Navigating standards and frameworks for distributed energy resources

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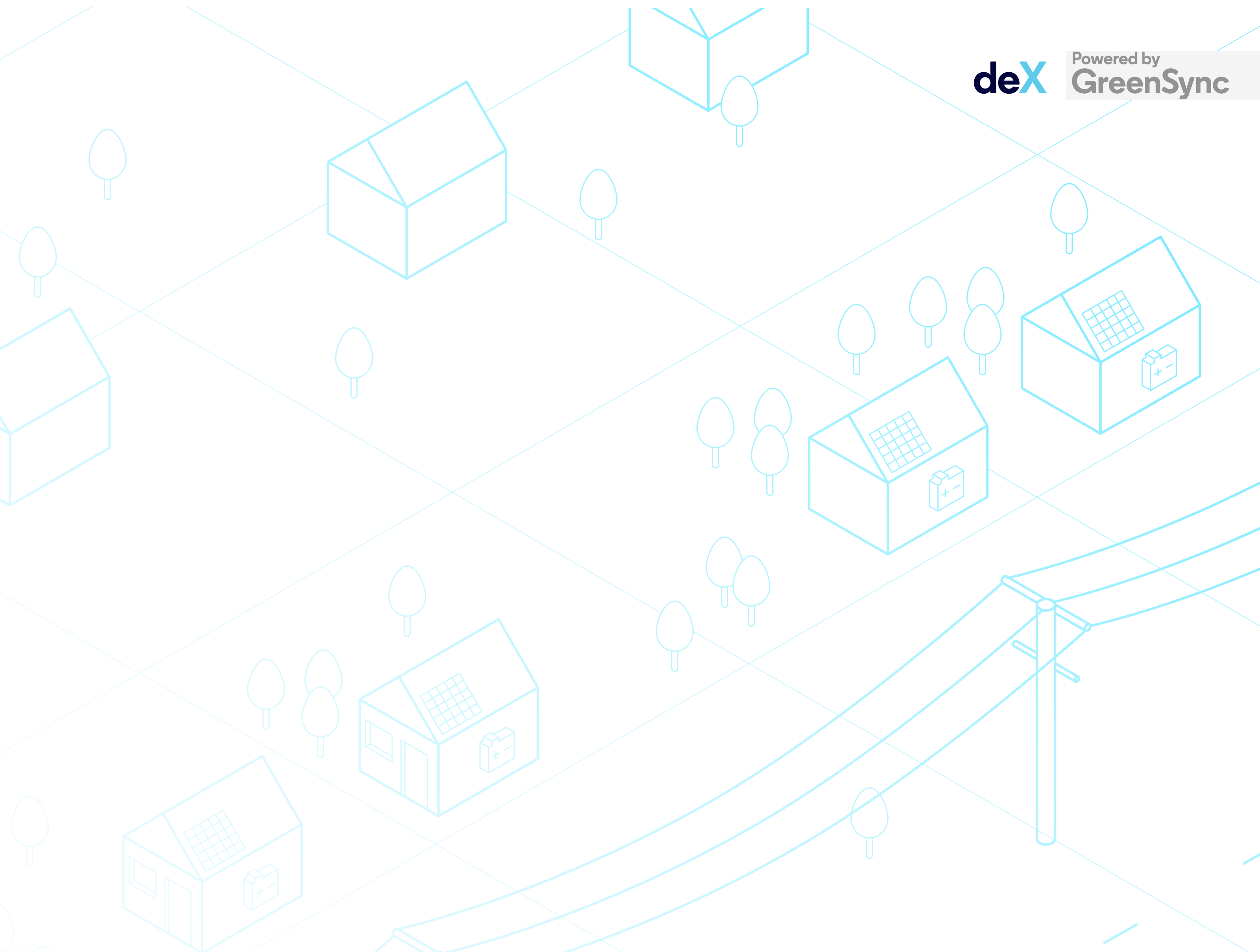

Contents

1 Executive summary

Due to the meteoric rise of rooftop solar, and soon to follow with storage, EVs and other smart devices, Australia needs to rapidly implement methods for obtaining telemetry and dispatchability from these smart, distributed energy resources (DER). Doing this is key to managing rapid change as consumer-owned devices and distributed energy assets play an increasingly significant role in our energy system.

To make progress quickly and effectively, stakeholders often emphasise that Australia should look abroad and adopt what we can from other jurisdictions and standards bodies.

The big challenge for Australia is that we are further advanced in DER (particularly solar) penetration than other locations. As such, standards for telemetry and dispatchability are not mature, anywhere. Practical implementations in other markets are not at a scale where we can adopt a known model.

Given this reality, it's pragmatic for us to clearly acknowledge the role of standardisation for telemetry and dispatch ability which will emerge in the medium term. At the same time, from a pragmatic and practical perspective, we must continue to push on with implementations and inform what more is needed over and above the existing array of standards.

This document describes the role of standards, identifies the relevant existing standards for DER, and proposes a framework for discussion with governments, utilities and technology providers that supports evolution of DER standards for hardware and software.

Importantly, we recommend a 'standards in parallel with implementation' approach that is more common in the software and internet industry. The reason is that software application programming interfaces (APIs) can evolve very quickly, in some instances, on a weekly basis. Hardware and electrical standards cannot, and therefore require a more defined standards-first approach.

We also recommend learning from implementations in a way that allows us to be agile to extend and evolve standards as we encounter more use cases, and are inclusive of more DER technologies.

Something else we need to accept is that it is highly unlikely for us, as an industry or even a jurisdiction, to develop one standard to rule them all. Different geographies will fragment, and technology products will evolve quickly and forge new capabilities. This will mean there is a role for middleware - for adapters between standards, and vendor specific APIs - to enable integrations between systems today, and standards as they emerge.

Through this document, we articulate the role that standards play in relation to GreenSync's Decentralised Energy Exchange (deX) and the role that deX plays in bridging the gaps that are not addressed (yet) by agreed standards. For our part, we will provide the deX APIs to working groups and standards bodies as they evolve. We also believe that open access is fundamental to the success of enabling a rich DER ecosystem of tech vendors, grid operators and utilities all using common frameworks.

Perhaps more importantly, we outline the key role that deX will play as an adapter for different standards and different vendors, until such time that standards evolve to more readily fill the gap.

2 Distributed energy management and solutions

The distributed energy context

Where are we?

Our energy systems are changing at a rapid pace as consumer-owned devices and distributed energy generation assets of all sizes play an increasingly significant role in energy markets.

The 20th century centrally oriented electricity system is being required to respond in ways the architects did not design for. This system, and its rules, envisaged one-way power flows. It is now increasingly needing to manage two-way flows and many, many more participants.

As providers of an essential service, grid owners and system operators need to have reliable infrastructure and management approaches in place in order to provide supply security and public assurance. However, there is a risk that the assurance may not match reality due to national energy reform, climate change impacts on infrastructure and the built environment, aging fossil fuel generators, variable renewable generation and increasing uptake of DER.

Increasingly, diversified, distributed energy resources present a number of challenges to the system. The central one is how do we best coordinate everything, and continue to deliver affordable and reliable energy overall? Related to this, where, how and when might standards help? How do we implement, require or mandate these; in what order and over what timeframe?

How we incorporate both existing and emerging approaches into the new energy toolkit is of particular interest to decision-makers and to those providing the tools.

How did we get here?

Australia's distributed energy evolution has been pushed, pulled, sent up and down the "solar-coaster" alongside developments in technology, data, and products.

During the first 10-15 years of residential solar PV growth (~2000-2015) electrical connection and safety standards were (mostly) adhered to, but systems of almost any size connecting anywhere were accepted. DER ownership went from a novel concept to mass market adoption. In parallel, costs of solar reduced dramatically.

Over the last five years, as the rates of solar connections continued to grow, so did technical challenges. National standards on response settings for inverters (AS4777.2) came in and static export limits began to be imposed by some distribution companies as a way to mitigate technocal risks. While hosting capacity and over-voltage risk has been largely addressed through these changes, it has also led to some consumers experiencing export loss and seeing erosions of expected pay-back periods.

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2 Distributed energy management and solutions

Where are we going now?

The ownership model for generation assets has changed forever. Assets are increasingly diversified in type, number and location.

