

Determination of Tariffs for Wind Power in the German Renewable Energy Act

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Cost Determination – Principles in German Renewable Energy Act

Four-year revision cycle

Cost based price setting

**Cost determination ex-post via evaluation of realised power plants
by independent consultants**

Including evaluation of cost development over time

**Supplemented by expert judgements,
particularly on future progress**

Determination of average costs and cost ranges

Cost Determination – Calculation Base

Nominal Levelised Electricity Generation Costs

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

$$\text{Annuity} = \underbrace{\sum_{t=0}^T (I_t + OM_t)(1+r)^{-t}}_{\text{Present Value of Life cycle costs}} \cdot \underbrace{\frac{r \cdot (1+r)^T}{(1+r)^T - 1}}_{\text{Annuity Factor}}$$

Life Time (points to T)
Investment (points to I_t)
Operation & Maintenance Costs (points to OM_t)
Interest Rate (points to r)

German Wind Power 2011 Review - process

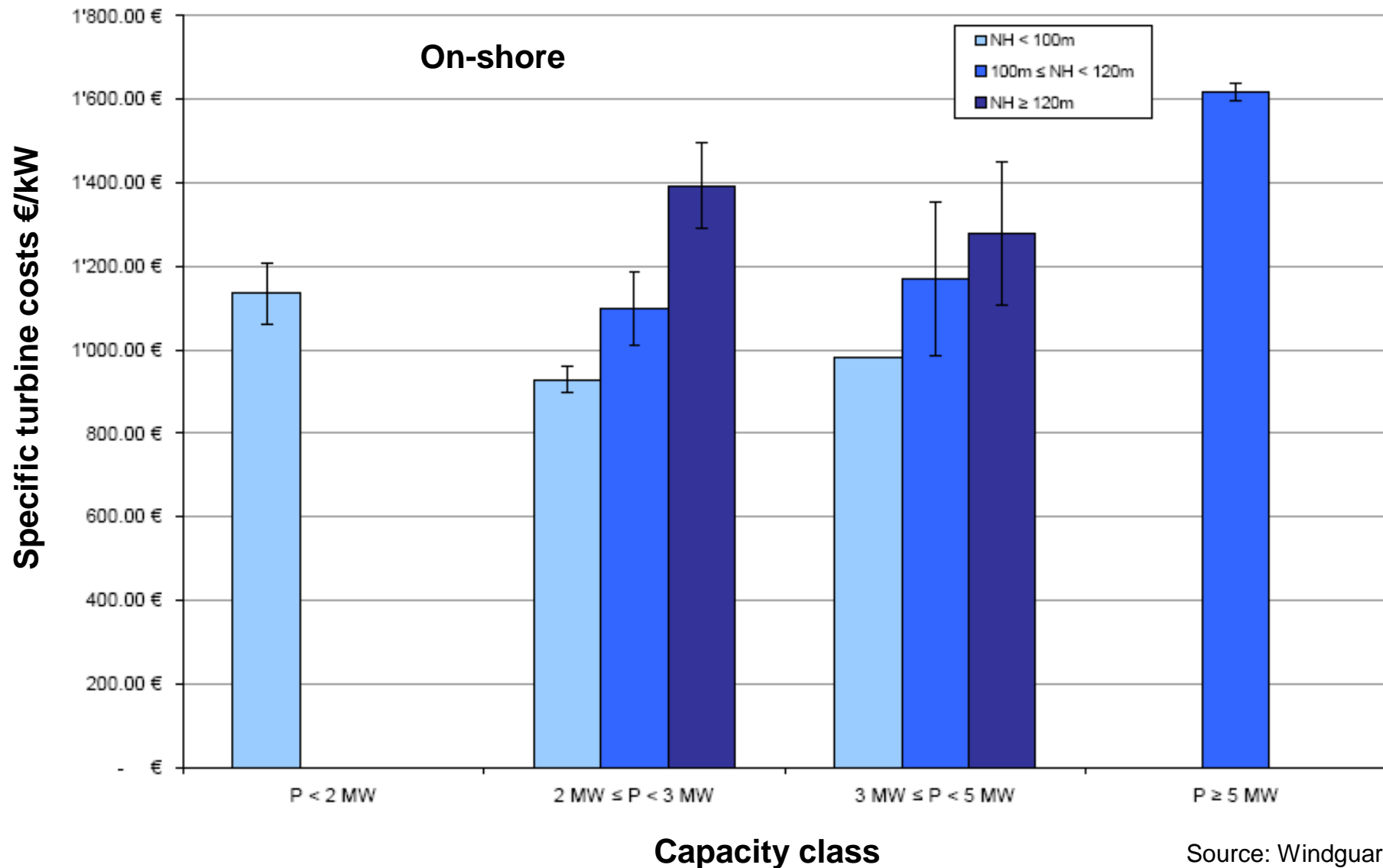
Report by independent consultant Windguard

