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Renewable Energy Tariffs Price-Setting from the Profitability Index Method

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I

Market regulation For renewables



Market regulations in favour of Renewables

<i>Sea based RE for power</i>	Regul. From prices	Regul. from quantities
Targeted on initial Investment	Subsidies Fiscal incentives Soft loans	Calls for tenders
Targeted on Production	Environnemental bonus Simple guaranteed tariffs Advanced tariffs systems	Quotas + green certificates or + carbon credits + derivative markets

Source: adapted from Menanteau & alii "How to promote RES successfully & effectively", Energy Policy, vol 32/6, 20

- ❑ **Success from regulation from prices : Germany, Spain, France, Portugal...**
- ❑ **Advantages of regulation from quantities are not yet demonstrated, and price for consumer are higher: wind UK > 10 c€/kWh, Italy > 15 c€/kWh vs 7 to 9 G, Sp, F, Portugal**



Two main options to regulate market for RES

□ Regulation by quantities

- ⇒ Quotas + competitive calls for tenders (eg: UK, France, Ir)
- ⇒ Quotas verified from RECs in % of consumption (or sales) + penalties in case of no compliance (UK, Be, It)

□ Regulation by prices

- ⇒ "Fixed prices" (eg wind power in Dk & Germany in the 90's)
- ⇒ "Environ. premiums" over the annual avoided cost (Spain)
- ⇒ "**ADVANCED TARIFFS**" (eg wind in Germany, France, Portugal)
 - ☆ Defined for each technology
 - ☆ Defined for each project, e. g. if variable average wind speed in diff. sites
 - ☆ 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 may decrease each year to take into account costs decrease



II

Introduction to the Profitability Index Method



The context to apply the PI method

- ❑ **A global economic analysis for preliminary studies**
- ❑ **Constant inflation, results in constant money of year 0**
- ❑ **Constant mean yearly Cash-flows :**
 - ⇒ Defines the « references cases »
 - ⇒ By extension following cases are also relevant :
 - ☆ Cash-flows parameters varying by x%/year above or under inflation rate
 - ☆ Cash-flows parameters varying by steps (e.g. wind tariffs T1, T2)
 - ☆ Variable cash – flows (replaced by the **equivalent constant cash-flow**)
- ❑ **Links with other methods :**
 - ⇒ Direct access from PI to IRR (Internal rate of Return), 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



III

The linear and universal model: Profitability Index versus Tariff



The model $PI = NPV / I = f(\text{tariff } T)$

- ❑ **NPV = (-I + Sum of discounted economic CFs before tax on profit in constant \$ of year 0, from year 1 to n)**
- ❑ **Discounted CF of year j = $CF_j / (1+t)^j$**
- ❑ **For constant Cash-Flow CF from years 1 to n:**
 - ⇒ Sum of discount. CFs = $CF / CRF(t,n)$, with $CRF = t / (1-(1+t)^{-n})$
- ❑ **Variable CFs can be replaced by the « constant equivalent CF » which gives the same economic profitability than the n variable CFs**
- ❑ **By definition: Profitability Index = $PI = NPV / I$**
- ❑ **PI results from tariff T by a linear relationship :**
 - ⇒ $PI = a (T - C_{vu}) - b$
 - ⇒ Where a and b are defined by project ratios (costs, energy yield)
 - ⇒ And C_{vu} is the variable cost due to fuel cost
 - ⇒ So C_{vu} is zero for hydro, wind, solar, geothermal power plants



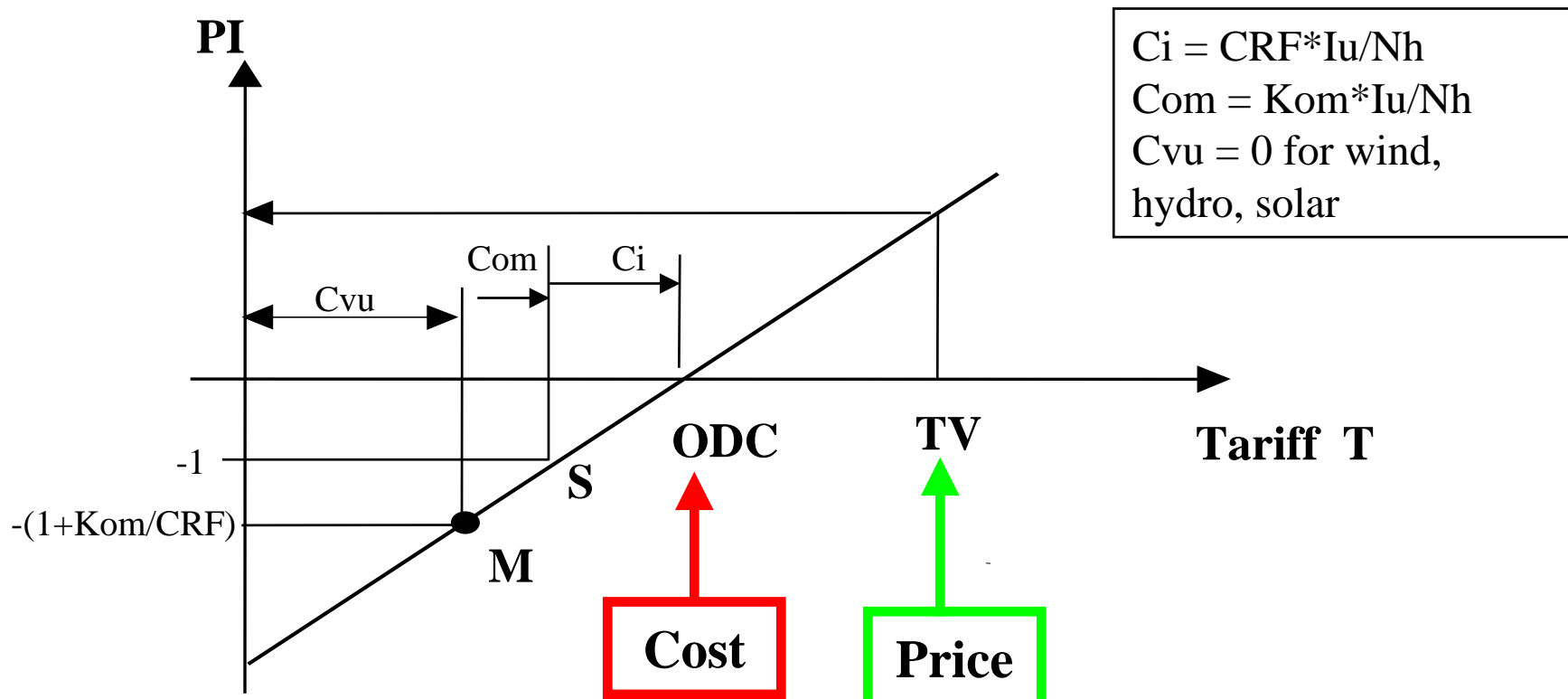
The model $PI = f(\text{tariff } T)$ (2)

⇒ Gives access to the universal linear diagram : PI versus tariff T

$$\Rightarrow PI = aT - b = (Nh / CRF \cdot I_u)(T - C_{vu}) - (1 + K_{om} / CRF)$$

☆ With : $T = \text{kWh tariff}$; $I_u = I / P$, $N_h = E_a / P$, $K_{om} = D_{om} / I$, $CRF = t / (1 - (1+t)^{-n})$,
 $C_{vu} = \text{variable part of the kWh cost} = 0$ for renewables, except biomass

☆ Where $I = \text{initial investment cost}$; $P = \text{rated power}$; $E_a = \text{annual energy sold}$; $D_{om} = \text{annual O\&M expenses}$, $t = \text{discount rate (AWCC)}$; $n = \text{years of operation}$





The model $PI = f(\text{tariff TV})$ (3)

⇒ Gives access to the direct link between PI and the Margin On Cost

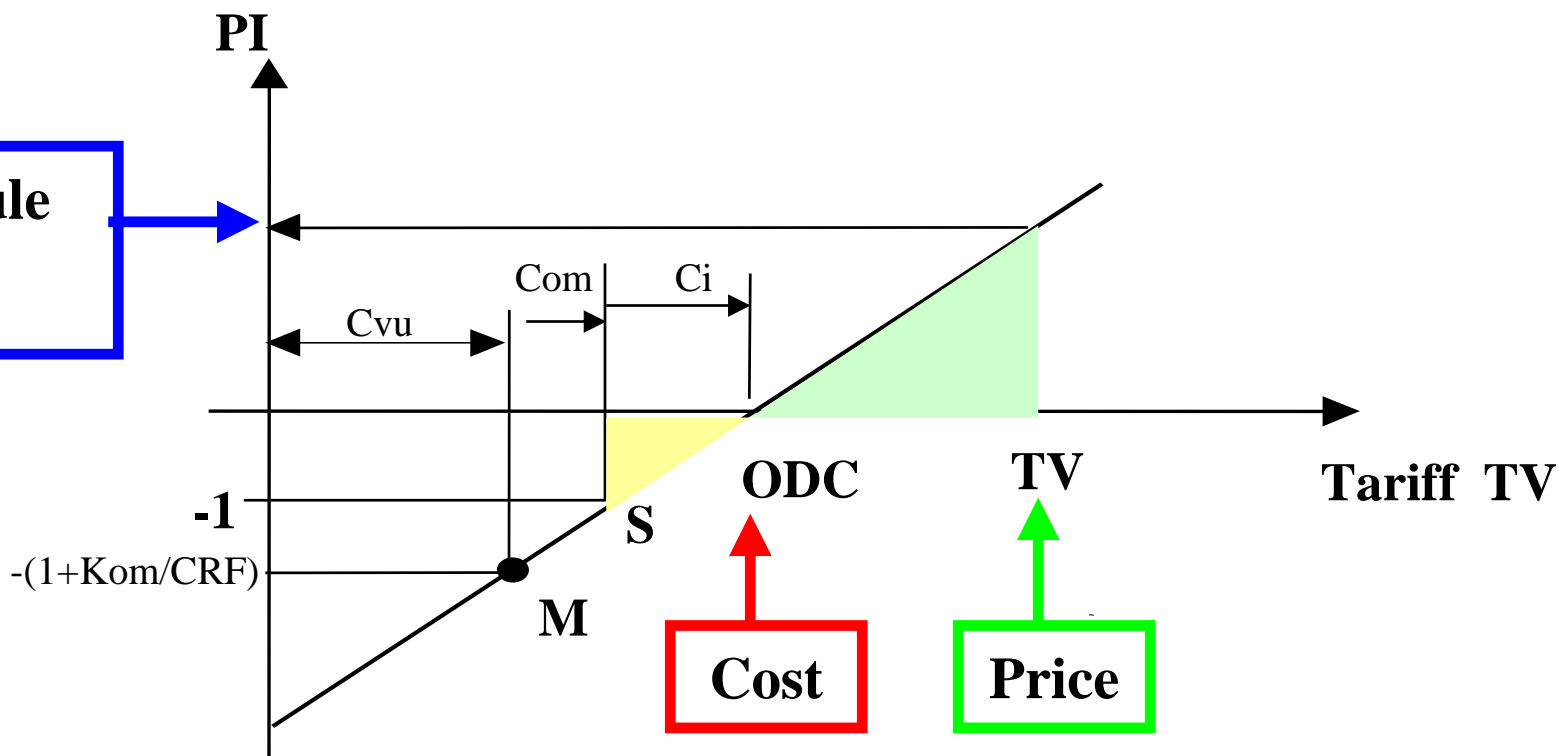
$$MOC = (\text{Price} - \text{Cost}) / \text{Cost} = (TV - ODC) / ODC :$$

⇒ From our Thalès colleague, from the green and yellow triangles:

☆ $PI / 1 = (TV - ODC) / Ci \implies TV = ODC + PI * Ci \implies$ basic role of Ci

☆ $PI = MOC / (Ci/ODC) \implies MOC = (Ci/ODC) * PI \implies$ basic role of Ci/CGA

