National Irrigators' Council

Empowering irrigation consumers electricity purchase arrangements Research reporting

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July 2018

sapere research group

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The authors gratefully acknowledge the generous and wise contributions made by Steve Whan and Warren Males, and funding support from Energy Consumers Australia.

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Executive summary

This research project for the Australian Agricultural Industries Energy Taskforce (the Taskforce), with funding support from Energy Consumers Australia, is intended to begin to empower irrigators as a consumer class to obtain materially lower prices for electricity used in agricultural irrigation. While there are caveats, our research supports our intuition that most irrigators are likely to be paying too much for the electricity they use for powering various types of agricultural irrigation equipment.

The problem

Retail electricity prices are rising at nearly twice the rate of inflation and wages. Historical irrigation/agricultural tariffs were typically at a discount to standard tariffs in recognition of lower cost demand profiles. These tariffs are obsolete already or transitioning to standard small business tariffs. This means irrigators have or are facing a double impact – higher general retail prices combined with moving to higher cost tariffs.

Electricity bills for agricultural irrigators are substantial per irrigator and as a group. They are a significant input cost. Rising power bills squeeze food and fibre producer margins and otherwise reduce competitiveness domestically and internationally.

Customer initiated tariff and retailer switching may be less likely outside metropolitan areas. Regional customers may be loyal to electricity retailers perceived to be local, even if this is no longer the case outside Queensland and Tasmania.

Standard business tariffs that rely on deemed demand profiles (net system demand profiles or NSLPs) may substantially exceed efficient costs relative to a typical actual irrigator demand profile (IDP). Interval data available from smart metering reveal differences in the costs to supply individual customers and customer segments, compared with deemed profiles. The interval data available from smart metering, combined with accessible data transfer systems, are together powerful tools enabling consumers to compare tariff offerings and to change demand behaviour where beneficial. These tools also enable retailers and networks to develop improved retail products and efficient tariff structures.

Outside Victoria, the rollout of digital metering is now retailer-led. This means the rollout prioritises areas and customers where most efficient and beneficial. Irrigators represent a substantial consumer segment. If irrigators have materially lower costs to supply than typical small business counterparts, or are more capable of reducing demand during a small number of peak demand periods; then irrigators could be prioritised and targeted for early deployment of modern retail tariff products and associated technology. This could be beneficial for both irrigators and retailers.

The objective of the project is to assemble an evidence base about the characteristics of irrigators as electricity users to test three inter-related hypotheses:

1. Irrigating farmers could obtain significantly lower prices from more active engagement in retail electricity markets – *finding the best offer.*
2. Irrigators as a customer segment typically have a lower cost demand profile compared with typical customers with similar consumption volumes –*cost reflective prices would be lower than current prices.*

3. Many irrigators would be prepared to power down or shut off irrigation demand, in response to well-designed tariff structures and advanced warning ahead of the small number of hours within each year when supply costs are very high – *irrigators can usually avoid high cost, high demand periods.*

Evidence relating to these hypotheses can be used to focus efforts by irrigator/agricultural advocacy groups both to:

a) empower irrigators to take actions to reduce their power bills, and

b) seek regulatory changes to support efficient network and retail tariffs, and better functioning and more competitive retail electricity markets, resulting in lower power bills.

The methodology and evidence base is set out in the main report. In brief we undertook a survey of irrigators and analysed their responses. In addition, with permission, we obtained energy consumption data and compared this with prevailing wholesale prices and the relevant deemed profile to use as a benchmark for current wholesale prices being paid.

The sample of respondents is small (148 respondents) and may not be representative. The analysis could certainly be extended and improved. Nevertheless, the consistency of results across regions and producer types provides us with a high level of confidence in the findings. Extension of the analysis is likely to lead to refinement but not an over-turning of our conclusions. We summarise our findings regarding each of these hypotheses below.

Finding the best offer

Based responses to our survey, irrigators' engagement with retail electricity markets ('shopping for power') is far lower than it could be, and there is significant dissatisfaction with the processes and outcomes. As a result, electricity bills across the group are likely to be materially higher than they could be.

Figure 1 summarises the findings on the level of market engagement. Overall, just over a third of irrigators sought alternative offers in the previous year. This is the same proportion that never sought alternative offers. Irrigators in Queensland are far less likely to have sought new electricity prices recently than elsewhere, as retail markets in most regional areas have not been opened to competition.

Figure 1 Timing of irrigators' last approach to market

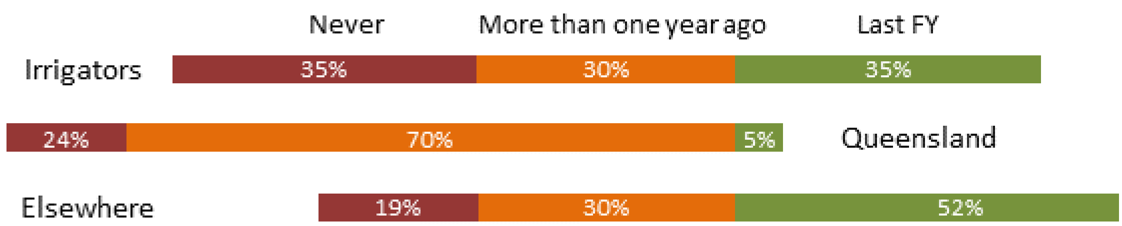
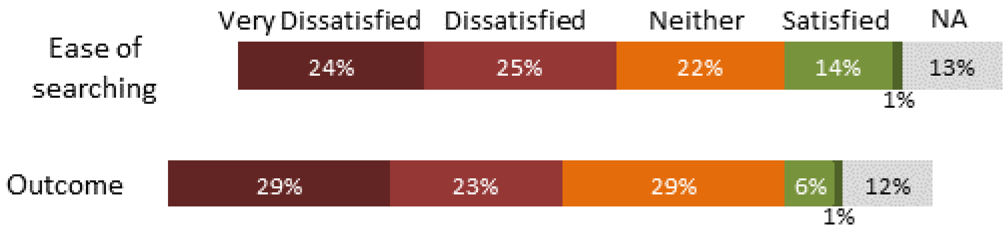


Figure 2 summarises the respondents' satisfaction with a) searching for tariffs suitable to electricity use for irrigation and b) with the price/tariff obtained. Only 15 per cent of respondents gave a satisfied rating for the ease of searching for electricity tariffs. Overall, 49 per cent were dissatisfied or very dissatisfied, varying between 44-54 per cent by jurisdiction.

Figure 2 Satisfaction with ease of searching suitable tariffs and price outcome obtained



Only seven (7) per cent of respondents were satisfied or very satisfied with the price/tariff that they obtained as a result of their engagement with retailers. Overall, 52 per cent responded with a dissatisfied or very dissatisfied rating, varying between 47-58 per cent by jurisdiction.

These results indicate that there is scope for Taskforce member organisations to encourage greater engagement with retailers. Engaging with energy services providers to identify and promote better value energy services for irrigators that have lower cost demand profiles could be worthwhile.

Cost reflective prices would be lower than current prices

Both the responses provided by the survey, and our analysis of interval meter data, strongly suggest that irrigation demands have lower costs to supply compared to 'typical' small customer demands. This reflects the following.

- There is no evidence to suggest that irrigation demand is high let alone increases during extreme heatwaves, when maximum annual demand and very high power supply costs are most likely.
- It appears unlikely pumps are running at full capacity at times of peak system demand. Across states and different types of primary produce, use of pumps predominantly coincides with times when system demand is at just 30-55 per cent of system annual maximum demand.
- Seasonal irrigation demand peaks in late spring (Queensland) or early summer (elsewhere) reflect rainfall variations between regions. Demand peaks are not driven by very high temperatures.
- While about 45 per cent of irrigation equipment operates continuously over a day, other equipment is operated predominantly overnight and at a minimum during afternoons (at the mostly likely time of system peaks).
- Pump demand profiles are demonstrated by interval data generally to be 'flat': that is when pumps are being used, demand is at/above 90 per cent the pump's maximum demand.

The non-coincidence of maximum irrigation demand with maximum system demand has a direct effect on the delivered cost of electricity, both wholesale and network (transmission and distribution), for irrigators. For example, Table 1 below provides the volume weighted average (VWA) wholesale electricity costs of individual irrigation demands compared with the VWA costs of the system demands represented by the deemed profile for small customers. These clearly demonstrate the reduced wholesale cost (using half hourly wholesale price data for the relevant periods) of different irrigation profiles compared with the relevant deemed demand profile.

Table 1 Comparison of volume weighted average spot market costs

Individual irrigation demand prices are compared with contiguous aggregate prices ($/MWh)

DNSP	Crop	Irrigation profile	Deemed profile	Irrigation/deemed profile
Ergon	Sugarcane	$48.06	$107.83	59%
SAPN	Fruit and nuts	$82.51	$134.95	64%
Powercor	Lucerne 1	$68.84	$82.60	83%
Powercor	Lucerne 2	$63.07	$82.60	76%
Powercor	Tomato	$58.32	$82.60	71%
Powercor	Cotton	$49.57	$82.60	60%
Powercor	Tomato	$56.11	$82.60	68%
Powercor	Cotton-Lucerne	$60.85	$82.60	74%
Powercor	Cotton	$50.49	$82.60	61%

As shown in the right hand column, the unitised wholesale energy cost of the various irrigation profiles (IDPs) is between 59 and 83 per cent of the deemed profile (NSLP) cost. This is a conservative measure of the risk adjusted difference in the wholesale cost of supplying IDPs relative to NSLPs, after taking into account forward wholesale trading risk.

This means that retail prices set on the basis of deemed small customer profiles could over-compensate retailers or allow retailers to cross-subsidise other customers by a substantial amount. Given the typically medium to high electricity volumes used for irrigation, the cross-subsidy portions of total annual irrigator bills are likely to be very substantial.

The reduced cost of the network component of retail prices for the irrigator above profiles is difficult to quantify. This is largely because current network tariff structures throughout the NEM are poorly designed and do not reflect efficient costs.[1]

Periods of network congestion and high supply costs do not align perfectly with wholesale congestion and high supply prices. Nevertheless, the highest network and wholesale supply costs are strongly related to periods of very high demand. Depending on the network tariff

1 See for example a report by the present authors for CANEGROWERS: *Comments on Energy Queensland Tariff Structure Statement Issues Paper 2018*.

structure, the indicated unit price premiums for wholesale costs shown above are a useful indicator of the possible price premium contained in network charges.

Together, wholesale and network costs are by far the largest component of total retail supply costs and prices. If these delivered supply costs were 80 per cent of the total retail bill, and if delivered supply costs for an irrigator profile was 75 per cent of that for the relevant deemed profile, then the retail price would be around 20 per cent or one fifth higher than the efficient retail cost.

Across the sample of survey respondents providing cost data, total electricity costs exceed $3 million or $30 thousand per farmer on average, so that a 20 per cent saving represents material reduction in farm input costs ($6 thousand per annum).

Irrigators can usually avoid high cost, high demand periods.

Over half the respondents already engage in time shifting irrigation power demand in response to price signalling. Respondents indicated a willingness to engage in demand response but indicated their ability to respond to price and/or control signals was constrained by operational considerations – reconfiguring irrigation equipment and the associated labour.

Nevertheless, our comparison of survey responses and interval data suggests many irrigators could under-estimate their capacity to power down demand during limited high system demand/high price periods. This is because they typically perceive a coincidence between their own maximum demand and system maximum demand that is much higher than the actual coincidence.

As noted earlier, our quantitative analysis of irrigator demand profiles strongly suggests that the likelihood that high irrigator demand coincides with high system demand periods is very low. This means there is an opportunity for irrigators to engage with various demand response signals.

On the other hand, the benefits would be relatively modest, because the value at stake appears low. Nevertheless, the option value of reducing demand, to both networks and retailers, may further contribute to opportunities for improved tariff design with lower prices than otherwise.

The network tariff reform problem

The conclusions above highlight the opportunity to reduce retail power prices by perhaps around 20 per cent via the introduction of cost reflective retail prices supported by the early deployment of digital metering equipment, where beneficial. However, distribution network tariff structures pose a significant risk and impediment to efficient retail prices.

The risk is that, in order to obtain the benefits of lower cost wholesale prices, via the selection of a time of use or demand related retail tariff, irrigators could find themselves assigned to a disadvantageous network tariff. The network tariff could substantially increase network charges and result in a higher retail tariff compared with a "flat" tariff with a single volumetric (energy) rate.

The problem arises from time of use energy or demand tariffs with very broad peak price charging windows. The proportion of the year where premium peak prices are applied vastly exceeds the proportion of the time during which total demand across the system is close to its annual maximum. These tariff structures may result in excessive charges for irrigators to the extent their energy or maximum demand is significant during periods of medium system demand – for example afternoons and early evenings from 1 December to 28 February. In some distribution areas, maximum demand tariffs are even applied outside the summer months.

Remaining on a flat tariff may also be problematic. This is because networks are being encouraged by regulators to impose a penalty on flat tariffs, in order to encourage retailers and consumers to switch to time of use tariffs. For many customers time of use customers will result in lower network charges and these lower charges need to be compensated from higher charges from other customers, including those remaining on flat tariffs.

The fundamental problem with network tariff reform is that it is applying congestion pricing – essentially charging for future network capacity augmentations in current network bills – in the absence of congestion almost everywhere in the NEM outside Victoria. In addition to the problem of charging windows being set incorrectly, this situation has because the threshold for applying congestion prices is being set relative to a proportion of maximum system demand instead of the point where incremental demand triggers a requirement for augmentation. In reality, there is no forecast congestion at least to 2026 in all but a few parts of the NEM outside Victoria.

In the small number of areas where congestion is a risk, this is a result of new connections (e.g. coal seam gas related connection in regional Queensland or NSW). Under the relevant regulations, the augmentation cost arising from these new connections should not be borne by existing customers via standard control network tariffs.

So far, however, the AER has not been responsive to these concerns and has approved the first round of TSS across the NEM. The problem of inefficient network tariffs can only be addressed by changing decisions by the AER on future TSS.

Next steps

We understand the Taskforce has limited resources and may have to prioritise its responses to this report. Within these constraints, we suggest the Taskforce could consider the following actions and initiatives.

1. Communicate and disseminate the key outcomes of this project, by distributing the executive summary, perhaps in a more accessible form. The outcomes should be shared with the same group that received the survey, with special thanks and acknowledgement to those who responded. Similarly, there may be opportunities for the authors to present the findings to future gatherings of the organisations represented on the Taskforce.