Solar energy generation is coincident with weather systems and daylight hours, making its output relatively predictable. Over time, this correlation will lessen as battery storage, EVs and other technologies are connected behind one meter. Their behaviour is less tied to weather and may be harder to predict.

These assets can be managed collectively to optimise energy cost savings for an individual household, according to their preferences and needs. However this individual optimisation may not correlate to the most efficient or best outcome for the local grid, or the system.

At scale, using technology available and emerging today, DER can be managed collectively to optimise costs and capacity at an aggregated level through platforms and tools. At this level too, aggregation that optimises a fleet may not correlate to the best physical outcome for the distribution grid or wider system. Given this context, there is a push by utilities for control and access to these assets to enable better coordination, overall. The energy industry, locally and globally, is grappling with how to set standards and frameworks that support this direction.

Four steps to DER management maturity

For some, the clear answer is utility control of DER, pursued via top-down requirements. For others, utility access to DER is seen as a pathway to DER owner participation in markets. Both paradigms are driving discussion on standards and protocols at the asset behaviour and interface levels. Understanding and then bridging this divide in a way that supports competition, product development cycles and delivers value for consumers is a challenge.

GreenSync supports a four-step approach to DER management:

- Sensible autonomous behaviour of DER
- Connectivity and visibility of DER
- Remote control of DER
- Flexible markets for DER services

The fourth step is particularly important as the driving ambition of the first three steps and the one that ultimately returns value to customers.

Each step is given further context and explained below.

2 Distributed energy management and solutions

Sensible autonomous behaviour of DER

With the increasing pace of DER adoption, there is an opportunity to ensure that newly installed equipment improves - rather than impairs - the health of the local grid. For example, most modern DER equipment can monitor the local network, and respond - autonomously - to counteract voltage and frequency disturbances.

The presence of such DER functionality can improve local network safety, and potentially help to defer investment in network infrastructure. Consumers could be encouraged to install equipment that provides such services either by mandate or through incentive programmes.

Connectivity and visibility of DER

The next step on the path to maturity is visibility.

We continue to see thousands of solar PV systems and hundreds of batteries being connected to our grid every week.[1] Most Australian distribution networks have little idea where they are, or what they are doing. In earlier times, this lack of visibility over the Low-voltage (LV) network wasn't a problem, but it is becoming a major challenge as we accelerate towards having 40-50% of installed generation capacity behind-the-meter.[2]

Knowing where DER have been installed is a great start, but distribution network operators and system operators increasingly need near-real-time visibility of DER state and activity, so that they can better understand power flows and predict constraints. Such visibility can be achieved in a number of ways:

- Direct integration between the DER equipment and DNSP systems
- Integration via an intermediary, such as the DER vendor
- Monitoring via third-party equipment installed alongside the DER

Most options require some form of (internet) connectivity, which then raises questions about cybersecurity.[3]

[1] See for example, http://www.cleanenergyregulator.gov.au/PublishingImages/SRES%20media%20resource/Quarter%202%20 2019/SRES-tracker-map.jpg
[2] ENA - CSIRO (2017). Electricity Network - Transformation Roadmap, final report. (p. i) https://www.energynetworks.com.au/sites/default/files/entr_final_report_april_2017.pdf
[3] Note: Cybersecurity is a key area of interest. We are pursuing work on this topic, separately, and are keen to include and incorporate input and engagement from interested partners and stakeholders.

2 Distributed energy management and solutions

Remote control of DER

Internet connectivity is required to provide near-real-time telemetry, but it also creates opportunities to remotely control the behaviour of smart DER.

The real value comes from DER owners allowing others to control or constrain the behaviour of their assets. For instance, such control could:

- Enable the creation of Virtual Power Plants (VPPs), which effectively "generate" electricity through control of DER
- Provide the basis for "peer-to-peer" power sharing
- Allow a network operator to dynamically limit solar generation in a constrained part of their network
- Provide electricity retailers a hedge against changes in wholesale prices
- Allow DER owners to obtain additional benefits from their capital investment (which might otherwise go underutilised).

We think it that it's important to obtain explicit consent from DER owners, when enabling such control, and that such consent is best thought of as a contract between the DER owner and another party.

Flexible markets for DER services

Our ultimate goal is to enable "remote control" of DER at scale. This is also the point at which customer value can be unlocked. To achieve control at scale, digital "marketplaces" are required so that those wishing to obtain DER services and those willing to provide them can find each other and form contracts.

Effective marketplaces will involve:

- Mechanisms for tendering and bidding (requesting and offering) services
- Definition of standard DER service products (commodities), allowing competing bids to be compared
- Supporting services such as settlement and impartial baselining.

Flexibility is required, as it is likely that different "DER service products" will be traded, and different marketplace rules will apply, in different jurisdictions.

3 Standards

A standards primer

What are standards?

When discussing standards in this context, we mean technical standards, which are formal documents that establish some kind of norm. Such standards are useful in contexts which require many parties to agree on the details of a technology, process, or practice.

Standards exist for many aspects of modern life, e.g. measurement (the metric system), financial accounting (IFRS), quality management (ISO 9001), and information security (ISO 27001).

Standards are useful in contexts where there is benefit in everyone doing something in a consistent way, or meeting minimum requirements. Standards can support speed of adoption, level the playing field, increase interoperability and ensure safety.

Who defines standards?

Any organisation can publish a technical document with the intent of promoting convergence and consistency. The extent to which that document is considered a standard depends on the extent to which that organisation is recognised as an authority.

Organisations that publish standards relevant to DER include:

- Electricity industry bodies such as IEEE, and IEC
- Smaller consortiums like the SunSpec, OpenADR and Open Charge Alliances
- Computing industry bodies such as the IETF and W3C
- National bodies such as Standards Australia and the US National Institute of Standards and Technology

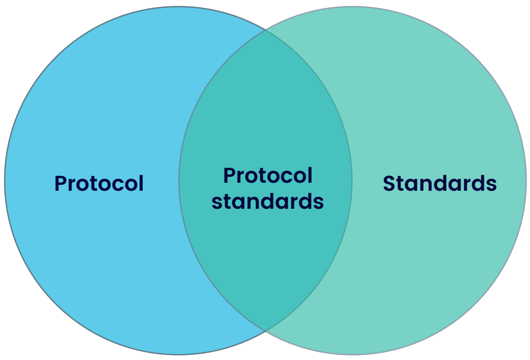
Standards vs protocols

People sometimes confuse the terms standard, and protocol, so we're keen to clarify that:

- A protocol is a means of communication over a computer network
- A standard documents an agreed norm

Protocols that operate over the Internet are sometimes referred to as Application Programming Interfaces (APIs).

Some protocols are standardised; some aren't. The overlap between protocols and standards is often referred to, unsurprisingly, as protocol standards.



3 Standards

Proprietary approaches and de-facto standards

It is also useful to be aware of non-standard, proprietary approaches. Here we use proprietary to mean any solution defined and owned by a particular entity. Tight control by the owning organisation means that such approaches can iterate and evolve much faster than standards can, and provide benefits to customers much earlier.

In some cases, proprietary approaches become so successful that they are implemented outside the originating organisation, becoming "de-facto" standards.

