Renewable Energy Tariffs Price-Setting

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I

Market regulation For renewables

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Market Regulation for RES

- **A market regulation is necessary to attract private investors**
- **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 CO_2 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

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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 & Germany in the 90's)
  - ➩ "Environ. premiums" over the annual avoided cost (Spain)
  - ➩ "**ADVANCED TARIFFS**" (eg wind power in Germany, France)
    - ✰ 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 are decreasing each year to take into account costs decrease

Market regulations in favour of Renewables

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

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

- **Subsidies: only on demonstration and pilot projects**
- **Soft loans: interest because of high investment cost and risk**
- **Success from "advanced tariffs" (Germany, Spain, France, Portugal)**
- **Advantages of regulation from quantities are not yet demonstrated**

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II

Introduction to the Profitability Index Method

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Introduction to the Profitability Index Method

- **Here is a solution, but what was the problem ?**
  - ⇨ Need of a simple economic analysis method for projects & programmes managers (engineers) and for decision makers
  - ⇨ Need to assess RETs costs and profitability versus fossil energy
    - ☆ ADEMEstarted to assist Ministry of Industry in 1993 (Wind, CHP)
    - ☆ First for kWh cost (1993: wind, CHP) then tariffs (RETs, CHP 1996-2001)
- **The opportunities:**
  - ⇨ Simple tools: ODC of RE based kWh since 1991
  - ⇨ First concepts of the PI method in late 90's
  - ⇨ First official use by ADEME for wind power tariffs (97-2001)
  - ⇨ International studies: EC DG12 & TREN, UN-FAO, IEPF...
  - ⇨ Tentative design of Wind Power Tariffs for SEI (Sustainable Energy Ireland, 2002)

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The context to apply the PI method (1)

- **Before decisions: a method and its related tools for:**
  - ⇨ Assessment of energy technologies and applications : sensibility studies, costs and tariffs, present and future profitability...
  - ⇨ Market development for renewables, energy efficiency, DSM…
  - ⇨ Definition and monitoring of pilot and dissemination programmes in liberalised markets
  - ⇨ Decision to invest or not in specific projects
- **After decisions : explanation of success or failure stories**
- **To be completed after conclusions by :**
  - ⇨ Financial analysis with the profile of investors, the fiscal context
  - ⇨ Detailed study of aids (tariffs, subsidies…), fiscal, regulatory, administrative and legal context before investing or before launching large scale dissemination programmes

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The context to apply the PI method (2)

- 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 rate
    - ✫ Cash-flows parameters varying by steps (e.g. wind tariffs TV1, TV2)
    - ✫ Variable cash – flows (replaced by the equivalent constant cash-flow)
- 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

Making a difference between cost and price

- **Profitability index** PI **= Net Present Value / Investment**
- **Gives both kWh manufacturing cost and selling price:**
  - ⇨ Tariff **T** = ((1 + **PI**)CRF + 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=4 %)
    - ➔**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

Comparing criteria PI, IRR, PBT

- **IRR, PBT: values of t and n for which project NPV = 0**
- **Profitability if: IRR > t (= AWCC), and if PBT < n project**
- **simple PBT=I/CF=> no discounting. Prof. if SPBT< 1/CRF**
- **Limits and actual and potential problems (IRR & PBTs):**
  - ⇨ Criteria not proportional to profitability in $
  - ⇨ No fixed and rational "zero point" for profitability = 0
  - ⇨ No direct access to the project NPV
  - ⇨ No use possible within simple formulas
- **Versus advantages of the PI criteria:**
  - ⇨ PI is proportional to the profitability in $
  - ⇨ Logical starting point: PI = 0 for profitability zero
  - ⇨ Direct access to the NPV (from the definition: NPV = PI.I)
  - ⇨ Direct explicit formula possible using PI (like °K versus °C !)

From the PI to IRR and PBT values

- **Link PI / IRR (Internal Rate of Return of the project):**
  - ⇨ CRF (IRR, n) = (1 + PI).CRF (t, n) ;
  - ⇨ with (1+PI) = Benefit /Cost Ratio
- **Link PI / dPBT (Discounted Pay-Back Time):**
  - ⇨ CRF (t, dPBT) = (1 + PI).CRF (t, n)
- **Link PI / sPBT (Simple Pay-Back Time) :**
  - ⇨ sPBT = 1 / (1 + PI).CRF(t, n) = 1 / CRF(t, dPBT)
  - ⇨ sPBT= 1 / CRF(IRR, n)
- **See following graphs and examples**

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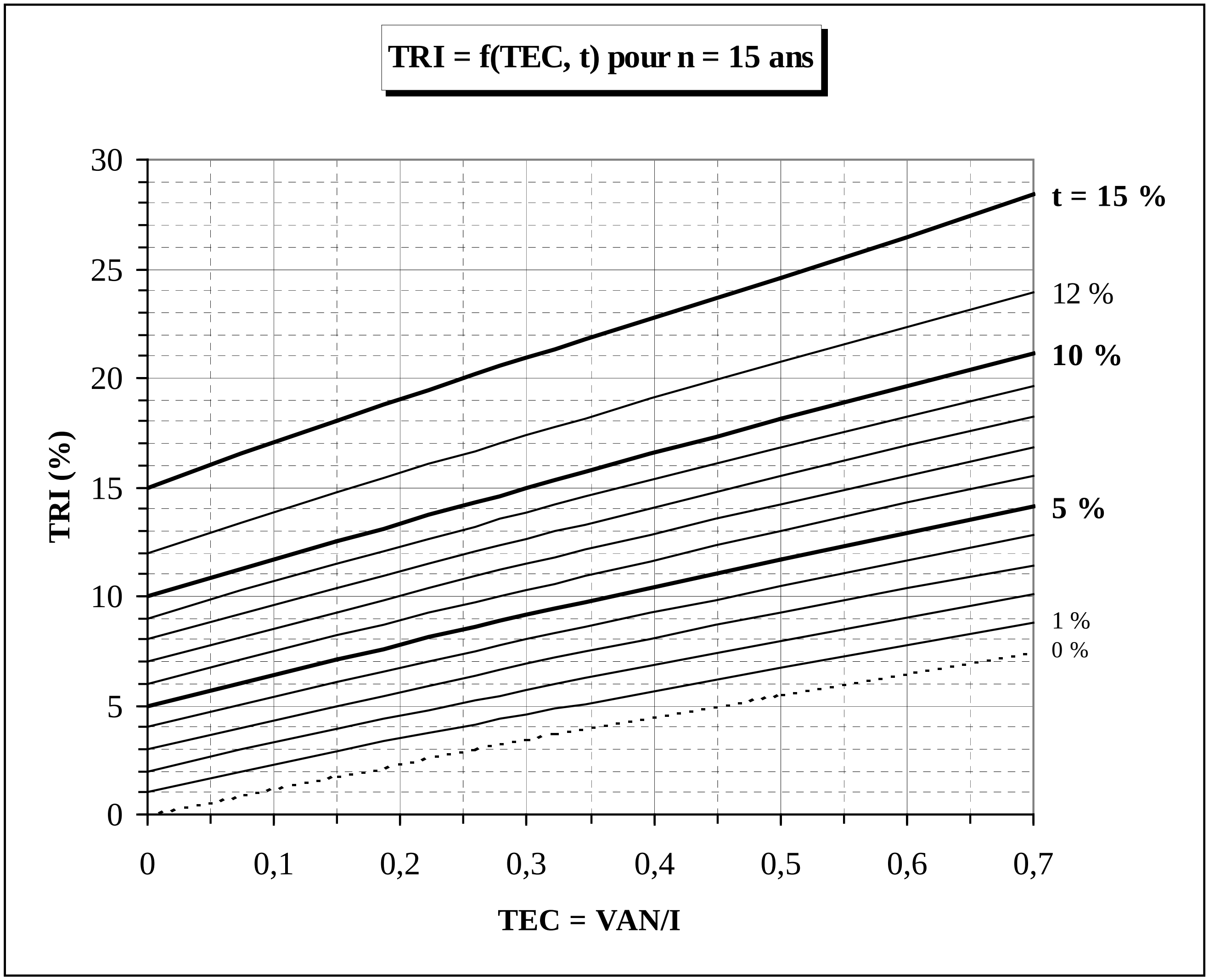
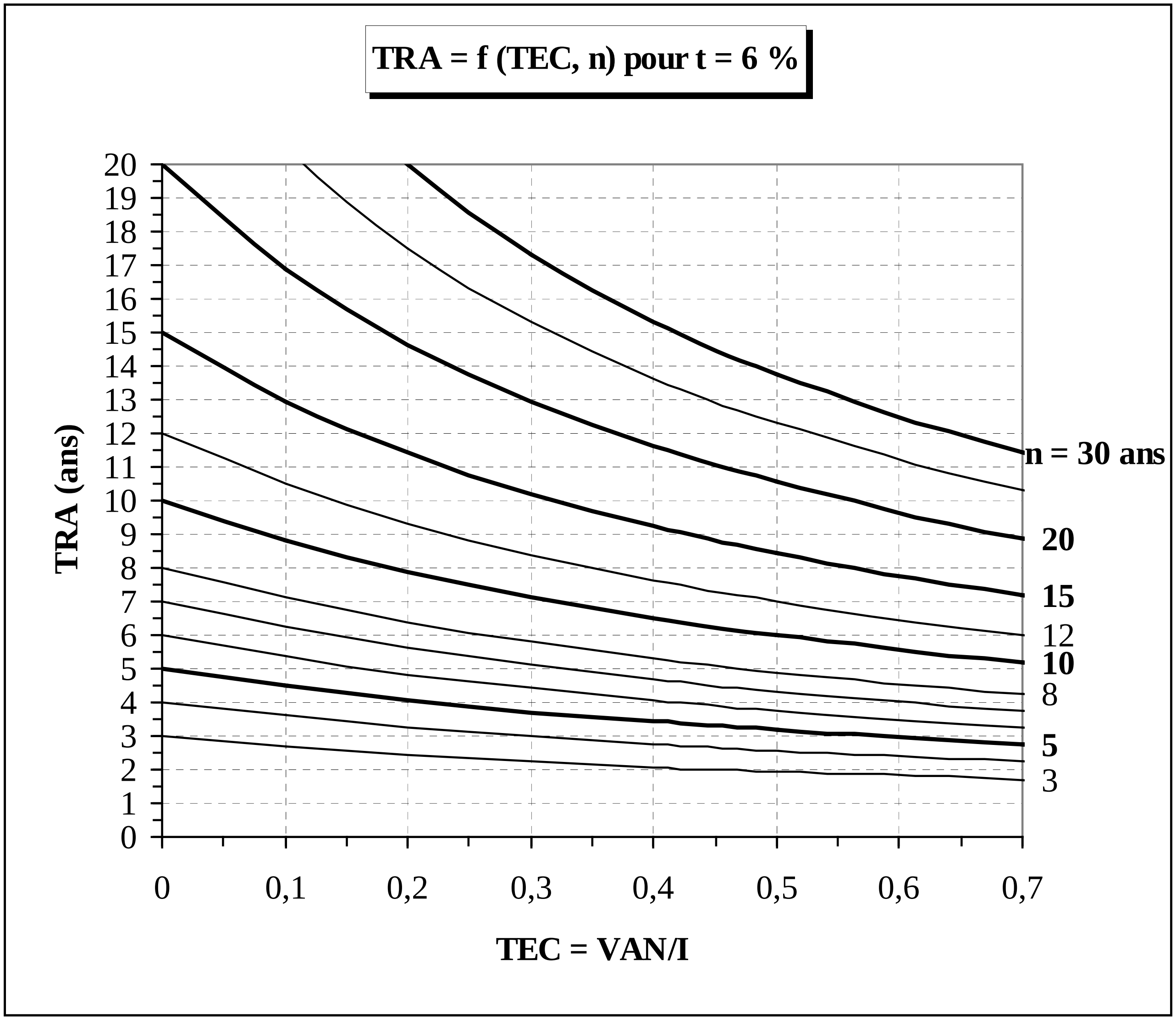
Links PI / IRR for n = 15 years