2. Drawing on the outcomes and the material generated for this project, consider development of guidance materials to encourage and assist irrigators to engage with energy markets, to illustrate the potential bill reductions, and to reduce perceptions that demand side participation (powering down pumps) would severely impinge on irrigator operations.

3. Consider approaching energy services companies and retailers, highlighting the potential for retailers to increase market share by offering farmers lower prices, while at the same time maintaining adequate risk adjusted profits. This discussion could also encompass

development of more efficient and innovative retail tariffs and the targeted deployment of new technology (e.g. digital meters), where beneficial.

4. Engage in consultation processes around the development of distribution network tariff structure statements, in support of moving to tariff structures that do not impose financial penalties for irrigators and which reward irrigators to the extent their demand is low or zero during periods of very high network demand.

5. Seek opportunities to inform relevant regulators, including the ACCC and the Australian Energy Regulator, of the need to improve the efficiency of retail markets, including in regional areas, and to encourage increased competition and movement toward cost-reflective retail tariffs, supported by the early deployment of digital meters, where beneficial.

1. Overview and approach

This research project for the Australian Agricultural Industries Energy Taskforce (the Taskforce) is the first step in a potential stream of work that aims to empower irrigators as a class to engage the energy market to secure lower costs for electricity pumped irrigation. As electricity prices rise, irrigators are under pressure to control costs that squeeze their margins. The existing knowledge is very limited but suggests savings are achievable - this requires:

- An assessment of irrigator engagement in competitive retail markets and review of demand characteristics of irrigators, including their heterogeneity.
- A test of the potential for targeting irrigators for early smart meter deployment to enable critical peak pricing and opportunities for retailer/irrigator co-investment in non-grid alternatives.

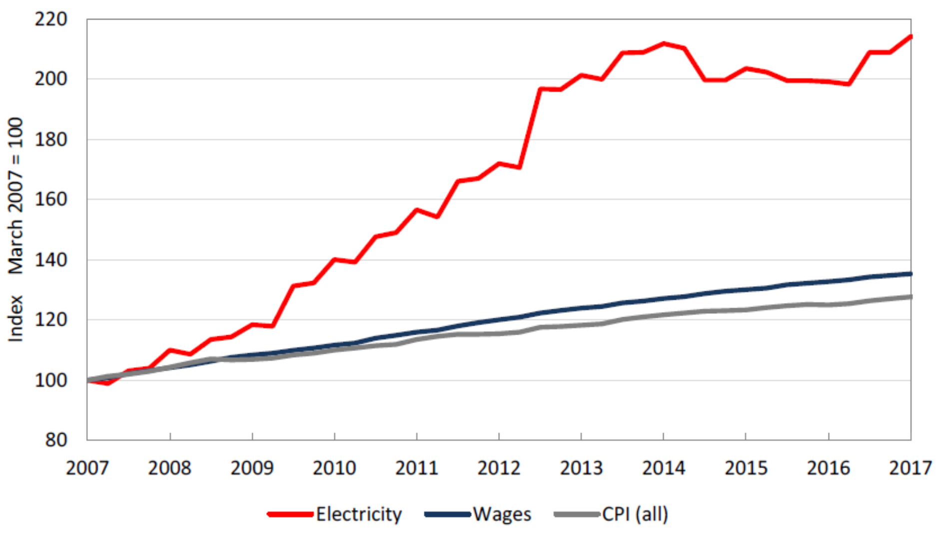
This section reviews in more detail the problem for irrigators that we are trying to address with this work and hence the research objective for this project and the research method.

Sapere Research Group has been engaged by the National Irrigators' Council (NIC), which managed the project on behalf of the Taskforce with a Taskforce steering group. The project was funded by Energy Consumers Australia with co-contributions by Sapere and the Taskforce.

1.1 Problem definition and research objective

1.1.1 What is the consumer problem?

Figure 3 CPI for electricity compared with other sectors and wage growth



Source: ACCC, Retail Electricity Price Inquiry, Preliminary Report, Sept 2017

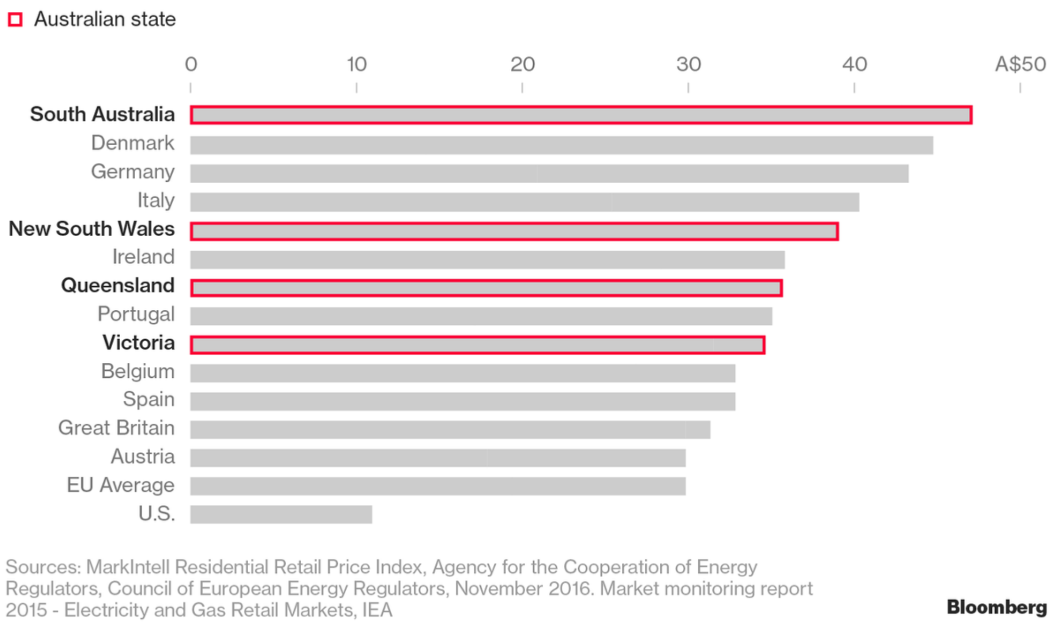
Electricity is one of the major costs for irrigators, often over 30 per cent of total costs. Rapidly increasing prices are impacting directly on the viability and competitiveness of

Australian irrigators, which impacts a range of food and fibre products including fruit and vegetables, dairy, sugar cane and cotton.

The impact is particularly severe on irrigators with pumped and pressurised systems, meaning that often producers who have invested in water efficient systems find those efficiency savings more than eaten up by increased power bills.

Rising electricity costs are forcing irrigators to make difficult decisions about continuing irrigated production, changing crops or going off grid with distributed generation. Electricity prices are impacting negatively on individual farmers and farming companies along with the Irrigation Infrastructure Operators in the sector. Forward contract prices, and recent spot price outcomes, both indicate substantial increases in future retail electricity prices are likely. This will occur either as market contracts expire, or as default contracts are re-priced. Rising prices will have substantial adverse impacts for irrigator production, profitability and competitiveness.

Figure 4 Price for electricity compared across jurisdictions



Source: Bloomberg Quint https://www.bloombergquint.com/politics/2017/10/05/how-energy-rich-australia-ended-up-with-world-s-priciest-power#gs.If_W5Xg

Current studies published by ECA (small business tariff tracker) indicate larger small business customers may achieve electricity costs savings exceeding 30 per cent by actively engaging the competitive market for energy services products.[2] The evidence available (e.g. June 2007 Review of the Effectiveness of Energy Retail Market Competition in South Australia Phase 3 Report for ESCOSA, NERA Consulting) indicates that small businesses

2 Small and Medium Enterprise (SME) Retail Tariff Tracker Project, Analysis of small business retail energy bills in Australia, Preliminary Report, October 2017, Prepared by Alviss Consulting, with Energy Consumers Australia http://energyconsumersaustralia.com.au/publication/sme-retail-tariff-tracker-preliminary-report-october-2017/

may be less likely than other customer segments to engage in competitive retail markets and switch from higher to lower priced retail contracts.

Small businesses individually tend to have limited power over retail pricing outcomes. Irrigators have attractive demand profiles and significant volumes compared with typical small businesses users. This is because irrigation consumption does not correspond to or drive wholesale spikes that are a major driver of retailer's supply costs.

Historical irrigation/agricultural tariffs have largely been removed already or are transitioning to standard small business tariffs. Unfortunately, standard business tariffs substantially over-estimate irrigators' costs of supply to the extent they rely on deemed (net system demand) profiles for each network area.

The rollout of smart metering that reveals these differences in costs of supply is now retailer led:- irrigators represent a consumer segment for whom demand aggregators, procurement brokers, energy services companies and traditional retailers may competitively develop innovative energy products that deliver cost savings to irrigators and profits to providers. The interval data available from smart metering is the most powerful tool for consumers to understand and control their costs.

Irrigators have insufficient information to engage these energy services providers, individually, collectively or in partnership with an energy services provider. This includes a lack of information on both details of historical demand profiles and flexibility of future electricity demand as the basis for comparing the relative merits of energy products. There is for example no nationwide service comparable to the Victorian State Government price compare tool, which enables consumers to upload their historical individual demand profile information in order to assess alternative retail products and pricing offerings.

1.1.2 How can irrigator organisations help?

The objective of this project is to develop the knowledge base of irrigator organisations that enables them to empower their members' engagement in the market. It is 'pre-feasibility' study to identify the homogeneous and heterogeneous features of this consumer group that underpin their control of their electricity cost of supply, and to identify engagement strategies including individual and collective bargaining options for the short and medium term.

The project seeks to identify irrigator consumption characteristics that underpin their costs of supply and capabilities for demand response. Understanding these is a pre-condition for effectively engaging the market through, for example, comparing existing retail market offers or engaging energy services companies specialising in improving the bargaining power of consumers (e.g. Bid Energy and Energetics). The project also seeks to identify irrigator customer segments and markets where collective bargaining may leverage their considerable buying power and attractive consumption attributes, from an electricity supplier perspective.

In the long term, the project will empower irrigators to negotiate lower electricity contracts, and to foster the introduction of new technology to support innovative electricity supply arrangements. This could include the introduction of smart metering to support various forms of critical peak pricing that materially reduces the cost of electricity supply, while minimising disruption to irrigator operations. This could in turn substantially reduce average irrigator electricity prices without reducing the productivity, output and competitiveness of irrigator operations.

See for example http://bidenergy.com/procurement-and-contract-management/ and http://www.energetics.com.au/our-services/energy-and-carbon-markets

1.1.3 Research objective

The objective of the project is to assemble an evidence base about the characteristics of irrigators as energy users to assess three inter-related hypotheses about electricity market failures.

1. That irrigating farmers are less engaged in retail electricity markets than otherwise, and hence could make savings from higher engagement.
2. That a number of factors mean that irrigators have a lower cost demand profile relative to the cost-driving events in the supply chain, and hence would be offered cheaper prices in workable markets compared to other consumer segments.
3. That (some) irrigators have significant ability to engage in (temporal) demand response at the times of cost-driving events, where effectively signalled by prices, and hence would be able to reduce their costs further.

Evidence (dis)proving these hypotheses can be used to focus efforts by irrigator/agricultural advocacy groups to both a) empower irrigators to reduce their electricity costs and b) advocate for irrigators to regulators to address market failures.

1.2 Perspectives on electricity sector costs

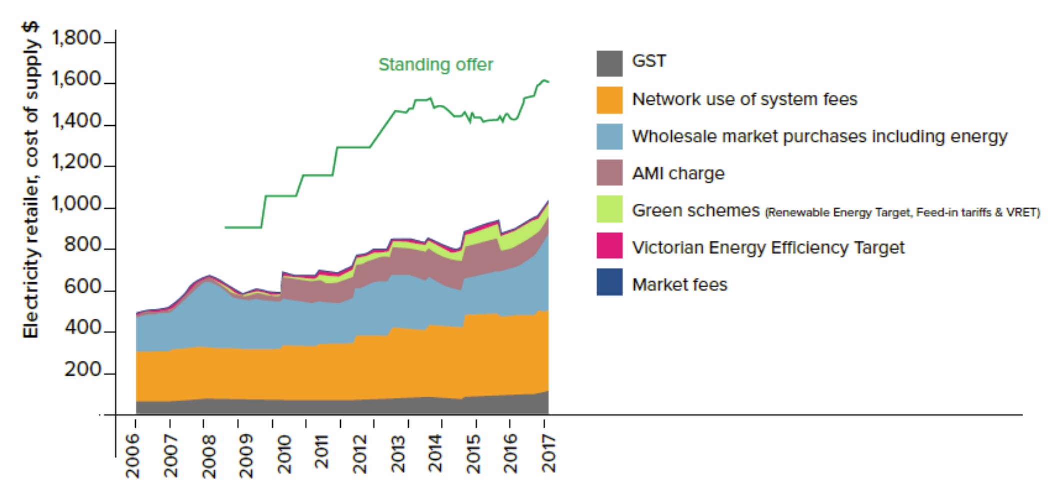
These hypotheses are based in an understanding of in energy cost stacks, cost-reflective pricing and consumer engagement from experience in Australia, New Zealand and elsewhere, including for irrigation consumers on behalf of CANEGROWERS.

Consumer engagement in markets

Workably competitive markets are a virtuous circle, with engaged consumers actively demanding products and services from markets that encourage the entry of service providers to compete to deliver those products and services. There is extensive evidence in Australia, NZ and UK of the 'lazy tax' on disengaged energy consumers – residential consumers may save over 30 per cent by shopping around, but often fail to do so.

Recently the Independent Review of the Electricity & Gas Retail Markets in Victoria (Thwaites' Review) investigated the apparent growth in the retail component of customer bills in what is regarded as one of the most competitive retail energy markets internationally, as illustrated in Figure 5.

Figure 5 Overview of costs of electricity supply – average 4MWh Victorian energy customer (excludes retailer own costs), 2006–17



Source: State of Victoria, Independent Review of the Electricity & Gas Retail Markets in Victoria (Thwaites' Review) August 2017

The review found a fundamental market failure that business rivalry for consumers did not enforce efficiency and reduce prices for consumers, but rather added costs that are unrestrainedly passed through to consumers. [3]

> *"Various constraints in the nature and design of the retail energy market make it unlikely the deregulated market will deliver the intended long term benefits to consumers."*

The key reason identified is that energy is an essential service, so that consumers cannot constrain the energy market by exiting. The market encourages retailers to continue to add costs which add little benefit to consumers but they invariably pay for.

