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INTERNATIONAL DEVELOPMENT ASSOCIATION
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ESMAP

The Art of Advanced Renewable Tariffs Systems (ARTs) Design: Some Lessons from Past and Ongoing Experiences

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ANNEXES

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Market regulations in favour of RES: focus on FITs (ARTs)

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

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

- **FITs and "Advanced FITS" (ARTs) are more efficient**
- **Subsidies and fiscal incentives: only for initial programme phases**
- **Soft loans: very interesting because of high investment cost and development banks interest and involvement**
- **Calls for tenders: very often poor results (UK, F…), unless to create national RE industry before implementing FITs (China…)**
- **Quotas + green certificates: poor results, shift to FITs (UK, Italy)**

Main FITs parameters: example of FITs grading

Example: **WFC, "Grading North American Feed-in Tariffs", Paul Gipe, May 2010**

The Gold Standard Report Card	France	Germany	Spain Fixed Payment
Program caps	10	10	10
Project size caps	8	10	8
Contract terms (years)	10	10	10
Technologies included: Wind, Solar PV, Hydro, Biogas, Biomass	10	10	10
Tariffs based on cost of generation	10	10	10
Tariffs differentiated by technology	10	10	10
Tariffs differentiated within each technology (granularity)	16	20	16
Tariffs differentiated by resource intensity for wind energy	10	10	0
Inflation indexing	6	0	6
Bonus points for programs with multiple tracks (US) or community power adders			
Total	90	90	80
	A	A	A-

➔ **See also Feed Laws and FITs data base by Paul Gipe at: www.wind-works.org**

Defining a targeted fair and sufficiently attractive profitability for investors from FITs

Fairness and efficiency (1): general framework

- **Short, medium and long term sustainable energy scenario based on energy sufficiency, energy efficiency, renewables**
- **Fair competition between renewables and fossil fuels:**
  - ⇨ Taking into account long term energy security and externalities
  - ⇨ Full LCOE assessment, not only marginal short term fuel cost
- **Defining an RE-IPP status and relevant conditions:**
  - ⇨ Grid access, transparent and fair projects authorization
- **Lowering risks for IPPs, equity and debt providers**
  - ⇨ "TLC" (Transparency, Long term, Certainty) for FITs systems
  - ⇨ Mandatory purchase of all RE-based kWh during PPAs
  - ⇨ Fair, sufficiently attractive, but not undue profitability
  - ⇨ Differentiation between FITs: scale, type, quality of resource
- **Over-cost compensation mechanism**
  - ⇨ Not from national state budget
  - ⇨ From all electricity consumers and international finance (CO_2)

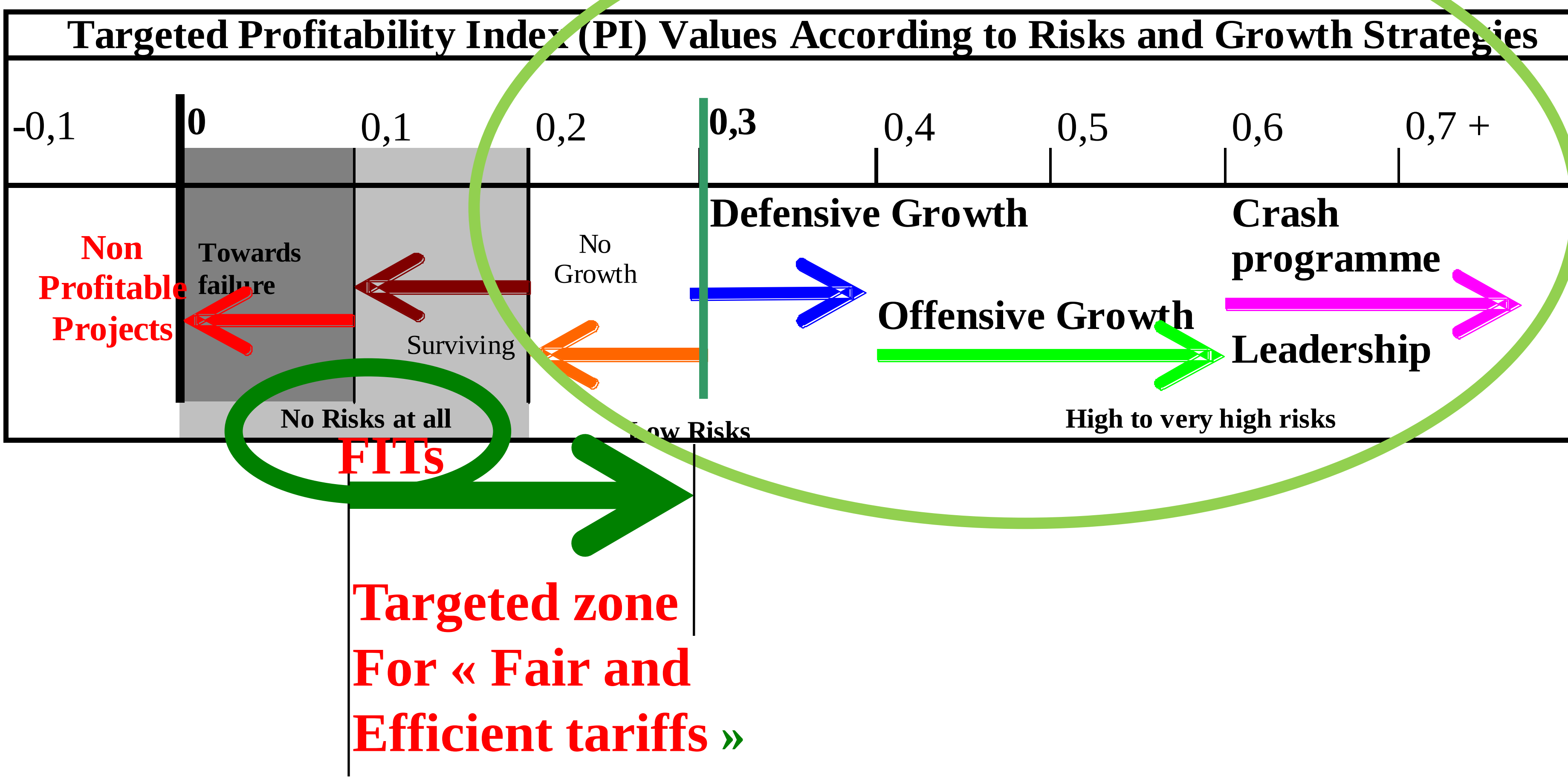
Fairness and efficiency (2): which profitability level ?

- **FITs must be based on the value of renewables**
- **➔They must be based on "cost + <u>fair profit</u>"**
  - ⇨And not on "avoided costs", or on a "market referent" based on present low cost fossil fuels based kWh costs
- **Measuring "Fair profit" only by IRR is dangerous**
  - ⇨Profitability results not from IRR but from the difference between IRR and investor's cost of capital ("WACC")
- **Fine tuning more reliable from the project net present value (NPV) per $ invested : PI = NPV / I** ***(PI = Benefit to Cost Ratio - 1)***
  - ⇨<u>For zero risk projects</u>: no fuel costs, mandatory purchase, **<u>FITs</u>**
  - ⇨From success stories and failures: **<u>0.1 < PI (= NPV / I) < 0.3</u>**
    - **PI < 0.1: not sufficiently attractive FITs, not sufficiently GWs/year and insufficient additional tens of TWh/year from investors**
    - **PI > 0.3: undue profitability and large over-costs leading to market overheating and at the end to "stops & go"**

Profitability Target Choice for FITs

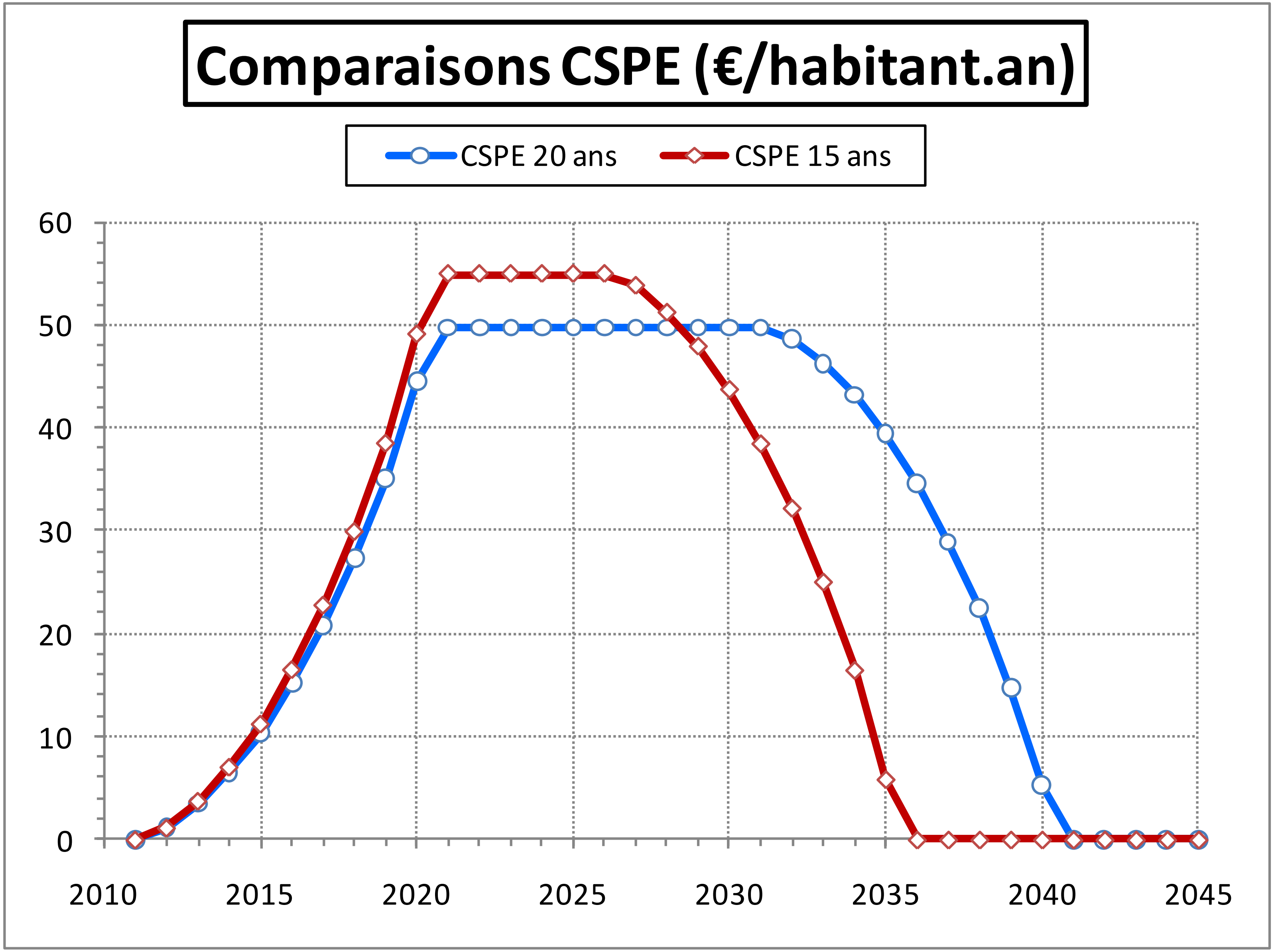
Using the "Universal Profitability Index Scale":

Fast and stable Growth of Manufacturing Industry on free markets



Choice of PPA duration n: impact on overcost

(€/people.year, 2011 PV FIT assessment for an IRENA Member State)