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



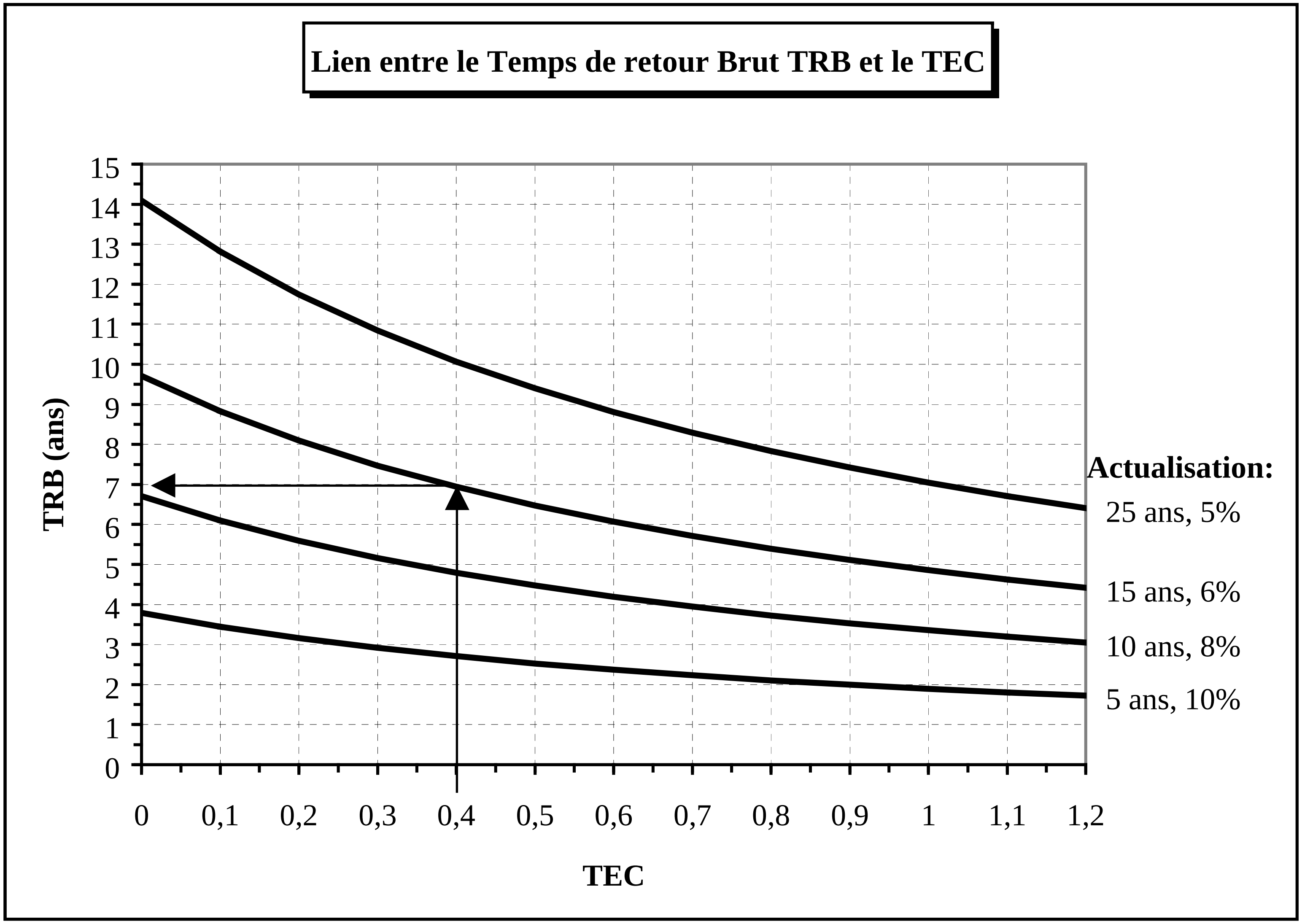
Link PI / discounted PBT for t = 6 %

- 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 !



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The linear and universal model: Profitability Index versus Tariff

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The model PI = f(tariff TV) (1)

- **Advantage: complete characterization of techno. & appl.**
- **Demonstrated and published added value :**
  - ⇨ODC and Tariffs for RE based power plants : wind power, SHP, geothermal, solar PV
  - ⇨Universal graphs ODC, TV = f(TV/Iu) for zero fuel cost technologies
  - ⇨Prospect for ODC and tariffs for wind power
  - ⇨Rational definition for ODC and tariffs for CHP plants
  - ⇨Rational definition of DSM (« negawatts ») cost and profitability
  - ⇨Various energy services: PV water pumping, heat pumps...
  - ⇨From comparisons on the same graph between RETs and fossil based power plants :
    - ☆Tariffs or « environmental bonus » for RETs
    - ☆First evidence of minimum value of Pi : 0.3 and corresponding tariffs

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The model PI = f(tariff TV) (2)

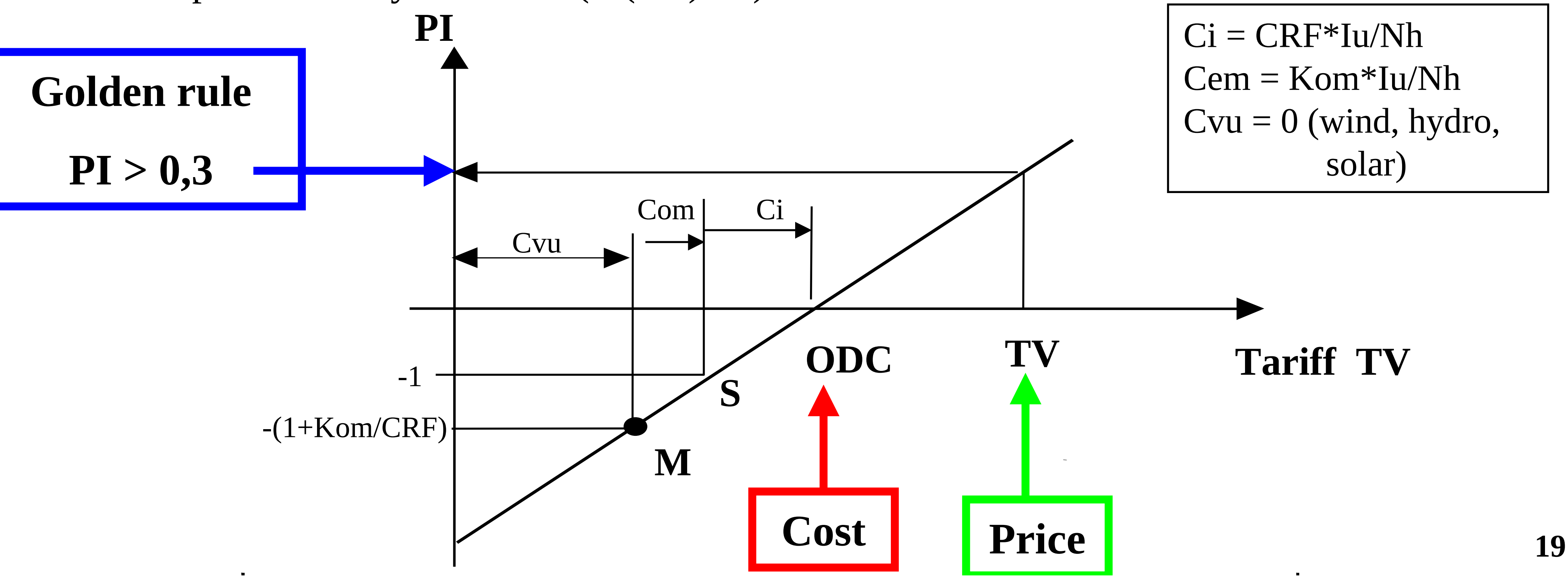
- **NPV = (-I + Sum of discounted CFs from year 1 to n)**
- **Discounted CF of year j = CFj / (1+t)^j**
- **For constant Cash-Flow CF from years 1 to n:**
  - Sum of discounted CFs = CF / CRF(t,n)
- **Variable CFs can be replaced by the « constant equivalent CF » which gives the same economic profitability than the n variable CFs**
- **By definition: Profitability Index = PI = NPV / I**
- **PI results from TV by a linear relationship :**
  - PI= a (TV-Cvu) – b
  - Where a and b are defined by project ratios (costs, energy yield)
  - And Cvu is the variable cost due to fuel cost
  - So Cvu is zero for hydro, wind, solar, geothermal power plants

The model PI = f(tariff TV) (3)

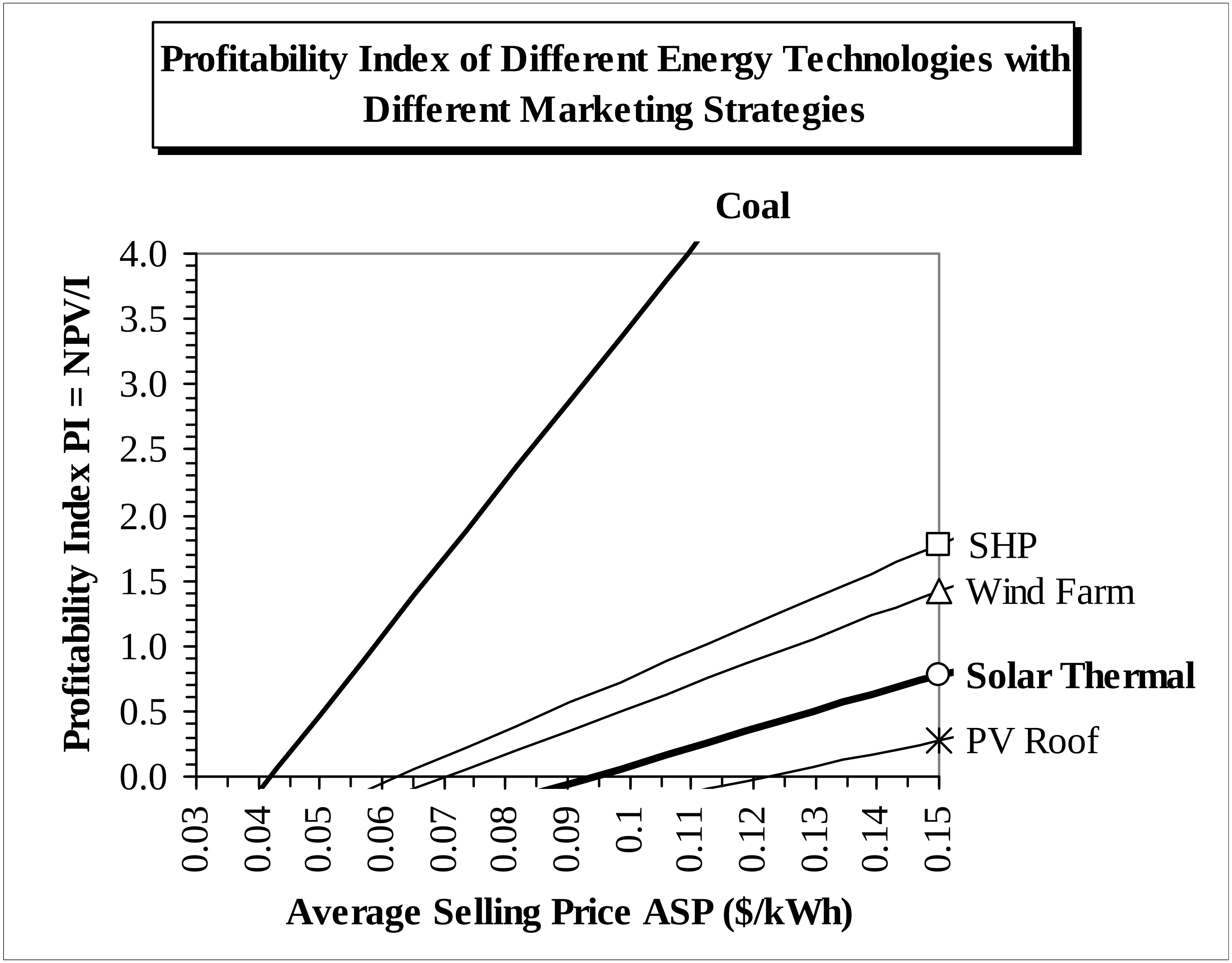
⇨ **Gives access to the universal linear diagram : PI versus tariff TV**

⇨ **PI = aTV - b = (Nh / CRF.Iu)(TV - Cvu) - (1 + Kem / CRF)**

- ✰ With : TV = kWh tariff; Iu = I / P, Nh = Ea / P, Kom = Doem / I, CRF= t / (1 - (1+t)exp-n), Cvu = variable part of the kWh cost = 0 for renewables, except biomass
- ✰ Where I = initial investment cost ; P = rated power ; Ea = annual energy sold ; Dom = annual O&M expenses, t = discount rate (AWCC) ; n = years of operation : CRF = capital recovery factor = t/(1-(1+t)^-n)



