Integrated course „Energy Economics“
- Renewable Energy Support Schemes -
- Generation Capacities -

Chair of Energy Systems | Department of Energy Systems
Technische Universität Berlin

Outline

- Renewables support schemes
- Generation capacities

Motives for renewables support

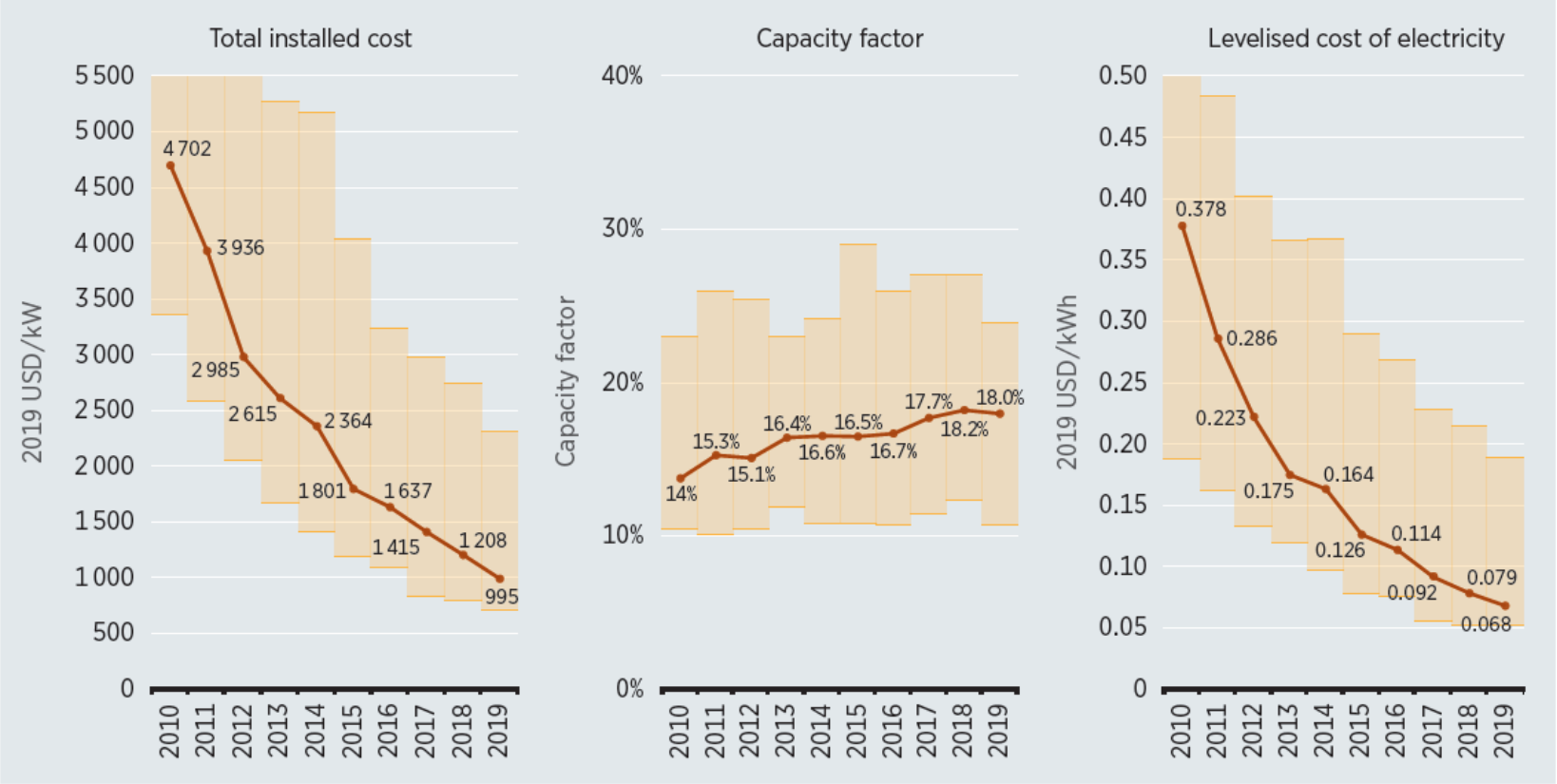
- reducing carbon emissions
- reducing cost through knowledge spillovers
- developing an export industry by early specialisation
- energy security: limiting dependence on fossile fuels imports
- ancilliary benefit: generating employment

Three groups of support schemes:

- Public financing – public investments, loans, grants
- Fiscal incentives – subsidies and tax reductions
- Requirements for electricity consumers to pay for RES:
  - fixing price
  - fixing amount

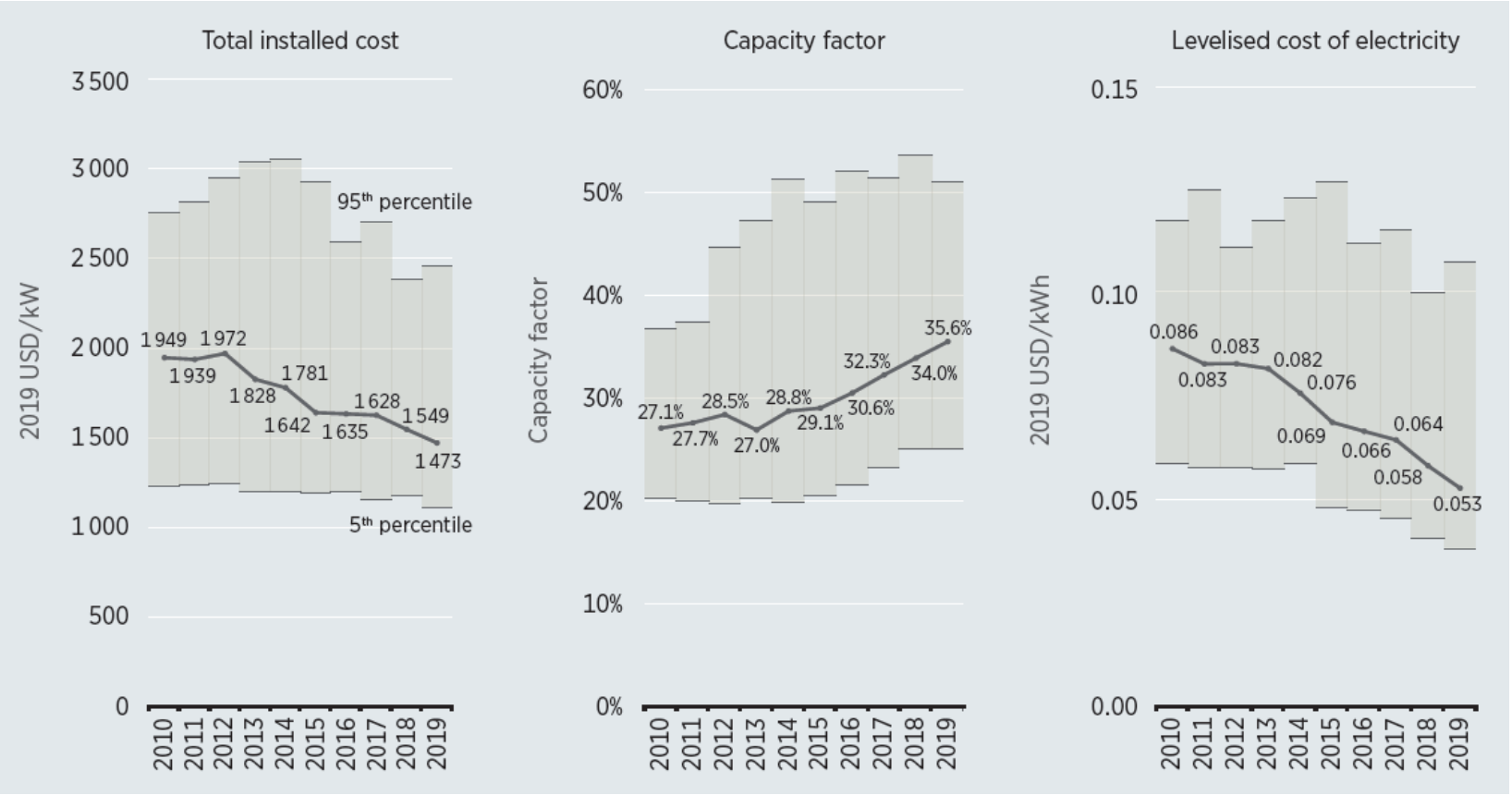
Source: Green and Yatchew (2012)

