Renewable Electricity in Germany – the Renewable Energy Act

Dr. Martin Pehnt

Institut für Energie- und Umweltforschung Heidelberg

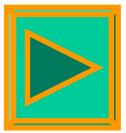
martin.pehnt@ifeu.de *www.ifeu.de*

Peru, August 2008

Content

- RE in Germany
- The Renewable Energy Act (EEG)
  - Guiding Principles
  - 4 major EEG Elements
- Feed-in tariffs
  - Methodology
  - Example Wind
  - Example Hydro
- Outlook
- Afternoon: Comments on Peruvian Systems

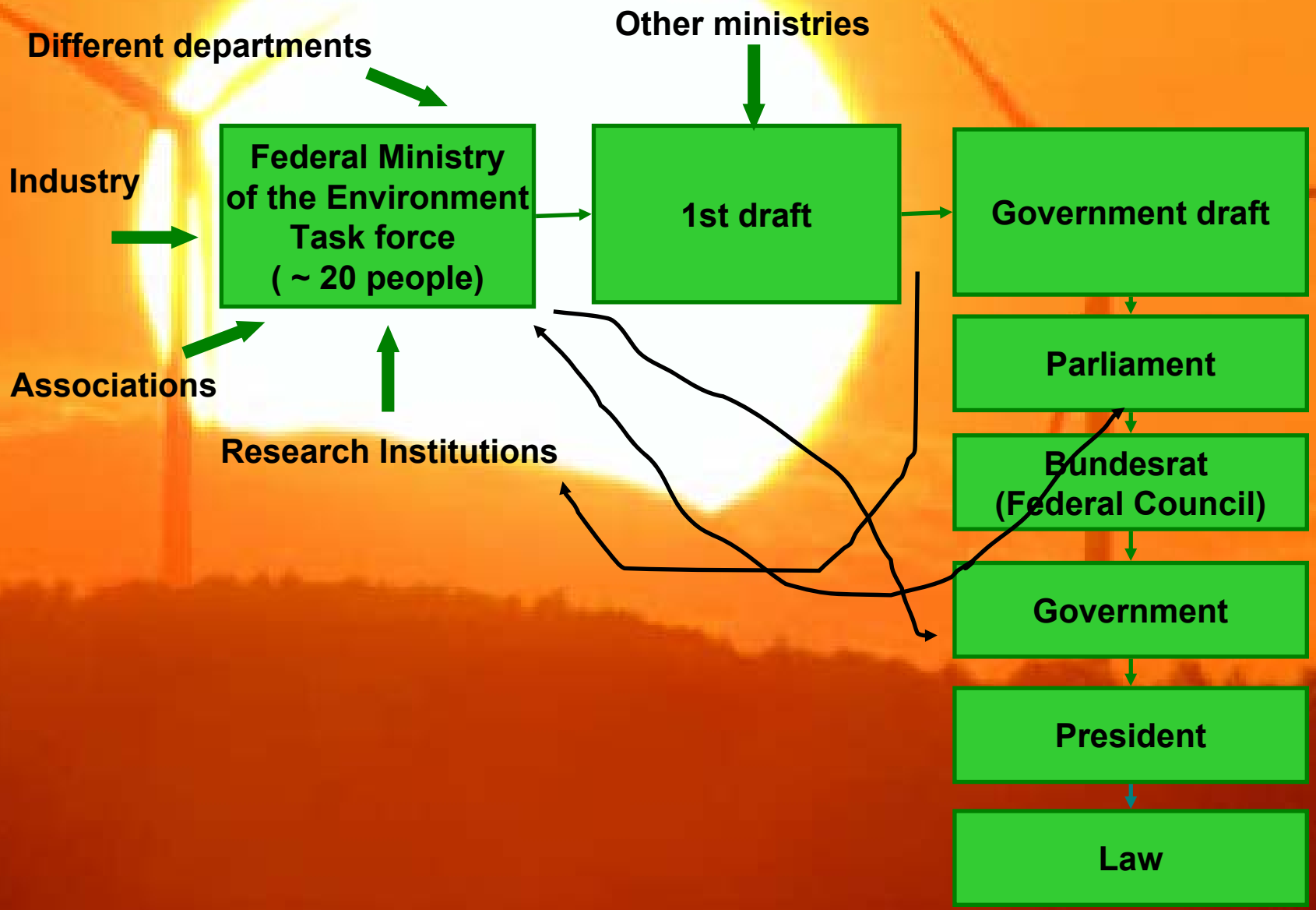
EEG 2009



Tariffs

- **IFEU: Institute for Energy and Environmental Research**
  - **Research institute working on energy, transport, waste, environmental products, LCA, policy instruments etc.**
  - **50 researchers**
  - **Working on behalf of Federal and State government and agencies, associations, NGOs, industry**
- **Department „Future Energy Systems“ (Renewables, cogeneration, new energy and transport systems, energy efficiency)**
  - **Scientific advisor of Federal Ministry of the Environment**
  - **Involved in Renewable Energy Act, Market Incentive Program, Energy scenarios, BMU Electro mobility strategy, etc.**
  - **Member of Task Force Renewable Energy Act**

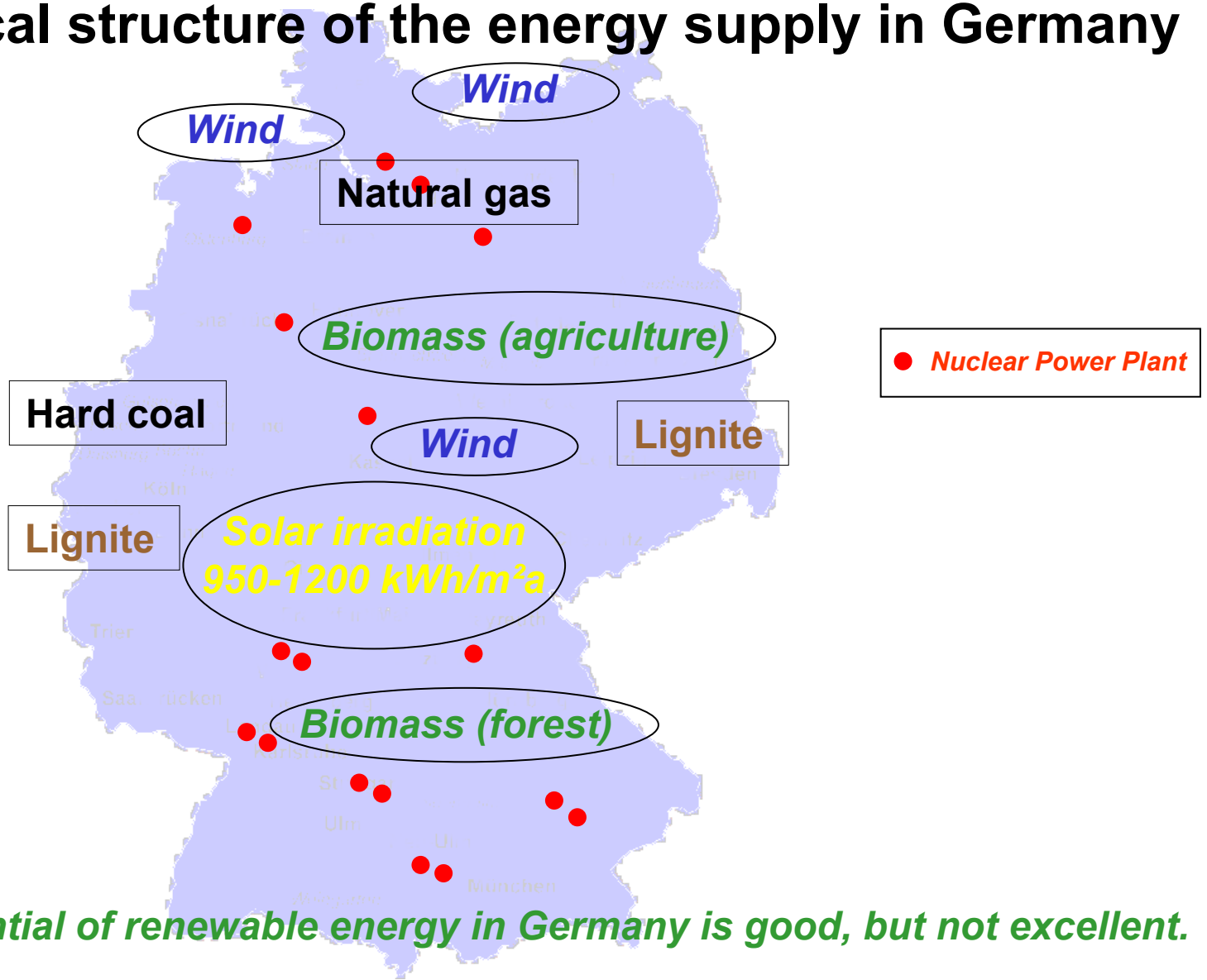
Process of Enacting the Renewable Energy Law



Renewable Energy Act

- 1991 „Feed-in Law“: very simple predecessor
- 2000 Renewable Energy Act
- 2004 Renewable Energy Act First amendment
- 2008 Renewable Energy Act Second amendment

Geographical structure of the energy supply in Germany



The potential of renewable energy in Germany is good, but not excellent.

Dr. Martin Pehnt www.ifeu.de

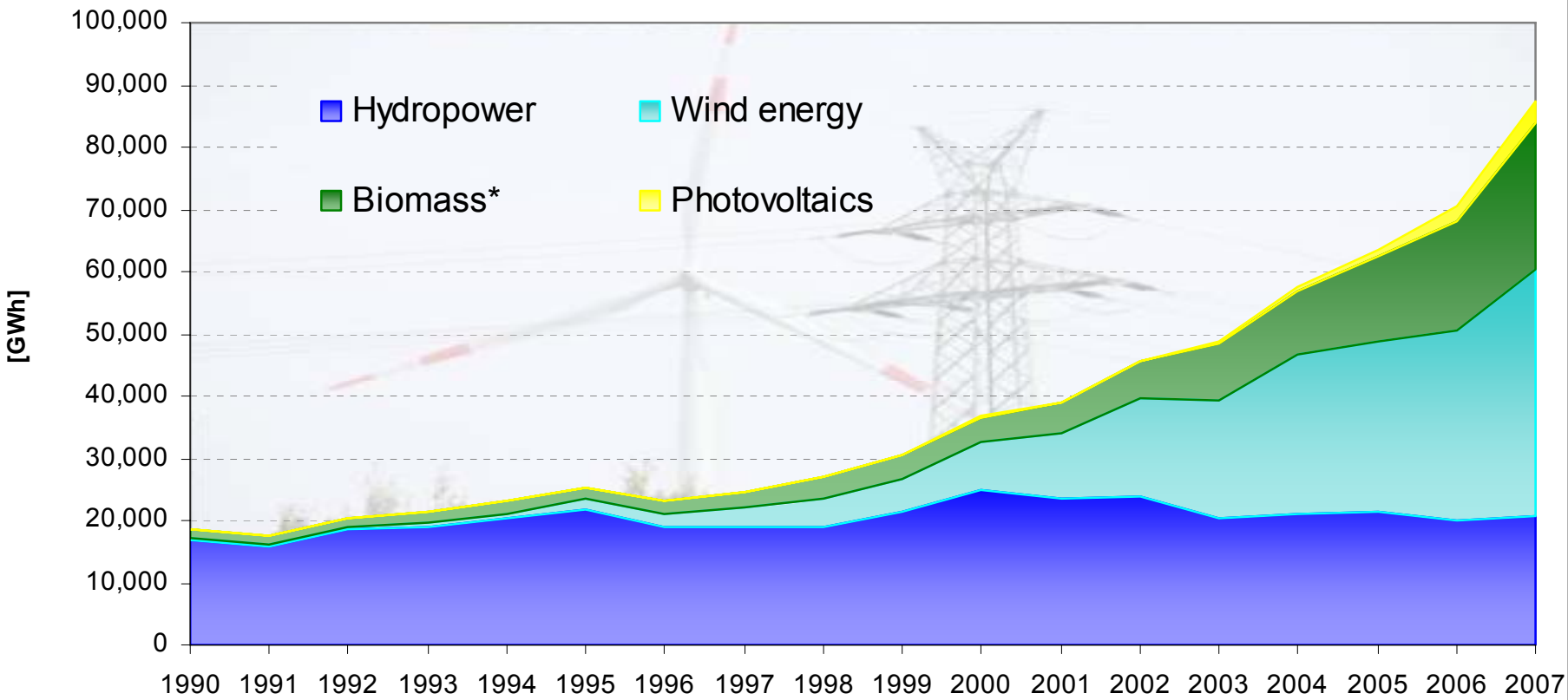
Status of Renewables

Year Share in %	2000	2007			
Primary Energy	**2.6**	**6.7**			
Final Energy	**3.8**	**8.6**			
Electricity	**6.3**	**14.2**			
Fuels	**0.4**	**7.6**			
Heat	**3.9**	**6.6**			

