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# 2002 Irish Renewable Energy Forum

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## Advanced Tariff Systems for a Fair and Rapid Uptake of Renewable Energy and the French Experience

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# Content

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- ❑ **Market regulation options for electricity from RES**
- ❑ **The European and the French context**
- ❑ **Principles and method to define fair & efficient tariffs**
- ❑ **The French wind power tariff system ( $P < 12$  MW)**
- ❑ **Possible adaptation of "advanced tariffs systems" to the Irish wind context**
  - ⇒ Possible improvements
  - ⇒ Case studies:
    - The "Kilkenny 2001 Tariffs"
    - The "Kinsale 2002 Tariffs"
- ❑ **Conclusions**

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# Market Regulation for Electricity from RES

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- ❑ **A power market regulation is necessary to attract private investors and to avoid future "stranded costs"**
- ❑ **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<sub>2</sub> emissions, no radioactive waste
  - ⇒ **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)
  - ⇒ **Burden 2** : "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

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## □ Regulation by quantities ("the stick")

- ⇒ 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 ("the carrot")

- ⇒ "Fixed prices" (eg wind power in Dk & G in the 90's)
- ⇒ "Environmental premium" over avoided cost (eg Spain)
- ⇒ "**ADVANCED TARIFFS**" (eg wind power in G, F)
  - ➔ Defined for each technology
  - ➔ Fixed tariff within a contract, 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
  - ➔ Over-cost charged on all electricity consumers on equal basis

# The European Context

## □ Sept 7th 2001 EU Directive:

⇒ RE based electricity should be 22% of EU15 demand in 2010 instead of 14 % in 1997

⇒ Each member state can choose its best RE policy

⇒ If insufficient national results within 4 years, EU can demand member states to adopt the proven best practices and incentives (e. g. minimum feed in tariffs)

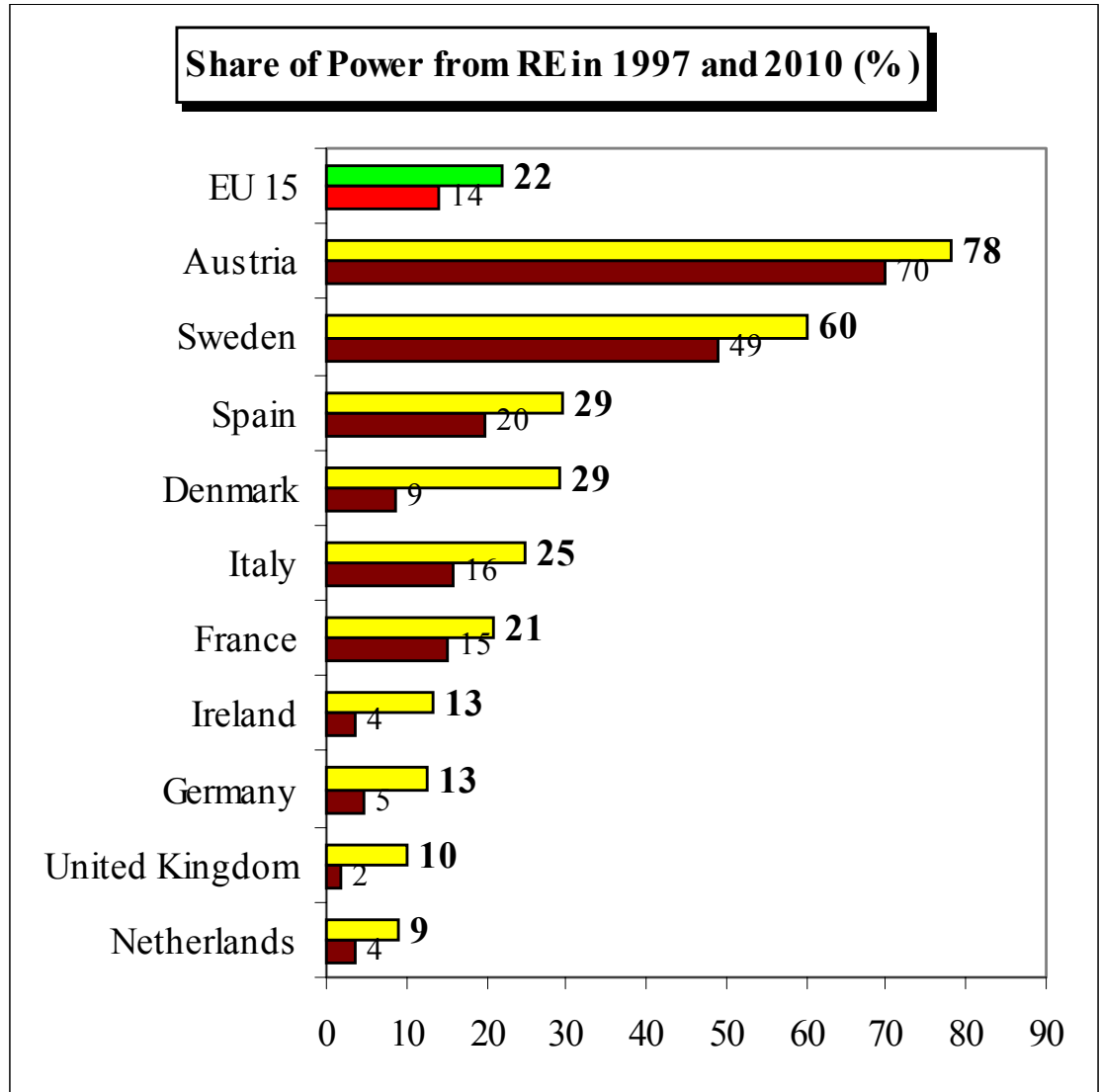
## □ 2010 target for wind power :

⇒ 1997: Second contribution (after hydro and biomass) : 40 GW, 80 TWh/year

⇒ EWEA target is now:

→ 60 GW in 2010

→ including 5 GW offshore



# The French Context Within the EU Directive

- ❑ **For France: increase from 15 % to 21 % (including large hydro: 66 TWh)**
  - ⇒ Requires a minimum increase of 40 TWh/year of new RE (excluding large hydro)
  - ⇒ Requires a minimum of 11 GW of wind power in 2010 (versus 0.07 GW in 2000)
  - ⇒ Wind power should contribute to 73 % of new renewable energy increase (81% of new RE power increase)
- ❑ **Those preliminary figures are to be discussed before bottlenecks are assessed (grid access...) and official French commitments are decided and published**

Additional contribution of RETs in France in 2010			Nh ref	P reference	
(2001 ADEME estimate)	TWhe/an	%	h/year at Pref	GW	%
<b>Wind Power</b>	<b>29</b>	<b>73%</b>	2 600	<b>11,2</b>	<b>81%</b>
Biomass	5,9	15%	5 000	1,2	9%
Small Hydro Power	4	10%	4 000	1,0	7%
Geothermal Energy	0,8	2%	7 000	0,1	1%
Photovoltaics	0,3	1%	1 200	0,3	2%
<b>TOTAL new RE contribution</b>	<b>40</b>	100%		<b>13,7</b>	100%
Total with large Hydro	107				
Total 2010 demand incl. DSM	510	<b>21%</b>			

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# Principles for Efficient and Fair Tariffs

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## ❑ **Taking into account return of experience and context:**

- ⇒ Competitive calls for tenders (e. g. “EOLE 2005”)
  - Not enough efficient for new French Wind Energy goals: from 5 up to 11 GW installed in 2010 (within the EU RE electricity Directive)
  - Feb. 2000 French electric law: the only solution for projects > 12 MW
- ⇒ Green certificates: not proven, not sufficient for 5 to 11 GW
- ⇒ “Fixed Tariffs”: past and ongoing successes (Dk, G, Sp...)

