LOW CARBON LIVING CRC

The NED Modelling capability

Utilisation and engagement planning

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- originality
- methodology
- rigour
- compliance with ethical guidelines
- conclusions against results
- conformity with the principles of the Australian Code for the Responsible Conduct of Research (NHMRC 2007),

and provided constructive feedback which was considered and addressed by the author(s).

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Background

A series of research projects funded by the Low Carbon Living (LCL) CRC, the CSIRO and agencies such as Sydney Water, Sustainability Victoria and the NSW Office of Environment and Heritage have been developing and piloting an Agent-Based Modelling (ABM) approach to better understand the decisions made by community members when they are presented with a range of resource conservation products and services, or are selecting resource consuming appliances and fixtures.

What does NED stand for?

This stands for three of the key reasons for using an Agent-Based Modelling, i.e. Nudge, Emergence and Diversity. See review paper for further description of these terms (Moglia et al., 2017).

What is an ABM?

ABM is a computer simulation technique, and Agents are software representations of individuals or organisations and can refer to different types of people and information involved in the decision-making process. To illustrate how this may work, for example purchasing a water efficient appliance is likely to involve interactions amongst householders considering a purchase, sales agents promoting a product, and information sources such as the media. Specific benefits of the ABM approach are:

- Being able to describe how the interaction of different types of agents (households, salespeople, media, builders, etc.) lead to the adoption of behaviour.
- Capturing a range of behavioural drivers, including ones that aren't usually captured, especially non-monetary drivers of behaviours.
- Because Agents represent individuals, being able to describe the diversity of attributes across a population rather than relying on averages or other statistical techniques.
- Being able to describe the different ways that agents may make their decisions, i.e. based on heuristics, social influence and limited information, rather than to assume economic rationality or perfect information.

Our models would normally be developed to help policy makers and network planners in energy, transport and water who want to reduce uncertainty when evaluating outcomes of decisions and to understand possible scenarios' impact on investment decisions or policy actions.

Why do I need a model?

Often you don't need a model, but you may need a model for a range of different reasons such as:

- You may need to justify the business case of your actions, i.e. to quantify likely outcomes and costs.
- You may want to find a way to integrate your data and knowledge into decision making in a coherent manner. Models provide one way for you to achieve this.
- You may want to provide a way to collect organisational knowledge, data and information in the same location so that when there are staff changes, they can have easy access to this. Models can also provide a good way to get new staff up to speed about a context.
- You may want to manage your policies and actions in an adaptive manner. Models provide a way to explore expectations, monitor outcomes and explore why expectations and outcomes do not align. This will help you structure your investigations and data collection.

Why an ABM?

There are many modelling approaches that you may consider, but ABMs provide a useful approach for describing and understanding how people are likely to respond to a decision triggers,use heuristics, and consider the influence of social interactions amongst a network of agents.

Why is the approach different?

Unlike many current methods such as consumer surveys which do not capture the complexities around consumer decision making, we embed:

- Different types of agents (see Figure 2), such as sales and information agents, acknowledging that the process of adoption is typically dependent on a complex web of interactions.
- A flexible user interface that allows for exploring a whole range of 'what-if' scenarios.
- Non-monetary drivers of behaviour, such as relating to agent-held intrinsic values, normative pressures, as well as practical limitations towards adoption.
- Inertia in the translation from intention to action, due to the slow diffusion of communication across a population.

What modelling platform do we use?

We use NetLogo which is a multi-agent programmable modelling environment. It is used by many tens of thousands of students, teachers and researchers worldwide. More information about the NetLogo platform can be found here, https://ccl.northwestern.edu/netlogo/

Can I trust an Agent-Based Model?

Generally, the principle applies that the accuracy of your model will depend on the data and knowledge you put into it. It has been shown that statistical approaches and agent-based models have a similar capacity to predict behaviour. The main difference with an agent-based model is that it provides more flexibility when exploring hypothetical scenarios, i.e. more suitable for exploration. We have validated our model for the water conservation context and found that we can replicate past behaviour with some level of calibration.

Contexts for which we have used our models

We have applied our models in a range of contexts in particular, the adoption of energy efficiency in buildings, commuters' choice of transport mode, and householders' adoption of water-efficient appliances and behaviours. This report describes efforts, insights and plans to increase utilisation and adoption of this capability

How we model the decision to adopt?

To describe the choice of individuals to adopt resource efficient technology or behaviour we need to move beyond any relatively simplistic models of human behaviour and attempt to describe a broader range of complexities. There are numerous theories that describe consumer behaviour. Examples are theories about human needs, motivational processes, social comparison theory, social learning theory, the theory of reasoned action which all represent aspects of consumer behaviour.

More specifically, throughout our projects, we have explored five different lenses on consumer choice:

- Behavioural science,
- Social practice,
- Media and communications,
- Household priorities and perceptions, and
- Technology attributes.

None of these perspectives holds the full answer to describing household decision making yet jointly we think that they provide a useful starting point, and provide design principles for the ABM that we develop. Factors that we consider are shown in Table 1. To embed these, we have adopted a meta-theory of consumer behaviour, i.e. the Consumat theory, which encapsulates many other such theories (see Figure 1). This meta-model is particularly suitable for developing simulation models. The Consumat theory operates at different scales. Individual behaviour leads to collective (macro) level outcomes, which in turn influence individual scale decision making. At the individual level household, agents are equipped with needs which may be more or less satisfied. These represent behavioural drivers. When confronted with a consumption choice, an agent will evaluate to what extent the choice will satisfy needs, but this will be done under a certain degree of uncertainty. Depending on the degree of need satisfaction and uncertainty, agents use different cognitive processes for making a decision: repetition, deliberation, imitation and social comparison. In practice within simulations, this means that the agents are sorted into four different categories: Repeaters, Optimisers, Inquirers and Imitators.

