AGGREGATED ENERGY USE AT THE AUSTRALIAN NATIONAL UNIVERSITY

Prepared by: **U6464150**
U5333986

May 2021

Individual energy flow through sub-communities toward campus aggregation: strategies for ANU Executive to increase energy efficiency and improve sustainability

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1 EXECUTIVE SUMMARY

This report determines how energy use is aggregated from individuals, through subcommunities using the ANU Research School of Astronomy and Astrophysics (RSAA) as a case study to the whole of the Australian National University (ANU) campuses. This report is presented to the ANU Executive to inform short, medium and long term strategies that can be implemented to support behavioural change, reduce energy use and encourage long term campus sustainability.

An analysis of existing ANU policies and performance was conducted against the United Nations Environment Programme Greening Universities Toolkit for sustainable development best practice at the ANU. This was completed to determine a baseline level of performance and the effectiveness of existing policies that the ANU and RSAA operate within in term of international best practice guidelines. Following this analysis, systems thinking and modelling are used to understand how behaviour change decreases individual and aggregated energy consumption on campus, what leverage points exist within the system and what interventions can help reduce energy use.

Analysis of modelling results suggests individuals contribute to school-wide energy consumption through an interplay of factors including motivation, convenience, perceived significance of actions and expectations of the sustainability committee. Three feedback loops and leverage points were identified through the research for targeted intervention.

The first feedback loop demonstrated that an increase in an individual's perception of the significance of their actions in a common space can influence those around them and result in more individuals engaging in pro-environmental behaviours. The second feedback loop identifies how individual access to continuously updated energy use data at a sub-sector (school, building, room) level contributes to increasing the perceived significance of individual actions in a common setting. The third feedback loop demonstrates that increasing individual involvement or connection to initiatives acts as a motivator to engage in pro-environmental behaviours that reduce energy use.

The three leverage points identified in the model and analysis relate to the perceived significance of individual actions in a common space, RSAA sustainability department initiatives and increased motivation to reduce energy use. Using these leverage points, the project team have identified short, medium and long term complimentary initiatives and strategies that will combine to influence student and staff behaviour locally within the RSAA and across the broader campus.

Short term strategies target 'easy wins' through initial intervention points such as supporting the established RSAA Sustainability Committee and extending its mandate to include energy reduction initiatives. Other short term strategies link to baseline UNEP results by conducting and communicating the results of a comprehensive energy audit to encourage accountability and ownership, and continuing to financially incentivise individual schools to reduce aggregated energy use through returning savings to school specific projects. Additional interventions include focusing on communication and developing practical guidance for individual schools to implement existing ANU Below Zero and Energy Management Strategies.

Medium and longer term strategies build on short term intervention points and include developing a sustainability focused communication strategy and embedding sustainability and net zero objectives in the broader course curriculum. These initiatives are targeted at building a sustainable culture with an ambition of self-perpetuating longevity amongst staff and students. Additional initiatives include investigating lighting and HVAC management systems to practically reduce energy use and improve efficiency and alignment to global World Green Building Council decarbonisation targets for existing and new build buildings.

2 INTRODUCTION

The Australian National University (ANU) passed resolutions in 2020 to respond, adapt and mitigate collectively to the impacts of climate change through the resources at its disposal and by minimising GHG emissions in its operations (ANU, 2020). Within these resolutions, ANU also recognised that it needs to respond to climate change with a combined focus on world leading climate research and effective actions to minimise and adapt to climate change (ANU, 2020).

The ANU is at the forefront of this opportunity with a commitment in May 2021 to reduce emissions to below zero by 2030. This resolution comes in addition to existing commitments (with a range of strategic plans) and community expectations that ANU operates with sustainable intent (ANU, 2021). Given this context, this report has been prepared for the ANU executive team to consider intervention opportunities from a baseline case study of the ANU Research School of Astronomy and Astrophysics (RSAA). This report addresses the existing performance of the RSAA against the ten principle of a sustainable university according to the United Nations Environment Programme Greening Universities Toolkit before identifying leverage points and a strategic plan to improve performance.

This report uses the principles of the sustainable universities toolkit to understand how individual energy use is aggregated from individuals, through subcommunities to the campus level to determine leverage points and recommendations for improvements. This report is guided by the following questions:

1. *How does behaviour influence individual & aggregated energy consumption?*
2. *What leverage points exist that can help drive recommendations?*
3. *What energy reduction strategies have been implemented in other universities and how effective have these efforts been? / What is considered best sustainability practice for universities?*

3 SETTING THE SCENE - WHAT IS A SUSTAINABLE UNIVERSITY?

Universities operate in challenging environments as complex and dynamic entities with diverse organisational cultures, structures and regulatory environments (Dave, et al., 2014). In addition, universities have to consider limited funding capacity that prioritises short time-frames for returns on investment, meeting external pressures for action on sustainability and community, government and society aspirations for sustainability focused research and application (Dave, et al., 2014).

Given the role of education and function of universities as significant consumers of energy, resources and economic productivity, there is a significant opportunity for universities to engage in sustainability initiatives and contribute to the climate change response (Dave, et al., 2014). In this context, universities and academia are positioned to lead by example as catalysts for change, social and political action whilst functioning as centres of learning and information exchange (Dave, et al., 2014).

