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Contribution from the Profitability Index Method to Advanced Fair and Efficient PV FITs Designs

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Introduction: references and activities

- **30 years of professional career on renewables**
  - Private industry (SOFRETES): solar water pumping for DCs
  - ADEME: 81- 85 : French PV plan; 86-93 Head, solar energy Dpt : first French PV & Wind grid connected programmes; 93-2008 : Senior Expert : PI Method, design of French 2001 wind tariff, expertise for « Advanced Renewable Tariffs »: Ireland, Ontario…
  - Independant Consultant and Trainer on renewables since 4/08:
    - **Studies and Expertise on FITS**: UNDP (Pakistan, Tunisia), OSEA/GEEA (Ontario FITs), studies for private PV & wind investors
    - Training for renewables and sustainable projects economic analysis: EUREC Master on renewables, INES-RDI, CSTB, private companies.
- **This independent study:**
  - To test two models of advanced PV FITs in Europe
  - Not related to EU MS past or ongoing national PV FITs designs
  - Self-financed, EPIA support for transport & acommodation for this presentation and discussion
  - **Content and conclusions are personal and do not necessarily represent EPIA or MS views on sustainable PV FITs**

Rationale and context for global economic analysis

- **Analysis before impact of fiscal measures**
  - ➪ Before tax on profit
  - ➪ Before amortization and financial provisions
- **Analysis before sharing project profitability between:**
  - ➪ Investors (providing equity)
  - ➪ Banks (providing debt)
  - ➪ State (from tax on profit)
- **Well running economy, contained future inflation rate**
  - ➪ i < 5 %/year (mean value on 15 to 20 years)
  - ➪ Calculation in **constant € of year « zero »**

- **➔Economic analysis is more reliable, transparent, simple and rapid than financial analysis (but it must be of course « the one and the other » and not «the one or the other»)**
- **➔Market regulation for sustainable technologies must be defined first from global economic analysis, then financial context and measures must be checked or adapted**

The economic and financial engineering

❑ Global project economic analysis

- ➩Expenses: Capex (studies, total investment cost **I**), OPEX : O&M, fuel expenses (bioenergy), cost of capital (AWCC = t %)
- ➩Turnover: energy sold to the grid * tariff
- ➩Cash Flow = turnover – OPEX before tax on profit
- ➩Calculation of the **Net Present Value (NPV)** before tax:
- ➩NPV = -I + Sum of discounted CF = -I + S_{1-n}\{CFj / (1+t)exp(j)\}

➩Project is Profitable if NPV > 0

❑ Financial analysis

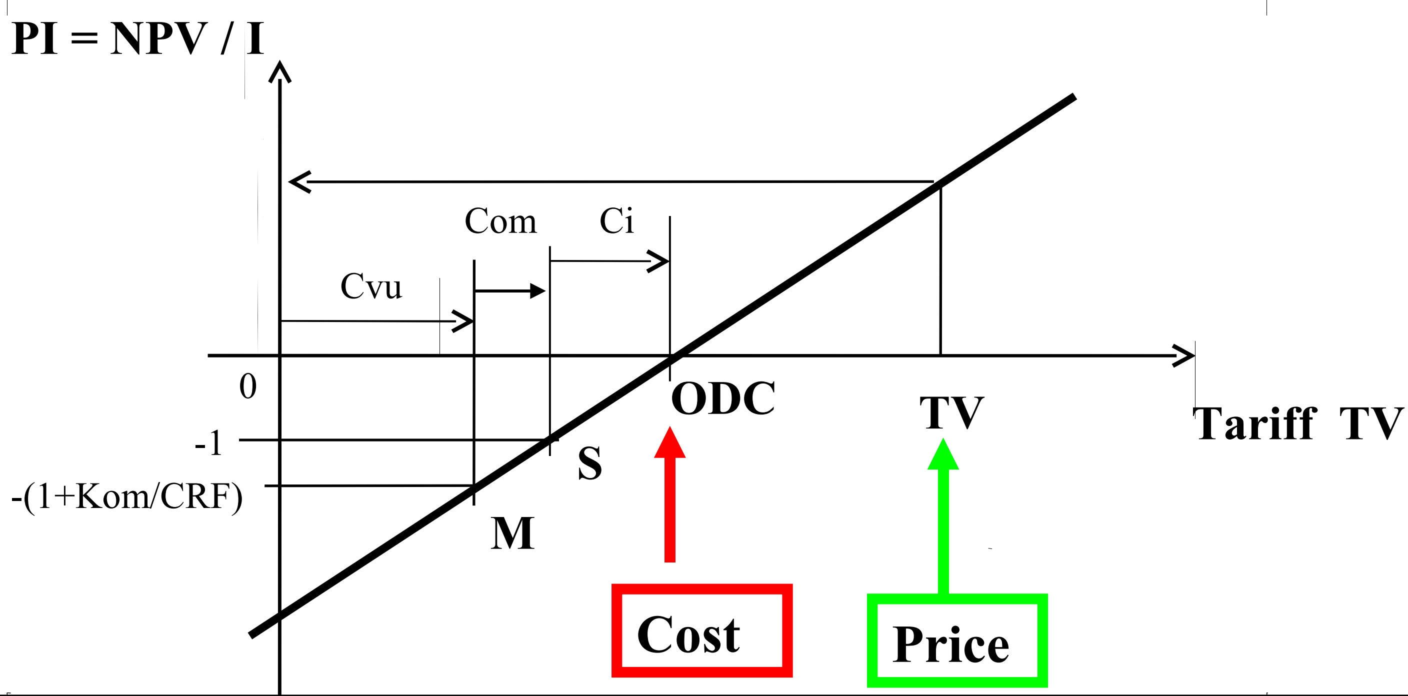
- ➩Taking into account fiscal context, actual financing, amortization, financial provisions, substracting tax on profit…
- ➩Calculation of the **Return On Equity after tax: ROE**
- ➩**Comparing the project ROE and its risks with the ones of other options of investing equity**
- ➩Verifying **Debt Service Coverage Ratio DSCR > 1.2 to 1.3**

Added value of the « PI Method» for economic analysis

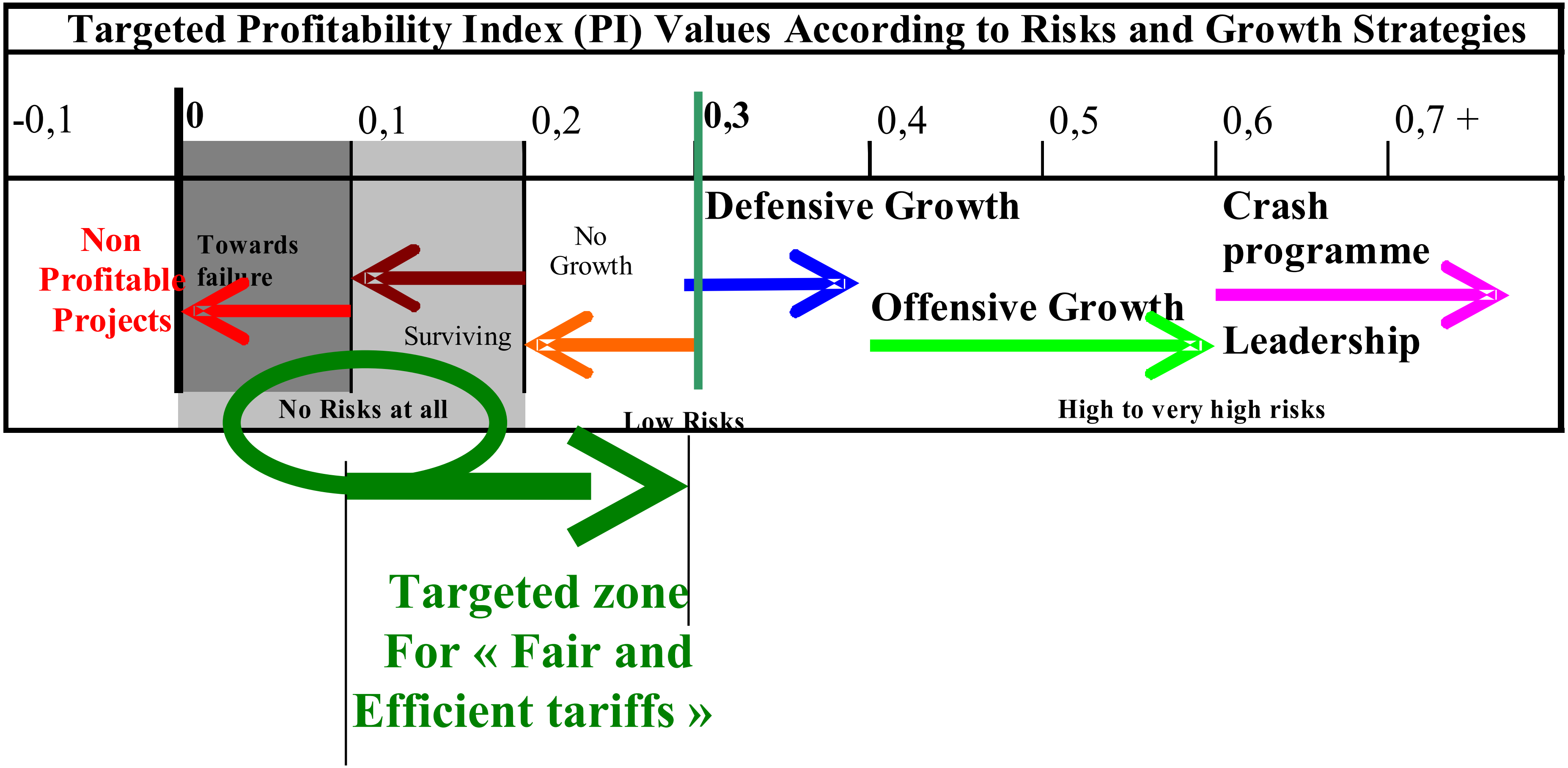
- **The « Profitability Index » PI:**
  - ➩ Indicates the efficiency of invested capital : **PI = Net Present Value (NPV) generated by each € invested**
  - ➩ **PI = NPV / I** = (-I + Σ discounted cash Flows) / I
  - ➩ Discount rate t = factor of cost = project averaged weighted cost of capital before tax (and not t = targeted project IRR value !)
- **Advantages :**
  - ➩ Gives direct access to **NPV = PI * I**
  - ➩ **PI = a * TV - b** where TV is the kWh selling price (« tariff »)
  - ➩ Gives access to both the « kWh manufacturing cost » (its Overall Discounted Cost ODC) and its « selling price » (TV)
  - ➩ Link PI and X = TV/ODC: link PI/industrial & commercial strategies
  - ➩ **Possibility to define an « Universal profitability scale based on investors strategies »**

The universal linear profitability graph PI = a * TV - b

- ⇨ **Overall Discounted Cost (ODC)** is defined by the crossing of the profitability line and the horizontal axis
- ⇨ **Points M and S define the cost structure:**
  - ¶ Ci created by investment cost
  - ¶ Com, created by fixed O&M costs
  - ¶ Cvu, variable fuel part (= 0 for solar, wind, hydro, geothermal)
- ⇨ **Tariff TV defines the project profitability index PI**



Synthesis: the universal profitabilty scale based on PI



Application to advanced fair and efficient PV Tariffs

Context – PV case

- **Constant cash-flows components or replaced by their equivalent constant values giving the same result**
- **Annual energy sold: constant from year 1 to n (kWh/y) Ey:**
  - ⇨ **Photovoltaics: Ey = Kp.Eia.Pc / Go** (kWhac/year)
  - ⇨ **Kp** = Rgm / Rgo(STC) ; grid connected PV: 0.69 < **Kp** < 0.79
  - ⇨ **Eiy** = kWh/m2.an in the plane of modules ; **Pc** in kWp ;
  - ⇨ **Go** = 1 kW/m2 (STC : standard test conditions)
- **Ratios:**
  - ⇨ **Iu** = I / Pc (€/kWp installed): **this study: 2700 to 5000 €/kWp**
  - ⇨ **Nh** = Ey / Pc (h/year) ➔ PV : Nh = Kp.Eia; EU: 770 to 1520 h/y
  - ⇨ **Kom** = Dom / I; Dom = €/y O&M & big repairs: 1.5 to 2 % **(this study: 1.75 %)**
  - ⇨ **t** = averaged weitghted cost of capital (AWCC) before tax (real)
    - ¶ t = % Equity.ROE + % Debt.td , and t = (tn - i) / (1+i) = 4 to 6.5% real (**this study: 5% real**)

Context: taking into account future inflation

- **Future inflation rate considered constant from year 1 to n**
- **All cash-flows parameters in constant € of year « 0 » : €(0)**
- **Economic analysis in constant € of year (0)**
- **Will be the case if choice of real discount rate t (% real)**
- **Within a power purchase agreement (PPA):**
  - **Tariffs are considered here 100 % protected against inflation**
  - *Not often the case: France 60 % protected, Germany: 0 %...*
  - Rationale and impact if not fully protected: cf Chabot EWEC08
  - If not 100 % protected: following initial tariffs values to be compensated (by a higher initial value) from the future effect of inflation in order to get the same targeted projects economic profitability levels