Long-term targets

Year Share in %	2000	2007		2020	2050
Primary Energy	**2.6**	**6.7**			**>50**
Final Energy	**3.8**	**8.6**		**18**	
Electricity	**6.3**	**14.2**		**>30**	
Fuels	**0.4**	**7.6**		**(17) 12**	
Heat	**3.9**	**6.6**		**14**	

Development of RE electricity in Germany

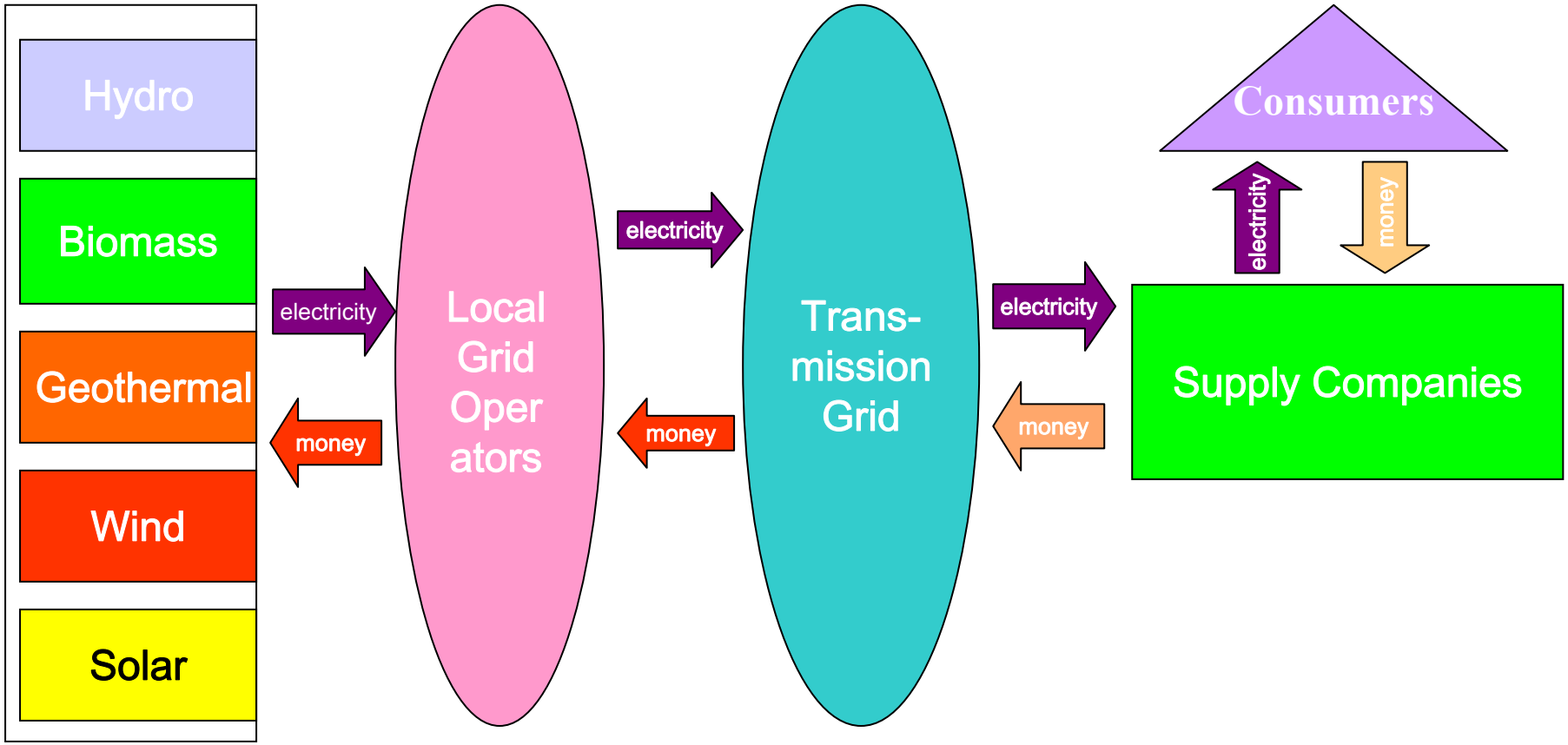


* solid, liquid, gaseous biomass, biogenic share of waste, landfill and sewage gas;
Electricity from geothermal energy is not presented due to the low volumes of electricity
Source: Source: BMU according to Working Group on Renewable Energies / Statistics (AGEE-Stat)

BMU 2008

Dr. Martin Pehnt www.ifeu.de

How does the Renewable Energy Sources Act (EEG) work?



Source: BMU

Dr. Martin Pehnt www.ifeu.de

Guiding principles

- Climate and resource protection
- Technological innovation and technology development
- No monopolization by a particular technology or region (technological diversity)
- Enough flexibility to avoid undesirable developments, but enough stability to provide secure framework
- Support efficient, well-designed systems

Consequences for EEG Design

- → Company/RE operator must get sufficient, but appropriate profit
- → Each category of renewable energy (wind, solar, biomass etc.) gets specific support
- → Not just supporting installation, but also requiring strong performance from installations
  - → Tariff for energy, not capacity
  - → Special boni for efficient renewable systems (e. g. cogeneration)
- → Wind: Site-specific feed-in tariff

Element 1:
Priority access for RE to the power grid

- Obligation to supply grid connection for RE (§5)
- Obligation for DNO / TGO to reinforce grid (§9)
- Obligation to take up, purchase and distribute RE electricity (§8)
  - Local asymmetries (e. g. wind-rich North) are balanced nation-wide via an allocation
- „Feed in management“ in cases where grid is congested (§11)
  - DNO/TGO must come up for the lost income under certain conditions when RE systems are shut off
- Clear and fair allocation of costs (§13)
  - Connection to closest grid is paid by RE operator
  - Reinforcement / optimisation of grid is paid by grid operator
  - Transmission costs are paid by the final customer.

All paragraphs refer to the EEG 2009. Download under www.erneuerbare-energien.de

Element 2:
Fixed feed-in tariff

- Fixed tariff for every kilowatt hour produced from RE for in general 20 years
- based on the average cost to install and operate a RE system (including an appropriate rate of return on equity)
  - Tariffs are not based on avoided costs. Avoided costs are only used to calculate the macroeconomic costs of the Renewable Energy Act.
  - Note: in the German Cogeneration Act, small (fossil) cogenerators get a fixed premium plus the average avoided cost based on the quarterly average of the spot market

Element 2:
Fixed feed-in tariff (systems installed in 2006)

	2006 (Cent/kWh)	Degression (%/a)
Hydropower	6.65-9.67	0
Biomass (<20MW)	8.15-17.16	1.5
Geothermal Energy (<20MW)	7.16-15.00	1.0
Wind energy (onshore)	5.28-8.36	2.0
Wind energy (offshore)	6.19-9.10	2.0
Solar energy	40.6-56.8	5.0

Degression: The tariff is in general constant for commissioned installations, but depends on the year of the initial operation. The later an RE installation is commissioned, the lower the tariff will be. * Only for hydropower > 5 MW

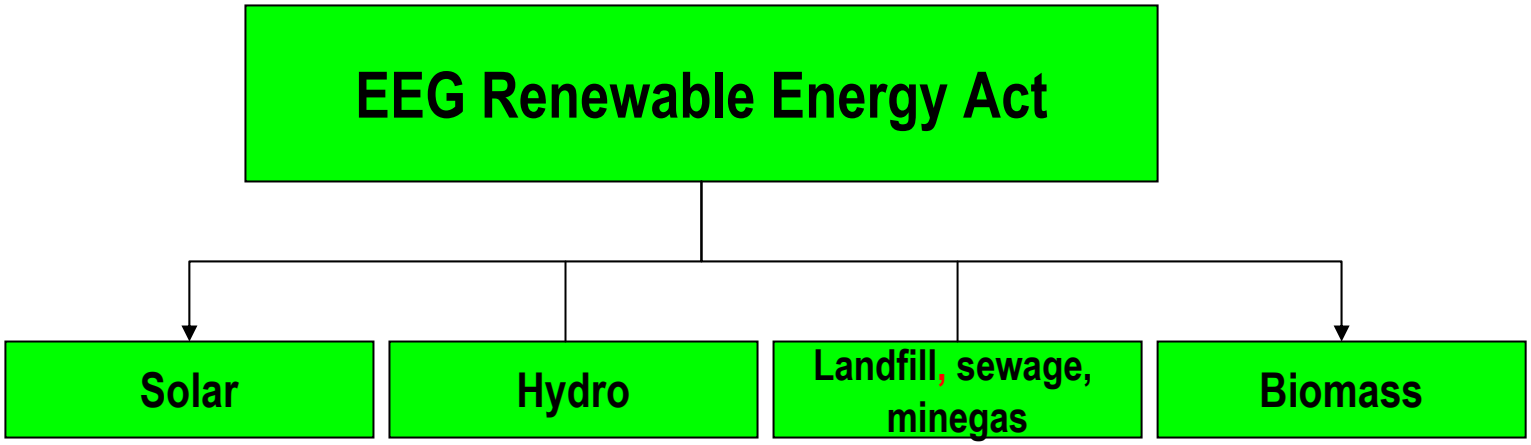
Source: BMU

Element 3:
Dynamic instrument

- **Tariffs are nominal → Inflation reduces real tariff**
- **Differentiation of the tariffs along start-of-operation-date: Prices are decreased annually by a fixed rate („degression factor“)**
  - **RE industry has to lower cost!**
  - Note: The tariff is in general constant for commissioned installations, but depends on the year of the initial operation.
- **Extra innovation bonus, CHP bonus**
- **Evaluation of the tariffs in 2007 and every four years**
  - **to avoid over- or under subsidy**

