'électricité et du Gaz (STEG), Annual Report, 2006

Around 95% of Tunisian power generating capacity is natural-gas fired, with 4% oil-fired, 2% hydro and 0.6 % wind. Public orientation is to develop natural gas use as far as possible, whenever substitution is possible, since as mentioned earlier the country has some own resources and hence limits recourse to imported hydrocarbons.

2. External Costs for Fossil Fuel Based Energy Technologies

2.1. Introduction to impacts

Main externalities are impacts of power plants emissions, upstream and down stream impacts, these corresponding to transport activities of fuel on one side and of electricity on the other side. Three kinds of impacts of electricity production are considered:

- Impacts on health, where damages are mainly caused by inhalation, direct contact (skin, eyes.) or by infected food
- Greenhouse gas (GHG) emissions
- Impacts on agricultural productivity, where deposits of chemicals rejections on ground and their displacement by precipitations lead to losses in agricultural production.

2.2. Impacts and measurement indicators for 3 reference plants

For fossil fuel based energy technologies, measure and evaluation of externalities are grounded on the study of three cases, representing three plants. These plants have been selected especially because of the availability of information: two important natural gas thermal plants (Rades A and Rades B) and a small heavy fuel thermal plant (Goulette).

For each power plant, the following emissions have been measured or estimated[4]

- GHG emissions: CO_2, CH_4, N_2O

Then monetary values for health and GHG costs were derived on EcoSenseWeb adjusted for regional characteristics and considering Tunisian health services tariffs.

For reference technologies, on both sides of health costs and global warming costs, analysis led to the main following conclusions:

- GHG emissions are much more important for the heavy fuel power plant (Goulette) than for natural gas power plants (Rades A and Rades B) which are similar on this ground; this can be seen in quantities of gas rejected or in monetary costs;
- For unit health costs, the heavy fuel power plant seems to be less costly than the natural gas power plants. Actually, although the fact that the heavy fuel power plant release more major

[4] Except for few pollutants emissions estimated locally by STEG, externalities of the reference plants were calculated according to a proxy approach by Jiří Balajka (PROFING), using technical input data.

Power Plant	Rades A	Rades B	Goulette
CO2-t/year/Gwh	170,5	169,5	1432,4
CH4- t/year/Gwh	3,3	3,3	55,4
N2O- t/year/Gwh	0,4	0,4	11,1
Health Costs-€-2000/ Year/Gwh	266,9	464,5	190,5
Global Worming Costs-			

2.3. Overall impacts and monetized costs

For GHG emissions measurement, on the basis of EcoSenseWeb results for power plants studied, an overall indicator expressing the average emissions of the reference energy mix was needed. As mentioned earlier, the focus was made on three main gases: CO_2, CH_4 and N_2O.

To define a weighted indicator of Global Warming Potential (GWP), let's recall that, for this purpose, a molecule of CH_4 and a molecule of N_2O are respectively equivalent to 21 and 310 molecules of CO_2.

Relying upon the structure of electricity production network, an average indicator of GHG emissions of a representative energy mix is then calculated; the estimation is 0,634 teCO_2 /MWh[5].

For agricultural productivity losses, a specific estimation is made, grounded on ExternE Methodology, more precisely on SO_2 concentration model only, NO_2 and O_3 being not considered[6].

Estimation yields the following result: at an average distance of 50 km, the SO_2 concentration deposited on the ground is of 1,288E -3 ppb for one hour of emission. Thus the relative change in agricultural output is equal to 0,093 %.

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[5] The following table presents data for this calculus :

2-2.Reference network Global Warming Potential (GWP)

Fuel	(%)	1	21	310	GHG Emissions Factor ($teCO_2$/MWh)
		Emissions Factor CO_2 (kg/GJ)	Emissions Factor CH_4 (kg/GJ)	Emissions Factor N_2O (kg/GJ)	
Natural gas-Turbine	45	55,1	1,00	0,100	0,545
Natural gas-CC	45	29,3	0,53	0,053	0,311
Heavy fuel	7.5	77,5	3,00	0,600	3,319
Wind	0,4	0,0	0,0	0,0	0,0
Hydro	2,1	0,0	0,0	0,0	0,0
Mix	**100**				**0,634**

Source : Estimation by Jiří Balajka (PROFING) and own calculation

[6] We used the local Gaussien Model to estimate the concentration at a point in the space. We found that for combined cycle and gas turbines power stations no SO_2 discharge is noticed. So these impacts will be limited to thermal power stations. References taken are Rades A and Rades B plants, since fuel plants release of SO_2 are negligible.

This change appears in various agricultural products like common wheat, the barley, potato, sugar beet and oats. But in our study we will consider only corn.

Finally, we can summarize monetized energy externalities costs as following:

- *Health costs*: 530 €(2008) per GWh
- *GHG emissions costs*: At the rate of 20 € the $teCO_2$, these costs amount 12 680 €(2008) per GWh
- *Agricultural productivity losses*: for 2006 production, the loss amounts 0,5474 million €(2008)[7]

3. Energy External Costs Applications

3.1. Economic assessment of energy projects

External costs estimated have been used to perform a Cost Benefit Analysis involving wind energy. The project is a wind plant, with an installed capacity of almost 35 MW, and a forecasted annual production of about 90,1 GWh; the point is to assess the profitability of the project to the whole community, and say if the wind plant contributes to the welfare of the country.