A sustainable university, as defined by the UNEP is “one in which the activities of a university are ecologically sound, socially and culturally just and economically viable” (UNEP, 2014). The project team conducted an assessment against the 10 best practice principles of a sustainable university as defined by UNEP to determine a baseline to inform intervention strategies. These were assessed as either ‘effective’ or as ‘opportunities for improvement’ against peer reviewed literature based on direct data from RSAA and publicly available information from ANU. The following 10 principles constitute university sustainability:

Table 1: Baseline against UNEP principles for sustainable universities:

UNEP Principles of a sustainable university	Data collection: ANU and RSAA	Assessment and recommendations
1. Clear articulation and integration of social, ethical and environmental responsibility in the institution's vision, mission and governance.	At campus level ANU supports and articulates social, ethical and environmental values through its Strategic Plans (2019 -2024) and ANU Governance Handbook (ANU, 2019; ANU, 2021). Campus values are routinely communicated via email and community events (ANU, 2021). Feedback from the RSAA suggested challenges of flowing ANU campus policy though to RSAA due to school location off campus and operating with a level of independence (own utility bills etc). Primary data indicated a desire to change behaviours, however leadership is needed at the campus and executive level to inspire confidence.	ANU clearly articulates social, ethical, and environmental responsibility through its vision, mission and governance, however there is an opportunity for these to be linked through the hierarchy from individual School through to the entirety of the Campus. Gu et al (2012) argues that achieving lower energy consumption through green strategies must occur from alignment of organisational business goals and strategies with effective communication (Gu, et al., 2012). **Opportunity for improvement:** integrate social, ethical and environmental responsibilities in the plans at the school level for RSAA to align with the ANU hierarchy.
2. Integration of social, economic and environmental sustainability across the curriculum, commitment to critical systems thinking and interdisciplinarity, sustainability literacy expressed as a universal graduate attribute.	ANU provides a level of commitment through its Strategic Plan 2019 – 2024 with a focus on research, innovation, and quality of education. ANU does not explicitly identify graduate attributes for critical thinking unlike comparable institutions such as the University of Canberra, University of Sydney, University of Technology Sydney or Notre Dame (UTS, 2021). Data from the RSAA does not provide a comprehensive assessment against this criterion in terms of curriculum and graduate outcomes. However, indirect evidence of this is provided through sustainability programs ran by the RSAA with a focus on waste management and recycling.	Graduate Skills (2009) argue the benefit of critical thinking is fundamental to being an active and engaged citizen. This complements sustainability as a core competency and skill to participate in the work force, commit to life-long learning and being actively engaged locally and globally with sustainability (Graduate Skills, 2009). **Opportunity for improvement:** identify graduate attributes publicly and incorporate a focus on environmental sustainability. This may lead to direct benefits including changing behaviours during the course of studies resulting in benefits to the broader campus.
3. Dedicated research on sustainability topics and consideration of "quadruple bottom line" sustainability aspects in all other research.	ANU promotes environment and sustainability initiatives though the Fenner School of Environment and Society which is currently ranked 24th in the world with a focus on integrated research and training (ANU, 2021). The RSAA is included as a focus area that contributes to sustainability topics through the Advanced Instrumentation and Technology Centre (AITC) at Mount Stromlo Observatory (ANU, 2021). Feedback from the RSAA supports a high energy insensitivity with peak energy requirements during operation and testing.	Embedding suitability in research has strong correlations to improved business performance including increased competitive advantage, effective stakeholder engagement, improved risk management and fostering innovation (Whelan & Fink, 2016). **Effective:** ANU's broad focus on sustainability and environmental research is effective. This is supported with key objectives in its Strategic Plan (2019 -2024), however could be improved through further commitment at the School level.

4. Outreach and service to the wider community, including partnerships with schools, government, nongovernmental organisations, and industry.	ANU runs outreach and enrichment programs for the wider community through the RSAA. These include focus projects, work experience and workshops (ANU, 2021). ANU also engages with government, non-government organisations and industry though its Global Engagement and International Strategy (ANU, 2021).	Community engagement and information sharing is fundamental to generating community support and delivering effective outcomes for projects, social acceptance and behaviours for sustainable development (Environment, Land, Water and Planning, 2017). **Effective:** ANU's focus on collaboration and partnerships is supported through its Strategic Plan (2019 -2024) such as building a culture of engagement across and beyond ANU.
5. Campus planning, design and development structured and managed to achieve and surpass zero net carbon/water/waste, to become a regenerative organisation within the context of the local bioregion.	At a campus level, ANU have commitments to reduce greenhouse gas emissions from buildings and other operational emissions (ANU, 2020) ANU has an Acton Campus Master Plan and Energy Management Strategy with objectives including: • A leading energy efficient campus • Carbon positive community with 100% renewable energy • A technologically enable infrastructure network • Independently certified excellence • Platform for infrastructure innovation (ANU, 2019). Data from RSAA suggests that these ambitions exist but are not communicated or structured through internal policies or plans. There are no current strategies to reduce energy use that involve changing behaviour with a focus in the Sustainability Committee at RSAA on waste rather than electricity use.	Benefits of integrated planning, design and development combined with organisational greens strategies has two significant benefits: • Reduced operating costs – reduced energy and water consumption, lower long term maintenance costs and reduced emissions in service use. • Improved workplace productivity and health resulting in long term sustainable benefits for the business (Dave, et al., 2014). **Opportunity for improvement:** Feedback from RSAA suggest that infrastructure upgrades are made from a financial perspective (i.e. solar panel installation), however there is no plan to retrofit or upgrade existing facilities. Buildings rebuilt post 2003 bushfires were not build to significant green standards with older buildings having heavier energy consumption.
6. Physical operations and maintenance focused on supporting and enabling "beyond zero" environmental goals, including effective monitoring, reporting and continual improvement.	As mentioned above, ANU passed a climate change resolution at the campus level that recognises that ANU needs to respond to climate challenges and adapt to and mitigate the changing climate and its consequences. This includes a focus on minimising the University's GHG emissions (in line with commitments to be greenhouse gas negative as soon as possible) (ANU, 2020). RSAA feedback indicated the main driver that contributed to beyond zero goals were from a financial motivation – not leadership or motivation for 'beyond zero' goals. There is monitoring and reporting for waste initiatives however not for energy use or consumption.	Long term green strategies have significant benefits including reduced operating costs and positive engagement. Strategies can be top down (management driven) or bottom up (staff and student driven) – a combination of both is required for effective implementation. Commitments to beyond zero goals require high level leadership to motivate participation with effective monitoring and communication. **Opportunity for improvement:** Feedback from RSAA suggest a lack of executive leadership and direction from the campus level to the school level. Additional communication and mobilisation from the executive to the individual schools is required to motivate engagement.

