SUSTAINABLE DEVELOPMENT: FROM ECO-HOMES TO ECO-REGIONS
ME3 Master's Thesis – Southern Cross University, Gold Coast, Australia

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Abstract

The Scenic Rim is a significant agricultural region an hour west of Australia’s third largest city, Brisbane, and also the coastal beaches of the Gold Coast. This region has been driven by agriculture for its entire history. However, Brisbane and the Gold Coast region are rapidly expanding and as a result, there is expected to be a massive urban overflow into the Scenic Rim region, resulting in the region’s population more than doubling in less than 20 years. While this shift presents many opportunities for the region, it is also accompanied by many challenges. The Scenic Rim Community Plan 2011-2026 states that the citizens of the Scenic Rim intend to promote sustainable development, create jobs with locally run businesses, and establish a strong infrastructure that compliments their other goals (Scenic Rim Community Plan, 2011). The infrastructure of the region will be under a large amount of pressure with the sudden influx of people migrating there.

Complex adaptive systems theory (CAS) combined with transition theory is used here as a framework to show that the system is dependent on the interaction of agents and the feedback from those interactions as well as feedback from the entire system and external environment. CAS also states that a system is susceptible to changes in the environment, whether that be new rules and policies, or external disturbances. CAS is a good representation of a region as a region is comprised of a complex array of agents interacting with each other towards regional outcomes. System rules from a regional perspective refer to laws and policies which can have long reaching effects on a region if changed. Referring to a region in terms of CAS means region must be resilient and adapt to external system disturbances such as this mass migration or natural disasters. This research uses CAS and transition theory to show that in order to be adaptive as well as move the region towards the desired state of sustainability, the agents within the system must interact under new system rules which provide an environment that promotes and enables this transition. The key is to determine those rules or policy changes.

A literature review showed that the main challenges faced by existing sustainable developments around the world were transportation, local employment, and sustainable housing, whether they were eco-homes, eco-villages, or eco-cities. The challenges found in the literature were combined with the hybrid CAS/transition theory framework in order to create a general template for addressing regional sustainability. The template provided a process which involved determining region specific sustainability projects, defining the agents responsible for those projects, and then discovering the system rule or policy changes required to push the agents to implement those projects. The implementation of these projects becomes the policy scenario within the scenario planning phase of this project.

Utilizing this template with the general lessons learned from the literature combined with a significant amount of collaboration with the main stakeholder in the project, the Scenic Rim Regional Council, several potential sustainability projects were brainstormed in order to create a policy scenario. While these three projects alone were not expected to transition an entire region towards sustainability, the research focused on defining a process and template which could be scaled up in future projects to eventually result in a transition to a new desired state of regional sustainability.

Three of the brainstormed potential projects were chosen to be analyzed in further detail in this project included repairing the old train line out of the Scenic Rim and creating a transit hub in the largest town Beaudesert, creating a co-working space close to the transit hub, and creating minimum requirements for new homes to have photovoltaics as well as solar hot water installed on their roofs. These three projects were chosen because together they address local employment, transportation, and housing in some capacity. Together these solutions formed the policy scenario within this research. In order to analyze the potential impact of these three solutions, an approximate energy model of the Scenic Rim Region was created. In this model, the solutions were modeled in a policy scenario and then regional performance up until 2040 was simulated and compared against a “business as usual” scenario in which it was assumed no changes were made in the future and projected performance was based solely on historical trends. The results of this analysis demonstrated that the policy scenario was able to drastically reduce the electricity demand of the housing sector in the Scenic Rim as well as drastically reducing the oil demand in the region. An approximate economic analysis was done of the policy scenario. The QLD PV feed in tariff and decreased electricity bills from the SHW system would more than offset the increase to the homes mortgage caused by the PV and SHW systems. The gas savings from only driving into the city once per week by using the co-working space more than offset the rental cost. The restored rail line would have a high initial investment, but the shared cost with Logan City combined with increased use results in the rail line paying for itself by 2029. This process and the hybrid CAS/transition theory framework proved to be quite effective and have the potential to be scaled up significantly to fully transition a region towards a sustainable future.
1.0 - Introduction:

The world is facing a global crisis that goes far beyond the economy. The consequences of climate change alongside ever increasing prices of fossil fuels are making people re-think how they live and the choices they make regarding energy use. While most people have trouble quantifying climate change and whether or not we are even the cause of it, they will always pay attention when it directly impacts their wallets. Community members are educating themselves daily about climate change and other global issues through social media and through seeing the results of demonstration sustainability projects such as the massive solar thermal plants in Spain, sustainable housing emerging in their communities, and net zero communities and even cities around the world. As this trend continues, people are going to continually strive to live in a more sustainable manner to reduce their daily expenses but also need to acknowledge that sustainable options are also a choice.

However, it is very difficult for most people to have a significant impact on large energy issues such as moving away from coal power plants or finding a way for developing countries to develop in a more sustainable manner. The potential economic hardship of such changes is frequently raised as a barrier to implementation of change and frustrates those people attempting to implement the change in historic development or economic patterns. There are two areas in which people can see the immediate impacts of their decisions: in the buildings in which they live and work, and through the methods in which they travel. Globally, buildings account for 40% of the world’s energy and material flows, 17% of the world’s freshwater withdrawals, and 25% of the world’s wood harvest (IEA, 2012). Globally, the transportation sector accounts for around 30% of energy demand and the vast majority of oil consumption (IEA, 2012).

The International Energy Agency (IEA) estimates that in OECD countries, residential and commercial building sectors of the economy are responsible for 30-40% of primary energy consumption and 30-40% of total greenhouse gas emissions. The energy consumption of these sectors has been continually increasing since the 1960’s and will continue to do so in the future. While this is the case, the building sector also offers the single largest potential for energy efficiency improvements (IEA 2005).

There have been many positive examples of efficient building implementations around the world. In terms of residential buildings, there are now homes that create more energy than they use and actually make the owners money. Beyond this there is a new trend of eco-communities or eco-villages where an entire community is designed to meet a high efficiency and environmental standard such as the Currumbin EcoVillage in Australia, as seen to the right in Figure 1. There are even cases which go beyond a community to create an eco-city such as Masdar in the United Arab Emirates, as seen in Figure 3. These are some unique cases of a group of passionate people coming together to try to make a difference, but they rely on building a new community from the ground up which is not a realistic solution for the built world. For the world to ever hope to transition towards sustainability, solutions must be found for the built world and this can only be achieved if sustainability is addressed on a larger scale. These sustainability efforts all face similar challenges throughout their implementation which all relate to the fact that they are not integrated into an existing society. It is not enough to just target buildings when referring to sustainability as there are many other sectors failing to meet that term. Sustainability in its fullest sense not only refers to energy sustainability, but to an entire system and the interactions within that system. For example, it is not enough to just target buildings in Australia because even to most energy efficient buildings will not change the fact that people need to drive to them because the public transit infrastructure in most of Australia is severely lacking. Sustainability must be approached by looking at an entire system and addressing not only environmental, but also economic and social sustainability using the triple-bottom-line approach.
While eco-homes focus strictly on the technical side of the efficiency and performance of a home, eco-communities address the more complete definition of sustainability utilizing this triple bottom line approach. As stated by Kemp and Loorbach, “Sustainability in its broadest sense is about progress, through the creation of economic, environmental and social capital, towards meeting present development needs and ensuring future development requirements can be met” (Kemp and Loorbach, 2006). However, these eco-communities and eco-cities have many other challenges which could potentially be corrected if sustainability was addressed from a broader, regional perspective. While regional sustainability is an extremely complex task, it would be significantly more beneficial for a country if sustainability was approached through the built environment and integrated in society as opposed to spending vast amounts of money on segregated communities built from the ground up to be different and self-contained, separating them from the region that surrounds them.

Regional sustainability faces many challenges mainly due to the already existing infrastructure systems which are very difficult to transition to sustainable systems as they are distributed over large distances, have significant but dispersed impacts, and have multiple and frequently conflicting stakeholders (Dasgupta and Tam, 2005). This research focuses on how sustainability can be addressed in the built world from a regional perspective in order to transition a region to a resilient and sustainable future.

The application of this project focuses on an agricultural region in south-eastern Queensland, Australia known as the Scenic Rim. The Scenic Rim Region is like many other non-coastal regions across Australia: secluded, disconnected, driven by agriculture, and with a generally lower cost of living than their coastal counterparts. The Scenic Rim is a significant agricultural region an hour west of the coastal beaches of the Gold Coast and only an hour away from Australia’s third largest city, Brisbane, as can be seen in Figure 2. This region has been driven by agriculture for its entire history with farms decorating the majority of its landscape as seen in Figure 4. However, the Gold Coast region is rapidly expanding and as a result, there is expected to be a massive urban overflow into the Scenic Rim area, with the result that the region’s population will double in less than 20 years. While this shift presents many opportunities for the region, it is also accompanied by many challenges. The Scenic Rim Community Plan 2011-2026 states that they intend to promote sustainable development, create jobs with locally run businesses, and establish a strong infrastructure that compliments their other goals (Scenic Rim Community Plan,
The infrastructure of the region will be under a large amount of pressure with the sudden influx of people migrating there.