ARTs (1): renewable tariffs are differentiated

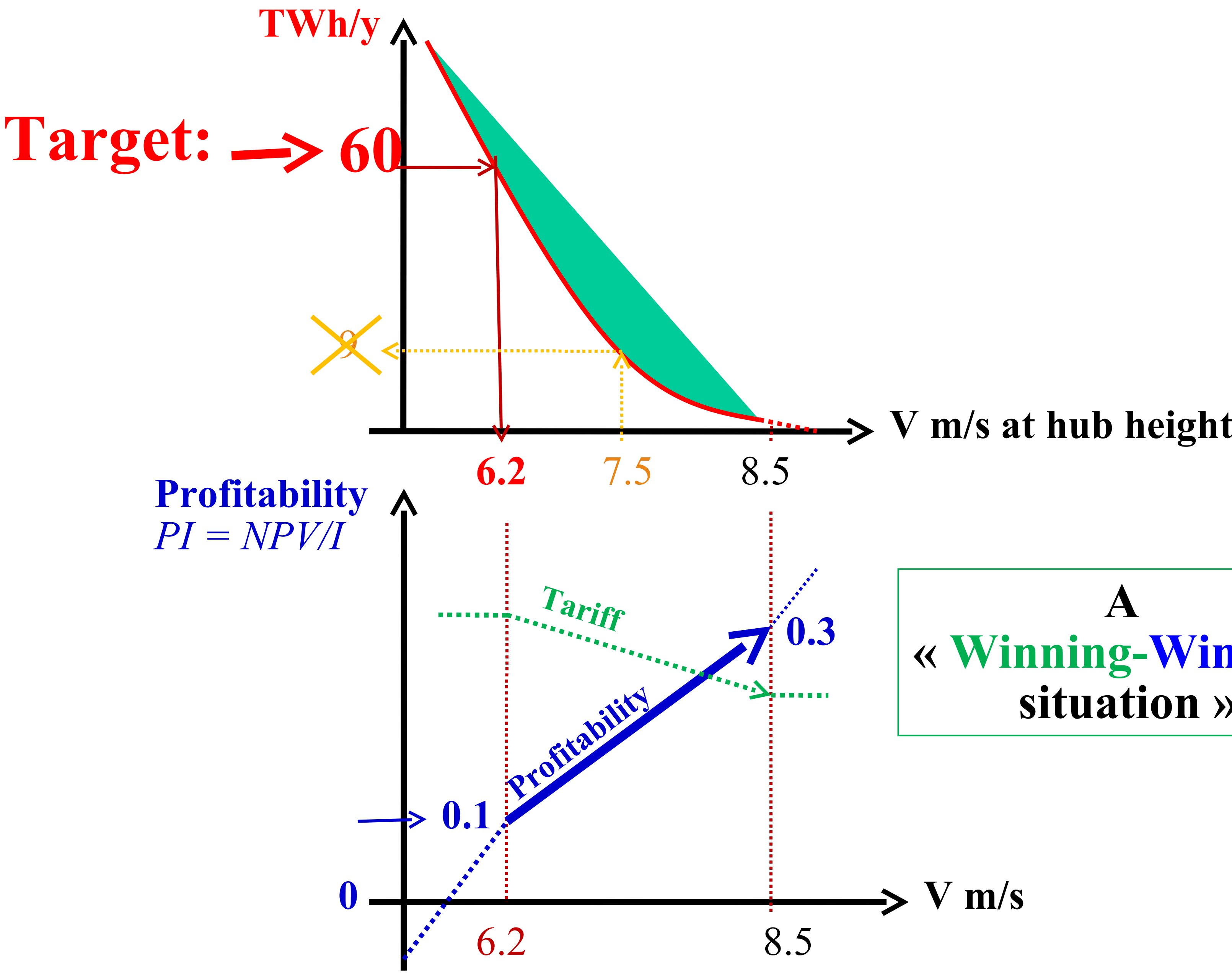
- **By renewable energy technologies**
  - Wind
  - Solar photovoltaic, solar thermal power plants
  - Small hydropower
  - Bioenergy: biogas, solid biomass, biomass part of MSW
  - Geothermal energy
- **By size, type of projects**
  - Small, medium, large; domestic, community, commercial
- **By Applications**
  - Wind: onshore, offshore
  - PV: Building integrated, non BI, PV plants on land
  - According to rated power range: biomass, biogas, Hydropower
  - High efficiency CHP
  - Options for time of delivering / grid ancillary services
- **By quality of sites:**
  - Wind: Germany since EEG 2000, France, Portugal…
  - **PV: as much usefull as wind in specific contexts**

ARTs (2): renewable tariffs are Cost + Profit based

- **Often based on IRR (Internal Rate of Return)**
  - ⇨ But which IRR ??
    - ¶ Project IRR or IRR on equity only (Return On Equity: ROE) ?
    - ¶ Before or after tax on profit ?
    - ¶ Real or nominal ?
  - ⇨ Which « rule of the thumb » to use ????

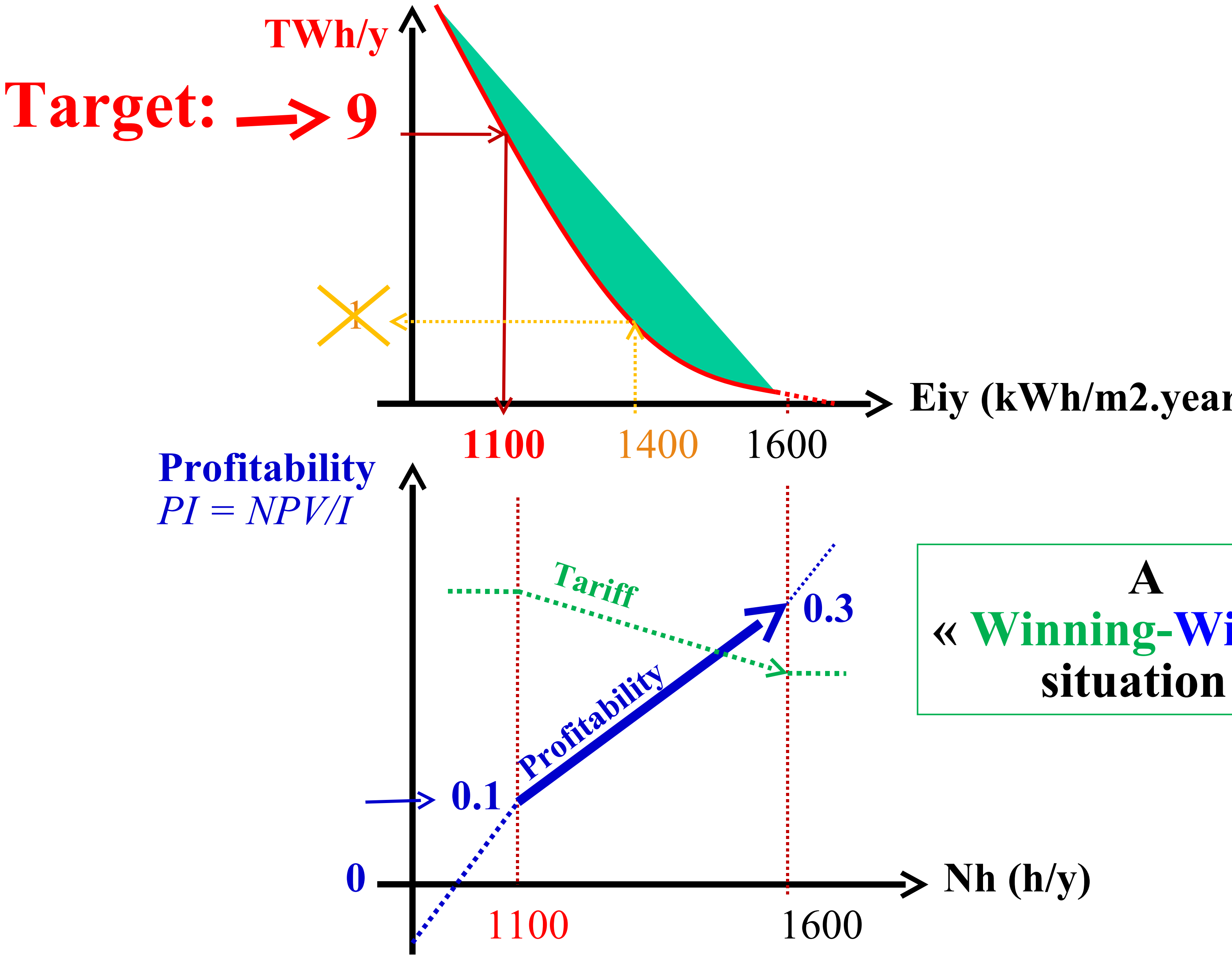
- **Fine-tuning easier and more reliable from the Profitability Index than from IRR**
  - ⇨ **Rationale targeted PI range can be chosen from the « Universal PI value scale » and the related targeted industry and market dissemination strategies**
  - ⇨ On this scale PI values are the same with different ***n*** values
  - ⇨ PI values directly proportional to NPV
  - ⇨ PIM gives both the kWh cost, the cost structure and the targeted selling price (« tariff »), and a direct link PI ⇔ margin on cost
  - ⇨ (PI numerical values are the same using nominal discount rate and current € or real discount rate and constant € of years « 0 »)

ARTs (3): Tiered Wind Tariffs Principle



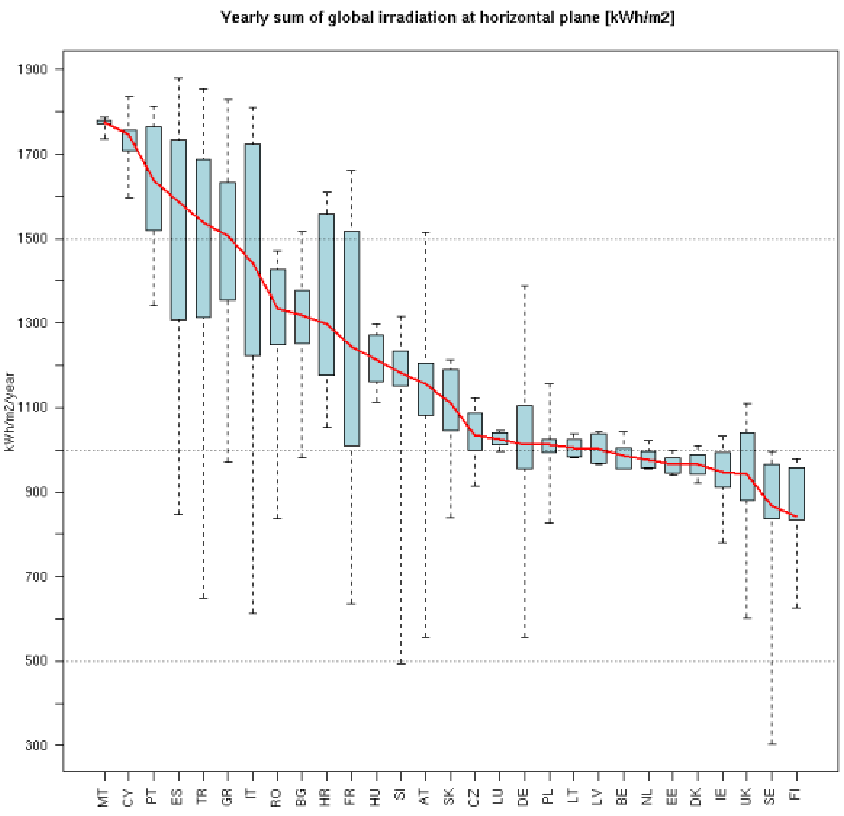
A
« Winning-Winning situation »

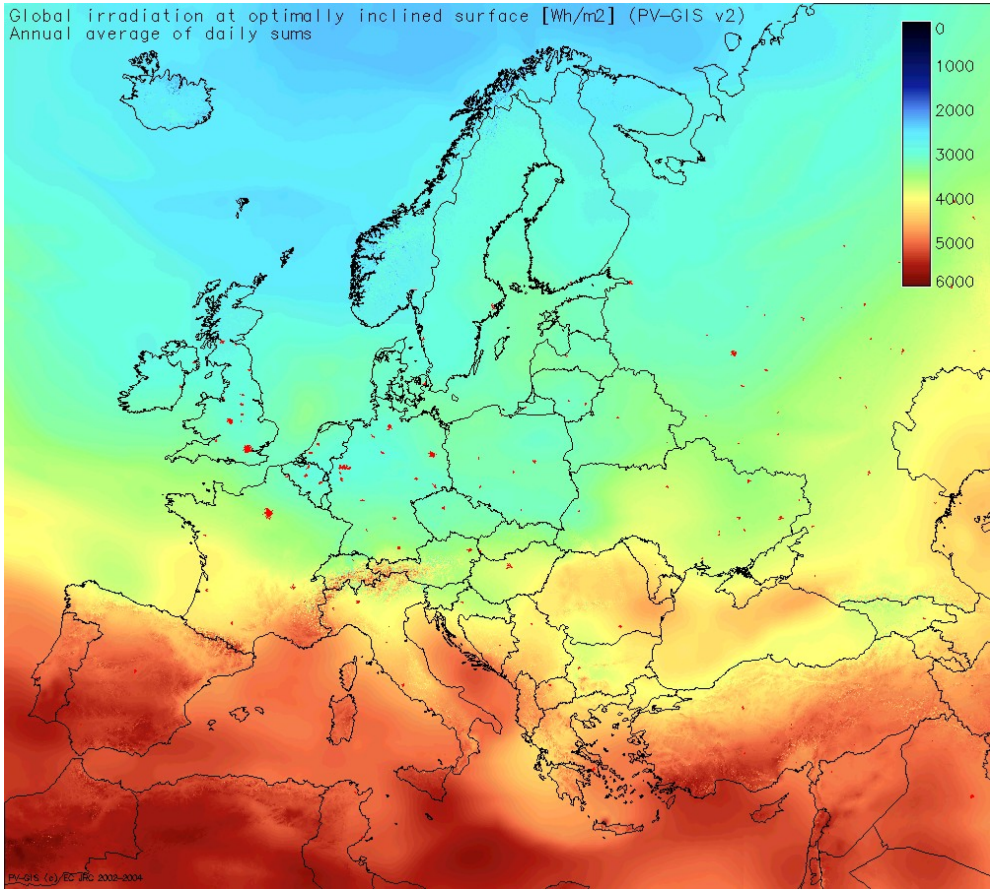
ARTs (4): Tiered PV Tariffs Principle



A
« Winning-Winning situation »

Taking into account European solar irradiation levels (1)