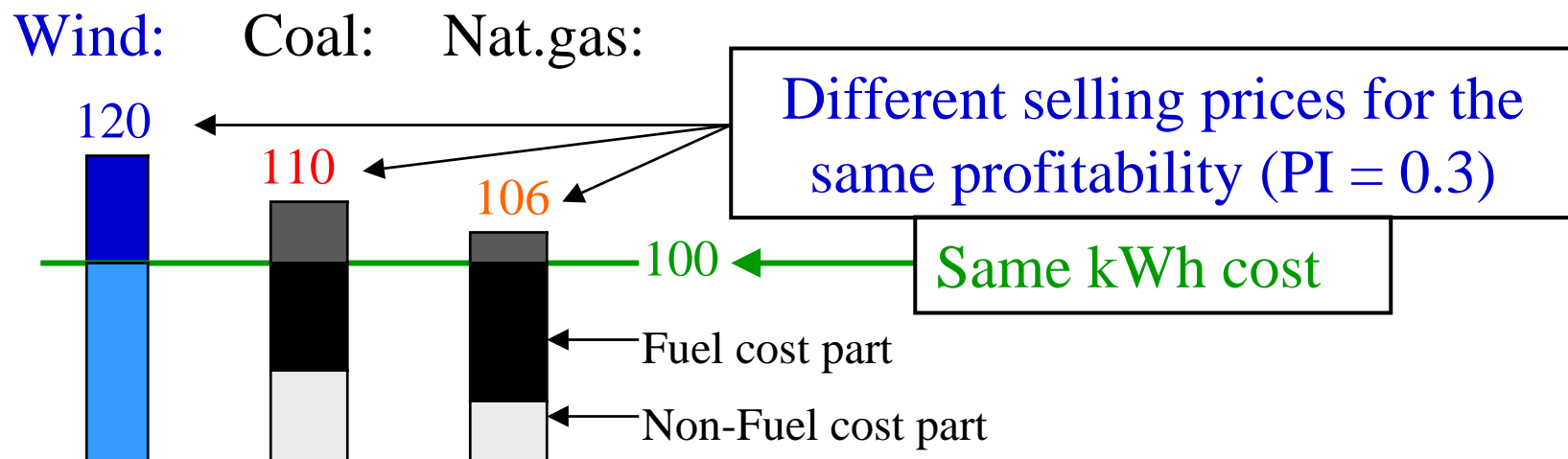
Golden rule
 $PI > 0,3$





The link: $PI = k.MOC$ (2)

- ❑ The « zero fuel cost RETs paradox » (wind, hydro, solar, geothermal based power plants) :
 - ⇒ $(MOC_{wind} / MOC_{fossil}) = (\text{cost} / \text{non fuel cost part})_{fossil}$
 - ⇒ $MOC_{wind} = 2 \text{ times } MOC_{coal} = 3 \text{ times } MOC_{nat. gas} !$
 - ⇒ Minimum 10 % MOC from coal plants $\implies PI = 0,3$
- ❑ Implies also minimum PI value of 0.3 for RE projects





Comparing criteria PI, IRR, DPBT

- ❑ **IRR, DPBT: values of t and n for which project NPV = 0**
- ❑ **Profitability if: $IRR > AWCC = t$, and if $DPBT < n$**
- ❑ **simple $PBT = I / CF \Rightarrow$ Profitability if $SPBT < 1 / CRF$**
- ❑ **Limits and actual and potential problems (IRR & PBTs):**
 - \Rightarrow Criteria not proportional to profitability in \$ of NPV
 - \Rightarrow No fixed and universal "zero point" for profitability = 0
 - \Rightarrow No direct access to the project NPV
 - \Rightarrow No possible use with simple formulas
- ❑ **Versus advantages of the PI criteria:**
 - \Rightarrow PI is proportional to the profitability in \$ (NPV)
 - \Rightarrow Logical starting point: $PI = 0$ for profitability zero
 - \Rightarrow Direct access to the NPV (from the definition: $NPV = PI \cdot I$)
 - \Rightarrow Direct explicit formula possible using PI (like $^{\circ}K$ versus $^{\circ}C$!)



From efficient PI value to IRR and PBT rational values

- **Link PI \Leftrightarrow IRR (Internal Rate of Return of the project):**

 - ⇒ $CRF(IRR, n) = (1 + PI).CRF(t, n)$;
 - ⇒ with $(1+PI) = \text{Benefit / Cost Ratio}$
 - ⇒ $\rightarrow NPV = I * PI = I * \{ [CRF(TRI, n) / CRF(t, n)] - 1 \}$
- **Link PI \Leftrightarrow DPBT (Discounted Pay-Back Time):**

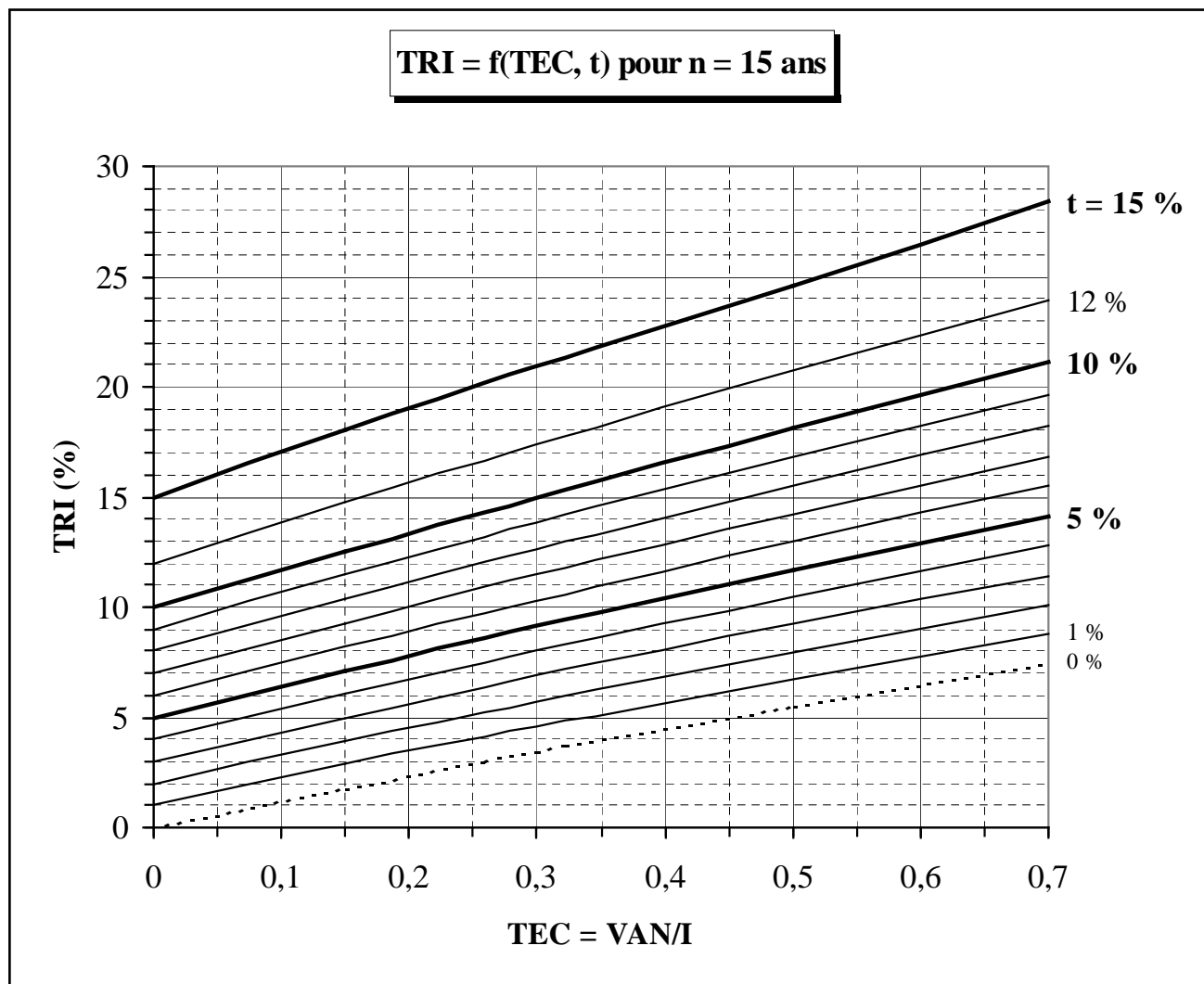
 - ⇒ $CRF(t, DPBT) = (1 + PI).CRF(t, n)$
- **Link PI \Leftrightarrow SPBT (Simple Pay-Back Time) :**

 - ⇒ $SPBT = 1 / (1 + PI).CRF(t, n) = 1 / CRF(t, DPBT) = 1 / CRF(IRR, n)$
- **See following graphs and examples**



Links PI / IRR for n = 15 years

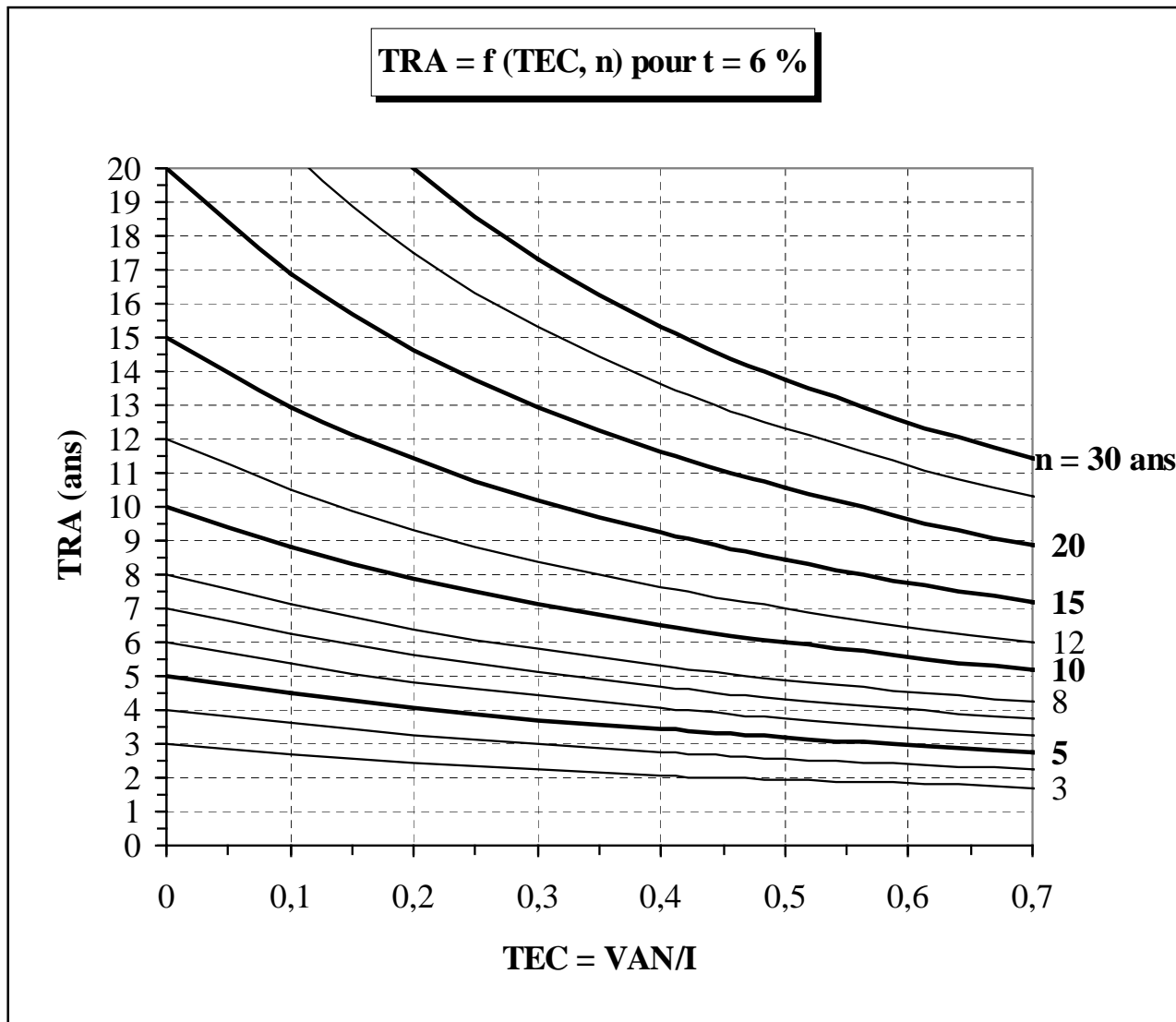
- Ex: $t = 6\%$: 100 % PI variation from 0.15 to 0.3 : IRR vary only from 8 to 10.3 %