While this may seem like an attractive solution for those looking for lower cost of living, it will present many challenges to those people and to the region if the proper planning does not take place. This project aims to define a general template for regional sustainability through the use of a literature review on challenges faced by current sustainable developments of all sizes around the world combined with a hybrid complex adaptive systems theory (CAS) and transition theory framework. Complex adaptive systems theory was chosen as it accurately represents a large system such as a region due to its vast size in terms of area, problems, and stakeholders which results in an extremely complex system which must adapt to many system disturbances. Transition theory was chosen as the region is wishing to move towards a sustainable future which is a strong case of a large scale and complex transition. Utilizing this general template for regional sustainability, the Scenic Rim application will be addressed by discovering how sustainability can be achieved in the Scenic Rim from a regional perspective while also addressing massive urban encroachment.

Figure 4 - The Scenic Rim Landscape
2.0 - Objectives

This project has been broken down into three systematic phases in order to address the both the general thesis question of how can any region transition towards sustainability using a hybrid CAS/transition theory framework, as well as the specific thesis question of how the Scenic Rim Region can utilize this template to transition towards a sustainable future while also addressing massive urban encroachment. Each of these phases is outlines below as well as in Figure 5.

1. Literature Review

The ultimate goal of the literature review is to define a general template for addressing regional sustainability from a regional perspective. This will be done by combining the hybrid CAS/transition theory framework with scenario planning and lessons learned from the analysis of sustainable development implementations around the world using Leximancer software. The framework will provide a systematic process to be followed while the Leximancer analysis will outline key areas to focus on when addressing sustainability based on challenges faced by existing sustainable developments.

2. Methodology

The second phase will utilize the general template for regional sustainable development created in phase one in order to address the Scenic Rim Region application. The template will provide the process while ensuring the Scenic Rim learns from past development challenges while the specific case will work with key stakeholders in order to address region specific concerns such as urban encroachment and lack of public transport. In the nature of CAS, this phase will define specific sustainable implementations and policy changes which will be used to drive the transition towards regional sustainability. These policies will combine to create a policy scenario for the scenario planning aspect of this project.

3. Analysis & Discussion

The final phase of this project will be to compare and analyze scenarios created during the scenario planning. This will be done analytically by create an approximate energy model of the Scenic Rim Region using Low-range Energy Alternatives Planning System (LEAP) software to project the region’s energy performance into the future. Within this model each of the sustainability projects proposed in the second phase will be modeled in a policy scenario. This policy scenario will be compared against a “business as usual” scenario which represents how the region will perform if no changes are made based on historical patterns.
3.0 - Literature Review

Addressing sustainability from a regional level is extremely complex as there are a huge number of factors and stakeholders with different and conflicting interests. The first step of the literature review will be to define a research framework and the second step will be to analyze sustainable developments of different sizes around the world to determine common themes in terms of challenges faced from conceptualization to implementation. Complex adaptive systems theory (CAS) plus transition theory will provide a framework and process which could be followed for other regional level projects. Combining the CAS framework with the lessons learned from the literature review creates a general template for addressing sustainability from a regional level which could be used as a starting point for any region attempting to become sustainable. This general template combined with the specific case and stakeholder involvement results in a thorough process for transitioning a given region towards sustainability.

3.1 – RESEARCH FRAMEWORK

While there are many potential frameworks that could be used in this case such as regime theory, institutional theory, planning/negotiation theory, social/technical theory, systems theory, it was felt that the most appropriate in this case would be complex adaptive systems theory (CAS). CAS represents a regional level analysis well as a region is comprised of complex interactions between many individuals and must be able to adapt to system disturbances in order to survive.

CAS is used here to show that the system or region must be resilient and adapt to disturbances such as this mass migration or even natural disturbances such as droughts and floods. CAS also shows that in order to do this as well as move the region towards the desired state of sustainability, the agents within the system must interact under new system rules which provide an environment that promotes and enables this transition. The key is to determine those rules or policy changes.

3.1.1 – Complex Adaptive Systems:

The concept of CAS can be fairly complex so it will be simplified and summarized here. Figure 6 below shows a visual outline of the simplified model. Ultimately CAS defines a system as a group of agents with different perspectives, or schema, of the system which interact and make decisions with each other within a given landscape. If several agents share a schema, it is called a vision. Multiple agents interact within one landscape and these decisions lead to specific outcomes in the landscape (Dubois and Gadde, 2002). Every decision and interaction that takes place results in this outcome feedback into the system (Brown, 2012). This feedback as well as feedback from the environment then changes the behaviour of each agent as the landscape evolves (Lewin and Regine, 2003). This is a continuous process in which the landscape continually adapts and evolves based on the agents’ behaviour, hence why it is considered “complex”.

This landscape exists within a given environment which defines the rules of the system and contains external factors which affect the landscape. External factors include human factors such as population change as well as natural factors such as natural disasters. A landscape must be able to evolve and adapt to these external factors in order to survive, hence the “adaptive” component. The environment outlines rules in which the system must work under, such as the law or government policy. These rules control how the system behaves so by changing the rules, the system behaviour changes. If an external factor exists that the system may not be able to adapt to, then it might be possible to modify the rules in order to modify the systems behaviour in such a way that will help it adapt to that external factor.

![Figure 6 – CAS Visual Model](image-url)
Beyond this basic model, a CAS has several important properties. The three most important properties are self-organization, adaptation, and emergence. Self-organization is the natural tendency of systems to come to some equilibrium, whether it be negative or positive. Adaptation, or homeostasis, is a systems ability to evolve in order to deal with disturbances to the system. Emergence is the creation of new properties that could not be predicted (Rhodes and MacKechnie, 2003.)

Systems frequently arrange themselves in three different ways: network, hierarchical, or market-based. Network arrangements occur when agents interact primarily via rules of collaboration. Hierarchical arrangements occur when agents interact according to rules of control. Market-based arrangements occur when agents interact according to rules of competition (Keast et al., 2006). While these are three very distinct arrangements, it is also possible for systems to arrange in a combination of the three depending on which agents are most dominant at a certain time. Agents can work towards personal or collective goals and the behaviour of these interactions and interdependencies will result in systematic outcomes at a cumulative level (M. L. Rhodes, 2008). The dominant governance arrangement at a given time will affect and change the rules of interaction between agents and ultimately modify the outcome of those interactions and in turn modify the emergence of new system properties depending on whether they experience collaboration, competition, or control (Brown, 2012). For example, if government, public service, and local business agents interacted with a shared vision of sustainability and under the right system rules, sustainable infrastructure could emerge without directly targeting infrastructure as these agents share certain values (Loorbach and van Raak, 2005). Modifying people’s vision will ultimately modify their behaviour on a larger scale (Klijn and Koppenjan, 2006).

In CAS there are two types of rules: top down and bottom up. Rules that regulate the system are top down rules while rules that regulate agent actions are bottom up rules (Holland, 1995). The regional government can choose rules which push agents to adopt new (more sustainable) approaches from a top down perspective by modifying policy. Modifying policy results in a change in governance which affects specific industries, which in turn affects specific projects. These projects then have a direct effect on the system, thus closing the feedback loop in what is known as the project approach (Brown 2012).

A bottom up approach would require targeting specific agents to drive smaller sustainable projects which on a large scale could lead towards regional sustainability. While the bottom up approach can be quite effective, it would also be very difficult to implement on a regional level due to the large and complicated system. Therefore in this project, a top down approach will be utilized in order to create an environment which makes sustainable development not only feasible but desired. Ideally this process will result in several sustainable projects to be implemented simply by modifying policy. This is similar to growing a plant by providing the required nutrients, water and sunlight, with the goal of producing fruit; it might fail but under the correct circumstances it will be more likely to succeed.

3.1.2 – CAS in the Scenic Rim

In the case of the Scenic Rim, the environment is the Scenic Rim Region itself and the rules are the policies and regional laws put in place by the Scenic Rim Regional Council and higher level governments. The external factors in this research include the expected population increase, climate change, and common natural disasters such as droughts and floods. This research aims to address all of these external factors in some capacity by finding the appropriate system rule or policy changes which will form a system environment that drives positive change with respect to these factors. For this research the most important agents within the system include: land developers, the regional government, the local population, public services, and local businesses. These high level agents are specific enough for this project because the goal is to define system rule or policy changes which will have a large scale effect on the region. In order to have a large scale effect, high level agents must be addressed. High level agents also allow this general model to be applicable to more regions around the world as this common problem is being faced in many locations globally. These 5 agents cover a large spectrum of issues concerning regional governments such as energy, water, waste, transportation, employment, and regional growth.

It is assumed that this system already exists and functions and that the Scenic Rim is a CAS as it has demonstrated in the past that it has the ability to adapt to system disturbances on some level. This project only focuses on the environment rules and how specific policy changes made by the Scenic Rim Regional Council could not only allow the region to adapt to urban encroachment, but also trigger a transition towards sustainability.
3.1.3 – Transition Theory

While CAS is a good framework to model a general region, this scenario could also utilize another complimentary framework: transition theory. Transition theory is a framework where a system goes through short periods of radical change followed by long periods of stability (Loorbach and van Raak, 2005). This phenomenon is known as a punctuated equilibrium (Tushman and Romanelli, 1985). The community of the Scenic Rim wishes the region to move towards a sustainable future. Concerns over climate change and increasing price of oil and electricity are making people rethink the way they live and view their environment. This move, or transition, towards a sustainable future is an excellent application of transition theory. Therefore in the nature of CAS, the agents of the Scenic Rim must have a shared schema, or vision, of sustainability in order to make this transition more likely. As this will be combined with CAS, there are no predetermined outcomes, but it is possible to increase the odds of one particular outcome occurring by creating the correct set of system rules to drive it.

