Flexibility Challenges and Opportunities

Lachlan Blackhall

Entrepreneurial Fellow and Head, Battery Storage and Grid Integration Program

The Australian National University

Acknowledgement of country

I acknowledge and celebrate the First Australians on whose traditional lands we live and work, and pay my respect to their elders past and present.

Who Am I?

- Previously
  - CTO and Co-Founder of Reposit Power (VPP Software and Systems).
- Currently
  - Head, Battery Storage and Grid Integration Program.
  - Independent Chair of the Interoperability Steering Committee (ISC).

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BSGIP
Materials, Battery Technologies and Characterisation

BSGIP
Energy System Control and Coordination

Battery Storage and Grid Integration Program

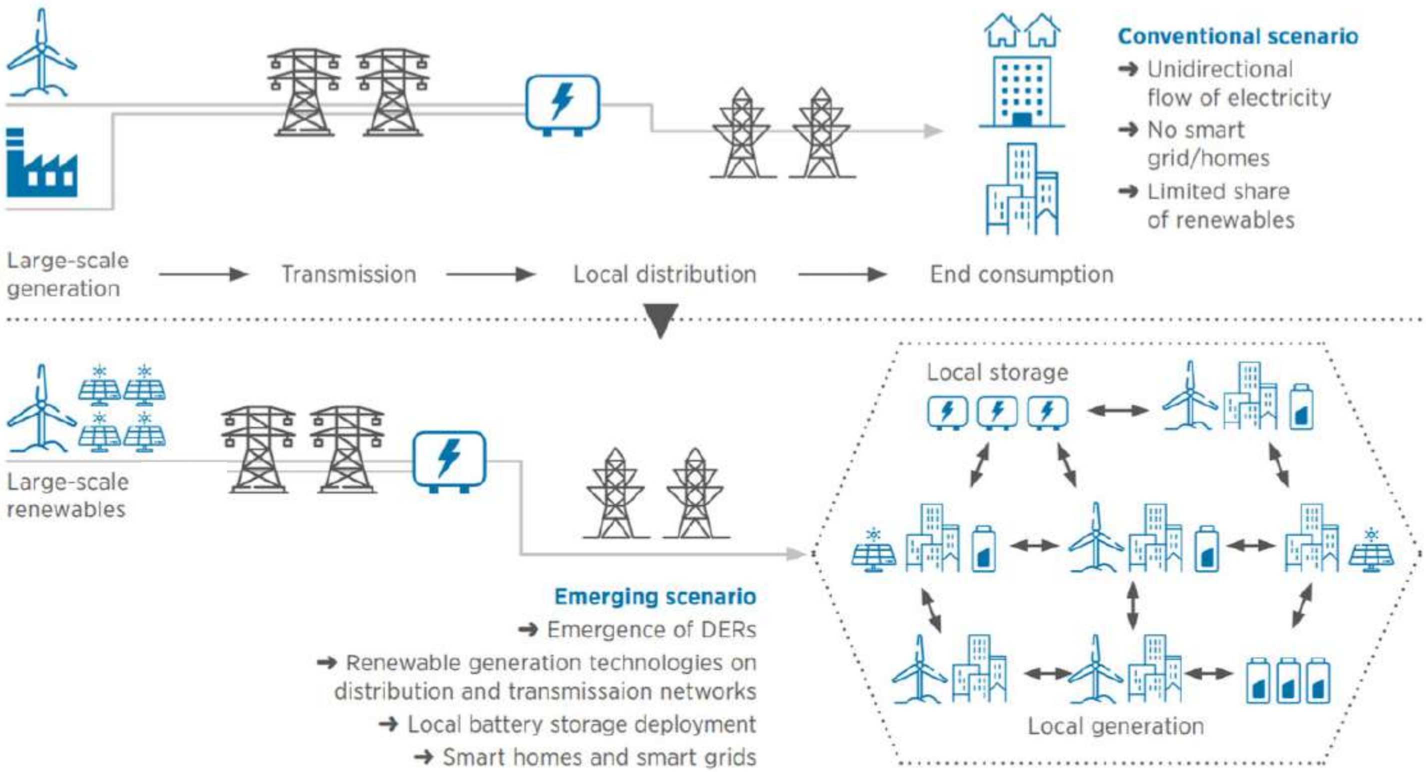
BSGIP
Energy System Modelling and Analysis

BSGIP
Social Science, Economics and Policy

Interoperability Steering Committee

- Formed in 2021 to provide independent technical advice to support DER integration and interoperability.
- Membership includes market and regulatory bodies and industry groups.
- Employs subject matter experts and a secretariat who undertake the work of the committee.
- Has become central to DER integration and interoperability in Australia.