## ❑ **Basis: fair profitability for private investors:**

- ⇒ Minimum profitability for strong market growth, including on low quality sites largely available (from  $N_h = 2\,000$  h/y)
- ⇒ No undue profits on high quality sites: tariffs adapted to potential energy yields
- ⇒ Simple system, easy to define, to control and to adapt
- ⇒ Not state aid: charging the cost on all electricity consumers

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# Method (1)

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□ **Simple, innovative and powerful economic analysis: using the « Profitability Index Method » (EWEC 99)**

⇒ Profitability index **PI** = (Net Present Value) / (Investment)

⇒ Gives both « kWh manufacturing cost and selling price »:

→ Selling Price = Tariff **T** =  $((1 + \mathbf{PI})K_d + K_{om}) I_u / N_h$  (Euro/kWh)

◆ **K<sub>d</sub>** = **Capital recovery factor** (based on actual discount rate =  $t$  = AWCC = Average Weighted Cost of Capital, and  $n$ ):  $K_d = t(1+t)^n / (((1+t)^n)-1)$

◆ **K<sub>om</sub>** = **O&M ratio** = yearly O&M expenses / Investment (wind:  $K_{om} = 0.04$ )

◆ **I<sub>u</sub>** = **investment cost ratio** =  $I / P$  (EURO/kW)

◆ **N<sub>h</sub>** =  $E_y / P = \text{kWh} / \text{kW}$  = number of hours per year at rated power

→ If **PI** = 0, Tariff **T** = ODC (Overall Discounted Cost), Margin = 0

⇒ Direct link **PI**  $\iff$  **IRR**

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

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## Method (2)

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### □ **Margin on cost, MOC**

$$\Rightarrow \text{MOC} = (\text{Price} - \text{Cost}) / \text{Cost}$$

### □ **MOC of Fossil versus Renewable Energy Sources**

$\Rightarrow$  Introducing **Kfuel**

$\rightarrow$  **Kfuel** = cost per kWh without fuel cost / cost per kWh

$\rightarrow$  **Kfuel** = 1,0 for Wind; 0,5 for Coal; 0,33 for CCGT

$$\Rightarrow \text{MOC} = \text{PI} * \text{Kfuel} * (\text{Kd} / (\text{Kd} + \text{Kom}))$$

At equal kWh cost, if **PI** Renewables = **PI** Fossil, then:

$$\text{MOC}_R / \text{MOC}_F > 1 / \text{KFUEL}_F$$

**A Renewable energy investment commands a higher margin to reach the same profitability than a Fossil energy investment !!**

## Method (3)

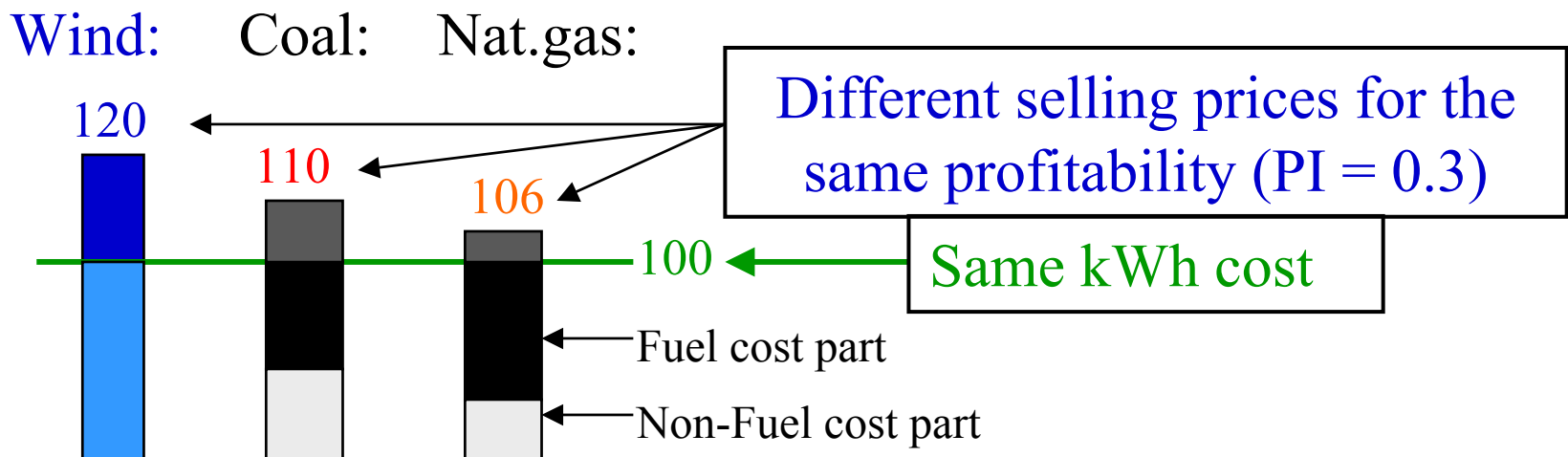
- ❑ **The « zero fuel cost RETs paradox » (wind, hydro, solar, geothermal based power plants) :**

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

⇒ MOC wind = 2 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)**



# Principles for Tariffs Definition and Calculation

- ❑ **Two successive tariffs levels (F: only for P < 12 MW):**
  - ⇒ T1 fixed for all projects from years 1 to 5 (= German idea !)
  - ⇒ T2 variable for projects from years 6 to 15 (diff. From Ger.)
  - ⇒ T1 and T2 define a constant “equivalent tariff”,  $T_{eq}$
  - ⇒ Ref.  $N_{hmin}$  :  $PI = P_{Imin} \Rightarrow T_{eqmax} = T2_{max} \Rightarrow T1 = T2_{max}$
  - ⇒ Ref.  $N_{hmax}$  :  $PI = P_{I_{max}} > P_{Imin} \Rightarrow T2_{min}$

- ❑ **For a specific project (P < 12 MW):**

⇒  $N_h$  from average values years 1 to 5

⇒ T2: linear calculation

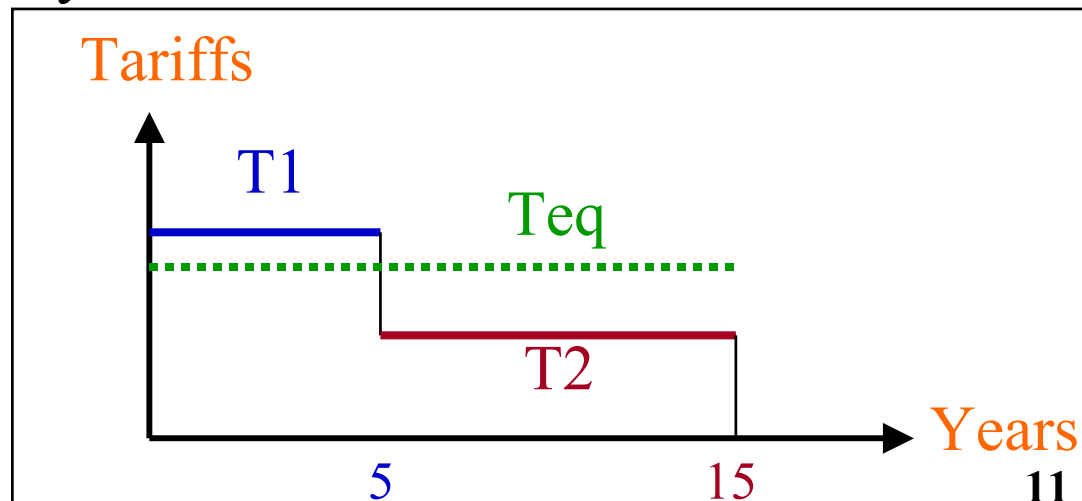
⇒  $T_{eq}$  from (T1, T2, t)

