Battery Storage and Grid Integration Program

5 Year Impact Report

Australian National University

Supported by ACT Government

The Battery Storage and Grid Integration Program acknowledges, celebrates and pays respect to the Ngunnawal and Ngambri people of the Canberra region and to all First Nations Australians on whose traditional lands we meet and work, and whose cultures are among the oldest continuing cultures in human history.

The Battery Storage and Grid Integration Program is generously funded by the ACT Government through the Renewable Energy Innovation Fund initiative, the Australian National University, and through project funding from various industry partners and grant bodies.

Australian National University

Supported by

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Contents

Introduction

Established in 2018 as an initiative of the Australian National University, with the generous support of the ACT Government, the Battery Storage and Grid Integration Program (BSGIP) undertakes socio-techno-economic research, development and demonstration activities to support the global energy transition and help achieve economy-wide decarbonisation.

The Program celebrates its fifth birthday in 2023. Since its inception in 2018, the Program has grown exponentially to over 50 staff and students with diverse academic, industry, gender and cultural backgrounds. The Program has deliberately built a diverse, multi-disciplinary team with broad expertise that includes engineering, chemistry, computer sciences, physics, economics and the social sciences.

Work within the Program encompasses detailed disciplinary work on components or subsystems, but also focuses on how we integrate these together into the broader energy system.

At the component level, we are conducting basic research into future battery chemistries, and optimisation scenarios for new devices and storage technologies. Armed with this understanding we identify, design and implement new capabilities, systems, technologies, and operating models to underpin our future decarbonised and resilient energy system. This integration work is acknowledged as the grid integration challenge. Solving the grid integration challenge is fundamental in ensuring a successful energy transition and achieving our decarbonisation goals.

13 BSGIP staff & student countries of birth

9 BSGIP babies

45% Percentage of BSGIP leadership team who identify as female

50+ Staff and students

Our approach to our work is through translational research and development activities, simultaneously advancing the body of knowledge and advancing the practice in the field. This practice is characterised by a path from deep and foundational research contributions to being able to have impact on industry and the community at large. Our research, development and demonstration activities are also deeply interdisciplinary, informed by, built on, and extending disciplinary expertise. We work closely with industry, government and other researchers on projects based in specific locations or areas, with a broad focus on global impact through an approach we term, from local to global.

Over the past five years we have deepened the Program's research capabilities across all four research themes:

BSGIP
Materials, Battery Technologies and Characterisation

BSGIP
Energy System Control and Coordination

BSGIP
Energy System Modelling and Analysis

BSGIP
Social Science, Economics and Policy

BSGIP has demonstrated significant impact in Australia and internationally as a key partner in the ACT Government's efforts to maintain Canberra as a centre for world-class battery storage and grid integration research, commercialisation, business development and usage. BSGIP has strong roots in the ACT and a focus on having significant impact in the ACT as well as nationally and internationally. Our work includes current and emerging projects that are developing, deploying, and managing vital pieces of energy infrastructure, including solar, batteries, electric vehicles, and electric buses.

BSGIP has successfully leveraged our initial grant from the ACT Government's Renewable Energy Innovation Fund (REIF) to attract a further $18 million in project funding, and is involved in key national projects worth over $120 million with more than 40 partners. With our partners we have led on national energy transition issues through research, knowledge sharing, developing policies and standards, and deployment of tools and software platforms.

I am delighted to share with you some examples of our impact in this report celebrating our first five years of operation. I would like to take this opportunity to sincerely thank the ACT Government for their generous and ongoing support of our Program, and I look forward to our future collaboration. I would also like to thank our project partners past and present. In particular I would like to thank the Program's staff and students, who have dedicated themselves to our mission and vision and produced the impressive outcomes we celebrate within this report. I am very proud of the work we do, the impact we have had, and look forward to the impact we will continue to have into the future.

Professor Lachlan Blackhall
Entrepreneurial Fellow and Head,
Battery Storage and Grid Integration Program.

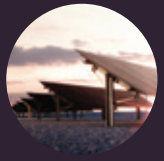
The Battery Storage and Grid Integration Team, 2022.

Timeline

2018

- 3 April 2018 – BSGIP commences operating
- Engagements in China, Singapore, Taiwan, USA, and Germany
- Delivered 50 presentations
- > 20 industry partners
- Construction commences on labs

2019



- 30 staff and students
- Advisory board established
- Teaching in Engineering and Chemistry
- 10 journal publications
- Raised >$7M in additional funding

2020

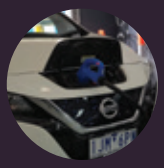
- Working with >24 industry partners
- 6 submissions to national consultations
- Evolve project demonstrates the first dynamic operating envelope results for real network models and data (in QLD)
- 6 webinar events, 35 presentations, 17 seminars
- 42 staff and students

2021

- 13 publications
- Launched Battery Lab and DERLab
- BSGIP's research into neighbourhood batteries makes the cover of Nature Energy
- 50+ staff and students
- Raised ~16M in additional funding
- Contributing to national projects worth >119M with >30 partners

2022

- Involved in key national projects worth over $120 million with more than 40 partners
- BSGIP recognised with seven awards
- Delivered evolve and REVS projects, impactful research and development of real-world DER integration
- BSGIP technology deployed in 6 networks in 4 jurisdictions
- 18M in additional project funding



