Integrated course „Energy Economics“
- Electricity markets fundamentals -

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

Outline – Electricity Markets

Electricity Markets Fundamentals

Economics of electricity generation

Energy trading – Wholesale markets

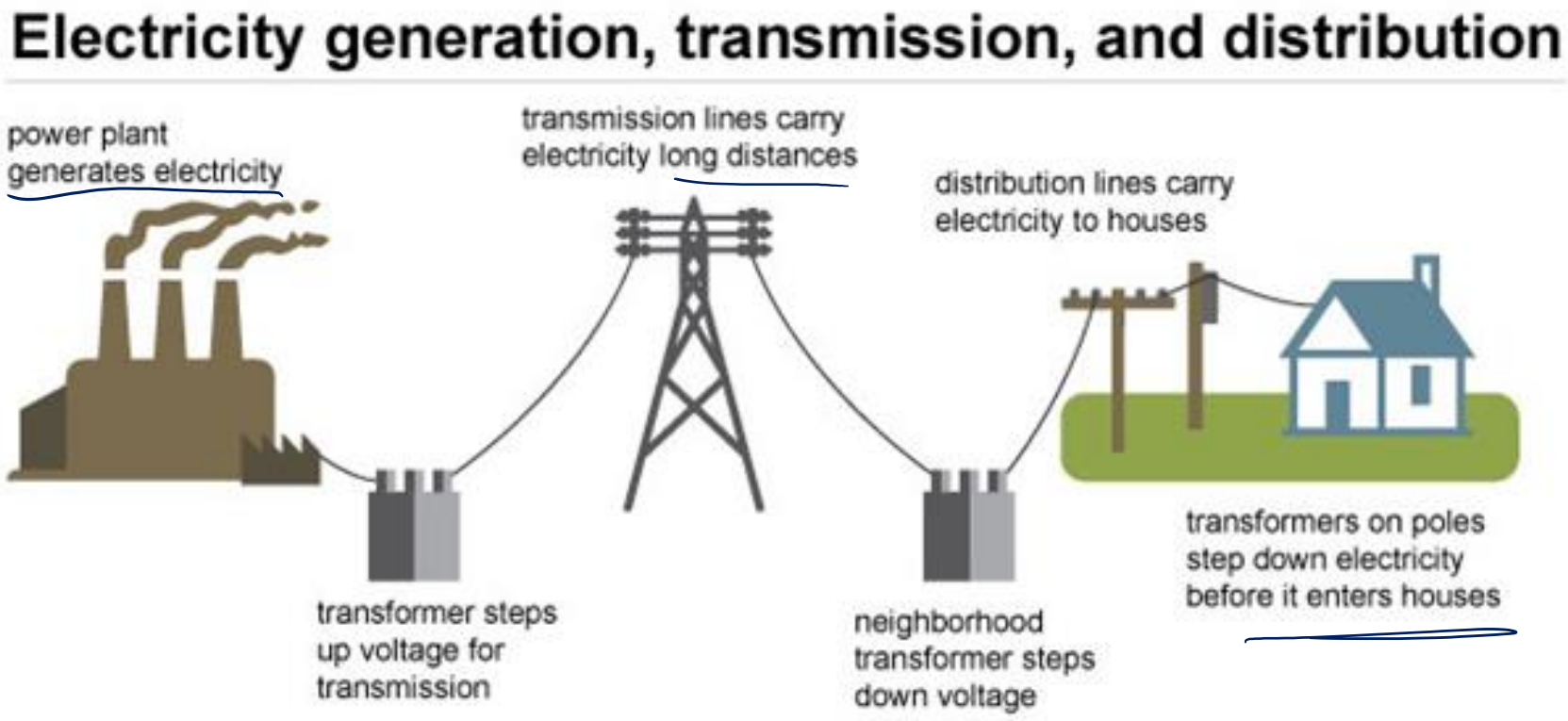
Economics of electricity grid

Retail markets

Outline – Electricity Markets Fundamentals

- Electricity demand: Load duration curve
- Electricity supply: Merit order
- Electricity value chain
- Market participants
- Market structures

Electricity market: Technical view



Source: U.S. EAI

Electricity market: Economic view

Commercial infrastructure

Technical infrastructure

Electricity is produced in power plants.

Produced electricity is offered/traded in the wholesale market.

Produced electricity is transported to final consumers via transmission and distribution grid.

Electricity retailers procure electricity in the wholesale market for supplying final consumers.

Final consumers buy electricity from retailers.

Electricity market: Historical development

Historically, a vertically integrated company (often state-owned) performed all the activities from generation to supply to final consumers.

Since early 1990s: liberalisation (deregulation/restructuring)

- introduction of competition to the activities where competition is considered possible
- state regulation in the areas of natural monopoly

Electricity market: Natural monopoly

Natural monopolies occur in industries for which it is only economically efficient to have a single provider due to economies of scale (decreasing average costs with increasing scale of production).

Electricity transmission and distribution is a decreasing cost industry: Duplicating the grid is economically inefficient.

Yet, natural monopolies – like monopolies in general – tend to overcharge and underserve.

Electricity market: Unbundling

Competitive conditions for electricity generation and retail can be created by state regulation aiming at:

- Costs transparency

  → prevent cross-subsidies*

- Non-discriminatory access to the grid

  → grid connection and transmission/distribution services

** allocating costs from competitive activities to grid operation*

Unbundling is a set of organisational measures to separate transmission and distribution networks from generation and retail activities.

It aims at ensuring independence of a grid operator from other activities in a vertically integrated company and at preventing discrimination of other market participants.

Electricity market: Unbundling types

Accounting u.: separate book-keeping for regulated activities

Legal u.: separate legal entity operates a regulated activity

Management u.: personal requirements for members of management bodies of a grid operator

Operational u.: TSO/DSO should have sufficient resources for operations (rather than relying on other parts of the vertically integrated undertaking). Restrictions for shared services (HR, IT, legal, finance etc.)

Informational u.: non-disclosure of commercially sensitive information from regulated activities (grid operation) to other units; otherwise - non-discriminatory disclosure to all market participants

Ownership u.: grid is operated by an entity with a separate ownership control.

Electricity market: Unbundling in the EU

1996: 1st Energy Package – Directive 96/92/EC

accounting and informational unbundling for vertically integrated undertakings (VIU)

