Reactive Power Procurement : Lessons from Around the World

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Contents

About the Paper

Aim:

- To look at the international experience in managing and procuring reactive power (RP) in order to identify key lessons.

- To explore the auction design theory and provide key recommendations for procurement

Reactive Power Procurement: General Findings

At transmission:

- Limited or inexistent market-based mechanisms for the procurement of RP and voltage support by ISOs (with some exceptions: Australia, UK).
- Some reasons behind these findings:
    - The local nature of RP does not help ("VARs do not travel well").
    - Limited number of potential providers, then lack of competition.
    - Technological/modelling issues (IES, 2017).
- Procurement of RP/VS closer to real time is limited:
    - A common practice for specific ancillary services (regulation, reserves).

At distribution:

- RP requirements based on connection standards (e.g. 0.95 PF).
- Procurement of RP from DER is not yet a fact.
- Financial incentives (VAR charges) may also apply.
- Connection standards are evolving (e.g. use of smart inverters).

Can the deployment of DER help to reverse this state of affairs?

- DER can also introduce additional system complexity, then "trials" are required to "measure and evaluate" the effectiveness of DER in providing RP and voltage support *(Exelon Corporation, 2016).*
- Need for greater DER visibility by SOs and more coordination among parties.

Reactive Power Procurement: General Findings

Table 1: A Comparison of Ancillary Services in the USA and GB (selected services)

	Ancillary service markets and names	USA							GB
		CAISO	ISO-NE	MISO	PJM	SPP	NYISO	ERCOT	NG (2)
Regulation/Frequency Response	Regulation		RT	DA,RT	RT (1)		DA,RT		
	Regulation Up	DA,RT				DA,RT		DA	
	Regulation Down	DA,RT				DA,RT		DA	
	Regulation (performance)				RT			NA	
	Regulation Up Mileage	DA,RT				DA,RT			
	Regulation Down Mileage	DA,RT				DA,RT			
	Regulation Service		RT						
	Regulation movement						DA,RT		
	Regulating Mileage			DA,RT					
	Frequency response								
	Mandatory frequency response								
	Firm Frequency Response (dynamic)								monthly tenders
	Firm Frequency Response (static)								monthly tenders
Reserves	Spinning reserve	DA,RT		DA,RT		DA,RT	DA,RT		
	Ten-minute spinning reserve		RT, F						
	Synchronised reserve				RT				
	Responsive reserve							DA	
	Non-spinning reserve	DA,RT					DA,RT	DA	
	Ten-minute non-spinning reserve		RT, F						
	Quick start				RT				
	Thirty-minute operating reserve		RT, F						
	Supplemental reserve (3)			DA,RT	RT (4)	DA,RT			
	Ramp reserves (5)	RT		DA,RT					
	Reserve								
	BM startup								
	Fast reserve								monthly tenders
	Optional Reserve Services								
	Short term operating reserve (Committed)								3 tenders/y
	Short term operating reserve (Flexible)								3 tenders/y
	Short term operating reserve (Premium Flexible)								3 tenders/y
Others	Reactive power (voltage support)								
	Mandatory reactive power service								
	Enhanced reactive power service (6)								semestral tenders
	Black start					NA			

market-based mechanisms (tenders)

other (cost-based, lost opportunity cost, revenue-based, mandatory)

Markets: DA: Day Ahead, RT: Real Time, F: Forward (pre-DA), NA: No available

(1): Regulation in PJM is provided by a combination of resources following 2 signals: RegA (slow response) and RegD (quick response).

(2): Simplified list of AS as of Dec. 2017, (3): Provided by online or off-line resources in MISO/PJM, (4): PJM uses a day-ahead scheduling reserve in addition to the RT for supplemental reserve (30min), (5): Ramp product: Up and Down Ramp Capability (MISO), Flexible Ramping (CAISO).

(6): Not currently active for procurement. The full list of removed products can be found at NG (2017c) and NG (2018c).

