'Over the edge' – energy risk trading in a negative demand environment

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Abstract

Large scale distributed energy resource deployment is expected to result in negative regional demand in grid-edge markets. While the price signal provides the economic rationale for consumption, a cohesive risk management framework for negative prices underpinned by foundation risk trading mechanisms are required for co-ordinated operational, commercial and investment decision-making.

Introduction

On Sunday 11 October 2020, just past midday, a new record for minimum demand of 300MW was set in the South Australia region of the National Electricity Market (NEM). Minimum operational demand levels in the region have been on a steep downward trend since 2012, and with ongoing deployment of rooftop solar is projected to tip over into negative minimum demand-between 2021 and 2024. While grids around the world have contended with the ramp challenges of the now famous 'duck curve', negative demand poses an enhanced set of challenges for grid operators and market participants alike. While the economic signals for additional consumption during the belly of the duck are manifest in negative prices, the question of how to elicit changing consumption patterns is still open. In particular, we point to the paucity of risk trading instruments that provide hedge protection against low and negative demand phenomena. In this paper, we highlight the operational and commercial implications of negative demand on a regional and system wide level. We further emphasise the importance of expanding the scope of exchange-traded and bilateral risk trading instrumentscatered towards a low or negative demand environment.

Minimum demand trends and tip-over points

With ongoing growth in rooftop solar deployment, South Australia is likely to be the first gigawatt scale power system in the world to reach negative operational demand. The Australian Energy Market Operator (AEMO) expects this to occur within the next 1-3 years. Other regions in the National Electricity Market (NEM)of Australia such Victoria are also following in this trend (with negative tip-over expected in the next 6-7 years), which suggests that by the next decade a significant portion of the grid may face negative minimum demand. While there are characteristics of the system and topology that make the challenge in NEM unique, this is also of relevance for grids experiencing significant expansion in distributed energy resources (DER) penetration.

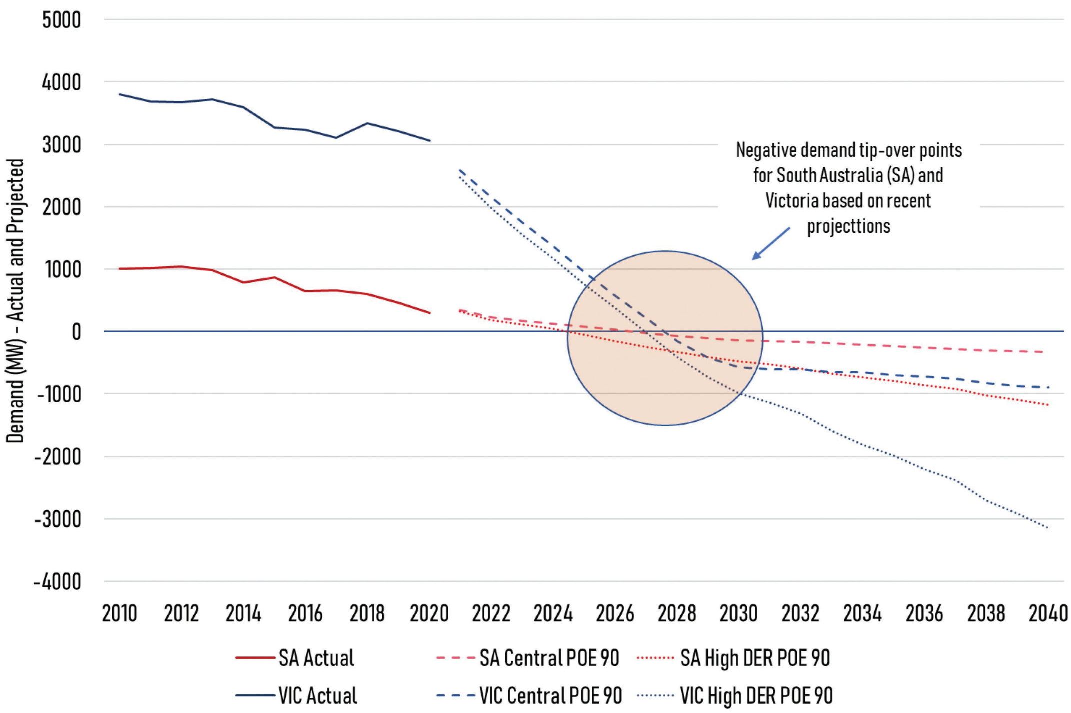


Figure 1. Minimum Operational Demand – Actual and Projected for South Australia and Victoria Source: AEMO. Scenarios presented are the 'Central' and 'High DER' cases underpinning the 2020 Electricity Statement of Opportunities (ESOO).