Dr. Martin Pehnt www.ifeu.de

Element 4:
Differentiation according to type of RE

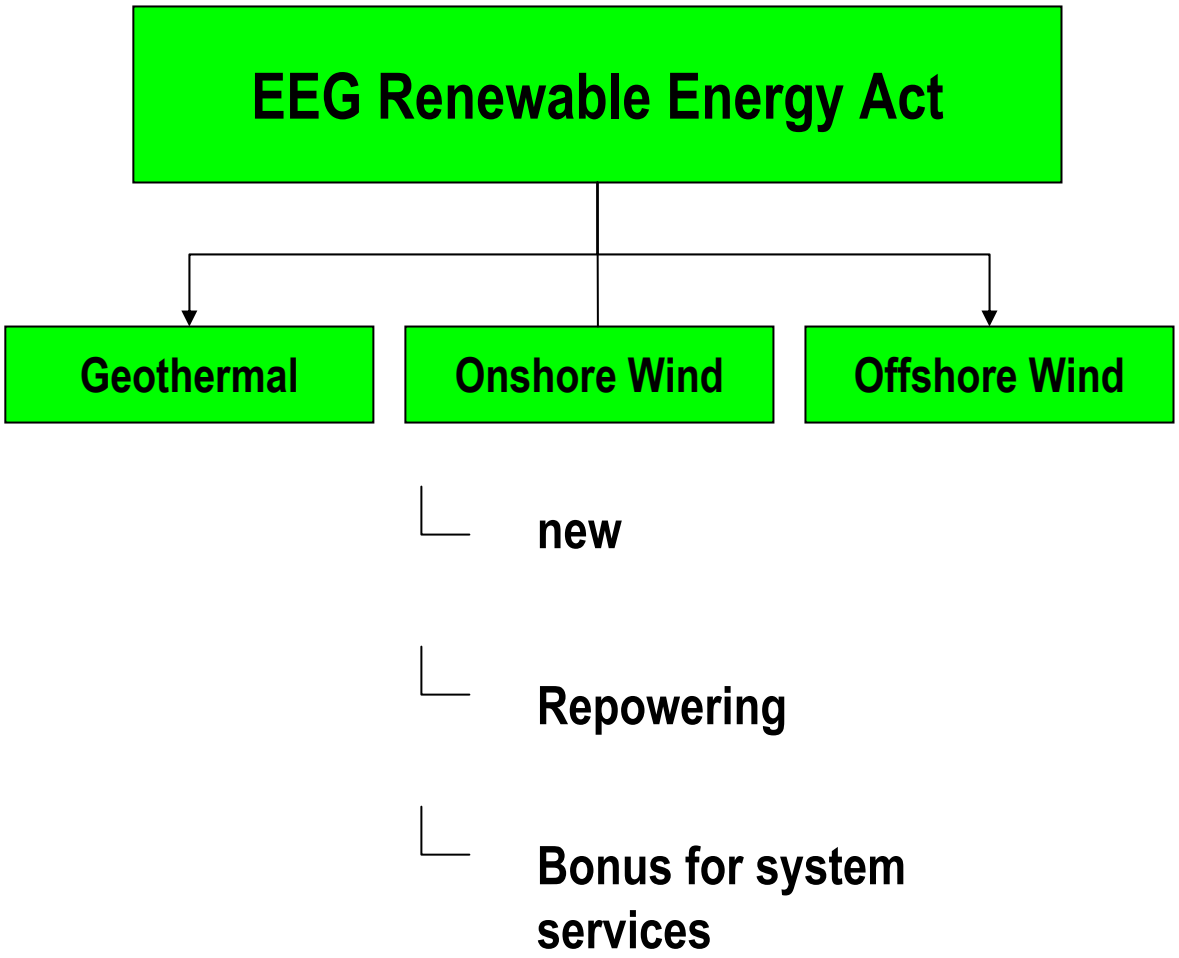


- roof - mounted
- free-standing

- < 5 MW new (greenfield)
- < 5 MW modernised
- > 5 MW renewal

- < 150 kW, 150–500 kW, 500 kW-5MW, 5-20 MW
- Bonus for energy crops and manure
- Bonus for cogeneration
- Bonus for innovative technologies

Element 4:
Differentiation according to type of RE



Are these principles also relevant to Peru?

	Germany	Peru
Climate and resource protection	Relevant	Relevant
Technology development	Major RE R&D and export activities→ industry	Limited
Technology diversification to enhance energy security	Relevant	Relevant (e. g. avoid hydroelectr. which is depending on weather and climate)
Technology diversification to support rural / farmers	Biogas as new income for farmers → local income	?
Equal/even geograf. distribution of RE, particularly wind	Increase acceptance (wind was installed at coastal sites) Reduce grid congestion in Northern Germany	Not so relevant because penetration (of wind) is still marginal

How are the tariffs set?
Methodology

- Cost based price setting
- Cost determination ex-post via evaluation of realised power plants by independent consultants
  - “Renewable Energy Sources Act (EEG) Progress Report” *
  - Evaluation of market growth as a function of the tariff
  - Evaluation of cost development over time
- Revision every four years

* Download www.erneuerbare-energien.de

Nominal Levelised Electricity Generation Costs

$$\text{Levelised Electricity Cost} = \frac{\text{Annuity of Life Cycle Costs}}{\text{Mean Annual Electricity Generation}}$$

Life Time or "Feed-in Time" — Investment — Operation & Maintenance Costs — Interest Rate

$$\text{Annuity} = \sum_{t=0}^{T} (I_t + OM_t)(1+r)^{-t} \cdot \frac{r \cdot (1+r)^T}{(1+r)^T - 1}$$

Present Value of Life cycle costs — Annuity Factor

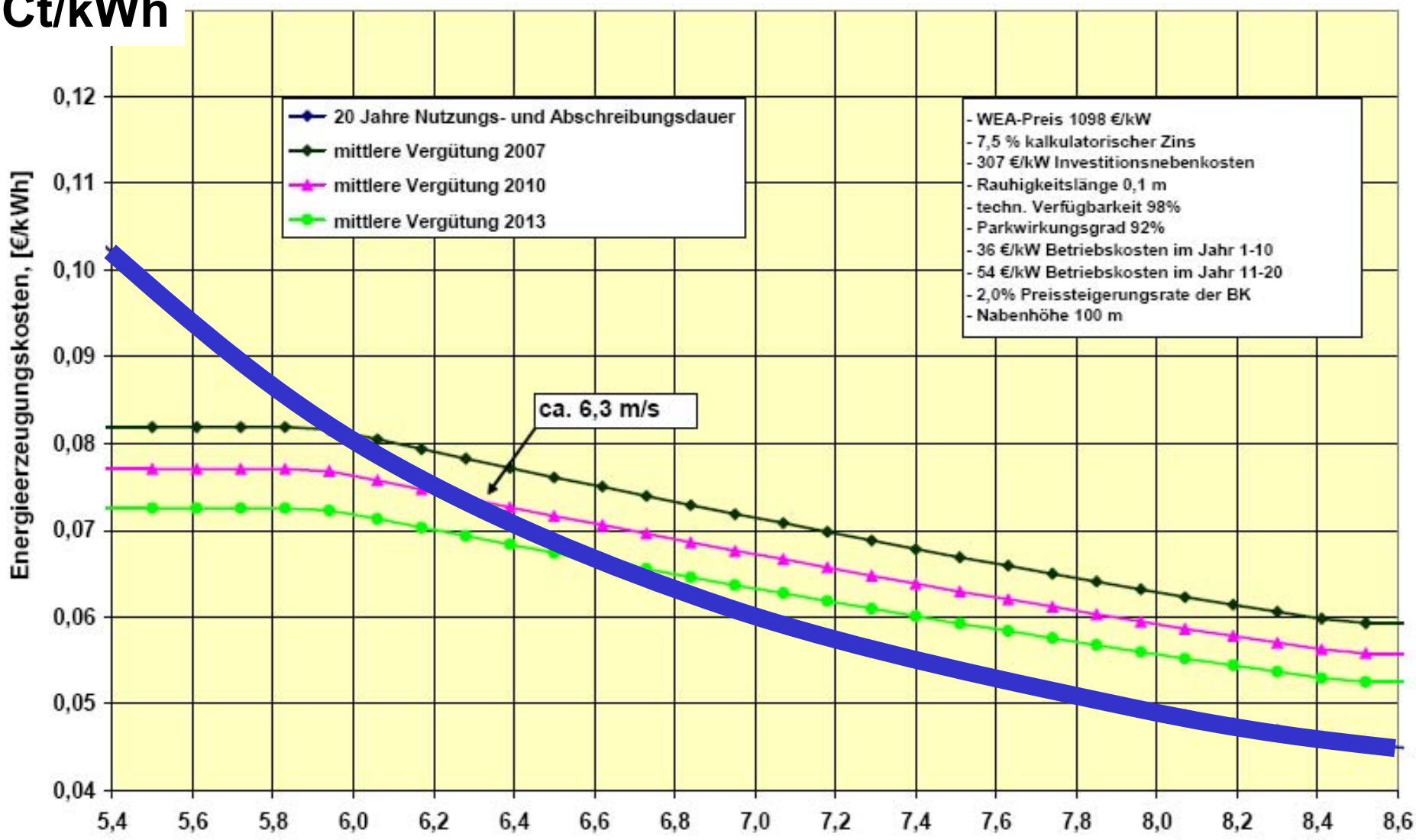
Dr. Martin Pehnt www.ifeu.de

- **Interest rate mirrors economic incentive to operate system**
  - **Private operator (e. g. small PV): lower economic expectation, higher share of equity → lower interest rate**
  - **Larger, „professional“ operators (e. g. large wind park): higher economic expectation, higher share of debt → higher interest rate**

Example Wind Power (1.5 MW; 100 m hub height)

- Data sources: 518 wind power plants, 75 operators, literature search
- Investment cost: wind power 1098 €/kW, 307 €/kW balance of system
- Interest rate
  - Equity 12 % (30 % share)
  - Debt 5.5 % (soft loan, 70 % share) → 7.45 % average interest rate
- O&M: 36 €/kW (year 1-10); 54 €/kW (year 11-20)

Electricity Generation Cost (1.5 MW; 100 m hub height)