Example of use: cmparing different power plants



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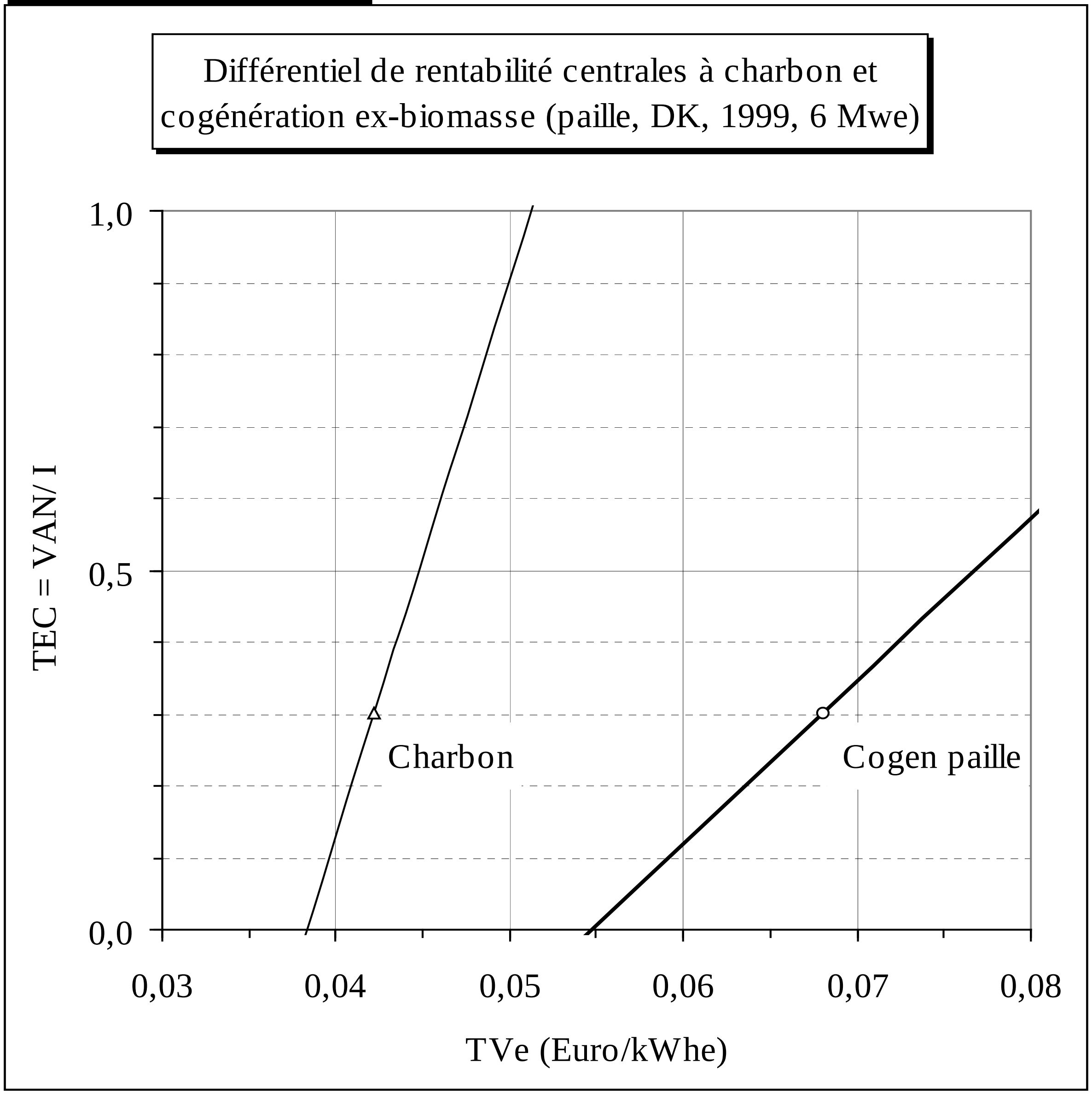
Example : comparing coal & CHP from biomass

- **Differences:**
  - ➪ costs: 1.7 c€/kWh
  - ➪ Tariffs 2,6 c€ (+50%)
- **Efficient Tariffs 6,8 c€ versus 4,2 (+62%)**
- **Tariffs CHP in EU15**
  - ➪ G: 8.7 to 10.2 c€
  - ➪ DK: bonus 1.3 to 4.6 cE/kWhe
  - ➪ Sp: bonus 3 cE/kWhe



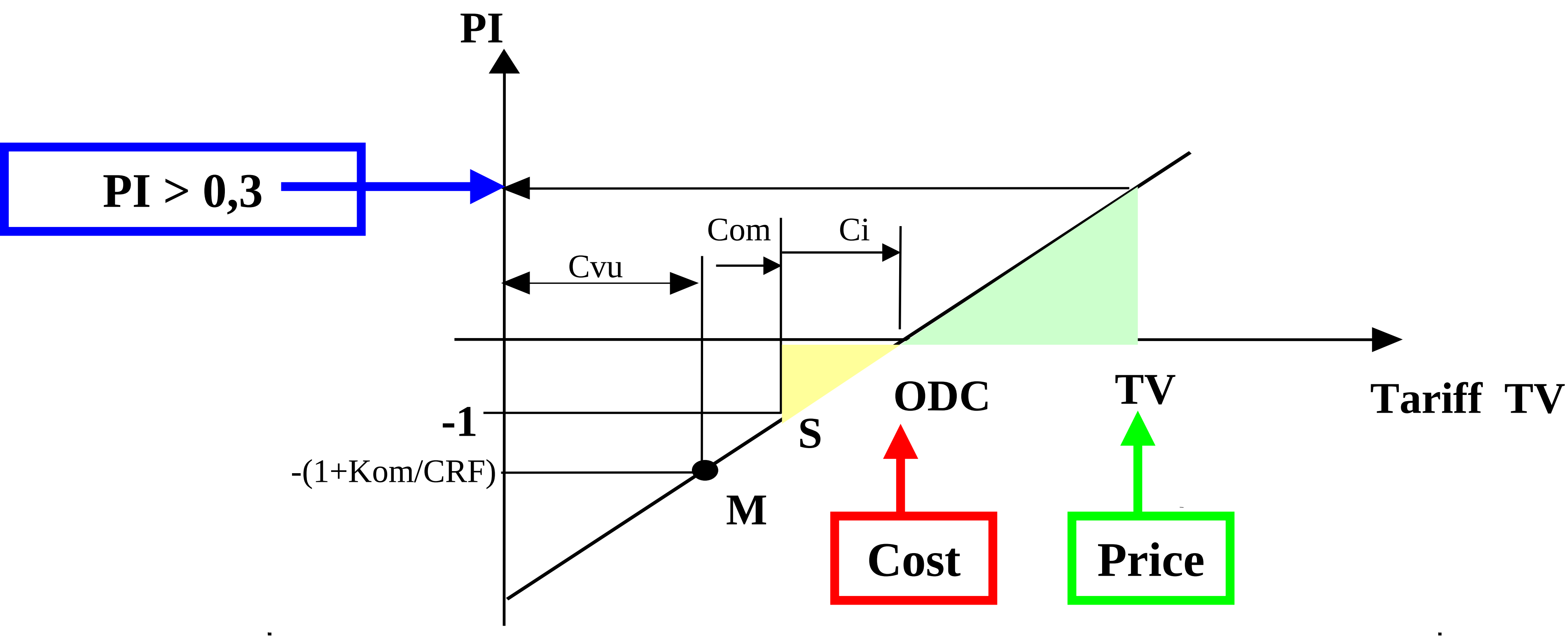
The model PI = f(tariff TV) (4)

⇨ Gives access to the **direct link between PI and the Margin On Cost**
MOC = (Price - Cost) / Cost = (TV-ODC) / ODC) :

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

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

☆ PI = MOC / (Ci/ODC) ==> MOC = (Ci/ODC)*PI ==> basic role of Ci/CGA



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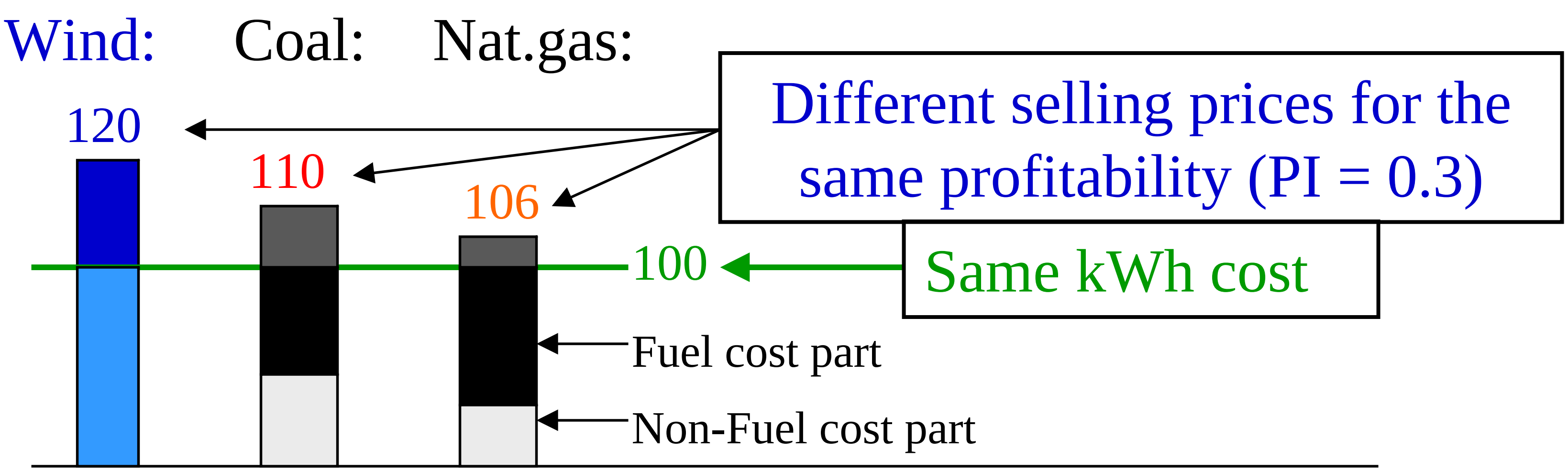
The link: PI = k.MOC (Margin On Cost)

- **MOC = (TV-ODC)/ODC = {Kfuel. CRF/(CRF+Kom)}.PI**
- **Access to ref. PI values: "minimum": 0.3, "Robust growth": 0.4 to 0.5, "crash programme": 0.6 to 1**
- **Demonstrates the "free energy sources paradox" (RETs except biomass, nuclear fusionFusion):**
  - ⇨ (MOCr/MOCf) = 1/ kFuelf (= 3 for CCNG, =2 for coal ST)
  - ⇨ This result is not related to the cost and performance of RETs
    - ☆ Example (next slide): if RE kWh ODC = ODC NG = Coal = 100 UM
    - ☆ For PI = 0.3, TV kWh NG = 106 ; TV Coal = 110 ; TV RE = 120
  - ⇨ Taking into account this paradox is a prerequisite for a sound dissemination policy of renewables in liberalised markets. A sound regulation in favour of RETs on the long term must take into account this intrinsic difference between MOC and so between tariffs even at same cost level of kWh.

The link: PI = k.MOC (2)

- **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)**



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IV

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

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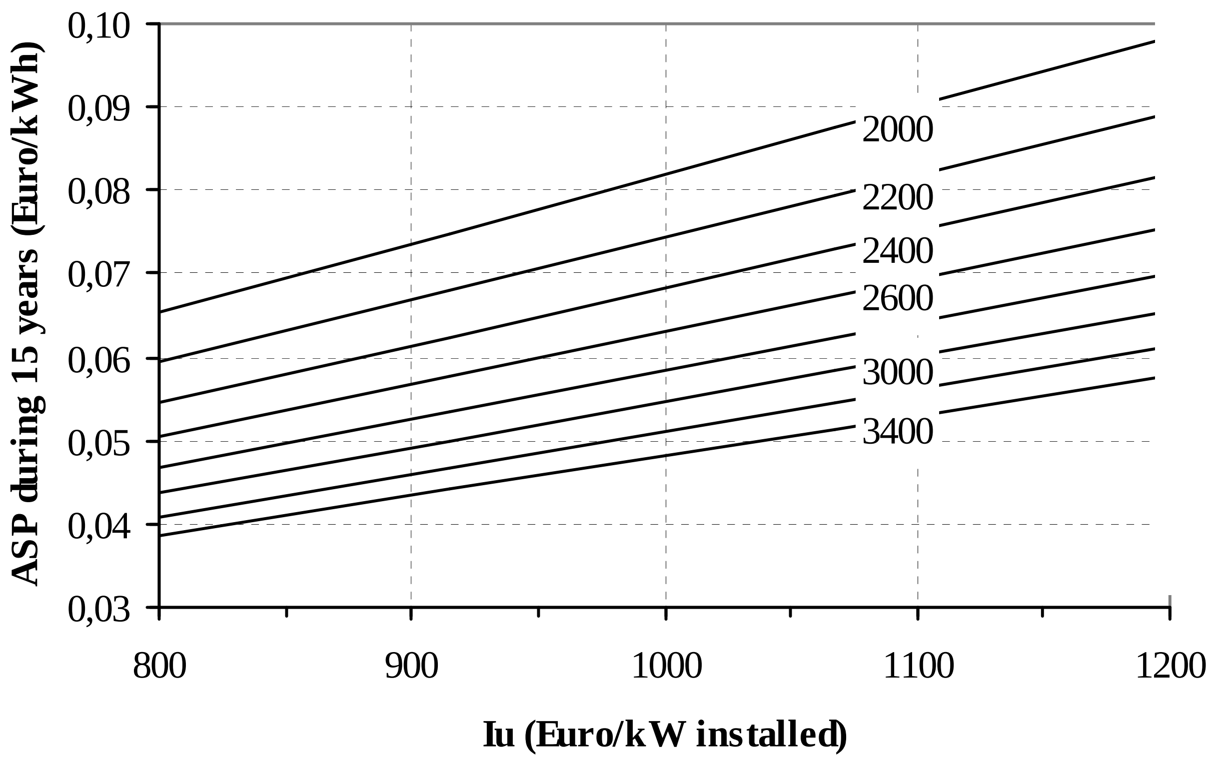
First approach: efficient tariffs versus Iu & Nh

