Australian Tropical Research Foundation

10 Oct. 2018

Response to Sunverge Second "Powering Daintree" Report

Prefacing Comments

There appears to be little significant difference between this document (**2nd Powering Daintree**) and the initial one.

We continue to emphasize that **Option 5** with variations (i.e. upgrading individual RAPS systems) would be the most economical and the most equitable, however we acknowledge that provision of 2 micro-grids in the two high energy-use "hot-spots" in Cape Tribulation and Cow Bay should be considered.

Given the existing high residential uptake of "Hybrid RAPS" (usually solar plus some form of fossil-fueled backup for poor weather) in the area, as illustrated in the included maps, there is little point in replacing this with a grid-equivalent system. Upgrading older installed RAPS systems to modern technology should be a priority (and would be at a significantly lower cost), coupled with efforts to educate users on energy efficiency and system maintenance. **Provision of a local central facility to deal with equipment failures and advise on design or upgrade would be highly valued.** Coupled with this is the need for some standardization of installed RAPS equipment, to facilitate such service. The cost of this Option 5 will be considerably less expensive, far less disruptive and more sustainable than the other options suggested by Sunverge**.**

Hot water heating does not require electrical input. Modern evacuated tube solar collectors work well in this environment, are not prone to the failures of flat plate collectors and are available in a variety of configurations ("Run on Sun"). Sunverge appears to have a fixation on having hot water heating as a load levelling device, using and wasting substantial amounts of fossil energy

The consultation process used by Sunverge was exceedingly selective and biased (and only appeared to address members of the Daintree Power lobby group) – as a result it did not sample or involve or capture the views of the great majority of the residents of the Daintree Coast community.

No assessment of costs of connection to the properties (or associated costs such as upgrading of house wiring or metering) was made.

Given the need to respond to the outcomes of the latest IPCC report, support for local Hybrid RAPS can be the only possible approach – as the other options suggested are fossil fuel-based and require technology that is not mature, "sustainable", nor is required in the volume suggested by Sunverge.

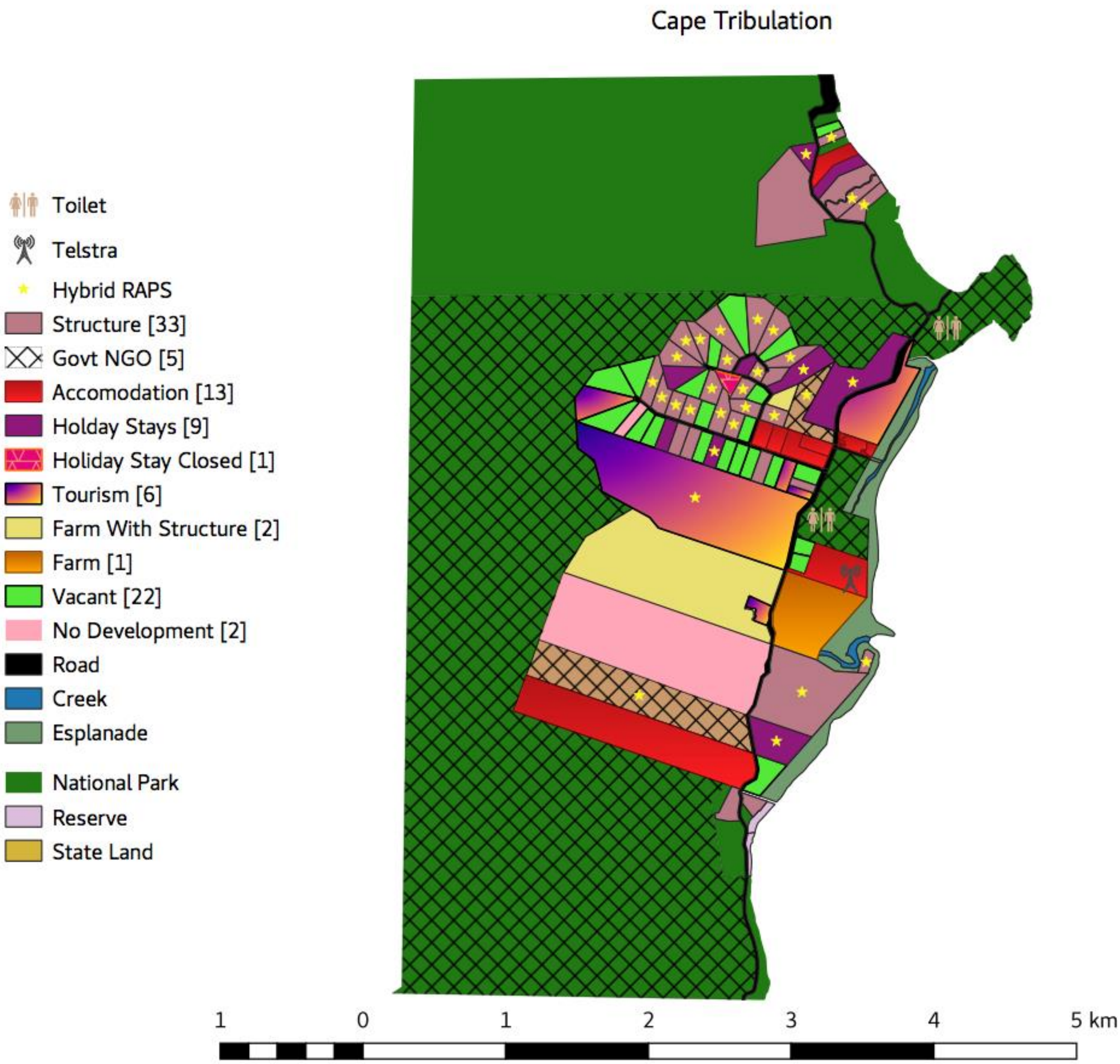
From our analysis of the situation in the Daintree Coast, the Sunverge assumption of 930 lots which could be potential customers is grossly erroneous.

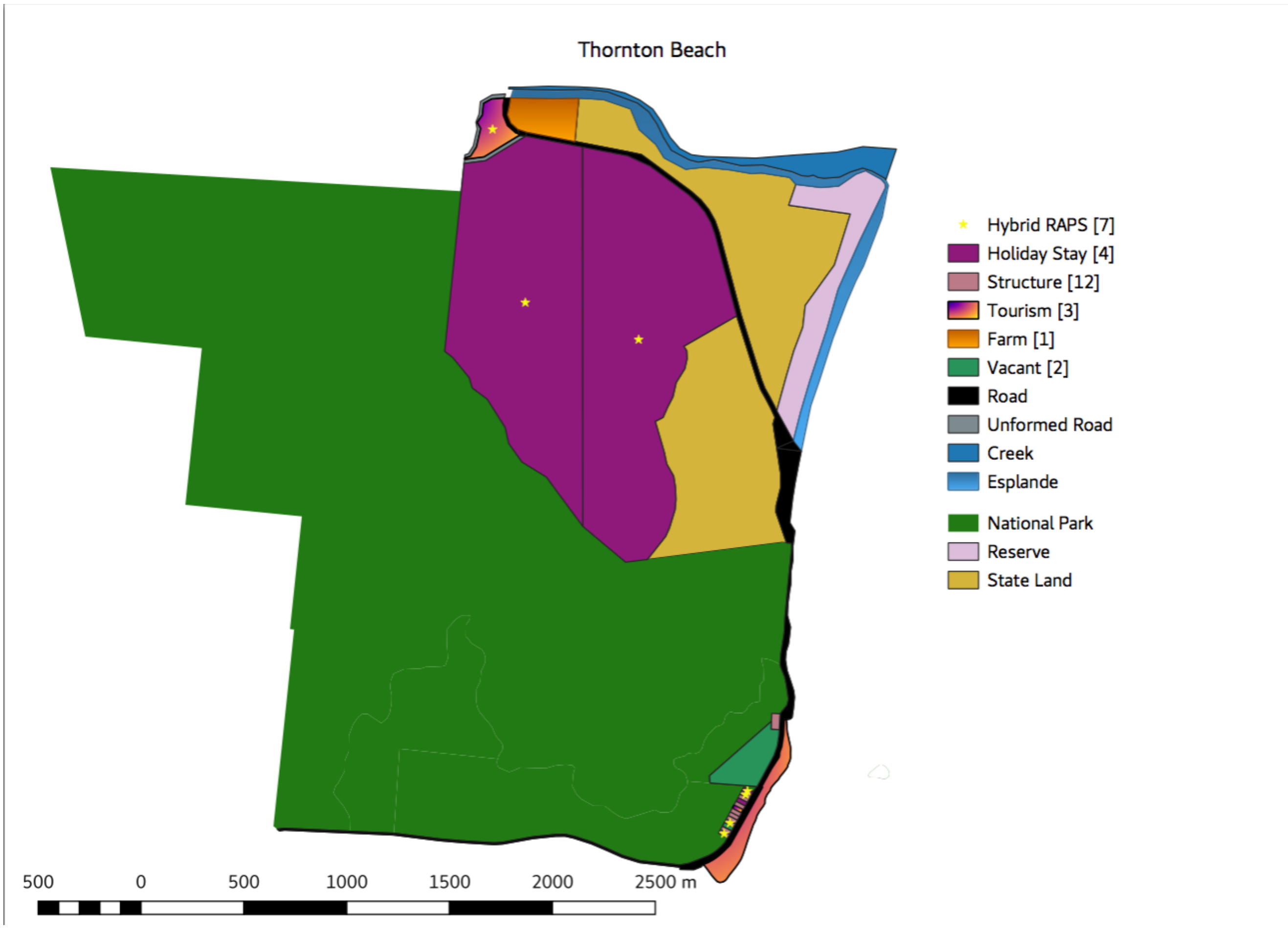
Sunverge is assuming 930 blocks with 502 residences ("likely customers"). The reality is vastly different. Of 770 identified properties, 400 were either vacant or undevelopable (because of buy-back, etc.) giving 370 possible customers, of which 312 already have a hybrid RAPS (PV + generator backup) system. This means that the potential identified market is 31 (commercial establishments without hybrid RAPS) in Cow Bay and Cape Tribulation. These could each be served by a micro-grid. The remainder are mostly unidentified landholders (Parks, etc.)

Approximately 300 blocks of the 400 vacant/undevelopable blocks identified are buy-back blocks, either funded by Government or by organizations such as Rainforest Rescue. These blockscannot be sold or developed. This still falls short of the required number of 450 buy-back blocks required to permit grid style electrification (GH&D 1998 EIAS- FNQEB Proposed Daintree Powerline.)

Maps

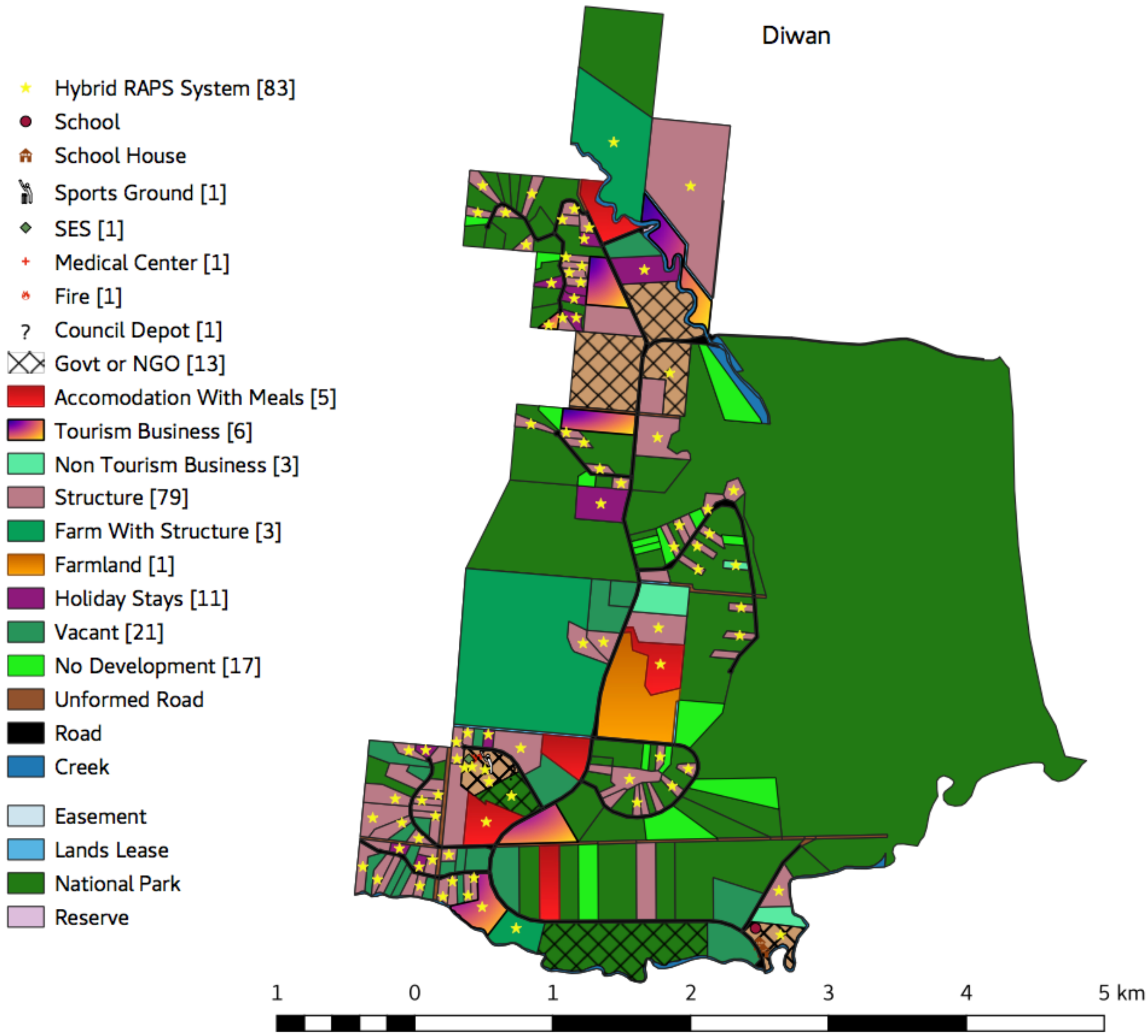
These plot the distribution of current Hybrid RAPS installations within the Daintree Coast region, and the distribution of various land usage types, particularly commercial**. This material has been developed from both satellite data and on ground inspection**. See also additional maps in the response section.