The path to standardisation

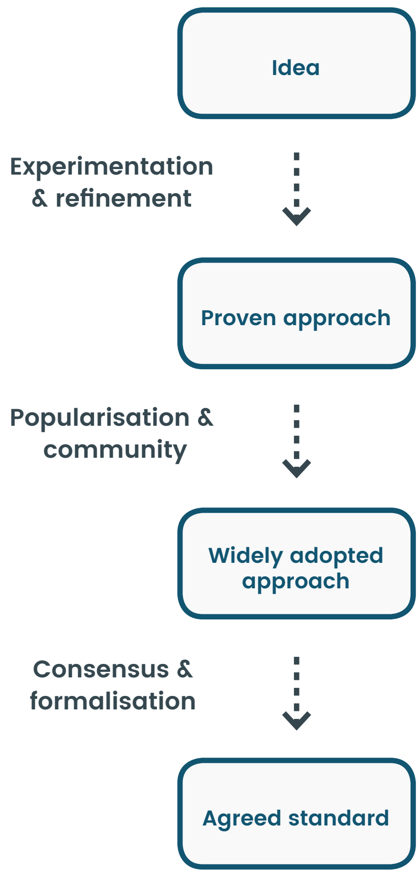
Developing an official standard is no small undertaking, as it typically requires significant amounts of consultation, consensus and compromise. ISO guidance on developing standards states that:

> *"Like a symphony, it takes a lot of people working together to develop a standard. ISO's role is similar to that of a conductor, while the orchestra is made up of independent technical experts nominated by our members. ...*
>
> *From first proposal to final publication, developing a standard usually takes about 3 years."*

Beware premature standardisation

Given the cost and time required to develop a standard, they are best seen as a tool for consolidation, rather than innovation. In the words of Tim Bray, co-author of the XML markup format:

> *"Our job [as standard authors] is to write down what we already know works, to do it as cleanly and clearly as possible in as few pages as possible, then get out of the way."*



It is usually easier to develop standards when there are one or more known, proven approaches to build upon. Indeed, de-facto standards often provide the basis for later official ("de jure") standards.

3 Standards

Open vs closed standards

So-called open standards are freely available for people to reference and implement, without charge or constraint. Well-known open standards include those that power the internet, published by the Internet Engineering Task Force, and the World-Wide Web Consortium.

Many standards, however, do not meet these criteria:

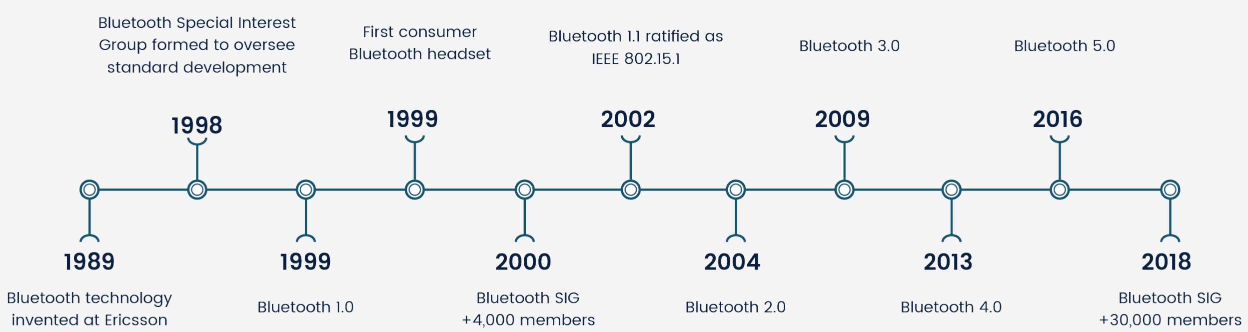
- Some standard specifications can only be obtained by purchasing the documentation. For example, it costs around US$400 to purchase a copy of IEEE 2030.5, and AU$370 for a copy of inverter standard AS/NZS 4777.
- Some standards reference patented technology and require implementers to pay a royalty or license fee.

Such constraints may hinder the adoption of the standards concerned.

Spotlight on a successful protocol standard – Bluetooth

Let's consider the trajectory of one protocol standard known to most people. Bluetooth is a wireless communication technology, designed to work over short distances, with low power requirements.

Bluetooth has been very successful and these days is implemented in most smartphones, personal computers and wireless peripherals. But, you might not know it's history:



Bluetooth is an open standard, with specifications freely available from www.bluetooth.com.

3 Standards

DER Standards

There are lots of DER standards and protocols already. For more detail, refer to the DER Standards Reference section later in this document for details on some we think are particularly relevant to DER management and coordination.[4]

Different types of DER standard

On reviewing the many DER relevant standards, we identified four broad categories. The first is connection standards. These are vitally important for safe electrical connection. The next three categories, though, are particularly relevant to the management of distributed energy resources; behavioural, interface and information model standards.

Connection standards describe how connections are made safely between electrical equipment and the electricity grid or other equipment. This group also include standards for how equipment should be designed and installed to avoid or reduce hazards such as electric shock, mechanical damage or fire.

Behavioural standards describe the expected behaviour of electrical equipment. They often include components and capabilities designed to protect the equipment itself, or the things connected to it.

Interface standards describe ways to communicate with equipment, to observe and/or control it's operation. These include:

- Physical interface standards which involve a hardware connection to the equipment
- Network protocol standards (including APIs) which define how to communicate with equipment via a computer network

Information model standards define concepts, and describe how to represent those concepts as data. These are useful building-blocks when defining network protocols. Using the postal system as an analogy, a protocol defines a way to put a letter in an envelope and have it delivered to a specified address, whereas an information model describes how to interpret the contents of the letter.

How DER standards can help

If you are tempted to reach into the barrel of standards and pull out a fully formed stack to meet all your DER management needs, you may be disappointed. Many were created to serve and solve particular aspects or interfaces between utilities and vendors, or to support particular DER technologies. Some are coupled to the regional or jurisdictional context in which they were created. Quite a few are relatively new. Still others are emerging in practical demonstrations but are not ready for wide-scale adoption.

We think that standards will add the most value in areas where numbers are large and consistency is useful. The obvious example is electrical connection of DER and their behaviour in the context of local electricity networks.

Protocol standards may be useful for specific system interfaces but their application should be considered on a case-by-case basis.

[4] Note: While we have sought to capture relevant standards for DER, we cannot guarantee this is "all there is".

4 GreenSync's deX

GreenSync is a technology company with experience building DER management solutions for electricity consumers, retailers, and networks. As such, we have thought long and hard about how to enable DER coordination, for the mutual benefit of all concerned.

We are convinced that successful management of DER can only be achieved through coordination between all stakeholders, including DER equipment manufacturers, owners, operators, energy retailers and distributors, market operators, and related service-providers.

Our Decentralised Energy Exchange (deX) aims to make such coordination easier.

An overview of deX

deX is built around a central exchange, accessed via API. The exchange:

- Provides a vendor-agnostic means of communication between participants
- Acts as a shared (impartial) system-of-record
- Supports markets, allowing a variety of services to be offered and procured
- Allows network and market operators to observe and moderate activities.

In the deX ecosystem, all data and control signals flow via the exchange.

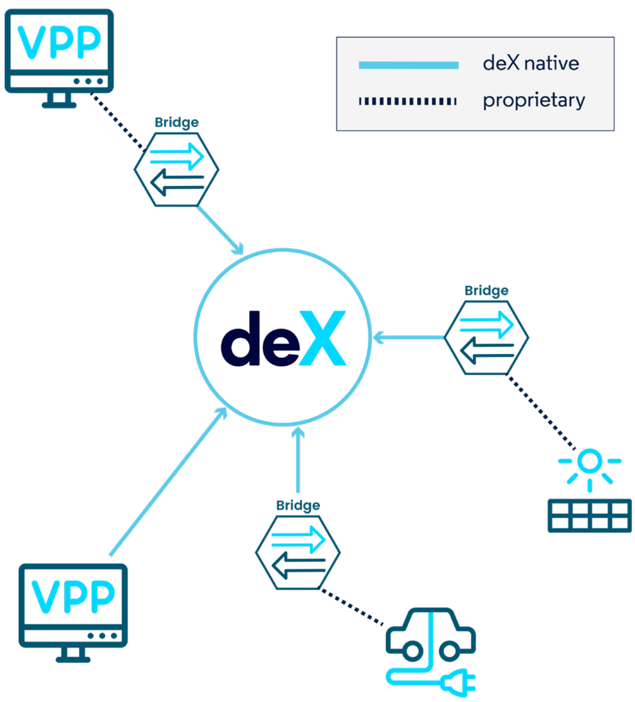
Integrating with deX

A participant on deX could be a DER owner or operator, a VPP operator wishing to aggregate DER, a network or market operator, or a variety of other roles. Participants generally don't use deX directly; instead, they use one of a growing number of integrated systems, which act as their agent on deX.

Some newer systems have been built to integrate with deX directly, via its API. However, as the deX platform is so new, this may be uncommon.

Integrating an existing system with deX typically involves building a bridge, which continuously synchronises that system with deX. Such bridges need to be fluent in both that system's native means of communication and the deX API.