Global weighted average of total installed cost and LCOE for solar PV 2010-2019



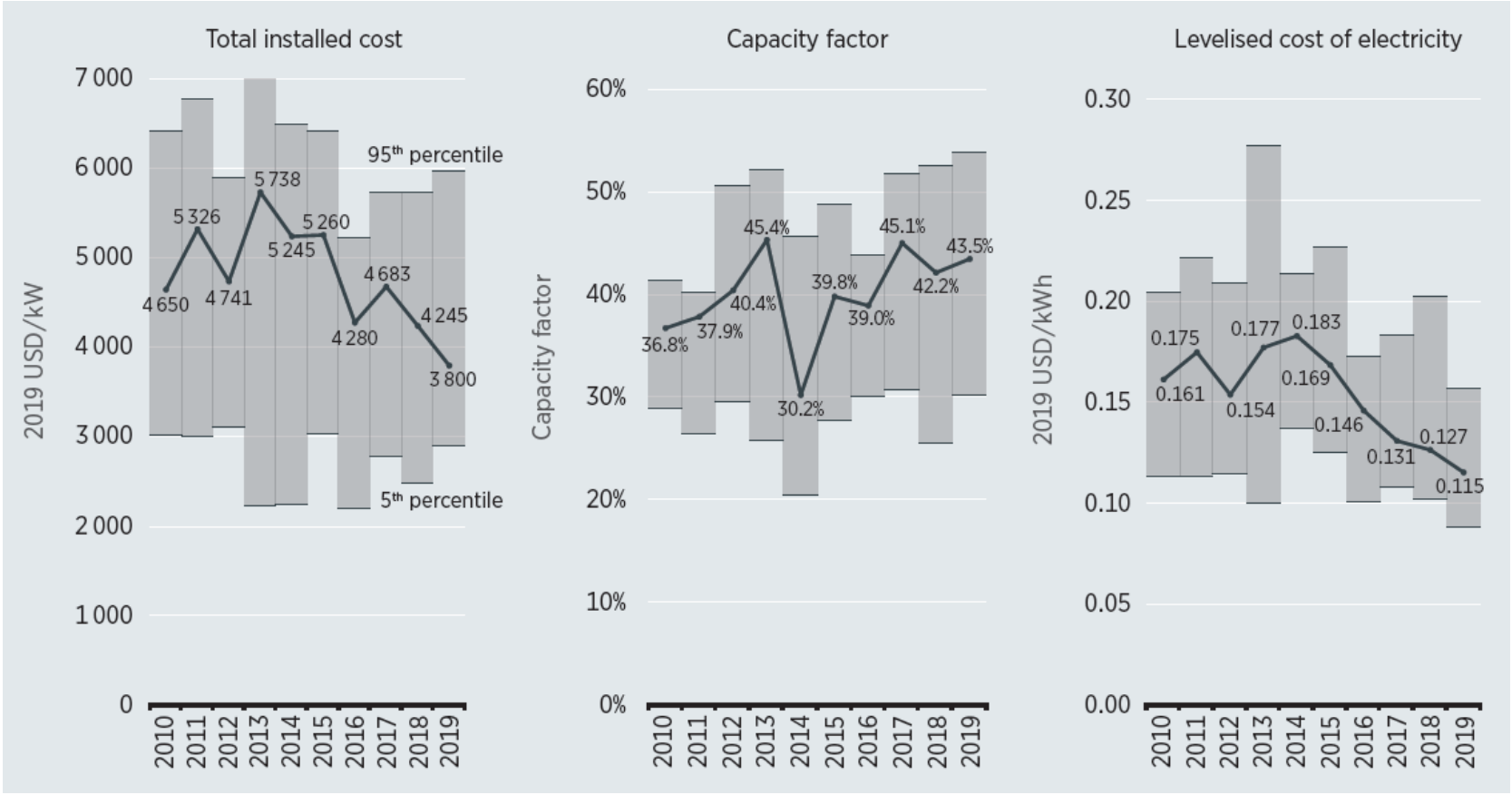
Source: IRENA (2019)

Global weighted average of total installed cost and LCOE for onshore wind 2010-2019