7. Policies and practices which foster equity, diversity and quality of life for students, staff, and the broader community within which the university is based.	ANU's Strategic Plan 2019-2024 identifies the values and vision for the campus whilst acknowledging the importance of equity and diversity. This is called out with specific initiatives through building a culture of collegiality and engagement and creating an unrivalled campus environment. Feedback from RSAA suggests that MSO is removed from the campus consideration with low consideration for funding or prioritisation for upgrades.	Acknowledging cultural development, diversity and striving for equity is central to the adaptive process of realising sustainability and driving behavioural change (Dave, et al., 2014). **Opportunity for improvement:** ANU has the policies and commitments at executive and campus level – improved dialogue and communication through to individual schools such as RSAA is required to ensure that implementation on the ground is achieved.
8. The campus as "living laboratory" – student involvement in environmental learning to transform the learning environment.	ANU has a collaborative approach to student engagement with commitments in the Strategic Plan 2019-2024 to create an unrivalled campus environment with a focus on the natural environment and amenity. Feedback from RSAA suggests that these plans are not well integrated toward the school level and are focused at schools on campus, not necessarily off campus like RSAA.	Experience globally confirms a combination of top management commitment and staff and student engagement is crucial for successful performance of sustainability programs in university (Dave, et al., 2014). **Effective:** ANU's focus on collaboration and partnerships is supported through its Strategic Plan (2019 -2024) such as building a culture of engagement across and beyond ANU
9. Celebration of cultural diversity and application of cultural inclusivity.	ANU's Strategic Plan 2019-2024 identifies the values and vision for the campus whilst acknowledging the importance of equity and diversity. This is called out with specific initiatives through building a culture of collegiality and engagement and creating an unrivalled campus environment. Feedback from RSAA suggests that MSO is removed from the campus consideration with low consideration for funding or prioritisation for upgrades.	Acknowledging cultural development, diversity and striving for equity is central to the adaptive process of realising sustainability and driving behavioural change (Dave, et al., 2014). **Opportunity for improvement:** ANU has the policies and commitments at executive and campus level – improved dialogue and communication through to individual schools such as RSAA is required to ensure that implementation on the ground is achieved.
10. Frameworks to support cooperation among universities both nationally and globally.	ANU has a strong focus on global engagement and international strategy, with a proven record of engaging with governments, universities and other institutions – including international liaison offices (ANU, 2021). Feedback from RSAA did not explicitly address this criterion.	Community engagement and information sharing is fundamental to generating community support and delivering effective outcomes for projects, social acceptance and behaviours for sustainable development (Environment, Land, Water and Planning, 2017). **Effective:** ANU's focus on collaboration and partnerships is supported through its Strategic Plan (2019 -2024) such as building a culture of engagement across and beyond ANU

4 ENERGY AGGREGATION

There is a broad range of biophysical, societal and institutional aspects that influence university sustainability. From the sustainability assessment, the project team determined that principles one, five and six had strong opportunities as leverage points to influence RSAA energy aggregation throughout this report.

> **Principle 1:** Clear articulation and integration of social, ethical and environmental responsibility in the institution's vision, mission and governance.
>
> **Principle 5:** Campus planning, design and development structured and managed to achieve and surpass zero net carbon/water/waste, to become a regenerative organisation within the context of the local bioregion.
>
> **Principle 6:** Physical operations and maintenance focused on supporting and enabling "beyond zero" environmental goals, including effective monitoring, reporting and continual improvement.

In terms of individual energy use behaviour, these principles translate into three key areas to consider when thinking about energy use at RSAA. First, there needs to be understanding of the school's activities and energy use impacts so that policies effectively target intervention areas within the school system. The development of policies must combine top management and executive commitment with student and staff engagement, to better incorporate the different roles, experiences and expectations of these groups. Whilst ANU's 'Below Zero Initiative' provides an overarching goal and direction for the campus, direct feedback indicates that the implementation of this policy at a campus wide level is challenging in terms of scale. This is attributed to a lack of detail within the resolution and an uncommunicated path forward that may prevent school committees from taking decisive actions. However, it can also afford the RSAA (and other schools) the liberty to implement their own policies tailored to context-specific circumstances. Nevertheless, this may present a risk of disjointed and inefficient implementation.