2003: 2nd Energy Package – Directive 2003/54/EC

legal, management, operational and informational unbundling

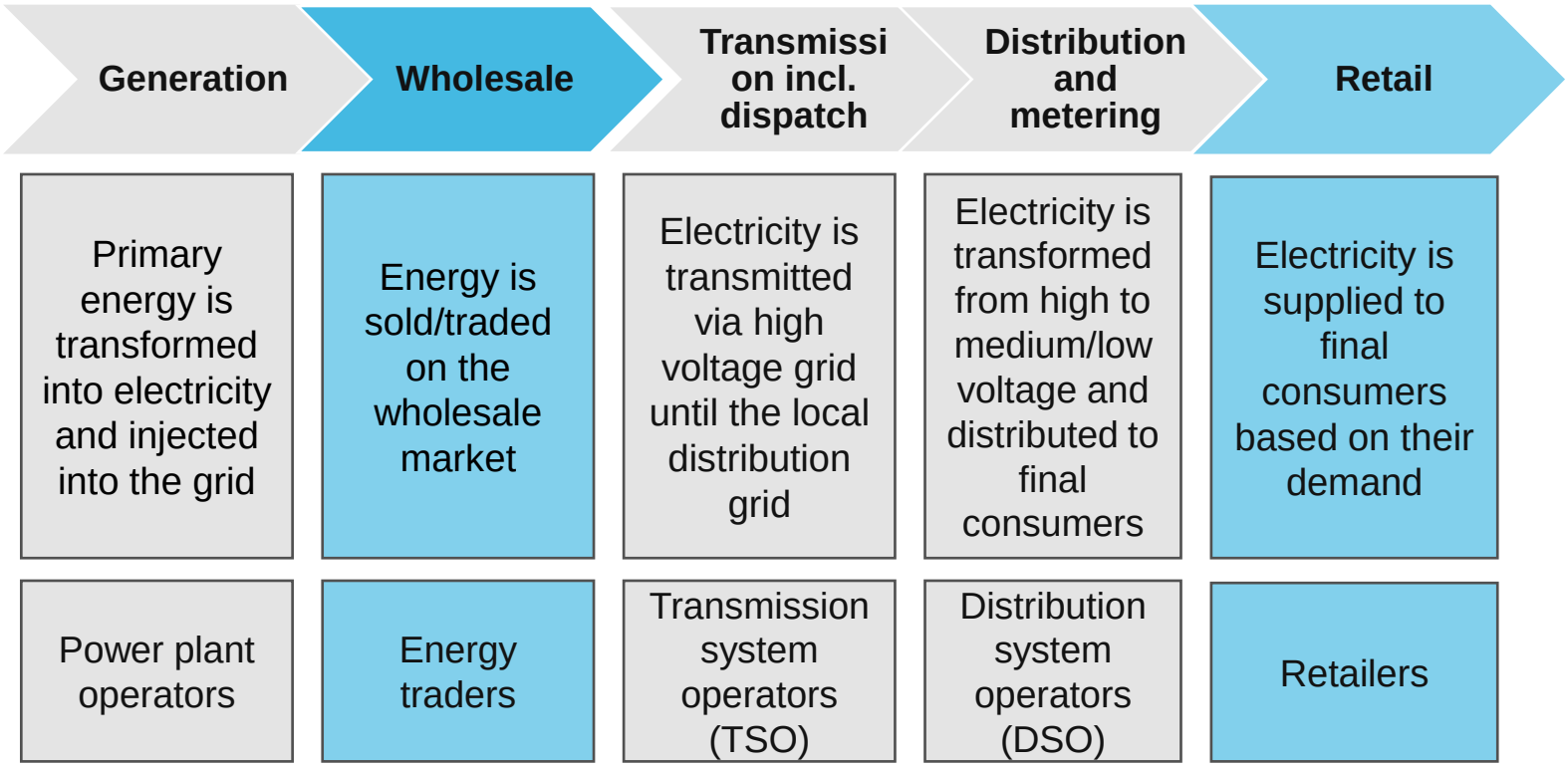
2009: 3rd Energy Package – Directive 2009/72/EC

TSO: ownership unbundling; alternatively ISO or ITO model

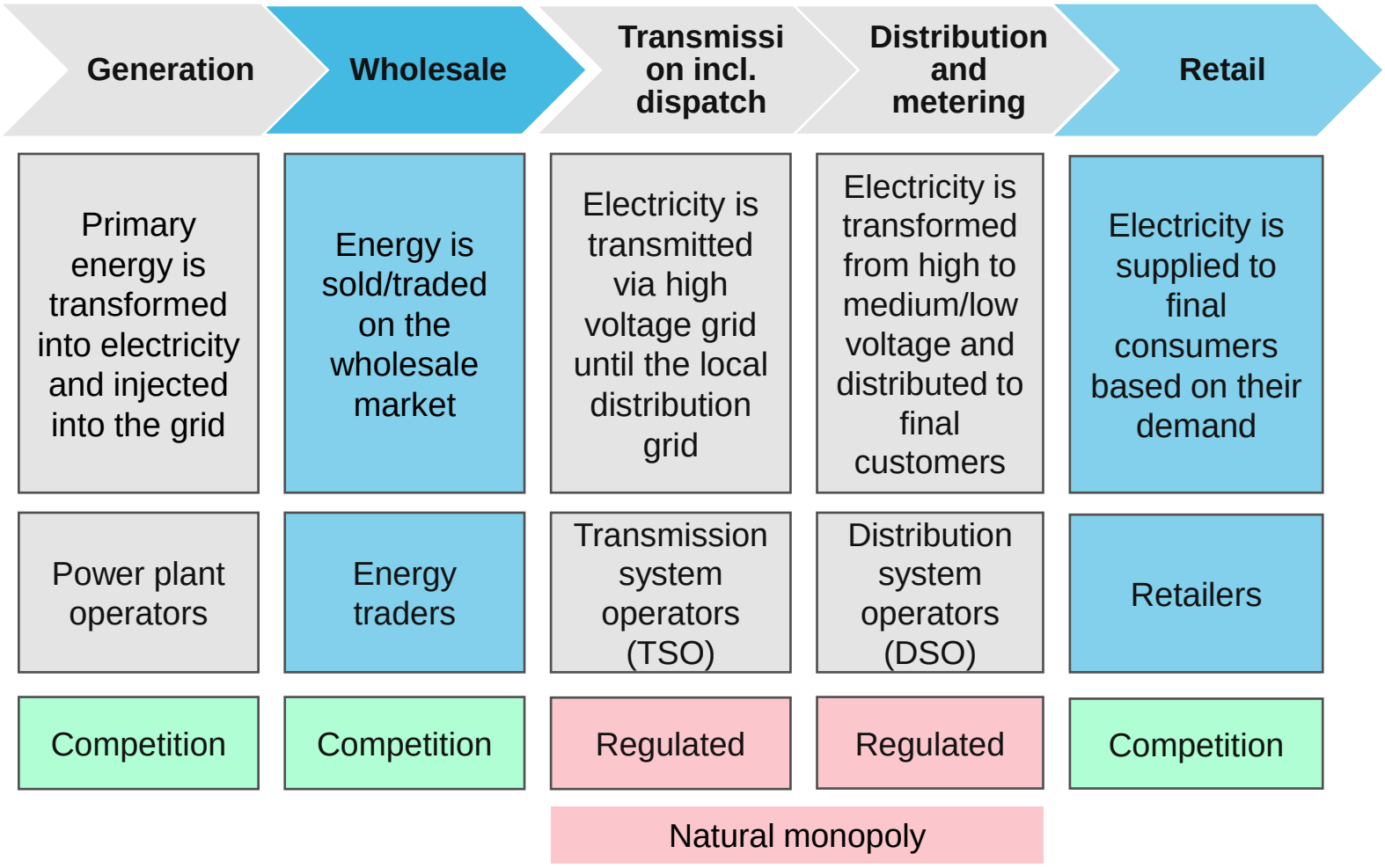
- ISO: while the VIU keeps ownership control, an independent system operator operates the grid, incl. decisions on third-party access and investment planning
- ITO: TSO remains part of VIU but is subject to additional stricter requirements for effective independence

DSO: legal, management, operational and informational unbundling

Electricity value chain: Main actors



Competitive and natural monopoly activities



Electricity market: Objectives

Objectives of an electricity market design:

- Short-run efficiency

  → making the best use of existing resources (generation capacities etc.)