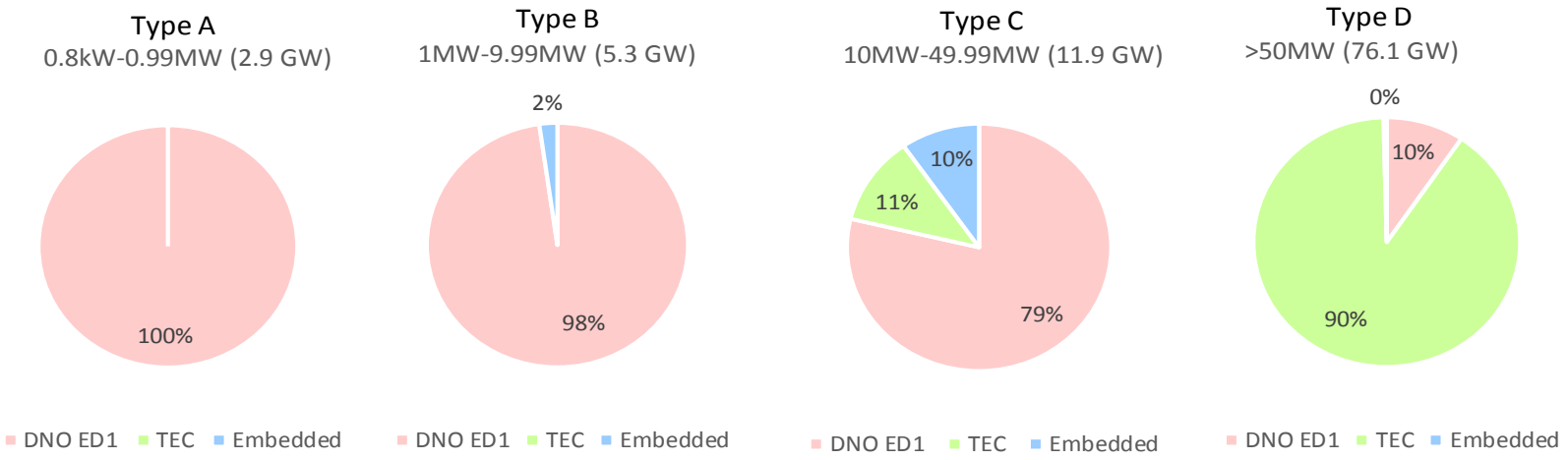
Source: Anaya and Pollitt (2017, p. 31), ISO-NE (2018a), NG (2017a), Potomac Economics (2017).

Reactive Power Procurement: General Findings

Network Code Evolution:

- Network Code on Requirements for Generators (RFG) - new generating facilities.
- Will help to support RP (technical capabilities) and harmonised solutions.
- Specific technical requirements arranged in four bands (Type A – Type D), based on capacity (MW) and connection voltage (kV).
- In GB:
  - 88% generation on Type B&C&D (2015) but 67% on Type A&B (2021).
- RP capability from DER is expected to take a more active role.

Figure 1: Generation by band in Great Britain



DNO ED1: refers to generators connected to the distribution network. TEC: refers to generators with transmission entry connection.

Embedded: refers to generators connected to the distribution network with access rights to the transmission network.

Figures from Nov. 2015. (TEC, Embedded), week 24 2015 (DNO). Source: NG (2018a, p. 176).

Reactive Power Procurement: General Findings

Table 2: RP Procurement and Payment Methods by SOs: A Comparison

Country	SO	Procurement method		Type of payment						Periodicity
		Compulsory/ Mandatory	Tenders	Capability	Availability	Enabling	Utilisation	Opportunity costs	Others	
USA	CAISO	✓						✓		variable
	NYISO	✓		✓				✓	✓	variable
	PJM	✓		✓				✓		variable
	ISO-NE	✓		✓				✓	✓	variable
Australia	AEMO (GM)		✓		✓			✓	✓	variable
	AEMO (SCM)		✓			✓			✓	variable
GB	NG (ORPS)	✓					✓			variable
	NG(ERPS)		✓		✓		✓			every six months, with term contract minimum 1 year and then in six-month increments

GM: generation mode, SCM: synchronous condensor mode. Others include: testing charges, cost of energy used to energise equipment that provides voltage support.

