Some characteristics and lessons from the French renewable electricity regulation and tariffs system

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Market Regulation for Electricity from RES

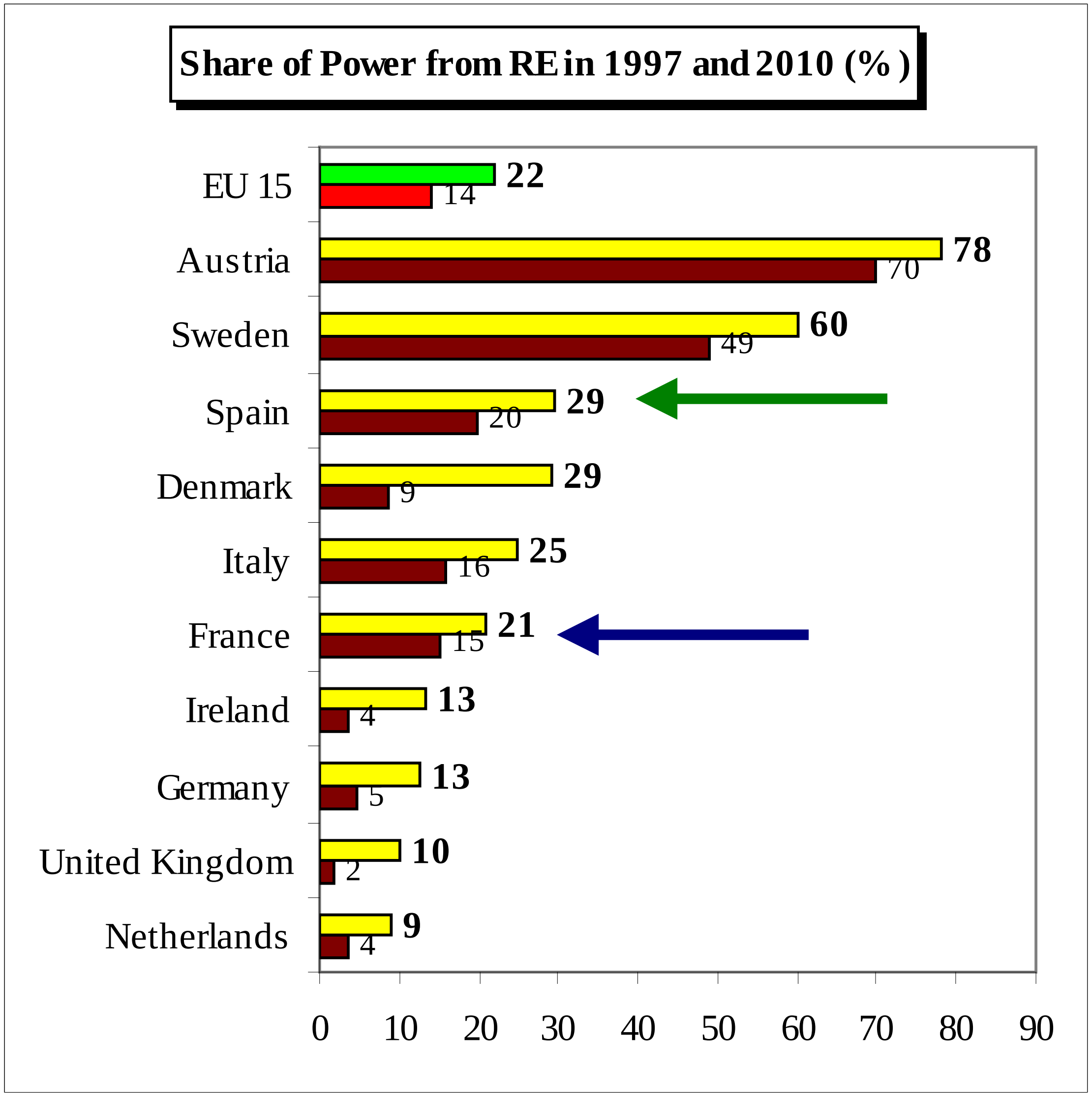
- **A power market regulation is necessary to attract private investors and to avoid future "stranded costs"**
- **This regulation should take into account specific characteristics of RETs**
  - ⇨Benefit 1 : no fuel costs: no burden in case of new oil crisis
  - ⇨Benefit 2 : no CO2 emissions
  - ⇨Benefit 3 : no fuel costs, so future decrease in investment cost will give proportional cost/tariff decrease for new projects
  - ⇨Burden 1 : long period of time before enjoying profitability (discounted pay-back time: 10 to 15 years or more)
  - ⇨Burden2 : "The free energy sources paradox" (see later): for the same profitability, the margin on the cost of a RE based kWh must be twice or three times higher than the margin on a kWh from a fossil fuel based power plant

Two options to regulate market for RES

- **Regulation by quantities**
  - ⇨Quotas + competitive calls for tenders (eg: UK, F in 90's, Ir)
  - ⇨Quotas verified from RECs in % of consumption (or sales) + penalties in case of no compliance (UK, Be, Nl, It)
- **Regulation by prices**
  - ⇨"Fixed prices" (eg wind power in Dk & G in the 90's)
  - ⇨"Environ. premiums" over the annual avoided cost (Spain)
  - ⇨"**ADVANCED TARIFFS**" (eg wind power in G, F)
    - ➔Defined for each technology
    - ➔Defined for each project, e. g. if variable average wind speed (
    - ➔Fixed tariff within a contract, e. g. defined first from the potential and then from the actual energy yield measured during the first 5 years
    - ➔Tariffs for new projects are decreasing each year to take into account costs decrease

The European Context

- **Sept 7th 2001 EU Directive:**
  - ⇨RE based electricity should be 22% of EU15 demand in 2010 instead of 14 % in 1997
  - ⇨Each member state can choose its best RE policy
  - ⇨If unsufficient national results within 4 years, EU can demand member states to adopt the proven best practices and incentives (e. g. minimum feed in tariffs)
- **2010 target for wind power :**
  - ⇨1997: Second contribution (after hydro and biomass) : 40 GW, 80 TWh/year
  - ⇨EWEA target is now:
    - ➔**75 GW in 2010**
    - ➔including 10 GW offshore



The French Context Within the EU Directive

- **For France: increase from 15 % to 21 % (including large hydro: 66 TWh)**
  - ⇨Requires a minimum increase of 40 TWh/year of new RE (excluding large hydro)
  - ⇨Requires a minimum of 11 GW of wind power in 2010 (versus 0.24 GW in 2003)
  - ⇨Wind power should contribute to 73 % of new renewable energy increase (81% of new RE power increase)
- **Those preliminary figures are to be discussed before bottlenecks are assessed (grid access...) and official French commitments are decided and published**

Additional contribution of RETs in France in 2010			**Nh ref**	**P reference**	
(2001 ADEME estimate)	**TWhe/an**	%	h/year at Pref	GW	%
Wind Power	**29**	**73%**	2 600	**11,2**	**81%**
Biomass	**5,9**	15%	5 000	1,2	9%
Small Hydro Power	**4**	10%	4 000	1,0	7%
Geothermal Energy	**0,8**	2%	7 000	0,1	1%
Photovoltaics	**0,3**	1%	1 200	0,3	2%
TOTAL new RE contribution	**40**	100%		**13,7**	100%
Total with large Hydro	107				
Total 2010 demand incl. DSM	510	**21%**			

The "Profitability Index" (PI) method

- **A global economic analysis for preliminary studies**
- **Constant inflation, results in constant money**
- **Constant mean yearly Cash-flows :**
  - ⇨Defines the « references cases »
  - ⇨By exension following cases are also relevant :
    - ➔Cash-flows parameters varying by x%/year above or under inflation
    - ➔Variable cash-flows parameters replaced by their constant equiv. value
- **Links with other methods :**
  - ⇨Direct access from PI to IRR, PBP (pay back period), but much more precise (linear variation of PI versus NPV)
  - ⇨Direct link of PI versus Margin on Cost ==> link with industrial and commercial strategies and policies
  - ⇨Wise states: almost same economic and fiscal profitability levels

Method (1)

