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**Optimising economic incentives for
geothermal energy development**

Contribution from the "Profitability Index method"

Bernard CHABOT

Senior Expert

ADEME

500 route des lucioles - 06560 Valbonne - France

E-mail: bernard.chabot@ademe.fr

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Introduction

□ What is the problem ?

⇒ Define an optimum mix for economic incentives for RETs:

☆ Guaranteed tariffs or environmental premiums

☆ Supplementary revenue on separate markets: green certificates, carbon credits

☆ Subsidy on initial investment

☆ Soft loans

⇒ Define a simple and reliable economic analysis method for projects & programmes managers and for decision makers

□ The opportunities:

⇒ European and French experience on economic incentives for renewables and energy for efficiency (e.g. CHP, DSM)

⇒ ADEME and French experience defining and using the "Profitability index Method" (PIM)

The need for economic incentives

- ❑ **In liberalised energy markets, the main force for market development is profitability of investment in projects, in order to attract private investors**
- ❑ **Global economic profitability is required and not only profitability on equity after fiscal incentives**
- ❑ **RETs projects, including geothermal ones, present specific characteristics:**
 - ⇒ Long term commitment (10, 15, 20 or even 30 years)
 - ⇒ Fixed annual energy yields from "nature" (except biomass)
 - ⇒ Delivering commodities: "clean" heat, power
 - ⇒ In general, economic profitability lower than using fossil fuels
 - ⇒ But environmental advantages: no GHG emissions, no waste

The need for a market regulation for RETs

❑ **Without regulation, investors will choose fossil fuels**

❑ **Two kinds of regulation:**

⇒ **By quantities ("the stick"):**

- ☆ Quotas of RETs based energy imposed on producers or on consumers
- ☆ Quotas are based on amount of "green certificates", which can be traded
- ☆ Two incomes: from energy and from derivatives (green certificates)
- ☆ "Sufficient" Penalties if the quotas are not proved

⇒ **By prices ("the carrot"):**

- ☆ Guaranteed prices, or guaranteed "environmental premiums" for energy
- ☆ Values based on a "fair profitability" for state of the art projects
- ☆ Specific values for different technologies, qualities of sites (e. g. wind)
- ☆ Future cost decrease can be taken into account.

Comparing regulations for RETs

□ Regulation by prices is:

- ⇒ Very efficient: example: wind power : "Old DK", G, Sp versus UK, Ir, NL, "new DK": GWs versus MWs
- ⇒ Very simple: example EEG law in Germany, French tariffs
- ⇒ Not more costly if specific tariffs for different RETs and if taking into account costs decreases
- ⇒ Not a state aid and not an adverse effect on competition if over-cost is passed on all consumers (e. g; : G, Fr, Sp...)

□ Regulation by quotas:

- ⇒ Seems more "market oriented" (?????)
- ⇒ But requires in fact a more detailed and a more stringent regulation and requires a future global/regional market (at least EU market for green certificates and carbon credits)
- ⇒ No medium and long term visibility on prices: no decisions from investors for long term projects (15 to 30 years).

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

The context to apply the PI method (2)

- ❑ **A global economic analysis for preliminary studies**
- ❑ **Constant inflation, results in constant money (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 TV1, TV2)
- ❑ **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

The basis of the PI method

□ Definitions:

⇒ $PI = NPV / I =$ Profitability Index

⇒ Based on the discounting approach :

☆ $t =$ discount rate = average weighted cost of capital (AWCC, a cost factor) and not an « opportunity cost » (a profit parameter)

☆ $n =$ number of years considered for the economic analysis (with a residual value $Valres > 0$ if $n <$ technical life cycle)

☆ $Kd = t(1+t)^n / (((1+t)^n) - 1) =$ capital recovery factor

□ Using ratios:

⇒ Investment cost ratio: $Iu = I / P$ (EUR / kW)

⇒ Energy yield : $Nh = Ey / P$ (kWh/y. kW = h/year at rated power)

⇒ O&M expenses ratio: $Kom = DOM / I$ (without fuel expenses)

⇒ Fuel costs : zéro (RE except biomass) or $Fc / (Rg / LHV)$

□ Clear difference between cost and selling price (tariff TV)