Data sources for costs

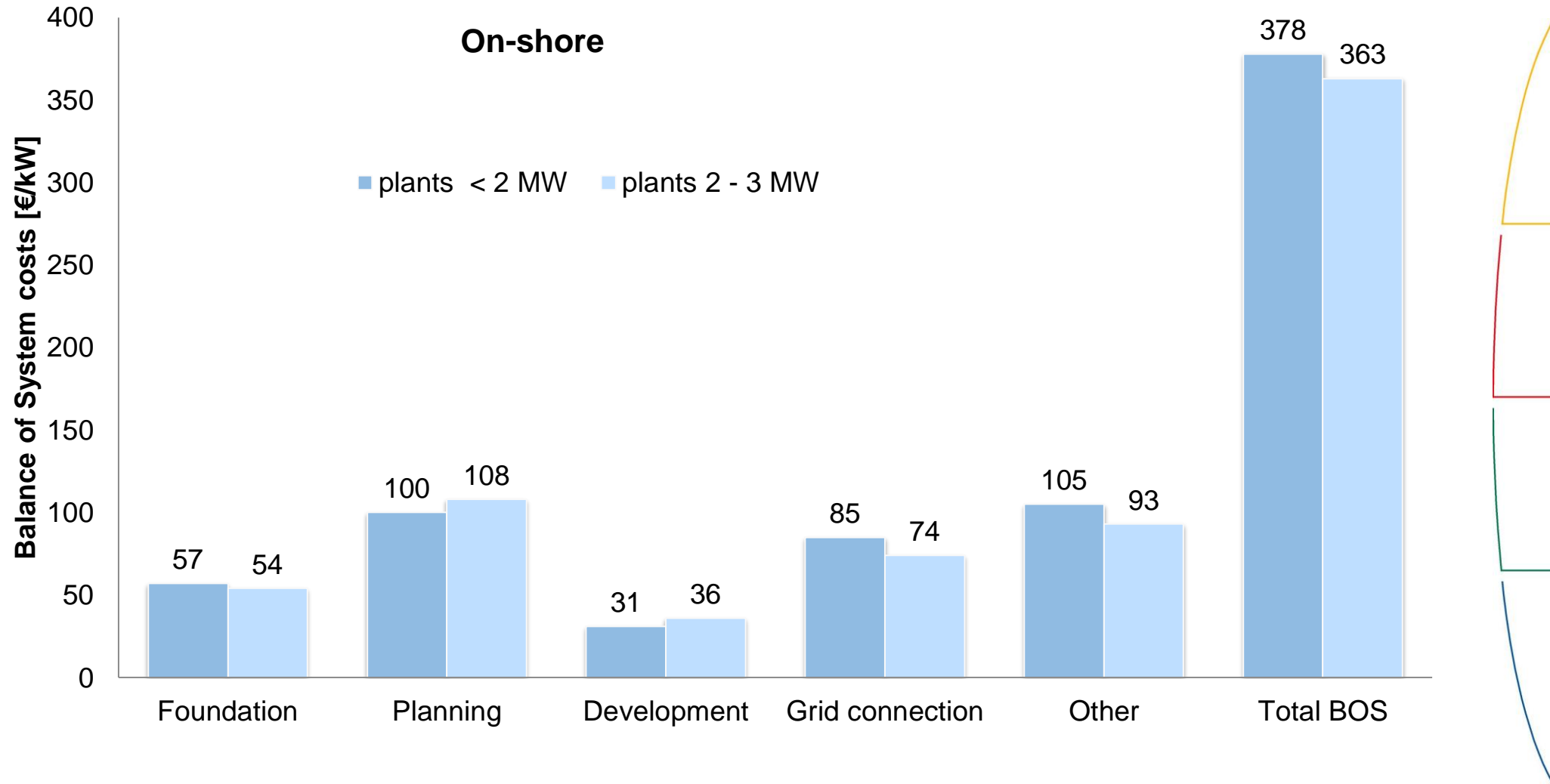
- **survey among plant manufacturers in two cycles (2010, 2011)**
→ **23 different turbine types (800 kW – 5 MW)**
- **survey among plant developers and operators on wind power onshore**
→ **data on 80 wind farms with 690 MW**
- **survey among plant developers on wind power offshore**
→ **data on 16 wind farms with 2400 MW**

Content: e.g. year of commissioning, turbine type, total capacity, guarantee term, investment costs, balance of system costs, operating costs by operation year

German Wind Power 2011 Review – results of survey



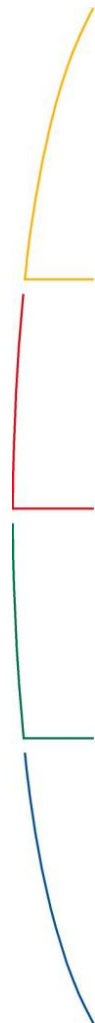
German Wind Power 2011 Review – results of survey



Source: Windguard 2011

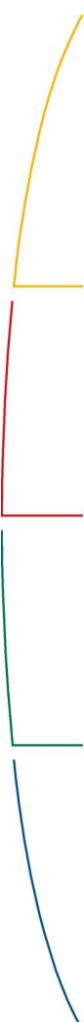
German Wind Power 2011 Review – parameters onshore

Investment Costs Plant:	Depending on turbine capacity and hub height 973 – 1393 €/kW
Balance of System Costs:	363 €/kW
O&M Costs:	1st 10 yrs: 2.19 €/kWh 2nd 10 yrs: 2.49 €/kWh
Inflation rate:	2 %/yr
Interest rate:	Equity 12 % (25 % share) Debt 5,5 % (75 % share) ➔ Weighted Average Cost of Capital 7,125 %



