TECHNICAL WORKING GROUP

OPERATIONAL SUBGROUP

ENERGY SECURITY BOARD

21 SEPTEMBER 2022

AGENDA

Time	Topic
2:00	Meeting objectives
2:05	Incorporating storage and other energy limited plant into the CMM/CRM • Recap • Spot trading including impact of CMM/CRM • Contract trading including impact of CMM/CRM • Access allocation
3:15	Interconnector access and settlement: • Access in today's market • Access in the future market with congestion reform • Design issues for CMM and CRM
3.55	Next steps
4:00	Close

STORAGE

Outline of opportunity costs and trading of plant with storage and how to incorporate into CMM/CRM

OUTLINE

- Recap on storage and other energy limited plant
    - Scope of technologies
    - Desirable locations for storage investment
    - Opportunity costs
    - Marginal value of storage
- Spot trading of storage and energy limited plant
    - Impact of CMM/CRM
- Contract trading of storage plant
    - Principles of access regime for storage plant
    - Impact of CMM/CRM
- Access arrangements

STORAGE AND OTHER ENERGY LIMITED PLANT

Scope

When contemplating any access regime for storage or other energy limited plant it should work for:

- Hydro
- Pumped hydro
- Batteries
- Supercapacitors
- Thermal plant with energy limitations due to:
  - Fuel contracts
  - Fuel stockpiles
- Dispatchable loads with energy limits
- ‘Battery of the nation’?

Desirable locations

- The constrained-off side of constraints where there is substantial VRE generation:
  - Pump or charge when there is excess VRE and low prices
  - Generate or discharge when there is a shortage of VRE or high prices
- Near loads and on the unconstrained side of constraints
- On the constrained-on side of constraints to meet local loads

STORAGE AND OTHER ENERGY LIMITED PLANT

Marginal costs of operation

For hydro plant it is often assumed that they have very low short run marginal costs.

Although they may have low marginal costs in terms of operation and maintenance they can have high opportunity costs associated with the use of stored water.

The idea of opportunity costs also applies to all storage plant.

Opportunity costs

- Opportunity cost or economic opportunity loss is the value of the next best alternative foregone as the result of making a decision.
- For instance, a hydro generator with storage must determine whether it is better to use its water now or later.
- The situation is slightly more complicated for a pumped hydro as it determines whether it is better to generate, pump or do nothing.
- Similarly a battery must determine whether it is better to discharge, charge or do nothing.
- The notion of opportunity cost plays a crucial part in ensuring that scarce resources are used efficiently.

STORAGE AND OTHER ENERGY LIMITED PLANT

Marginal value of storage

In a competitive market, the marginal value of storage represents the expected increase in revenues for a small increase in energy or water stored.

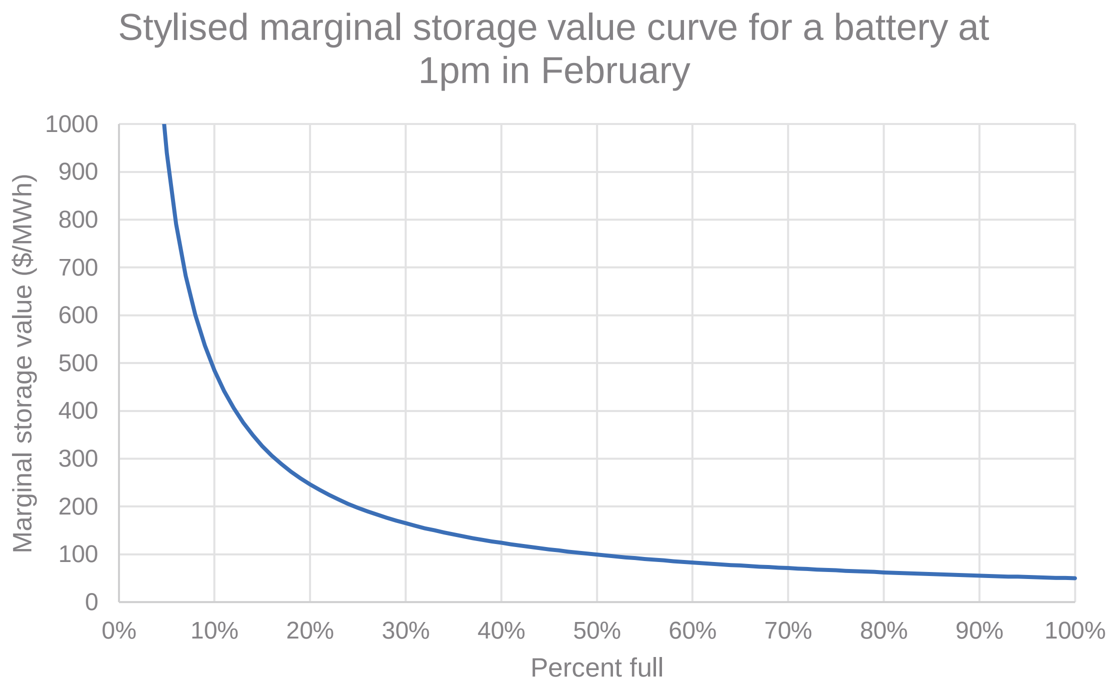
The marginal value of the state of charge (energy stored) in a battery is largely dependent on the stochastic nature of future electricity prices.

- Note that generators when operating batteries also need to consider the battery's maximum number of cycles of charge and discharge that it may have in the supplier's contract. Each charge and discharge cycle has an opportunity cost.

The marginal value of water stored in a reservoir is dependent on the amount of energy stored in other hydro power reservoirs and batteries and accounts for the stochastic nature of inflows and electricity prices.

The marginal water value can be expressed as $ per Ml when referenced to a specific large storage reservoir or may be converted to $ per MWh terms when applied to a specific hydro generating unit or power station based on an assumption of average water use efficiency.