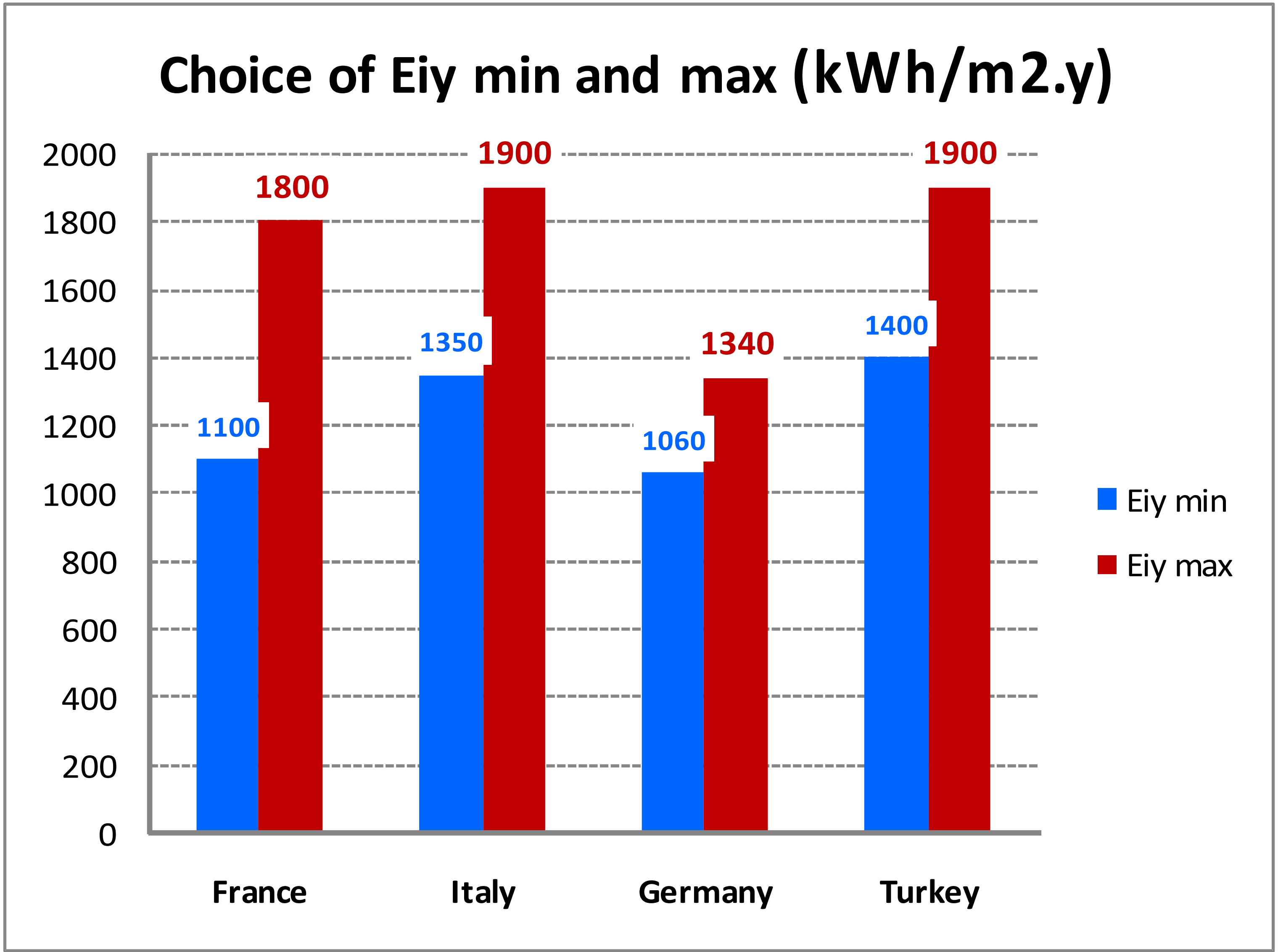




Source: JRC – PVGIS

Taking into account European solar irradiation levels (2)

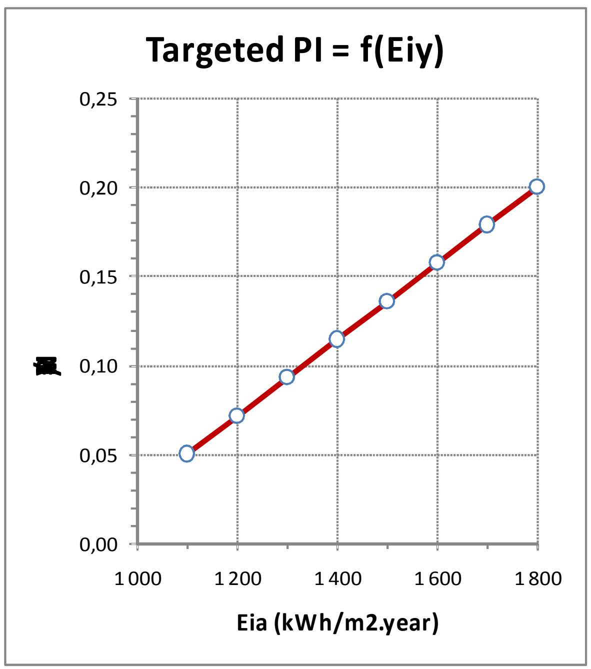
Values chosen for case studies presented here (annual solar irradiation Eiy in optimal plane of modules, without any shadows):

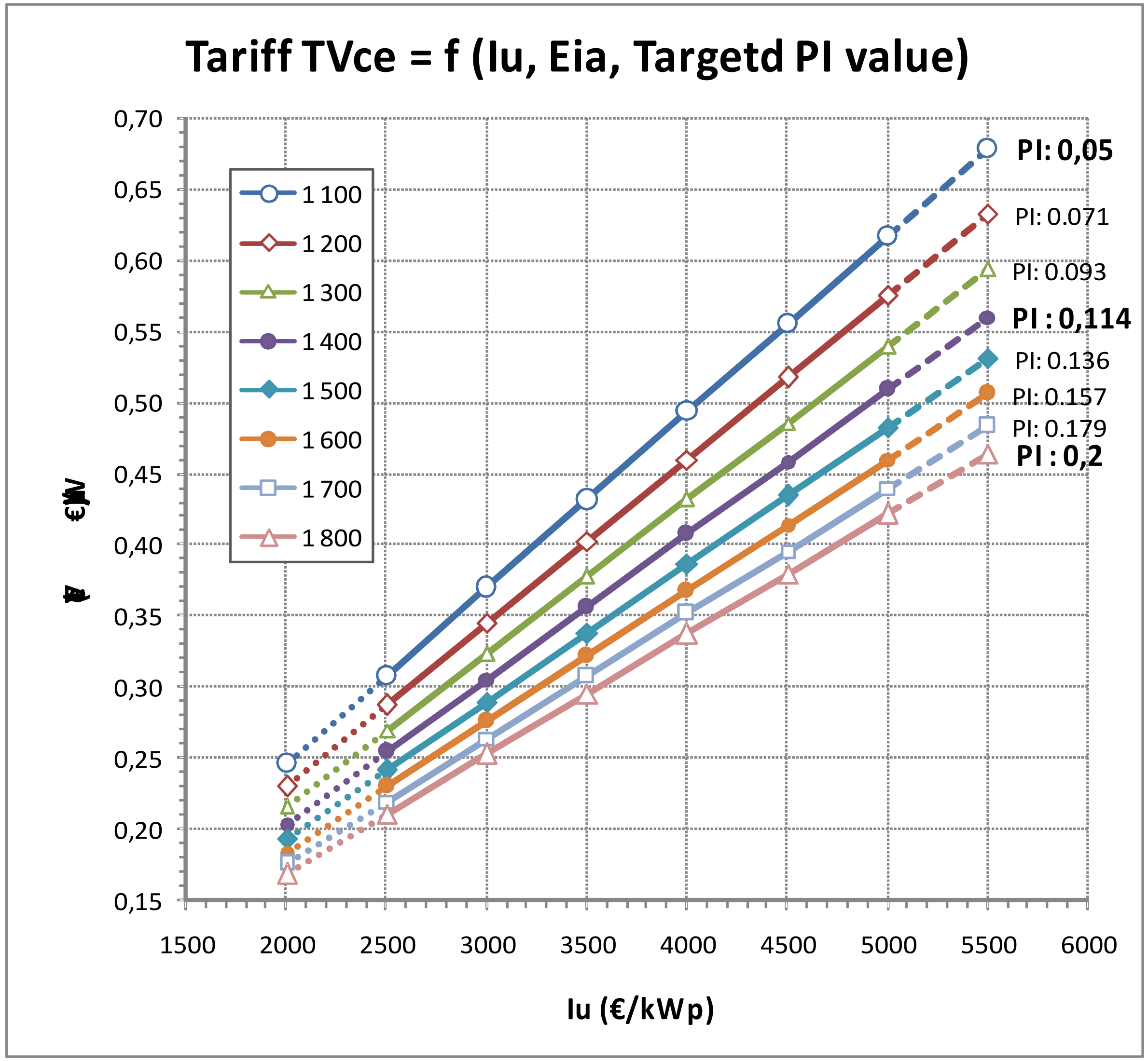


First model
for advanced fair and efficient
PV FITs

First potential solution: variable tariffs on fixed period (20 years)

- ❑ **Targeted PI: from PI = 0.05 at Eiy = 1100 kWh/m2 to PI = 0.2 at Eiy = 1800 (France)**
- ❑ **➔ Too large discrepancies between tariffs ➔ difficult to implement**

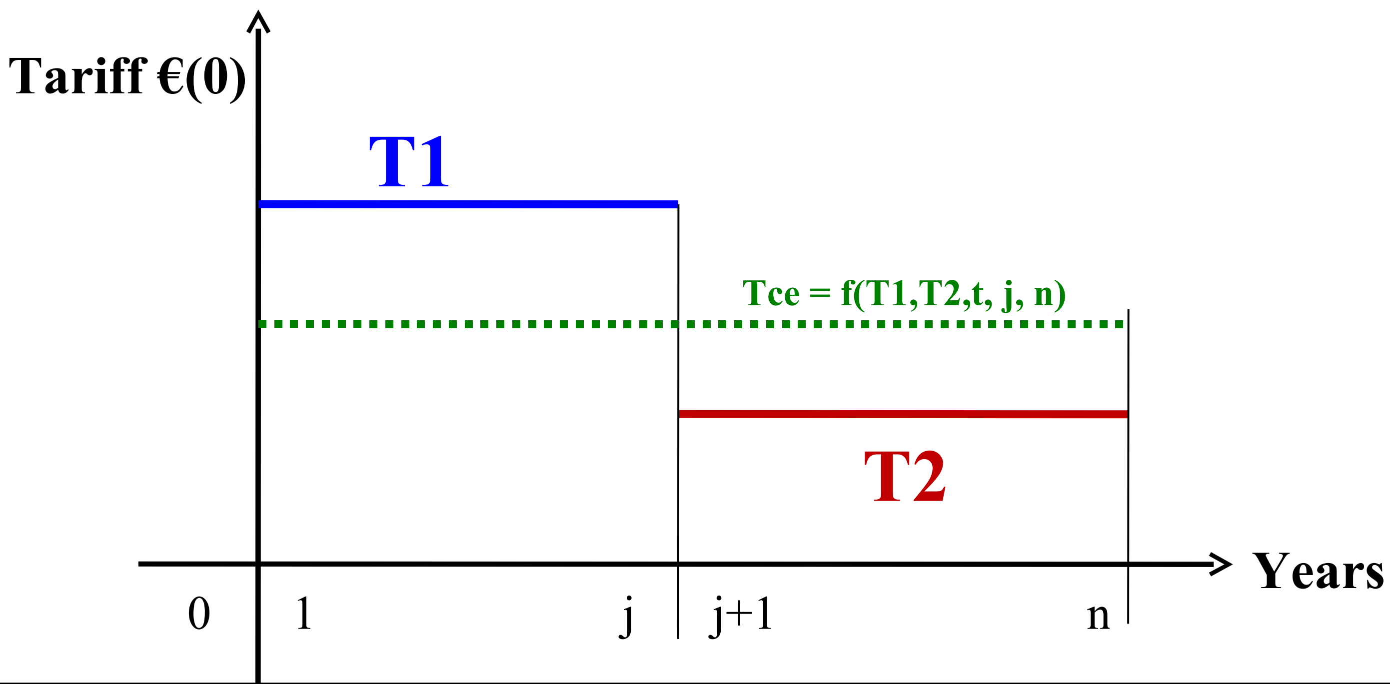




Second model
for advanced
fair and efficient PV FITs

Suggested design of an advanced PV tariff system (1)

- **Inspired from the German EEG 2000 wind tariff system**
- **T1 on years 1 to j and T2 from year j+1 to year n: constant values for all projects in the tariff system**
- **j: variable from j = jmin to j = n**
- **Tce = constant equivalent tariff, giving the same profitability than T1 and then T2**
- **For a specific project: j = f (potential maximum energy yield at he project location)**
- **Potential energy yield in this study: from PVGIS for Eiy (kWh/m2 in the optimal plane of modules, without any shadow) and performance ratio Kp = 0.75**
- **In this study:**
  - ⇨ t = real discount rate = AWCC (= 5 % real), tariffs 100% protected against inflation in a PPA
  - ⇨ **T2 = 0.1 €/kWh** to get no overcosts vs other RE tariffs and market/consumer electricity prices



