Welcome to our energy user workshop for the Converge project. Converge is testing a new method of managing network capacity called “shaped operating envelopes”. We will describe this method a little later to get your thoughts on it.

Converge is trialling this technology with 1,000 battery owners in the ACT. The outcomes from this workshop will go into recommendations that will influence how and if the shaped operating envelope technology is implemented after the trial.

Introduce Pip, Laura, Sarah. We are researchers who work at ANU and are the facilitators of the discussion today.

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Our aim today is to understand your thoughts about householder batteries and other appliances integrating with the grid and about some new technical solutions that are supporting this integration. We will get to this by stepping through some points about electricity capacity on the grid and its management as much more devices such as solar PV and electric vehicles are added.

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Our agenda today is:

- We start by providing you all some background and introducing some key concepts
- We will then break into three groups to discuss some questions
  - Due to the number of people here we have chosen to break up into smaller groups for discussion.
- We will then have a short coffee and snack break
- Then we will come back together and do another short presentation. At the end we'll introduce our second set of questions
- Then we will break into groups again
- Then come together to close

We will let you know about each step as we get to it.

There is a $50 thank you for participating. You can collect on your way out.

In breakout discussions we will facilitate and record what you say but also encourage people to write thoughts on sticky notes or directly on the provided paper. We can't guarantee everyone will get a chance to speak.

We have asked you all to fill out consent forms today. Additionally, we wanted to double check verbally before starting the discussion that you are all aware that:

- This discussion will be recorded.
- Everything is reported anonymously. We tend to report quotes and insights using a code for the workshop or individual pseudonyms or individual codes.
- While we don't expect to discuss anything harmful, if anything feels uncomfortable in the conversation we absolutely understand if you skip that part of the discussion or if you feel you need to step back from the table and the discussion at any time.
- There is an information sheet online and some copies here. In that it explains further detail about the above points and how we work with the workshop discussions. This information sheet includes information about how you can withdraw comments from the study if you need to as well.

Note tea/coffee/stretch break at about 7:15PM. At that point we will invite you all to stretch and grab a drink and some snacks.

I'll be reading in this presentation so I may sound a little mechanical. This is just so we can be sure we say everything that needs to be said.

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This project is responding to some current energy systems challenges and opportunities that aren't yet well know in the community, so before we get to the workshop, we will share background about why the trial is being run.

This first presentation covers the concept of capacity in the distribution network or the poles and wires that run down your street and supply you with electricity or take your generation away. This is a key concept that underpins the technology Converge is trialling which is why we are presenting it

We may also refer to the poles and wires as the grid

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Begin by defining

- Distributed energy resources? A whole range of connectable appliances are now referred to in the electricity industry as distributed energy resources or consumer energy resources. For example solar panels, batteries, electric vehicles, air conditioners and hot water systems.
- Grid integration – connecting what are often called consumer energy resources, like your battery, to the grid. This may include implementation of some control method (like the methods we will describe later).
- Virtual power plants are a way to connect lots of distributed energy resources together so they can bid together into energy markets. Some of you in this room may currently be in a virtual power plant. Particularly if you have a battery.

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There are significant changes occurring in our electricity generation and supply in Australia that have driven technical innovation around integrating energy resources with the grid over the last number of years.

Some of you may be aware of some of these changes, particularly those of you who have batteries or solar at home.

We will explain them in more detail now.

The changes we are seeing have been motivated by some key influences over the last few decades which critically have included:

- the uptake of air conditioning, electric water heaters, pool pumps, and other appliances that often consumed energy at similar times and caused large peaks in electricity demand
- the substantial growth in photovoltaics connected to electricity grids (which led to high loads back on the grid when the sun was out);
- aspirations to increase renewable energy in the electricity system,

The network businesses are therefore managing both peak solar generation and peak demand. This means that there are places where there is not enough capacity in the network to provide new energy users or new energy demands.

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These factors above impact capacity management. Networks have been managing the capacity in their network for a long time. Network capacity management is really about caring for the grid assets and knowing their electrical limits. Examples of these are thermal limits (e.g. ensuring assets don't get too hot), and the maximum power assets can transmit before the voltages consumers receive get too high or low.