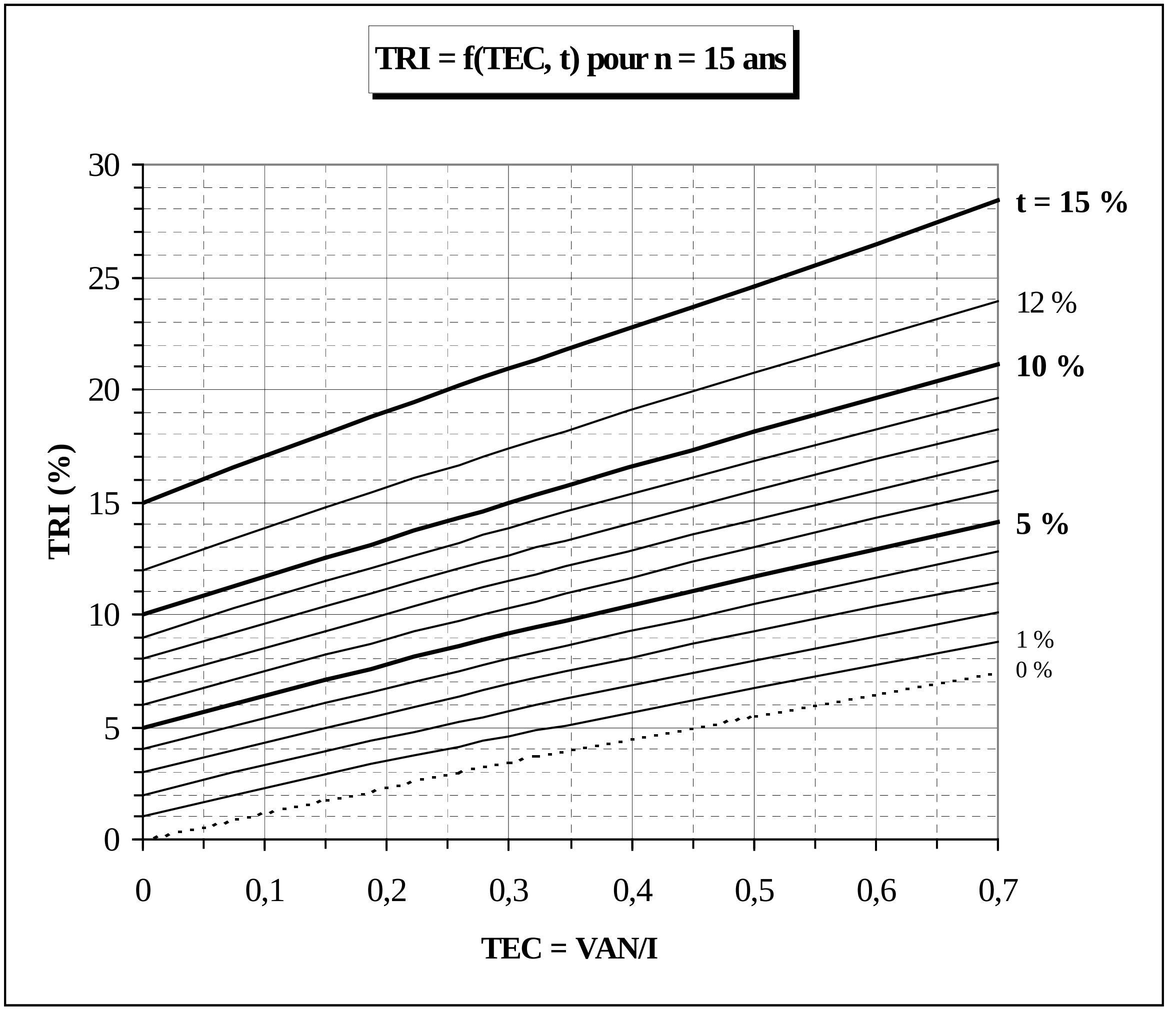
- **Profitability index** PI **= Net Present Value / Investment**
- **Gives both kWh manufacturing cost and selling price:**
  - ⇨ Tariff **T** = ((1 + **PI**)Kd + Kom) Iu / Nh + Cvu (Euro/kWh)
    - ◆**CRF** = **Capital recovery factor** (based on actual discount rate = t = AWCC = Average Weighted Cost of Capital, and n): **CRF**= t / (1-(1+t)^-n)
    - ◆**Kom** = **O&M ratio** = yearly O&M expenses / Investment (wind: Kom = 0.04)
    - ◆**Iu** = **investment cost ratio** = I / P (EURO/kW)
    - ◆**Nh** = **Ey / P** = kWh / kW = number of hours per year at rated power
    - ◆**Cvu** : variable cost (fuel cost part: Cvu = Fuel Cost / (Efficiency.LHV)
  - ⇨If **PI**=0, Tariff =ODC (Overall Discounted Cost), Margin = 0
- **Direct link** PI <==> IRR or DPBT (disc. PB time)

CRF (IRR, n) = (1+PI).CRF (t, n)

CRF (t, DPBT) = (1+PI).CRF (t, n)

Links PI / IRR for n = 15 years

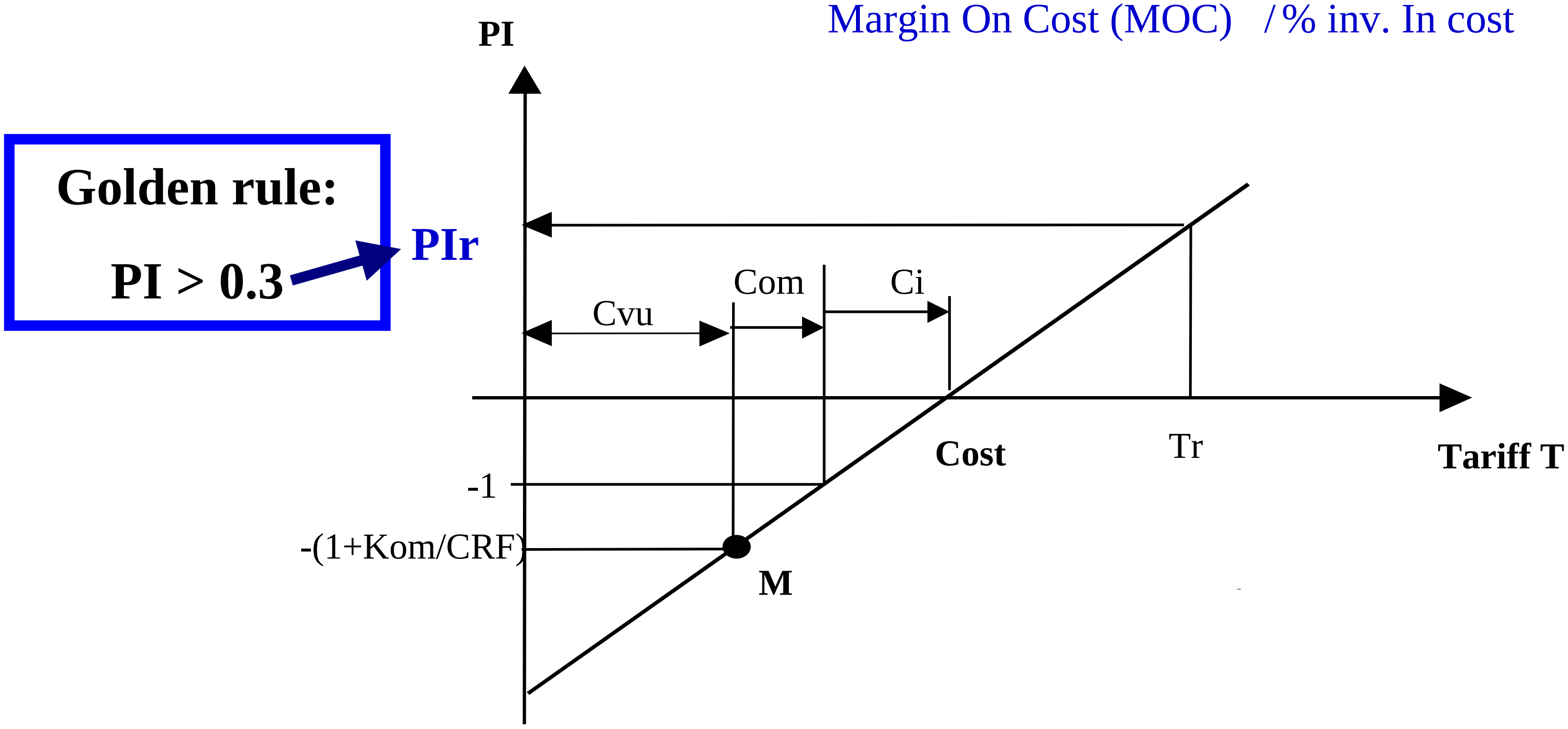
- **Ex: t = 6 %: 100 % PI variation from 0.15 à 0.3 : IRR vary only from 8 to 10.3 %**



Method (2) Universal linear model PI = f(Tariff T)

- ⇨PI = aT - b = (Nh / CRF.Iu)(T - Cvu) - (1 + Kom / Kd)
  - ➔where Iu = I / P, Nh = Ea / P, Kom = Dom / I, CRF = t / (1 - (1+t)exp-n)
  - ➔Cvu = part of cost due to the fuel (Zero for wind/solar/hydro systems)
  - ➔Com = part of the cost due to O&M costs = Kom.Iu / Nh
  - ➔Ci = part of the cost due to the investment cost = CRF.Iu / Nh
- ⇨From Thales of Milet: PI = {(T-Cost)/Cost} / (ci/Cost)

Margin On Cost (MOC) / % inv. In cost



Method (3)

- **Margin on cost, MOC**
  - ⇨ **MOC** =(Price-Cost)/Cost
- **MOC of Fossil versus Renewable Energy Sources**
  - ⇨ Introducing Kfuel
    - ➔ Kfuel = cost per kWh without fuel cost / cost per kWh
    - ➔ Kfuel = 1,0 for Wind;   0,5 for Coal;   0,33 for CCGT
  - ⇨ **MOC =PI***Kfuel*****(Kd/(Kd+Kom))

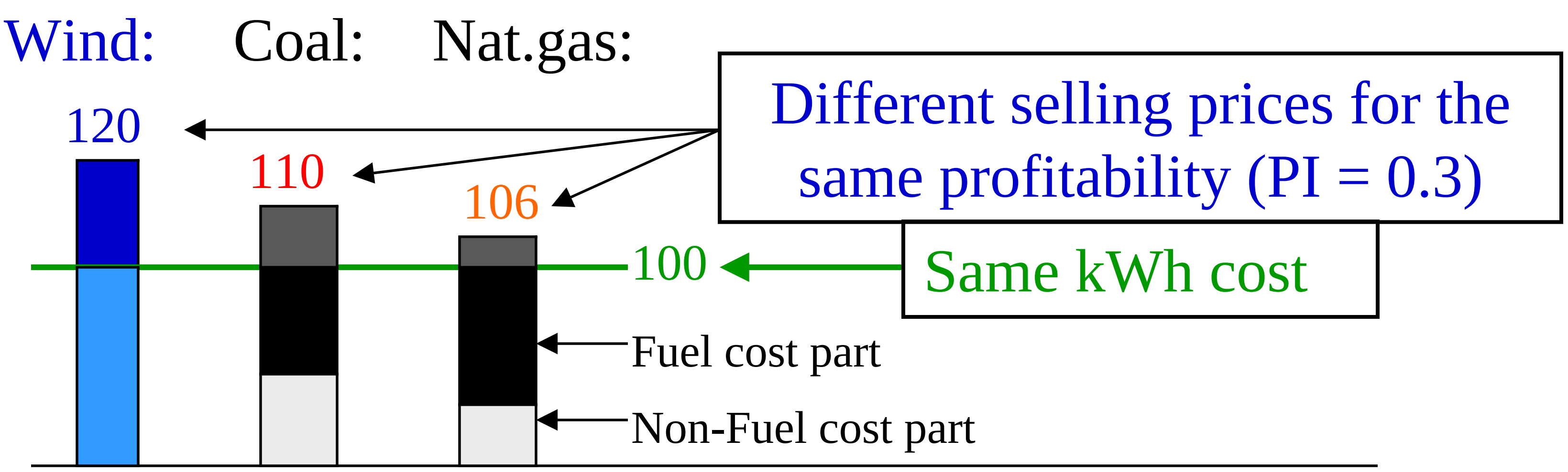
At equal kWh cost, if **PI** Renewables = **PI** Fossil, then:

$$\mathbf{MOC_R \;/\; MOC_F \;>\; 1 \,/\, KFUEL_F}$$

A Renewable energy investment commands a higher margin to reach the same profitability than a Fossil energy investment !!