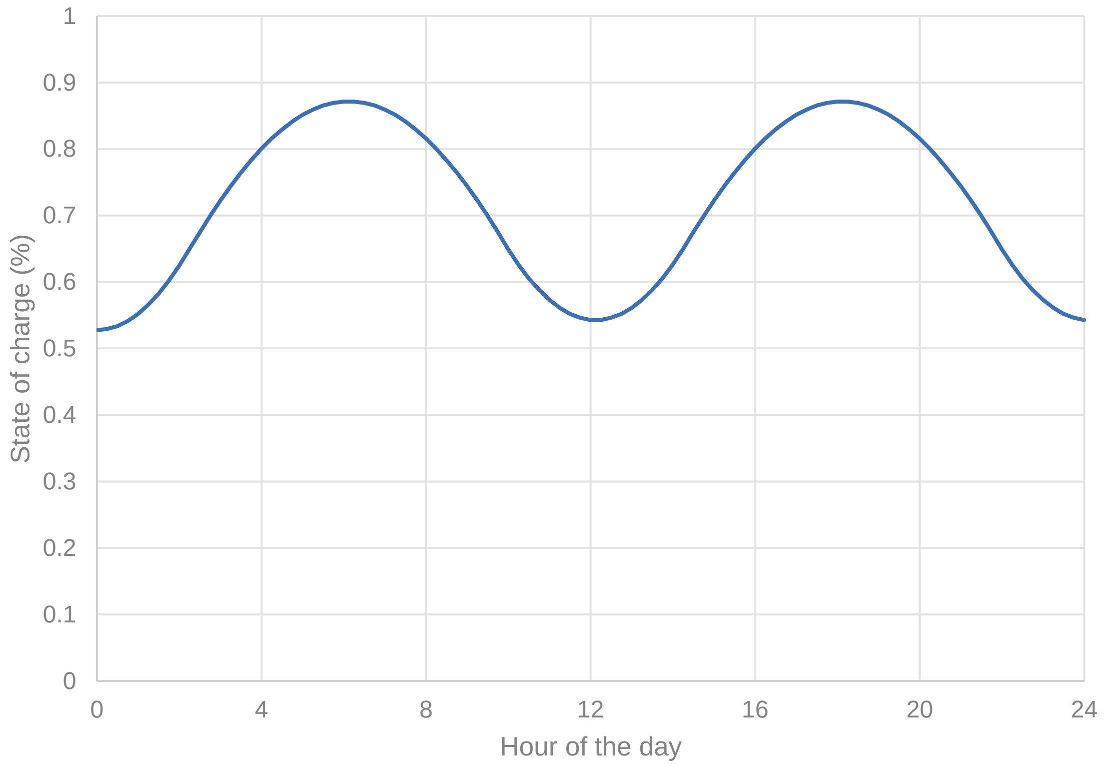
Stylised marginal storage valuation curve



Marginal storage valuation curves will change by time of day and month of year.

STORAGE AND OTHER ENERGY LIMITED PLANT

Stylised state of charge (SOC) for constant $90/MWh marginal SOC values



Round cycle efficiencies of storage plant

Pumped hydro

- Pumping is approximately 85% efficient at fixed pumping MW level
- Generating is approximately 85% efficient around efficient output levels
- Round trip efficiency of about 72% efficiency

Battery

- Round trip efficiency of about 85% efficiency
- Charging is approximately 92% efficient
- Discharging is approximately 92% efficient

Spot market (physical) operations of storage plant with CMM/CRM

- The physical operations of storage plant under the CMM/CRM will be based on the plant's LMP
- If we assume the round trip efficiency of a storage plant is e^2 and its marginal value of storage is MVS
- If we assume that the plant can't materially affect the LMP then:

  If MVS > LMP/e then pump or charge

  If MVS < LMP $\times$ e then generate

  Otherwise do nothing

Storage contracting - objectives

The principle objectives for contracting include providing:

- generators and energy storage systems with reasonably certain revenue streams when combined with their spot market revenues
- new generation and energy storage investments with reasonably certain revenue streams and incentives to actively participate in the NEM
- VRE generation with contracts that can firm their revenue streams or complement their outputs
- retailers and wholesale customers that are participating in the NEM with reasonably certain cost streams when combined with their spot market costs.

Storage plant contracting

- Storage plant is a well suited to being exposed to volatility; increased volatility should mean increased revenues
- A storage plant's physical market revenue volatility can be hedged by selling a range of contracts such as:
    - swaps / swaptions
    - caps
    - floors
    - collars
    - virtual storage contract (floor m hours and cap n hours)
    - power purchase agreements (PPAs)

STORAGE AND OTHER ENERGY LIMITED PLANT

How to efficiently fit storage plant into CMM/CRM arrangements?

- No major issues on the physical and LMP side
- Potential issues on the access allocation side. How storage plant gets access to the RRPs will materially impact the ability to contract and hedge this plant and consequently will affect investments in storage plant.
- The tables in the following slides outline the desired market outcomes from an owner's perspective. Some of these access allocations may result in unproductive wealth transfers. The more controversial areas of access are highlighted in yellow in the tables.
- When contemplating the appropriate access for storage the following issues should be considered:
  - What sort of hedging contracts will storages want to enter into?
  - What sort of hedging contracts will retailers and other market customers, VRE generation and dispatchable generation like to enter into with storages: swaps, swaptions, caps, floors, collars, look back options, virtual storage contracts etc.? Will these be referenced to the RRP or some LMPs?
  - How will the access regime affect the contracting of storages in terms of contract quantities, counterparties and types of contracts? Will this make a difference to market based investments in storage and VRE plant?
  - Should storages be treated like any other generation of dispatchable load?

Potential access arrangements for storage when LMP <= RRP

- Table below summarises the desired market outcomes from an owner's perspective. Some of the access allocations may result in unproductive wealth transfers. Areas for discussion are highlighted in yellow.

Plant owners' desired physical and access outcomes for storage when LMP <= RRP

Situations where LMP <= RRP		
Marginal value of storage (lowest to highest)	Desired spot market arrangement	Desired access arrangement to RRP
MVS <= LMP x e	generate	generation access (RRP-LMP)
LMP x e < MVS < LMP / e <= RRP x e	neither generate nor pump/charge	generation access (RRP-LMP)
LMP x e < MVS <= RRP x e < LMP / e	neither generate nor pump/charge	generation access (RRP-LMP)
LMP / e < MVS	pump/charge	no load access (LMP-RRP)
RRP / e < MVS	pump/charge	no load access (LMP-RRP)

Potential access arrangements for storage when LMP >= RRP

- Table below summarises the desired market outcomes from an owner's perspective. Some of the access allocations may result in unproductive wealth transfers. Areas for discussion are highlighted in yellow.