Fairness and Efficiency (3): differentiated tariffs

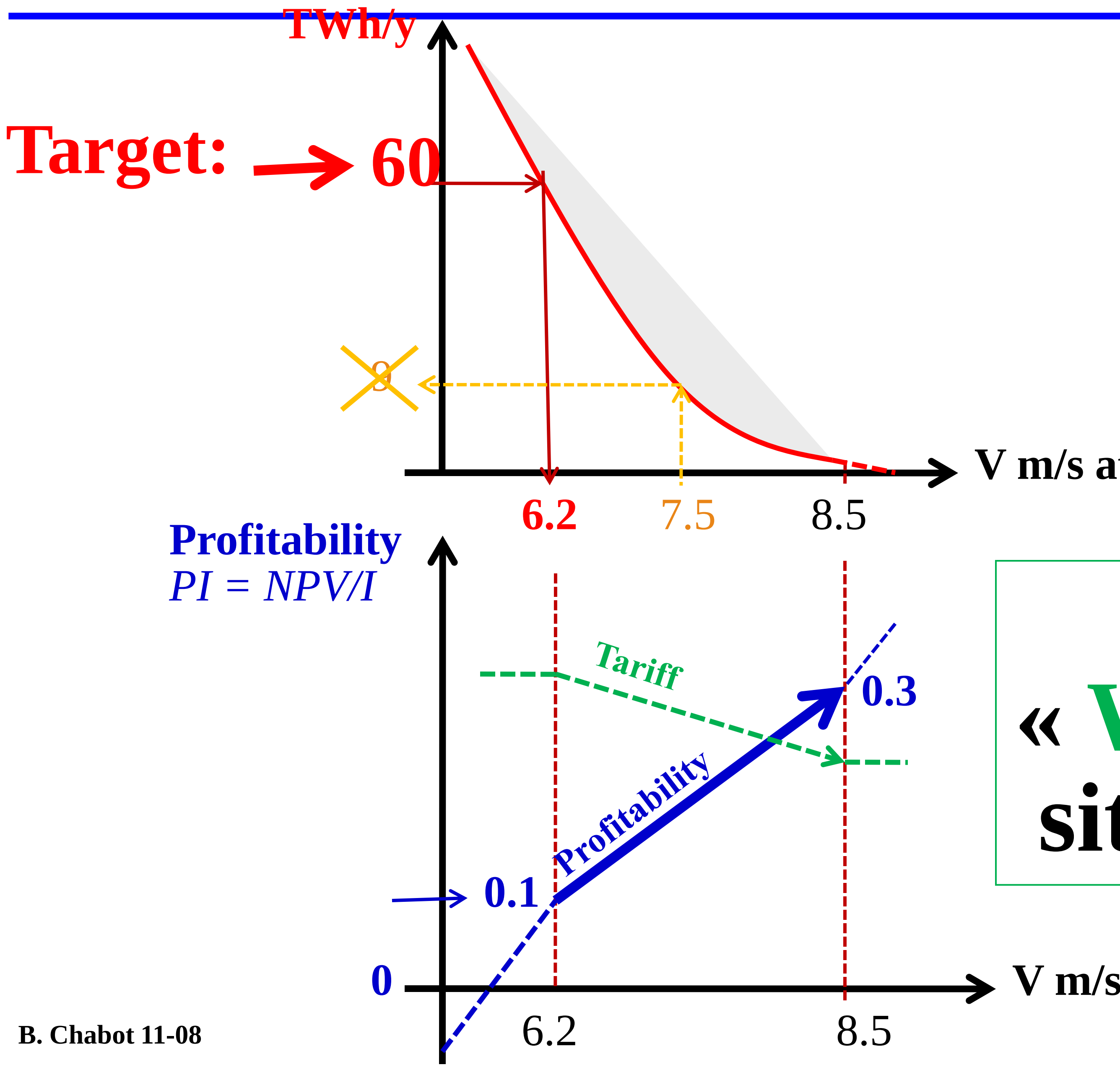
- **Efficiency requires to deliver**
  - ⇨ Increasing TWhs/year and % of electricity demand from RES-E
  - ⇨ In order to decrease the part of non sustainable technologies
- **Medium (10 years) and long term (20 to 30 years) targets and scenarios must be defined and optimized**
  - ⇨ TWh/year, % of electricity demand
  - ⇨ Over-costs and benefits by blending
    - Low kWh cost RES-E technologies (onshore wind, hydropower)
    - Base load RES-E (geothermal power)
    - Dispatchable RES-E technologies: simple power plants and CHP systems using biomass and biogas with resource storage
    - Emerging RES-E technologies (PV, offshore wind)
- **Optimization requires differentiated FITs by technologies, size, application (e. g. BIPV), <u>quality of sites</u>.**

"Advanced Renewable Tariffs": RE FITs adapted to different sites with different potential energy yield: * Wind (1) * Solar PV (2)

Fairness and Efficiency (4): differentiated FITs

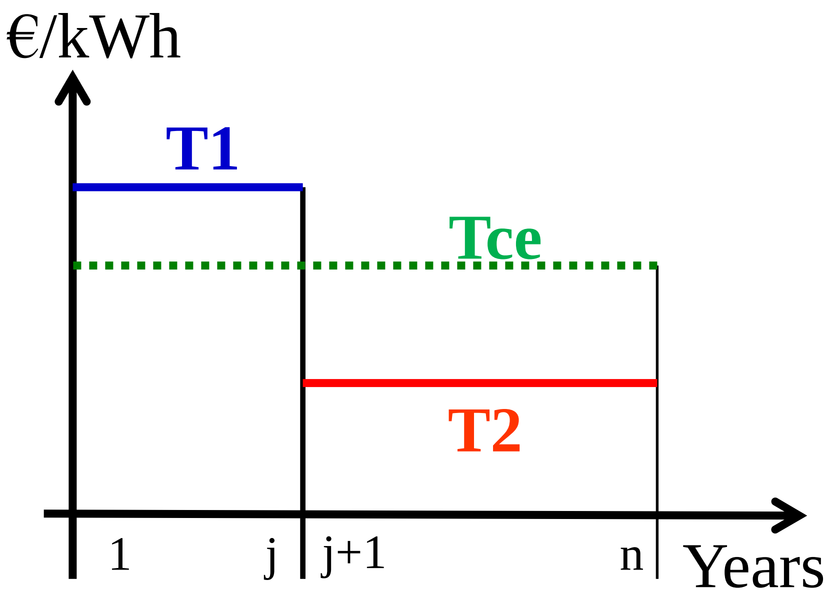
- **Creating a "Win-Win situation" (wind, PV)**
  - ⇨ For investors: minimum profitability on lower quality sites, increasing profitability on higher quality sites
  - ⇨ For electricity consumers: FIT and over-costs decreasing on higher quality sites, not undue profitability on those sites
- **Introduced in 2000 with a huge success by Germany for wind power, then France and Portugal**
- **Detailed proposals for wind: Ontario (not implemented), Pakistan (decision pending)**
- **Also possible and of high value for solar PV**
  - ⇨ Case studies in 2009 for 5 European countries
  - ⇨ Detailed case study and proposal for California in 2010
  - ⇨ In both cases, more simple for PV than for wind !
- **➔ Innovation is also possible for the design of simple, reliable, fair and efficient FITs !**

ARTs : Advanced Wind Tariffs Principle



A
« Win-Win
situation »

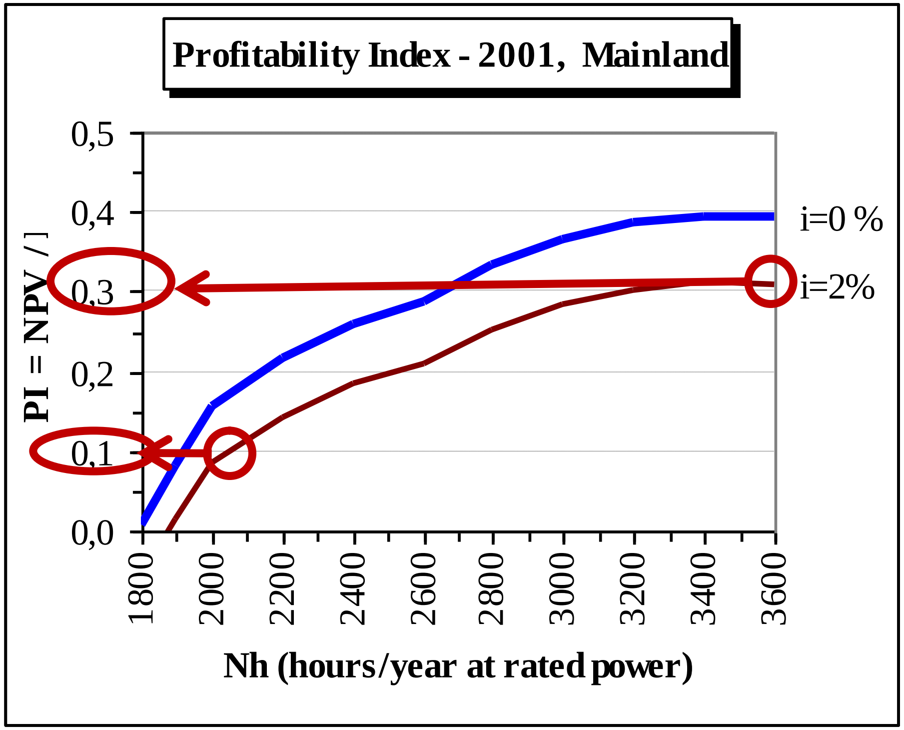
Wind FITs differentiation: example of Germany and France

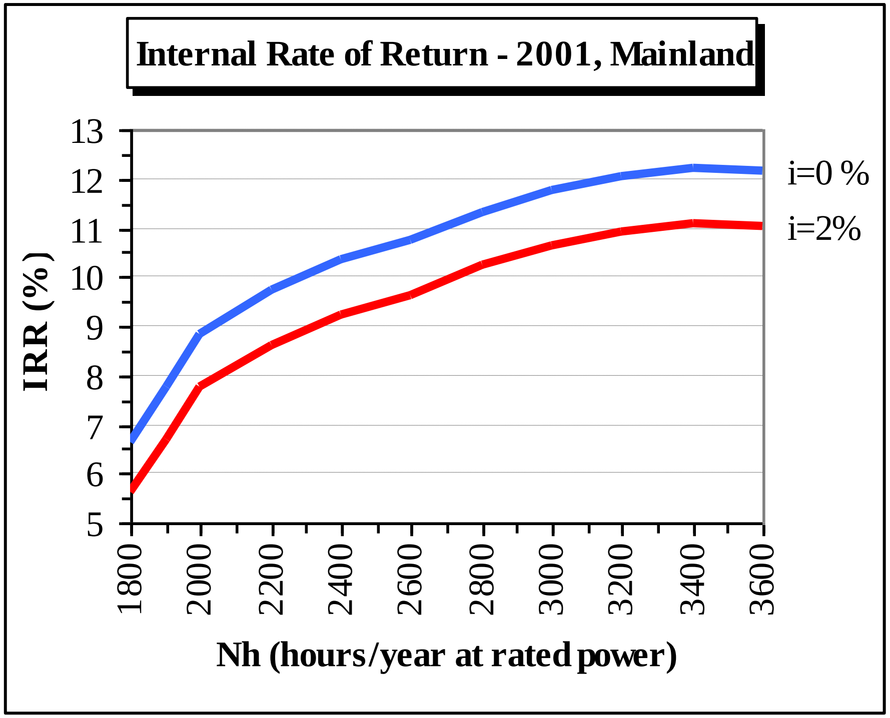


	Germany	France
T1	Fixed	Fixed
T2	Fixed	Variable
Tce	Variable	Variable
j	Variable 5 to 20 years	5 years (till 2005) 10 years (> 2005)
n	20 years	15 years

- **Tce = constant equivalent tariff resulting from T1 and T2**
- **Simple to design and to implement (Germany: 2000; France: 2001)**
- **Tce is much more lower on high quality sites than T1**
- **Simple for (automatic) management and for monitoring**
- **Efficient:**
  - ⇨ End of 2011: Germany 22.3 GW; France: 6.6 GW
  - ⇨ Smooth and rational repartition on all the windy regions, not only on the most ones which are frequently high environmentaly sensitive

Reference profitability : example of French 2001 wind tariffs





❑ Results:

⇨Reliable system, still in use (minor changes in 2006)

⇨Could be improved by switching from capacity factor to Eas (kWh/m2.year) to favor high capacity factors wind turbines

⇨Target in the French NREAP: 19 GW onshore in 2020

Example 1:
2009 Wind Pakistan Tariff proposal from the 3 days UNDP-AEDB workshop

(TA for UNDP Wind Project Pakistan)

