

FAIR AND EFFICIENT TARIFFS FOR WIND ENERGY: PRINCIPLES, METHOD, PROPOSAL, DATA AND POTENTIAL CONSEQUENCES IN FRANCE

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ABSTRACT: After a short presentation of the French rapidly changing context for the development of wind power, this paper presents the principles, the method and the detailed formulas to establish a "fair and efficient" tariff system for wind energy. The method used by ADEME to propose and to help to define such a wind energy tariff system was the "Profitability Index Method" of which recent developments are presented. The new French tariff system defined in the 8th of June 2001 *arrêté* for wind power plants under 12 MW is described. Its potential consequences on the profitability of projects and on the wind power development in France are presented. As a minimum of 5 GW and up to 10 GW of wind power could be installed in France in 2010, some figures of the related over-cost incurred are given and discussed.

KEYWORDS: Feed-in Tariffs, Tariff Structures, Business Issues, Policies.

1. INTRODUCTION: THE FRENCH CONTEXT

In France, the "EOLE 2005" programme launched in 1996 selected 55 projects representing 360 MW, of which 78 MW were installed at the end of 2000, and 47 MW were due to be installed in 2001 [1].

In January 2000, within the French national plan against the climate change, the official goal for 2010 was to install 3 000 MW of wind power.

Within the frame of the negotiation of the European Directive on electricity from renewable energy sources under the French Presidency of the European Union, it was announced by the French government in May 2000 and confirmed in December that 5 000 to 10 000 MW of wind power should be installed in France in 2010 [2], and that a new system based on fixed tariffs would replace the EOLE 2005 calls for tenders for projects under 12 MW. The final and may be binding figure for the official wind energy target in France in 2010 will be probably defined within the frame of the discussions and decisions following the future adoption of the European directive on electricity from renewable energy sources.

To help to define the new tariff system, an ad-hoc working group was created by the Ministry of Industry in August 2000, with representatives from Ministry of Industry, wind industry experts (mainly from FEE, the French "France Energie Eolienne" association and from the SER, the "Syndicat des Energies Renouvelables"), EDF and ADEME.

The final tariff system as described in the June 8th 2001 *arrêté* [3] for the first 1 500 MW of signed contracts is mainly based on the proposals and conclusions of this working group, with some details added further by the French Authorities.

2. PRINCIPLES FOR EFFICIENT AND FAIR TARIFFS

From the past decade, it is clear that a key factor for the fast wind energy development in Europe was the success of the policies based on fair fixed tariffs versus the ones based on competitive calls for tender [4].

That is why, in France, it was decided within the general frame (article N° 8) of the February 10th 2000 new law on electricity [5] that competitive calls for tenders will be used only for wind power projects over 12 MW. Under this power limit, considering that the European market for green certificates was not existing and that it was not proven that such an economic instrument would be able to achieve the 2010 goals (5 to 10 GW installed), it was decided for projects under 12 MW to consider the "premium prices schemes" in Europe, mainly the past Danish and the recent Spanish and German wind power tariffs systems who proved to be very successful.

So the basis of the new French tariff system is also to create the conditions for a "fair profitability" for private investors in wind power projects, using state of the art wind turbines, so that on medium quality sites (in France, approximately from 6 m/s at hub height) a minimum profitability is possible, and so that on high quality sites (in mainland France, practically under 8.5 m/s at hub height) the profitability may be higher, but not undue. The initial ADEME proposal to the ad-hoc working group and the final system are inspired from the German system, but as it will be detailed later, they differ on tariff conditions after the first five years of operation.

The "over-cost" implied by those tariffs will not be covered by the national public budget. It will be charged equally on all electricity consumers, from their equal contribution per kWh consumed to a specific fund raised to cover all the public services charges of the electricity sector. Among them, are those resulting from the development of renewable energy technologies for power production in order to comply with the Kyoto agreement and also with the adoption of the future European directive on electricity from renewable energy sources.

The ADEME proposal for profitability levels and the detailed tariffs values are based on the "Profitability Index Method" (PIM) already described for its application to grid connected wind power plants [6]. The conclusions from this global economic analysis method were also checked from the tariff proposal by FEE [7] and SER based on a conventional financial analysis including profitability results on equity. The official tariff system as described in [3] for the first 1 500 MW of signed contracts differs only slightly from the conclusions of those two analysis.

As the PIM is so simple and powerful to define a tariff system, it will be described shortly before detailed results for the French tariff system are described.