3.1.4 – Scenario Planning

The desired overall system outcome is adaptation to urban encroachment and a transition towards regional sustainability. Utilizing this combination of transitions theory combined with CAS, a policy scenario can be created where specific policies can be found by working backwards (Brown, 2012). This can be done in the following steps:

1. Define a group of smaller sustainability projects through collaboration with key stakeholders, such as the Scenic Rim Regional Council, which could lead to the overall goal of regional sustainability.
2. Outline the driving regional agents responsible for these projects out of the five high level agents used in this research.
3. Those agents need to interact under specific sets of rules which will drive them towards those smaller sustainable efforts. These rules are what need to be determined whether it be through changes in government policy or incentives.

If the correct new system rules are discovered, then simply by modifying policy and implementing the correct incentives, these rules could trigger the transition to regional sustainability (Brown, 2012). However, rules change and evolve as the system does, therefore that must be taken into account when defining the rules. It is crucial during the scenario planning to involve the key stakeholders in order to find effective and lasting solutions as this is an extremely complex system (Beach, 2008). Stakeholder involvement will heavily come into play during the application component of the research once the general template for regional sustainability has been completed. The most involved stakeholder in this case will be the Scenic Rim Regional Council as they will be required for any policy changes in the Scenic Rim.

3.2 – Literature Focus

Developing a sustainable development strategy at a regional level is a large and difficult task. In order to develop a successful plan, it was crucial to learn from past mistakes. These past mistakes and challenges that were faced by existing eco-communities were found in an array of journal articles. A broad and unbiased set of challenges and flaws could only be found by using papers on existing developments of different sizes from different locations around the globe. These developments ranged from eco-homes all the way to eco-cities. Naturally these developments faced a broad range of challenges, but the goal was to see if there were any consistent challenges across all sizes of sustainable developments.

The goal of the literature review was to include a broad range of eco-communities from small developments all the way up to eco-cities around the world. There are problems and challenges faced by all developments and the goal of this review was to compile evidence of the issues in order to find common themes. These common themes will be used to define a more complete view of sustainability from a regional perspective. The sustainable developments focused on in the literature review are listed below as well as shown on a world map in Figure 7.

Eco-Homes

- Canelo Project – Canelo, Arizona. This is a unique non-profit group that works to connect people, culture, and nature (The Canelo Project, 2013). This group builds green homes around the world using straw bale walls as natural insulation.
Currumbin EcoVillage Homes – Currumbin, Australia. The EcoVillage was studied in terms of both the entire village as well as detailed research on individual homes located there. These homes are designed to meet the highest standards in terms of energy, water, waste, efficiency and materials.

Eco-Villages

Currumbin EcoVillage – Currumbin, Australia. TheCurrumbin EcoVillage is an international award winning eco-community with 270 acres broken up into 147 lots, including several small businesses. Homes constructed in the EcoVillage are required to meet a very high standard of sustainability in terms of energy, waste, water, and efficiency. The EcoVillage is completely self-sufficient in terms of energy use and is completely autonomous in terms of water and waste water recycling. The village is also unique in that the site is comprised of 80% open space with 50% environmental reserves (The Ecovillage atCurrumbin, 2013).


Eco-Cities

Songdo International Business District – Songdo, South Korea. Songdo is a new eco-city being developed on 1,500 acres of reclaimed land in South Korea. This new development aims to set new standards for sustainability in terms of building design, systems engineering, urban infrastructure, and community planning. The development includes around 100 buildings, over $10 Billion USD invested, and will be the first LEED certified district in Korea (Songdo Master Plan, 2013).

Shenzhen – Guangdong, China. Shenzhen is China’s first low-carbon eco-city. The city of Shenzhen boomed from a population of 30,000 in 1989 to a massive 14 million by 2010, classifying it as a mega city. Shenzhen has turned into a pilot project for eco-cities in China to meet a high standard of sustainability and greatly reduce carbon emissions (Shenzhen, China, 2013).

Caofeidian Eco-City - Luannan, Tangshan, Hebei, China. Caofeidian has been developed as a “demonstration area for scientific development”. The entire city is 150 square kilometers and aims to become the home of 800,000 people. Construction is still in progress and should be completed by 2020 (Caofeidian, 2013).

Tianjin Eco-City - Binhai, Tianjin, China. The Tianjin Eco-City is the second government-to-government project between Singapore and China with the vision of becoming “A thriving city which is socially harmonious, environmentally-friendly and resource-efficient – a model for sustainable development”. The city has an area of about 30 square kilometers and is aimed to house 350,000 residents after its completion in 2020 (Tianjin, 2013).

Mentougou Eco Valley - Beijing, China. Mentougou is aiming to become the ”Ecological Silicon Valley” as a 100 square km development housing 50,000 people as well as 9 environmental research institutes, other companies, a city center, and small residential villages. This eco-city is still waiting for approval to begin construction and aims to be carbon neutral. Buildings are placed on the natural land topography; the city produces its own water and recycles waste and water back into the ecosystem (Mentougou, 2013).

Tangshan Bay Eco-City – Tangshan, China. Tangshan is a 30 square km eco-city in the planning stage which will be carbon neutral. The goals and vision of the city include to be livable, innovative, accessible, green and blue, climate neutral, flexible, beautiful, resource efficient, and healthy (Tangshan Bay, 2013).

Masdar City – Abu Dhabi, United Arab Emirates. Masdar City, as shown in Figure 3, is a massive project where an entire city is being built to be carbon, water, and energy neutral. The 6 square km city will cost around $22 Billion USD and take some 8 years to complete starting in 2006. The city will house a 40-60MW solar power station and has a mission beyond the city itself to “invest, incubate and advance the establishment of a clean energy industry in Abu Dhabi and around the world” (Masdar, 2013).
Several themes were discovered during the examination before a software analysis of the literature was conducted. Across the board it appeared that there was a general shortage of jobs inside the eco-communities resulting in long commutes to work which works against their sustainability principles. In eco-cities there was never a balance between the residential population and the number of jobs available. Most eco-cities are really just green districts within another city so their space is limited mainly to residential buildings and public services with some commercial buildings. This means people have to commute to work outside of the eco-city to their workplaces which are frequently quite far. Eco-villages have the same problem only amplified. Generally eco-villages are located far away from existing towns and cities because the people living there also want a connection with nature and the land is much cheaper for the developers. This affordability comes with other costs because eco-villages are not designed to be employment hubs so the locals are forced to commute long distances to work. This lack of employment effects well-being and satisfaction as they have to spend more time commuting and it becomes unsustainable because people have to drive long distances to work. This situation completely works against the values of the people living there as they are now spending more on gas and in turn emitting more. As these eco-villages are built in new locations, there is no public transportation infrastructure to the people living there so they cannot even take the bus which is a huge disadvantage.

Masdar city was a unique case where an entire city is built from the ground up to be fully self-contained and net-zero. At the moment it is still under construction so there are not many employment opportunities for the residents living there, however there will be in the future. Transport within the city will be all sustainable infrastructure, but the connection outside of the city is not as easy. The problem with creating a stand-alone city is that it is ultimately completely cut off from the surrounding area. A stand-alone eco-city will be good in and of itself, but it would not be an interacting member of a region which means nothing outside of the city would gain much from its existence. Masdar is an amazing project but it does not address the built environment which will be a crucial factor in the years to come.

### 3.3 – LEXIMANCER LITERATURE THEME ANALYSIS

Excerpts from many journals regarding the problems and challenges faced by these different sized eco-communities were compiled and then analyzed using Leximancer Software in order to find common themes. Leximancer is a software which analyzes text in order to identify concepts within the text by finding clusters of related, defining terms as conceptualized by the Author (The Pioneering Leximancer Approach, 2013). Not only does the software allow you to find common concepts, or themes, from multiple sources, it also shows you how these themes are connected throughout the different texts. This software is then used to create a diagram which visually represents the themes found, their interconnections, and the paths between themes. The final diagram of this analysis is shown below in Figure 8. While each of these unique communities faced challenges based on the specific project, there were several common challenges that were revealed in this analysis. In Figure 7, the bubbles and large text each represent a specific theme found throughout the texts. The titles of these bubbles are automatically generated based on the strongest word found within a given theme. However the titles can be edited so that overarching concepts can be clearly identified. For example, the Utilities bubble was originally called
“Water” but it also encompassed energy so it made more sense to change it to Utilities, hence why there is no word within the bubble called “Utilities”. All of the smaller words in this diagram represent common key words found throughout the different texts. These key words are then grouped together with other words inside theme bubbles. If a specific word appears in the texts in different contexts then it can link to several themes, hence the overlapping bubbles. The most important feature of this diagram is how different themes link to each other. For example, while Utilities is not directly linked to Challenges, it is linked to Technology which is linked to Challenges, meaning that the technological aspect of utilities is a challenge.