Plant owners' desired physical and access outcomes for storage when LMP >= RRP

Situations where LMP >= RRP		
Marginal value of storage (lowest to highest)	Desired spot market arrangement	Desired access arrangement to RRP
MVS <= RRP x e <= LMP x e	generate	no generation access (RRP-LMP)
RRP x e < MVS <= LMP x e	generate	no generation access (RRP-LMP)
LMP x e < MVS <= LMP / e	neither generate nor pump/charge	no generation access (RRP-LMP)
RRP / e < MVS <= LMP / e	neither generate nor pump/charge	load access (RRP-LMP)
LMP / e < MVS	pump/charge	load access (RRP-LMP)

STORAGE AND OTHER ENERGY LIMITED PLANT

*Refer to **Appendix A** for additional materials on bidding incentives for different categories of storage (included after the TWG meeting in response to TWG member queries).*

Access arrangements

Under all access arrangements, physical generation and pumping/charging is priced at LMP at the margin.

Some of the key issues surrounding access relate to the contracting and hedging arrangements of storage plant i.e. the type of contracts they want to enter and whether these are referenced to the RRP or LMPs.

Key questions

- Is it necessary or desirable to offer load access for pumping/charging when LMP>RRP?
- Should storage have the same access rights as other generation to RRP?
  - In particular, when LMP < MVS < RRP should storage plant have access to the RRP?

    Note that it will be very difficult to estimate or predict at any one time a storage plant's MVS

Supplementary questions to consider as part of response

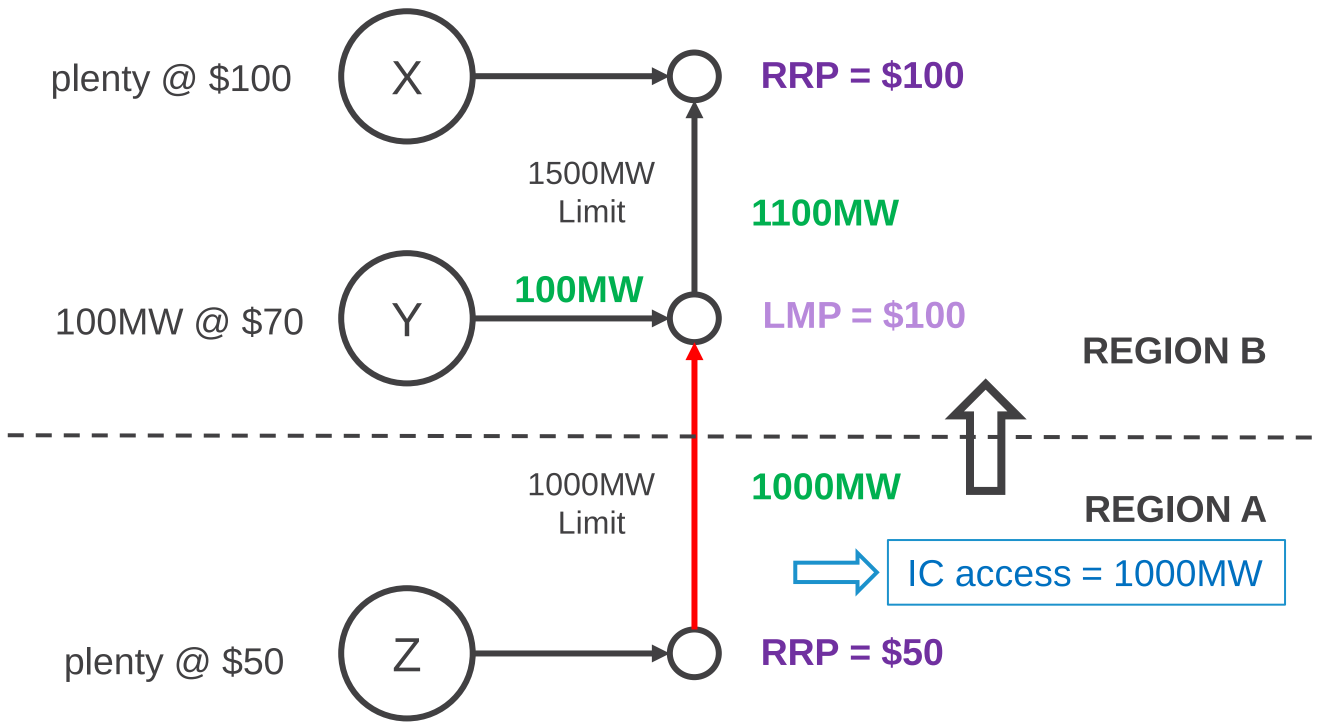
- If storage plant does have access rights that are the same as all other generators should these reflect in some way the energy limitations of the plant?
- Is it possible to efficiently regulate or develop administrative rules for the access of energy limited plant?
- Is it possible to implement the equivalent of energy limits into bidding for access in the CRM and queueing models by, say, limiting the number of hours a plant can bid at the price floor?
- Are there other market based approaches that could be used?