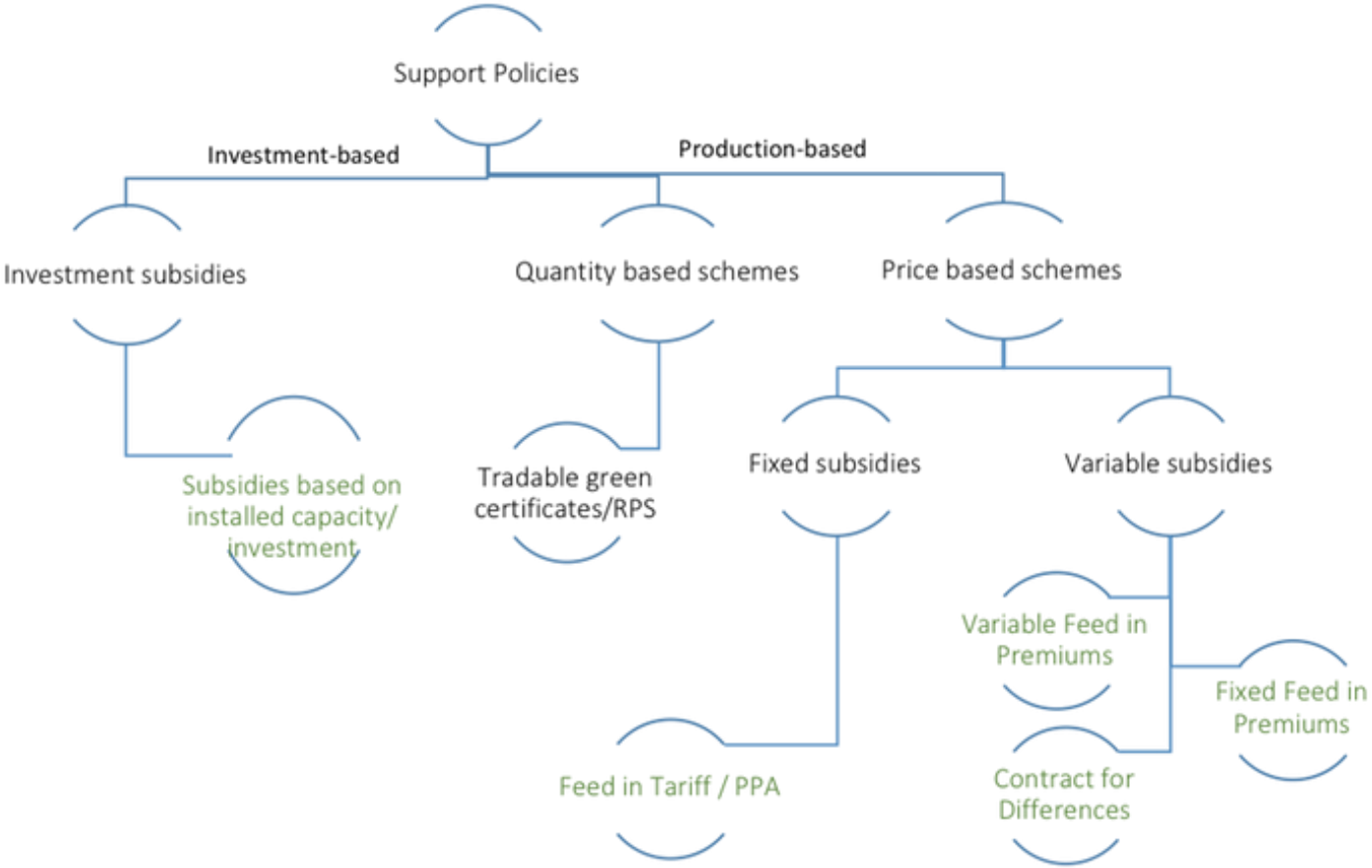
Source: IRENA (2019)

Global weighted average of total installed cost and LCOE for offshore wind 2010-2019



Source: IRENA (2019)

Renewable Electricity Support Schemes in Europe



Note: Support levels in these schemes can be set both using auctions or administratively

Source: OEE

European Union’s RES policies

2030 energy and climate framework

Key targets for 2030:

- At least 40% cuts in greenhouse gas emissions (from 1990 levels)
- At least 32% share for renewable energy
- At least 32.5% improvement in energy efficiency

European Green Deal

- towards carbon-neutral economy by 2050

Renewable Electricity Support Schemes in Europe

EU Clean Energy Package (2018): binding target of 32% for renewable energy sources in EU's energy mix by 2030

Price control	Obligation of grid operators (or ISO) to purchase all offered renewable electricity at legally defined (and technology specific) fixed feed-in payments	Dominant model but challenged by the EU Commission
	Legally defined and technology specific market premium (on top of the market price) granted to renewable generators that have sold the electricity	Similar to Contract for Differences
Volume control	Obligation of retailers to hold a minimum number of Renewable Electricity Certificates (RECs) issued by registered renewable generators	
	Renewable portfolio standard (retailers must physically purchase a minimum share of renewable electricity)	Do retailers have the capacity to comply?
	Renewable investment tenders (government defines the renewable capacity additions and selects the investors that ask for the lowest market premium)	Model preferred by the EU Commission

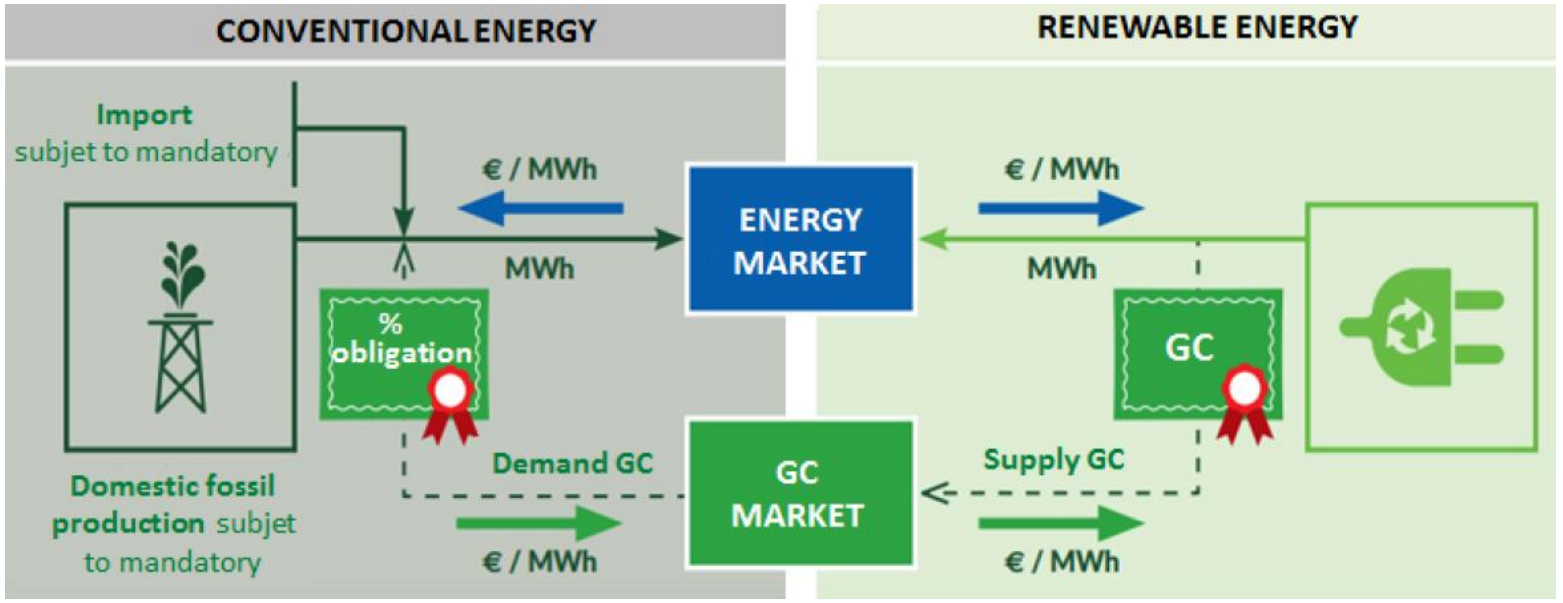
RES support mechanisms: Green Certificates (GC)

- Fossile fuel-fired generators are required to replace every year a certain percentage of their energy production with RES.

