

# Overview of electricity wholesale price formation models in European (EU) markets

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# Price Formation Models in Wholesale Markets

Focus on Europe (EU), and on Day Ahead and how it links to subsequent Intra Day, and Balancing, and various Exchange and OTC/bilateral based Forward/Future (hedging) Markets

## 1. Basic background to what is applied today in pan-EU SDAC and SIDC

- a) SDAC based on an Implicit Auction which simultaneously delivers Uniform Prices (marginal prices) based on equilibrium (sell+IMP = buy +EXP) per Bidding Zone and Implicit pricing (in case of congestions) of utilized CZ capacity
- b) SIDC based on a Continuous Implicit Market with pay as bid based on bid/ask matching of orders stacked according to price and time of entry and trade possibilities between BZs based on available CZ capacity. Traded after SDAC results, thus SDAC acts as an initial benchmark for SIDC and then combined with projections of later (e.g. real-time) Balancing prices that sets ISP.

## 2. Basic background to Balancing Mechanisms – automatic/manual, as capacity reservation and/or energy activation, etc.

- a) Traditionally national or in a few cases (e.g. Nordic) regional, but now gradually shifted to joint EU platforms (MARI for mFRR, PICASSO for aFRR,...)
- b) When it comes to pricing rules for activated/accepted BAL orders there has been a mix of e.g. Pay as Bid and Pay as Clear models
- c) Likewise for BRP Imbalance Settlement Pricing (ISP) there have been different and changing models for active/passive balancing and ISP (e.g. 1 vs. 2-Price Models for imbalances, differing for production vs. consumption, and in terms of ISP MTU; 60, 30 or 15 Min)

## 3. Basic background to Exchange and bilateral/OTC long term Forward/Future (hedging) Markets in Europe (EU)

- a) In the majority of EU MS there has been established Future/Forward trading in e.g. month, quarter and year ahead contracts where the SDAC Bidding Zone and/or Regional System Prices are used as underlying reference prices used for settlement/clearing during delivery
  - i. The liquidity in such contracts, especially beyond 3 year horizon, has varied over time, and in many MS/regions the turnover and open interest in relation to physical underlying has been low, while also very significant liquidity has materialized at times in several other MS'/regions
  - ii. Trading done via Regulated Exchanges and in bilateral/OTC markets, which to a fair degree in many MS+ end up cleared via Regulated Clearing Houses
  - iii. Trading is mainly done via continuous trading and “pay as bid” principles via bid/ask spreads on Exchanges and OTC-platforms, and as such reflecting market expectations of variations in future spot (e.g. SDAC) prices when considering short-/long-term fundamentals, external factors and uncertainties/risks
- b) In addition, LTTRs (FTRs) are offered on many EU CZ borders (e.g. where pre-existing forward liquidity deemed to not be sufficient) via a TSO platform, and separately long-term bilateral contracts, such as PPAs, are in varying degrees traded, and likewise CfDs are offered, e.g. for new and pre-existing intermittent RES by some (MS) authorities via e.g. auctioning.

# Price Formation Models in Wholesale Markets

Focus on Europe (EU), starting from Day Ahead and Intra Day, and how it links to (real-time) Balancing, and various Exchange and OTC/bilateral based Forward/Future (hedging) Markets

## 4. Explanation of why Pay as Clear is more efficient (superior) than Pay as Bid in among others Day Ahead Markets (SDAC)

- a) Basic pre-conditions and reasons for when Pay As Clear is superior
- b) Support of Pay As Clear from practical experience in development & operation of day ahead implicit auction spot markets (SDAC),
- c) Level of complexity in market setup differ in Pay as Clear vs. Pay as Bid, with the latter likely introducing more complexity,
- d) Gaming and manipulation risks differ in Pay as Clear vs. Pay as Bid setups, with the latter likely increasing risks due to changes in bidding behaviour
- e) Level of elasticity, and that primarily costs (variable/fixed) and values (e.g. for consumption & storage) are reflected in the Orders (bids) will likely be reduced in a Pay as Bid setup while it is a cornerstone in competitive, liquid, Pay as Clear setups

