Introduction

Welcome everyone – great to see such a good turnout.

I'm Wilf Johnston vice chair at Sustainable Energy Now and I'll be your MC for this evening.

This is a deepish dive into one aspect of the question "Can Renewables Run the WA Grid " and we can learn from the Iberian Blackout.

Whilst the talk tonight will focus on technical aspects, there are also wider lessons to be learned on politics, social science and the misinformation and disinformation circulating long after the event itself.

Emergency Response

In the unlikely event of an emergency, you may need to evacuate following the Whoop-Whoop sound, please follow the direction of security. Fire exits are the rear and front of the auditorium - the designated assembly area is to right as you leave the building

Acknowledgement of country

- We acknowledge the traditional custodians of the land (Boodja) we are meeting on, the Whadjuk people.
- We recognise Whadjuk people's connection to Country as we come together to talk about ways that we can address the climate crisis that significantly impacts country
- We recognise elders past and present
- We recognise that sovereignty was never ceded

Year in Review

It's been a very productive year for us, with over 770 attendees to our events this year (not including this one), a 25% increase in members and a 50% increase in LinkedIn followers.

We have a new committee in place for 2026, and I'd quickly like those that were able to attend to stand up (Fraser, Aria, Caroline, Zara, Paul, Armaan & myself)

As a 100% volunteer-based organization, I'd like to give a quick round of applause for those who have given their time to SEN in 2025, and those who will in 2026!

Introducing Fraser Maywood

I'd like to introduce SEN's chair Fraser Maywood – Fraser tells me he graduated in 1981 in electrical and electronic engineering from Robert Gordon's Institute of Technology in Aberdeen and has forgotten anything he may have learnt last century.

Please welcome Fraser to the lectern for a primer talk.

Fraser's Presentation Notes

<Intro Slide>

Thanks Wilf. This primer is intended for the general public who are interested in the energy transition but perhaps uncertain on the limits to what renewables can do in a larger grid.

It's a primer for Carlos's presentation so people have a basic understanding so they can follow the story.

The presentation will be available via SEN's website so you can go back and review it later

It is NOT intended to be comprehensive or address ALL aspects of the energy transition

Thanks to Craig Carter who commented on the presentation - all mistakes are mine alone

<Click What's the bare minimum you need to know?>

Poles and wires – how hard can it be?

Energy objectives are Supply Security, Affordability and Environmental Impacts

The WA State Electricity Objectives expand on these to provide greater guidance and introduce a capital efficiency test on reliability.

<Click WA Grids>

We have two main grids in WA : the North West Interconnected System and the South West Interconnected System. They are not interconnected nor connected to the east coast networks – this includes potential access to the East Coast's long duration electricity storage.

There is however no strong business case for interconnecting the SWIS and NWIS, nor the SWIS and the National Electricity Market.

We have multiple micro grids across the state – most are islanded, i.e. not connected to the main grid, and some that can connect and disconnect from the main grid to improve reliability.

<Click Demand Forecast and Energy Mix>

Security of supply – do we have enough energy now and into the future and what does the energy mix need to look like to ensure we don't have what the industry calls "unserved energy"

Energy Policy WA and the Australian Energy Market Operator both produce forecasts to help shape government policy, public and private investment.

Forecasts are nearly always wrong. The trick is to forecast frequently.

Demand forecasting and energy supply are part of energy modelling which takes into account a range of factors including the nature of weather variable renewable energy.

Modelling by EPWA, AEMO, SEN and others highlight that flexible, dispatchable generation is required with sufficient reserve capacity and short and long duration energy storage.

One area that is not fully reflected in energy models is the generation, storage and supply of industrial heat as we decarbonise industry via electrification.

Implicit in making models work in practice are things like weather forecasting, demand management, energy efficiency, storage, advanced technologies and AI that smooth and firm VRE.

As a past energy minister like to remind us there is no transition without transmission … what they were a bit slower on was the planning and funding for sufficient transmission.

Here in WA, we are currently in a race to see if we can build sufficient transmission and replacement generation to enable timely coal closure.

<Click Summer's Day>

Modelling by SEN and others indicate there are times on the WA grid when all the energy can be served by wind, solar and batteries – with gas back-up.

<Click Spring 2025>

The SWIS continues to break records in terms of renewables contribution - the most recent one was on 30th November where RE supplied 100% of demand.

