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# Optimising economic incentives for geothermal energy development

## *Contribution from the "Profitability Index method"*

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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)
    - ☆ "Sufficent" 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 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)
- **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

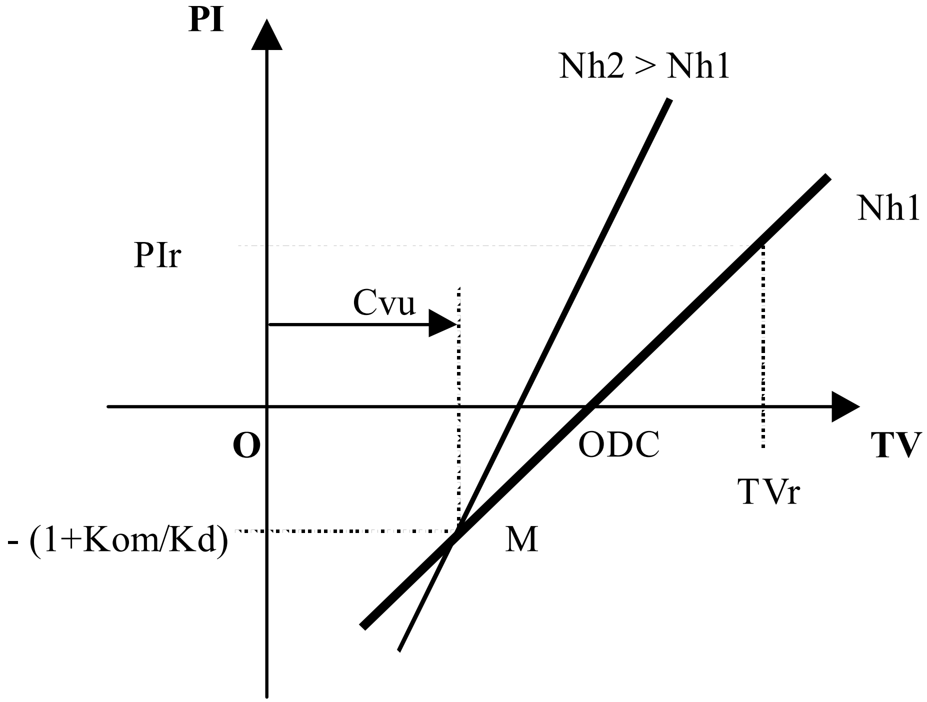
# The basis of the PI method

- **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(tariff TV)    (1)

- **NPV = (-I + Sum of discounted CFs from year 1 to n)**
- **PI = NPV / I = a (TV-Cvu) - b**
  - ⇨ a = Nh / (Kd.Iu) ;  b = -(1 + Kom/Kd) ;  Cvu = Fc/(Rg.LHV)