Our Future Electricity System



https://www.irena.org/-/media/Images/IRENA/Infographics/2019/Feb/Innovation-Landscape---Distributed-energy.jpg

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Why Flexibility?

Operating the Electricity System (@30,00ft)

- System Requirements
  - Energy Reliability (Supply = Demand)
  - Energy Security (Stability)
- Network Physical and Operational Limits
  - Voltage Limits
  - Thermal Constraints
- ***We achieve these operational requirements by controlling energy assets.***

Flexibility

- The shift to renewable and distributed generation and storage changes the point(s) of control in the system.
- Flexibility is simply about ensuring we have *enough controllable assets* to achieve the operational requirements.
  - Does not require all assets to be controllable (i.e. some assets will remain passive).
  - Does require an understanding of ‘enough’ in various scenarios.

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Flexibility Building Blocks

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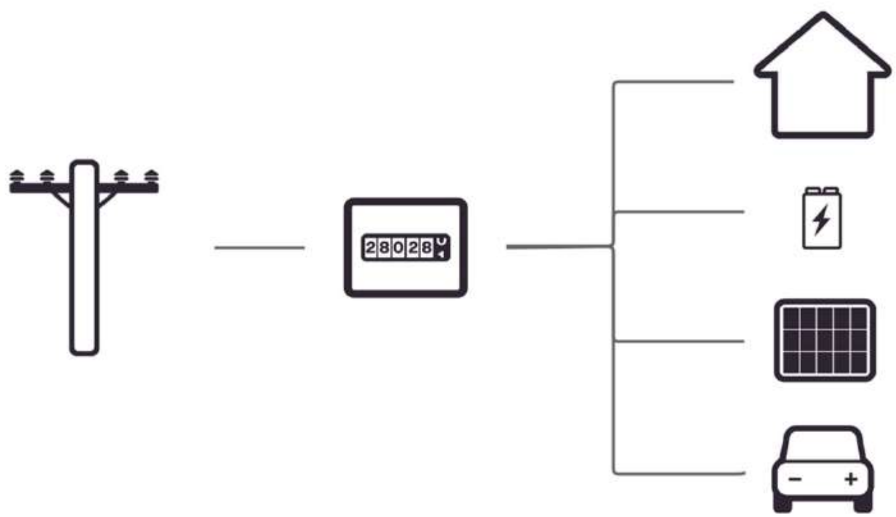
Flexibility Building Blocks

- Device Standards (Physical Response)
- Communications and Data (Visibility)
- Orchestration and Coordination
  - Setpoints; or
  - Envelopes and Incentives.
- Policy

