Consumer-oriented TCO Optimization for a Private Prosumer

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Problem / Research Question

PV as Volatile Source

Small Scale Storage

Investment and Other Costs

Incentives and Changing Frameworks

. . .

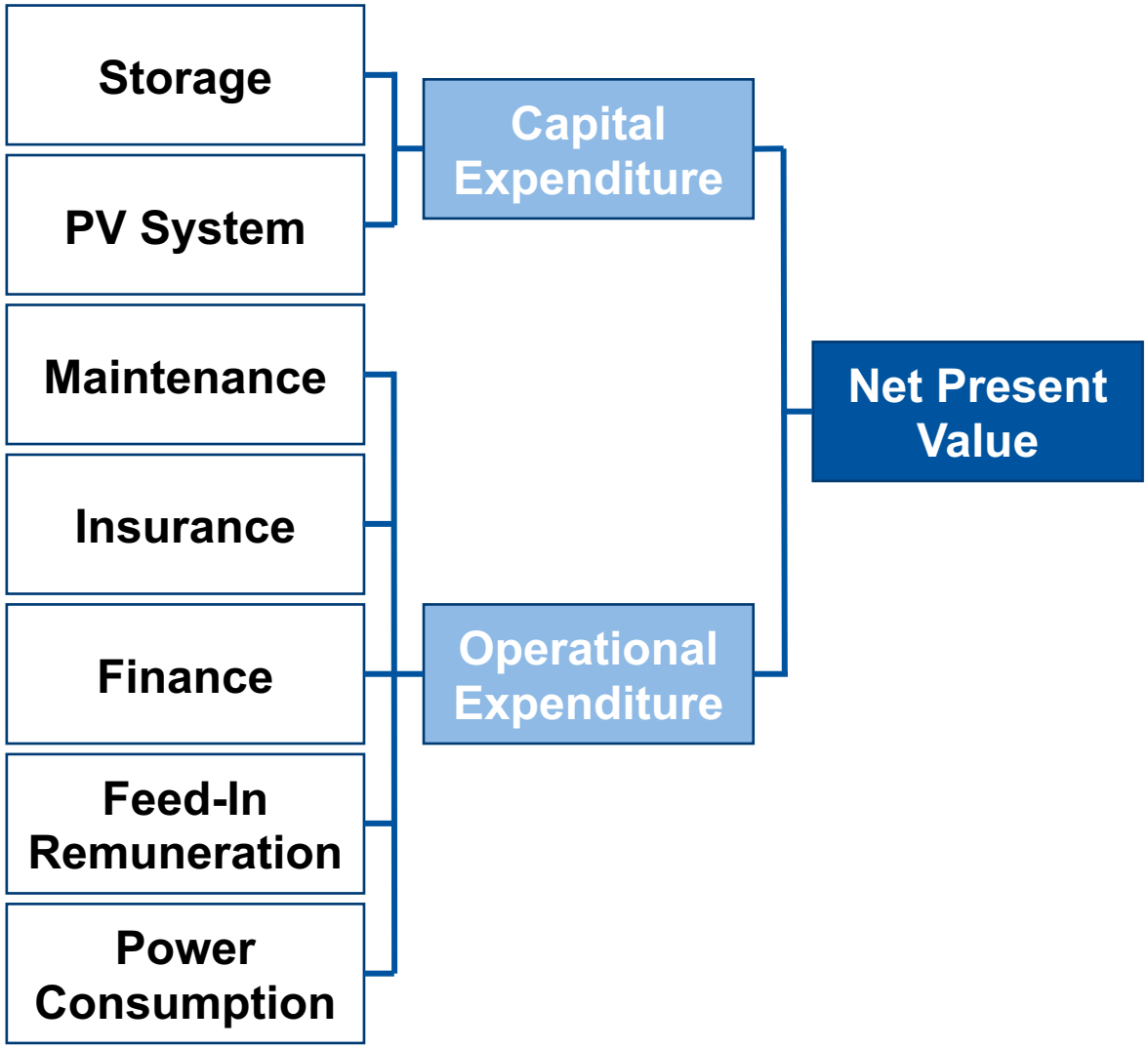
What is the TCO_C for different photovoltaic (PV) systems in combination with BES systems in different usage scenarios?

What is the most cost-effective option regarding a PV-BES-system from the user perspective considering German market conditions?