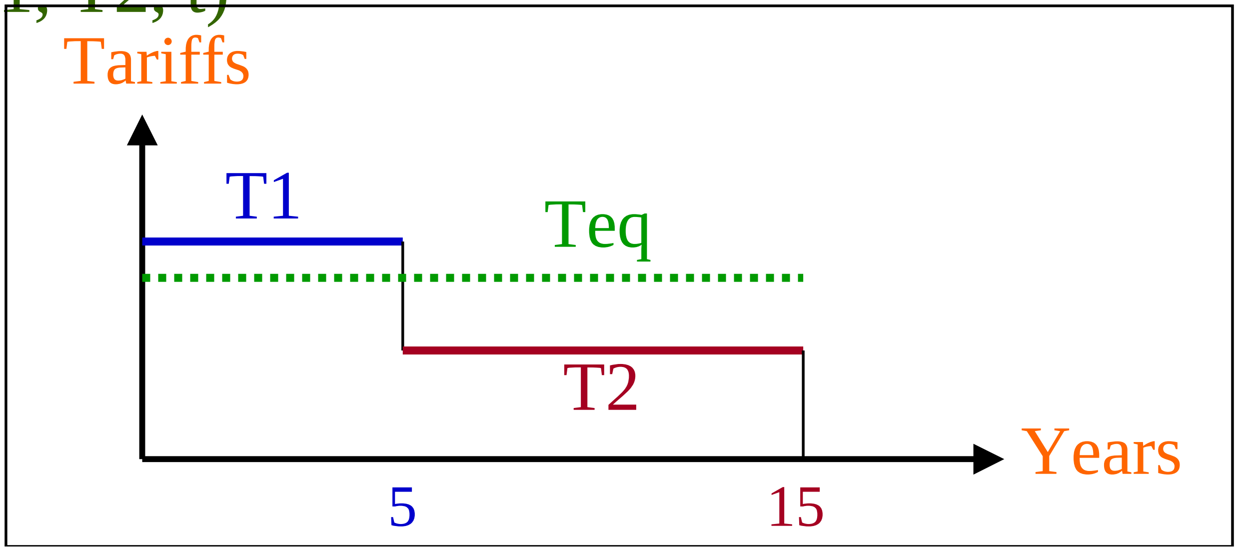
- **Example : grid connected Wind Farm**
- **Basis: PI = 0.3, discounting: 6%, 15 years, Kom = 3%**
- **Tariff ASP versus Iu and mean annual average yield Nh (h/year at rated power)**
- **Example: for Iu=1000 E/kW and Nh = 2400 h/year (ACF = 27.4%), ASP = 6.8 Euro/kWh**

Efficient Windpower Tariff ASP Versus Average Yield Nh and Investment Cost Iu Based on Profitability Index PI = 0.3
(Discounting: 6% on 15 years, Kom = 3%)



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", Teq
- **For a specific project :**
  - ⇨ Nh = averaged Ey / P from values years 1 to 5 (hours/year)
  - ⇨ T2: linear calculation from values at Nhr = 2000, 2600, 3600
  - ⇨ Teq from (T1, T2, t)

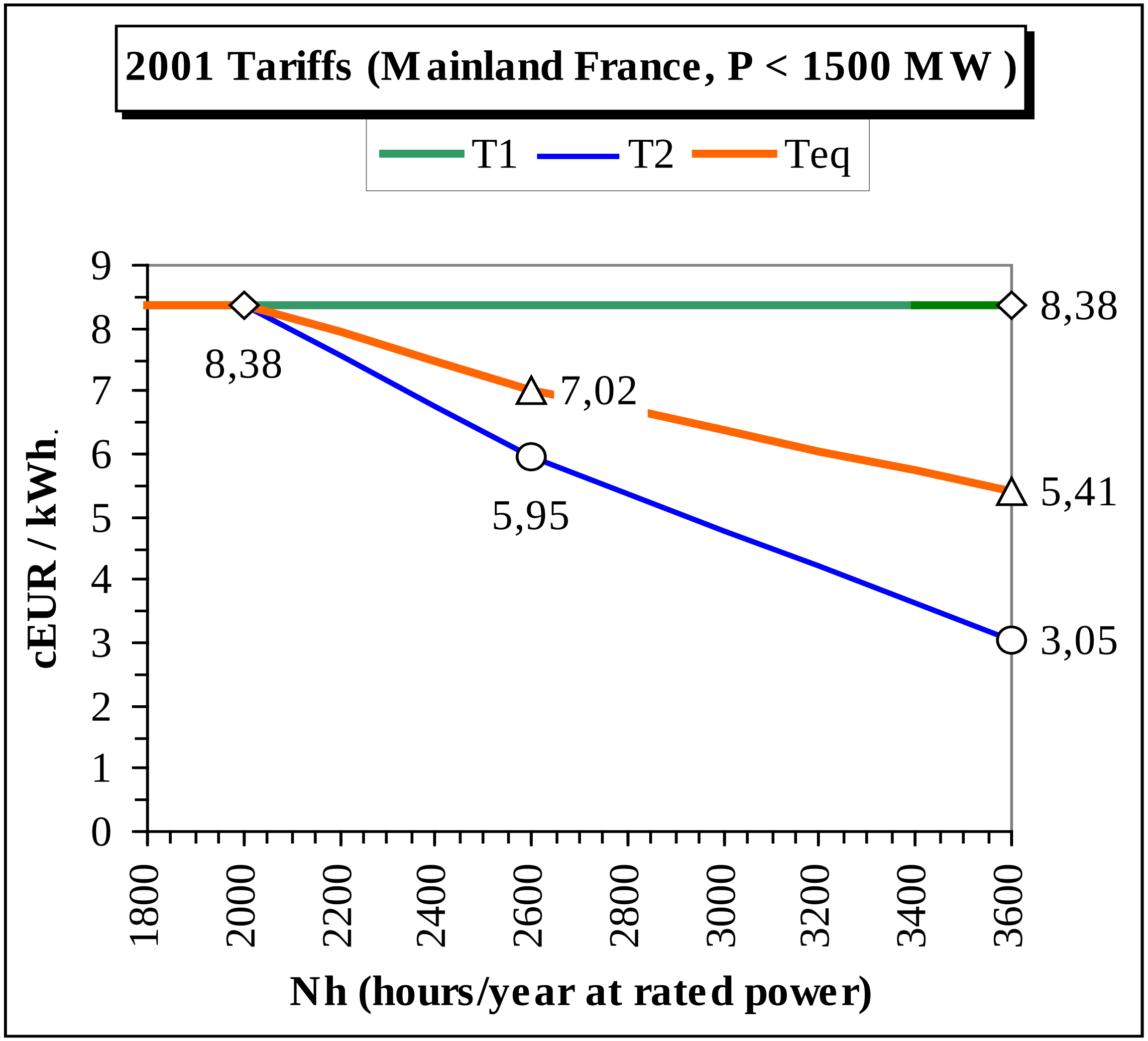


Tariffs: Other Principles and Final "Details"

- **Indexation for tariffs within a specific contract:**
  - ⇨ Only 60% ==> decrease of profitability with inflation rate
- **Two sets for Nhr min, max & intermediate ref. values:**
  - ⇨ "Favourable" till sums of signed contracts is under 1.5 GW
  - ⇨ "Less favourable" after 1.5 GW of signed PPA (2005 ?):
    - ✩ Nhmin = 1900 hours/year instead of 2000, Nhint = 2400 instead of 2600 and Nh max = 3400 instead of 3600
- **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)**
- **T2 values for years 6 to 10 and years 11 to 15:**
  - ⇨ Less 25% for kWh beyond the value of Nhref x 5 x P

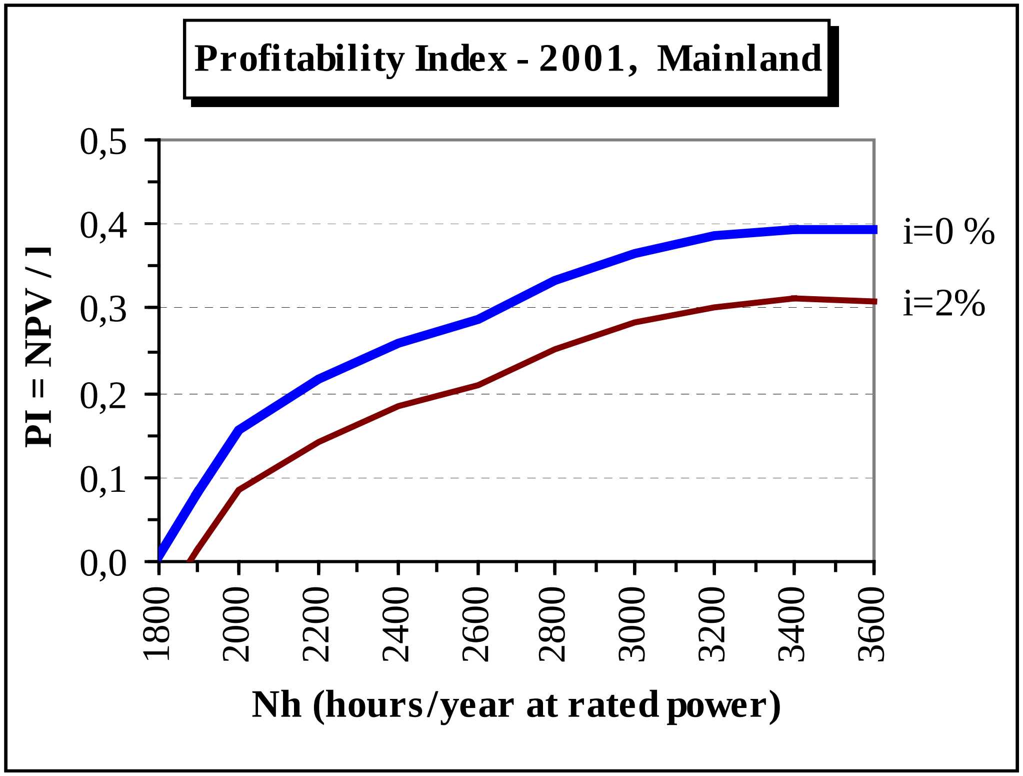
Wind tariffs: June 8th 2001 Arrêté, 2001 tariffs

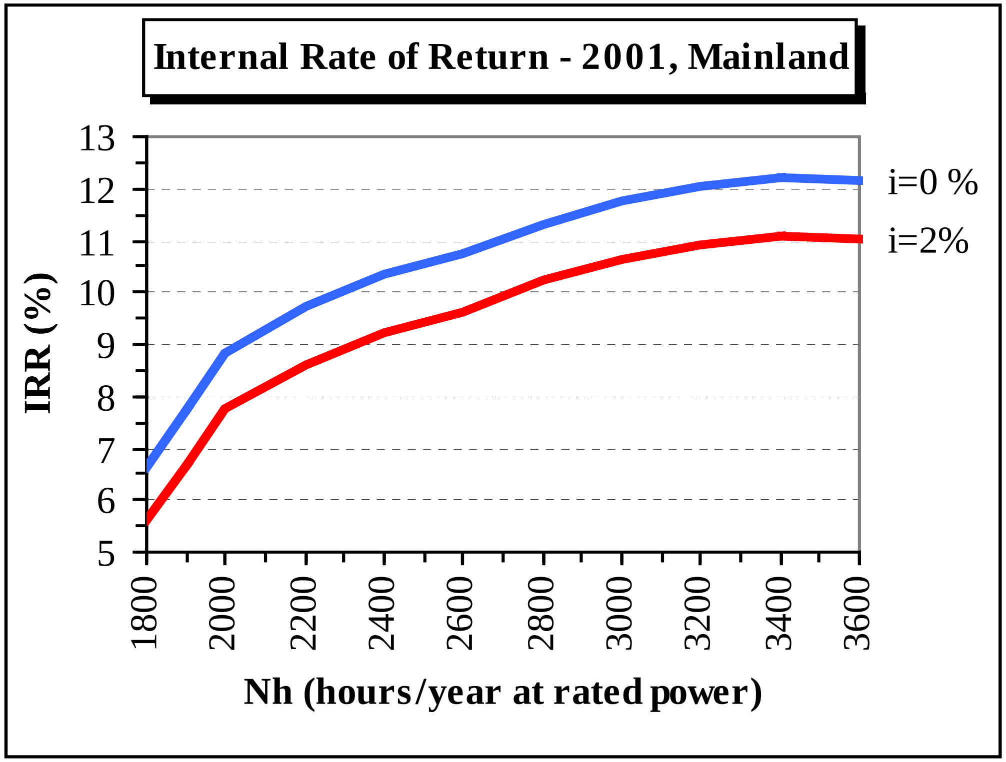
Reference values for 2001 tariffs					
Mainland France, projects < 12 MW					
	P (MW)	P (MW)	cEUR / kWh		
Nh:	<1500	<1500	**T1**	**T2**	**Teq**
Nhmin:	2000	1900	8,38	8,38	8,38
Nhint:	2600	2400	8,38	5,95	7,02
Nhmax:	3600	3300	8,38	3,05	5,41
Corsica & Overseas Depart. projects <12 MW					
	P (MW)	P (MW)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

