This report was collated by Arup in collaboration with the ANU Working Group representing the Facilities & Services Division and the Energy Change Institute. It was supported by work carried out by students of the Energy Change Institute.

Contents

i. Introduction 3

1. Objective 1: A leading energy efficient campus 6

2. Objective 2: carbon positive community with 100% renewable energy 16

3. Objective 3: A technologically enabled infrastructure network 22

4. Objective 4: Independently certified excellence 28

5. Objective 5: A platform for infrastructure innovation 32
Introduction

Flows of energy are essential to functions and services of an environment in which people work, study and live. Energy used on the Acton Campus constitutes a significant part of the energy needs of over 20,000 people and of activities influencing a much greater part of our society.
In making decisions about this environment, the Australian National University (ANU) acknowledges the imperative of reducing Greenhouse Gas (GHG) Emissions. It supports the United Nations 17 Sustainable Development Goals (SDGs). Several of these—Affordable and Clean Energy, Industry Innovation and Infrastructure, Sustainable Cities and Communities, Responsible Consumption and Production, Climate Action—relate centrally to Energy use and are guiding goals for the development of this Strategy.

The current scale of campus energy use—generating approximately 100,000t of greenhouse gases per year—plus projected new major developments, and upgrades in particular to computing infrastructure, as well as the unusual nature of energy use for specialist research applications present challenges in reduction of energy use.

The ‘energy trilemma’ encapsulates the tensions between three distinct aims for future energy systems: (1) maintaining a reliable and secure energy supply, (2) ensuring long term affordability and (3) drastically reducing GHG emissions associated with energy supply.

The ANU can solve this trilemma for the Acton Campus by adapting its energy systems and use to become more flexible, responsive and decentralised, and leverage them for active participation and influence in a future energy market built on intelligent use of renewable energy sources.
The ANU Acton Campus Energy Management Strategy sets out principles, targets and actions to guide continuous improvement in energy management for campus buildings and infrastructure. It provides the detail and background to aspects of the ANU Acton Campus Master Plan and Design Guide relating to energy.

It sets in place five overarching objectives for the campus:
1. Leading energy efficient campus
2. A carbon positive community with 100% renewable energy
3. A technologically enabled infrastructure network
4. Independently certified excellence
5. A platform for infrastructure innovation.

Scenario modelling underlying the strategy and targets has prioritised initiatives by lifetime cost effectiveness in reducing energy use and associated GHG emissions. In a continually changing market and technological context these priorities are likely to shift. Building efficiency targets are tied to legislation evolving in this context, however they will need review and re-evaluation on a regular basis.

The University has annual sustainability reporting responsibilities required by the EPBC Act, Tertiary Education Facilities Management Association (TEFMA), and National Energy and Greenhouse Reporting.
Objective 1: A leading energy efficient campus
The first step to an energy strategy making best use of renewable and sustainable sources is to cut avoidable energy use. Not only does this directly reduce emissions, but it also streamlines the scale of investment—monetary and in embodied emissions, materials etc.—required for transition to clean energy sources. It cuts cost to the University, for energy supply as well as investment in on-campus transmission infrastructure. Efficiency is the hallmark of good design.

Currently, the ANU Acton Campus is the single largest energy customer in the ACT, driven not only by the extent of its facilities but also by energy intensive specialist research applications and high-end computing facilities.

The targets in this section are based on modelling and experience of achievable improvements, but practically achievable reductions for the varied uses on the Campus will need to be investigated on a case by case basis and targets be reassessed progressively. Here lies some of the greatest potential for energy savings with positive investment returns.

Building targets are referenced against the minimum energy performance requirements of the National Construction Code (NCC) Section J. The NCC is regularly updated, and future revisions to Section J are anticipated to reflect advances in technology and drive increasing stringency for new development targets. The extent of stringency increases, and the achievability of improvement targets must be reassessed at the time of such revisions.
A leading energy efficient campus

Strategy:

Energy efficiency design standards for new buildings and upgrades, set to improve building energy use over NCC compliant benchmarks.