Previous Research

#	References	Business Admin.		Economic	Technical	PV	BES	Miscellaneous
		other	TCO					
1	(Rosen & Madlener 2016)			X				• Changes in market regulations • Enable trading of energy for prosumers
2	(Rylatt et al. 2013)			X	X			• Market model • Prosumer is embedded in an aggregator structure
3	(Comello & Reichelstein 2016)	X				X		• Economic efficiency of PV in the U.S. • Remuneration system
4	(McDowall 2017)				X	X	X	• Meaning of BES for the autarchy of micro grids
5	(Bertolini et al. 2016)	X	X			X		• Impact of a PV system for micro grids
6	(Klise 2013)	X	X			X		• TCO for PV systems in the U.S. • Incl. discounted CF
7	(Kamankesh & Agelidis 2017)	X		X		X		• Optimising the management of the grid with high share of RES and V2G
8	(Vosoogh et al. 2014)	X		X	X	X	X	• Optimising the energy flow in a micro grid
9	Kappner et al.	X	X	X	X	X	X	• Calculating the profitability of a PV system with BES • Real data sets • Taking into account technical restrictions

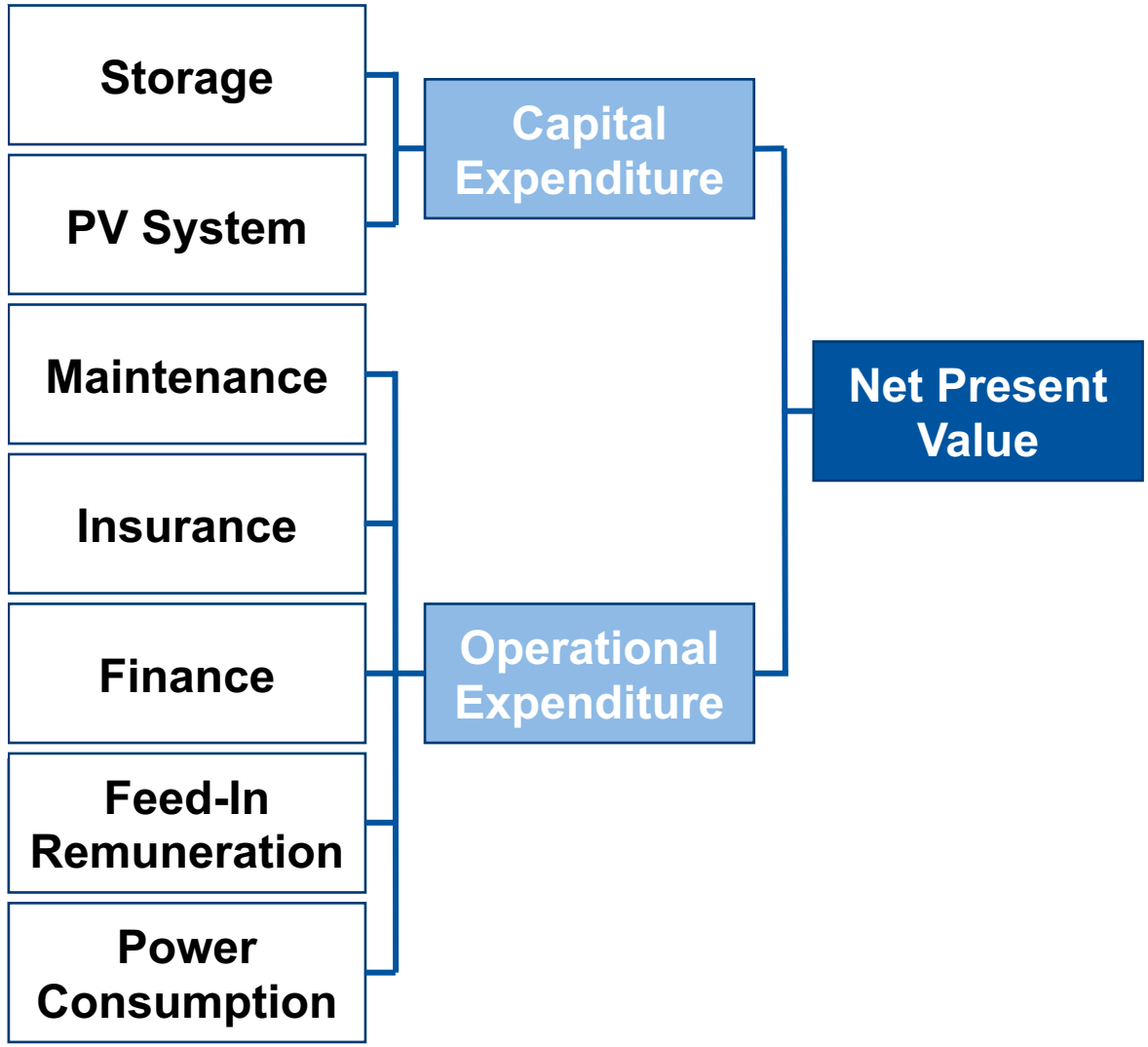
Model Overview



Model Overview

PV panels:

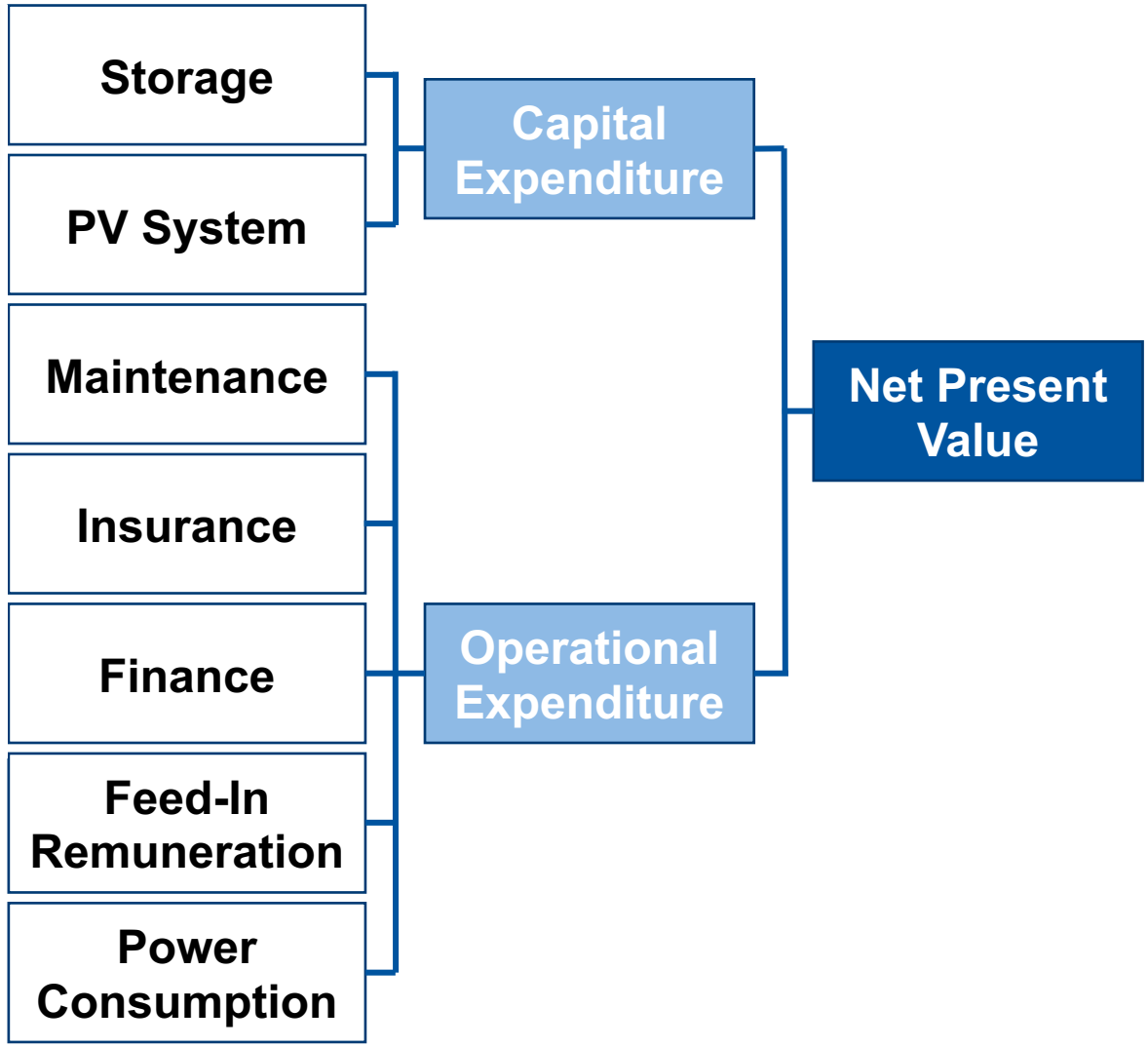
- Real market data: Sizes and costs
- Sizes up to 10 kW_p (limited by law)
- Production profile calculated with real weather data



