A POWER MARKET DESIGN TO DECOUPLE ELECTRICITY PRICES FROM SOARING NATURAL GAS PRICES

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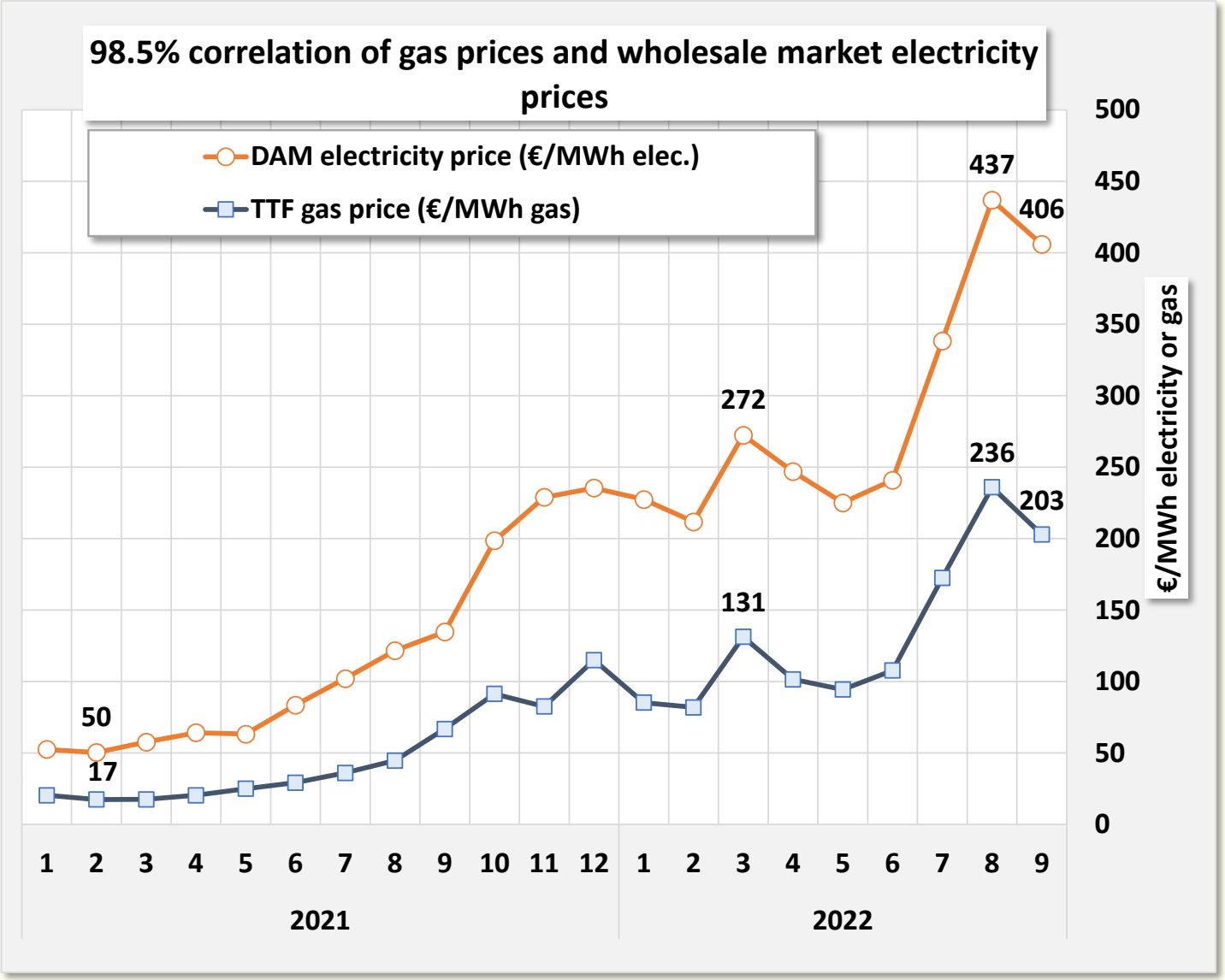