□ Simple models: $PI=f(TV)$, $MOC=f(PI)$, $Si = f(PIf, PIi)$

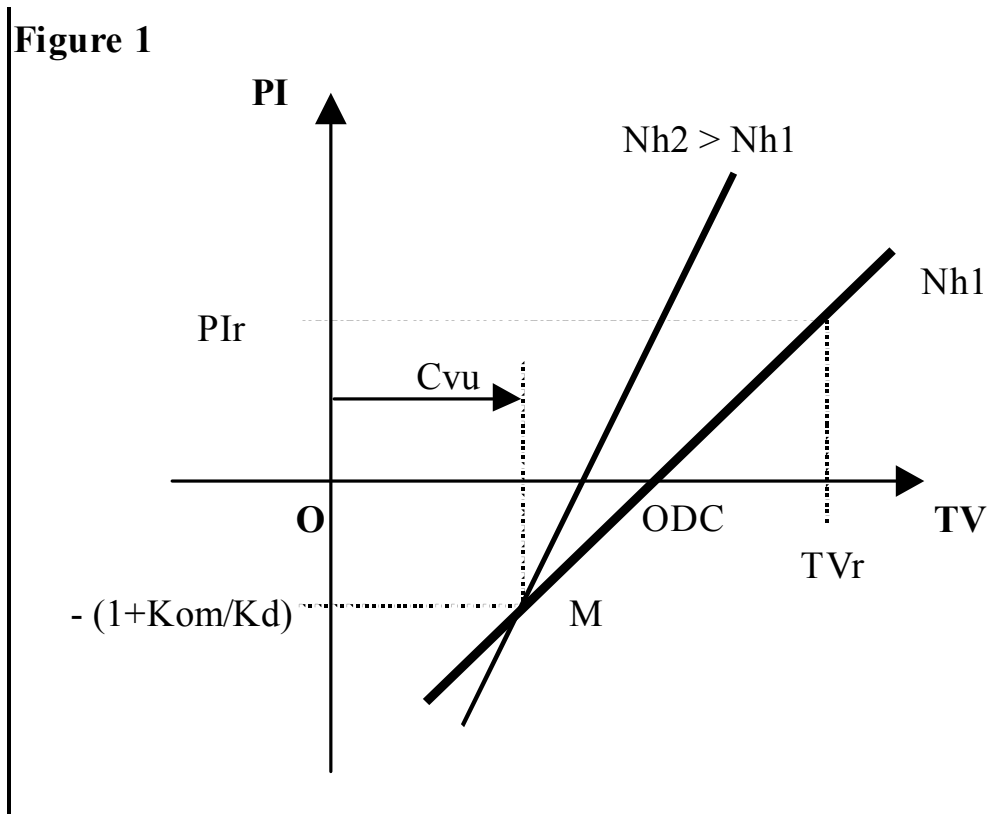
The model $PI = f(\text{tariff } TV) \quad (1)$

□ $NPV = (-I + \text{Sum of discounted CFs from year 1 to } n)$

□ $PI = NPV / I = a (TV - C_{vu}) - b$

$\Rightarrow a = N_h / (K_d \cdot I_u) ; \quad b = -(1 + K_{om}/K_d) ; \quad C_{vu} = F_c / (R_g \cdot LHV)$

Figure 1



Legend and definitions	
PI	Profitability index = NPV / I
TV	Tariff (average selling price)
ODC	Overall discounted cost
Cvu	Variable cost due to fuel cost
Fc	Fuel cost (EUR/kg, EUR/m ³)
Rg	Yearly average global efficiency
LHV	Low heating value of the fuel
Nh	kWh / year, kW (hours/yr)
Kom	O&M expenses ratio = DOM / I
DOM	Yearly average O&M expenses
I	Initial investment cost
P	Rated power (kW)
Iu	Investment cost ratio = I / P
Kd	Capital recovery factor = $f(t, n)$
t	Discount rate = AWCC
n	N° of years for economic assess.

The model $PI = f(\text{tariff } TVe)$ for CHP

□ Data:

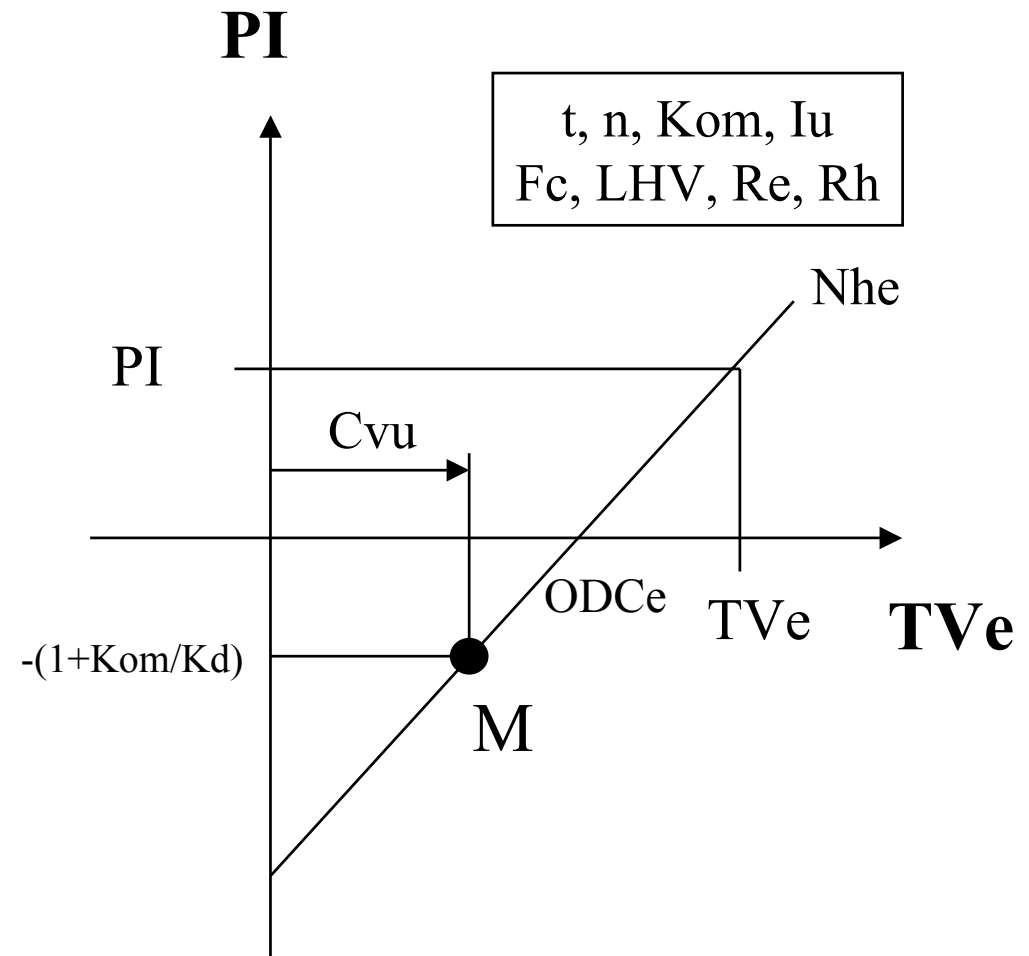
- ⇒ Discounting: $n, t = \text{CMPRC}$
- ⇒ $Iu = I/Pe$ (EUR/kWe)
- ⇒ $Nhe = ELa/Pe$ (hours/year)
- ⇒ $Kom = Dom/I$
- ⇒ $Re = Ela/THI$; Ela : annual electr. sold
- ⇒ THI = total yearly heat input from fuel
- ⇒ $Rh = Heats/THI$; $Heats$: annual heat sold
- ⇒ Fc (EUR/kg, EUR/m³)
- ⇒ LHV (kWht/kg, kWht/m³)
- ⇒ TVh (F/kWht)

□ $PI = a(TVe - Cvu) - b$

- ⇒ $Cvu = (Fc/Re.LHV) - (Rc/Re)TVh$

□ $Tve = c Iu + Cvu$

- ⇒ $c = (1+TEC)Ka(1-Si) + Kem(1-Se)/Nhe$



The model $P_i = f(\text{tariff } T_V)$ (2)

- ❑ **Advantage: complete characterisation of technol. & appl.**
- ❑ **Demonstrated and published added value :**
 - ⇒ ODC and Tariffs for RE based power plants : wind power, SHP, geothermal, solar PV
 - ⇒ 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 P_i : 0.3 and corresponding tariffs

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

- ❑ $MOC = (TV-ODC)/ODC = \{K_{fuel} \cdot K_a / (K_a + K_{om})\} \cdot PI$
- ❑ 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 fusion):
 - ⇒ $(MOC_r / MOC_f) = 1 / k_{Fuel}$ (= 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)

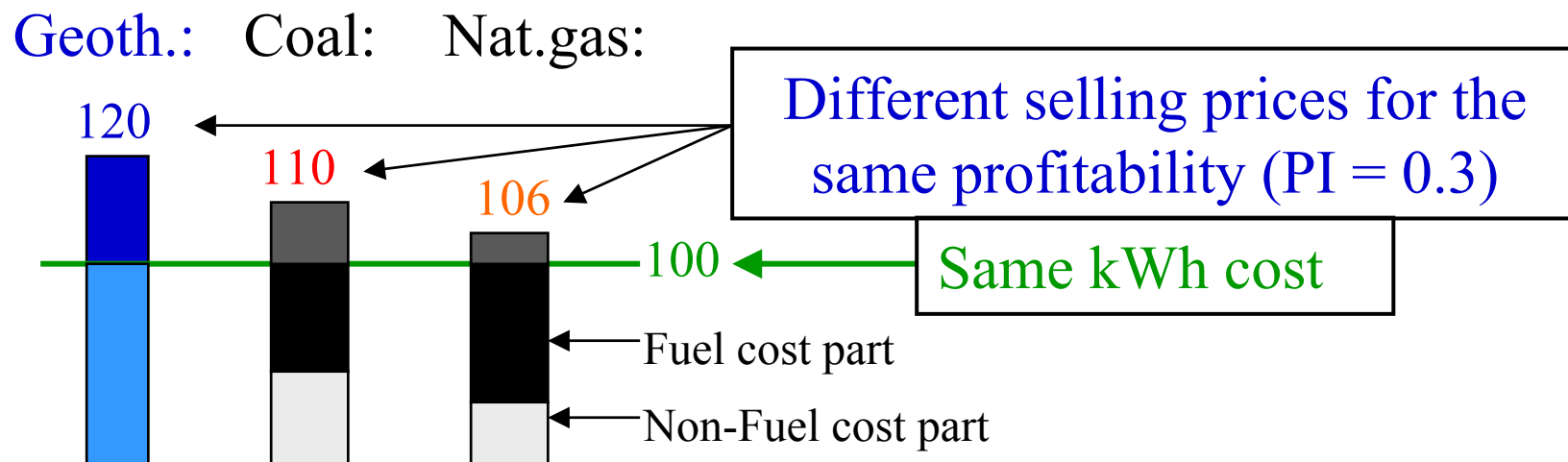
- ❑ The « zero fuel cost RETs paradox » (wind, hydro, solar, geothermal based power plants) :