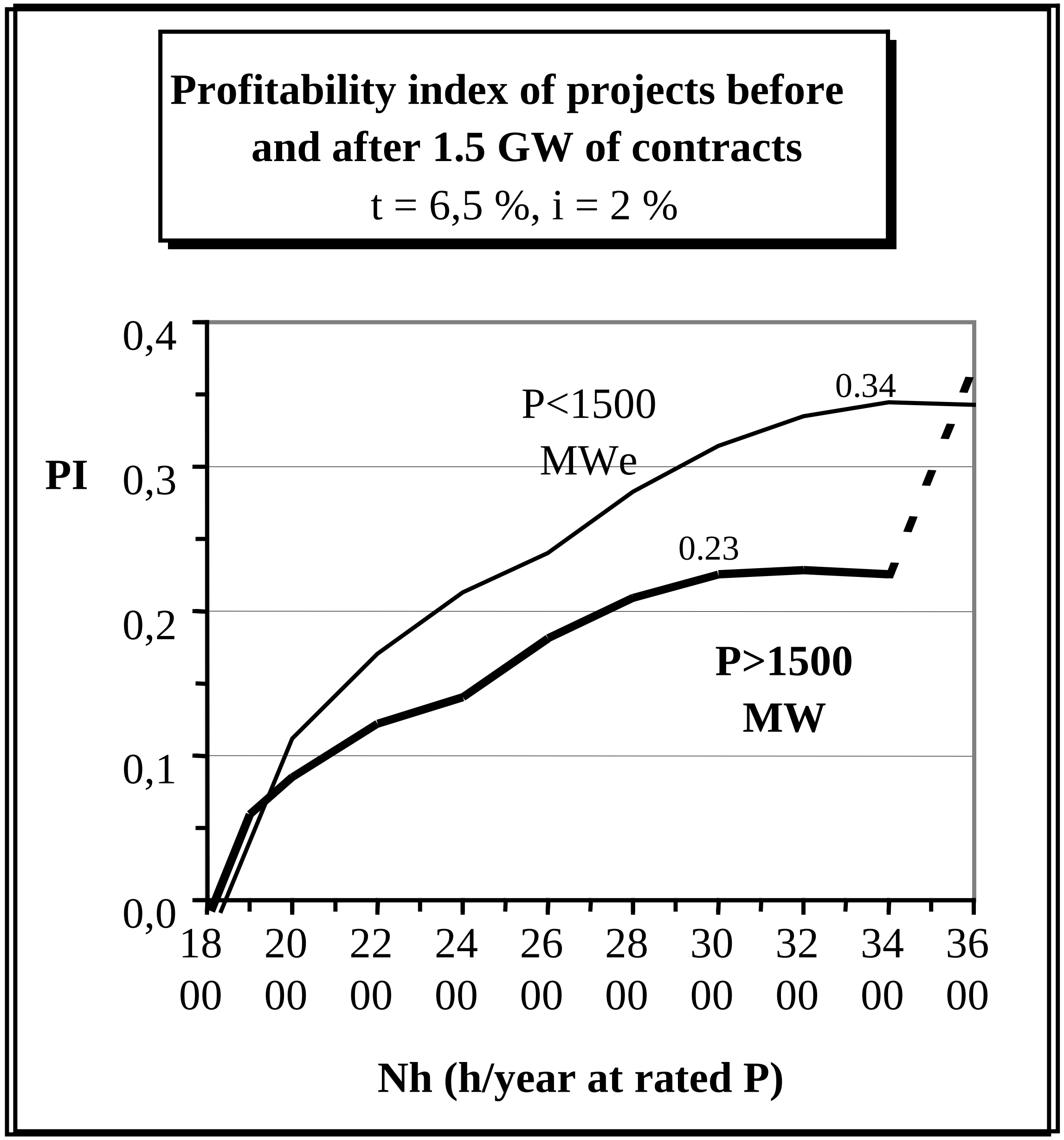




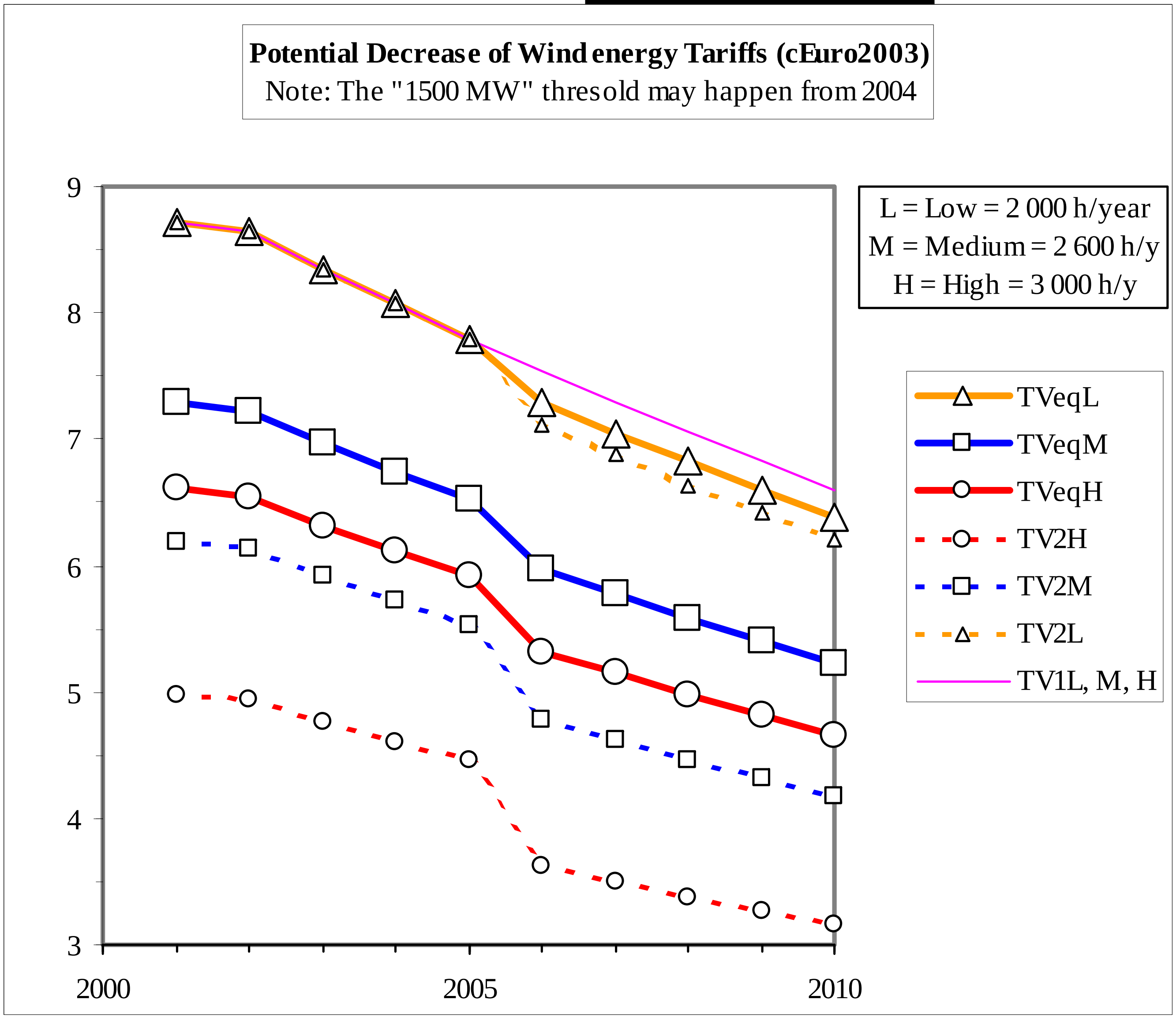
- **Reference case (P < 12 MW per project):**
  - ⇨ Iu=1067 EUR/kW. Value at year 16: 15% of initial invest.
  - ⇨ Yearly O&M expenses: Kom = 4 % of initial investment
  - ⇨ Mean inflation rate 2001 - 2015: i = 0% or i = 2 % / year
  - ⇨ Profitability index: NPV per € invested

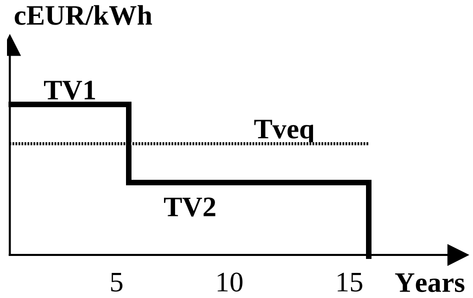
Profitability before & after 1.5 GW of contracts

- As sum of grid connection files is around 14 GW:
- Profitability assessment for new projects must be done also with > 1.5 GW tariffs
- Decrease of profitability may be important!



Example of Tariffs Decrease (infl. rate: 2 %/year)





Note: **actual tariffs may differ (ICHTTS and PsdA indexes may not vary as inflation rate)**

Source: **B. Chabot, ADEME, 2003**

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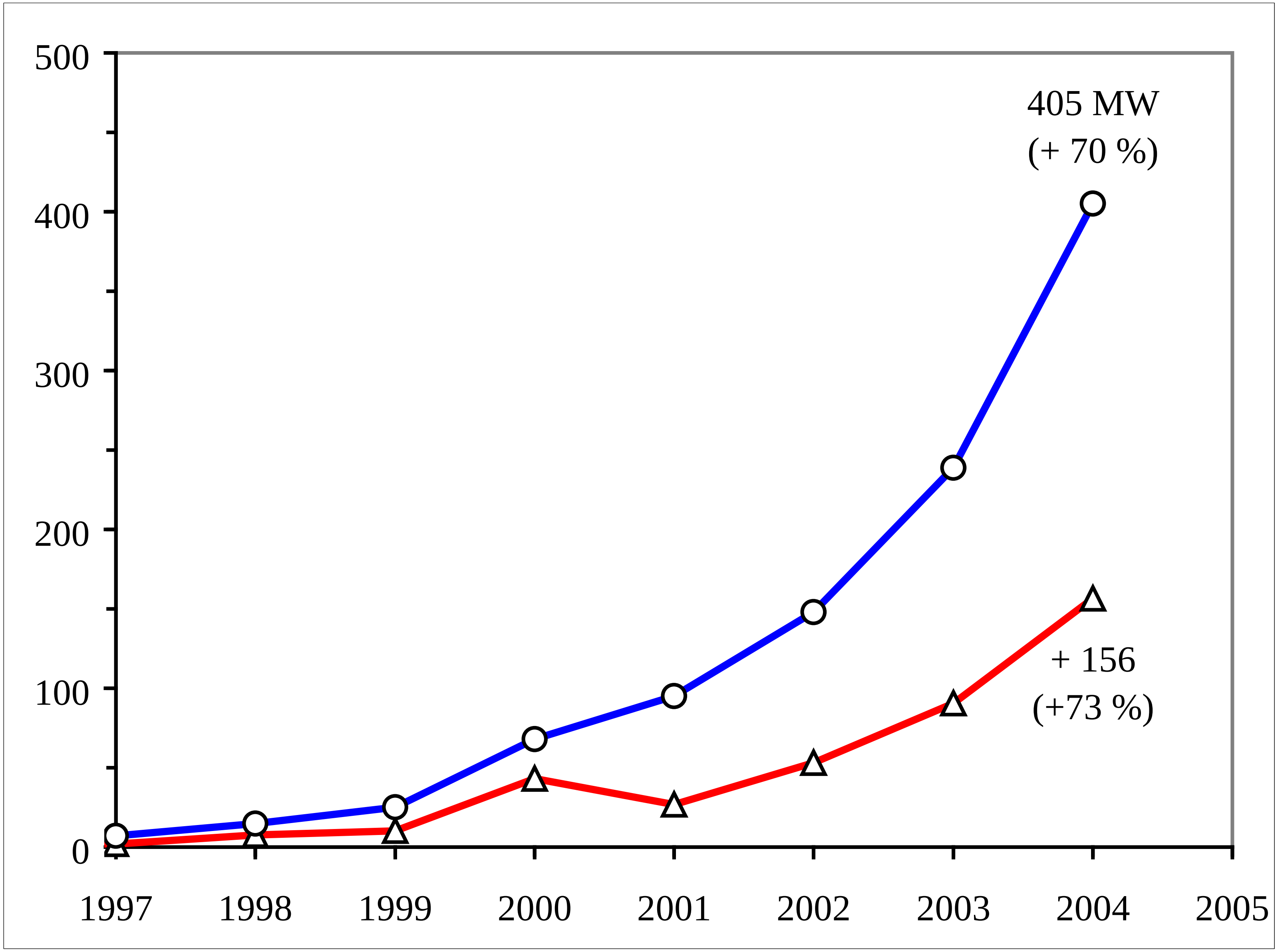
Wind Power development in France