At the same time there is extensive evidence of consumer disengagement in general, but particularly for business and regional consumers. Most recently this is exemplified by the Commonwealth Government requested Rule changes focusing on stimulating consumer engagement including *Advance notice of price changes*, *Notification of end of fixed benefit period*, and *Preventing discounts on inflated energy rates.*[4]

Consumer demand relative to cost drivers in the supply chain

System congestion is the major cost driver in the supply chain – it underpins the marginal cost supplier principle of the wholesale market, and meeting reliability requirements means building network capacity in advance larger than the peak of demand (with a safety margin). However these peaks are frequently misunderstood – perhaps 20-40 per cent of supply chain costs including both network and wholesale cost are due to a handful of hours on a handful of days each year.

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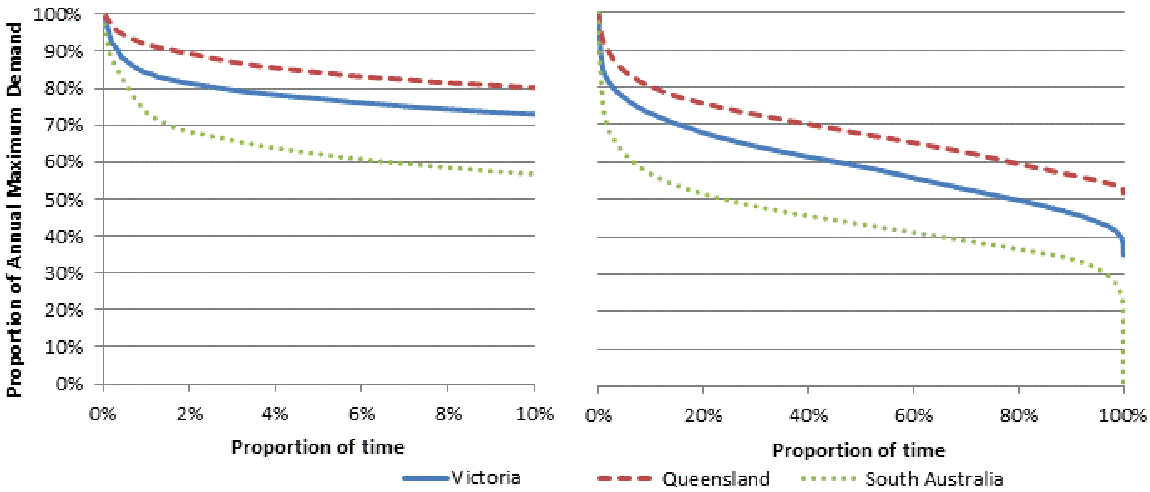
3 Independent Review of the Electricity & Gas Retail Markets in Victoria, 2017: Australian Energy Market Commission (AEMC) 2017, 2017 Retail Energy Competition Review, Final report, July 2017.

4 See AEMC website https://www.aemc.gov.au/our-work/changing-energy-rules/rule-changes

Most of the time system costs are moderate, including daily peaks on most days. But in the last 2 per cent of time when demand exceeds 90 per cent annual maximum demand costs accelerate. This is illustrated in the demand duration curves (LDCs) plotted in Figure 6 of state demand (see detailed discussion on interval data visualisation in Section 4.1).

While each jurisdiction varies in detail, the general shape of the curve is the same – demand varies in a medium range for most of the time, but sharply peaks up toward annual maximum demand for very short periods, cumulatively adding to less than 180 periods across the year.

Figure 6 Demand duration curve – state demand

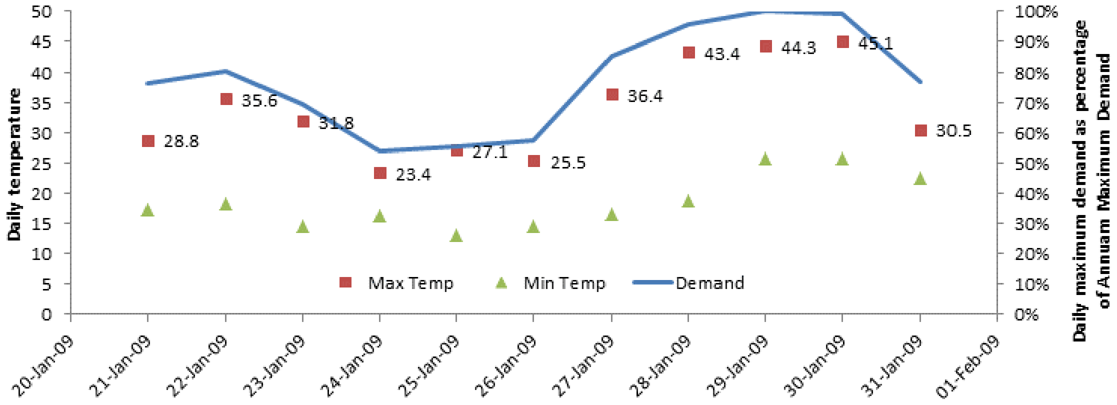


1. LH chart focuses on the first 10 per cent of the full LDC shown in RH chart.

While there are differences in the characteristics of network and generation peaks, in general they are coincident, frequently driven by urban cooling demands in the latter part of heat waves - Figure 7 below illustrates an example for the system peak in Victoria in 2009.

Demands that do not reflect the annual profiles of cooling demands can hence have substantially lower supply chain costs, and changing consumer behaviour at those times of peak demand has significant benefit to networks and generators, such that price offers for such demands/behaviour should be cheaper. Previous work strongly indicates irrigators do not substantially contribute to temporal congestion. A workably competitive market would offer irrigators prices that reflect that.

Figure 7 Victorian maximum demand in 2009



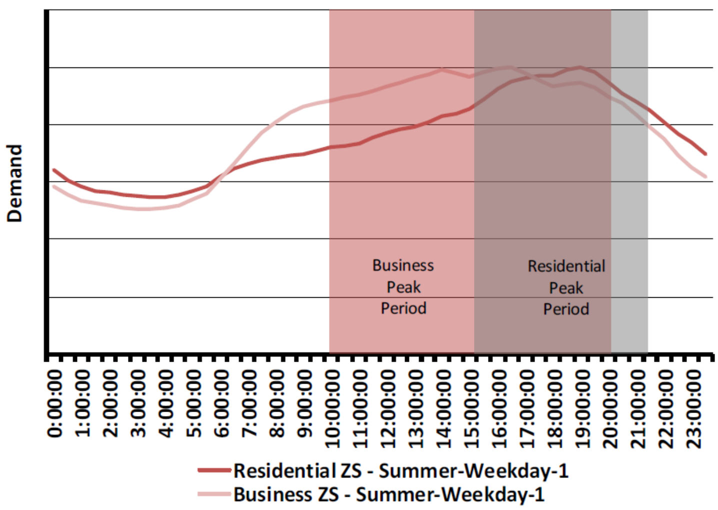
Source Simon Orme, Dr. James Swansson, Implications of extreme weather for the Australian National Electricity Market: historical analysis and 2019 extreme heat wave scenario, Report prepared for the Australian Department of Industry, August 2014.

A note on misinformation in daily profiles

Daily usage profiles do not convey useful information about periods of system peak demand as they inevitably involve averaging over the relevant periods and depict times that are not relevant.

Figure 8 shows an example of a daily usage presented to the AER in a regulatory determination. The chart is intuitively comprehensible, depicting the natural diurnal cycle of commencing daily activity following a night time of sleep, reaching a peak of activity before declining again towards sleep time, the shape reflecting the type of activity pursued during the day.

Figure 8 Example of daily profiles

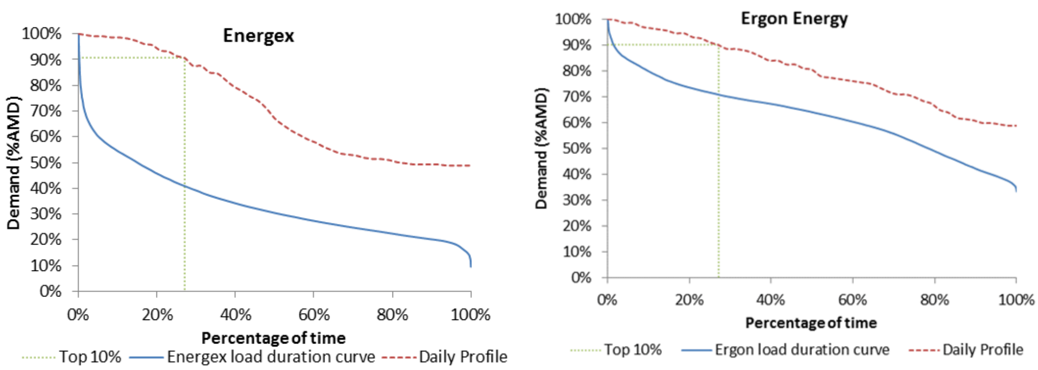


Inherently this depiction of 48 ½ hour intervals discards the 17,472 remaining intervals in the year. This may involve either simply ignoring them by focusing on one day, such as the day of peak demand, or by aggregating them, such as an annual or seasonal average for each ½ hour period.

Discarding the information in the annual profile in this way distorts understanding of system peaks, such as the hours on other days that demand exceeds a defined peak threshold. Figure 9 depicts this distortion, comparing the actual demand duration curves with the curves implied by daily profiles for the same customer segments. Extrapolated over the year, the daily profile is considerable flatter than the actual profile and significantly overstates the proportion of time that actual demand approaches its maximum and therefore the minimum of spare capacity and the likelihood of congestion.

A full period of not less than one year of interval data is most valuable to analysing and understanding a customer's consumption behaviour are times of marginal demand (approaching 100 per cent of system annual maximum demand) compared with times of infra-marginal demand (below 90 per cent, say of system annual maximum demand).

Figure 9 Measuring and mis-measuring consumption during periods of maximum utilisation of the network



Source: Sapere analysis of Energex/Ergon NSLP and TSS daily profiles

Capability for demand response and energy efficiency

Following on from the 'passive' supply chain cost characteristics of consumer demand profiles, consumers may actively modify their demand profiles in response to prices that signal peaks in supply chain costs. Demand response is extensively used in other market segments - while irrigators may need to pump during hot weather and heat waves, perhaps particularly for certain crops, a question is: what is their capacity to minimize demand at key times, typically a few hours of an afternoon on a few days each year? Similarly energy efficiency is established as a 'first fuel', and pump technology has improved – what opportunities exist for irrigators and what do these imply for their demand profiles.

1.3 Heterogeneity

While we speak about 'irrigators' as an electricity demand segment, we are aware that neither agriculture nor the use of irrigation are homogeneous. The National Electricity Market is the longest interconnected network in the world stretching over six states/territories. On the agricultural production side there are a variety of climates, crops, scales, irrigation methods, irrigation equipment and associated energy demand volumes, profiles and costs. On the electricity consumption side there are 13 network areas and associated retail markets, some of which are competitive, three large retailers and dozens of small retailers, five wholesale markets, six state regulators, two major tariff classes and a variety of tariff structures before even considering price diversity (for different products) and dispersion (for similar products).

In examining these research hypotheses, understanding the richness of the heterogeneity of irrigators as a whole is important to being about to generalise the findings into advice to farmers. It is important to understand the extent of heterogeneity among irrigators in terms of the farm's primary crops, scale, the methods of irrigation and equipment used to place the findings regarding energy use characteristics in context and understand the applicability of characteristics discovered in one context to irrigation in another.

1.4 Scope and approach

The scope of this project is that of a "prefeasibility" study, developing the Taskforce understanding of the research assumptions/hypotheses, assessing the existing information and accessing new information where necessary as the basis for a baseline understanding of current consumer engagement, their consumption characteristics, possible barriers and options for alternative engagement. In doing so the gaps in information are identified.

Desktop review

The first phase of the study involved desktop review of relevant materials available from the Taskforce including information obtained from organisations' websites and internal research supplied directly. The focus of this review was to identify existing information on irrigators' own energy consumption profiles and energy market engagement that might avoid directly engaging with irrigators for this information. This reflected a Steering Group preference to avoid survey fatigue among farmers.

However, finding little information in these materials on the three hypotheses, described in Section 2, the Steering Group agreed to proceed with primary research through a survey and seeking usage data.

Survey

The second phase involved the design, testing and implementation of a survey of irrigators. In particular the survey would provide new data from jurisdictions and agricultural sectors not previously examined, to test the cogency of the three hypotheses across this heterogeneous group. To explore these three hypotheses the survey asked question in four areas:

- Characteristics of the farm and type of irrigation, to provide context identify the heterogeneity of irrigators as an energy consumer segment.
- About irrigator engagement with the retail market.
- About irrigation's current energy use for comparison with periods of peak system demand and assessment of exposure to current peak costs of supply.
- About irrigator's potential for demand response strategies to reduce exposure to future and peak costs of supply.

The online survey was developed in SurveyMonkey in consultation with the Steering Group, including survey testing with farmers, with particular regard to ensuring technical language and answer options were inclusive for this heterogeneous group. The survey was launched in late November 2017, promoted by Taskforce organisations to their members. Data was collected until March 2018.

Responses

The overall response from farmers is summarized in Table 2 below - 148 farmers commenced the survey, all but one of whom responded to domain 2, and about two thirds responded to domains 3 and 4. This response is assessed as adequate for the stated purpose of preliminary testing the cogency of the research hypotheses outside of Queensland and/or sugar producers and scoping further research.

Section 3 provides the initial analysis of survey responses. The information collected about the farm in part support the Taskforce members interrogating this data for insights specific to their own membership demographic.

Table 2 Summary of survey completion by domain

Domain 1: the farm	Domain 2: irrigation energy use	Domain 3: Retail market engagement	Domain 4: demand response
148	147	96	94

Interval data

The third phase involved collection and analysis of ½ hour interval data for irrigation demands. This high resolution information of how individual demands behave compared with system demand provides the fundamental evidence for the assumptions underpinning the second and third hypotheses. While the survey responses provide indicative evidence for these hypotheses, obtaining interval data specifically for irrigators provides the foundation for quantitative evidence definitively answering these research questions. Section 4 provides the analysis of interval data for irrigation demands that provides key results for this project.

The survey sought interest from respondents in providing usage data from their interval meters for analysis in this research. Sapere approached those respondents that were willing to complete authority to access data as a third party.