Projects

National

Community energy modeling, Customer-focused network management, Distributed Energy Integration Program (DEIP) Interoperability Standards Committee & Dynamic Operating Envelope Working Group, My Energy Marketplace, Grid-scale battery storage, EV-ready grid project, Sodium-ion and potassium-ion batteries, Hybrid energy storage, Benchmarking lithium-ion battery electrode materials, multi-energy system modelling for decarbonising agriculture

QLD

evolve

NSW

Southcoast u-grid Reliability Feasibility Study (SuRF), RouteZero, evolve

ACT

Realising Electric Vehicle-to-Grid Services (REVS), Converge, ANU Below Zero initiative, Jacka Community Battery Analysis, Big Batteries Concept Design Workshop, Picomu, Suburb Zero, evoEnergy EV Grid project

TAS

TasNetworks EV Grids, TasNetworks DSO strategy

WA

Project Symphony (in Perth), Broome Community Engagement with Horizon Power

VIC

Neighbourhood Battery Initiative, Yarra Energy Storage Systems, New Energy VOICES,

40+ Partners

18M Funding raised

30+ Projects

Impact Theme 1: Socio-Techno-Economic Systems

The distributed energy resources (DER) that will underpin the global energy transition include many technologies that will be funded by consumers and installed in their homes and streets, including rooftop solar PV, electric vehicles, and residential and neighbourhood battery storage.

It is therefore in the governance of this transition that we find some of the most challenging questions of our time, requiring technologists and social scientists to collaborate for the public good. At BSGIP, this **socio-techno-economic** approach and set of capabilities underpins everything we do.

Jemena Dynamic Electric Vehicle Charging Trial

A residential electric vehicle trial involving 176 EVs in the ACT, Victoria and Tasmania. The trial is extending the technology developed in the evolve project to support TasNetworks and Evoenergy by managing the electric vehicle charging in their respective networks.

Project Converge

Announced in December 2021, this $8.4 million project is exploring the grid participation of DER in the ACT. Partners include evoenergy, Zepben and the ACT Government. The project is exploring new ways to utilise smart software, rather than building more poles and wires, essentially allowing greater penetration of renewable energy into the national electricity market.

Converge is demonstrating the next evolution of dynamic operating envelopes, called 'shaped operating envelopes'. Shaped operating envelopes have the ability to optimise real-time control of DER assets. The technology aims to create financial benefits for people who own their own solar panels, batteries and/or electric vehicles, by enabling better access to energy trading markets. Converge also includes a comprehensive social science research investigation to better understand the perspectives of electricity users and market participants, and seeks to understand how public values such as 'efficiency' 'fairness' 'environmental stewardship' and 'reliability' can be integrated into technology design.

Yarra Energy Storage Systems (Fitzroy North Community Battery)

BSGIP is using its expertise in energy algorithms to develop and deploy a software package for Australia's first inner-urban community battery, a 110 kW/284 kWh system in Fitzroy North in Victoria. The project, led by the not-for-profit organisation Yarra Energy Foundation and working with electricity network CitiPower, aims to demonstrate the operational and commercial viability of a community battery model in an inner-urban setting.

Drawing on the Program's expertise, BSGIP has developed software that determines how to best operate the battery to serve the local community according to financial constraints and community-led input. The software underpins how electricity is tracked from rooftop solar panels to the battery and how and when it is discharged from the battery back to customers. BSGIP also collaborated with battery manufacturer Pixii and energy aggregator Acacia Energy to coordinate the operation and performance testing of a second smaller system installed in the DERlab in Canberra.

The battery was unveiled by the Victorian Minister for Energy, Environment and Climate Change, Lily D'Ambrosio on World Environment Day, 2022.

Project Edith

In 2022, BSGIP was chosen by Ausgrid as the key research and development partner for Project Edith. Project Edith, named after the first female engineer Edith Clarke, aims to showcase how the grid can facilitate technology and green energy solutions to participate in energy markets while staying within distribution network capacity limits.

Supported by BSGIP's dynamic operating envelopes and utility server solutions, Project Edith is exploring the use of dynamic network prices. Ausgrid and BSGIP are jointly developing a dynamic pricing engine to generate dynamic prices for different locations under different network and weather conditions. The rapid prototyping phase between June 2022 and March 2023 was successfully completed and the project is now moving into a phase of rapid scaling to more customers, more CER (customer energy resources) agents and more Distributed Network Service Providers.

ANU Below Zero Initiative

BSGIP is working as a key pillar of the ANU Below Zero Initiative, leveraging approaches and capabilities developed through our research and projects to support decarbonisation, including grid integration, modelling, and socio-techno-economic systems theory.

Using a detailed understanding of the sources of emissions at ANU and our expert understanding of emerging technology solutions, BSGIP is developing and demonstrating unique decarbonisation approaches and capabilities that can be scaled and replicated to accelerate decarbonisation in the ACT and across Australia.

Melbourne's first inner city community battery, the Fitzroy North Community Battery was launched in June 2022. Photo credit: Matt Krumins

Feature 1: Realising Electric Vehicle-to-grid Services (REVS)

Accelerating the integration of electric vehicles into the National Electricity Market through an Australian-first fleet demonstration combined with social-technical-economic research.