⇒ PI from  $T_{eq}$ ,  $N_h$ ,  $I_u$

- ❑ **Reference values:**

⇒  $I_u = 1067$  EURO/kW

⇒  $K_{om} = 4\%$ ,  $t = 6.5\%$



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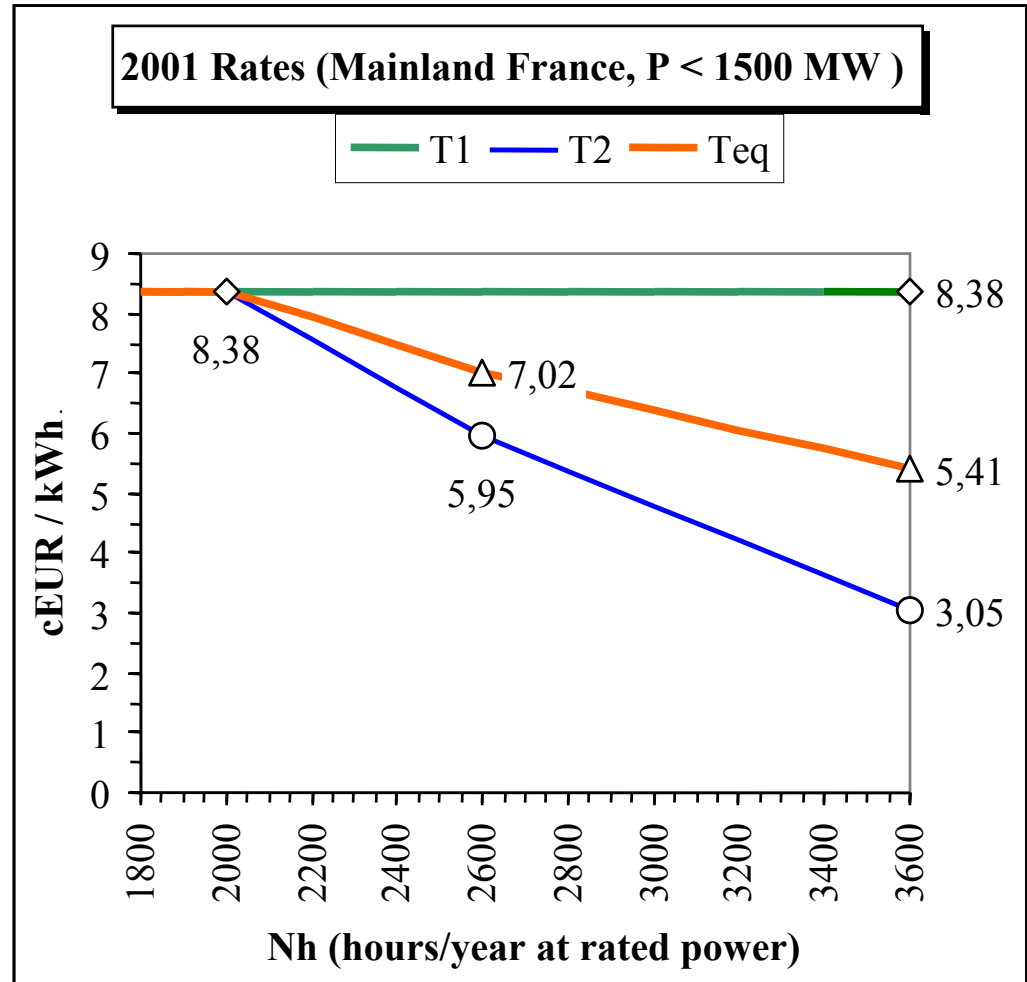
## Other Principles and Final “Details”

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- ❑ **Large diff.  $N_{\min}$ - $N_{\max}$   $\implies$   $N_{\text{hint}}$  and two R2 lines**
- ❑ **protection of tariffs within a specific contract:**
  - $\Rightarrow$  No perfect  $\implies$  decrease of profitability with inflation rate
- ❑ **Reference  $N_h$  value: average on 3 years (5 -worst-best)**
- ❑ **T2 values for years 6-10 & 11-15:**
  - $\Rightarrow$  Less 25% for kWh beyond ( $N_{\text{href}} \times 5$ )
- ❑ **Provisional reference  $I_u$  decrease for next years:**
  - $\Rightarrow$  -3.3 % per year from 2002 (current EUROS)
  - $\Rightarrow$  Formula for correction from inflation from 2003+
- ❑ **Two sets for  $N_h$  reference values:**
  - $\Rightarrow$  “Favourable” till sums of signed contracts is under 1.5 GW
  - $\Rightarrow$  “Less favourable” after 1.5 GW of signed contracts

# Results: June 8th 2001 Arrêté, 2001 Tariffs

Reference values for 2001 tariffs					
Mainland France, projects < 12 MW					
Nh:	P (MW) <1500	P (MW) >1500	cEURO / 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) <1500	P (MW) >1500	cEURO / kWh		
			T1	T2	Teq
Nhmin:	2050		9,15	9,15	9,15
Nhint:	2400		9,15	7,47	8,21
Nhmax:	3300		9,15	4,57	6,59

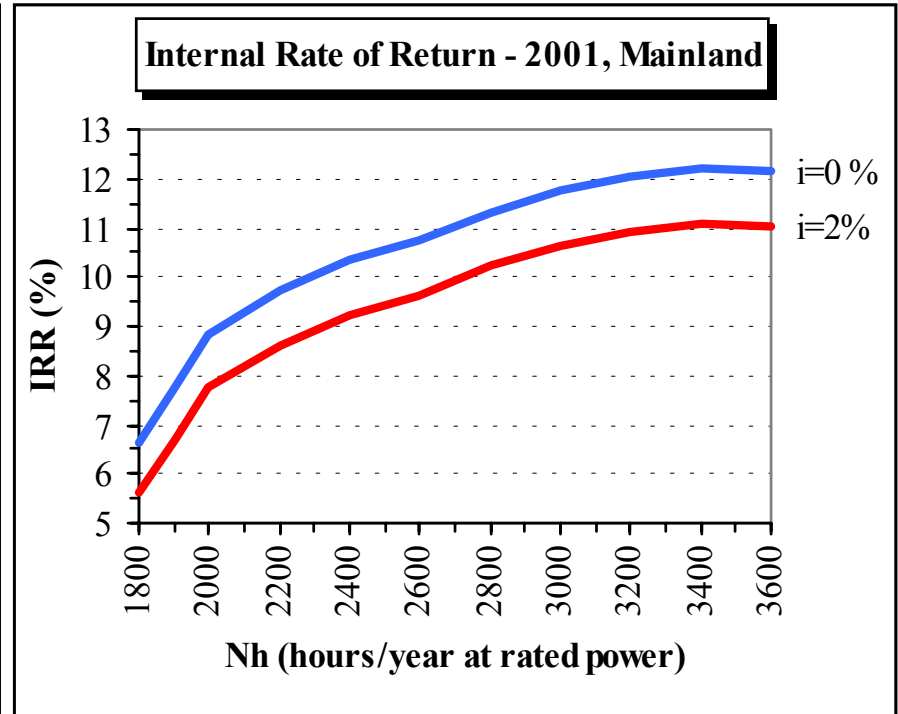
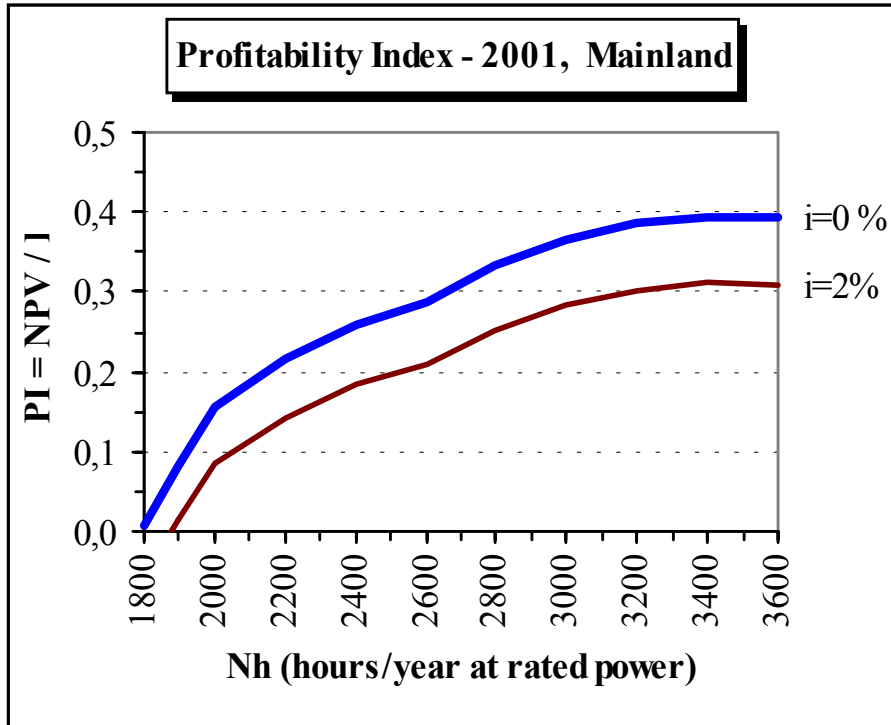