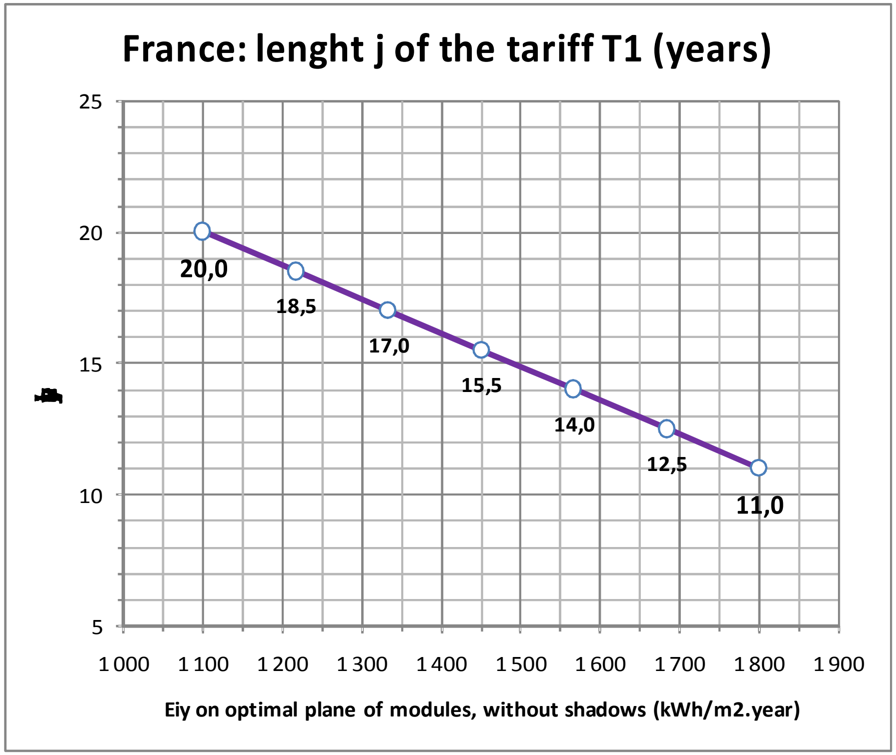
Suggested design of an advanced PV tariff system (2)

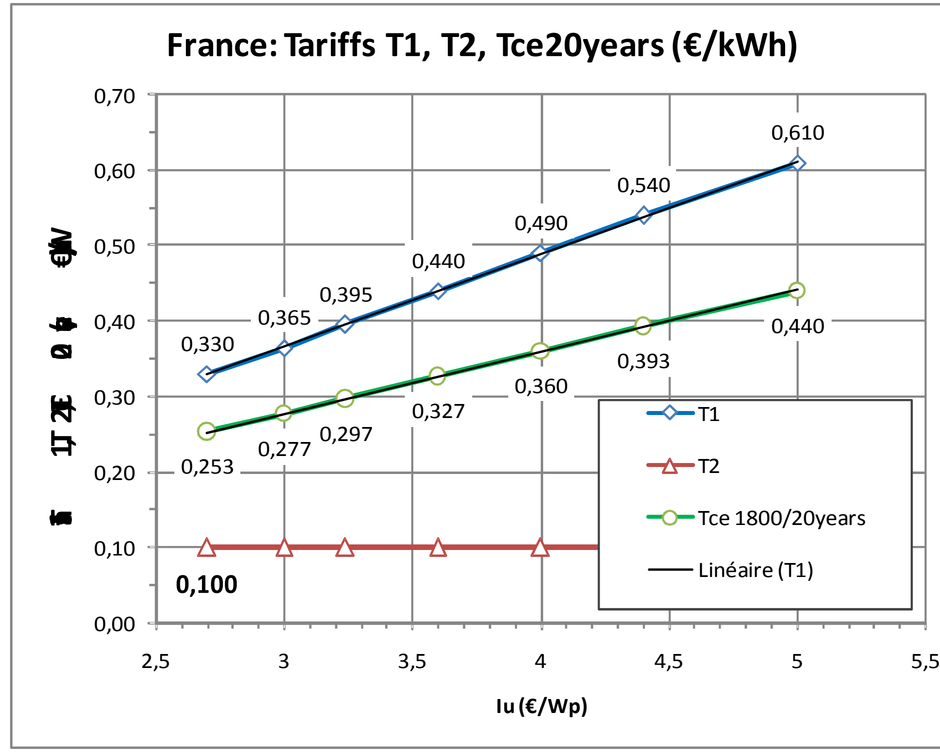
- **Advantages:**
  - « **Same tariffs for everybody** »: no discrimination among citizens !
  - No complicated calculation for ***j*** value determination: transparent public data
  - Gives a very strong incentive to maximise actual production of PV projects
  - Allows a minimum profitability on sites with the lowest solar irradiation
  - Gives a signal to get a large scale market development first in the sunniest parts of the country where:
    - **Profitability is increasing but not to an undue level**
    - The very low T2 tariff is **implemented faster, thus lowering the over-cost for electricity consumers**
- **At the end, in countries with large differences in solar irradiation (e.g. France, Italy, Spain, USA, China, India…) :**
  - PV deployment would be more evenly distributed in the country than with a fixed PV tariff
  - The overcost of the PV tariff system for electricity consumers would be lower than with an effective fixed PV tariff

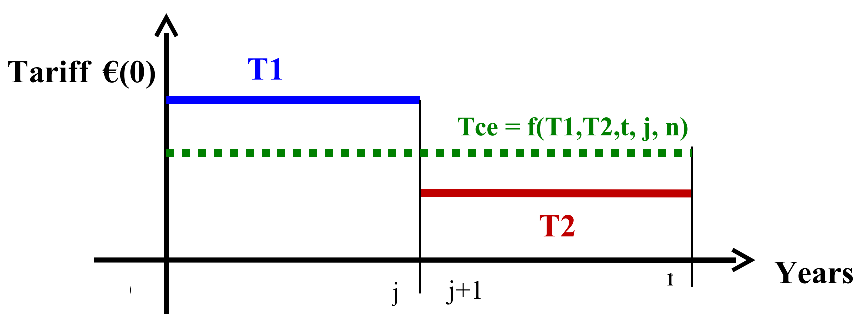
> **Ambitious PV market deployment strategies such as those required by NAP for the 2020 RE Directive application would be more easily accepted by governments and citizens**

Case study (1): France: tariff parameters

- n = 20 years, Jmin = 11 years
- PVGIS: Eiy varying from 1140 (Lille) to 1900 (Draguignan). Choice: Eiymin = 1100; Eiymax: 1800 kWh/m2.year

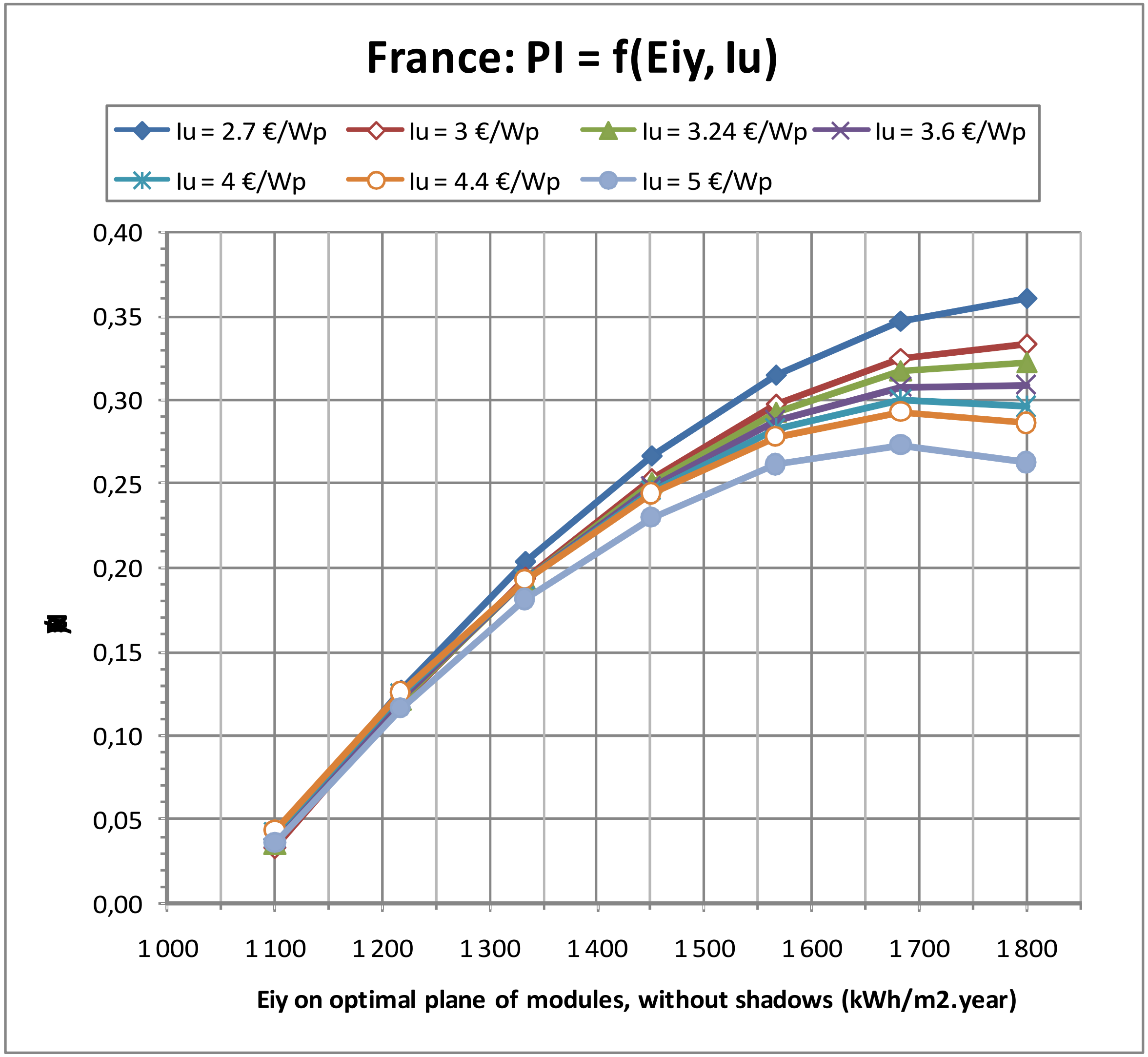






Case study (1): France: profitability results

- n = 20 years, Jmin = 11 years
- France is the EU country with the largest differences in Eiy values, and the proposed differentiated tariff system can work : minimum profitability is positive, maximum profitability can establish a strong market growth, without undue profitability levels:



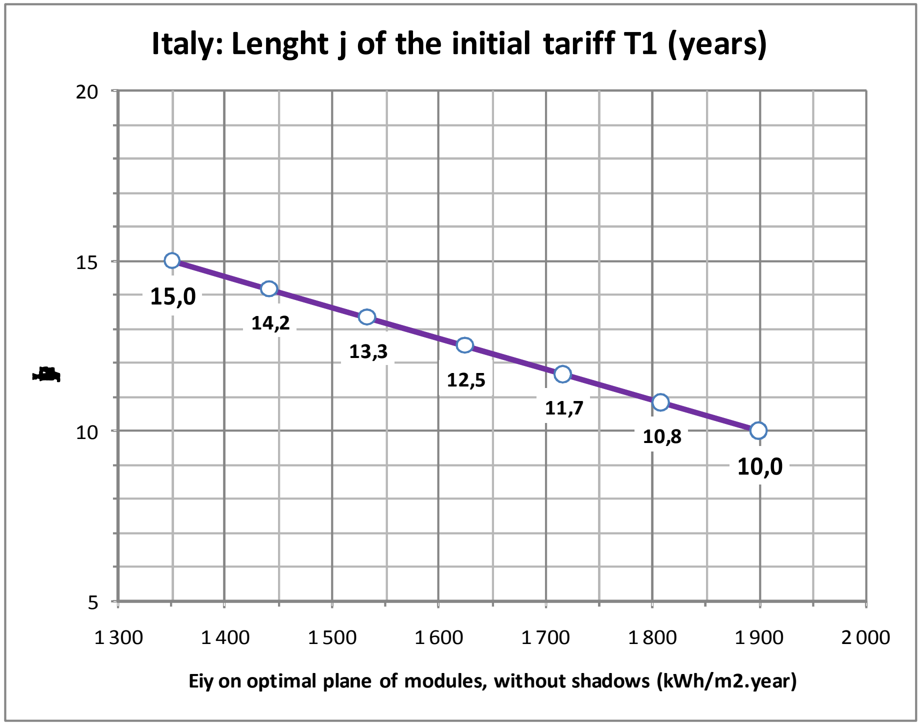
Exemple de sites	Eia 30° Sud	
	kWh.m2/an	kWh/j
Lille	1100	3,0
Paris	1200	3,3
Tours	1300	3,6
Limoges	1400	3,8
Lyon	1500	4,1
Valence	1600	4,4
Nîmes	1700	4,7
Toulon	1800	4,9

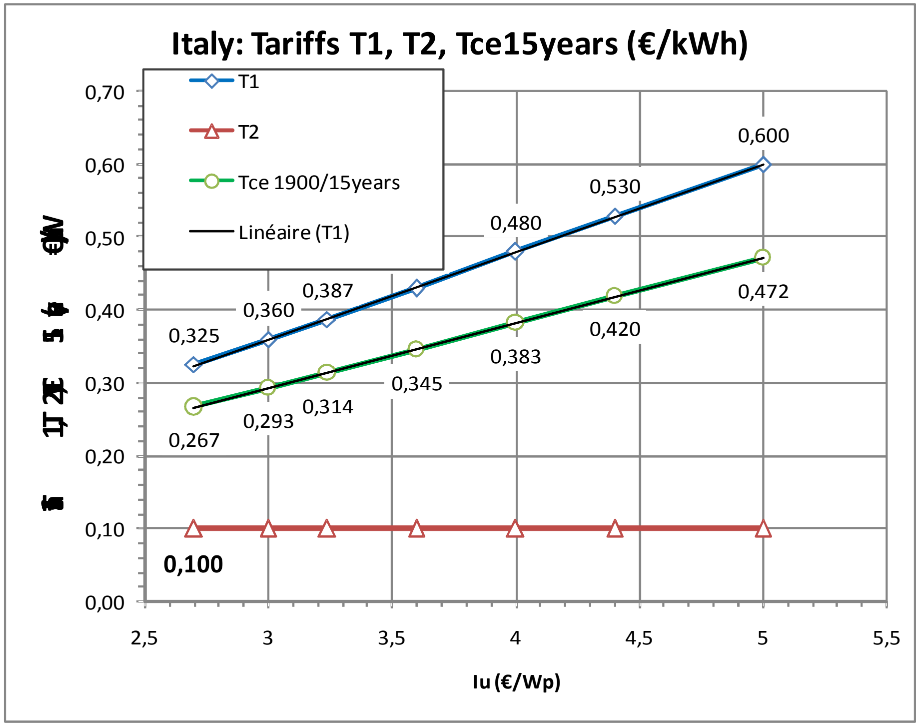
Conclusion from the France case study

- **It can works and create a « winning-winning situation »**
  - ⇨**j** varying from **11 to 20 years**: sensible decrease of over-cost for electricity consumers, lower discounted pay back period in the sunny part of the country
  - ⇨**PI** in optimal conditions **varying from 0.05 to 0.35**: clear incentive to develop first the sunny part of the country, and also possibility to develop less sunny part with a positive economic profitability
- **Even in this most difficult case !**
  - ⇨Maximum difference between mini and maxi solar irradiation in EU countries