<Click Dunkleflaut>

Renewable sceptics like to point out the sun doesn't always shine and the wind doesn't always blow …

This is not news, and whilst batteries significantly extend the range of solar, it does serve to highlight that energy planning needs to consider inter-seasonal, inter-annual and inter-decadal forecasts so demand can be met at all times - not just on average

This diagram from SEN's modelling shows the impact of a wind drought combined with low solar output over the course of a winter week.

The key take away is that large scale renewables require large scale back-up.

<Click What is Electricity>

Electricity is an electromagnetic wave (like radio, light, microwaves).

Electric field vectors are shown in red and Magnetic field vectors in blue.

To dispel an idea much loved by politicians – electrons are not green and they tend to drift rather than flow.

<Click Generators, Transmission, Load>

These are the main building blocks in a grid – generation, transmission and load.

Loads consist of large industrial loads and multiple commercial and residential appliances consuming energy.

Power transformers step-up the voltage to make transmission more efficient and step-down transformers are used to serve the distribution network and for connecting large industrial loads.

Circuit breakers are designed to interrupt the flow of electricity either as normal switching or as protection when breakers trip to isolate faults and equipment.

<Click Key Terminology>

If you've ever bought rooftop PV the suppliers assume you know your AC from your DC and what a hybrid inverter is.

The grid runs on alternating current as does your house. Your EV uses DC storage in batteries and usually AC motors to drive the wheels.

These are some of the common terms and how they relate.

Power is volts x amps and energy is the amount of power generated or consumed over a period of time (kWh, GWh etc).

<Click Grid balance, Generation and consumption, frequency control>

One of the main grid challenges is managing a stable frequency as load and generation fluctuate.

The amount of supply must match the amount of demand at all times.

In the diagram, an excess of supply represents more weight on the supply end of the balance, tipping the see-saw in the direction that increases system frequency. If there is undersupply (or demand increases suddenly) frequency falls.

Power systems need inertia to provide time to respond to supply / demand changes. Armchair experts were quick to point out that the Iberian blackout was caused by insufficient inertia in the system due to too much renewables. The actual story is much more complicated and nuanced as Carlos will explain.

Inverter based resources, like wind solar batteries, can produce synthetic inertia using power electronics and control algorithms to inject or absorb power during a disturbance to help stabilize the grid's frequency.

Low frequency oscillations are a feature of grids and caused by faults or imbalance between supply and demand. Grid design includes means to dampen these oscillations using Power System Stabilizers or power oscillation damping controllers in inverter-based resources.

Undamped oscillations can become sustained and grow and threaten the stability of the power system and can lead to blackouts.

<Click Protecting the grid when things go wrong >

Grids are very dynamic environments and have to be robust to manage a large operating envelope. Faults can arise from a variety of sources as noted.

We need to be able to quickly and effectively distinguish between normal operation, including operating at the upper limits of equipment's rated capacity, and fault conditions.

This is the job of protection relays that needs to be quick, accurate, reliable, selective and stable throughout the operating envelope.

One signature of a fault is high fault current which traditional large thermal generators can produce. There are other ways of detecting fault conditions such as differential current, distance relays (using voltage/current to find location via impedance), and analyzing impedance changes.

Inverter based resources (wind, solar, batteries) produce lower fault current but can be programmed to detect and respond to faults.

Grids need to be able to operate normally under fault conditions by isolating faults, and not have a fault propagate throughout the system. Inverter based resources can be programmed to have 'fault ride through' to provide robustness and to avoid similar equipment responding inappropriately to a fault and have an avalanche of trips under a common mode failure scenario.

This is a picture of a synchronous condenser (SynCon) that emulates large generators by providing fault current, inertia and voltage support. They are like large electric motors, don't burn fuel and can be used in larger grids with high contribution from inverter-based resources.

<Click Voltage Stability … Weak and Strong Grids>

"Electrical system strength" is a catch-all term for a combination of physical parameters that describe how well a power system can maintain voltage and frequency stability following a disturbance.

Wind and solar farms (or other generation assets) can't always be connected to strong parts of the grid due to suitable physical locations, land use, environmental approvals, network constraints etc.

Long transmission lines can lead to weaker grids

Grids can be strengthened by introducing additional equipment such as battery energy storage, synchronous condensers (SynCons), and static compensators … and / or configuring inverter-based resources as grid forming rather than grid following which I'll explain later.

Voltage stability is dynamic and system response changes under various operating conditions, such as disturbances, load variations, and equipment failures.

A key point is that voltage stability (unlike frequency control) is needed locally. This involves generating or absorbing reactive power which I'll explain later.