Unprecedented energy price crisis

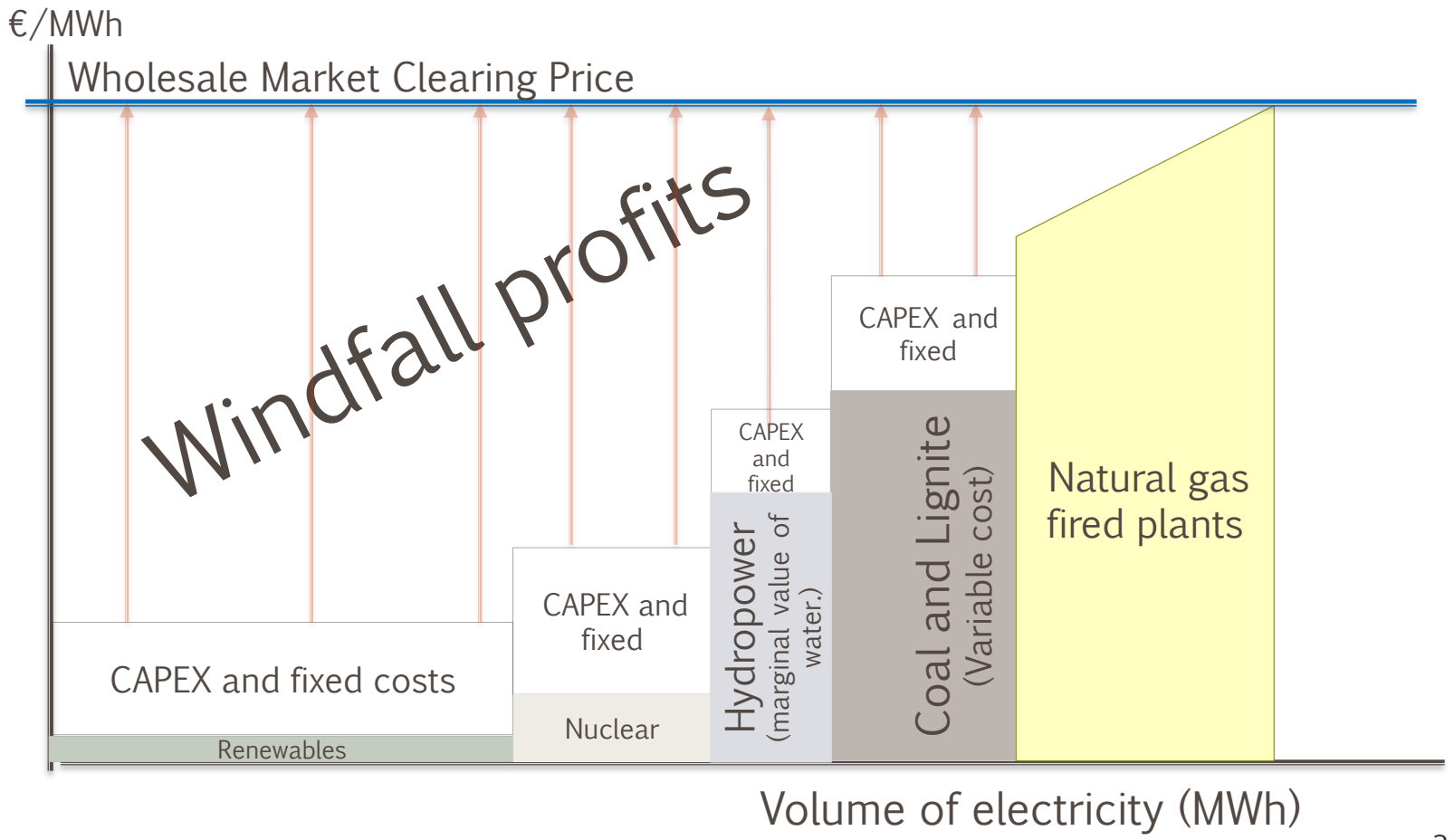
- Compared to prices at the beginning of 2021:
  - Natural gas x 10
  - Wholesale electricity prices x 8
  - Retail electricity prices, depending on the share of fixed price contracts
- Wholesale electricity prices strongly dependent on natural gas prices
  - Natural gas, needed to balance other sources, is systematically the wholesale market price setter
  - But less than 1/3 of electricity comes from natural gas