The Australian transport sector is currently a major source of pollution, contributing approximately 20 per cent of Australia's total greenhouse gas emissions. Electric vehicles (EVs) are an increasingly important mode of transport with the potential to substantially reduce emissions of greenhouse gases and other toxins.

Alongside lowering emissions, there is a second, substantial benefit to the uptake of EVs in Australia. EV batteries have the ability to accelerate Australia's energy transition by boosting energy security.

EV batteries are large – roughly five times larger than household batteries, and when fully charged they typically store about as much energy as an average household uses over two to four days. The national fleet of EV batteries could play a vital role by providing grid support services.

The Realising Electric Vehicle-to-grid Services project, or 'REVS', demonstrated the feasibility of EVs instantly discharging their batteries when the national grid needs extra power.

The trial consisted of 50 ACT Government EVs and one ActewAGL EV, making it the largest demonstration of vehicle-to-grid (V2G) services in Australia to date. The cross-sector project looked at the entire electricity and transport supply chains and created roadmaps and recommendations to deploy V2G technology at a national scale.

In particular, BSGIP sought to discover what makes V2G attractive to customers, manufacturers and service providers. The ANU team of engineering, social, and economic researchers worked to understand the full range of opportunities and barriers of V2G services.

The BSGIP team published eight ARENA knowledge sharing reports, with topics including:

- testing of the bi-directional charger in the DERlab
- the economics of V2G under current and emerging market structures, and
- social research on fleet managers and EV technology innovators.

The demonstration side of the project was also completed in 2022, with vehicles and chargers in place and actively enabled to provide frequency support during upcoming contingencies. The consortium's hard work getting the first bi-directional charger to be compliant with Australian regulations is now facilitating further installations in one (soon to be many) distribution networks.

"REVS calculates market growth will see almost 16 million passenger vehicles of all types on the road in 2040. Even if only 10 per cent – or about 1.5 million – of those vehicles were V2G capable and providing 11 GW of dispatchable storage, then that could potentially offset more than $6 billion in grid investment. That, in turn, would lower the cost of electricity."

→ ARENAWIRE

BSGIP Key Statistics (2018 – 2023)

25 Reports delivered

2 Specialist laboratories

28 Published papers

70+ International engagements

49 Public seminars

7 Awards

First electric vehicle chargers now on campus: The Acton campus is home to the University's first electric vehicle (EV) chargers, including a bi-directional charger used for testing in the REVS trial. ANU Vice-Chancellor, Professor Brian Schmidt and Dr Bjorn Sturmberg, BSGIP Research Lead.

Impact Theme 2: Grid Integration

Electrification is gaining momentum as a pathway to economy-scale decarbonisation, but it is only one piece of the puzzle. The key to effective decarbonisation will be the integration of all of these new generation, storage, and transportation technologies into our electricity system.

Grid integration requires capabilities that allow these new technologies to talk to each other and work together. These integration capabilities encompass new systems, algorithms, and technical standards, a vitally important contributor to beneficial integration outcomes.

Effectively integrating all of these technologies into our electricity system will also be a key enabler for achieving more resilient infrastructure and communities. Renewable and distributed energy generation and storage can underpin microgrids and neighbourhood energy systems that ensure that communities continue to have access to energy during volatile weather and natural disasters.

Grid integration modelling and utility software

BSGIP is working to progress the state-of-the-art in modelling and analysis to understand the behaviour and performance of energy systems characterised by a high penetration of renewable and distributed generation and storage. We are working to develop new capabilities, algorithms and systems that allow for the effective optimisation, control, coordination, and orchestration of multi-energy systems.

BSGIP's foundational project in utility software to support integration was *evolve* (see Feature on page 12). Following the success of *evolve*, BSGIP's dynamic operating envelope (DOE) and shaped operating envelope (SOE) technology is now being deployed in four further pilots by networks in four Australian jurisdictions. In the future there are plans for further demonstrations with deployment in at least six of Australia's networks, increasing system scale, demonstrating the ability to build capabilities on top of evolve through other projects and more joint research and commercial opportunities.

DEIP - The Distributed Energy Integration Program

DEIP is a collaboration of government agencies, market authorities, industry and consumer associations work together to maximise the value of customers' distributed energy resources (DER) for all energy users. One of the major achievements of the Program was an implementation guide enabling technology systems, devices and software to "talk to each other", released in August 2021. The Common Smart Inverter Profile (CSIP) – Australia (otherwise known as the Australian Implementation Guide for IEEE2030.5) is a set of guidelines for the management of DER in the electricity system that enable interoperability. CSIP also includes a common understanding of what information will be shared, the format for the information and how it is to be used among network and system operators.

The CSIP publication marks the culmination of over two years of collaboration and work between industry, R&D organisations and market and regulatory bodies including the Australian Energy Market Operator, ARENA, the Australian Energy Market Commission, the Australian Energy Regulator and the Australian National University, facilitated through DEIP.

My Energy Marketplace

Energy monitoring, previously the domain of network service providers, is now being provided by innovative technology companies like Wattwatchers. The My Energy Marketplace (MEM) project, led by Wattwatchers, involves the Australia-wide deployment of smart energy devices in 5000 homes and small businesses, as well as 250 schools, to allow energy data to be monitored in real time.

As a project partner, BSGIP has successfully developed methods for estimating power flow and voltage levels across all points in a distribution network. The method can be used by smart software to intelligently enable the coordinated integration of increasing amounts of solar, batteries and electric vehicles into our electricity networks, with a minimal number of monitoring devices and therefore minimal cost.