INTERCONNECTOR ACCESS AND SETTLEMENT

OUTLINE

- Interconnector access in today’s market design
- Implications for future interconnector access
- Design issues for CMM and CRM

STATUS QUO: PURE INTER-REGIONAL CONSTRAINT



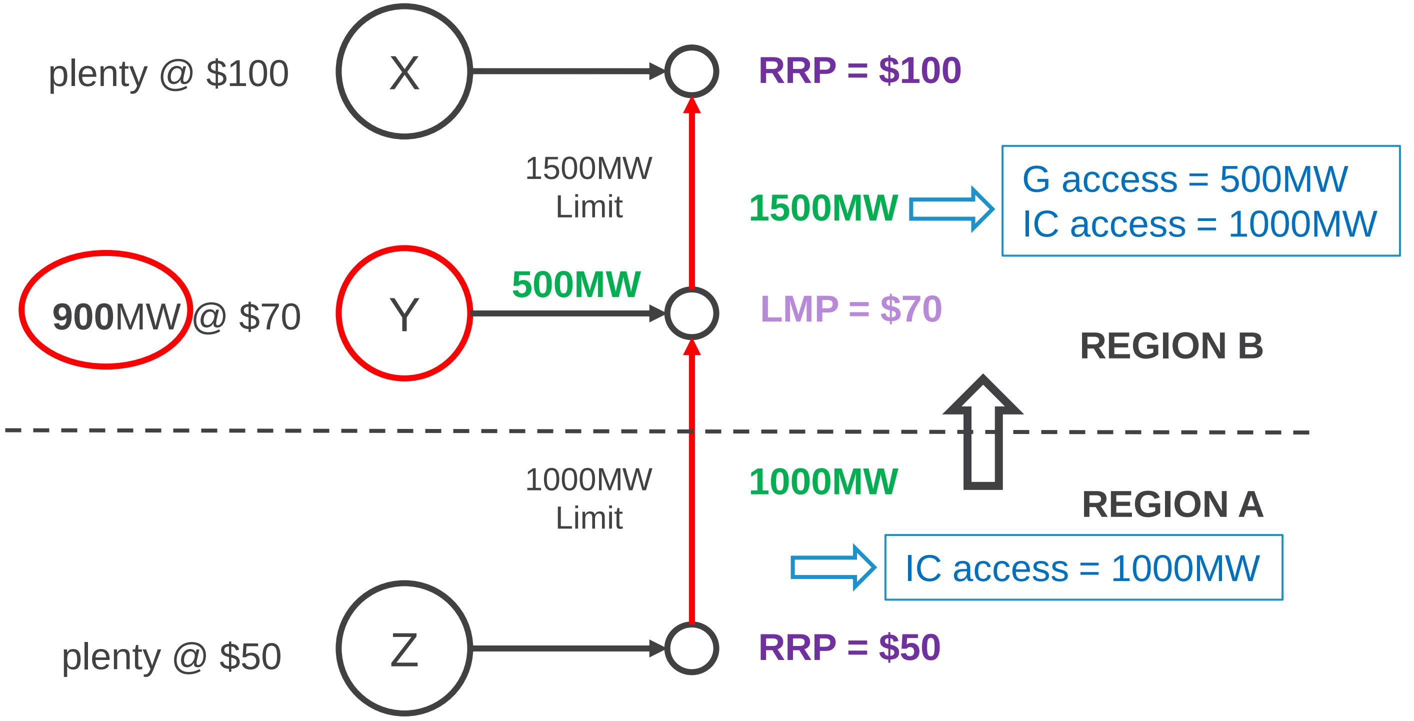
IC Settlement

1000MW flow
$50 price difference

IRSR$ = $50,000

Interconnectors get sole access rights on pure inter-regional constraints

STATUS QUO: HYBRID INTER-REGIONAL CONSTRAINT: COST-REFLECTIVE BIDS