Wind Power ART for Pakistan: targeted PI

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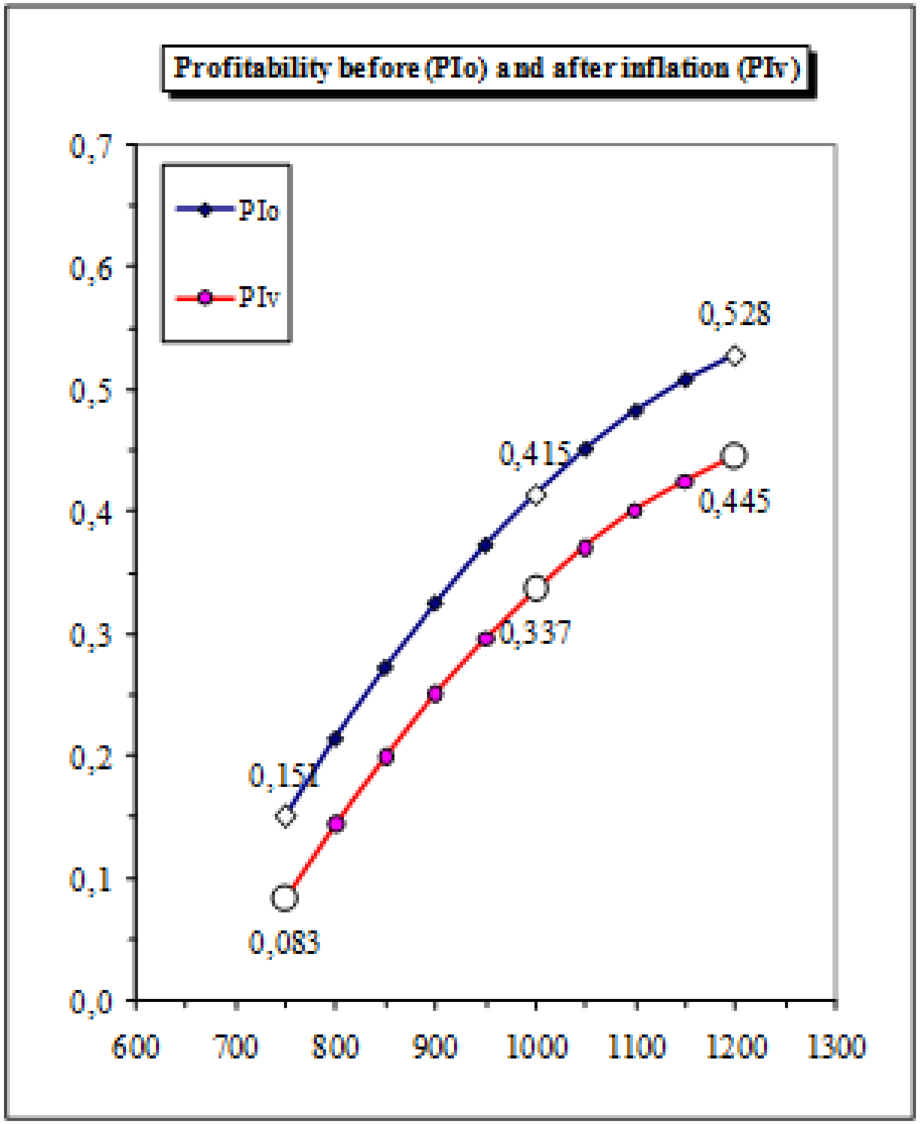
Profitability Index (= NPV / I) of wind projects versus Eas (kWh/m2.year) without and with inflation (5%/y.)

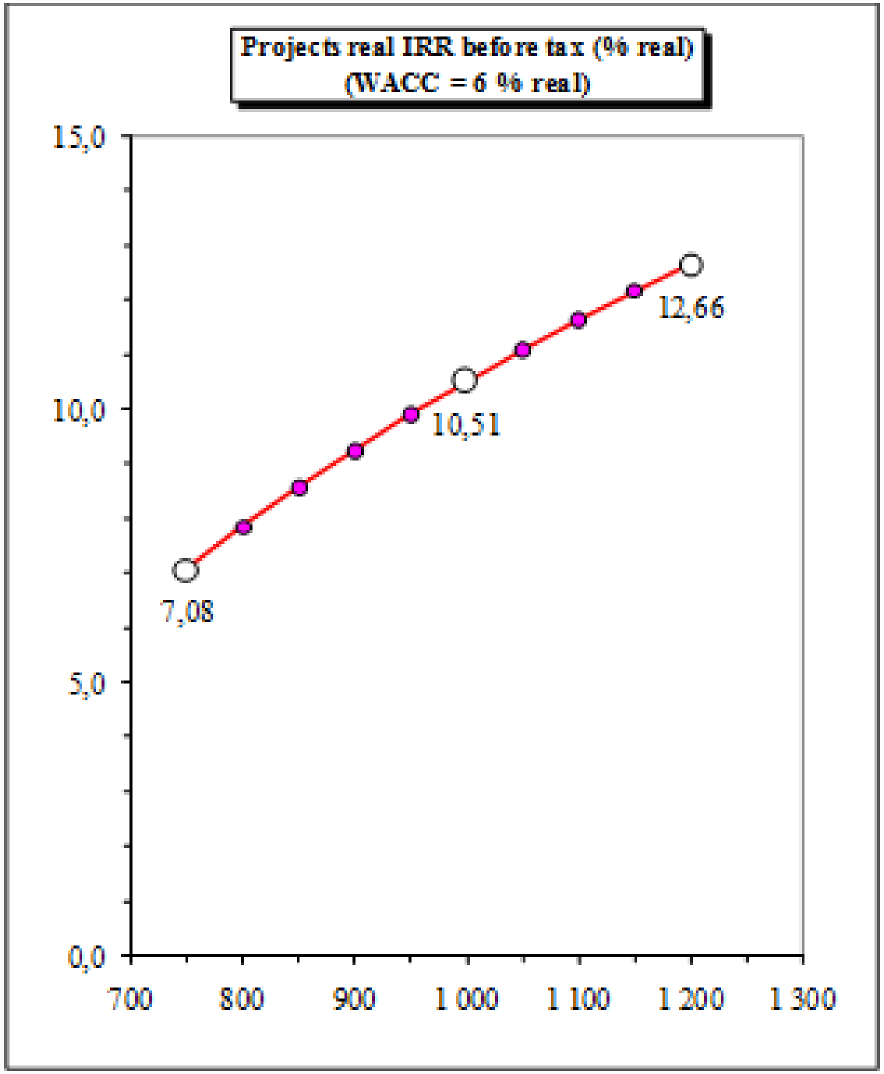


Source: B. Chabot on 2009/2

Wind Power ART for Pakistan: corresponding real IRR

-

Project real IRR before tax versus Eas (kWh/m2.year)



Source: B. Chabot on 2009/2

Wind Power ART for Pakistan

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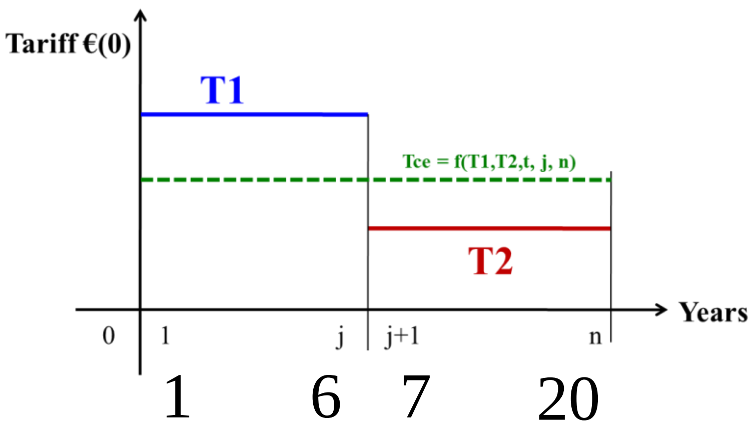
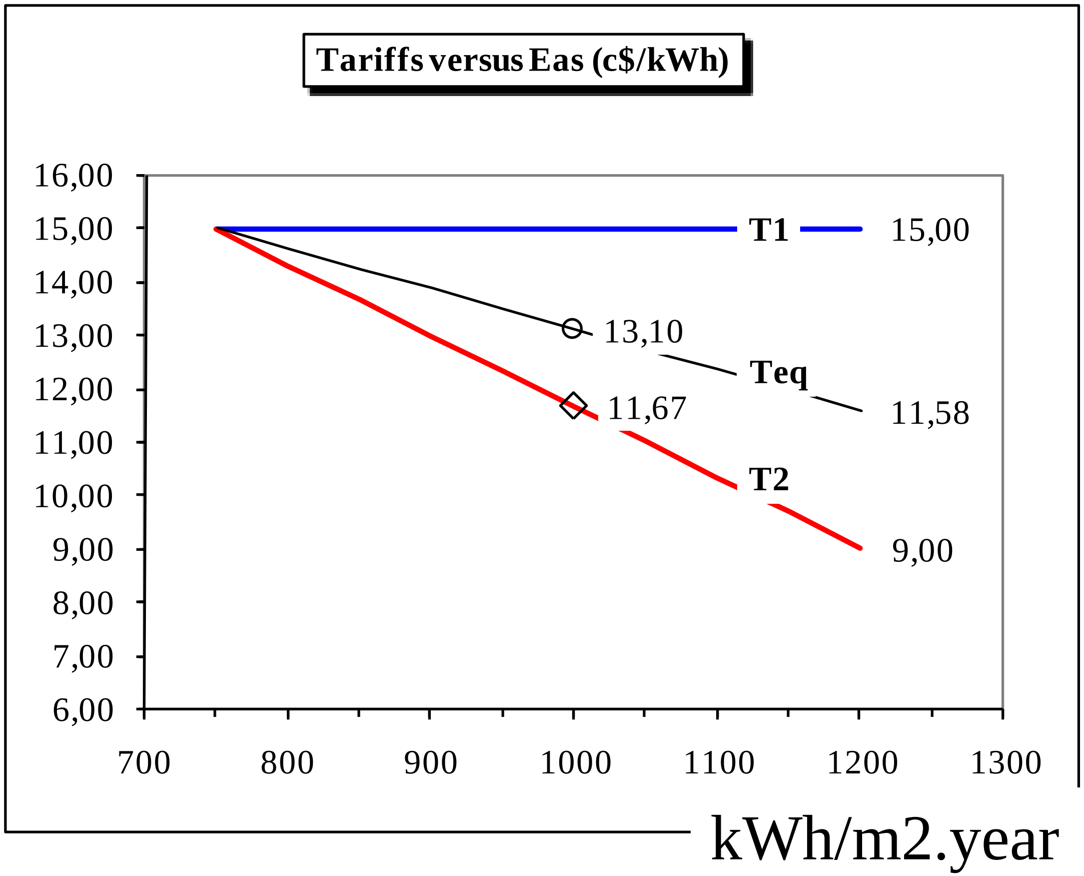
Tariffs T1 (on 6 years) and T2 (years 7 to 20) and equivalent constant tariff Teq versus Eas (kWh/m2.year)