Grid-scale batteries

BSGIP and renewable energy company Neoen are investigating the services grid-scale batteries can provide to accelerate Australia's energy transition. BSGIP is analysing the impact grid-scale batteries have had so far, with the goal of understanding whether these batteries are being installed where and how they are needed. Ultimately, this project will inform the policies and reforms required to best utilise and promote the installation of grid-scale storage.

RouteZero

A pilot project to drive down emissions in public transport and heavy transport, the $36 million project consisted of Australia's largest electric bus fleet (40 buses), charging infrastructure and a retrofitted bus depot in Leichhardt, Sydney.

As part of this multi-partner project, BSGIP collaborated with energy consultancy Zenobe and electricity transmission network operator Transgrid to create an analytics platform called RouteZero, which assessed the feasibility of electrifying bus routes and bus depots under Australian conditions.

Hornsdale Power Reserve, SA. Credit: Neoen.

Feature 2: Evolve

At its essence, the multi-award winning project Evolve is a software solution that implements contemporary customer preferences, integrating and maximising distributed energy resources (DER) into existing electricity networks. It is Australians who are choosing to pay for the installation of solar panels on their rooftops. The evolve platform is enabling better integration of these precious resources, collectively the largest generator of energy in Australia, to safely enter the electricity market.

Australia is at the forefront of distributed energy resources integration techniques due to our uniquely high rooftop solar uptake. This has created a need to control and coordinate the huge influx of DER entering our electricity grid. In response, BSGIP and technology company Zepben led the ARENA-funded evolve project, launched in February 2019.

The evolve project was the largest collaboration of distributed network service providers (DNSPs), technologists, aggregators, academia and government ever assembled. The $13 million, award-winning project sought to increase network hosting capacity and maximise the participation of DER in energy, ancillary and network service markets, ensuring the secure technical limits of the electricity networks were not breached.

In 2020, the evolve project demonstrated the first dynamic operating envelope results for real network models and data in Queensland. In 2021, two major pilot projects spun out from the research: in Western Australia, state-owned Western Power initiated Project Symphony, and in the ACT, Project Converge, led by evoenergy. Both projects build on the evolve solution and the use of dynamic operating envelopes to support the integration and market participation of DER. Since the completion of the evolve project in 2022, the software developed as part of the project has been used in numerous multi-million dollar renewable energy-based projects across Australia.

BSGIP learnings from the evolve project also assisted and contributed to the Distributed Energy Integration Program's Dynamic Operating Envelopes Workstream: Outcomes Report. The work continues to generate global interest as other countries start to face the issues associated with high DER uptake. All project reports from evolve are now available online through the ARENA Knowledge Sharing Hub.

evolve

Project Symphony

BSGIP is the lead technology partner for Western Power on Project Symphony, a two-year pilot project announced in December 2021. Project Symphony is a $35.5 million project, funded by the Western Australian State Government, the Commonwealth Government as part of ARENA's Advancing Renewables Program, and the Australian Energy Market Operator.

Project Symphony allows customer DER assets like rooftop solar, batteries and major appliances to be orchestrated as a virtual power plant (VPP) to participate in a future energy market, unlocking greater economic and environmental benefits for the WA community. The pilot is being conducted in the Perth region of Southern River, one of Perth's top solar districts, where almost 50 per cent of households have rooftop solar. It is orchestrating the DER of around 500 WA homes and businesses.

Awards – Engineers Australia

Engineers Australia Canberra Excellence Project Award, project winner for *evolve*

Sir William Hudson Award, Engineers Australia National Awards, finalist for project *evolve*. This award recognises Australia's top engineering projects and the teams behind them.

Impact Theme 3: Energy Futures

BSGIP's work in Energy Futures represents an interdisciplinary understanding of energy systems. We focus on how people and social systems interact with technology, economics, regulation and policy to shape Australia's energy future.

We are particularly interested in energy justice, responsible research and innovation, value sensitive design and energy democracy – anticipating issues, building concerns into technology design, and informing public policy. We are also focused on governing energy transitions, including integration of DER, how publics are imagined and considered, and how different imaginaries of the future grid materialise in funding, technology design, regulation and public policy.

Community energy models

BSGIP's first in-depth analysis into community energy modelling, and the precursor to our work with neighbourhood batteries. This ARENA-funded project analysed community energy models from a technical, regulatory, economic and social perspective, identifying a range of ownership and operation models. Findings, available on the ARENA website, include the following:

Community batteries:

- Can be cheaper than household batteries, due to economies-of-scale.
- Can allow more solar energy to be installed in the suburbs, increasing hosting capacity
- Can bolster local resilience, including socially, economically and electrically, and
- Can increase the cost effectiveness of battery storage by servicing many customers and markets.

Award

Engineers Australia Canberra Excellence Project Award, Highly Commended for Community Energy Models project.

Neighbourhood-scale batteries

BSGIP is at the forefront of worldwide research into neighbourhood-scale batteries, which have the potential to address energy equity and provide benefits to all energy users. BSGIP has undertaken a number of ground-breaking projects into neighbourhood batteries, providing guidance to government and a broad range of stakeholders into the viability of this new form of technology.