Thornton Beach
Hybrid RAPS [7]
Holiday Stay [4]
Structure [12]
Tourism [3]
Farm [1]
Vacant [2]
Road
Unformed Road
Creek
Esplande
National Park
Reserve
State Land
500
0
500
1000
1500
2000
2500 m

DIWAN


Diwan
Hybrid RAPS System [83]
School
School House
Sports Ground [1]
SES [1]
Medical Center [1]
Fire [1]
Council Depot [1]
Govt or NGO [13]
Accomodation With Meals [5]
Tourism Business [6]
Non Tourism Business [3]
Structure [79]
Farm With Structure [3]
Farmland [1]
Holiday Stays [11]
Vacant [21]
No Development [17]
Unformed Road
Road
Creek
Easement
Lands Lease
National Park
Reserve
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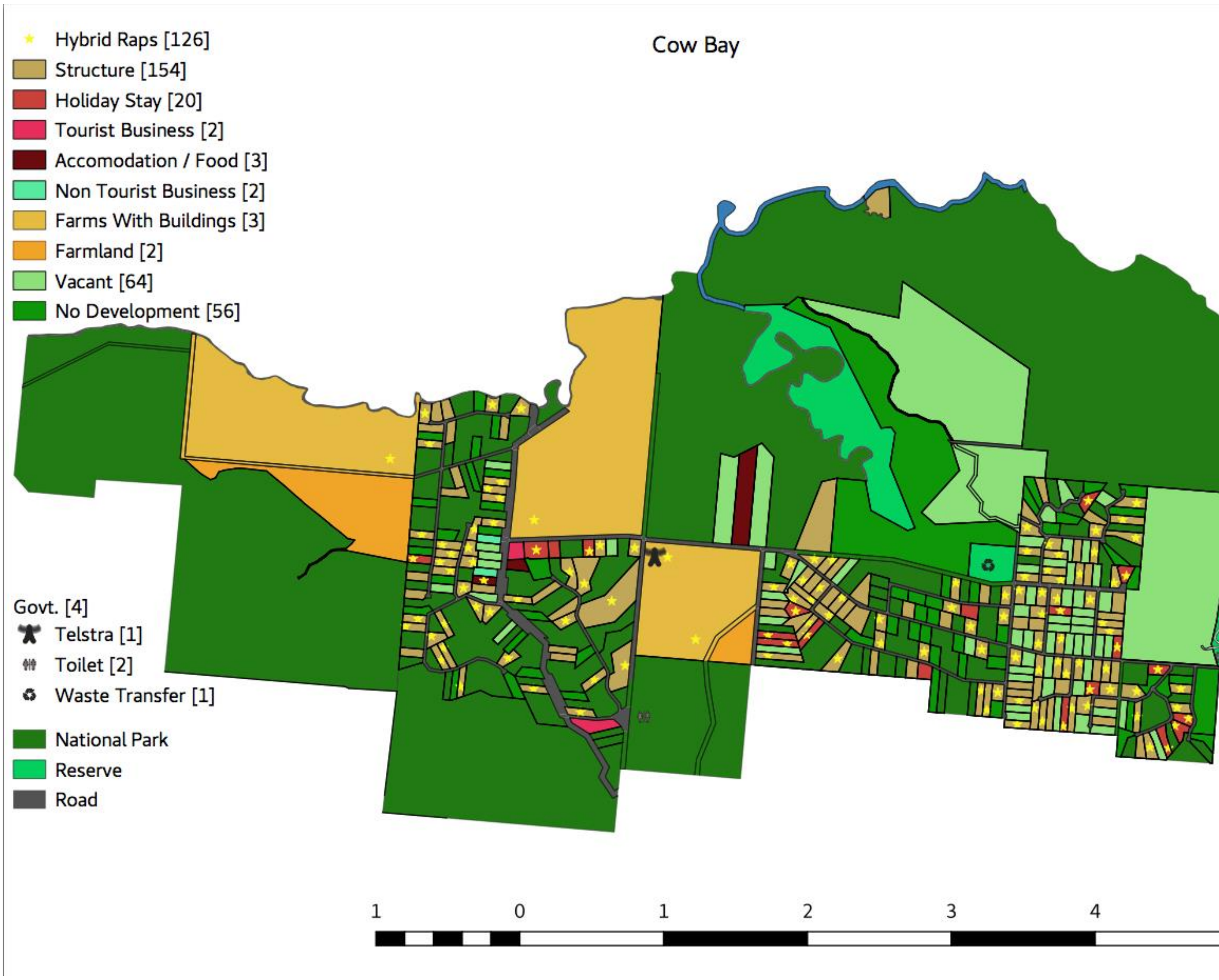
1
2
3
4
5 km


Hybrid Raps [126]
Structure [154]
Holiday Stay [20]
Tourist Business [2]
Accomodation / Food [3]
Non Tourist Business [2]
Farms With Buildings [3]
Farmland [2]
Vacant [64]
No Development [56]
Cow Bay
Govt. [4]
Telstra [1]
Toilet [2]
Waste Transfer [1]
National Park
Reserve
Road
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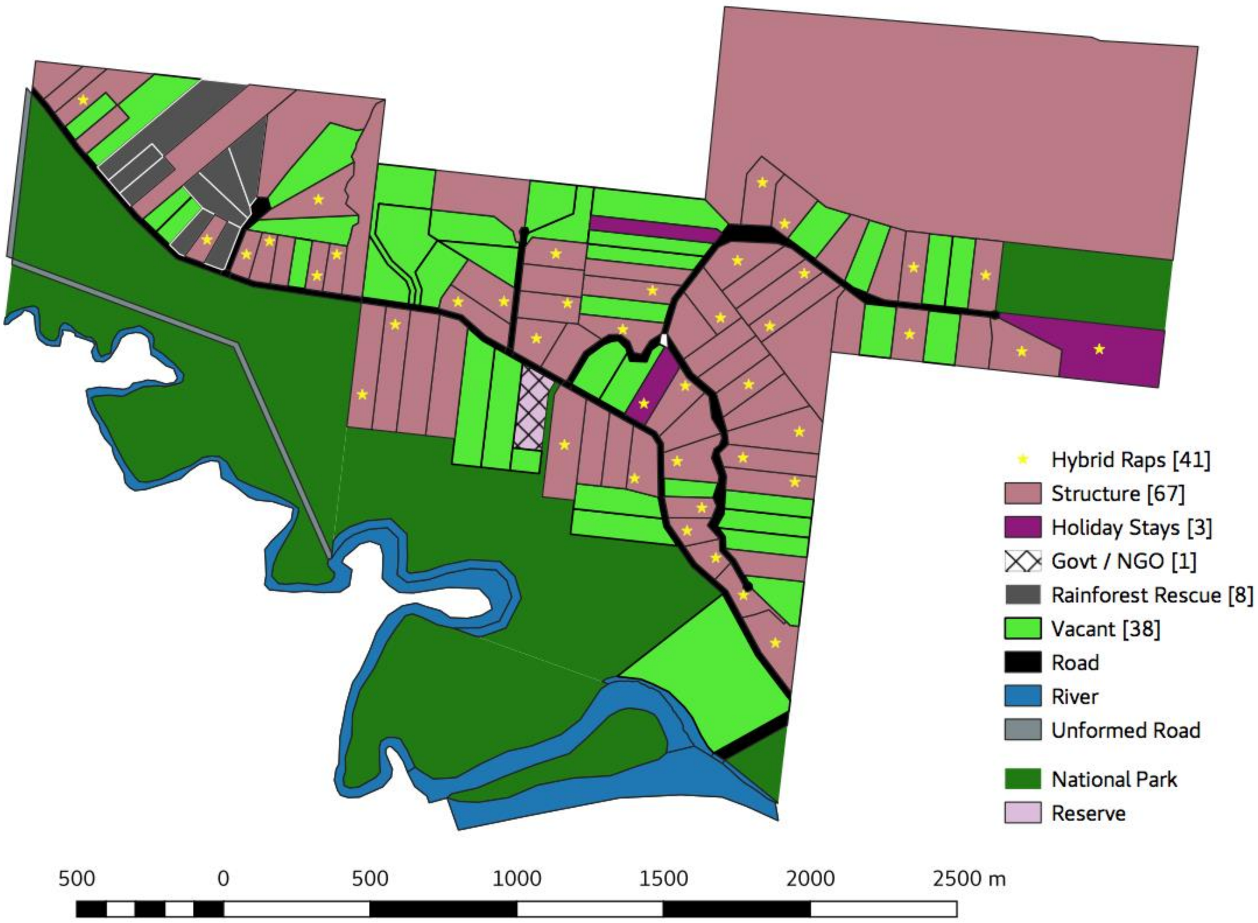
3
4

Forest Creek



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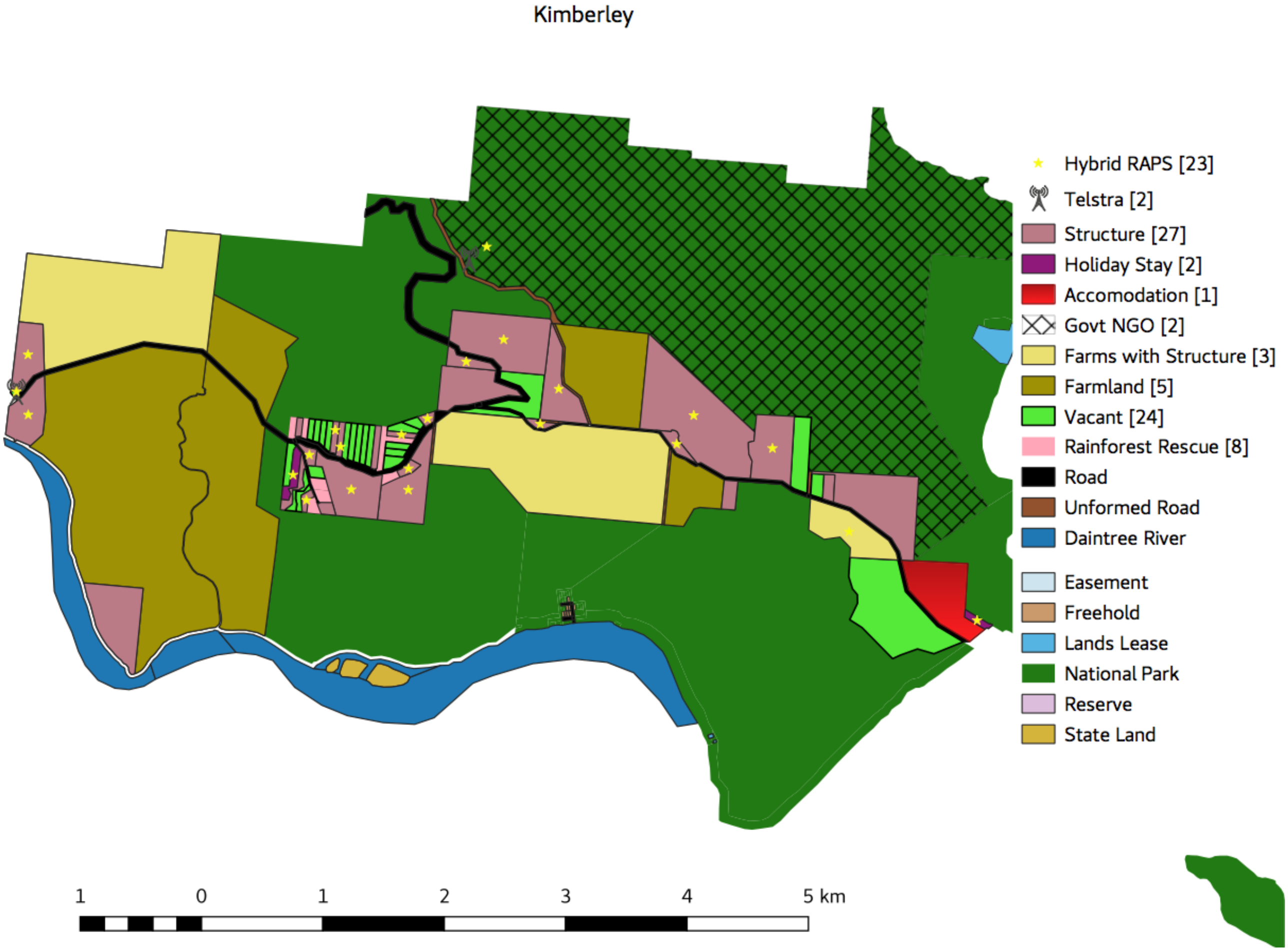

Kimberley
Hybrid RAPS [23]
Telstra [2]
Structure [27]
Holiday Stay [2]
Accomodation [1]
Govt NGO [2]
Farms with Structure [3]
Farmland [5]
Vacant [24]
Rainforest Rescue [8]
Road
Unformed Road
Daintree River
Easement
Freehold
Lands Lease
National Park
Reserve
State Land
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Appendix 1 – Sunverge document with comments

(Comments on this document is highlighted in red in the following pages).