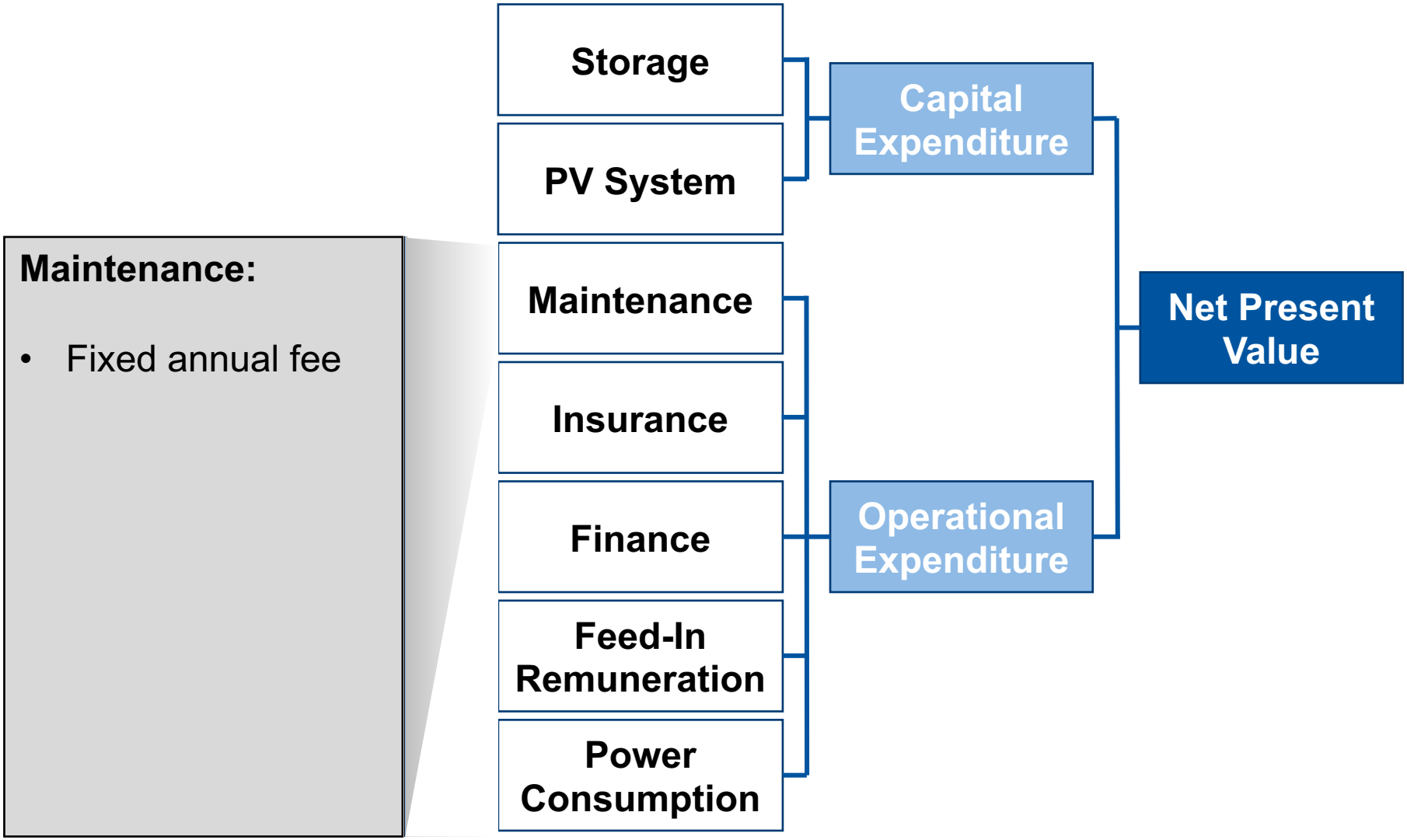
Model Overview

Storage:

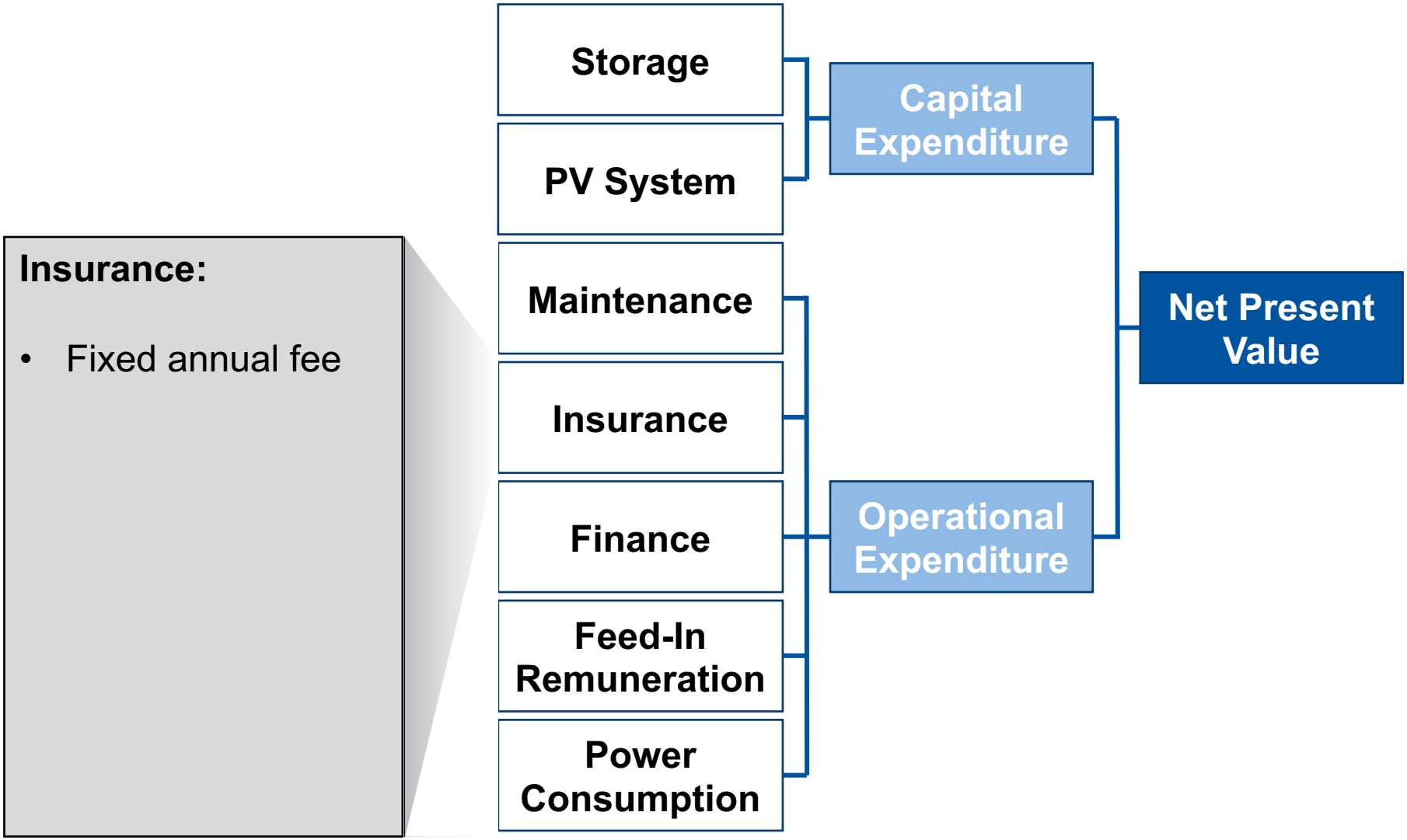
- Installed additionally to an existing PV system or simultaneously with a new PV system
- Real market data: Sizes and costs
- Assumed lifespan of 20 years