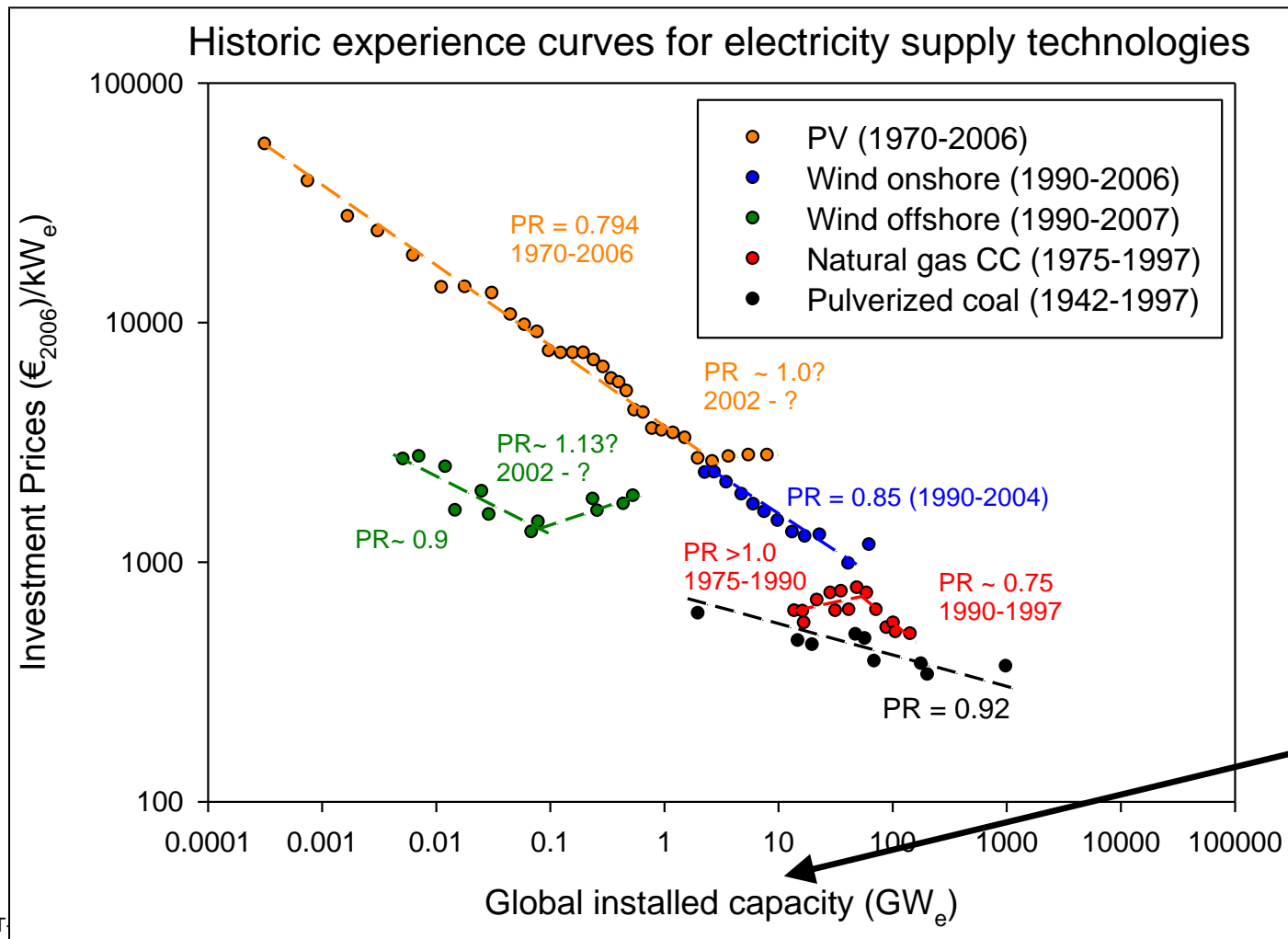
Calculated Costs of Wind Power

Site quality	% of reference site	60%	80%	100%	120%	150%
Specific energy yield	kWh/m ² /a	610	810	1030	1170	1460
LEC	Ct/kWh	11.84	9.53	8.33	7.16	6.25



Cost degradation

Renewable energy technologies usually features large cost reduction potentials → New plants are generating cheaper than existing plants