Since the document was converted from the supplied .pdf document, there are some formatting issues which could not be corrected.

(SUNVERGE) Executive Summary

Sunverge has been engaged by ARENA to:

- Define the challenges faced in supplying energy in the Daintree community;
- Identify options to supply power to residents of the Daintree community, including analysis of current state technologies (traditional and renewable) and analysis of system and energy load data;
- Analyse tariff and financial structure options to enable a community-based scheme which rewards efficient behaviours and delivers improved infrastructure; and
- Develop options and recommendations for pilot and broader rollout of energy supply technologies to the Daintree community

This report presents Sunverge's findings from its investigation and engagement with members of the Daintree community and key stakeholders including representatives from Queensland's Department of Energy and Water Supply, Douglas Shire Council, Wet Tropics Association and the Jabalbina Aboriginal Corporation.

As part of the process, Sunverge reviewed a number of existing studies and reports relevant to power supply issues in the Daintree community, including the 2017 Ener-G report and Ergon Energy's engineering 2013 Daintree Supply Report. Many of these studies relied on information contained in previous reports with little reliance on gathering primary data to establish load profiles for energy and load requirements.

Sunverge sought to improve the accuracy of the energy requirements analysis and thus the accuracy of supply option definition by undertaking real metered data analysis, spatial survey analysis, and analysis of Sunverge's own load data set for Far North Queensland combined with standard power system planning and forecasting practices.

Sunverge undertook spatial analysis, gathered energy consumption data from a number of sites and devel Load and Generation spatial arrangements determined the number and expected type of transformers, synchronous machines and cables, thus providing a more quantitative cost estimate open load profiles to establish the community power requirements. In the process Sunverge discovered significant differences between the different regions within the Daintree.

Sunverge also conducted meetings with a number of OEMs through a market sounding process to develop indicative costing at concept level for a range of solutions applicable to the Daintree area for comparison purposes. The network design process adopted was similar to that used by Ergon Energy. The expected

This information formed the basis for the analysis of the following five scenario options for complete power supply (i.e. network plus generation or standalone generation) to the Daintree community.

1. Single Daintree electrical microgrid with synchronous machines and a staged pathway for high renewable uptake
2. Multiple Daintree electrical microgrids (three segments)
4. Daintree gas microgrid with high renewable uptake using power to gas and biomethane
   Microgrid supply to Cape Tribulation (leverage of existing generation to extend in small LV networks)
5. Upgrade of individual Remote Area Power Supply options

Through discussions with key stakeholders, four main criteria for a successful power supply were agreed, being:

- Equity
- Reliability
- Environment and sustainability (including renewable potential)
- Economic

The five scenario options were each assessed against these criteria.

Each option was assigned a score from 1-5 for each of these criteria and summed for simple ranking of preferred supply options as set out in more detail in the Our Approach section of this document.

Power supply options assessed

As part of this process, Sunverge was able to investigate many different technologies and options at a high level for suitability. These included:

- Ultra-lean burning spark engines
- Liquid vs gas engines
- Heat to electrical recover (organic rankine cycle and inverter)
- Distributed micro combined heat and power generation
- Gas reticulation, in particular using polyethylene pipe (P.E)
- Hydrogen injection into P.E pipeline for storage (Fuel Cells)
- Traditional and modular battery energy storage systems and inverters
- Power to gas to power fuel cells (including high pressure)
- Methanation of hydrogen (fuel cells)
- HEMS (Primary hot water control over an IP network and local frequency sensing).
- Near synthetic inertia storage devices (ultra-fast battery and fuel cell systems).
- Traditional synchronous machines for inertia and fault power.
- Traditional cable vs overhead line systems.
- Traditional European vs American style LV networks and transformers
- Traditional MV switchgear (Extendable) to allow flexibility for future growth without significant capital expenditure.

Note – a complete absence of reference to PV generation, which is a well- established renewable technology. This report appears to concentrate on untried technologies – rather than adopting current proven technology – in particular solar photovoltaic.

Biofuels

With regards to biofuel options, it is noted that Sunverge and ARENA also made enquiries through the Queensland Government's Biofutures Queensland office. Feedback received indicated that production is limited and currently in feasibility study stage with numerous projects. Whilst commercialization of these projects remains some years away, the current indications are that the supply of biofuels is at present uneconomical but may be considered at future dates depending on renewable penetration targets and improvements in costs and technology.

Pathway to 100% renewables

The report finds Option 1 - Single Daintree electrical microgrid with a staged pathway for high renewable uptake to be the preferred option to supply reliable, renewable and cost-effective power to residents and businesses in the Daintree.

This option recommends the development of a full underground electric microgrid (network) to enable equitable and reliable access to power for customers and facilitate a greater diversity across loads thereby allowing a higher renewable self-consumption rate.

For the purposes or achieving equitable, reliable, economically sound and environmentally sustainable energy supply for residents, it is recommended that the network be supplied by an appropriate generation mix. This report proposes that such a mix could include synchronous gas generation, central and distributed solar, and a solar to gas facility to address seasonal solar irradiance and enable long term storage of excess renewable generation.

The report aims to provide a feasible pathway to an equitable, reliable, economically sound and environmentally sustainable energy supply for residents with the following recommendations.

1. A staged approach to building a reliable, low-impact underground microgrid which is initially serviced by a mix of traditional gas generation and solar PV and leverages regional skill sets
2. Subsequent to the provision of reliable, low impact microgrid power, exploring options to increase the renewable generation of the system to approximately 80% through:
   - first understanding the detailed load characteristics of the whole system based on analysis of installed system (traditional) generation for a period of up to one year, then based on actual system load data and detailed site investigation
   - implementing a plan to reliably increase renewable penetration and deploy innovative energy technologies including potentially large scale, long term storage (e.g. solar to gas)
3. Establishing a mechanism to allow customers to benefit from sharing their excess solar production (similar to a Feed-In Tariff scheme)
4. Implementing residential and business tariffs with a fixed and variable component similar to those offered to grid connected customers in regional Queensland
5. encouraging a public private partnership arrangement to the development of the microgrid
6. Obtaining stakeholder support and agreement on the key principles for engineering solutions, tariff structures, subsidies and schemes, ownership, regulation and governance
7. Funding the development of a next stage detailed Microgrid pre-construction study with reputable project proponent including detailed survey data, detailed engineering cost studies, pre-approvals and detailed project plan for Option 1. It is noted that the Queensland Government is currently considering its commitment to further studies relating to the supply of power in the Daintree and recommended that this be considered as part of those activities.

This is the most complex and unnecessary approach (although this is the most interesting from an engineering point of view).

Acknowledgements

Sunverge would like to thank representatives of the following stakeholders for their contributions to the development of this report from data gathering to the development of recommendations:

- Ergon Energy Corporation
- Jabalbina Aboriginal Corporation
- Wet Tropics Management Authority
- Queensland Department of Energy and Water Supply
- Russell and Teresa O'Doherty

In addition, we would like to thank the following Daintree residents and businesses whose support allowed Sunverge to gather the first real interval load data insights into energy consumption patterns in the Daintree:

- Russell and Teresa O'Doherty
- Cape Tribulation Beach House
- Heritage Lodge and Spa
- Daintree Tea
- Lync-Haven

We notice that the Sunverge authors appear to have taken little notice of the comments provided by Austrop to the original proposal – "Austrop Response to Powering Daintree 20 May 2018"

Understanding the supply challenge in the Daintree

The Daintree World Heritage listed rainforest is an area renowned for its spectacular scenery, dense rainforest, mountain ranges and rugged topography. It is one of Australia's largest rainforest wilderness areas and, with the exception of roads and limited freehold properties, has remained largely untouched by modern development.

Challenges to date

Visitors travel from all around the world to experience the scenic and natural beauty of the rainforest as it stretches down from the mountains to the coastline and reef.

Whilst eco-tourism contributes significantly to the Queensland economy, the ecological significance of the area has meant that debate has raged for decades over how development and conservation can coexist in an ecologically sustainable manner.

These debates include the dispute over the Daintree Coast subdivisions in the late 1970s, the now famous Daintree Blockade, National Park declarations in the early 1980s, World Heritage listing in the late 1980s, buy-back schemes in recent years and countless studies, inquiries and plans into power supply to the region.

Numerous studies have been undertaken over recent decades to specify the challenges faced by providing power supply to the Daintree community, including:

- Cost Estimates for Daintree Supply Option A (Dec 2013) Ergon Energy
- Cost Estimates for Daintree Supply Option B (Dec 2013) Ergon Energy
- Proposed Daintree Powerline Environmental Impact Assessment Study (Oct 1998) GHD
- Isolated Communities Power Options Study 2017 V2.0.pdf (2017) Ener-G
- Daintree Futures Study (Nov 2000) Rainforest CRC
- Environmental Protection (Water) Policy 2009
- Daintree and Mossman Rivers Basins Environmental Values and Water Quality Objectives Basins Nos. 108 and 109 and adjacent coastal waters (2009) Queensland Government
- Ergon's Developers Handbook Develop, Design and Construct Work version 8 Ergon Energy Daintree/Cape Tribulation Electricity Survey (March 2016) Compass

The area has been excluded from Ergon Energy's supply territory and successive state governments have been unable to find an equitable, reliable, economic and environmentally suitable solution to the challenge.

The following additional issues compound the complexity of the challenges associated with providing equitable, reliable, economic and environmentally sustainable power solutions to the residents and businesses in the Daintree.

Geographical challenges

- The region sits 'between the rainforest and the reef', with mountains to the west and ocean to the east and rivers marking the northern and southern boundaries of the area. The rugged landscape and steep ranges present a number of physical challenges for electricity and communications infrastructure, although most of these can be overcome by appropriate undergrounding along existing roads or easements.
- There is a known region through the Alexandra range which is rock and will need directional drilling to facilitate any underground network options. From discussions with drillers who have experience in the region for a telecommunications operator, indications are that most locations are favourable and so other quicker drilling methods or possibly even cable ploughing might be feasible. At this stage, given unknown variables, a conservative approach was taken in the option analysis. Engaging one or multiple local operators for detailed quotations and exact route planning as part of a pre-build investigation would tighten up this ambiguity.

  We suggest that Austrop has the data to allow a very full analysis of current property identifications and the distribution of hybrid RAPS and commercial users. This information is available on request.

The constraints of remote location, and limited access via river cable ferry, have potential for significant impact on both SAIDI (System Average Interruption Duration Index) and OPEX and OPEX costs of any grid.

- It is therefore recommended that the equipment installed be robust with high reliability and that modularity be introduced for components which have lower reliability so that failed components can be isolated and replaced without a significant adverse impact. This applies to all installed electrical equipment north of the Daintree River.
-
- Additionally, equipment such as energy storage systems and protection switchgear/relays should have components which have existing integrations schemes where all bugs have been discovered and remedied before being implemented in the Daintree.

Environmental challenges

- The Daintree is well known for its frontier approach to energy supply and has many dated residential solar power installations to enable isolated supply to homeowners and reduce individual generator running costs. Many systems have been in operation since the Queensland Government's successive Daintree Remote Area Power Supply Subsidy schemes dating back to 1996 and 2000 and rely on aged and inefficient technology.
- Correct, but many, if not most, have upgraded their systems, and have little desire for grid (equivalent) power.

  To quote a major installer
  "I have many customers who have gone in with their eyes open - spent the money on a well-designed system and have no interest in a grid connection.

With derived data from SP link and customers recorded diesel purchases we have determined the cost of electricity from diesel generation in a well-managed modern diesel generator (i.e. managed by an SP controller, partial recharge of batteries with only 100% recharge at programmed intervals, so engine is always running at around 80% capacity) is 25 cents per KWH after excise rebate. This compares well with town power costs, but of course doesn't include capital expenditure. However, once a grid is installed, there is a meter charge of $400.00 per year per meter (nationally mandated), and a solar export meter is around $300.00 to install"

However, a big wet season and high seasonal variances in solar output, combined with the absence of a grid mean that self-consumption? Definition? potential is low in the current community power supply arrangements. This report asserts that the introduction of a microgrid will serve as a platform through which diversity will be increased and solar potential can be maximised

This makes the assumption that our power usage and expectations can /should match urban communities (which are having to deal with rapidly escalating costs). Assisting residents to practice wise energy management is critical.