In addition to the above project the Battery Storage and Grid Integration Program conducted the following related projects:

- Engaging the Broome community on a proposed community battery project for Horizon Power.
- Cost benefit analysis into different community battery scenarios for the ACT Government.
- Neighbourhood Battery Initiative, see feature on page 16

Microgrid communities

The feasibility of microgrids is being explored in a transdisciplinary project to bolster energy resilience of residents in the NSW south coast shire of Eurobodalla. The Southcoast Microgrid (µ-grid) Reliability Feasibility (SµRF) project, funded by the Federal Government's Regional and Remote Communities Reliability Fund is modelling the use of renewable energy, including household, commercial and community solar, and small- and medium-scale batteries to provide power independent from the main grid.

The project will deliver a methodology for co-designing microgrids with local stakeholders based on results from co-design processes undertaken in the Eurobodalla, as well as innovative governance models for managing microgrids and addressing regulatory and policy barriers and opportunities. These will be based on studies into technical performance and opportunities for eight grid-tied microgrids in the Eurobodalla and an associated eight feasibility business cases and implementation plans.

Customer-focused network management

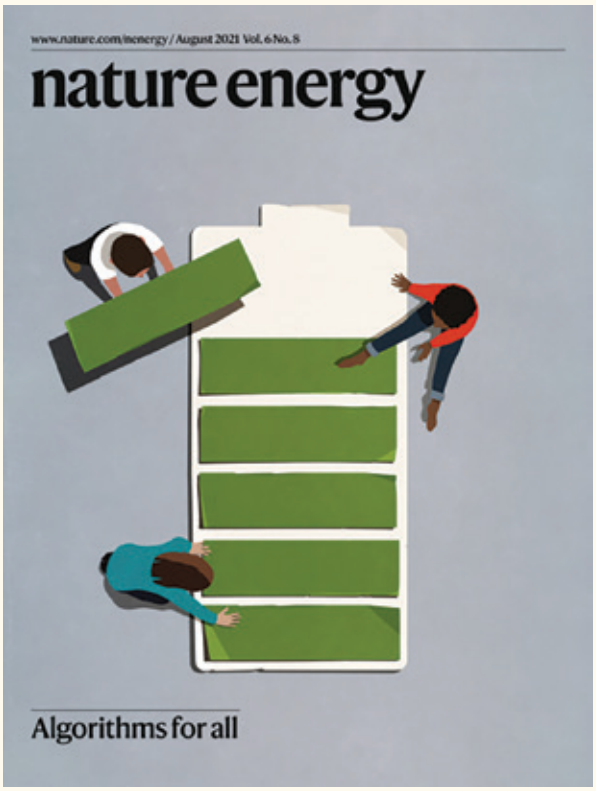
Funded by Energy Consumers Australia, this project aims to build a new model for including consumers earlier in energy system change processes. It does this by using value sensitive design: a way of integrating diverse and not easily quantifiable values into design processes.

Researchers facilitated focus groups and undertook document analysis to understand industry and consumer values before embarking on a design process to develop a set of value-responsive "vignettes" or stories. Vignettes describe what would happen to the energy system if we emphasised different values. These were taken back to consumers to understand their perspectives and refine these stories. Finally, the findings and the process used to generate the findings, were presented to industry.

New energy VOICES (Victorian energy and water Ombudsman Investigation into Consumer Experiences)

Research conducted in this project assisted the Energy and Water Ombudsman in Victoria to consider its future jurisdiction and operational focus and assist policymakers to ensure that the Victorian consumer protection frameworks, designed to safeguard householders, remain fit-for-purpose. Research also informed potential new areas of energy complaints that will arise as new energy products and services are developed and adopted.

The project focused on household experiences with new technologies including solar panels, batteries, electric vehicles, virtual power plants, microgrids, home energy management systems and peer-to-peer trading.



BSGIP's ground-breaking socio-techno-economic research into neighbourhood batteries made the cover of the August 2021 edition of the prestigious international journal 'Nature Energy'. The paper considers citizen preferences to develop six battery algorithms.

Feature 3: Neighbourhood Battery Initiative

BSGIP hosts Australia's pre-eminent researchers in neighbourhood-scale batteries, and has been engaged for the past few years in a partnership with the Victorian Government Department of Energy, Environment and Climate Action (DEECA) under their Neighbourhood Battery Initiative.

Neighbourhood-scale batteries will contribute significantly to energy system transformation in Australia. This medium-scale form of storage is defined as having capacity in the range of hundreds to thousands of kilowatts and is located 'in front of the meter' (between households and the electricity grid).

Neighbourhood batteries have the potential to provide a range of benefits to communities and the energy system, including balancing supply and demand, increasing network capacity for renewables, postponing network upgrade investments, enabling community energy self-sufficiency and sharing, and lowering electricity prices. As well as indirect benefits in creating models for participatory governance, building community and increasing the diversity and resilience of the energy system.

Neighbourhood batteries can store energy from rooftop solar panels during the day for use when it is needed in the evening (this is sometimes called 'solar soaking'). Other storage options, like big batteries and pumped hydro, can also help with this; but neighbourhood batteries could do this near where the solar is produced, which is more efficient than sending it away to be stored. A neighbourhood battery, which could store the solar power from dozens of rooftops, is also more efficient than every house having their own battery. What's more, it could make this local renewable energy available to people who can't have their own solar panels.