- Long-run efficiency

  → promoting efficient investment into new resources (generation assets, grid, storage etc.)

- Reliability

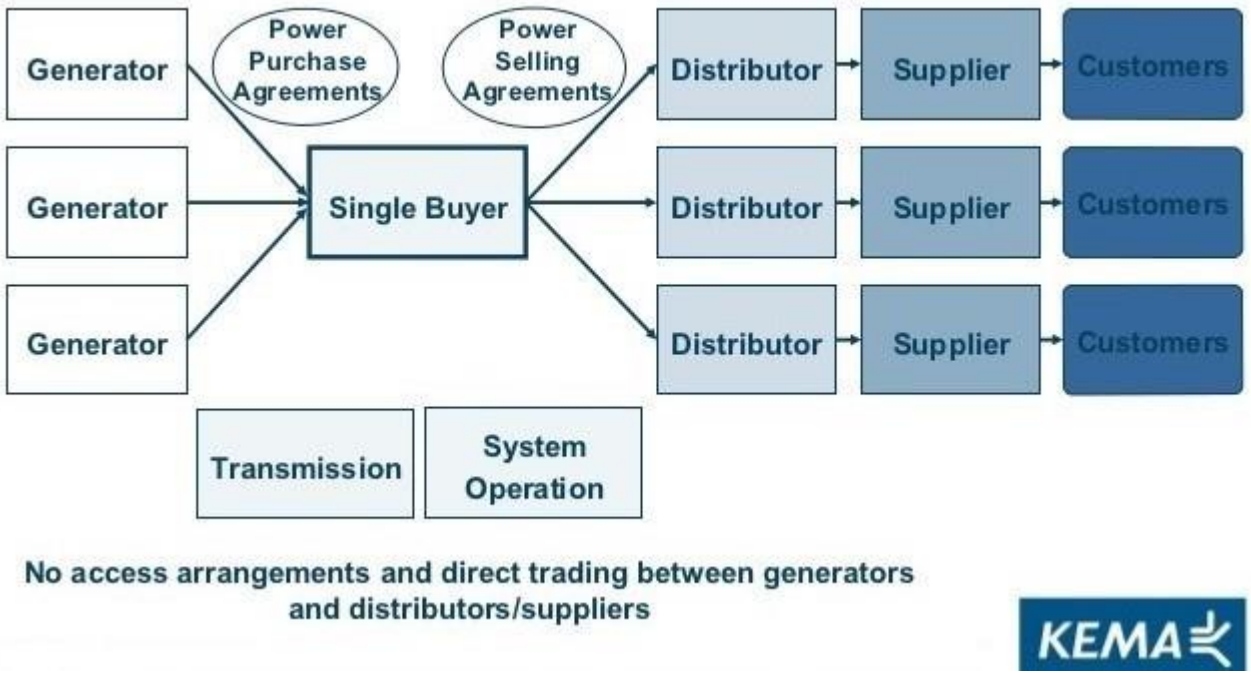
  → reserve for satisfying demand at times of generation shortage

Source: Crampton, Oxford Review of Economic policy, Vol. 33, No. 4, 2017, p. 591.

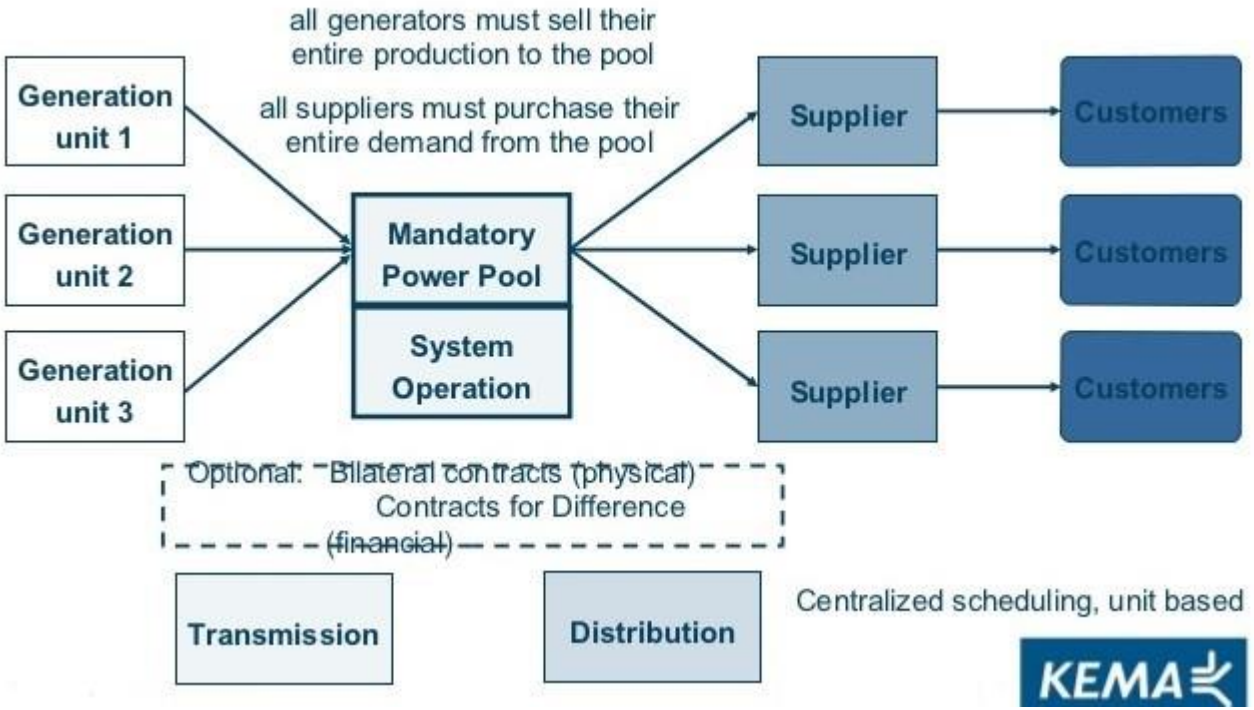
Electricity market structure types

- Single buyer
- Power pool
- Free wholesale competition
- Fully liberalised market with retail competition