- The balance between demand (from generators and importers under the GC obligation) and supply (RES generators) determines the GC price.

- The charges linked to the GC are translated to the final customers through the electricity price (on wholesale or retail market).

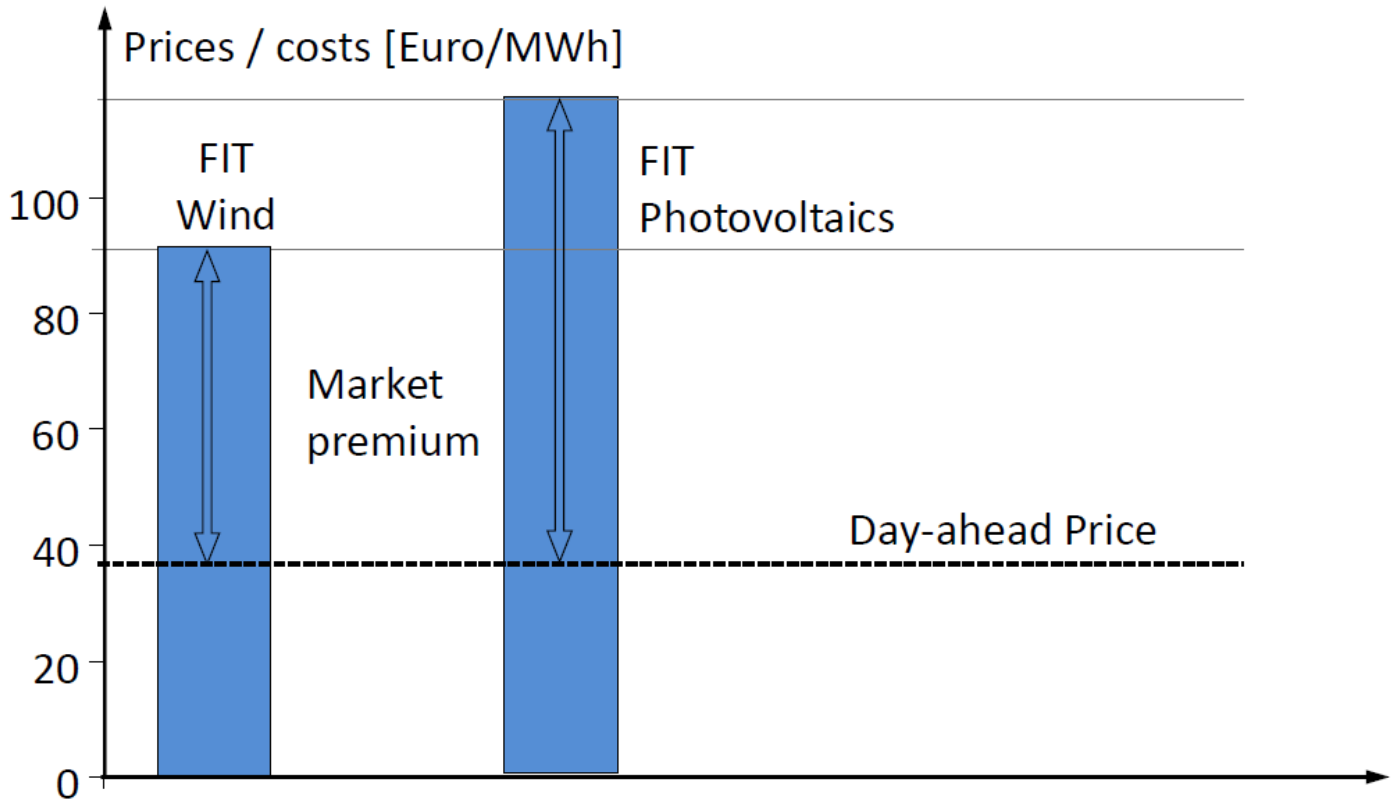
Green Certificates Mechanism



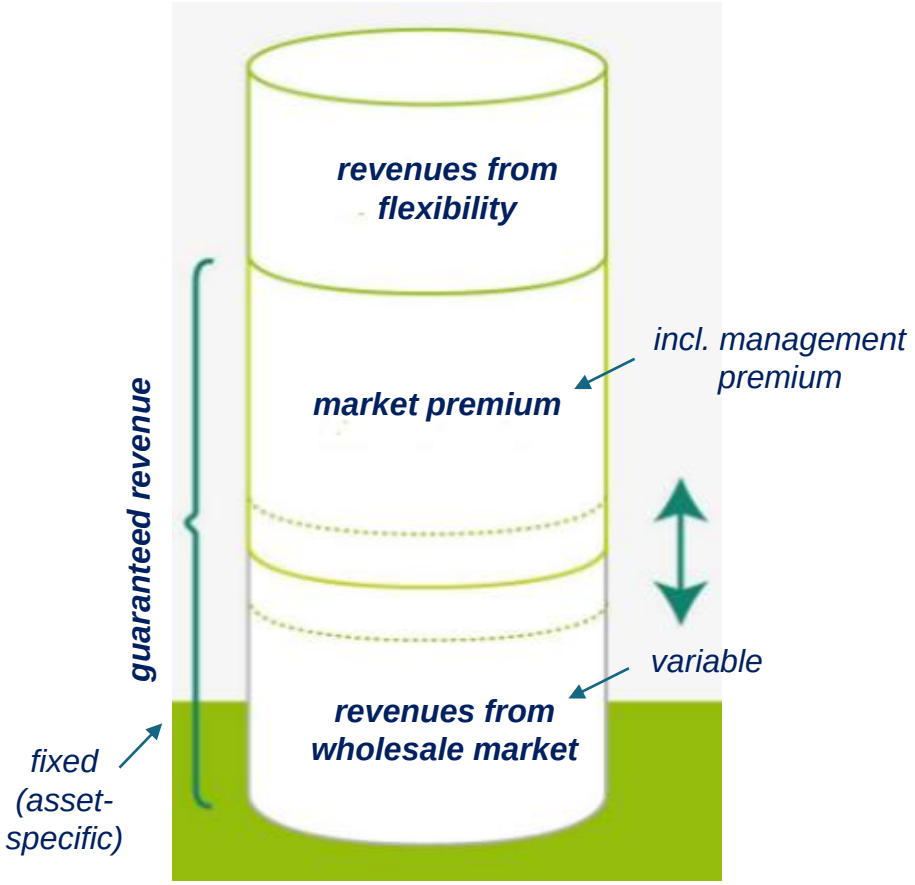
RES support mechanisms: Administered fees (all-inclusive or premium)

- The government fixes the price for each MWh produced or injected into the grid from RES.
- Normally, the fee depends on renewable source and size of power plant.
- Feed-in tarif (FIT)
- Premium ensures that at least FIT is covered and gives incentives for selling RES output directly on the wholesale market
- If the fee is coherent with the production cost, the government's RES output target can be met; otherwise it would be not reached or exceeded.
- The charges linked to the support system are paid by final customers.