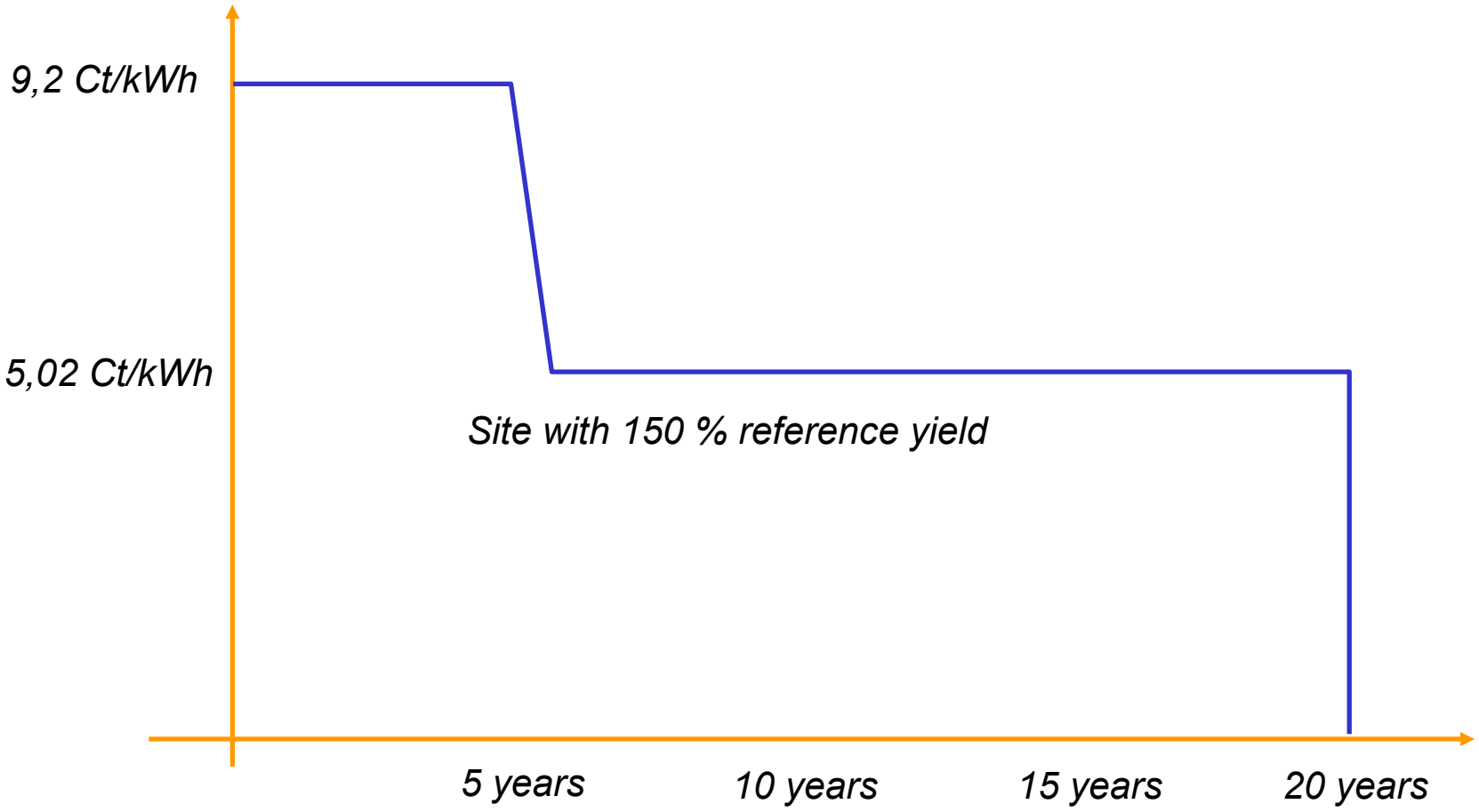


Source: BMU 2007

Proposal for new 2009 tariffs „Reference yield method“

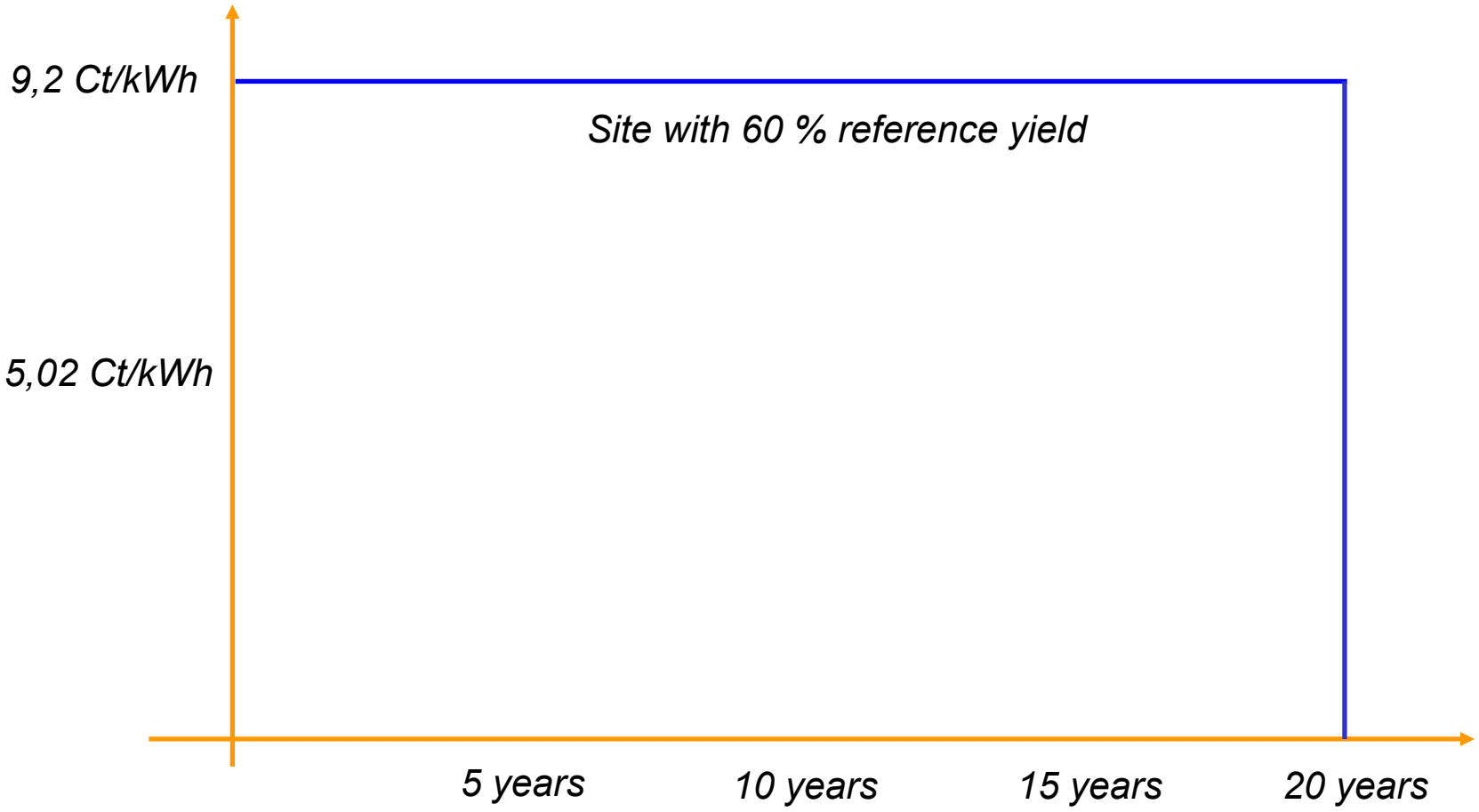
- Basic tariff: 5,02 Ct/kWh for 20 years
- This basic tariff is increased to 9,2 Ct/kWh for
  - 5 years for very good sites (150 % reference yield)
  - 16 years for good sites (100 % reference yield)
  - 20 years for medium sites (60 %)
- Reference yield is the yield of a wind turbine of a given manufacturer and hub height at a site with 5.5 m/s wind speed @30 m height
- Plus 0,5 Ct/kWh for wind turbines which provide certain services (blind power compensation, ...)

