

# **Development of Market and Cost of Small Hydropower Plants in Germany (up to 5 MW)**

**Results of a report on behalf of the  
German Federal Ministry for Economics**

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## Background

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### **Study of the Markets and the Costs- related to the Use of Renewable Sources of Energy**

The aim of the German Renewable Energies Act (Erneuerbare-Energien-Gesetz – EEG), which went into effect on 1 April 2000, is to promote the expansion of renewable sources of energy for the generation of electricity as a key element in protecting the climate and achieving a sustainable development. EEG obliges grid operators to buy electricity generated by the technologies to utilise renewable sources of energy covered by this Act at fixed rates of reimbursement.

As ISET's contribution to the preparation of the report required by Sec. 12 EEG, the status of the market launches and the cost development of systems for generating electricity within the meaning of Sec. 2 EEG are to be analysed on behalf of the German Federal Ministry for Economics. This was a joint project with the Institut für ökologische Wirtschaftsforschung (IÖW = Institute for Ecological Business Research). ISET was responsible for the fields of wind power and hydropower.

As part of these market analyses, the profitableness of various technologies, which take into consideration the relevant subsidy and fiscal aspects, will also be examined.

## Content of the complete report

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- Overview and general situation of renewable energies in Germany
- separate reports on photovoltaics, bio energy, wind energy, hydropower, geothermal electricity production with
  - a brief description of the technology
  - available resources
  - development of the market (national, import/ export, business volume, employment)
  - development of the cost
- development of the market for green electricity

published as book:

*Markt- und Kostenentwicklung erneuerbarer Energien. 2 Jahre EEG - Bilanz und Ausblick*, Erich Schmidt Verlag, Berlin 2002

Authors: Hirschl, Bernd; Hoffmann, Esther; Zapfel, Björn; Durstewitz, Michael; Hoppe-Kilpper, Martin; Bard, Jochen

## **Development of Market and Cost of Small Hydropower Plants in Germany (up to 5 MW)**

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- **brief description of historical development**
- **recent development**
- **relevant legislation (StrEG and EEG)**
- **business volume and employment**
- **cost and profitability**
- **summary and comments**

## historical development

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<b>19. cent.</b>	<b>60.000 to 70.000 water wheels as power source for small enterprises, mills, etc.</b>
<b>1849</b>	<b>Invention of Francis turbine</b>
<b>1890</b>	<b>Pelton turbine</b>
<b>1913</b>	<b>Kaplan turbine</b>
<b>1925</b>	<b>37.000 water wheels and 21.000 turbines in operation more than 50% of the total capacity of the installed turbines of 1.400 MW is used for electricity production. mean power of turbines 65 (kW), mean power of water wheels 6 kW.</b>
<b>1980</b>	<b>only 2.000 mills left (after „Mühlensterben“)</b>
<b>1985</b>	<b>about 13000 existing water rights, 2/3 of sites below 25 kW</b>
<b>after this</b>	<b>trend reversal for private sites (not electricity boards)</b>