Second, planning and designing the university according to best practice green star ratings that optimizes energy use by taking into consideration site-specific characteristics. Aside from offering an opportunity to showcase best practice principles and technologies, this can address the largest source of GHG emissions progressively over time whilst having operational cost efficiencies. Currently the buildings at the RSAA are not held to any energy efficiency standards and there are no initiatives to target energy use behaviour change. RSAA sustainability policies are currently limited to reducing energy usage through passive signage (turn off when not in use), encouraging composting and diverting waste from landfill to recycling. According to feedback, these policies have shown positive uptake, especially by students more than staff. Therefore, there is some indication that when given the opportunity to engage in pro-environmental behaviours there is a level of responsiveness and motivation to engage. This presents an opportunity at least in the short-term to implement behaviour focused initiatives with a low cost and capital outlay with the realistic expectation of tangible improvements in pro-environmental behaviour.

Finally, operations and maintenance should focus on achieving energy conservation through policy interventions and behaviour change, energy efficiency through maintenance and capital works and be powered by renewable energy. Monitoring, evaluation and communication of energy use must become a regular activity for universities to improve and involve stakeholders. Improving communication to stakeholders (both staff and students) was a strong theme provided during data collection and analysis. Strong communication and articulation of pathways, combined with monitoring and progress updates provides a level of accountability, transparency and motivation for continued changes in behaviour. Implementing regular communication, status updates and reporting progress milestones (in terms of policy and programs) has a direct effect in maintaining motivation levels amongst staff and students and can contribute to creating a culture of sustainability within RSAA.

5 MODELLING

The complexity and nature of variable interdependencies within the RSAA energy system required systems analysis and modelling to effectively analyse the first two research questions:

1. *How does individual behaviour contribute to school-wide energy consumption?*
2. *What leverage points exist that can help drive recommendations?*

The first step to answering both questions involved developing a causal loop diagram on Vensim (VENTANA Systems, Inc. 2015) depicting behaviours that influence energy use. These diagrams are composed of variables, links and influences on one another (positive or negative). A preliminary literature review was conducted to determine and understand the variables that motivate individuals to alter energy use patterns consciously or subconsciously and by which methods – these are briefly discussed below.

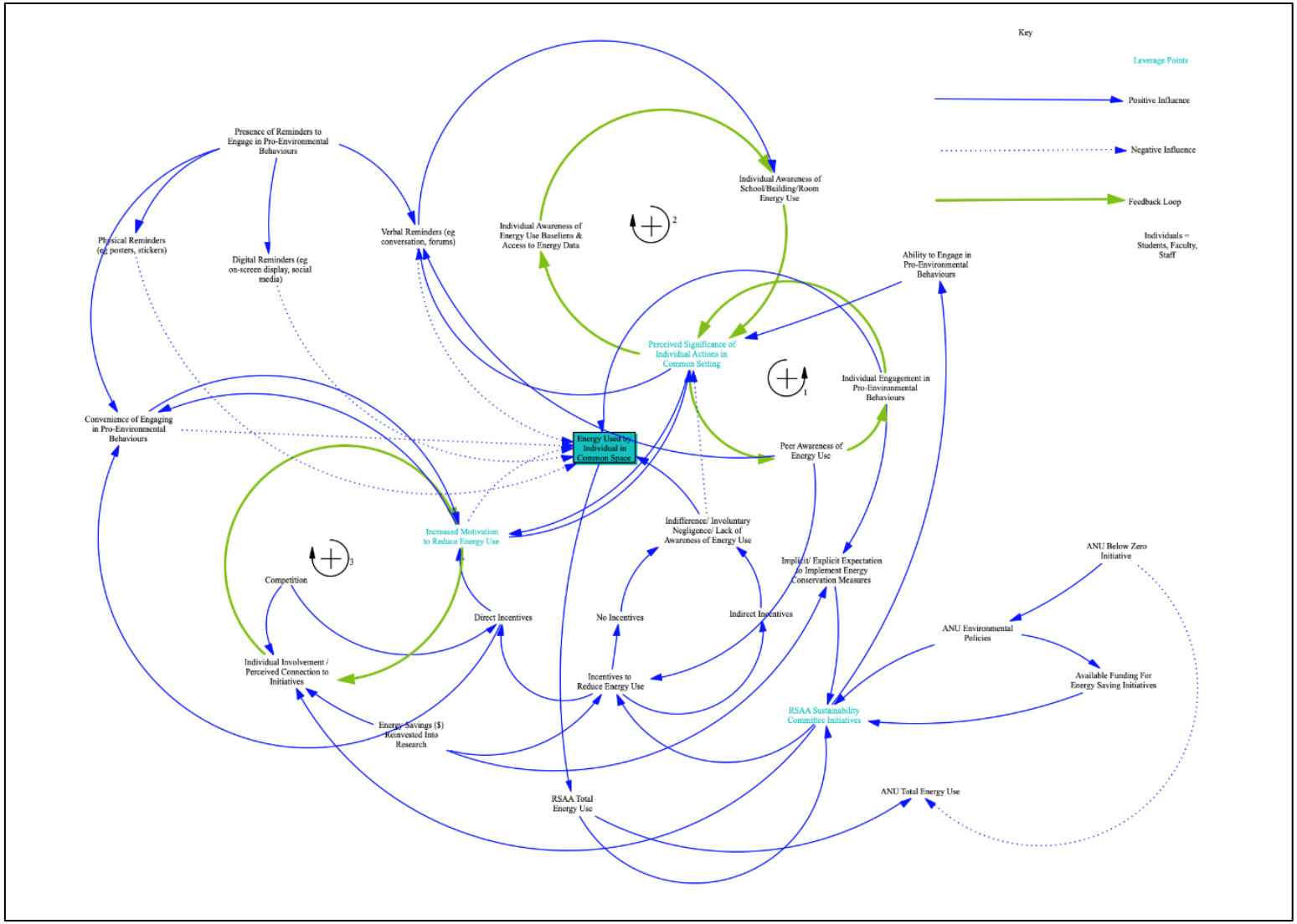
The aggregated nature of school-wide energy use may prove an unintended barrier for increasing individual, pro-environmental behaviour. Individuals on campus do not incur the costs of energy consumption and therefore lack financial incentives to decrease it (Dietz, 2014). Despite this, even if individuals were motivated to save energy, they would still have no access to electricity consumption data to assess and determine their contribution. This translates into a lack of a benchmarks and motivators for individuals to measure the effectiveness of their energy saving efforts (Thondhlana & Ancha Lindelwa Bulunga, 2018). Consequently, individuals may determine that reducing energy in common spaces is beyond their control as spaces are shared by people who may not engage in pro-environmental behaviours.