Short term intervention:

Collection of windfall profits to transfer to consumer bills

- Marginal cost pricing rule for the wholesale market
  - Pay as bid is not applicable
- Natural gas needed in the majority of time slices
- Poor demand response and low storage
- Large proportion of resources with total cost (CAPEX+fixed+variable) significantly below market clearing prices

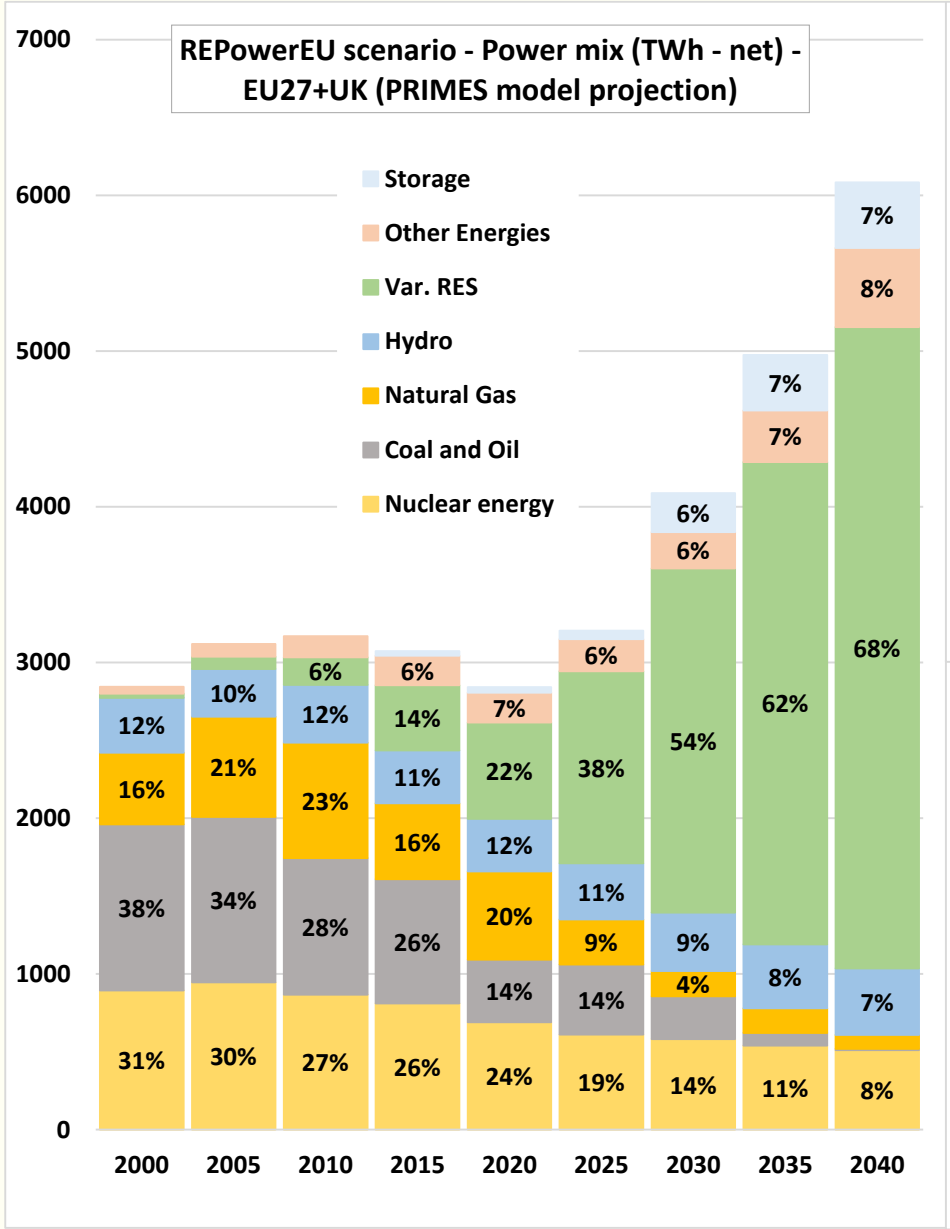
- Natural gas prices drive very high wholesale market clearing prices
- Thus, marginal system costs are higher than total average costs
- Well-functioning retail markets should sell electricity at total average costs if marginal costs are systematically higher
- If not, a market failure occurs
- State intervention is necessary to collect the super-normal profits to the benefit of consumers