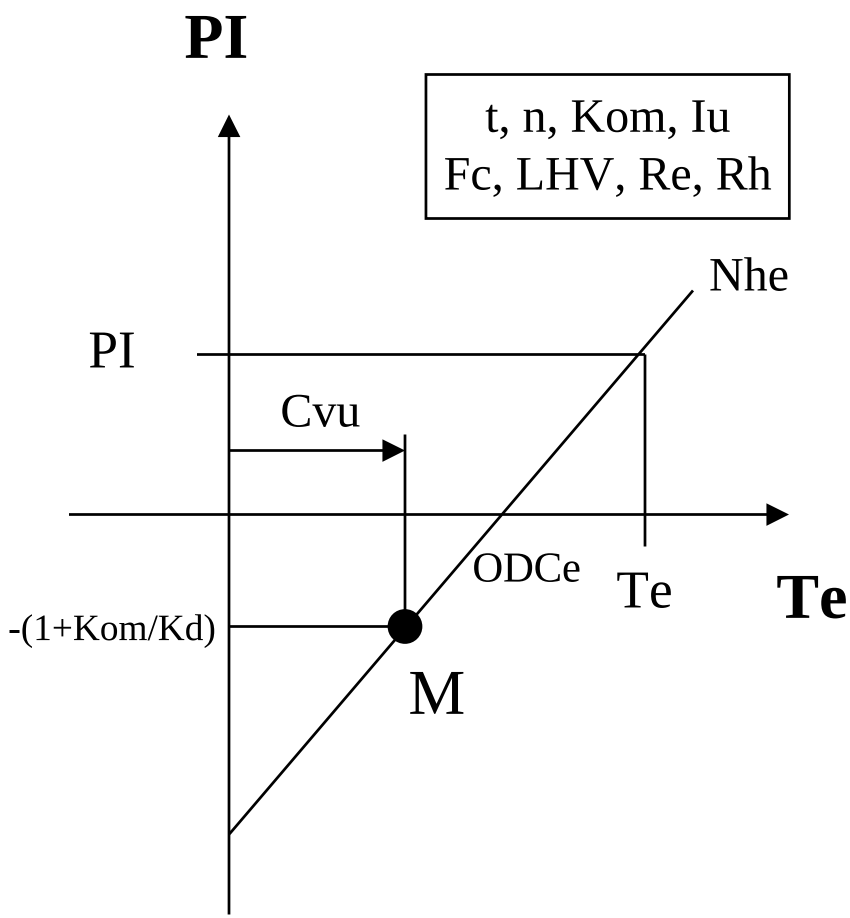
Method (4)

- **The « zero fuel cost RETs paradox » (wind, hydro, solar, geothermal based power plants) :**
  - ⇨(MOC*wind* / MOC*fossil*) = (cost / non fuel cost part)*fossil*
  - ⇨MOC wind = 2 times MOC coal = 3 times MOC nat. gas !
  - ⇨Minimum 10 % MOC from coal plants ==> PI = 0,3
- **Implies minimum PI value of 0.3 for wind projects (project IRR = 10% for t = 6 % and n = 15 years)**



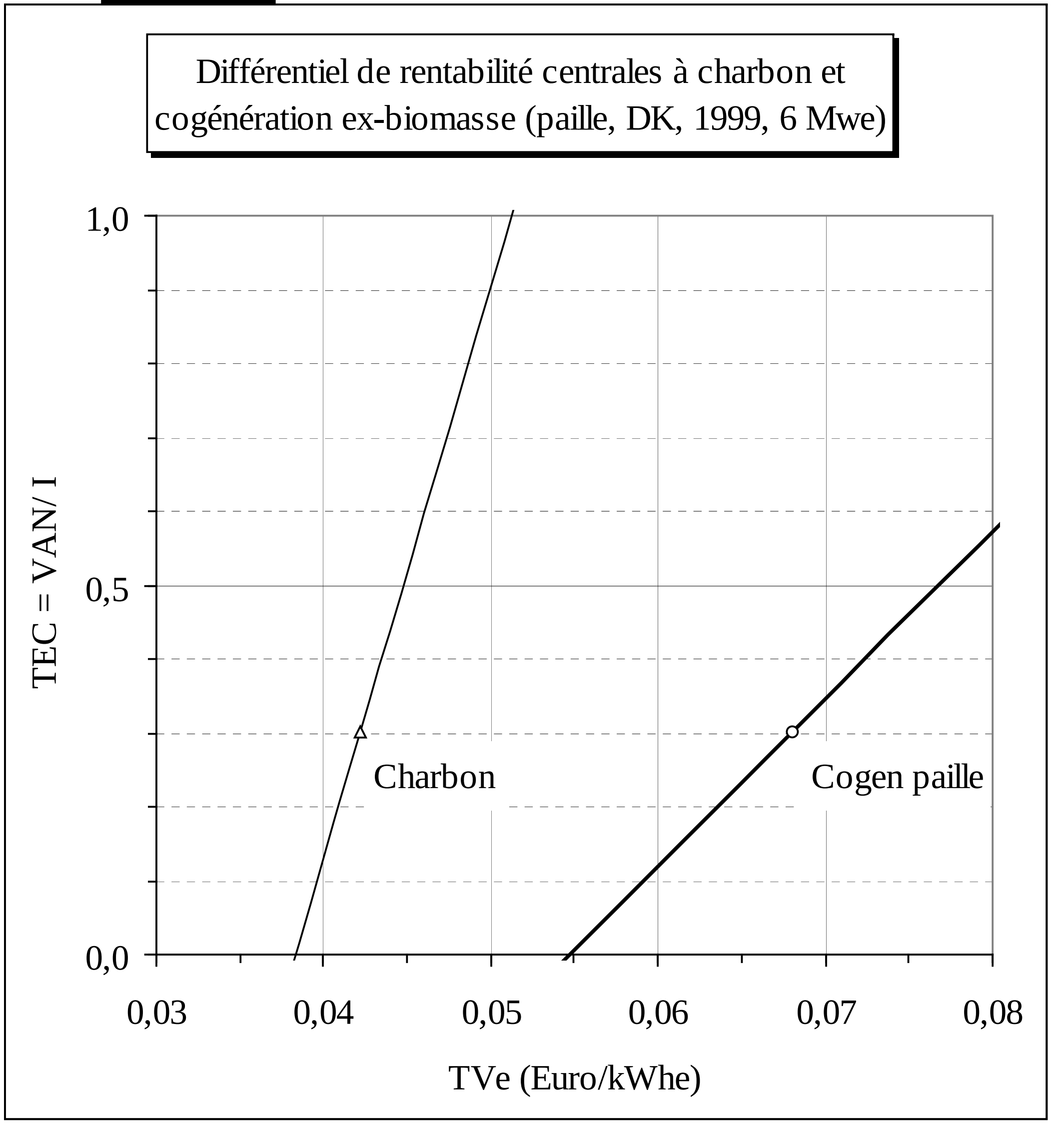
The model PI = f(electricity kWh tariff Te) for CHP

- **Data:**
  - ⇨Discounting: n, t = AWCC
  - ⇨Iu=I/Pe (EUR/kWe)
  - ⇨Nhe=ELa/Pe (hours/year)
  - ⇨Kom=Dom/I
  - ⇨Re=Ela/THI; Ela: annual electr. sold
  - ⇨THI = total yearly heat input from fuel
  - ⇨Rh=Heats/THI ; Heats: annual heat sold
  - ⇨Fc (EUR/kg, EUR/m3)
  - ⇨LHV (kWht/kg, kWht/m3)
  - ⇨TVh (F/kWht)
- **PI = a (TVe-Cvu) - b**
  - ⇨Cvu=(Fc/Re.LHV) - (Rc/Re)TVh
- **Tve= c Iu + Cvu**
  - ⇨c = (1+TEC)Ka(1-Si)+Kem(1-Se)/Nhe