Certification and annual energy performance reviews used to achieve improvement targets:

- setting specific energy target within certification schemes—all new buildings to target 40% reduction from NCC compliant benchmark, demonstrated using energy modelling
- target for major refurbishments – design to target 10% improvement over Section J
- integration of Smart monitoring and open source backbone – hold design stage metering workshops on all projects
- all projects will target integration with existing and future Hub central plants
- integrate renewable energy where possible—consider PVs on all new buildings and design roofs to be PV ready where feasible
- new building services to be 100% electric
- carry out Building Air Tightness testing as standard on new buildings
- use Passive House principles to guide design of new buildings.
A leading energy efficient campus

Strategy:

Ensure buildings operate as efficiently as possible.

- Benchmark existing buildings operation against the current NCC Section J compliant energy use, with an additional buffer of 20%.
- Benchmark all new and refurbished buildings in operation against their modelled design target plus 20% operational buffer.
- Energy audit all underperforming buildings & study feasibility of upgrades.
- Audits of process loads identified in underperforming buildings, with target to enable demand management.
- Provide common open source backbone for energy measurement & finalise roll-out of Smart Meters.
- Automated energy monitoring, improvement monitoring, feedback to Colleges and building operators.
- Portfolio based monitoring to be developed in conjunction with independent certification strategy.
- Integrate with the renewable energy strategies.
Energy vs Benchmark - All Buildings

LEGEND
Energy Intensity vs Benchmark (%)

0 100 200
A leading energy efficient campus

Strategy:

District Energy Plants enabled as integral parts of the Master Plan Hubs.

- Use the concentration of future development in mixed use Hub areas to leverage efficiency of District Energy Plants.
- With first major project in each Hub area, develop a feasibility study and staging plan for a District Energy Plant.
- Decide distribution strategy (such as chilled water loop, condenser water loop, loop vs headed pipes) on a case-by-case basis for each Hub.
- District Energy Plant to be developed flexibly to enable progressive expansion.
- Integrate with transition to 100% electrical – where feasible, prioritise Ground Source Heat Pumps. Central boilers for supplementary should be considered as bridging technology only.
- Refurbishments of HVAC systems to prioritise connection to District Energy Plants and all-electric technology.
A leading energy efficient campus

LEGEND
- Hubs where energy plants are integrated
- Integrated district energy plants
- Connections
- Catalyst sites

District energy plants
A leading energy efficient campus

Figure 1. District Energy Plants in Kambri Hub

Figure 2. District Energy Plants in Fellows Hub
Figure 3. District Energy Plants in Sullivans Hub

Figure 4. District Energy Plants in Barry Hub
Objective 2:
A carbon positive community with 100% renewable energy
The University’s vision is to be an active agent in achieving the vision of a zero Carbon future set out by the ACT.

Beyond utilising the state’s anticipated delivery of carbon neutral energy through its electricity grid and offsetting emissions from other energy use, it will contribute to building local renewable capacity on the Acton Campus. This not only supports the transition of the energy market, but creates cheaper energy ‘behind the meter’ avoiding losses and costs associated with transmission from external providers. As a secondary priority, campus capacity can be supplanted by off-site renewable installation allowing larger scale.

Natural gas forms a substantial part of the current energy mix. The University recognises however that ultimately electricity enables much more straightforward use of renewable sources and intends to move fully to this single flexible form of energy. Current trends show that emissions from electricity in the ACT have reduced over recent years, while those from natural gas have increased.

Shifting to electricity currently appears more promising for emission reduction than substitution of natural gas by renewable gas at large scale, but the potential for example for Hydrogen to establish its own energy distribution economy should be monitored and considered in future development of this strategy.
A carbon positive community with 100% renewable energy

**Strategy:**

On-site renewable target of at least 5% of annual energy, as part of overall 100% renewable energy supply.