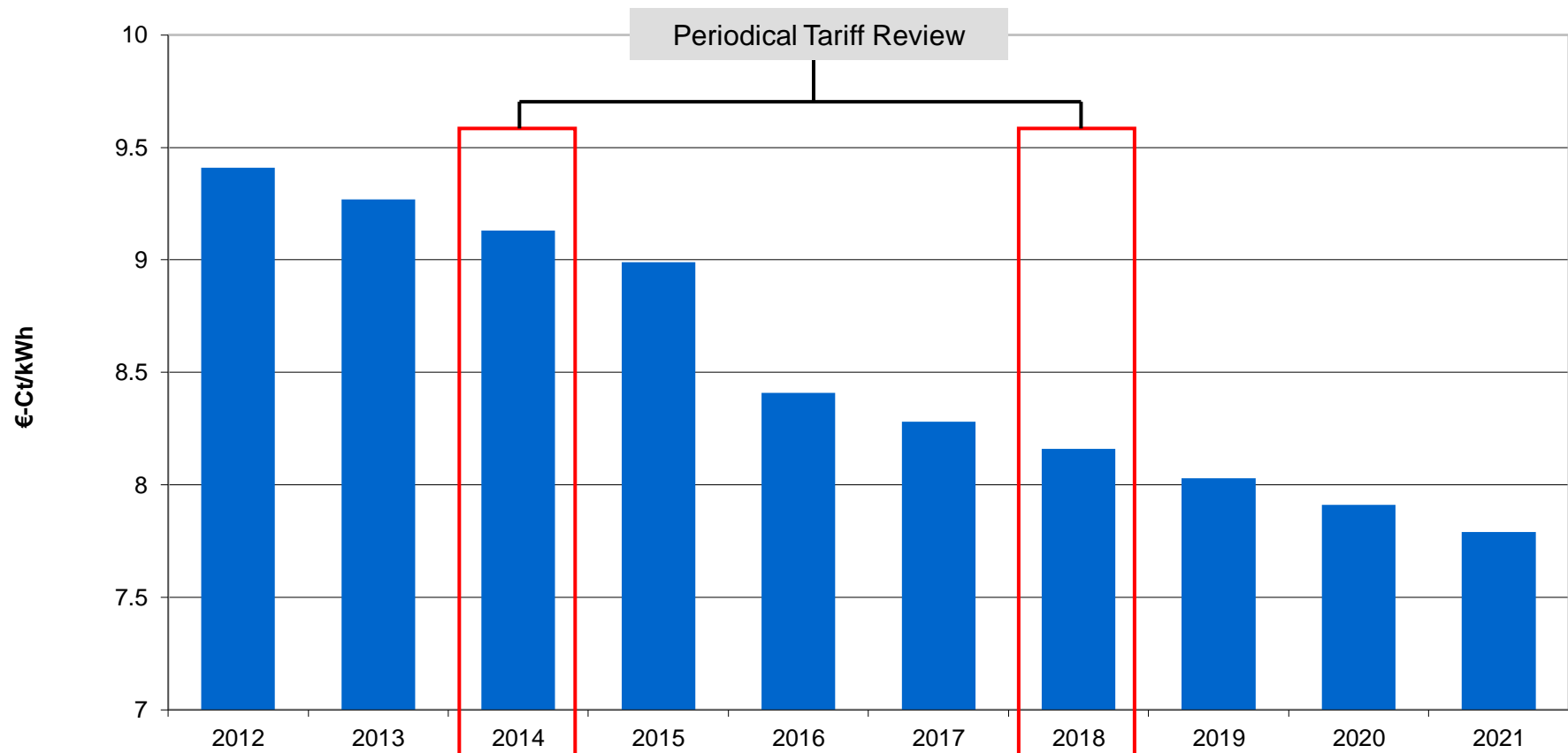


**National vs.
global learning!**

Source: Junginger et al. 2010

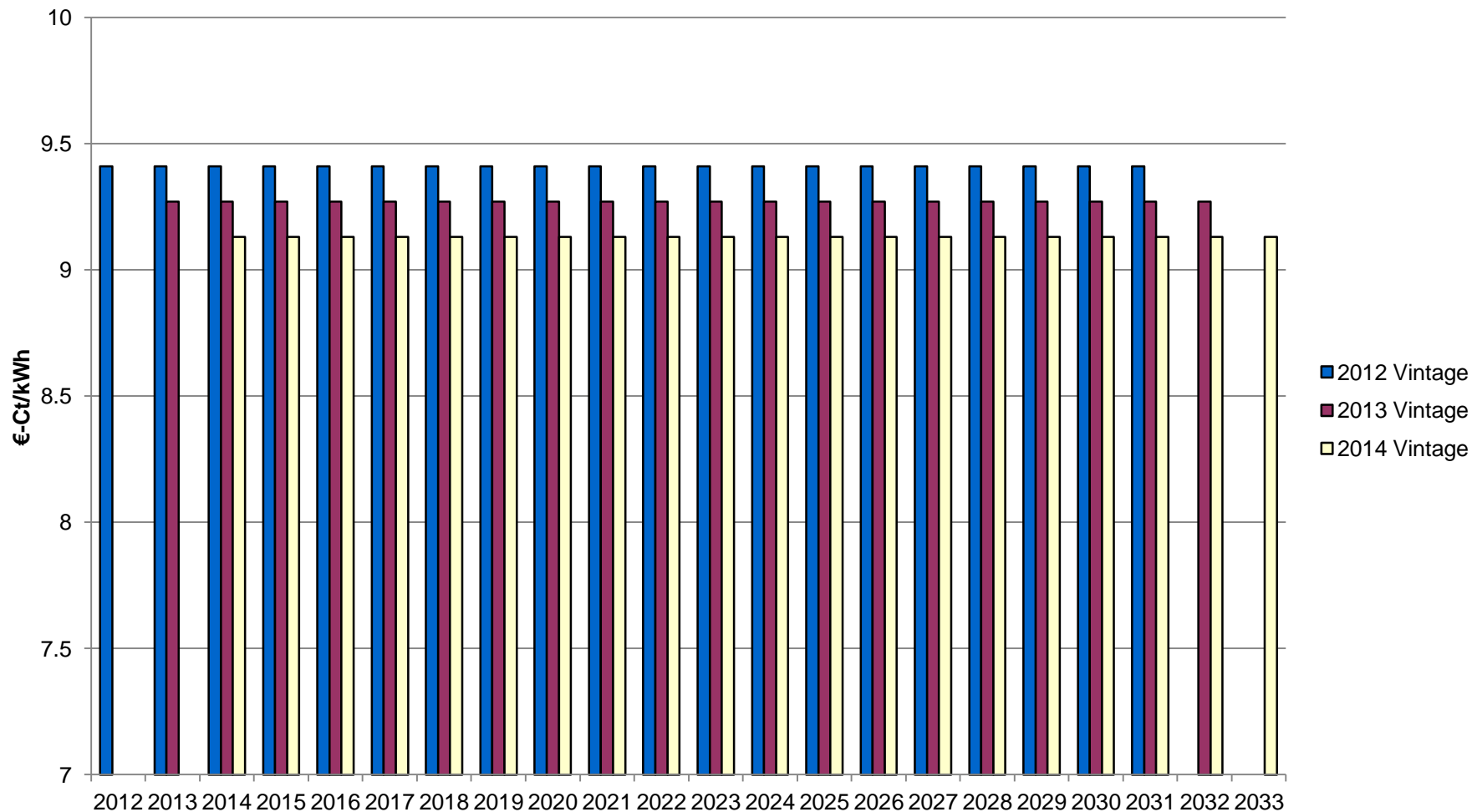
Degression rates for new power plants

FIT Degression with 1.5% p.a.



Degression rates for new power plants

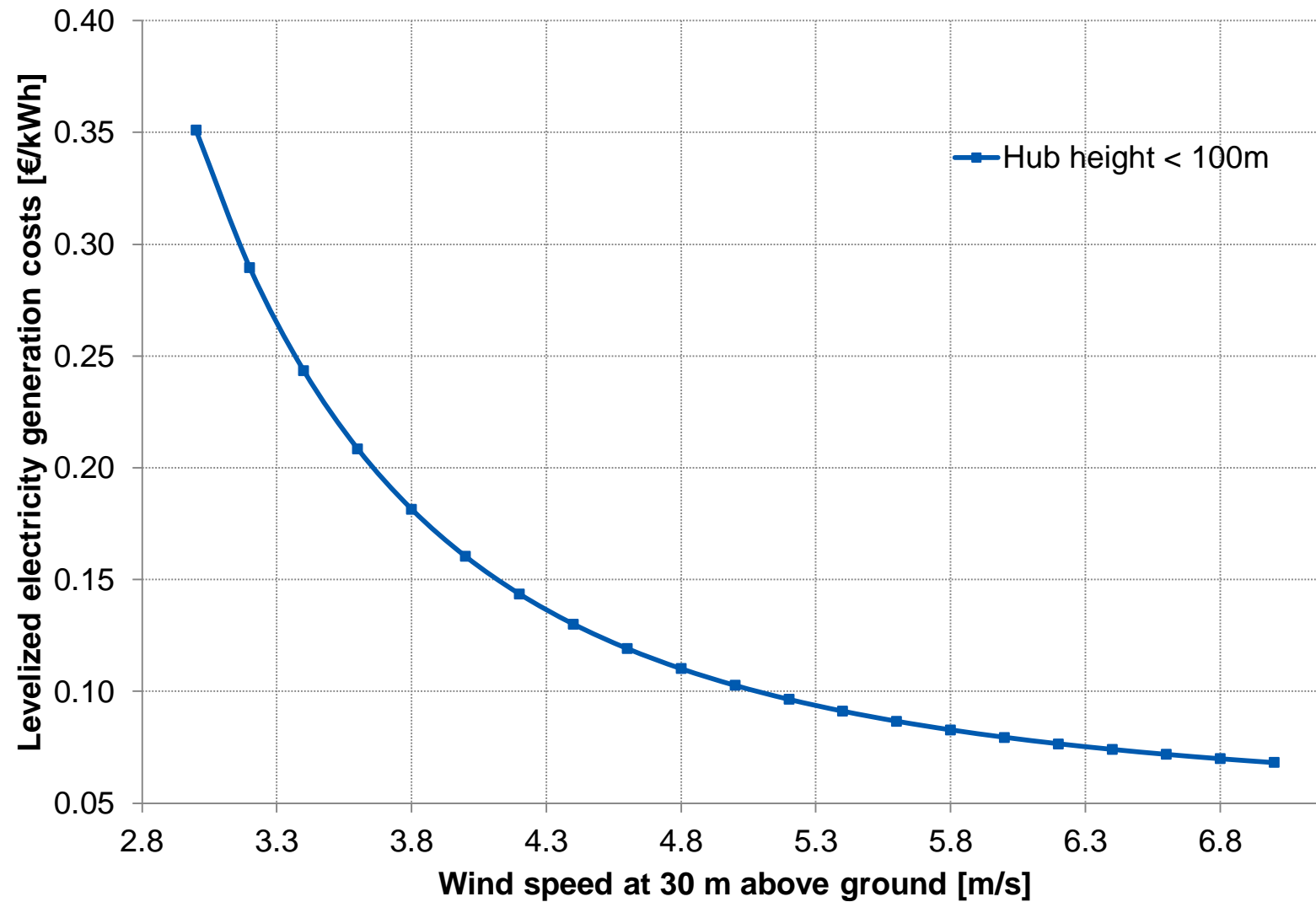
FIT Degression with 1.5% p.a.