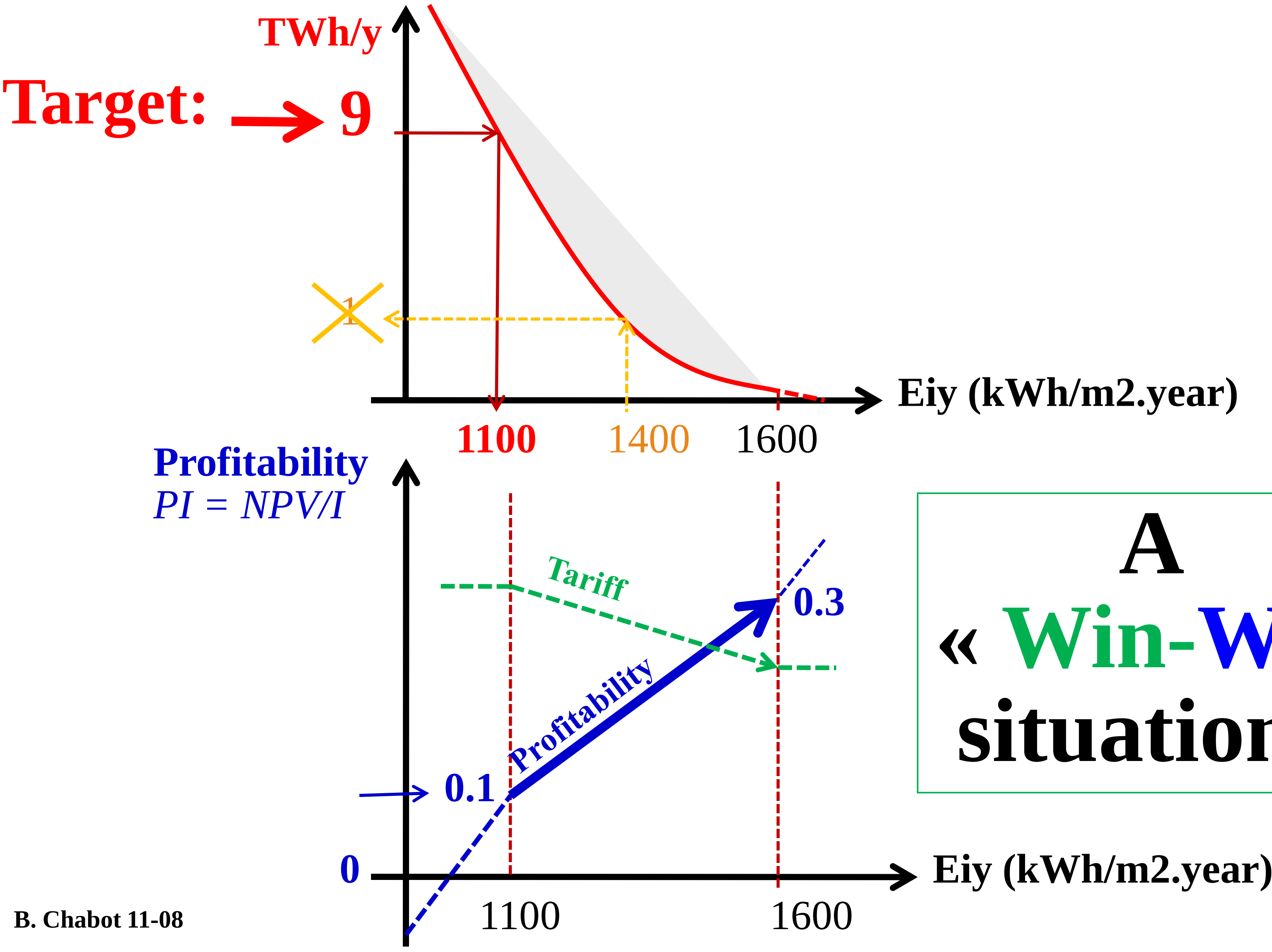
Source: B. Chabot on 2009/2, UNDP-AEDB Workshop and report

Example 2:
Universal Smart PV FIT
(USPV FIT model)

Challenges for an USPV FIT model

- **"Keep it simple" !**
  - For its design and implementation
  - For understanding and use:
    - By electricity market regulators, decision makers
    - By grid operators and/or utilities purchasing and paying the PV kWh
    - By project developers, investors and owners
- **"TLC compatible" (Transparency, Longevity, Certainty)**
  - As explained in the 12/2009 Deutsche Bank Group report "Paying for RE: TLC at the right price"
- **Flexible**
  - Must cover very different cases for :
    - **Solar irradiance range** between Eiymin and Eiymax (kWh/m2.year)
    - **Investment cost ratio**: from small domestic PV roofs to large PV plants
  - Must be implemented in different contexts and countyries

ARTs : Advanced USPV Tariffs Principle

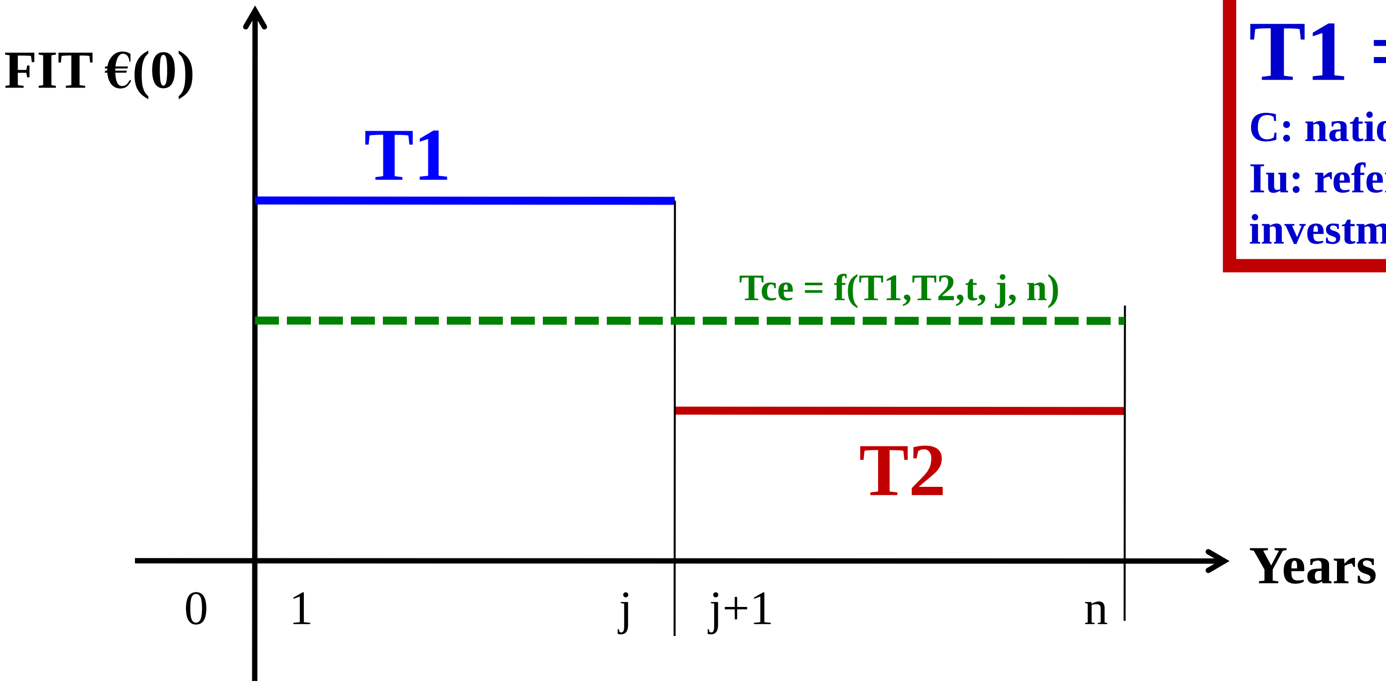


A « Win-Win situation »

Suggested design of an USPV tariff system

"Universal Smart PV FIT system"

- Inspired from the German EEG 2000 wind tariff system, but much more simple for PV
- T1 on years 1 to j and T2 from year j+1 to year n: constant values for all projects in the tariff system for a specific PV application (residential, or commercial or PV plants…)
- 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: from national solar GIS (PVGIS or PVWATTs) for Eiy (kWh/m2 in the optimal plane of modules, without any shadow) and performance ratio PR = 0.75
- Case studies EPIA 2009: France, Germany, Italy and Spain, Turkey.
- Case study 2010: USA: California



T1 = C * Iu

C: national constant
Iu: reference investment ratio

Basic principles to design a USPV FIT

❑ **The fundamental advantage of the USPVFIT model:**

$$T1 = C * Iu$$

$/kWh $/kWp dc at STC

With C= {(1 + PImin) * CRF(t,20) + Kom} / (PR*Eiymin)

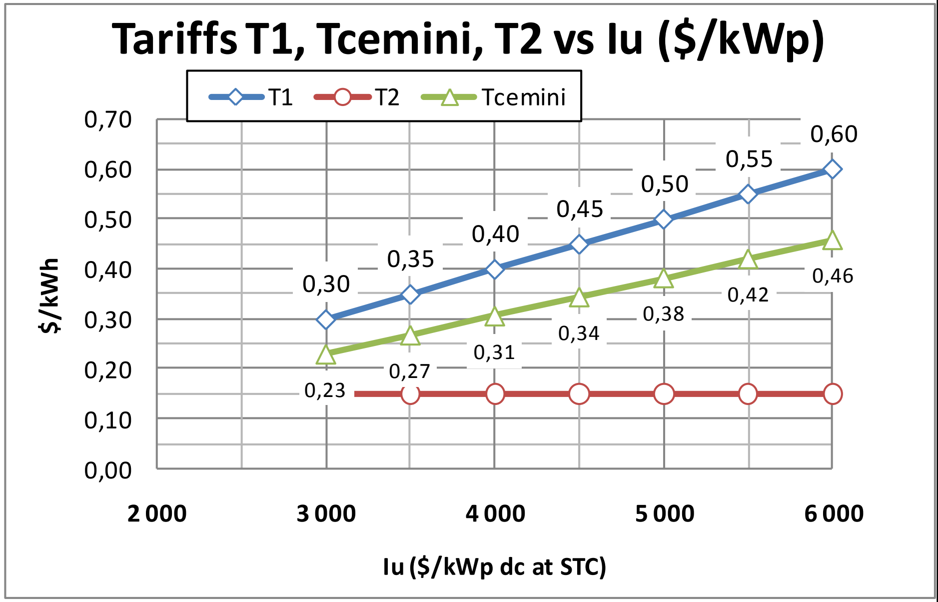
C = "State economic solar constant"