Building more network assets has been a way that these constraints have been managed in the past.

Other methods of capacity management without upgrades include time of use prices or tariffs that make electricity more expensive when lots of people tend to use it. There are other management methods, including the new ways of managing capacity we will discuss today.

Slide 8

This is a picture of what we mean by capacity

Networks need to accommodate maximum demand or maximum generation. This picture shows maximum demand

So it is critical to know maximum demand and generation as it defines how large the network needs to be.

Demand varies throughout the day. If more people use appliances at the same time demand will be high and a larger network is required. If people all use appliances at different times the demand is lower, and a smaller network is required.

This is a picture here of how people use energy today. Note that this does not include solar PV generation which would reduce demand in the middle of the day or in some cases make it negative.

You can see in this case network size is driven by one point on the curve (around 7:30AM).

Changing energy demands led to networks putting a lot of money into upgrading the poles and wires around a decade or so ago as people got more energy-hungry appliances. This led to increased energy prices. People tended to react negatively to this approach of upgrading the networks at the time.

A little after the upgrades, there was a concerted effort to introduce time of use pricing as a way to both try and reduce peaks and better communicate to consumers the costs of using energy at particular times.

By making some times more expensive than others, the intent was to encourage people to move electricity use away from busy times of the day (sometimes called peak times) and to other less busy times of the day. Some of you may already be on time of use pricing. Not everyone who is on time of use pricing realizes that they are.

Slide 9

Another energy load is coming into play quickly now in the form of electric vehicles. Potentially charging EVs may add relatively large energy demands on top of our old ones.

And there is concern that people will charge their vehicles at the same time, rather than spread out, making peaks demand more extreme.

An example of how EVs could impact peak demand is shown here

Slide 10

Layered into this situation so far presented, we then had:

- advances in battery technology and its availability leading to them being installed with network connections (before they were mainly off grid technology),
- advances in communications between appliances, aggregators and the networks leading to opportunities for appliances and networks to 'talk' and 'negotiate' about energy use, and
- increasing electrification as some supplies (like gas) becomes less available and renewable energy is supplied via electricity systems.

So with all of this, householders with batteries or solar energy are now producers and consumers, or could be said to have a two-way interaction with the grid.

Virtual power plants have emerged, among other things to take advantage of two way interaction. Any battery owners on VPPs may be familiar with this.

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So networks are now managing two way energy flows, peak solar, and peak demand that increasingly includes EVS. Networks, energy retailers and governments, among others, are seeking ways to manage the loads and congestion.

A commonly accepted intent is to manage without major upgrades of the network, as that can cause price to increase for energy users.

The electricity systems sees consumer and other distributed energy resources as part of the solution to capacity management and to increasing proportions of renewables. As mentioned, distributed energy resources include a range of appliances that can produce energy, consume energy and interact with the network in a 2-way flow/negotiation.

Electricity system organizations, including networks, see DER appliances in homes and small businesses as useful in assisting to manage network energy flows and delaying or stopping upgrades to increase capacity.

For example, Virtual Power Plants that connect batteries in homes, enable networks to ask for access to energy stored in batteries. Shifts in energy to less busy times can also be further negotiated with consumers via connections to their distributed energy assets.

This in reality means the grid might direct times water could be heated or turn off an appliance - normally relatively briefly. Currently there is a lot of thinking going into ways to integrate DER further with the grid and then to scale it.

One benefit of integrating DER is a contribution to the various markets that enable energy and other types of energy related services to be bought and sold in Australia. Virtual power plants - VPPs - are one way consumer energy resources are coordinated to enable their participation in markets. Being connected to a market won't suit everyone.

However, DER connected to the grid is not always simply positive for networks. Participation in markets can encourage lots of devices like batteries to all charge or discharge at the same time (for example, when prices are high or low). This can further exacerbate the network capacity issues we described earlier. So networks are considering how they can enable DER to connect without needing to expand their networks.

The picture here illustrates the progression to new ways of working that the industry is describing.