- **Repeaters** are not going to "make the consumption choice" and will require circumstances to change in subsequent years to become more engaged and aware enough to shift them to the other decision categories.
- **Optimisers**, on the other hand, will "make the consumption choice" and will remain a participant in subsequent time steps.
- **Inquirers** may or may not "make the consumption choice", depending on how satisfied they feel about the offering after they have gathered more information. Hence, increasing the parameter values of "Framing" and "Influencing the influencers" can potentially elevate the level of satisfaction of Inquirers to adopt the WaterFix program in a later time step.
- **Imitators** copy the behaviours of others in their social network, and thus may or may not choose to "make the consumption choice" depending on how many other households have already adopted the program, based on social normative pressures.

What data do you need?

Broadly speaking, these data types are usually needed:

- Data to understand what drives community members' decisions. This is typically collected using a survey. We will prepare and organise the survey collection for you.
- Data to understand what drives influencing agents' and decision activation agents' decisions. This can be collected either via expert knowledge (from you or directly from people in the market place) or via some sort of survey. The nature of this depends on what you will like to model so there are unfortunately no generic answers, but we are happy to discuss approach with you.
- Past rates of adoption: to allow us to calibrate critical parameters in the model we generally will require some past rates of adoption to be available. We can operate without this, but calibration certainly helps our level of certainty in estimates. This can also be collected as part of the adaptive management of outcomes.
- Future attributes of technology/behaviour: it may be that the performance of behaviours or technologies will change over time. If so, we will need to establish to what extent this occurs. We are happy to work with you to explore this issue.

Table 1: Factors that influence the adoption of behaviour/technology

Issue	Description
Cognitive Biases	It is important to incorporate the latest and most relevant aspects of behavioural science because humans make decisions based on heuristics and are subject to a range of common biases.
Social comparisons	Choices are often based on social processes which involve implicit or explicit peer pressures.
Imitation	Decisions are often based on heuristics and perhaps the most common one is the imitation of peers.
The role of media	Decisions are influenced by perceptions which in modern society is strongly influenced by media.
Limited bandwidth and strict budgets	People will make decisions in contexts with competing demands for time, effort and money.
Non-monetary priorities	There are many aspects that people will consider of which are non-monetary and often also non-quantitative such as lifestyle or comfort factors.
Decision triggers	Decisions are made only at certain times, and it may be useful to consciously trigger additional decisions in order to speed up the transitions process.
Heterogeneity	People make decisions based on individual circumstances and priorities, which vary considerably across a population.
The frequency of proactive or passive decisions	The way that choices are presented, and when they are presented, to consumers, is critically important for the outcome, especially as it influences the average frequency by which people will make decisions.

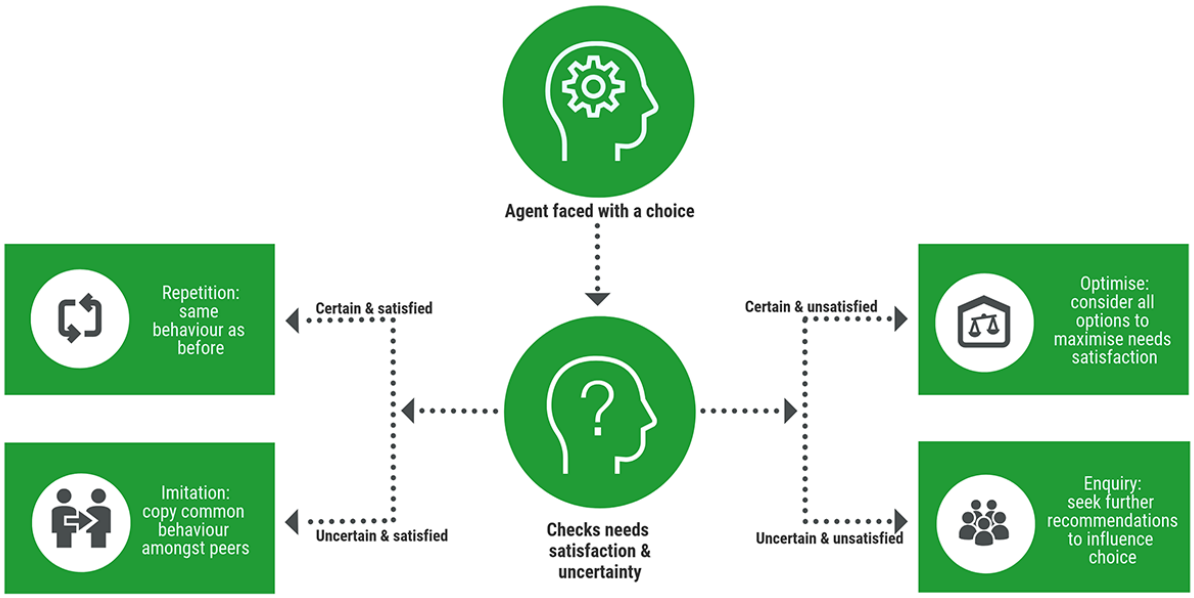

Figure 1: The Consumat meta-model of choice.