Link PI / discounted PBT for $t = 6\%$

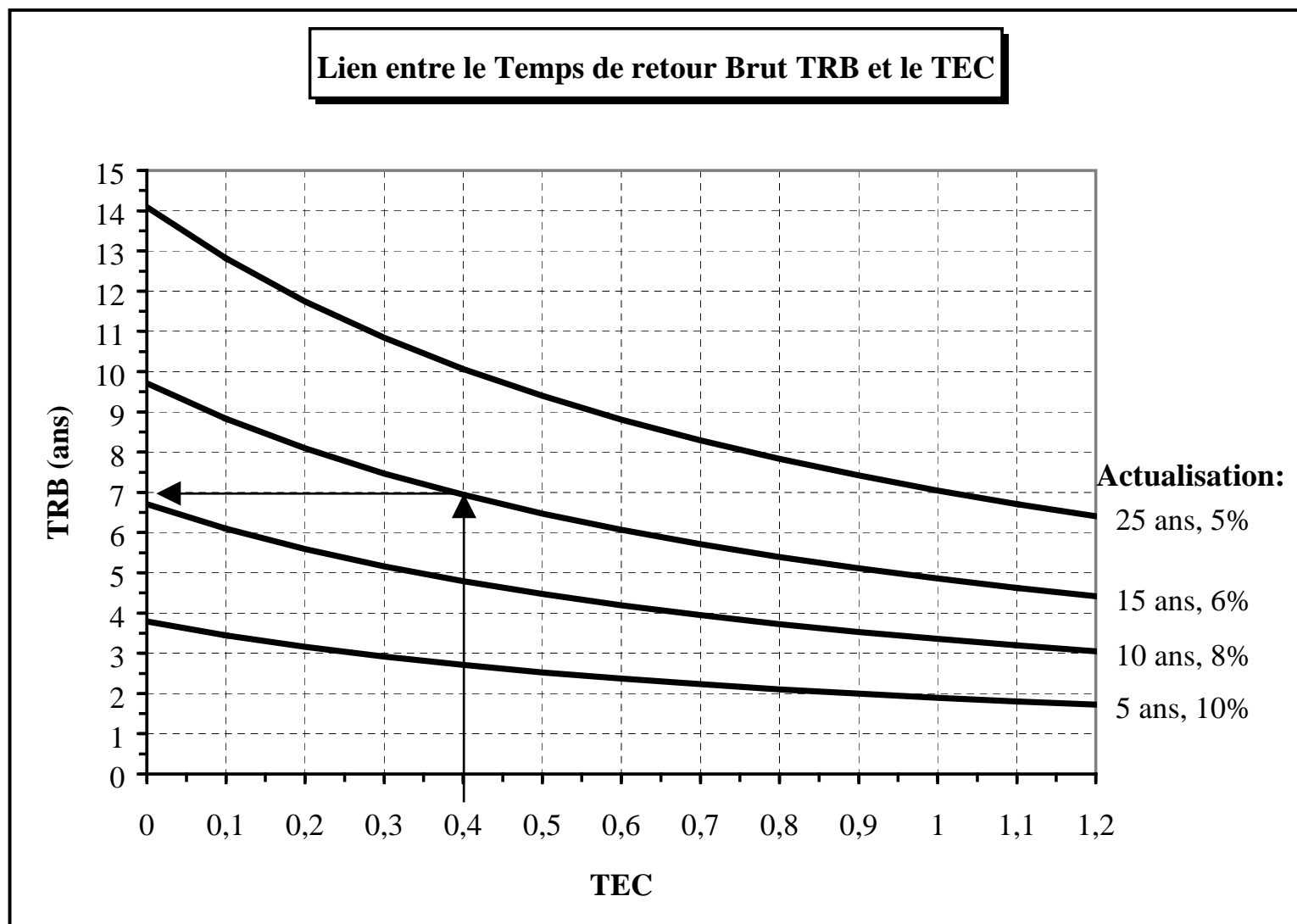
- Ex: $n = 15$ years: 100 % PI variation from 0.15 to 0.3 : PBT vary only from 8.2 to 7 years !





Links PI / simple PBT

- Ex1 : 15 years 6 %: sPBT vary from 8 to 7 years ==> PI and NPV divided by 2 !





IV

Case study of an advanced tariff: The 2001 French Wind Power Tariff System



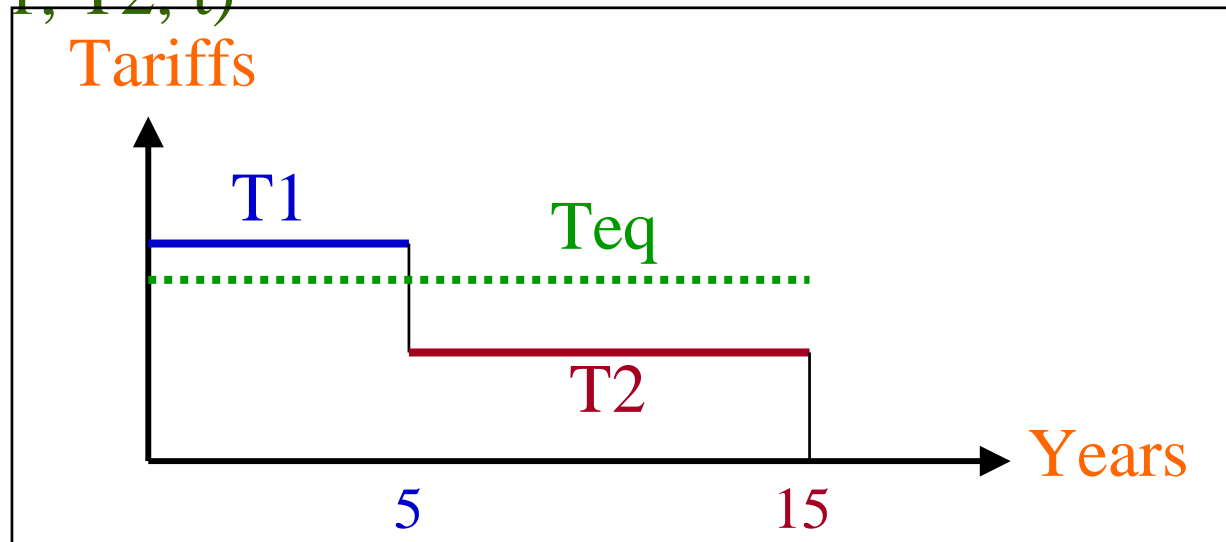
The French advanced wind tariff sytem

□ Two successive tariffs levels :

- ⇒ T1 fixed for all projects from years 1 to 5 (= German idea !)
- ⇒ T2 variable for projects from years 6 to 15 (diff. from Germ.)
- ⇒ T1 and T2 define a virtual constant “equivalent tariff”, T_{eq}

□ For a specific project :

- ⇒ N_h = averaged E_y / P from values years 1 to 5 (hours/year)
- ⇒ T2: linear calculation from values at $N_{hr} = 2000, 2600, 3600$
- ⇒ T_{eq} from $(T1, T2, t)$





Tariffs: Other Principles and Final ‘Details’

- ❑ **Indexation for tariffs within a specific contract:**
 - ⇒ Only 60% ==> decrease of profitability with inflation rate
- ❑ **Provisional tariffs decrease for next years:**
 - ⇒ -3.3 % per year from 2003 (current EUROS)
 - ⇒ Formula for correction from inflation from 2003+
- ❑ **Reference Nh value: average on 3 years (5 -worst-best)**



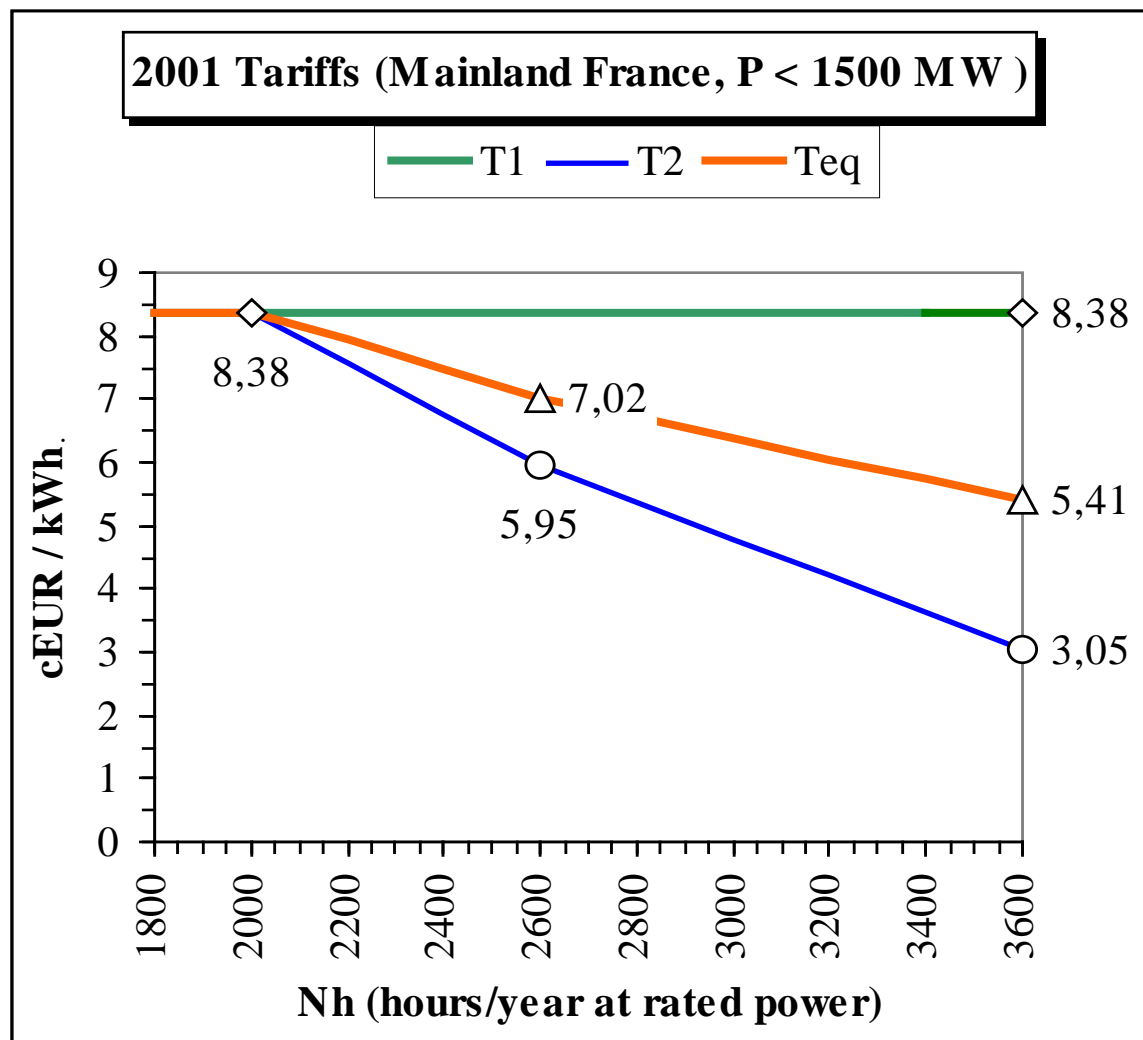
Wind tariffs: June 8th 2001 Arrêté, 2001 tariffs

Reference values for 2001 tariffs					
Mainland France, projects < 12 MW					
Nh:	P (MW)	P (MW)	cEUR / kWh		
			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)	cEUR / kWh		
			T1	T2	Teq
Nhmin:	2050		9,15	9,15	9,15
Nhint:	2400		9,15	7,47	8,21
Nhmax:	330		9,15	4,57	6,59