Model Overview



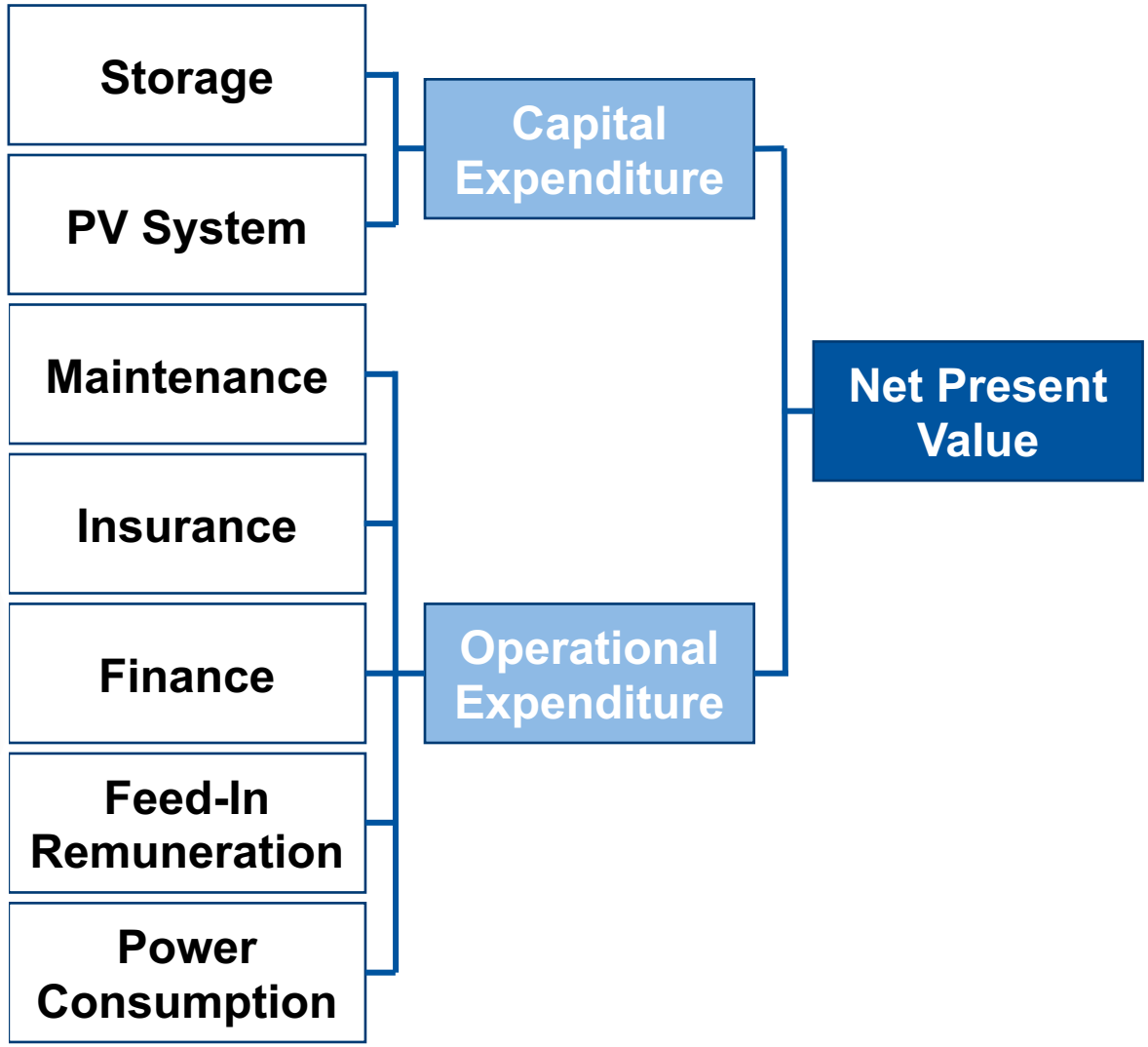
Model Overview



Model Overview

Finance:

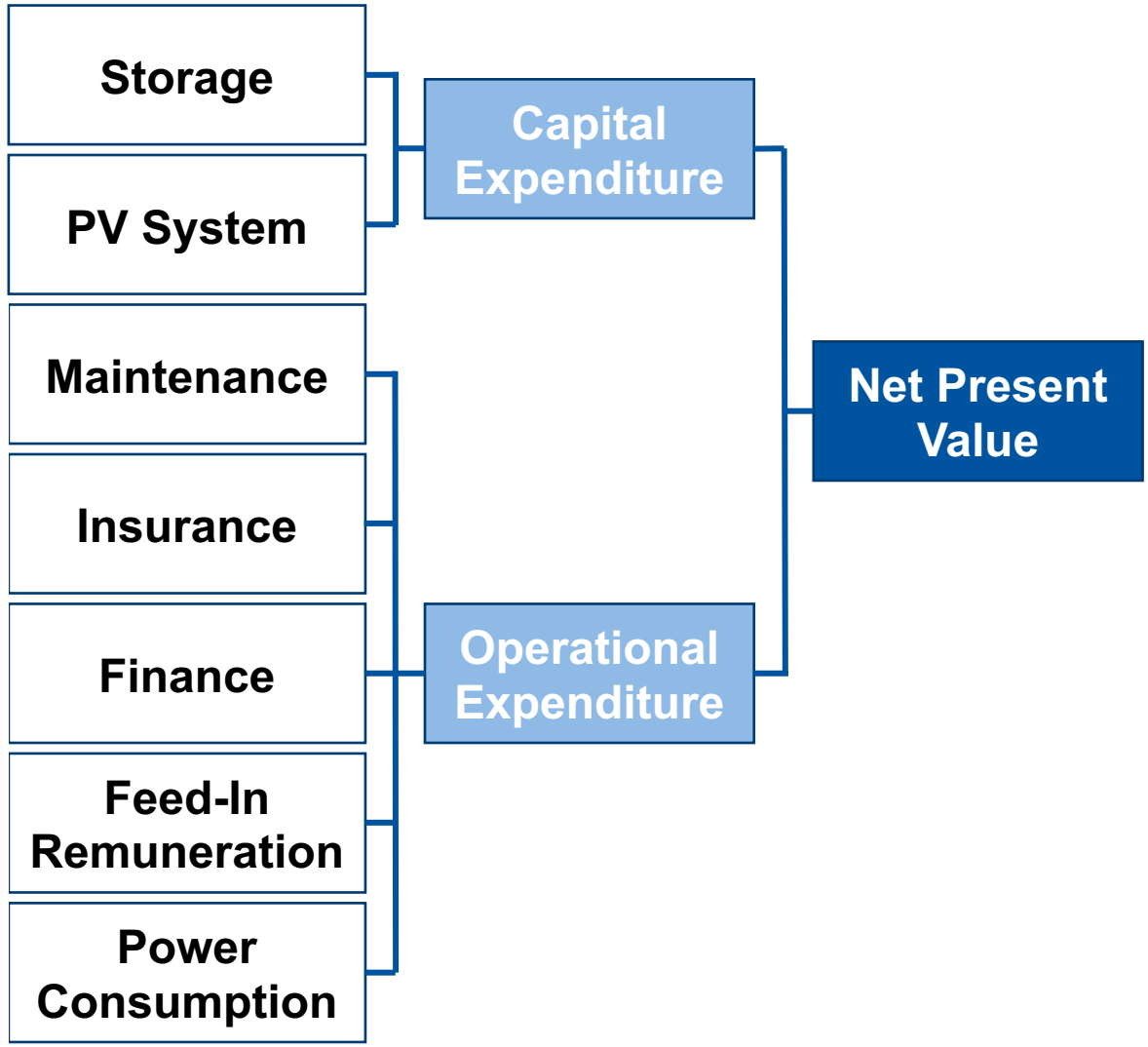
- Internal interest rate similar to inflation rate
- Special loans by KfW
- Repayment bonus by Federal Government