- Solar technology feasibility review in future building designs to maximise opportunities.
- Roll out photovoltaic (PV) installations on existing rooftops based on feasibility studies carried out, targeting 3.1MW capacity by 2021.
- Review roof structure and PV feasibility on other buildings when these are being refurbished.
- Require consideration of PVs on all new buildings as part of standard project brief.
- Consider PVs on roofs and shade structures as part of any car park upgrades.
- Develop solar street lighting poles as part of the new Hub public space and connecting Promenades.
- Consider off-site Photovoltaics as a secondary priority to ‘behind the meter’ PVs.
- Purchase remaining demand 100% Carbon neutral, using Carbon Offsets until energy provided in the ACT is 100% Renewable.
A carbon positive community with 100% renewable energy
A carbon positive community with 100% renewable energy

Strategy:

Move to 100% electrical heating to support use of renewable sources.

- With new buildings and upgrades, target use of 100% electrical heating technologies to enable 100% renewable building energy use.
- Prioritise Ground Source Heat Pumps for district energy plants – locate boreholes at interface to open spaces.
- For buildings not connected to hub district energy plants, employ single bore geothermal, air source heat pumps or reverse cycle units.
Strategy:

Carbon neutral for all ANU Scope 1, 2 and 3 Emissions.

- Develop an integrated greenhouse gas accounting tool to report on all Scope 1, 2 and 3 emissions.
- Purchase offsets eligible under the National Carbon Offset Standard (NCOS) against all greenhouse gas emissions for Scope 1, 2 and 3 by 2020.
- Transition the ANU vehicle fleet to electrical.
- For new car parks consider trial of EV to Charge stations.
Objective 3: A technologically enabled infrastructure network
The Acton Campus’s embedded electricity network offers a unique opportunity to create a microcosm of a future decentralised energy market in which Distributed Energy Resources (DER) coordinated by digital communication technology optimise efficiency and stability of network services and bring renewable energy sources to their full potential.

DER include local energy generation such as rooftop photovoltaic systems, energy storage, and systems and appliances with a level of controllable demand such as hot water systems, air conditioning and smart technology fridges and freezers. Digital technology can be employed to manage these and adjust for the intermittency of renewable sources such as solar and wind. Traditional energy consumers can thus also provide generation of energy and services to the network, for example committing to lower their demand in response to high general demand on the wider grid.

The ANU is already engaging with the network provider on such bilateral services. It has a unique opportunity to leverage its position as the largest institutional electricity customer in the ACT to demonstrate value of demand management capability and negotiate appropriate financial rewards. The University’s internal monitoring and energy accounting can be used to pilot test tariff systems reflecting this.
A technologically enabled infrastructure network

Strategy:

Transform the ANU energy networks into a Smart Infrastructure system by integrating energy supply infrastructure with real time metering and monitoring, building automation, local energy production and storage.

Shape the future demand management economy with predictive management technologies through partnerships.

> Provide an open source communication and control data network within the university.

> Provide demand management capability through Building Monitoring and Control System (BMCS) interfacing with sensors, building services and appliances.

> Integrate campus renewable energy systems with thermal and electrical energy.

> Integrate process load management as applicable—to be considered e.g. in audits of process loads and the upgrades of central computing facilities.

> Enable automated capture of demand, consumption, generation, and building environment and use data. Integrate the existing smart meters within the open source communication and data network.

> With the first major project in a Hub area, develop a plan to implement district networks with a local Smart Infrastructure capacity, with the capacity to interconnect Hubs into campus wide infrastructure later.

Phased roll-out of pilot Hubs, and integration with Campus and Smart grid
Strategy:

Enable smarter utilisation of facilities with open connected booking and measuring of resources.

- Incorporate flexible learning space planning principles – level floors, movable furniture, retractable walls; train teaching staff in the practical use of flexible learning arrangements.
- Develop a University online space booking system to allocate space use on opt-in basis.
- Use data from BMCS (CO2 sensors, people counters or room conditioners) to identify operational utilisation feedback to the online system.
- Leverage blended learning (i.e. partially online learning) to utilise spaces other than dedicated learning space.
- Target: double the intensity of learning space use.
A technologically enabled infrastructure network

Strategy:

Create system resilience through shared decentralised energy generation and local storage.