## status of total hydropower utilisation in Germany in 2000

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eb = electricity boards

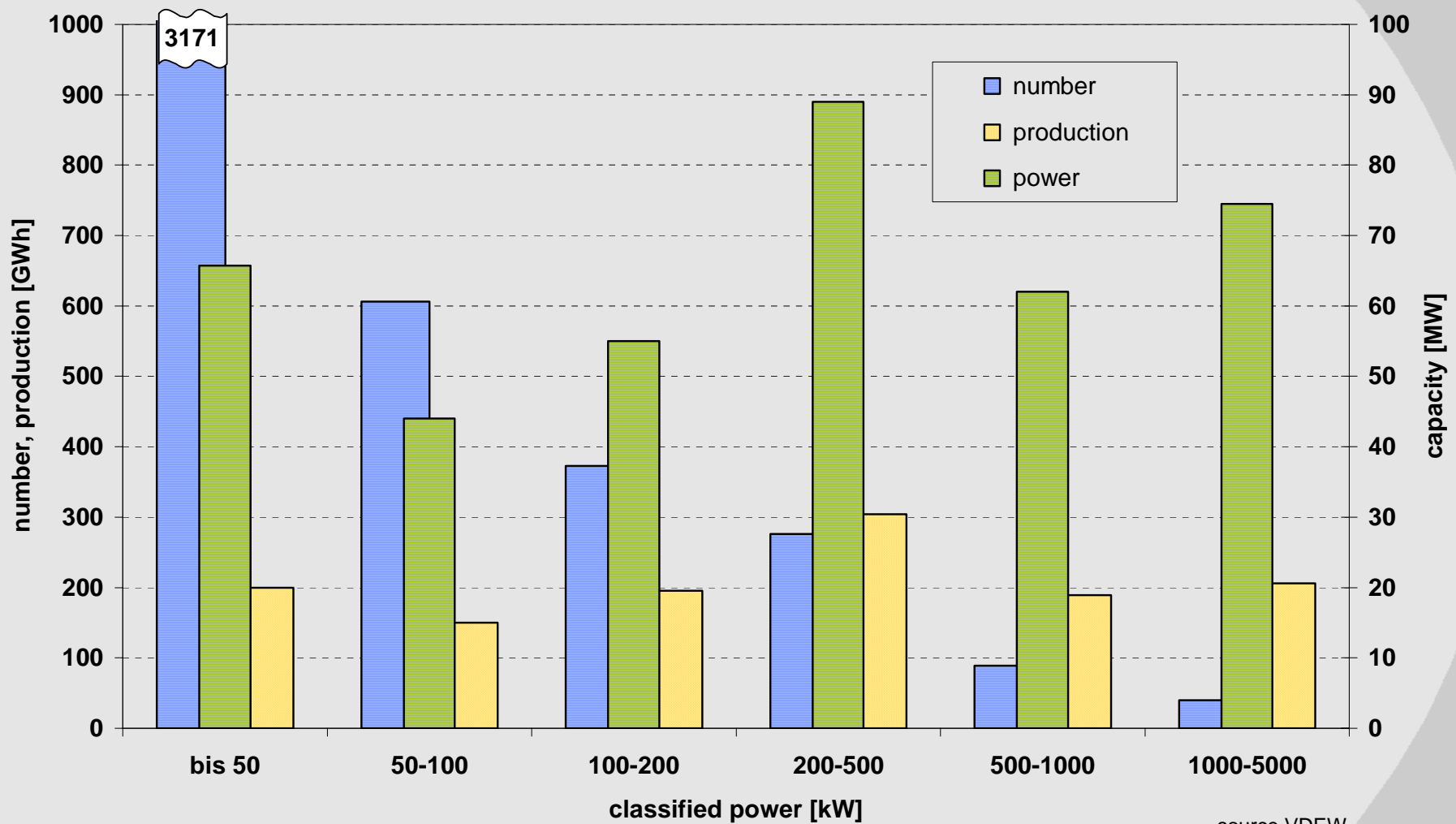
		owned by eb
installed capacity:	4900 MW	82 %
production:	20 bill. kWh	90 %
number of plants:	ca. 6250	10 %

sites below 5 MW

(proportion of total)

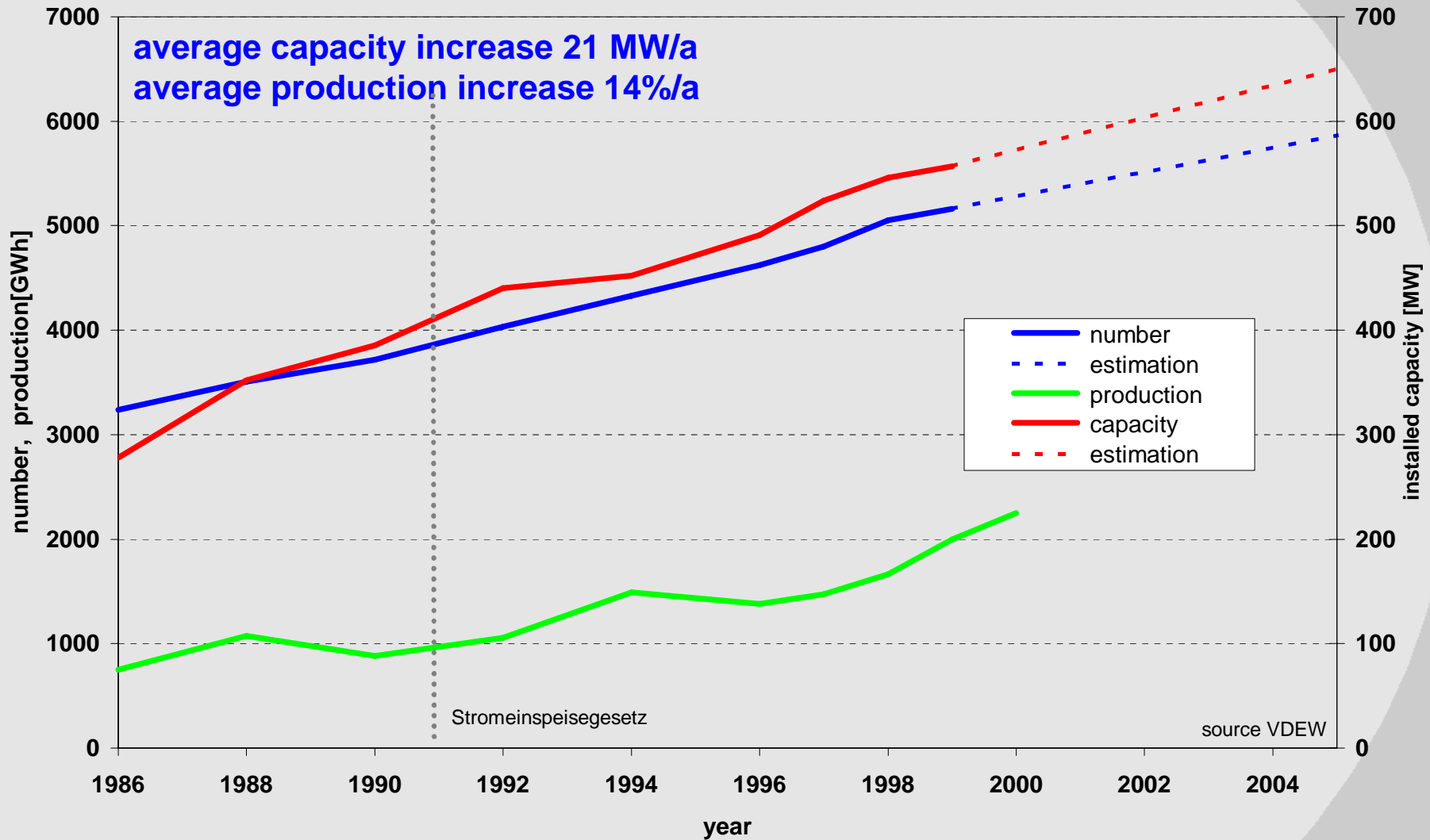
			owned by eb
installed capacity :	1200 MW	24 %	50 %
production :	5,3 bill. kWh	25 %	57 %
number of plants :	ca. 6000	95 %	7 %