From the diagram, it is clearly seen that there are many common challenges across areas including technology, policy, community, employment, utilities, locality, and conventionality. It can also be seen that not all of these themes are connected to the Challenges theme. This is because even though the papers analyzed were manually cut apart into only relevant sections, there was still some content which discussed both challenges and other themes in the same passage.
Figure 8 outlines all of the themes directly linked to the Challenges theme by outlining them in a bold red. The direct themes linked to the Challenges theme, their theme bubble, as well as their likelihood in the text are outlined below in Table 1. Likelihood in these cases is simply the number of times which a word appears throughout all of the articles.

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Theme</th>
<th>Likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change</td>
<td>Policy</td>
<td>17%</td>
</tr>
<tr>
<td>Government</td>
<td>Policy</td>
<td>14%</td>
</tr>
<tr>
<td>Initiatives</td>
<td>Community</td>
<td>11%</td>
</tr>
<tr>
<td>Land</td>
<td>Technology</td>
<td>11%</td>
</tr>
<tr>
<td>Environment</td>
<td>Community</td>
<td>11%</td>
</tr>
<tr>
<td>Policy</td>
<td>Policy</td>
<td>9%</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Technology</td>
<td>8%</td>
</tr>
<tr>
<td>Design</td>
<td>Technology</td>
<td>7%</td>
</tr>
<tr>
<td>System</td>
<td>Technology</td>
<td>5%</td>
</tr>
<tr>
<td>Economic</td>
<td>Community</td>
<td>5%</td>
</tr>
<tr>
<td>Water</td>
<td>Utilities</td>
<td>5%</td>
</tr>
<tr>
<td>Urban</td>
<td>Technology</td>
<td>4%</td>
</tr>
<tr>
<td>Work/Employment</td>
<td>Employment</td>
<td>4%</td>
</tr>
<tr>
<td>Planning</td>
<td>Challenges</td>
<td>3%</td>
</tr>
<tr>
<td>Community</td>
<td>Community</td>
<td>2%</td>
</tr>
</tbody>
</table>

These overriding themes connected to the challenges theme can then be taken as the common challenges faced by the sustainable developments analyzed. Many of these challenges outlined by the literature review were quite expected and are general challenges with any new development, not just sustainable ones. While the software analysis simply returns common words grouped within themes, the contextual meaning of these words can be determined using the pre-software analysis of these articles. As many common themes were determined simply from reading the articles, the proper contextual definitions can be inferred. The different challenges are defined below, listed under their respective themes. While these are just the words directly linked to the challenges, it is important to note that other words can be linked to challenges using the paths between words. For example, while Energy is not a direct challenge in and of itself, it is linked to challenges through Systems, which is likely referring to challenges with integrating renewable energy systems such as photovoltaics with current energy systems, or simply the general challenge of new energy systems.

Technology

It is clear from Figure 8 that technology has the largest relationship with the challenges theme as they have the largest overlap of any themes. As would be expected, this results in the largest number of direct links to the word challenge. Those direct links are outlined below with a brief description of the assumed meaning of the challenge in this context based on knowledge from reading the articles.

1. Land – land requirements and zoning problems associated with sustainable developments and the associated infrastructure.
2. Infrastructure – challenges faced with the implementation of a new infrastructure system or a secondary sustainable infrastructure system which involves not being connected to the old infrastructure system. In some cases, generally in EcoVillages, there were significant challenges with missing infrastructure such as public transportation to urban areas.
3. Design – technical design challenges associated with eco communities as they are more complex and challenging than typical designs and use a systems approach.
4. System – large scale and highly integrated systems are extremely complex and challenging and communities and cities are perfect examples of this.
5. Urban – for EcoCities these are likely the challenges associated with integrating sustainability into the built environment. There is also the challenge of the influence of local industry and how a sustainable development can work with this local industry in a mutually beneficial way. This is especially challenging...
when the local industry contradicts the sustainability goals of the new community, such as a coal mining town. For smaller sustainable developments, the urban challenge is more referring to the challenge of the developments distance from the nearest urban area.

**Policy**

Policy was another theme that was directly linked to the challenges theme, hence the overlap of the theme bubbles in Figure 8. It is interesting to note that the themes Policy, Technology, and Challenges all intersect at one point meaning that there are some instances where there could be challenges with a linked policy/technology aspect. However, there were none directly found in this study. All direct links with challenges are outlined below:

1. **Change** – this refers to people’s general resistance to change. This is faced by any new idea that is significantly different than conventional ways. This is especially a challenge with contractors as most rarely have the opportunity to work with green technology and step out of their conventional comfort zone.
2. **Government** – challenges related to working with governments. Governments have the power to severely inhibit sustainable developments if they do not have a similar vision. This theme is strongly linked to policy.
3. **Policy** – government policies at all levels can be a challenge faced by a sustainable development if they work against the development. Certain policies or lack of policies can make the development process extremely challenging. These are policies at all levels of government. A municipal government may be very supportive of a sustainable development, but that does not mean that the regional or federal governments are.

**Employment**

The Employment theme was a relatively small theme that was not directly connected to the challenges theme. However there was one direct link to the challenges concept even though the themes themselves did not interact.

1. **Work/Employment** – challenges caused by employment in all aspects for sustainable developments. For EcoVillages, employment locations of residents are frequently located a long distance from the sustainable community in which they live. Long commutes with poor public transit works against the sustainable principles they are trying to live by. EcoCities frequently offer minimal employment opportunities directly in the cities themselves requiring many residents to commute a fair distance to their employment locations.

**Community**

Community had the second largest overlap with the Challenges theme, resulting in the second largest number of linked concepts to the challenges concept:

1. **Initiatives** – initiatives can be a challenge for people and governments to put in place and to redeem. However, people and governments need to drive sustainability initiatives or nothing will ever change.
2. **Environment** – challenges faced designing in such a way as to minimize environmental impact.
3. **Economic** – challenges strictly referring to money. The design and implementation has a higher up-front cost compared to conventional implementations. It can be difficult for people to see the cost benefit analysis.
4. **Community** – this refers to all community centered challenges whether it be from the community to an outside party or challenges within the community. Eco-communities have a very strong element of community interaction and community decision making. This can be very challenging for some residents as it can almost seem intrusive compared to the individualistic lifestyles led by conventional developments. This more involved decision making process, while a good thing, can also lead to increased conflict as more people are involved in the decision making process.

**Utilities**

The Utilities theme was not directly linked to the Challenges theme, but it is linked through the Technology theme. This means that generally Utilities are not considered a challenge except when referring to the technological aspect of Utilities. This is why the only direct concept link to the challenges concept is Water which is in both the Utilities and Technology themes.
1. **Water** – challenges associated with sustainable water use and collection. This is one of the more drastically different technical design aspects which can have large impacts on implementation complexity, cost, and infrastructure impacts.

**Challenges**

There was one concept which did not belong to any themes besides the Challenges theme. This concept was Planning, which is a very high level, general concept that does not belong to any of the other themes as it is just an overall challenge of these projects.

1. **Planning** – planning is a challenge for any development but even more so for an eco-development as many more aspects are taken into account regarding environmental, economic, and social interaction and impacts. While this can seem a challenge compared to conventional methods, this more extensive planning process becomes very beneficial in the long run and can save a large amount of money on future infrastructure upgrades.

3.4 – GENERAL TEMPLATE FOR REGIONAL SUSTAINABILITY

The challenges outlined in the previous section each link to one or more of the five system agents using the hybrid CAS/transition theory framework discussed earlier. Each agent and their associated challenges are outlined in Table 2 below. These are general challenges that the system agents in any region would likely face and therefore can be used as guidelines for a general template for regional sustainability. Ultimately this means that these challenges need to be taken into account when defining sustainability projects in order to increase the chances of transitioning a region towards sustainability. Even though it does not guarantee a region will transition, it creates an environment which is more likely to produce that outcome. The general template cannot define any specific rule changes at this point as the rule changes will be very region and case specific.

<table>
<thead>
<tr>
<th>Agents</th>
<th>Challenge Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regional Government</strong></td>
<td>Government&lt;br&gt;Initiatives&lt;br&gt;Land&lt;br&gt;Policy&lt;br&gt;~System&lt;br&gt;~Work (incentives)&lt;br&gt;~Planning&lt;br&gt;Urban</td>
</tr>
<tr>
<td><strong>Public Services</strong></td>
<td>Infrastructure&lt;br&gt;~Work (group work spaces, start-up hub)&lt;br&gt;Water</td>
</tr>
<tr>
<td><strong>Local Businesses</strong></td>
<td>~Work</td>
</tr>
<tr>
<td><strong>Developers</strong></td>
<td>Environment&lt;br&gt;Design&lt;br&gt;~System&lt;br&gt;~Planning</td>
</tr>
<tr>
<td><strong>Local Population</strong></td>
<td>Change&lt;br&gt;Economic&lt;br&gt;Community</td>
</tr>
</tbody>
</table>

The template for regional sustainability combines the framework defined by the hybrid CAS and transition theory frameworks, combined with the main challenge themes outlined by the literature review on global
sustainability challenges. As shown in Table 2, all of these common challenge themes are addressed by the five high level agents. These five agents interact in the regional system as defined by CAS and shown below in Figure 9. The template states that these agent interactions need to be directed by newly defined system rules in order to implement the desired sustainable solutions. The template outlines this process:

1. Define region specific sustainability projects which combined could transition a region towards sustainability.
2. Define the agents responsible for those projects.
3. Create new rules or policies which will drive the required agents to implement the desired projects.