This third party data collection process is itself very complex. While retailers and networks have an obligation to provide meter data to consumers and their authorised representatives, each DNSP is at liberty to define their own information and verification requirements for 3rd party authorisation and meter identification, their mechanism for data delivery and their format for data containing 17,520 intervals per year (the minimum required period). For example at the time of study:

- Powercor in Victoria requires photo ID to verify the identity of both the customer and authorised 3rd party - the simplest method is for the customer to access and forward the data.

- South Australia Power Network (SAPN) has a web data portal for customers and 3rd parties, requires detailed information to register a meter for access, and requires 3rd parties to hold written customer authorisation for access at the time of access.
- Ergon in Queensland requires a form completed by customer and 3rd party forwarded by email, and deliver data reports by email.

Further compounding this, some interval meters continue to be read as accumulation meters – in particular Ergon supplied accumulation meter reports for nine of ten NMIs.

Consequently, from 16 survey respondents both identifying they possess interval meters and willing to share data, seven provided authorities for 18 NMIs, for which interval data was provided for nine, including one Victorian respondent providing data for seven meters.

The data received was reshaped into a common format to be imported into a database together with AEMO interval data on state demand, net system demand and regional reference prices. Producing a contiguous set of data for these series, analysis of interval data for individual demands can

- compare the demand duration curve of electrical equipment/pumps with that derived from aggregate and 'typical' individual profiles;
- analyse the coincidence of individual demand with periods of system peak demand; and
- compare resulting volume weighted average prices for the wholesale component of the cost stack.

While a greater number of irrigator samples representing a wider range of the heterogeneous group of irrigators would further develop the understanding of irrigator characteristics compared to other consumer segments, this sample is sufficient to confirm the working hypotheses about irrigator demands.

2. Assessment of available data

Existing data held by Agricultural Industry Energy Task Force member organisations has been collected and reviewed with respect to the following topics.

- Irrigator participation in electricity markets – that is general characteristics of irrigation methods, crops, electric irrigation demands (i.e. pumps, winding motors) energy consumption and costs, seasonality factors etc.
- Irrigator energy consumption profiles – specific ½ hour interval demand profiles for greater than one year, for irrigation methods/crops.
- Irrigator electricity market engagement – particularly in competitive markets, variety of tariffs offers, how often irrigators examine the market seeking better prices.

This includes information obtained from organisations' websites and internal research directly supplied in some cases, including

- NSW Farmers Federation, particularly advice material on energy planning, use, efficiency, purchasing and generation for irrigation and in shed (including AgInnovators).
- Queensland Farmers Federation, particularly Irrigators Energy Savers Program case studies.
- Dairy Australia, particularly Smarter energy use program of energy assessments, and
- NSW Irrigation Council

Our initial assessment is that the current information is useful and there are benefits to more broadly sharing the available information between jurisdictions and agricultural sectors. However this information does not address the three main research topics.

Much of the relevant information provided so far appears to have been prepared with funding from the Australian government and focuses on energy and water efficiency and generation opportunities and advice in response to the carbon tax. While useful, it is limited in the following respects:

- The information is nearly 5 years old.
- The extent the advice led to significant energy efficiency savings or more effective energy shopping remains unclear, particularly the extent that material prepared for one organisation/jurisdiction is relevant of found to be relevant or utilised by the members of others.
- There is little data on the irrigator participation in electricity markets.
- On consumption profiles, it is possible that energy consumption profiles data were acquired in the context of preparing this advice, but it is not clear that the consumption profile data is held by the relevant representative organisations. The data probably remains with the consulting firm or government agency that undertook the research.
- There is no data on the extent irrigators were actively shopping in search of better prices.
- There is no data on the extent to which demand management might be an opportunity for reducing power prices without disruption to irrigation activities.

3. Irrigator survey

In the absence of either specific evidence relating to the research hypotheses to irrigator segments other than cane growers or actual (rather than inferred) demand profiles for irrigation demands, the objective of primary research through a survey of irrigators was to collect an initial sample of data about the research hypotheses from the broader irrigator community from jurisdictions and agricultural sectors not previously examined, including indicative, survey question-based responses and authority to obtain actual consumption data for high resolution analysis. This data provides a preliminary test the research hypotheses and the scope for further research. In particular the survey would provide a test of the cogency of the hypotheses across this heterogeneous group.

To explore these three hypotheses the survey asked question in four areas:

- Characteristics of the farm and type of irrigation, to provide context identify the heterogeneity of irrigators as an energy consumer segment.
- About irrigator engagement with the retail market.
- About irrigation's current energy use for comparison with periods of peak system demand and assessment of exposure to current peak costs of supply.
- About irrigator's potential for demand response strategies to reduce exposure to future and peak costs of supply.

3.1 The farm

In section 1.4 it was noted that while the number of survey respondents was small at 148, this is still deemed useful for the purpose of testing the cogency of the research hypotheses outside of Queensland and/or sugar producers and scoping further research. This is demonstrated by the heterogeneity of irrigators illustrated by Table 3 below, including the distributions of respondents by primary produce and jurisdiction.

While Queensland sugar cane growers are clearly activated to respond to a survey on the topic of irrigation energy costs, a significant number of responses were received from NSW/ACT and South Australia and a quota from Victoria, and from 15 other categories of primary produce. This includes six categories of primary produce in Queensland other than sugar. In particular a good number of responses were received for producers of fruit and nuts, grapes, cotton, cereal and vegetables. To the degree that aggregate responses provide data to support the research hypotheses, this support may be considered a relatively common characteristic of irrigation demands. The individual results for any jurisdiction or produce will be indicative, providing the foundation for more targeted research.

Within each jurisdiction, Figure 10 below indicates the distribution of responses by water catchment area.

Table 4 below provides indicators of the variety of variety of the scale of farming and irrigation by primary produces, together with some associated irrigation equipment and associated electricity costs.

Table 3 Heterogeneity of respondents: primary produce by jurisdiction

Primary produce	New South Wales/ACT	Queensland	South Australia	Victoria	Total
Sugar	0	53	0	0	53
Fruit and nuts	13	0	13	0	26
Grapes	12	0	12	1	25
Cotton	9	6	0	1	16
Cereal	4	0	0	1	5
Pasture - Hay	2	1	0	1	4
Vegetables	1	1	3	0	5
Pasture - Other Grazing	1	1	0	1	3
Rice	2	0	0	0	2
Pasture - Beef	1	0	0	0	1
Pasture - Dairy	1	0	0	0	1
Lucerne	1	0	0	0	1
Cut flowers	0	1	0	0	1
Nurseries	0	0	1	0	1
Onions	0	0	1	0	1
Citrus	0	0	1	0	1
No longer used due to high water costs	0	1	0	0	1
Total	**47**	**64**	**31**	**5**	**148**

Figure 10 Count of respondents by catchment area

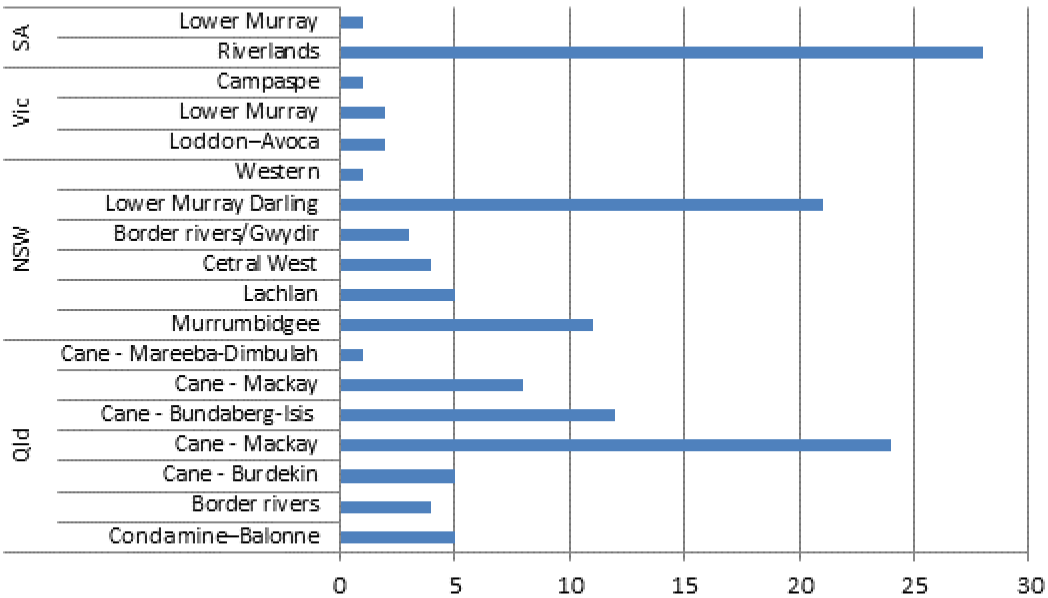


Table 4 Indicative farm characteristics by produce

Primary produce	Farms	Ave area (hectare)	Ave irrigated area (hectare)	Proportion irrigated	Pump Electric (count)	Pump non-electric (count)	Average electricity costs
Cereal	5	2202	830	49%	7	2	$44,000
Citrus	1	300	6	2%			
Cotton	16	5544	1618	34%	88	47	$180,909
Cut flowers	1	10	5	50%			
Fruit and nuts	26	377	71	73%	41	0	$31,088
Grapes	25	148	64	89%	47	1	$19,728
Lucerne	1	670	520	78%			
Nurseries	1	219	6	3%	0	2	$20,000
Pasture - Hay	4	341	265	80%	9	4	$32,775
Pasture - Other Grazing	3	12725	135	28%	1	0	$5,894
Rice	2	1250	650	88%	4		$14,000
Sugar	54	181	135	85%	112	26	$18,114
Vegetables	5	847	52	5%	5	1	$32,922
Total	**120**	**1206**	**336**	**72%**	**303**	**83**	**$43,713**

3.2 Retail market engagement

The basic metric of market engagement is whether, and if so how long since farmers engaged with the retail market seeking optimum electricity prices for their irrigation demand. The quality of that engagement includes indicative measures of farmers' search costs (measured as the ease of locating prices) and their satisfaction with the result obtained, measured on a Lickert scale from 'Very Satisfied' to 'Very Dissatisfied', with the option for 'not applicable'..

Figure 11 charts the time since respondents last approached the retail market for better prices, segmented by jurisdictions. Sixty per cent of respondents have approached the retail market at some time in the last 5 years, most frequently (35 per cent) in the most recent financial year. This may reflect some self-selection bias in the group responding to the survey – that is those farmers that are currently or have recently been concerned about their irrigation electricity costs may have been more motivated to respond to the survey invitation.

However thirty five (35) per cent have never engaged the market, and slightly more than 5 per cent have not engaged in more than five years. Two thirds of those are in Queensland: this result is probably related to the limits of retail competition in that state.

Figure 11 Approach to market by jurisdiction

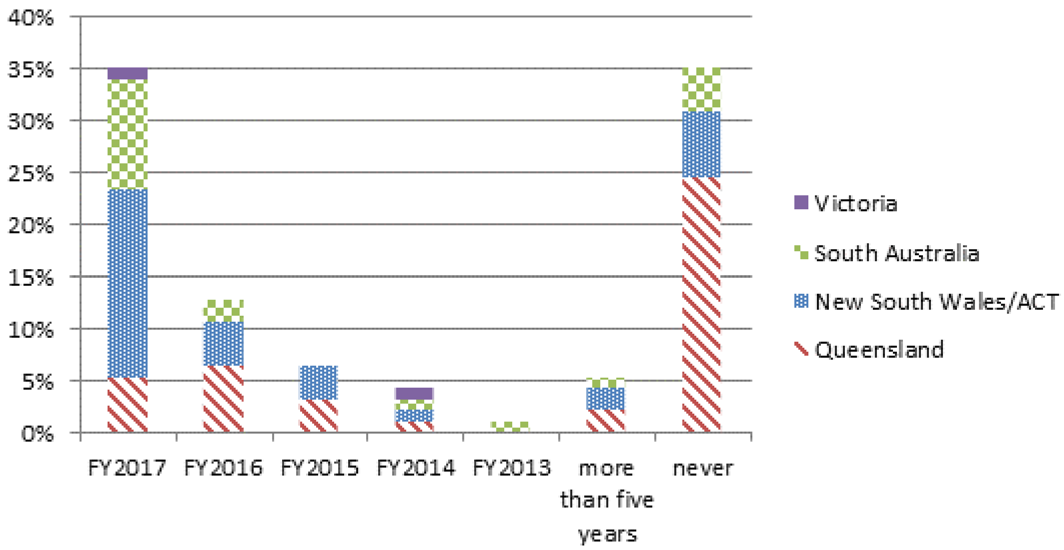


Figure 12 and Figure 13 illustrate the responses on the ease with engaging retail markets and satisfaction with the price/tariff obtained, measured on a Lickert scale from 'Very Satisfied' to 'Very Dissatisfied', with the option for 'not applicable'. Considering the limitation of market offers in Queensland, that segment of respondents is split out to compare the overall result with those respondents in other markets. For both questions there is higher proportion of Queenslanders responded for whom the question is not applicable.

Figure 12 indicates nearly half are dissatisfied or very dissatisfied with the ease with engaging retail markets – excluding Queensland this increases to a combined 54 per cent dissatisfied and just 13 per cent satisfied and 2 per cent very satisfied. The proportion neither satisfied nor dissatisfied is relatively constant 21 - 23 per cent across segments.