## distribution of private hydropower plants in 1996 (without ebs)

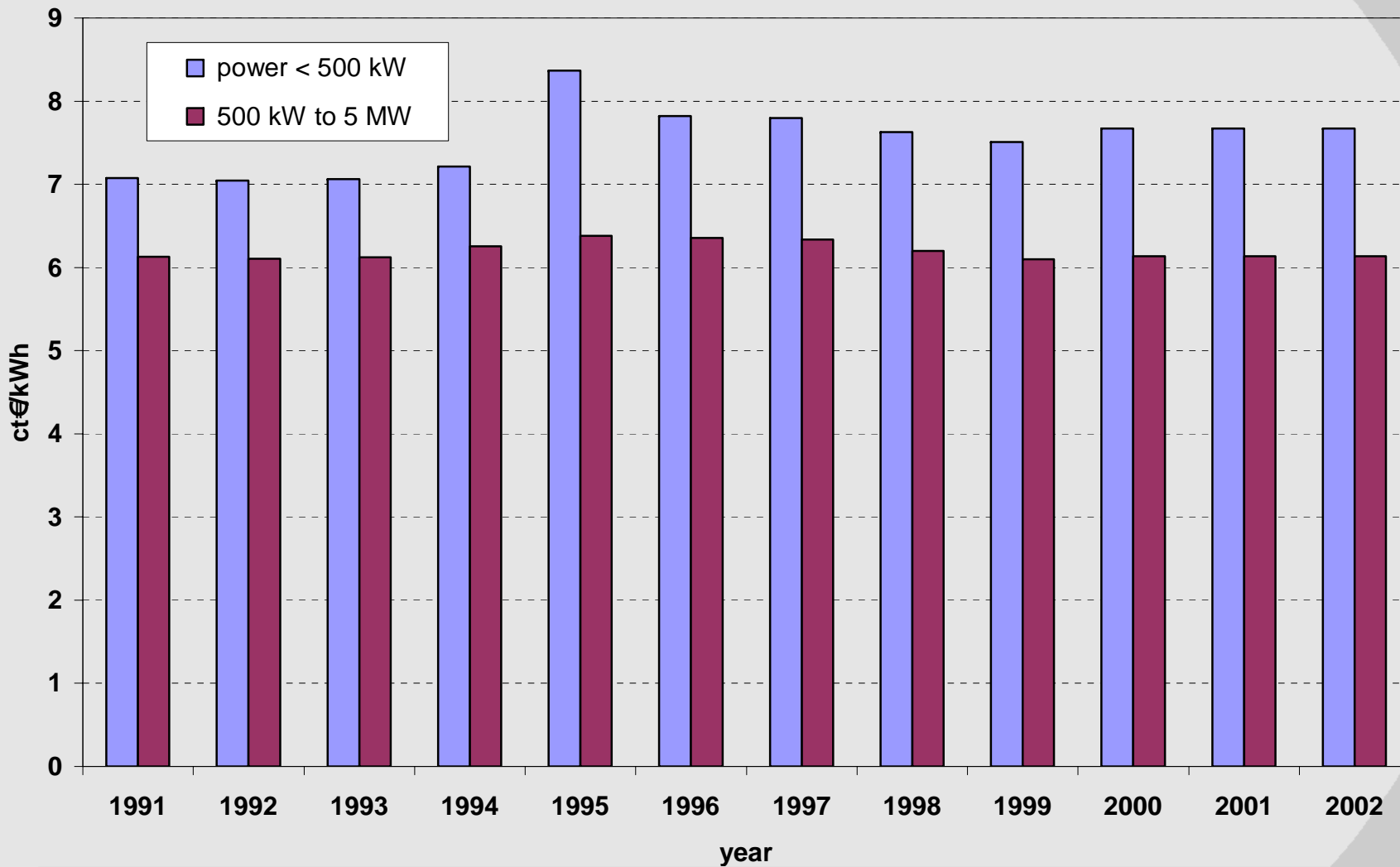


source VDEW

## development of installed capacity (< 5MW) between 1986 and 2000 (without ebs)



## price for sale to the grid (StreG, EEG)



## estimated business volume and employment

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assumption: 20 MW/a of new capacity at cost of 5000 €/kW