$$\Rightarrow (MOC_{wind} / MOC_{fossil}) = (\text{cost} / \text{non fuel cost part})_{fossil}$$

$$\Rightarrow MOC_{wind} = 2 \text{ times } MOC_{coal} = 3 \text{ times } MOC_{nat. gas} !$$

$$\Rightarrow \text{Minimum } 10 \% \text{ MOC from coal plants} \Rightarrow PI = 0,3$$

- ❑ Implies minimum PI value of 0.3 for wind projects (project IRR = 10% for $t = 6\%$ and $n = 15$ years)



The Model : $\text{Tariff} = f(I_u)$ at $PI = PI_{\min}$

❑ Example for geothermal power

❑ Based on:

⇒ $PI = 0.3$ (minimum value)

⇒ $K_{om} = (O\&M)_y/I = 10\%$

❑ Efficient tariff = aI_u

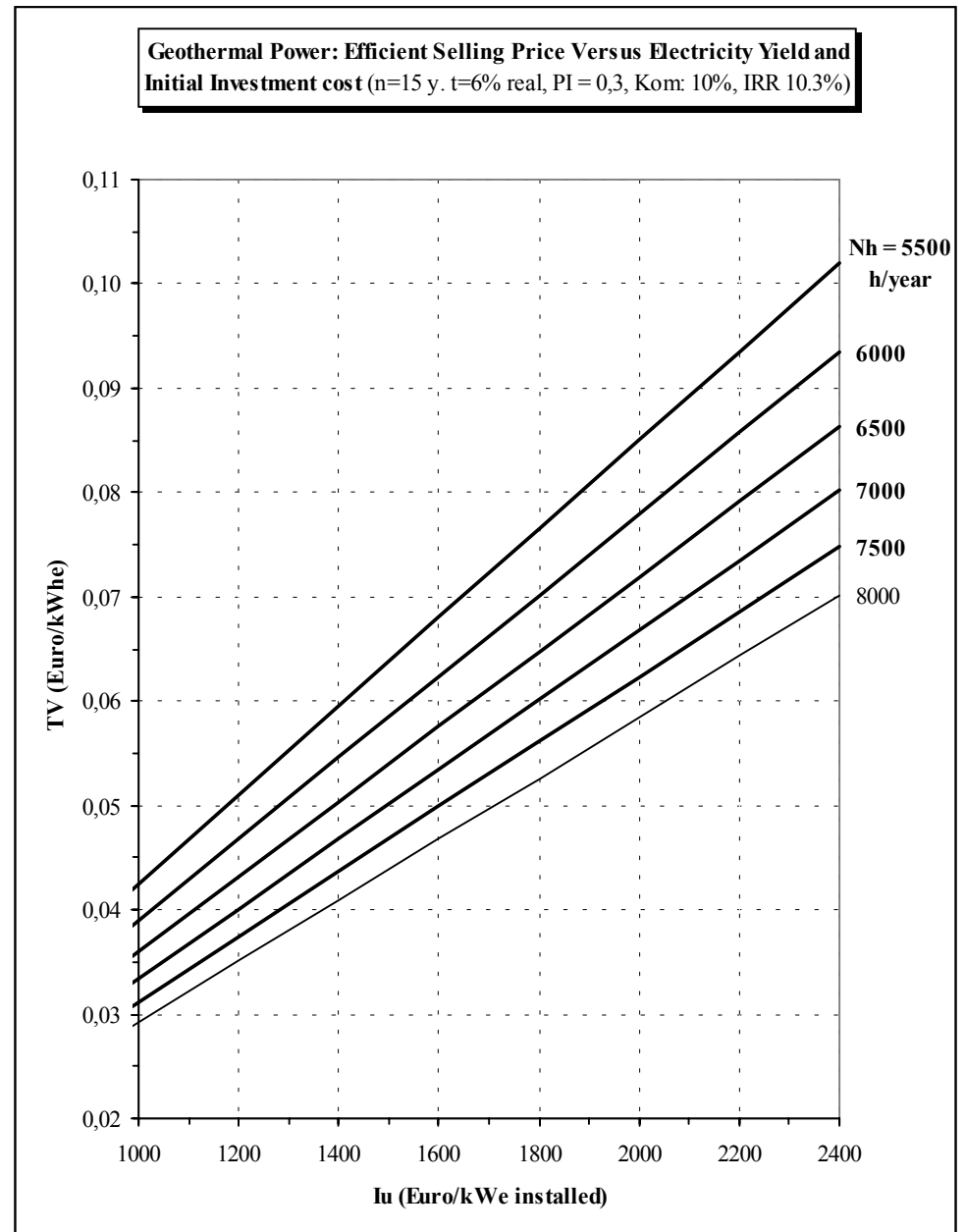
❑ $N_h = E_y/P_e$ (hours/year)