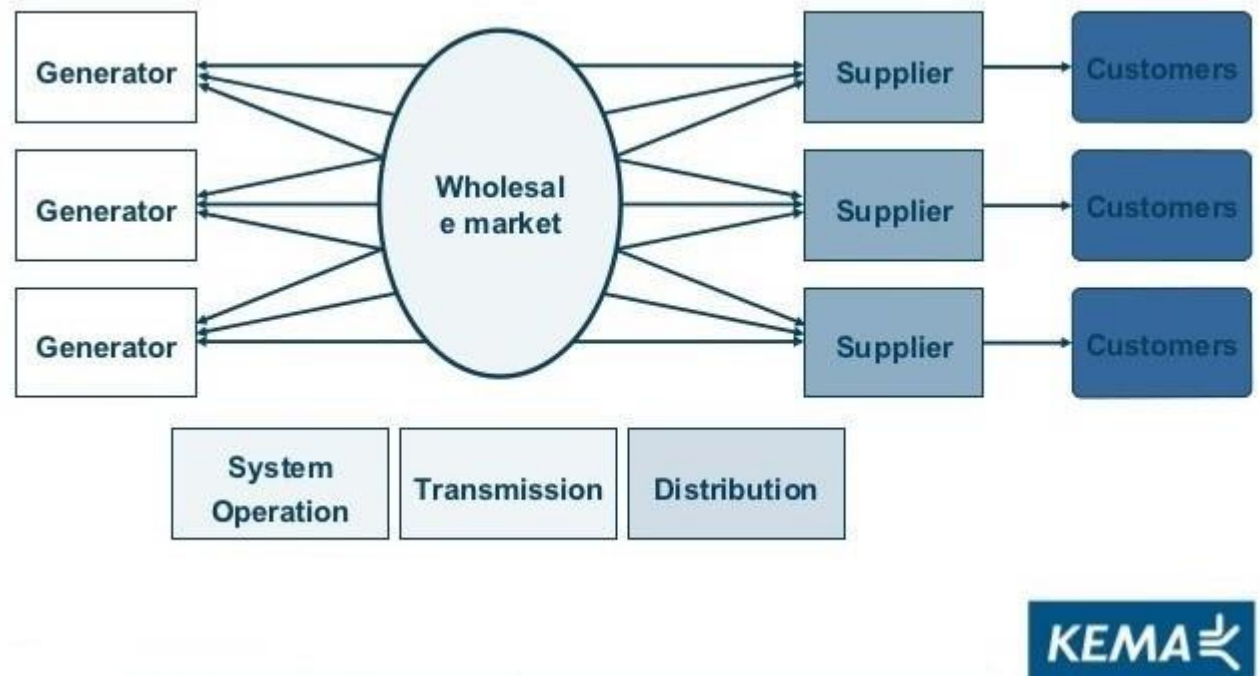
Electricity market structures: Single buyer



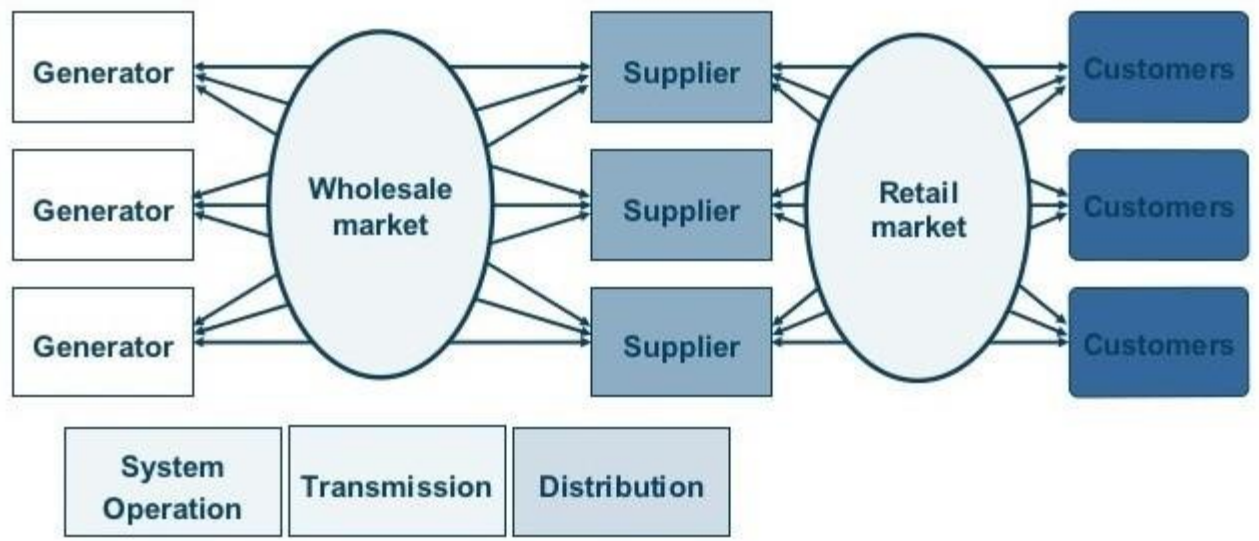
Electricity market structures: Power pool