- As a World Heritage listed area, there have been strong concerns about the potential environmental risks associated with energy infrastructure development in the area. These risks need to be addressed through any proposed energy supply option, however it should also be noted that any decisions regarding future supply options should take into account ways in which to reduce the current environmental damage caused by the burning of over 4 million litres of diesel per annum and in some cases the dumping of out-dated lead acid batteries into the eco-system.
-
- This figure of 4 million litres is unsubstantiated. Most households use a small gasoline generator. Plus the distributed nature of the diesel/gasoline generators means that the exhaust impact on the rainforest is very low.

  Since lead acid batteries have a high recycle value, residents should be encouraged to take old batteries to recycling centres that pay for scrap such as NQ Recyclers (Federation Street, Cairns) for example.

- This report recommends the development of a power system which will significantly reduce the environmental impact of current supply solutions whilst(while) at the same time demonstrating an economically sound solution with a pathway to 100% renewable energy supply in the area.
-
- Given our energy expectations there is no way that total reliance on renewables will satisfy the energy wants of many residents. So far, there appears to be little if any efforts by businesses to reduce their energy usage, despite the availability of plenty of well-tried solutions.

Due to the Daintree being a heavily forested area direct shading was also estimated on a roof by roof basis as part of the survey of roof area to estimate available rooftop PV potential. While some solutions are available for roofs with intermittent shading from a branch such as micro inverters or DC optimizers such solutions are typically more expensive than traditional string inverter systems and do not make up for lost energy not falling on a particular panel during shading. As seen below a significant proportion of roof space available has significant shading and is not viable for installing any sort of PV panels. Expensive than traditional string inverter systems and do not make up for lost energy not falling on a particular panel during shading. As seen below a significant proportion of roof space available has significant shading and is not viable for installing any sort of PV panels.

This is rubbish. Because areas around buildings have generally already been cleared to some extent for light access and cyclone protection, most roofs actually have quite adequate solar exposure. It's primarily an absence of clearing of overhanging vegetation (which will have no impact on WH values). MPPT charge regulators are considered essential in this solar environment. While panel based 240V micro inverters could overcome the shading problems associated with series-string arrays (a shaded panel restricting the output of the string) – they would still need a dedicated 240V battery charger. PV is now much cheaper than 10 years ago and people can afford to oversize to make up for shading and overcast weather

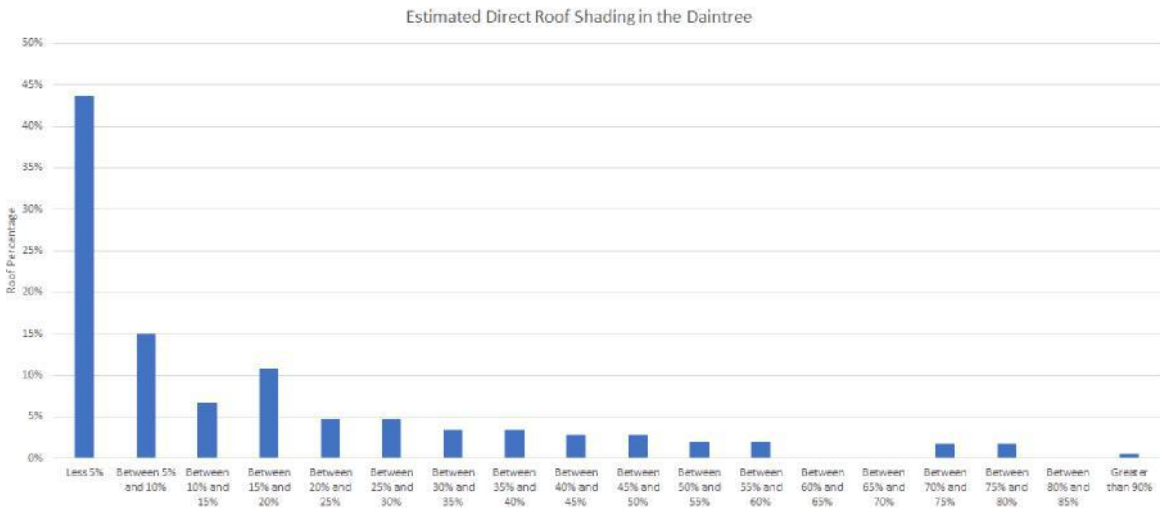

Fig 1.0 Estimated Distribution of Roof Shading (Tree/Branch Overhand via Aerial Photography)

∞ Roof shading isn't uniform over the whole Daintree region or load class. Cape Tribulation, for example, has significant roof-top shading issues and is one of the largest regions needing energy to be transported to this location or generated locally via traditional liquid or gas hydrocarbons.

Where did this data come from? AUSTROP has analysed this – and the results are available.

The image below represents typical conditions for accommodation cabins which are one of the most significant load contributors within the Daintree Rainforest area. As shown, many premises are in scenic but poor photovoltaic locations.

Fig 1.1 Accommodation Cabins, Typical for the Daintree and a Large Load Sub Group

The cabins illustrated are from Beach House (Cape Tribulation) which has not installed energy saving systems (such as tag room switches), or installed solar panels. Also, most buildings have A/C installed, in buildings that are **not insulated** and have **louvre windows** (so there is considerable air and energy loss).

Diverse stakeholders

- The ongoing debate between development and conservation in the Daintree region shows the extent of diversity of views amongst stakeholders.
- Common feedback amongst the majority of reports to date indicates that there would be support for a scheme which provides a more equitable, reliable, environmental and economic solution to the supply challenges of the Daintree. Sunverge believes that its preferred option will provide a solution which best meets these objectives and adheres to the wishes of the vast majority of Daintree residents.

  Unfortunately, because of the very biased and limited "sampling" of residents by Sunverge, this is not correct.

Economic challenges

- Power systems have traditionally been built using public resources on the premise that electrification enhances community welfare and the public good.
- In the case of the Daintree, there is a strong economic motivation to substitute diesel generation costs at the premises. However, the economic challenges associated with low customer numbers per installed kW or km of network, environmental restrictions and challenging physical environment mean that a suitable solution will require some level of government incentive or subsidy in order to build a scheme which meets all the requirements of the community. The costs associated with the preferred solution are listed later in this report and will require detailed investigation as part of the next stage of pre-construction works.
- In addition to diesel fuels being used for electrical generation, significant LPG is also being consumed within the Daintree for almost all (water) heating and cooking usage. This additional infrastructure is also restricting the local businesses and reducing funds for upgrades and overall improvement such as more efficient AC systems. Below is a typical LPG installation for a larger commercial site.

Fig 1.2 Large LPG Tanks, LPG used for Cooking and Heating (Primary Hot water), Typical Supplier Elgas

Inter-tie into the Ergon Energy Network has been proposed by many different studies and was included as part of an option that Ergon Energy did in 2013. This option would require significant reliability and loadflow/protection studies along with likely network upgrades. Ergon Energy's report from 2013 noted that for only supplying Forest Creek and Cape Tribulation a new feeder to supply this additional load would cost in excess of $16M to construct .

Technological challenges

- A number or technological challenges exist in a densely rainforested community that is humid, close to the sea and prone to cyclones and monsoons.
- From a network perspective, overhang from foliage would cause a number of significant issues to any overhead configuration.
- All wiring in this region MUST be underground
- From a system stability perspective, numerous microgrid challenges are specified in detail below, however these include typical issues experienced with loads in microgrids, lack of diversity, and establishing the right mix of generation to support a transition to renewables. The system will also need fast response mechanisms to cope with sudden load changes the intermittency of renewables as well as long term storage to cope with seasonality.
- Given that the majority of users will be domestic (which includes B&Bs and holiday stays) the usage pattern is relatively easily established – we do not have manufacturing (possibly Tea Plantation) so do not have to cope with sudden and unexpected grid loads.
-
- In addition, the system would need communications and metering infrastructure, although it is expected that this would be a minor incremental cost to the overall microgrid development.
-
- The strong wet season and location 'within a bowl' from the mountain ranges to the immediate west and between Cow Bay and Cape Kimberley presents seasonality challenges for significant renewables as long term or baseload storage is needed to cater for periods of high rainfall and low solar production.
-

- That would be correct, given the Sunverge expectation that all residents are to have urban style power access and usage patterns.

Equity

- In addition to being excluded from traditional power supply solutions, there are various other barriers to equity for residents in the Daintree, for example:
    - Access to state and federal government schemes, including credits and rebates for electricity supply or the installation of energy efficient appliances or renewable generation. This report recommends the state and federal government investigate ways in which regulatory barriers can be amended to enable such schemes to be equitably accessed by members of the Daintree community. These schemes include access to renewables certificates (e.g. STCs), low income energy rebates associated schemes.
    - Access to affordable products and services. Whilst the Daintree community is not geographically distant from the city of Cairns, the study found that residents and businesses are charged a premium significantly higher than residents in Cairns and the surrounding region for electrical products and services. For example, quotes for solar installations were at least double those offered in Cairns, well above any extra charge for travel time. If a microgrid were in place, one potential role for the state government would be to assist in the creation of a market opportunity for the installation of solar PV similar to the recent initiative in remote communities. There will always be a differential in solar access – even after appropriate tree canopy clearing. Coastal locations will be at an advantage compared to those backed against the mountains.

- Population
- No existing electric network (excluded from Ergon regulated supply territory)
- 120km reticulated MV and LV line required to supply entire community
  - residents, non-residents, tourists etc
  - As noted in the Compass Research "Daintree/Cape Tribulation Electricity Survey"
- But not required under Option 5)
- Approximate direct distance of Daintree excluded territory 40km from Daintree River to Bloomfield River, northern and southern communities separated by the Alexander Range

Demand

- Dense, world heritage protected rainforest
- Solar farm potential in excess of 100MW based on spatial analysis of large cleared areas
- Rooftop solar DG marginal due to foliage and seasonality (tree clearing is not an issue – cyclone and safety)
- Large end of line load centre at Cape Tribulation (see suggested microgrid)
- Significant seasonality due to wet season, both long and short term storage needed for significant PV uptake. (requires better energy management)

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Site, customer and demand information

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Geographical description (e.g. size and description of key features/constraints)

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Daintree Characteristics

The following is a summary of key information in relation to the Daintree community.

The below table is a summary of the Load Duration Curve for the various communities within the Daintree and the entire Daintree system.

Fig 1.3 Estimated Load Duration Curves for the Daintree Networks from Model Described in this report.

The following table adapted from the Isolated Communities Power Options Study 2017 V2.0.pdf (2017) Ener-G highlights the variability in estimates regarding population.

A fairly unhelpful graph, given that it is an estimated usage curve – from estimated data.

Area	Dept of Energy 2005	Missing Link 2009 (lots)	Daintree power group 2016	ERGON report EOIs 2013 - customer	Ener-G 2017	Assumed no. of properties for energy calculations in this report
Cape Tribulation	97		69	42 residences	95lots optimistic/65 pessimistic	
Thornton Beach, Noah Ck.		23			25lots/17 residences	Pessimistic 17. Optimistic 25
Diwan	178			45	188lots/111 residences	Pessimistic 111 Optimistic 188
Cow Bay	139	317		89	184 residences 375 lots	

Cape Kimberley	206	**18**	**82lots/31 residence**	**NA**		
Forest Creek	**620**	**178**		**43 residences**	**166lots/94**	**NA**
Total		**587**	**800**	**237**	**930lots/502**	

Table 1: Table of Property and Customer numbers per community (re-formatted)

Ergon Energy's electricity network just crosses the Daintree River and connects to a few properties at the back end of Forest Creek.

See comments on property numbers in the introduction.

The Ergon network from Wonga Beach is approximately 13 km away from the river and is on a spur. The existing assets are light hardwood pole structures with air break switches along the backbone. As the line length would need to be significantly increased to even cater for just Forest Creek and Cape Kimberley, security and reliability for both the existing and new section would need automated switches such as sectionlizers and/or auto-reclosers, neither of which would probably be able to be installed on existing pole structures while staying within the planning limits of Ergon (detailed engineering per pole analysis would be required to confirm). Auto-reclosers would not improve reliability for Daintree residents but would protect the Ergon network upstream of the Daintree. Below is a typical pole in the lower Daintree along the Mossman Daintree Rd (courtesy of Google Maps street view)

Fig 1.4 Typical Three Phase Ergon Hardwood Pole Structure Supplying Lower Daintree (with small conductor)

There is likely to be a requirement for significant reinforcement of assets, including overhead conductor, thus triggering new cross-arms and new pole structures for the expected load from just Forest Hill and Cape Kimberley.

This is irrelevant. All distribution wiring must be underground.

Due to the line length it is expected that volt drop would be a problem, thus needing voltage regulators (probably open Delta systems most likely located at Forest Creek). A proper loadflow and fault analysis with Ergon would be needed. Ergon has previously stated reinforcement works could cost multiple million dollars if a new feeder is required due to additional load.

Further, the high impedance line would mean that residents of Forest Creek who connected to an Ergon main grid would likely be significantly restricted as to how much solar PV they can install. Sunverge specifically agreed during the process that it would not investigate an option to connect to the Ergon main grid for this specific report. This would require detailed work with Ergon reinforcement and reliability planners than was not considered or included in the scope.