Figure 12 Ease of searching prices/tariffs suitable to your electricity use for irrigation

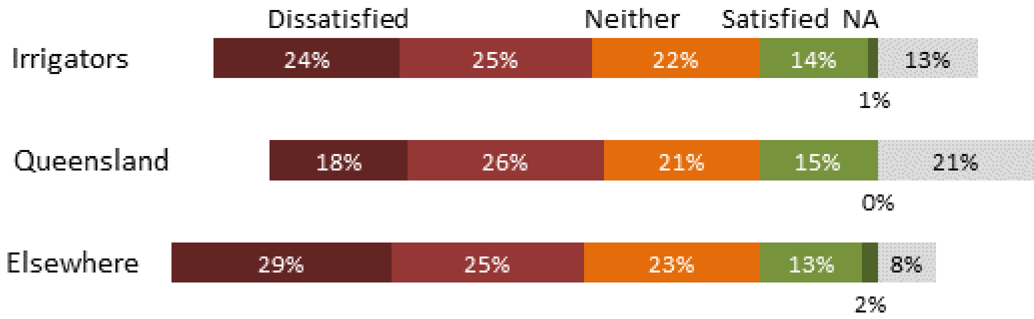
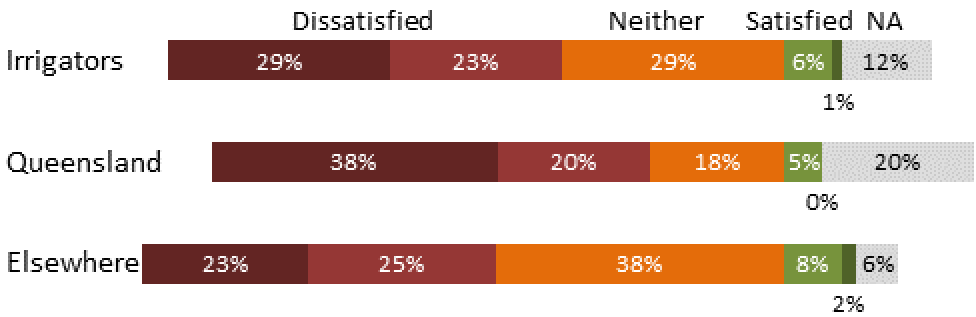


Figure 13 indicates nearly than half are dissatisfied or very dissatisfied (combined 49 per cent) with the ease with engaging retail markets, with 29 per cent neither satisfied nor dissatisfied and just 7 per cent expressing some satisfaction. Those respondents from Queensland expressing an opinion are more dissatisfied with the score increasing to a combined 58 per cent. Correspondingly, elsewhere there is a slightly higher level of satisfaction, but there is also a significantly higher proportion (38 per cent) neither satisfied nor dissatisfied.

Figure 13 Satisfaction with the price/tariff you obtained



3.3 Irrigation and irrigation energy use

Irrigation in Australian agriculture is heterogeneous as there are a wide variety of choices available to irrigators regarding the purpose, methods and equipment employed for irrigation.

- The flow of water for crop irrigation can occur in two stages, from a water source to storage and from source/storage to crops. This may require 'on-farm' pumping for one or both stages, or 'off-farm' water pressure may be sufficient to deliver water and drive irrigation equipment.
- Irrigation methods can generally be categorised in main three classes: surface irrigation (flood, furrow or level basin) where water is distributed by gravity; sprinkler irrigation where high pressure water is sprayed over surfaces; and microsystems using a pipe network above or below ground to deliver a low volume of water by drips or microsprays.

- There is a wide range of irrigation equipment available for each irrigation method.

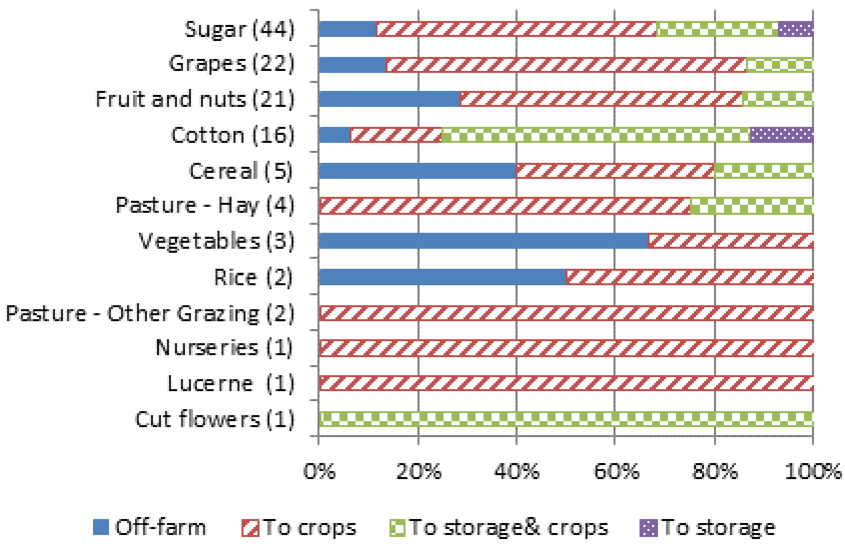
Ultimately the electricity consumption profiles of an irrigator is related to this equipment and the way in which it is employed, so these characteristics provide important context to individual profiles(in Section 4), and relating individual and segment results to irrigator groups more broadly.

Irrigation purpose, methods and equipment

Figure 14 shows the purpose of on farm pumping by irrigators' primary produce (given as a proportion as the number of respondents for each crop varies, as illustrated in Table 3 above). Figure 15 illustrates the purpose by the classes of irrigation method.

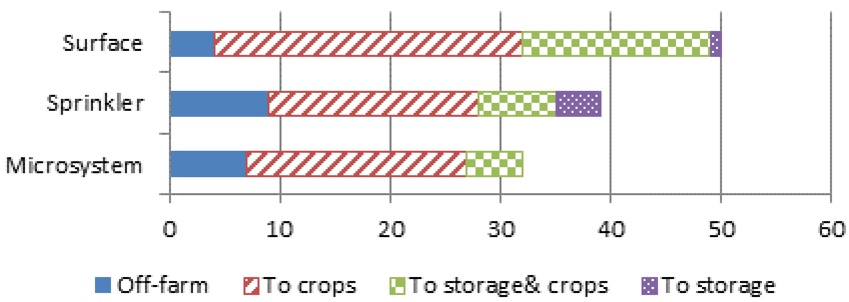
For nearly all respondents the primary purpose is delivery water to crops - just 4 per cent exclusively pump to storage, for sugar and cotton crops. A further 24 per cent pump to storage before pumping to crops.

Figure 14 Purpose of on farm pumping by primary produce (proportion)



1. 'Off-farm' indicates off farm supplied water pressure is sufficient for irrigation

Figure 15 Purpose of on farm pumping by irrigation method (number)



1. 'Off-farm' indicates off farm supplied water pressure is sufficient for irrigation

For the large majority this involves on farm pumping – just 17 per cent have off farm water delivered at sufficient pressure to meet their irrigation method requirements. This includes farmers employing sprinklers and microsystems requiring pressurised water, as well as surface irrigation.

Figure 16 provides a breakdown of irrigation methods by primary produce. Table 5 provides a high level breakdown of associated irrigation equipment.

Figure 16 Heterogeneity of irrigation method

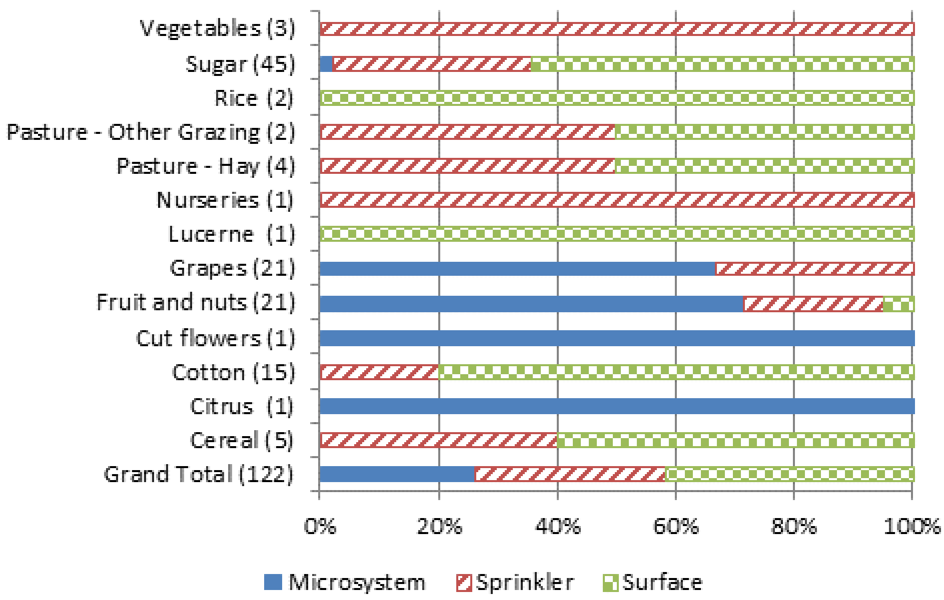


Table 5 Heterogeneity of irrigation equipment

Irrigation equipment	Use
Microsystem pipe network	36%
Pivot irrigators	15%
Winch irrigator	22%
Other	26%

Electric irrigation pumps and costs

Respondents provided data on their electric irrigation pumps and associated costs. Table 6 provides an aggregate summary by jurisdiction of respondents engaged in on farm pumping (so excluding those not pumping on farm for irrigation). This includes the total electric pump capacity and approximate annual electricity costs for irrigation - these figures are self-reported costs, and while the survey asked for costs for irrigation exclusive of other farm costs, these are not independently verified.

Table 6 Aggregate and overall average on farm irrigation pumping by jurisdiction

	New South Wales/ACT	Queensland	South Australia	Victoria	Grand Total
Average	$40,413	$22,046	$27,815	$87,167	$31,136
On farm pumping	35	48	17	3	103
Total pump capacity (kW)	5,012	8,221	1,813	2,540	17,586
Whole dollars	$1,414,457	$1,058,205	$472,850	$261,500	$3,207,012

Across this sample total electricity costs exceed $3 million or $30 thousand per farmer on average, so that a 10 per cent saving represents material reduction in farm input costs. Table 7 breaks down Table 6 by primary produce.

Table 7 Overview of on farm irrigation pumping characteristics by primary produce

On farm pumping	Count	Total capacity (kW)	Aggregate Cost	Irrigated area	Unit cost per hectare
Cereal	3	280	$82,000	1,750	$47
Cotton	15	11,837	$1,935,000	24,137	$80
Cut flowers	1			5	$0
Fruit and nuts	15	1,351	$419,768	1,275	$329
Grapes	19	1,015	$193,645	1,066	$182
Lucerne	1			520	$0
Nurseries	1		$20,000	6	$3,333
Pasture - Hay	4	484	$131,100	1,060	$124
Pasture - Other Grazing	2	22	$5,894	270	$22
Rice	1	40	$14,000	1,100	$13
Sugar	40	2,357	$377,605	5,614	$68
Vegetables	1	200	$28,000	85	$329
Grand Total	**103**	**17,586**	**$3,207,012**	**36,888**	**$87**

Seasonal and diurnal variation of irrigation pump demand

Understanding the seasonal and diurnal variation of irrigation pump demand is one of the most significant analytical results of this research, because the costs of electricity supply vary over time. Peak system costs correspond with peak demand for energy: for the past two decades access to inexpensive air-conditioning has driven an increase in cooling demands on the electricity system peak demand in most jurisdictions. So peak demand is typically associated with hot afternoons in summer.

Hence understanding the difference between irrigation demands and cooling demands underpins the difference in the costs to supply irrigators. These are revealed in high resolution in interval consumption data, examined for the available cases in section 4 below. But the self-reported temporal variability of demand revealed through the survey can demonstrate the relative homogeneity of this characteristic of irrigation despite the heterogeneity between these farmers for other characteristics.

Figure 17 and Figure 18 illustrate the reported temporal variability on annual and daily timeframes. Each of these charts plots the proportion of respondents that indicated that they irrigate in a given month or hour, so that these charts demonstrate the aggregate likelihood that irrigation demand may occur at that time.

Figure 17 shows the seasonal timing starting in July, clearly demonstrating the increase in the demand for water with warmer seasons, peaking in late spring/summer. Figure 17 segments the respondents by jurisdiction as a proxy for climate, which suggests a slightly earlier peak in late spring in Queensland compared with other states. This peak ahead of the summer heat wave season suggests some capacity for demand response on demand peak days

Figure 17 Irrigation's seasonal timing

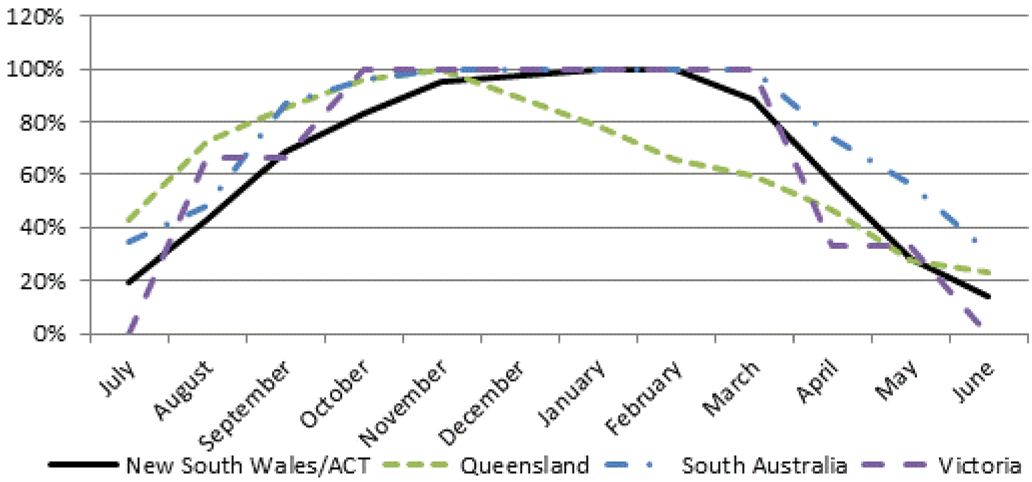


Figure 18 shows the diurnal timing, starting at midnight, plotting the proportion of respondents segmented by jurisdiction (total of all responses represented by the black line) that indicated they irrigate in a given time period, including in the last column continuous/24 hour irrigation. Nearly a half of all respondents irrigate continuously, including 71 per cent of respondents from NSW/ACT.[5]

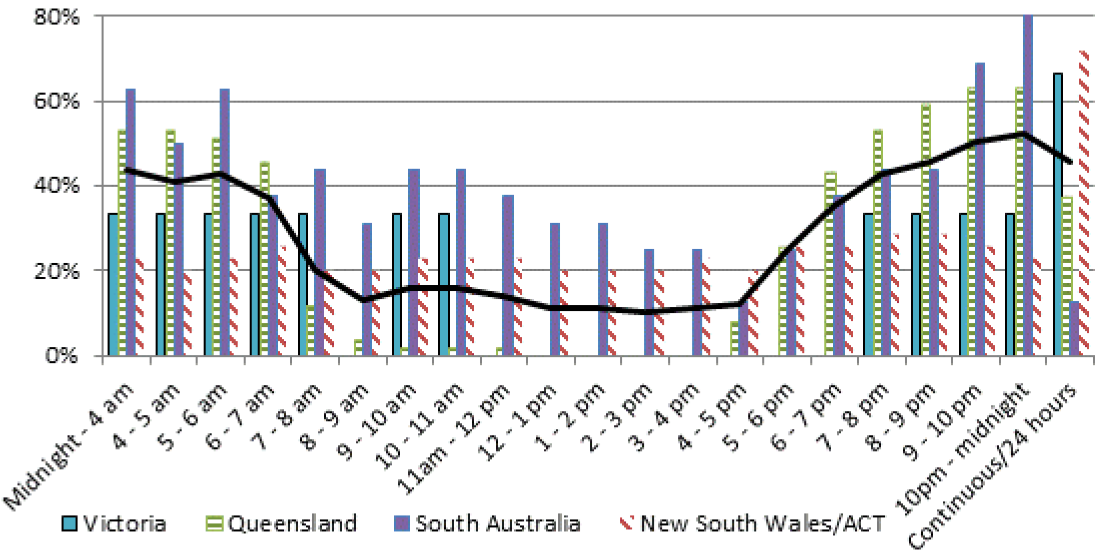
The rest of Figure 18 shows the behaviour of the remainder of the respondents that irrigate at some point during the day. The aggregate plot clearly illustrates the prevalence of day time irrigation between 8am and 5pm is low (10 – 15 per cent of respondents), with 4 to 5 times as many respondents irrigating during overnight hours. The column charts indicate some variation between states – NSW is comparatively flat while South Australia varies between 10 and 80 per cent depending on the time of day.