- Roll out large scale on campus electricity storage based on batteries, to reduce the significant cost of peak charges, infrastructure upgrades, and to reduce HV/MV network stresses.
  - *Trial a large precinct scale Flow Battery array with the first Hub to receive a district energy plant.*
  - *New buildings with PVs are to incorporate battery storage. This can be via connection to a Hub facility, or local storage within the building.*
- *Provide centralised thermal storage in for district energy plants in Hubs.*
- *The first Hub Central Energy Plant development is to incorporate a pilot storage plant.*
Objective 4: Independently certified excellence
The University is committed to driving energy efficiency and sustainability performance in its projects and across its existing Acton Campus assets. Independent verification and certification is recognised as a key accountability mechanism and incentive to ensure implementation of suitable measures.

ANU will search for and settle on a best suited verification approach within the next five years. The approach needs to encompass driving energy performance of new building projects, assessing the performance of the existing portfolio, and tying in with holistic sustainability certification of the campus community.
Strategy:

Identify a suitable independently certified tool for the future to provide ongoing operational verification for all buildings and a holistic rating of the campus.

> ANU to proceed with this process and identify a tool which allows a streamlined process to report across all existing and new campus buildings, reviewing energy performance as part of certification against holistic sustainability targets.

Strategy:

Establish contractual targets for energy in operation and design requirements to drive sustainability in new building designs, based on 40% improvement over Building Code of Australia Section J (Energy) minimum performance.

> Achievement should be verified by comparative energy modelling in the design phase and metered in service.
Strategy:

Target Carbon Neutral Certification against the National Carbon Offset Standard (NCOS).

> Recognising the need for standardisation in emissions offsetting, the Department of the Environment and Energy’s Carbon Neutral Initiative has established the NCOS for Organisations and Precincts, offering best practice guidance also employed for building certification in major sustainability rating tools by the Green Building Council of Australia (GBCA) and NABERS.
Objective 5:
A platform for infrastructure innovation
Current research coordinated by the ANU Energy Change Institute (ECI) holds the promise to advance future technologies that can be employed to deliver the intent of this strategy in fields such as renewable energy storage and smart energy systems. The development of campus buildings and infrastructure serve as an opportunity to pilot and prove such technologies where possible, promoting both academic research and energy performance of the campus.

Conversely, data from new infrastructure and campus and systems can be used for research and for education of the next generation of researchers in the field.

The University’s intent is to connect the aspirations of the ANU Acton Campus Energy Management Strategy with research and academic excellence in the energy field, internally and in external collaborations. Beyond the technological aspect, in particular sharing the experiences that will be gathered in establishing a Smart campus energy infrastructure and using this to account for energy use and cost can be a valuable contribution to the transition of the wider energy market.

The University is uniquely placed to leverage its own academic resources in shaping the energy ecosystem of the Acton Campus.
Strategy:

Campus as classroom – The campus provides a platform for research and education;

> Energy performance is a visible component of the campus experience – integrate renewables and energy efficiency measures in architectural expression and in infrastructure shaping the future campus structure.

> Incorporate visible smart infrastructure as a defining element in new Hub public space and Promenade connections.

> E.g. develop an ANU smart street light as a campus wide recognisable item, integrating with the Smart Grid backbone infrastructure, and providing WiFi access points.

> Visible renewables – target façade integrated PVs, tracking PV installations, Micro scale Concentrated Solar Power, and Micro Wind turbines as research resources and design elements.

> Identify an area along Parkes Way for larger area standalone renewable energy technology installations to showcase the University’s commitment to on-campus renewables externally.

> Develop University digital apps and dashboards to give energy performance feedback to students and staff.
Strategy:

Digital informatics programmes strategically deployed to encourage future behavioural change.

- Enable open source energy information to be accessible for research and app development.
- Provide a curated campus app with specific feedback ability.
- Implement an annual program of behavioural change events and programs for students, staff, building custodians and contractors.
- Provide feedback and education to Colleges and departments, exploring gamification of energy improvements.
Strategy:

Collaborative energy research programmes related to the Master Plan to be developed.