However, in order to find the region specific sustainability projects, this template must be combined with a specific regions challenges and desires through stakeholder involvement. Once these region specific sustainability projects are defined, a final regional sustainable development plan can be defined with this template along with different policy scenarios when referring to scenario planning. Ultimately this template could be applied to any region around the world as it addressed general challenges using a framework that is applicable anywhere as a starting point.

![Figure 9 - Regional Sustainability CAS Diagram](image-url)
4.0 – Methodology

The Scenic Rim region is facing massive urban encroachment meaning that over the next 20 years the population is projected to more than double based on 2011 census data, as seen below in Figure 10 (Census - For a Brighter Future, 2011). The population in all of Queensland will be increasing significantly over the next few decades, but the population in the Scenic Rim will increase even more by comparison, as seen below in Figure 11 (Census - For a Brighter Future, 2011). The Scenic Rim has an extremely low population density as it is almost three times larger than the Gold Coast with significantly lower population. While this is the case, the vast majority of the land is comprised of farms and will remain that way as the government is not willing to break up large farm land into small boutique farms. As a result, the only real population density increase will be in the town of Beaudesert where the majority of the population is expected to locate to.

Figure 10 - Scenic Rim Population Projections

Figure 11 - Scenic Rim Population Projections vs. Queensland

Figure 13 on the next page shows a map of the Scenic Rim as a visual aid. The southern border of the region is touching the border separating Queensland from New South Wales and is also a line of mountains, hence “Rim”. In fact, the entire southern half of the Scenic Rim is lined with mountains which have resulted in a large valley of high quality soil which stemmed the agriculture industry to take root there as shown below in Figure 12. However, the agriculture industry in the Scenic Rim has been suffering of late and in turn the Scenic Rim culture is suffering as agriculture is deeply imbedded in their history.
The largest towns in the region are Boonah with a 2011 population of 2,474 and Beaudesert with a population of 12,524. Beaudesert is located in the north-east of the region as seen in Figure 13 and is expected to take the vast majority of the migrating population. Beaudesert is only 70 km's from Brisbane and less than 70 km's from the beaches of the Gold Coast, translating to around an hour drive from each. The large pink section to the west of Beaudesert in Figure 13 is a new industrial park positioned directly over the existing freight rail line that will connect those industries to Brisbane International Airport and the majority of Eastern Australia. This industrial park is virtually empty at the moment and just waiting to be filled. This has the potential to provide many local jobs for people moving to Beaudesert and puts the town in a good position in terms of economic growth. While this may be good for the economy, it will not benefit the suffering agriculture industry unless complimentary industries move into that space creating more demand for locally produced goods.

Figure 13 – The Scenic Rim
The reason for this massive migration is simple; homes in the Scenic Rim are significantly cheaper than in the surrounding areas as shown below in Figure 14. For example, the total new residential building value in the Scenic Rim is approximately 93% less than in the Gold Coast. This less expensive housing will presumably attract a younger demographic looking for their first home as well as other low income families. However, moving to the Scenic Rim will force them to own more vehicles and spend more on fuel than they did in cities which will account for a large portion of their incomes. The literature review outlined several weaknesses in current sustainable housing developments to date. The two largest weaknesses were lack of public transportation and employment locations being far from the housing developments. Therefore in order to address these issues from a regional level, the sustainable development plan in the Scenic Rim needs to address residential housing, transportation, and employment on top of their case specific concerns. These three sectors will cause severe impacts on the existing infrastructure of the region and will require significant planning in order to adapt in time and even more so if they wish to transition towards sustainability simultaneously. After a significant amount of time spent working with key stakeholders in the Scenic Rim project, it was discovered that their top regional concerns are transportation, employment, and housing, so that lined up nicely with the regional sustainability template.

Over the course of this project, a substantial amount of time was spent working with the Scenic Rim Regional Council in order to find potential solutions that were feasible for the region to implement, ideally without having to move up to provincial or federal governments for support or approval. One of the biggest problems for these people will be the commute to work. There are only 2 main highways out of the Scenic Rim and they already face large amounts of congestion and traffic problems. There is no train infrastructure connecting the main populated areas to the Gold Coast or Brisbane and the bus system has very few connections and infrequent routes. Figure 13 clearly shows how the Queensland transit system (the white lines) completely misses the Scenic Rim. The only rail line within the Scenic Rim is mainly used for freight and does not have any stops in the region. This lack of alternative methods of travel to work will be a big problem especially in the beginning as people will keep their old jobs in the city and commute from their new rural homes. If these problems with homes, employment, and transport are not addressed in a proactive manner, these unsustainable long distance commutes will continue, people will be frustrated by their lost time and uninvolved in their communities due to lack of time, and with few regional employment opportunities there will be no regional economic growth beyond people using the region for cheaper accommodations.

4.1 – Sustainability Efforts

In order to find potential sustainability efforts or projects, discussions and brainstorming had to take place with the Scenic Rim Regional Council using the lessons from the literature review and general regional sustainable development plan. The final projects chosen out of this brainstorming and collaboration would be combined to create the policy scenario in this research. Some of these potential sustainability efforts are listed here:

1. Long distance transportation – modify existing rail line for passenger trains
2. Bus transit upgrades
3. Implement car sharing
4. Implement bike sharing
5. Implement solar street lights
6. Sustainable housing developments
7. Groupwork hub (co-working space)
8. Start-up hub
9. Incentives for work and innovation in local industry (agriculture)

4.1.1 – Sustainability Projects

While there are many potential sustainability efforts that could be proposed in the Scenic Rim, many of them would be out of the regional government’s direct power to implement and would therefore take a very long time to be implemented. Due to this, several upgrades were focused on that were generally within the regional government’s power and this projects timeframe to analyze:

1. **Public Transportation**

   Sustainability in terms of transportation means reducing travel distances, promoting alternatives to motor vehicles, and reducing private motor transportation by promoting public motor transportation. Currently, the Scenic Rim is completely cut off from the existing train infrastructure in southern Queensland and only has a few buses which run in and out of the region. Due to this, more than 92% of people living there commute to work with a motor vehicle as seen below in Figure 15, and only 3.8% of households do not own a car as defined by the 2011 census. Traffic congestion is already a big problem when trying to travel up to Brisbane or over to the Gold Coast during commuter hours and this trend will just become worse as the population of Beaudesert increases. Figure 15 also show what will happen in a “business as usual” scenario if the method of travel share percentage does not change over the next 20 years. This will result in over 23,500 motor vehicles traveling to work each day by 2031 compared to the 11,500 currently.

![Figure 15 - Scenic Rim Methods of Travel to Work](image)

As stated earlier, one of the main goals for transportation sustainability is to provide alternatives to motor vehicles which the region is clearly failing to do at the moment. Therefore the sustainable transportation policy will be to have a minimum of 10% of the population traveling to work by train by the year 2020. In the Scenic Rim there is an old rail line that has been out of use for about 40 years which almost connects with the Queensland rail system. This rail line could be restored along with the bridges and old train stations which still exist in some capacity and connected with the Queensland rail system. The vast majority of the population migrating to the Scenic Rim is moving to the main city Beaudesert, which would naturally be a perfect location for a transportation hub to be built. This hub would be located in the center of the city right where the old Beaudesert train station is. The station itself is still in good shape with the entire old track still intact in that area, as seen below in Figure 16, and surrounded by a large dirt parking lot. This parking lot would be upgraded to allow not only for passenger parking, but also a carpool meeting point.
Figure 16 - Existing Beaudesert Train Station

Responsible Agents:
- Regional Government
- Public Services

New Policy: Reduce the percentage of people traveling to work by private motor vehicle by a minimum of 10% by 2020 through the repair of the old train line and the installation of a transit hub in Beaudesert.

2. **RESIDENTIAL ENERGY EFFICIENCY REQUIREMENTS**

While it would be ideal to implement a policy which forces all new homes to become net zero or positive energy homes, it is also highly unrealistic at this point. The literature review focused mainly on building new communities with net-zero homes, but that only addresses a small portion of a region that can afford these homes. The Scenic Rim will likely be expanding with mainly low-income families looking for inexpensive housing. Therefore it was decided that it would be more effective to target energy efficiency standards in new homes as opposed to trying to promote net-zero homes. Eventually policy changes will get to that point, but in the meantime there needs to be a smaller step by simply increasing minimum efficiency standards.

On average Australian homes break down their energy consumption into about 37% electricity (not including water heating), 25% water heating, and 38% heating and cooling as can be seen in Figure 17. While the regional government does not have the power to force developments to become eco-communities, they do have the power to implement mandatory regulations for energy efficiency components on new constructions. The policy here would be to force all new constructions to be built with a minimum of 1.5kW installed grid-connected photovoltaic (PV) system and minimum 315L solar hot water system. In Australia, a small solar hot water system like this could account for at least 80% of the homes hot water needs, and the 1.5kW PV system could offset about 72% of the remaining electricity requirements (Home Energy Consumption, 2010). If all new homes built in the Scenic Rim over the next 30 years meet this requirement, there will be a significant decrease in residential electricity consumption in the region. The combined additional cost to each home would be under $9,000, as can be seen in Figure 18, (before government rebates) with a payback period (PBP) to the owner of around 5 years. This is a very acceptable PBP and the benefits to the region are substantial.