Electricity market structures: Wholesale competition

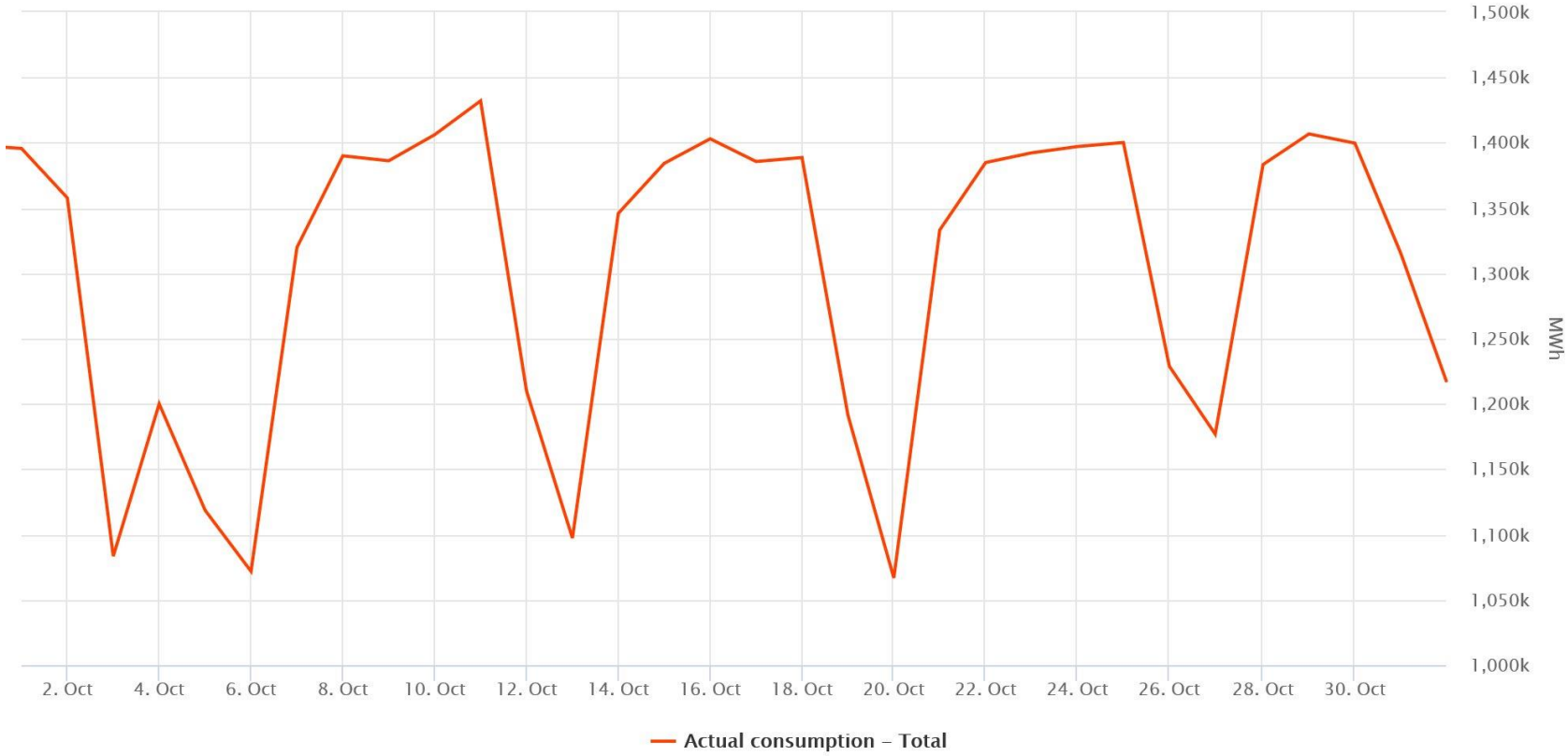


Electricity market structures: Retail competition



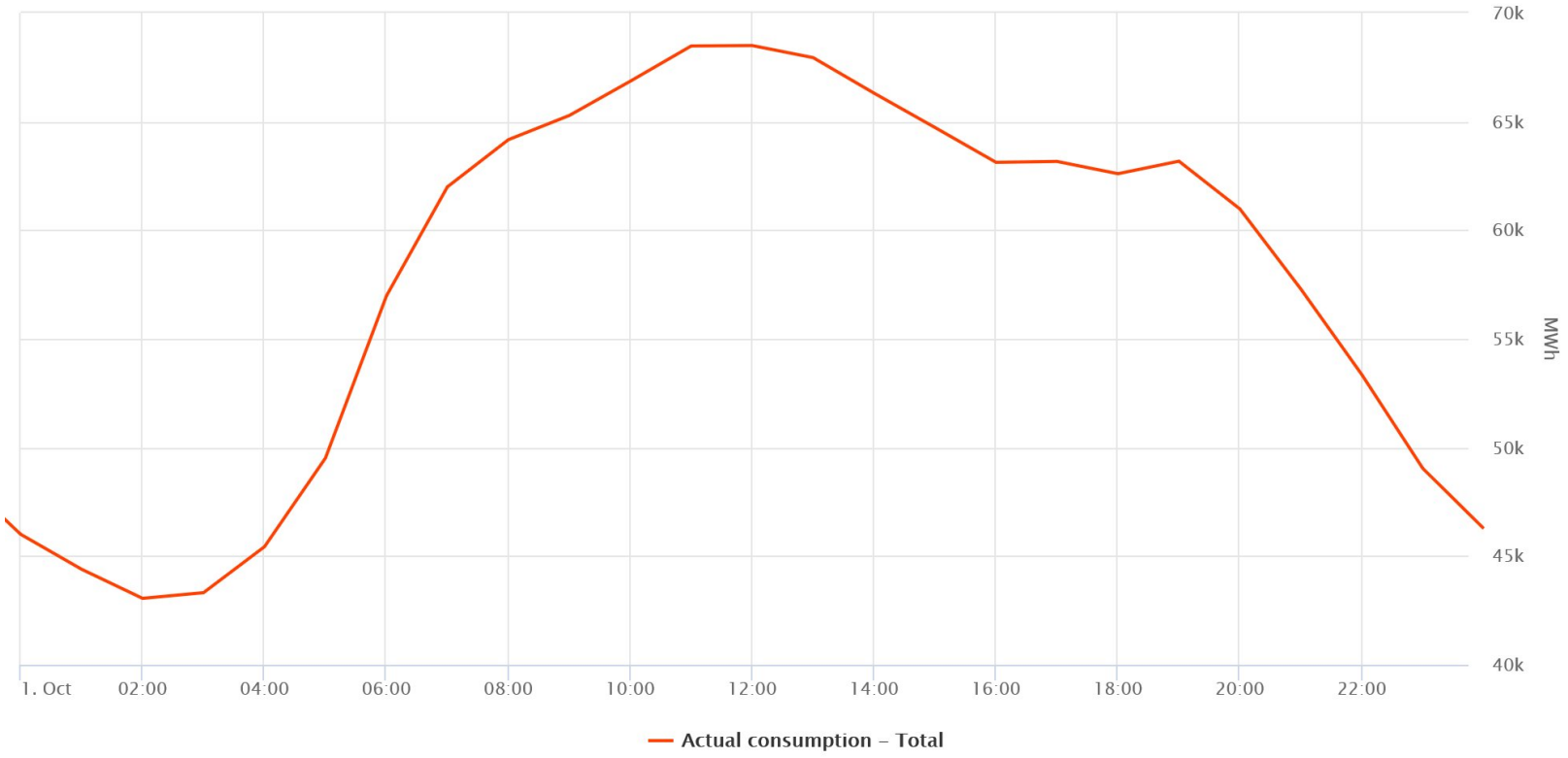
Load curve Germany – October 2019

Electricity demand fluctuates throughout the day, the week and across seasons.



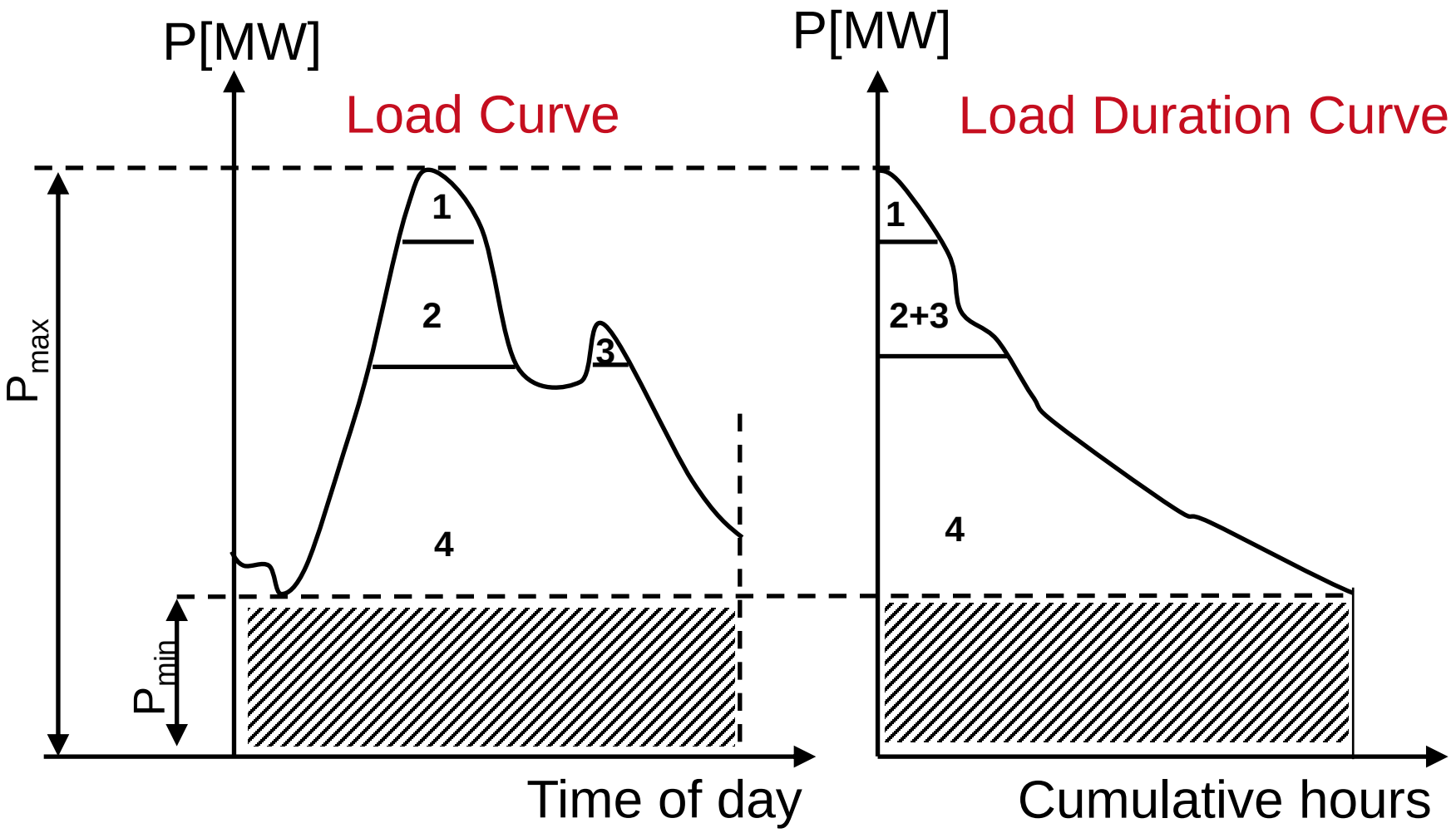
Source: SMARD

Load curve Germany – 1st October 2019



Source: SMARD

Load Curve and Load Duration Curve



Matching supply and demand

Electricity is virtually non-storable.