## □ Hypothesis for Teq:

⇒ Real discount rate  $t = 6.5\%$

⇒  $n = 15$  years

# Results: 2001 projects profitability (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

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# Adaptation, Control, Monitoring

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## □ Possibility to easily adapt reference values:

⇒ From wind atlas and GW goals:

→ Nh min, Nh max: minimum and maximum quality of sites

⇒ From economic and fiscal context:

→ PI min and PI max (increased profitability with energy yield)

⇒ e. g. in France: Corsica and overseas departments

## □ Control: is “fraud” on Nh on years 1-5 profitable ??

⇒ Increase of profitability with Nh: incentive to good yields

⇒ Discounting: advantages to first years cash-flows (CFs)

⇒ Maximum debt years 1 to 5-7: need to maximise first CFs

## □ Monitoring:

⇒ Actual Iu, Kom, Nh (versus Ws), economic profitability

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# Potential Consequences

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## □ Potential consequences:

- ⇒ 5 to 10 GW in 2010 (compared to 3 GW goal in jan. 2000)
- ⇒ Easier to achieve than with only competitive calls for tenders and/or green certificates (not excluded for  $P > 12$  MW)
- ⇒ Attention to be given to projects planning, grid connection, public acceptance, “popular involvement” in wind projects

## □ $P > 12$ MW: future calls for tenders from CRE

## □ Over-cost estimation for a 9 GW goal:

- ⇒ Charged over all electricity consumers (contribution to a specific fund for all electricity public services charges)
- ⇒ For 9 GW in 1/1/2010 (total 2001-2025: 325 TWh)
  - Total < 5 bEUR (discount rate: 5%, avoided cost 4,1 cEURO/kWh)
  - Maximum in 2017: < 1cF/kWh (<0.15 cEURO/kWh)

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# Adapting the French Wind Power Tariff System

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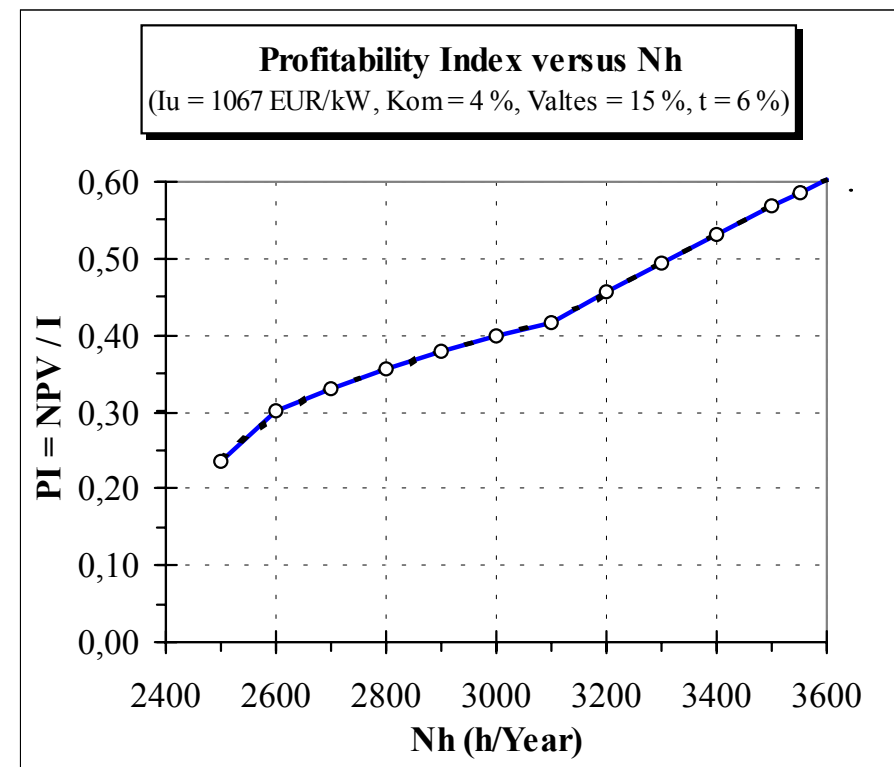
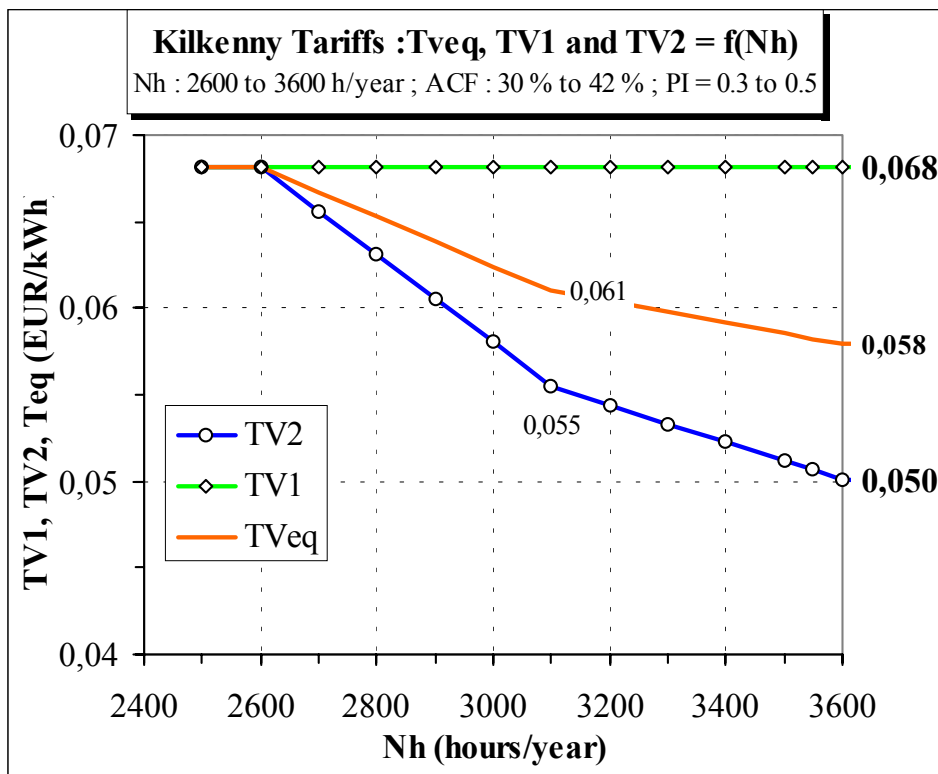
## ❑ **Some Improvements are possible:**

- ⇒ Replace the energy yield ratio  $Nh$  (kWh/kW.year) by  $Eas$  (kWh/m<sup>2</sup>.year)
  - ➔ See the rationale in the Chabot-Kellet-Saulnier paper at Global Wind Power Conference, Paris, April 2002
  - ➔ Gives less "temptations" to "manipulate" the P/S ratio of the wind turbines
- ⇒ Avoid the sharp step from "favourable conditions before 1,5 GW of contracts" to "less favourable ones after 1,5 GW"
- ⇒ Get a better protection of the tariff within a contract from the effect of inflation (eg 80% of the tariff protected instead of only 60 % in France or 0 % in Germany)

## ❑ **Case studies in the case of an "European Windy Country": Ireland**

# First case study: the “Kilkenny 2001 Tariffs” test

- ❑ Based on 15 years contracts and rather high PI values
- ❑ Based on a  $Nh$  energy yield from 2600 to 3600 hours/year (7.5 to 9 m/s at hub height)
- ❑ Tariffs rather high but lower than in France (obvious!)