Feed-in-tariff and Market Premium Mechanism



Feed-in-tariff and Market Premium Mechanisms



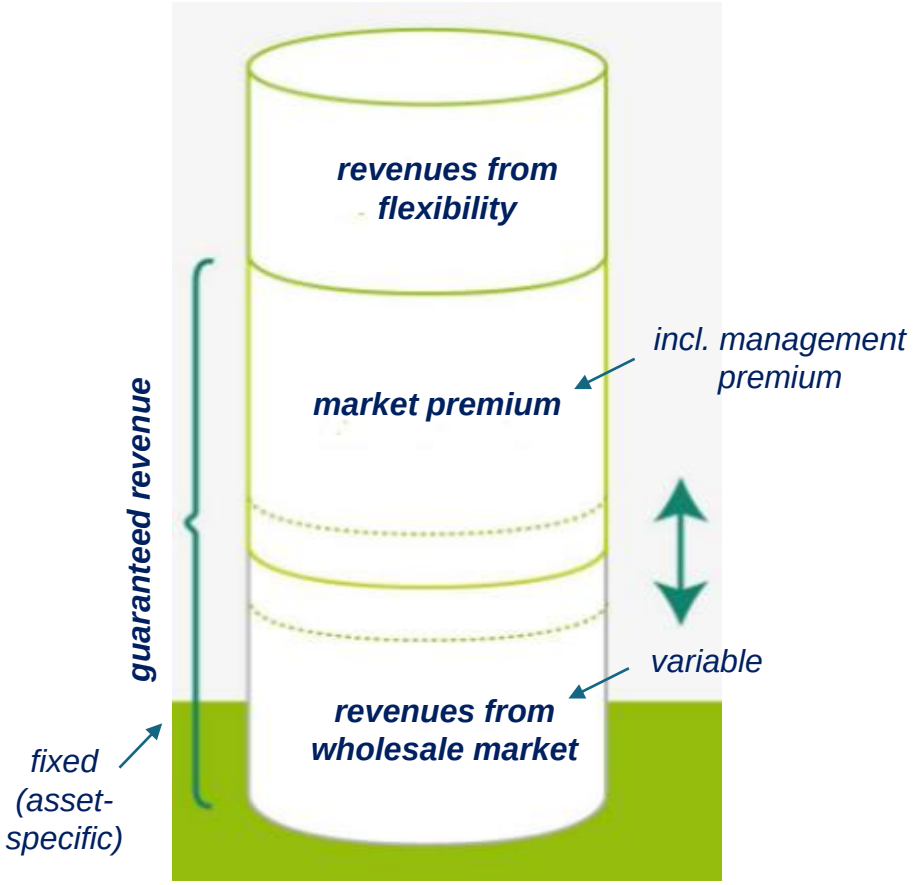
Source: Next Kraftwerke

RES auctions under market premium scheme

EEG 2017:

- Predetermined auctioned capacity for RES new build
- Prequalified projects bidding their reference value (guaranteed revenue)
- Installation-specific reference value

Auction requirement for
- Offshore wind
- Onshore wind and solar PV from 750 kW
- Biomass from 150 kW



Source: Next Kraftwerke

Market integration objectives of RES

Market integration objectives	Dimensions of achievement of objectives	Contributions to overarching objectives
Demand-oriented generation of RES electricity and increased flexibility of RES plants	Prevention of surplus supply situations via voluntary curtailment in times of negative electricity prices	Contribution of RES to security of supply is increased;
	Shift of feed-in to times when demand is strong and prices are high:	Costs of RES promotion are reduced through an increase in RES market value;
	• Intermittent RES: Maintenance planning, installation design oriented towards market value and system requirements	Cost reductions in the overall system (e.g. lower balancing energy prices and system integration costs)
	• Dispatchable RES: targeted load shifting	
	Increased remote controllability of RES installations	
	Participation of RES installations in the balancing energy market	
Efficient marketing of RES electricity	Reduced transaction costs of marketing RES electricity	RES promotion costs are reduced
	Increased forecasting quality and reduction of costs of procuring balancing energy	
	Competition for efficient marketing forms	
Market-driven production and investment decisions	Competitive determination of RES remuneration	RES expansion costs are reduced
	RES producers become regular market players	

Source: Purkus et al. Energy, Sustainability and Society (2015) 5:12

Renewables support levy (green fee)

$$\text{RES levy} = \frac{\text{RES support payments} - \text{RES marketing revenue}}{\text{Adjusted non-preferred final electricity consumption}}$$

Adjusted final electricity consumption is equal to total final electricity consumption minus:

- Share of electricity consumption of energy intensive industries, which are exempted from the levy
- Own generation (self-consumption), which is partly exempted from the levy

Direct and Indirect Costs of Renewables

Cost of new RES capacity invested in Germany in January 2012

Euro/MWh$_{el}$	Onshore wind	Offshore wind	PV	Bio methane
Premium above electricity price	55	152	153	182
Integration costs gas grid	-	-	-	22
Transportation costs gas grid	-	-	-	19
Power distribution grid extension	26	-	15	-
Power transmission grid extension	8	8	1	-
Costs offshore grid	-	26	-	-
Risk offshore grid	-	3	-	-
Merit-order effect	-28	-29	-32	-29
Backup capacity	27	22	27	-
Power grid losses	3	12	-	-
Total	**67**	**194**	**164**	**194**

Expenditures for Electricity

Final user expenditures in Germany	2010	2011	2012	2013	2014
	Billion Euros p.a.				
Total domestic expenditures	**60.9**	**63.6**	**64.3**	**71.0**	**70.3**
Expenditures induced by the government	**17.2**	**23.0**	**23.3**	**30.0**	**32.3**
Electricity taxes	6.4	7.2	7.0	7.0	6.6
Concession fees	2.1	2.2	2.1	2.1	2.0
Renewable electricity levy	8.3	13.4	14.0	19.8	22.3
Combined heat and power Levy	0.4	0.2	0.3	0.4	0.5
Offshore grid levy (§ 17F ENWG)	-	-	-	0.8	0.8
Expenditures regulated by the government	**16.9**	**17.6**	**19.0**	**21.2**	**21.4**
Fees for the transmission grid	2.2	2.2	2.6	3.0	3.1
Fees for the distribution grid	14.7	15.4	16.4	18.2	18.3
Expenditures driven by the market	**26.8**	**23.1**	**22.0**	**19.8**	**16.6**
Market value of renewable electricity	3.5	4.4	4.8	4.2	4.1
Conv. generation, marketing, sales	23.3	18.6	17.2	15.6	12.6