total turnover about 100 Mil. €/a, thereof

30 Mil. €/a for manufacturers, equals ca. 240 employees

50 Mil.€/a for civil engineering, equals ca. 530 employees

15 Mil.€/a for other components, planning, etc. ca. 120 employees

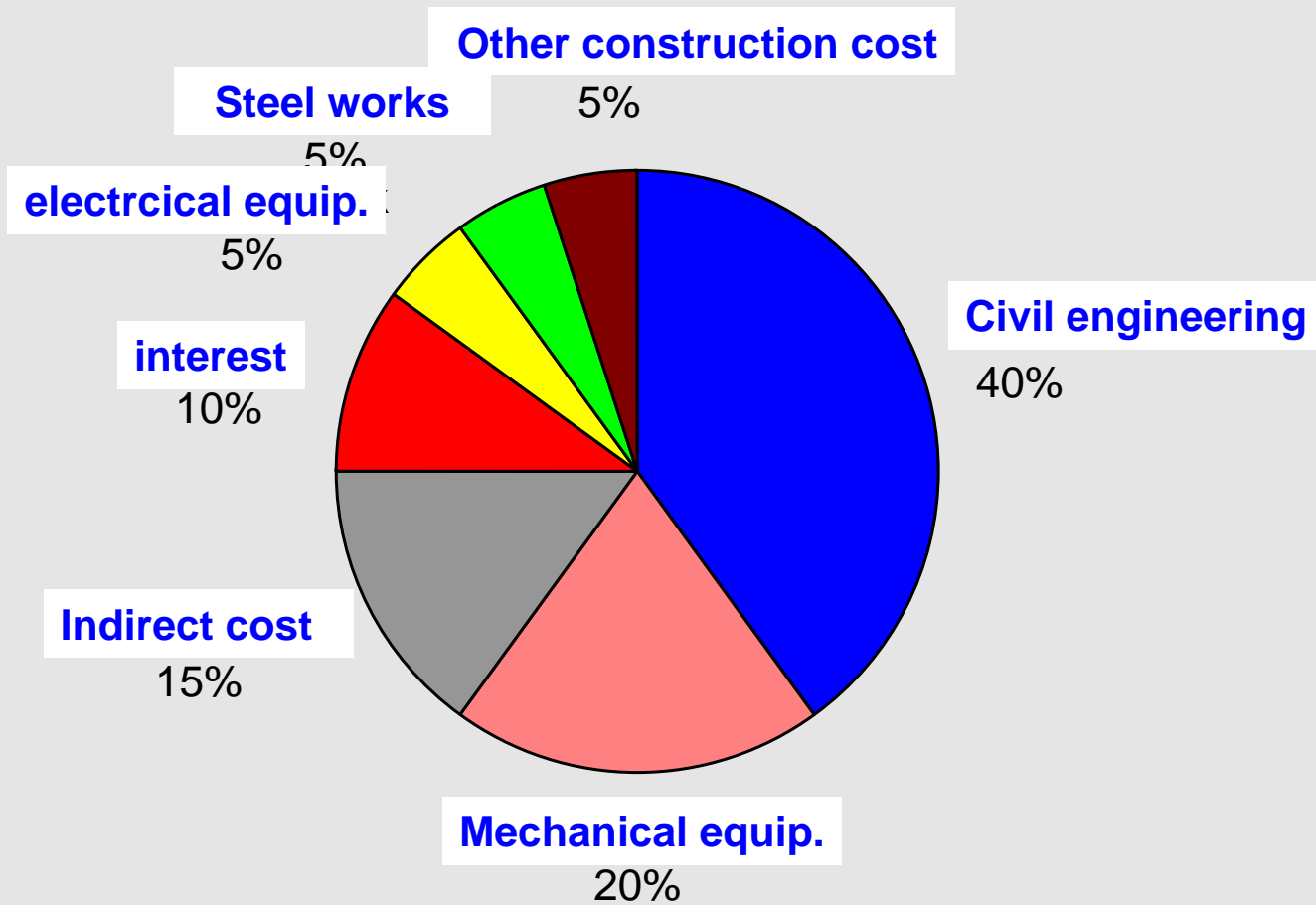