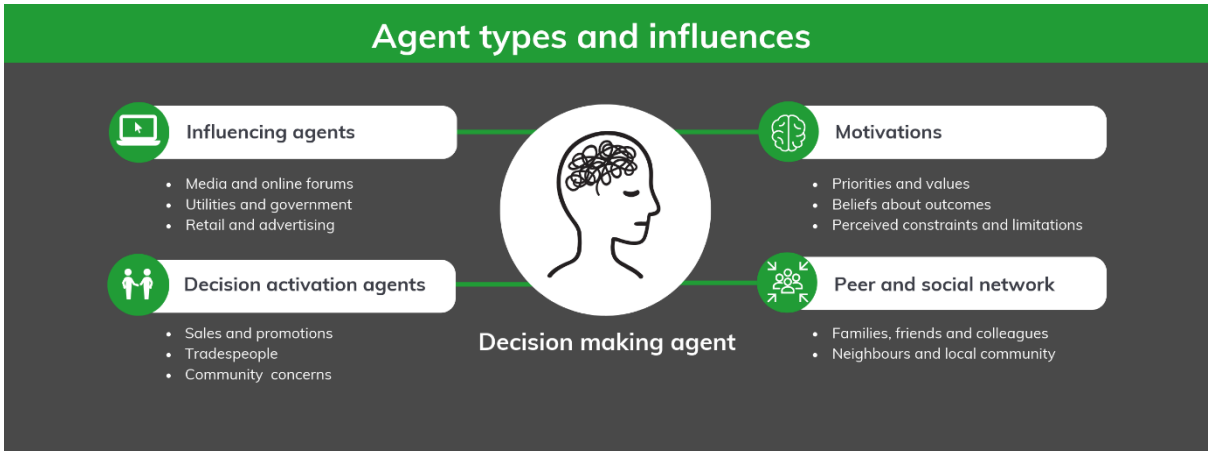

Figure 2: Types of agents in our models.

Projects

RP3002: A Framework for Low Carbon Living Community Policy & Program Development

This project modelled the uptake of cost-effective, energy-efficient retrofits for commercial buildings as described by Higgins et al (2014). It set out to develop an ABM framework to identify and understand the network relationships between building owners/tenants in different locations and their complex response to intervention options. It also set out to develop a decision-support tool (DST) to help assess the impact of interventions/programs for promoting building energy efficiency retrofits. This helped allow key stakeholders to simulate various interventions to create incentives to improve the energy performance of the existing building stock. Figure 3 provides an example of the the visualisation of the outputs from the RP3002 project. Several reports were written as output (Marquez, Higgins et al. 2013; McGregor, Marquez et al. 2015; Marquez, McGregor et al. 2017).

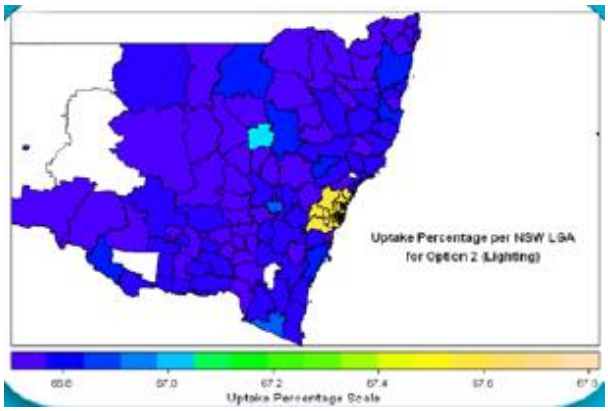

Figure 3: Example of visualisation of outputs from RP3002

RP3028: A Virtual Market for Analysing the Uptake of Energy Efficiency Measures in Residential and Commercial Sectors

This project modelled the public uptake of low carbon and energy efficient technologies and practices by households and businesses under different market interventions. It extended the previous research (RP3002) into the residential and small to medium business sectors, whilst producing innovative methods that accommodate market-based incentives. The model used ABM to represent consumer behaviour, social networks and their responses to non-financial incentives and barriers. The resulting model was a “virtual market” aimed to enable the stakeholder agencies to better understand, design and evaluate different types of market interventions (e.g. incentives, information, training, finance, codes), through exploring technical, economic and behavioural parameters. Figure 4 is a flow chart of the model developed under RP 3028. After a review of ABM as applied to the context (Moglia, Cook et al. 2017), the model was published in the *Journal of Artificial Societies and Social Simulation* (Moglia, Podkalicka et al. 2018) as well as in the final report of the study (Moglia, Podkalicka et al. 2018).

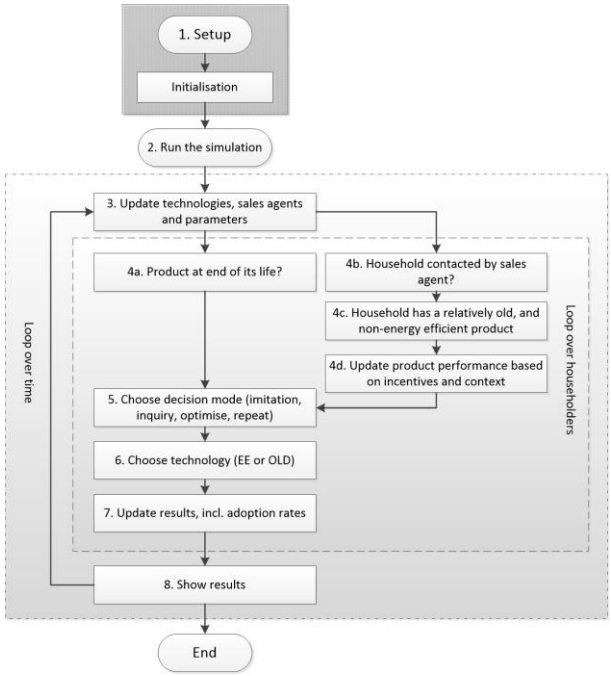

Figure 4: Flow chart describing the model developed in RP3028. (Moglia, Podkalicka et al. 2018).

RP3035: Modelling the Uptake of Water Conservation and Efficiency Measures in Sydney

This project further developed the outputs from the studies RP3002 and RP3028 by adapting an existing ABM developed in these projects to understand the relationship between residents and their complex response to a set of intervention options to promote the uptake of water conservation and efficiency measures. The output of the project was an ABM, building on an existing model, and its application to a small set of interventions to promote water conservation. The final output was published in the final report and in articles (Moglia, Cook et al. 2018; Tapsuwan, Cook et al. 2018; Moglia, Cook et al. 2019).