The bridge approach allows us to adopt a variety of existing systems (such as DER, DER management systems, trading systems, network distribution management systems) to work with deX. Because such bridges can be built by anyone - GreenSync, technology vendors, third parties - we have many ways to drive the diversity of the deX ecosystem.



deX technology integrations (proprietary systems)

4 GreenSync's deX

How deX supports the maturation of DER management

The **autonomous behaviour of DER** is not the focus of deX, but we welcome industry efforts to align in this area. Autonomous behaviour is important to protect the grid and promote the installation of more capable DER.

When it comes to **visibility and control** of DER, deX becomes very relevant. The central exchange architecture makes it possible for participants to see and control a multitude of different DER types, using a common language, without having to integrate directly with DER operators. Our API-based architecture and bridge pattern enables a clear path to integration of many types of DER into the ecosystem.

Building on that foundation, deX will host **flexible markets** that can be used to procure the services of DER (individually, or in aggregate) without additional system-integration work. And by involving network and market operators, deX will minimise barriers to adoption.

How standards fit in the deX ecosystem

deX is young and the field of DER management is still evolving quickly. GreenSync does not think it is helpful to attempt standardisation of the deX API today; however, there is definitely a place for standards in the deX ecosystem as outlined below.

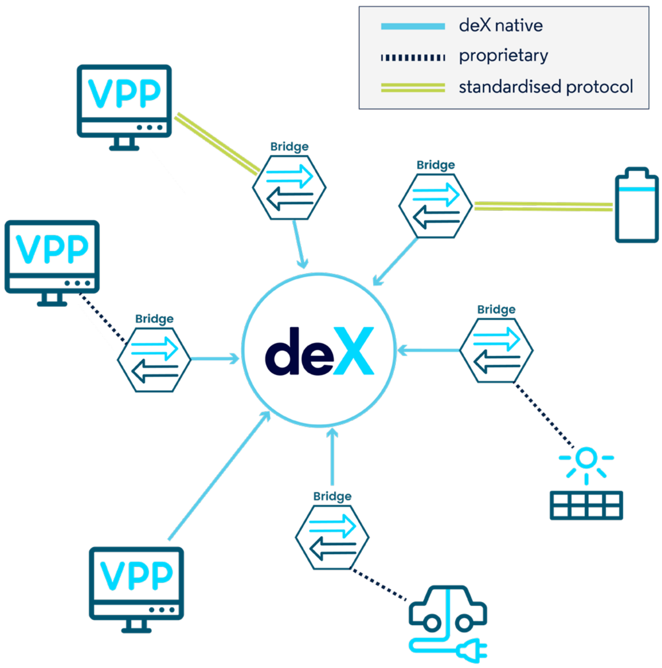
Integrating standardised protocols into deX

The deX ecosystem will increase in value to all users as it grows larger and becomes more diverse, so we'll do whatever we can to make it easier to connect DER (and other systems) to deX.

Today, the bridges that integrate deX with external DER management platforms all speak proprietary protocols - the native tongues of those external platforms. Because we have focused on leading platforms, these integrations have provided access to large numbers of DER. But this approach may not be cost effective as we address the long tail of DER types.

As some point out, it may make commercial sense for us (or a partner) to build bridges to standardised protocols (such as IEEE 2030.5, or OpenADR), and so gain access to a multitude of different DER types, and/or DER management systems.

The bridge-building approach means we can integrate whatever standard protocols make most sense for the markets we operate in, and adapt to whatever new standards evolve.



deX technology integrations
(proprietary systems & standards)

4 GreenSync's deX

deX may defer the need for interface standards

The point of an interface standard is to allow either of the two integrated systems to be replaced by a different (but similar) system that plays the same role. In the deX ecosystem, all communication between systems is brokered by the deX exchange, so the systems involved need only know how to talk the deX API.

Integration via deX achieves the same goal as having an interface standard for direct integration, and so reduces the need to develop such interface standards.

Learning from standards

We have learned much from our study of DER management protocol standards, and plan to continue research in this area. In particular, we plan to borrow ideas and concepts from existing standards, as we believe this will make it easier to build bridges between deX and other systems.

Informing new standards

In the years ahead, we will learn a great deal about what works (and what doesn't) in the area of DER management. If the deX API is successful, we might hope that others in the industry adopt it as a de-facto standard. More likely, we will work with other companies to agree standards that borrow ideas from a number of successful APIs. We hope that deX will be on that list.

Addressing the gaps: what standards don't cover

DER can (mostly) provide at least basic visibility via behavioural asset capabilities. A number of standards and protocols canvass how systems interface to do this and other services like demand response. These standards set the pathways for access and control, but do not address customers' permissions and choices.

In order to bridge this gap, we approach control of DER from the perspective that it is shared. Access and shared control is enabled in deX via consent being set by customers who are the asset owners.

To encourage and support advanced capabilities becoming more commonly installed, we are developing two key underpinning customer agreements for participation in deX:

- Digital Asset Registration
- Dynamic Connection Agreements

Digital asset registration (in deX) allows deX to validate information about the asset with the vendor and make appropriate portions of information about the asset visible. This allows the asset owner to provide system-supporting visibility and to be available for energy service contracts that may become available over time.

Dynamic Connection Agreements provide a framework for DER owners to permit the network to request curtailment from their asset under specified network conditions. While our approach here is not a 'standard', it establishes a streamlined pathway for customer permitted support from and control of DER. These components support the provision of DER service contracting and establishment of markets.

5 How do we navigate forwards?

Moving beyond the roadblocks

Taking what we can from existing standards for DER is a good starting point. We know, however, that our path forward needs to navigate new and emerging standards in a way that supports all parts of the market. We need to be realistic about where standards help and where they aren't yet ready and to work through consistent approaches so we can navigate to a better future.

To take us to a high penetration DER future that delivers a reliable, secure, safe and low emissions energy system we need the four-step approach to DER management:

1. **Sensible autonomous behaviour** of DER
2. **Connectivity and visibility** of DER
3. **Remote control** of DER
4. **Flexible markets** for DER services

To take these steps, we think, requires an implementation approach that enables rapid change and evolution for software APIs while leveraging hardware behaviour and connectivity, set and defined by DER standards.

It is important to recognise there is no one standard to rule them all. As such, the role for middleware that can act as an adapter between standards, and vendor specific APIs is a crucial element to enable integrations between systems today, and standards as they emerge.

A key role for deX is as an adapter for different standards and different vendors, until such time that standards evolve to more readily fill the gap.

Additionally, deX plays a role in bridging the gaps that are not addressed by standards. We see a role for us to support others is in relation to customer experience and permission for assets to be shared by the customer with other parties who can benefit from visibility, access and control - networks, retailers or others.

To navigate from these capabilities to flexibility markets for DER services requires collaboration and iterative steps that build towards that future. These steps will help the industry to get in front of the DER wave while also addressing near-term risks to the energy system and driving to better outcomes for all consumers.

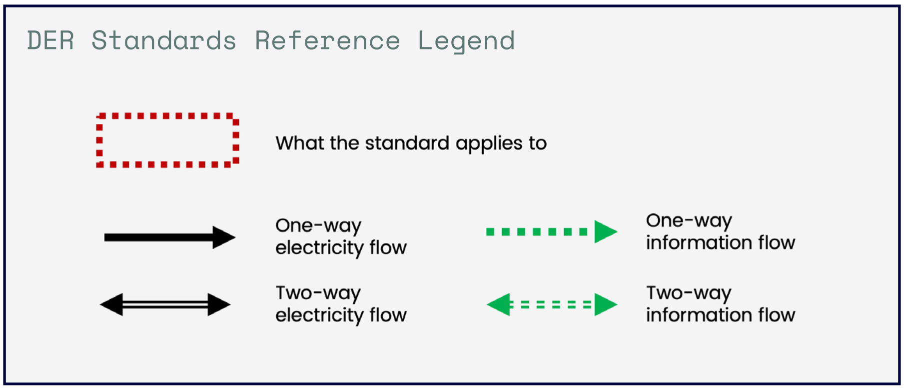
Appendix: DER standards reference

APPENDIX: DER Standards Reference

Behavioural Standards

Interface Standards

Information Models



IEEE 1547 (2018)

Interconnection and interoperability of distributed energy resources with associated electric power systems interfaces

What:
The technical specifications for, and testing of, the connection, interoperability and exchange of information between utility electric power systems and DER.