Model Overview

Feed-In Remuneration:

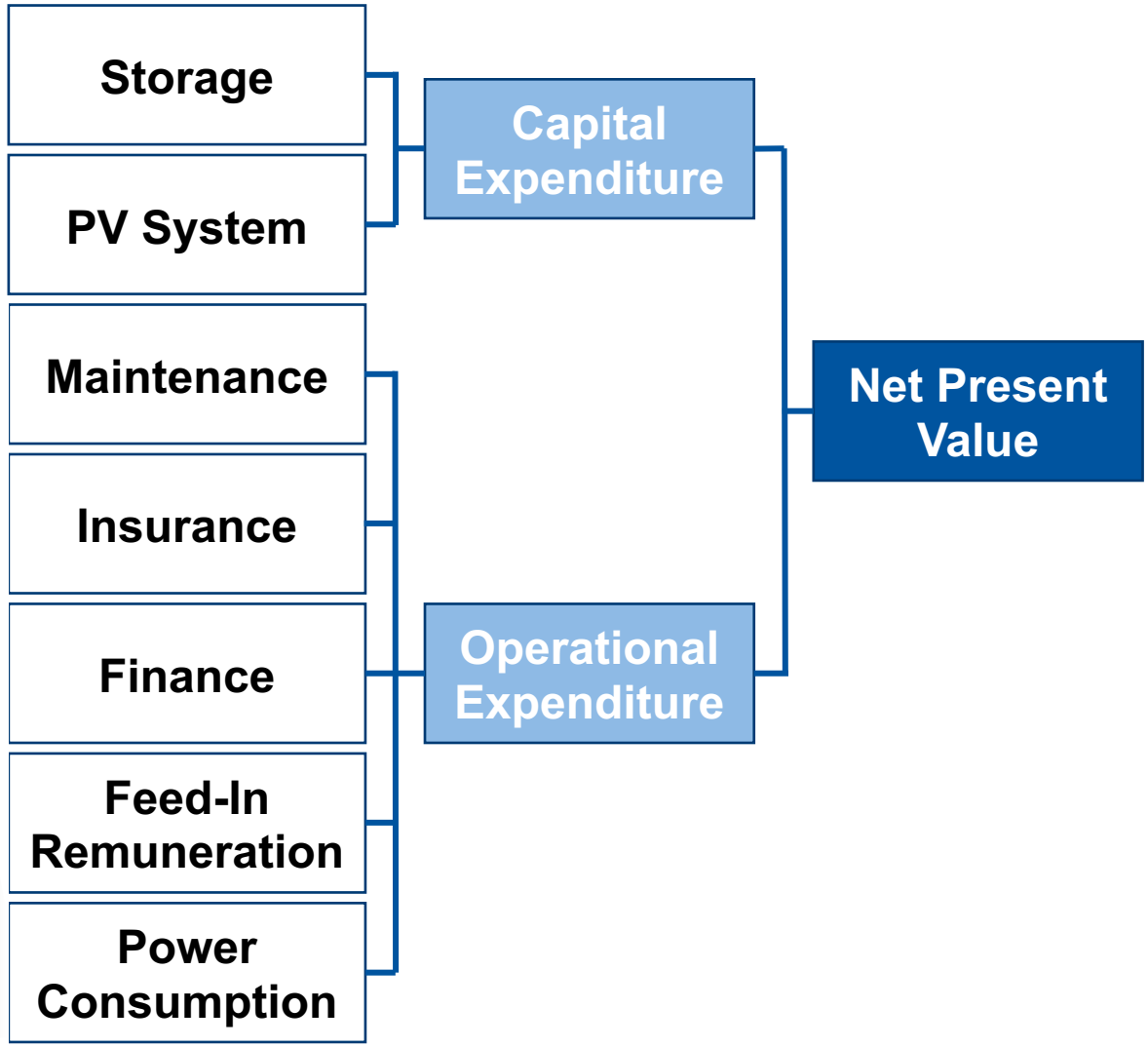
- Standard set: 0.12 €/kWh
- Range: 0.04 €/kWh – 0.507 €/kWh