„Reference yield method“: very good site



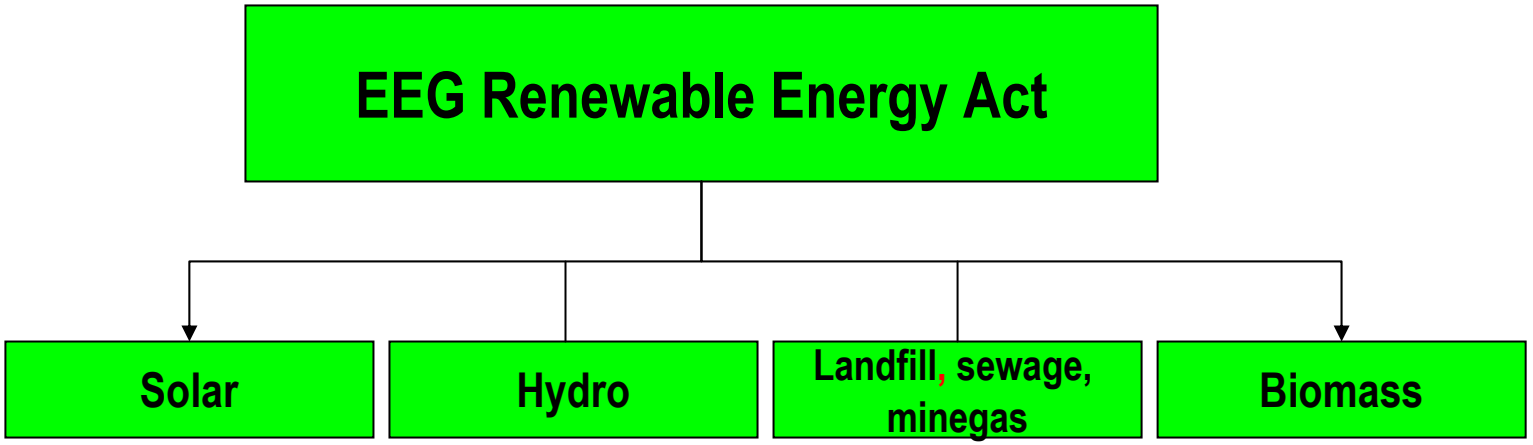
Dr. Martin Pehnt www.ifeu.de

„Reference yield method“: medium site



Dr. Martin Pehnt www.ifeu.de

Differentiation according to type of RE



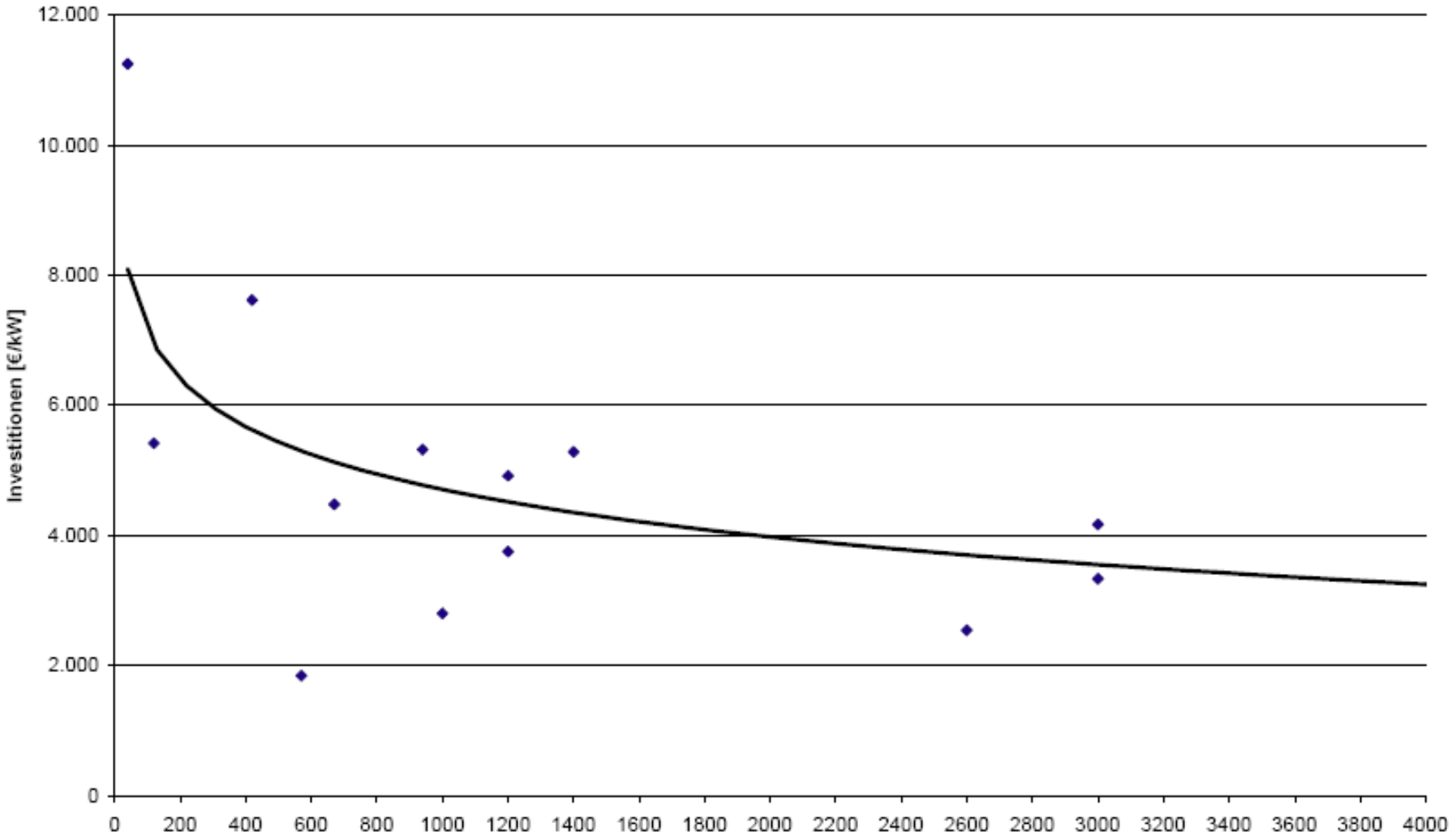
- roof - mounted
- free-standing

- < 5 MW new
- < 5 MW modernised
- > 5 MW renewal

- < 150 kW, 150–500 kW, 500 kW-5MW, 5-20 MW
- Bonus for energy crops and manure
- Bonus for cogeneration
- Bonus for innovative technologies

Dr. Martin Pehnt www.ifeu.de

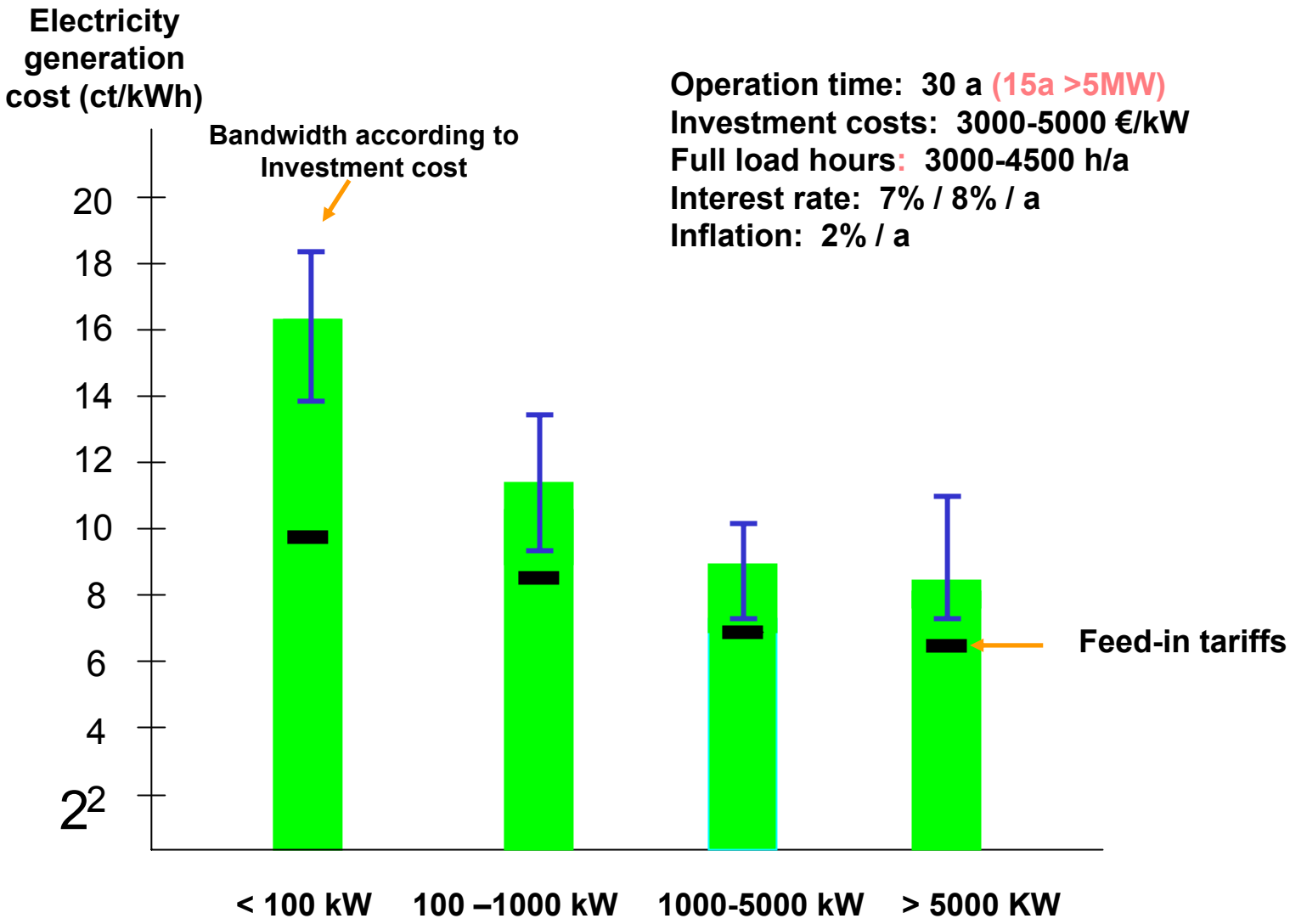
Investment cost (€/kW) for run of river plants in Germany



Source: Fichtner 2007

Dr. Martin Pehnt www.ifeu.de

Example Hydropower: ex post evaluation of 2006 tariffs



Dr. Martin Pehnt www.ifeu.de

2009 Tariffs: Systems < 5 MW

New systems	
P < 500 kW	12,67 Ct / kWh
500 kW < P < 2 MW	8,65 Ct / kWh
2 MW < P < 5 MW	7,65 Ct / kWh

Modernisation	
P < 500 kW	11,67 Ct / kWh
500 kW < P < 5 MW	8,65 Ct / kWh

2009 Tariffs: Systems > 5 MW

P < 500 kW	7,29 Ct / kWh
500 kW < P < 10 MW	6,32 Ct / kWh
10 MW < P < 20 MW	5,80 Ct / kWh
20 MW < P < 50 MW	4,34 Ct / kWh
P > 50 MW	3,5 Ct / kWh

Ecological requirements for getting the feed-in tariff

- A „high environmental status“ of the system or a significant environmental improvement
  - min. flow rates
  - Retaining capacity management (Stauraumbewirtschaftung)
  - Improvement of coastal structures
  - Biological passability
- New hydropower only
  - in combination with an existing barrage or
  - without continuous cross river structure

- In Peru: Social requirements?

Dr. Martin Pehnt www.ifeu.de

German discussions

2005 : Attemps to introduce quota failed

- Heavy protest from industry and RE operators

- Feed-in tariffs have proven in most European countries to be the most effective and efficient instrument to promote Renewable Electricity, because

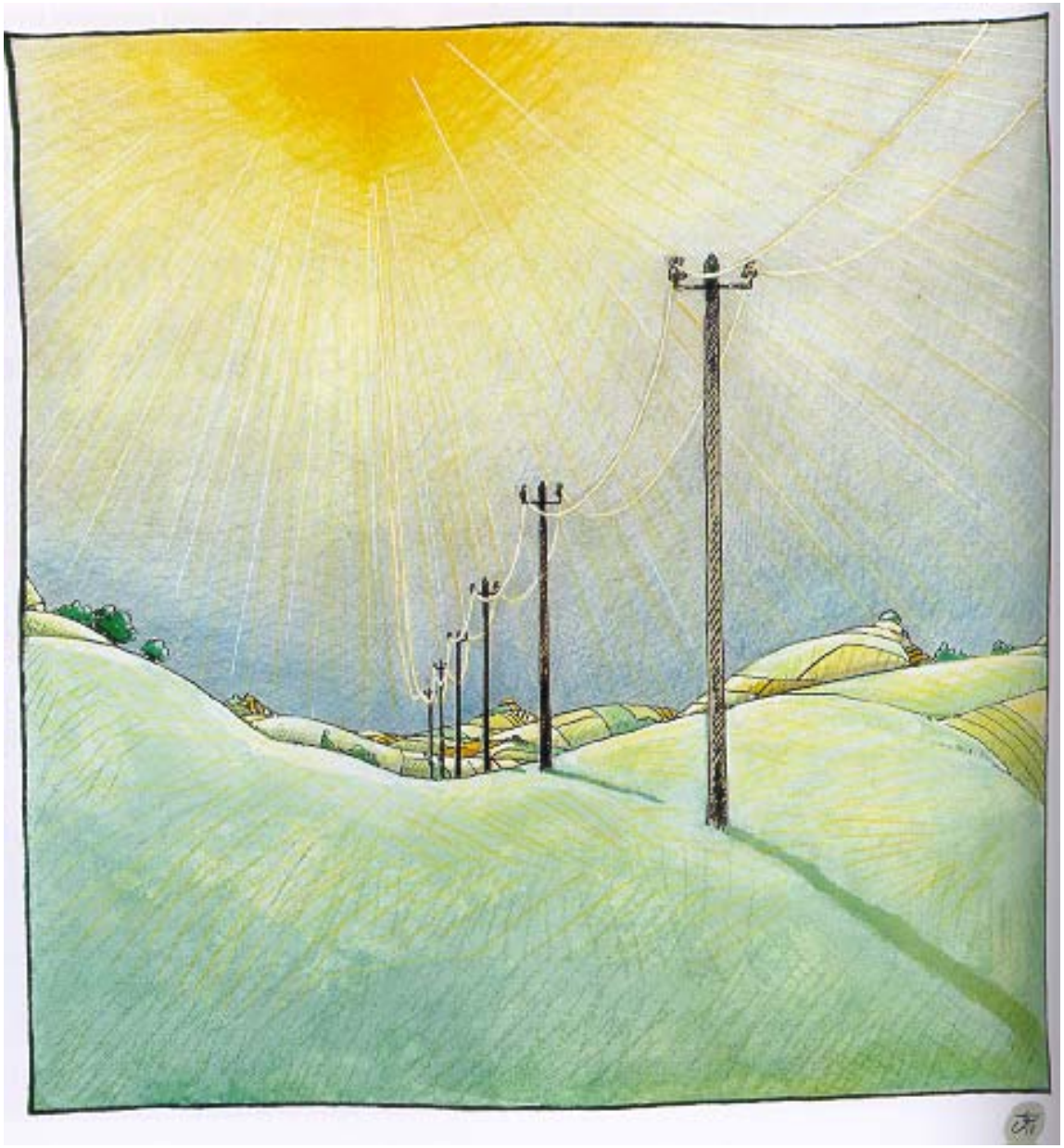
  - the prices are known; the investment risk is lower than for quotas/certificates;
  - different incentives for different technologies can be easily given;
  - Quotas/certificates support mainly large producers

2008 :

Discussion of optional direct marketing of RE and spanish model (spot market price plus fixed premium or cap and floor premium)

„The elegance of simplicity is often attractive, but in renewable energy policy it can lead to inferior outcome.“

(K. Mallon, 2006)



Comments and Questions on Peruvian Mechanism

- It is very good that Peru has taken action to implement a RE support mechanism!
- Question of understanding:
  - The RE operator gets the spot market price plus XX?
    - Is xx auctioned? Then there cannot be a technology specific premium, unless there are separate auctions for different RE
    - Are xx calculated tariffs?
    - Is the tariff only the cap?
- Creating a level-field seems a prerequisite for RE success and an adequate first step to make RE more economically attractive → remove natural gas subsidies (fuel subsidy and transmission cost for CCGT) (also important for large hydropower)

Comments and Questions (2): Terms and Definitions

- It is important to have a minimum target. But why a target ceiling?
  - What happens if the target ceiling is not achieved? Who is in charge? Penalties in case of (a) non-compliance and (b) non-delivery?
  - What happens if the target ceiling is exceeded? → Uncertainty for RE operators
  - The target should increase and not remain steady over 5 years
- What is the Article 5, „Premium and tariff will be calculated taking into account the different RERs“: differentiated according to technology or site or size?
- Is biogas, landfill gas, sewage gas, (mine gas) included in „biomass“?
- Grid connection: Preferred connection of RE only up to the target?