Demand is barely responsive to wholesale price fluctuations.

Thus, electricity supply and demand are balanced by continuous adjustment of generation.

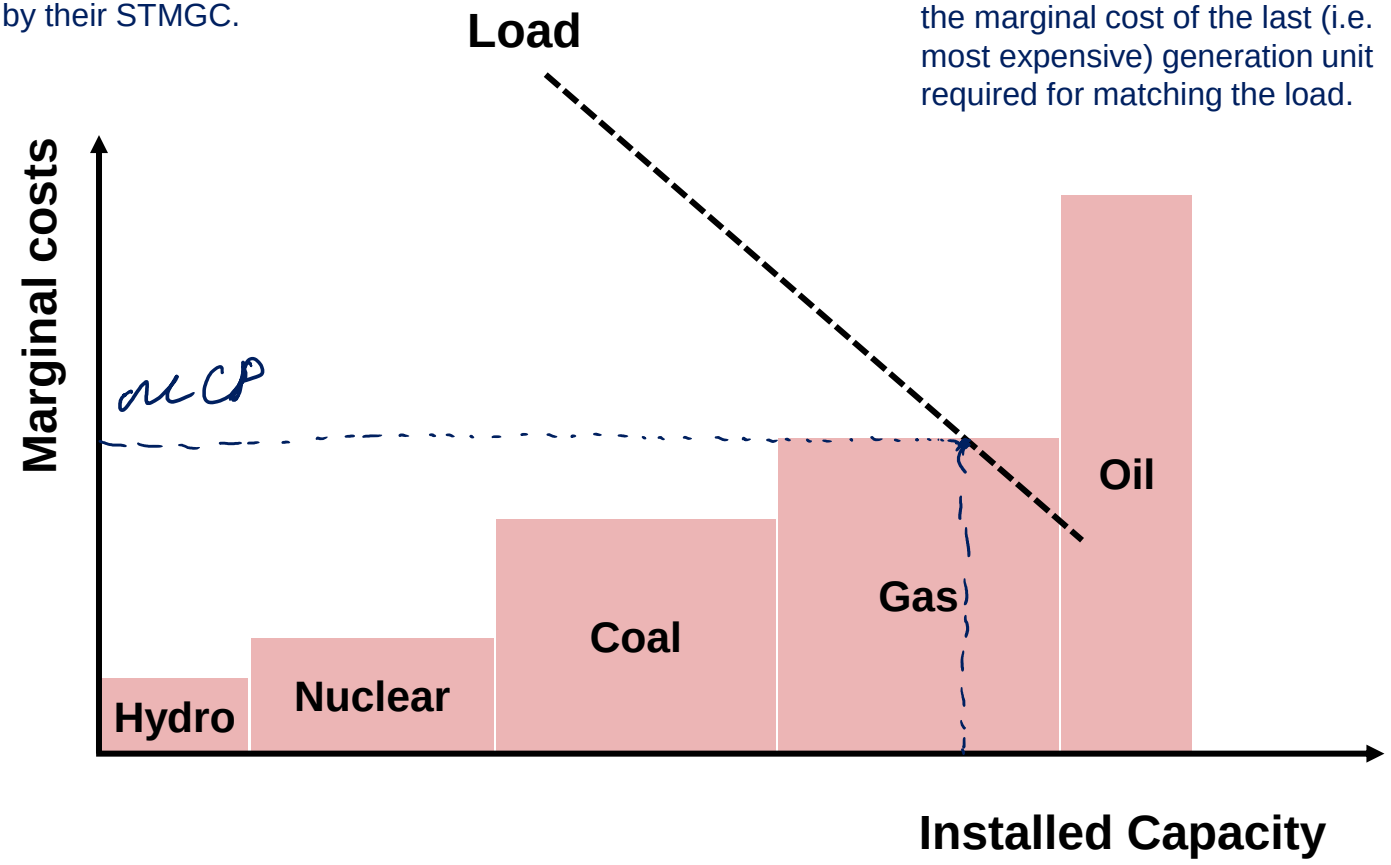
Categories of costs in power production

	Relevance for		
	Operational Decisions	Decommissioning Decisions	Investment and Expansion Decisions
Costs depending on capacity		[€/MW]	
• Capital costs (annuity) • Labour costs • Fixed O&M costs		 X X	X X X
Costs depending on operation		[€/MWh]	
• Fuel costs • CO2 costs • Other variable costs (e.g variable O&M costs, ramping costs, start-up costs)	X X X	X X X	X X X