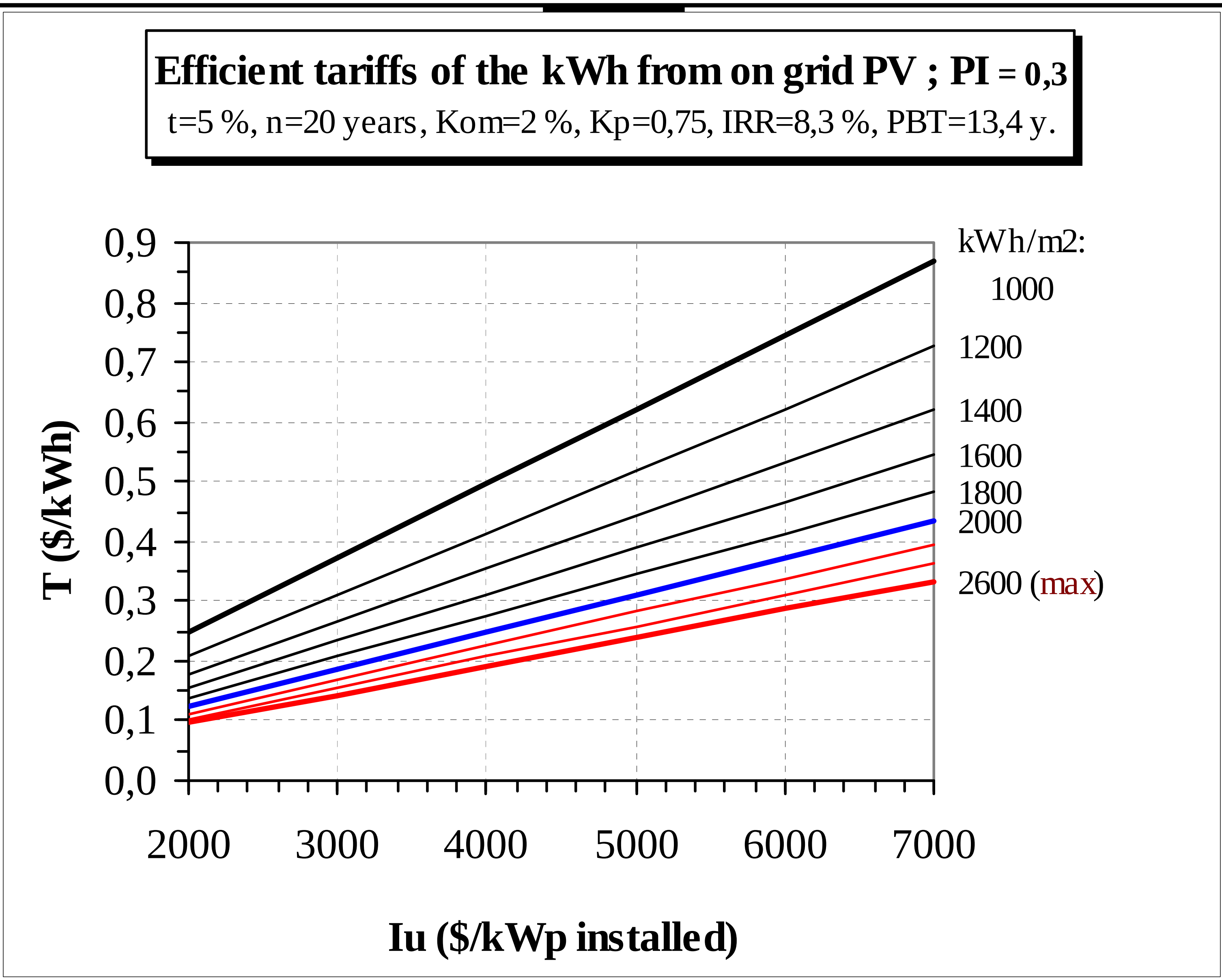


Example 1: comparing coal & CHP from biomass

- **Differences:**
  - ⇨costs: 1.7 c€/kWh
  - ⇨Tariffs 2,6 c€ (+50%)
- **Efficient Tariffs 6,8 c€ versus 4,2 (+62%)**
- **Tariffs Chp**
  - ⇨G: 8.7 to 10.2 c€
  - ⇨DK: bonus 1.3 to 4.6 cE/kWhe
  - ⇨Sp: 3 cE/kWhe



Example 2: efficient tariffs for commercial PV

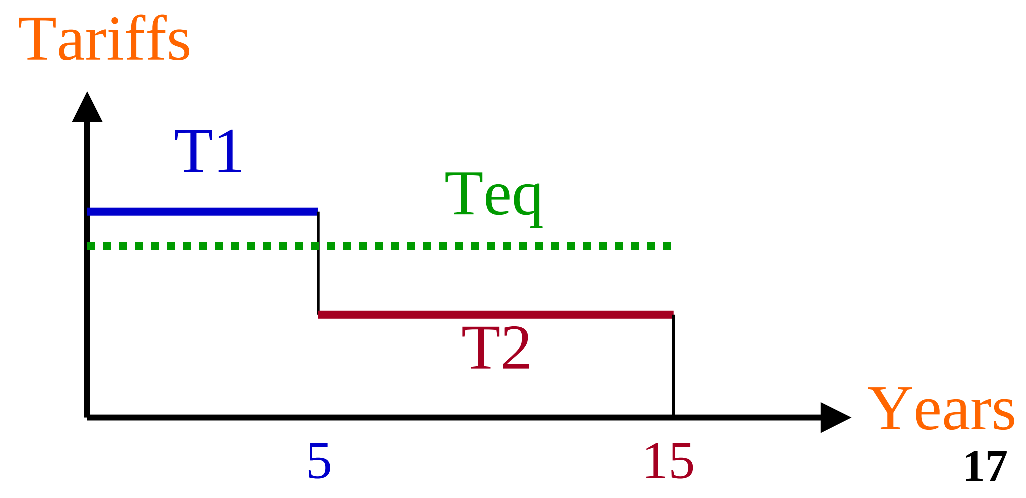


Example 3: “Advanced tariffs” for Wind Power

- **Taking into account return of experience and context:**
  - ⇨Competitive calls for tenders (e. g. “EOLE 2005”)
    - ➔Not enough efficient for new French Wind Energy goals: from 5 up to 11 GW installed in 2010 (within the EU RE electricity Directive)
    - ➔Feb. 2000 French electric law: the only solution for projects > 12 MW
  - ⇨Green certificates: not proven, not sufficient for 5 to 11 GW
  - ⇨“Fixed Tariffs”: past and ongoing successes (Dk, G, Sp...)
- **Basis: fair profitability for private investors:**
  - ⇨Minimum profitability for strong market growth, including on low quality sites largely available (from Nh = 2 000 h/y)
  - ⇨No undue profits on high quality sites: tariffs adapted to potential energy yields
  - ⇨Simple system, easy to define, to control and to adapt
  - ⇨Not state aid: charging the cost on all electricity consumers

Principles for Tariffs Definition and Calculation

- **Two successive tariffs levels (F: only for P < 12 MW):**
  - ⇨T1 fixed for all projects from years 1 to 5 (= German idea !)
  - ⇨T2 variable for projects from years 6 to 15 (diff. From Ger.)
  - ⇨T1 and T2 define a constant "equivalent tariff", Teq
  - ⇨Ref. Nhmin : PI=PImin => Teqmax=T2max =>T1= T2max
  - ⇨Ref. Nhmax : PI = PImax > PImin => T2min
- **For a specific project (P < 12 MW):**
  - ⇨Nh from average values years 1 to 5
  - ⇨T2: linear calculation
  - ⇨Teq from (T1, T2, t)
  - ⇨PI from Teq, Nh, Iu
- **Reference values:**
  - ⇨Iu=1067 EURO/kW
  - ⇨Kom = 4%, t=6.5%



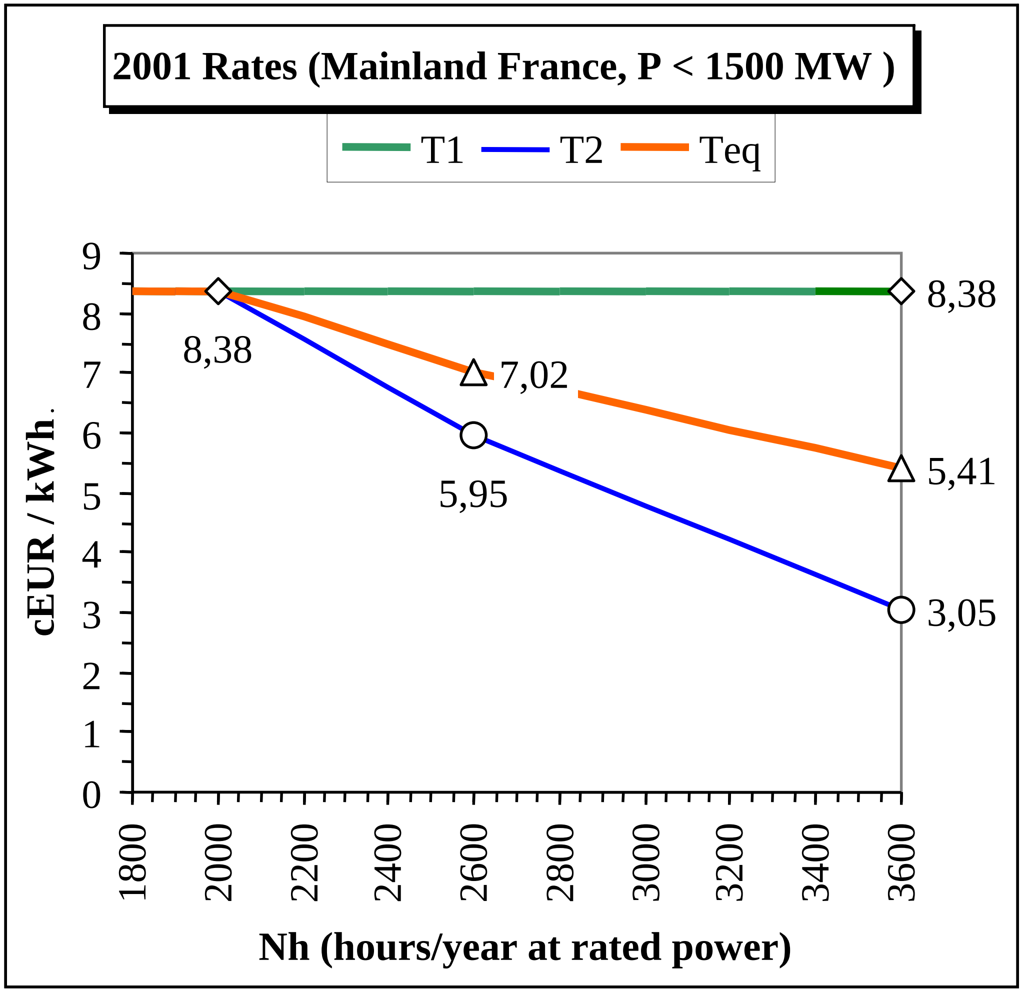
Other Principles and Final "Details"