Intervention strategies aimed at changing energy use behaviour focus on increasing individual awareness of energy use and how it collectively impacts the aggregated total. This can be achieved through incentives, nudges, submetering, peer education and community involvement with energy-use initiatives (Dave, et al., 2014). Behaviour change strategies have the advantage of being low-cost options that may yield positive results depending on implementation (Dietz, 2014). Nevertheless, energy savings induced by rewards can be short-lived, information campaigns alone seldom lead to behaviour change, and energy use feedback (submetering) can prove expensive depending on the desired granularity of data (Staddon, et al., 2016).

After considering this information, a causal loop diagram was mapped using Vensim to visualize and determine the drivers of individual energy use behaviour and how these contribute to school-wide energy consumption. Figure 1 shows the dynamic interactions between internal and external motivators of individual energy use in the RSAA. These motivators are embedded within the broader university context and its policies, predominantly the ANU's Below Zero Initiative and the allotted financing for sustainability initiatives in the RSAA.

As labelled in Figure 1, plain arrows represent positive influences on individual variables and dotted arrows represent negative influences. Green arrows signify that connected variables are part of a feedback loop. The signs in the middle of feedback loops indicate whether the loop is positive (reinforcing) or negative (balancing) and if it flows in a clockwise or counter-clockwise direction. Variables in turquoise represent leverage points. Variables that directly influenced three or more other variables were considered leverage points where interventions could be applied. The boxed variable labelled 'Energy Used by Individuals in Common Space' is shown at the centre of the graph to enable clear visualization of the actions that directly impact an individual's energy use.

Figure 1: Causal loop diagram of energy use behaviour in common spaces of the RSAA



6 RESULTS AND DISCUSSION

Feedback loops occur when a group of variables are circularly linked, influence and interact with each other. Depending on direction of flow, feedback loops can be either reenforcing or balancing (Meadows, 1999). As depicted in Figure 1, there are three distinct feedback loops and three leverage points. All three leverage points have positive reinforcing loops which create virtuous cycles that influence more of the same action.

Feedback loop one demonstrates that an increase in an individual's perception of the significance of their actions in a common space can influence those around them resulting in other individuals engaging in pro-environmental behaviours. These behavioural changes can be attributed to two psychological factors. First, as an individual's peers become increasingly aware of school energy use, they may feel increasingly empowered to reduce energy in common spaces (shift from external to internal locus of control) (Carrico & Riemer, 2011). Second, increased peer awareness and engagement in pro-environmental behaviours can lead to individual uptake due to group conformity and repetition by imitation (de Pinho, 2015). It is worth noting that, with the majority of behavioural change initiatives, this feedback loop can reinforce itself only in the short-term. This is due to student turnover and available resources, which require that the committee regularly maintain motivation and spark interest in reducing energy use through behaviour change (Thondhlana & Ancha Lindelwa Bulunga, 2018).

The second feedback loop relates to how individual access to continuously updated energy use data at a sub-sector (school, building, room) level contributes to increasing the perceived significance of individual actions in a common setting. Real-time energy use feedback tends to implicitly enhance awareness and, by default, consideration of individual energy use (Staddon, et al., 2016). Whittle et al (2020) found that engaging individuals with energy data can lead to questions about responsibility, agency and the role individuals can take on to reduce energy. Said increase in curiosity may lead to the creation of solutions to reduce energy demand as well as holding managers and facilities accountable. Feedback loop two shares a leverage point and variable with feedback loop one. Therefore, real-time individual awareness of energy use has the potential to increase pro-environmental behaviours.

The third feedback loop demonstrates that increasing individual involvement or connection to incentives acts as a motivator to engage in pro-environmental behaviours that reduce energy use. This connection, along with the drive to achieve can, in some cases, be more important than the reward itself (Thondhlana & Ancha Lindelwa Bulunga, 2018).

Leverage points are places in a system's structure where small modifications can result in major changes (Meadows, 1999). Variables that directly influenced three or more variables were considered leverage points where interventions could be applied. Modelling per Figure 1 identified three leverage points: *Perceived significance of individual actions in a common space, RSAA sustainability department initiatives & increased motivation to reduce energy use.*

The variable labelled "Perceived Significance of Individual Actions in a Common Space" can directly increase "Verbal Reminders Regarding Pro-Environmental Behaviours", "Peer Awareness of Energy Use" and "Individual Awareness of Energy Use Baselines" and Access to Energy Data". Intervening in the system through this variable, requires applying a 'Conscious Leverage' (Meadows, 1999). This type of leverage attempts to change the mindset out of which energy use behaviour in RSAA common spaces arises. Since this intervention attempts to challenge behaviours, major changes can arise. These require, however, significant amounts of effort to implement (de Pinho, 2015).