□ Hypothesis for Teq:

⇒ Real discount rate $t = 6.5\%$

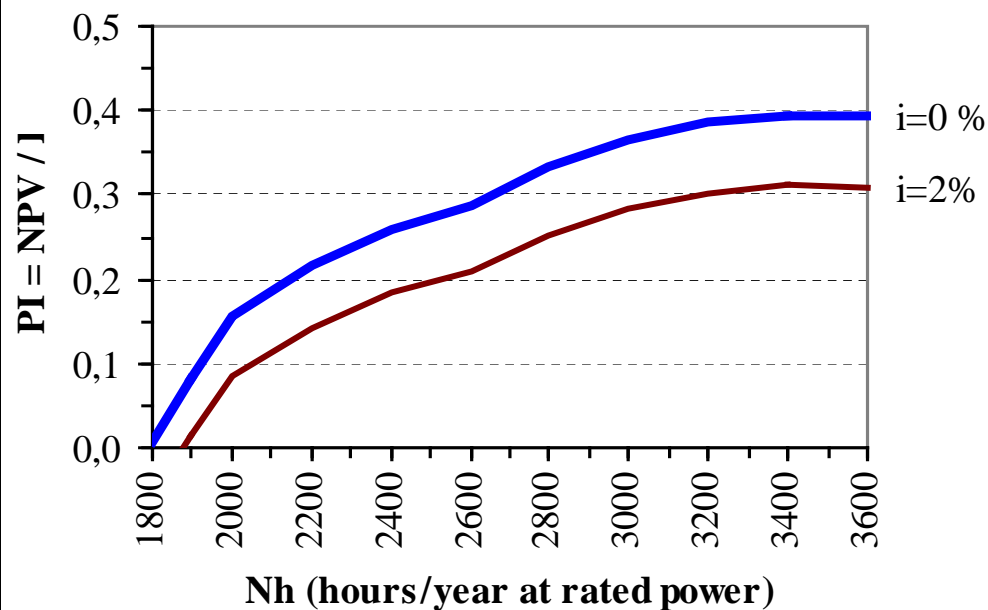
⇒ $n = 15$ years



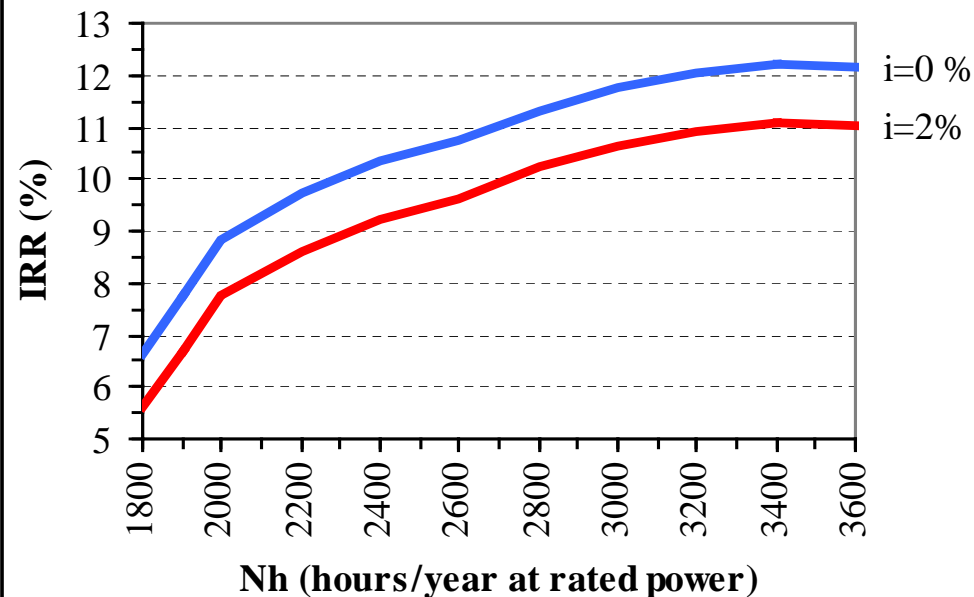


Tariffs: 2001 potential profitability (Mainland)

Profitability Index - 2001, Mainland



Internal Rate of Return - 2001, Mainland

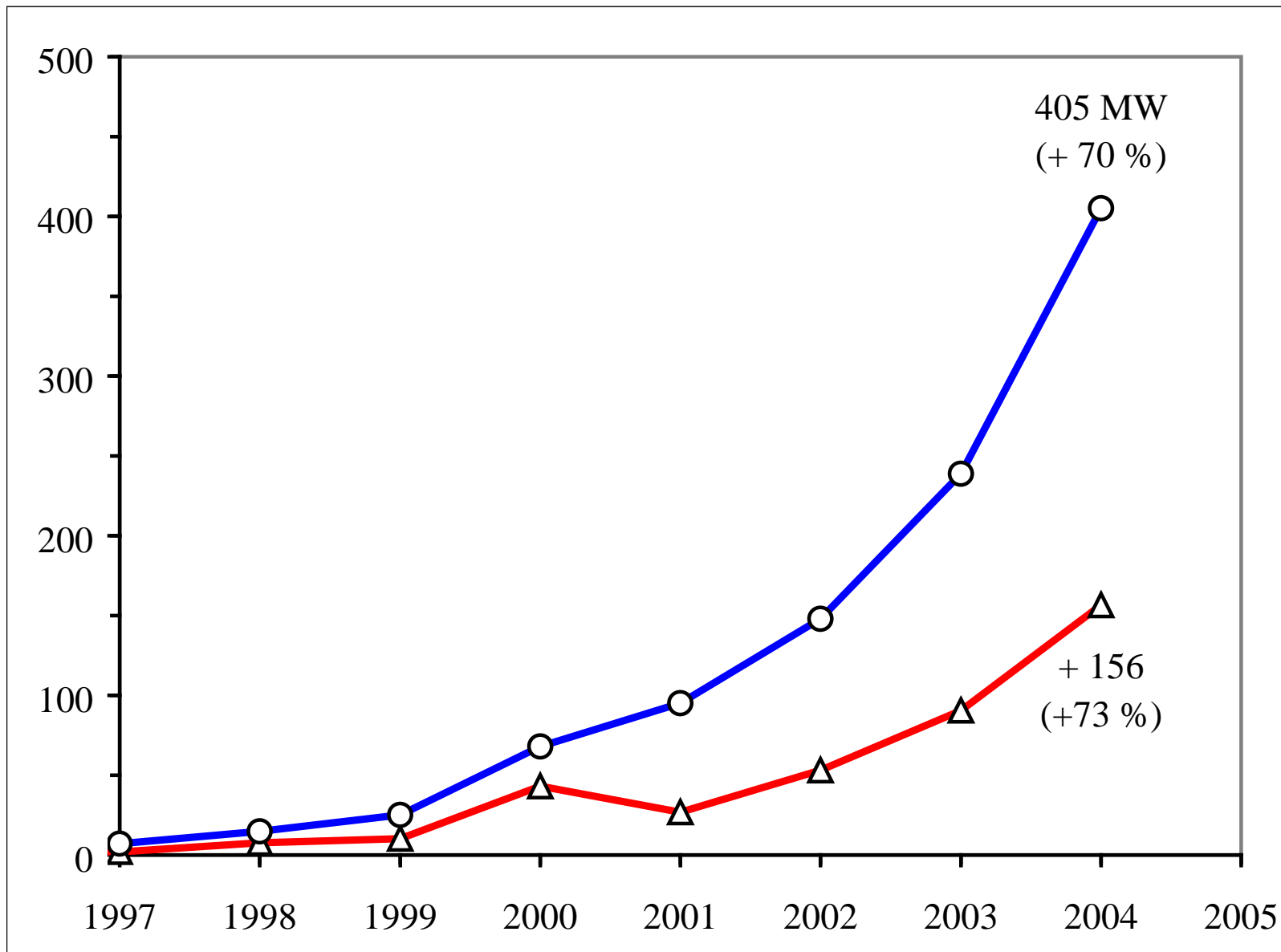


□ Reference case ($P < 12$ MW per project):

- ⇒ $I_u = 1067$ EUR/kW. Value at year 16: 15% of initial invest.
- ⇒ Yearly O&M expenses: $K_{om} = 4$ % of initial investment
- ⇒ Mean inflation rate 2001 - 2015: $i = 0\%$ or $i = 2\%$ / year
- ⇒ Profitability index: NPV per €invested