- **Large diff. Nhmin-Nhmax ==> Nhint and two R2 lines**
- **protection of tariffs within a specific contract:**
  - ⇨ No perfect ==> decrease of profitability with inflation rate
- **Reference Nh value: average on 3 years (5 -worst-best)**
- **T2 values for years 6-10 & 11-15:**
  - ⇨ Less 25% for kWh beyond (Nhref x 5)
- **Provisional reference Iu decrease for next years:**
  - ⇨ -3.3 % per year from 2002 (current EUROS)
  - ⇨ Formula for correction from inflation from 2003+
- **Two sets for Nh reference values:**
  - ⇨ "Favourable" till sums of signed contracts is under 1.5 GW
  - ⇨ "Less favourable" after 1.5 GW of signed contracts

Results: June 8th 2001 Arrêté, 2001 Tariffs

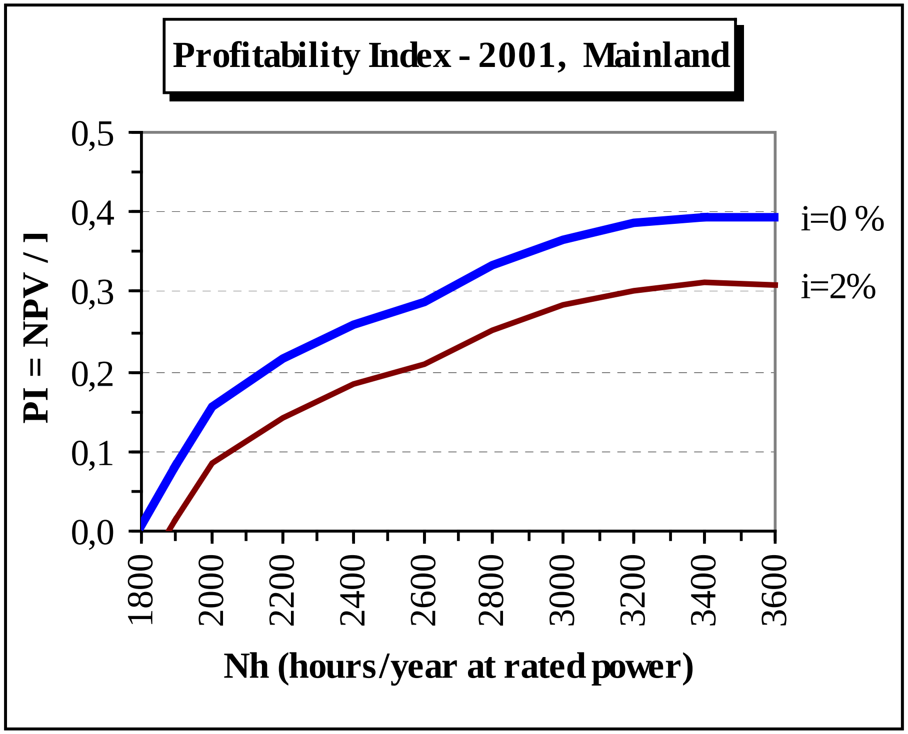
Reference values for 2001 tariffs					
Mainland France, projects < 12 MW					
	P (MW)	P (MW)	cEURO / kWh		
Nh:	<1500	>1500	T1	T2	Teq
Nhmin:	2000	1900	8,38	8,38	8,38
Nhint:	2600	2400	8,38	5,95	7,02
Nhmax:	3600	3300	8,38	3,05	5,41

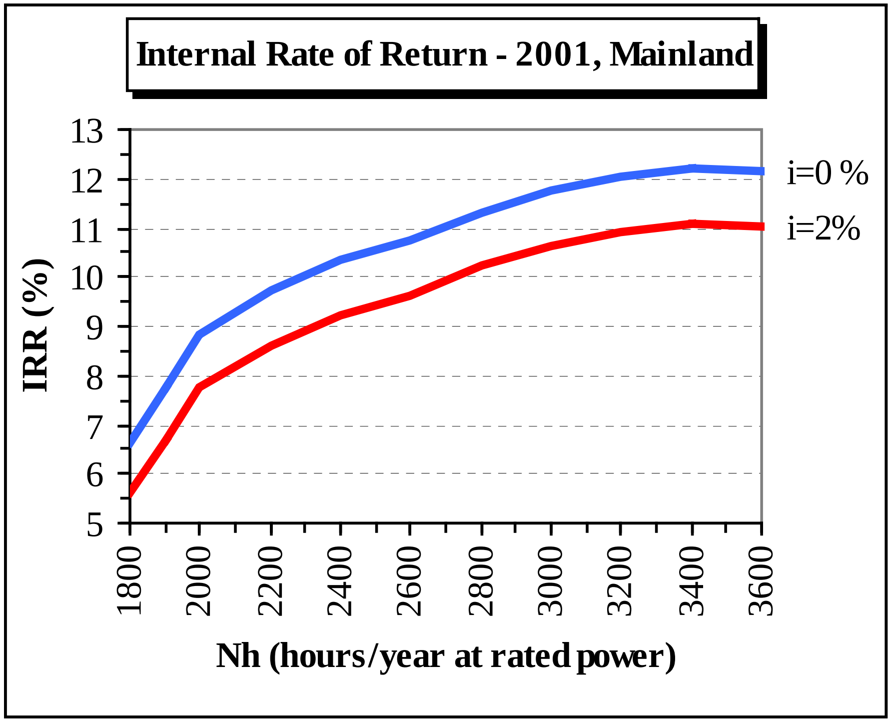
Corsica & Overseas Depart. projects <12 MW					
	P (MW)	P (MW)	cEURO / kWh		
Nh:	<1500	>1500	T1	T2	Teq
Nhmin:	2050		9,15	9,15	9,15
Nhint:	2400		9,15	7,47	8,21
Nhmax:	3300		9,15	4,57	6,59



- **Hypothesis for Teq:**
  - ➩Real discount rate t = 6.5%
  - ➩n = 15 years

Results: 2001 projects profitability (Mainland)





❑ **Reference case (<u>P < 12 MW per project</u>):**

⇨Iu=1067 EUR/kW. Value at year 16: 15% of initial invest.

⇨Yearly O&M expenses: Kom = 4 % of initial investment

⇨Mean inflation rate 2001 - 2015: i = 0% or i = 2 % / year

Adaptation, Control, Monitoring

- **Possibility to easily adapt reference values:**
  - ⇨From wind atlas and GW goals:
    - ➔Nh min, Nh max: minimum and maximum quality of sites
  - ⇨From economic and fiscal context:
    - ➔PI min and PI max (increased profitability with energy yield)
  - ⇨e. g. in France: Corsica and overseas departments
- **Control: is “fraud” on Nh on years 1-5 profitable ??**
  - ⇨Increase of profitability with Nh: incentive to good yields
  - ⇨Discounting: advantages to first years cash-flows (CFs)
  - ⇨Maximum debt years 1 to 5-7: need to maximise first CFs
- **Monitoring:**
  - ⇨Actual Iu, Kom, Nh (versus Ws), economic profitability

Potential Consequences

- **Potential consequences:**
  - ⇨7 to 10 GW in 2010 (compared to 3 GW goal in jan. 2000)
  - ⇨Easier to achieve than with only competitive calls for tenders and/or green certificates (not excluded for P>12 MW)
  - ⇨Attention to be given to projects planning, grid connection, public acceptance, "popular involvement" in wind projects
- **P > 12 MW: future calls for tenders from CRE (12/2003)**
- **Over-cost estimation for a 9 GW goal:**
  - ⇨Charged over all electricity consumers (contribution to a specific fund for all electricity public services charges)
  - ⇨For 9 GW in 1/1/2010 (total 2001-2025: 325 TWh)
    - ➔Total < 5 bEUR (discount rate: 5%, avoided cost 4,1 cEURO/kWh)
    - ➔Maximum in 2017: < 1cF/kWh (<0.15 cEURO/kWh)