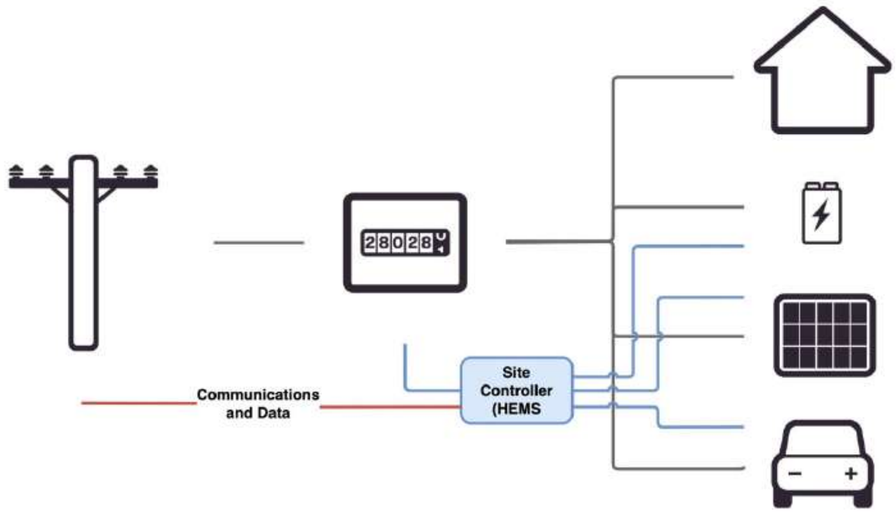
Device Standards

- The inverter connection standard is AS/NZS 4777.
- Emerging use of AS/NZS 4755.
- These technical standards define the physical response of an asset.



Communications and Data

- DER integration using IEEE2030.5.
  - CSIP-AUS + Testing Guide
  - Both via Home Energy Management System (HEMS) and Direct to Device.
- EV integration using OCPP + CSIP-AUS
- Utility scale assets integrated using Scada (DNP3).
- ***A Site Controller Performance Standard is needed to link device standards and communications protocols.***



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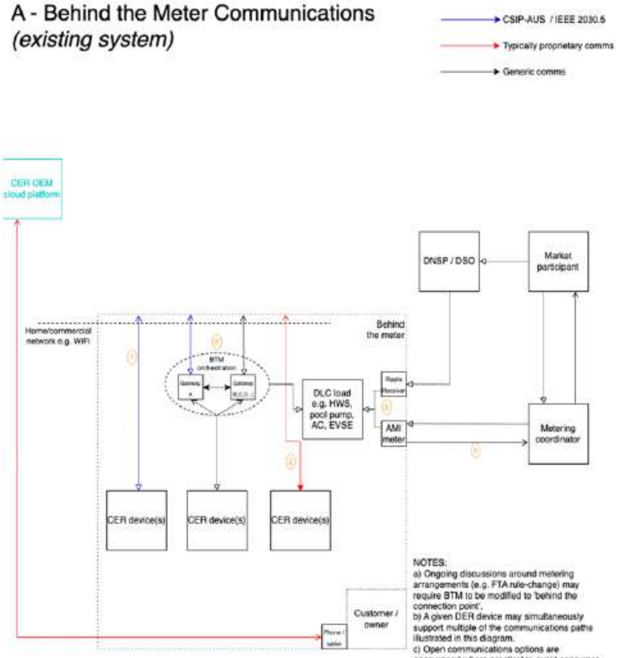
DER Reference Architecture

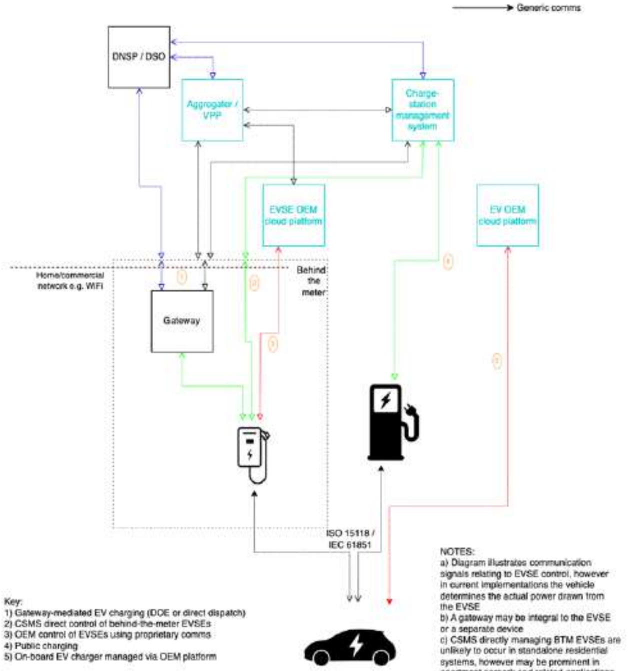
A - Behind the Meter Communications *(existing system)*



Key:
1) CSIP-AUS native device comms
2) Gateway BTM comms (many options, including SunSpec Modbus, IEEE 2030.5 / CSIP-AUS, DNP3, MQTT, OpenADR, OPC, etc.)
3) Proprietary device comms (e.g. vendor/cloud control) which may also include firmware upgrades.
4) Metering data
5) DNSP- or market-driven direct load control e.g. off-peak hot water.