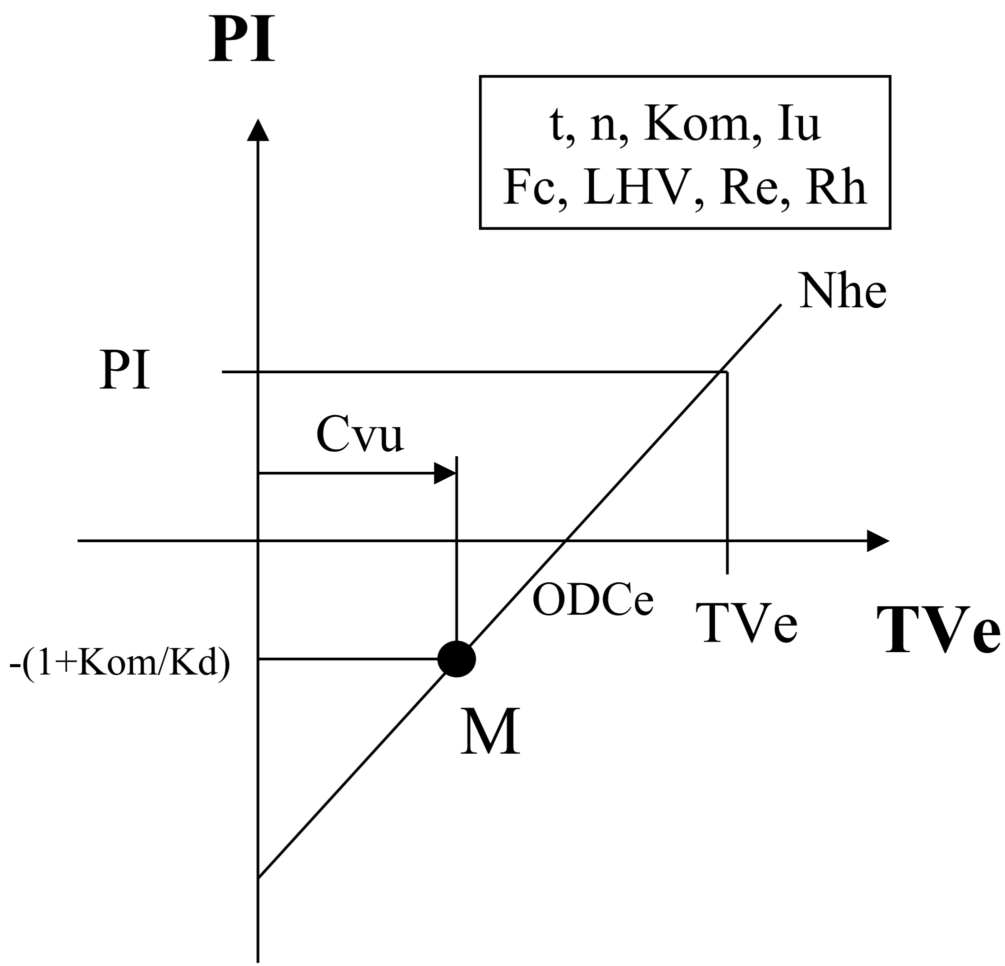
**Figure 1**




| Legend and definitions | |
|---|---|
| **PI** | Profitability index = NPV / I |
| **TV** | Tariff (average selling price) |
| **ODC** | Overal discounted cost |
| **Cvu** | Variable cost due to fuel cost |
| Fc | Fuel cost (EUR/kg, EUR/m3) |
| Rg | Yearly average global efficiency |
| LHV | Low heating value of the fuel |
| **Nh** | kWh / year. kW (hours/an) |
| **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 year s for economic assess. |

# The model PI = f(tariff TVe) for CHP

- **Data:**
  - ⇨ Discounting: n, t = 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 PI = f(tariff TV) (2)

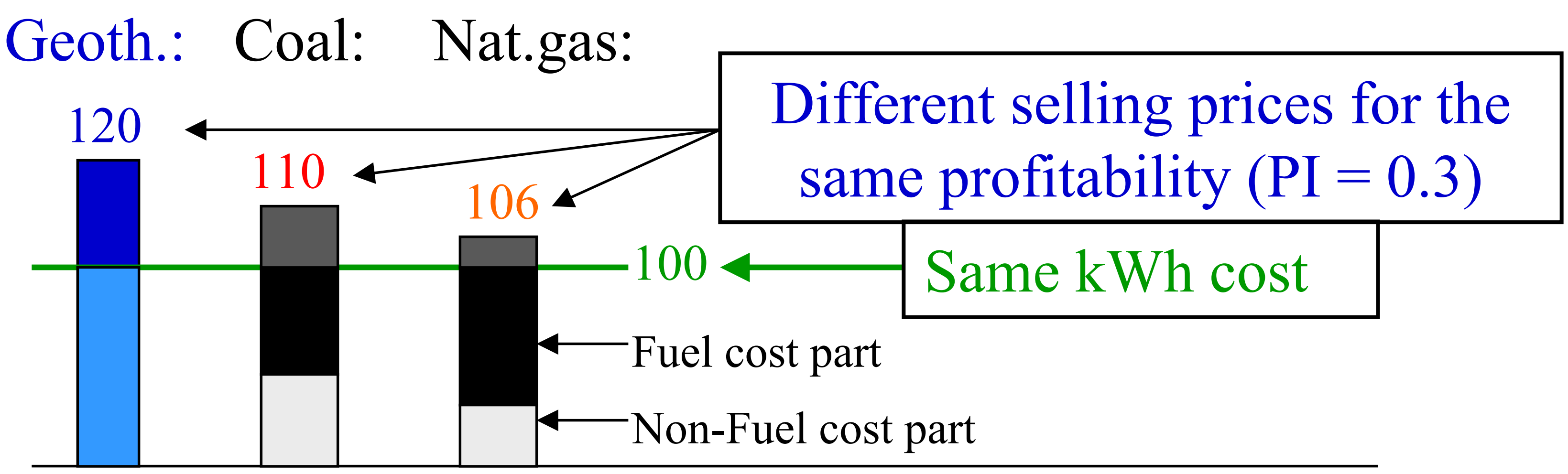
- **Advantage: complete characterisation of technol. & appl.**
- **Demonstrated and published added value :**
  - ODC and Tariffs for RE based power plants : wind power, SHP, geothermal, solar PV
  - Prospect for ODC and tariffs for wind power
  - Rational definition for ODC and tariffs for CHP plants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

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

- **MOC = (TV-ODC)/ODC = {Kfuel. Ka/(Ka+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.