Our approach

As part of our study, Sunverge proposed to undertake the following actions:

- investigate how the physical energy will be supplied to the various communities within the Daintree area (including possible MV/LV reticulation);
- analyse and develop tariff structure options to support deployment and funding of improved infrastructure and achieve efficient and reliable community power supply;
- analyse and compare finance structure options to enable a community based scheme which rewards efficient behaviours and improved infrastructure;
- conduct engineering analysis of current state microgrid technologies for improved efficiency, local generation and self-consumption and reliability within the microgrids;
- provide analytical review and modelling of required programming to optimise losses and self-consumption across the microgrid, including reporting on how distributed assets will act as one group to minimise total energy usage/losses of diesel/gas, while providing incentives for efficient behaviours;
- model the interaction between multiple units within the microgrid/s; and
- develop indicative costing (through market sounding) at concept level for a range of solutions applicable to the Daintree area for cost benefit comparison purposes
- conduct preliminary engagement meeting with each of the key stakeholders;
- conduct research to reveal more information, including information such as type of existing water heating and other electrical and thermal loads; and
- conduct a high level assessment of energy efficiency options, including survey of existing stock and cost/benefit of replacement for stock like hot water, lighting, etc.

In addition to these items, and given the data challenges surrounding the Daintree area, we decided to reconcile with existing reports especially engineering reports such as those done by Ergon Energy and the general planning methodology such as ADMD with any significant differences needing to be explained.

As part of the process, Sunverge met with key stakeholders from Queensland Department of Energy and Water Supply (DEWS), the Daintree Power Committee (DPC), members of the community, Jabalbina Aboriginal Corporation (none of whom live in the area) , Wet Tropics Management Authority and Douglas Shire Council.

However, they did not meet with other groups or domestic users.

Review of studies undertaken to date

The following studies were reviewed as part of this process.

- Cost Estimates for Daintree Supply Option A (Dec 2013) Ergon Energy
- Cost Estimates for Daintree Supply Option B (Dec 2013) Ergon Energy
- Proposed Daintree Powerline Environmental Impact Assessment Study (Oct 1998) GHD
- Isolated Communities Power Options Study 2017 V2.0.pdf (2017) Ener-G
  Daintree Futures Study (Nov 2000) Rainforest CRC Environmental Protection (Water) Policy 2009
- Daintree and Mossman Rivers Basins Environmental Values and Water Quality Objectives Basins Nos. 108 and 109 and adjacent coastal waters (2009) Queensland Government

- Ergon's Developers Handbook Develop, Design and Construct Work version 8 Ergon Energy
- Daintree/Cape Tribulation Electricity Survey (March 2016) Compass Research

It is noted that whilst many of these studies provide valuable insight into the supply challenges for the Daintree community, none has to date performed a system energy forecast based on actual metered data and load profiles to support the development of credible supply options for the Daintree community. For example, Ergon Energy's 2013 report explicitly stated that it was using the information it had at hand such as 4kVA and 20kVA for ADMD and its 'price book', to give the most detailed physical engineering study to date in the Daintree.

As such, Sunverge proposed to undertake sample metering data and build system load profiles and potential distributed PV profiles to improve the options analysis for both the spatial and temporal differences throughout the network. This dataset then allowed for a more detailed approach rather than using the standard ADMD for different classes (Residential, Commercial and Industrial) that is typically implemented and often more than adequate for standard new developments. The spatial approach, whilst more complex, was deemed more appropriate for the Daintree due to its clustering of high load accommodation lots compared to the typical Ergon network (explained in further detail later on and contrasted to what was known back in 2013).

The spatial characteristics provided more detail into size of reticulation by determining locations of load centres and potential generation locations, estimated locations of transformers. This analysis informed the type of network which was to be designed (i.e. more typical European with large LV feeders off large transformers or a more American/OHL network with many smaller transformers and smaller transformers) when both thermal (load) and voltage considerations are taken into account.

Temporal characteristics provided both the ADMD for the different classes (useful for reconciliation purposes), total energy throughput, system stability issues, low load durations and determining the requirements for long and short energy storage (dependent on the amount of PV generated).

Establish existing load data

Sunverge undertook a process of data gathering and calculations to establish the load profiles and energy usage intervals of the various customer segments that make up the power consumption in the Daintree.

Unfortunately, it was restricted to “friendly” sites, and is totally unrepresentative of the community’s requirements.

The methodology and calculations are listed below in Attachment C, however the next section of the report details the approach including the installation of metering equipment on a sample of sites to improve the accuracy of energy load planning.

Metering on “friendly” sites

The following five sites had metrology equipment installed for a period to assist in the study. These sites were a mixture of load types but included important high load sites with a significant known diesel burn, thus including sites which have material impact on this investigation with respect to required reticulation and generation size.

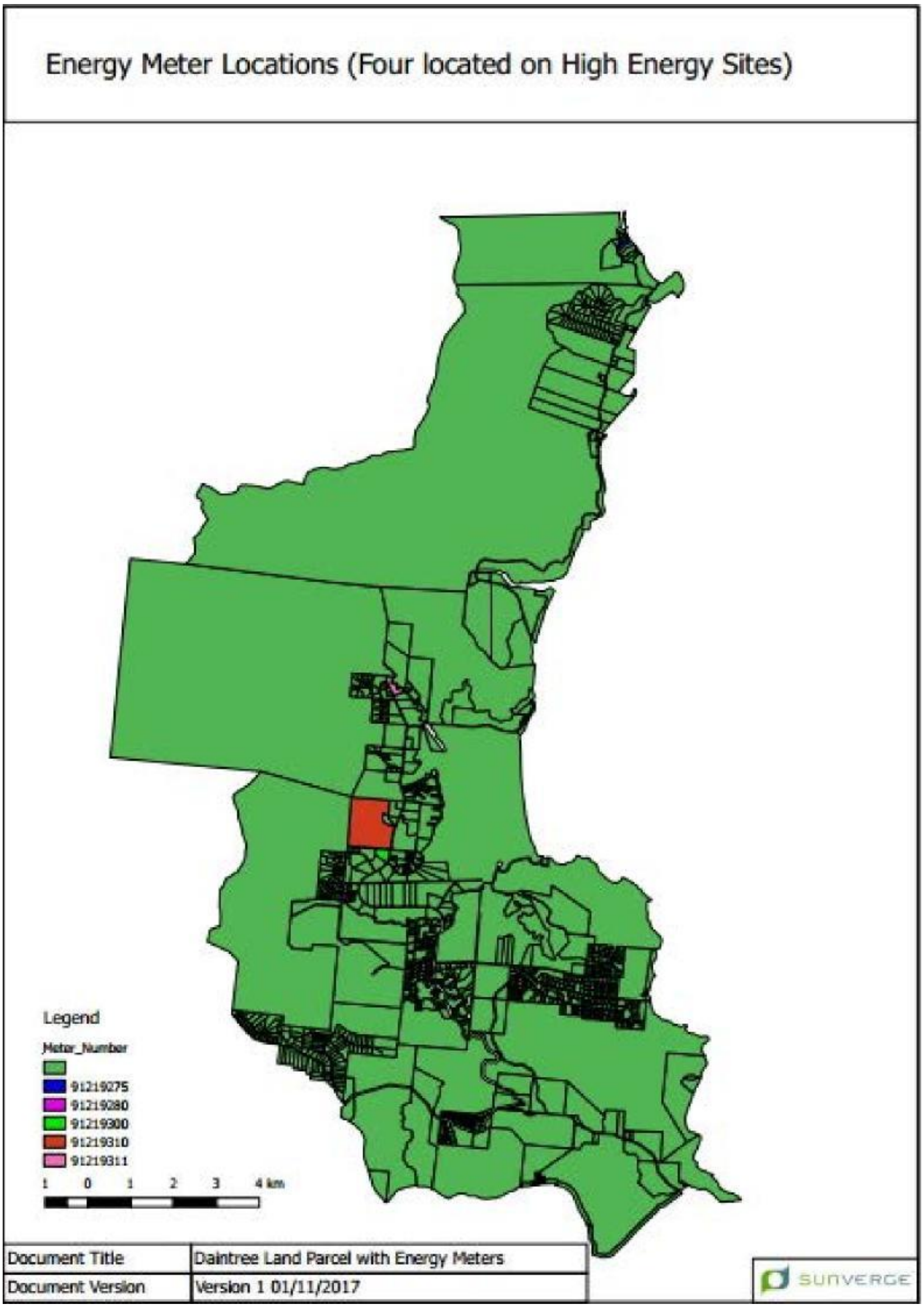


Fig 2.0 Two Week 1/2 Hour kW, kVA, kVAr Meter Locations

Develop load profiles

Establishing accurate load profiles in the Daintree is critically important as the load assumptions underpin the fundamental design of any supply solution. Such considerations include volt raise/drop, thermal capacity, number of transformers, generators and switchgear, size of cables, storage and spinning reserve/very fast demand response (load or generation) etc. The potential for variance is high. It is noted that a previous study found the total system peak to be 1.38MW, which was significantly less than the 3.4MW peak based on actual data calculated through Sunverge's system modelling. Whilst the 1.38MW figure was based off the best available information they had at the time. It should be noted the same study stated potentially $16M more would be needed over and above the estimated cost of $40M to build this network.
Given the high potential cost variability, Sunverge considered it important to derive an accurate picture of these characteristics with the information available to head off unforeseen expenses such as what may have occurred using the previous dataset.

Sunverge created a spatial roof top area model which was used against known consumption (yearly diesel consumed litres) and LPG/heating (some of which was qualitative data from interviews). This then allowed an apportioning by roof area and load class. This was especially useful for the residential customers as previous yearly consumption data was lacking and needed to be created. For residential customers which had the least amount of data but the greatest number of potential connections the ADMD was very similar to what Ergon Energy use for their planning developments providing confidence in the methodology used.

Load profile creation not only determines how much energy is being consumed in the Daintree but it also determines network utilization in the area. It defines the diverse power and energy requirements across different regions and thus the required network topography needed to leverage that diversity.

Load profiles are especially important for power calculations, After Diversity Maximum Demand (ADMD) calculations, network sizing (thermal and voltage) and PV self-consumption and storage required when adding PV for example to offset thermal generation.

In addition such profiles are needed in maximizing the efficiency of the thermal plant and thus how many and what type of generation is needed (number of machines, size and fuel type for example) for reliable power supply.

Until recently there was very little available accurate energy data with respect to detailed consumption let alone actual load profile as there is no energy metering in the area. Many studies conducted to date have relied at best on surveys and at worst on speculative and subjective data sources.

Ergon does not typically provide 8760 (hourly annual) data profile, so Sunverge relied on its own internal metered data set as well as the profiles gathered in the metering exercise. For new developments Ergon provides ADMD calculations for different classes Residential and Commercial below and above Mackay. This is standard system planning practice around the world. Utilities seldom provide non-diversified full year profile data as most don't have a significant dataset.

Sunverge collected as much data as it could with the assistance of the Daintree Power Committee, DEWS, publicly available information, site visits and discussions with locals.

The data that was collected was then combined with geospatial analysis and subsequent metrology data to allow a consumption chart per land parcel to be created.

The land parcel consumption was then joined by type (Residential, Commercial or Industrial) and size to over twenty different profiles drawn from Sunverge's existing database of actual multi-year loads in Far North Queensland and reconciled to those that were measured at certain sites.

These profiles were then scaled to ensure the energy component remained the same and thus provided a profile for each land parcel with a permanent building on it. This process then allowed a spatial join to be performed to allow for analysis of the load and power distribution and thus the benefits of leveraging the diversity between the various regions (Forrest Creek, Cape Kimberly, Diwan, Cow Bay and Cape Tribulation).

Verification and metrology

Owing to time constraints due to access to Ergon metering equipment, Sunverge was able to gather approximately 2 weeks of shoulder season half-hour interval data including watts and vars.

Physical site data-loggers were placed at five different locations, including the atypical load site (being Daintree Tea Farm - Industrial load with significant motor loads). Three typical commercial accommodation sites were included in the metering exercise with one site being a very large user in Cape Tribulation a top 5 load consuming over 110k litres of diesel annually. Finally, a typical residential dwelling for the Daintree with two people residing at the premise was also included as verification for the data set Sunverge already had for Far North Queensland and the spatial modelling apportioning used (load apportioning via Residential roof area).

This is an unacceptable approach, as the "friendly sites" are all high energy users, who have been lobbying for grid power equivalent to be supplied to the area for years.

As a percentage of total load, we expect these sites to be around 5% of total consumption. However, given similarities especially around accommodation type and appliance stock, it is believed to be reflective of pre-existing profiles seen in other regions which are hot and humid.

In addition to the metering exercise, some sites also logged their Diesel consumption during this period. This data was useful as a validation to the assumptions used which were based on verbal statement during site visits and typical machine efficiencies for their type. The diesel efficiencies chosen for modelling were 0.32 (commercial) and 0.28 (residential) which collated well with the consumption and metered results seen onsite during the two week period.

As expected the operators of the diesel generators in the Daintree are currently performing optimization by manually ensuring the machines are running only when needed and sufficiently loaded. Residential operators would turn their systems off during low use periods and ran on batteries (i.e. at night), while commercial operates had multiple machines which they turned on and off depending on the load onsite.

Profile verification was also performed. In the case of the Daintree tea site the profile was fully generated off the metered data as this was a very unique load usage both in the Daintree and elsewhere (large rotating plant being turned on and off).