Operational demand is distinct from the concept of net load that is synonymous with the duck curve. While the duck curve measures 'net load' which is demand minus grid scale variable renewable energy (VRE) generation, operational demand only includes the impact of DER behind-the-meter, but does not include grid-scale VRE. This distinction is important for two reasons. First, the incorporation of the impact of grid scale VRE (particularly solar) on a negative minimum demand region exacerbate the rampingrequirements of the system. Second, the ability for a system operator (SO) to curtail grid-scale resources either via the security constrained dispatch process or as part of automatic generator shedding schemes provide a tool to manage security impacts (i.e. a safety valve if operators consider system security to be at risk). For the most part security-driven curtailment of distributed energy resources (DER)is not present in grids around the world, though this is an important measure under consideration in relation to grids reaching minimum demand operational limits.

A recent review of the South Australian minimum demand by AEMO raised a range of system security issues emerging from the issue of negative demand (AEMO, 2020). Two particular issues highlighted relate to (i) increased complexity and risks during islanded operation of the region (which while not considered an N-1 contingency – is part of a suite of risks requiring protection (ii) the risk ofvoltage-driven instability and disconnection of distributed inverters in low system strength conditions. It is important to note that while 'negative demand' is part of a subset of grid integration requirements under higher VRE and inverter penetration, it has the potential to exacerbate the existing suite of system risks. Of the range of measures highlighted to mitigate the issue, of particular criticality is the urgent enhancement of DER controllability and response (both as part of normal operation, as well as response under disturbance).It also underscores the rationale for more storage and "solar-soak" resources.

Market implications and the state of risk trading

These operational conditions are being reflected in the spot market with a greateroccurrence of low and negative prices[1]. A record occurrence of negative prices, 10% of the time, were experienced in South Australia during the third quarter of 2020, with September recording negative prices over 22% of the time. Reduced demand driven by DER, along with high VRE output and interconnector constraints were key drivers of this shift.

There has been some operational response to date from participants– certain renewable projectshave been observed to have self-curtailedtheir generation in response to negative prices (with suggestions that many renewable power purchase agreements now contain 'negative-price' clauses requiring a project to curtail if prices fall below certain thresholds (AER, 2020).In addition offer patterns and increased cycling of thermal dispatchable generation appear to reflect solar peak risks (McArdle, 2019).

Yet an energy-only market design is dependent upon transparent and deep risk trading mechanisms to enable these signals to flow into decisions on investment, expansion and retirement across a diversity of capital sources(Deng and Oren, 2006). Risk trading enables participants to better hedge and manage risk preferences, though we note that traditional risk trading mechanisms have been catered towards a positive price environment. Price dynamics in many markets continue to shift towards negative pricing periods given the VRE merit-order effects. Low or negative demand has the potential to exacerbate the persistence, recurrence and severity of negative prices, and as such risk trading and hedging instruments need to evolve to allow management of such price risks.

The renewable hedging problem has been a challenge for markets around the world and a range of different approaches have been adopted to date. Table 1 sets out a sample of products and instruments considered in hedging the risk of variability and uncertainty from renewable resources. Shape products, such as solar firming or super-peak products (Maisch, 2020), aim to adapt the volumetric profile of energy contracts to a renewable environment, evolving from the traditional peak / off-peak distinction. A range of weather-linked products have been developed based on wind and solar insolation patterns (Bhattacharya et al, 2015). Products such as 'Low Wind Day' and 'Low Wind Season' certificates provide opportunities for wind projects to obtain downside volume protection, but the issue of price protection still remains (especially under high and correlated wind outcomes across a market or region) . The Proxy Revenue Swap (Bartlett, 2019) has emerged as a popular form of risk hedging for renewable projects for 'proxy revenues' – which offer a fixed payment to projects in exchange for a formula-based estimate of a projects variable revenues given wind/insolation patterns and market prices, but with the project retaining operational risks. Counterparties for such contracts have included parties non-traditional energy counterparties including insurance/reinsurance companies, and hedge funds. Part of the rationale for such counterparties is the natural diversity offered by wind and solar projects, relative to other risks the party's portfolio. Finally 'price floor' contracts or put swaptions have also been proposed (NSW Department of Planning, Industry and Environment, 2020) – these provide a project with the right but not the obligation to sell its energy at pre-determined strike price. Thus should prices fall below the strike, the project is hedged from such price volatility. This would be the corollary

Table 1. A range of risk trading mechanisms for hedging variable renewable energy