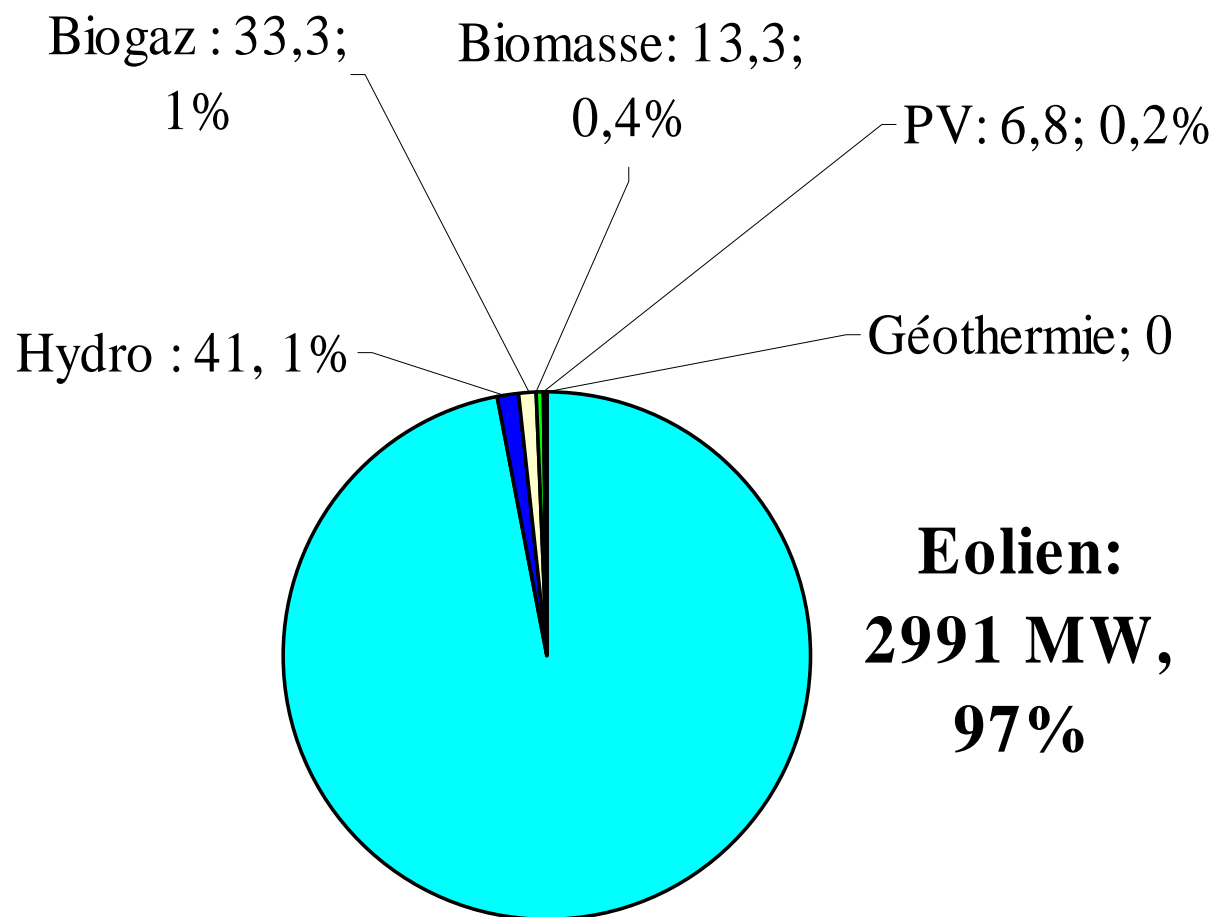
Wind Power development in France





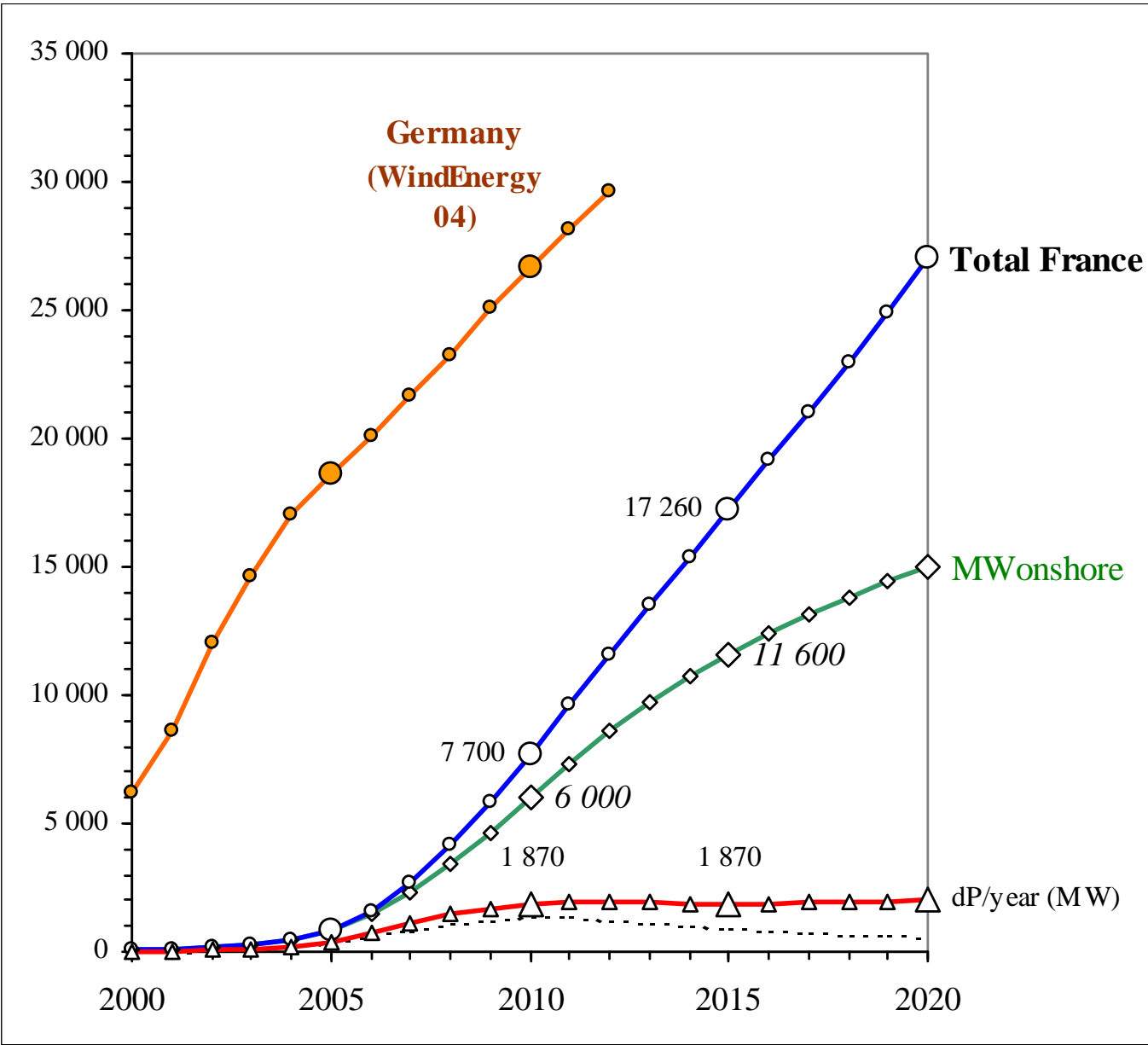
Effectiveness of wind tariffs: 3 GW of Buill. Permits

Répartition 6/05 des 3087 MW de demandes de raccordement RPD



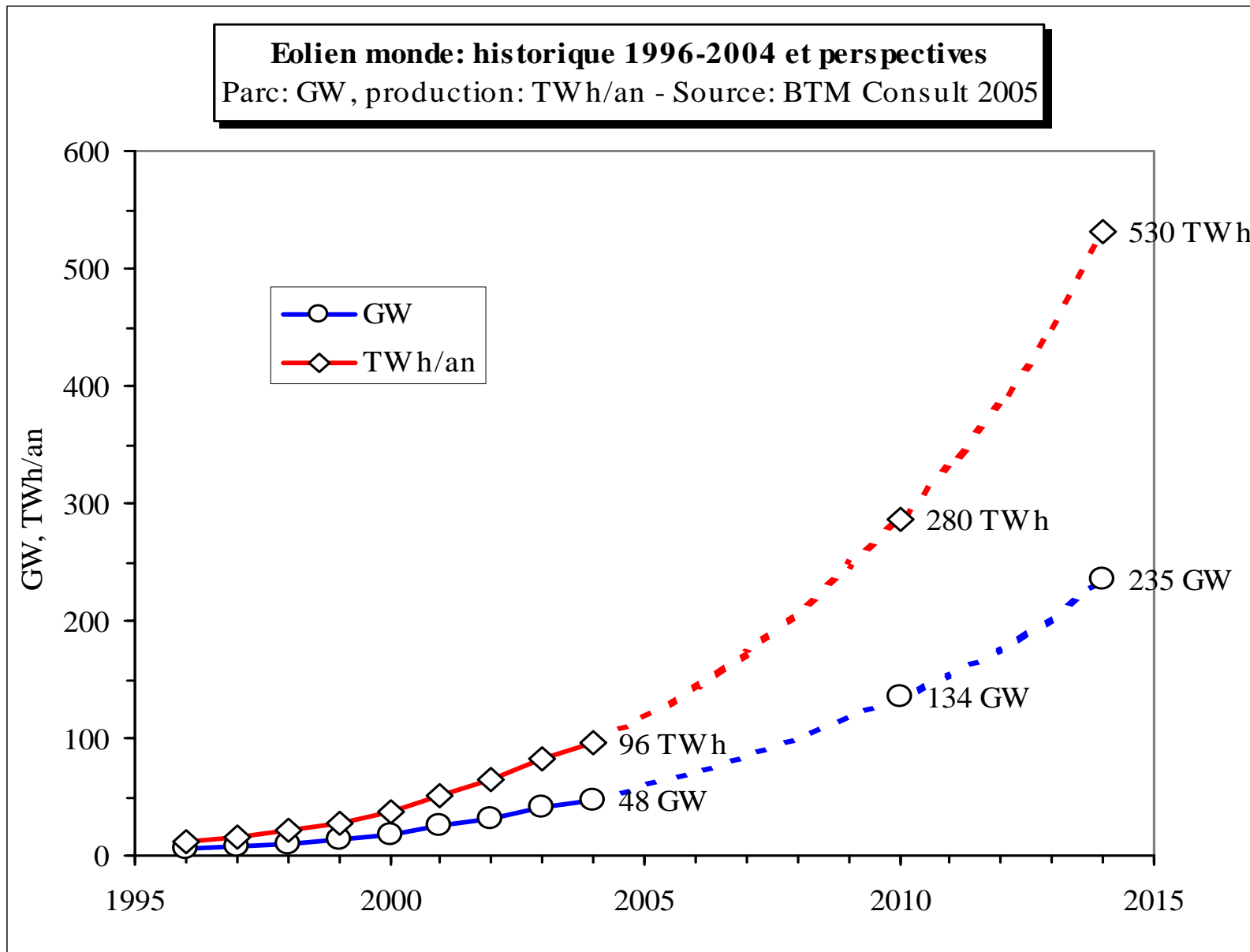


France: Potential Wind Power Development up to 2020





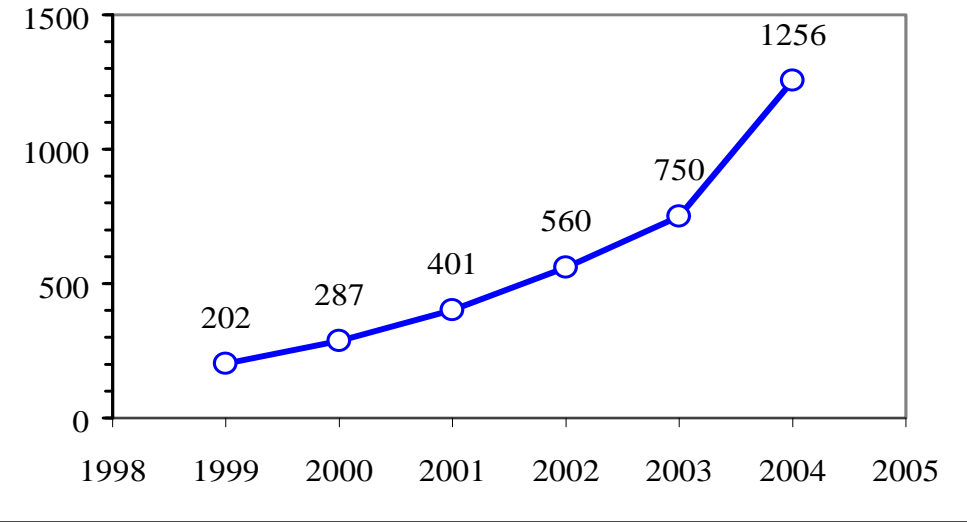
Global Wind power Market Assessment (BTM05)



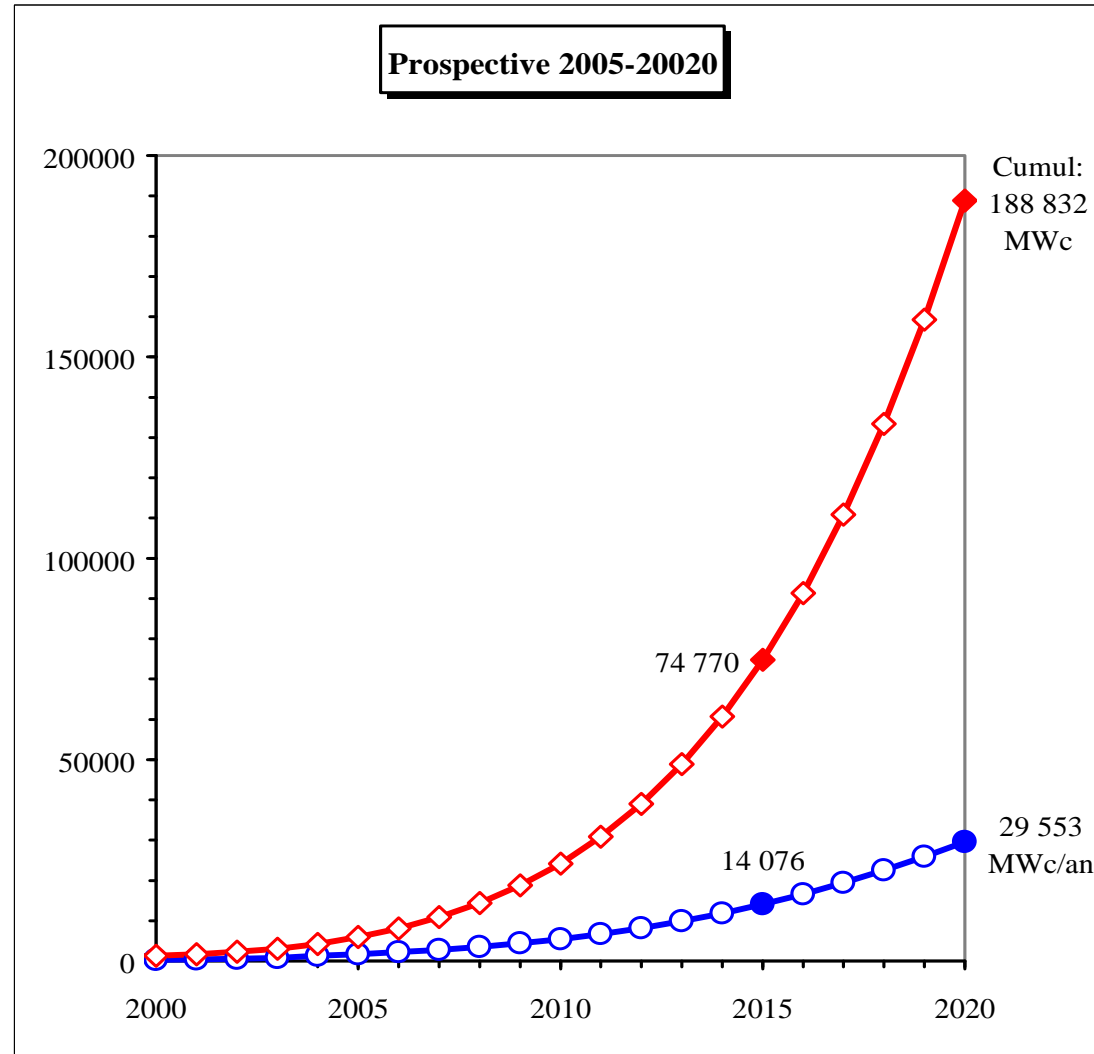


Global PV market: history and one scenario

Production Cellules Photovoltaïques (MWc/an)