❑ Example:

⇒ $I_u = 1800 \text{ €/kWe}$

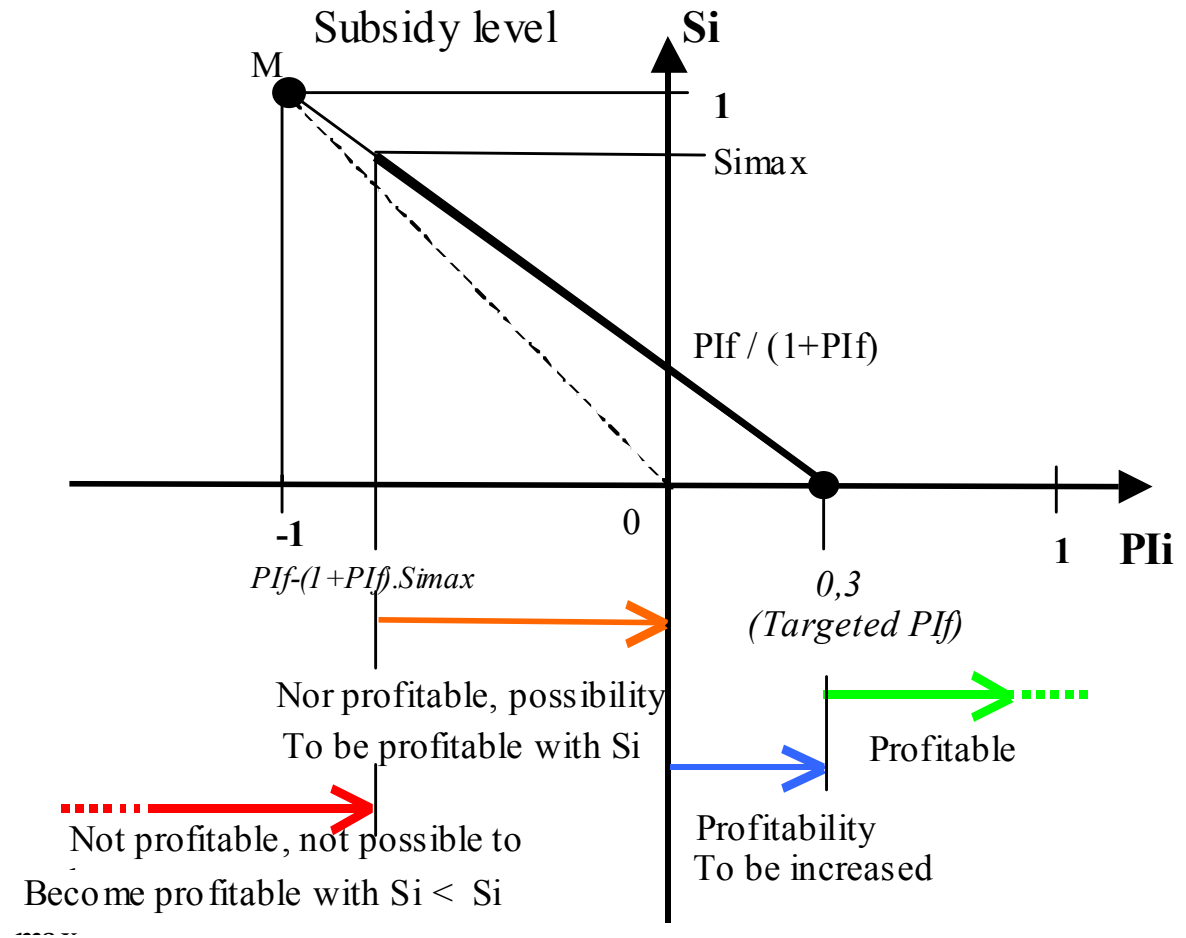
⇒ $N_h = 7000 \text{ h/y}$

⇒ required tariff = 0.06 €/kWh on 15 years



A rational management of subsidies from the PIM

- ❑ **P_{Ii} before subsidy < 0**
- ❑ **Goal : P_If after subsidy S_i**
 - ⇒ $S_i = (P_{I_f} - P_{I_i}) / (1 + P_{I_f})$
- ❑ **Rational policy for subsidies targeting:**
 - ⇒ $P_{I_f} > 0,3$: business
 - ⇒ $P_{I_f} = 0$: rational minimum
 - ⇒ $P_{I_f} < 0$: investment based on a consumer choice (e.g. environmental protection)
e.g. : domestic solar systems, electrical car...
- ❑ **P_If < 0 : marketing:**
 - ⇒ N_c max customers = f (P_If)
 - ⇒ N_c actual = f' (N_c max, time)