Product Examples	Description	Risks hedged
Shape Products		
Solar Shape	Fixed-for-floating swap, volume sculpted to solar profile	Price risk over time block
Inverse Solar Shape	Inverse of Solar Shape Product	Price risk over time block
Super peak	Fixed-for-floating swap, volume sculpted to shoulder peaks	Price risk over time block
Weather linked-contracts		
Low Wind Day	Payouts based on wind/irradiance over day	Weather
Low Wind Season	Payouts based on wind/irradiance over season	Weather
Price trigger		
Swaptions/Price Floors	Provides payout if price falls below threshold	Low price volatility
Insurance products		
Proxy Revenue Swap	Fixed payment for proxy revenue	Multiple

of a price cap contract that underpins traditional risk management approaches to pricevolatility (for high prices) (Simshauser, 2018).

A proposal: exchange-traded zero exercise price put options (ZEPPO)

It is recognised that the management of financial risks relating to new energy sources is not a homogenous exercise. Indeed this heterogeneity can provide natural locational, temporal andseasonal-diversification in larger energy portfolios. As such, it is apparent that the approach to risk trading for each participant will be diverse and nuanced to reflect specific project or portfolio risks. However, it is also important that the market be anchored by a product or a set of products that provide participants with a transparent indication of price risks in the new environment.

This could come from an exchange traded 'price floor' contract that would mirror existing price caps contracts, which together with cap contracts and other derivates would provide a market guide for storage investment in electricity markets. A zero-exercise price put option (ZEPPO) would provide the buyer with the right to sell energy at a zero strike price (Figure 2). This would provide buyers with a payoff equivalent to the value by which the spot price is smaller than zero and provide generators with price protection from negative prices. Correspondingly for storage or consumers that are able to flexibly consume during negative pricing periods, it could provide a source of premium income to underpin short to medium term commercial decisions. This contract would provide an indication of market perceptions of negative price risks, and can provide a price guide for longer term agreements that underpinning investment.

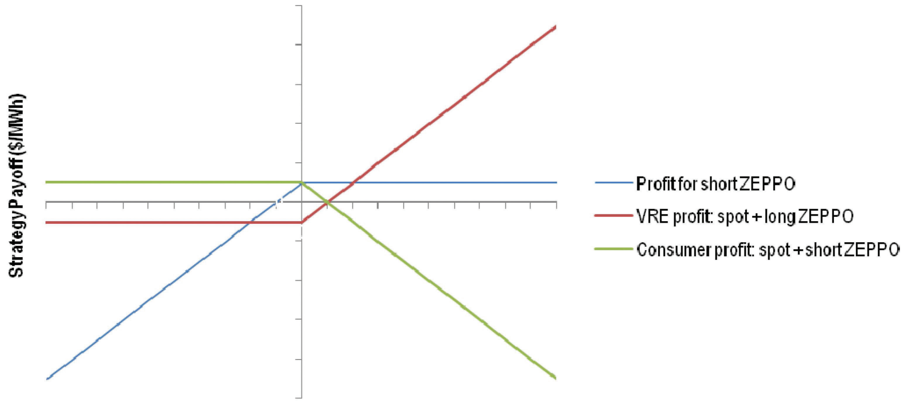
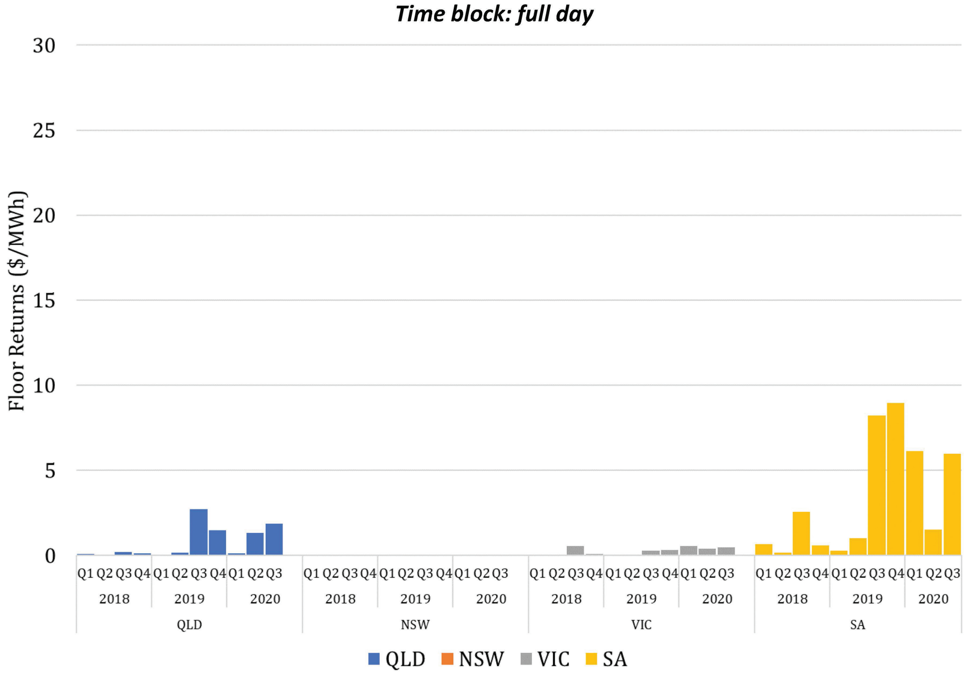