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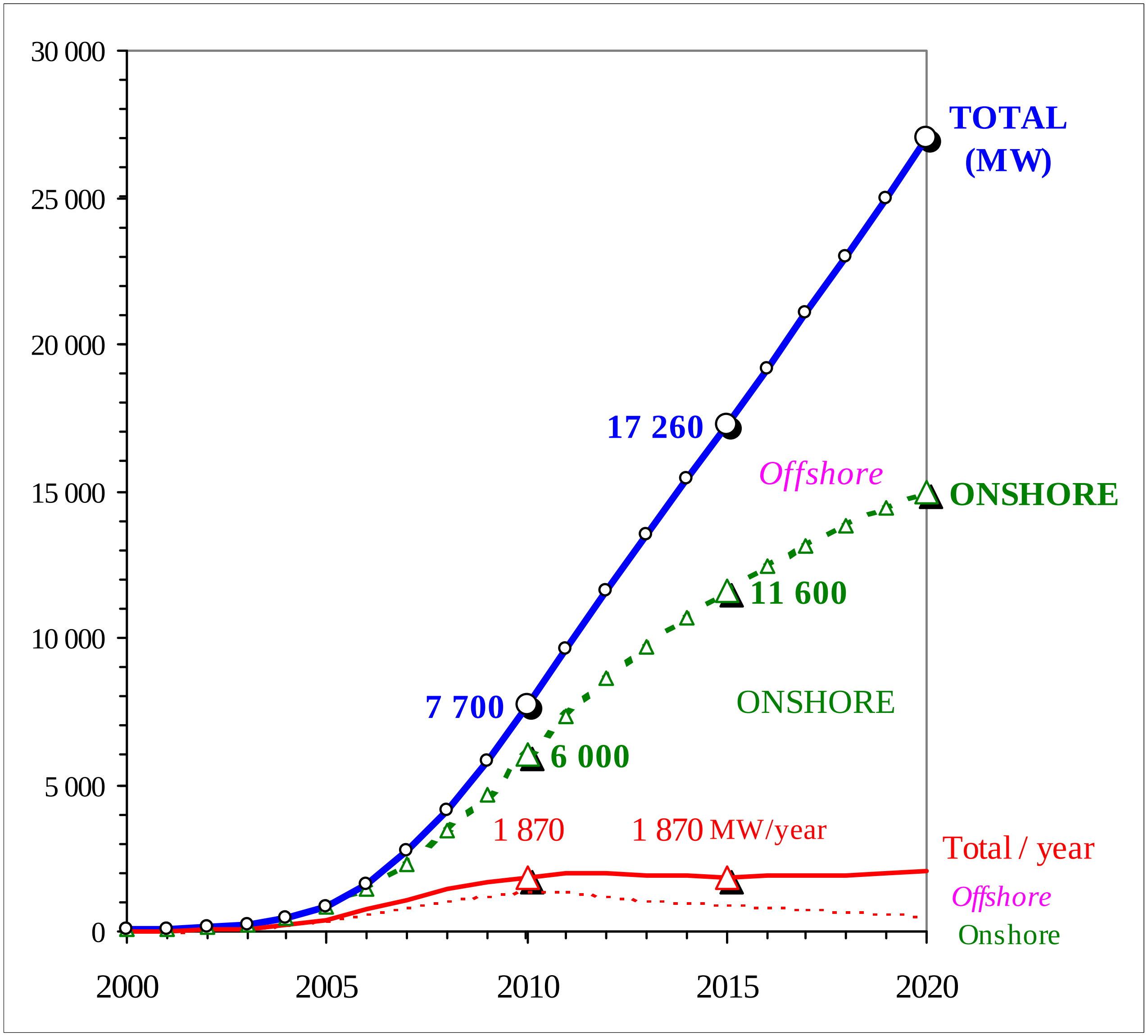
France: Potential Wind Power Development up to 2020



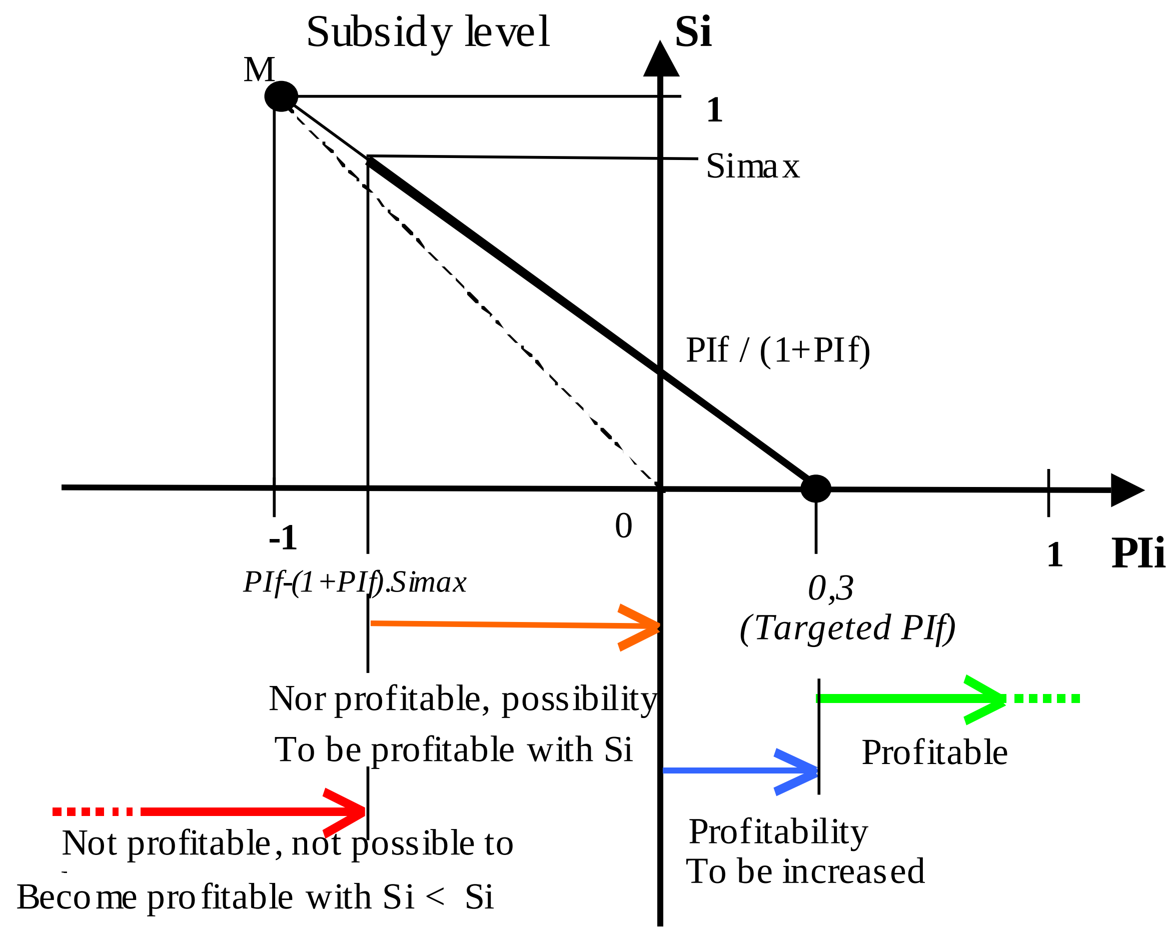
Source: B. Chabot, ADEME, Systèmes Solaires, mai-juin 2003, Paris

V

Case Study 2:
Rational Management of Subsidies from the Profitability Index

A rational management of subsidies from the PIM

- PIi before subsidy < 0
- Goal : PIf after subsidy Si
  - ⇨ Si = (PIf -PIi)/(1+PIf)
- Rational policy for subsidies targeting:
  - ⇨ PIf > 0,3 : business
  - ⇨ PIf = 0 : rational minimum
  - ⇨ PIf < 0: investment based on a consumer choice (e.g. environmental protection) e.g. : domestic solar systems, electrical car…
- PIf < 0 : marketing:
  - ⇨ Nc max customers= f (PIf)
  - ⇨ Nc actual = f' (Nc max, time)