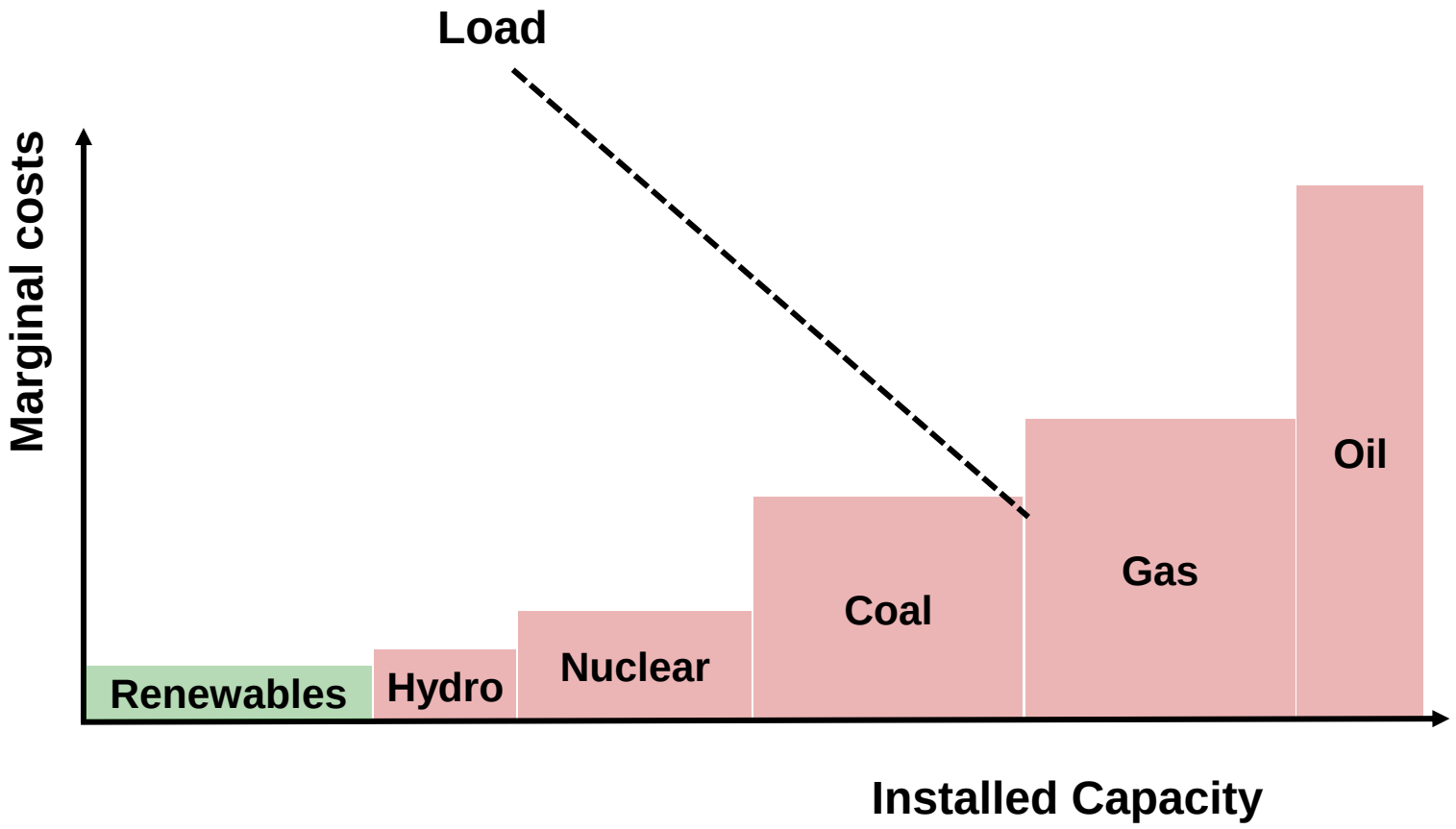
Merit Order

Available generation capacities arranged by their STMGC.

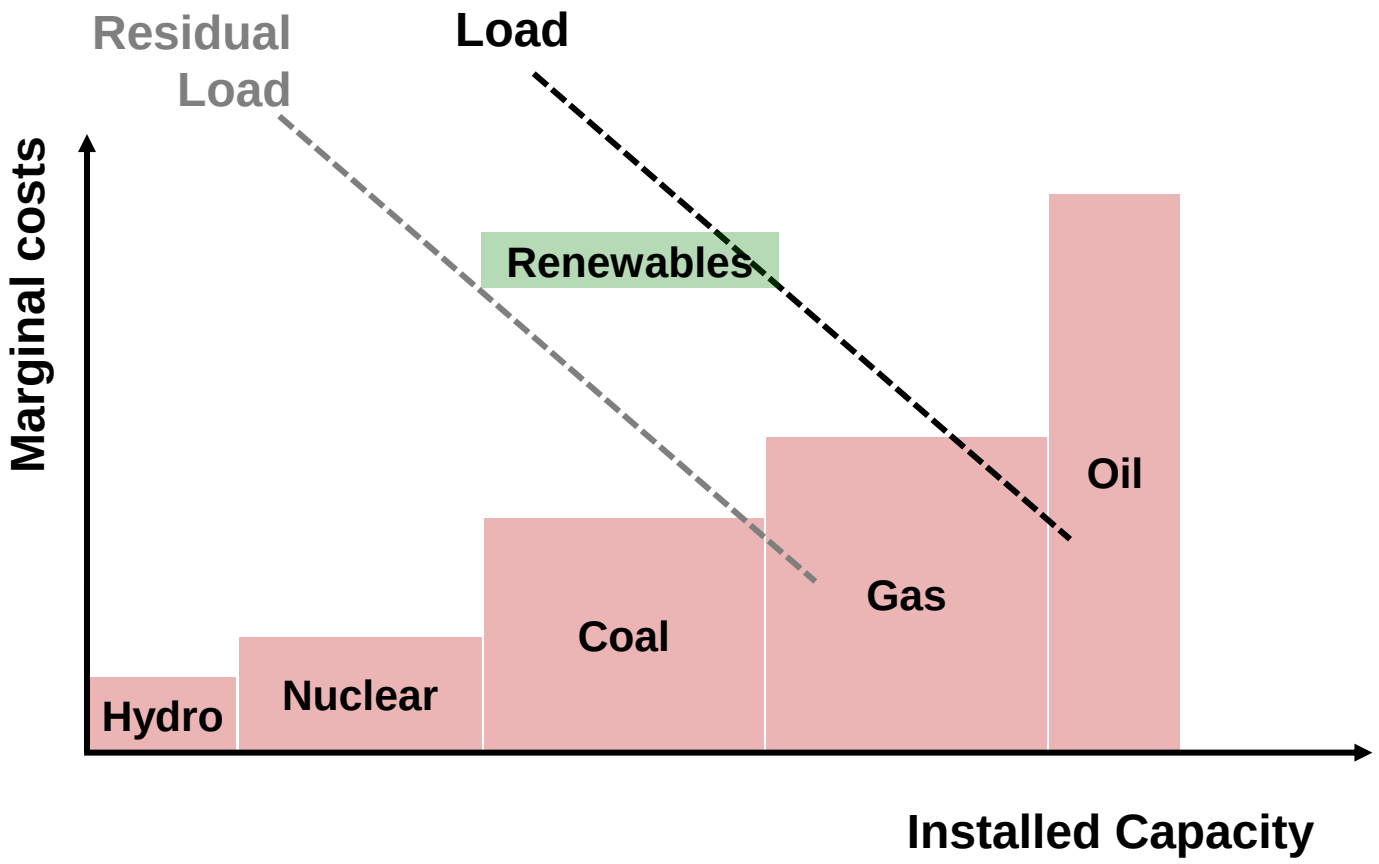
The market clearing price equals the marginal cost of the last (i.e. most expensive) generation unit required for matching the load.