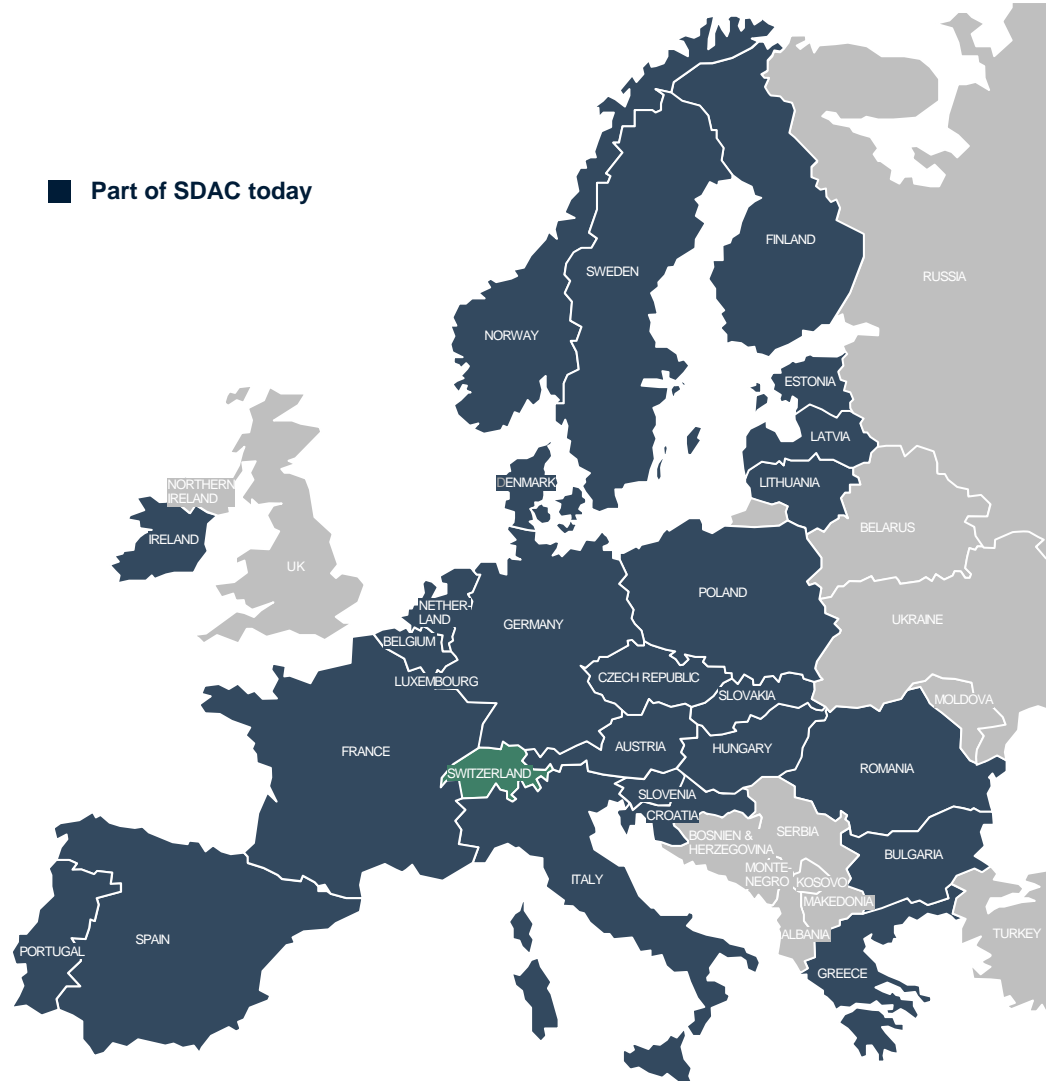
## 5. What alternatives to wholesale spot Uniform (marginal) Prices per Bidding Zone (BZ) based on supply/demand equilibrium, including CZ capacity utilization, is there in theory and practise?