3. THE PROFITABILITY INDEX METHOD (PIM)

3.1 Definitions, basic parameters and formulas

The profitability index (*PI*) is simply the ratio between the Net present Value (*NPV*) of a project and the required initial investment *I*: $PI = NPV / I$

The discount rate to use with the PIM is not the targeted internal rate of return (*IRR*), but the Average Weighted Cost of Capital (*AWCC*). Its reference value used to define the French tariff is $t = 6.5\%$ (real, corrected from inflation, as all tariffs and parameters will be defined in constant 2001 Euros).

Other basic parameters and reference values used to define the tariffs are:

- The depreciation period *n* (15 years).
- The capital recovery factor *Kd*, defined by:

$$Kd = Kd(t, n) = \frac{t(1+t)^n}{(1+t)^n - 1}$$

- The investment cost ratio: $Iu = I / P$, and the residual value *Valres* of the project after *n* years of operation, expressed as a fraction of the initial investment.
- The yearly constant average O&M expenses ratio $Kom = Dom / I$, where *Dom* is the mean annual O&M expenses (including provisions for big repairs).
- The yearly average energy yield or capacity factor expressed as $Nh = Ey / P$ (hours/year at rated power), where *Ey* is the mean yearly amount of energy sold to the grid.

For a targeted profitability index value *PI*, the required constant tariff *Teq* from year 1 to year *n* is:

$$Teq = \frac{(1 + PI - \frac{Valres}{(1+t)^{n+1}})Kd + Kom}{Nh} Iu \quad (1)$$

and of course, for $PI = 0$, the tariff *Teq* is equal to the Overall Discounted Cost (*ODC*) of the kWh.

From (1), there is a direct relation between the *PI* value of a project and its IRR (Internal rate of return) value:

$$Kd(IRR, n) = (1 + PI)Kd(t, n) \quad (2)$$

For example, for $n = 15$ years and $t = 6\%$, for $PI = 0.3$, $IRR = 10\%$, an IRR value considered as a minimum to attract private investors in long term projects such as wind power projects.

3.2 The margin between cost and price

The first advantage of the PIM is to make a clear difference between the “cost” of a kWh and its “selling price” (the tariff), the difference between the two values defining the margin and creating the profitability of the project.

Using the “Margin on cost” *MOC*, defined as:

$$MOC = \frac{(Price - Cost)}{Cost} = \frac{Teq - ODC}{ODC} \quad (3)$$

then for all power plants with constant annual cash flows:

$$MOC = Kfuel \frac{Kd}{Kd + Kom} PI \quad (4)$$

$$\text{With } Kfuel = \frac{NFCP}{ODC} \quad (5)$$

where *NFPC* is the “non fuel cost part” of the kWh (its overall discounted cost *ODC* less the part of this cost related to fuel expenses).

Of course, for all renewable energy technologies (RETs) without fuel expenses (hydro, wind, solar, geothermal based power plants), $Kfuel = 1$. Instead, for fossil based power plants, $Kfuel < 1$. For example, *Kfuel* is around 0.5 for modern coal based power plants and around 0.33 for natural gas based combined cycles power plants.

3.3 The “zero fuel cost RETs” paradox

Using (4) both for zero fuel cost RETs (index *r*) based and fossil based power plants (index *f*) gives:

$$\frac{MOCr}{MOCf} = \frac{1}{Kfuel_f} \frac{Kdr}{Kdf} \frac{(Kdf + Komf)}{(Kdr + Komr)} \quad (6)$$

If we compare a renewable energy based project (without fuel costs, so excluding biomass projects) and a fossil one, with the same discounting conditions *t* and *n* and the same targeted profitability, then $Kdr = Kdf$, as *Kom* is in general lower from RETs based power plants than from fossil based ones. So (6) demonstrates the “**Zero fuel cost renewable energy technologies paradox**”:

$$\frac{MOCr}{MOCf} > \frac{1}{Kfuel_f} \quad (7)$$

So, from this paradox based on (7), in order to get the same profitability from a zero fuel cost RET power plant project and from a fossil based one, the margin on cost for the renewable project must be higher than the one of the fossil based project.

For example, for the same profitability, a zero fuel cost RET project must have a margin on cost:

- Around two times higher than in the case of a coal based power plant.
- Around three times higher than in the case of a natural gas combined cycle power plant.

In other words, if a wind power plant is “manufacturing” a kWh at the same cost level (e. g. 100) than the cost levels of a coal and a natural gas power plants, to get the same profitability (e.g. $PI = 0.3$), the relevant selling prices of each kWh must be around:

- Only 104 for the natural gas power plant.
- 110 for the coal based power plant.
- And 120 for the wind power plant!

In liberalised electricity markets, the minimum margin on cost for coal power plants is around 10%. As this margin corresponds for a modern coal plant to a profitability level $PI = 0.3$ (see example in reference [6]), the minimum profitability index level for a wind power

plant project should be also 0.3, a minimum value also derived as seen above from the link between *PI* and *IRR*.