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So in summary,

- A large role of distribution networks is ensuring enough capacity to supply demand
- Capacity needs are driven by peak demand
- Networks have been trying to avoid increasing network size and cost by encouraging people to shift consumption and generation to times outside of peak periods
- New technology (like EVs, batteries, PV) is a mixed blessing
    - It can cause additional peak demand
    - But could enable new ways of working that reduce peak demand

Slide 13

Now we are moving to breakouts. We will have three of these and 30 minutes to discuss some questions that relate to the presentation we just gave.

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Thank you for participating in the first round of questions. Now we want to discuss the specific technology we are trialling in the Converge project – Shaped operating envelopes (or SOEs).

Like last time this is a recorded presentation

Slide 15

One approach networks are using is to limit or constrain the operation of DER to ensure they fit into the network capacity limits. The picture here shows conceptually the shift in consumption required for a 10% reduction in peak demand.

This might mean that exports of solar generation from someone's roof to the network can be reduced by networks when there is not enough capacity in the poles and wires for grids to take the energy from the solar panels.

The same approach could conceptually apply to consumption from EVs. Batteries can also use this mechanism to charge or discharge energy at times the networks need it.

This also enables virtual power plants to coordinate their operation then sell the energy at a time when it is more valuable.

From the point of view of a network this is a pragmatic solution. But it will have an impact on how people use and generate electricity.

Networks expect certain types of equipment in consumer houses are likely to be able to change their behaviour in response to these constraints including:

- Solar generators generating less when there is not enough network capacity
- Batteries changing how they charge or discharge to respond to capacity limits
- Electric vehicles, hot water cylinders, pool pumps, and air conditioners reducing consumption or turning off when there is not enough network capacity

Trials of this technology have so far showed that there are relatively small changes in consumption or generation needed, but it is unclear if the amount of consumption changes required will increase in the future.

There are a number of ways that networks could implement capacity constraints. We will now discuss three of these: Fixed operating envelopes, Dynamic operating envelopes and Shaped operating envelopes.

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To illustrate these three methods I will use this picture. In it we have four houses with a total of 15 kW of PV and a 10kW transformer. So clearly there are times when generation exceeds the ability of the network to take it.

We are using PV generation here to describe as that is the way that most networks are using this technology today. Networks are thinking about applying the same technology to loads (such as EV chargers) too.

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Fixed envelopes refer to set upper and lower bounds that electricity flows on the grid must stay within. Usually these are set conservatively.

They are the hard guides used to date to decide what solar can been connected to any given part of the grid, because exporting solar causes a peak.

Networks have a maximum allowable capacity that consumers must not exceed at all times and they must set this to avoid problems or breakages. Over time as networks experience increasing numbers of problems they have reduced this capacity to the point where in some places consumers are not able to export anything at all because there are times when the network cannot accept generation.

Static envelopes are named as such because they are set and used across a period of time and are not able to be changed that easily. Static envelopes are determined ahead of time to cover an identified worst case scenario.

SO in this case, we might assume that at some point the fourth consumer will install PV so we only allow each person to install a 2.5kW PV system. This leaves 2.5kW of spare capacity for the fourth person in the future.

Obviously this is a significant reduction in system size compared to what these consumers want, so DOEs are proposed as a way to allow these people to install bigger PV systems

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Dynamic Operating Envelopes are proposed as a way to reinstate the ability for consumers to install larger solar systems while giving networks certainty that they can manage the capacity of their networks.

DOEs are enacted digitally via platforms and act as a mechanism for allocating available capacity in a more dynamic way taking into consideration changing requirements on the network at different times of day and for different seasons. DOEs enable networks to split the available network capacity among groups of people who need access to it in real time.

For example this could mean apportioning energy export capacity among those with solar PV systems. This in some ways is like static export envelopes that vary throughout the day. Technology installed in people's homes then receives these allocations and automatically changes its behaviour to fit within the network capacity allocation.

The required technology is usually installed with the solar system and may require an additional control box which the consumer must purchase.