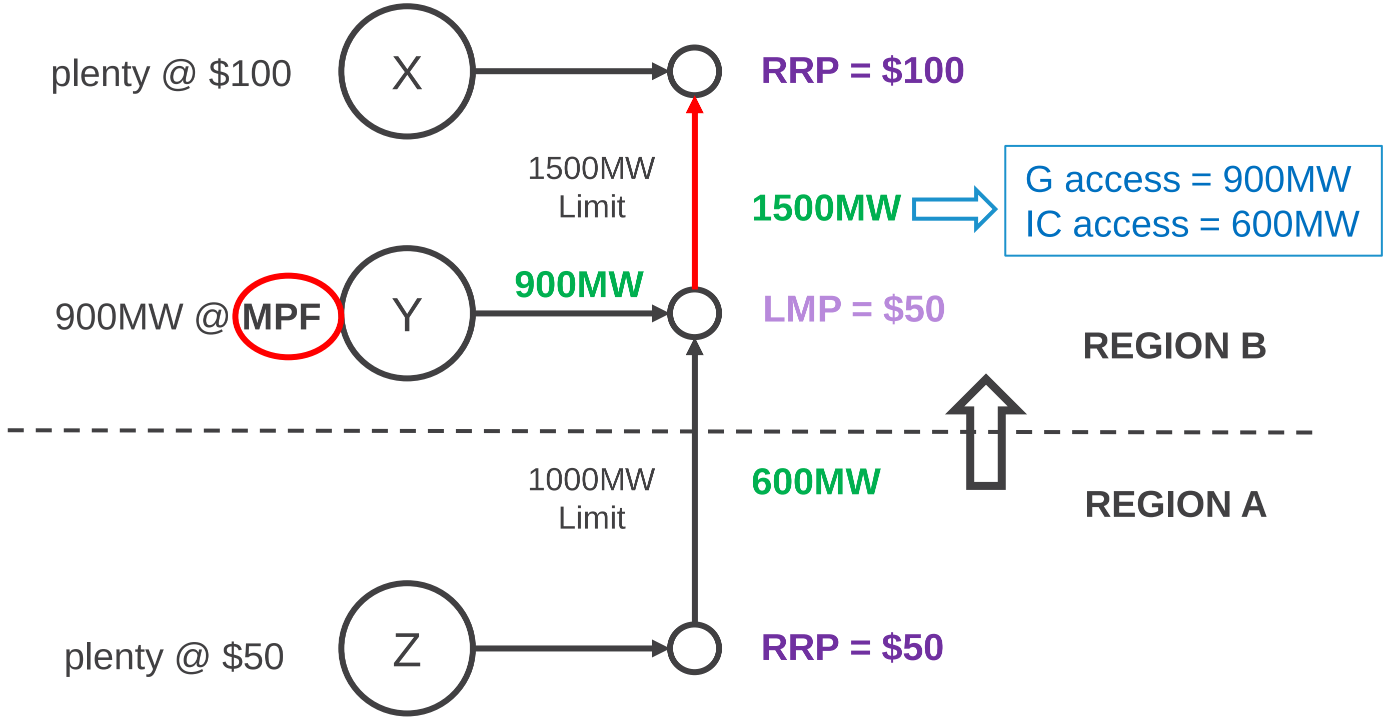
IC Settlement

1000MW flow
$50 price difference

IRSR$ = $50,000

Access shared based on relative costs of local and inter-regional generator

STATUS QUO: HYBRID INTER-REGIONAL CONSTRAINT WITH MPF BIDDING



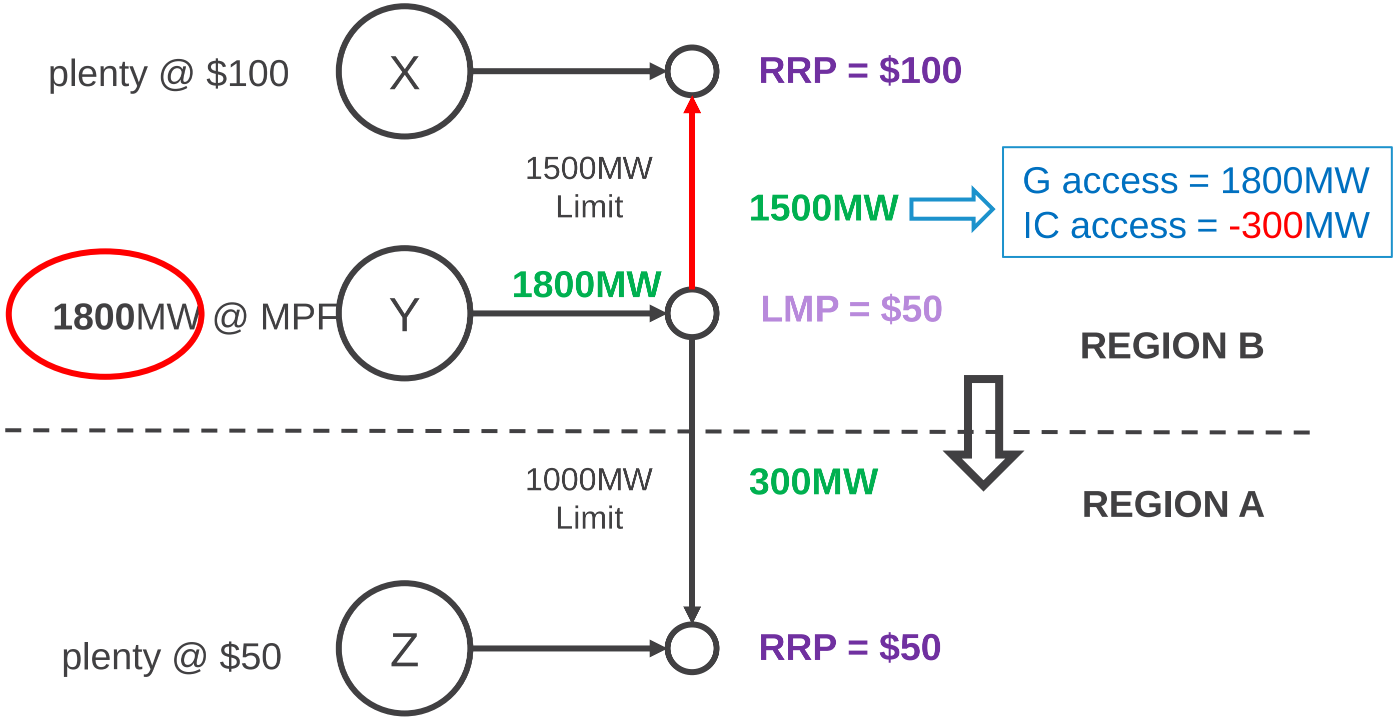
IC Settlement

600MW flow
$50 price difference

IRSR$ = $30,000

Interconnectors get *junior* access rights on hybrid inter-regional constraints
This arises because local gens can bid MPF but inter-regional gen cannot