2010 case study: California domestic PV, wo PTC

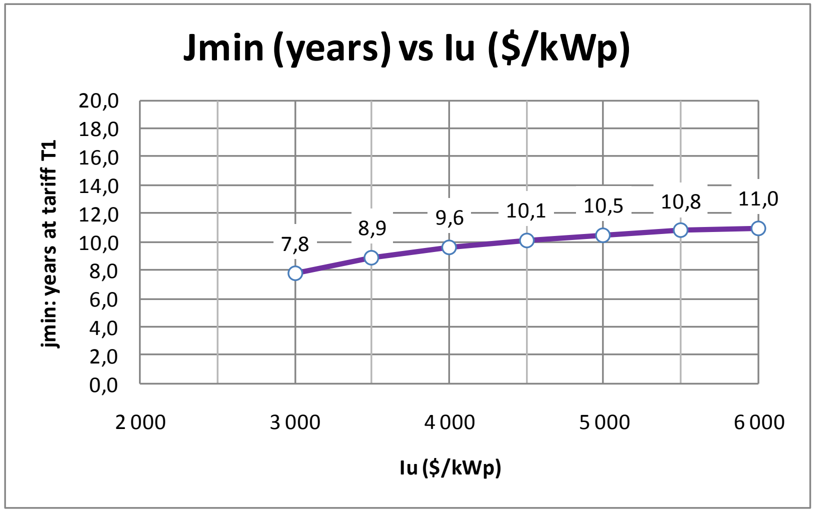
❑ Results: tariffs T1, T2, Tcem

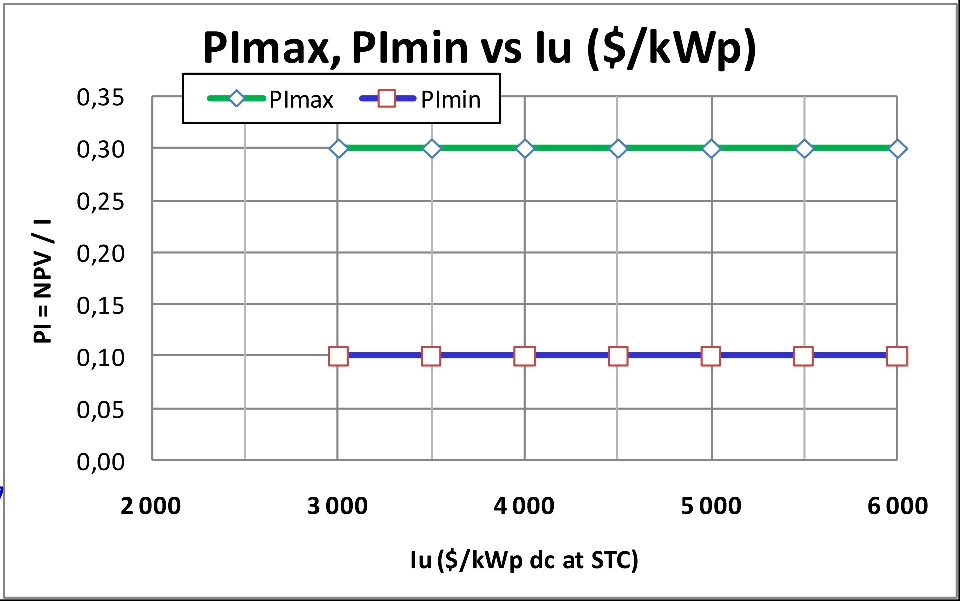
T1 = 10 * Iu

c$/kWh $/Wp



❑ Results: Jmin



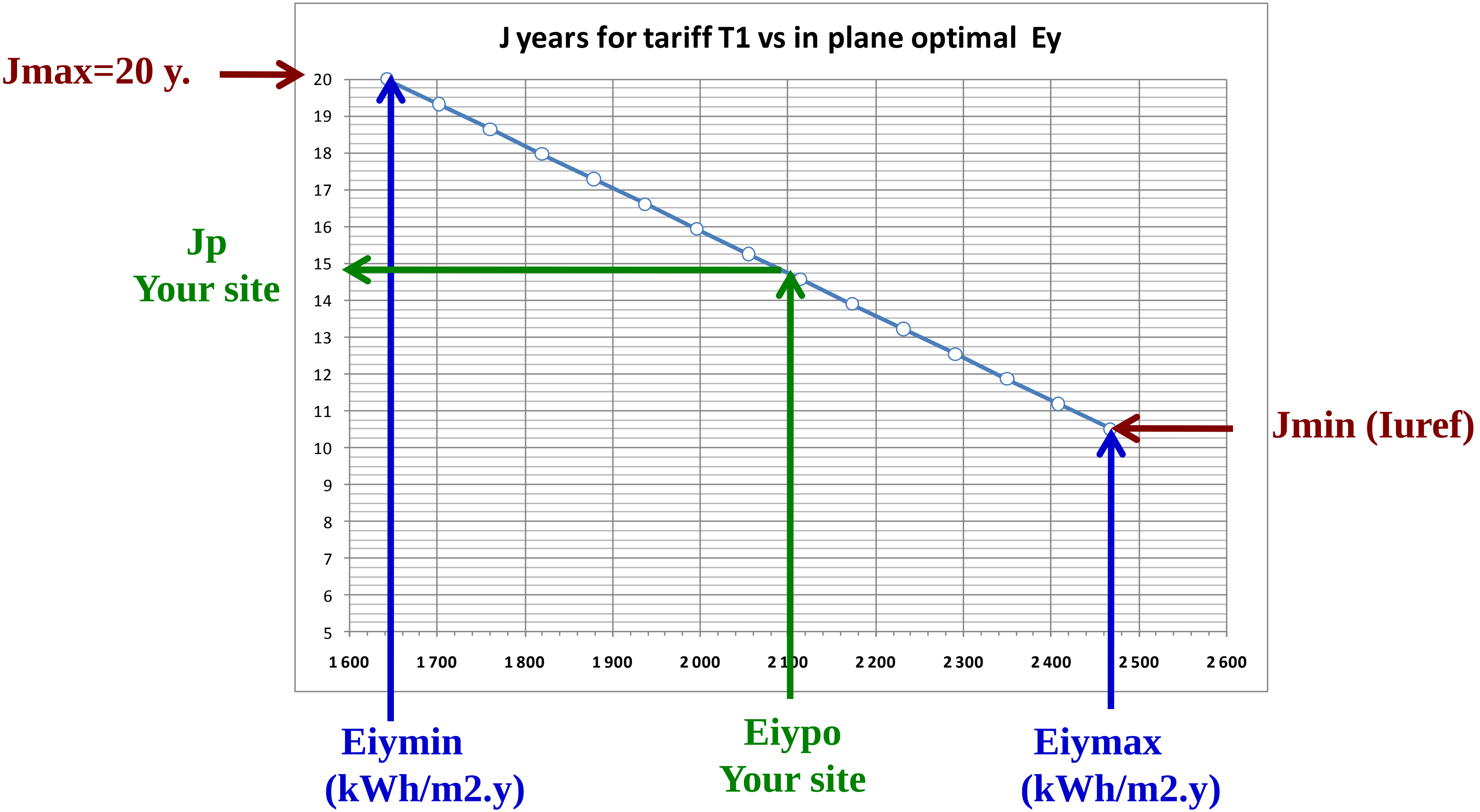


❑ Result: PImax and PImin

⇨ (T1 calculated for Profitability to be independent from Iu)

Use of a USPV FIT system for a specific site in a state

Example: California (Eiymin: Arcata, Eiymax: Dagget, 2010 Iuref = 5000 $/kWp)



Conclusions

- **If well designed and calculated, FITs and ARTs are the most efficient market regulation for large scale implementation of grid connected electricity**
- **Experience has demonstrated that ART's correct design and calculation within a transparent and cooperative decision process is possible and efficient**
- **Experience has demonstrated that ARTs knowledge sharing and capacity building for local stakeholders and decision makers is possible within short time frame**
- **This knowledge sharing and related capacity building should avoid poor FITs design and deceiving results in developing countries**
- **Methods and tools used for ARTs design can be extended also for energy efficiency market regulation**

ANNEXES

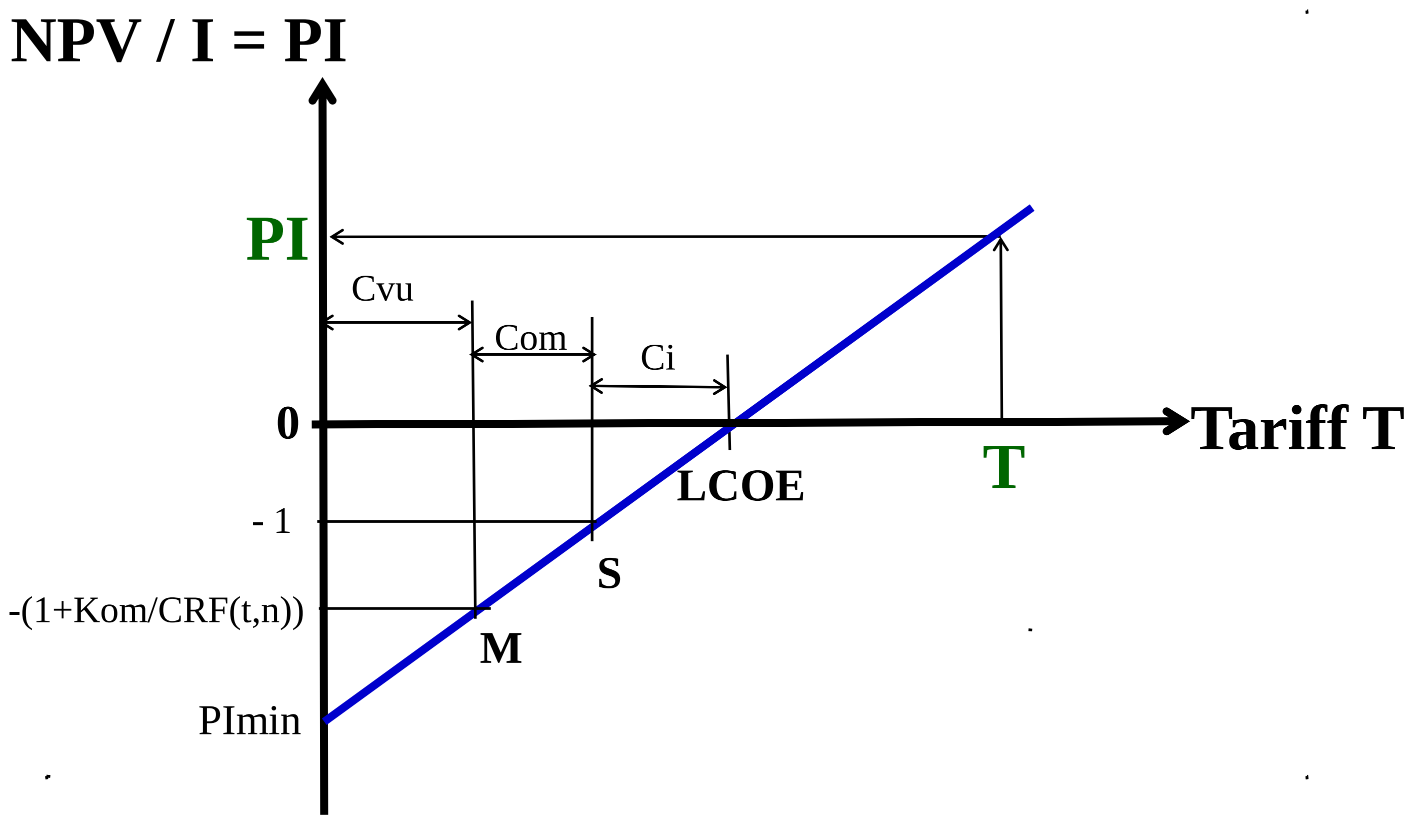
Defining « fair and efficient profitability » from the Profitability Index

PI = NPV/I

The universal linear profitability model: PI = a * T - b

- ⇨ PI = {Nh/[CRF(t,n)]*Iu} – [1 + Kom / CRF(t,n)]
- ⇨ Ci = part of LCOE created by investment cost I
- ⇨ Com: part of LCOE created by O&M expenses Dom
- ⇨ Cvu: variable part of LCOE created by fuel cost DV
- ⇨ CRF(t,n) = t/{1-(1+t)^-n} = Capital Recovery Factor

- ⇨ Iu = I / P ($/kW)
- ⇨ Nh = Ey / P (kWh/year)
- ⇨ Kom = Dom / I
- ⇨ Cvu = DV/Ey ($/kWh)
- ⇨ t = discount rate = WACC
- ⇨ n = number of years of operation



Fair profitability: a simple and reliable model

- **FITs must be based on "cost + fair profit", formula :**

⇨ FIT=Tariff = T = [(1 + **PI**) * CRF(t,n) + Kom] * Iu / Nh + Cvu

- **PI = targeted Profitability Index = NPV/I**, from the "universal PI scale"
  - PI = 0 ➔ To = "manufacturing cost of kWh" (LCOE)
  - **PI = target value between 0.1 to 0.3 ➔ T = "selling price" = FIT**
- Nh = Ey / P (kWh/kW.year) = capacity factor in hours/year at rated power
- Kom (%) = Dom / I = ratio of O&M annual expenses (e.g. 4% for wind)
- Cvu = part of kWh cost from fuel cost (0 for hydro, wind, solar, geothermal energy)
- CRF(t,n) = capital recovery factor = t / {1-[1+t] ^(-n)}
- **t = real discount rate = WACC before tax on profit**
  - OECD countries: 5 % real < t < 6.5 % real
  - t is NOT the targeted project Internal Rate of Return (IRR)
- **n** = duration of the Power Purchase Agreement (PPA)