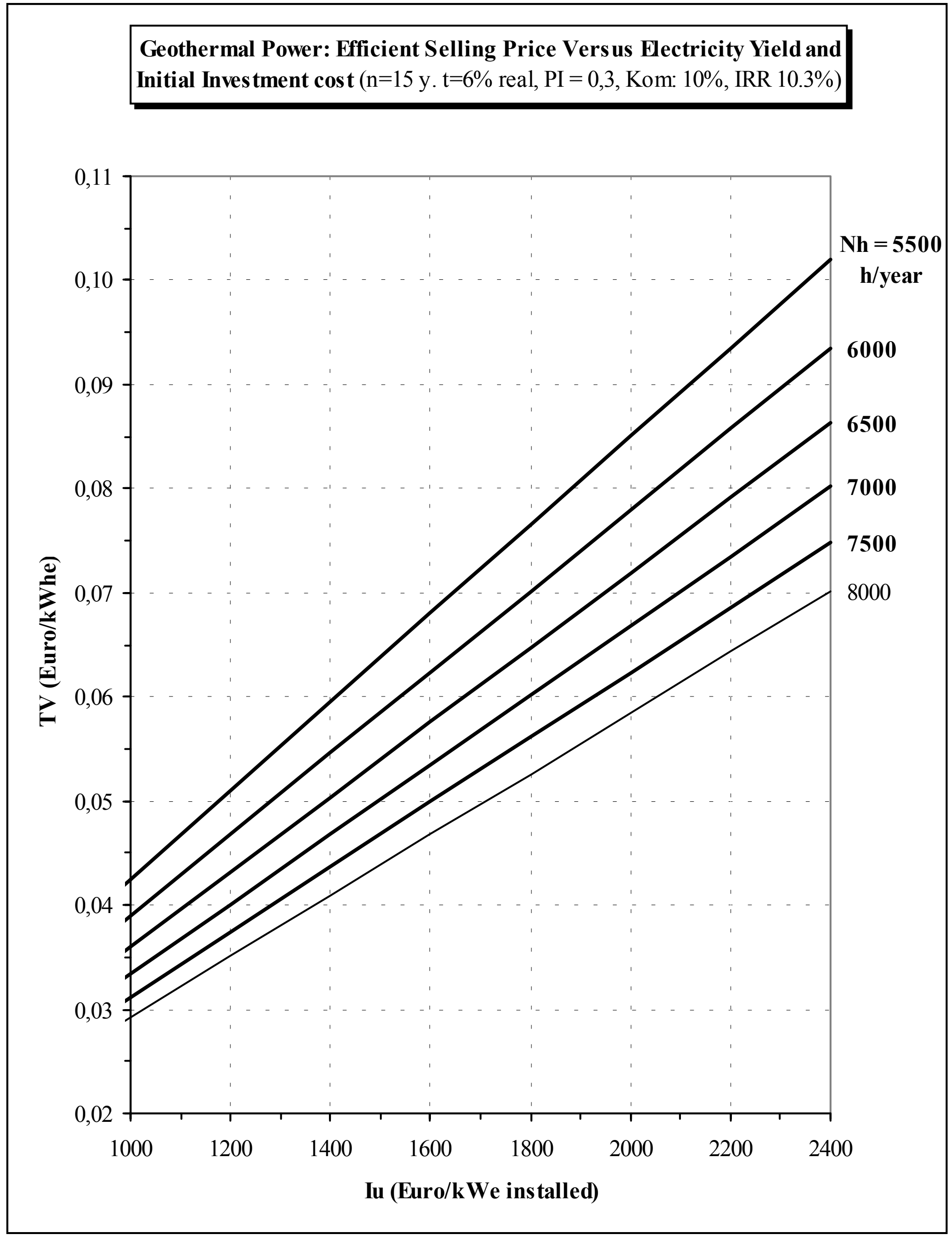
# The link: PI = k.MOC (2)