- a) There is always a possibility to make the grid modelling more granular/detailed, e.g. via an enhanced NTC-modelling or rather via so called Flow Based or even (like in the US) Nodal Based Pricing. However that does not in itself change the fact that Uniform Prices per BZ would still apply
- b) There are methods, such as Non Uniform Pricing (or Convex Hull), that can enhance the algorithmic performance to reach optimization of Social Welfare (Economic Surplus) that is being challenged by non-linear market features (e.g. multi-period blocks). However, such methods do not change that Uniform Prices per BZ will still largely apply, thus only a small subset of Orders are accepted at prices above Uniform Prices and compensated via "Uplift Costs". A key challenge with adding of such a method is how to ensure it does not increase gaming/manipulation risks, and beyond that the level of improvement in algorithmic performance might not be big enough to justify the added complexity it introduces in the overall trading model.
- c) In theory, there can be elements of "price regulation" introduced in the spot market, e.g. applicable for Supply Orders (plausible also for Demand) or rather for the remuneration of Supply deemed to be from (generation) sources with costs/values below marginal, thus below the Uniform Price(s) given by the supply/demand equilibrium per BZ in the integrated (SDAC) market. However, on a principal and practical level it inevitably creates distortions in the free and efficient short-term supply/demand price formation, thus risks to also introduce skewed/distorted signals for long-term price formations that directly or indirectly are linked to short-term spot prices.

## 6. Geopolitics have triggered short-term emergency interventions, and opened the debate to deliver legislative proposals on re-design of EU energy markets – what is key to keep in mind for the latter?

## 7. Questions and discussions triggered by this presentation?

# 1. Basic background....



## Pay As Clear (Uniform Pricing) is a common feature across the EU Single Day Ahead Coupling market

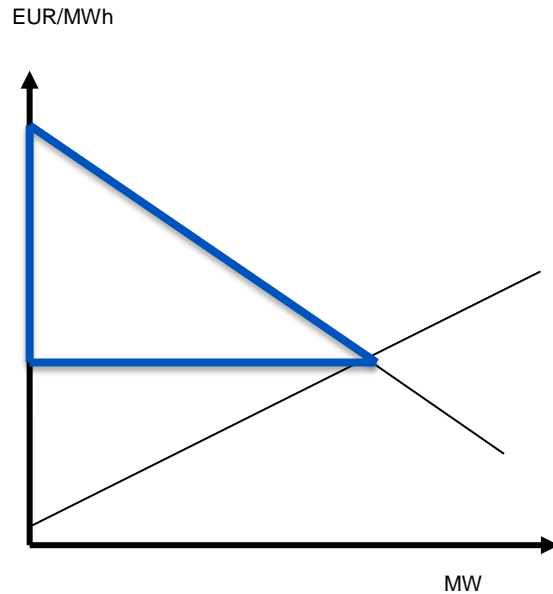
- The Price Coupling of Regions (PCR) initiative and systems ensures coupling of Day-ahead electricity markets in the form of Single Day Ahead Coupling (SDAC) that stretches across all of EU plus Norway
- SDAC is based on a joint price calculation algorithm (PCR Euphemia) and common procedures that delivers hourly electricity prices per Bidding Zone, and planned flows on, and implicit pricing of, CZ capacity
- In the vast majority of regions - e.g. Nordic, Baltic and CORE - that are part of SDAC the concept of Portfolio Bidding is applied, while so called Unit Bidding is applied in a few countries, e.g. Italy, Spain & Portugal.
- In all Bidding Zones (countries) part of SDAC the method Pay As Clear is applied for settlement of sell and buy\*\* based on the equilibrium between internal BZ supply and demand, including resulting import/export flows.
- In the SDAC market the Pay as Clear equilibrium per BZ forms the basis for what normally will result in a flow from surplus (low price) to deficit (high price) BZs and thus determines the size of (TSO) Congestion Revenues in case there are BZ-to-BZ grid congestions.

Note:\*\*In Italy which has multiple internal BZs there is a special bidding and settlement process, called PUN, which in simplified terms results in that the demand side pay in-line with a national average while the supply side receive payments according to the different internal BZ prices.