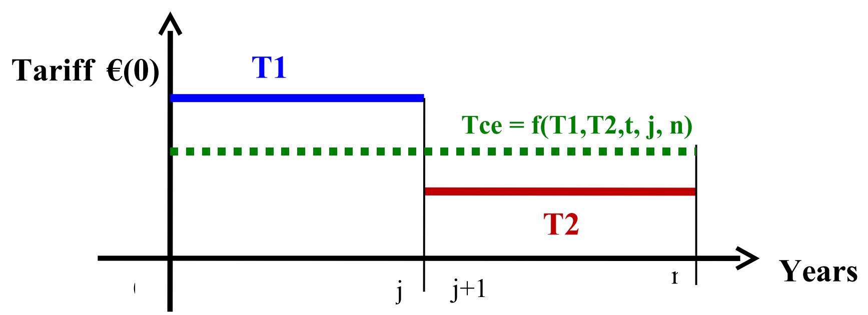
Case study (2): Italy: tariff parameters

- n = 15 years, Jmin = 10 years.
- PVGIS: Eiy varying from 1390 (Trento) to 2040 (Ragusa). Choice: Eiymin = 1350; Eiymax: 1900 kWh/m2.year



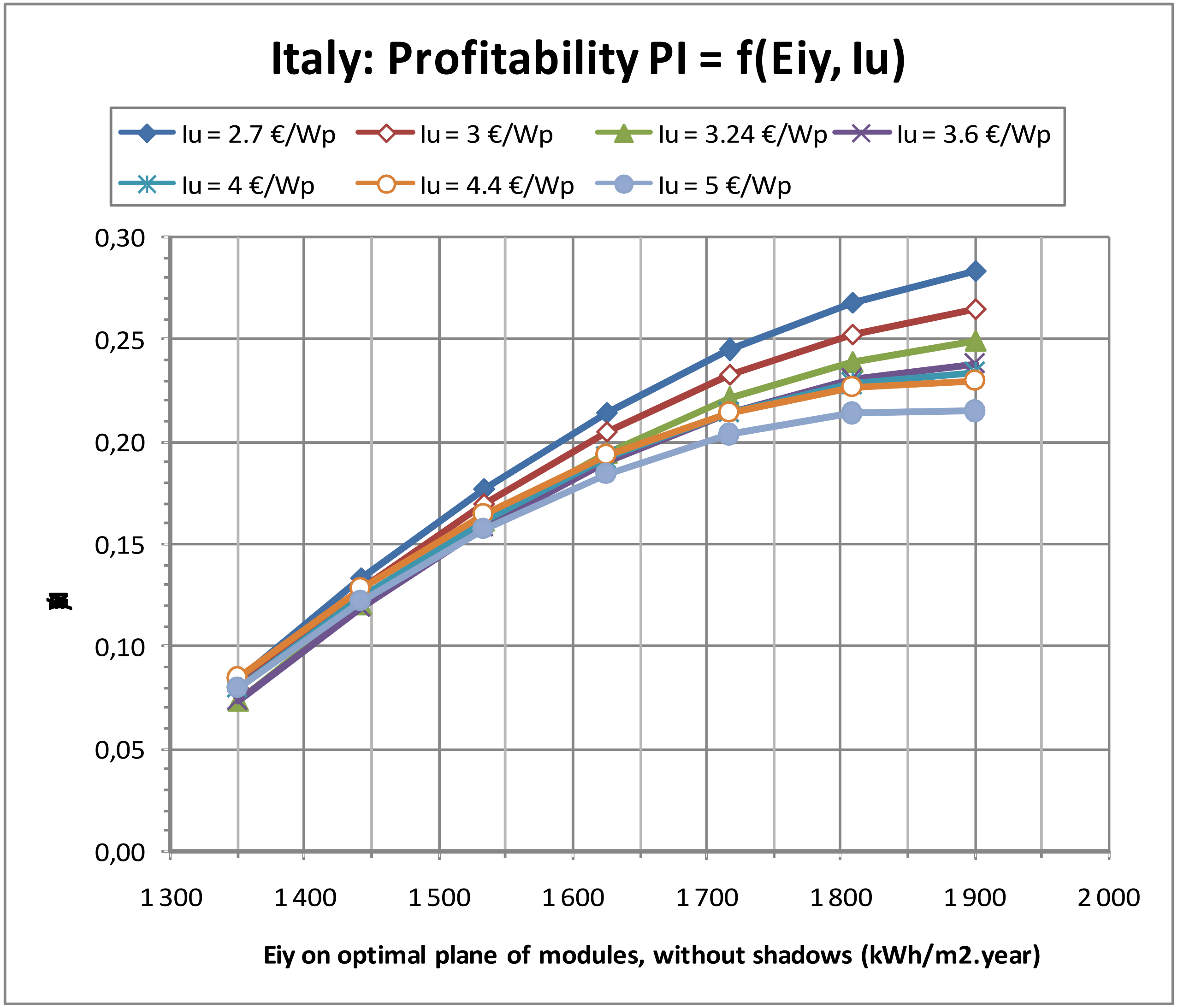


Note: in continental Spain, Eiy range values are quite the same than in Italy, so this tariff proposal could be also considered for Spain



Case study (2): Italy: profitability results

- n = 15 years, Jmin = 10 years
- In Italy (or continental spain) : minimum profitability is positive, maximum profitability can establish a strong market growth, without undue profitability levels:



Conclusion from the Italy case study

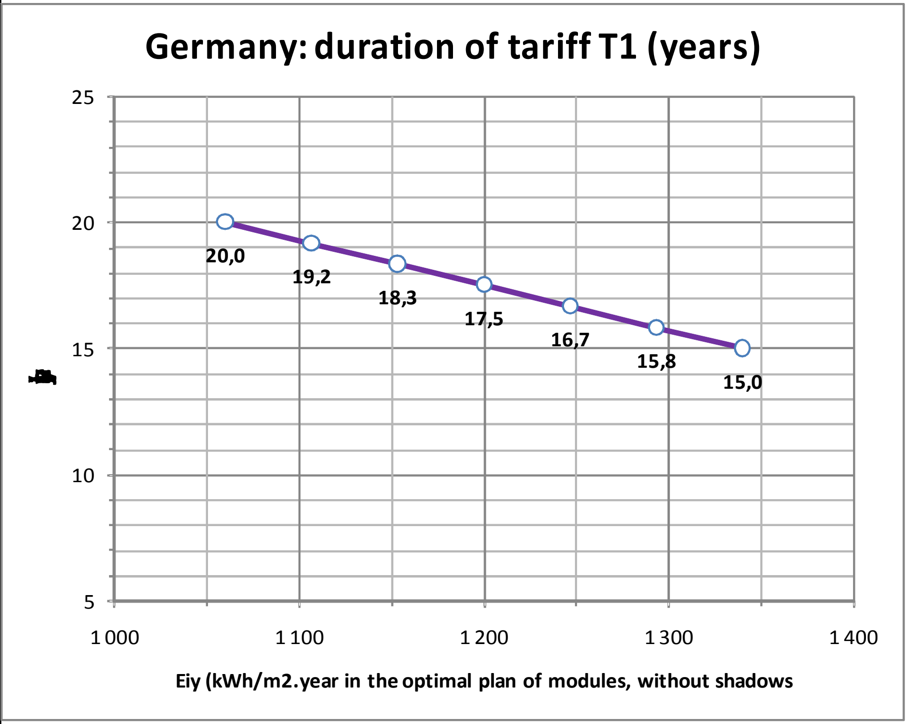
- **It can works and create a « winning-winning situation »**
  - ⇨ **j** varying from **11 to 15 years**: sensible decrease of over-cost for electricity consumers and its duration, lower discounted pay-back period for investors
  - ⇨ **PI** in optimal conditions **varying from 0.07 to 0.27**: clear incentive to develop first the sunny part of the country, and also possibility to develop less sunny part with a positive economic profitability
- **Can cover also Spain (except Canary island)**

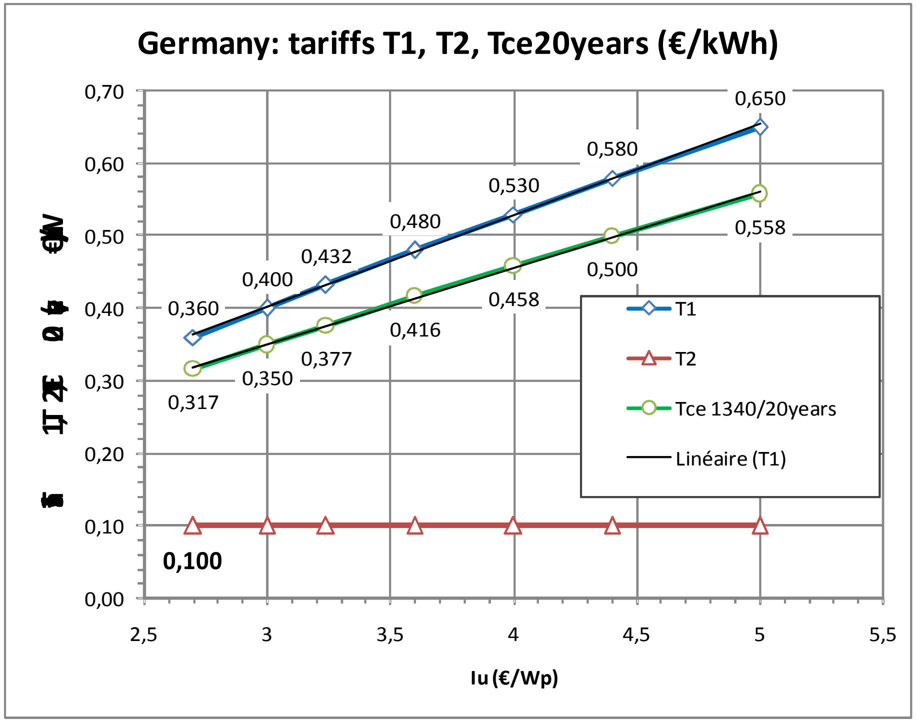
Case study (3) : Germany

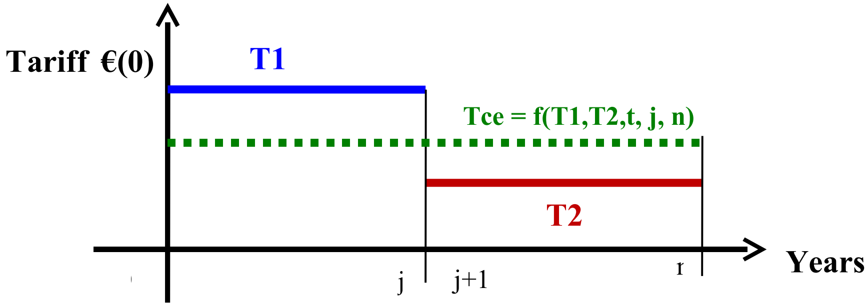
- **Why a case study for Germany ?**
  - The case for a country with more homogen solar irradiation
    - PVGIS: Eiy varying from 1100 (Hamburg) to 1390 kWh/m2.y (Oberstdorf)
    - **Choice for this model: min = 1060; max: 1340 kWh/m2.y (Munich: 1300)**
  - Historically, variable tariffs were assessed but not chosen
  - A test for this model: comparison with actual tariffs
- **Results confirm that variable tariffs advantages are less marked than in the case of France and Italy/Spain, but are also present and valuable**
- **Results show this model gives higher tariffs that actual ones, may be because:**
  - German PV market is the most mature one in the world
  - German PV market prices are lower than in France and Italy
  - German PV industry can accept fast decreasing tariffs by anticipating or creating fast modules + systems costs decreases
- **This model can be easily adapted with lower targeted PI values in sunny areas to simulate a dynamic market**

Case study (3): Germany: tariff parameters

- **n = 20 years, Jmin = 15 years.**
- PVGIS: Eiy varying from 1100 (Hamburg) to 1390 kWh/m2.y (Oberstdorf) **Choice for this model: 1060 to 1340**