- **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)**



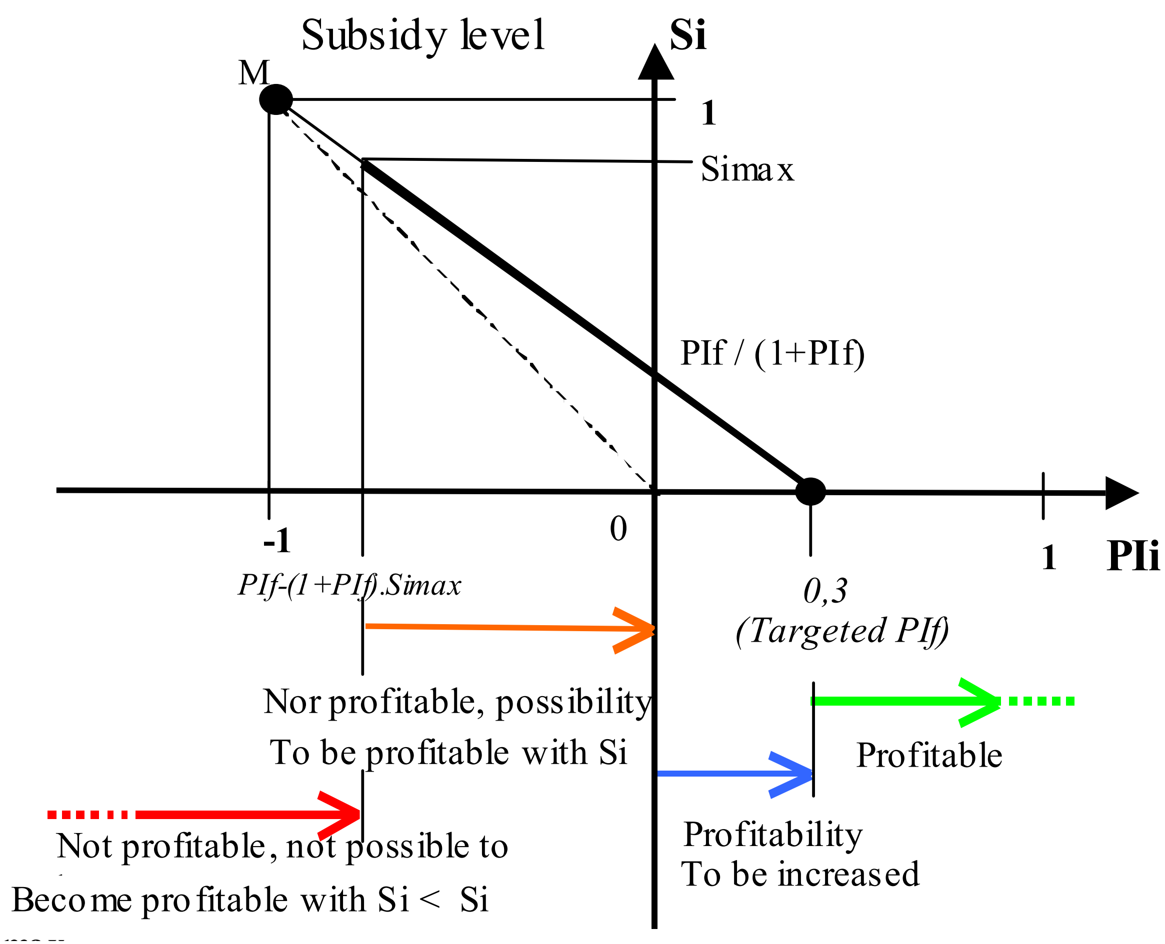
# The Model : Tariff = f(Iu) at PI = PImin

- **Example for geothermal power**
- **Based on:**
  - **PI = 0.3 (minimum value)**
  - Kom = (O&M)y/I = 10 %
- **Efficient tariff = aIu**
- **Nh = Ey/Pe (hours/year)**
- **Example:**
  - Iu = 1800 €/kWe
  - Nh = 7000 h/y
  - required tariff = 0.06 €/kWh on 15 years