STATUS QUO: COUNTER-PRICE FLOW



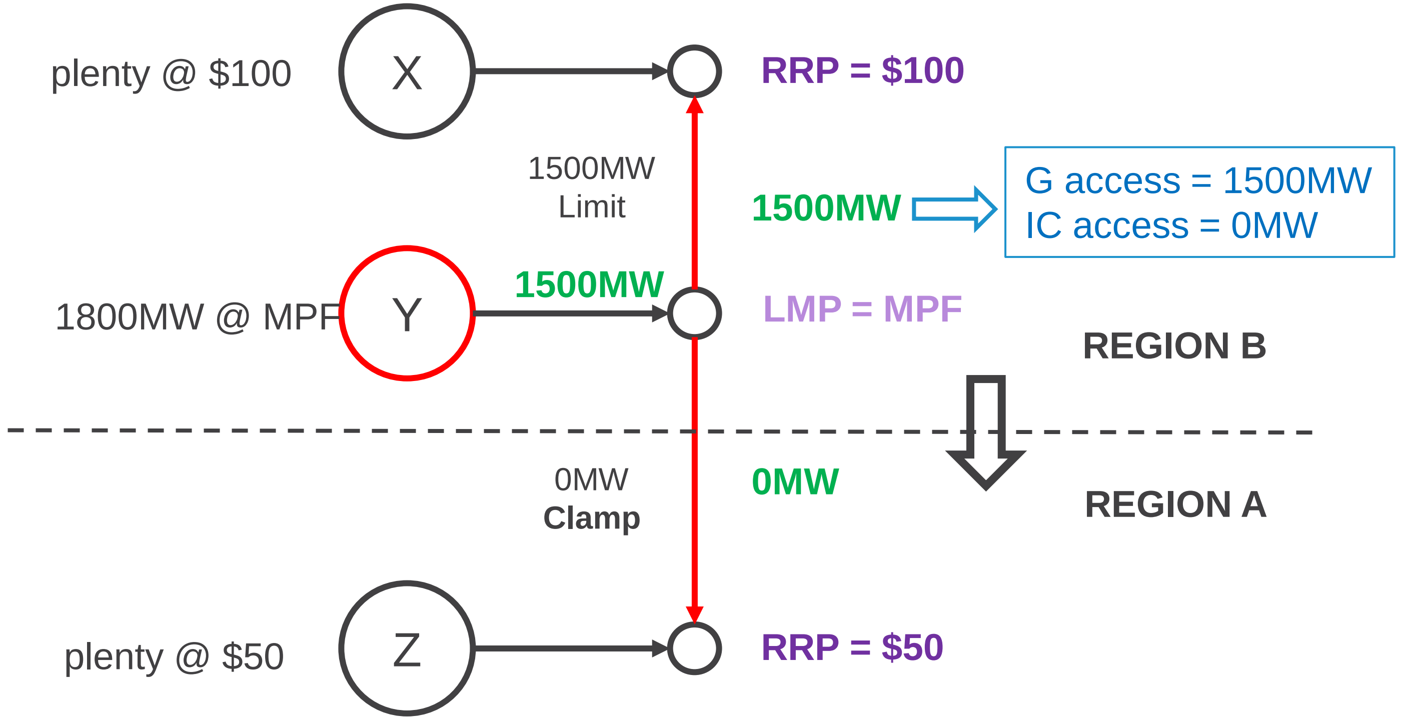
IC Settlement

300MW flow
-$50 price difference

IRSR$ = -$15,000

Counterprice flows mean IC access has *negative* value

STATUS QUO: CLAMPED COUNTER-PRICE FLOW



IC Settlement

0MW flow
-$50 price difference

IRSR$ = $0

Counterprice flows are clamped to avoid IRSR deficit from negative access value
Clamping means restricting generator access

STATUS QUO CONCLUSIONS AND ACCESS MODEL PROPOSED POLICY

Status quo

- Interconnectors get sole access on pure inter-regional constraints
- Interconnectors get *junior* access on hybrid constraints
- Clamping avoids interconnector access having negative value

Proposed policy for future access models

- Interconnectors get analogous access rights under CMM and CRM
- Different mechanisms are used to achieve this in the two access models

INTERCONNECTOR ACCESS UNDER CONGESTION MANAGEMENT MODEL

- Access is independent of physical dispatch: so no need for clamping
- Entitlements allocated separately on each binding constraint: Pay$ = Entitlement x Congestion Price
- On each constraint, Entitlements allocated first to generators, up to the constraint capacity (RHS value)
- Any remaining capacity is allocated to interconnectors
- Need a method to allocate between multiple interconnectors: based on *nominal* IC availability
- Aggregate of all pay$ allocated to relevant IRSR

INTERCONNECTOR ACCESS UNDER CONGESTION RELIEF MARKET

- Based on the access dispatch: no need to clamp physical dispatch
- Pay$ = IC access dispatch x inter-regional price difference
- Access dispatch outcomes similar to status quo: eg with constrained generators bidding MPF and so getting dispatch priority over interconnectors
- Need to clamp access dispatch, similar to today’s clamping of physical dispatch

CONCLUSIONS

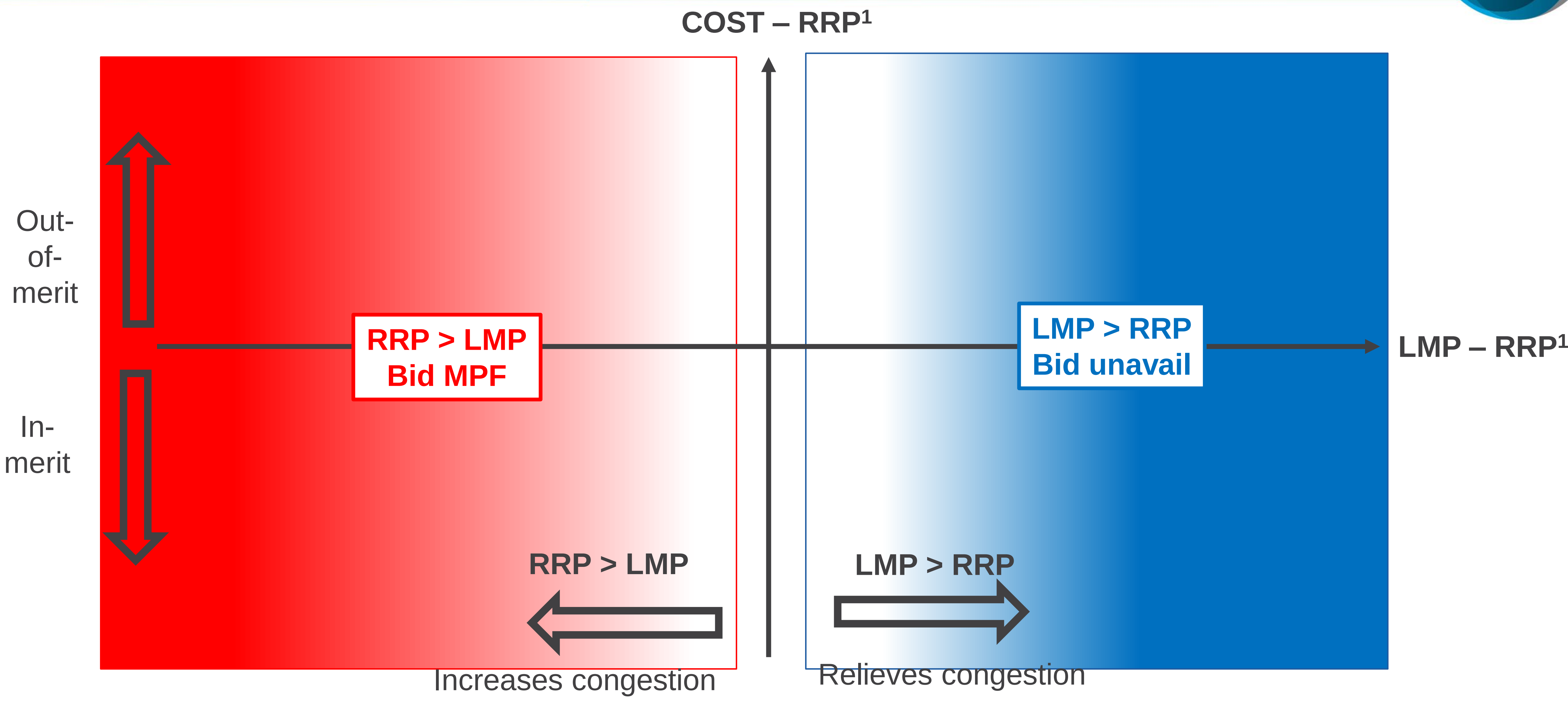
- Access priority for interconnectors versus generators, in the new access models, should reflect the status quo: interconnector access is junior but not materially negative.
- In the CMM, this can be done through the design of the methods that allocate entitlements between generators and interconnectors on each constraint that binds in physical dispatch.
- In the CRM, this occurs automatically, by applying similar bidding and clamping rules in the access dispatch to those applying to today's physical dispatch.
- Irrespective of how interconnector access is allocated, the separation of access from physical dispatch means that physical dispatch efficiency is improved and no clamping of physical dispatch is needed.