![Energy Breakdown in Australian Homes](image)

*Figure 17 - Energy Breakdown in Australian Homes*
Australia is in an ideal position for the use of solar energy as they have relatively consistent sunshine throughout the year. To be sure that the data from these website quotes were accurate, a PV system simulation was conducted using PVSyst software which output the data shown below in Figure 19. This analysis resulted in a very high performance ratio of about 74.1% in the Brisbane area which is comparable to the Scenic Rim.

![Figure 18 - Quote for PV System and SHW System](image1)

![Figure 19 - PV Analysis in Brisbane](image2)

Responsible Agents:

- Regional Government
- Residential Developers

New Policy: Minimum 1.5kW PV and minimum 315L SHW system installed on all new homes being constructed.

### 3. Local Employment

As stated previously, one of the immediate concerns with this urban overflow is the fact that people will need to commute long distances to work as they continue with their previous jobs. It is very difficult to suddenly create enough jobs in the required industries which would convince people to work in companies located in the Scenic Rim. Therefore a good alternative is to create an environment which allows people to work from a distance which is becoming very common as technology allows for simple long-distance collaboration. The problem most people find with working from home is that it lacks the social interaction component existing in their current workplace. This is where the idea of a co-working space comes in. A co-working space is a facility which
provides a desk and internet connection for people working there in an open concept floor plan which allows for interaction with others that use that space. People from many different industries work in these spaces which allows for cross-industry interaction and collaboration. The National Broadband Network (NBN) rollout is underway at the moment in Australia which means that over the next few years there will be high speed fiber internet connections all across Australia, and there are already locations in Beaudesert where they are being installed. This high speed network will be an important asset to people working from a distance to connect them effectively with the outside world.

Currently about 2.5% of the Scenic Rim population works from home which provides a significant number of people that would use this service immediately, as shown below in Figure 20. After discussions with one of the founders of a co-working space in the Gold Coast, it was discovered that many of the new people using the space began working from a distance as a result of the co-working space opening. The co-working space would be located right downtown Beaudesert close to the transportation hub to connect the people working there both virtually and physically with the outside world. This would allow for easy access to long distance transportation in case the users needed to commute into the city for meetings.

![Image](https://example.com/image.png)

**Figure 20 - People Working from Home in the Scenic Rim**

This solution will get people spending more time in the Scenic Rim, which means they would spend more money locally, and they would be more involved in the local community on top of reducing the number of people commuting to the city each day. The space could also be used for local software start-ups which could help drive innovation in the region as well.

**Responsible Agents:**
- Regional Government
- Local community
- Local businesses (buying local)

**New Policy:** increase people working from a distance to 5% by 2020 through the implementation of a co-working space by 2015.

### 4.2 – Change to Rules

A summary of the system changes in the form of policy changes are outlined below in Table 3 alongside the expected long term effects on the system. Actual quantities to these effects will be determined in the analysis section.

<table>
<thead>
<tr>
<th>Change to Rules</th>
<th>Long Term Effects on System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail line reconstruction plus transit hub</td>
<td>Fewer people driving to work each day and more connectivity with the rest of Queensland.</td>
</tr>
<tr>
<td>Minimum 1.5kW PV and 315L SHW installation on new homes</td>
<td>Lower electricity demand of homes.</td>
</tr>
<tr>
<td>Co-Working Space</td>
<td>More people working from “home” and spending more money on the local economy. Fewer people commuting in and out of the Scenic Rim.</td>
</tr>
</tbody>
</table>
5.0 – Analysis & Discussion

Due to the short nature of the project, there was not enough time for results of the policy implementations to be gathered. This situation would leave the work done here with very little in terms of outputs. Therefore the final stage of this project was to create an approximate energy model of the Scenic Rim Region and to analyze the potential effect of the policy changes by projecting the model into the future using the already existing population projections.

Modeling and simulation of energy systems are important tools that can help to put together the policies of nation, or in this case a region, in order to achieve specific goals and targets. LEAP (Low-range Energy Alternatives Planning System) provides a platform for structuring data, creating energy balances, projecting demand and supply scenarios, and evaluating alternative policies (Heaps, 2012) and has been used for the calculation of the energy systems as a support for policy evaluation.

The main objective of this section is to approximately analyze the current situation of the energy system in the Scenic Rim, using official published data for the consumption of energy inside the region, thereby connecting it to the expected population and economic growth of the Scenic Rim. This data is used in LEAP to study the current situation of the energy system in the region and provide two scenarios for the future up to 2040: a baseline (Business as Usual) scenario, and a new policy scenario. The policy scenario will be using the methodology from the CAS section where the specific projects will be modeled assuming the policy changes made by the Scenic Rim Regional Council have the desired effect on the targeted agents resulting in these projects being implemented.

5.1 – SCENEIC RIM SCENARIO PLANNING

Part of this project included creating a visual representation of the Scenic Rim case. Figure 21 here represents two sectioned views of that model. The left shows the entire Scenic Rim Region and how the current rail infrastructure basically bypasses it. The Queensland (QLD) light rail system is in white while the red represents the existing single rail line which goes through the Scenic Rim which is mainly used for freight and only serves one or two passenger trains a day and has no stops in the actual Scenic Rim. The line in green leaving Beaudesert in both the left and right images shows the rail line which is proposed to be re-commissioned in this project. This decommissioned rail line goes almost all the way to the existing QLD light rail line and it would take relatively little to connect the two lines, resulting in a harmonious and sustainable connection from the Scenic Rim to both the Gold Coast and Brisbane.

Figure 21 - Scenic Rim Visual Project View
Figure 22 shows a zoomed and scaled view of downtown Beaudesert with the current geographic information system (GIS) planning grid overlaid as this is where the majority of people will be migrating to. The building at the end of the green rail line represents the transportation hub where the train will depart from and where the carpool lot will be. This is the end of the train line which is located right behind the Scenic Rim Regional Council office building right in the center of Beaudesert. The old train station and tracks still exist in some capacity in that area as can also be seen in Figure 22. The small orange building represents the co-working space which would be located in a central location in downtown Beaudesert. This co-working space would ideally be located in close proximity to the transit hub in order to allow easy access to long distance transportation from the office space without the need for vehicles to get there. This will be important if people working there need to travel to meetings outside the Scenic Rim or vice versa. The clusters of green homes represent new residential developments which will have the required efficiency upgrades incorporated. These green homes are laid out on top of several of the many currently zoned residential areas. The already zoned residential areas are more than twice the size of the current town, so increasing the efficiency of every home will have a massive regional affect.

The implementation of these three projects would ideally result in the emergence of sustainable infrastructure based on the agents’ shared vision of sustainability. For example, the addition of large amounts of photovoltaics would result in upgrades to the electricity distribution grid as a massive influx of intermittent power generation could not be handled by the current grid. While this is seen as a negative impact in many cases, it is an opportunity for this small region to upgrade their outdated electrical grid with a more efficient grid that can handle renewables. Sustainable infrastructure could also emerge in the water sector through decentralized waste water treatment using technology such as constructed wetlands. Bus infrastructure improvements would likely emerge as well due to the increased demand around the growing town. This could vastly shift the number of people driving to work as they could use the bus for local transit and the new train for long distance transit. The potential emergence of sustainable infrastructure is shown above in Figure 22 as the blue lines connecting the three solutions.

5.2 – CURRENT ACCOUNTS OF THE SCENIC RIM

The first stage in any energy model and simulation is to create the model of the past up until the present day. This case, known as “Current Accounts” in this model, was created using existing data on different aspects of the Scenic Rim Region. This was not an easy task as most energy related data is strictly done at a national or at best provincial level. This is a very simplified energy model as the solutions being modeled only affect the housing and transport sector. On top of that, there is no change of regional energy production being modeled as it is beyond the scope of this project. That being said, it is still a fairly complex model with a large amount of data required. To give an idea of the complexity of the energy model, here is a breakdown of the historical data required:

**Key Assumptions:**

- Gross Regional Product (GRP)
Population
- Added Value of all sectors

**Demand:** Every sector broken down with every fuel, the associated fuel share, the final energy intensity, and then an activity level linked to population growth, GRP, and the respective added value of that sector. The sectors include:

- Households
- Agriculture
- Services
- Industry
- Transport

As this model was made from a regional perspective and not all of this data was specifically available, several assumptions needed to be made. The first assumption was regarding the gross regional product (GRP) of the Scenic Rim. There was no data for the Scenic Rim alone, but there was a GRP for an area known as West Moreton which combines the Scenic Rim and 3 other small regions in the area. All of these regions within West Moreton are similar agricultural regions. Therefore it was assumed that a GRP could be estimated for the Scenic Rim by using the GRP per capita history of West Moreton and multiplying it by the respective historical population in the Scenic Rim in order to find an approximate GRP for the region.

It was assumed that homes in the Scenic Rim would have a similar historical demand breakdown as in the rest of Australia. It was also assumed that the fuel shares or percentages of each of the agricultural, service, industry, and transport sectors would be similar to that of the rest of Australia. This should be a relatively accurate assumption as most industries behave uniformly across the country. The main focus in this model and simulation is around households and transportation, and all assumptions made in those sectors are quite accurate.

### 5.3 – Business As Usual vs. New Policy Scenario

Once the Current Accounts model of the Scenic Rim was created and working properly, it was relatively simple to project into a “Business as Usual” (BAU) scenario as the population projections were already known, and the model was designed with everything linked to population. As would be expected, the BAU scenario assumed that no changes would be made over the time of the simulation and that everything would just increase with the increasing population based on historical trends.