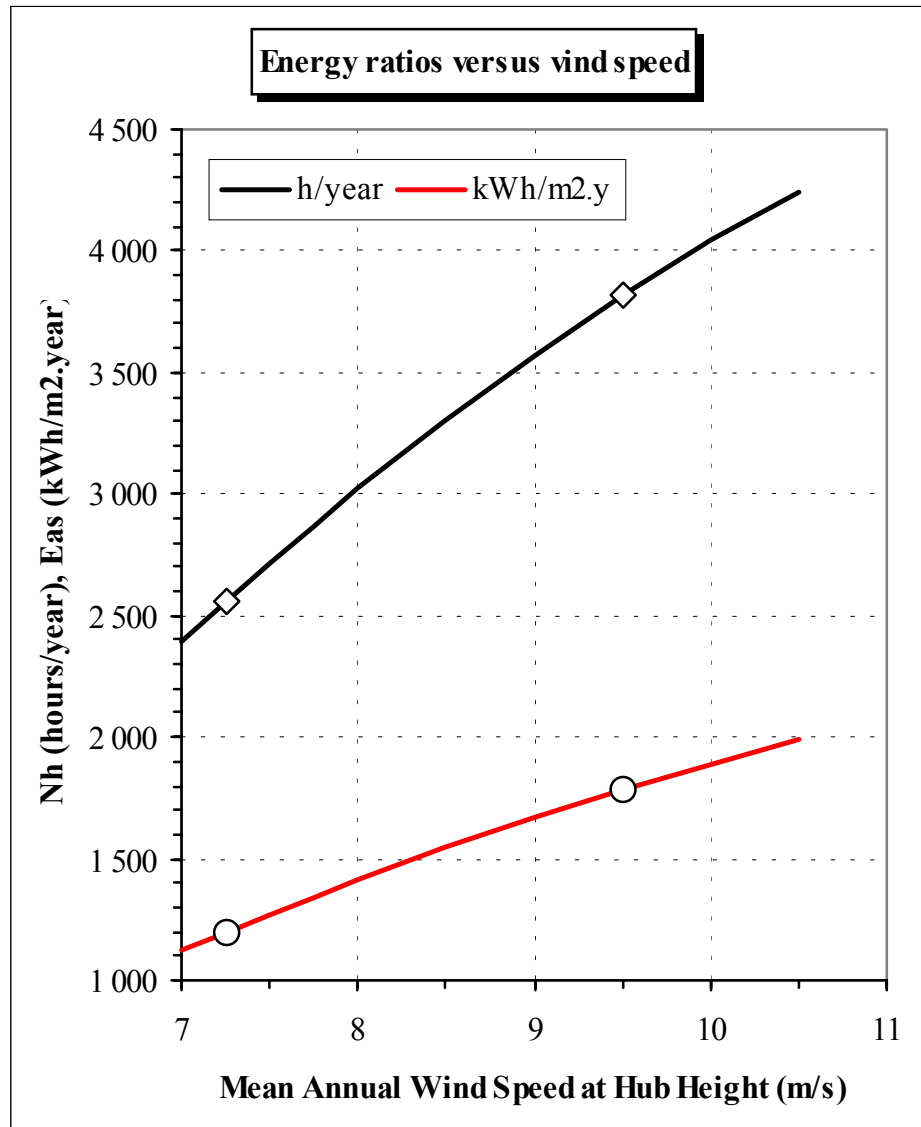
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# Introducing the "Kinsale 2002 Tariffs" test

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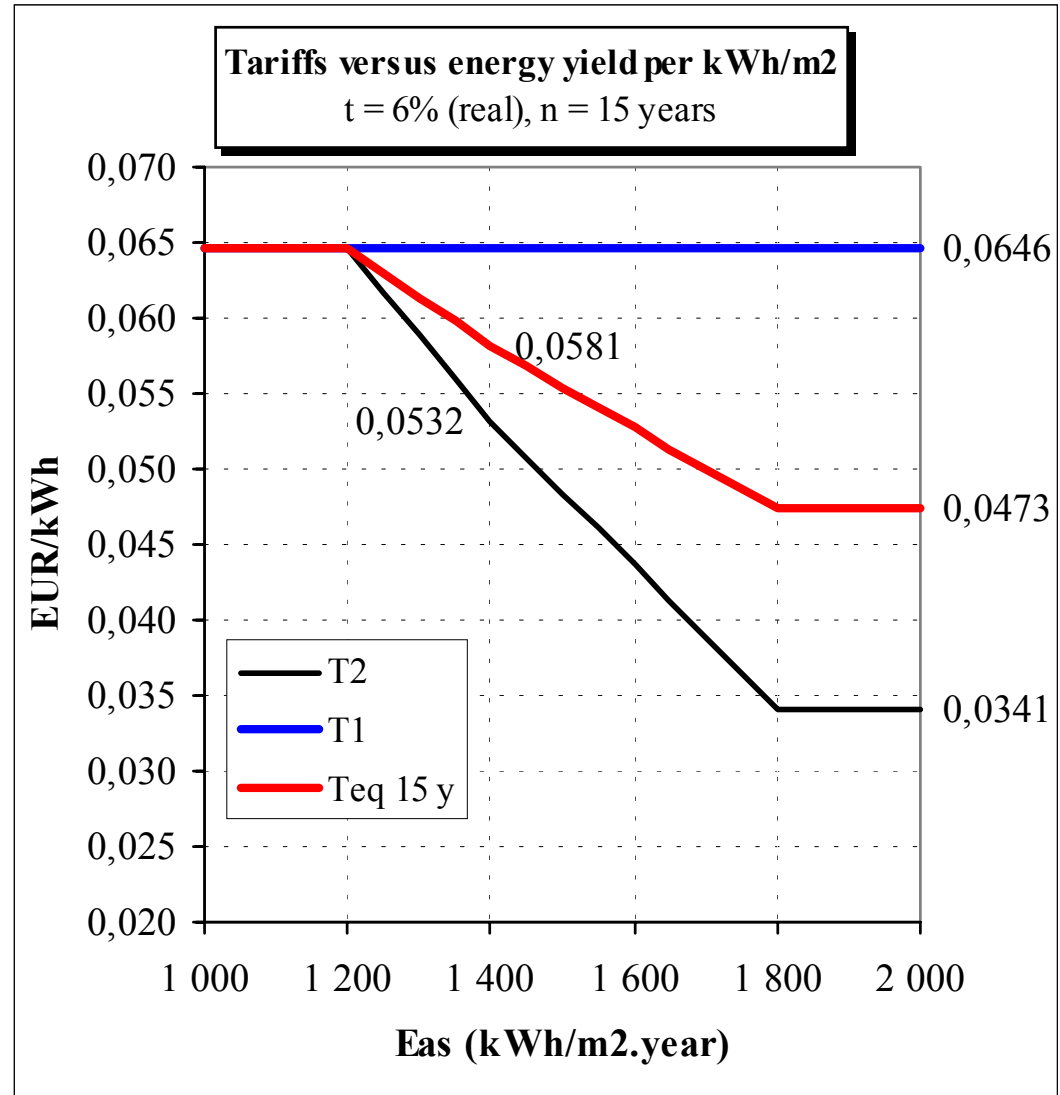
- ❑ **Not "The solution", only an illustration of the method**
- ❑ **Based on the *Eas* energy yield (kWh/m<sup>2</sup>.year)**
  - ⇒ *Eas min* = 1200 kWh/m<sup>2</sup>.y (around 7.3 m/s at hub height, equivalent to *Nh* = 2600 h/y for a 460 W/m<sup>2</sup> wind turbine, or equivalent to an average annual capacity factor *ACF* = 30 %)
  - ⇒ *Eas max* = 1800 kWh/m<sup>2</sup>.y (around 9.5 m/s at hub height, equivalent to *Nh* = 3600 h/y or *ACF* = 41 %)
  - ⇒ An intermediate *Eas* = 1400 kWh/m<sup>2</sup>.year (*Nh* = 3000 h/y)
- ❑ **Calculation based on:**
  - ⇒ Real averaged weighted cost of capital = discount rate *t* = 6 %
  - ⇒ Purchase contracts on *n1* = 15 years or *n2* = 20 years
  - ⇒ Investment cost ratio: *Ius* = 468 EUR/m<sup>2</sup> of swept area (*Iup* = 1000 EUR/kW for a WT with *Ps* = 468 W/m<sup>2</sup>)
  - ⇒ O&M expenses ratio: *Kom* = 4 % of investment, per year