Model Overview

Power Consumption:

- Rule: first own produced energy, second supplied energy
- Price per kWh supplied energy: 0.29 €/kWh



Model Overview

Calculation of NPV and Annuity

Calculation NPV

$$C_{NPV} = C_{Capex} + \sum_{t=1}^{T} \frac{C_{Opex,t}}{(1+i)^t}$$

Calculation Annuity

$$C_{TCO_C} = C_{NPV} \frac{(1+i)^t * i}{(1+i)^t - 1}$$

Symbol	Explanation	Content
C_{Capex}	Capital Expenditure	PV System + Battery Energy Storage
C_{Opex}	Operational Expenditure	Electricity Cost + Feed-in Remuneration + Maintenance + Insurance + Financing
C_{TCOC}	Annual Consumer-oriented Total Cost of Ownership	Evenly Distributed Costs per year
i	Interest Rate	3 %
C_{NPV}	Net Present Value	Cumulated Costs discounted to year 0
t	Period	1-20
T	Period under Review	20 years
TCO_C	Consumer-oriented Total Cost of Ownership	

Results

Scenario Analysis

Household Size		Size of PV System [kW_p]									
		no PV	4.88			7.32			9.76		
		Annuity [€]	Battery [kWh]	Annuity [€]	Self-sufficiency	Battery [kWh]	Annuity [€]	Self-sufficiency	Battery [kWh]	Annuity [€]	Self-sufficiency
	1 Person 1714 kWh	-511.97	0	-387.24	47.37%	0	-302.07	49.58%	0	-219.71	50.83%
			6	-776.95	86.20%	6	-695.09	91.54%	6	-622.19	94.80%
			10	-992.72	87.36%	10	-909.50	92.61%	10	-836.6	95.83%
			16	-1258.86	88.16%	16	-1174.80	93.31%	16	-1102.14	96.53%
	2 Persons 2812 kWh	-839.94	0	-640.39	43.82%	0	-547.94	46.79%	0	-461.07	48.54%
			6	-988.44	75.86%	6	-887.97	82.84%	6	-802.93	86.85%
			10	-1200.98	77.35%	10	-1098.79	84.79%	10	-1011.34	88.96%
			16	-1465.53	77.84%	16	-1362.60	85.67%	16	-1274.04	90.28%
	3 Persons 3704 kWh	-1106.38	0	852.65	41.40%	0	-752.98	44.84%	0	661.92	46.87%
			6	-1177.93	69.03%	6	-1062.26	76.69%	6	-968.14	81.18%
			10	-1387.15	70.63%	10	-1268.25	79.17%	10	-1169.87	84.08%
			16	-1649.99	71.45%	16	-1529.78	80.29%	16	-1430.33	85.43%
	4 Persons 4432 kWh	-1323.84	0	-1029.69	39.67%	0	-923.41	43.41%	0	-828.44	45.64%
			6	-1341.68	64.45%	6	-1215.03	72.41%	6	-1113.96	76.93%
			10	-1545.62	66.22%	10	-1415.10	75.08%	10	-1307.67	80.46%
			16	-1805.95	67.44%	16	-1674.87	76.24%	16	-1565.92	81.81%

Summary / Outlook

Key Findings

- Installing a PV system always creates a **financial added value**.
- The choice of the **largest possible PV system** is always the **best alternative** (up to 10 kW_p). Nevertheless, regardless of the size of the household, any size of a PV system is inancially worthwhile.
- The use of a BES significantly increases the self-sufficiency rate of a household, but **does not achieve a financial advantage** in any constellation.
- In order to make the use of BESs financially advantageous, the acquisition costs of BESs must be reduced and the household load increased.
- The **sector coupling** offers possibilities for extending the load: integration of CHPs and EVs

Thank you very much for your attention

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