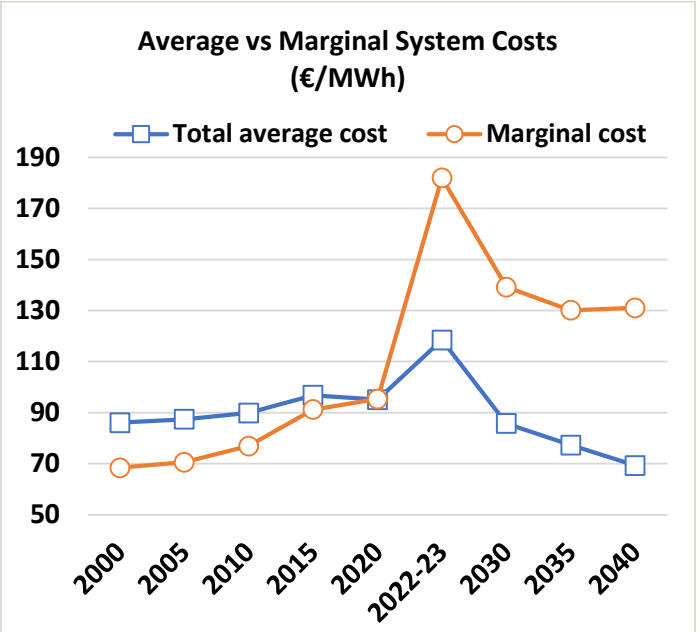


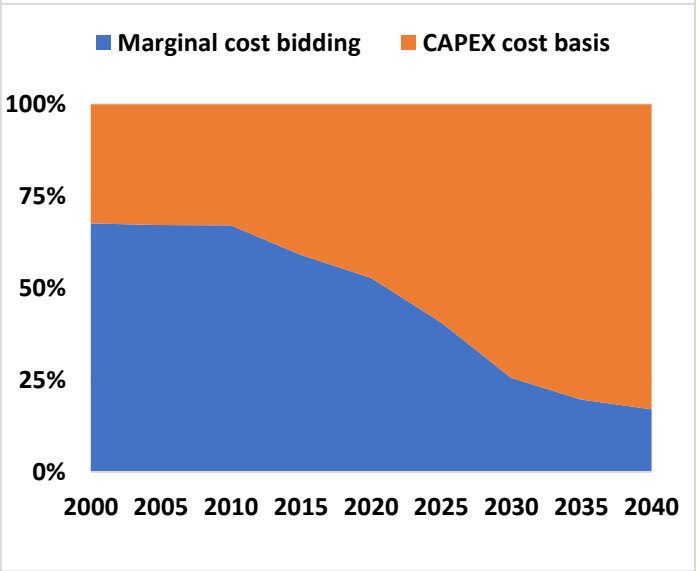
Net-zero carbon transition

(REPowerEU projection)

- The power mix drastically restructures away from fossil fuels
- The system's cost structure shifts from OPEX to CAPEX
- The marginal cost bidding resources have a diminishing share, below 25% already by 2030
- The CAPEX-depending resources need long-term contracts to get affordable capital financing
- The gas price crisis brought earlier than expected the situation where marginal system costs are systematically higher than total average costs; this is likely to perpetuate in the future within the green transition.
- (the opposite was occurring in the past)