Prospective 2005-2020





PV pricing: Case study OSEA (soft loans)

- ❑ Either $PI = 0$ or if $PI < 0$: subsidy Si on initial investment
- ❑ Two cases: $t = 3\%$ and $t = 0\%$ (“soft loans”)
- ❑ Two locations: Toronto (1100 kWh/m².year in the plane of PV modules) and Ottawa (1400 kWh/m².year)

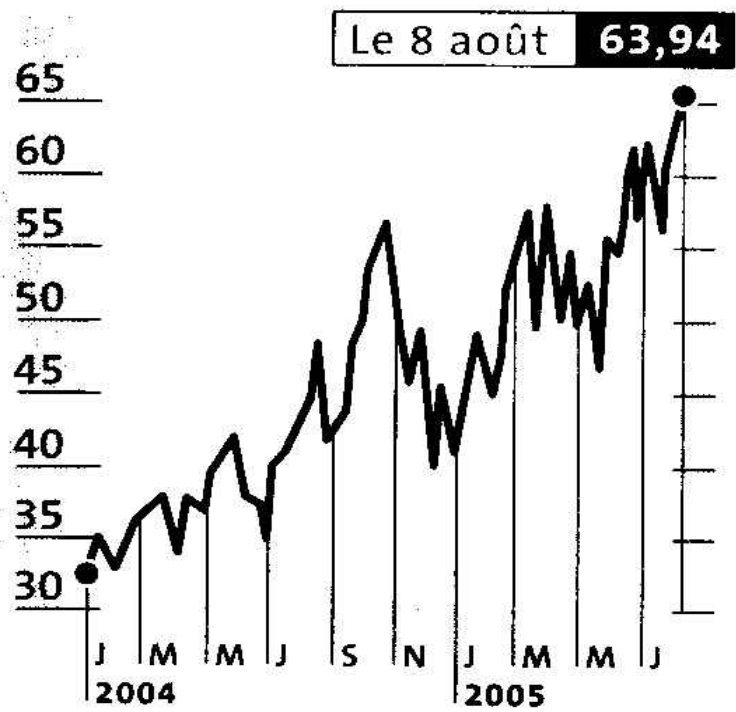
Place (Eia kWh/m ² .year)	Iu \$/Wp	I	Nh	ODC	Ci		Com		Pl	Si	Siu	TV	TV
		\$	h/year	\$/kWh	\$/kWh	%	\$/kWh	%		\$	\$/Wp	\$/kWh	€/kWh
TORONTO <i>1100</i>	12	36 000,0	825	1,018	0,727	71%	0,291	29%	0,000	0	0,00	1,02	0,61
	10	30 000,0	825	0,848	0,606	71%	0,242	29%	0,000	0	0,00	0,85	0,51
	7	21 000,0	825	0,594	0,424	71%	0,170	29%	0,000	0	0,00	0,59	0,36
TORONTO <i>1100</i>	12	36 000,0	825	1,018	0,727	71%	0,291	29%	-0,300	10 800	3,60	0,80	0,48
	10	30 000,0	825	0,848	0,606	71%	0,242	29%	-0,300	9 000	3,00	0,67	0,40
	7	21 000,0	825	0,594	0,424	71%	0,170	29%	-0,300	6 300	2,10	0,47	0,28
OTTAWA <i>1400</i>	12	36 000,0	1050	0,800	0,571	71%	0,229	29%	0,000	0	0,00	0,80	0,48
	10	30 000,0	1050	0,667	0,476	71%	0,190	29%	0,000	0	0,00	0,67	0,40
	7	21 000,0	1050	0,467	0,333	71%	0,133	29%	0,000	0	0,00	0,47	0,28



The coming Energy and Climate crisis...

NOUVEAU RECORD

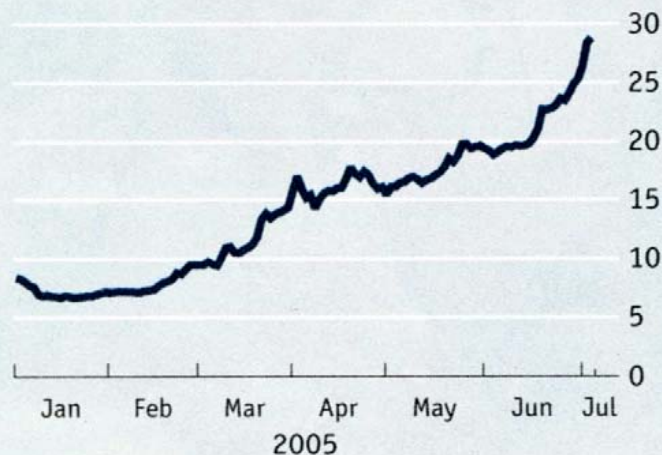
Cours du baril de brut en dollars, à New York



Source : Bloomberg

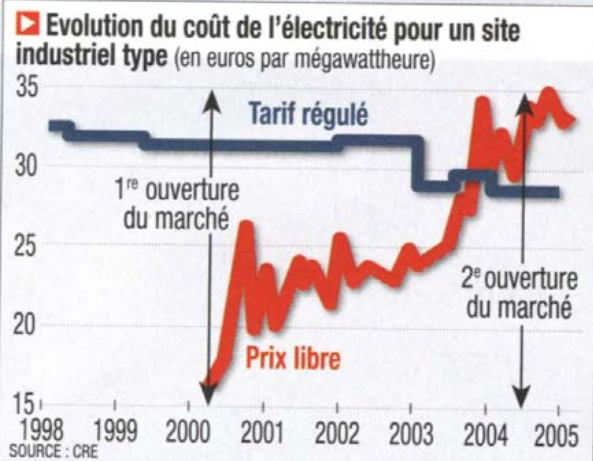
Gassy

EU emissions trading*
€ per tonne of carbon dioxide



Source: Point Carbon

*Over-the-counter market

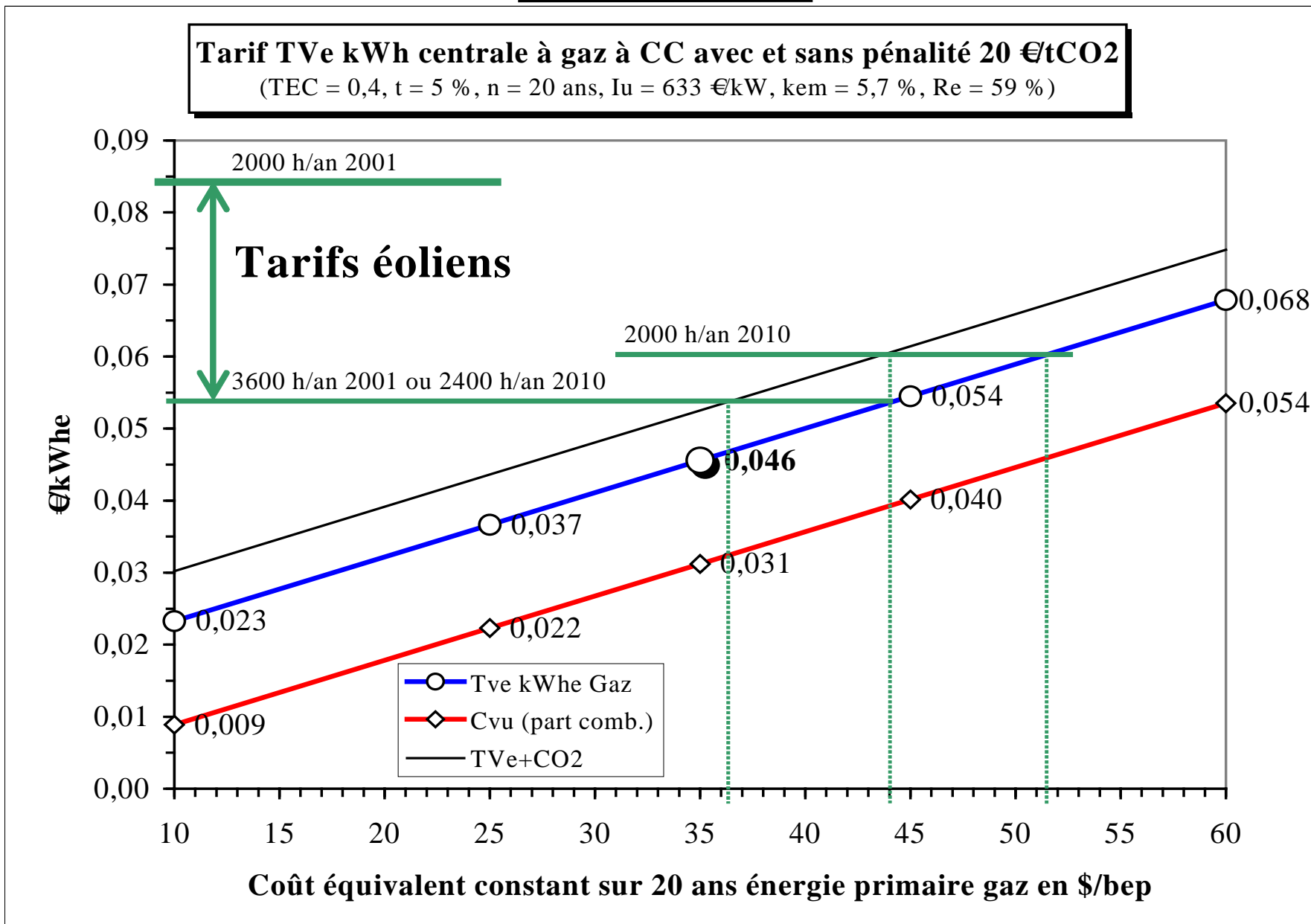


Les tarifs non régulés s'envolent

■ L'écart entre les tarifs régulés et les prix libres se creuse. Depuis la première ouverture du marché, en 2000, les producteurs d'électricité ont ainsi pu augmenter leurs tarifs de 4% en moyenne.