Figure 2. Hypothetical returns for a price floor product



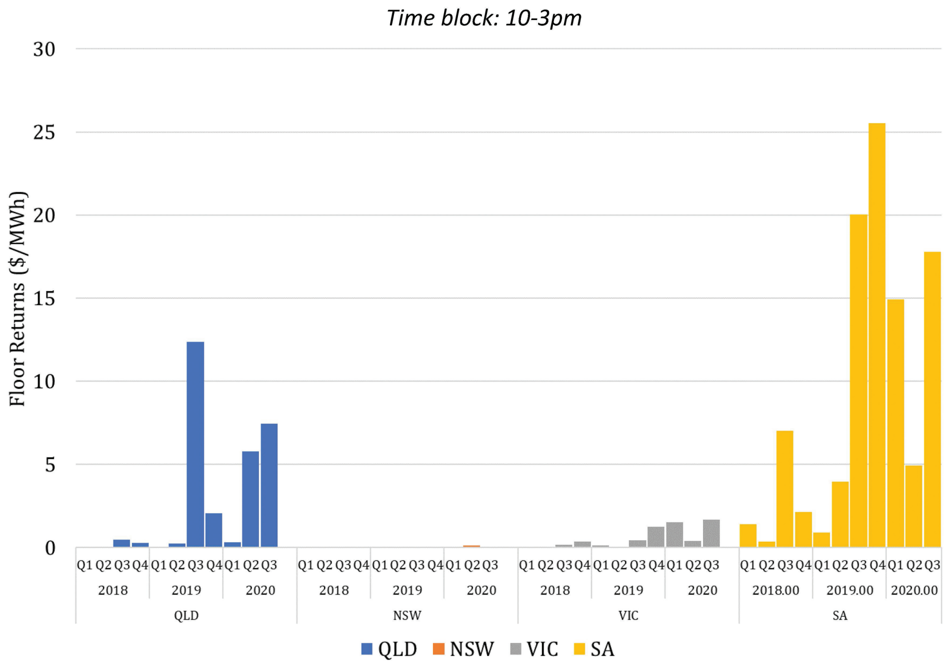


Figure 3. Hypothetical returns for a price floor product

Figure 3 maps the historical returns to a hypothetical ZEPPO (put option with a strike prices of $0/MWh) applying over two time blocks – the full day (top panel) and a 10am-3pm (bottom panel) time block. Given the increased frequency and quantum of negative prices, the returns to a hypothetical price floor has been increasing for certain regions, and should current trends continue downside risks require serious consideration for a modern electricityrisk manager.

While a price-floor may not be optimal for all projects and situations, an exchange-traded, transparent and liquid indicator of negative price risk perceptions would aid risk managers in managing downside prudential exposures, and would allow participants to use such price indicators in the structuring of more bespoke solutions.

A price floor could also be coupled with existing price cap contracts to form a contract that provides an indication of contracted returns to grid storage. This contract formed by the combination of shorting a price-cap (call option) contract and shorting a price-floor (put option) contract. An ideal counterparty for such a contract would be resource that can be confident of generating at prices above the cap price, and consuming at prices below the floor price. Such a contract, common in other commodity markets, would provide a sense of value for grid-storage. Again this would provide an important price anchor for project financiers and developers.

Finally we make the point that the development of risk trading instruments, exchange traded or otherwise are not enough in and of themselves. They need to be coupled with an enhanced prudential risk framework across the industry that provide standards for the management of these financial risks. With the expected growth of distributed and variable sources of energy, these risks are not likely to disappear any time soon, underscoring the criticality of industry leadership on negative price risk management.

Footnotes

[1] It is important to note that while prices are often an outcome of a variety of factors, negative demand has the potential to add further downward pressure.

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