total ca. 890 employees

operation and maintenance for all plants (< 5MW)

estimated total volume ca. 120 Mil. €/a ca. 1200 employees

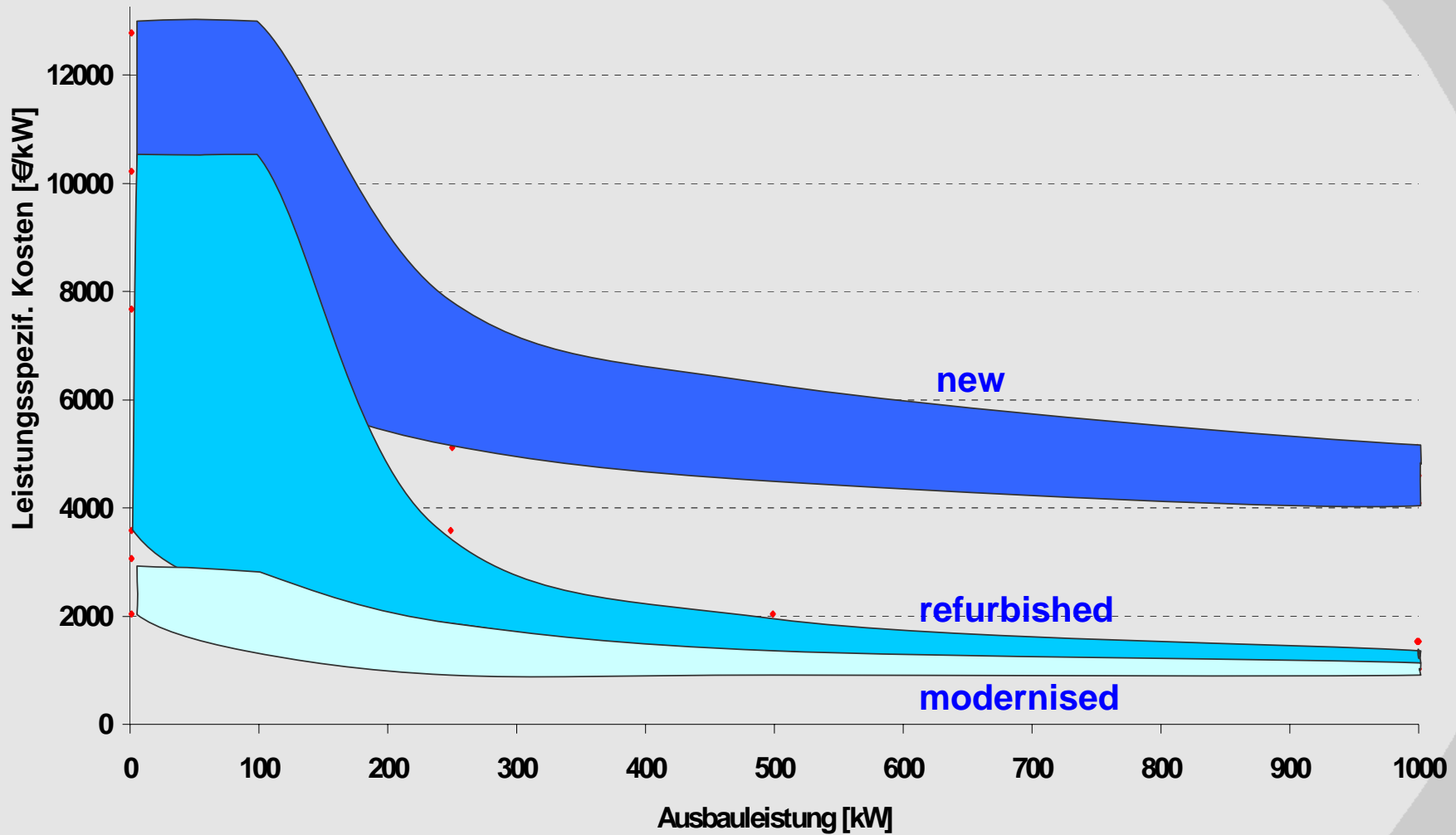
**total annual business volume in Germany** 220 Mil. €/a  
**equivalent employment aprox.** 2000 employees