# Example of energy yields versus wind speed



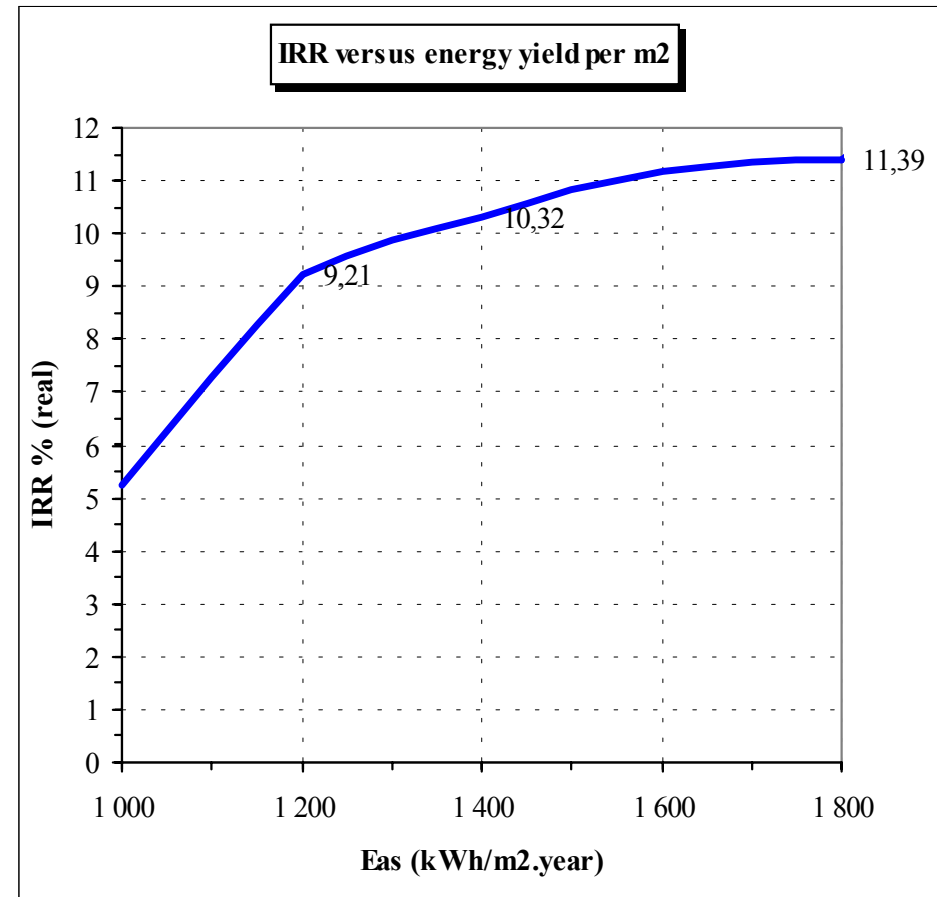
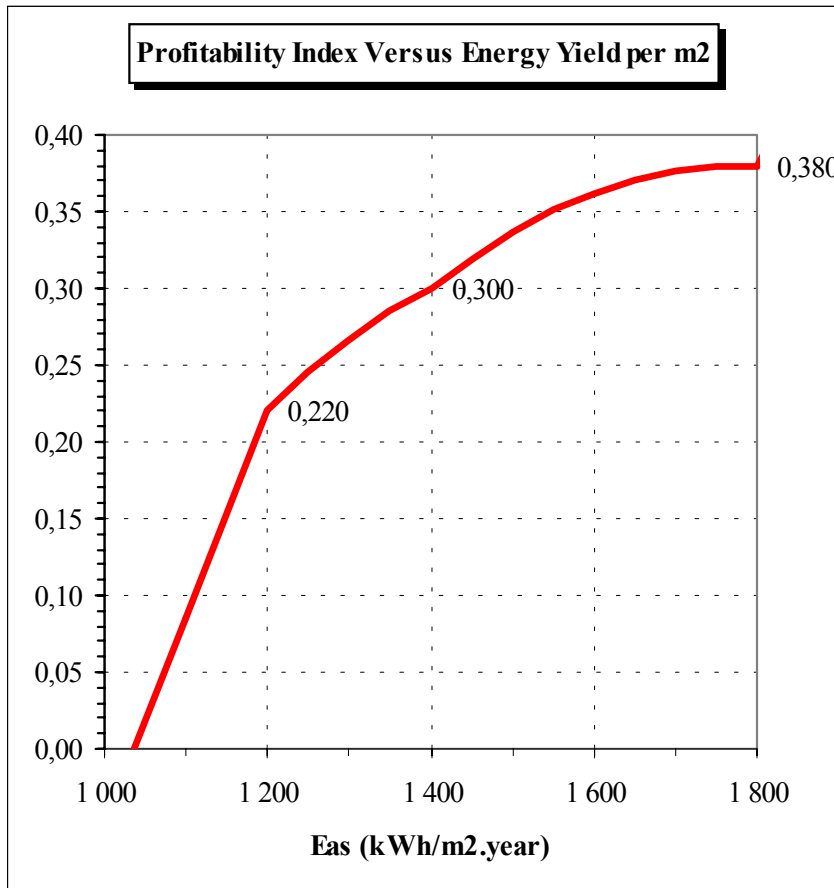
# Results for purchase contracts on 15 years

- ❑ **T1 from year 1 to 5**
- ❑ **T2 from year 6 to 15**
- ❑ **Teq calculated from**
  - ⇒ T1,
  - ⇒ T2
  - ⇒ t (AWCC, different for each investor, here  $t = 6\%$ )
- ❑ **For  $E_{as} < \text{or} = 1200$ :  
T1=T2=Teq**