Wind Tariffs as an insurance against increasing power prices





V

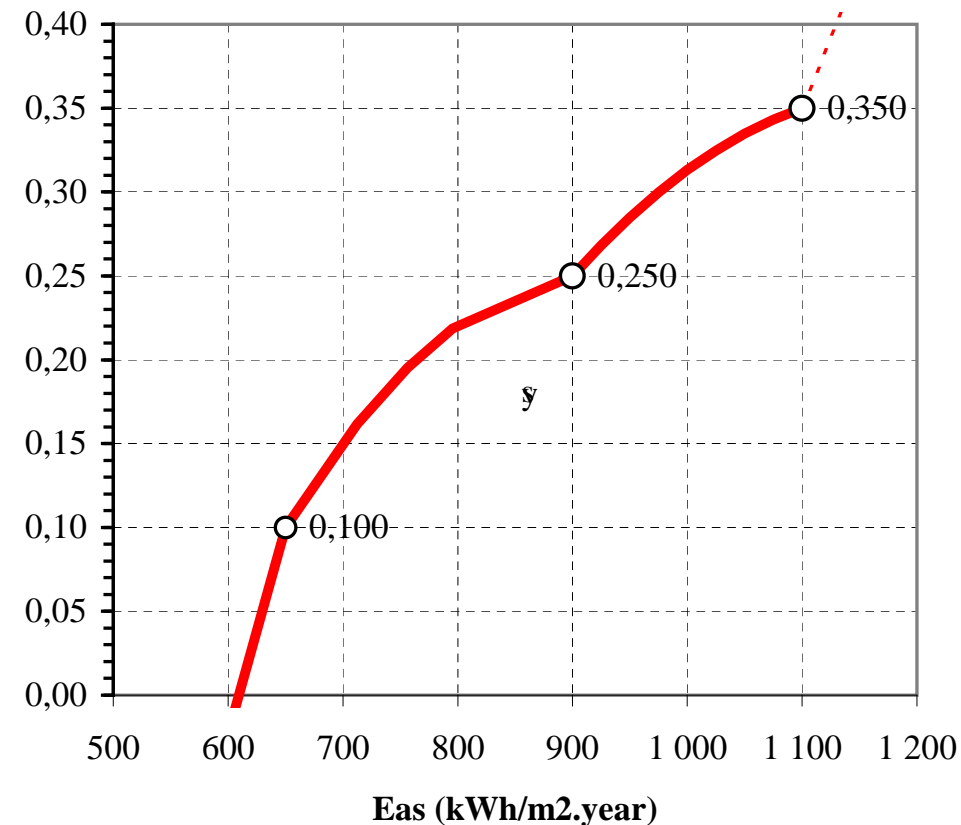
Case Study 2:
OSEA Wind Power Pricing
Workshop 1/2005



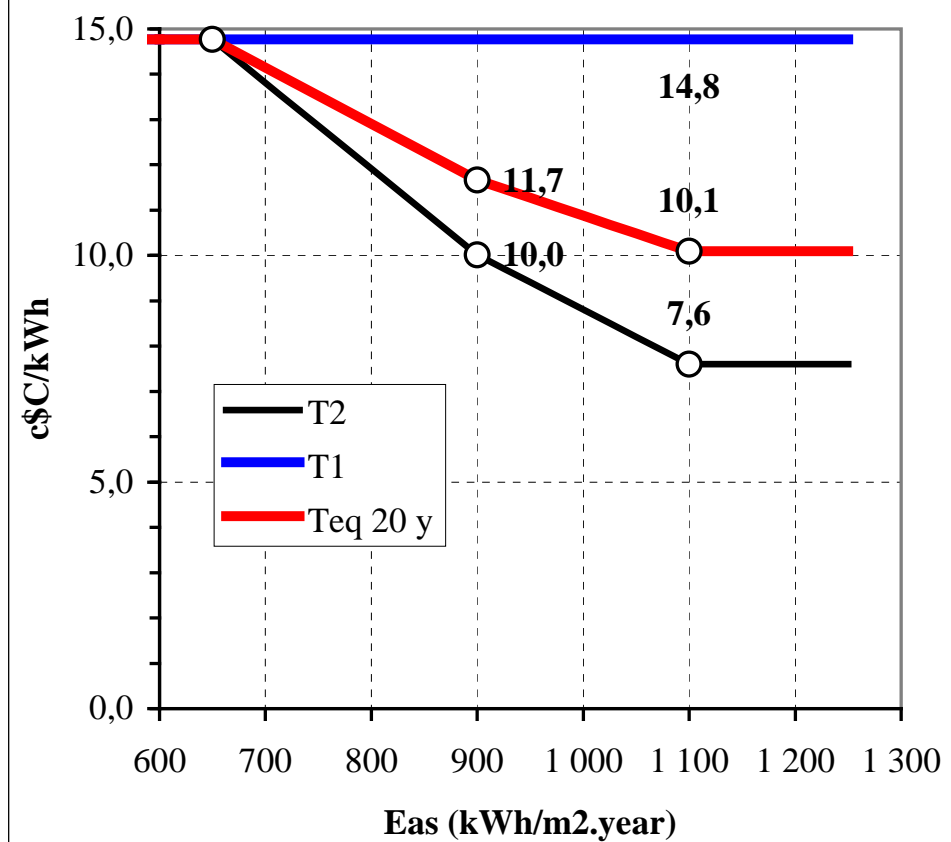
Preliminary results in January 2005

- ❑ Capacity factor Nh replaced by Specific energy yield Ey (kWh/year.m2)
- ❑ Hypothesis: full indexation to inflation (constant power purchase of tariff)

Profitability Index Versus Energy Yield per m2

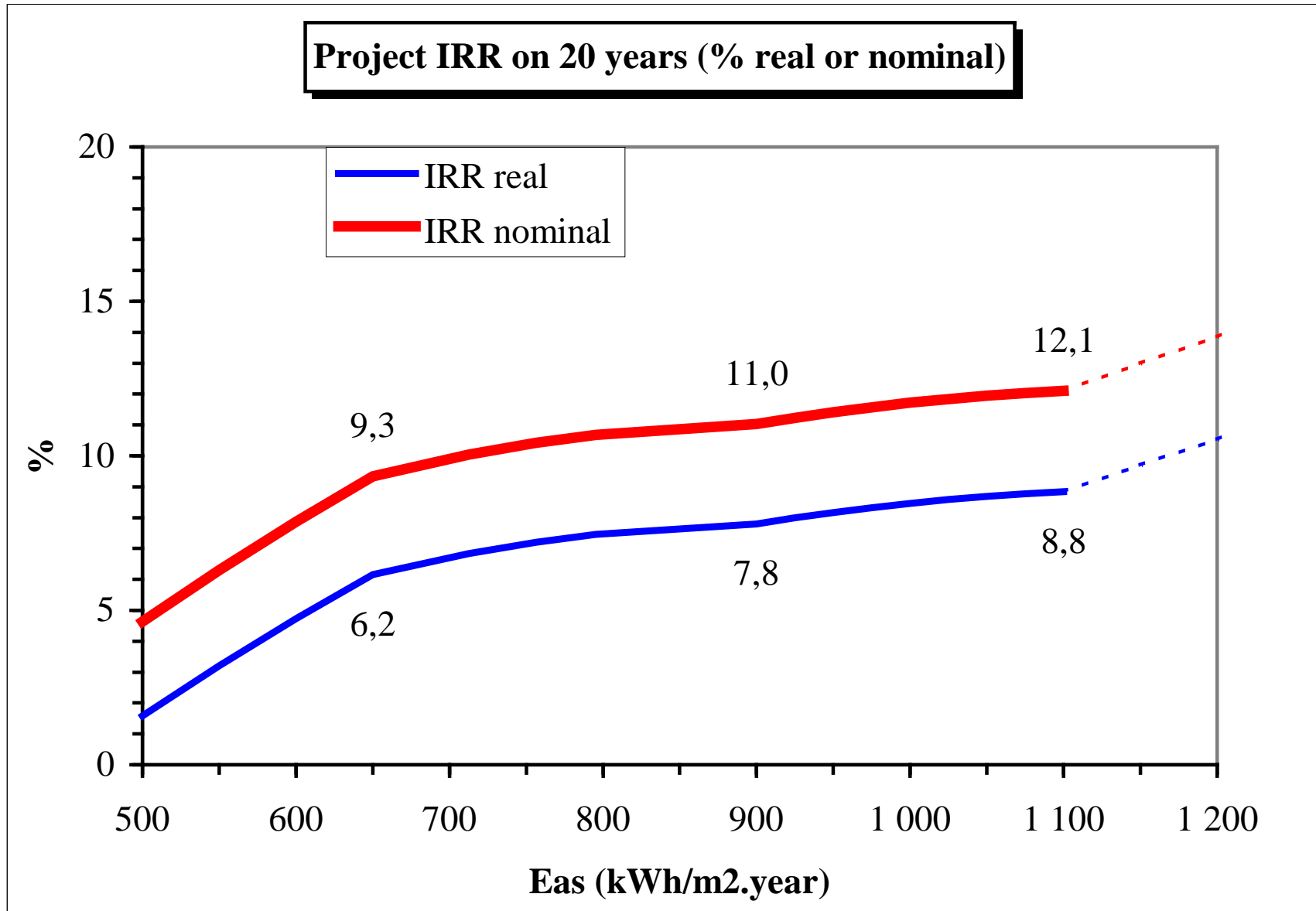


Tariffs versus energy yield per kWh/m2
 t = 5% (real), n = 20 years, Kom = 4%, Iu = 1600 \$/kW





Information on project IRR from PI values





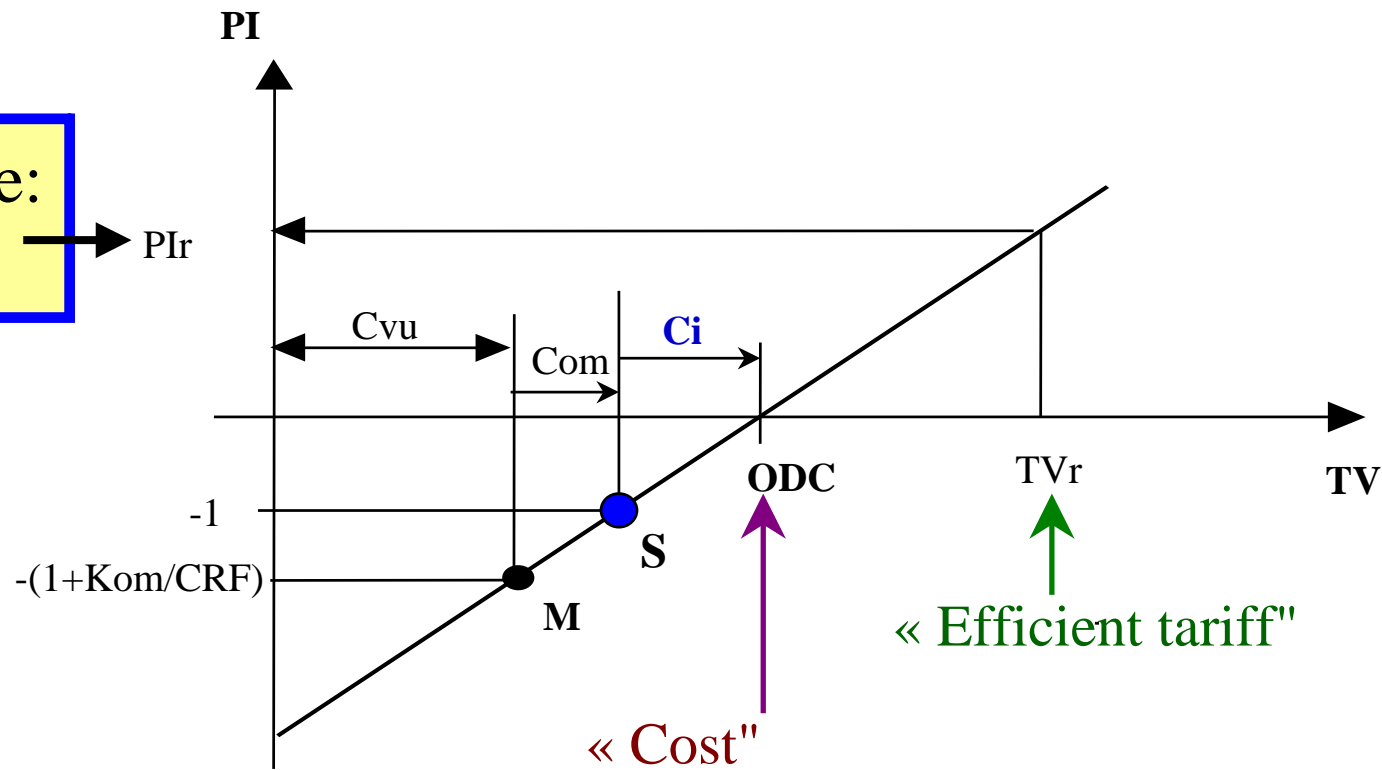
III

**Taking into account or designing
potential incentives for
renewables**



Designing an « Efficient tariff »