Comments and Questions (3): Auction

- **Why is the premium auctioned?**
  - **What is auctioned? Energy? Capacity?**
  - **How often are the auctions carried out?**
  - **How will varyiing energy output be coped with?**
  - **For how long is the premium guaranteed? Does it allow financial security for RE operators for many years?**
  - **Disadvantages**
    - **higher uncertainty for investors and financors**
    - **More complex**
    - **The enhanced risk increases the interest rates/the cost of the system**

Comments and Questions (4): Tariff design

- Should be kept simple
- Based on clear and reliable calculation procedure
  - My suggestion: based on average cost of RE installation and operation
  - Why not avoided cost from natural gas power plants?
    - If the main aim is to bring new systems into the market, only if there is economic incentive high enough RE systems will be built.
      - Either, avoided NG costs are too high → Windfall profits
      - Or, avoided NG costs are too low → no systems will be built
      - Or, avoided NG costs are appropriate → they should be („coincidentally“) the same as RE cost based tariffs
    - Ideally, NG subsidies should be eliminated
    - Any technology banding will be difficult
    - Long-term reliability and predictability?
- Technology banding yes, but only very limited categories, e. g. small hydro, wind, biomass and others
  - My recommendation: no site-specific tariff

Bidding procedure in Portugal

- Coexistence of feed-in and bidding
- Bidding two blocks of wind capacity, total 1500 MW
- Bids are evaluated based on credit point system (weighting)
  - Economic efficiency compared to a standard feed-in tariff (20%)
    - Maximum credit points, when 5 % below feed-in tariff
  - Contribution to development of local industry clusters (45 %)
    - Investments in less developed regions of the country
    - Job creation
    - Export volume
  - Technical management
  - Promoting innovation (e. g. R&D money)

„My personal favorite“ – first draft

- **Step 1: Remove NG subsidies. This increases the opportunity costs and will make part of the RE projects feasible without a premium**
- **Step 2:**

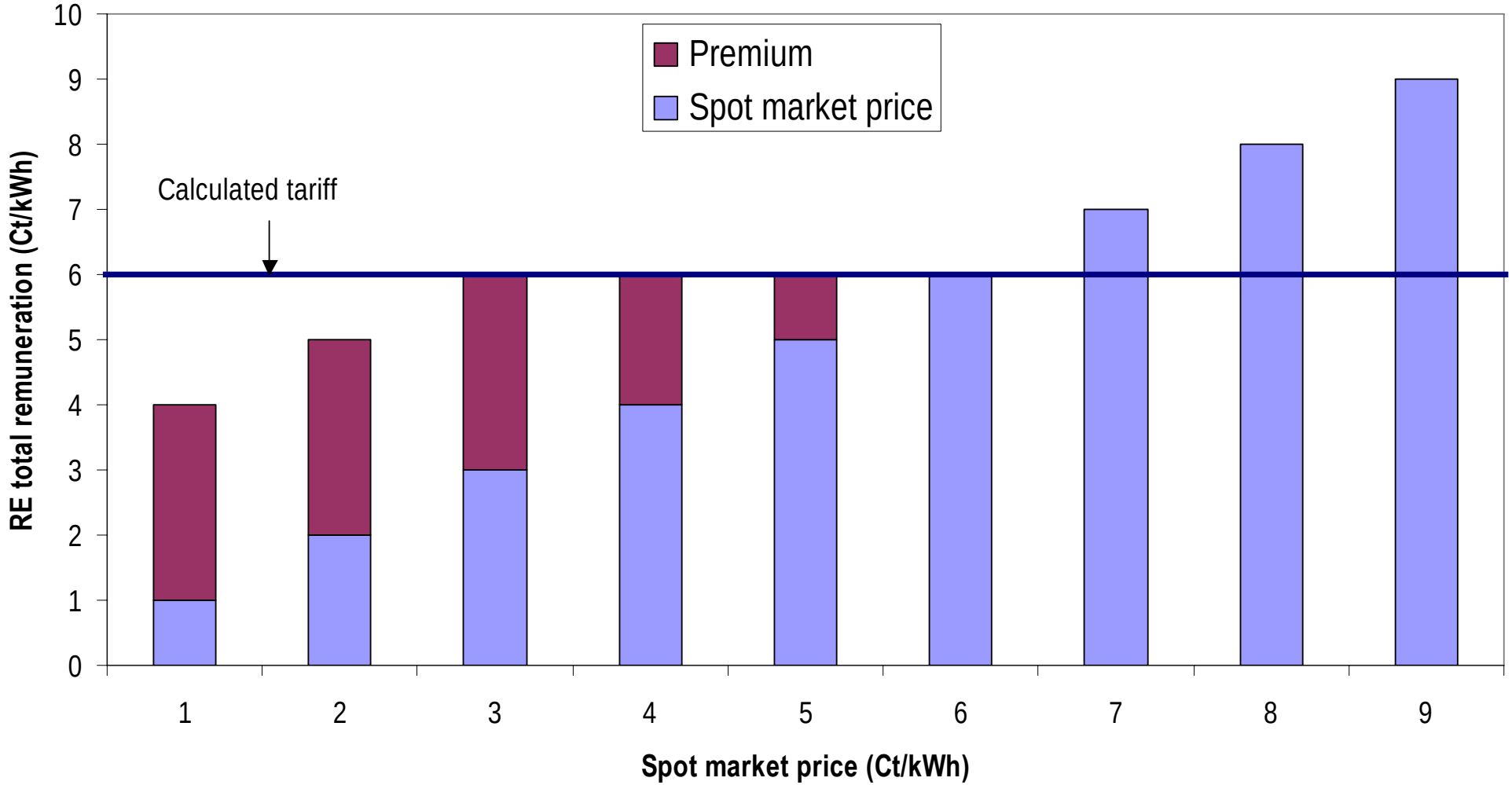
  Premium with cap (and possibly floor)

  Simple technology banding (small hydro, wind, others)

  Possibility to adjust premiums

  Simultaneously adjust planning procedure for RE systems to avoid time gap and remove other barriers

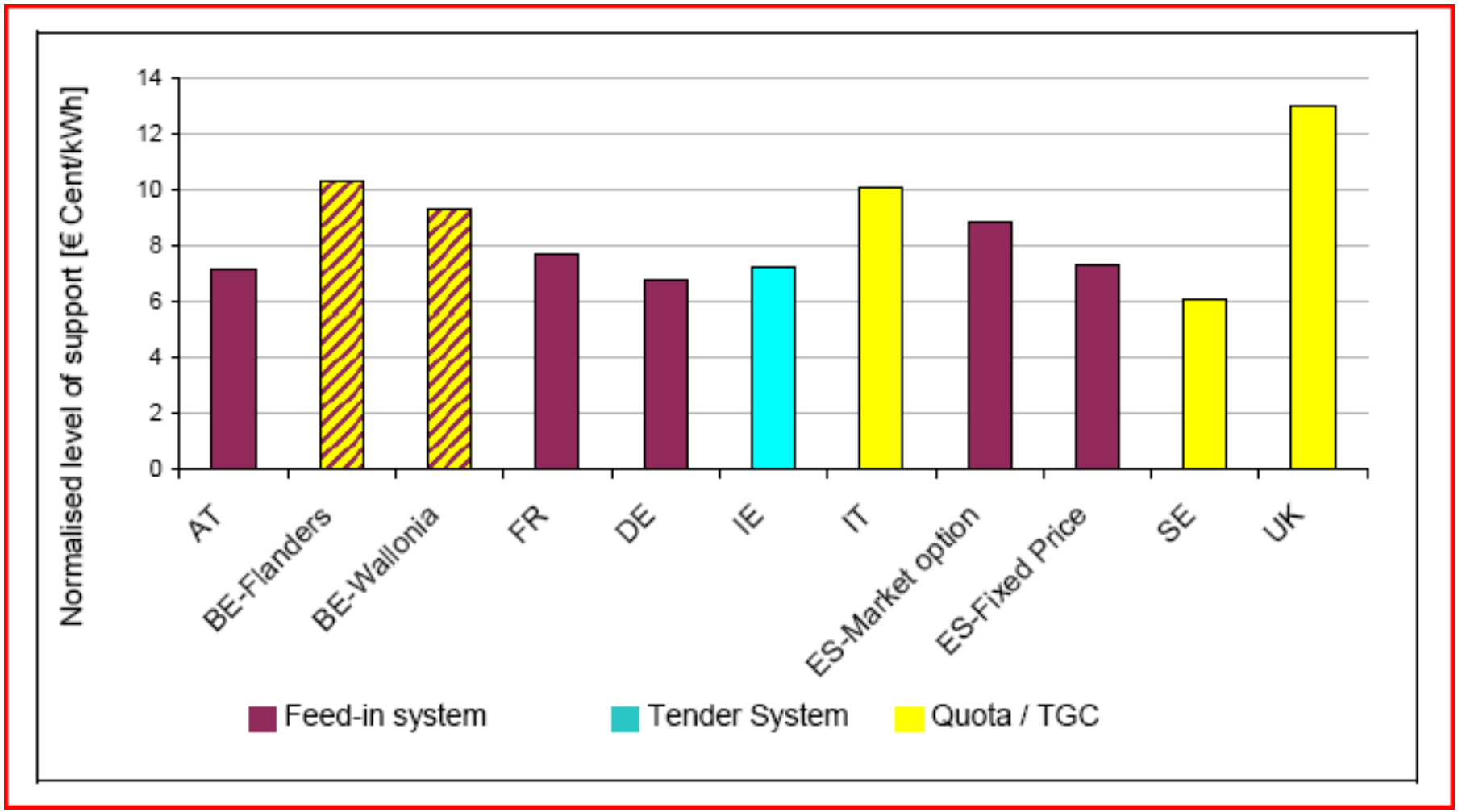
Support scheme (indicative numbers only!)