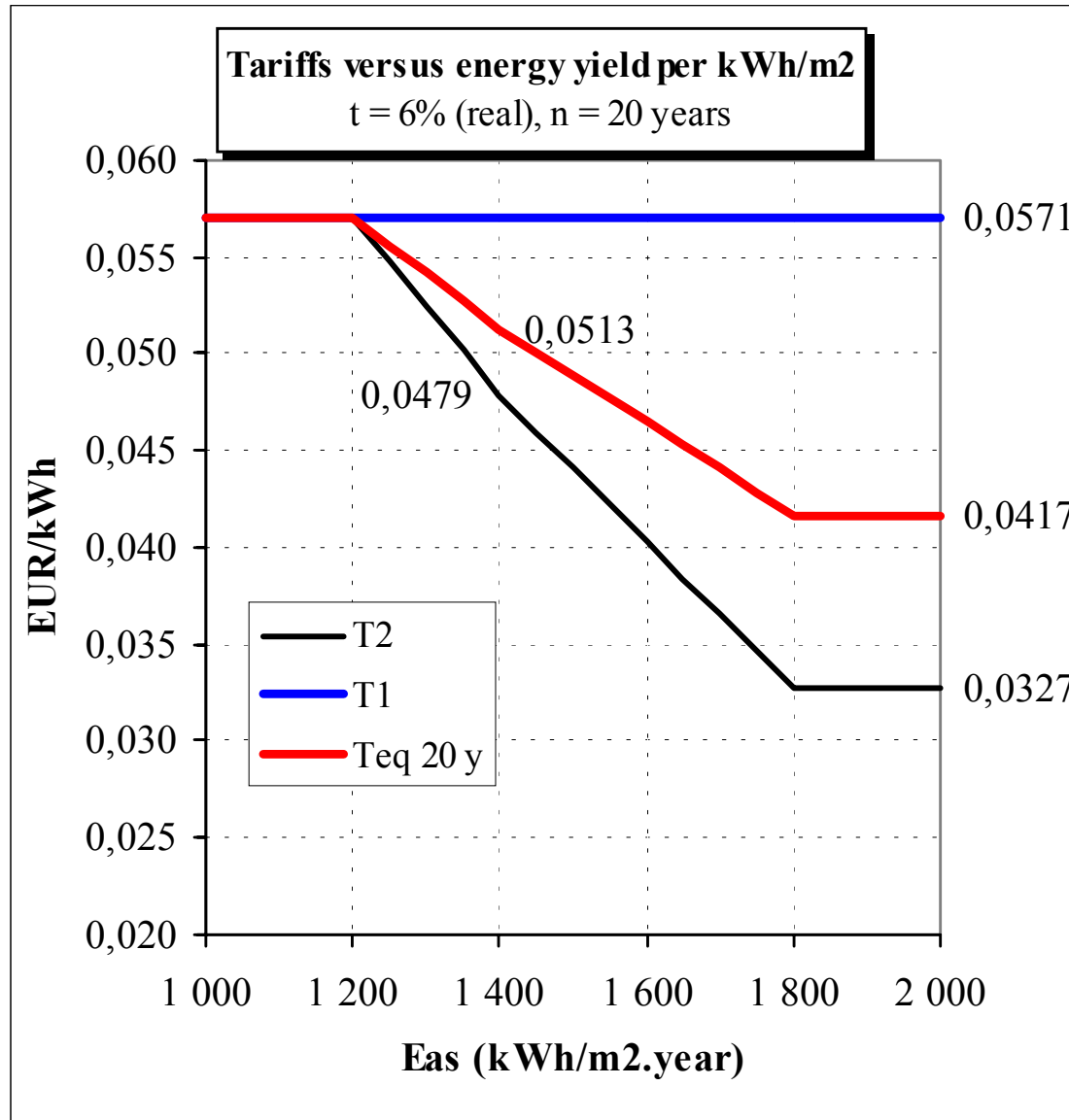


# Profitability results for 15 years contracts

- ❑ Profitability increases with Eas (to lower over-costs)
- ❑ PI from 0.22 to 0.38 ; IRR from 9.2% to 11.4 %

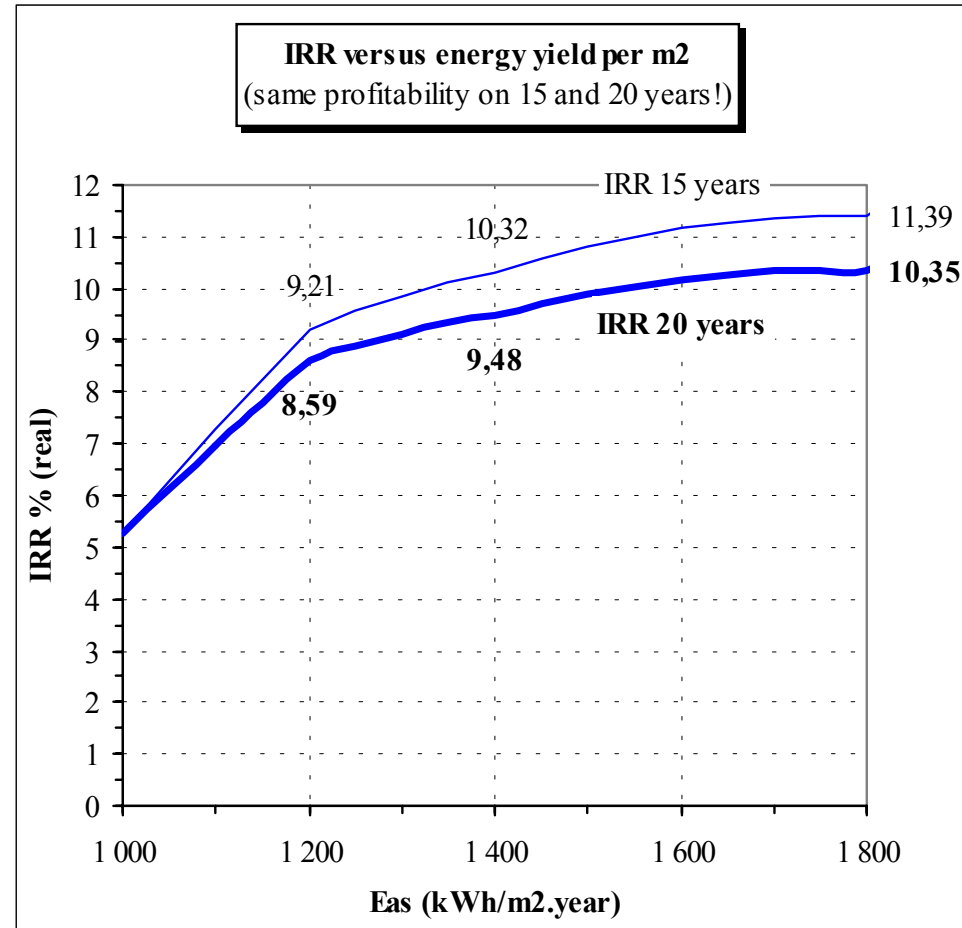
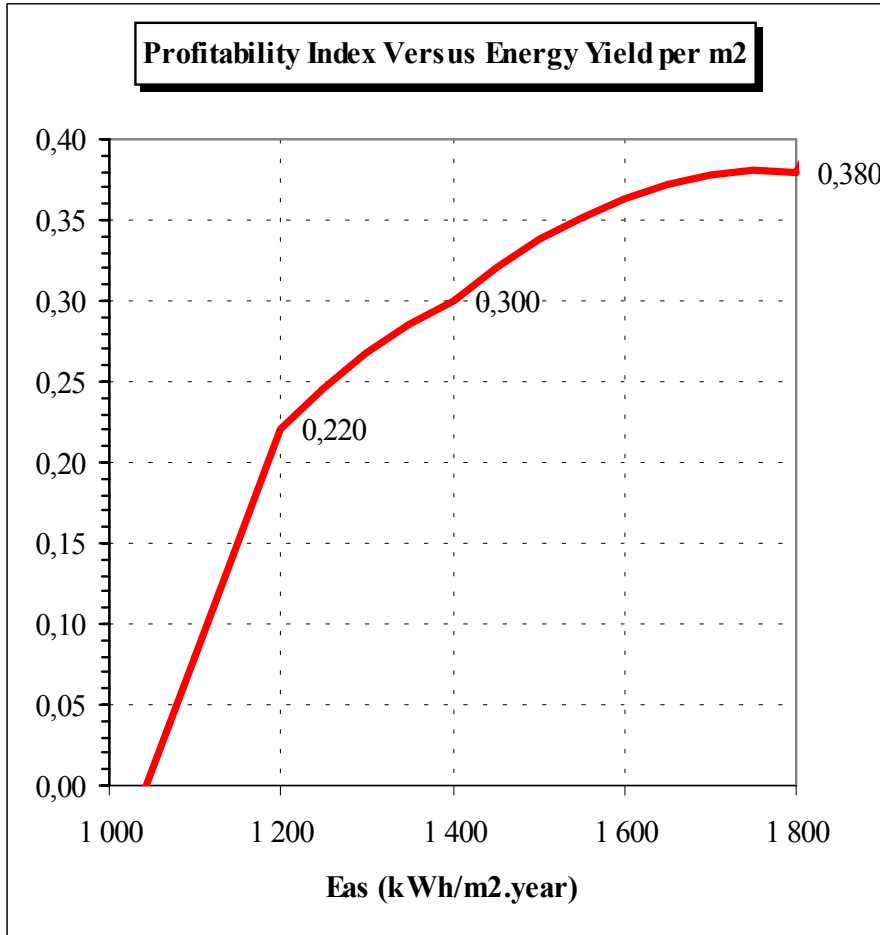