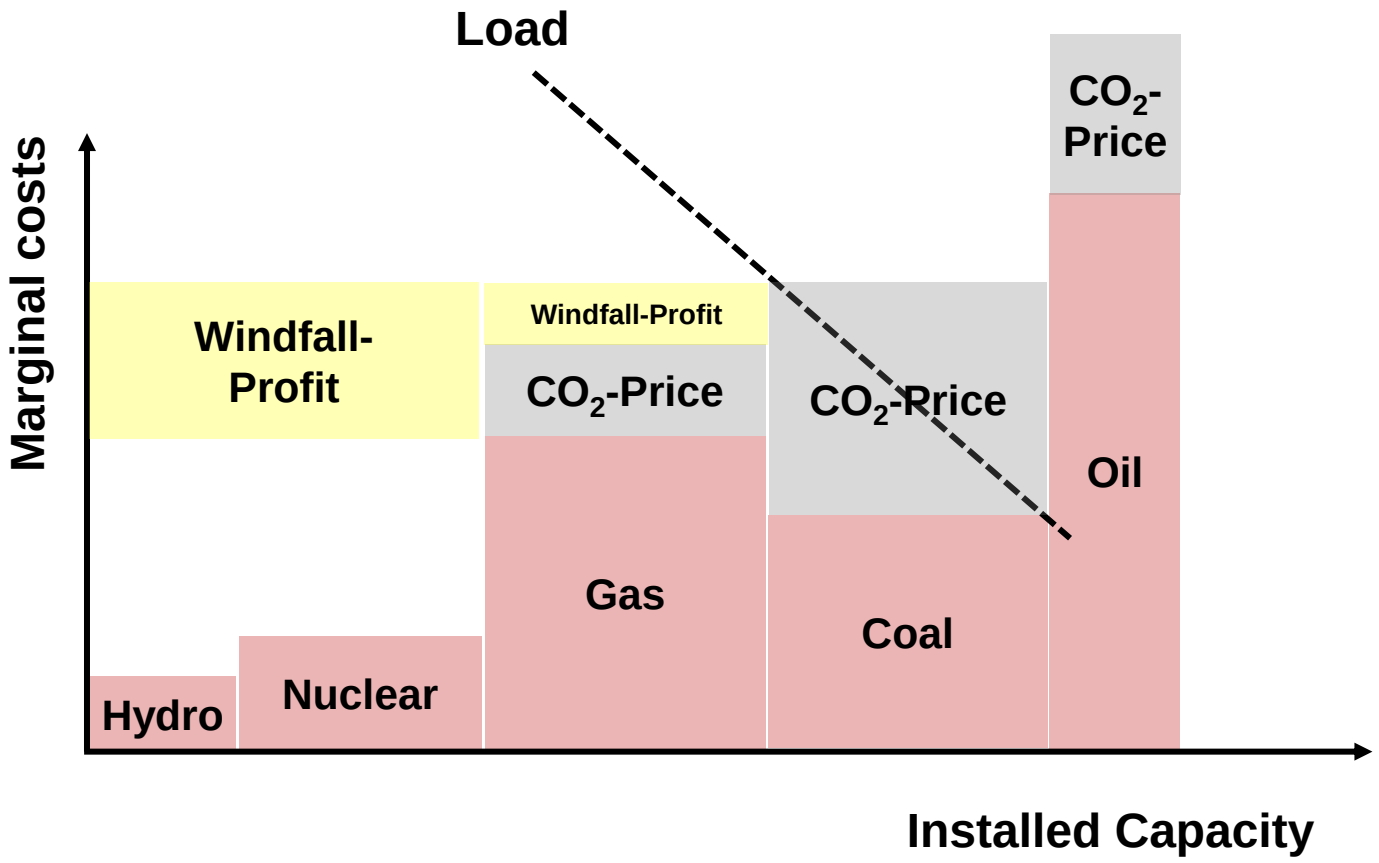
Merit Order Effect of Renewables



Merit Order


Residual Load
Load
Marginal costs
Renewables
Oil
Gas
Coal
Nuclear
Hydro
Installed Capacity

Merit Order - Impact of CO_2 – Prices



Task 1) Load Duration Curve

The peak load in a power system is 16 000 MW. Other load values and their durations in a year are given in the table.

Load [MW]	*Duration [h]*
≥ 12 000	1 500
≥ 8 000	4 500
≥ 6 500	7 000
≥ 4 000	8 760

a) Sketch a **load duration curve**.

b) What are the limitations of electricity market analyses based on a load duration curve?

c) What is the so called "**residual load**" and what does it imply?

Task 1) Load Duration Curve

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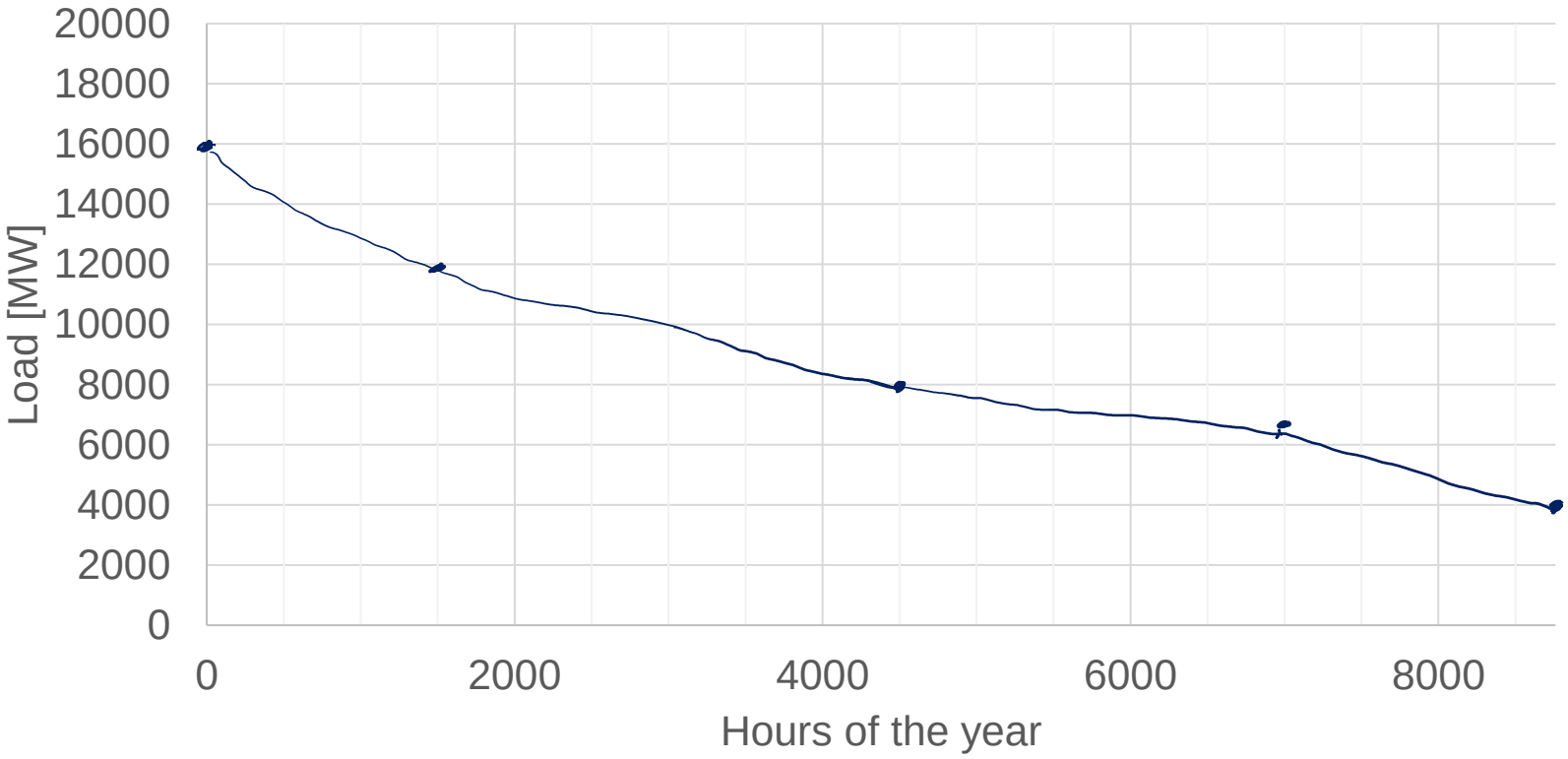

Task 1) Load Duration Curve

b) What are the limitations of electricity market analyses based on a load duration curve?

The load duration curve describes the duration of certain load levels but not their actual sequence and timing. It can be applied in analyses where the chronological aspect is irrelevant or can be neglected.

However, chronological load curve modelling is required for the representation of e.g. storage operation, start-up costs, ramping constraints or dispatch of power plants.