NOTES:
a) Ongoing discussions around metering arrangements (e.g. FTA rule-change) may require BTM to be modified to 'behind the connection point'.
b) A given DER device may simultaneously support multiple of the communications paths illustrated in this diagram.
c) Open communications options are encouraged where practical to avoid consumer lock-in and enable churn.
d) A given site may include one or more gateway devices (e.g. HEMS, site controllers etc.) that may intercommunicate, and manage disparate CER (ideally in a coordinated fashion for the consumer's benefit).
e) Several of the followning diagrams refer to a "BTM System"; this diagram describes the detailed comms flows that can occur within a BTM system on those architectures, including e.g. the presence or absence of gateways etc.

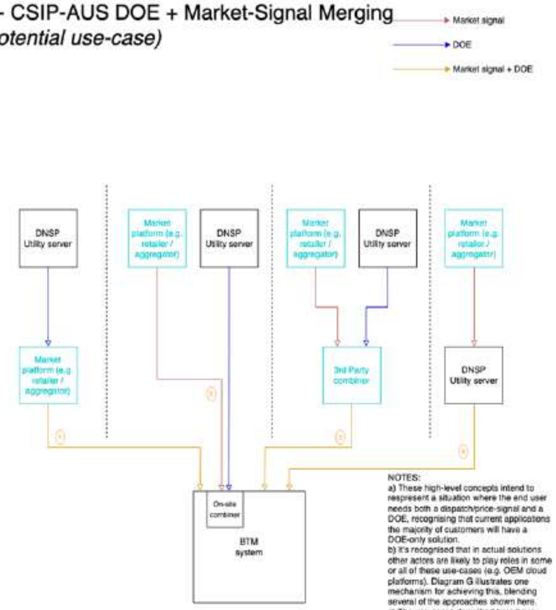
B - Electric Vehicle Smart Charging *(existing system)*



Key:
1) Gateway-mediated EV charging (DOE or direct dispatch)
2) CSMS direct control of behind-the-meter EVSEs
3) OEM control of EVSEs using proprietary comms
4) Public charging
5) On-board EV charger managed via OEM platform

NOTES:
a) Diagram illustrates communication signals relating to EVSE control, however in current implementations the vehicle determines the actual power drawn from the EVSE
b) A gateway may be integral to the EVSE or a separate device
c) CSMS directly managing BTM EVSEs are unlikely to occur in standalone residential systems, however may be prominent in apartment carpark and related applications

E - CSIP-AUS DOE + Market-Signal Merging *(potential use-case)*



Key:
1) Market platform DOE pass-through
2) On-site signal combining
3) Third-party signal combining
4) DNSP DOE pass-through

NOTES:
a) These high-level concepts intend to respresent a situation where the end user needs both a dispatch/price-signal and a DOE, recognising that current applications the majority of customers will have a DOE-only solution.
b) It's recognised that in actual solutions other actors are likely to play roles in some or all of these use-cases (e.g. OEM cloud platforms). Diagram G illustrates one mechanism for achieving this, blending several of the approaches shown here.
c) The use-cases described here have been deemed technically feasible under IEEE 2030.5 & CSIP-AUS, however they may not all be suited to the Australian market & regulatory environment.
d) DOE signals are supplied by a utility server; these do not have to be operated by a DNSP/DSO, however the values are likely to be sourced from a DERMS or similar system operated by the relevant DNSP.
e) While these use-cases describe DOE limits alongside market-signals intended to influence the dispatch of CER, operation of devices will be influenced by other exogenous factors including consumer behaviour and third-party signals.

Orchestration and Coordination – Setpoint Control

- Centrally calculating setpoints for all distributed assets is impractical. Requires
  - Vast amounts of real-time data.
    - Low communications latency.
  - Knowledge of behind the meter preferences.
  - Data sharing between the system and distribution network operator (complicated!).