The leverage point "RSAA Sustainability Department Initiatives" directly affects and incentivises reductions in energy use. It can also increase individual involvement and perceived connections to initiatives by

involving the RSAA community. This variable can develop strategies to increase an individual's ability to engage in pro-environmental behaviours.

The last leverage "Increased Motivation to Reduce Energy Use" directly reduces "Energy used by individuals in a common space". However, it also increases "Individual Involvement/ Perceived Connection to Initiatives" since motivation to reduce energy use in common spaces fundamentally arises from the presence of direct incentives. A higher motivation to reduce energy use is also shown to increase the convenience of engaging in pro-environmental behaviours. This is because individuals tend to perceive pro-environmental behaviours as less of a burden when there is motivation to engage in them underpinned by direct incentives (Staddon, et al., 2016).

7 RECOMMENDATIONS

Modelling completed in Figure 1 identified three leverage points: *Perceived significance of individual actions in a common space, RSAA sustainability committee initiatives & increased motivation to reduce energy use.* Though indirectly connected in Figure 1, all three points reinforce each other which means leaders within the RSAA and broader ANU Executive Team are in a unique position to implement targeted short, medium and long term initiatives that are likely to influence behavioural change.

7.1 Short term opportunities

Short term opportunities can be used as initial 'easy wins' to motivate staff and students to engage in energy saving behaviours. With this lens in mind, the project team has suggested the below strategies:

7.1.1 Support RSAA Sustainability Committee - RSAA level

Figure 1 shows that RSAA sustainability committee initiatives are a leverage point that can affect individual involvement in energy reducing initiatives and willingness to engage in pro-environmental behaviours. Therefore, the ANU Executive Team should implement or support strategies that will engage individuals within the broader RSAA community.

Increasing the RSAA's Sustainability Committee initiatives and helping individuals understand the significance of their actions in a common space requires effective communication of stainability initiatives and goals (Djordjevic & Cotton, 2011). This provides the school community with opportunities to focus on issues, take ownership and accountability. Strategies directed at promoting education and awareness of energy use can be communicated through a variety of channels including through forums, newsletters, posters, reminders via social media or displaying energy use data on screens (Staddon, et al., 2016). Holding competitions and offering incentives to reward pro-environmental energy use behaviour has shown to significantly decrease energy use in other universities (Thondhlana & Ancha Lindelwa Bulunga, 2018; Michetti, 2020). The Sustainability Committee should regularly review the effectiveness of communication activities to develop strategies for improvement, if needed (Djordjevic & Cotton, 2011).

Both Rhodes University in South Africa and Otago University in New Zealand implemented initiatives to increase awareness of energy use in student residences. The strategy involved communicating energy use best practices through forums, newsletters, posters and reminders via social media. Additionally, incentives were offered and residence students were involved in creating posters and holding forums. Rhodes University reduced energy use by 12% and Otago University, for its part, was able to reduce energy use by 10.7% in a span of 8 weeks (Bekker, et al., 2010; Thondhlana & Ancha Lindelwa Bulunga, 2018).

7.1.2 Conduct a comprehensive energy audit and communicate results - RSAA level

Conducting an energy audit will provide baseline values for energy use whilst prioritising low, medium and high energy intensive activities (Dave, et al., 2014). This will allow for the analysis, trending and

interpretation of data to either change activities (e.g. programming computer data processing during cooler or low energy cost times). This will also allow the development and implementation of targeted energy conservation measures based on site specific and context appropriate energy use in areas where individuals have a limited ability to engage in pro-environmental behaviours (e.g. hallway lighting) (Dave, et al., 2014). Additionally, these may substitute behaviour change initiatives in areas where the convenience of engaging in pro-environmental behaviours may be low (e.g. disconnecting vampire appliances).

It is important that the results of this audit are communicated to the broader community to encourage ownership of results and motivate engagement (Wang, 2019). From literature, initiatives that were most effective at reducing energy use after audit results were those based on data analysis with submetering. For example, Harvard University's Data-Driven Behaviour Change Campaign installed electrical submetering in high energy use laboratories to collect data and enable energy reduction competitions (Michetti, 2020). All groups averaged energy reductions (from lighting) of 37% over a 3 week period with the winning group reducing energy use by 73.6% (Michetti, 2020; Thondhlana & Ancha Lindelwa Bulunga, 2018). Therefore, the RSAA should consider conducting a comprehensive energy audit to determine priority areas and additional strategies such as submetering to reduce energy use.

7.1.3 Financially incentivise individual schools to reduce aggregated energy use - RSAA level

Implementing financial incentives in relation to energy use has the ability to directly influence how much energy is used in a facility if it is linked to a financial incentive (Elbaz & Zait, 2018). Currently, reductions in energy use within RSAA buildings translate into energy savings reinvested into projects. So far, the RSAA identified that this was a successful motivator for buildings to actively reduce energy use. Therefore, the college managers should consider leveraging the possibility of further energy savings as a motivator for individuals to engage in pro-environmental behaviours and obtain support for energy-efficient upgrades. The RSAA community's positive uptake on recycling and food waste may be indicative of the responsiveness and willingness of individuals to consider energy-saving behaviours. Reminding them of further financial incentives obtained through reducing energy use could enhance the community's predisposition to engage in behaviours that achieve these (feedback loop 3 , Figure 1).

Given the appetite and effectiveness of this strategy, it should be considered by the ANU Executive Team for roll-out once baselines are established across other schools on campus.

7.1.4 Develop guidance for implementation of ANU below zero and energy management strategies

As stated in Table 1, the ANU's Below Zero Initiative, Acton Campus Master Plan and Energy Management Strategy intend to drive short and long-term goals within the university (ANU, 2021). However, there are currently no guidelines or means of ensuring that implementation of these policies is happening at lower levels through the schools – particularly in the case of RSAA.