<Click Grid Following vs Grid Forming>

Grid-following inverters synchronize with and inject current into an existing grid. They are unable to operate independently when disconnected from the grid in islanded mode. A battery and hybrid inverter can still operate to power your house if the grid goes out.

Grid-forming inverters create their own voltage and frequency to control the grid, enabling islanded operation, "black start" capability and increased stability.

They can however be unsuitable in stiff grids that have high strength that resists changes in voltage and frequency.

Many modern inverters are capable of switching between modes to adapt to grid conditions.

<Click Reactive power>

There are three main different types of load: resistance, inductance and capacitance.

These cause a change in the phase angle between the Voltage and Current waveforms. Voltage is shown in Red and labelled U and Current is shown in Blue and labelled I which stands for **current** or **intensity**

The predominant type of load locally in a grid determines the type and amount of reactive power required.

As we noted previously we need the right amount of reactive power in the system to maintain grid and voltage stability and this is created and adsorbed locally in the grid using a range of equipment such as capacitor banks, syncons, static VAR compensators or statcons, shunt reactors and also changing transformer settings online.

< Open Cycle Gas Turbine vs Combined Cycle>

You may have heard the term OCGT and CCGT

In an open cycle gas turbine, the fuel is burnt in a combustion chamber which expands across the turbine blades, turns the turbine and generator. The heat generated is then vented to the atmosphere.

In a combined cycle gas turbine, some of that heat is recovered to convert water into steam that drives a steam turbine and generator.

Open cycle gas turbines are generally less efficient but are quicker to start-up, easier to turn down and are generally more flexible operationally.

<Summary>

Demand forecasting and modelling in context leads to insights on the required energy mix

This leads to ensure there are sufficient generation, storage & auxiliary resources in the system with adequate monitoring, control and protection systems

And the need for a plan, funding and resources for the energy transition

There needs to be competent resources dedicated to keeping large complex systems operating correctly and to also manage the energy transition

It’s not unlike spinning plates.

Carlos Gamez Introduction by Wilf

Thank you Fraser.

I'd like to introduce Carlos Gamez.

Carlos founded Nova Energy Consulting in 2022 and brings more than 27 years experience across the energy, asset management and digitalisation sectors.

Carlos served as Head of Asset Performance at Western Power where he was instrumental in the enablement of the transformation of the grid whilst meeting the objectives of the in-service network.

As a published author, Carlos has contributed ideas that help shape the future of the electrical energy industry.

Please welcome Carlos to the lectern to discuss the root causes behind the Iberian blackout and the lessons we can learn for the WA energy transition.

Carlos Gamez Presentation

About the Panellists and Slido

Many thanks' Carlos for that engaging and informative presentation.

Audience questions will be tabled using the Smart Phone App SLIDO using the QR code or meeting number shown - questions can be upvoted and we will be answering the most popular questions first.

I'd like to introduce two additional panellists to join Fraser and Carlos on stage for audience Q&A.

Liz Aitken is the Principal of Empire Carbon & Energy, a seasoned energy and carbon specialist with 25+ years' experience helping industrial and mining clients transition to lower-cost, lower-carbon energy through renewable power and strategic carbon markets, and navigating complex Australian energy and carbon regulation.

Steven De Clerck is the Chief Operating Officer at Collgar Renewables where he is responsible for operations & maintenance of 222 MW Collgar Wind Farm as well as delivery of Collgar's new renewable energy projects. In a previous life, Steven was Engineering Manager on Marinus Link and responsible for interconnecting Belgium and Germany with HVDC

Please welcome Liz, Steven, Carlos and Fraser to the stage.

Backup Questions

1) We have seen misinformation thrive recently. There was a recent survey that spoke of ⅔ of community supporting renewables, but the same people only thought 40% of their neighbours agreed. Any thoughts on how we can do better?
2) Historically, wind has been the lowest cost RE per MWh, with an output profile that aligns better to when the energy is needed. As wind construction costs increase, and battery storage costs reduce, at what point does solar+storage take over?
3) In a recent Energy Insiders podcast, an interviewee was concerned that power engineers were not across a lot of the grid forming capability of the latest power inverters. Do you think this is an obstacle to advancement?

Wrap Call to Action

Thanks to everyone for turning out and the great questions.

Get informed – sign-up to Pete Milne's newsletter and support independent journalism

Get organised: support join or start a group … like SEN !

Talk to your family, friends and neighbours

Contact your State and Federal MPs – they need to hear first hand and often your views on the urgency of the energy transition

Thanks everyone and good night.