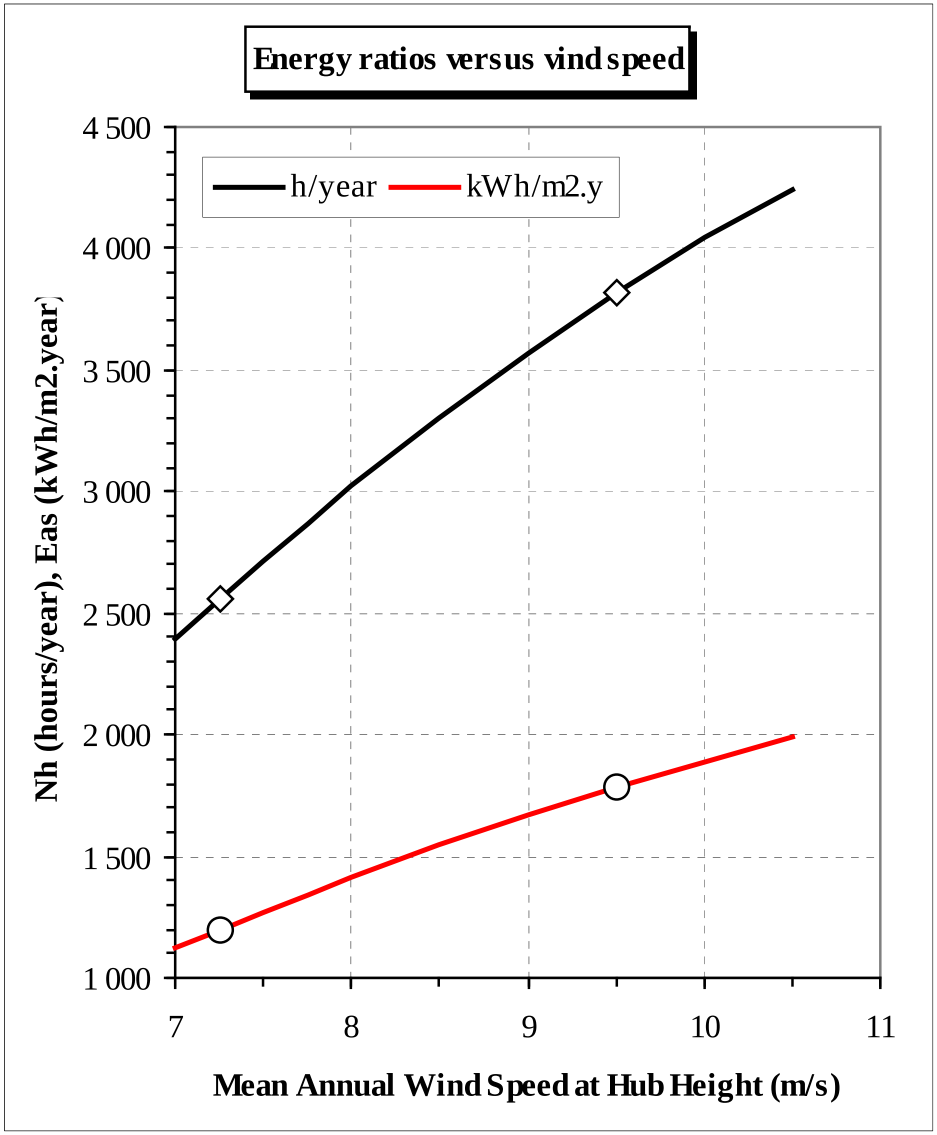
Adapting the French Wind Power Tariff System

- **Some Improvements are possible:**
  - ⇨Replace the energy yield ratio *Nh* (kWh/kW.year) by *Eas* (kWh/m2.year)
    - ➔See the rationale in the Chabot-Kellet-Saulnier paper at Global Wind Power Conference, Paris, April 2002
    - ➔Gives less "temptations" to "manipulate" the P/S ratio of the wind turbines
  - ⇨Avoid the sharp step from "favourable conditions before 1,5 GW of contracts" to "less favourable ones after 1,5 GW"
  - ⇨Get a better protection of the tariff within a contract from the effect of inflation (eg 80% of the tariff protected instead of only 60 % in France or 0 % in Germany)
- **Case studies in the case of an "European Windy Country": Ireland**

The ADEME / SEI "Kinsale 2002 Tariffs" test

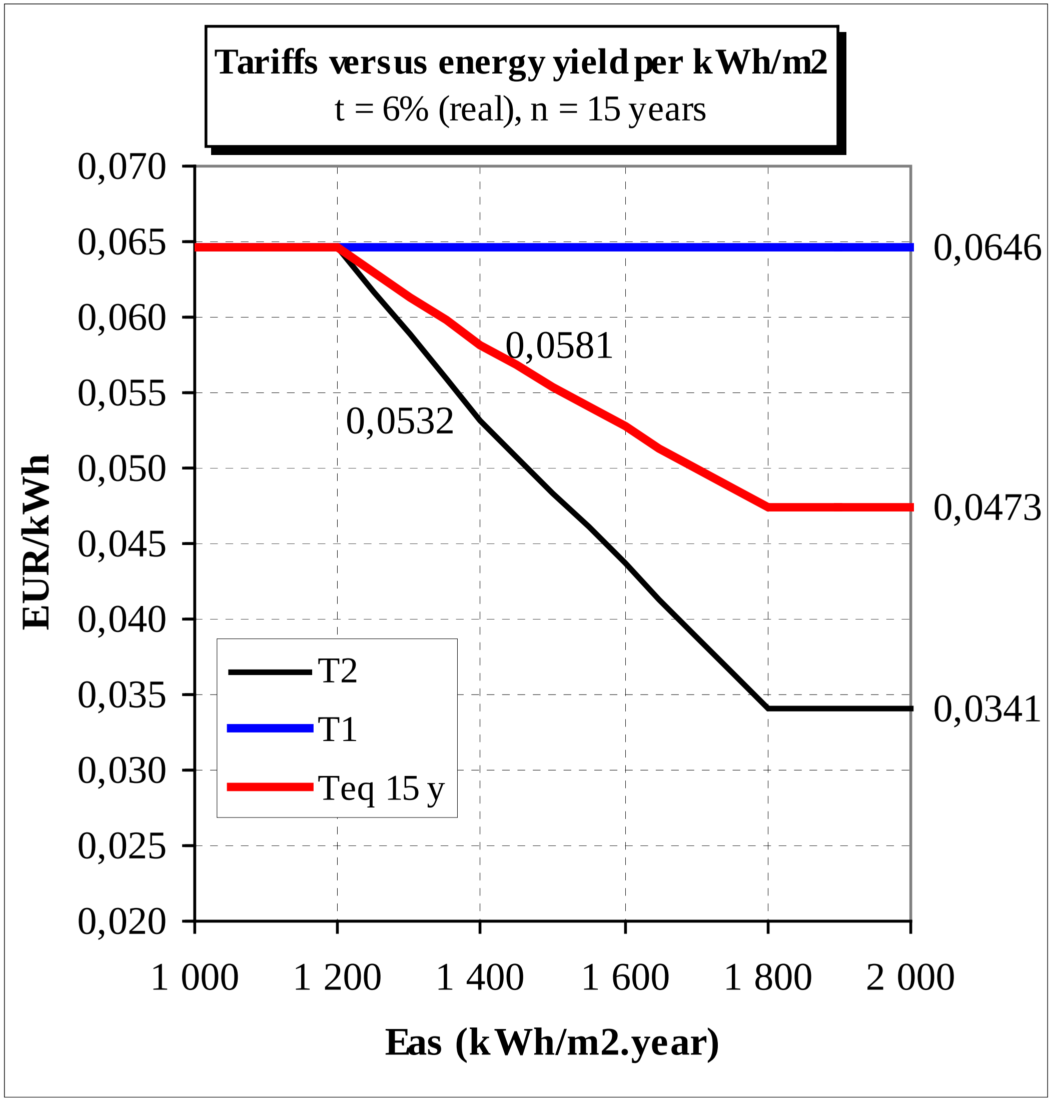
- **Not "The solution", <u>only an illustration of the method</u>**
- **Based on the *Eas* energy yield (kWh/m2.year)**
  - ⇨*Eas min* = 1200 kWh/m2.y (around 7.3 m/s at hub height, equivalent to *Nh* = 2600 h/y for a 460 W/m2 wind turbine, or equivalent to an average annual capacity factor *ACF* = 30 %)
  - ⇨*Eas max* = 1800 kWh/m2.y (around 9.5 m/s at hub height, equivalent to *Nh* = 3600 h/y or *ACF* = 41 %)
  - ⇨An intermediate *Eas* = 1400 kWh/m2.year (*Nh* = 3000 h/y)
- **Calculation based on:**
  - ⇨Real averaged weighted cost of capital = discount rate *t* = 6 %
  - ⇨Purchase contracts on *n1* = 15 years or *n2* = 20 years
  - ⇨Investment cost ratio: *Ius* = 468 EUR/m2 of swept area (*Iup* = 1000 EUR/kW for a WT with *Ps* = 468 W/m2)
  - ⇨O&M expenses ratio: *Kom* = 4 % of investment, per year

Example of energy yields versus wind speed



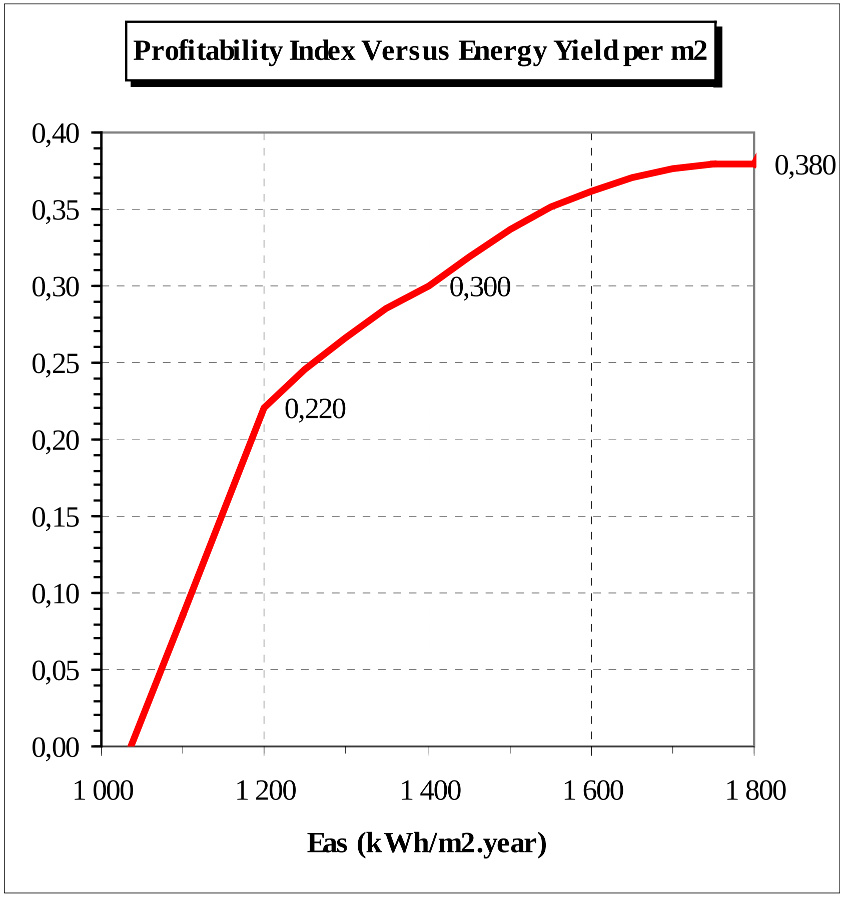
Results for purchase contracts on 15 years