Despite the timeframes required to develop this guidance, the ANU Executive Team should consider the importance of developing implementation strategies for schools to use. A school-level strategy to decrease energy use should start by determining current baselines, indicators and finally setting objectives and targets in the identified areas. UNEPs Greening University Toolkit suggests that targets should be challenging but achievable and guided by data. Time-bound plans with regular reviews and sustainability reporting of the achievements can help ensure the effectiveness of these strategies (Dave, et al., 2014).

7.2 Medium term opportunities

Medium term opportunities should be considered complimentary when developing short term strategies. These strategies are likely to require baseline data and will need to leverage early policies.

7.2.1 Develop Sustainability Communication Strategy - RSAA level

Feedback from RSAA, as outlined in table 1 and throughout the model, identified communication as a critical tool in changing individual and community behaviour. Given this, developing a sustainability-focused communication strategy within the RSAA that links to the broader university sustainability policy, energy management policy and net zero ambitions will play a key role in engaging individuals. Efforts must emphasize two-way communication, regular communication of important information and accountability (Dave, et al., 2014). Energy reduction achievements should be communicated to strengthen feedback loops involving "Perceived Significance of Individual Actions..." and "Increased Motivation to Reduce Energy Use" (Figure 1). Dave et al (2014) suggest following the ISO14063:2020 Environmental Management — Environmental Communication Standard as a policy guideline. Among other things, it highlights the importance of not losing corporate (school in this case) memory whilst remaining accountable for future actions and projects related to sustainable energy use behaviour.

7.2.2 Embed sustainability and net zero objectives in broader course curriculum

Embedding net zero initiatives and objectives into broader course curriculum will contribute to a culture of sustainability and may influence student behaviour whilst on campus. This aligns with UNEPs Greening University Toolkit principles in table 1. Literature shows that behavioural change can decrease energy use while creating a culture that facilitates the adoption of sustainability initiatives (Gustafson & Longland, 2008).

This information matches modelled outcomes in Figure 1 with individuals engaging in pro-environmental behaviours causing positive ripple effects across the campus due to people's social nature (conversations, conformity, repetition by imitation) and an increase in perceived significance of individual actions. This will require consistent review as new students arrive each semester and will require familiarisation with sustainability programs. Furthermore, attitudes and behaviours are some of the most challenging places to intervene in a system as doing so may require going against habits and social norms (de Pinho, 2015).

7.2.3 Lighting and HVAC management - RSAA level

Lighting re-fits may substitute behaviour change initiatives in areas where the convenience of engaging in pro-environmental behaviours is low. Completing a lighting re-fit is an 'easy' win as a short to medium-term initiative with a comparatively low payback. From the literature, approximately 20% of a commercial building's primary energy can be attributed to lighting (Department of Energy, 2020) Replacing low efficiency incandescent lamps with LED lights that use 75% less energy and last 25 times longer (usually energy star ones) can significantly reduce energy use at a comparatively low cost (Department of Energy, 2020). Therefore, there are significant energy savings to be achieved by re-fits. The ANU Below Zero Strategy hopes to undertake several projects including a transition to LED lighting. This goal could help the RSAA obtain some necessary resources from the university for re-fits (ANU, 2021)(Department of Energy, 2020).

When aiming for the 'easy' upgrades in energy efficiency, consideration should be given to implementing lighting and HVAC design and controls. For example, lighting control designs may include occupancy sensing, light dimmers and controlled zoning to increase energy savings. Modifications to HVAC systems could include designated shut off periods (e.g. 6pm – 6am) or 'smart monitoring' to reduce output when heating or cooling is not required in low use periods. These investments should be considered with a focus on long term sustainability with upfront capital costs over extended time periods (25+ years).

7.3 Long term opportunities

The commercial landscape and timeframes of established and new buildings represents a significant intervention point for which green strategies can be implemented over building life cycle.

7.3.1 Alignment to global World Green Building Council decarbonisation targets

The World Green Building Council (WGBC) developed a focus paper on sustainable buildings with targets on climate action including that all buildings are totally decarbonised over their lifecycle (World Green Building Council, 2020). The project team recommends the ANU Executive Team to consider aligning itself to targets established by WGBC such as using low carbon materials and construction processes, reducing demand through high energy and material use efficiency and annually monitoring, analysing and reporting on building performance. The project team also recommends any new building or refits have a net zero embodied carbon content with a 2050 objective of all existing buildings being net zero.

8 CONCLUSION

The ANU is in a unique position to lead the way on university climate change adaptation and mitigation given its ambitious targets, commitments and resolutions to reduce emissions. An analysis against the UNEP guidelines for sustainable universities found that the ANU is well on its way to satisfying many of these sustainability criteria. Nonetheless, areas for improvement include strengthening the flow of information and energy efficiency guidelines from the top executive levels through to individual schools. Additionally, the university would benefit from developing and encouraging energy efficiency standards, policies and behaviour change initiatives at individual school levels to improve sustainability.

With these findings in mind, the team set out to understand how behaviour change decreases individual and aggregated energy consumption on campus, what leverage points exist within the RSAA system and what interventions can help reduce energy use. Given the complexity and variable interdependencies of energy use aggregation within the RSAA, systems thinking and modelling were used. Analysis of modelling suggests individuals contribute to school-wide energy consumption through an interplay of factors including motivation, convenience, perceived significance of actions and expectations of the sustainability committee.