So what does that mean?
This is one of the few standards that addresses most types of DER and in many cases, it is becoming the "go to" standard for DER interconnection (both hardware and software). It clearly outlines that all DER must meet certain communication protocols, reporting and control requirements:

- Reporting/monitoring requirements: The DER must be able to communicate nameplate information, configuration information, as well as a range of monitoring information types (e.g. power, voltage, frequency, operational state, connection status).
- Functionality requirements: The DER should be able to operate in different power quality modes (constant power factor, voltage-reactive power, voltage-active power or constant reactive power). It also describes how to perform voltage and frequency ride through.
- Communication protocols: The DER must be able to communicate via one of three standard protocols: IEEE 2030.5, IEEE 1815 or SunSpec Modbus.

This standard provides requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection. It also includes general requirements, responses to abnormal conditions, power quality, islanding and test specifications and requirements for design, production, installation evaluation, commissioning and periodic tests.

Where:
Mainly the United States of America. Being considered in other regions, including Australia where it is now possible for Standards Australia to adopt IEEE standards.

Who it applies to:
Equipment manufacturers and networks.

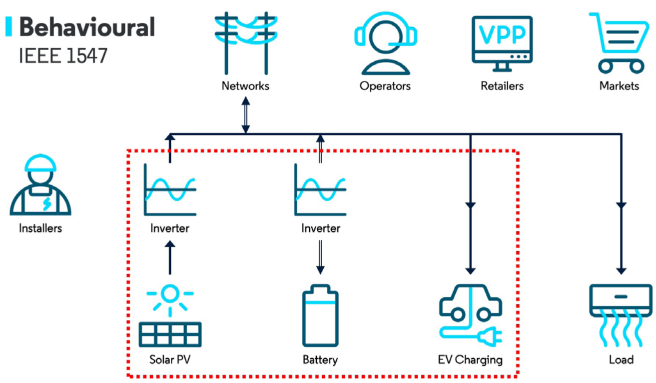
Why is this important?
IEEE 1547 has long influenced the way the energy industry does business. It has helped to modernise our electric power systems infrastructure by providing a foundation for integrating clean renewable energy technologies as well as other distributed generation and energy storage technologies. Australia is actively looking to incorporate requirements listed under IEEE 1547.8 into the updates to the Australian standard AS/NZS 4777.2.

Status:
This standard was first published in 2005. Currently under review with completion expected in 2019 or 2020.

Related standards:

- AS4777.2
- UL 1741SA - Standard for inverters, converters, controllers and interconnection system equipment for use with DER
- IEEE 2030.5
- IEEE 1815
- SunSpec Modbus

Learn more:
IEEE Standards



IEC 62109 (part one and part two)

Safety of power converters for use in photovoltaic power systems

What:
Covers the safety requirements relevant to DC to AC inverter products.

So what does that mean?
This standard was developed to address the emerging safety requirements for solar power conversion equipment. It looked at a range of inverter types, as well as the different functions and devices they connect to.

Essentially, this standard covers:

- General and device type electrical ratings and tests
- AC outputs and DC inputs requirements
- Safety requirements and hazards i.e. insulation, fire testing, chemical and liquid hazards
- Safety installation
- Safety by device type

Where:
Global

Who it applies to:
Initially it was applied predominantly to inverter and power conversion equipment manufacturers and solar photovoltaic power providers. Over time, the standard has been extended to a wider group of inverter-based DER systems.

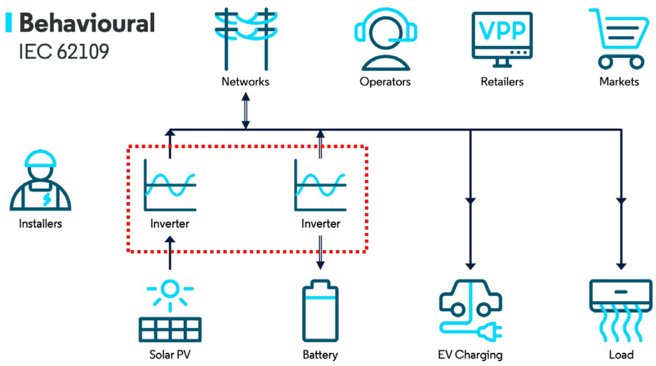
Why is this important?
Keeps equipment safe and within legal operating limits

Status:
The standard was first released in 2011. Since this time there have been amendments to align with emerging safety standards and technology. An update is planned for 2020.

Related standards:

- CEI EN 61557-8: Electrical safety in low voltage distribution systems up to 1000 V AC and 1500 V DC Equipment for testing, measuring or monitoring of protective measures - PART 8: Insulation monitoring devices for IT systems.

Learn more:
[International Electrotechnical Commission]



AS/NZS 4777.1 (2016) & 4777.2 (2015)

Grid connection of energy systems via inverters and inverter functionality trading

What:
AS/NZS 4777.`1 specifies the general safety installation requirements for grid connection of inverters. AS/NZS 4777.2 covers hardware capability requirements for inverters that inject power into the grid on a low voltage network.

So what does that mean?
This standard mandates the electrical installation requirements for inverters, related energy systems and grid protection devices with ratings up to or equal to 200kVA, for the injection of electric power through an electrical installation to the electricity distribution network at low voltage. AS4777.2 specifies inverter functionality and capabilities to ensure stable grid connection, including passive anti-islanding.

Where:
Australia, New Zealand

Who it applies to:
Inverter and power conversion equipment manufacturers, solar photovoltaic power providers, equipment installers and distribution networks.

Why is this important?
You are required to comply with this standard if you intend to design, install or operate a small generation unit that uses an inverter to connect to the grid. Compliance with this standard is key in Australia, and is mandatory that all new energy systems connected to grid via inverters abide by this governing standard.

Status:
Originally created in 2002, a major revision was released in 2015 as AS/NZS 4777.2. This standard established local power quality (Volt-watt and Volt-VAr) response setting requirements for complying equipment. This imposed 'set and forget' settings for maximum voltage to limit the production of solar power and reduce the instance and impact of high voltage on the local grid.

A key challenge with implementation was that these power quality modes were not mandatory. Recent analysis also showed that not all inverters are actually set correctly (even if they could be), so not all are responding "as expected" which creates challenges for the local distribution network.

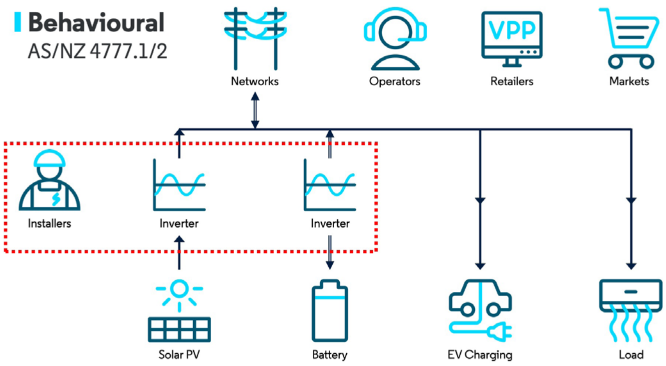
Australian networks, the market operator and technology vendors see there is an opportunity to modify, update or replace the requirements of AS/NZS 4777.2 to support more sophisticated solutions to local voltage issues.

Standards Australia has instigated a formal review which should be completed by 2021, with a key change to be mandating power quality modes. There is an expectation the update to this standard will reflect aspects from AS/NZS 4557 and IEEE 1547.

Related standards:

- IEC 62109 was used as a base for AS/NZS 4777.2
- This Standard should be used in conjunction with AS/NZS 3000
- AS/NZS 5033 Installation and safety requirements for photovoltaic arrays

Learn more:
SAI Global - AS/NZS 4777.1



IEC 62116

Test of anti-islanding protections

What:
Mandates the detection and prevention of inverter islanding

So what does that mean?
One of the main concerns with inverter-based generators is that inverters could feed parts of the public grid, even when the grid is disconnected from the main power system. This is called an "unwanted island" and poses a series of system security and safety risks. The standard ensures that islanding conditions are detected, and islanding generators can be disconnected from the public grid.