Taking into account "Green and/or Carbon Certificates"

- ❑ Assuming a constant Q_{ac} /year amount of green certificates or carbon credits sold on the environmental market from year 1 to year n
- ❑ Assuming a constant mean selling price of ASP_c per credit
- ❑ Assuming an "Additional yearly Cash Flow" from selling certificates $ACF_c = Q_{ac}.ASP_c$, the "Additional PI" is: $aPI_c = ACF_c / (Kd.I)$
- ❑ Assuming an initial PI value PI_i before subsidy si (%) on initial investment and before selling certificates
- ❑ Assuming a targeted final PI value PI_f after subsidy on investment and after selling certificates
- ❑ The final profitability index is: $PI_f = (si + iPI + aPI_c) / (1 - si)$
- ❑ And the increase of profitability of the project, expressed in profitability index is : $D(PI) = (PI_f - PI_i) / PI_i = (si.(1 + PI_i) + aPI_c) / [(1-si).iPI]$
- ❑ So, from the PIM, it is easy to assess and to define an optimum incentive mix from tariff of energy, subsidy on initial investment and mean tariff of green certificates or carbon certificates

Comparing criteria PI, IRR, PBT

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

From the PI to IRR and PBT values

❑ **Profitability 0 \implies ODC = TV \implies**

❑ **Link PI / IRR:**

$\Rightarrow K_d(\text{IRR}, n) = (1 + \text{PI}) \cdot K_d(t, n) ;$

\Rightarrow with $(1 + \text{PI}) = \text{Benefit / Cost Ratio}$

❑ **Link PI / PBT :**

$\Rightarrow K_d(t, \text{PBT}) = (1 + \text{PI}) \cdot K_d(t, n)$

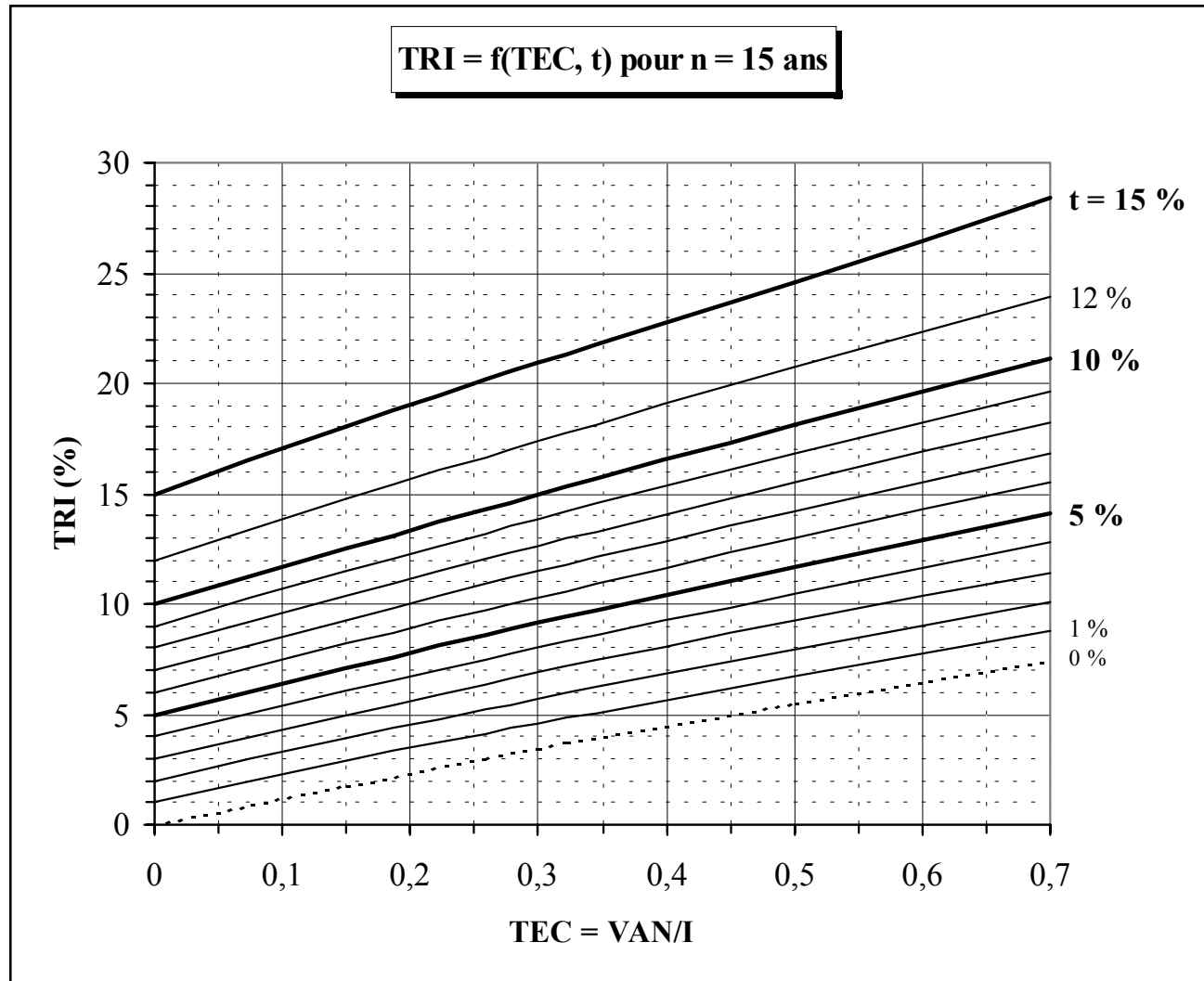
❑ **Link PI / simple PBT :**

$\Rightarrow s\text{TRB} = 1 / (1 + \text{PI}) \cdot K_d(t, n) = 1 / K_d(t, \text{PBT}) = 1 / K_d(\text{IRR}, n)$