Orchestration and Coordination - Envelopes and Incentives

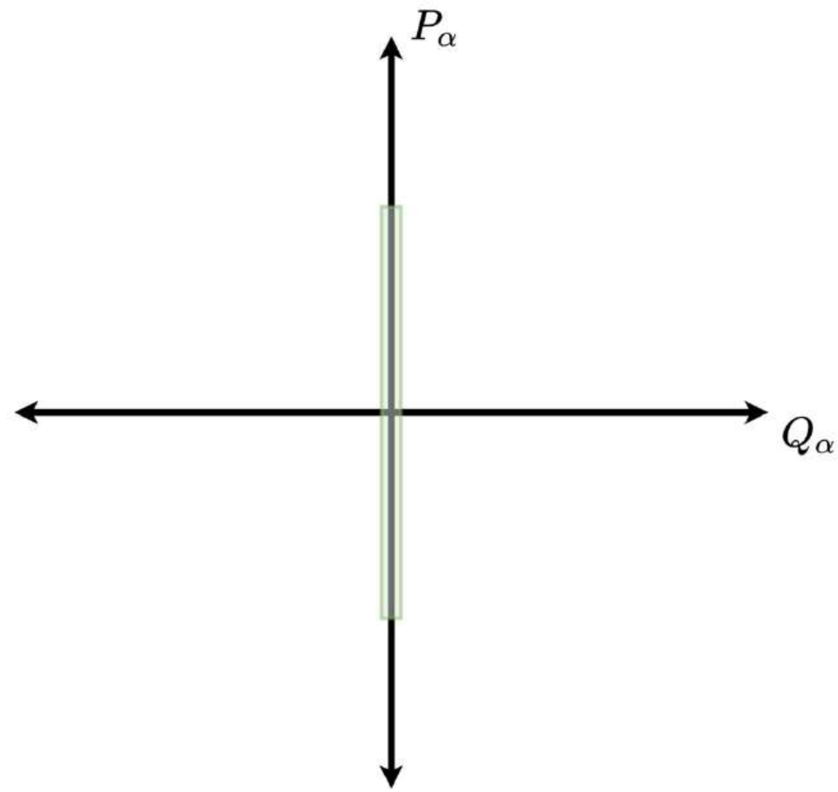
- It is possible to separate network capacity management from the flows of energy in the network and manage them separately.
  - Network capacity is managed via Dynamic Operating Envelopes (DOEs).
  - Energy flows are managed / incentivised through energy markets and network services contracts or markets.

Dynamic Operating Envelopes

- In a given time interval, a dynamic operating envelope (DOE) is a principled allocation of the available hosting capacity to individual or aggregate connection points that guarantees that the physical or operational limits of the network and system are not breached.
- The physical or operational limits of the network and system can be due to:
  - Thermal limits
  - Voltage limits
  - Minimum demand (system security constraints)
- Operating Envelopes are to be published per connection point and can be aggregated up in aggregation zones. An aggregation zone corresponds to a collection of assets that are located ‘behind’ the same binding constraint.