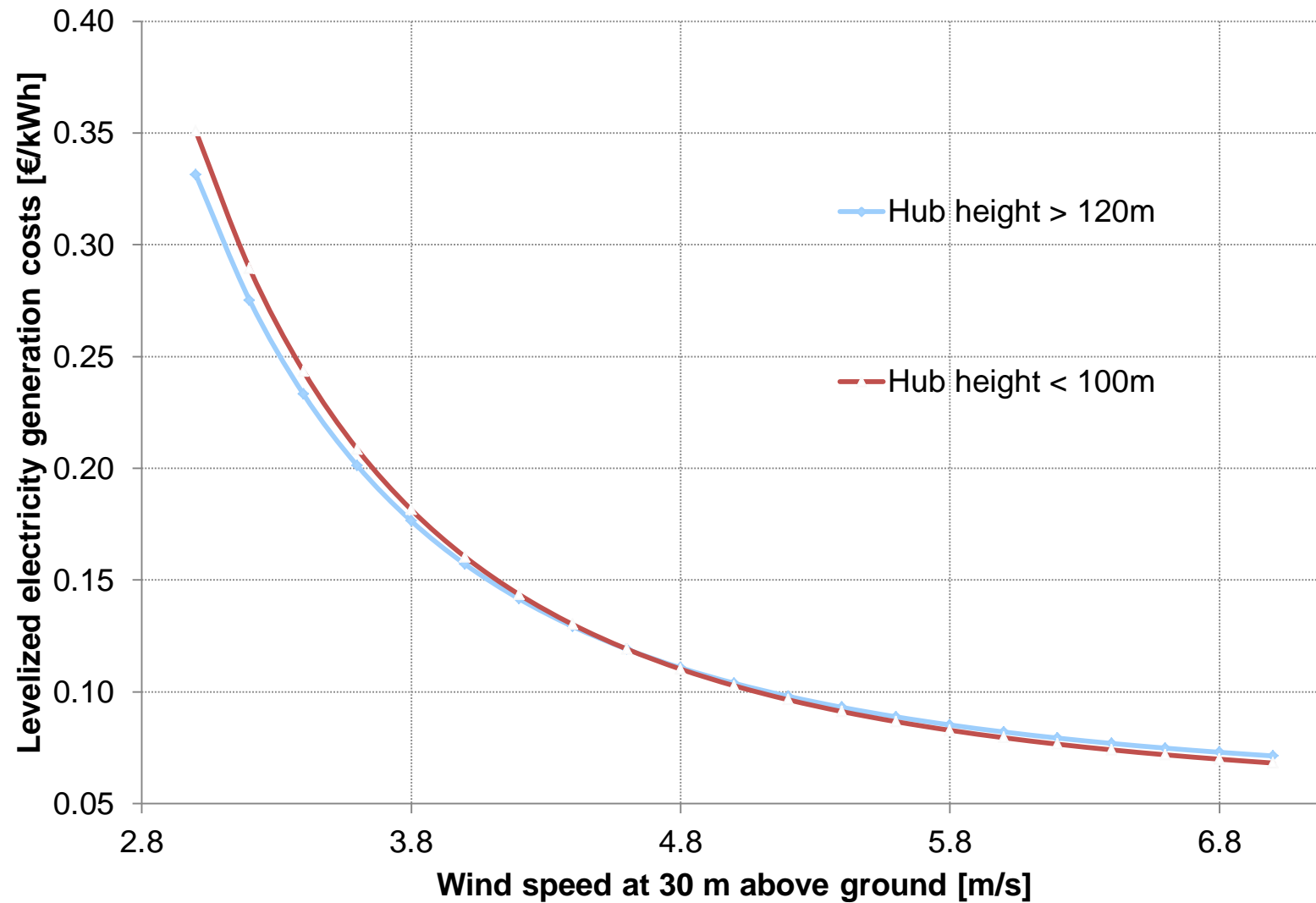
Dealing with uncertainty – Example Steel prices



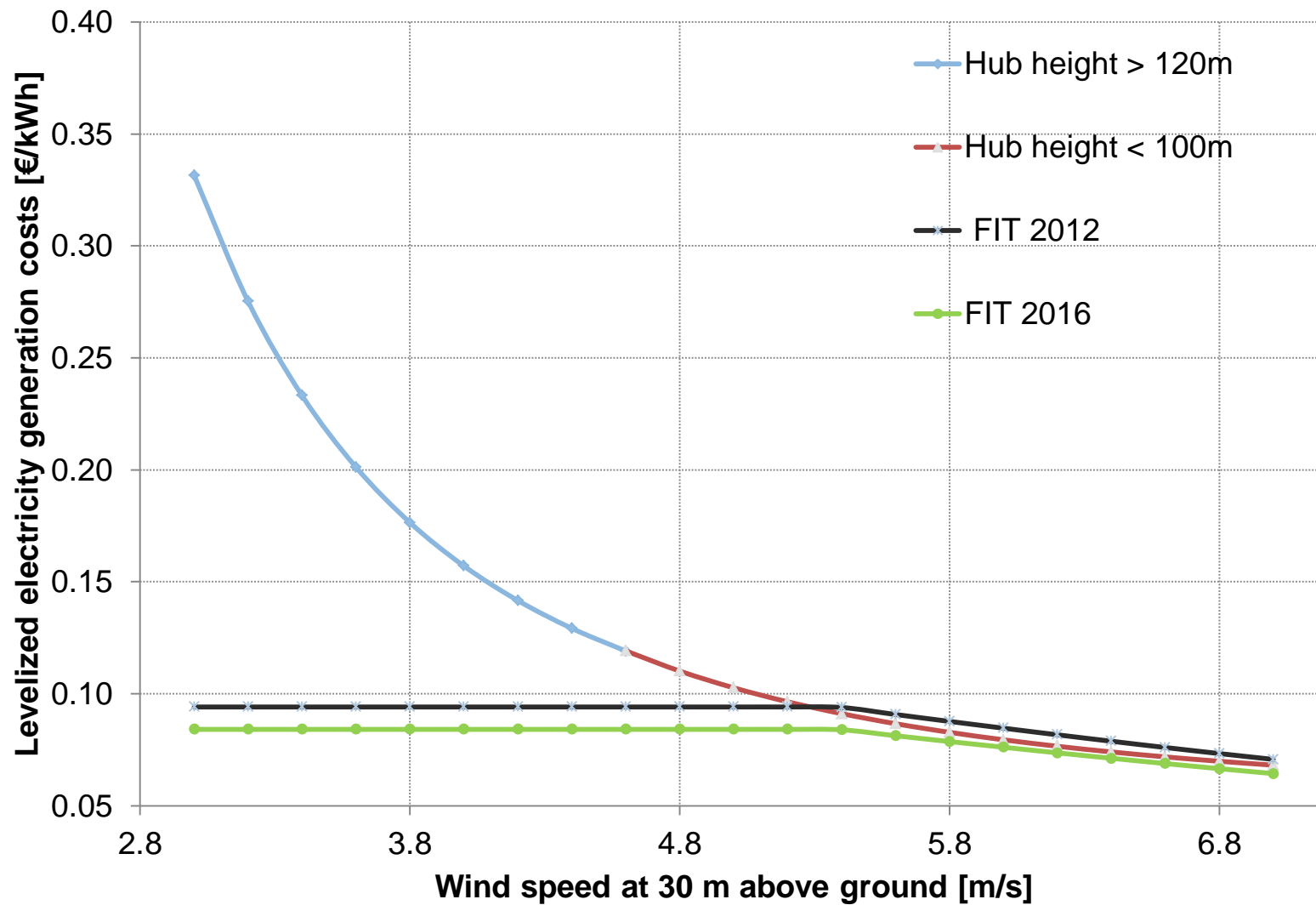
Levelized Electricity Generation Costs – Wind Power