Source: AEMO (2017a), CAISO (2017), NYISO (2017a, 2014), ISO-NE (2018b), PJM (2018), NG Reactive Power Service Guides.

- *ISOs from the USA apply different capability methods (NYISO: fixed rate set at: $2,747/MVAr year, others: based on FERC method: American Electric Power - AEP).*
- *In GB under the ORPS a fixed rate is applied for utilisation (£3.19/MVArh aver. Jan-Jul. 2017).*
- *Loss of opportunity costs: only when generators operate outside their mandatory range.*

Case Studies

Case studies:

- Explore different market-based initiatives that may involve the participation of DER.
- We have chosen case studies of RP and similarly procured DER services.
- Involve trials (pilot project) and Business as Usual (BAU).
- Cases:

From Australia (BAU)

- **AEMO tenders for acquiring NSCAS (network support and control ancillary services)**

From USA, CA (pilot project)

- **DRAM (Demand Response Auction Mechanism)**

From UK (pilot project)

- **Power Potential (RP procurement from DER via auctions)**

Case Studies - Australia

AEMO tenders for acquiring NSCAS

Overview

- NSCAS: non-market ancillary service (AS)
- Procured by *AEMO* or Transmission Network Service Providers (TNSPs) to maintain power system security and reliability.
- TNSPs with primary responsibility to acquire NSCAS.
- AEMO will procure if the NSCAS gaps remain unmet after the TNSPs attempt to procure.

Products

- VCAS (Generation Mode , Synchronous Condensor Mode).
- Can be for short term (generating units)/long term (reactive plants) solutions or a combination.
- Provided by existing or new plants/generating units.

Evaluation criteria and offers selection

- Selection of tenders at the least cost possible.
- Assessment of the optimal combination of VCAS (locational effectiveness, others).

Table 3: Example of Effectiveness

VCAS Equipment locations (when connected at or near 330 kV substations)	Effectiveness at reducing overvoltage at both Kangaroo Valley and Upper Tumut (%)
Kangaroo Valley, Upper Tumut	100
Capital, Bendeela	97
Lower Tumut	93
Canberra, Williamsdale	90
Yass	76
Wagga	72
Jindera	59
Dapto, Marulan, Bannaby	50

Source AEMO

Case Studies – California

DRAM (Demand Response Auction Mechanism) – State level initiative

Overview

- Mandated by California Public Utility Commission in Dec. 2014.
- Design and implementation of DRAM: through pilot programs by three IOUs.
- Allows the California SO (CAISO) to add demand response resources.
- Gradual deployment (DRAM pilot 1, 2, 3, 4) with specific budget allocated to IOUs.
- Type of auction mechanism: pay-as-bid auction.
- A more cost-effective method to secure DR capacity (by IOUs).

Products

- Different types of Resource Adequacy (RA): System, Local, Flexible
- Different types of Demand Response Products:
- Prohibition of specific resources for load reduction during DR events.

Evaluation criteria and offers selection:

- Qualitative assessment: Based on qualitative factors - QF.
- Quantitative assessment:
  - Offers ranked by Net Market Value (NMV)

$$NMV = Benefits - Costs\ (*)$$

(*) Costs lower than the long-term avoided cost of generation (US$ 113.20/kW-yr.)