# 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)



# Taking into account "Green and/or Carbon Certificates"

- Assuming a constant Qac/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 ASPc per credit
- Assuming an "Additional yearly Cash Flow" from selling certificates ACFc = Qac.ASPc, the "Additional PI" is: aPIc = ACFc / (Kd.I)
- Assuming an initial PI value *PIi* before subsidy *si* (%) on initial investment and before selling certificates
- Assuming a targeted final PI value *PIf* after subsidy on investment and after selling certificates
- The final profitability index is: PIf = (si + iPI + aPIc) / (1 - si)
- And the increase of profitability of the project, expressed in profitability index is : D(PI) = (PIf - PIi) / PIi = (si.(1 + PIi) + aPIc) / [(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

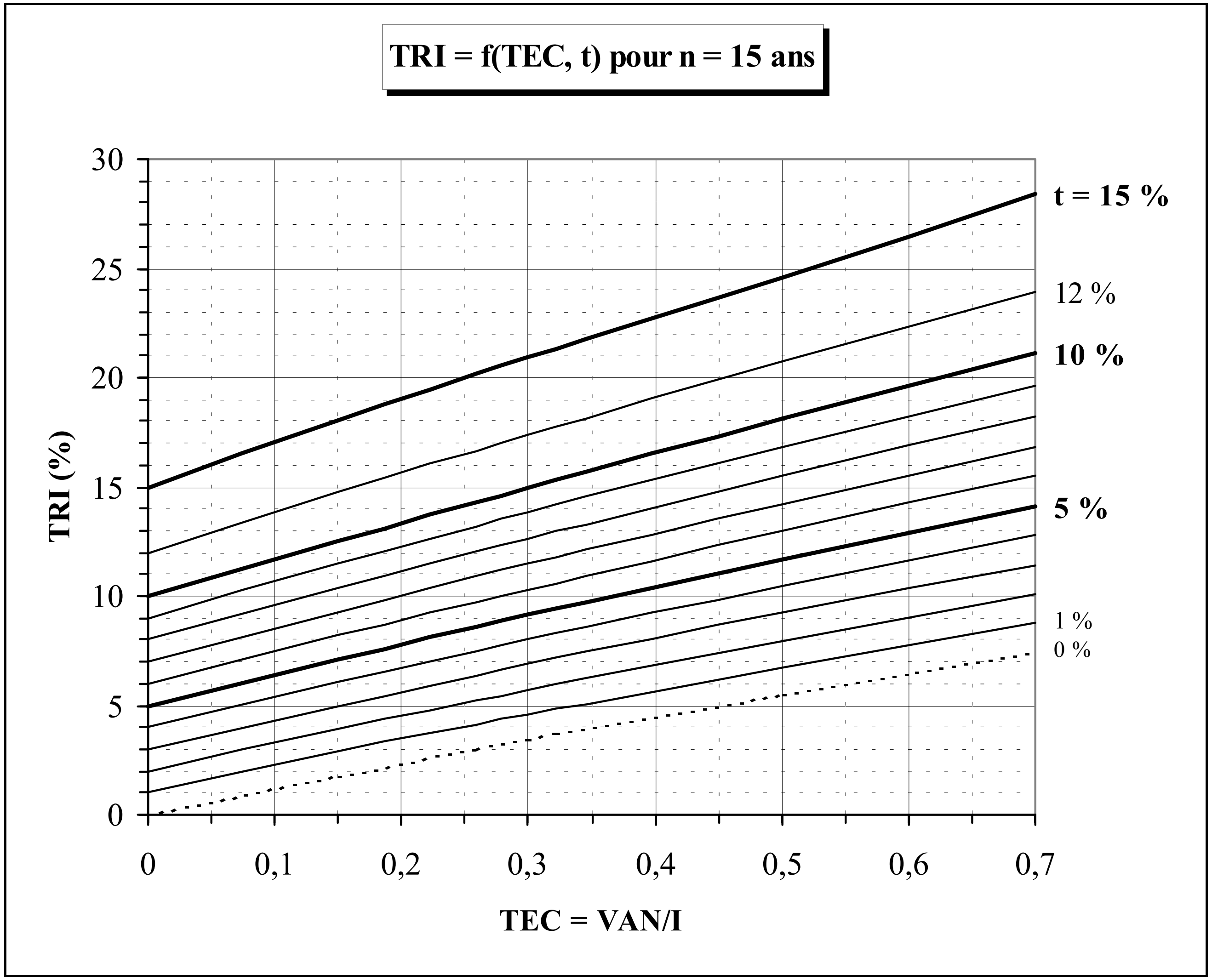
- **IRR, PBT: values of t and n for which project NPV = 0**
- **Profitability ==> IRR > t (= AWCC), PBT < n project**
- **simple PBT=I/CF=> no discounting. Prof.=> SPBT< 1/Ka**
- **Limits and actual and potential problems (IRR & PBT):**
  - ⇨Criteria not proportional to profitability in $
  - ⇨No fixed 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