Where:
Global

Who it applies to:
Inverter manufacturers, network utilities and microgrid operators

Why is this important?
This standard is critical for inverter safety, with most inverter manufacturers already in compliance. Policy makers (including those in Australia) are proposing to incorporate the results of the experimental feasibility assessment into state and federal policy revisions. We also note that some Australian distribution networks and the Victorian Government's solar homes program have made this a mandatory requirement.

Status:
The standard was first published in 2008, with a major update carried out in 2014. The standard is due for revision in 2020.

Related standards:
» IEC TS 61836 - technical specification

Learn more:
IEEE XPLORE - IEC 62116

UL 1973

(USA) Battery standard (safety)

What:
This standard specifies the safety testing regime for batteries that may be applicable for household use as well as vehicle and auxiliary power and light electric rail applications.

So what does that mean?
This standard is considered the most 'rigorous' testing regime for household batteries in the world. Whilst the standard doesn't review battery performance, it does evaluate the energy storage systems ability to withstand 'simulated abuse conditions' that may be relevant to a residential context.

Where:
USA, Australia, New Zealand

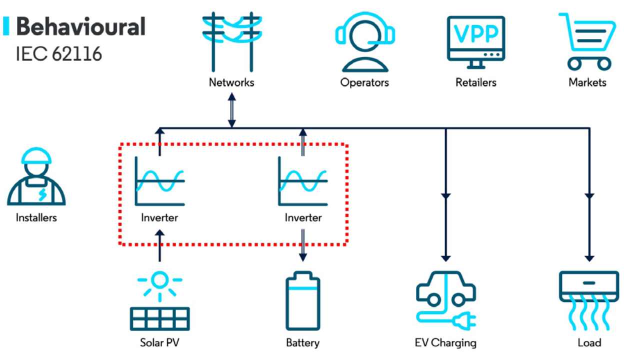
Who it applies to:
Battery manufacturers

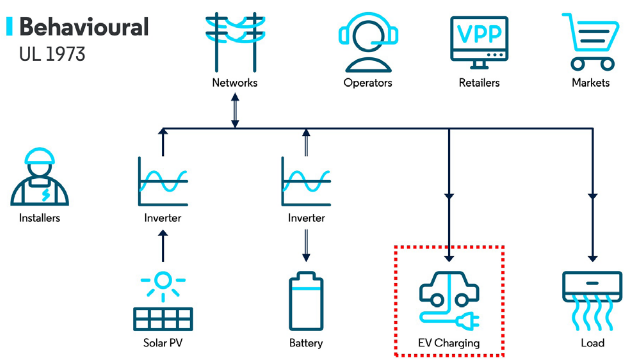
Why is this important?
This testing methodology not only applies to lithium-based batteries but also to other chemistries; it is chemistry-agnostic. It is currently being used by manufacturers as the minimum specification for household battery solutions due to there being no specific standard for household battery storage.

Status:
Active, last updated in 2018.

Related standards:
» IEC 62619

Learn more:
Standards Catalog - UL 1973





IEC 62619

(Europe) Battery standard (safety)

What:
Specifies the requirements and tests for the safe operation of lithium batteries used in industrial applications across Europe.

So what does that mean?
The standard itself provides several testing methodologies to examine how safe lithium-ion batteries are whilst in operation. The original intention of the standard was to provide a safeguard for industrial-sized batteries which is now being applied to household-sized battery systems. Like its USA equivalent (UL 1973) it does not provide coverage over battery performance metrics.

Where:
Europe, Australia

Who it applies to:
Battery manufacturers.

Why is this important?
The core ideal for this standard and included tests is to provide a safeguard that both cells and batteries, even in cases of battery stress, will "pose no significant threat". Significant threat is determined to be fire, explosion, the escape of chemicals and gas as well as negative impact to grid infrastructure. Adoption of this standard has helped to set a new safety benchmark for nascent lithium battery technology and its use in household and commercial applications.

Status:
Active, last updated 2017.

Related standards:

» UL 1973

Learn more:
International Electrotechnical Commission

IEC 61724-1

PV System performance and monitoring

What:
Outlines the equipment, methods, and terminology for performance monitoring and analysis of solar PV systems.

So what does that mean?
The standard sets the requirements for an accurate data collection model for solar PV systems. Additionally, it helps to set out the types of equipment (e.g. sensors, monitoring devices) required and how they should be installed to ensure data accuracy.

Where:
Europe

Who it applies to:
Monitoring device manufacturers, aggregators, distribution networks

Why is this important?
This standard helps to set out a framework for data collection for Solar PV systems which help the industry to be consistent in how it measures different metrics of performance. This will allow for visibility of devices with greater accuracy. Additionally, parts of the standard may be adapted for data monitoring of other DER within a network including energy storage systems and electric vehicles.

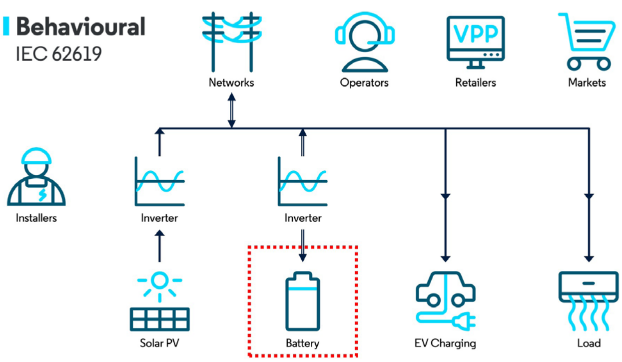
Status:
Active

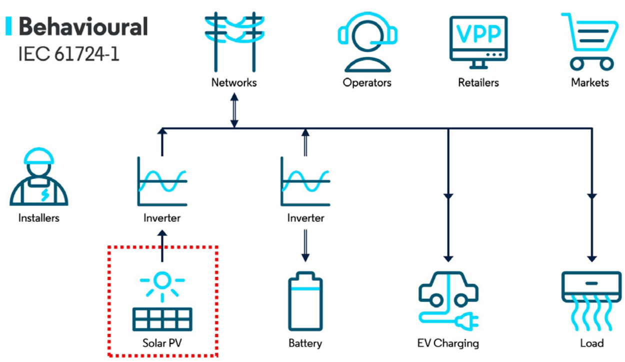
Related standards:

» AS/NZS 4777.2

» IEC 62109

Learn more:
Internationa Electrotechnical Commission





AS/NZS 4755-2017

Demand-response capabilities and modes

What:
This standard specifies the framework for demand response capabilities and supporting technologies, demand response enabled devices (DRED).

So what does that mean?
The framework and DRED technology specified by this standard allows DER to alter, in eight different ways, from their normal mode of operation based on an initiating signal originating from a remote agent e.g. distribution network, market operator, retailer. This change in behaviour may be in response to a price or grid security signal.

Where:
Australia, New Zealand

Who it applies to:
Hardware manufacturers, distribution networks, retailers, market operators

Why is this important?
This standard is applicable across a wide range of DER including solar PV, air-conditioners, hot water systems, EV chargers and pool pumps. It also allows the controlling agent (the market operator or distribution network) the ability to control loads using eight different modes to meet the requirements of a price and/or grid security signal on a network.

Status:
Active, most recent revision was in 2017. A further revision is currently underway (August 2019). There are also growing calls for AS/NZS 4755 to be incorporated into a revised version of AS/NZS 4777.2. Watch this space.

Related standards:

» IEC 62746:2018

Learn more:
SAI Global

IEEE 1815-2012

What:
This protocol has been designed for most network power communication systems (like SCADA) and helps to monitor remote equipment located at electrical substations such as circuit breakers, sensors and voltage transducers.

So what does it mean?
The protocol specifies the structure, functions and interoperable application options. It has a number of subsets for particular devices or asset types. The protocol was developed for low-cost distribution feeder devices but can be used for more complex, full-featured systems.

Where:
Global.