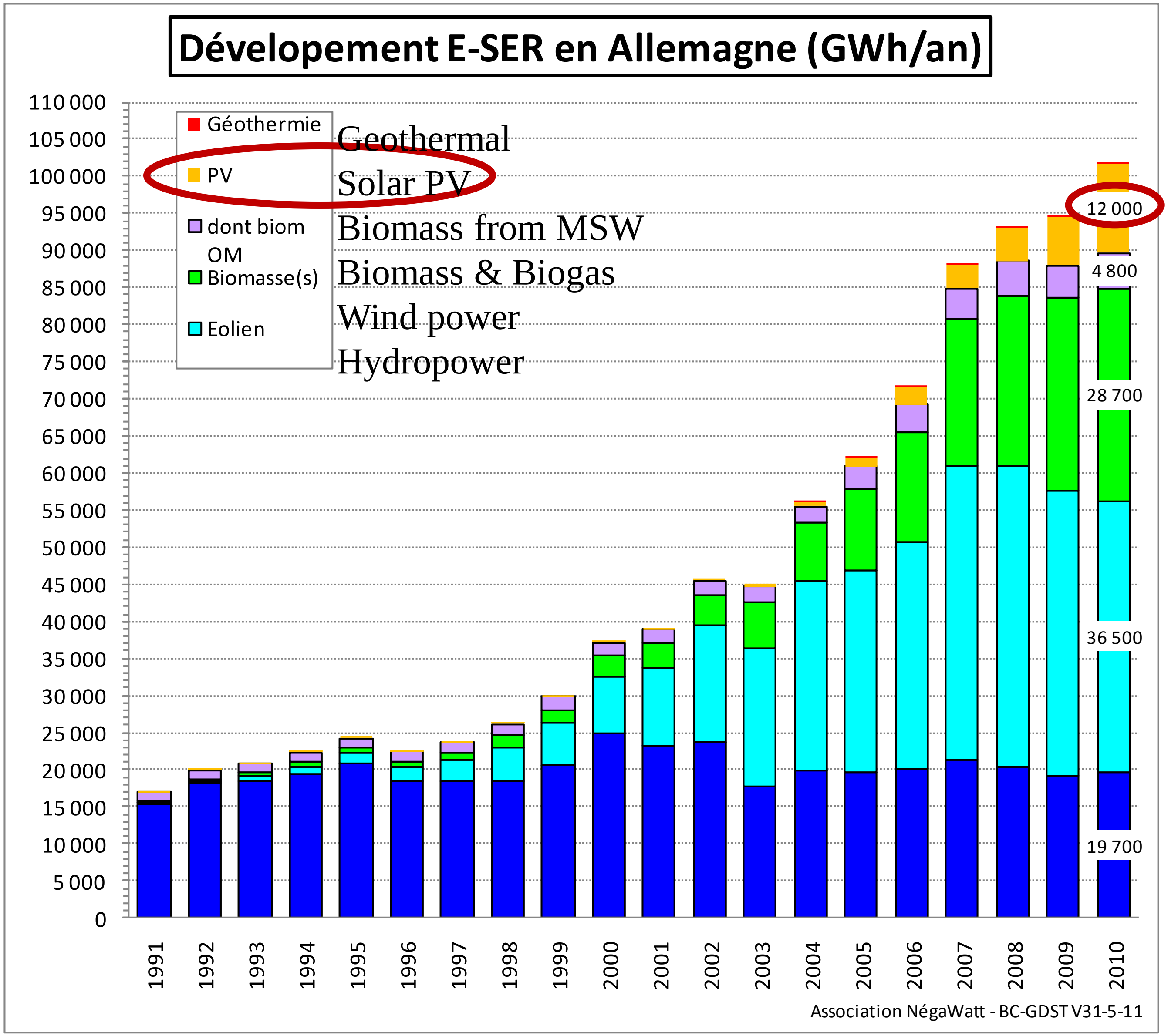
⇨ Equivalent to: T = [CRF(**IRR**,n) + Kom] * Iu / Nh + Cvu

- **PI more reliable than IRR to define "fair profitability"**

Case study:
coping with recent decreasing grid connected PV installation costs

- Germany
- Italy
- France

Germany: 1991-2010 RES-E production (GWh/y)



Source of data: BMU

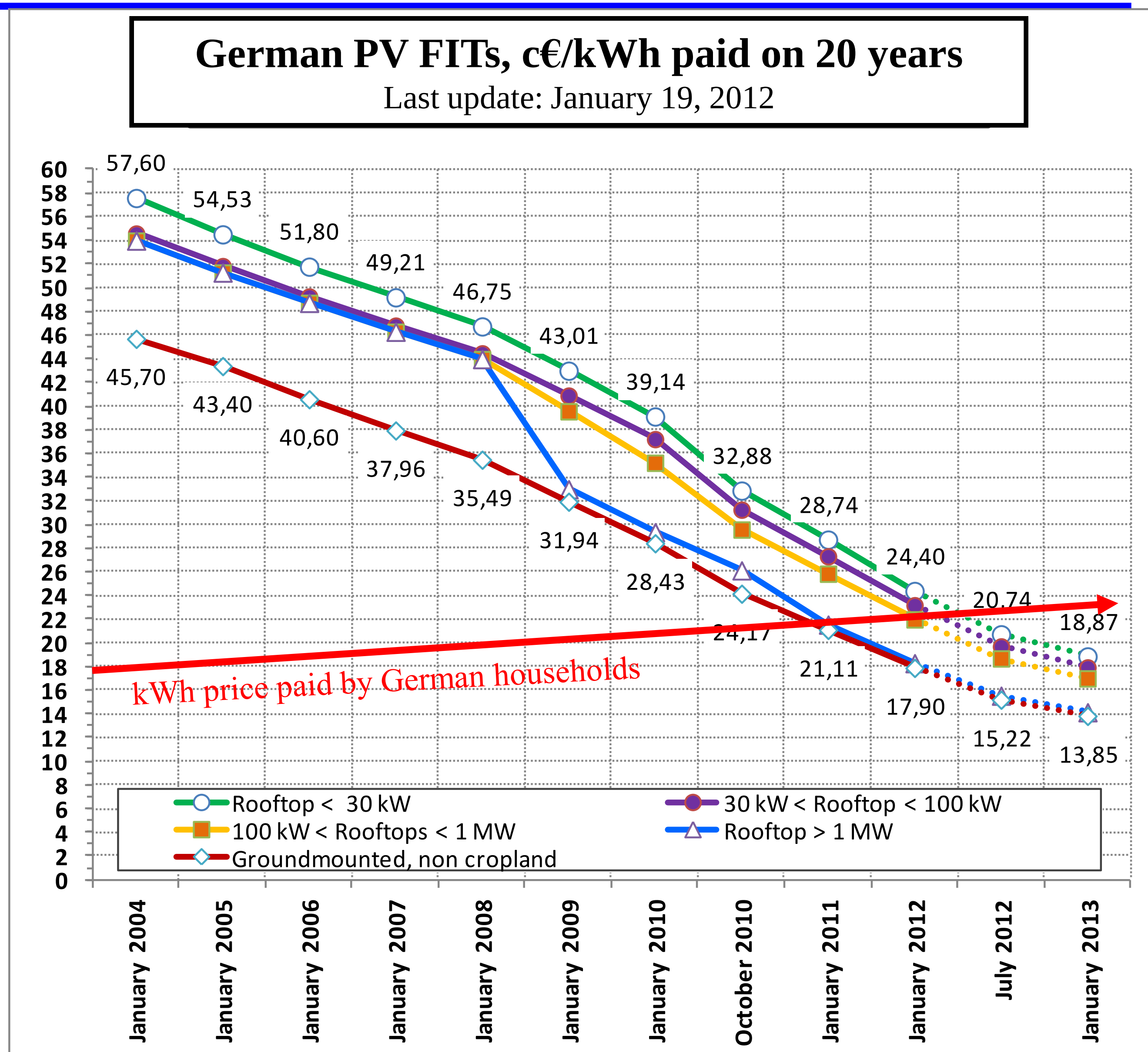
German PV FITs from EEG

German PV FITs
January-December 2011

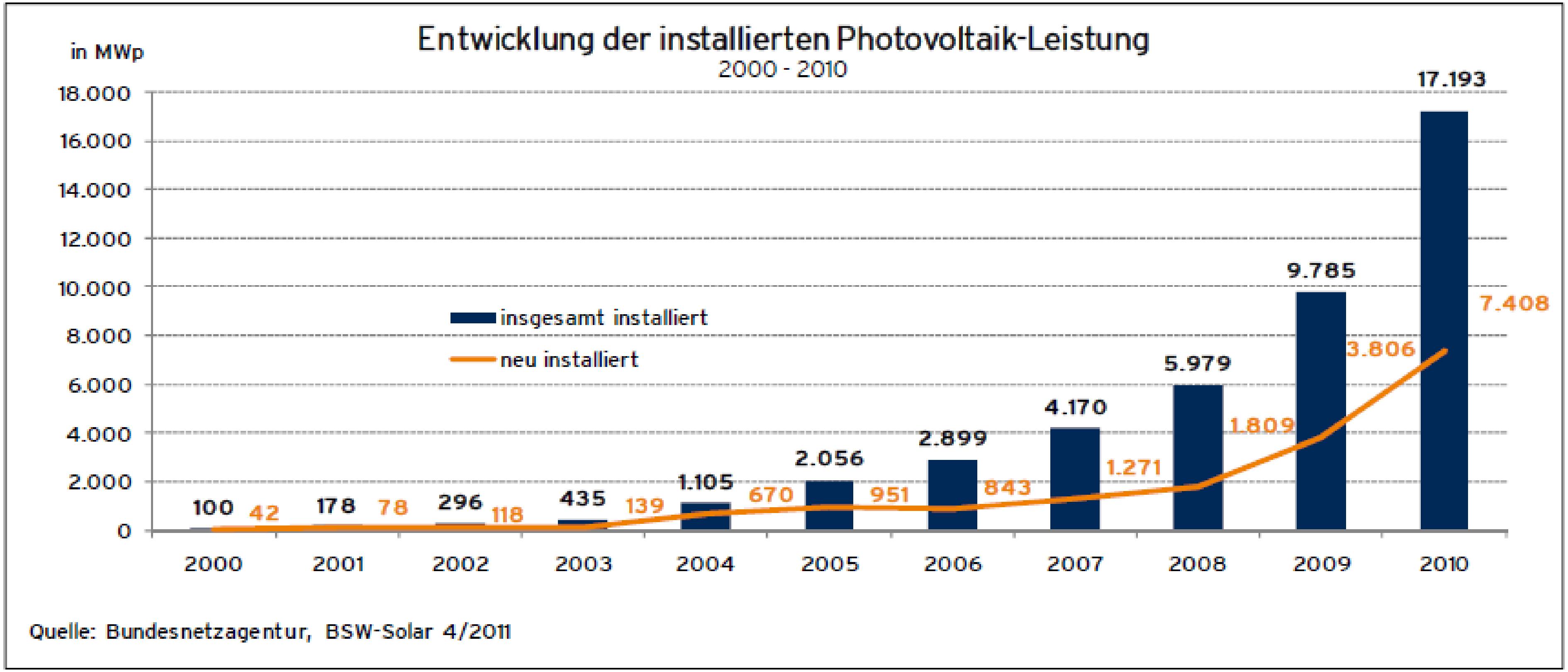
Tarifs PV Allemagne janvier à décembre 2011		
09/08/2011	Tarif PV sur 20 ans	c€/kWh
	Pc < 30 kWc	28,74
Toits	30 < Pc < 100 kWc	27,33
	0,1 < Pc < 1 MWc	25,86
	Pc> 1 MWc	21,56
Sol	Standard, non agricole	21,11
	Réhabilitation	22,07

German PV FITs
January-July 2012
(under discussion)

Tarifs PV Allemagne de janvier à juin 2012		
11/11/11	Tarif PV sur 20 ans	c€/kWh
	Pc < 30 kW	24,40
Toits	30 kW < Pc < 100 kW	23,20
	100 kW < Pc < 1 MW	22,00
	Pc > 1 MW	18,30
Sol	Sol non agricole standard	17,90
	Sol réhabilité	18,80

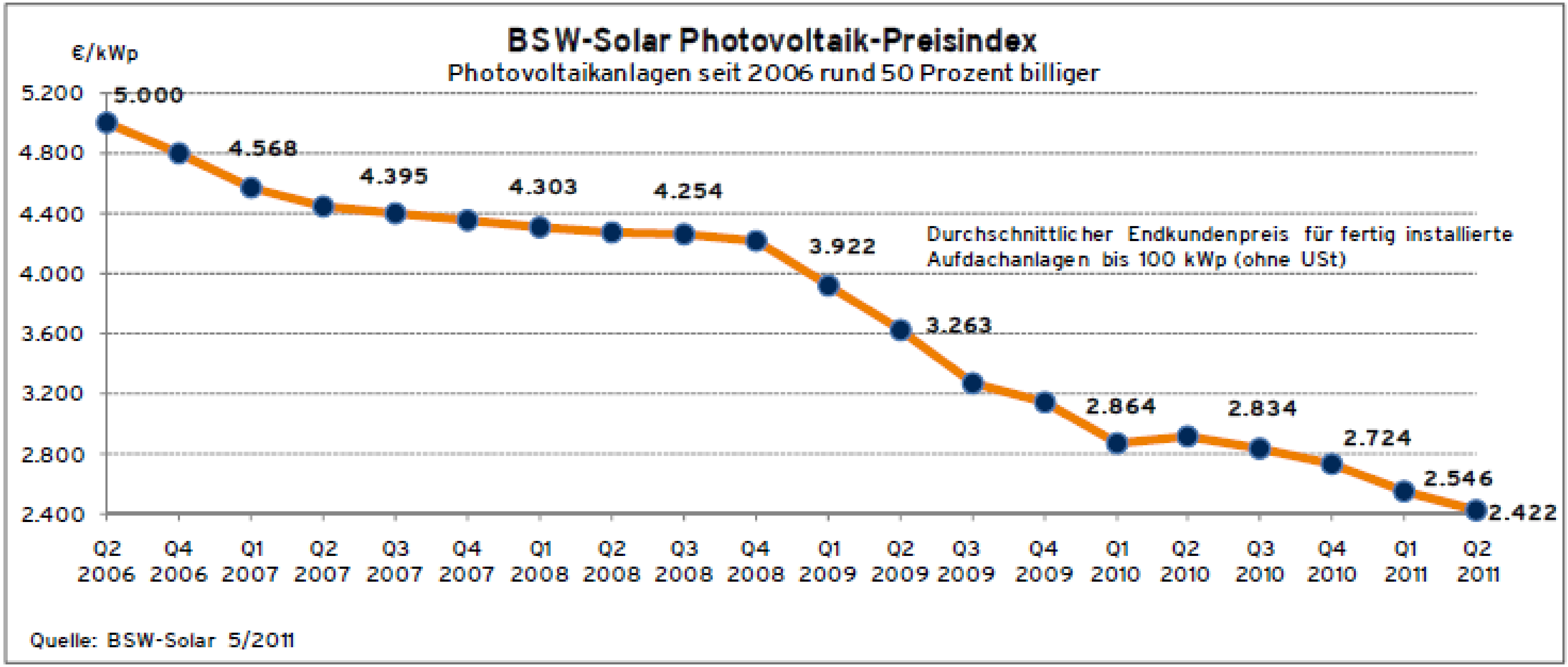


PV in Germany: installed power and annual market (MW)