Levelized Electricity Generation Costs – Wind Power



Levelized Electricity Generation Costs – Wind Power



Summary

- Cost oriented tariff setting
- Supplemented with incentives
- Levelised electricity costs is central for determining appropriate tariffs
- Individual wind tariffs for consideration of specific wind resource

Reserve Slides



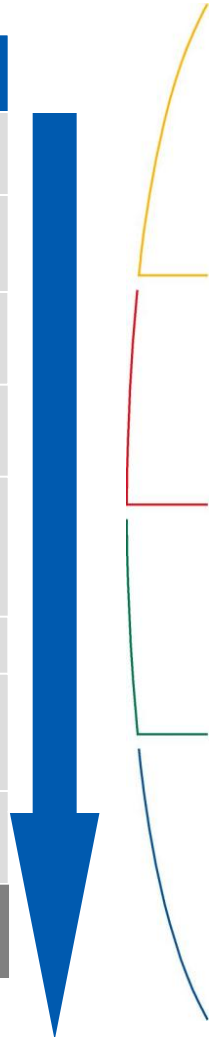
Calculation of the Levelized Electricity Costs (LEC)

Main Influencing Factors

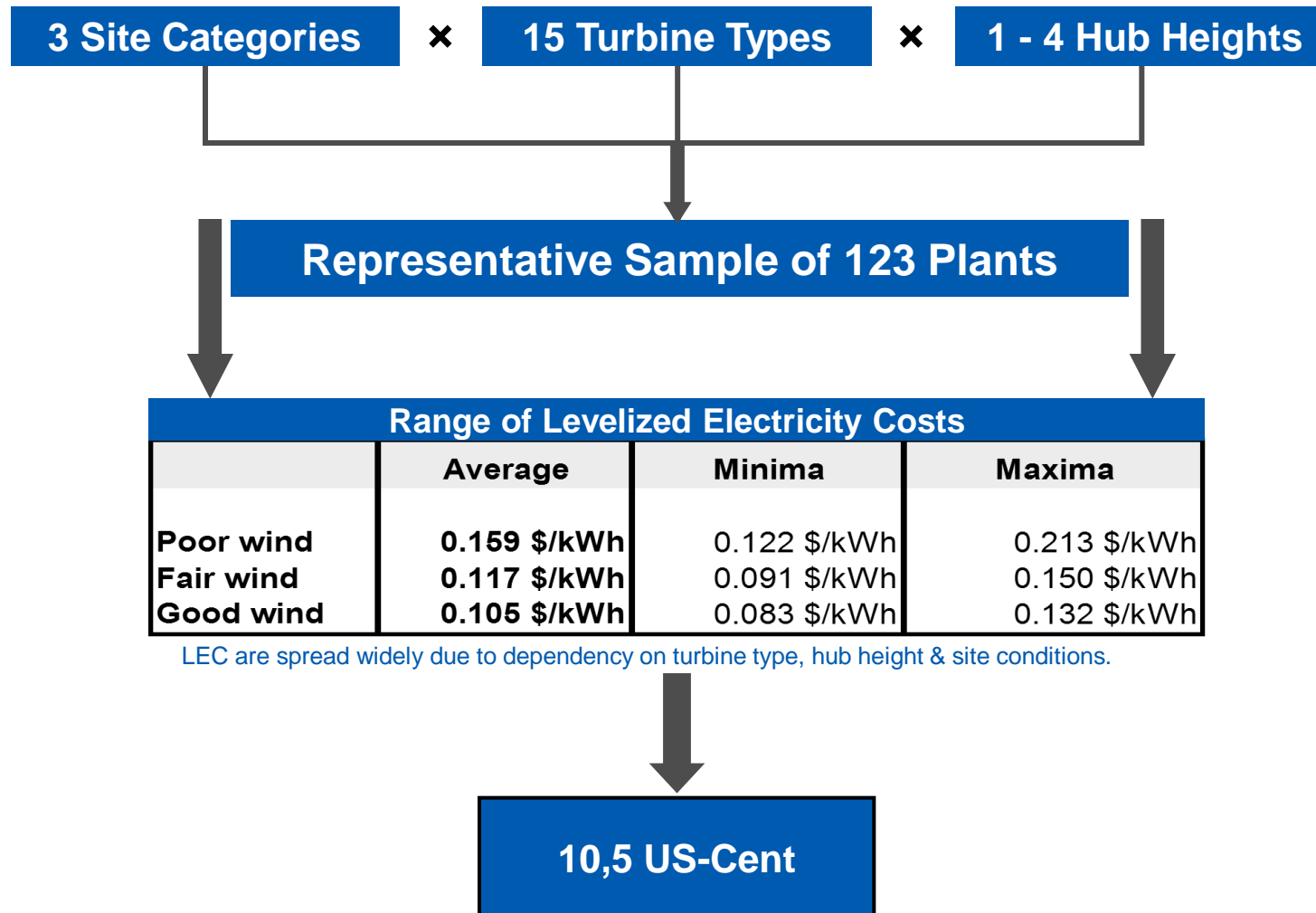


Vietnam: Calculation of the Levelized Electricity Costs (LEC)