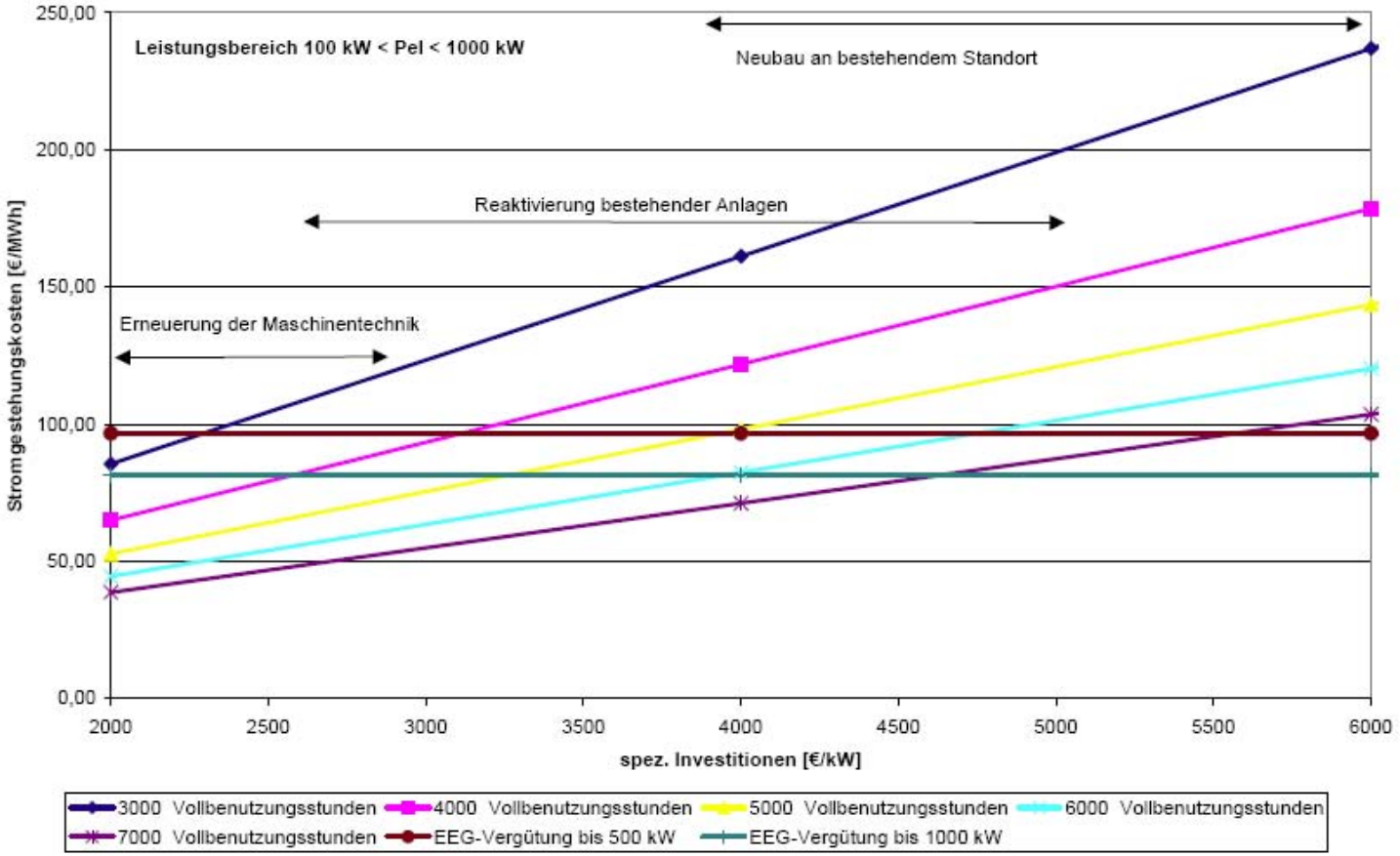
Dr. Martin Pehnt www.ifeu.de

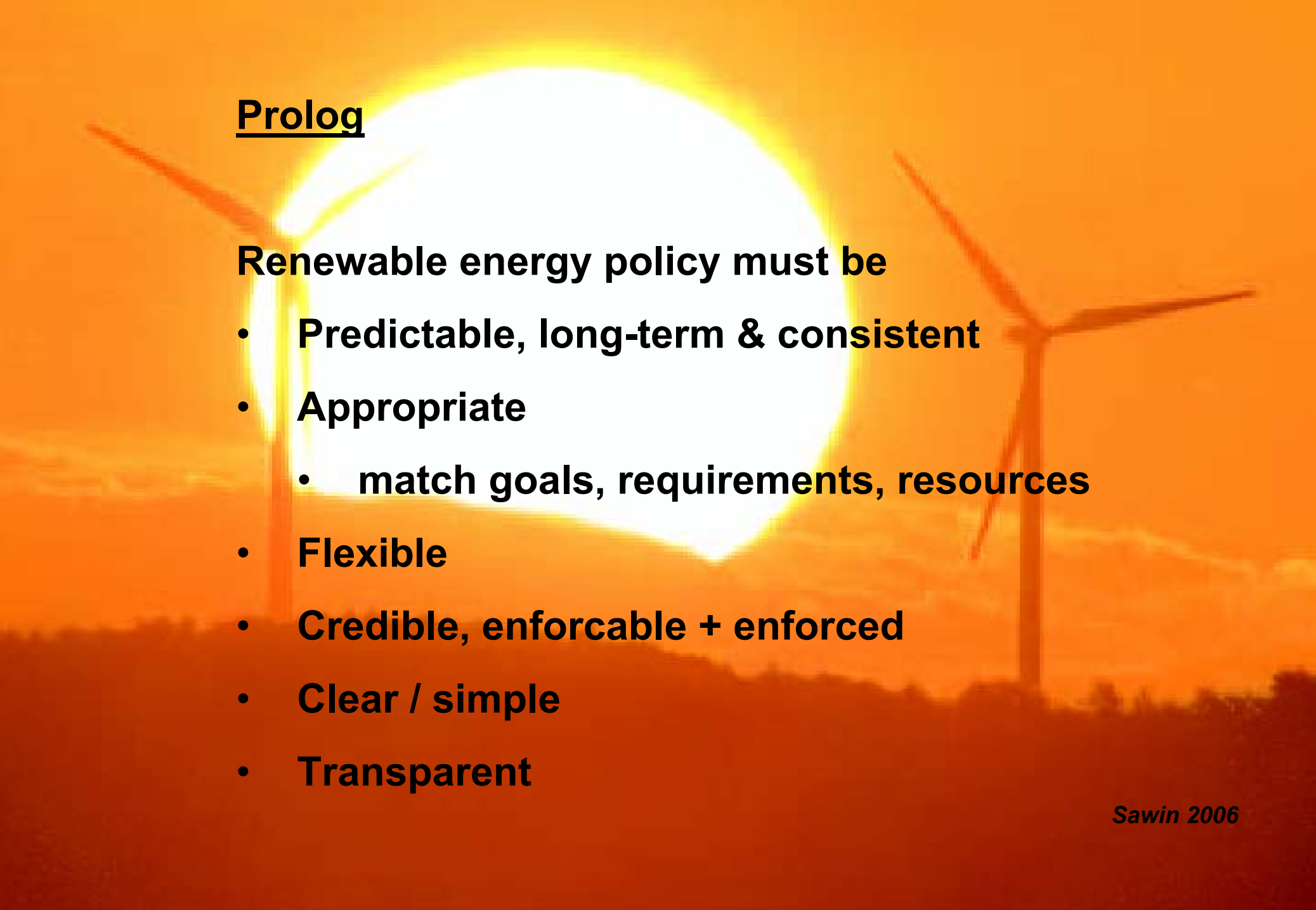
Evaluation criterion	Weighting	Sub-criterion	Weighting
1. Increased economic efficiency	20 %	Reduced tariffs for generated electricity	20 %
2. Development of industrial clusters	45 %	2.1. Direct investments by the project	11 %
		2.2. Indirect investments by the project	8 %
		2.3. Direct employment created	11 %
		2.4. Indirect employment created	8 %
		2.5. Gross turnover of the industrial clusters	7 %
		2.6. Sustainability of the project (project reliability, project stability, export volume)	multiplicative factor to the sub-criteria 2.2
3. Technical management of the project	25 %	3.1. Technical management of the wind parks	10 %
		3.2. Technical management of the turbine production	2.5 %
		3.3. Storage capacities for generated electricity	7.5 %
		3.4. Additional measures for voltage control	2.5 %
		3.5. Cooperation regarding frequency regulation	2.5 %
4. Innovation promotion	10 %	Innovation promotion	10 %

Level of Support in Different Support Schemes



ISI (2006)


Leistungsbereich 100 kW < Pel < 1000 kW
Neubau an bestehendem Standort
Reaktivierung bestehender Anlagen
Erneuerung der Maschinentechnik
Stromgestehungskosten [€/MWh]
250,00
200,00
150,00
100,00
50,00
0,00
2000
2500
3000
3500
4000
4500
5000
5500
6000
spez. Investitionen [€/kW]
3000 Vollbenutzungsstunden
4000 Vollbenutzungsstunden
5000 Vollbenutzungsstunden
6000 Vollbenutzungsstunden
7000 Vollbenutzungsstunden
EEG-Vergütung bis 500 kW
EEG-Vergütung bis 1000 kW