- Establish an ANU Framework for internal cost reflective allocation of energy charges to incentivise College and building operator contribution to the strategic aims, which may serve as an example to inform national debate on energy tariff reform.
- Engage actively to promote and continue collaboration with energy supply and research stakeholder such as the Australian Renewable Energy Agency (ARENA), CSIRO, Energy Networks Australia (ENA) and the ACT energy network provider (AGL/Evoenergy).
- Establish and continue collaboration programmes with other universities internationally, such as through the International Alliance of Research Universities (IARU), to share expertise and learning on campus scale energy strategies.
- In development of all Precinct Master Plans, hold a concept stage review with representatives of the University’s Energy Change Institute (ECI) and the Facilities and Services Division (F&S) to identify opportunities for inclusion of research initiatives into energy systems.
- Identify an opportunity to pilot thermal storage technologies being investigated at ECI, providing allowance for make good costs; if successful integrate in district energy plants.
Ice is safe and low cost. It freezes with large latent heat, but at $0^\circ\text{C}$.

Guest gas

Gas hydrate can form at 5-12°C, but only at high pressures (>40 bar).

Primary additive

Salt additives allow gas hydrate to form at low pressures.

Secondary additive

Gas hydrate forms rapidly under 4 bar when the chilled water temperature is 7°C.
Recommendations in this document to achieve strategy objectives have been formulated based on scenario modelling based on 2017 Campus energy use data. This was overlaid with projected future growth of building area and staff and student numbers against estimates of achievable savings, both for annual energy consumption of electricity and gas as well as peak demand, for scenarios including:

- upgrading existing buildings and equipment
- introducing stringent new building energy standards
- district Energy Plants in Hub areas
- national Computing Infrastructure heat recovery
- retrofit Photovoltaics to suitable existing building roofs
- photovoltaic generation on majority of new building roofs
- heating conversion to 100% electrical sources
- introducing large scale energy storage
- implement Smart infrastructure with demand management capability.

With estimated increases in demand of area currently targeted, and as a crucial component of the increases in required computing facility power, the combination of these approaches can reduce the energy requirements so that a net reduction is achieved in line with the current Environmental Management Plan.

As the ACT electricity supply is targeting a quick transition to 100% renewable energy, the GHG emissions impact of the Acton Campus will be most efficiently countered by the shift from gas heating to 100% electrical energy, while supporting the ACT transition via the campus electricity generation and storage initiatives. Beyond emissions, energy strategy decisions should be primarily based on lifetime cost to the University, taking into account security of supply by decentralising and diversifying generation, storage and network services.
Detail decisions on the technologies and initiatives implemented to achieve the aims of this strategy must be reviewed at the time of procurement to take advantage of technological and market advances. At the time of writing the following lend themselves to consideration as strategies with a potential positive Net Present Value:

- smart infrastructure (including integrated smart metering; Wireless load management of freezers, DHW, chillers with buffer tanks etc.; network sensing; dynamic metering of distribution capacity; occupant sensing and feedback) enabling variable building tariff pricing and bill optimisation
- surveys to identify large plug in loads and facilitate remediation
- retro commissioning - identify phantom loads, Mechanical and Electrical engineering audits of underperforming buildings
- timers on key appliances
- behavioural change programs

- adaptive comfort setpoints combined with mixed mode ventilation (BMCS or occupant controlled)
- data centre and computing efficiency measures (consolidate servers, virtual servers, high temperature servers, reduced redundancy on non-critical servers, thin clients)
- waste heat recapture from computing servers
- district heating / cooling in small precincts
- ground source heat pumps, coupled with chilled & hot water storage
- on-site Photovoltaics (roof, building integrated, carparks and other)
- off-site Photovoltaics as a secondary priority (incurring transmission losses, but allowing large scale)
- biodigester / renewable gas
- battery storage (Li-ion batteries, Flow batteries for larger scale applications)
- piloting storage technologies being researched at ECI such as hydrolysis & hydrogen fuel cells, clathrate thermal storage.