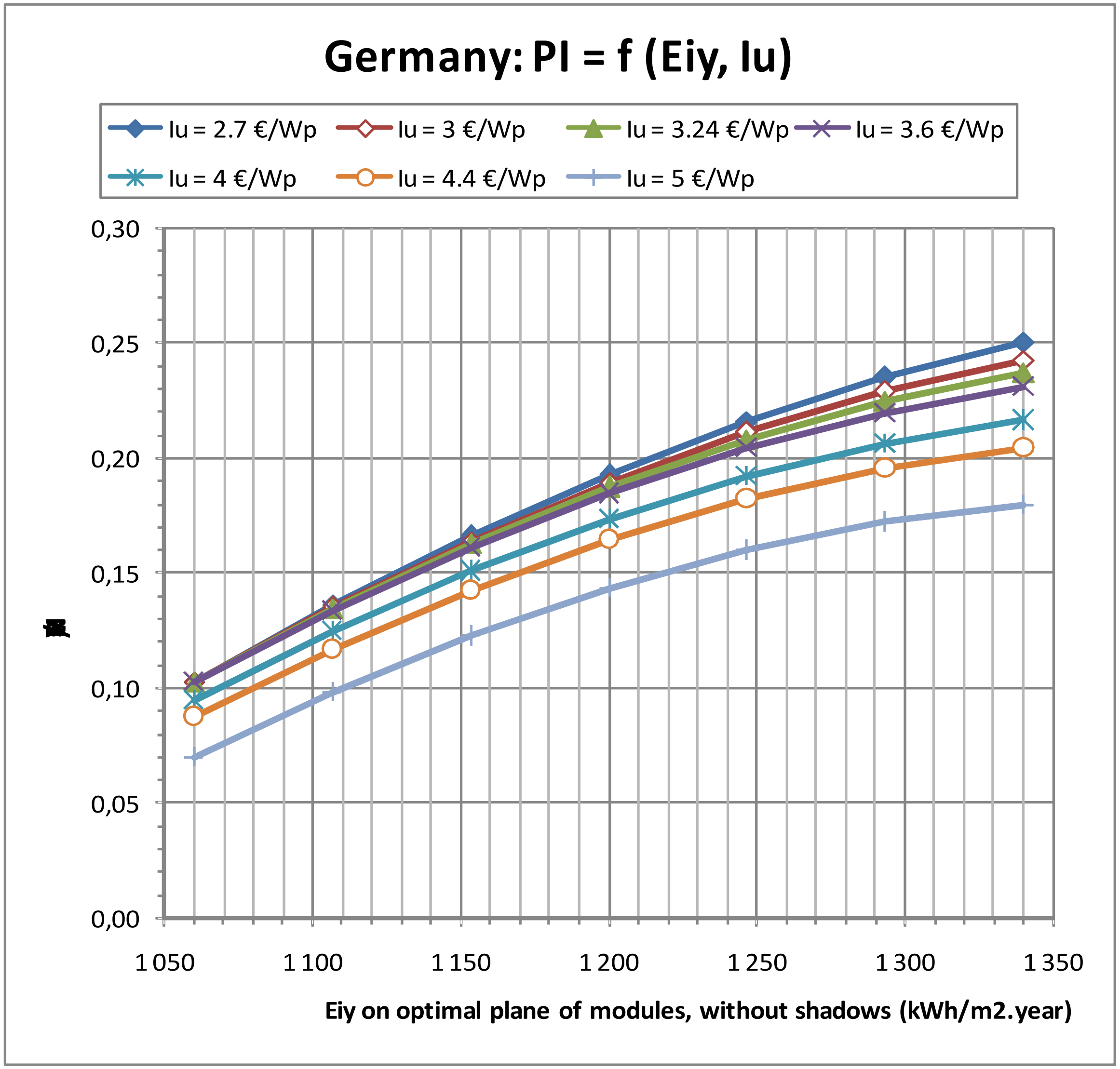






Case study (3): Germany: profitability results

- n = 20 years, Jmin = 15 years
- In this potential tariff system for Germany: minimum profitability is positive, maximum profitability can establish a strong market growth without undue profitability levels after investments from « early adopters »



Conclusion from the German case study

- **It can works and create a « winning-winning situation »**
  - ⇨**j** varying from **15 to 20 years**: sensible decrease of over-cost for electricity consumers and its duration, lower discounted pay-back time for investors in the sunny part of the country
  - ⇨**PI** in optimal conditions **varying from 0.07 to 0.25**: clear incentive to develop first the sunny part of the country, and also possibility to develop less sunny part with a positive economic profitability

- **More detailed potential impact calculation on over cost decrease on the 2010-2040 period is needed**

- **As present, the « simple EEG tariff » is well known and successfully used by investors, so changing the system could be rejected both by investors and government if this advantage on over-cost for consumers is not large**

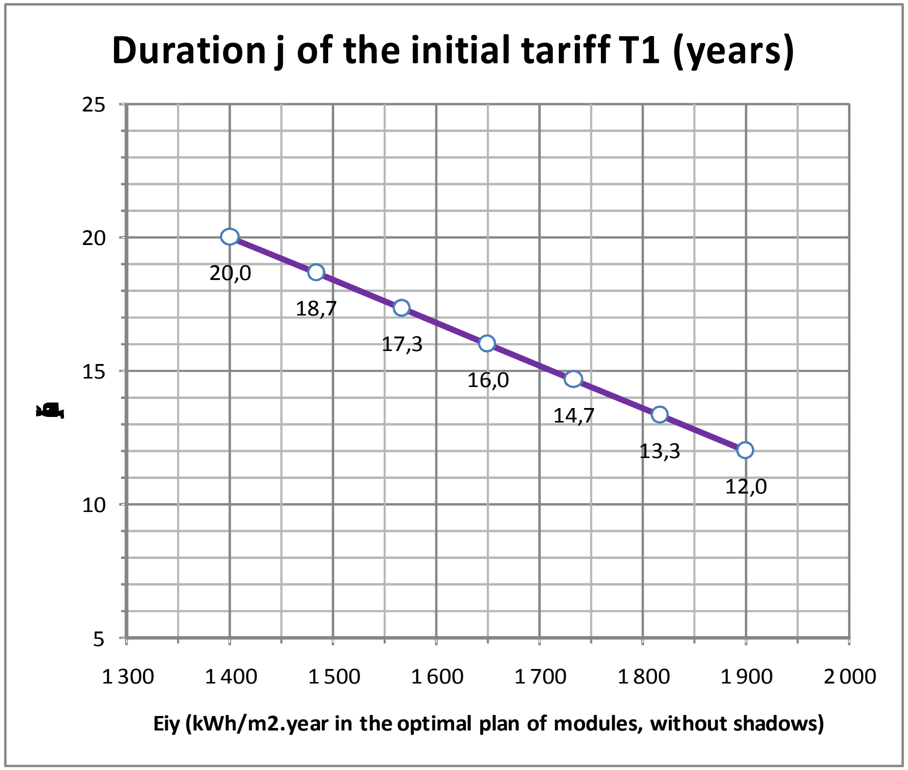
Case study (4) : Turkey

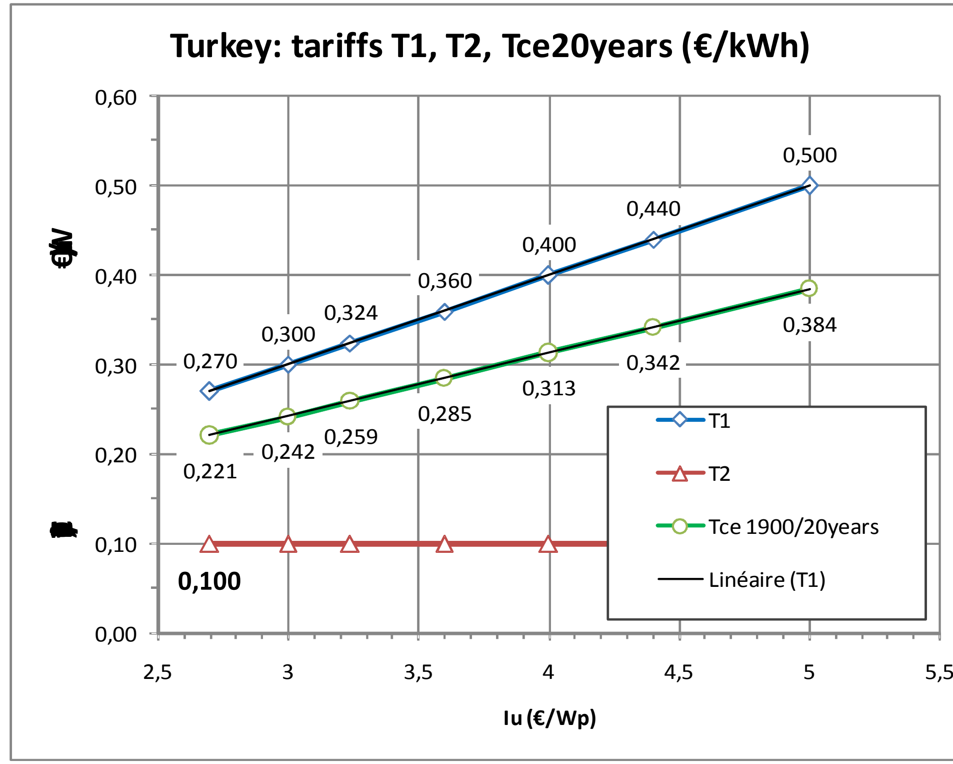
- **Why a case study for Turkey ?**
  - The case for a non EU country but a EU candidate country
  - Turkish grid connected PV market will start soon
  - Also with variable solar irradiation : slightly better than Italy
    - ¶ PVGIS: Eiy varying from 1450 (Istamboul) to 1990 kWh/m2.year (near Fethiye)
    - ¶ **Choice for this model: min = 1400; max: 1900 kWh/m2.year**

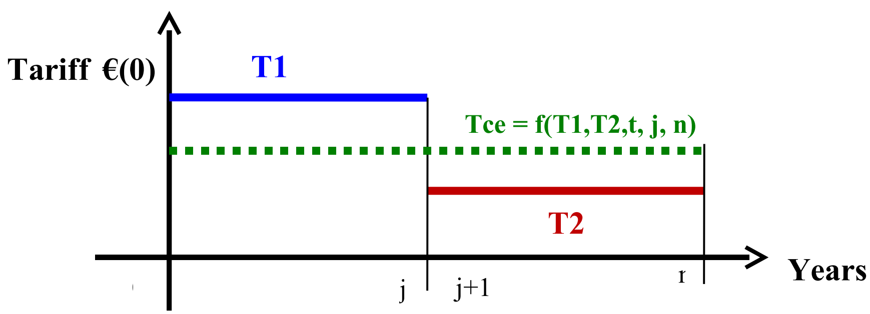
- **Test for lower tariffs than in the Italy case study: choice n = 20 years versus n = 15 years, to lower short term over-cost for electricity consumers**

Case study (4): Turkey: tariff parameters

- **n = 20 years, Jmin = 12 years.**
- PVGIS: Eiy varying from 1450 (Istambul) to 1990 kWh/m2.y (near Fethiye); **Choice for this model: 1400 to 1900**

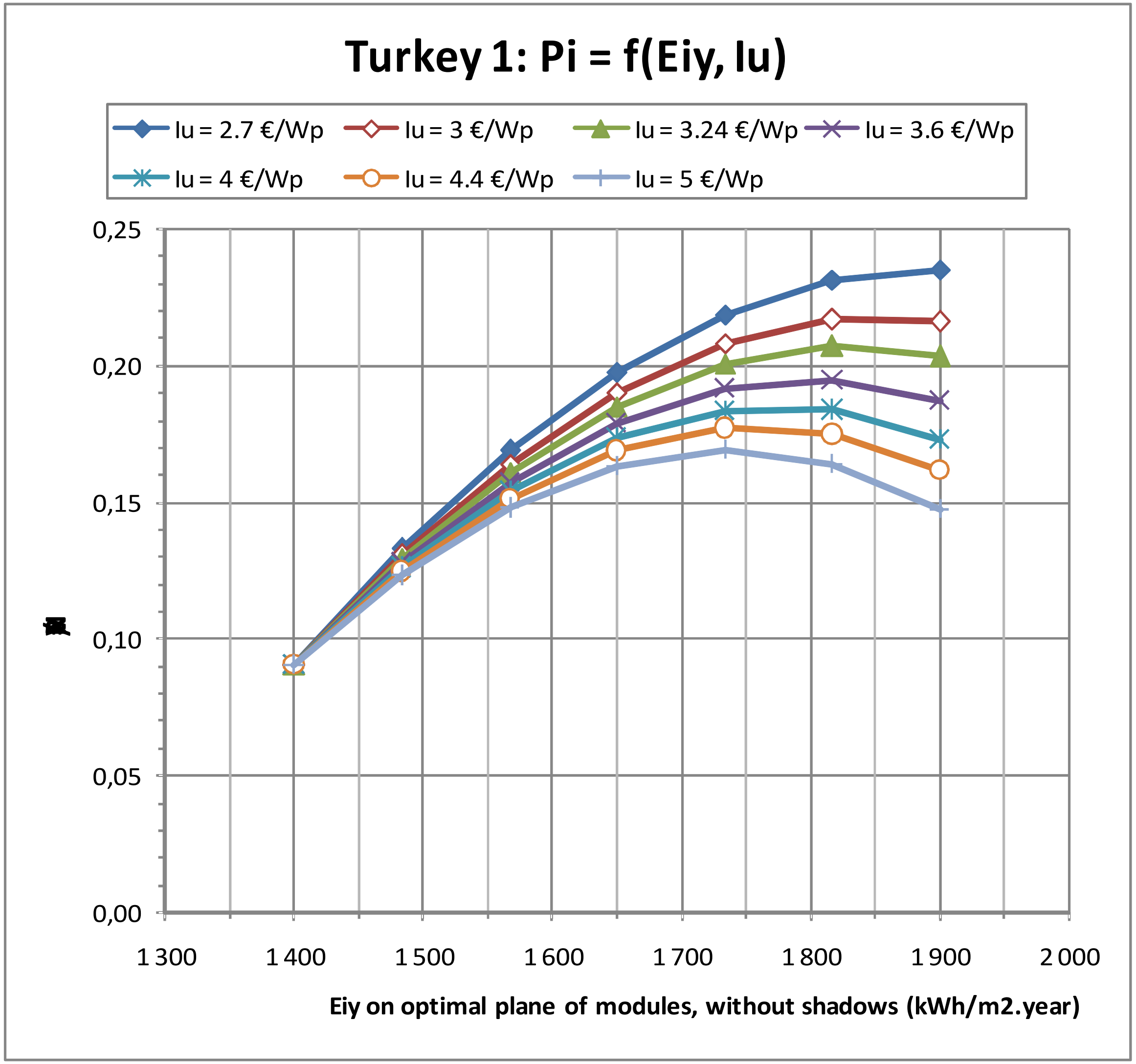






Case study (4): Turkey: profitability results

- n = 20 years, Jmin = 12 years
- In this potential tariff system for Turkey: minimum profitability is positive, maximum profitability can establish a strong market growth without undue profitability levels