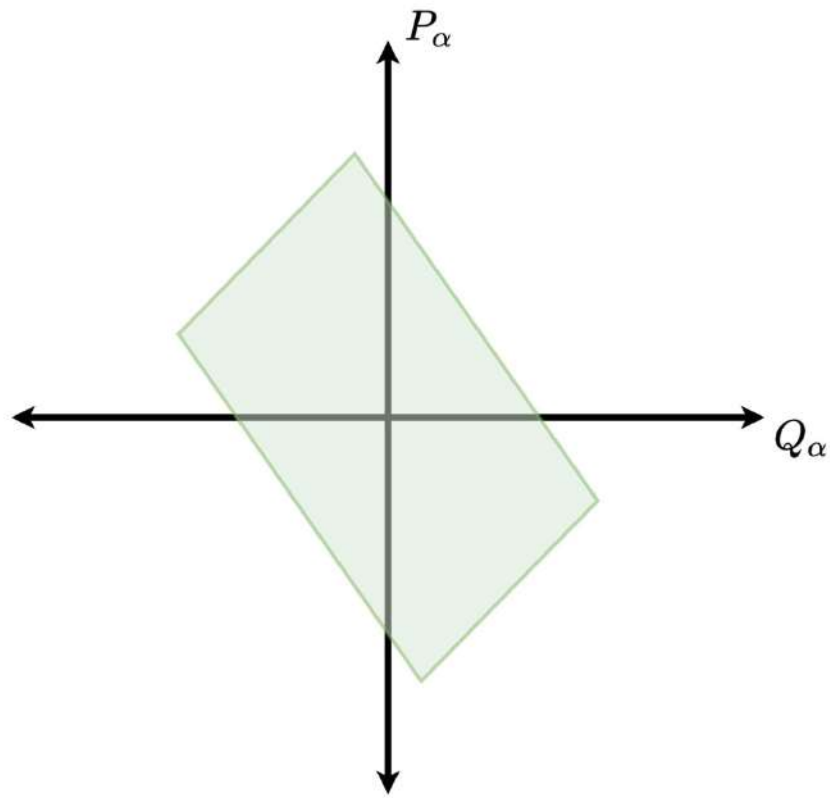
Dynamic Operating Envelope

An illustrative operating envelope for an individual DER asset or connection point that only provides real power.



Dynamic Operating Envelope

An illustrative operating envelope for both real and reactive power that would arise at an individual node when both network voltage and thermal constraints are considered jointly.

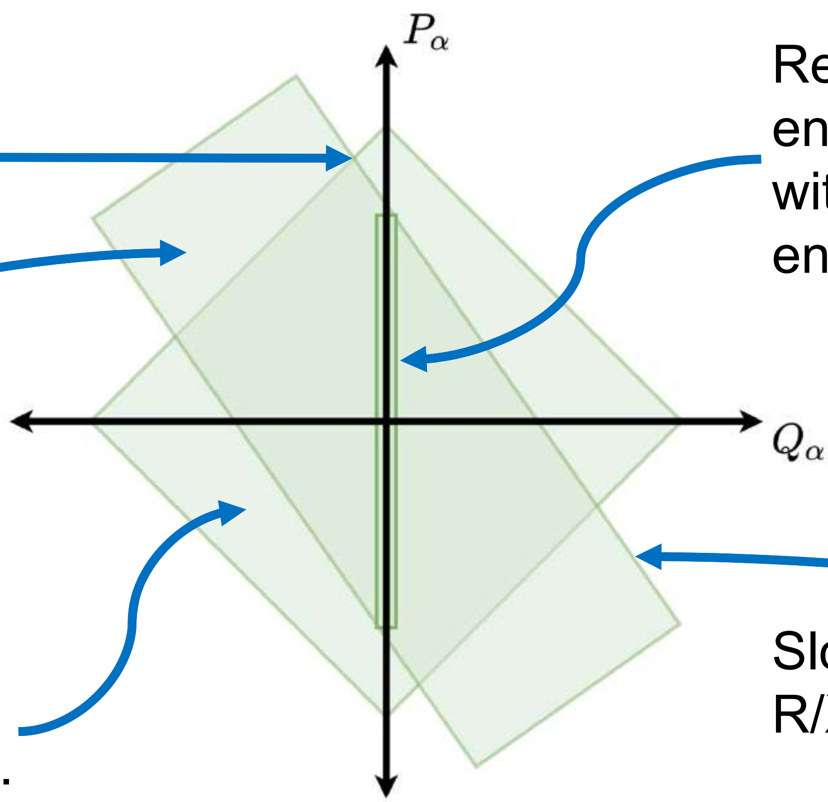


Dynamic Operating Envelope

Envelope definition admits local Watt / Var compensation to increase real power import and export.

Feasible region based on voltage constraints.

Feasible region based on thermal constraints (affine).



Real power operating envelope contained within general operating envelope definition.

Slope is a function of R/X ratio for the network.