Dynamic operating envelopes are from the perspective of the grid and for the grid. So while they are interacting with the consumer solar generation, they are thinking from the point of view of ensuring capacity stays with its limits. The dynamic element and interaction with solar means they can utilize more of the available capacity when compared with strategies that used static envelopes.

You can see here in this example, there are a few ways there is more capacity:

- We could allocate the extra 2.5kW across the 3 people who are connected
- At other times of day the network capacity could be higher, meaning more generation
    - Although the opposite can also be true
- Larger PV systems can generate at their limit more often

DOEs only go so far. There are some challenges with dynamic operating envelopes. In particular, DOE approaches are not aware of how much capacity consumers need or want.

This means that in some cases people may get assigned capacity they don't need while others don't get capacity they do need. Similarly, consumers who are willing to offer cheap energy may be prevented from generating in preference to people who are offering expensive energy.

We are aware that people have many different reasons for wanting to generate electricity. We are referring to price here because that is the way the energy system usually measures value.

Also there is open discussion at the moment among distribution networks around what the right way to allocate capacity is. We have presented one method that is being considered here but there are also others under consideration that would change how capacity is allocated somewhat.

For example, you can see the consumer with the 3kW system has a lower export limit than they would under the FOE option. There are active discussions around whether this is the right outcome.

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Project Converge is trailing an approach that layers up on the idea of DOEs, and this is shaped operating envelopes (SOEs).

Shaped operating envelopes further shape the two way energy flows by understanding the energy available in distributed energy sources and demands in any given part of the network in more detail.

The key difference between shaped and dynamic operating envelopes is that shaped operating envelopes consider the preferences of consumers or aggregators, the value of the energy that is being offered by aggregators into the energy market, and opportunities to use support from consumers to expand network capacity.

In effect this adds a step to the start of the DOE calculation where aggregators can tell distributors, via the SOE engine what they would like to generate or consume.

For the energy system/the grid it provides the ability to select which DER will result in the best grid outcome (lowest price) if assigned capacity. It also gives them the knowledge they need to pay consumers to make larger changes to their consumption or generation if it results in an overall cheaper network. And it can help manage capacity and keep the network in the operating values - making best use of what we have available within the safe working capacity of the network.

For consumers it requires them to appoint an aggregator to act on their behalf. If any of you have a battery with controls by Reposit or Evergen, they are the sorts of organisations who might be your agents in a future such as this.

Conceptually consumers need to inform aggregator of their preferences so that aggregators can request capacity from networks accordingly. Aggregators may have different ways to collect these preferences (e.g. some may specifically ask, or others may assume preferences based on the product consumers purchase from them).

SOEs require extra information and extra factors to be taken into account over DOEs. This is to ensure that intentions and desires of aggregators and customers are factored in so that operations better tailor to what is needed, wanted and available, so there is less waste of potential capacity.

Batteries a key part of shaped operating envelopes used for grid integration

Ultimately DOEs and SOEs reduce the need for physical upgrades of networks for capacity purposes and through this will assist to keep electricity costs as low as possible.

In this case you can see the impact of SOEs. The consumers with the 3kW and 5kW systems were bidding at the lowest price therefore they have a higher export capacity than the consumer with a 7kW system. This is intended to result in a lower price for energy overall because the lowest cost energy is preferentially dispatched.

It is expected that aggregators will be the ones determining price on behalf of PV owners. Different aggregators may give their customers different levels of influence over this price-setting process.

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So in summary, the three techniques can be described as:

- FOEs: limiting what can connect to ensure capacity limits are not breached
- DOEs: Allocating capacity in real time without a view of consumer's capacity needs
- SOEs: Allocating capacity in real time with a view of consumer's capacity needs as communicated by aggregators

So you can see each one steps up complexity and level of involvement of consumers in exchange for some additional benefit.

Slide 21

Now we are moving to breakouts. We will have three of these and 30 minutes to discuss some questions that relate to the presentation we just gave.

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We are at the end of our time today/tonight.

If you have any other thoughts please email us or write it on a sticky note/paper on your way out. We appreciate you sharing any further thoughts you want to share.

We will take transcripts form today and use them in our analysis

Don't forget your vouchers!