⇒ Defining a tariff for a sustainable good or service





Effect of a subsidy si on the initial investment I

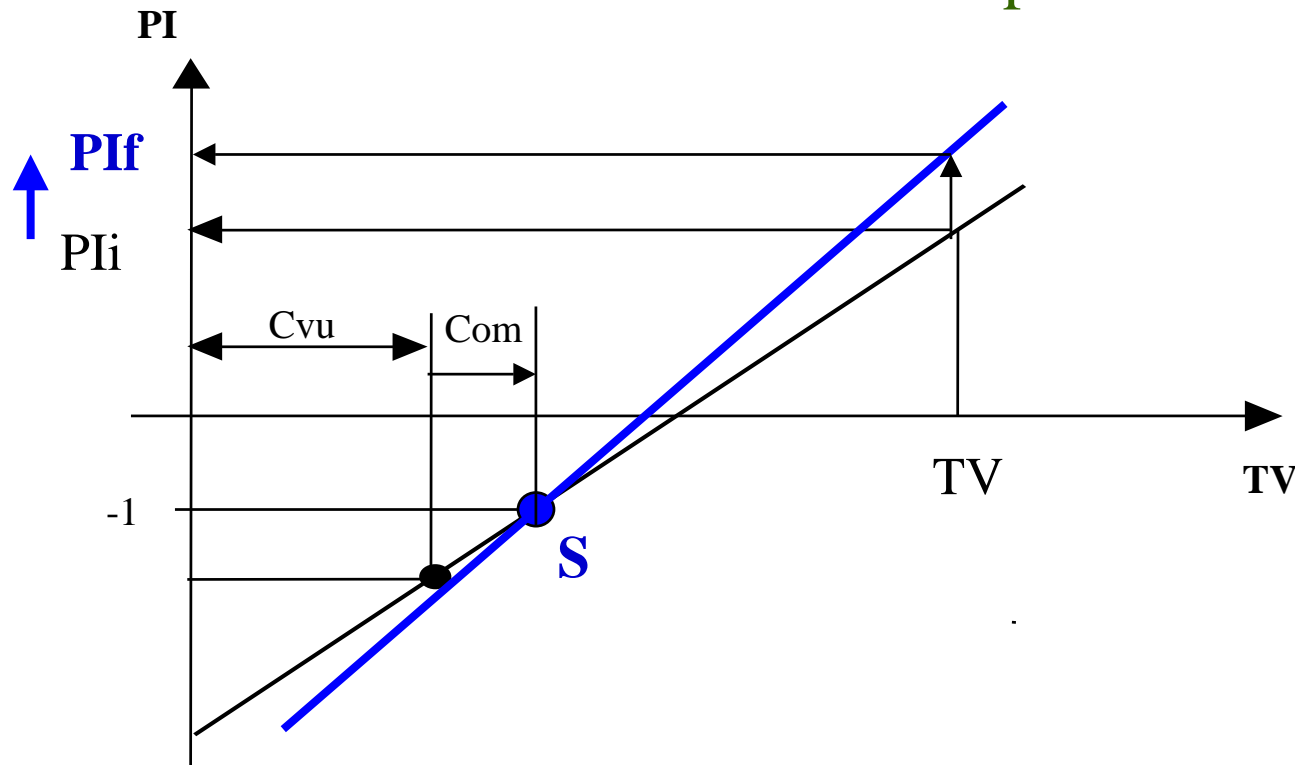
⇒ Simple relationship :

☆ Subsidy rate si : $si = (PI_f - PI_i) / (1 + PI_f)$ where:

☆ PI_f = target value of final profitability index PI (after subsidy)

☆ PI_i = initial PI value (before subsidy)

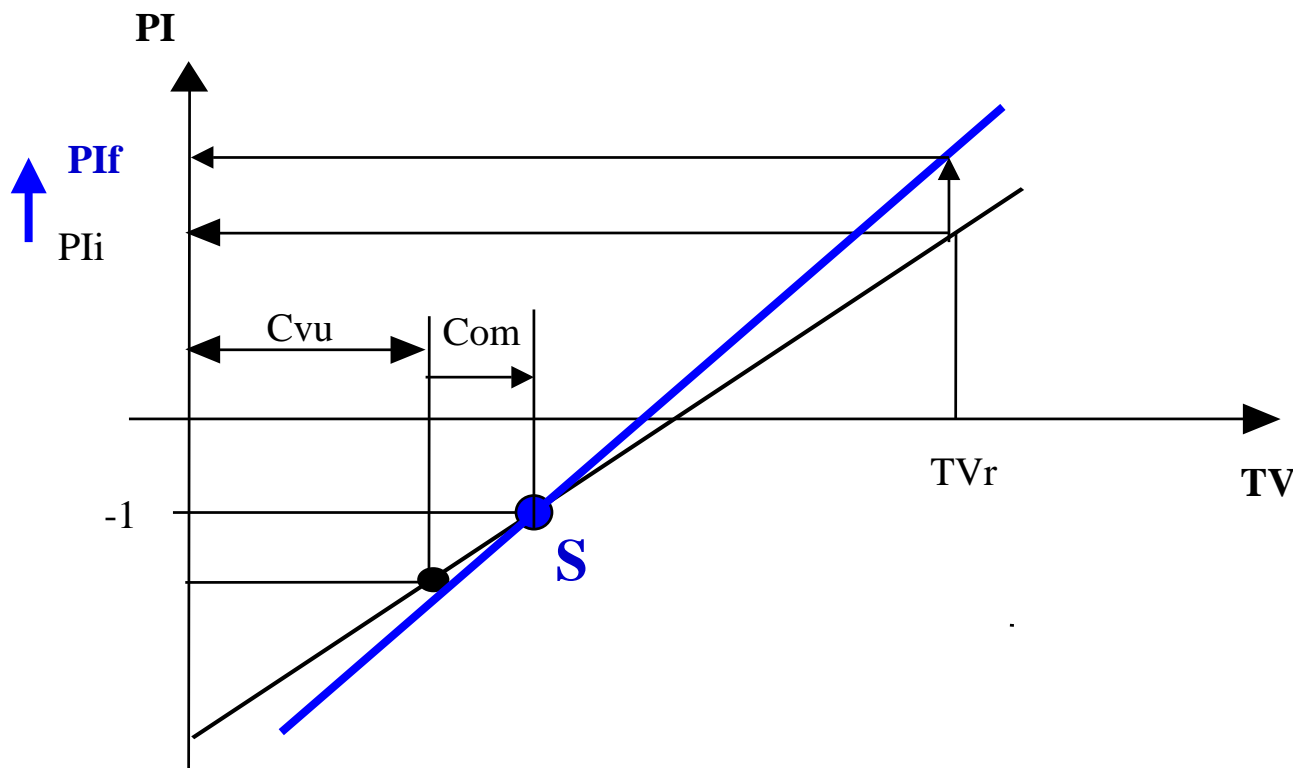
⇒ The "PI versus tariff" line turns around its "S" point





Impact of soft loans

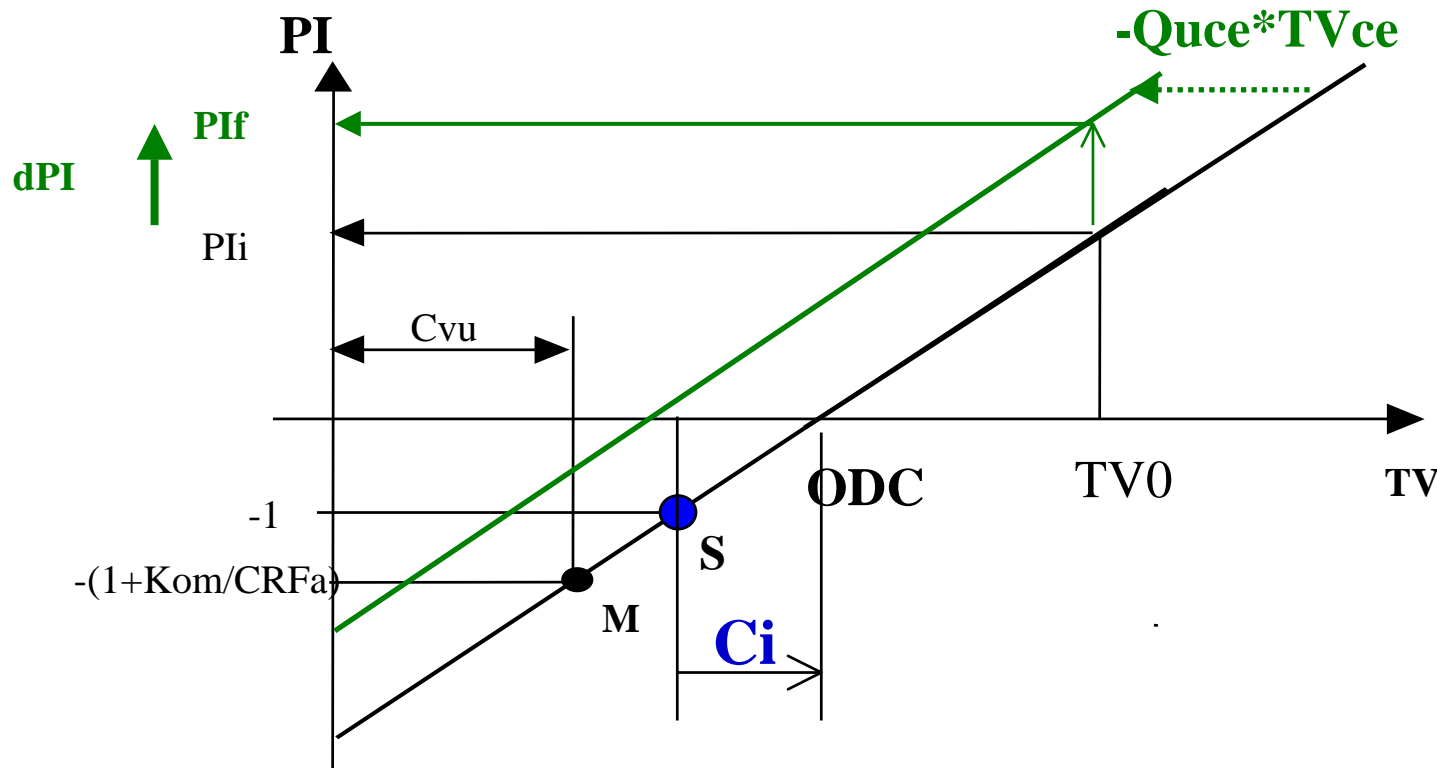
- ⇒ Conventional financing scheme: $t_0 = AWCC_0 \implies CRF_0(t_0, n)$
- ⇒ Soft loans \implies soft financing $\implies t_s < t_0 \implies CRF_s(t_s, n) < CRF_0(t_0, n)$
- ⇒ Increase of PI: $(1 + PI_s) / (1 + PI_0) = CRF_0 / CRF_s$
- ⇒ Equivalent subsidy si on investment: $si = 1 - CRF_s / CRF_0$





Potential impact of selling "Carbon Credits"

- ⇒ Avoided CO2 emissions : Q_{uce} (kg CO2/kWhe). Selling price of carbon credit : TV_{ce} (€/ avoided kg of CO2). Price bonus: $TV_{ce} * Q_{uce}$
- ⇒ The "PI line" translates horizontally of a $TV_{ce} * Q_{uce}$ value (€/kWhe)
- ⇒ The Thalès - Chabot theorem: $dPI = (Q_{uce} * TV_{ce}) / C_i$
- ⇒ Or: $dPI = \{ (Q_{uce} * TV_{ce}) / CGA \} / (C_i / CGA) \Rightarrow$ basic role of C_i / CGA





Conclusions

- ❑ **"A bit of theory is very practical"**
- ❑ **Simple, innovative and powerful method and tools to define market deployment strategies and policies for sustainable energy technologies**
- ❑ **A vast prospect for use :**
 - ⇒ Extension to all other energy services : energy savings, energy efficiency, DSM (see ECEEE 2005 Mandelieu conference)
 - ⇒ Clean and efficient buildings versus conventional ones
 - ⇒ Clean and efficient industrial process versus conventional ones
 - ⇒ CO2 policies: easy demonstration that CO2 taxes would lead to coal based power plants instead of natural gas combined cycles !
 - ⇒ Potential stranded costs analysis in a context of rising fossil fuels costs.
- ❑ **ADEME is open to co-operation by sharing knowledge and experience**