BSGIP developed a framework and guidelines for the development and implementation of neighbourhood batteries as part of the Neighbourhood Battery Initiative. The research conducted through this project extended beyond technical and economic aspects of energy technologies to consider a range of social dimensions, including public participation, distributional issues, accountability and democracy, and environmental dimensions, including decarbonisation, energy and resource use, and lifecycle impacts.

This research is transformation-oriented and practical, in not only seeking to understand system changes, but in actively contributing to shifts towards a decarbonised, resilient and just energy system, and in generally seeking changes towards a better future. In this vein, the project aims to open up the concept of neighbourhood batteries to encourage new ways of thinking and acting in an energy policy field that generally conceives of 'value' in narrow terms.

As such, rather than (only) documenting how neighbourhood batteries are being conceived in Australia, (e.g. what drives these technologies, what narratives, values etc underpin them), our focus is also on how we could roll out neighbourhood batteries to better meet communities' complex and diverse needs.

Associate Professor Marnie Shaw, BSGIP and Lily D'Ambrosio, Victorian Minister for Energy, Environment and Climate Change at the launch of the Tarneit Community Battery.

Neighbourhood Battery Knowledge Hub

Launched in February 2023, the Neighbourhood Battery Knowledge Hub is designed to cater for a range of people at different stages of the neighbourhood battery journey. Developed by BSGIP, in consultation with practitioners and policy-makers, these guidelines are informed by research analysis and lessons learnt from battery projects that are being rolled out across Australia.

The Hub is an online resource that includes information on how to design a business model and operating model for your battery (including ownership), technical specifications, project management and governance and tools for evaluating the battery's social, financial and environmental impacts.

BSGIP also launched a Neighbourhood Battery Impact Framework, to assist in the evaluation of models and projects as this emerging technology is implemented.

Access the Hub via the link on the Battery Storage and Grid Integration Program website.

bsgip.com

Tarneit Community Battery, Melbourne.

Battery Materials

BSGIP designs, builds and characterises new battery storage devices, based on a fundamental understanding of different chemical and material behaviours. We also explore opportunities for battery recycling, reuse and failure analysis based on characterisation capabilities.

Sodium-ion & potassium-ion batteries

Research conducted within the Battery lab seeks to discover and improve negative and positive electrode materials for sodium-ion and potassium-ion batteries, two forerunners in the disruptive battery technologies race that could be set to rival lithium batteries. Carbon-based materials, alloying/conversion negative electrode materials and appropriate positive electrode candidates such as layered and polyanionic materials are synthesised and evaluated. Various strategies are employed to understand their electrochemical reaction mechanisms and improve their cyclic stabilities and high rate performance.

Hybrid energy storage

Researchers aim to improve hybrid capacitors, such as lithium-ion capacitors (LICs) and related devices, in two ways. The first group of activities aims to increase energy density of LICs by utilising alternative battery-type negative electrode materials. The second group of activities is focused on creating new, sustainable versions of these devices through the use of sodium chemistry. The battery materials team is actively involved in prototyping configurations of new sodium-ion capacitors that would operate on an analogous principle to LICs. These research activities assist with the development of new energy storage systems with simultaneous characteristics of high power and energy densities.

Dual-ion batteries

BSGIP researchers from the Battery Lab were awarded an Australian Research Council (ARC) Discovery grant valued at $420,000 over three years from 2021, for a project on dual-ion electrochemical systems. The team is exploring new concepts of high voltage batteries and capacitors. In addition to the development of new types of electrochemical cells, significant attention is being given to the advancement of characterisation methods such as liquid cell transmission electron microscopy and x-ray computed tomography of batteries and capacitors.

Benchmarking lithium-ion battery electrode materials

To assist industry the ANU battery team offers comparative assessments of battery electrode materials versus state-of-the-art commercially available standards. The team has vast experience in the synthesis and testing of various materials for lithium-ion batteries and offers services to industry, benchmarking battery materials versus established industry standards. The team can perform characterisation of materials using a range of chemical and physical techniques. Steps involved in studying the feasibility of a material in the battery storage application:

1. Physical/chemical characterisation:

The structure and morphological characterisation studies of the material are performed using various techniques such as X-ray diffraction, scanning and transmission electron microscopy, spectroscopic techniques and low-temperature N2 adsorption.

2. Electrochemical characterisation:

Electrochemical properties of a material are analysed using electroanalytical techniques (galvanostatic charge-discharge, cyclic voltammetry and electrochemical impedance spectroscopy). The properties of the material are studied initially in a half-cell, i.e. against a lithium reference metal, followed by their evaluation in a full cell (against a practical opposite electrode).