#### 5.3.1 – Housing Sector

The housing sector would be facing relatively large changes based on the policy changes proposed in the previous section. These policy changes of mandatory solar hot water heating and a minimum PV installation on new homes would affect the fuel share of the housing sector. Figure 23 below outlines the fuel share of the housing sector in the New Policy scenario until 2040. The addition of 1.5kW of PV installed on the roof of the average home in Brisbane, Australia (a close approximation for the Scenic Rim) would generate an average of 2300kW hours of electricity per year, working out to about 72% of electricity needs not including water heating. This number was used to project the change in the the “Solar Power” fuel and take away from the electricity fuel share. Water heating encompasses about 25% of energy demand in Australian homes. On average a solar hot water system can offset 80% of water heating needs. This data was used to estimate the increase in the “Solar Water” field seen in Figure 23 below. The increase in the Solar Water field was also phased in over the current electricity share as the majority of homes in the region use electric water heating. It was assumed that this policy would come into play by 2015 and that by 2040 all homes would be newly constructed in reference to 2015, therefore by 2040 all homes reach the maximum use of PV and SHW systems. This is a conservative estimate as solar technology will increase in efficiency and decrease in cost over this time period meaning there would likely be an even larger shift. The fuel share change also takes into account the current rate of people adding PV and SHW systems to constructed homes. However, this is also the case for the BAU case as the trend increases regardless of the potential policy changes.
Once the simulation was run, the exact change in demand of specific fuels in specific sectors could be output. Figure 24 below shows a comparison of the BAU case and the Policy scenario in terms of the electricity demand (in terajoules) in the housing sector over time. As would be expected, the electricity demand in the BAU scenario increases in a similar manner as the population. With the new policies scenario, the electrical demand still rises in the beginning but at a slower rate, and then eventually begins to decrease again around the year 2019. This shows that by around 2025, the electricity demand in homes will have fallen back down to 2011 values and that by 2040 the electricity demand of the housing sector will be almost negligible. This may appear drastic, but by 2040 the housing sector would be comprised of mostly all new homes compared to today and these homes would only have a very small fraction of their 2011 electricity demand remaining. In reality, the non-renewable electricity demand would likely be 0 by 2040 if this policy was put in place because PV efficiency would increase with decreasing cost meaning larger systems would be installed, while general building efficiency would increase in parallel reducing the overall energy demand of homes.

Figure 25 below shows the comparison of the solar energy demand of the BAU scenario vs. the Policy scenario. This solar energy demand includes both photovoltaics and solar hot water systems as it is being used to show the electricity offset that the two systems would have on the electricity demand. This graph shows the total amount of solar energy being utilized by a home and does not represent the amount of solar electricity being fed back into the grid. The actual amount of solar energy being fed into the grid by the PV system would be approximately 75% of this total solar amount shown. This means that by 2040, approximately 435 TWh of solar energy will be fed into the grid after subtracting the BAU solar energy which is mainly SHW systems. This amount would require significant upgrades to the electrical grid in the region to handle such a large amount of intermittent power. However, for the purpose of this research, it has to be assumed that this work would be done in parallel to this project as it is beyond this scope. This is a drastic policy implementation, but it is clear...
from Figure 24 that this would have immense impacts and cost reduction across the region over time as well as increasing energy security and independence from fossil fuels.

Figure 25 - BAU vs Policy Scenario – Solar Demand

5.3.2 – Transport Sector

The other main sector of focus was the transport sector. The policy change of adding a transportation hub and restoring the old rail line modifies the overall activity level in the transport sector as the population shifts from road transportation to rail transportation as can be seen below in Figure 26. As the transportation hub and rail line restoration would take time to complete, it was assumed that it would be up and running as of 2020, which is clearly seen in Figure 26 by the jump in rail activity in 2020. It is assumed that rail use will continually increase from 2020 on. The actual increase in rail use was estimated based on current rail use in other towns in Australia which are connected to the rail infrastructure such as Ipswich just to the north of the Scenic Rim. This number was generally between 10-15%, therefore a very conservative starting percentage in 2020 would be around 10% and increased continuously as rail travel becomes more convenient and cost effective and as road congestion and petrol prices continue to increase. In reality the percentage would likely be higher than 10% because there will likely be a general shift towards rail over the next 5 years and 10% was a conservative estimate from 2011 standards. That being said, the exact amount of increase is less important than the concept and the trend. It is also assumed that an increasing number of people will find other methods of travelling to work (biking, carpooling, walking, etc.) as petrol prices and road congestion increase as can be seen in the increasing “Other” activity level in Figure 26.

Figure 26 - Scenic Rim Transport Method Activity Level
The addition of a co-working space does not necessarily change the activity level of any one method of travel, but it would impact the total travel demand as some people move to work from a co-working space as opposed to traveling to their offices in the city. It needs to be assumed that these people will equally come from people traveling previously with road, rail, and other, hence why the percent share of these categories is not affected by it. Figure 27 shows a comparison of the BAU scenario to the new policies scenario in terms of the demand for petrol products in the transport sector. As expected the BAU scenario continually increases with population, but the petrol (in terajoules) use in the policy scenario is significantly different. In the simulation, it was assumed that the co-working space was implemented by 2015 which is why there is a shift in the demand then. The use of the co-working space is expected to increase over time; therefore it reduces the petrol demand over time as a result. In 2020 there is a drop in the petrol demand as the transportation hub and restored rail line open which significantly decreases the petrol demand as people begin to use the train. The use of petrol is still increasing until around 2035 when the increased use of the rail system and co-working space finally affect the petrol consumption enough to begin decreasing it with respect to the previous year. The use of electric vehicles or general efficiency increases in motor vehicles cannot be seen in either of Figure 26 or Figure 27 because it needs to be assumed that these general increases would occur in both the business as usual scenario and the policy scenario as they were not directly targeted in this work.

5.4 – ECONOMIC ANALYSIS

While these solutions performed well in the energy model, it is important to take into account economic considerations when considering the feasibility of any project. This section outlines a very approximate economic analysis of each of the three solutions in order to get a better idea of the cost implications sustainable solutions such as these would have on the Scenic Rim Region.

5.4.1 – Housing Efficiency Policy

Even though the Queensland government has recently significantly reduced the feed in tariff for photovoltaics (reducing it this year from 44¢/kWh to 8.1¢/kWh) the use of photovoltaics and solar hot water systems are still feasible. Ultimately the Queensland government reduced the tariff because PV systems were getting significantly cheaper and they had to reimburse too many tariffs. An approximate cash flow of the $9,000 PV and SHW system is outlined below in Figure 28.

![Figure 27 - Scenic Rim Scenario Comparison - Transport Oil Product Demand](image)
Figure 28 - Housing Efficiency Policy - Cash Flow

The PV system on its own is able to pay for itself under the feed-in tariff, but there is no tariff for SHW systems. While there is no tariff, there is a rebate on SHW systems in Queensland which works out to $1,221 for the 315L system used in this study. However, what is more important than the rebate for SHW systems, is the amount of energy saved by reducing the amount of electricity required to heat a home’s water and in turn the amount of money saved. This amount of energy was calculated using the average Australian homes electricity demand for homes using electric water heating which worked out to around 5500kWh/year and the assumption that this 315L unit could offset 80% of the water heating share of electricity (~40% of the 5500kWh/year). This provided an energy savings per year. Those values were then multiplied by the projected electricity prices up to 2040 to obtain a yearly cost savings by the solar hot water system.

The amount of photovoltaic energy sold back to the grid with the feed-in tariff was calculated through a PV simulation and financial analysis using PVSyst software. This simulation used the exact solar panels and system that would be installed and simulated it over the course of an entire year to determine the exact amount of energy that could be generated in Brisbane, which is comparable to the Scenic Rim. It was assumed that the panels would decrease their annual production by 0.7% as they age, and that after the 20 year feed-in tariff program was over, the tariff would drop 50%. This explains the trend in the green component of Figure 28 above.

The solar hot water savings combined with the photovoltaic energy sold not only covers the cost of the addition components (assuming a 20 year mortgage at 5%) but it actually pays the owner a small amount to have it installed as can be seen in Figure 29. It is a very small amount until the 20 year mortgage is over and then the payback continues at a much higher amount. While this is a very small profit to begin with, it would be larger if larger PV and SHW systems were installed. This is more to show that there would be no negative impact on the owner of the house even though they may be deterred by the $9,000 price tag. If these systems were added to the cost of new homes they would not only be feasible but a healthy investment, even if it is a small return. This is a win-win situation as owners begin to make money off the systems and the region has significantly lower non-renewable electricity demand.
5.4.2 – Co-Working Space

The economic analysis of the co-working space was quite simple. The rental cost of a desk at a co-working space is around $250/month. Assuming the user of this co-working space used to commute to Brisbane every day for work (~69km’s from Beaudesert) and that they only needed to travel to the city once a week for meetings, they would be saving 552km’s of driving per week. This reduces driving time by at least 8 hours per week but likely by more as that does not take into account traffic congestion. By combining gas price projections and car efficiency upgrade projections until 2040, an approximate savings per month can be determined by renting a desk at the co-working space. The trend of the monthly gas savings compared to the co-working space rental is outlined in Figure 30. On average, the rental of a co-working space saves the user around $145 per month in gas savings after subtracting the rental cost. To sum it up, the users save money, save significant driving time, and spend more time in their local communities which means they are more likely to become involved in the community and spend more money at local stores, benefiting the regional economy even further.