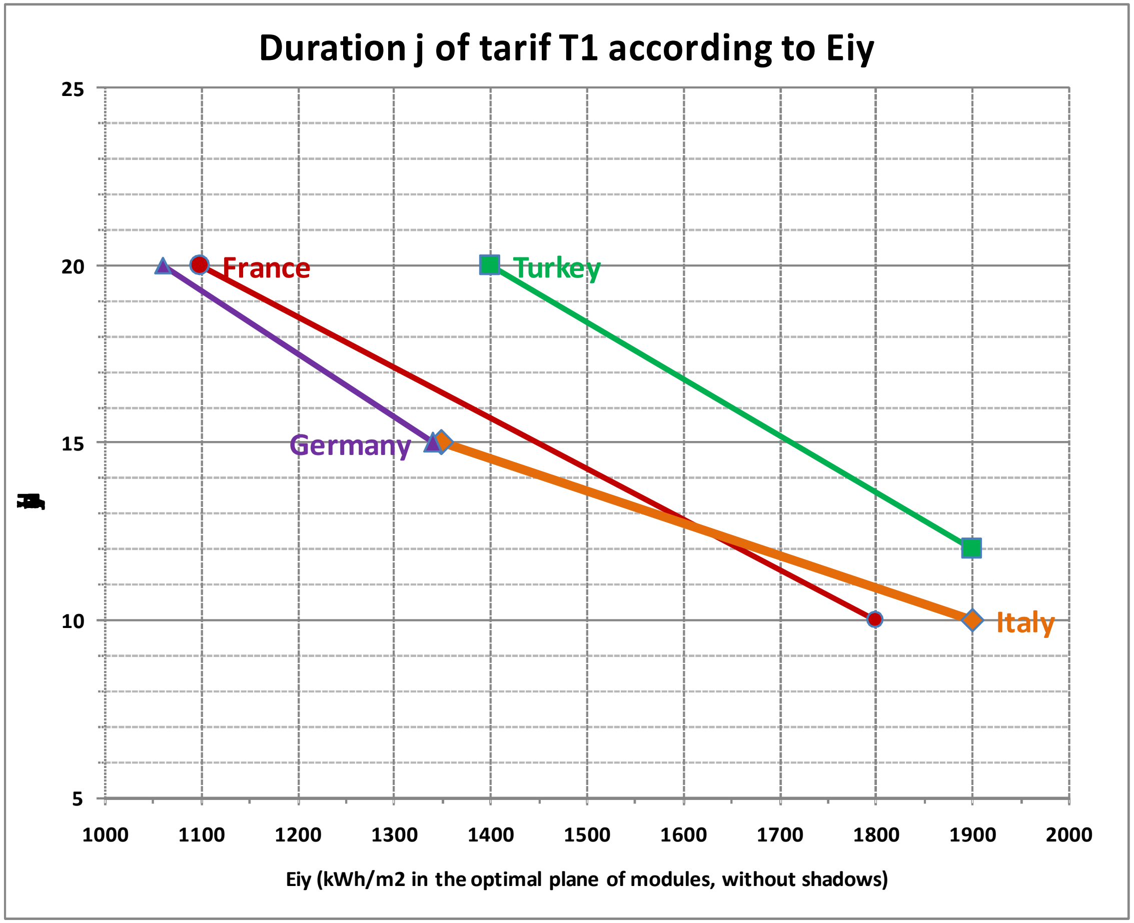
Conclusion from the Turkey case study

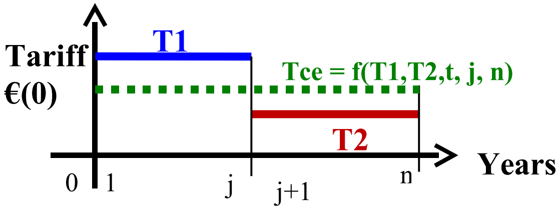
- **It can works and create a « winning-winning situation »**
  - ⇨**j** varying from **12 to 20 years**: sensible decrease of over-cost for electricity consumers and its duration, lower discounted pay-back period for investors
  - ⇨**PI** in optimal conditions **varying from 0.09 to 0.23**: clear incentive to develop first the sunny part of the country, and also possibility to develop less sunny part with a positive economic profitability
- **Option n = 20 years gives lower tariffs than in the Italy case study (n = 15 years)**
  - ⇨Lowering short term over-cost for consumers
  - ⇨PV FITs system would be more acceptable by market regulator/government

Second model
case studies comparisons
and synthesis

Case studies comparisons: duration of PPAs

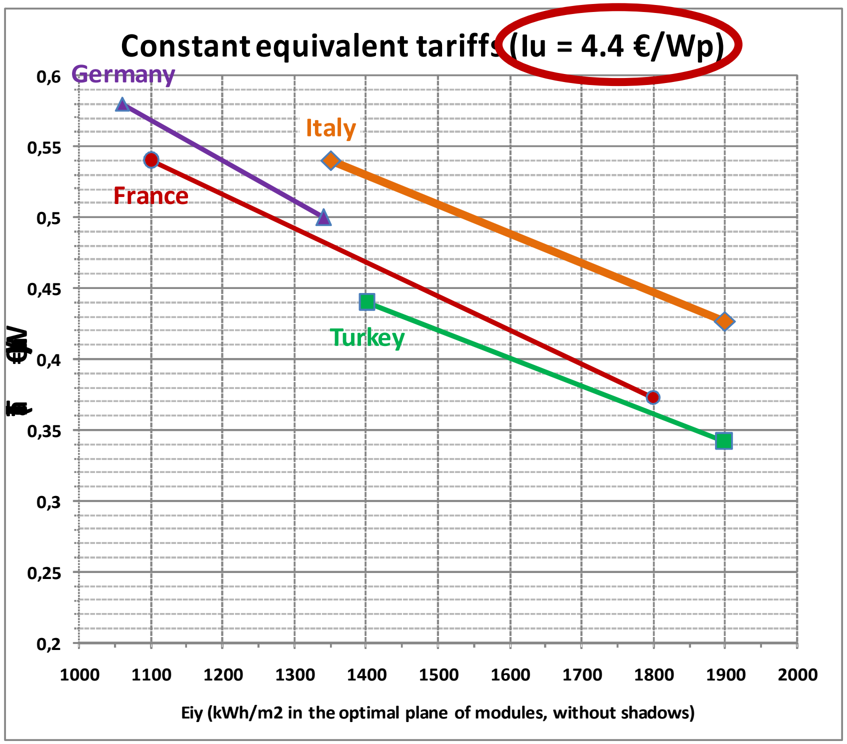
- Values of n: 20 or 15 years. Values of j: 10 or 12 years
- Tariffs characteristics must be adapted to each countries: a unique « European PV tariff system” is not possible

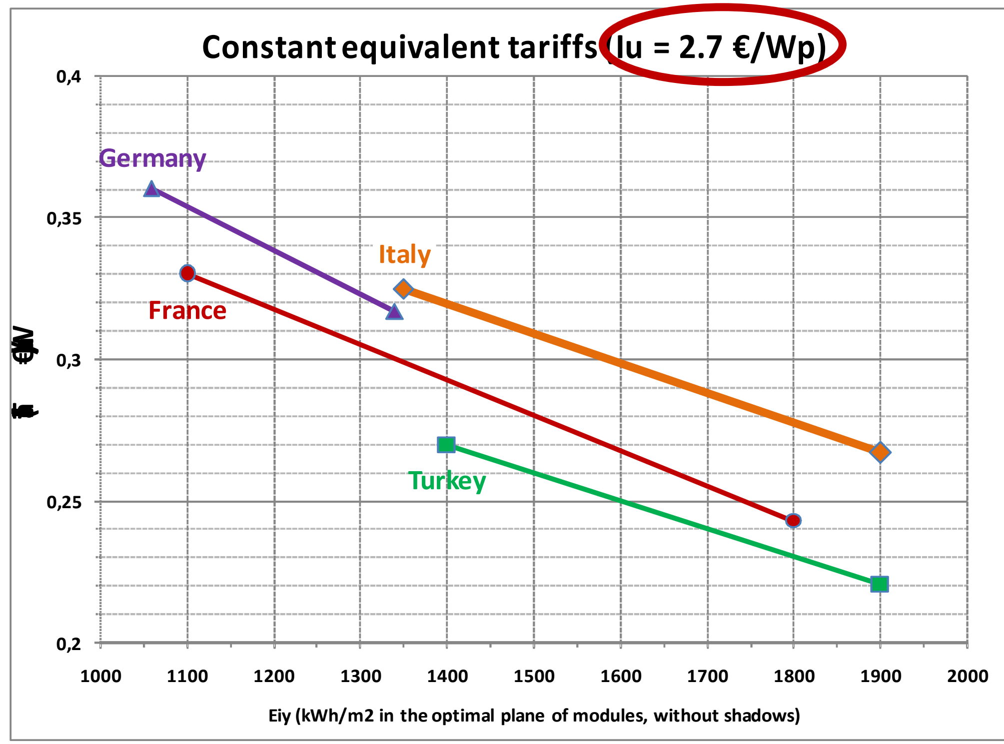


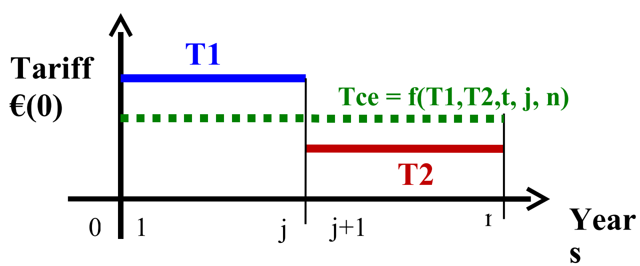


Case studies comparisons: example of tariffs levels

- **Values of « Equivalent constant tariff Tce = f(T1, T2, n, j, t)**
- **Two examples of Iu values: 4.4 €/Wp (domestic PV roofs 2008-2010) and 2.7 €/Wp (large PV plants 2017-2020)**







Conclusion on the second model case studies

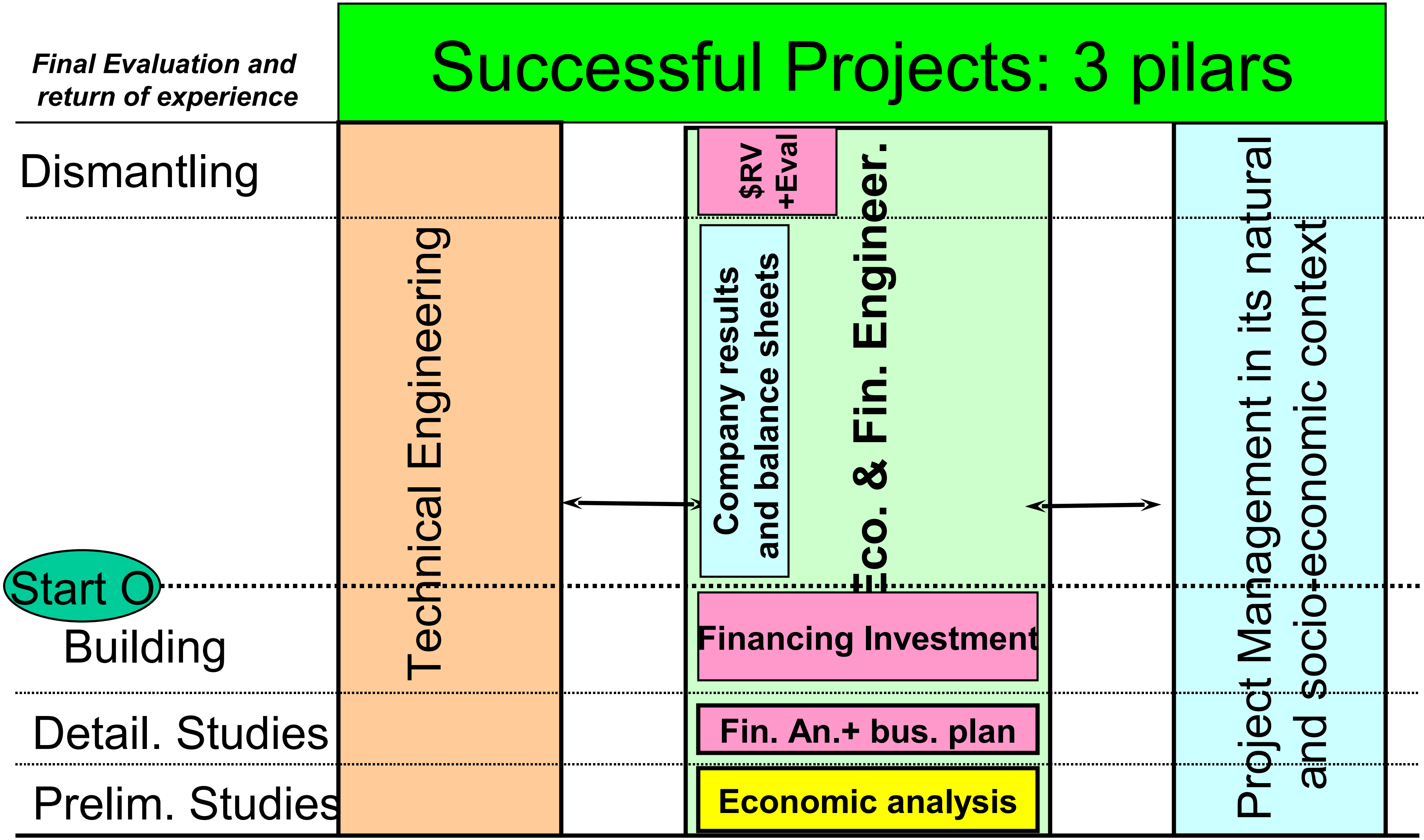
- **This advanced fair and efficient PV FIT model can work**
- **It creates in all cases a « winning-winning situation »**
  - ⇨ Decreasing and shorter overcost for electricity consumers
  - ⇨ Giving incentive to develop first the sunnier parts of the country and also offering a minimum positive profitability in the least favoured parts
  - ⇨ It avoids undue profitability on best sites
  - ⇨ It gives a sufficient profitability in a large part of countries to create dynamic, robust and long term growth of PV markets
- **Its implementation can be made easily**
  - ⇨ More simple than similar systems already implemented with success in the more complicated case of wind power (in Germany, and with a slightly different solution in France and Portugal)
  - ⇨ Its monitoring and adaptation to changing contexts (e.g. faster decrease of investment cost ratio) can be made easily
- **It can be adapted to all EU present and future MS (if in country variation in solar irradiation requires it)**
- **It could be also used in other countries: USA, China, India…**