- **Profitability 0 ==> ODC = TV ===>**
- **Link PI / IRR:**
  - ⇨ Kd (IRR, n) = (1 + PI).Kd (t, n) ;
  - ⇨ with (1+PI) = Benefit /Cost Ratio
- **Link PI / PBT :**
  - ⇨ Kd (t, PBT) = (1 + PI).Kd (t, n)
- **Link PI / simple PBT :**
  - ⇨ sTRB = 1 / (1 + PI).Kd(t, n) = 1 / Kd(t, PBT) = 1 / Kd(IRR, n)
- **See following graphs and examples**

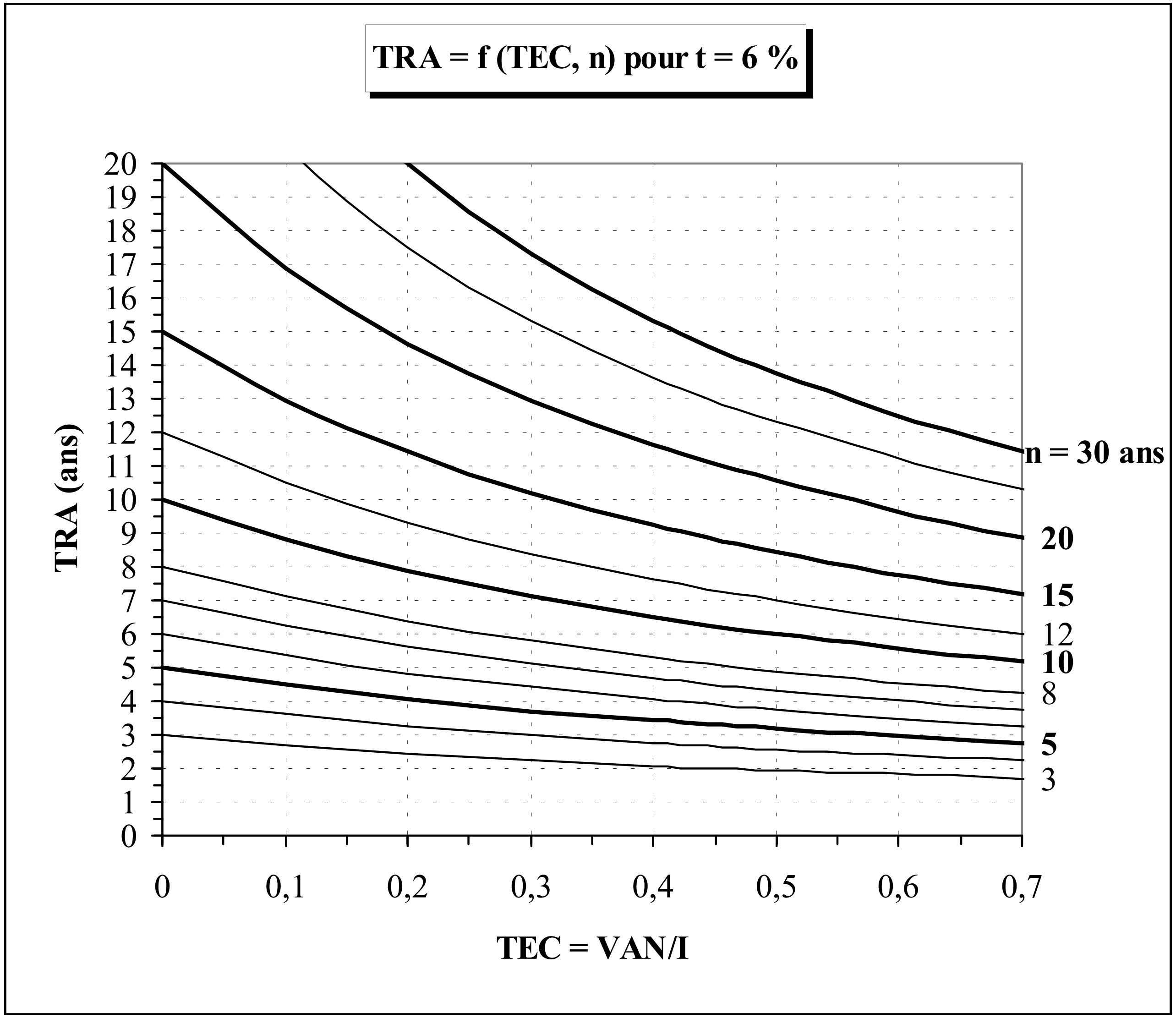
# Links PI / IRR for n = 15 years

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



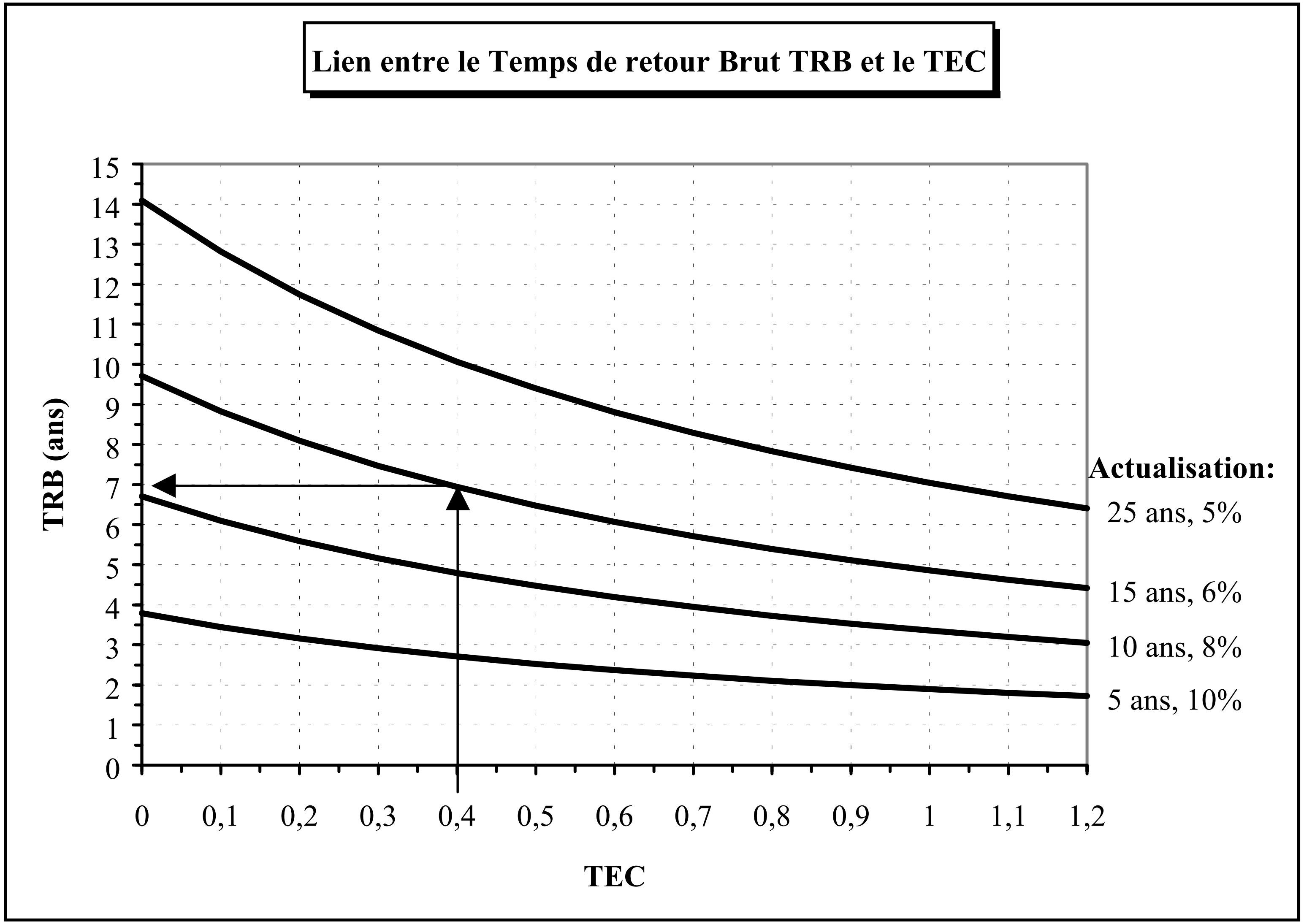
# Link PI / PBT for t = 6 %

- **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...