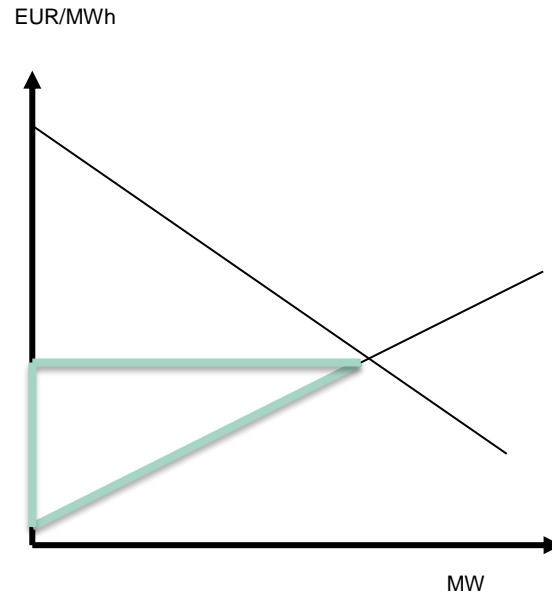
# 1. Basic background...

SDAC principles applied in the PCR Euphemia algorithm related to optimization of overall welfare surplus (economic surplus):

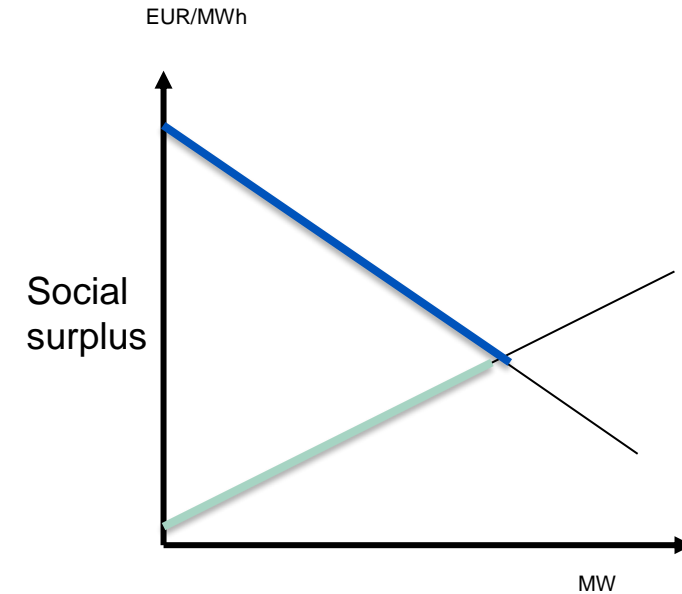
Consumers' surplus



Producers' profit



Consumers' surplus  
+  
Producers' profit

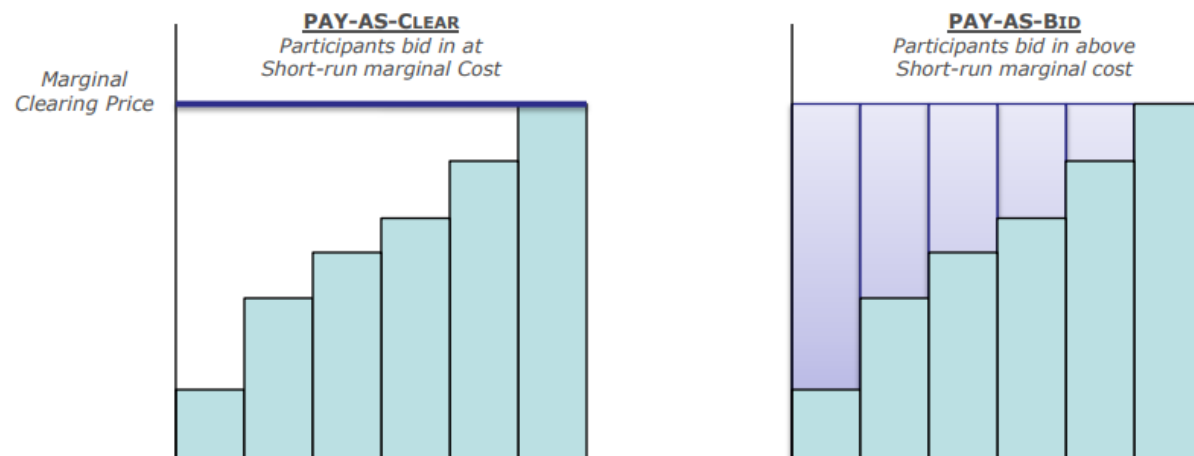


**Simplified case only valid for one Bidding Zone without considering Cross Zonal Capacity, while it for the latter also is a TSO Surplus in the form of Congestion Revenues whenever there is a NTC/FB bottlenecks resulting in different prices in adjacent BZs.**

## 4. Arguments for Pay as Clear as superior to Pay as Bid

### In theory, pay-as-bid and pay-as-clear should produce similar results

- Under pay-as-clear participants are *automatically awarded* the price of the most expensive offer accepted
- Under pay-as-bid participants have the *incentive to bid* at the price of the most expensive offer accepted



**This assumes (i) a homogenous product , (ii) sufficient levels of competition and (iii) perfect information**

However, the picture clearly illustrates that in case of a Pay As Bid setup the incentive to provide sales (“production”) bids at marginal cost will not apply.

Instead, market parties with comparatively low marginal cost supply will instead have incentives to guesstimate\*\* the marginal cost of the plants needed to reach equilibrium and then to place their orders close to that price level.

Therefore, it can be assumed that a more speculative bidding behavior, higher price volatility, and more frequent self-dispatch contrary to expected “merit order” will occur in a Pay-as-Bid based Day Ahead Implicit Auction.