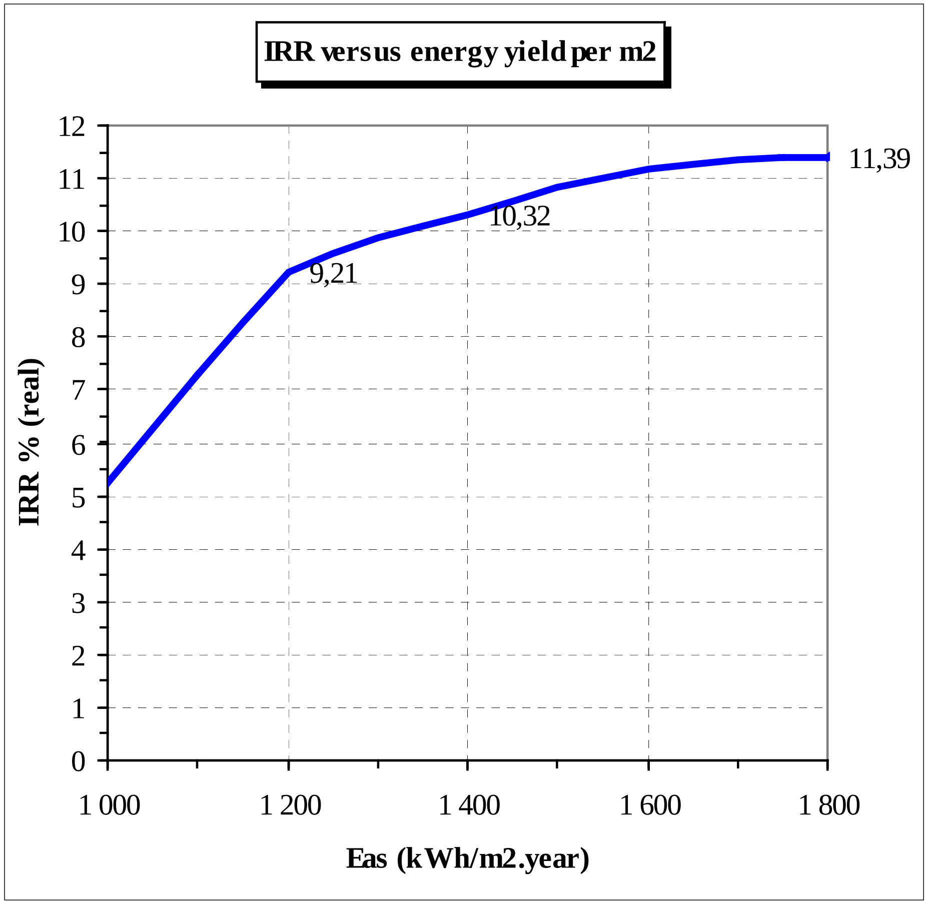
- **T1 from year 1 to 5**
- **T2 from year 6 to 15**
- **Teq calculated from**
  - ⇨T1,
  - ⇨T2
  - ⇨t (AWCC, different for each investor, here t = 6%)
- **For Eas < or = 1200: T1=T2=Teq**



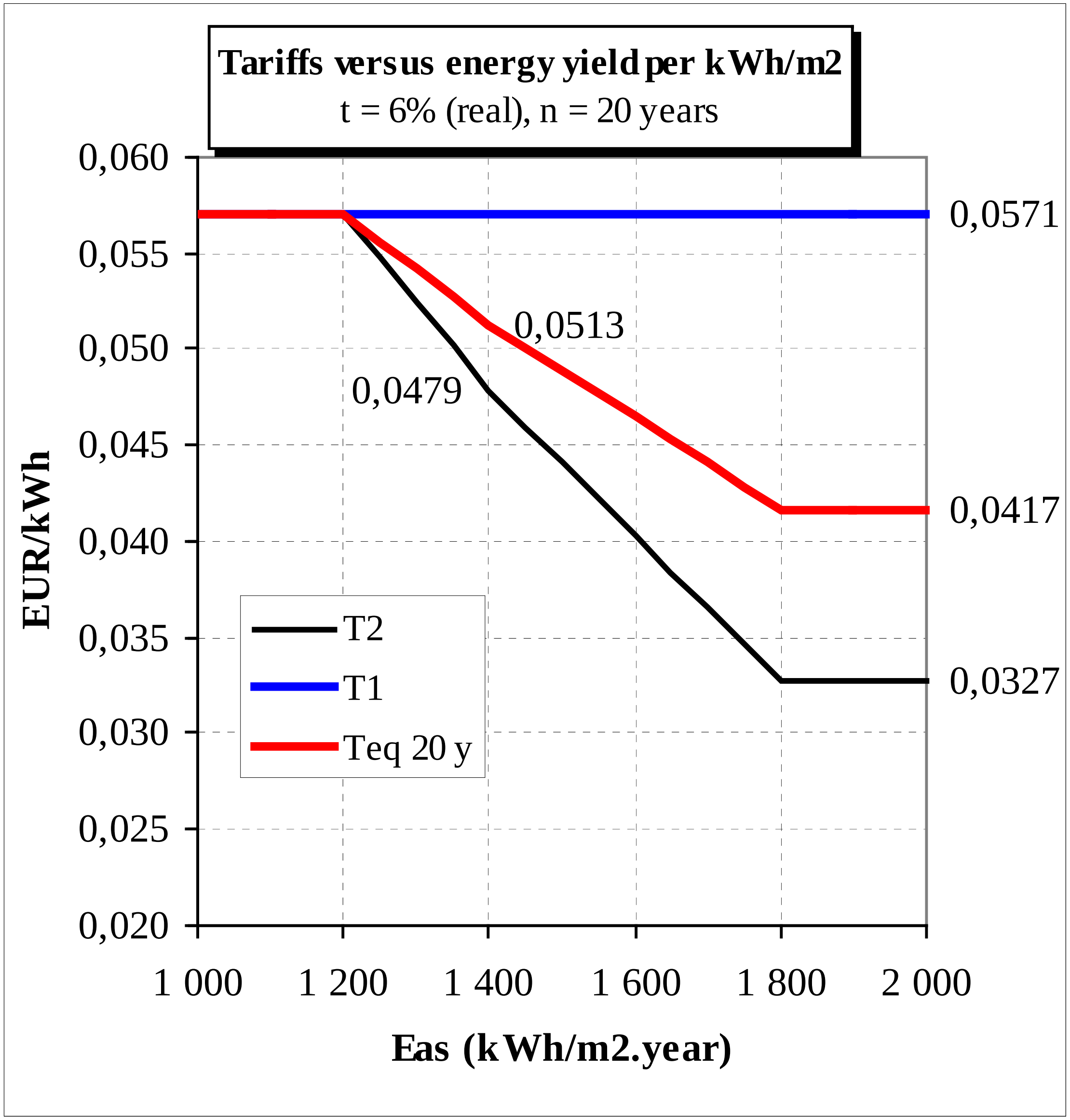
Profitability results for 15 years contracts

- Profitability increases with Eas (to lower over-costs)
- PI from 0.22 to 0.38 ; IRR from 9.2% to 11.4 %