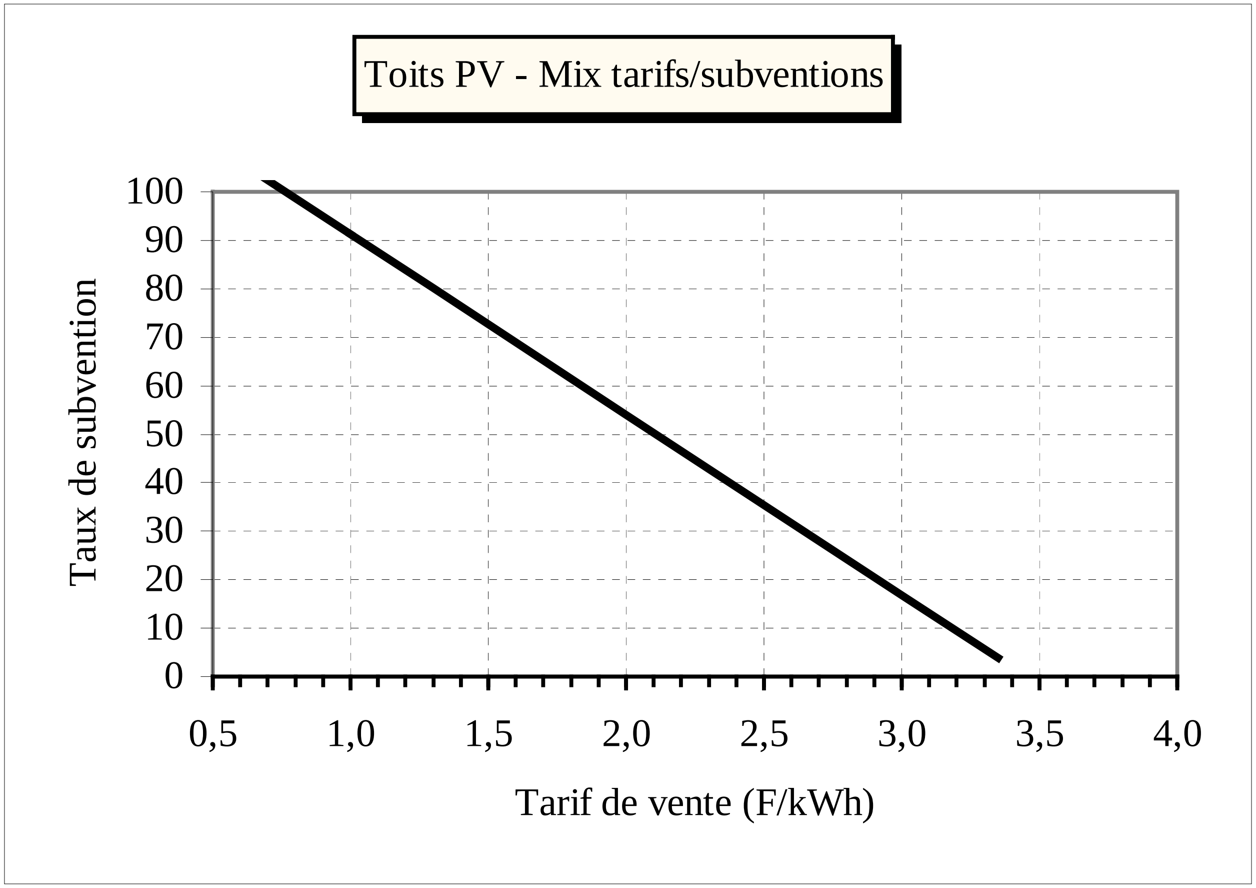


Example : tariffs / subsidies balance for PV roofs

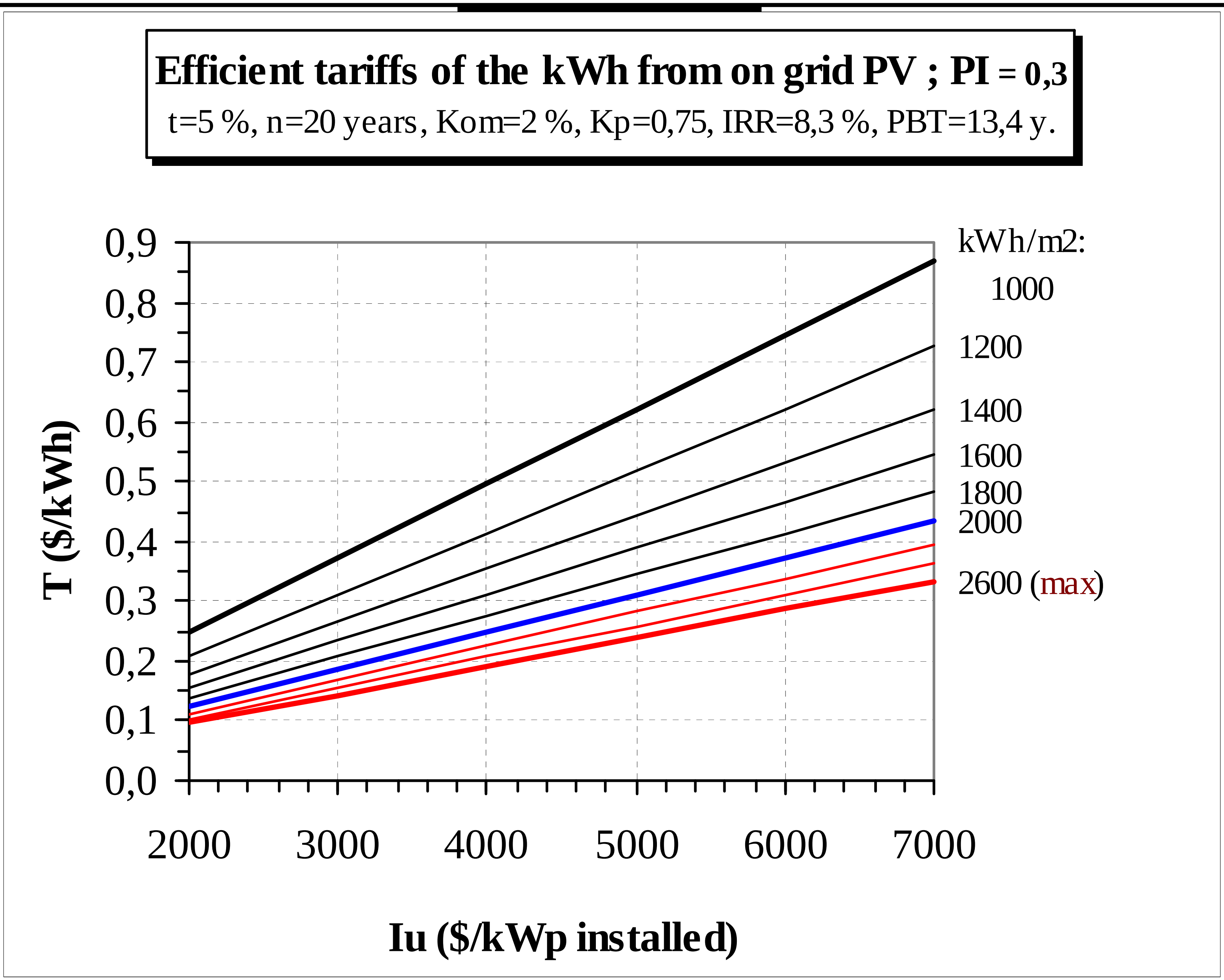
Case of a domestic customer, mainland France

- nominal tn = 3 % ===> actual t = 0,5 %
- n = 20 years

Toits PV	Cas	Métropole
	Variante	Centre (3,8)
Ei	kWh/an.m2	1 400
Kp		0,70
Nh	h/an	980
t	%	0,50
n	ans	20
Ka		0,05267
Pc	kWc	2,00
Iu=I/Pc	F/Wc	50,0
I	F	100 000
Kem=Dem/I	%	1,50
CGA	F/kWh	3,45



Efficient tariffs for commercial PV (1US$=1 €)



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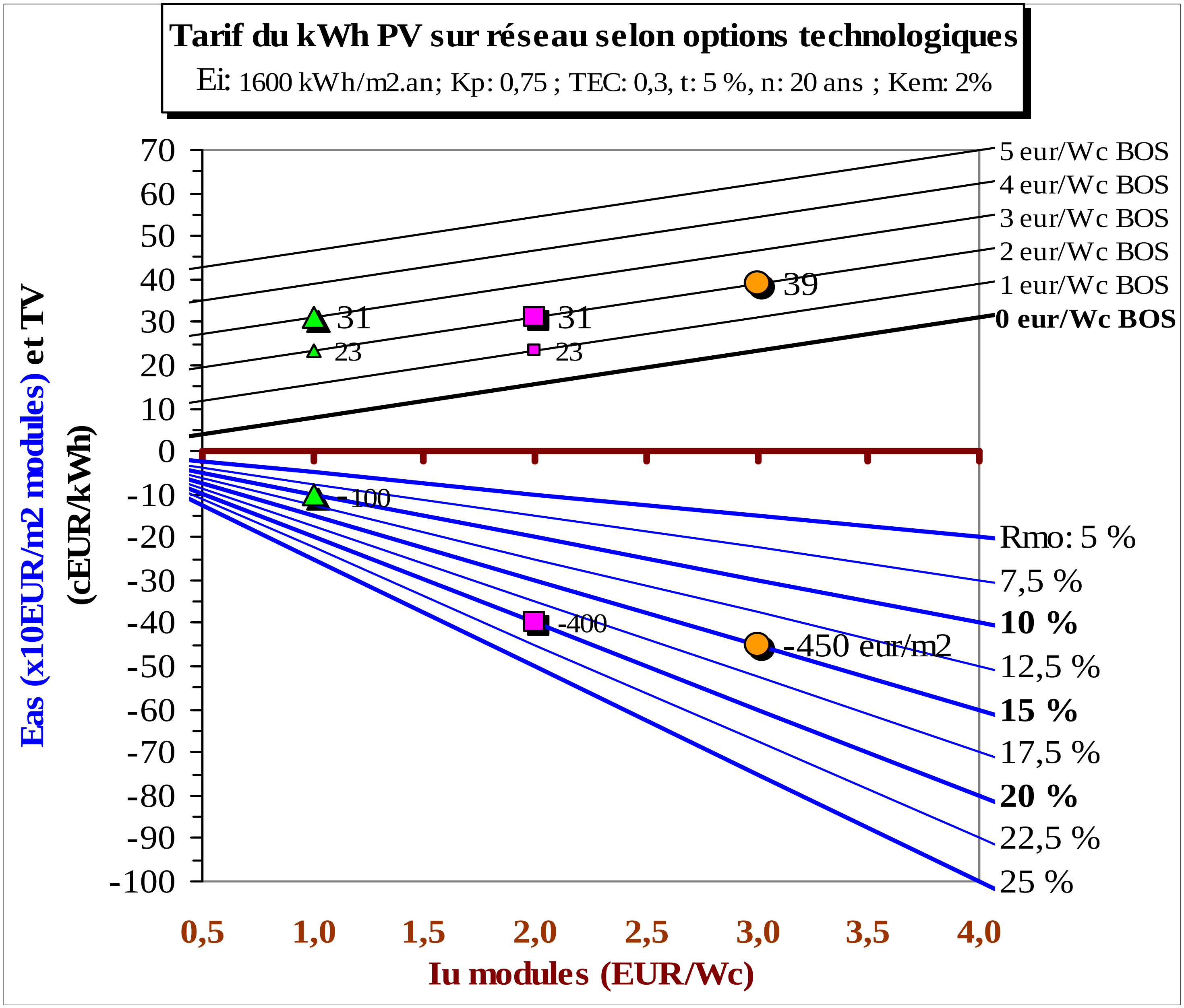
PV power and energy costs and prices



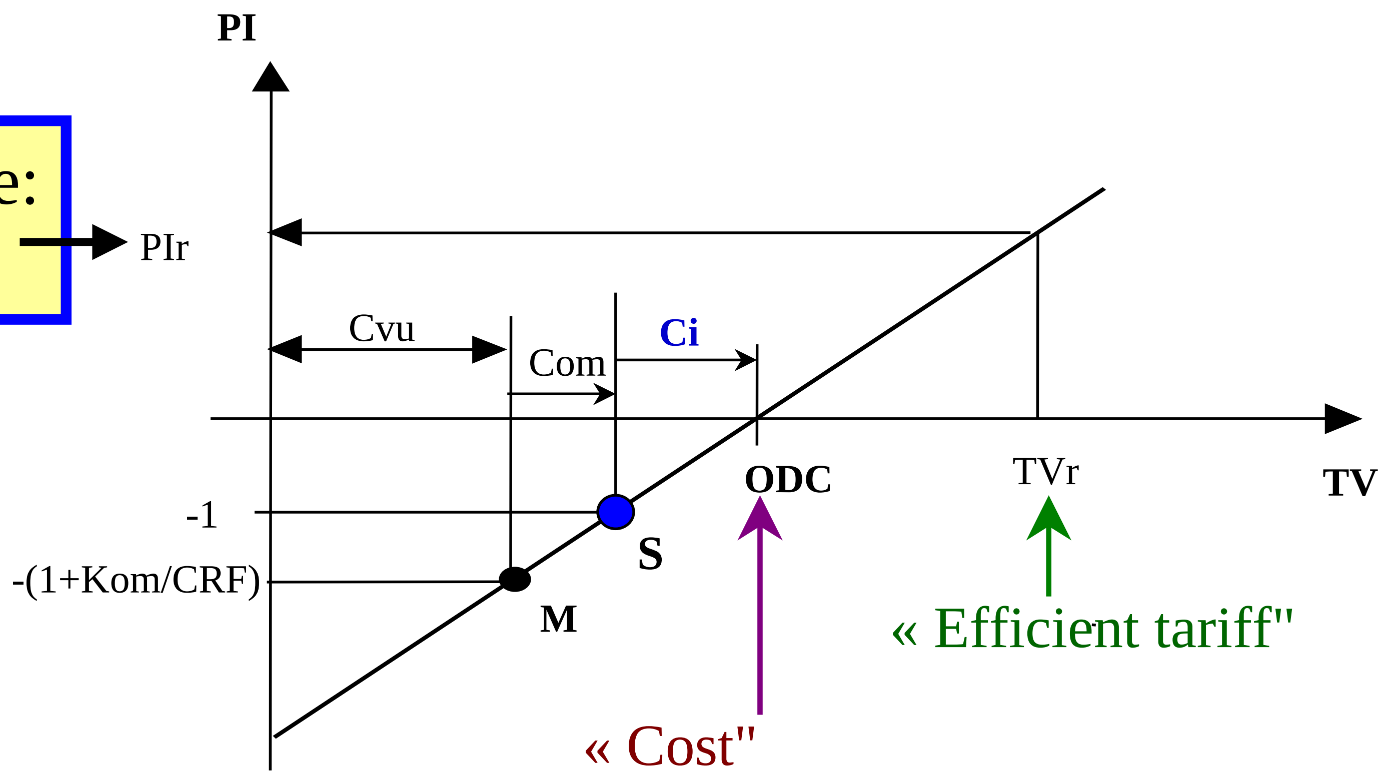
III

Taking into account or designing potential incentives for renewables

Designing an « Efficient tariff »

- ⇨ Defining a fixed tariff for a sustainable good or service
- ⇨ Example: RE in Germany: Refit 1991, EEG 2000:
  - ✰16 GW, >36 TWh/y in 2005, 55 000 jobs, towards 90 TWh/y in 2020
- ⇨ Adaptation in France: was possible in 2001 only for wind energy:
  - ✰6 à 10 GW in 2010, 20 à 30 TWh/y in 2010, more than 10 000 jobs ??

Golden rule:
PI > 0.3

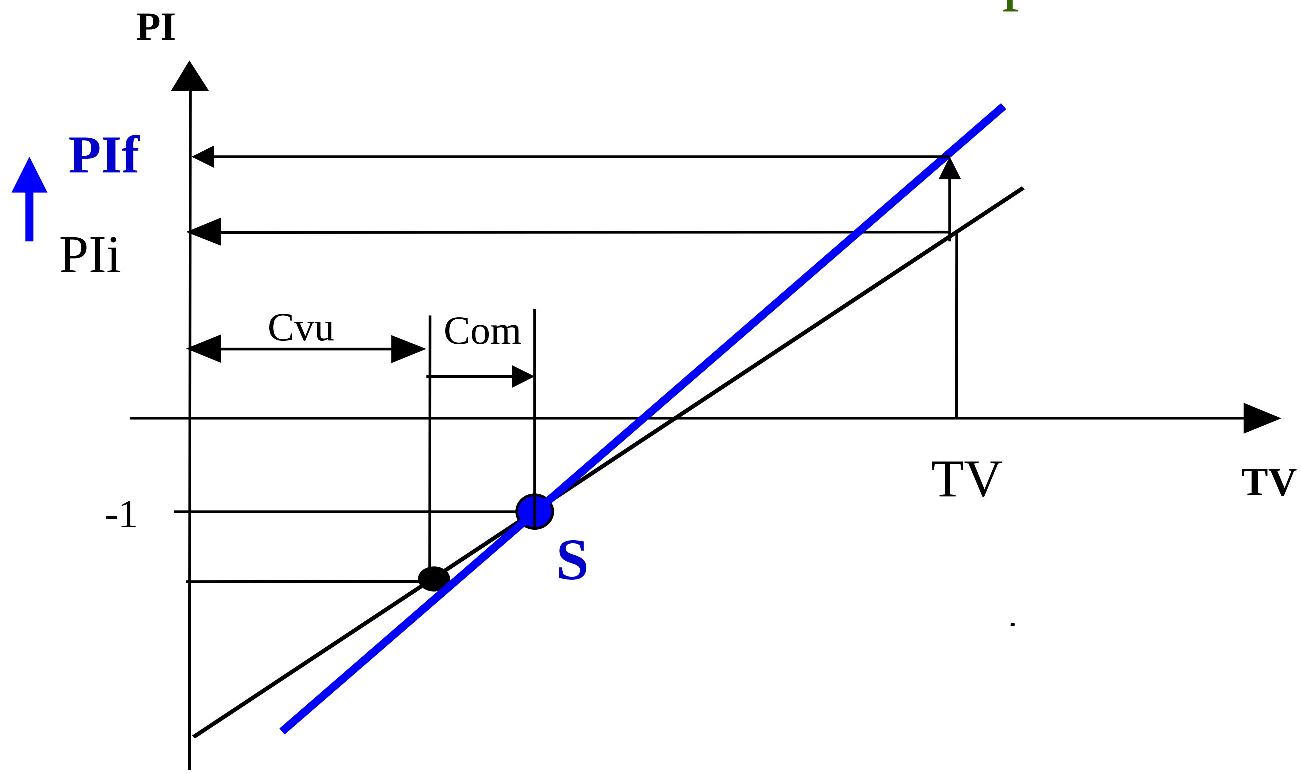


Effect of a subsidy *si* on the initial investment I

⇨ Simple relationship :