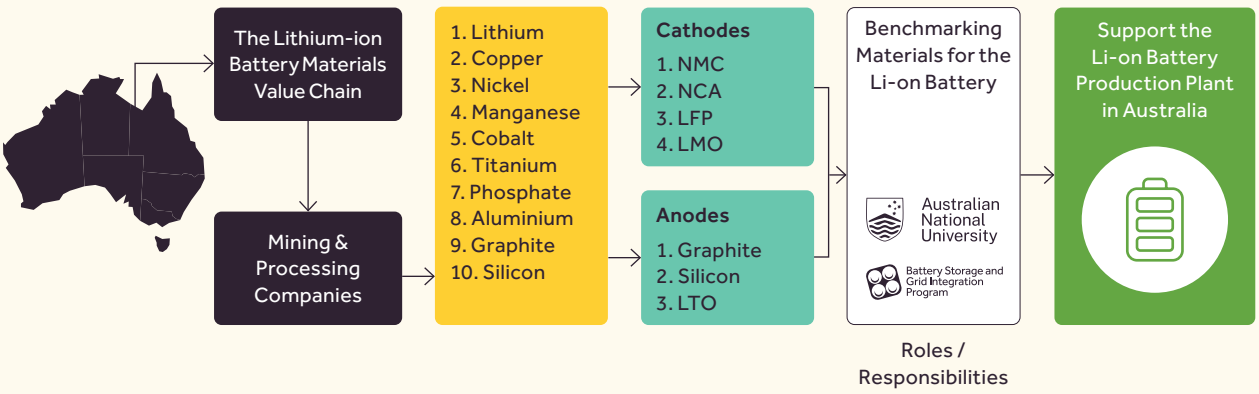
3. In-operando studies:

The phase and morphological transformations of a material during its electrochemical activity may be studied using in-operando X-ray diffraction, transmission electron microscopy or micro-CT analysis.

4. Failure analysis:

The electrode failure analysis is conducted using a broad range of analytical techniques and instrumentation available in ANU laboratories.

Our research activities can assist in the development of the battery materials industry in Australia. These activities are a part of a broad research program enabled by the ANU Battery Lab.



Laboratories

The Battery Storage and Grid Integration Program hosts two world-class laboratories enabling cutting-edge research to optimise power systems and explore the next generation of batteries. Both facilities launched in 2021.

Battery Lab

Launched in February 2021, The Battery Materials and Energy Storage Laboratory (the Battery Lab) is advancing research in lithium-ion batteries, optimising their enabling materials, providing characterisation, and testing and assessing sustainable, next-generation batteries.

Lithium-ion batteries are becoming a dominant storage technology in a whole spectrum of applications, ranging from the next generation grid to electric bikes and drones. According to predictions by Bloomberg New Energy Finance, the lithium-ion battery market will be worth USD $116 billion annually by 2030. Considerable research and development efforts are concentrated on testing various types of lithium-ion batteries and recycling battery cells or reusing them for their "second life". The Battery Lab will engage in working in these important areas as well as in providing insightful characterisation of battery materials and cells.

It is not clear however, if the dramatic expansion in the use of batteries can be sustained by lithium-ion battery technology alone. A feasible strategy is to complement the use of lithium-ion batteries with alternative battery storage solutions that utilise more sustainable materials and chemical elements.

This national facility enables research into new battery storage technologies including lithium-ion, sodium-ion and potassium-ion batteries, hybrid capacitors and supercapacitors. The Battery Lab supports the characterisation, development and performance testing of battery materials, electrolytes and devices.

The facility is hosted within the Research School of Chemistry at ANU.

Inside the Battery Lab

DERlab

Launched in July 2021 the DERlab (Distributed Energy Resources Laboratory) is a state-of-the-art facility that mirrors the electricity grid. The lab provides a failsafe environment in which to rapidly, efficiently and securely develop and test technologies and systems before deploying them into the live grid.

Open to industry and researchers, the lab allows for the safe testing of new technologies such as monitoring and communication devices, smart controllers, aggregation (e.g. virtual power plant) and market participation software and other innovative new products under development, in a multi-platform environment that simulates real-world conditions prior to roll-out.

The DERlab represents an important national facility for collaborative development and testing of new capabilities to support the operation of 21st century electricity systems.

Previously, the only way to test the interaction of DER with the grid was to install devices in the live grid, often in customers' properties. This is costly and laborious.

Critically, the grid mostly operates under conditions that do not expose devices to system-critical extremes, which are becoming increasingly dependent upon the behaviour of DER. Not testing devices under these extremes creates real physical and reputational risks.

The DERlab overcomes these limitations by providing a fail-safe testing environment. The lab simulates a distribution network that can be brought to a user defined operating state and into which users can connect a collection of commercial and custom devices.

Users can test the communication and control functionalities of their devices; interrogate the integration and interaction of multiple devices; and explore the system dynamics of DER devices operating under ordinary and extraordinary grid conditions.

The DERlab has been made possible by the investment of $1.5 million from the ACT Government's Priority Investment Program. Partners include ITP Renewables, evoenergy and UNSW Canberra.

"The new Distributed Energy Resources Laboratory cements Canberra's position as the national leader in renewable energy innovation and collaboration...the facility will unlock new opportunities around renewable energy capability that will ultimately translate into new investments, economic growth, lower energy bills and new jobs for Canberrans."

→ ACT CHIEF MINISTER ANDREW BARR, SPEAKING AT THE DERLAB LAUNCH

Launching the DERlab, ACT Chief Minister Andrew Barr and ANU Vice-Chancellor Professor Brian Schmidt.

Outreach

The Battery Storage and Grid Integration Program focuses on doing things that haven't been done before. We believe that great things can only be achieved by working in conjunction with others and our outreach program aims to inform and educate by building energy literacy. But most importantly we strive to provide a sense of agency by bringing others along on the energy transition journey with us.