The residential load profile was compared to what would have been chosen for that site via the Daintree spatial load apportioning model. The hot water in particular can be seen with morning and smaller evening spikes. This aligns to typical bathing behaviours and supports the proposal to switch the LPG hot water systems onto electricity to improve network stability and utilisation and allow for some controllable load to occur.

Additionally the residential Daintree metered load actually had a slightly better solar PV utilisation factor compared to the Sunverge model for the same location and time due to its slightly higher midday load, therefore improving the expected system performance compared to that which was originally modelled (seen below).

The chart below represents the metered Daintree residential load averaged into a day compared to the Sunverge existing residential data set using multi-year Far North Queensland data within Sunverge's load profile data base and adjusting for roof size (square metres for a residential home).

For the metered Daintree residential load, the profile has been averaged out across a day from the available data. The modelled data set used real customer data from Far North Queensland and the same month as the metered data for the Daintree Residential load.

For this chart, the data represents data gathered during early November.

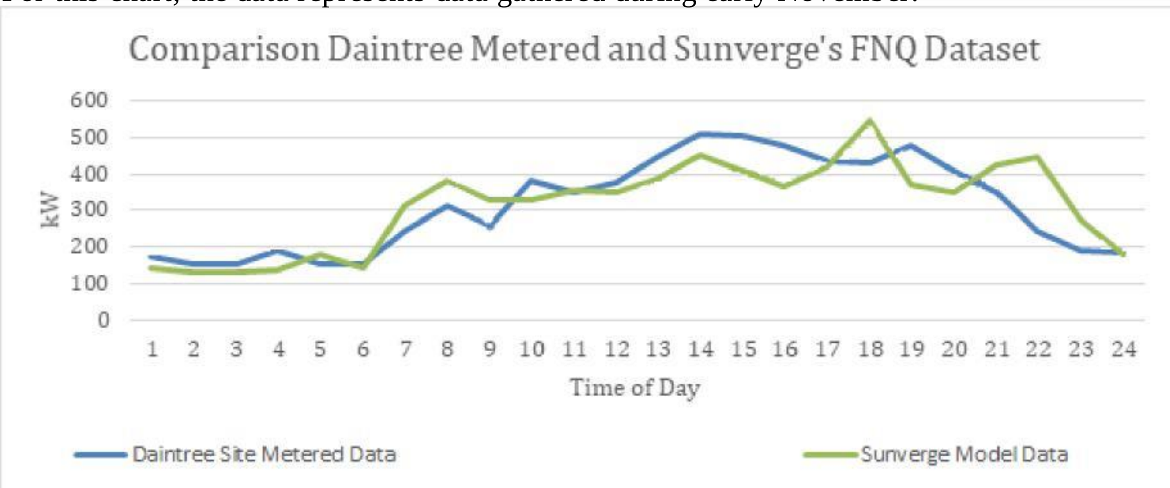


Fig 2.1 Comparison between Actual Measured Load and Daintree Load Model for Early November (Res)

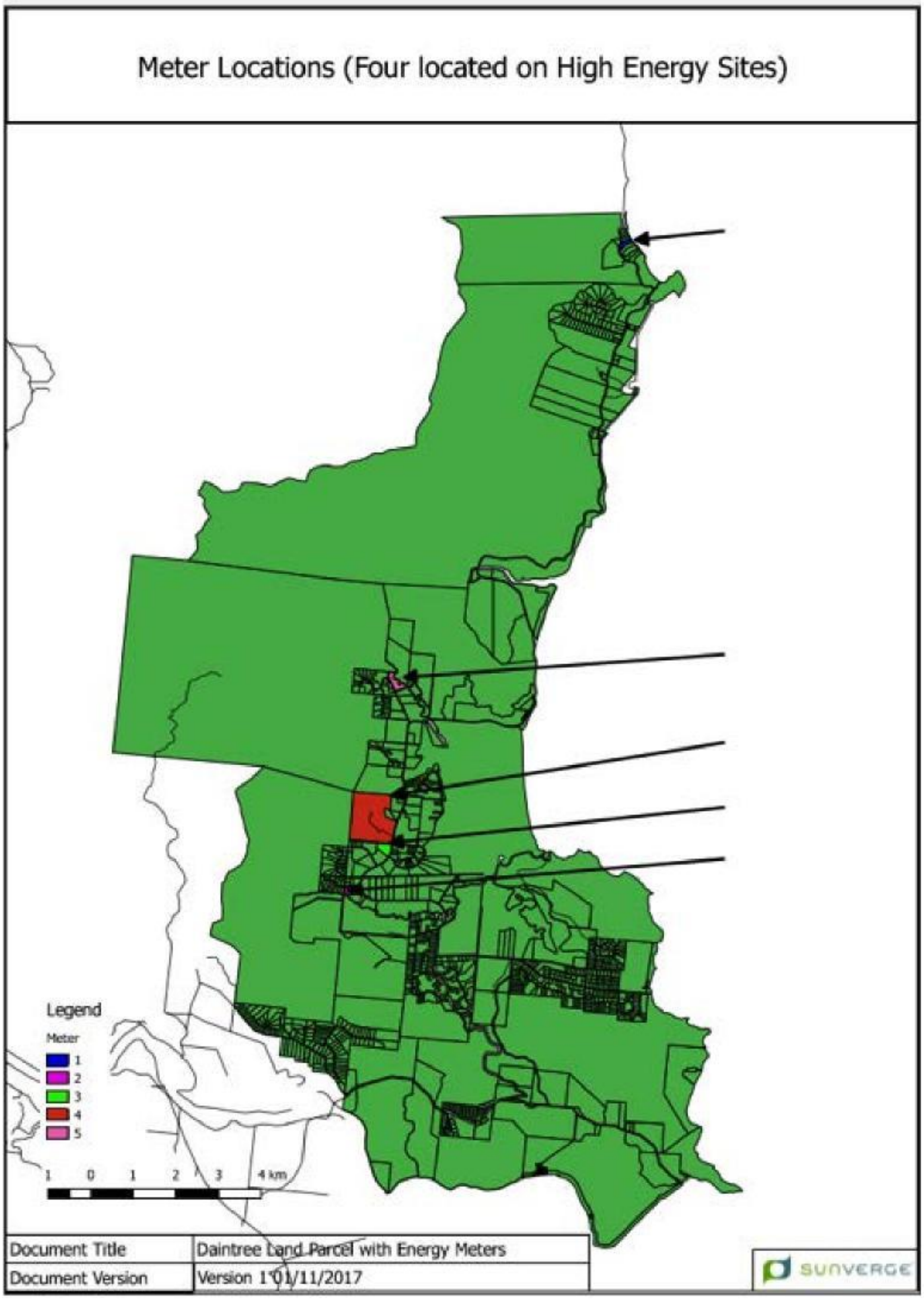


Fig 2.2 Properties with Meters 1. Cape Tribulation Beach House 2. Heritage Lodge and Spa 3. Lync-Haven 4. Daintree Tea Farm and 5. Residential Property

Profile Generation

All land parcels with a consumption figure were assigned an 8,760 scaled profile (hourly profile over one whole year). This profile was generated by firstly defining if the land parcel has been grouped into a business (commercial or industrial) or Residential. In line with how the consumption data was generated many businesses actually ran over multiple individual land parcels, thus all the individual land parcels belonging to an individual business needed to be collected. Additionally, any known consumption for a business needed to be assigned directly to this group, for example one of the larger businesses with a known diesel consumption below at Cape Tribulation where multiple land parcels belong to the same business

Fig 2.3 Above highlights the roof centroids for this particular business over multiple Land Parcels

Once every land parcel had been assigned its specific profile, these were spatially joined to the network in question. In addition Monte Carlo analysis was performed in determining the expected ADMD per distribution node.

Austrop has a full analysis of current roof shading – which, as it was pointed out in the text, is an issue that can be changed readily by judicious tree trimming, removal, or re-location of solar panels.

This analysis is useful for both a reconciliation check with Ergon Energy and in determining the structure of the microgrid, i.e. a larger more centralized MV/LV transformer and LV network (European style) or a more distributed smaller MV/LV and LV network system (North American network style).

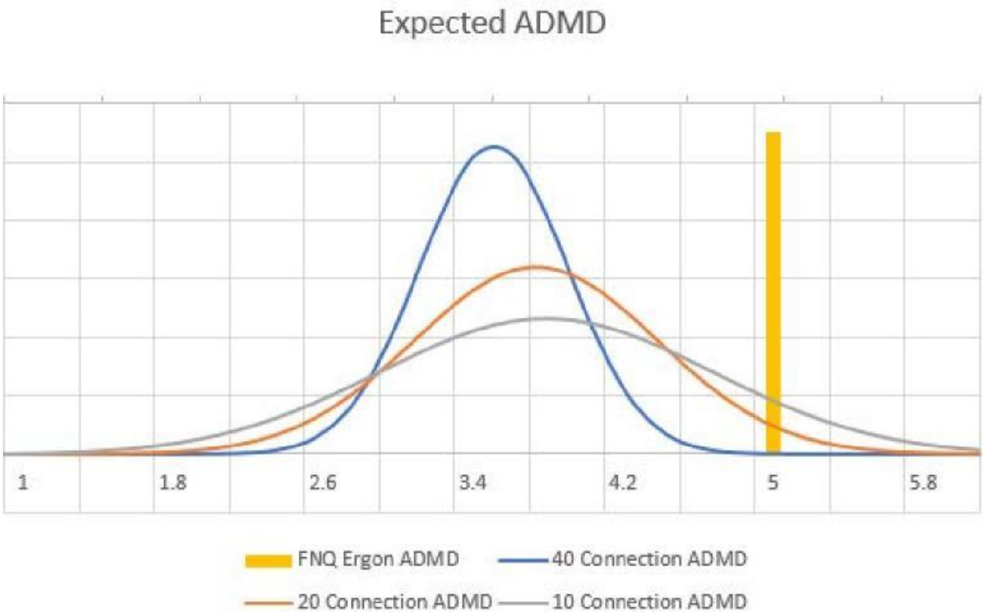


Fig 2.4 After Diversity Maximum Demand Distributions for Different LV Connection Counts (MV/LV Dst Planning) expected ADMD in Daintree

This graph needs explanation – X axis? Y axis? Otherwise meaningless.

As can be seen the ADMD calculations fall within the Ergon Energy report expectation for the areas below Mackay (4kVA). In part this is because the Daintree has an older, smaller occupancy than

FNQ and so a slightly lower expected consumption level even when connected to the microgrid compared to FNQ.

For FNQ, Ergon Energy state 5kVA for the ADMD in their developer's handbook (https://www.ergon.com.au/ data/assets/pdf file/0004/6736/PW000101R104-Developers-Handbook.pdf) for sites north of Mackay.

This appears to be the expected CONTINUOUS demand per household – the use of KVA in this situation is confusing.

It is suggested for the Daintree microgrid to increase both diversity and thus lower the ADMD and therefore amount of installed equipment (kVA based).

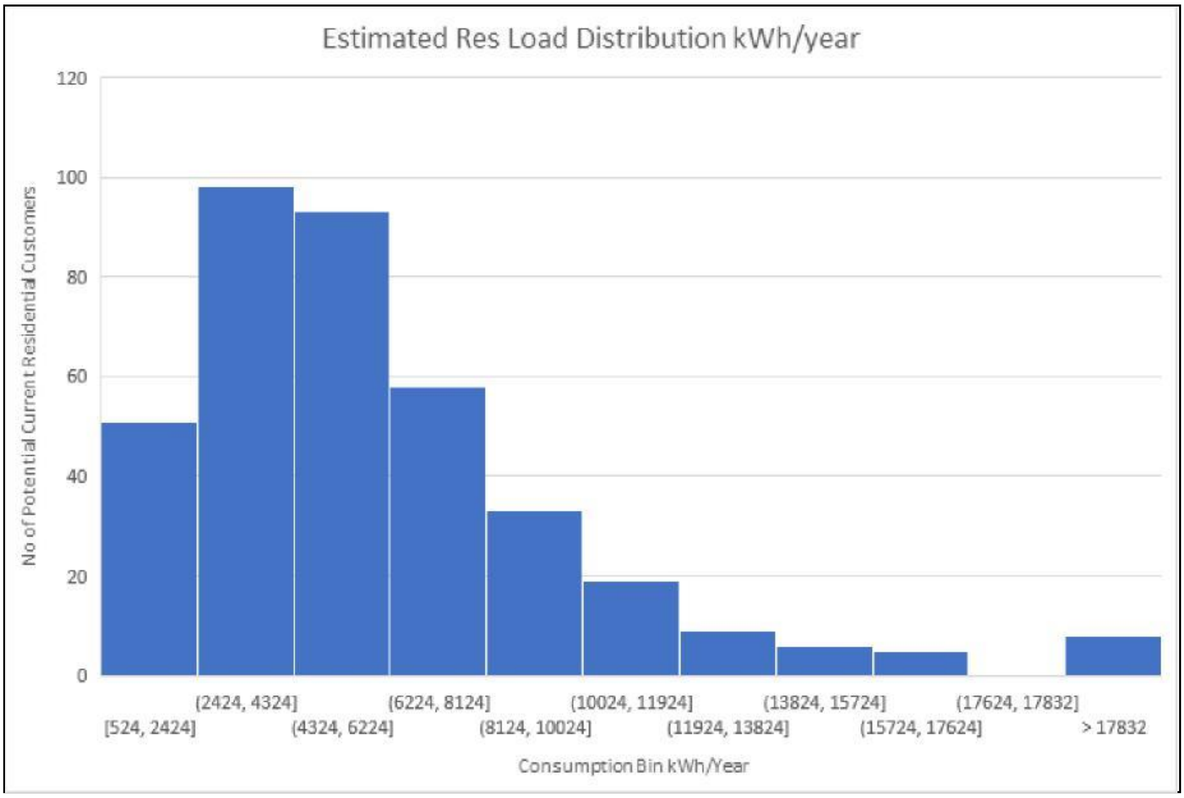
Sunverge is proposing to follow a more European style of network configuration. Additional benefits with such a model in the Daintree are higher fault current levels (typically transformers are around 80% of system impedance ignoring generators) and lower maintenance as cables have both a longer life and less proactive maintenance requirements compared to above ground structures (i.e. increased transformers).