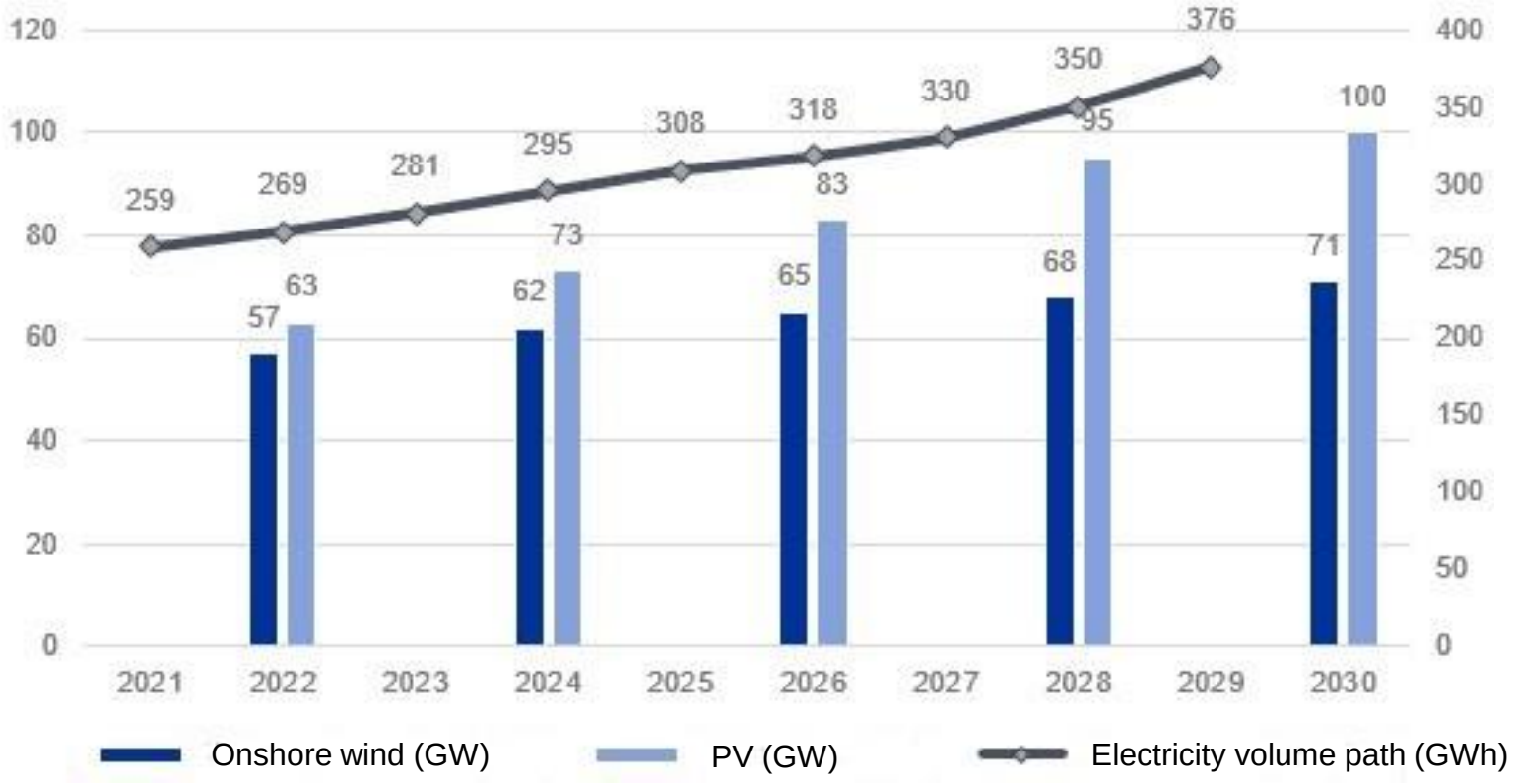
German Renewables Act (2021)

- At least 65% share of renewable energy in gross electricity demand in 2030

- 100% CO_2-neutral electricity generation and consumption by 2050

Continuous, cost-efficient and grid-adjusted RES expansion.

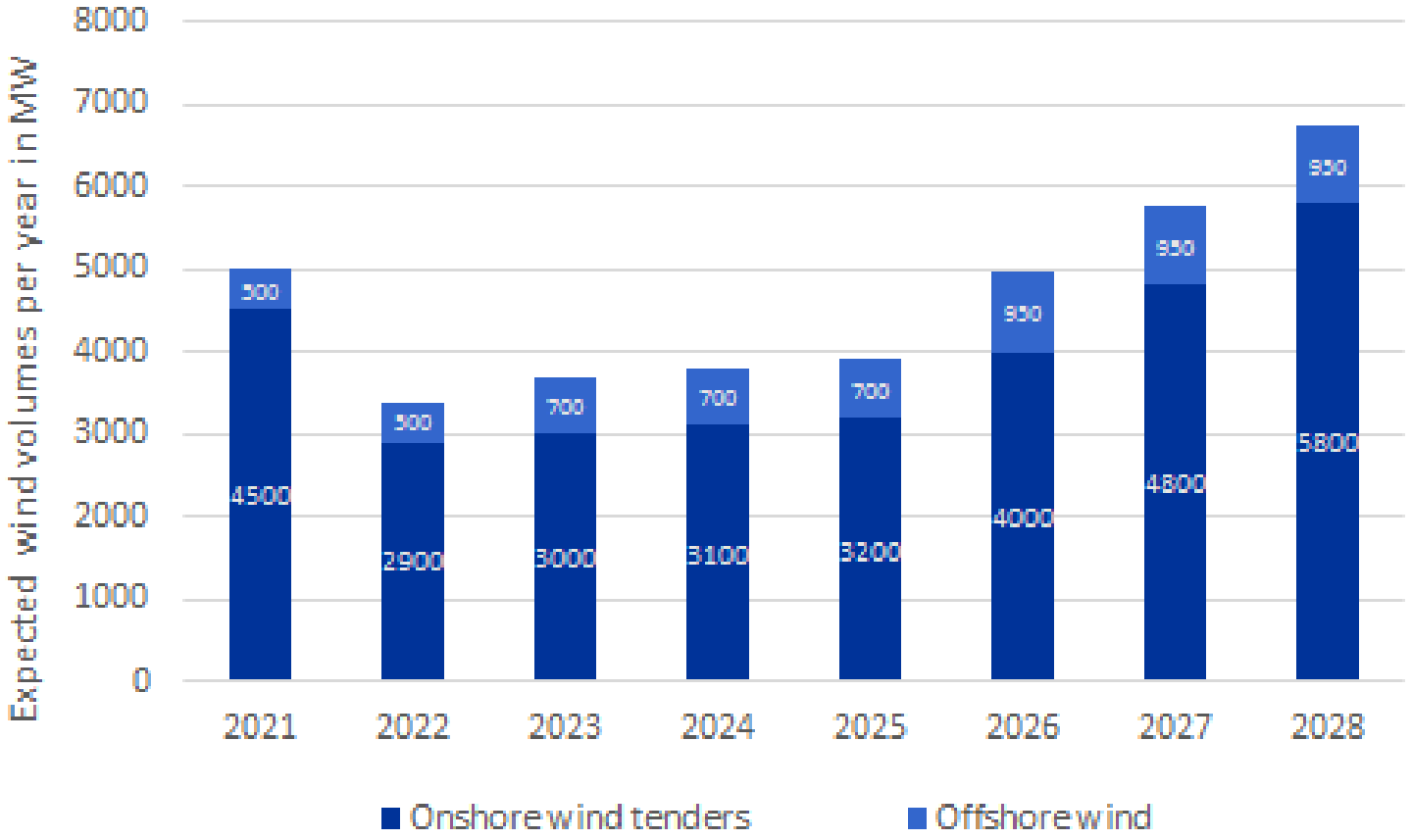
German Renewables Act (2021): RES expansion pathway



Source: IKB Deutsche Industriebank

For offshore wind, yearly auction volumes are determined by BNetzA to ensure synchronisation with required grid expansion and reach 20 GW by 2030 and 40 GW by 2040.