These results concord with expectations of efficient water use for crop production, focused overnight to avoid evaporation losses during the day. Significantly for the timing of

5 The high proportion for Victoria reflects the low total number of responses from Victoria.

electricity use, Figure 18 indicates lower demand for pumping demands during the old 2 – 5 pm peak window, and slightly higher (but potentially deferrable) demand during the new 5 – 8 pm peak window.[6]

Figure 18 Irrigation's diurnal timing



3.4 Demand response

Demand response refers to the ability of electricity consumers to change demand for electricity in response to signals from suppliers at particular times of high demand. This signalling may be 'passive' based on a price signal to which a consumer may or may not respond, or it may involve ceding the network operator some control over the consumer's demand in return for a lower price overall.

Just seven respondents reported that they already engage in demand response, mostly some form of time of use or off peak demand control tariff. One South Australian respondent included their involuntary move to a transitional demand tariff.

Respondents were invited to indicate on a scale from 0 to 100 their willingness to consider demand response incentives, and the flexibility/adaptability of their irrigation system to participate in such schemes. Figure 19 suggests that while there is a strong willingness to consider demand response strategies to controlling irrigation costs, there is a countervailing perception of a farm's flexibility/capability to do so.

6 The timing of daily peak demand on the system is being deferred to latter in the data by solar PV generation by predominantly north facing solar panels.

Figure 19 Flexibility and willingness to consider demand response

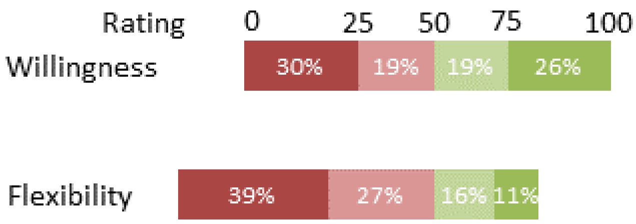
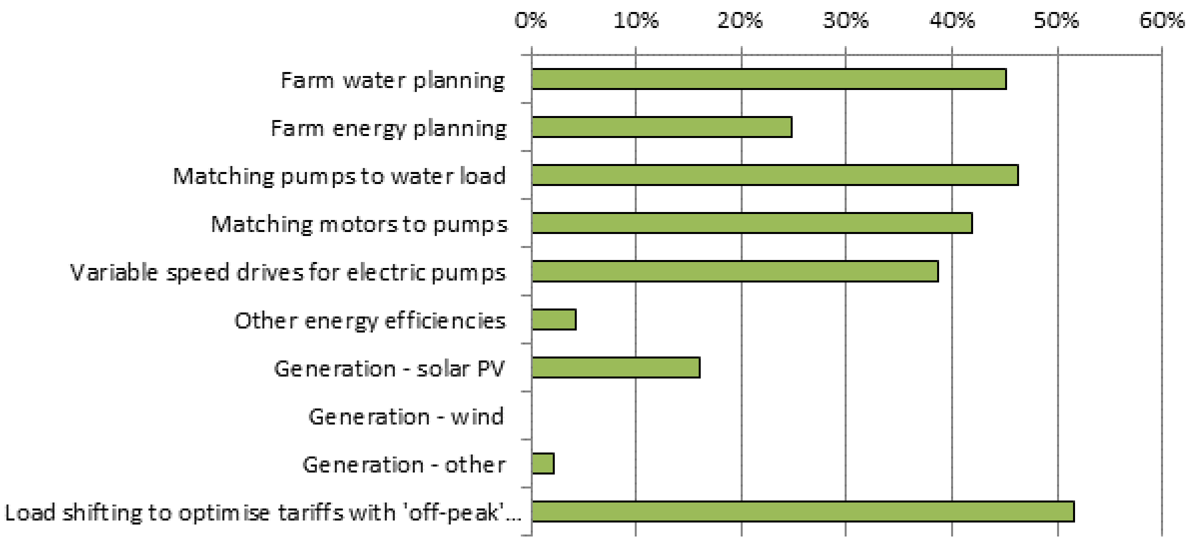


Figure 20 illustrates irrigators past approaches for controlling irrigation costs. Half have engaged in farm water planning, and one quarter in farm energy planning. A significant number have pursued energy efficiency strategies for electrically pumped water. Around 15-20 per cent have installed on farm generation.

Significantly over half have reported demand shifting in response to price signalling. This contradicts the trend indicated above – that irrigators are willing but inflexible toward moderating demand in response to price signals. As noted above the timing of irrigation suggests an opening for demand response strategies. There may be a communication/understanding issue to explore here, regarding the technical implementation of any demand response initiative (which was broadly defined in the survey).

Figure 20 Exploration of alternatives



4. Irrigators interval data

Interval metering records the volume of electricity consumed for each ½ hour interval of the day, or 17520 data points per annum. This granularity of data about a customer's consumption behaviour is the greatest tool for understanding the costs to supply the individual demand compared to the broader system, and hence the benefits and opportunities of certain patterns of consumption.

While the sample of pump demands obtained through this project is still relatively small, this sample powerfully demonstrates both the key attributes of irrigation demand profiles and the commonality of these attributes across this heterogeneous group.

4.1 Data visualisation

Visualising 17520 data points per annum is always difficult, so we employ some industry standard tools (demand duration curves, Figure 21) to graphically understand and compare consumer demands before delving into more detailed analysis (Figure 24) and considering such demands under some "cost reflective" tariffs proposed by the current network pricing reform (Section 4.2.2).

The demand duration curve (LDC) for any demand illustrates the amount of time that a demand is at a given level of demand within a fixed period in a plot of demand in a descending order of magnitude. Here both demand and time are given proportionately as the percentage of annual maximum demand and the percentage of time in the year. The total energy consumed by the system, the product of demand and time, thus is represented by the area under the curve. The ranked LDC for a year is more convenient to read with than the demand curve that includes daily and seasonal fluctuations.

The demand duration curve provides a visualisation of asset utilisation and hence, for example, technical assessment of service requirements or economic assessment of the value of utilisation. It is commonly employed in economic dispatching, system planning and reliability evaluation. In an economical ideal, any asset would be 100 per cent utilised all of the time except when withdrawn from service for maintenance. For this ideal demand the cost of the asset is spread out over the time that it is used, so the unit rate is lower. But you rarely see that!

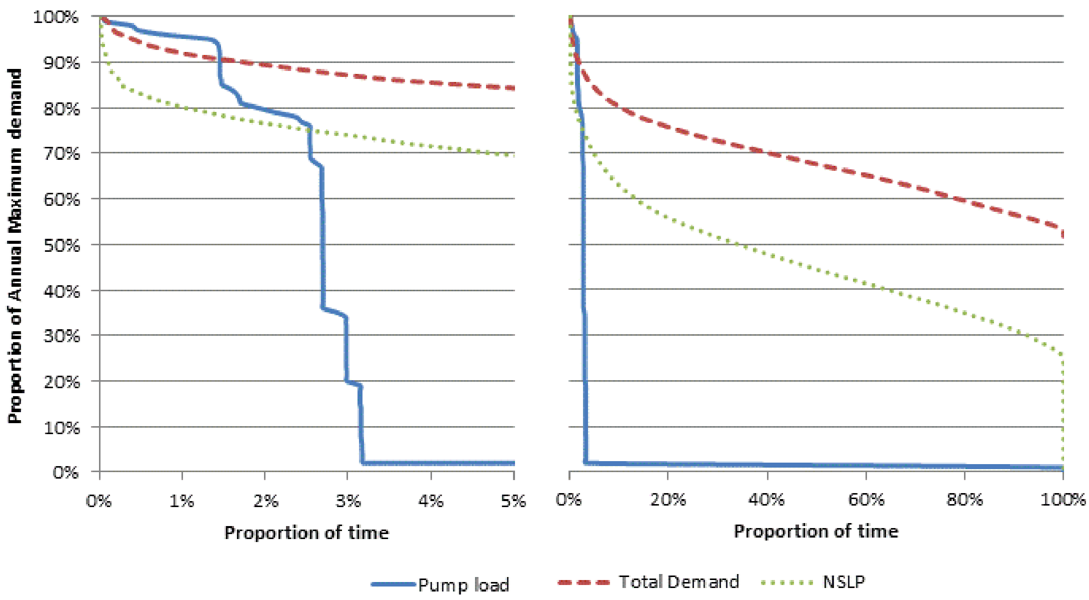
Figure 21 shows the demand duration curves (LDCs) for an irrigation site compared with two measures of aggregate demands, state total demand and the net system demand profile (NSLP) for the corresponding state and distribution network.

State 'Total Demand' provides a typical LDC for an aggregate system like the power system. A minimum capacity is in use constantly (although the exact bits at any time will always be changing) in this case ~55 per cent at right hand side of chart. This demand and the capacity are always there, so effectively it is cheapest element of the system. For shorter periods more capacity is required to meet higher demand, and ranked by proportion of AMD this curve is smoothly increasing moving to the LHS by definition.

The net system demand profile (NSLP) for each network area is produced by AEMO as the basis for wholesale market settlement of small residential and business customers with accumulation metering (small as opposed to a car factory or aluminium smelter) – it can be thought of as the aggregate demand of these customers, or de facto the 'typical' demand for this class. In particular it is the demand shape assumed for general small business tariffs onto which irrigators are being shifted. Total demand by state is indicative of the entire system demand including both this mass market of small customers together with very large commercial/industrial consumers.

Where it gets interesting is as demand approaches annual maximum demand – the left hand chart in Figure 21 focuses in on this part of the curve. Unlike the ideal, the top 20 per cent of total demand occurs for less than about 10 per cent of the time or 870 hours in the year. You must have the capacity to meet that demand, but it is used for a short period, so it is expensive (and scales non-linearly). For example in generation the analogy (it doesn't actually work like this) is you have a generator sitting around idling, waiting for the few hours of the year it is required to do work. Although slightly different, the economics is similar for network assets.

Figure 21 Demand duration curve – Queensland/canegrower



2. LH chart focuses on the first 5 per cent of the full LDC shown in RH chart.

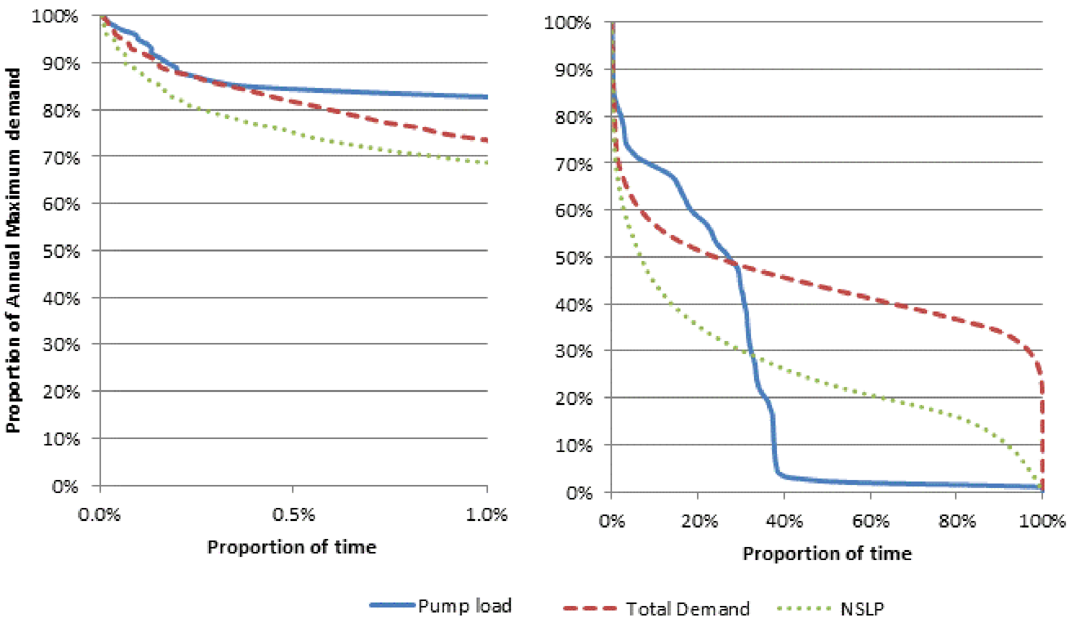
For individual customers, Figure 21 illustrates that the NSLP, representing the typical profile of small customers. Significantly, this profile is peakier than total demand – the top 20 per cent of this mass market of small customers has a duration of just about 240 hours, or about 2.75 per cent of the year. So the associated costs for small customers are going to be more extreme (and priced into those tariffs). These costs have to be met. Arguably the point about cost-reflective tariffs (retail or network) is that the costs of this infrastructure are borne by those that contribute to demand for it.

Clearly the large consumers making up the rest of total demand collectively have a flatter profile, flattening the total profile in turn. This is the part of the basis for lower unit prices to this segment of consumer demand.