RP2021: Greening Suburban Travel

Our ABM was only one part of this larger project. The main aim of this project was to review international best practices and trends in the provision of high-priority, transformative initiatives to tackle the mobility challenges facing suburban communities. It investigated travel demand drivers and determinants of possible shifts in travel behaviour, undertook sustainable transport planning studies focusing on pathways to increasing customer usage of public and active transport, and modelled the impacts and benefits of networked smart bus systems, on-demand access to transport and

emerging disruptive transport technologies. The project also developed a framework for supporting effective investment decisions that increase the uptake of low carbon transport interventions. The model that we developed in this project is published in a report (Cook, Moglia et al. 2019).

SP0018: The Commercialisation of CSIRO Energy Efficiency Policy Adoption Diffusion Modelling

The final study in this series of research projects explores how to increase the rate of utilisation and commercialisation of the outputs produced. The report describes the approach used, in general terms, as well as engagement and utilisation plans, as well as a theory of change and description of next steps. This involved several activities, such as interviews of stakeholders, validation of the modelling approach, developing a business model for the approach, and a Launch Camp activity to explore commercialisation and utilisation opportunities of these products. Figure 5 presents one of the first iterations of the Gaddy Pitch of the NED project.

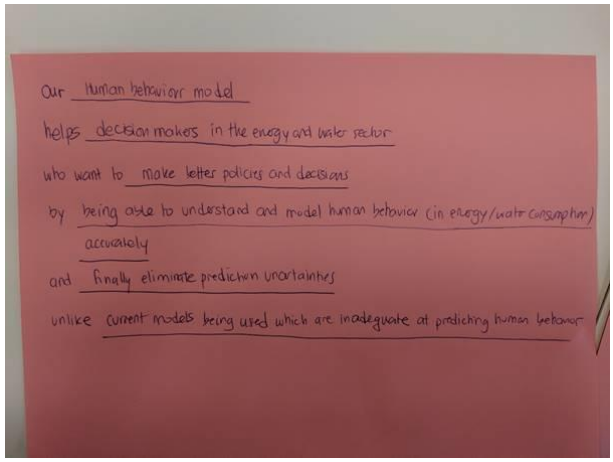

Figure 5: A work in progress output from the Launch Camp by the team.

Engagement and Utilisation plan

Activities

The engagement and utilisation plan for the NED-ABM capability was developed on the basis of the following activities:

1. A consultancy, Common Capital, undertook a review of commercialisation and adoption pathways for the ABM capability. This report, based on consultation with potential users, identified three potential business models (Link to report).
2. The project team participated in a two-day Launch Camp. This process helped to refine the business canvas for the NED-ABM capability, including honing of the value proposition and customer segments likely to be most receptive.
3. Following the Launch Camp, there were a number of customer conversations with potential users of the modelling capability to test assumptions around the value proposition and customer segments.

In addition to the above activities, there have been a number of engagement activities to help communicate the modelling capability to potential customers, which has included: invited presentations to utilities and state government agencies, and conference paper, which has been accepted for a platform presentation.

Business Canvas analysis

The following summarises the final version of the business canvas, which was developed iteratively, with refinements following customer conversations. The focus was originally on modelling the uptake of energy and water efficient appliances for different consumer segments (e.g. residential and commercial). However, it was found that the real 'pain point' for customers was understanding demand, in particular, the how and when of people's energy and water demand.

The growing complexity of energy and water supply networks due to the emergence of decentralised generation and supply, as well as the introduction of disruptive technologies, has made the task of understanding the likely network effects of policies much more difficult. Particularly, considering the lack of uniformity in how people use energy and water. Energy and water network provide essential services and represent billions of dollars of investment. Therefore, understanding the potential impact of new technologies, such as household solar photovoltaic and battery systems, or how water demand management can be used to maintain the security of supply during periods of drought.

Current approaches to understanding consumer behaviour, and resulting impacts on utility networks are limited in helping to understand the complexity of how different people make decisions, as they are often based on average behaviour. Surveys are often used to gain an understanding of the consumers' perceptions and stated behaviours. However, our approach, which combines statistical analysis of survey data and ABM enables deep insights on how different customers might respond to policies and incentives designed to encourage more sustainable resource use.

Value proposition

Our human behaviour model helps decision-makers in the utility (water and energy) sector by being able to understand and accurately model human behaviour responses to policies and interventions designed to encourage more sustainable consumption of energy and water resources. The approach can improve the prediction accuracy to understanding human behavioural responses to policy initiatives when compared to current approaches.

Figure 6 presents the value proposition canvas developed for utilities, which highlights how the modelling approach can deliver value and help to address some of their current pains.