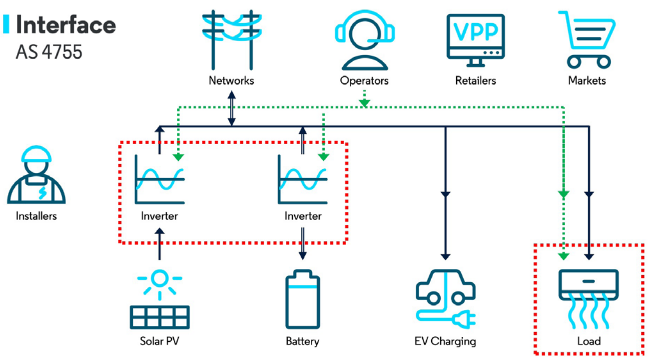
Who it applies to:
Network utilities and independent system operators

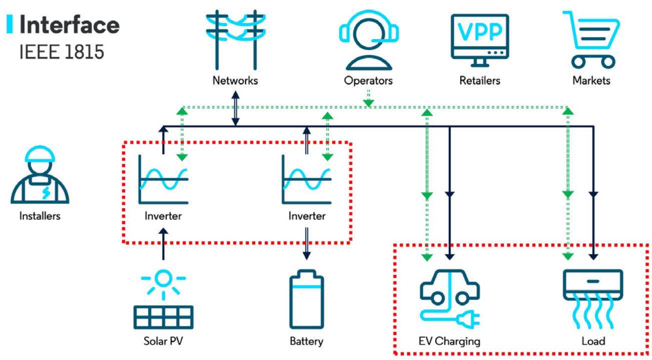
Why is this important?
This standard has been around for a long time - even before internet connectivity was the norm. It has set precedents for many low-level communication standards. It is now being referenced more broadly for DER communications and connectivity standards.

Status:
An application note was released in 2018 to support additional functionality including basic DER monitoring, alarms reporting, emergency modes and power control modes.

Related Standards:
N/A

Learn more:
IEEE XPLORE Digital Library





IEEE 2030.5-2018

Standard for smart energy profile application protocol

What:
Initially this standard was designed to cover smart energy information protocols for home or business premises (Zigbee Smart Energy Profile 2 - SEP 2). It has now been extended to cover inverters and other types of DER.

So what does that mean?
This standard looks specifically at the application protocol that enables the transportation of digital information between the utility and the end user. It covers a range of devices and software types including smart inverters, smart meters, electric vehicle charging, demand response programs, smart thermostats and smart appliances.

This standard covers the mechanisms for transporting and exchanging application messages, the exact messages exchanged including error messages and the security features used to protect the application messages are defined in this standard.

Where:
Mainly being used in California, with other regions looking closely at the approach used here for potential application in other jurisdictions. Horizon Power (regional WA vertically integrated utility) is trialling this approach in their DER management system.

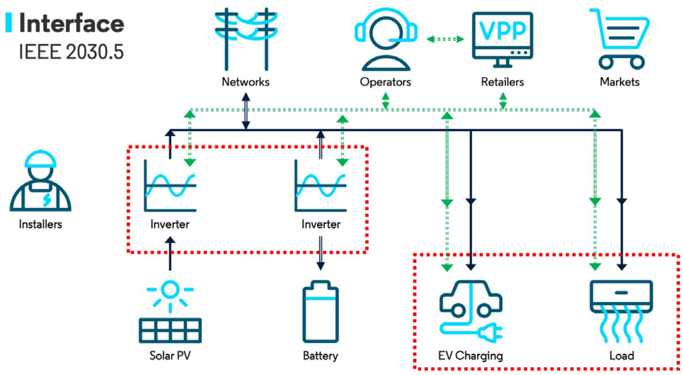
Who it applies to:
Inverter manufacturers, software developers, equipment and hardware manufacturers.

Why is this important?
It has been adopted as the defacto communication protocol between utilities and DER in California in the United States of America with other regions in the US and other countries considering this as a pathway to upgrade DER functional requirements and establish communications frameworks for DER-aggregator-utility arrangements.

Status:
There was a major update released in December 2018 which incorporates the DER grid functions update from IEEE 1547 (2018).

Related standards:
- IEEE 1547 (2018)
- OCCP 2.0 - Open charge point protocol
- CSIP (Common Smart Inverter Protocol is a profile of IEEE 2030.5 for inverters)

Learn more:
IEEE Standards Association



California Rule 21 & the Common Smart Inverter Profile (CSIP)

What:
Rule 21 is the State of California's approach to managing increasing amounts of solar generation. It is not a standard, but a tariff that describes the interconnection, operating and metering requirements for generation facilities to be connected to a utility's distribution system.

Among other things, it requires the use of smart inverters in solar installations, mandating adherence to IEEE 1547 for solar connections, and (a subset of) IEEE 2030.5 to allow utilities to communicate with inverters for visibility and control. That subset of IEEE 2030.5 is called the Common Smart Inverter Profile (CSIP).

So what does that mean?
While not a standard itself, Rule 21 enforces existing standards for grid connection. It allows residents and business owners who wish to install generation, like rooftop solar or storage (ie. a battery), on their premises to do so in a way that is safe for the wider grid.

The California government is cracking down on "dumb inverters", to ensure all inverters have certain capabilities that enable safe operation of the electric grid as more and more renewables are connected.

Rule 21 contains many aspects of interconnection, including:

- Technical requirements for inverters
- Metering and monitoring requirements
- Certification and testing criteria
- Procedures and timeframes for reviewing installation applications
- Fee schedules to process applications and perform impact studies
- Pro forma application and agreement forms
- Allocation of interconnection costs
- Provisions specific to net metering facilities
- Technical operating parameters
- Procedures for dispute resolution

Where:
Created by the California Public Utilities Commission for the state of California in the United States of America.

Who it applies to:
Currently it affects investor-owned network utilities in California such as Pacific Gas & Electric Company, Southern California Edison, and San Diego Gas & Electric Company. Phase 1 of the program has a direct impact on solar inverter manufacturers selling into the region. In the long term, it will impact any energy hardware manufacturer selling into California.

Why is this important?
Standards being developed in other jurisdictions are identifying Rule 21 precedents to form the basis of their policy and approach to connection requirements.

Status:
Phase 1 was effective in September 2017, phase 2 was recently extended to be due to in August 2019 and phase 3 is now expected by January 2020.

Related standards:

- IEEE 1547
- IEEE 2030.5 (CSIP)
- Test criteria: UL 1741 SA

Learn more:
http://www.cpuc.ca.gov/Rule21/

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IEC 62746 / OpenADR 2.0

Automated demand response model

What:
A communications data model designed to facilitate sending and receiving automated demand response (ADR) signals between a utility and a residential or business energy user.
So what does that mean?

So what does that mean:
The model enables pre-programmed control systems to take action, based on a demand response signal (such as price), allowing an event to be fully automated.

Open ADR 2.0:

- Defines the interface functions and features of a demand response automation server
- Addresses how third parties will interface with and use the functions of the demand response server in order to automate various aspects of the demand response program including calendaring/scheduling of DR events.
- This standard also explores dynamic pricing models.

Where:
There are implementations in the United States of America, Japan, Europe and likely China as well.

Who it applies to:
Third parties such as utilities, independent system operators, energy and facility managers, aggregators, software including virtual power plants, and hardware manufacturers including electric vehicle manufacturers

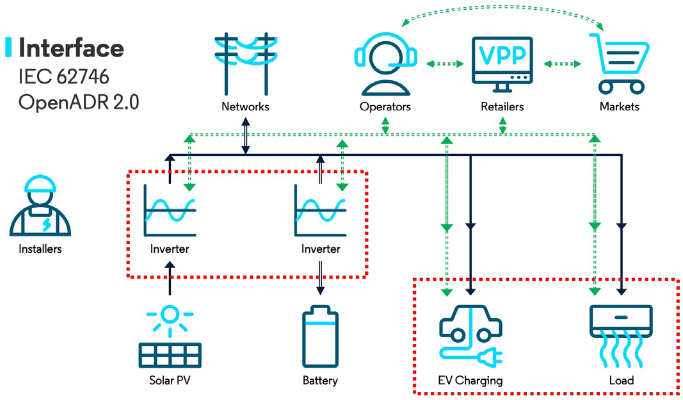
Why is this important?
Being open source, OpenADR is becoming very popular. The fact that it is designed to cover signals from both market and grid operators and implements the energy service interface approach of a service interface, rather than a control interface, makes it one to watch.