# Results for purchase contracts on 20 years

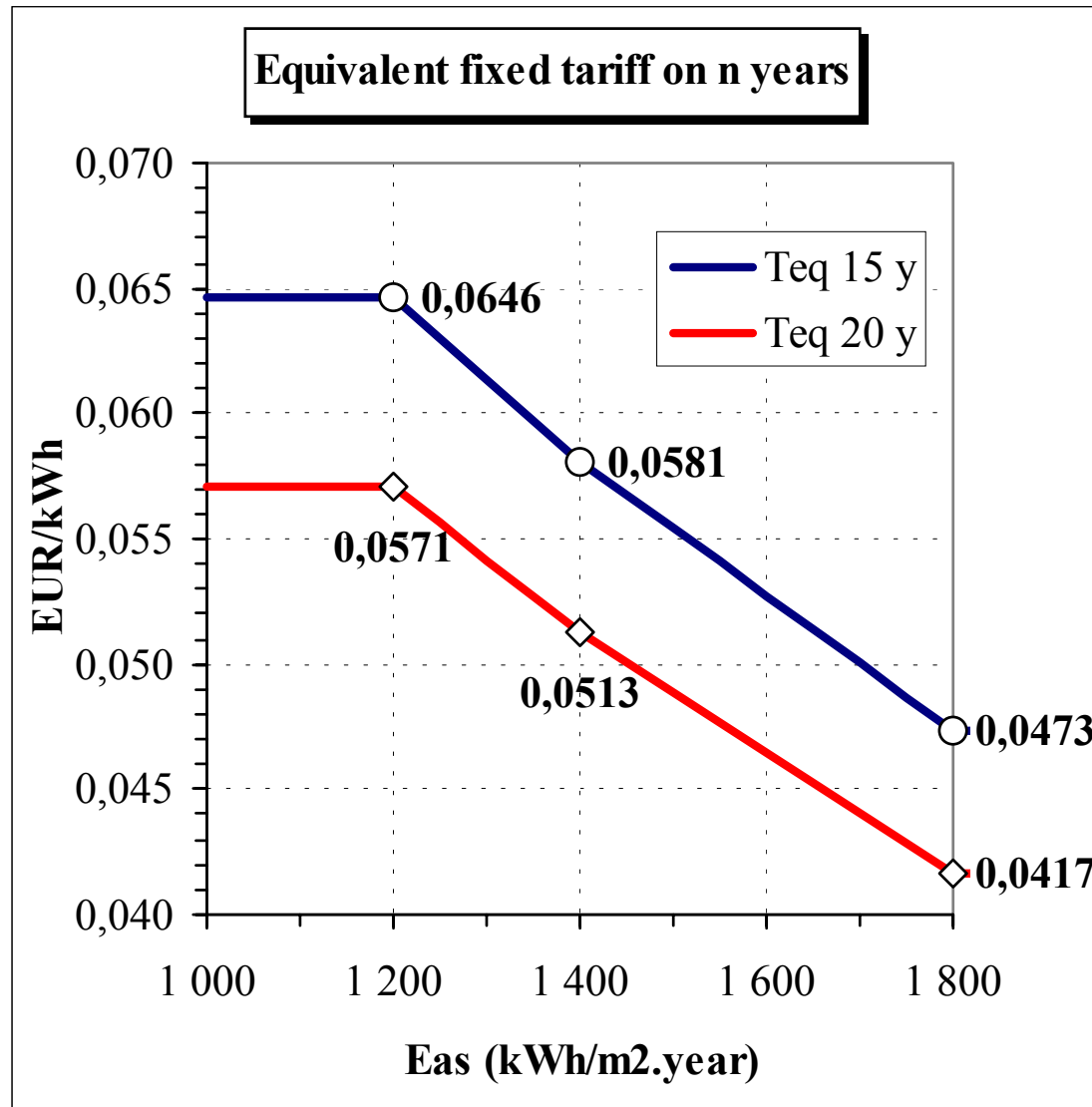


# Profitability results for 20 years contracts

❑ Same hypothesis for PI values ==> same profitability



# Comparison of tariffs on 15 or on 20 years



# Synthesis of numerical values

- ❑ Values are for  $I_u = 1000 \text{ EUR/kW}$ ,  $t = 6 \%$ ,  $Kom 4\%$
- ❑ To be tested with precise Irish data ( $t$ ,  $I_u$ ,  $Kom$  values) !

Reference energy yield				Tariffs for contracts on 15 years (cEUR/kWh)				
V	Eas	Nh	Fc	T1	T2	<i>Teq</i>	PI	IRR
m/s	kWh/m <sup>2</sup> .y	h/year	%	cEUR	cEUR	cEUR		%
app 7,3	<b>1200</b>	2600	30%	<b>6,46</b>	6,46	6,46	0,22	9,2
app 8	<b>1400</b>	3000	34%	6,46	<b>5,32</b>	5,81	0,3	10,3
app 9,5	<b>1800</b>	3600	41%	6,46	<b>3,41</b>	4,73	0,38	11,4

Reference energy yield		Tariffs for contracts on 20 years (cEUR/kWh)				
	Eas	T1	T2	<i>Teq</i>	PI	IRR
	kWh/m <sup>2</sup> .y	cEUR	cEUR	cEUR		%
	<b>1200</b>	<b>5,71</b>	5,71	5,71	0,22	8,6
	<b>1400</b>	5,71	<b>4,79</b>	5,13	0,3	9,5
	<b>1800</b>	5,71	<b>3,27</b>	4,17	0,38	10,4

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# Conclusions

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## ❑ **Defining a fair and efficient tariff system is possible**

- ⇒ Taking into account other “success stories” (Dk, G, Sp, F...)
- ⇒ Within a deregulated electricity market ("advanced tariffs")

## ❑ **The Profitability Index Method gives:**

- ⇒ A rational basis for minimum values of profitability
- ⇒ Simple formulas to define, monitor, adapt the tariff system

## ❑ **Positive market answer in France after 2001 wind tariffs**

- ⇒ 20 GW of files ( $P < 12$  MW), 7 to 10 to be built before 2010
- ⇒ Over-cost should not be over the ones from 7 to 10 GW by other ways (including stranded cost from less secure systems)

## ❑ **Light case study for the Irish wind context shows that:**

- ⇒ Adaptation of advanced tariffs systems is easy
- ⇒ Due to good winds, tariffs should be lower than in Ger. & Fr.