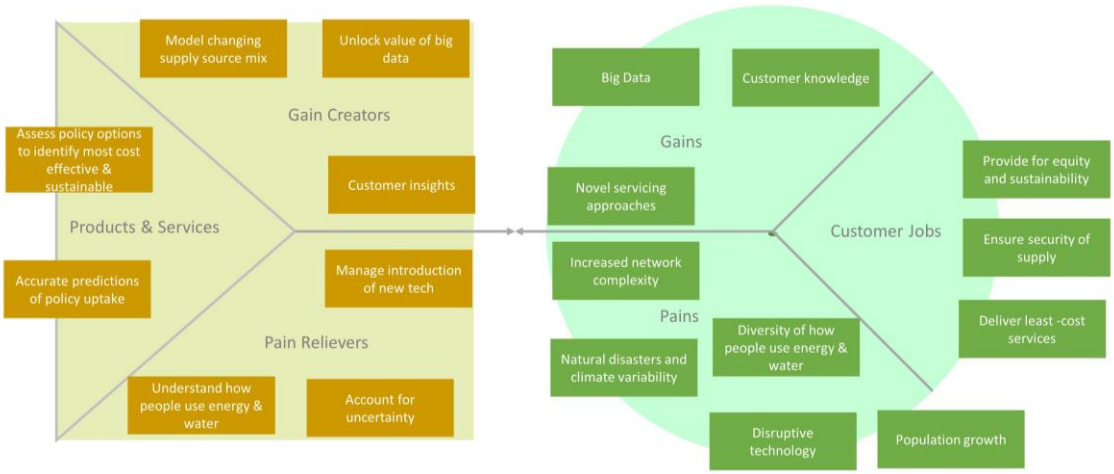

Figure 6: Value proposition canvas for utilities

Key customer segments

The process has identified three main customer segments, which are outlined below.

Utilities – Water and energy utilities face a number of pains in managing: population growth, ageing assets, the introduction of distributed infrastructure and disruptive technologies, climate change, etc. In addition, there is a need for utilities to provide cost-effective and reliable services, while achieving sustainability targets. The task of designing cost-effective approaches to encouraging more sustainable demand patterns in consumers is impeded by the lack of understanding of customer behaviour. The tool can help provide insights on how and where customers use water/energy, and how they might respond to policies and incentives.

Policy-makers - State and Federal Government agencies are looking for guidance in developing policy frameworks to encourage more sustainable use of energy and water resources.

Boutique consultancies – Our modelling capability can provide a competitive advantage for small-scale consultancies that specialise in delivering to government and utility customers in the sustainability area. For this customer type, the consultancy would be responsible for identifying and securing market opportunities, project scoping and managing customer interactions. This would reduce the workload on the NED team, who would focus on the delivery of the bespoke modelling tool. Customer conversations revealed that there is a market for our ABM modelling capability. In particular, interest in how potential customers can better understand uncertainties in human behavioural responses to policies and incentives that are intended to encourage more sustainable demand patterns.

The chosen delivery framework is discussed more at the conclusion of the report.

Website

The website has been designed to provide accessible and helpful information about the NED modelling capability to potential customer groups.

The website is intended to provide an effective communication and engagement tool for potential customers and champions of the approach by providing information on the modelling, simplified versions of the models, and how it has been applied has been presented in a range of user-friendly infographics with supporting text, and links through to more detailed information. The website can be updated with new project cases and refinements of the modelling approach to ensure that content stays relevant. The website also ensures the NED capability is discoverable, and that potential customers can contact the team.

Potential customers interested in the modelling approach are likely to want to evaluate the approach and compare against other offerings from market competitors before they engage further. The website provides a gateway that can help customers to do the following:

- Assess the expertise of the NED team and the validity of the approach.
- Evaluate track record with similar customers based on previous projects.
- Understand the value of the approach through the information presented.
- Experiential learning by providing simple versions of web-hosted versions of the models.

Structure: The website has been designed to provide information at two levels to support the targeted user groups, which are: 1) decision-makers and planners, 2) data analysts. The first group are typically time-poor and require information that highlights the value proposition of the modelling tool, and that validates based on previous applications the capacity of the NED tool to deliver value. The data analysts will be more interested in the technical details of the modelling approach, including data requirements, technical support required and validity of the approach.

A key insight from ongoing collaborations as well as customer conversations was the need for a 'champion' of ABM within a customer organisation to have access to information that can help sell the value to decision-makers while reassuring technical staff around the data and in-house ability needed to apply the model. The website is an important tool for providing that support to organisation champions to help build understanding and support for the NED modelling capability. The high-level structure of the website is depicted in Figure 7.

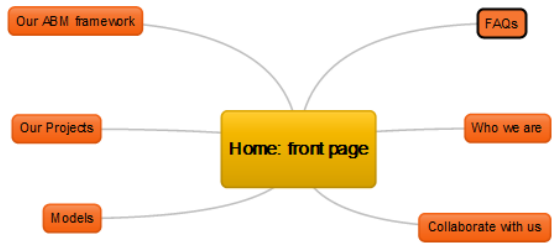

Figure 7: Website structure

Communication and support: The NED website will only be of value if the target audience is aware of its presence, and are motivated to access it. The website will be promoted through a range of avenues, which include:

- Presentations at conferences and workshops.
- Follow-up emails to customer conversations.
- CSIRO and CRC LCL promotional materials. This includes the upcoming roadshow.

It is planned that the website will initially be supported and maintained for a period of two years, and then evaluated if website traffic and market success justify ongoing support.

A Theory of Change

Here we present a “theory of change” based on one of the case studies we have been working on.

Adoption of resource conservation measures is one method by which government departments or utility companies and community are able to reduce the demand on finite resources by a growing population. Resource conservation targets the reduction of day to day resource use by customers without reducing their utility, which is, making customers naturally more efficient in how they use resources. Being resource efficient can also reduce the expenditure on associated infrastructure and use of resources such as energy.

To make resource efficiency and conservation part of the people’s everyday decisions, we need to better understand what drives people to do what they do. A tool that can consider the drivers behind customer choices to adopt or not adopt resource wise behaviours, technologies and services will help to define the types of programs available in the future and how they should be delivered. A better understanding of how to design and deliver products and services that meet broader community needs, beyond saving the resource, will help to embed efficient resource use into everyday life.

Government departments or utility companies have an obligation to ensure that their customer’s money is spent effectively. As such, there is a need to justify and provide evidence to support investment decisions. Having a tool that can inform the design of resource conservation programs and estimate likely program costs and benefits will provide justifiable evidence to decision making processes.

Figure 8 illustrates how benefits from using this tool in a utility’s decision-making processes may flow on to the customer and society in general.