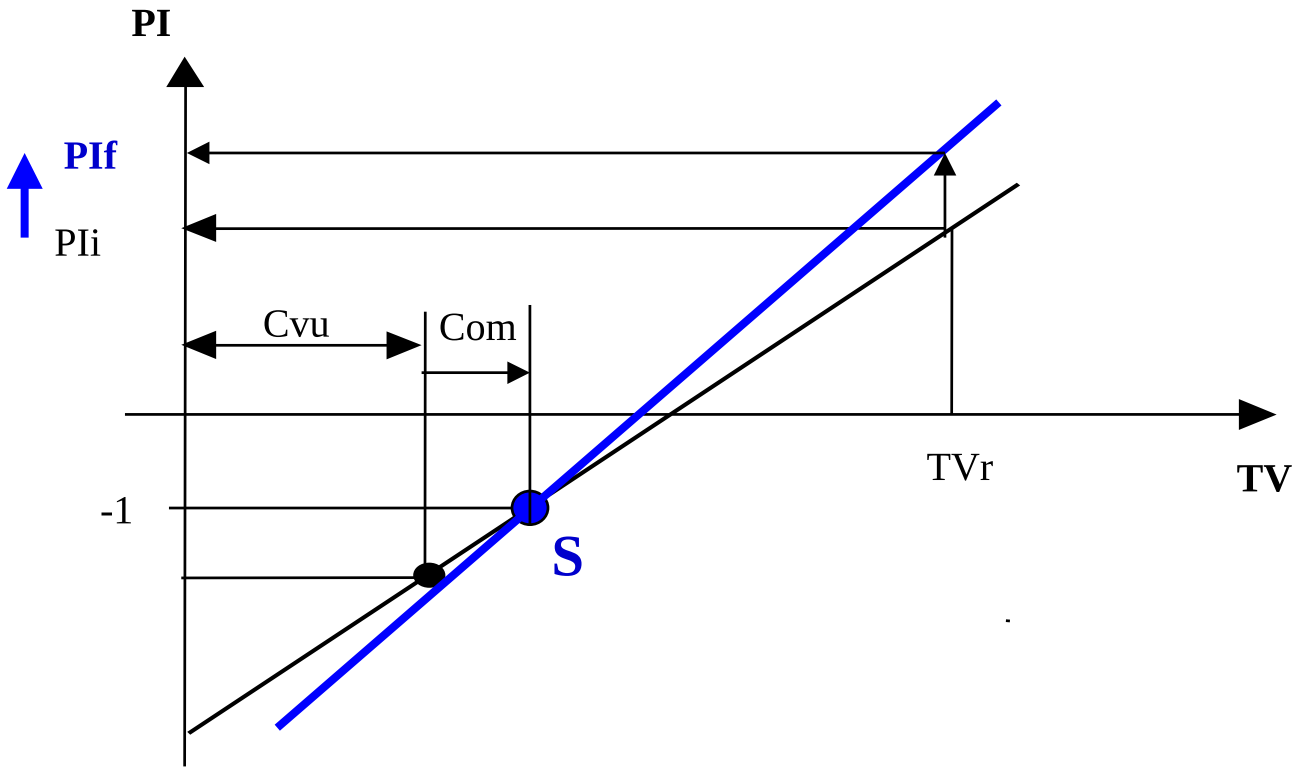
- ☆Subsidy rate *si*: **si = (PIf - PIi) / (1 + PIf)** where:
- ☆PIf = target value of final profitability index PI (after subsidy)
- ☆PIi = initial PI value (before subsidy)

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



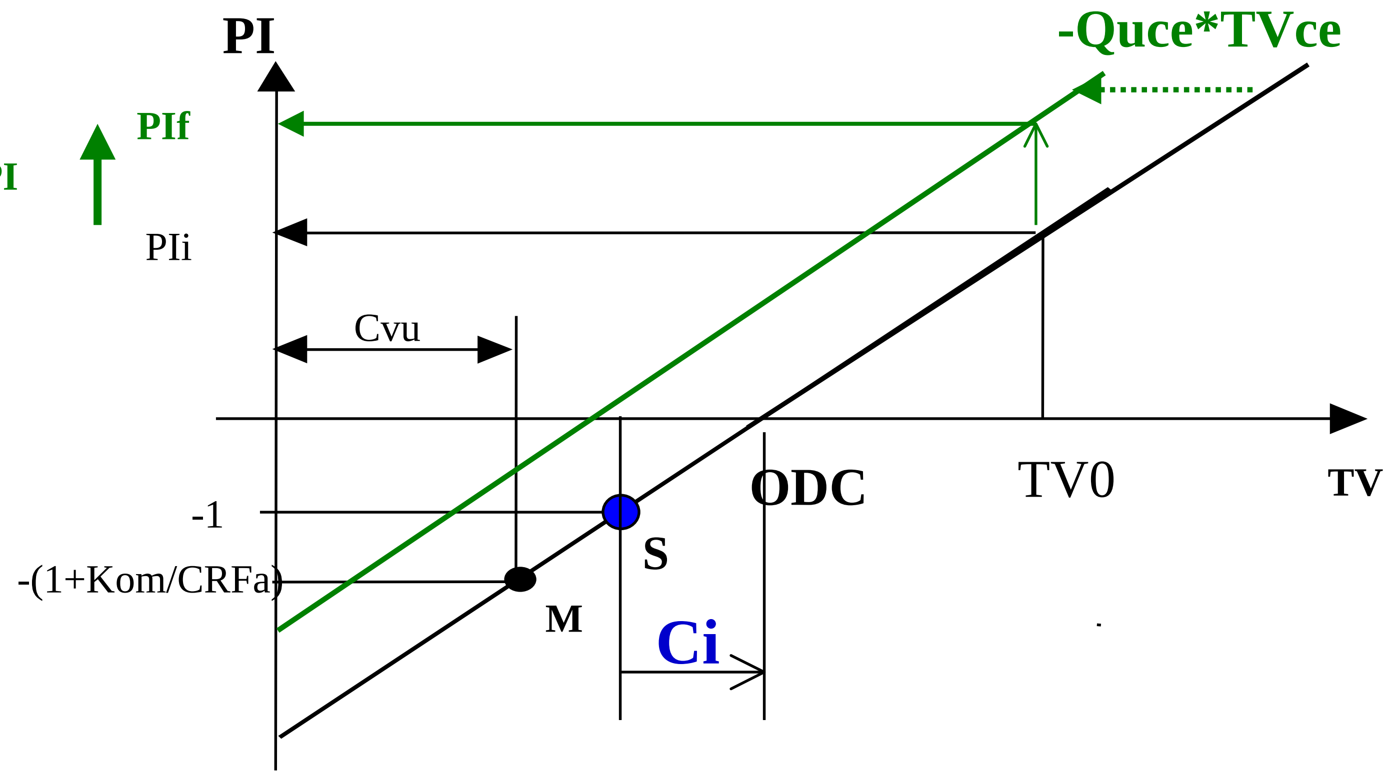
Impact of soft loans

- ⇨Conventional financing scheme: to = AWCC0 ==> CRFo(to,n)
- ⇨Soft loans => soft financing ==> ts < to ==> CRFs(ts,n) < CRFo(to,n)
- ⇨The "PI versus tariff" line turns around its "S" point
- ⇨Equivalent subsidy *si* on investment: **si = 1- CRFs/CRFo**



Potential impact of selling "Carbon Credits"

- ⇨Avoided CO2 emissions : Quce (kg CO2/kWhe). Selling price of carbon credit : TVce (€ / avoided kg of CO2). Price bonus: TVce*Quce
- ⇨The "PI line" translates horizontally of a TVce*Quce value (€/kWhe)
- ⇨ The Thalès - Chabot theorem: dPI = (Quce*TVce) / Ci
- ⇨Or: dPI = {(Quce*TVce)/CGA} /(Ci/CGA) => **basic role of Ci/CGA**



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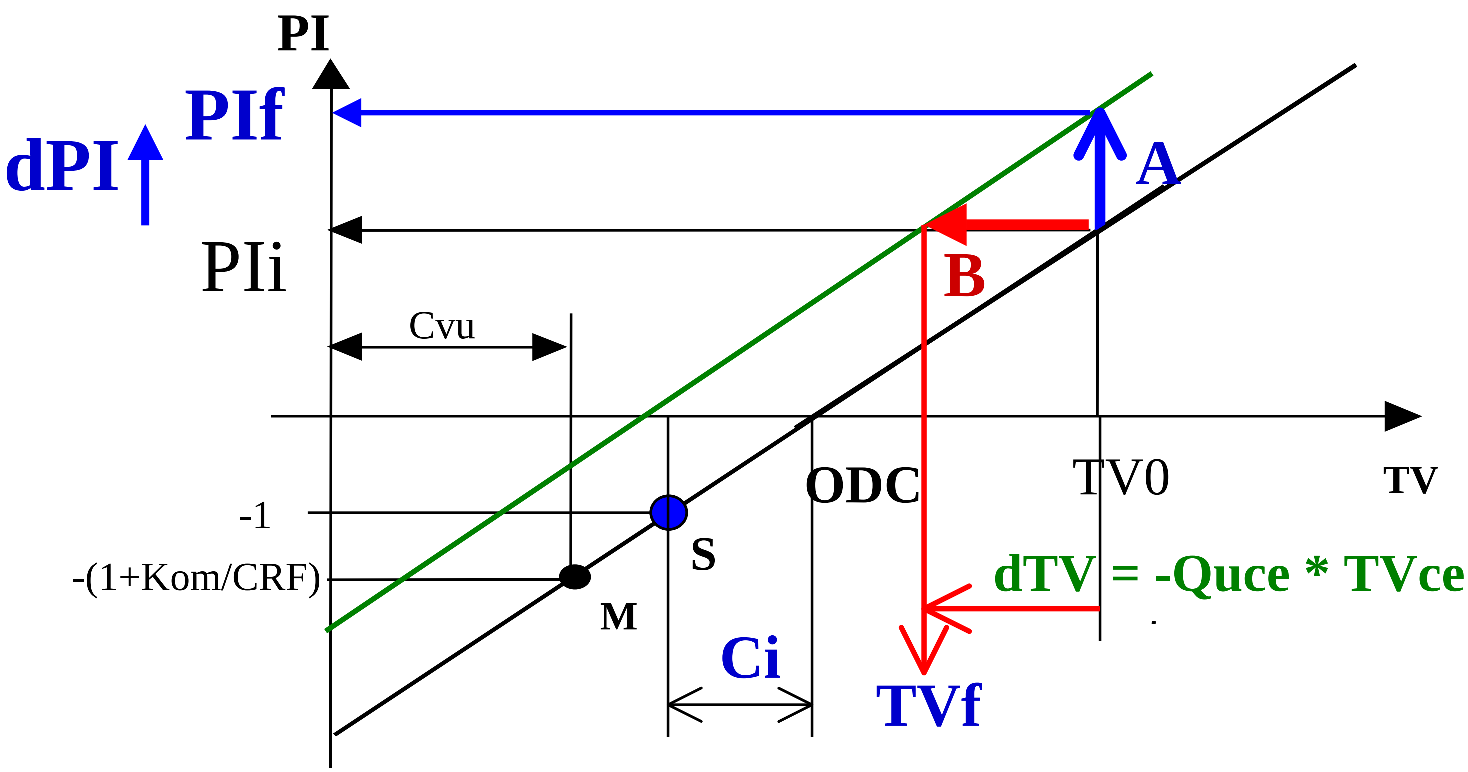
Two strategies to benefit from "Carbon Credits"

⇨ **A** : increasing profitability of the project if the initial profitability index *PIi* is too low (e. g. < 0.3) and if carbon credit can be sold by the plant owner : **Pif = Pii + dPI , with dPI = Quce * Tvce / Ci**

⇨ **B : If *PIi* is sufficient, decrease the price : TVf = TV0 - Quce*TVce**



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 and to evaluate them**
- **Past validation:**
  - ⇨ Good accordance with detailed financial analysis (wind tariffs, F)
  - ⇨ Used with success for the French Wind power tariff system
  - ⇨ Used for training sessions : ADEME, CDER, AME/STEG...
  - ⇨ Recognition from professional bodies and investors
- **A vast prospect for use :**
  - ⇨ Extension to al other energy services (energy savings, DSM…)
  - ⇨ For decentralised rural electrification in DC…
  - ⇨ ADEME is open to information, cooperation, training...