Note: \*\*Typically not hard given acquired knowledge (and historic transparency) about that costlier supply often needs to be activated to reach “supply/demand” equilibrium in the given BZ/country. It is typically also easier in smaller, concentrated, e.g. with fewer competitors, BZs/regions or in case of a limited mix of production resources and demand/storage flexibility.

Note: The illustration and the text above it is a small abstract from an OFGEM presentation, namely <https://www.ofgem.gov.uk/sites/default/files/docs/2012/10/pay-as-bid-or-pay-as-clear-presentation.pdf>

## 4. Arguments for Pay As Clear (i.e. Uniform/Marginal Pricing)

- Provides a strong incentive to reflect levelized operating costs in bid prices
- Means that electricity typically will be produced from the cheapest generation sources
- Means carbon emitting generation will only generate electricity when necessary to meet demand
- Allows part of capital costs of investments, e.g. in intermittent RES, to be recovered (which would otherwise have to come fully from subsidies or capacity mechanisms)
- Sends a signal about both where new investment would be required and for consumption adaptations
- Allows one single price to emerge from an auction
- Is transparently published, and it is easily understandable by market buyers and sellers
- Allows a better allocation of resources across the continent by connecting electricity markets across Europe, and contributes to security of supply by ensuring electricity is produced and flows to where it is most needed
- Considerable academic literature and studies support the notion of Pay As Clear being superior to Pay As Bid