Figure 8: Potential benefits of using this tool by utility companies or government departments, in terms of flow on effects to society.

On the basis of working with the stakeholder, the following applications were considered in the development of our tools.

1. **Use of the tool to develop and design new resource conservation-related products and services (see Figure 9):**
    I. To understand the drivers of decisions and the interactions between different segments of the community.
    II. To identify potential opportunities for resource conservation activities and their key features of success to be considered in the ideation process, e.g. types of products or services, types of segments with participation or influence, design or delivery features that would impact the success of uptake.
    III. To assess the value proposition of each proposed prototype to determine those most likely to succeed prior to running a pilot program. Success may be measured based on - the level of adoption, type of potential resource savings or cost-effectiveness.
    IV. Based on the results of the pilot, the tool may be used to decide whether to progress, refine or suspend the program.

V. Data from the tool and pilot can be used in existing approval processes and investment frameworks, such as the Economic Level of Resource Conservation, multi-year resource conservation planning and demand forecasting.

2. **Use of the tool to assess potential opportunities to revisit old and existing programs:**
   I. To assess options to refine previous or existing programs and re-evaluate their potential uptake and cost-effectiveness.
3. **Use of the tool to provide evidence to support a more holistic evaluation of resource conservation programs:**
   I. To provide a means to justify and quantify the indirect costs and benefits of resource conservation programs, e.g. reduction in greenhouse gas emissions, impact on waste products.
   II. To provide a quick and low-cost approach to testing the uptake potential of new or redesigned programs.
   III. To provide supporting evidence to justify assumptions on non-financial factors associated with resource conservation.
   IV. To provide an opportunity to initiate and inform conversations on the potential direct and indirect benefits of resource conservation in strategic, planning and policy projects.
   V. To consider the benefits of potential delay in infrastructure spending.
   VI. To provide evidence to influence changes in the market, regulation and planning policies.
4. **Use of the tool to inform the estimation of the future demand for resources:**
   I. To provide potential uptake and resource savings from a range of programs for inclusion in forecasts of resource demand that informs resource usage prices.
   II. To provide potential uptake and resource savings from a range of programs to inform long-term scenario based demand forecasts for region/city-wide resource planning.

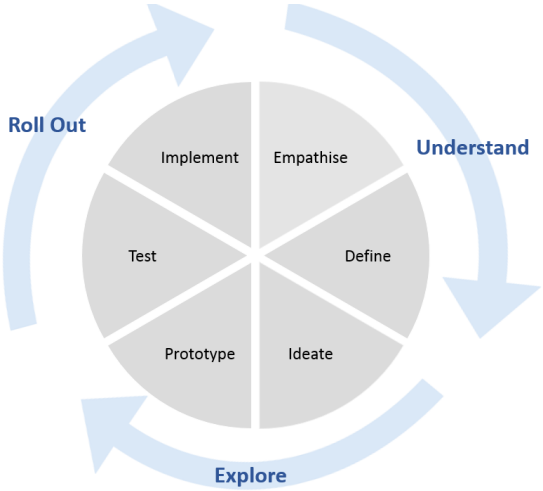

Figure 9: Development and design process.

Stakeholder perceived key factors for adopting the tool(s):

The stakeholder operates in a highly regulated environment. To maximise the adoption and use of the tool it must be able to provide quantifiable evidence-based data and referenced justifiable assumptions.

- One major opportunity is for this tool to inform the stakeholder's methodology to estimate the economic level of resource conservation. This measure compares the levelised cost of a project against the value of the resource, as measured from the perspective of the whole community. The methodology, therefore, tries to include all costs and benefits, such as social and environmental benefits and costs, even if they do not directly affect the stakeholder or resource users. The total 'societal' levelised cost is then used to determine if the program/project is economically efficient or not. Under standard operation, only economically efficient projects can be implemented.
- The tool must be user-friendly and it must be easy to add, modify and compare programs/projects and assumptions. Any assumptions in the tool must be referenced in the tool. This will ensure the longevity of the tool and build trust in the approach and outputs.
- The outputs from the tool must be easy to interpret and to share with both technical and non-technical staff. This will ensure the results are understood, consistent and adopted by all those who should use them, e.g. strategists, planners, policy, program managers.

To illustrate how the approach can be used, Figure 10 illustrates how the tool may promote the uptake of water conservation, by connecting to broader customer and community benefits.