APPENDIX A

Bidding incentives for different storage categories

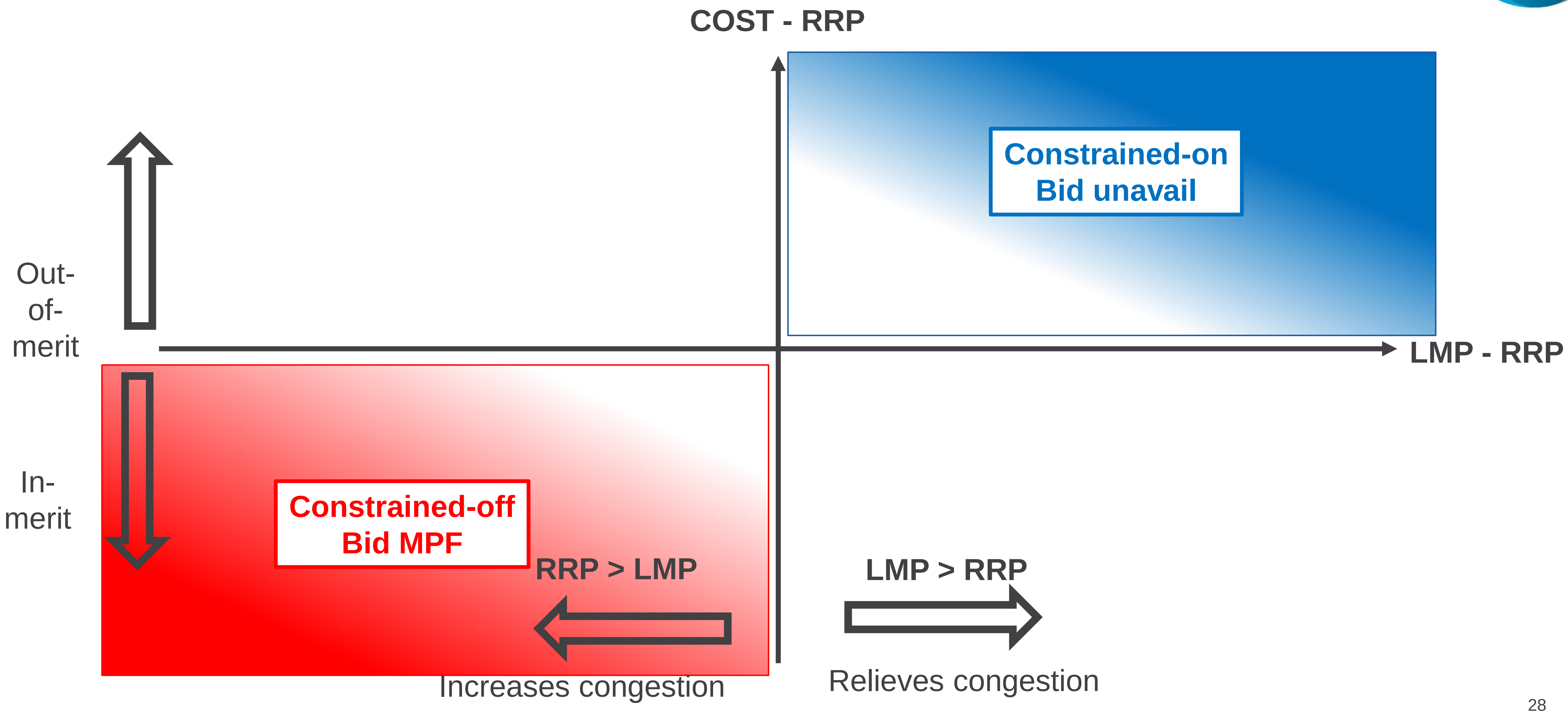
Appendix A included after the TWG meeting held 21 September 2022 in response to TWG member queries