❑ **See following graphs and examples**

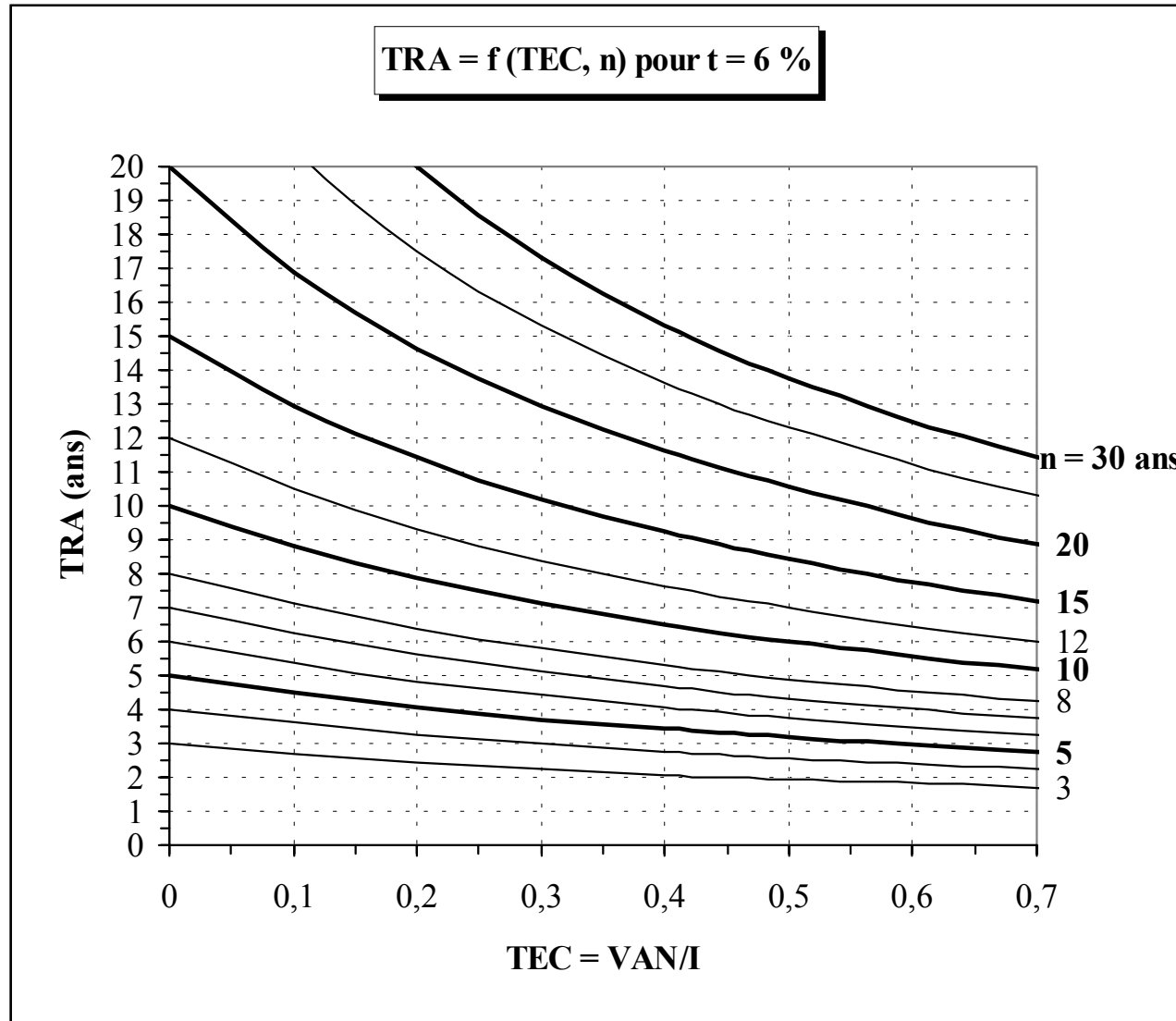
Links PI / IRR for n = 15 years

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



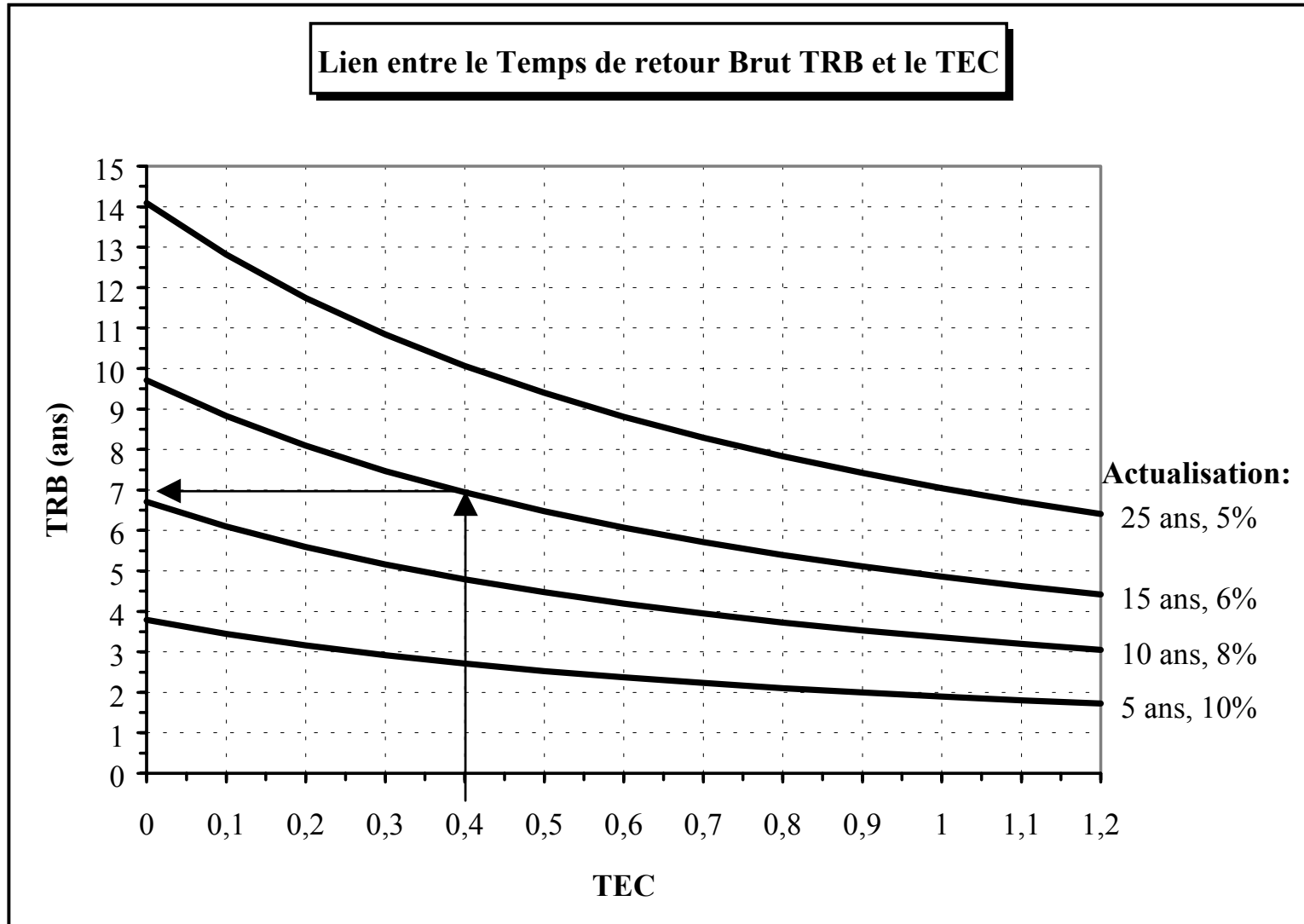
Link PI / PBT for $t = 6 \%$

- 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 !



Conclusions

- ❑ **"A bit of theory is very practical"**
- ❑ **PIM = a simple, innovative and powerful method and tools to define market deployment strategies and policies for RETs and to evaluate them**
- ❑ **Past validation:**
 - ⇒ Use to define French Wind power tariffs in 2001 and to design a potential Irish Wind Power tariff to be decided or not in 2004
 - ⇒ Good accordance with financial analysis
 - ⇒ Recognition and use by professional bodies and private and public investors
- ❑ **A vast prospect for use :**
 - ⇒ Extension to all other energy services (energy savings, DSM...)
 - ⇒ For decentralised rural electrification in DC...
 - ⇒ ADEME is open to information, cooperation, training...