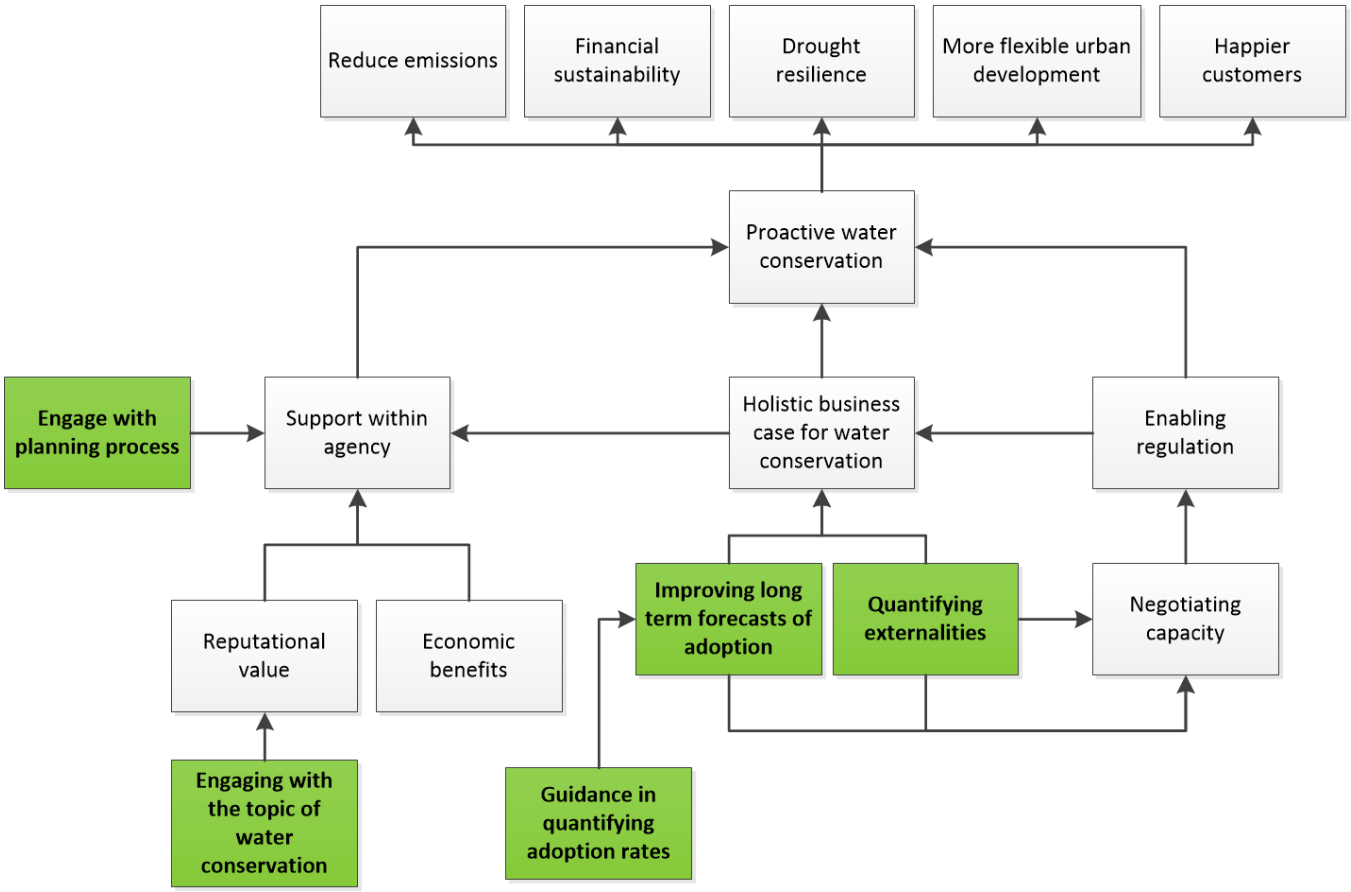

Figure 10: Theory of how the tool can be used to promote resource conservation

Validation of the approach

In all our interactions with potential clients, there was a desire to see evidence of successful backcasting i.e. what is commonly considered to be an important aspect of validation of models.

We, therefore, embarked on a validation exercise to ensure that, with adequate data, we are able to replicate past adoption behaviour. As a result of this, we were able to demonstrate a close fit between the observed and modelled adoption rate of the Sydney Water WaterFix program (see Figure 12). Details of this modelling exercise have been reported in the report for the LCL CRC project RP3035 (Moglia, Cook et al. 2019).

The report also has details of the relevant sensitivity analysis for the approach, including for key parameters that currently lack empirical foundation.

Figure 11: WaterFix is about a range of actions in the household, including to fix leaks and change to more water saving fixtures.

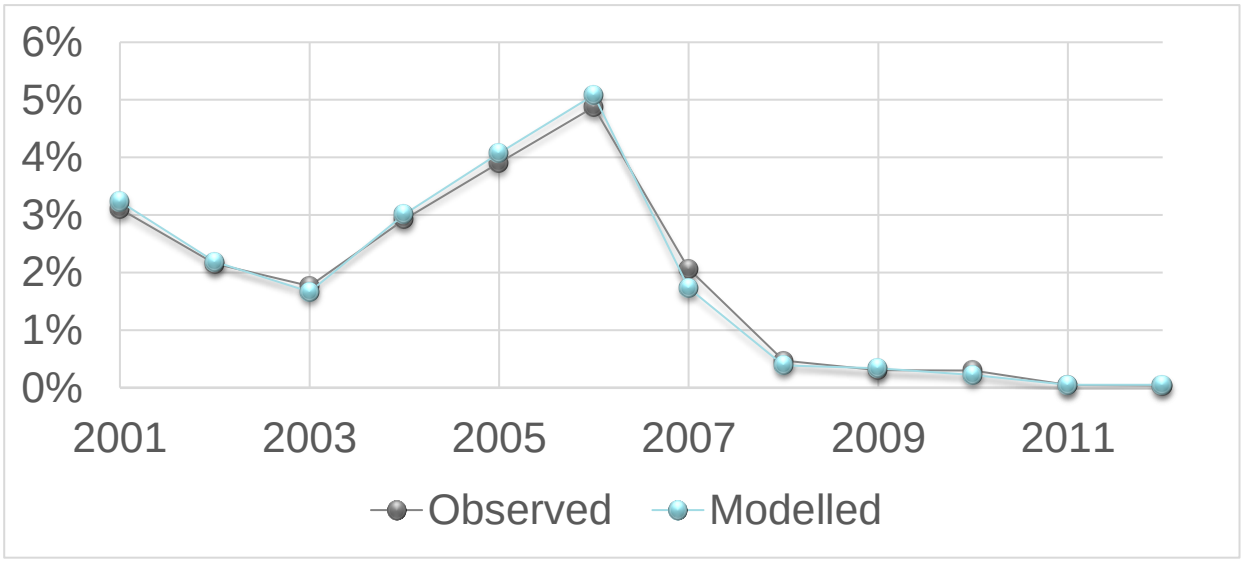

Figure 12: Close fit between observed and modelled adoption of the WaterFix program.