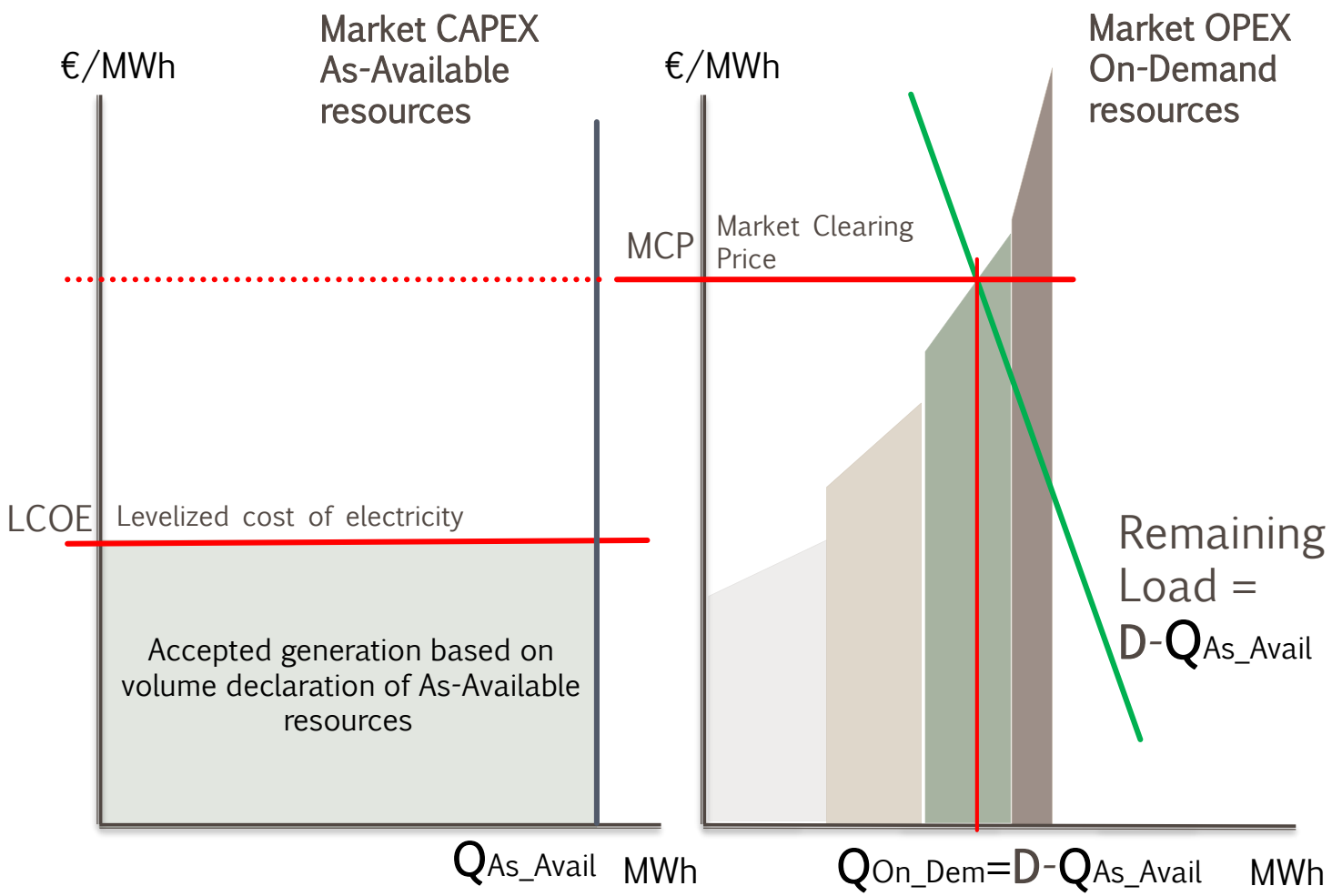
Therefore, we need to redesign the day-ahead market to achieve a decoupling of electricity prices from natural gas prices

Principles to respect:

- Maintain market competition
- Do not weaken price signals enabling demand response
- Achieve optimal market coupling and cross border flows
- Ensure adequate financing conditions to new investment adapted to the structure of costs to recover
- Encourage long-term bilateral contracting to induce market stability