DOE Projects in Australia

- Project evolve – Original DOE demonstration Project
  - https://arena.gov.au/projects/evolve-der-project/
- Project Symphony - DOE calculation Engine for Western Power
  - https://arena.gov.au/projects/western-australia-distributed-energy-resources-orchestration-pilot/
- Converge - Shaped Operating Envelopes for Evo Energy.
  - https://arena.gov.au/projects/project-converge-act-distributed-energy-resources-demonstration-pilot/
  - https://arena.gov.au/assets/2022/09/der-market-integration-trials-summary-report.pdf
- Project Edith - DOE and Dynamic Pricing Engine for Ausgrid.
  - https://cdn.ausgrid.com.au/-/media/Documents/Reports-and-Research/Project-Edith/Project-Edith-2022.pdf

Policy

- Technical capabilities without policy will result in over engineering.
- Policy without technical capabilities is unachievable.
- There needs to be clear, outcomes based policies - design and implementation follows outcomes.
- Outcomes must incorporate householder and community perspectives (social licence).

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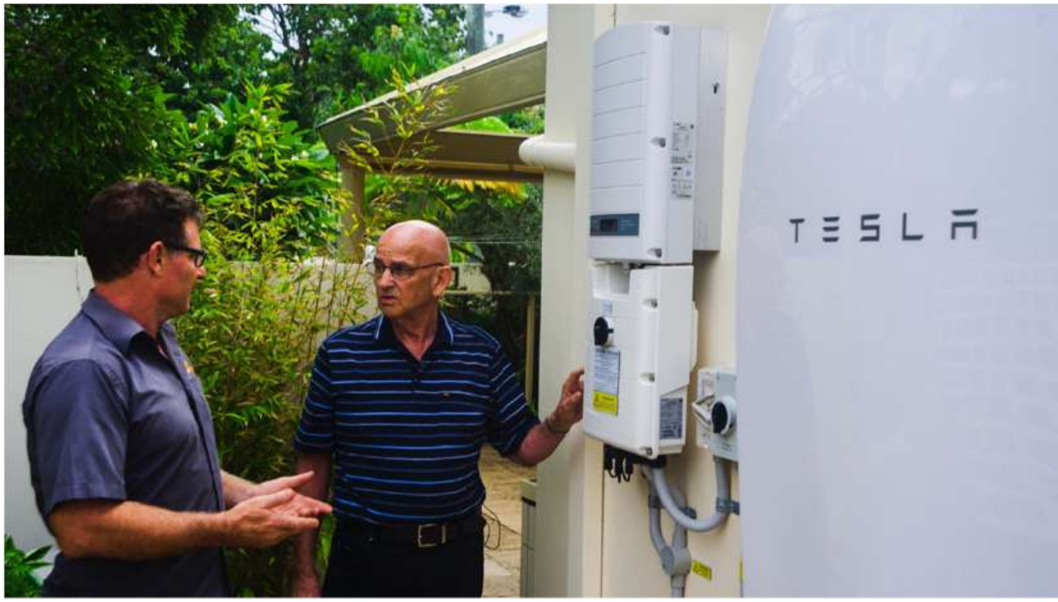
Asset Specific Flexibility Considerations

Solar

- Uplifting passive solar to active solar is important.
- DOEs provides important capabilities to prevent challenges caused by solar reverse flows:
  - Minimum demand
  - Voltage limits

Storage

- DOEs encourage time shifting of energy at zero economic cost.
- DOEs are considered critical for enabling community and neighbourhood batteries in Australia.



EV

- V2G is not ready!
- Managed charging is a critical flexibility capability.
- DOEs underpin managed charging for EVs.

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Lessons Learned

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Flexibility Lessons Learned in Australia

- Physics always wins.
  - $$$ can’t change physics.
- Flexibility mechanisms need to be explainable, understandable, and staged.
  - Simple is better if possible.
- Capability uplift takes time.
- Need to understand the difference between markets and transactions.
- ***Important to collaborate globally!***

Thankyou

Lachlan Blackhall

lachlan.blackhall@anu.edu.au

+61 412 946 126

Battery Storage and Grid Integration Program

The Australian National University

Canberra, Australia

bsgip.com