This research identified three feedback loops and leverage points to direct possible recommendations to intervene in the system. The first feedback loop demonstrated that an increase in an individual's perception of the significance of their actions in a common space can influence those around them. This may result in more individuals engaging in pro-environmental behaviours. The second feedback loop identifies how individual access to continuously updated energy use data at a sub-sector (school, building, room) level contributes to increasing the perceived significance of individual actions in a common setting. The third feedback loop demonstrates that increasing individual involvement or connection to initiatives acts as a motivator to engage in pro-environmental behaviours that reduce energy use.

The three leverage points identified in the model and analysis relate to the perceived significance of individual actions in a common space, RSAA sustainability department initiatives and increased motivation to reduce energy use. Using these leverage points, the project team have identified short, medium and long term complimentary initiatives and strategies that will combine to influence student and staff behaviour locally within the RSAA and across the broader campus.

Short term recommendations were issued with the need to increase individual involvement and willingness to engage in pro-environmental behaviours in mind. These include supporting RSAA Sustainability Committee initiatives and communicating the results of energy audits with the community. Medium and longer term opportunities focus on steps that can contribute to facilitating and maintaining a culture of sustainability within the RSAA. Said strategies include developing a sustainability communication strategy, upgrading lighting and HVAC design and controls and aligning the ANU to the World Green Building Council targets for sustainable buildings. Additionally, the project team recommends identifying baselines and indicators prior to starting energy reduction projects and stresses the importance of monitoring and evaluating strategies at all stages to assess their effectiveness.

9 APPENDIX

9.1 Primary data – RSAA interview

Most energy intensive:

- Super computers consume a lot of electricity for cooling - complex data systems provided by source require storage and processing.
- National space testing facility high energy use when running/testing. School energy use peaks when there is testing going on. Data storage and processing facilities energy intensive.
- Advance Instrumentation and Tech Center (AITC) develops instrument 4 astronomy & space science – energy intensive

Community:

- 40-60 students including academics, technicians.
- Lecture & tutorial rooms for undergrad & postgrad courses.
- Facilities include Staff room, kitchen with standard appliances including fridges, microwaves, kettles
- Offices are typical – Computers, lighting, electric heating

On site generation:

- Not just yet - Getting 100 kW solar, supposed to cover 20-33% of footprint depending on the usage. Quotations in progress

How many buildings cover the school, age, upgrades:

- After 2003 fire, main building was rebuilt. AITC built after that too or its 2 buildings.
- The few buildings that survived are residences & some other building are not smart buildings - heavy energy consumption. Sustainability at ANU has considered this with smart lighting, however to be looked at University level (as part of ANU below zero), so has not been pursued at this stage.
- Unsure of the new building ratings

Current strategies to reduce energy use that involve changing behavior?

- None - Focus in 'Sustainability Committee' has been on reducing waste rather than electricity use (new solar panels). Few scattered stickers to turn off lights but that's all – questionable if effective.
- School pays for its electricity bill because its off campus (not centralized), so they're going to invest in solar panels (payback of 3-4 years), savings of 20-30 percent after 4 years off current utility bills.
- Looking to upgrade infrastructure where conferences are held so that people don't have to travel overseas (Zoom, skype). Smaller carbon footprint and cost savings.
- Have a lot of commercial entities like the AITC in the school so these pay for their electricity. It is up to the people working there to reduce energy if they want. Each dept has their own executive team responsible for managing costs. If they lower energy use they get to keep the energy savings and reinvest $ into projects and whatnot.
- Universities less funded through Government, tighter revenue

How do policy at campus level flow through to school? / where does efficiency rank?

- Implementation of policy at a campus level is very hard as ANU is such a big entity. School is off campus & paying for utility bills, gives them the mechanism to change human behavior by allowing different buildings to keep any money from energy savings.
- People want to change, but leaders need to drive.
- Need to monetize things to influence and incentivize behavior – funding direction back to college.
- The easier you can make it for ppl in the community to change their behavior, the more likely they will:
- Recycling boxes around the school where people bring in the right trash and staff sort it out. Send an email every few weeks reminding people about the boxes and how much has been recycled. Students have been more responsive than staff as they've probably had the idea of climate change more present.

Success stories in terms of efficiency programs:

- No success stories in the school relating to energy behavior or reduction. Hard to reduce electricity bills because some rooms have science equipment that uses a lot of energy & would need a lot of money for smart buildings.
- Composting was the only story. All kitchens have a food waste bin, take up has been good. Compost goes into community garden.
- On the habit change – manager has been making little fact sheets about food waste to stick near the bins and was also thinking about making some for energy use, like how much for lightbulbs.

9.2 Study limits

There are two main limits to the analysis and recommendations issued by this report. The first is a lack of specific energy use data that prevented the team from identifying focused areas where the RSAA could reduce energy use and quantities (e.g., lighting in classrooms, heating, specific equipment). The second limit was not being able to visit the school due to reasons beyond the team's control. Therefore, this report is based on interview data (Appendix 9.1), UNEP principles for sustainable universities (Table 1), literature on individual behaviour and strategies to reduce energy use in universities.

9.3 Statement of peer contribution

Qualitative and quantitative statement of individual contributions to the project:

Tom Atkins 50% of content and workload	• Introduction • Executive summary • Analysis of UNEP sustainable universities principles • Discussion and recommendations • Conclusion • Referencing / literature review • Formatting / review
Simone Antich 50% of content and workload	• Introduction • Executive summary • Modelling and system analysis • Results • Recommendations • Conclusion • Referencing / literature review • Formatting / review

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