- "As available" power resources
  - Have the interest to enter in a schedule for the next day that respects as close as possible their planned generation volumes
  - Have no or insignificant variable costs and do not need to submit marginal cost bidding to be placed in the merit-order
  - Need to recover capital and fixed costs according to a stable long-term program to raise affordable capital financing
  - Examples: stochastic renewables, nuclear energy, mandatory hydropower, biomass, cogeneration of high efficiency serving heat demand, storage associated with specific plants
- "On-demand" power resources
  - Typically the dispatchable generation resources, having the technical possibility to increase or decrease power depending on system operation requirements
  - Their marginal cost bidding (or opportunity cost bidding for some of them) induce the optimal merit-order
  - Examples: fossil fuel fired power plants, hydropower with a dam, storage plants, demand response, hydrogen

The Day-Ahead Market Split idea



- Buyers of electricity are charged at a weighted average unit cost ($WAUC$)

$$P = WAUC =$$

$$LCOE \cdot \frac{Q_{As\_Avail}}{Q_{As\_Avail} + Q_{On\_Dem}} + MCP \cdot \frac{Q_{As\_Dem}}{Q_{As\_Avail} + Q_{On\_Dem}}$$

- $LCOE$ is a weighted sum of different levelized costs of electricity of the various CAPEX-depending resources

How the Day-Ahead market split operates

Firstly the As_Available market

- The As_Available resources submit volume declarations for the next day
- Submissions are per bidding zone
- Least-cost optimization over the coupled countries determines
  - The accepted volumes per As_Available resource
  - The cross-border flows
- Objective to minimize: curtailment costs
- Constraints:
  - Net transfer capacities of interconnectors
  - Load to meet
  - TSOs' constraints regarding dispatching possibilities

Secondly the On_demand market

- The On-Demand resources submit price-volume bids, as today
- Demand response also submits bids
- Least-cost optimization over the coupled markets (as EUPHEMIA)
- Objective to minimize: social surplus (sum of producer and consumer surplus)
- Constraints:
  - Load to meet: Initial Load minus production by As_Available resources
  - Net transfer capacities constraint: Initial NTCs minus cross-border flows based on As_Available resources

Remuneration of resources

As_Available resources

- Three options:
  - **A. Bilateral contracts** – over the counter, any possible form, e.g., long-term PPAs; the off-takers conclude contracts on a bilateral basis independently of the spot markets, so they know the volumes covered by the PPAs
  - **B. Organised market for As_Available resources:** the resources submit volume and price bids (reflecting LCOEs) and are remunerated at the market clearing price. However, to avoid opportunity cost bidding, there must be a price cap on the As_Available market that reflects the long-term marginal cost of the resources
  - **C. Mixed design:** Mainly bilateral contracts as in A, but also a last-resort organized market as in B to accommodate resources lacking bilateral contracts

On_demand resources

- As today, the settlement is based on market clearing prices
- Also Intra-Day and Balancing markets remain unchanged

Market coupling

- It can be shown if the As_Available resources are generally dispatched in the merit order before the On_Demand resources, then the split market approach leads to the same merit order and cross-border flows as the single market
- As usually, interconnection congestion implies price divergence in the coupled markets

Μόνιμη λύση:
Διαχωρισμός της χονδρικής αγοράς ηλεκτρικής ενέργειας

Δύο χωριστές αγορές για την επόμενη ημέρα:
- ο καταναλωτής πληρώνει το σταθμισμένο μέσο κόστος και
- όχι όλη την ενέργεια στο κόστος του αερίου

Οι μονάδες ΑΠΕ, και αποθήκευσης, θα καλύπτουν τα 2/3 της ηλεκτρικής ενέργειας μέχρι το 2030. Αυτές δεν έχουν μεταβλητό κόστος, εξαρτώνται μόνο από κόστος κεφαλαίου και χρηματοδοτούνται κυρίως από διμερείς συβάσεις (κρατικές ή ιδιωτικές).

Μικρό μόνο τμήμα θα έχει μεταβλητό κόστος (κυρίως φυσικό αέριο) και μόνο για το τμήμα αυτό έχει νόημα η εκκαθάριση της χονδρικής αγοράς στο οριακό κόστος.

Ποιος ο λόγος επομένως το φυσικό αέριο να καθορίζει τις εισπράξεις όλων των τεχνολογιών ενώ θα έχει μικρό ρόλο, κυρίως εξισορρόπησης χωρίς ουσιώδη επίδραση στο πραγματικό κόστος;