It was also observed that the Daintree is very diverse with respect to energy consumption even among Residential loads. Direct discussions and previous studies support this conclusion. Whilst this energy diversity on the surface is a challenge for operators, larger LV networks to some degree mitigate against this as they incorporate more connections as seen in the ADMD distribution curve below.

The below graph is a histogram of the Residential Customers (with the Y axis representing the number of potential customers in each consumption group and the X axis representing the annual consumption group)

This data like all the load profile data was generated by Sunverge as there was no existing data for the Daintree. The data was reconciled with the typical non load profile ADMD and consumption data published by Ergon for reticulation planning development.

Fig 2.5 Expected Residential Load Consumption Distribution in the Daintree using Daintree Load Model



The analysis reveals the total system load peaks around late February, which is driven by FNQ profile habits of air conditioning. There is however some mitigation in that as this is also the tail end of the wet season in the Daintree, and as such the motels in the region are not at full occupancy.

This is probably fairly representative of current situation – which fails to justify the high load expectation given by Sunverge.

Some artificial additional weighting could be added however this peak is conservative for system modelling as additional weighting is qualitative and will make it easier for self-consumption of PV for the suggested PV farms.

It was thus determined to leave the dataset as it is as it comes from Sunverge's quantitative dataset for Far North Queensland and provides more of a worst case scenario with respect to Synchronous machine size requirements and fuel demands (i.e. less solar self-consumption or higher losses with storage systems).

This data principle comes from Sunverge's multi-year multi-second load dataset for the Northern Australasian region.

Ergon does not typically provide 8760 (hourly annual) data profile, so Sunverge relied on its own internal metered data set as well as the profiles gathered in the metering exercise.

For new developments Ergon provides ADMD calculations for different classes Residential and Commercial below and above Mackay. This is standard system planning practice around the world. Utilities seldom provide non-diversified full year profile data as most don't have a significant dataset.
This chart is of the entire Daintree Commercial, Industrial and Residential demand as derived by Sunverge. ll loads are added together on an hourly basis. Known consumptions were assigned directly. If a commercial load wasn't known then via a curve fit using the roof area to

assign an estimated consumption. Closest match profiles (via consumptions and class) where then assigned and scaled appropriately

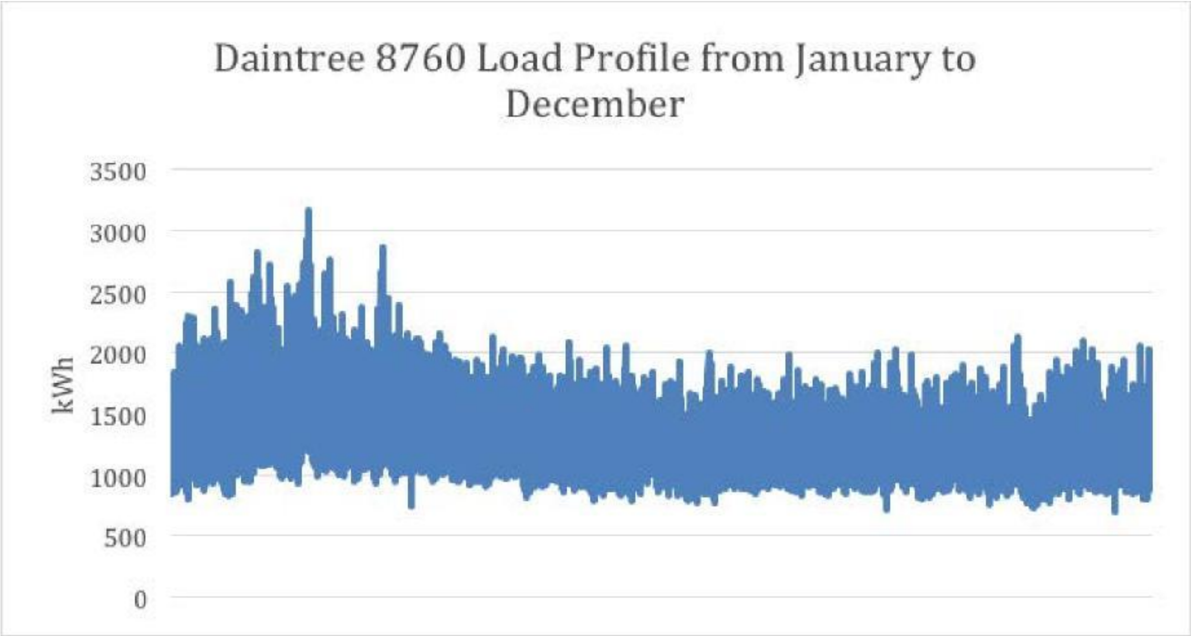


Fig 2.6 Estimated Yearly Load Profile for the Daintree using Daintree Load Model

As always, X axis is not defined.

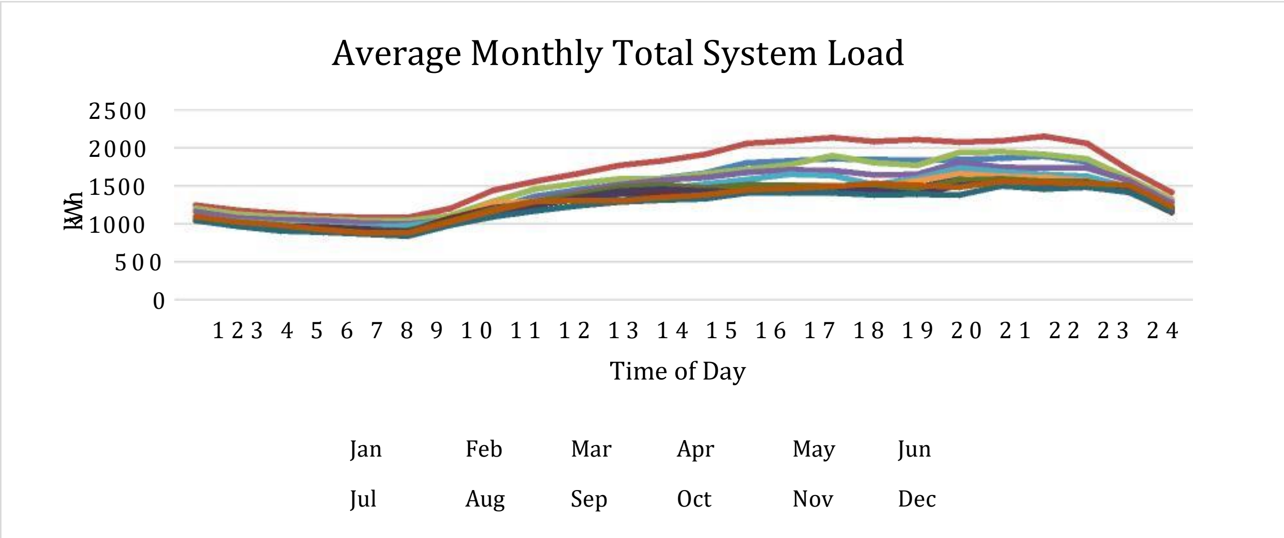
How was this data developed?

Common system planning practice for new developments (what the Daintree will become if a grid system is constructed) is to model systems based on demand and energy assumptions made from best available data sources. This is because metered data isn't available for new developments at the time of planning a new power system. In the absence of metered data it is important to test that modelled data reconciles with observations.

In this case a level of comfort is derived from the fact that the modelled data reconciled well with existing Ergon data points and with actual periods of metering performed

It is interesting to observe from the data that there is around 800kW of base load throughout the year and as expected the load has a strong commercial element in it thus allowing for a highly desirable diverse MV system.

Fig 2.7 Estimated Average Daily Profile for Each Hour for Each Month in the Daintree



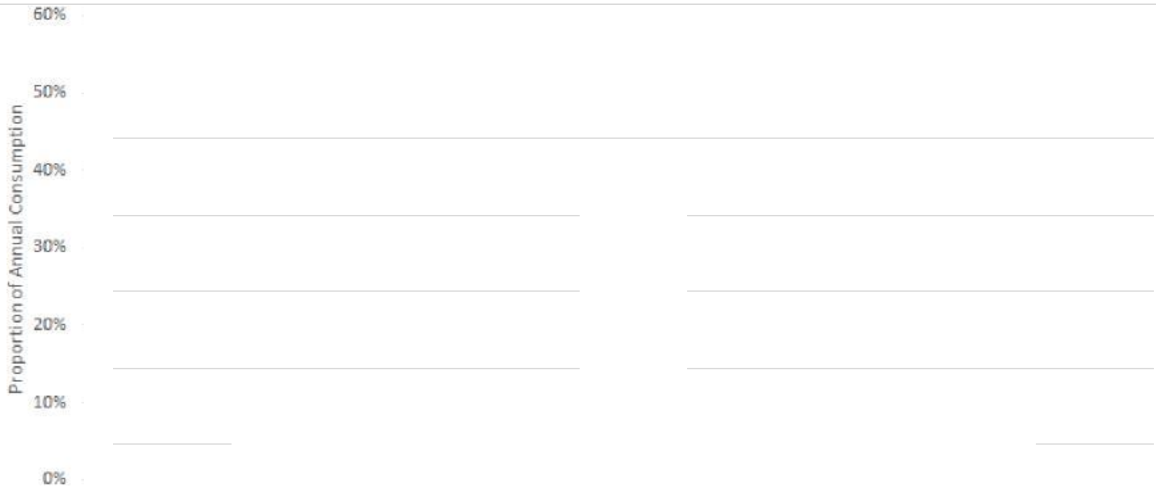


Fig 2.8 Approximate Consumption Breakdown in the Daintree

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The approximated breakdown considers large commercial loads which are greater than 100,000 KWH/year these are predominately the larger resorts and a few shops such as PK's at Cape Tribulation. The smaller commercial loads are mostly B&B's with a few others. It is expected that the proportion of Residential and SME will increase in the coming years if a microgrid is created due to freehold title blocks, however it is still expected that Large Commercial (Resorts) will continue to make up over 40% of all consumption within the Daintree Rainforest.

Spatially the Peak power demands are as expected located where there is a large commercial load centre as seen below.