## typical distribution of investment cost for SHP plants



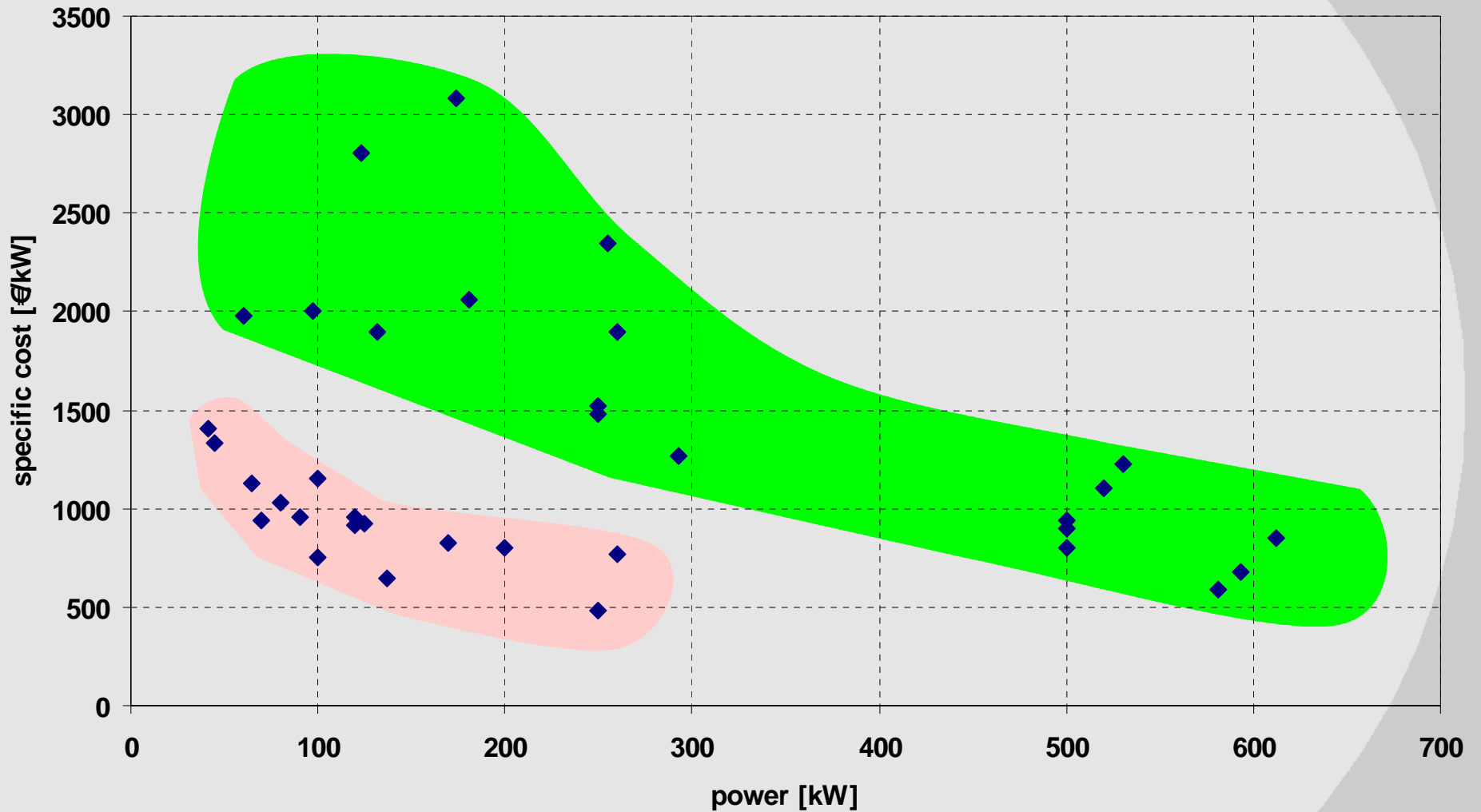
source: Giesecke

## specific investment cost for hydropower plants



source: VDI

## specific turbine cost



## basics of the economic calculations

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electricity cost (€/kWh) = annual cost (€/year) / mean annual production (kWh)