GENERATION: ACCESS BIDDING INCENTIVES

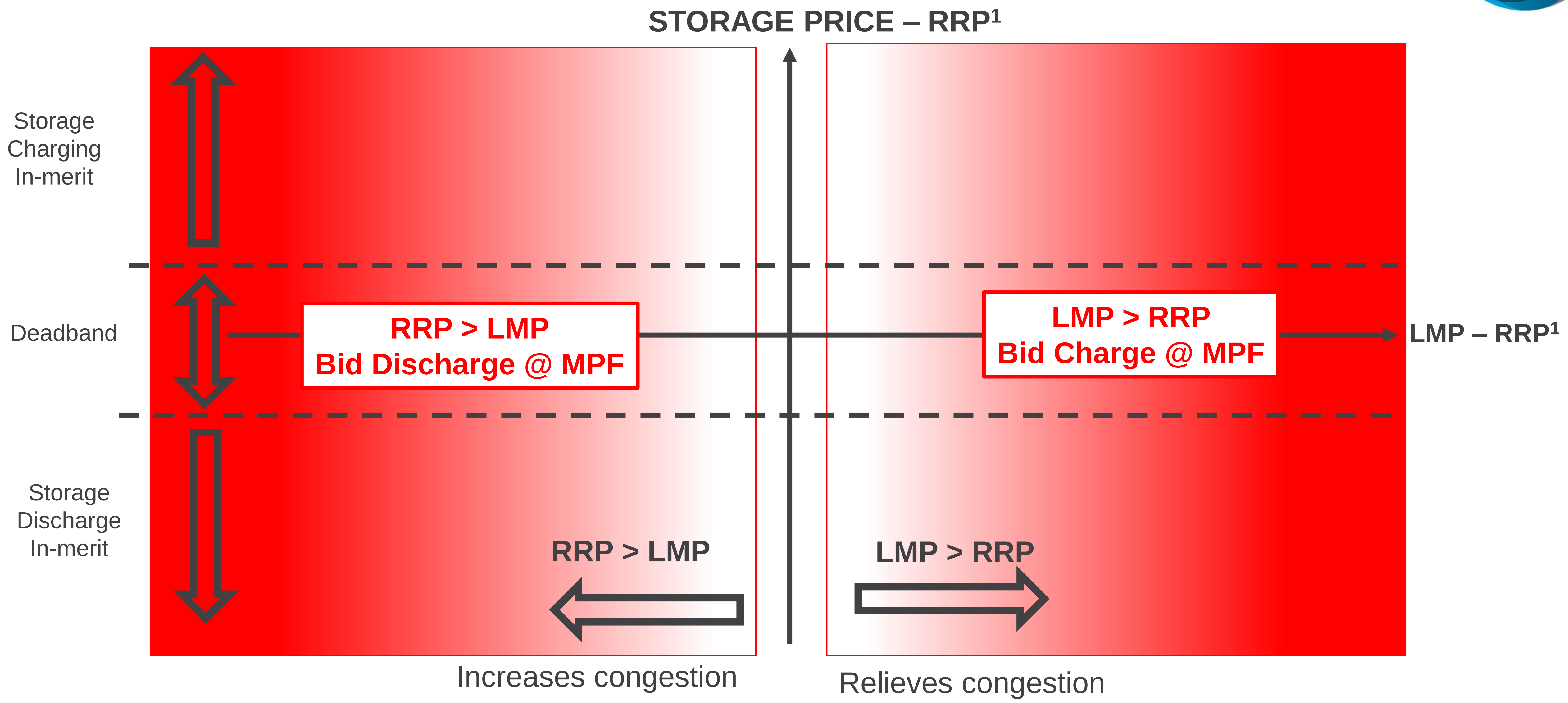


1. Based on forecast RRP and LMP

GENERATION: ACCESS BIDDING REGULATION

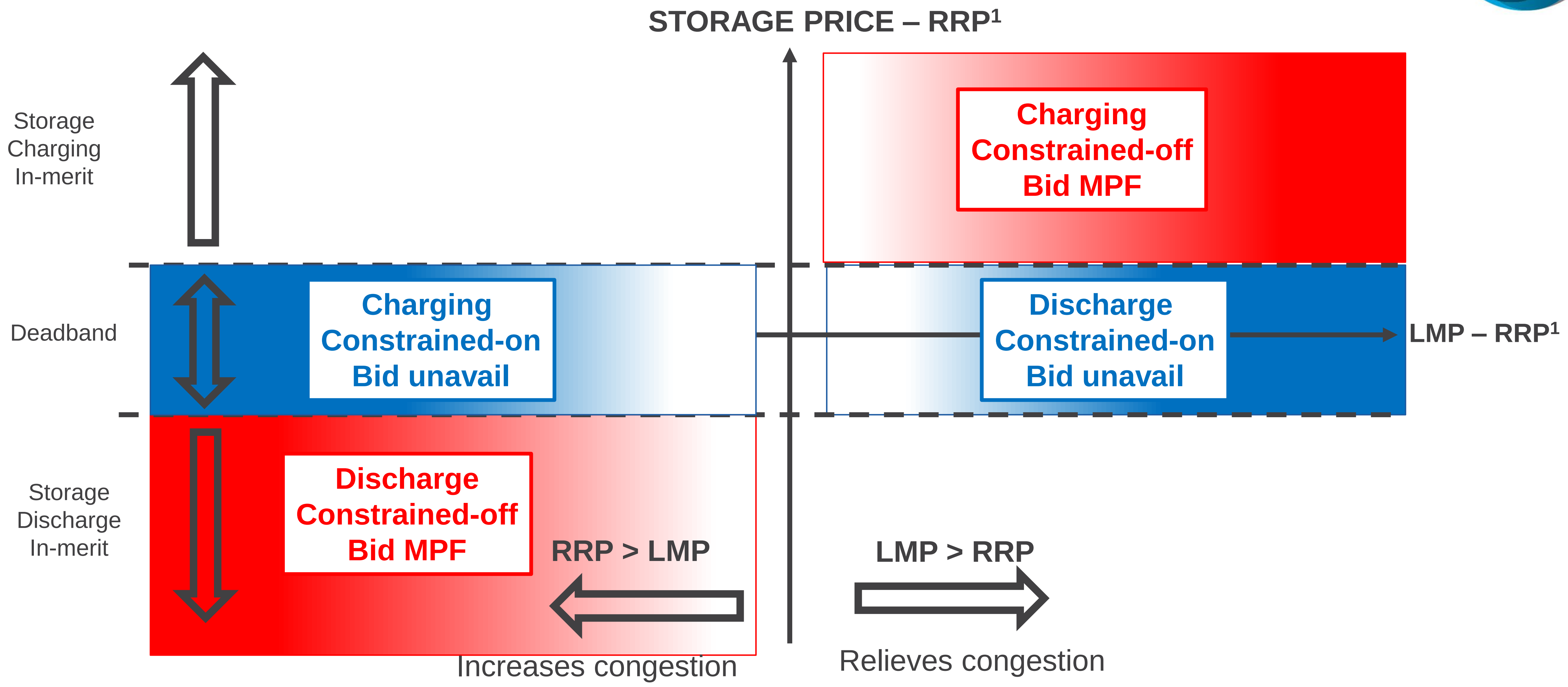


STORAGE: ACCESS BIDDING INCENTIVES



1. Based on forecast RRP and LMP

STORAGE: ACCESS BIDDING REGULATION



1. Based on forecast RRP and LMP

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