Source: BSW

PV in Germany: 2006-2010 cost decrease (€/kWp)

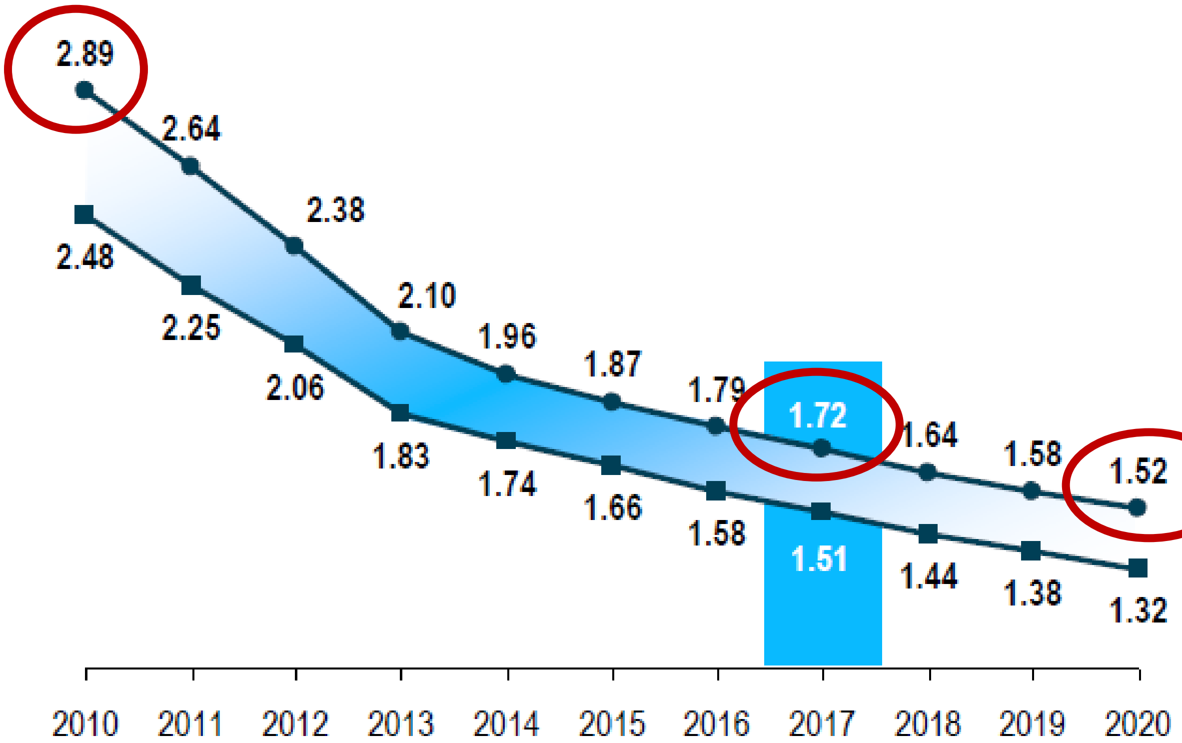


Note: installed €/Wp for systems < 100 kWp

Source: BSW

2010-2020 German BSW roadmap: costs (€/Wp)

System price model of German PV industry 2010-2020 [EUR/Wp]



1) Weighted from thin film and crystalline shares — Upper price trajectory — Lower price trajectory

Methodology and main assumptions

> Methodology
  - Bottom-up model developed together with German PV industry
  - Average values from various companies on module and BOS costs – without Asian production

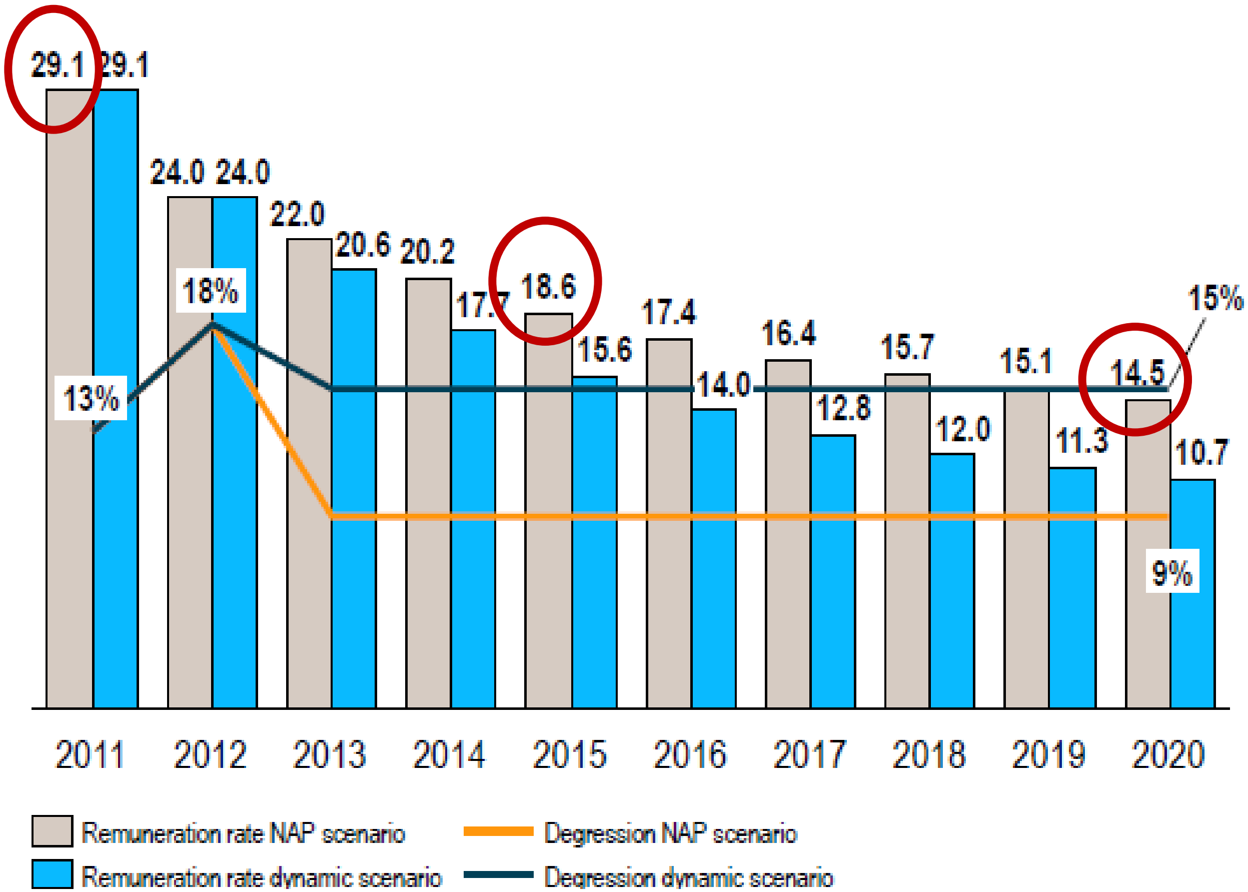
> Assumptions:
  - Investor perspective, i.e. including all margins of value creation and distribution
  - 30 KW system
  - Real prices 2010, excluding VAT
  - Thin film share increasing until 2020 – 30% presumed

Source: Roland Berger; various PV companies — PV Roadmap EN_FINAL.pptx | 15

Source : Directions for the Solar Economy
PV Roadmap 2020
Competitive – Photovoltaics on the way to becoming a central pillar of energy supply

2010-2020 German BSW roadmap: FITs

Remuneration development under assumed direct consumption, nominal [ct/kWh]



Comments

> Remuneration degression as in current EEG

> Direct consumption presumed to increase until 2020 – cumulative effect for total remuneration (20% direct consumption in 2020)

> 18% degression in 2012 is not yet the maximum amount possible

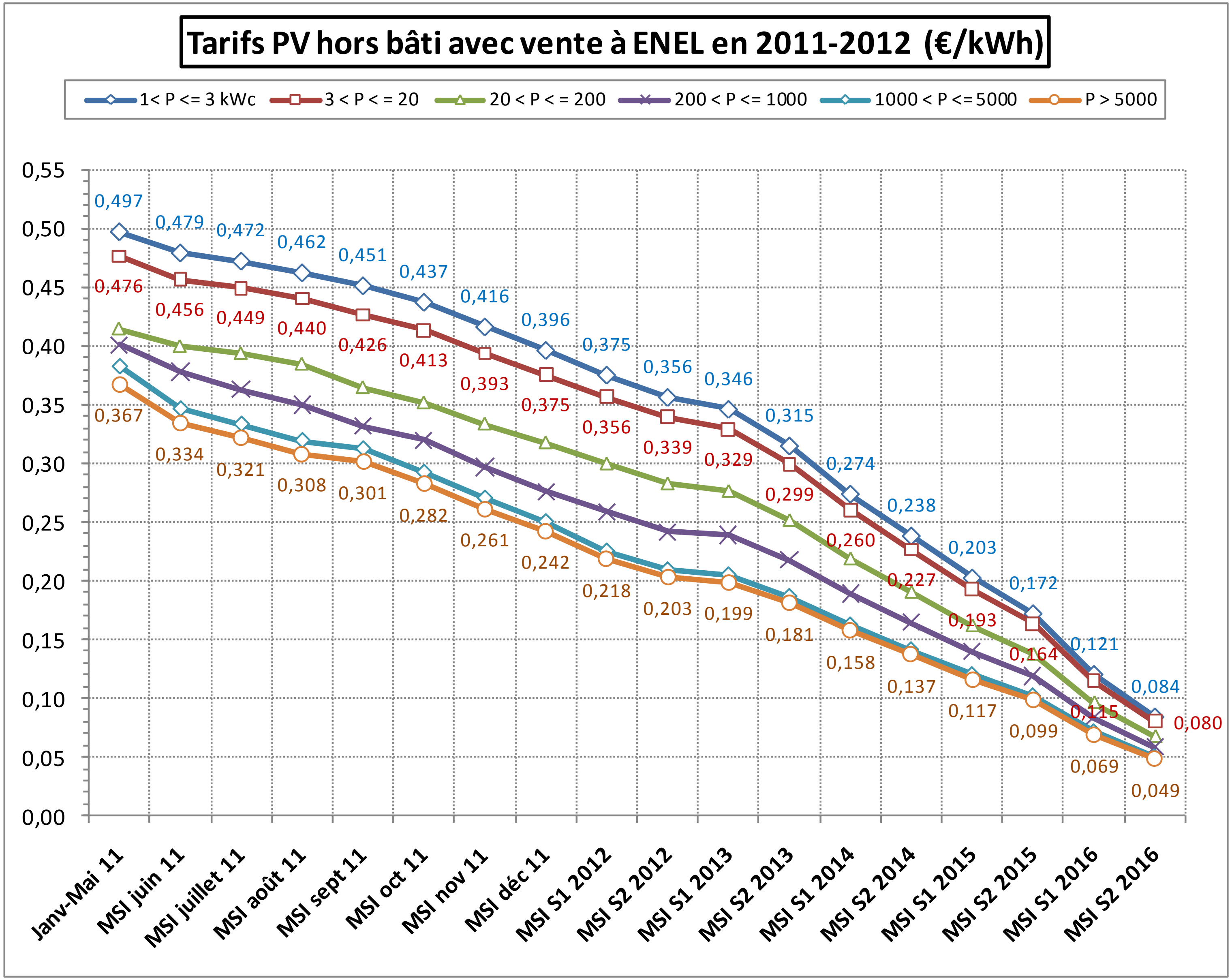
Source : BSW:

Directions for the Solar Economy

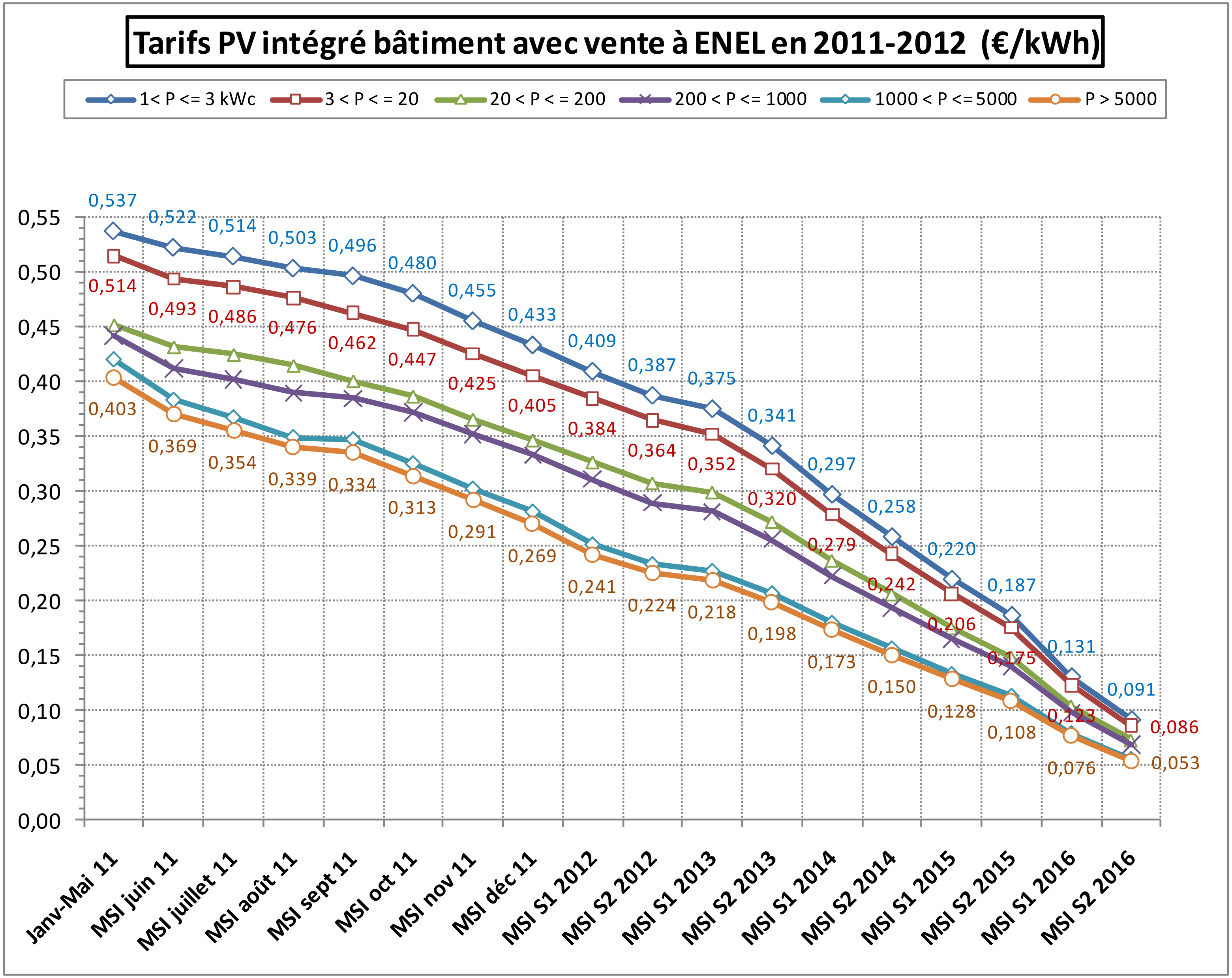
PV Roadmap 2020

Competitive – Photovoltaics on the way to becoming a central pillar of energy supply

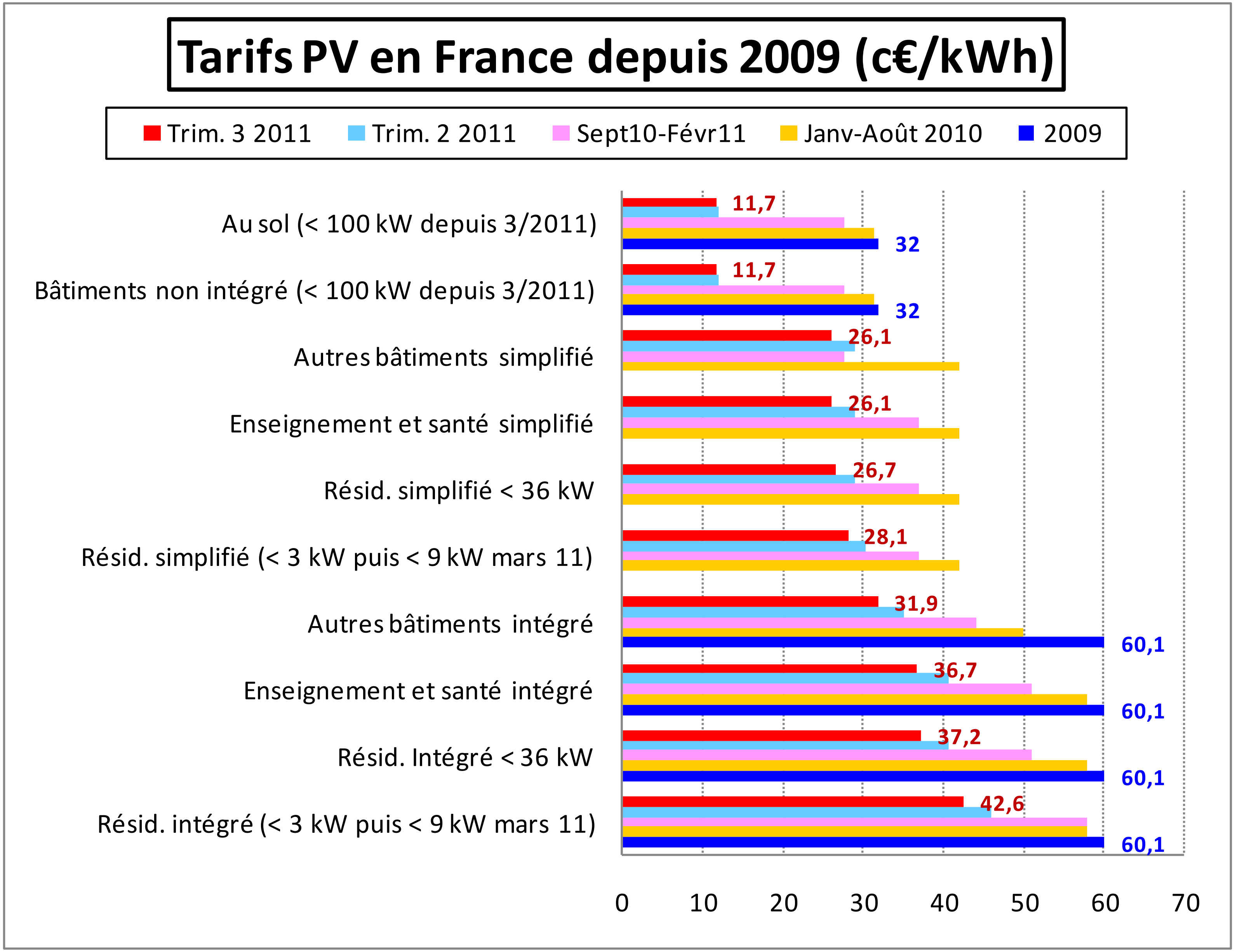
Italian PV FITs, « Conto IV, May 2011 »: on ground



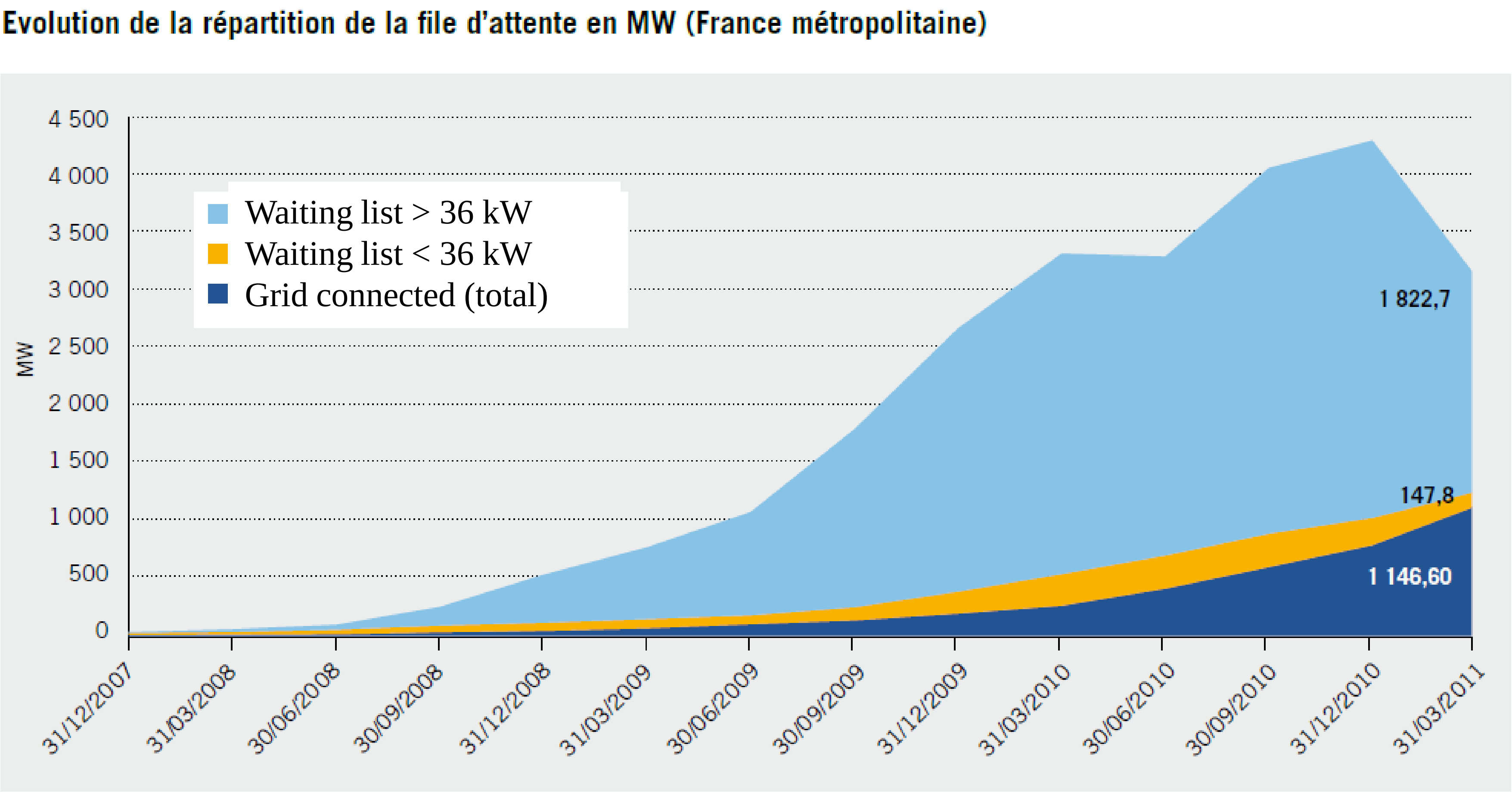
Italian PV FITs, « Conto IV, May 2011 »: BAPV



French PV tariffs: decrease from 2009 to 2011



PV in France and grid connection waiting list (MW)



(Source : SER-SOLER, d'après ERDF-EDF SEI)