This minimum targeted value of profitability index of 0.3 for reference wind power projects was used by ADEME to propose the first reference tariff values. Final official tariffs are slightly different and as it will be seen below, the final profitability index values for reference projects can differ from this theoretical minimum value of 0.3.

4. PRINCIPLES FOR FRENCH TARIFFS DEFINITION

4.1 Basic principles, parameters and formulas

Referring to the figure 1 below, the main parameters of the French wind tariff system for projects under 12 MW are:

- *T1*, a fixed tariff for all new contracts in a specific year for their first 5 years of operation (years 1 to *j*).
- *T2*, the specific different tariff for each project for years *j+1= 6* to *n = 15*.
- *Teq*, the equivalent fixed tariff from year 1 to *n* resulting from *T1* and *T2* and *t* and leading to a final economic profitability *PI*.

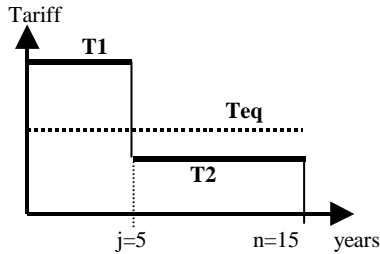


Figure 1: parameters for the French tariff system

- *Nhmin* and *Nhmax*: the minimum and maximum reference values of average energy yield (expressed in hours per year at rated power).
- *Plmin* and *Plmax*, the minimum and maximum reference values of the profitability index for reference projects with *Nhmin* and *Nhmax*.
- Reference cost parameters (mainland France, 2001 contracts): *Iu* = 1067 EUR/kW, *Valres* = 15 % of initial investment, *Kom* = 4%, *t* = 6.5%.

From those parameters, it is easy to define:

- *T1 = T2max = Teq* for the “low reference project”, defined by *Nh = Nhmin* and *PI = Plmin*. So, *T1* is calculated from equation (1), with *PI = Plmin* and *Nh = Nhmin*.
- *T2min*, the minimum value of *T2* for the “high reference project” defined by *Nh = Nhmax* and *PI = Plmax*. Its value is calculated from the following equation:

$$TV2 = K \left(\frac{Teq \min}{Kd(t, n)} - \frac{T1}{Kd(t, j)} \right) \quad (8),$$

$$\text{where } \frac{1}{K} = \frac{1}{Kd(t, n)} - \frac{1}{Kd(t, j)} \quad (9),$$

and where *Teqmin* is the value of *Teq* resulting of equation (1) using *Nh = Nhmin* and *PI = Plmin*.

4.2 Final data

The table 1 and the figure 2 give the *Nh*, *T1* and *T2* values defined in the “June 8th arrêté” [3]. The values for *Teq* are given here only for information and are calculated here from *t* = 6.5 %. For a specific real project, its *Teq* values can be calculated from *T1* and *T2* and from the AWCCC *t* of the investor, using the following equation:

$$Teq = \left(\frac{T1}{Kd(t, j)} + \frac{T2}{K} \right) Kd(t, n) \quad (10)$$

Table 1: Parameters for wind power tariffs in France:

Reference values for 2001 tariffs					
Mainland France, projects < 12 MW					
Nh:	P (MW)	P (MW)	cEURO / kWh		
	<1500	>1500	T1	T2	Teq
Nhmin:	2000	1900	8,38	8,38	8,38
Nhint:	2600	2400	8,38	5,95	7,02
Nhmax:	3600	3300	8,38	3,05	5,41
Corsica & Overseas Depart. projects <12 MW					
Nh:	P (MW)	P (MW)	cEURO / kWh		
	<1500	>1500	T1	T2	Teq
Nhmin:	2050		9,15	9,15	9,15
Nhint:	2400		9,15	7,47	8,21
Nhmax:	3300		9,15	4,57	6,59

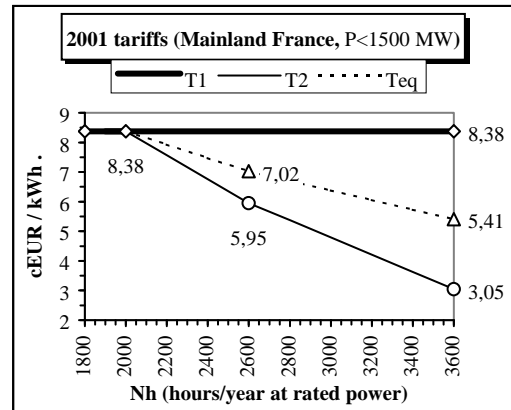


Figure 2: Tariffs *T1*, *T2* and *Teq* versus *Nh*

For projects with applications and contracts in further years, reference [3] gives all the details and the formulas required to calculate how reference tariffs *T1* and *T2* will vary according to the forecasted decrease in reference investment cost *Iu* and how they are corrected from the impact of inflation.