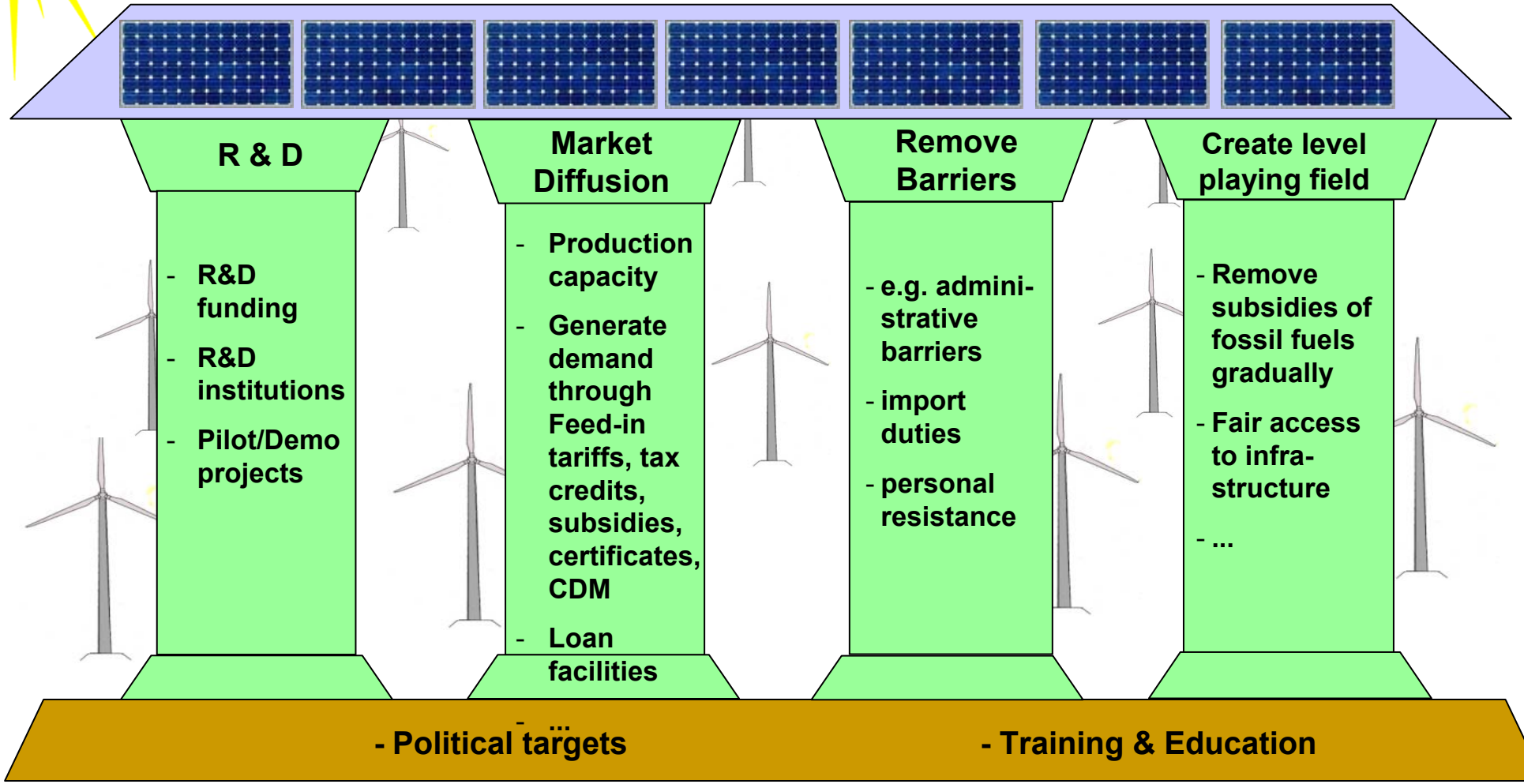
Prolog

Renewable energy policy must be

- Predictable, long-term & consistent
- Appropriate
  - match goals, requirements, resources
- Flexible
- Credible, enforcable + enforced
- Clear / simple
- Transparent

Sawin 2006

The Columns of Renewable Energy (RE) Support



Good Fundament

based on Langniss 2007 and own presentation

Financial support of RE electricity: Prices versus quantities

Price based

1. **Feed-in tariffs (FIT):**

   The price is set (guaranteed tariff), the quantity develops on the market

2. **Fiscal incentives**

3. **Investment grants**

Quantity based

1. **Competitive bidding/tender:**

   A market share is auctioned to the cheapest RES producers

2. **Green certificates:**

   RES quantity is set and has to be proven by (tradable) certificates

Assumptions for calculating hydropower tariffs

		Leistungs bereich < 100 kW	Leistungs bereich 100 kW < Pel < 1000 kW	Leistungs bereich 1000 < Pel < 5000 kW	Modernisierung und Erweiterung Leistungsbereich > 5000 kW	ökologische Ausgleichs-maßnahmen ohne Erzeugungs-verluste
		50 kW	1000 kW	5000 kW	20000 kW	
BASISDATEN						
Kalkulat. Betrachtungsdauer	a	30	30	30	15	30
Kalkulat. Mischzinssatz (real)	%/a	5	6	6	6	5
Inflation	%/a	2	2	2	2	2
Kalkulat. Mischzinssatz (nominal)	%/a	7	8	8	8	7
Spez. Personalkosten	T€/a	50	50	50	50	
Spez. Instandhaltungskosten	%/a	1,8	1,5	1,1	0,8	1
Spez. Kosten Versich., Verwaltung, Pacht	%/a	0,5	0,5	0,5	0,5	0,5
Spez. sonstige variable Kosten	€/MWh(el)	3,5	2,9	2,7	2,5	

Source: Fichtner 2007

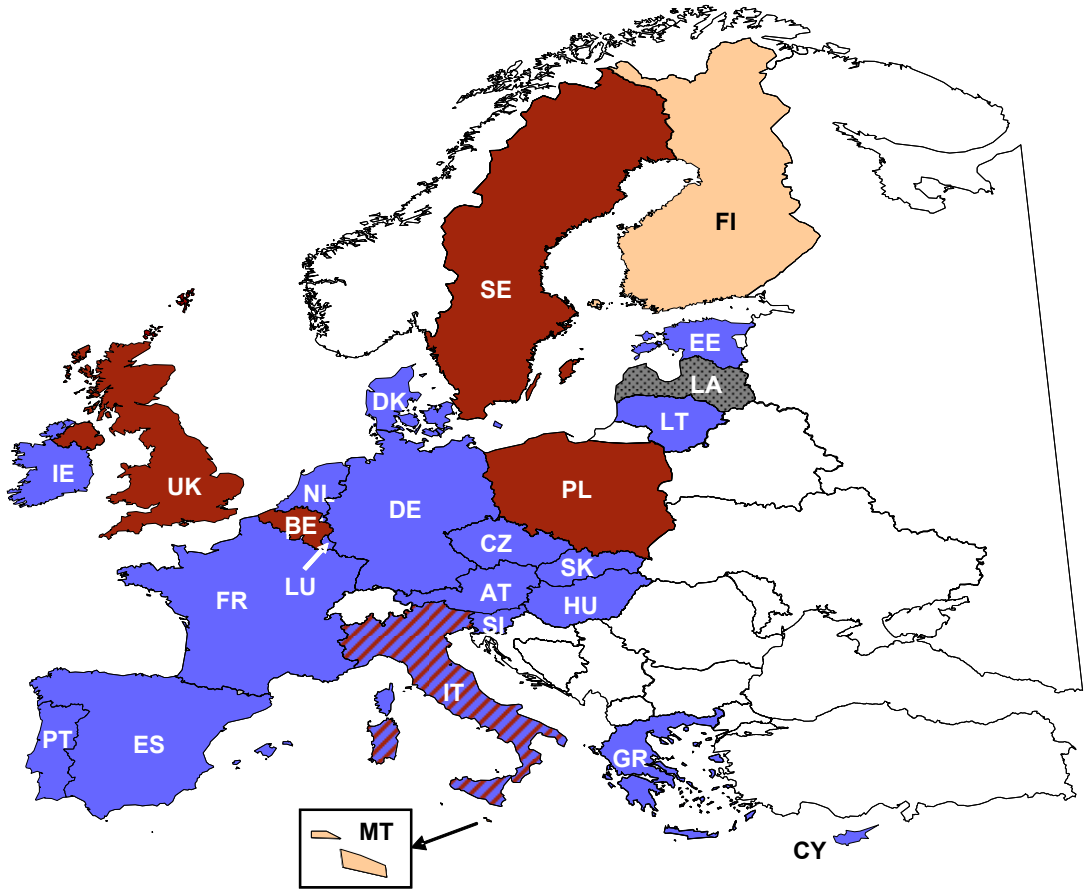
Experiences from bidding / tenders

- Use of lowest cost resources, i. e. geographically best resources
- Often larger scale, centralised projects

  Grid issues?

  Acceptance? Integration of local people?
- Adequate penalties in case of non-compliance and non-delivery
- No time gaps between bidding (no stop & go)
- Implement integrated planning
- Example NFFO (UK)
  - approval by local authority after bidding
  - stronger steerage and rules for local planning authorities necessary, e. g. marked out areas for wind developement

RE Electricity Support in Europe



- Feed-in tariff
- Quota / TGC
- Feed-in tariff and Quota / TGC
- Tax incentives / Investment grants
- Other system

A clear majority of EU countries uses feed-in tariffs as main instrument

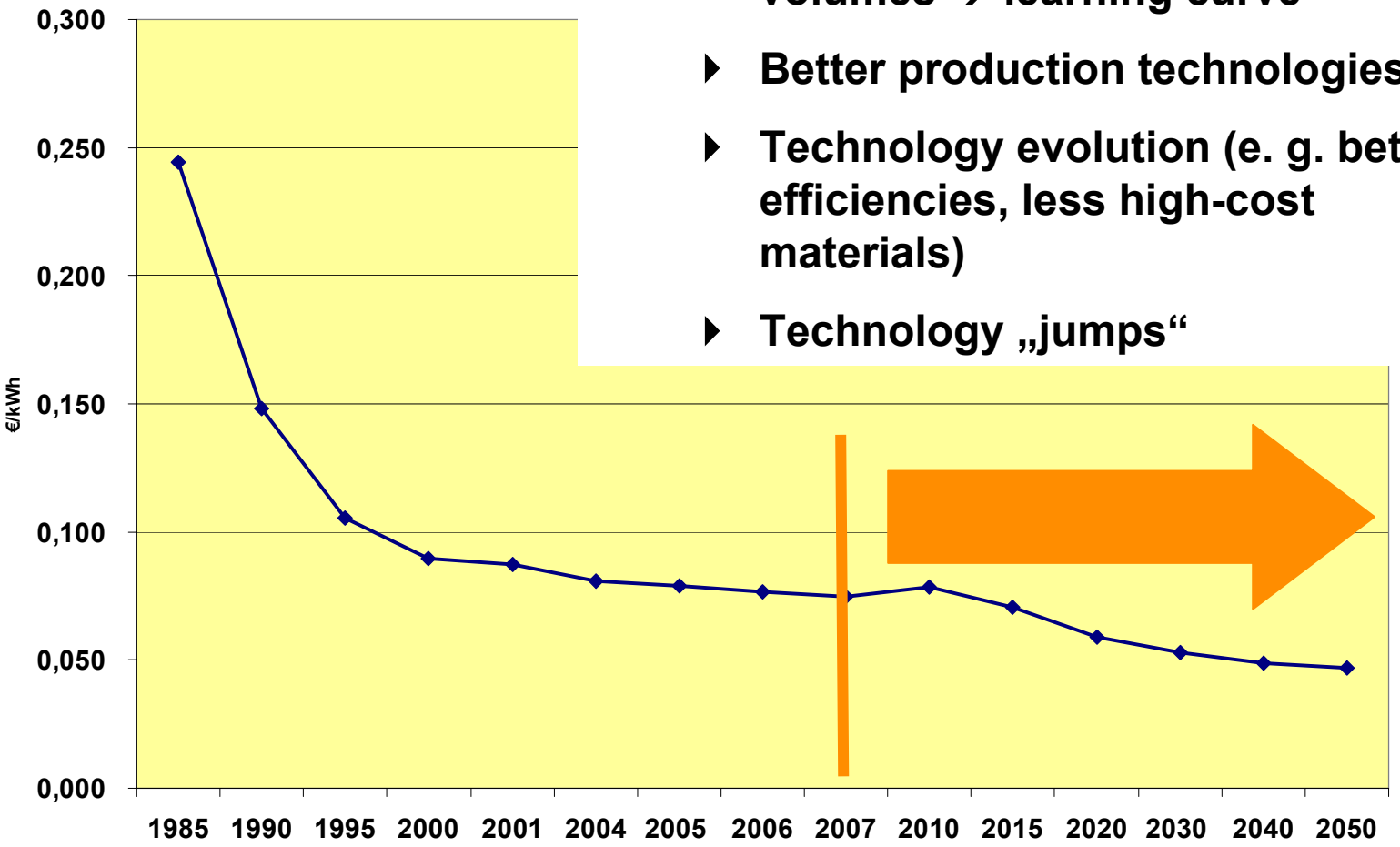
Plus > 30 States worldwide

Ragwitz (2006)

TGC Tradable Green Certificates

Cost development – wind (€$_{2000}$/kWh)

- Series production, high market volumes → learning curve
- Better production technologies
- Technology evolution (e. g. better efficiencies, less high-cost materials)
- Technology „jumps“



Lehr 2007

Dr. Martin Pehnt www.ifeu.de