Status:
The California energy crisis of 2002 served as the impetus for the effort that ultimately led to the creation of version 1.0 of the OpenADR standard. In November 2018, version 2.0 of the OpenADR standard was published and has now been added to the International Electrotechnical Commission (IEC) standards list as IEC 62746.10.1.

Related standards:

- OASIS Energy Market Information Exchange
  Common Information Models

Learn more:
Open ADR Alliance



SunSpec Modbus

What:
SunSpec is an application-layer communications protocol designed to achieve interoperability between DER components and smart grid applications. The SunSpec Alliance certifies DER system components and software applications for compliance with official communication standards.

So what does that mean?
Simply put, SunSpec standardises the representation of devices and their related device information. Sunspec Modbus covers:

» Required device information - the manufacturer, model and serial number
» The device type and category
» The vendor model - specific to each device vendor

Where:
Global

Who it applies to:
Inverter manufacturers, software developers, equipment and hardware manufacturers

Why is this important?
Modbus is widely considered as one of the oldest industrial protocols. It uses the standard addresses (naming conventions) for a particular value. Compliance is expected, particularly if you are an inverter manufacturer. For many it means that you can have one integration with a number of inverter types - which is a selling point.

Status:
Active. Updated to reflect IEEE 1547 updates

Related standards:
» IEEE 1547

Learn more:
Sunspec Alliance

OCCP 2.0

Open charge point protocol

What:
The OCPP was created to make electric vehicle networks and charging stations open and accessible.

So what does it mean?
This standard enables EV charging stations to use a consistent protocol. The protocol covers:

» Testing
» Smart and fast charging
» Device management
» Monitoring charging stations
» Transaction handling
» Display, messaging and support

Where:
Global

Who it applies to:
Electric vehicle manufacturers, charging hardware and software vendors.

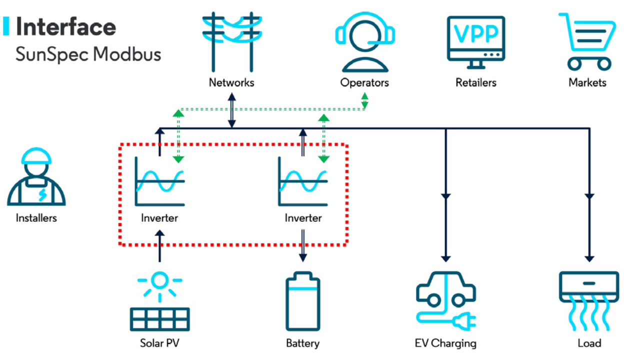
Why is this important?
In lieu of no other standard for electric vehicles in existence, OCPP was created. It quickly became the de facto protocol and is now used in more than 100 different countries.

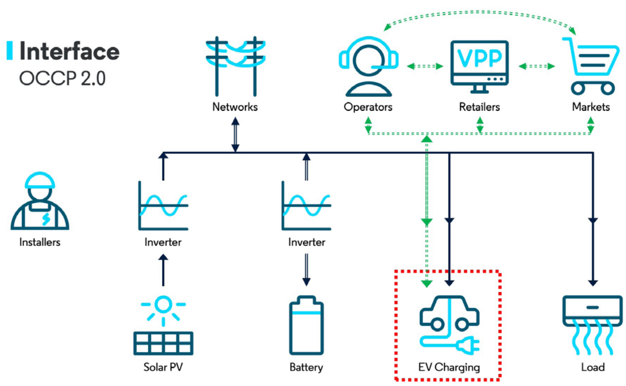
Status:
In April 2018 a new version of OCPP was released, OCPP 2.0. This new version contains a lot of new features covered in 116 real use cases. OCPP 2.0 is based on JSON[1].

Related standards:
N/A

Learn more:
Open Charge Alliance

1 JSON stands for JavaScript Object Notation. JSON is a lightweight format for storing and transporting data.





OpenFMB - Open Field Message Bus

Enabling grid edge interoperability and distribution intelligence

What:
This standard has been designed to facilitate the creation of an Internet of Things (IoT) ecosystem for utilities.

So what does that mean?

It enables smart meters, solar inverters, battery controllers, distribution grid control systems and communications network nodes to use their computing power to solve edge-of-grid problems that happen too fast for centralised grid control systems to manage. The technology makes this critical level of grid-edge communication possible by "translating" between the relevant protocols of different devices.

The standard covers:

- Combination of common data models
- Common command set
- Messaging infrastructure which allows different systems to communicate through a shared set of interfaces

Where:
United States of America

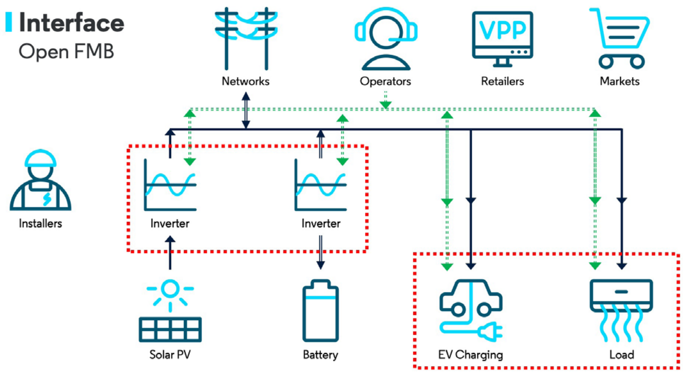
Who it applies to:
It is particularly noteworthy for inverter, equipment and hardware manufacturers, as well as software developers.

Why is this important?
This standard is in early formation and will be interesting to watch in coming years.

Status:
The project team represents all kinds of players within the smart grid industry including Duke Energy, who are moving very quickly to develop standards in this space. Using real-world use cases, they plan to rapidly move into standards testing by 2020.

Related standards:
N/A

Learn more:
Open Field Message Bus (OpenFMB)



Common information model (CIM) IEC 61970 and IEC 61968

What:
IEC 61970 describes the components of a power system and the relationships between each component. The IEC 61968 extends this model to cover other aspects of the power system data exchange. These two standards collectively are known as '**the CIM for power systems**'.

So what does that mean?
Essentially this standard defines an information model that helps to map the whole network so that information between systems and assets is fully compatible. Yes, you read that right... the whole network. This standard covers:

- Value parameters
- Data collection from different applications
- Messaging between applications
- The interfaces and architecture for distribution management systems (DMS).

Where:
Global

Who it applies to:
Network utilities, software providers and aggregators

Why is this important?
The CIM can be broadly applied to enterprise integration and related information exchanges between systems including but not limited to energy management systems (EMS), demand management system (DMS), planning, energy markets and metering. Some industry comments noted that the CIM is not able to support interactions such as demand response and transactive energy service provision (retail / aggregator provided services).

Status:
This standard is currently under revision. Major upcoming changes include the introduction of new classes to support flexible naming of identified objects and single line diagrams exchange.

Related standards:
There are calls for this standard to closely align to IEC 61850.

Learn more:
IEC 61970
IEC 61968

IEC 61850

Communication networks and systems in substations

What:
Initially this focused on substation automation. Over time the standard has evolved to cover other aspects of the distribution systems including DER that can connect to the grid.

So what does that mean?
The standard covers the common way of representing energy related data types such as the price of energy, metering data, DER and circuit breakers. This information model covers:

- Communication requirements for functions and devices
- Basic communication structure for substation and feeder
- Common data classes
- Specific communication service mapping
- Conformance testing
- Part 7-420 defines a standard DER logical device, its nodes and data objects

Where:
Global

Who it applies to:
Network utilities, software providers and aggregators

Why this is important:
This standard is well established and widely adopted across Europe and adoption is growing in the United States. It is the main information model for distribution-level assets to facilitate communication between them and SCADA systems. There are well established certification processes and labs to support its adoption.

Status:
Operational and currently being updated, with an expected publication date of March 2020.

Related standards:
Used and referenced in other standards, including:

- SunSpec
- IEEE 2030.5
- IEEE 1815-2012 (DNP3)
- OpenADR

Learn more:

- IEC 61850 on gegridsolutions.com
- IEC 61850 on IEC.ch

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