annual cost = capital cost (annuity) + O&M cost

O&M cost: ca. 2,5 to 4 % of total investment cost /a

chosen percentage O&M : 3,1 % of total investment cost /a

capital cost according annuity method:

economic span of life: 20 years

internal rate of return 7,8%

→ annuity 10,03 %/a of total investment cost

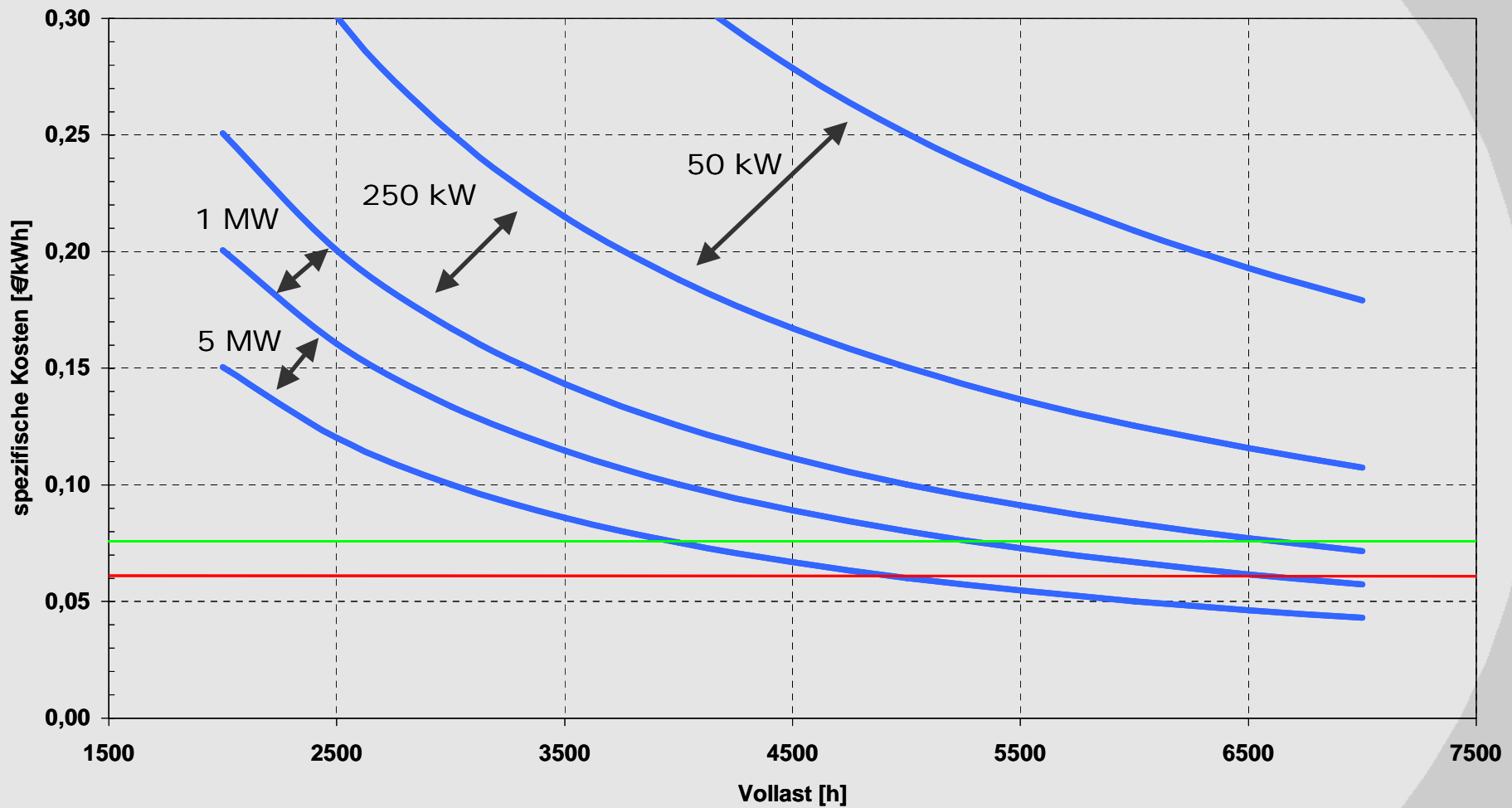
→ total annual cost = 13,13 %/a of total investment cost