For a specific project, the high initial tariff *T1* applies for the first five years of operation. Then, as indicated in

figure 2 below, the tariff T_2 from year 6 to 15 is calculated from a linear variation versus N_h , the mean actual yearly energy yield during years 1 to 5 (excluding the best and the worst year in the calculation). In order to avoid an artificial lowering of N_h by operators during the first five years to maximise the T_2 value, the number of kWh benefiting from T_2 is limited each following 5 years period to 5 times rated power times N_h . For kWh beyond, T_2 is lowered by 25%. In a specific contract, tariffs values are corrected each year from inflation, but only partially, with 40% of their value not taken into account in the relevant formula [3].

4.3 Results for profitability of reference projects

Reference projects in this analysis are defined by $I_u = 1067$ EUR/kW, $Valres = 15\%$, $Kom = 4\%$, and $t = AWCC = 6.5\%$ (real).

For 2001 reference projects of less than 12 MW installed in mainland France, their profitability index variation versus their N_h value is presented in figure 3, and its Internal Rate of Return variation versus N_h is presented in figure 4.

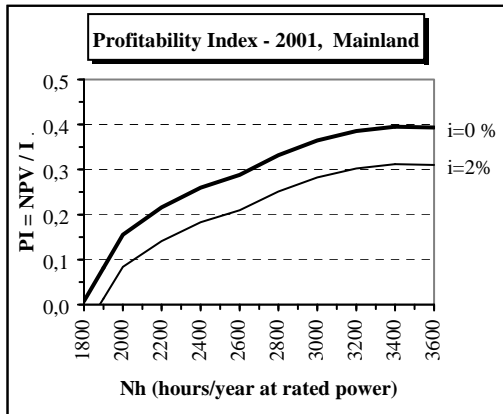


Figure 3: Profitability Index of a 2001 reference project

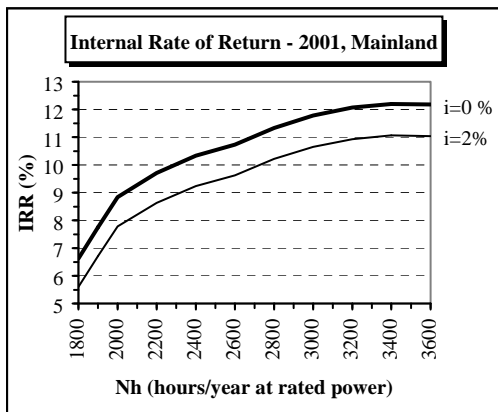


Figure 4: IRR versus N_h for a 2001 reference project

As it can be seen in each figure, with the reference costs described above, profitability is not always beyond the proposed minimum value of $PI = 0.3$. But profitability is increasing with N_h , as designed in order to give

incentives to developers using good sites (which often imply higher costs) and using wind turbines with high productivity and availability. One can see also that the forecasted mean inflation rate over the next 15 years has a great effect. For an inflation of only 2%, the decrease in PI vary from 46% to 21% from $N_h = 2\,000$ to $3\,600$ h/y, and the IRR decrease is more than 1 point. Of course, as $t = 6.5\%$, projects with $IRR < 6.5\%$ are not profitable.

5. CONCLUSIONS

With this new tariff system, France can now develop its huge wind potential at a pace as high as experienced recently in other countries with “fixed premium prices”. A minimum of five and up to ten GW could be installed in France in 2010, provided that all potential problems for grid connection and public acceptance are solved. And “fair and efficient tariffs” as the new ones are a prerequisite for that, as they can help farmers, citizens and local authorities to be involved as investors in wind projects.

The over-cost of the new tariff system is not too high. From an extrapolation of a previous study [8], for 9 GW installed at the beginning of 2010, around 325 cumulated TWh of wind energy delivered from relevant contracts from 2001 to 2025 would charge the French electricity sector by around 5 bEUR (discounting at 5% and with a mean avoided cost of 4 cEUR/kWh). The maximum yearly over-cost would be 670 current MEUR in 2018, less than 11 EUR per people or less than 0.15 cEUR/kWh.

As the over-cost from those tariffs will be passed equally over all electricity consumers, this tariff system is compatible with the liberalisation of the electricity sector, as it does not involve unfair competition. And it will help France to comply with its national, European and international commitments related to environment, and firstly, to comply with the objectives of the future European directive on electricity from renewables.

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