Similarly, as a single profile the NSLP represents an average of the spectrum of flatter and peakier profiles for the population of customers. The third profile in Figure 21 is one individual customer – in this case the pump demand from an irrigating farmer. The first observation of this pump demand is that it conforms with the anticipated shape of an irrigation demand – generally the demand is negligible for most of the year (nearly 97 per cent in this case) and close to 100 per cent of maximum demand when operating. The second observation is that it is a significantly flatter profile approaching the peak than the aggregate profile represented by either NSLP or total demand.

Figure 22 and Figure 23 show the LDCs for other irrigating farmers: Figure 22 for a fruit-nut grower from South Australia; and Figure 23 for seven individual profiles for a variety of primary produce from Victoria.

Figure 22 Demand duration curve – South Australia/fruit-nut grower

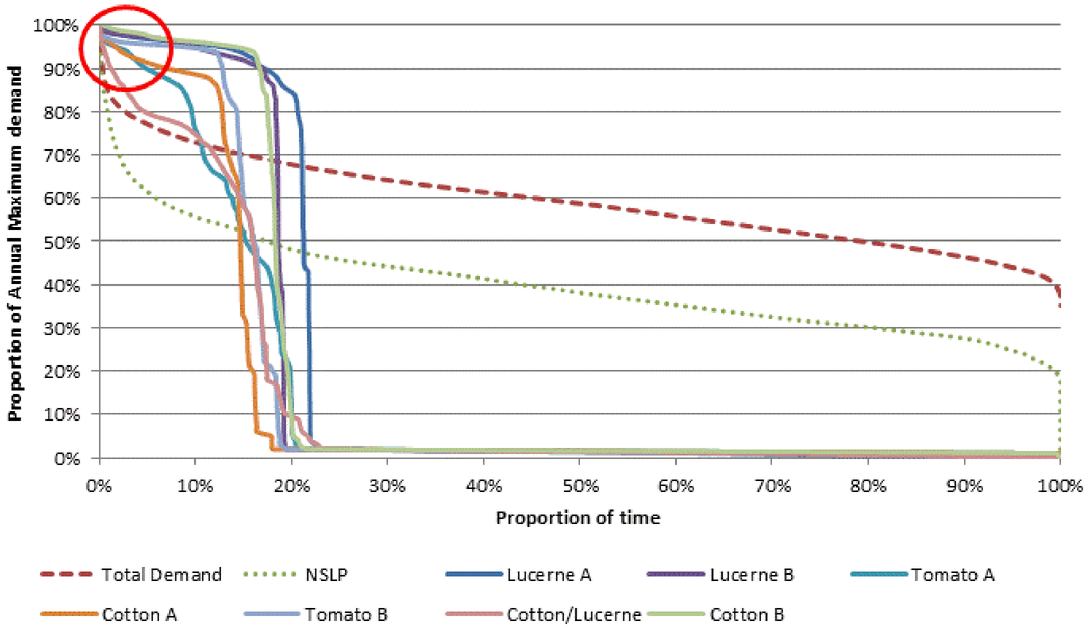


These LDCs all share the general characteristics visible in Figure 21. Most of these pumping demands are somewhat more like our ideal demand – close to 100 per cent on except when it is off, varying mostly in the total duration of utilisation. Even where some pumping demands are more graduated, they have a flatter LDC when approaching 100 per cent of annual maximum demand, flatter than NSLP and total demand.

Consequently a price based on the NSLP significantly exaggerates the underlying cost of these irrigator demands.

As a very general indication (remembering that the LH corner is far from linear), the incremental unit cost of the individual demands may be approximately the cost of the system demand about the point the irrigator demand rolls off toward zero – for example in Figure 21 at about 3 per cent of time corresponding to about 75-80 per cent of NSLP AMD, or in Figure 23 at about 20 per cent of time, so about 45-55 per cent of NSLP AMD.

Figure 23 Demand duration curve – Victoria/various



This figure compares annual demand profiles for various IDPs with NSLP and the total demand profile. For around 80 per cent of the year, irrigator demand is flat and close to zero. During the remaining 20 per cent of the year, irrigator demand is sustained at a high percentage of maximum demand. This means that IDPs can be disadvantaged by poorly designed tariff structures that target a wide charging window (a wide area on the horizontal axis) and with high demand charges.

As each LDC is ranked based on its own characteristics, a chart like Figure 23 is an aggregate visualisation of the year and does not tell us the timing when the irrigator demands peak relative to peaks in the system demand that drive aggregate costs. The next step examines the statistics of the peak demand more closely. Then these cost difference can be measured directly for wholesale electricity using regional prices. This is examined in Section 4.2 below

4.2 Coincidence of irrigator demand with network demand

As a product that cannot be stored and supply must match demand at every point in time, the costs of electricity supply to an individual consumer are related to that consumer's level of demand and the level of demand across the energy system at the same time.

- Directly, the wholesale market facilitates transactions such that the cost of generation is set by the marginal generator.
- Indirectly, the capacity of the whole network must be built to deliver system maximum demand with a safety margin.

Thus interval data for irrigation demands permits examination of the coincidence of individual user demand with system maximum demand periods to understand the exposure to system costs. These are illustrated in Figure 24 below for each of the irrigator profiles shown above.

Figure 24 considers the coincidence statistics of the ½ hour intervals between the individual demands and NSLP demands, considering the ½ hour intervals when each irrigation site is above 90 per cent of its own annual maximum demand, noting that this is a common 'on' threshold, varying between 3 and 20 per cent of the time.

The horizontal axis provides the count of intervals that meet this criterion, expressed as the percentage of all intervals meeting this criterion for that demand because the total count varies between the different demands.

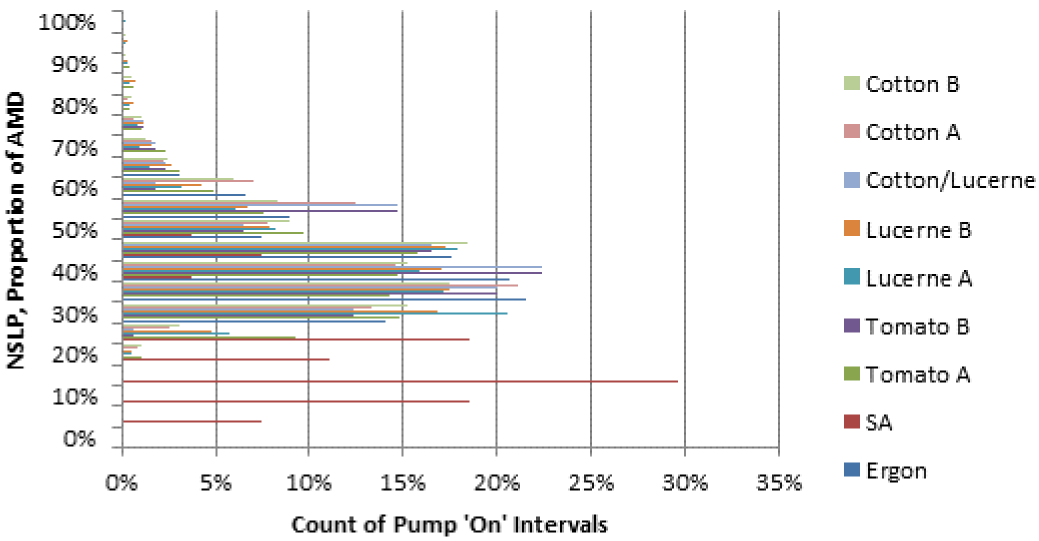
The vertical axis groups these counts by the coincident level of aggregate NSLP demand, expressed as a percentage of annual maximum demand – that is the vertical axis is the same as in the demand duration curves above.

The result for each pump demand is a distribution, approximately a skew normal distribution in shape, with some variation about a middle value. For eight of nine demands, that middle value is about 40-45 per cent, meaning that most frequently when these pump demands are 'on' system demand is only 40-45 per cent of annual maximum system demand. Across all seven demands, approximately 90 per cent of combined 'on' irrigation intervals are coincident with the range of 30-65 per cent of NSLP annual maximum demand. From the remaining 10 per cent, the high tail of the distribution is negligible:

- Just 3.8 per cent of intervals of the combined data are coincident with the top 30 per cent of NSLP demand.
- Just 0.3 per cent (equivalent of fourteen (14) ½ hour intervals or on average two (2) per pump demand) is coincident with the top 10 per cent of NSLP demand.

One of the irrigator demand samples here (SA) is lower than even this pattern.

Figure 24 Coincident of irrigation and network peaks



4.2.1 Volume weighted average wholesale energy prices

An estimate of the wholesale energy component of the cost of supply stack may be directly calculated using the demand profile and the corresponding wholesale market regional reference price (RRP) available from AEMO. The volume weighted average wholesale (VWA) price, which can be calculated using the interval data for a contiguous period, represents the wholesale cost of the demand purchased direct on the spot market. A prudent retailer may further reduce this cost by procuring physical and financial hedges.

Table 8 below calculates the VWA costs of individual irrigation demands compared with the VWA costs of the system demands represented by the total demand and NSLP. As the RRP constantly varies over different time frames for a variety of reasons, it is important to use a period not less than one year to average seasonal and diurnal variations. Each has been calculated for the period of last year of irrigation demand data available.

Table 8 clearly demonstrates the reduced cost of the irrigation demand profile compared to the aggregate profiles, varying between 59 and 83 per cent of the NSLP based cost. Alternatively, a retailer provisioning for these irrigators on the basis of NSLP demand will make a saving of 17 to 41 per cent.

The network component of the cost stack is harder to quantify as there is not a real time market that signals marginal costs of marginal demand with peak prices and recovers residual costs from infra-marginal demand. The character of wholesale market and network peaks varies in detail, where there may be one wholesale price peak interval in an afternoon where system demand smoothly rises and falls, but the fundamental balance of supply and demand means that there is a strong overlap between the two. Indicatively, then, the price premium in wholesale costs is a guide to that in network costs.

Table 8 Comparison of volume weighted average spot market costs

Individual irrigation demand prices are compared with contiguous aggregate prices ($/MWh)

DNSP	Primary produce	Irrigation demand	Total Demand		NSLP	
Ergon	Sugarcane	$48.06	$98.97	64%	$107.83	59%
SAPN	Fruit and nuts	$82.51	$114.62	76%	$134.95	64%
Powercor	Lucerne	$68.84	$83.87	82%	$82.60	83%
Powercor	Lucerne	$63.07	$83.87	75%	$82.60	76%
Powercor	Tomato	$58.32	$83.87	70%	$82.60	71%
Powercor	Cotton	$49.57	$83.87	59%	$82.60	60%
Powercor	Tomato	$56.11	$83.87	67%	$82.60	68%
Powercor	Cotton-Lucerne	$60.85	$83.87	73%	$82.60	74%
Powercor	Cotton	$50.49	$83.87	60%	$82.60	61%

4.2.2 Consumer demands and cost reflective network tariffs

The NEM is in the process of network pricing reform, intended to evolve network businesses and consumers away from predominantly 'flat' volumetric tariff structures to structures that reflect the spatial and temporal variation in network costs to consumers. The design principle of network pricing reform is that an element of the tariff sends the consumer a signal about the long run marginal cost (LRMC) of augmenting network infrastructure to meet additional demand. In the words of the National Electricity Rules, the LRMC tariff must have regard to:

> *the additional costs likely to be associated with meeting demand from retail customers that are assigned to that tariff at times of greatest utilisation of the relevant part of the distribution network; (Clause 6.18.5(f)(2))*

In the first round of tariff structure reforms most distribution providers have advocated for and had approved "monthly maximum demand" tariffs as a step along the cost reflective spectrum. Monthly maximum demand tariffs include this LRMC element as a price per unit demand (kW) for a *customer's own maximum demand* in each month. This may be modified seasonally – Ergon's STOUD tariff features a peak rate in December – February, illustrated in Table 9.

Table 9 Ergon SAC STOUD peak prices

Element	Unit	Off-peak	Peak	Premium	Premium %
Demand	$/kW/mth	10	97.088	87.088	871%
Usage	$/kWh	0.02375	0.02375	0	0%

Source Ergon 2018-19 Pricing proposal, Attachment-1-2018-19-Network-Tariff-Tables

These tariff structures have been approved and implemented even though they appear to be in breach of the National Electricity Law (see appendix).

Figure 25 below modifies Figure 21 to label the demand duration curves at the maximum demand in each month. For small customer connections, coincident demand on the relevant part of the distribution network is represented by the NSLP. Figure 25 illustrates that demand approaching the greatest utilisation of the network occur in summer months. A customer's own demand in other months, while perhaps varying significantly from this population average, can have little bearing on network utilisation.

Figure 25 Monthly demand network tariffs

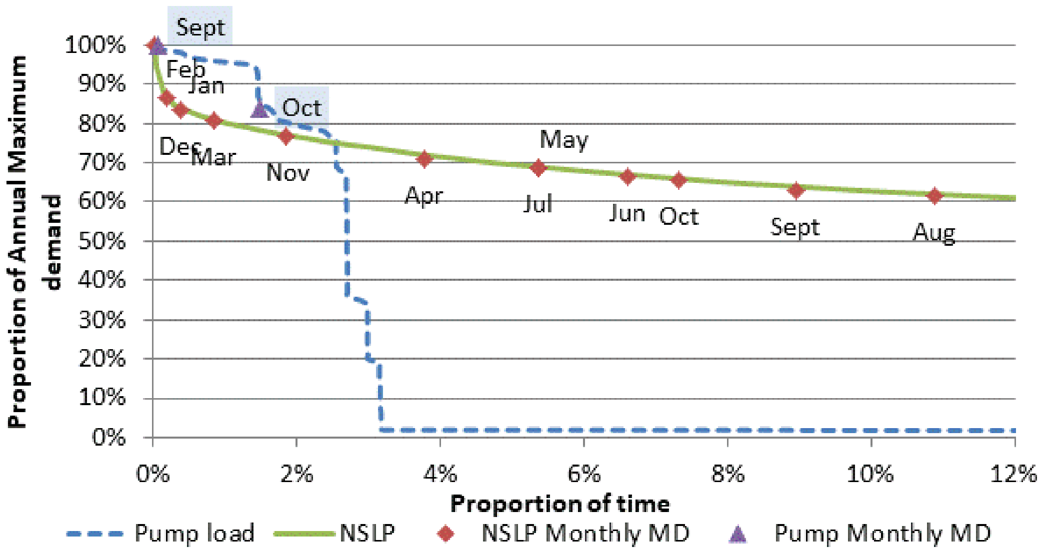


Figure 25 also labels the maximum demand in each month of the irrigator demand. In this instance the pump demand occurs only in September and October, months in which the NSLP does not exceed 70 per cent AMD. During peak months for network utilisation this pump demand is virtually zero.