The alternative situation is defined as the action of increasing the production of the conventional power stations. It is a representative mix of electric power, equivalent to the production of the wind power plant.

For the alternative situation, three kinds of impacts are considered: impacts on health, GHG emissions, and impacts on agricultural productivity.

As for the wind power plant, visual, sound and ornithological impacts are assumed to be negligible: besides the real lack of data, these effects could also appear not very perceptible to local population. In the following table, we summarize all costs and benefits of both the wind power project and alternative situation.

Table 3-1: Summary of the monetized impacts

Alternative Project (Energy Mix)

Item	Million €
Direct benefits: sales revenues (annual)	8,172
Direct costs: production cost (annual)	5,927
Indirect benefits: land use (annual)	0,111
Externalities Costs: Health costs (annual)	0,048
Externalities Costs: GHG costs (annual)	1,144
Externalities Costs: Agricultural losses (annual)	0,547

Wind power Project

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7 **2-3.Cost of agricultural production lost**

Product	Production[7] (1000 T)	Production without SO_2 effect (1000 T)	Lost production (1000 T)	Product price €/ ton	Cost of production lost (million €)
Durum wheat	1049,6	1050,58	0,98	470	0,4606
Common wheat	304,2	304,48	0,28	310	0,0868
Total					0,5474

Source: Observatoire National de l'Agriculture (ONAGRI), Tunis, and own calculations

Item	Million €
Direct costs: investments	39,6
Direct costs: operation and maintenance	0,35
Direct benefits: sales revenues (annual)	8,172
Indirect benefits: residual value of equipment (last year)	1,050
Externalities Costs:	0

To estimate the Net Present Value (NPV), a project's economic evaluation implies to use an economic discount rate[8].

The next table presents the NPV of the project and the alternative set, the latter calculated in two cases: once taking into account the social costs of energy externalities and indirect benefits, then without including these social costs and "opportunity" benefit, as it often happens even by public operators.

Table 3-2: Net Present Value

	Project	Alternative with externalities	Alternative without externalities
NPV (million €)	35,7	5,8	20,6

Source : own calculation

Calculations of NPV using economic prices, economic discount rate and social costs of indirect impacts of fossil fuel production technologies, show the importance of these costs since they correspond to almost 75% of the alternative production NPV.

They lead also to the important conclusion that the wind power project, compared to alternative situation, is obviously socially profitable and it is worthy to be implemented. Moreover, despite investments costs, the project is better than the alternative situation without externalities, where external costs are not included. This conclusion enlightens the importance of wind energy and the benefit the welfare of the country may derive from it.

3.2. Optimal regulation of externalities

A main option consists in internalization by price-based instruments. Standard economic theory recommendation for price-based internalization, with fiscal instruments, is to charge over

[8] An economic discount rate presents a significant difference with the financial discount rate (which is more or less related to the interest rate that the banks would make for the financing of the project). Various reasons may justify this gap, basically relying on likely divergence between inter-temporal individual choices and community global interest: consumption/ savings decisions, appreciation of risks, attention to future generations' welfare

- The second consists in considering the public investments returns historically noted; actually, this is a hard task because significant data is often missing. So we generally fall back on the discount rates used for these projects.

For Tunisian case, recent public bonds average interest rate is about 6,604 %[8]; and public projects adopted discount rates lying between 8% and 12%. Therefore, we consider a reference discount of 8%.

competitive market price a tax equivalent to external costs. This is also the basic assumption of the Environmental Tax Reform approach.

External costs being available now, for a suitable context, this direction would be a straight option for internalization and optimal regulation[9].

However, economic situations are generally far from this nice picture and oppose difficulties to implement this recommendation.

From this point of view, Tunisian situation shows, actually like some other similar countries, two major features: distortion in price system and particular incentive policy for renewable energies and energy efficiency.

- On the ground of pricing, energy goods, among them electricity, are strongly subsidized. For the latter, the bulk of the subsidy concerns the main input which is natural gas. This leads to a great departure from competitive prices and to a wide gap between sales prices and economic prices. In this situation, applying an eco-tax has no sense, since priority would be to check undesirable behavior raising tariffs to meet competitive levels.
- Connected with this part of public policy, investments in energy efficiency end renewable energies are also subsidized. There allowances for investment, reductions of customs duties on imported equipments or VAT exemption for equipments and products used.

Despite these complexities, a price-based internalization option could take the direction of differentiating excise taxes, putting, for example, distinct VAT levels taking into account external costs.

Along this path, we recall that external costs estimated for alternative project, expressing a representative energy mix, amount 19280 € per GWh, say 0,019 € per kWh, and about 21 % of economic price of electricity. As reported in Table , excise tax, including VAT, amounts only 12 % of economic price. This gap indicates the difficulty of the task.

Table 3-3: Average Electricity prices, taxes and external costs (€/kwh)

Sales price net of Tax	Economic price	Tax	% net sales price	% economic price	External costs	% economic price
0,06	0,091	0,011	18	12	0,019	21

Source: Tunisian Ministry of Industry and Energy, and own calculation

9 In fact marginal costs of externalities are in concern, so an implicit hypothesis of constant returns technologies (at least for pollution) is assumed.