Case Studies – California

DRAM (Demand Response Auction Mechanism) – State level initiative

Table 4: Summary of DRAM Pilots

Description	2016 DRAM (Pilot 1)	2017 DRAM (Pilot 2)	2018-2019 DRAM (Pilot 3)	2019 DRAM (Pilot 4)
Type of RA	System	System, local, flexible (cat. 2, 3)	System, local, flexible (cat. 1, 2, 3)	System, local, flexible (cat. 1, 2, 3)
Type of DR product	PDR	PDR, RDRR	PDR, RDRR	PDR, RDRR
Delivery Period	6 months Jun.-Dec. 2016	12 months Jan. – Dec. 2017	2 years (2018-2019) Jan. –Dec.	12 months Jan.-Dec. 2019
Budget	SCE:$6m, PG&E:$6m, SDG&E: $1.5m	SCE:$6m, PG&E:$6m, SDG&E: $1.5m	SCE:$12m, PG&E:$12m, SDG&E: $3m	SCE:$6m, PG&E:$6m, SDG&E: $1.5m
Procurement targets (minimum)	10 MW (SCE), 10 MW (PGE), 2 MW (SDG&E).	10 MW (SCE), 10 MW (PGE), 2 MW (SDG&E)	No minimum (MW).	No minimum (MW).
Procurement targets (maximum)	Based on approved budget limit or available authorised Rule 24 registrations.	Based on approved budget limit or available authorised Rule 24 registrations.	Based on approved budget limit or when there is a clear price outlier.	Based on approved budget limit or when there is a clear price outlier.
Scheduling coordinator costs	separated from the bid cost	separated from the bid cost	included in the bid cost	included in the bid cost
Capacity procured	40.5 MW	124.7 MW	over 200 MW	na (ongoing)
Regulatory framework Decision (CPUC)	D.14-12-024	D.14-12-024	D.16-06-029	D.17-10-017

RA: Resource Adequacy, DR: Demand Response, PDR: Proxy Demand Resource, RDRR: Reliability Demand Response Resource.

Source: CPUC (2017a, b), PG&E(2017), SCE (2015).

Case Studies - UK

POWER POTENTIAL

About the products

- RP and Active Power (AP) from DER (ideally connected at 33 kV or above).
- Total size between 10-50Mvar across the 4 GSPs, with at least 0.5MW/0.5MVAr.
- DER aggregated or directly connected.
- Exclusions may apply (AP and specific balancing services).

Participation criteria and eligibility

- DER located around 4 specific GSPs (southern region).
- Service (s) to be provided by DER in at least one of the 4 GSPs.
- Offers made only for 1 GSP at the same time.
- DER expose to different stages: Wave 1, Wave 2 (DER), Wave 3 (DER + Tran. Gen.)

Evaluation Criteria and offers selection

- Day-ahead auction wit pay-as bid method.
- Selection of offers based on a combination of lowest costs and highest effectiveness but limited to the current budget (up to £0.6m).
- An indication of low/high effectiveness is provided (heatmaps) for each GSP.
- Non-cost variables are not expected to be included in the selection of offers.

Discussion and Lessons Learned

1. Procurement of RP and the need for market-based mechanisms

- Global lack of market-based mechanisms for RP procurement (in contrast with other AS).
- RP suppliers generally subject to mandatory arrangements.
- Use of fixed methodology for RP compensation (flat rate or cost-based rate).
- Fixed methodologies should be enhanced and reflect real costs.
- Risk of over/under compensation can be mitigated by introducing more market-based solutions *(e.g. 200 Mvar, from a 200 MW plant with 0.9PF: CAISO:$0, ISONE: $225k, NYISO: $525k, PJM: $1.9m).*
- DER can help to deal with the poor locational effectiveness (Vars do not travel well).

2. A market-based approach for RP: The Conceptual of Auction Design

- New initiatives in auction design for RP procurement encourage new entrants (i.e. DER) in RP market, but future participation of new entrants should depend on whether they can compete.

- The importance of enhancing competition between the RP suppliers (i.e. DERs) across the different supply sites (i.e. GSPs) via a package auction design. The sale of multiple objects encourages price discovery and induce truthful bidding.

- Consideration of pay-as-clear price determination format which works better for true price discovery and maximises economic welfare.

Discussion and Lessons Learned

- The frequency and periodicity of the auction and the cost benefit of nearer to real time procurement and co-optimisation. Adjustment of RP offers and demand closer to real time and lower costs.

- The careful specification of the counterfactual against which the auction results are to be evaluated. RP can be acquired under different methods that need to be evaluated.

- The design of the contract between the DSO and TSO to incentivise optimal risk sharing. Suitable contract agreements can help with this.

3. Power Potential initiative as an opportunity to:

- Trial the technical/commercial solutions, new roles and new interactions.

- Identify regulatory barriers that may limit the value of procuring RP competitively from DER at large scale.

- Create a regional market for RP as represented by a group of GSPs.

- Be a first mover in the procurement of RP using DER.

Q&A

Thank you!