Additional capacities of onshore and offshore wind

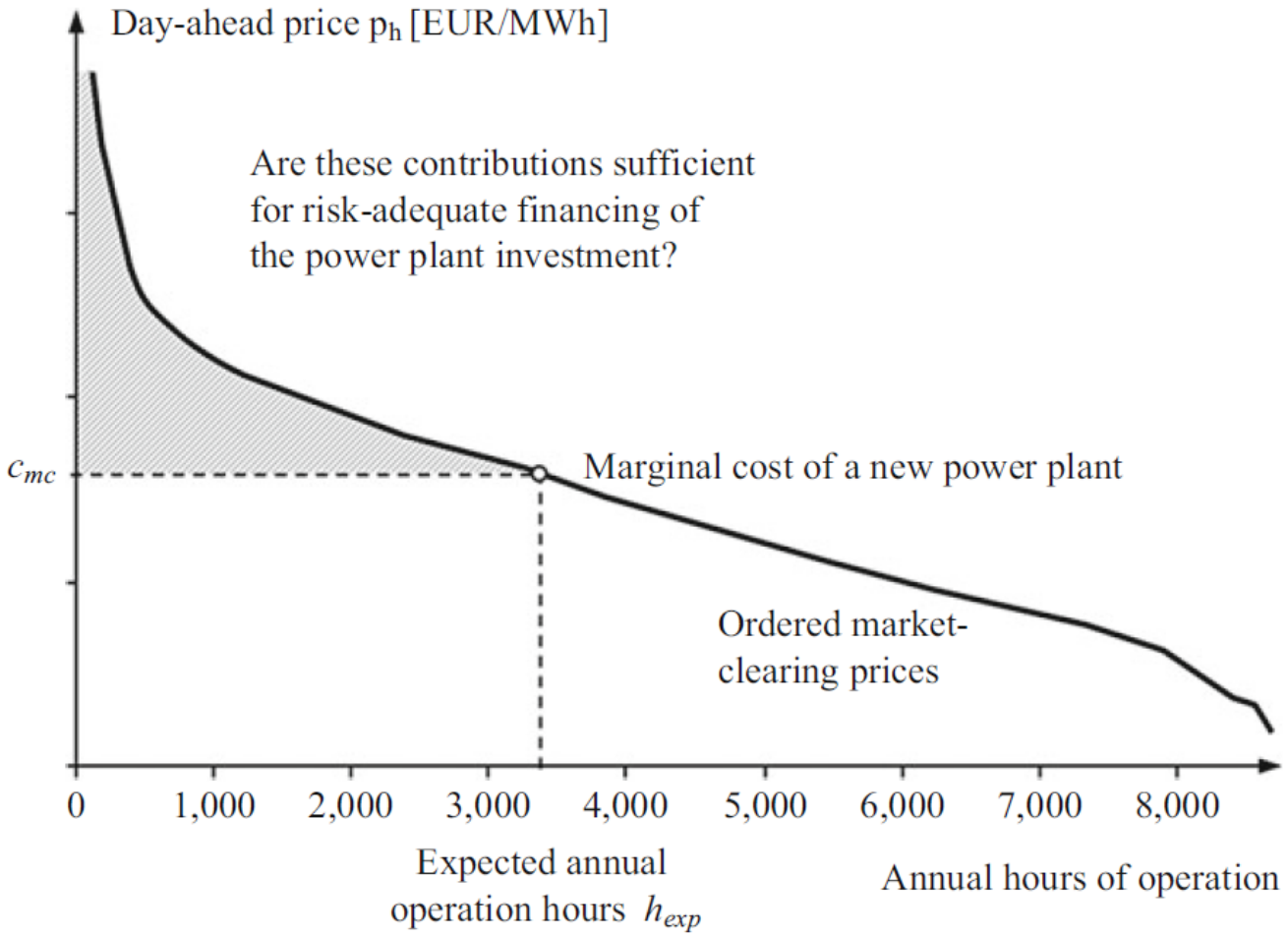


Source: Energy Brainpool

2. Investment into generation capacities

Erdmann / Praktiknjo / Zweifel (2017)

Annual Price Duration Curve



Erdmann / Praktiknjo / Zweifel (2017)

Task 1

Anwer the questions regarding the economics of technologies A and B based on the following techno-economic power plant data:

	Specific fixed costs	**STMGC**
	$\frac{Euro}{MW_{el} * a}$	$\frac{Euro}{MWh_{el}}$
A	140 000	40
B	80 000	50

a) Up to which number of full load hours is technology B cheaper than technology A?