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Figure 29 - Yearly Benefit from Housing Efficiency Upgrades

Figure 30 - Co-Working Space Cost vs. Gas Savings
5.4.3 – Rail Line Reconstruction & Transit Hub

The economic analysis of the rail line reconstruction and transit hub was significantly more challenging. While the rail line installation is a very costly endeavour, it is important to look beyond just the ticket sales when it comes to the investment and pay back from the tax-payers’ perspectives. In this analysis it was assumed that the government would be funding the rail line reconstruction using tax payers’ dollars, and therefore paid by the local people. When it is approached in this way, the gas cost offset for the people of the Scenic Rim can also come into the equation. The energy model simulations shown in Figure 27 outlined the energy difference in terajoules of the business as usual scenario compared to the policy scenario. Using an average energy per liter for gasoline of 35MJ/L and projected efficiency increases for cars, a total volume of gasoline savings could be found. This gasoline savings multiplied by the projected gasoline prices provides a yearly gas savings, which is shown in blue in Figure 31.

The next step was to determine the potential ticket sales. Using costing from the current Queensland rail line, it was conservatively estimated that a one way ticket would cost $10 from Beaudesert to downtown Brisbane. This cost combined with the increasing share of the increasing population of the Scenic Rim using the rail line after 2020, multiplied by the number of working days (assuming 3 weeks’ vacation) provides yearly ticket sales from the Scenic Rim people using the new line. In Figure 31 it is subtracted from the gas savings because the users shift from buying gas to buying train tickets.

The final component of the analysis was the actual cost of the rail reconstruction. This was a challenging cost to estimate as it is hard to say what the current condition of the existing track is. Data on multiple rail construction projects around Australia were found to provide some insight which projected an average of around $27 million per km of new rail infrastructure all in. However, there were some projects which were able to do it for around
$8 million per km. Another example found of a rail system in a developing country that was being reconstructed in a similar manner to this case had a cost of around $1.8 million per km (Railway Finance, 2013). As this was a developing country, the cost would be much higher in Australia, and since it was possible to implement a new rail line for as little as $8 million per km, it was assumed for this analysis that the reconstruction would cost $10 million per km which should be a conservative guess. The rail line is approximately 50km which results in a total construction cost of $500 million. Using the data from other rail lines in Australia, it was assumed that the operation and maintenance (O&M) costs would be $30 million per year. Then by assuming an interest rate of 10% on a 10 year loan for this project, the exact cash flow of the project could be determined. The project cost would be split between the Scenic Rim Region and Logan City Region as the line goes through both regions to connect with the Queensland rail system. In fact, less than 10% of the rail line would be in the Scenic Rim Region and the Scenic Rim only has 13.5% of the population of Logan City. Due to these facts, and to be conservative, it was assumed that the Scenic Rim would be responsible for 15% of the construction cost.

Combining all of this creates the cash flow for the project for the Scenic Rim Regional Council which is shown below in Figure 32. While this is an extremely approximate analysis, it shows that this Rail Line has a significant business case as this analysis shows that it would be profitable as of 2030 and these cash flows show a net present value of over $85 million, which is very acceptable for such a large project.

![SR Rail Line Cash Flow](image)

Using the concept from Figure 31, it is possible to determine the exact cost per person in terms of where their tax dollars would go with the implementation and operation of the train, and then offset that by the amount each person would save on average from the decreased petrol use. This personal cash flow of the average person in the Scenic Rim is shown below in Figure 33. This is a relatively acceptable outcome as this positive trend will continue to increase as time goes on. On top of that, this analysis assumes that no road upgrades would be required if the rail line was not put in place. On average, a new lane construction on a highway costs
$5 million per km. If a new lane was required in each direction even just for half of the distance from Beaudesert to Brisbane, that project cost would work out to around $350 million, and that is only if half of that road needs to be upgraded. Therefore it would seem that the $500 million dollar investment to reconstruct the rail line is a very comparable and sustainable solution.

Transport Economics - Cost per Person

Figure 33 - Transport Economics - Personal Cash Flow
6.0 – Conclusions & Recommendations

The results from this research show that the simple implementation or modification of government policy can have a vast impact on regional sustainability. While the energy model and simulation was only able to focus on energy demand and fuel share, it was able to show that through the implementation of these three policies (minimum photovoltaic and solar hot water requirements for new homes, minimum of 10% rail use by 2020 through the reconstructing the old rail line and transit hub, and minimum 5% people working from a distance by 2015 through the implementation of a co-working space), there would be a drastic reduction in non-renewable electricity demand in the housing sector, and that there would be drastic reduction in oil product demand in the Scenic Rim Region.

The decrease in household electricity demand from non-renewable sources was so severe that by 2040 there will be almost no demand for non-renewable produced electricity. Naturally there are complications with large scale PV implementations. This was beyond the scope of this research so it had to be assumed that difficulties with the existing infrastructure and intermittent power generation would be addressed in parallel by another party. The Queensland passenger train line in the area is powered solely by electricity, so as these trends of increased train use and increased PV share in the market; it is possible that one day the entire electricity and public transportation sector in the region could be carbon neutral as the trends converge.

An approximate economic analysis showed that each of the three solutions was not only feasible, but desirable. The QLD PV feed in tariff and decreased electricity bills from the SHW system would more than offset the increase to the homes mortgage caused by the PV and SHW systems. The co-working space would cost the user around $250 per month to rent a desk. If this resulted in that worker only commuting to Brisbane one day per week instead of 5, the user would save over $140 per month from gas savings after subtracting the desk rental. The restored rail line would have a high initial investment, but the shared cost with Logan City combined with increased use results in the rail line paying for itself by 2029.

The hybrid complex adaptive systems and transition theory framework was a good model of a region desiring to transition towards sustainability. The framework outlined by these theories provided a process for approaching regional level problems and by combining that with lessons learned from a literature review on sustainable development challenges around the world, the first ever template for regional sustainability was created. This unique template could now be applied to any region around the world as a starting position for addressing regional sustainability and to assist in scenario planning for the future.

This project was conducted under the knowledge that the Scenic Rim Regional Council desired sustainable solutions that they could implement independently from a policy level. The use of complex adaptive systems and transition theory was a perfect fit for this scenario. This not only resulted in region specific solutions, but it also resulted in the creation of a general template for regional sustainability which could be applied to virtually any region, especially one of the many regions in Australia going through a similar situation as coastal cities spread into their neighboring regions.

It was understood from the planning of the policy scenario that the policy regarding mandatory photovoltaic and solar hot water installations in newly constructed homes would be extremely difficult to implement as it would require policy changes at a provincial level as well. This fact alongside the current conservative government in Queensland makes it unlikely that this policy would be put in place in the near future. That being said, this research was less about the specific project outcomes and more about creating a new way of thinking and addressing this daunting task of regional sustainability. Even if none of these policies ever see the light of day, the process will be in the hands of the regional government and they will have a roadmap towards a sustainable future for whenever they have the right people in place to champion the task and a supportive provincial and federal government. Due to very short time constraints this research could only focus on 3 projects which is clearly not enough to transition an entire region towards sustainability, but the process is one which could be scaled up in future work.

This process of scenario planning was proven to be a very useful tool as it allowed for the creation of a model using these different scenarios. In this case it was only one policy scenario compared against a business as usual scenario, but this could easily be expanded in future work. If several policy scenarios were created due to budget limitations, this regional modeling can be a very useful tool to help determine the most effective scenarios to assist in a cost-benefit analysis. While this project only incorporated an energy model of the region, there are other software packages available that can analyze water consumption, waste generation and recycling, and even food security. With more time, an integrated system model utilizing all of these packages could be created in
order to take a more accurate model perspective of regional sustainability and each potential solutions impact on it. With more time, other potential sustainability efforts could have been modeled as well to show the potential benefits of more action.

There are many other sustainability efforts that could be taken in the Scenic Rim. As the region is currently undergoing a planning review, other solutions should be kept in mind to ensure that they can at least be put in place in the future without significant complications due to lack of planning. These solutions include upgrading the bus system in the Scenic Rim, installing solar powered street lights as a standard practice for all new road infrastructure, implement car and bike sharing systems within Beaudesert once the population reaches as size which makes it economically feasible. Potential solutions for employment include creating a start-up hub in Beaudesert connected with the co-working space to promote regional innovation and get more people working locally. The regional council could also provide monetary incentives for start-ups that are in the agriculture sector to drive innovation in the regions driving industry and historic culture. There could also be incentives that push agriculture related industries to move to the new industrial park to create a regional value chain to reduce costs and possibly even create a regional product. Another future project could be to extend the freight line that runs through the industrial park out to the relatively new Gold Coast International Airport. This could be a good option if the industrial park fills up enough to warrant it. In terms of housing, projects like EcoVillages would be great additions to the Scenic Rim’s drive for sustainability, especially if these EcoVillages were integrated with society. There will be a huge amount of residential development over the next few decades and it is likely that there will be a portion of the migrating demographic that could afford net zero homes, so that would be a great implementation if the correct developers are found. Clearly there is a lot that can be done in the region and it has a lot of potential if the right steps are taken in the coming years.
7.0 – References