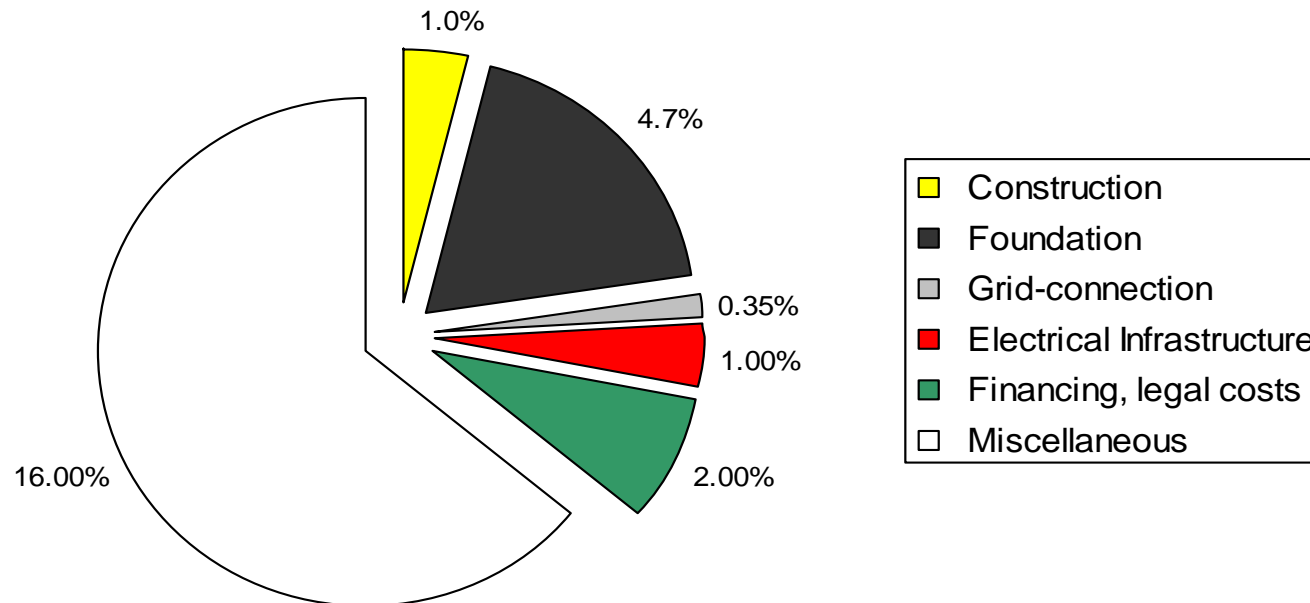
	Methods / Factors	
Site Selection & Characterization	mathematical and statistical analysis of wind-speed distribution depending on height, terrain properties and annual mean wind-speed at representative sites	
Selection of Reference Wind Turbines	different manufacturers, categorization regarding size, power curve, etc.	
Capacity Factor c	dependent on hub height: power production per year according to probabilistic wind function in relation to maximum power production per year under permanent full load	
Annual Gross Electricity Production	calculated using wind data of specific site and power curve of turbine	
Wind Farm Net Electricity Generation	wind plant auxiliary power demand (0,15% of gross plant generation) and shadowing effects withing wind park (96% park efficiency)	
Investment Costs	Wind Turbine	capacity, hub height, raw material price, market situation
	Incidentals	application case, grid voltage-level, local labour costs 25.1% of ex-works price of a wind turbine (22% less than in EU)
Operation & Maintenance Costs	fixed/variable costs, maintainance costs rise during technical lifetime, WACC, etc. O&M-Costs mathematically levelized to an annual rate	
Levelized Electricity Costs	(Levelized O&M costs + WACC) / total annual net electricity generation	



Vietnam: Creating of an artificial sample of wind power plants



Vietnam: Structure of Local Costs



Literature states 20 – 40 % of wind turbine costs as incidentals in Europe.

For Vietnam, local prices apply to Foundation Works, Construction Works, Grid connection Services and Internal Electrical Infrastructure.

The local prices have been determined by obtaining offers from local companies for an assumed 30 MW wind park project scenario consisting of 20 wind turbines with a hub height of 85 m each.

Incidentals were calculated as percentage of the ex works-price of a Nordex S70 reference-turbine (US-\$ 2,172,344).

These evaluated percentages for the Nordex S70 wind turbine have been transferred on and equally used for the LEC calculation of the other turbines.

Wind Energy Potential in Vietnam

Modified Wind Potential Analysis						
Wind Class	POOR	FAIR	GOOD	High	Very high	Sum
Average Wind Speed	< 6 m/s	6-7 m/s	7-8 m/s	8-9 m/s	> 9 m/s	
Area (km ²)	197.242	100.367	25.679	2.178	111	
Area (%)	60.60%	30.80%	7.90%	0.70%	>0%	
Potential (MW)	40,000	94,230	24,110	2,053	106	120,500
Percentage of tot		78.2%	20.0%	1.7%	0.1%	