$$Ann. = \frac{(1+p)^t \cdot p}{(1+p)^t - 1}$$

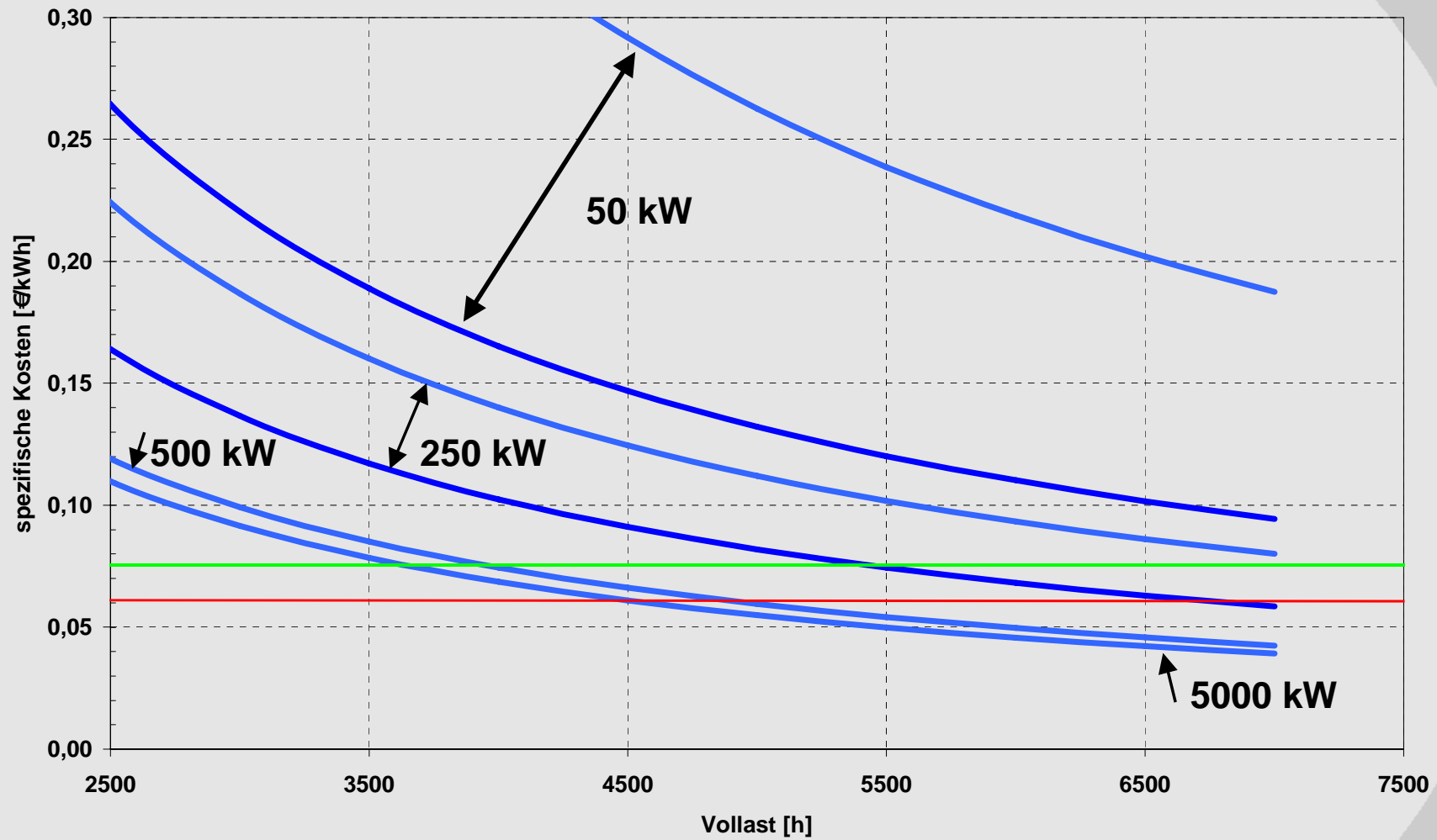
annual revenues (€): annual production (kWh) x tarif (€/kWh)

tarifs of EEG: 7,67 ct/kWh up to 500 kW and 6,65 ct/kWh up to 5 MW

## electricity cost for new built hydropower plants



## electricity cost for refurbishment of sites



## summary and comments

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- **EEG allows to continue the SHP exploitation trend**  
**by defined electricity rate**
- **currently no investment funds available**
- **current electricity rate not sufficient for feasible operation**  
**of micro schemes (<50 kW)**
- **5 MW-limit frustrates modernisation of larger plants**
- **strong regional differences in hydropower resource**  
**require compensation among electricity boards**
- **increasing environmental requirements cause increasing cost**
- **resources allow for further exploitation**