Instinctively the seasonality of this irrigation demand profile outside the months targeted by Ergon's STOUD peak charges suggest this tariff structure should be beneficial to the pump demand compared with the typical NSLP demand.

Estimating these bills holding the total energy fixed, only applying the different profile with varying maximum demand in different months, the energy tariff component is the same for both profiles and the bill difference will be due to the demand tariff component. Yet the estimated total annual bill is nearly identical for these two profiles, as shown in Table 10.

While the summer demand makes up just 5 per cent of the pump bill compared to 63 per cent of the NSLP bill, the total demand charges are nearly identical.

Table 10 Impact of profile on tariff outcomes

	Pump demand	NSLP
Total annual bill	$12,004	$12,034
Peak component proportion	78% (5% summer)	78% (63% summer)

Critical peak pricing tariffs

The challenge of temporal cost reflective tariff design is how to set *ex ante* tariffs that signal prices for network peak demand events for which the timing is only known with certainty *ex post*? This requires a robust probabilistic approach to predicting a consumer's likely contribution to future peak network demand based on their historical behaviour that can be robustly statistically validated. The broad tariff structure choices are

- An *ex post* charge, that looks back at what a customer's demand happened to be at what is revealed in time to have been the time of greatest utilisation of the network, or
- An *ex ante* charge that, based on the statistics of a customer's demand at those times that greatest utilisation of the network is most likely, providing a measure of that customer's probable contribution to network utilisation at future times that peak demand actually occurs.

Monthly maximum demand tariffs are one variation of the second. These options are passive in the sense that there is no active intervention by the energy provider (retailer or network) to communicate with consumers, providing consumers the option to modify their demand at times of peak network demand.

Critical peak pricing (CPP) tariffs are one variation of the first choice. In its simplest form, CPP provides one basic energy rate for a consumer's infra-marginal demand and a second peak rate for charged at times of system peaks. A key feature of CPP tariffs is that the supplier communicates with the consumer in advance of an expected peak event – typically one day ahead. Based on the system profiles illustrated, nominated peak events may occur for around 4 -8 afternoons in summer.

Under such a tariff, the coincidence statistics in Figure 24 suggest that it is highly improbably that an irrigator will have demand at these times, or that if they do it is probable that an irrigator can respond to the notification of an expected peak event by reducing their demand during that time.

5. Conclusions

This section provides a short overview of findings relative to the three key lines of research inquiry. In addition, we also comment on a significant barrier to the achievement of cost reflective, efficient retail prices for irrigators – network tariffs.

5.1 Finding the best offer

Based responses to our survey, irrigators' engagement with retail electricity markets ('shopping for power') is far lower than it could be, and there is significant dissatisfaction with the processes and outcomes. As a result, electricity bills across the group are likely to be materially higher than they could be.

Figure 1 summarises the findings on the level of market engagement. Overall, just over a third of irrigators sought alternative offers in the previous year. This is the same proportion that never sought alternative offers. Irrigators in Queensland are far less likely to have sought new electricity prices recently than elsewhere, as retail markets in most regional areas have not been opened to competition.

Figure 26 Timing of irrigators' last approach to market

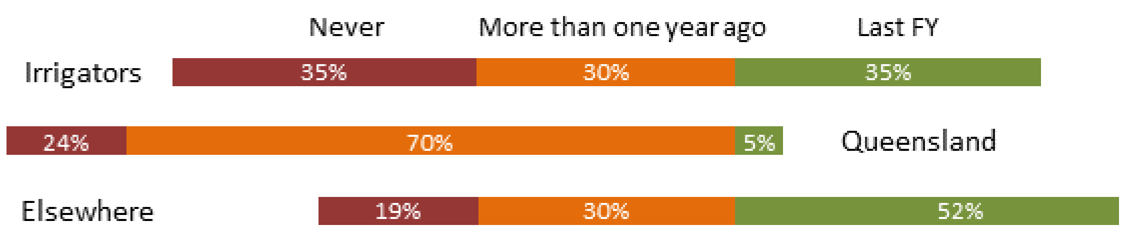
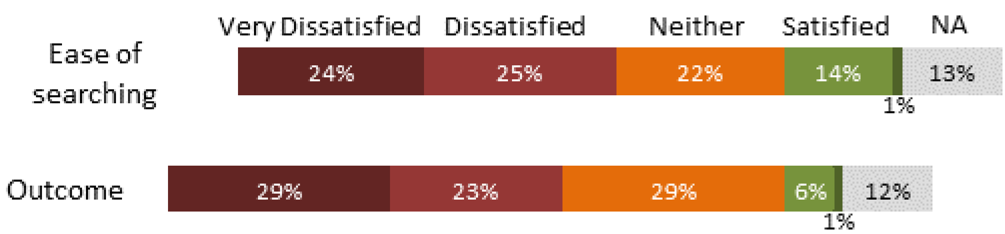


Figure 2 summarises the respondents' satisfaction with a) searching for tariffs suitable to electricity use for irrigation and b) with the price/tariff obtained. Only 15 per cent of respondents gave a satisfied rating for the ease of searching for electricity tariffs. Overall, 49 per cent were dissatisfied or very dissatisfied, varying between 44-54 per cent by jurisdiction.

Figure 27 Satisfaction with ease of searching suitable tariffs and price outcome obtained



Only seven (7) per cent of respondents were satisfied or very satisfied with the price/tariff that they obtained as a result of their engagement with retailers. Overall, 52 per cent responded with a dissatisfied or very dissatisfied rating, varying between 47-58 per cent by jurisdiction.

These results indicate that there is scope for Taskforce member organisations to encourage greater engagement with retailers. Engaging with energy services providers to identify and promote better value energy services for irrigators that have lower cost demand profiles could be worthwhile.

5.2 Cost reflective prices lower than current prices

Both the responses provided by the survey, and our analysis of interval meter data, strongly suggest that irrigation demands have lower costs to supply compared to 'typical' small customer demands. This reflects the following.

- There is no evidence to suggest that irrigation demand is high let alone increases during extreme heatwaves, when maximum annual demand and very high power supply costs are most likely.
- It appears unlikely pumps are running at full capacity at times of peak system demand. Across states and different types of primary produce, use of pumps predominantly coincides with times when system demand is at just 30-55 per cent of system annual maximum demand.
- Seasonal irrigation demand peaks in late spring (Queensland) or early summer (elsewhere) reflect rainfall variations between regions. Demand peaks are not driven by very high temperatures.
- While about 45 per cent of irrigation equipment operates continuously over a day, other equipment is operated predominantly overnight and at a minimum during afternoons (at the mostly likely time of system peaks).
- Pump demand profiles are demonstrated by interval data generally to be 'flat': that is when pumps are being used, demand is at/above 90 per cent the pump's maximum demand.

The non-coincidence of maximum irrigation demand with maximum system demand has a direct effect on the delivered cost of electricity, both wholesale and network (transmission and distribution), for irrigators. For example, Table 1 above provides the volume weighted average (VWA) wholesale electricity costs of individual irrigation demands compared with the VWA costs of the system demands represented by the deemed profile for small customers. These clearly demonstrate the reduced wholesale cost (using half hourly wholesale price data for the relevant periods) of different irrigation profiles compared with the relevant deemed demand profile.

Table 11 Comparison of volume weighted average spot market costs

Individual irrigation demand prices are compared with contiguous aggregate prices ($/MWh)

DNSP	Crop	Irrigation profile	Deemed profile	Irrigation/deemed profile
Ergon	Sugarcane	$48.06	$107.83	59%
SAPN	Fruit and nuts	$82.51	$134.95	64%
Powercor	Lucerne 1	$68.84	$82.60	83%
Powercor	Lucerne 2	$63.07	$82.60	76%
Powercor	Tomato	$58.32	$82.60	71%
Powercor	Cotton	$49.57	$82.60	60%
Powercor	Tomato	$56.11	$82.60	68%
Powercor	Cotton-Lucerne	$60.85	$82.60	74%
Powercor	Cotton	$50.49	$82.60	61%

As shown in the right hand column, the unitised wholesale energy cost of the various irrigation profiles (IDPs) is between 59 and 83 per cent of the deemed profile (NSLP) cost. This is a conservative measure of the risk adjusted difference in the wholesale cost of supplying IDPs relative to NSLPs, after taking into account forward wholesale trading risk.

This means that retail prices set on the basis of deemed small customer profiles could over-compensate retailers or allow retailers to cross-subsidise other customers by a substantial amount. Given the typically medium to high electricity volumes used for irrigation, the cross-subsidy portions of total annual irrigator bills are likely to be very substantial.

The reduced cost of the network component of retail prices for the irrigator above profiles is difficult to quantify. This is largely because current network tariff structures for most parts of the NEM do not reflect efficient costs.[7]

Periods of network congestion and high supply costs do not align perfectly with wholesale congestion and high supply prices. Nevertheless, the highest network and wholesale supply costs are strongly related to periods of very high demand. Depending on the network tariff structure, the indicated unit price premiums for wholesale costs shown above are a useful indicator of the possible price premium contained in network charges.

7 See for example xxx

Together, wholesale and network costs are by far the largest component of total retail supply costs and prices. If these delivered supply costs were 80 per cent of the total retail bill, and if delivered supply costs for an irrigator profile was 75 per cent of that for the relevant deemed profile, then the retail price would be around 20 per cent or one fifth higher than the efficient retail cost.

Across the sample of survey respondents providing cost data, total electricity costs exceed $3 million or $30 thousand per farmer on average, so that a 20 per cent saving represents material reduction in farm input costs ($6 thousand per annum).

5.3 Irrigators can avoid high cost periods

Over half the respondents already engage in time shifting irrigation power demand in response to price signalling. Respondents indicated a willingness to engage in demand response but indicated their ability to respond to price and/or control signals was constrained by operational considerations – reconfiguring irrigation equipment and the associated labour.

Nevertheless, our comparison of survey responses and interval data suggests many irrigators could under-estimate their capacity to power down demand during limited high system demand/high price periods. This is because they typically perceive a coincidence between their own maximum demand and system maximum demand that is much higher than the actual coincidence.

As noted earlier, our quantitative analysis of irrigator demand profiles strongly suggests that the likelihood that high irrigator demand coincides with high system demand periods is very low. This means there is an opportunity for irrigators to engage with various demand response signals.

On the other hand, the benefits would be relatively modest, because the value at stake appears low. Nevertheless, the option value of reducing demand, to both networks and retailers, may further contribute to opportunities for improved tariff design with lower prices than otherwise.

5.4 The network tariff reform problem

The conclusions above highlight the opportunity to reduce retail power prices by perhaps around 20 per cent via the introduction of cost reflective retail prices supported by the early deployment of digital metering equipment, where beneficial. However, distribution network tariff structures pose a significant risk and impediment to efficient retail prices.

The risk is that, in order to obtain the benefits of lower cost wholesale prices, via the selection of a time of use or demand related retail tariff, irrigators could find themselves assigned to a disadvantageous network tariff. The network tariff could substantially increase network charges and result in a higher retail tariff compared with a “flat” tariff with a single volumetric (energy) rate.

The problem arises from time of use energy or demand tariffs with very broad peak price charging windows. The proportion of the year where premium peak prices are applied vastly exceeds the proportion of the time during which total demand across the system is close to its annual maximum. These tariff structures may result in excessive charges for irrigators to the extent their energy or maximum demand is significant during periods of medium system demand – for example afternoons and early evenings from 1 December to 28 February. In some distribution areas, maximum demand tariffs are even applied outside the summer months.

Remaining on a flat tariff may also be problematic. This is because networks are being encouraged by regulators to impose a penalty on flat tariffs, in order to encourage retailers and consumers to switch to time of use tariffs. For many customers time of use customers will result in lower network charges and these lower charges need to be compensated from higher charges from other customers, including those remaining on flat tariffs.

The fundamental problem with network tariff reform is that it is applying congestion pricing – essentially charging for future network capacity augmentations in current network bills – in the absence of congestion almost everywhere in the NEM outside Victoria. In addition to the problem of charging windows being set incorrectly, this situation has because the threshold for applying congestion prices is being set relative to a proportion of maximum system demand instead of the point where incremental demand triggers a requirement for augmentation. In reality, there is no forecast congestion at least to 2026 in all but a few parts of the NEM outside Victoria.

In the small number of areas where congestion is a risk, this is a result of new connections (e.g. coal seam gas related connection in regional Queensland or NSW). Under the relevant regulations, the augmentation cost arising from these new connections should not be borne by existing customers via standard control network tariffs.

So far, however, the AER has not been responsive to these concerns and has approved the first round of TSS across the NEM. The problem of inefficient network tariffs can only be addressed by changing decisions by the AER on future TSS.

5.5 Next steps

We understand the Taskforce has limited resources and may have to prioritise its responses to this report. Within these constraints, we suggest the Taskforce could consider the following actions and initiatives.

1. Communicate and disseminate the key outcomes of this project, by distributing the executive summary, perhaps in a more accessible form. The outcomes should be shared with the same group that received the survey, with special thanks and acknowledgement to those who responded. Similarly, there may be opportunities for the authors to present the findings to future gatherings of the organisations represented on the Taskforce.

2. Drawing on the outcomes and the material generated for this project, consider development of guidance materials to encourage and assist irrigators to engage with energy markets, to illustrate the potential bill reductions, and to reduce perceptions that demand side participation (powering down pumps) would severely impinge on irrigator operations.

3. Consider approaching energy services companies and retailers, highlighting the potential for retailers to increase market share by offering farmers lower prices, while at the same time maintaining adequate risk adjusted profits. This discussion could also encompass

development of more efficient and innovative retail tariffs and the targeted deployment of new technology (e.g. digital meters), where beneficial.

4. Engage in consultation processes around the development of distribution network tariff structure statements, in support of moving to tariff structures that do not impose financial penalties for irrigators and which reward irrigators to the extent their demand is low or zero during periods of very high network demand.

5. Seek opportunities to inform relevant regulators, including the ACCC and the AER of the need to improve the efficiency of retail markets, including in regional areas, and to encourage increased competition and movement toward cost-reflective retail tariffs, supported by the early deployment of digital meters, where beneficial.