In order to bring our research to life, we collaborate with a wide range of partners on social, technical and economic issues relating to battery materials, energy storage and energy systems. Over the course of the past five years the Program has partnered with 43 + partners. As part of Australia's National University and generously funded by the ACT Government, we have an obligation to engage with the community and to share our research. We do this through a range of targeted outreach activities, providing expert advice to national, and state-based consultations; contributing to the public debate by engaging with the media, and hosting our own events and tours on campus.

Key statistics

- 18 Policy submissions
- 10 E-newsletters
- 23 Thought leadership media articles
- 9 Press releases
- 250 More than 250 presentations
- 4 Partnerships with grassroots community groups

BSGIP and ARENA hosted the 'DEIP Dive' 2022 (Distributed Energy Integration Program) on campus in September 2022.

Event highlights

- **Suburb Zero ACT launch event.** The Program hosted the public launch of a grassroots movement within Canberra.
- **DEIP Dive 2022:** BSGIP and ARENA welcomed to ANU close to 150 guests from industry, academia & government to discuss the integration of electric vehicles and other distributed energy resources.
- **The future of neighbourhood batteries in Australia.** In a first-of-its-kind conference, energy experts from across Australia converged at ANU to consider national approaches to this nascent form of technology.
- **Converge – enabling greater integration of rooftop solar into the grid.** Shane Rattenbury, Minister for Water, Energy and Emissions Reduction, and a panel of experts introduced this new project via on online webinar.
- **DERlab launch: new lab replicates electricity grid.** Andrew Barr, Chief Minister for the ACT, officially unveiled a new facility at ANU, heralding in a new age in the energy transition.
- **Battery Lab launch:** advancing research in lithium-ion and sustainable, next gen batteries.

Policy submissions

The Program has provided advice and evidence to 18 consultations by Australian Federal and state government departments, the Energy Security Board, Australian Energy Market Operator, Energy Networks Australia, the Australian Energy Market Commission, and the Australian Energy Market Regulator.

Presentations

Over the past five years, the Program has convened and participated in several significant national and international discussions and workshops on the pressing challenges of decarbonisation and grid integration.

In its first year of operation, the Program made over 50 presentations including in China, Singapore, Taiwan, and the USA. In its second year it made a similar number including notable international presentations such as the Global Energy Solutions Summit (USA), the International Clean Energy Forum, and China New Energy Chamber of Commerce (China). The COVID-19 pandemic hit in our third year of operation, but over the past three years Program experts have continued to deliver hundreds of presentations to projects partners, research institutions, funding bodies and energy regulators. BSGIP experts also presented at a number of international and national conferences.

BSGIP public seminar series

The BSGIP seminar series has covered a range of topics from vehicle-to-grid technology, energy storage, community-owned utilities, energy efficiency, caring for distributed energy resources, and justice in energy transitions.

In 2020 the BSGIP seminar series successfully transitioned online, originally due to the COVID lockdown. The transition to online proved so successful however that the decision was made to keep the seminar series online because of the benefits it affords, such as regularly hosting international speakers and extending our audience to those who may be interested. BSGIP online seminars are advertised via our social media channels and attract up to 60 participants per seminar.

BSGIP hosted the public launch of Suburb Zero ACT in April 2023 to a sold out audience of 600 people. L to R: Saul Griffith, author and inventor; Alex Sloan, Deputy Chair of The Australia Institute and David Pocock, Independent Senator for the ACT.

Awards

The Battery Storage and Grid Integration Program was bestowed with seven accolades in 2022 alone. These honours recognise world-leading impact and the depth and breadth of the Program's growth over the course of its initial five-year term.

Professor Lachlan Blackhall receiving the Engineers Australia Canberra Excellence Project Award for evolve

"I'm so pleased to see recognition for such a significant and impactful body of work," said Professor Lachlan Blackhall, Head of the Battery Storage and Grid Integration Program and Entrepreneurial Fellow at the Australian National University. "In terms of the impact of the project, we are now hearing about the interest for the technology pioneered through evolve in the UK. This is in addition to interest and uptake of our ideas in the United States and New Zealand. This is the ultimate recognition of a job well done!"

1. **Sir William Hudson Award, Engineers Australia National Awards, finalist for project evolve.**

   This award recognises Australia's top engineering projects and the teams behind them.

2. **M A Sargent Medal, Engineers Australia National Awards.**

   Awarded to Professor Lachlan Blackhall recognising a highly significant contribution, through technical innovation, to the science or practice of electrical engineering and leadership relating to electrical engineering.

3. **Engineers Australia Canberra Excellence Project Award, project winner** for evolve: smart software for the orchestration of 21st century electricity systems.

4. **Engineers Australia Canberra Excellence Project Award, Highly Commended Award** for a pioneering project on Community Energy Models.

5. **ACT Young Tall Poppy Award,** Dr Bjorn Sturmberg, Research Lead, Battery Storage and Grid Integration Program.

6. **Chloe Munro Scholarship for Transformational Leadership,** from the Clean Energy Council. Awarded to Associate Professor Marnie Shaw, Research Lead, Battery Storage and Grid Integration Program.

7. **Global Undergraduate Award.** A student from the Battery Group, Oliver Hervir, won an international student competition for his research into dual carbon batteries.

Collaborate with us

The Battery Storage and Grid Integration Program undertakes research, development and demonstration projects across the energy ecosystem.

We collaborate with our partners on social, technical and economic issues relating to battery materials, energy storage and energy systems. We focus on doing things that haven't been done before.

Battery Storage and Grid Integration Program

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