## 4. Arguments for Pay As Clear (i.e. Uniform/Marginal Pricing)

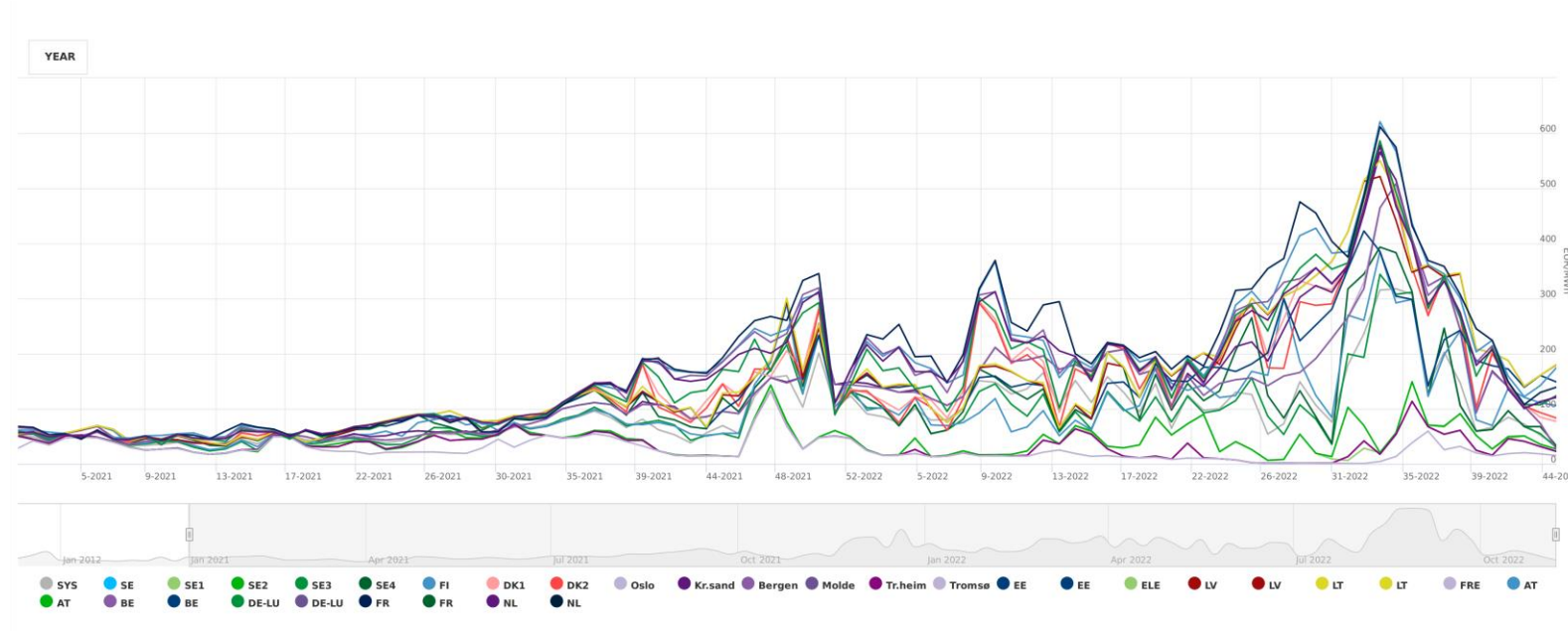
- Any move from Pay As Clear to Pay As Bid in the Day Ahead Implicit Auction (“SDAC”) would go against what is stated in the EU ELE DIR 2019/944, and in EU ELE REG 2019/943 and its “related legislation” CACM GL. For example:
  - Art. 3.1 ELE DIR: “Member States shall ... ensure that electricity prices reflect actual demand and supply”
  - ELE REG Art 3(b): “market rules shall encourage free price formation...avoid actions which prevent price formation on the basis of demand and supply”
  - ELE REG Art 6(4): “The settlement of balancing energy...shall be based on marginal pricing (pay-as-cleared) unless all regulatory authorities approve an alternative pricing method...following an analysis demonstrating that that alternative pricing method is more efficient.”
  - CACM GL [“Objectives of the Price Coupling Algorithm”] Art 38.1 (b) “uses the marginal pricing principle according to which all accepted bids will have the same price per bidding zone per market time unit”
- Such a shift would in practice require a shift from Portfolio to Unit Bidding, which would add a lot of complexity and make it harder for some market parties to be active in the wholesale market
  - Furthermore, Unit Bidding is a concept only applied in a few EU MS today, e.g. Spain/Portugal and Italy, while all countries in CORE, as well as Nordic and Baltic countries apply Portfolio Bidding.
  - In addition, key stakeholder associations (e.g. EFET) argue for a shift to Portfolio Bidding across Europe since they find Unit Bidding among others to be restricting competition and adding complexity
- In the competitive wholesale spot market where portfolio bidding is the norm it is a fact that increased sales volumes above a given price or a decrease of purchase volume above a given price does not automatically mean a change in respectively production or consumption, but instead an increased sales volume can be due to that consumption is reduced, and a decreased purchase can mean that consumption is not changed but that production is increased.
  - The point being that it is hard to define what part of changed volumes dependent on price level in a portfolio bid indicates “production costs or value of storage” (e.g. hydro reservoirs that can give production now or later) or “value of consumption” for a single (e.g. 60 Min) or multiple trading periods (e.g. blocks covering up to 24 hours), or the value of consuming now or reducing consumption for longer periods; days/weeks.