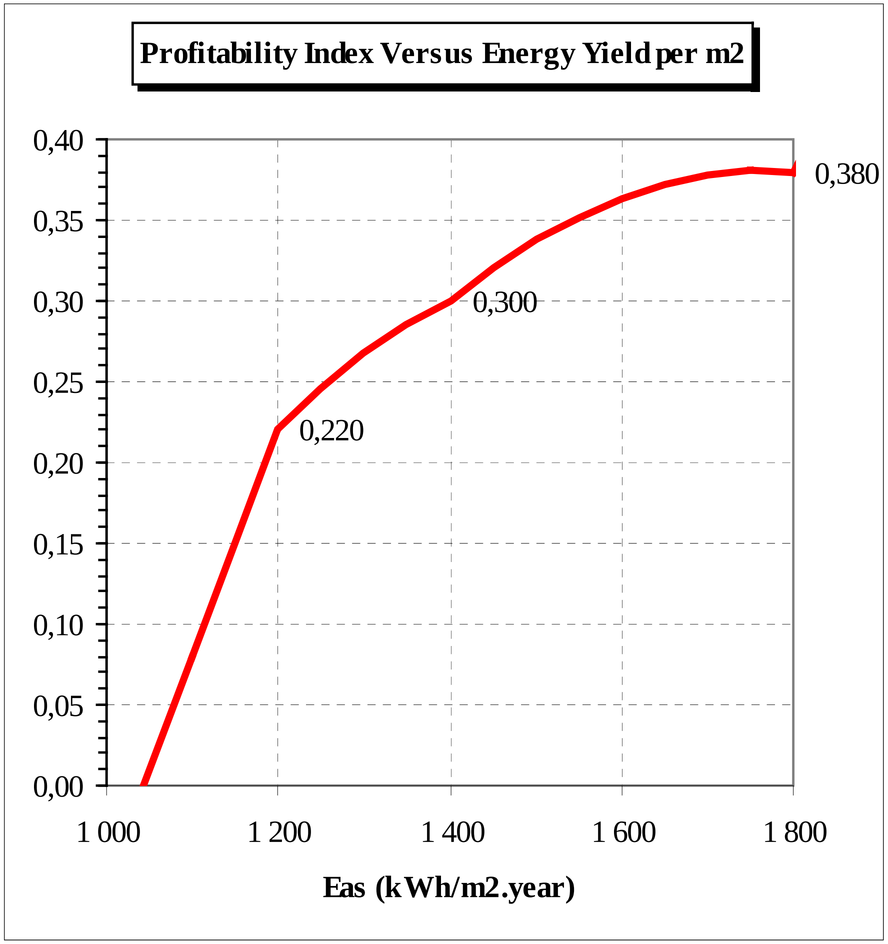


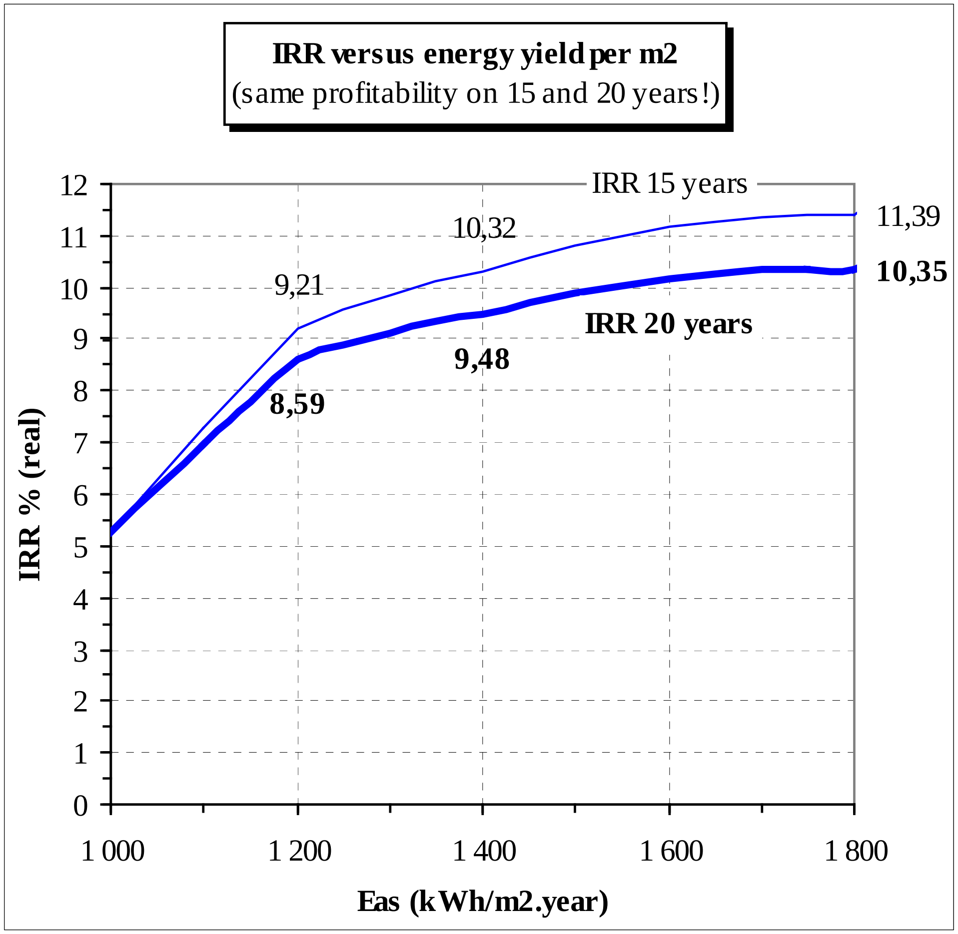
Results for purchase contracts on 20 years



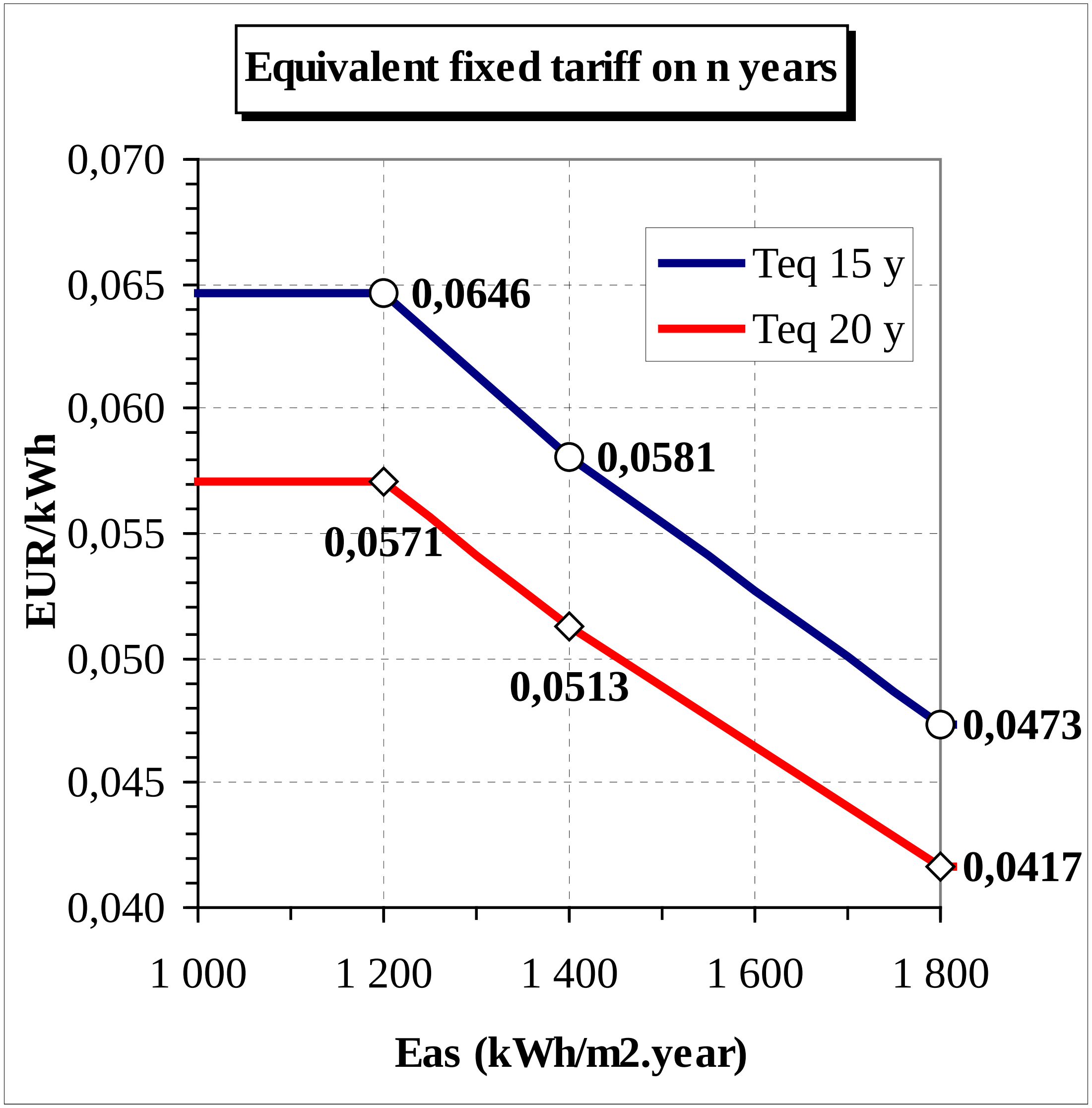
Profitability results for 20 years contracts

❑ **Same hypothesis for PI values ==> <u>same profitability</u>**





Comparison of tariffs on 15 or on 20 years



Synthesis of numerical values

- **Values are for Iu = 1000 EUR/kW, t = 6 %, Kom 4%**
- **To be tested with precise Irish data (*t*, *Iu*, *Kom* values) !**

Reference energy yield				**Tariffs for contracts on 15 years (cEUR/kWh)**				
V	**Eas**	**Nh**	**Fc**	**T1**	**T2**	***Teq***	**PI**	**IRR**
m/s	kWh/m2.y	h/year	%	cEUR	cEUR	cEUR		%
app 7,3	**1200**	2600	30%	**6,46**	6,46	*6,46*	0,22	9,2
app 8	**1400**	3000	34%	6,46	**5,32**	*5,81*	0,3	10,3
app 9,5	**1800**	3600	41%	6,46	**3,41**	*4,73*	0,38	11,4

Reference energy yield			**Tariffs for contracts on 20 years (cEUR/kWh)**				
	Eas		**T1**	**T2**	***Teq***	**PI**	**IRR**
	kWh/m2.y		cEUR	cEUR	cEUR		%
	1200		**5,71**	5,71	*5,71*	0,22	8,6
	1400		5,71	**4,79**	*5,13*	0,3	9,5
	1800		5,71	**3,27**	*4,17*	0,38	10,4

Conclusions

- **Defining a fair and efficient tariff system was possible**
  - ⇨Taking into account other “success stories” (Dk, G, Sp)
  - ⇨Within a deregulated electricity market ("advanced tariffs")
- **The Profitability Index Method gives:**
  - ⇨A rational basis for minimum values of profitability
  - ⇨Simple formulas to define, monitor, adapt the tariff system
- **Positive market answer in France after 2001wind tariffs**
  - ⇨14 GW of files (P < 12 MW), 7 to 10 to be built before 2010
  - ⇨Over-cost should not be over the ones from 7 to 10 GW by other ways
- **Light case study for the Irish wind context shows that:**
  - ⇨Adaptation of advanced tariffs systems is easy
  - ⇨Due to good winds, tariffs should be lower than in Germany & France
- **Ademe is open to collaborate with other EU RE agencies**
  - ⇨Exchange of information and experience
  - ⇨Also in view of the EC report on best regulation for RE dissemination