$LTMGC = C_{fix} + STMGC \cdot FLH$

$LTMGC_A = LTMGC_B$

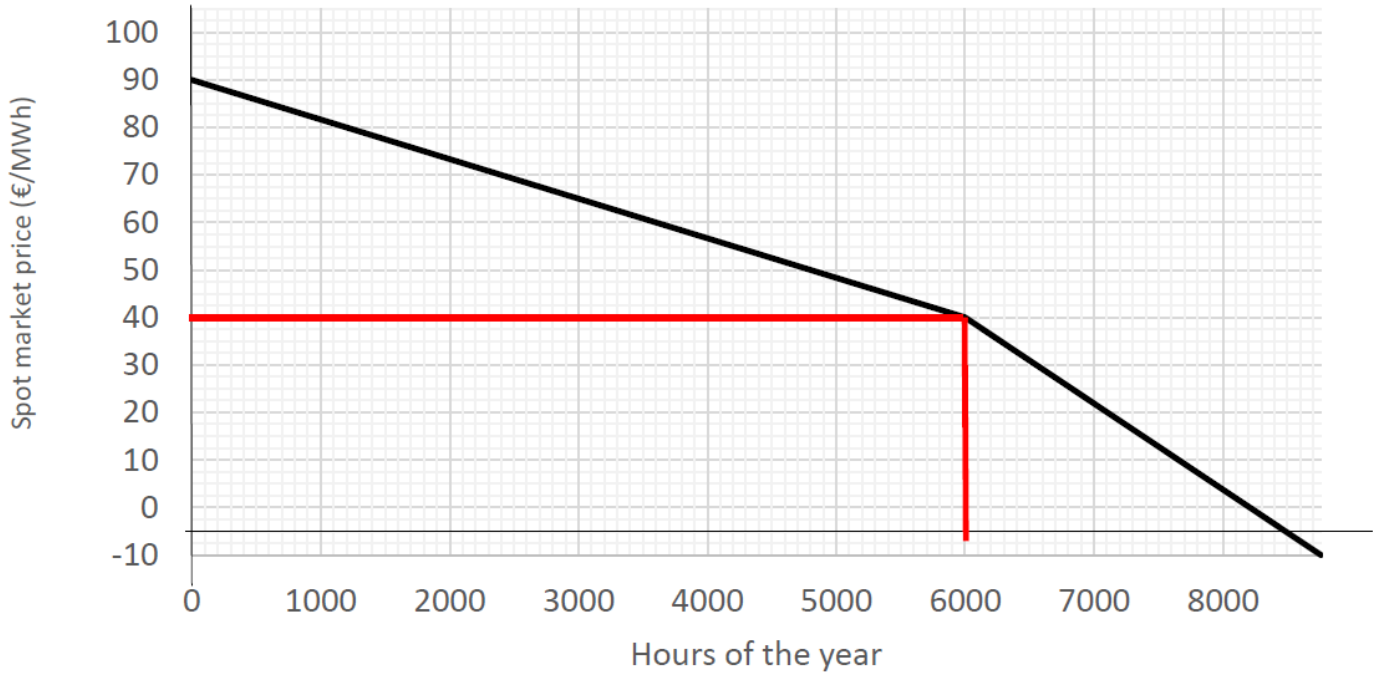
$140\,000\,€/MW_{el} \cdot a + 40\,€/MWh_{el} \cdot 6000\,h = 80\,000\,€/MW_{el} \cdot a + 50\,€/MWh_{el} \cdot FLH_B$

$FLH_B = \frac{380\,000 - 80\,000}{50} = 6000\,h$

found from graph on next slide for $STMGC = 40\,€/MWh_{el}$

Task 1

A:


Spot market price (€/MWh)
100
90
80
70
60
50
40
30
20
10
0
-10
0
1000
2000
3000
4000
5000
6000
7000
8000
Hours of the year

	Specific fixed costs	STMGC
	$\frac{Euro}{MW_{el} * a}$	$\frac{Euro}{MWh_{el}}$
A	140 000	40
B	80 000	50

Technische Universität Berlin

Task 1

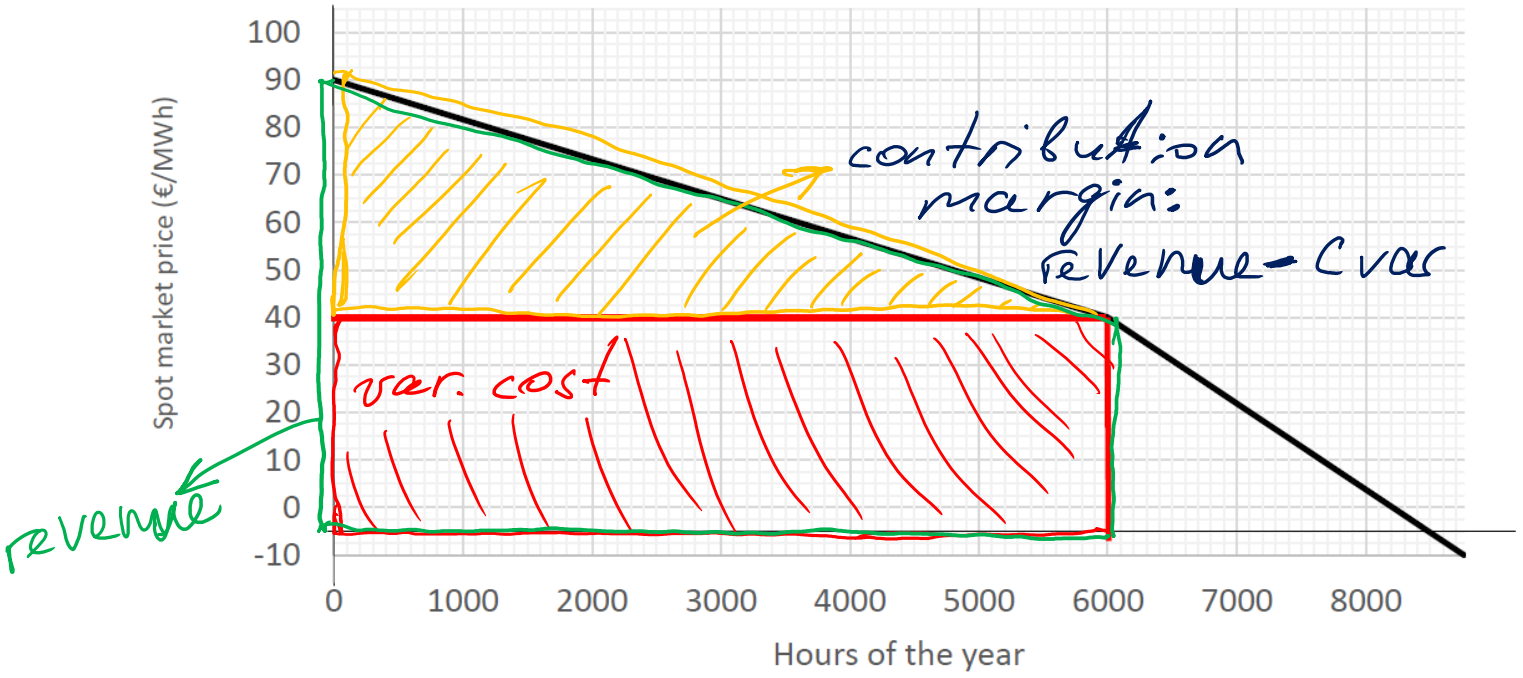
b) You sell electricity from power plant A on spot market which is characterised by a given price duration curve. Your generation unit has a rated capacity of 600 MW.

Calculate the power plant's:

- annual fixed costs in Euro
- annual variable costs in Euro
- annual contribution margin in Euro
- annual profit in Euro

Task 1

per MWel · a:



	Specific fixed costs	STMGC
	$\frac{Euro}{MW_{el} * a}$	$\frac{Euro}{MWh_{el}}$
A	140 000	40
B	80 000	50

Technische Universität Berlin

Task 1

- annual fixed costs in Euro

$C_{fix_A} = C_{fix_A} \cdot Cap;\ 140000 €/MW_{el \cdot a} \cdot 600 MW_{el} = 84000000 €/a$

- annual variable costs in Euro

$C_{var_A} = STMGC_A \cdot FLH_A \cdot Cap;\ 40 €/MWh_{el} \cdot 6000 h \cdot 600 MW = 144000000 €/a$

- annual contribution margin in Euro

$CM_A = \frac{(90-40) €/MWh \cdot 6000 h/a \cdot 600 MW}{2} = 90000000 €/a$

- annual profit in Euro

$G_A = CM_A - C_{fix_A};\ 90000000 € - 84000000 €/a = 6000000 €/a$