Preferred delivery mechanism

We hired sub-contractors to evaluate the market for us, and they explored three scenarios for which CSIRO could deliver this capability to market, which were:

- ***Consulting*** – co-investment projects where the CSIRO uses its research expertise and domain knowledge to enhance the existing Behavioural Economics driven ABM framework to provide policy recommendations as a consultancy service.
- ***Generic framework*** – a Behavioural Economics driven ABM framework that provides a starting framework that an end user with modelling and programming skills can modify. This allows them to customise the solution to incorporate their own IP and/or to address related but different policy questions. Potential customers include policy consultants who wish to differentiate their market offering and larger organisations that have in house modelling and analysis capability.
- ***Bespoke applications*** – Behavioural Economics driven ABM applications that are custom developed for clients who require recommendations in response to the same question, for example what solar/battery solution should be offered to a specific customer. This may be a background application that receives a data package about the client from a CRM system and returns the recommendation via an API. The software may be developed by partnering with a vendor that has a product they wish to enhance with this IP.

Interviews and assessment of the market-place were evaluated against “gains” and “pains” of each customer group as shown in Table 2.

These scenarios were also evaluated against achieving criteria, such as delivering science excellence, impact, research partnerships and revenue potential as shown in Table 3.

Our chosen business model

Customer feedback revealed that the way the tool is presented, delivered and supported is critical for the customer receptivity. In particular, it needs to be aligned to their decision making processes to provide effective support, and there is a need to consider how the future capability needed for applying and updating the model within the organisation. For these reasons, and given the review and advice from the consultants, it was found that the preferred business model is the development of bespoke applications (Option 3). This would involve the NED delivery team working alongside the customer organisation to adapt the model to their particular decision context, and ensuring that in-house capacity is developed to apply and update the model.

Table 2: Evaluation of different scenarios for delivery of capability.

	Consulting Full fee or co-investing	**Generic framework** A framework that the end user can modify	**Bespoke app.** An application that is simple to use
PAIN RELIEVERS			
Cost-effective	◕	●	◕
Accurate forecasts	●	●	●
Simple to use	●	◔	●
Data is available	◑	◑	◑
GAIN CREATORS			
Novel solutions	●	◕	◔
Flexible	●	◕	○
Can be deployed widely	○	○	●
Recognition as a thought leader	●	●	◑

Value proposition: ○ = Nil ◔ = Small ◑ = Moderate ◕ = Significant ● = High

Table 3: Potential for achieving key outcomes.

	Impact	**Science Excel**
Scenario #1	◔	●
Scenario #2	◑	●
Scenario #3	●	●

Value proposition: ○ = Nil ◔ = Small ◑ = Moderate ◕ = Significant ● = High

Next steps

The next step is to engage with the organisations that throughout interviews and other means have expressed interest in our products in order to quantify the extent of commercial and utilisation opportunities, as well as the investment required and the likelihood of success.

As part of the market review, we were able to provide a high-level assessment of the interest based on a general description of the product via telephone conversations, demonstrations of our software to interested stakeholders, collaborators, conference presentations and one to one meetings.

There is a consistently high level of demand for access to explore further with CSIRO scientists through in-depth use-case workshops, product demonstration and trials.

Strategy #1: We will disseminate our tools and research via articles, conferences, NED website, and other means. The main purpose of journal articles is to clearly establish the academic credentials, to show demonstrations and validation exercises.

Strategy #2: We will look to deepen collaboration with existing stakeholders around using the tool, and thereby to further develop the capability, demonstrate its use cases and gather further data to build our tools on.

Strategy #3: The use-case of most value to prospective users of the energy model is a demonstrated ability to forecast uptake of solar PV. There are also considerable opportunities in relation to reducing investment risks and operational management for electricity markets, especially in exploring the impact of technology adoption on the daily demand profiles. We, therefore, intend to build further capability via collaboration with other scientists in CSIRO and to collaborate with partners in order to aim for a larger amount of funding to address this set of related issues.

Strategy #4: We will keep going with exploring opportunities via telephone and one-to-one interviews and ask these questions to determine the size of the opportunities:

- What challenge or opportunity can this technology used for?
- Do you want to proceed with a project?
- What budget do you have?
- Who is the decision maker?
- What process and timeline applies to reach a decision?

We will ask these questions to determine the effort to deliver a project?

- What are the functional requirements for the software?
- What data is needed?
- What other services do we need to provide?

Reflections

This project has been different from the typical research study in that it explores how to maximise uptake and commercial potential of an existing capability, and this has had several benefits to the team:

1. **Capacity building**, it is very worthwhile to help researchers have a better understanding of how to maximise adoption and utilisation earlier in the research design process; this should have long-term benefits.
2. **Rewriting the role description of applied scientists** – currently, it is difficult for scientists to find the time and space for exploring these issues and it is not normally part of the role of, and so this has a tendency to fall between the cracks of current institutional structures. It should perhaps be a normal part of applied research that once mature enough, and with enough potential, there is a time when a "utilisation" project ought to be set up, such as this one.
3. **Always check utilisation assumptions**. There are – always - assumptions about where and how the developed technology ought best to be used, and such assumptions are sometimes wrong. There are at times applications that could prove far more profitable and/or impactful. The best way to test such assumptions is via stakeholder/customer conversations. Such conversations should be part of all applied research projects as a way to ground research activities.
4. **Business canvas**. In our case, we employed consultants to help us develop a business model for the capability. As it happened, this business model did not deviate very far from our own intuition. However, the process of using the business canvas is a good way to formalise and structure the thinking that leads to a decision on how to engage in commercial activities.
5. **Our project**. We have come a long way of proceeding towards providing services, advice and models on an ongoing basis for Australian governments in a way that is realistic and provides the necessary funding along the way.

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