General conclusions

- **The Profitability Index method, its linear PI model against tariff and its universal PI scale can help to a make fast and reliable assessment of different FITs models and proposals**
- **Advanced PV tariffs differentiated according to location:**
  - ⇨ Are worthwhile in countries with large differences in solar radiation such as France, Italy (Spain), Turkey, USA, China…
  - ⇨ Can be defined from a simple PV FIT system (e.g. " 2nd model")
    - ¶ **Easy to define and to implement**
    - ¶ **Easy to understand and to be used by investors and citizens**
  - ⇨ Can create a "**Winning-Winning situation**" both for investors and electricity consumers, **leading to lower PV FITs over-cost**
- **Such systems can be based on same schemes and principles, but must be defined country by country**
- **Knowledge transfer for this approach is very easy and has been already tested in various contexts and countries**

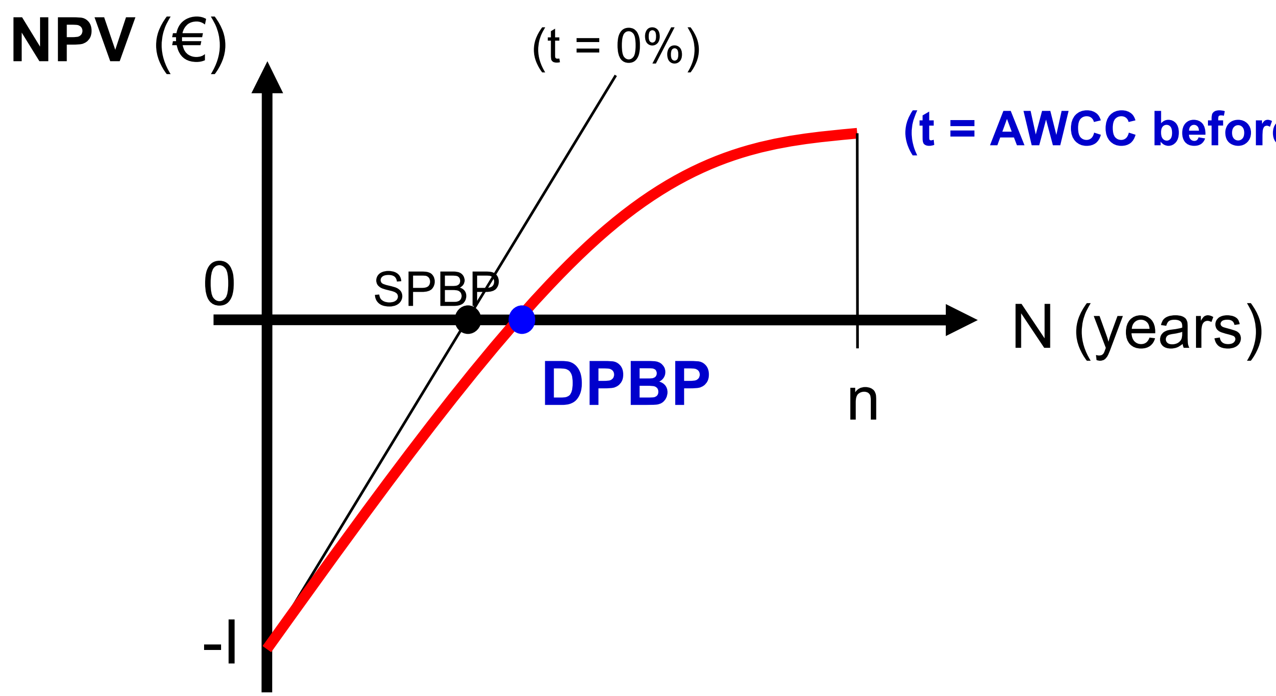
Complementary information for PIM and discussion

The 3 pillars of successful projects & programmes



Economic profitability criteria based on NPV > 0 (1):

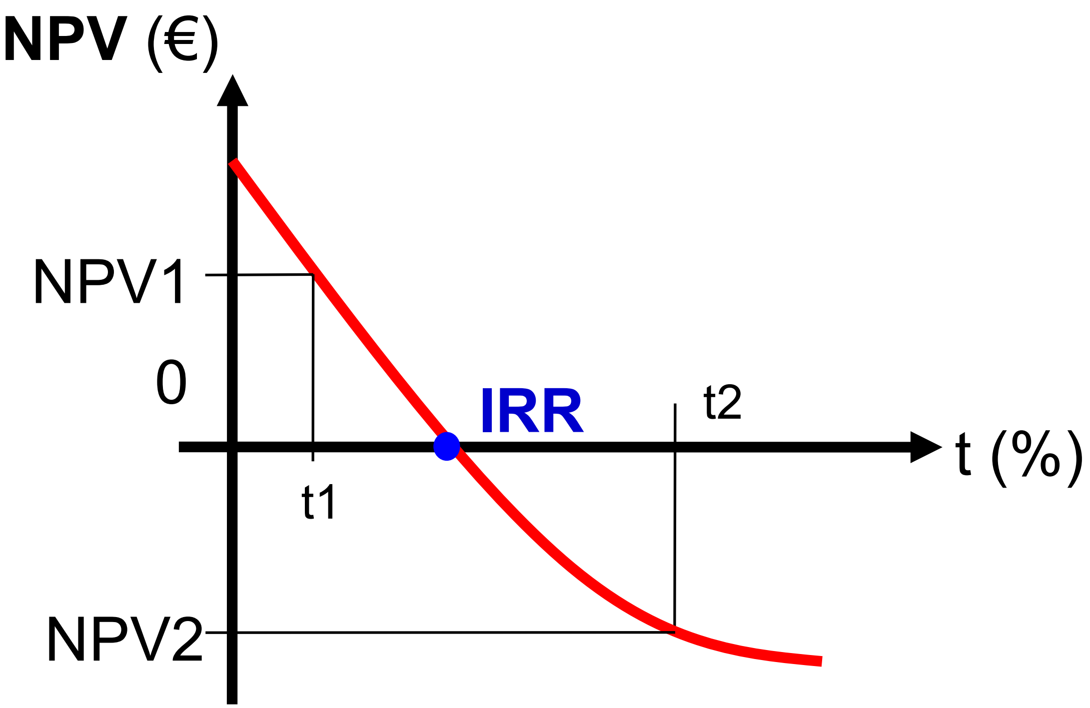
The Discounted Pay-Back Period (DPBP)



- **A project is profitable if its Discounted Pay-Back Period (DPBP) is lower than the number of years of operation *n***

- **Note:** for the lucky people with access to free money (debt and equity): calculation of the Simple pay-Back Period (SPBP = I / CF) and verify that SPBP < 1 / Capital Recovery Factor CRF(t,n) with CRF(t,n) = t /{1-(1+t)^-n}

Economic profitability criteria based on NPV > 0 (2):
The Project Internal Rate of Return (IRR)



❑ **A project is profitable if its IRR is higher than its Averaged Weighted Cost of Capital (AWCC)**

The IRR value cannot indicate by itself if the project is profitable or not! <u>One must provide to investors both the project t = AWCC and IRR values !</u>

Summary of conventional profitability parameters

❑ Net Present Value (€)

⇨ NPV = (Sum of discounted operating Cash-Flows) - I

➔ Cash-Flow = Turn-over – Yearly expenses (without amortisation, tax on profit)

⇨ Project is Profitable if NPV > 0 ; **But by how much** ????

❑ Project Internal Rate of Return IRR (%)

⇨ Virtual value of discount rate t for which NPV = 0

⇨ Project is Profitable if IRR > AWCC; **But by how much** ????

❑ Discounted Pay-Back Period DPBP (years)

⇨ Virtual value of *n* for which NPV = 0

⇨ Project is Profitable if DPBP < n ; **But by how much** ????

❑ Simple Pay-Back Period SPBP (years)

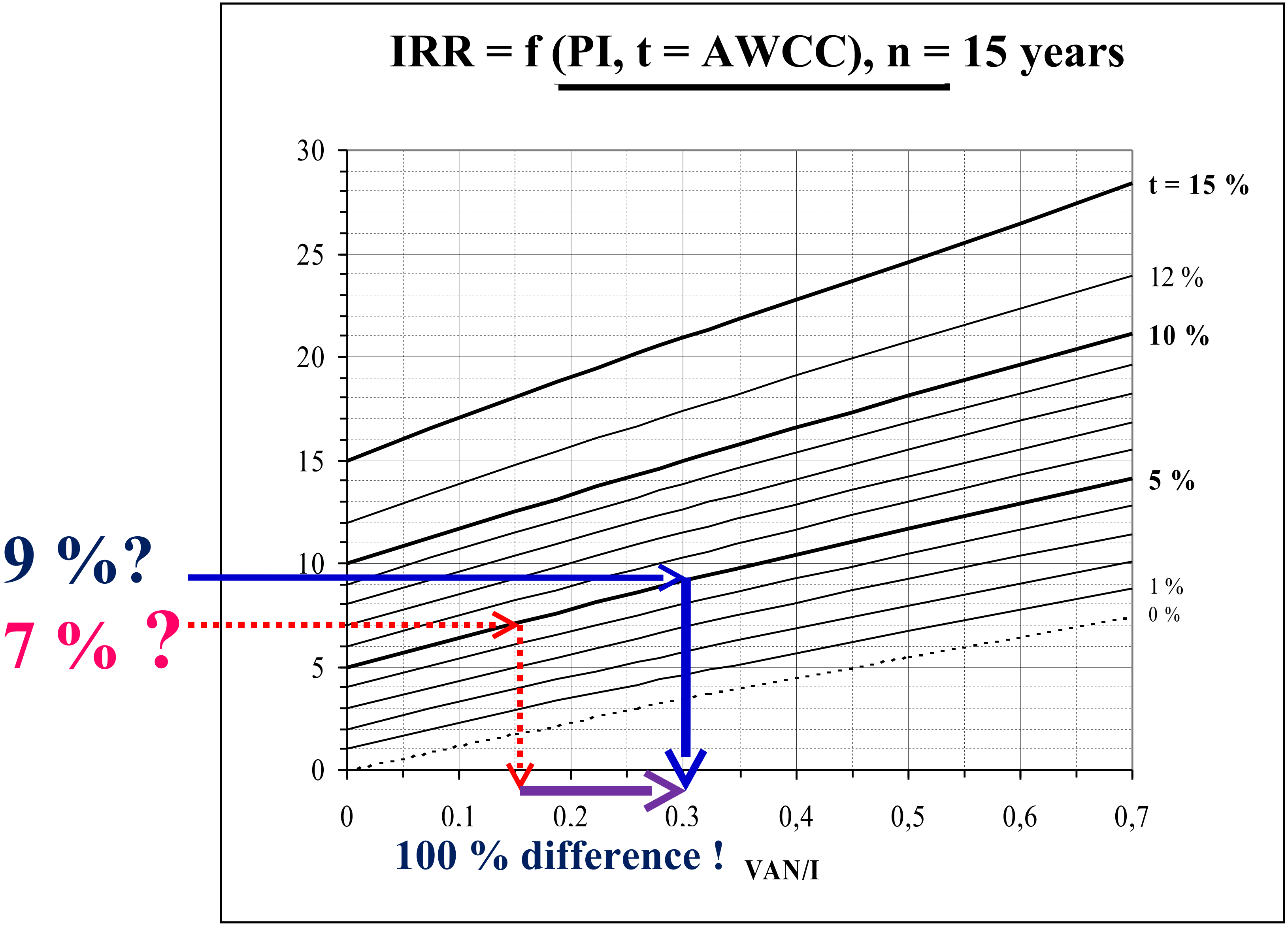
⇨ SPBP = I / CF « averaged »

⇨ Project profitable if SPBP < SPBPmax; **But by how much** ????

⇨ 36 "rules" for SPBTmax, **only 1 correct: SPBP < 1/CRF(t,n)**

Why choosing profitability target from PI and not IRR ?

If t = AWCC = 5 %: if IRR vary only from 7 to 9 % ➔100 % PI variation from 0.15 to 0.3, <u>and a related 100 % variation on NPV value</u> ! And another *n* value would give other IRR values…



Tariff calculation from the linear profitability graph

❑ From PI = f(TV), calculation of targeted tariff TV:

⇨ **TV** = {(1 + **PI**)*CRF + Kom} (Iu / Nh) + Cvu (€/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
- ¶ **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)

❑ The same graph and the same formula gives:

- ⇨ **Tariff TV**
- ⇨ **kWh Cost (with PI = 0)**
- ⇨ **Cost structure : Ci, Com, Cvu**