## 6. “Geopolitics have triggered...”

# A 'Perfect Storm' in European Energy Markets?

*European Day-ahead (spot) prices January 2021 – September 2022*



### 12 months ago: what we knew then..

- Energy transition and decommissioning of nuclear, coal and thermal production capacity (phasing out large baseloads)
- Higher CO2 cost
- Intensified price volatilities due to larger share of intermittent sources

### 12 months ago: what we didn't foresee then..

- Spiking gas prices towards year end 2021
- Russian invasion of Ukraine! (TTF at € 339 / MWh, 26th August 2022)
- French nuclear production at a historical low (32 of 54 reactors out)
- Heatwaves and drought in Europe and UK (worst in 500 years..)
- Near record low hydro balance in southern Norway
- Market intervention measures to ease the price shock and consumer burden
- Mandated demand destruction and energy rationing preparations

## 6. “Geopolitics...”: What is decided on European level? Key examples:

### Ongoing European projects (pre-dating the geopolitical crisis)

- There will be SDAC Flow Based CCM in the Nordics during 2024 if finally approved by NRAs
- SIDC pan-EU Intraday Auctions are in the making
- 15 min resolution on the way for SIDC & SDAC trading/pricing and CZ capacity allocation

### Political emergency interventions

- Demand reduction – already over 15% on gas since AUG ‘22 within EU, clear indications of electricity peak demand reduction in many EU MS
- Inframarginal market revenue price cap until end of June 2023 decided in an EU Council REG, implementation on MS’ levels not harmonised
- State support (e.g. loans) for collateral margin calls accepted and applied in some MS
- Cap on gas supply price and coordinated negotiation on gas contracts in the planning
- Market Correction Mechanism for gas and Intra-day volatility management mechanism for energy derivatives contemplated via EU Council REG

## 6. “Geopolitics...”: European Commission is working on proposals on re-design of the (wholesale) electricity (energy) market design

### Timeplan

- EC intends to go forward to adopt legislative proposals to review the EU electricity market design by end Q1-23
- An Impact Assessment & stakeholder consultation was indicated to be shared by mid-DEC 2022 (still pending)



### The exact scope and ambition of the proposals is still somewhat unclear

- Will the paper(s) only focus on lasting long-term measures or also short term (emergency) measures?
- Will for example “inframarginal cap” be suggested to under some conditions continue after June ‘23?
- How much will the proposals be flavoured by various MS political signals?

## 6. “Geopolitics...”: The market should be “protected” against short-term measures with negative, also long-term lasting, effects

- The efficient supply/demand price signals should be protected
- Market intervention ahead of the price signal can put security of supply at risk and deepen the crisis – every hour of the day the SDAC & SIDC markets help to provide a planned balance of generation and consumption, and efficient CZ capacity utilization, across EU 27 and Norway
- The surging power prices points to some obvious underlying root causes, e.g.:
  - › Overall energy supply shortage
  - › Soaring gas prices
  - › The green transition (phasing out stable/flexible baseloads and replacing it with intermittent RES – this is one key reason for “current” price volatility while also key for decarbonization)
  - › Europe, in particular Germany, has to become energy independent from Russia
  - › Limited CZ TSO transmission capacity and still fairly inflexible demand side
- It has never been more profitable to invest in new renewable production capacity, and policy makers should therefore focus to legislate predictable and stable frameworks that both attracts investments at scale and locations where needed, and which reduces project lead times
- **Ideally current short term emergency interventions should not be mixed with the long-term proposals on market re-design that should focus on enhancing the ability for markets to efficiently deliver on EU CEP & Fit-For-55 targets**