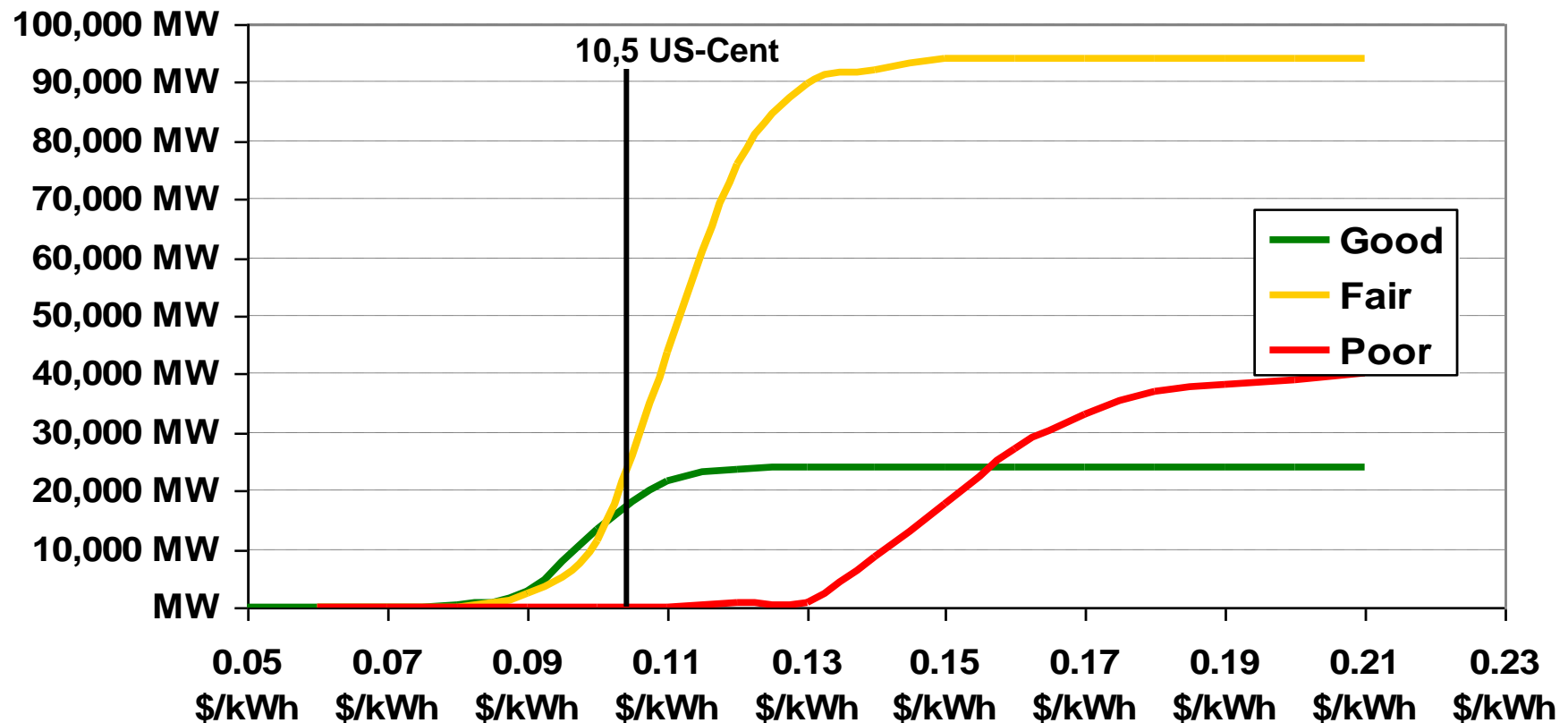
No information available about the Potential at locations with “poor” wind resources. A value of 40,000 MW has been assumed.

Sources:

- World Bank, “Wind Atlas of South East Asia”
- Study of Mr. Kahn Nguyen

Vietnam: Proposed Tariff Level

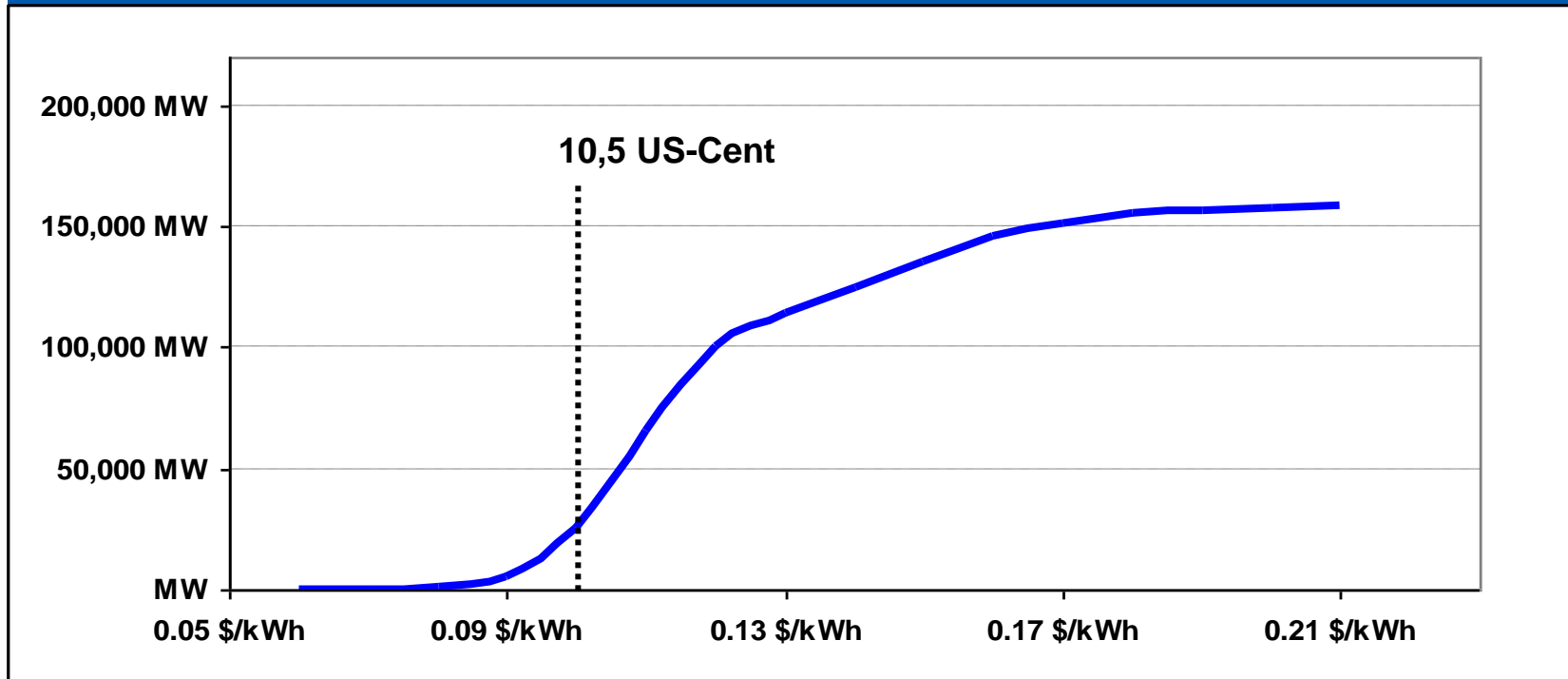
Potential New Capacity in Dependence of Tariff-Level



Category specific wind energy potential multiplied with the cumulative frequency distribution of LEC leads to the amount of capacity which can be added at a certain tariff-level.

Example Vietnam

Potential New Capacity in Dependence of Tariff-Level



**Recommendation for New Tariff Level:
0.105 USD/kWh for the year 2010**

- allows developing an average site with good wind conditions
- a capacity of **25 GW** could be mobilized at these costs
(not considering site restrictions beyond pure wind conditions)
- tariff thus sufficient to meet the target of **629 MW by 2020**