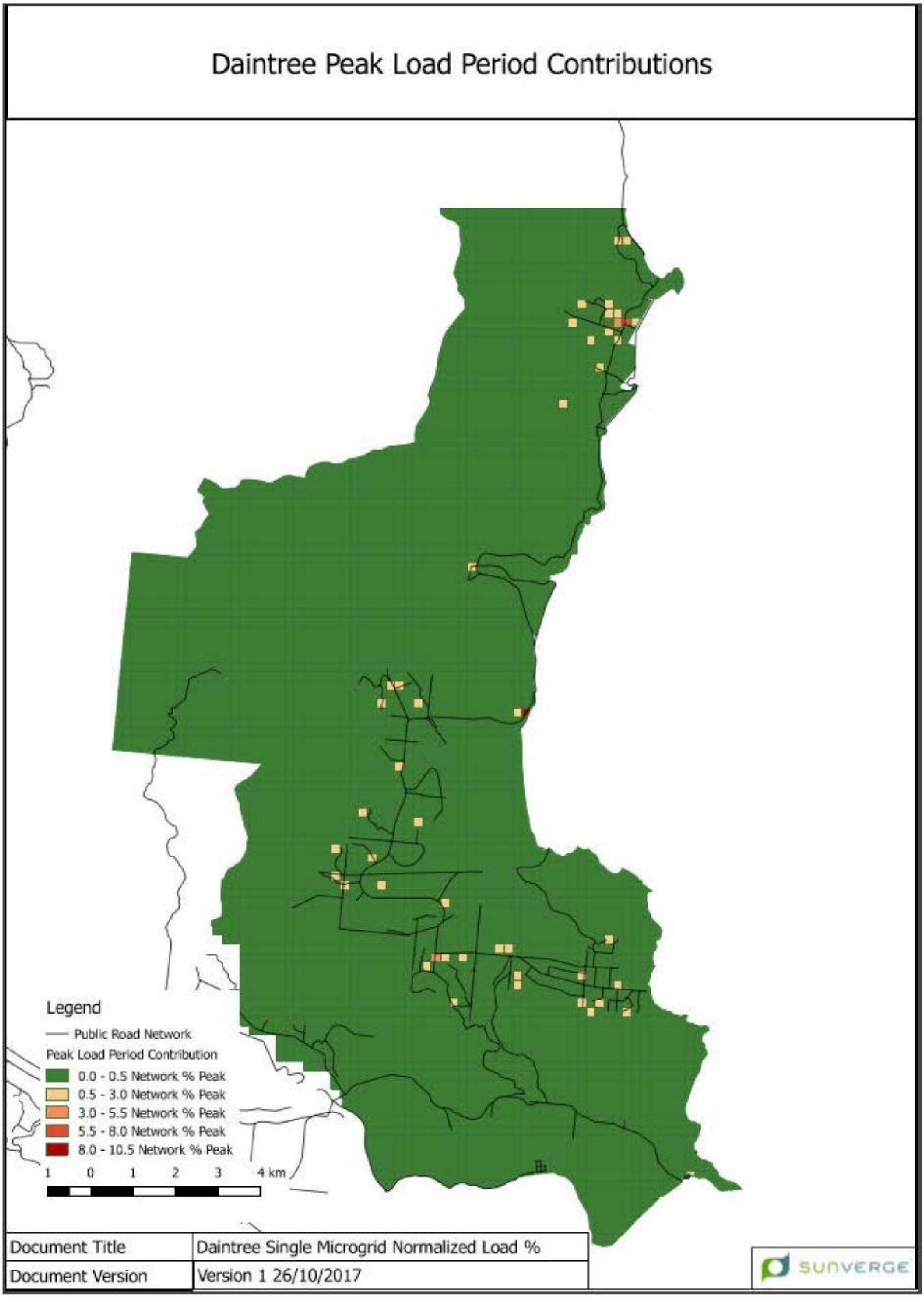
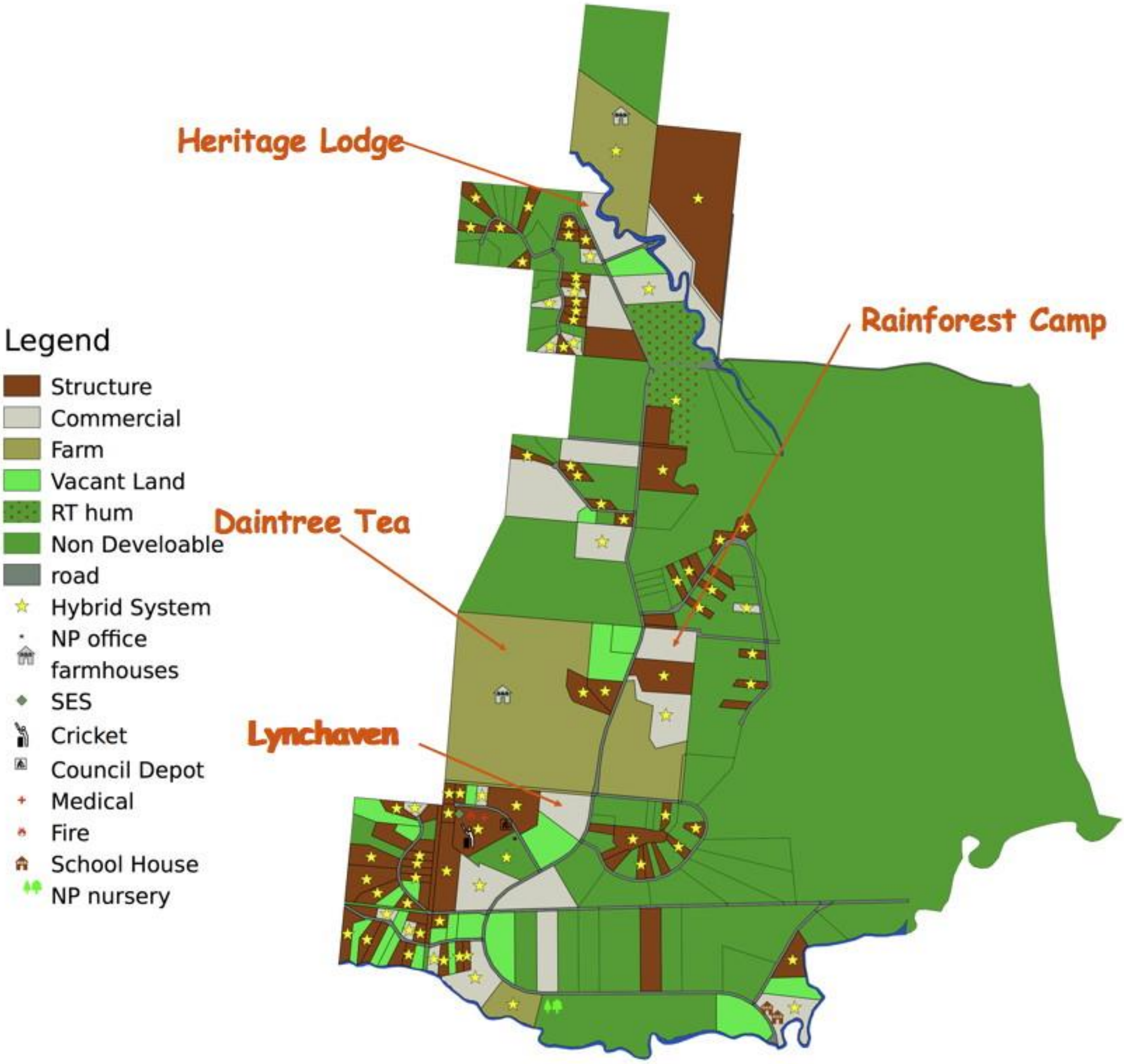


Fig 2.9 Peak Power Demands in the Daintree Especially Cape Tribulation (Microgrids need to consider Edge of Grid Demands such as above)



High energy users in Diwan

The properties indicated are the high energy users. Daintree Tea is an episodic high energy user (depending on harvest). Unfortunately, the peak users on the previous map are not identified – compare this map which gives far finer identification of potential users in the Diwan region. B&B's are almost equivalent to households in energy use.

Develop scenarios

From the above analysis, Sunverge was able to develop a range of scenarios for options to meet energy supply requirements within an isolated community.

Given the timeframe constraints on the study, five scenarios were developed through consultation with the core stakeholder group during the regular stakeholder meetings, including a mix of generation and network options from connected microgrids to distributed standalone systems. It was expected that these scenarios would be used to provide directional guidance on where next efforts should be spent in the development of any future power solutions.

The five scenarios determined for the purpose of this study were:

1. Single microgrid
2. 3 separate microgrids
3. Numerous small microgrids linked by gas pipelines
4. Extend [3] separate microgrids from existing generation assets at Cape Tribulation
5. Individual Remote Area Power Systems

The scenarios are detailed below with reference to their respective planning schemas, physical features, renewable potential and costs and benefits.

It should be noted that the estimates of grid connection were excluded from the scope of this study. Previous studies have suggested that the Ergon grid, which serves a very small number of properties at Forest Creek, may be able to be extended to serve the remainder of the Forest Creek Community of approximately 126 properties.

Estimates of cost of grid connection and possible required upgrades per household have proven to be difficult to assess (depends on who is being talked to) – however, unless grid connection costs and fixed charges are included in the pricing, we really have no idea.

Sunverge has not undertaken analysis of this option, however based on visual inspections of the existing network assets which extend from the nearest township, Sunverge considers that extensive work would need to be undertaken to upgrade the capacity of the existing network including power lines, poles, cross arms, transformers, switchgear and reclosers.

To consider this potential option it should be noted that significant analysis work including the Ergon network planning team needs to be undertaken.

Assess available market technology and market sounding

To assess current state technologies, Sunverge approached a number of relevant businesses for information about technical product solutions and their potential applicability to isolated tropical environments.

These included generation manufacturers, microgrid developers, equipment suppliers, fuel (gas and diesel) suppliers, directional drilling operators and renewable energy technology providers. We also approached a number of battery suppliers and new technology providers for control systems, communications and demand management devices. accordance with non-disclosure agreements, much of the information provided can only be disseminated in a way which does not disclose the identity of the vendor and as such will only be revealed at a high level for the purposes of this study unless specifically requested and approved by the vendor.

Prepare indicative costings

Sunverge prepared indicative costings for the 5 supply options listed.

As per our recommendation it should be noted that an in-depth pre-construction assessment would be needed in order to proceed to the development of any of the supply options. These indicative costings were developed on the basis of available information and discussions with vendors and should not be relied upon for project commencement until an in-depth study of costs and required approvals for the preferred supply option is undertaken.

The indicative costing for each Supply Option is listed below in terms of capital and operating expense assumptions for each option.

Assessment methodology for Supply Options

Once the Supply Options were defined and costed based on feedback from the market sounding, Sunverge assessed their relative merits using a simple scoring approach where each Supply Option was assigned a score between 1 and 5 for each Success Criteria based on its relative performance against the other Supply Options. Scores were then tallied up and the ranking of Supply Options determined with the highest value being the preferred option.

The assessment methodology is outlined in the table below: (makes little sense)

Success Criteria	Highest Score (5)	Lowest Score (1)
Equity	Ability to provide equitable access to affordable energy	Low percentage of equitable access to affordable energy
Reliability	Higher SAIDI and SAIFI reliability due to diversification and modular generators	Lower reliability due to single point failure or no N-1 on generation
Environment and sustainability	Likely to have low disturbance to fauna through existing easements	High initial and ongoing transport and diesel fuel dependency, leakage risk, sil contamination, etc.
Economics	Lower combined cost of CAPEX, replacements and operating and maintenance over system life	Higher combined cost of CAPEX and ongoing operations (e.g. fuel) across the entire customer base

Modularity and Future Proofing

If Option 5 were to be decided upon, then modularity is essential to ensure as much commonality of design and installed equipment as possible and to facilitate long-term maintenance and replacability. This should be coupled with the provision of one or more locally-based support personnel with access to adequate stocks of spares. To our awareness, there are no support organizations closer than Mossman (most are in Cairns or Julatten, or Tazali,) so the costs of transport are high and speed of response can be very low. Provision of local support would be a critical factor in making Option 5 effective.

Given the inherent risk and uncertainty associated with choosing options to build a power supply system, Sunverge has recommended the design of a network which will be able to cater for a range of Generation supply options should these vary from the recommended generation solution proposed. For the purposes of future proofing the system, and enabling different generation types a specific network configuration is proposed below. As with most new power system networks everywhere civil works are the single most expensive and restrictive component within the electrical power system network. It is proposed that the Daintree systems use standard sized European (Urban/Suburban Australian/New Zealand) construction technique typical for 7-9MVA feeders. This uprating of the MV network allows for flexibility in land procurement for hosting the primary generator sites and any future solar farm sites without issues of both voltage drop and thermal rating problems. This flexibility also provides significant load and distributed generation headroom on the expensive, fixed MV network with only a very small additional cost of a slightly larger cable. With this is mind a small incremental cost of using both ducts to protect cable assets is recommended and follows best practice within Australia. While the duct will slightly derate the thermal capacity of the cable, the water soaked soil compensates and the duct with draw wire both protects the cable extending life while the draw wire allows for quick replacement if cable can't be repaired thus saving costs and disruption issues for a future replacement job. XLPE cables are recommended due to their overload capability (elevated temperature) and for their relatively simplistic MV joints and terminations compared to other cable technologies. 185AL is a standard size allowing for standard boots to be used on distribution TX and switchgear bushings, thus providing cost savings and familiarity for fault crews in Queensland. Switchgear recommended for size and cost are secondary equipment that is extendable in the future. This allows the addition of more switch bays should the need arise. Equipment such as the ABB SafePlus and Schneider RM6 fulfil this and have sufficient thermal and fault making, breaking and withstand capabilities. This extendibility from either side allows for future generator bays should the need arise. Since the physical network will be designed for either modularity (Switchgear design) or significant hosting overhead (MV Cables) standard network augmentation can be implemented without significant additional CAPEX costs. Generation will be arranged in bays with spare room to allow for additional bays should sometime in the distant future additional generators are needed. Energy storage is also proposed to be modular in that they are also stored in bays, which also allow to future extending depending on the amount of PV connected to the microgrid. Sunverge has extensive experience with distributed generation systems especially Battery Energy Storage Systems. This experience has shown us that in remote locations in particular systems need to be fault tolerant and robust to ensure operational costs do not spiral. Sunverge considers that appropriate system design should ensure that if a fault does occur (both the battery module and Inverter) this fault only disconnects that piece of equipment or in the worst case a small sub group. This approach allows for the system to ride through a fault which may or may not clear itself with only minimum loss in performance. In addition for faults which need repair modular systems which are within 1 or 2 man lifts and that are virtually plug and play are desirable as callout costs and strategic spare are prohibitive for large and complicated equipment. Both the Power to Gas (ITM) and the Battery/PCS (Poweroad and Sinexcel) come in modular blocks allowing for future extension. In the case of the Battery/PCS these are also both in standard 19inch 3U rack size where the modules allow for easy extension but also improved low power efficiency by temporary turning off modules not needed. This modular approach allows for significantly easier future proofing as the units themselves are almost plug and play coupled with the proposal to use extendable MV switchgear and an oversized MV cable backbone significant growth can be accommodated and it would be proposed that a similar approach be implemented where the developer pays a contribution cost as is typical for NEM connected grids in Australia.

Supply Options

The following table provides a summary of the key considerations, issues, costs and benefits of the assessed options.

Each schema is set out individually in more detail below.

	Option 1	Option 2	Option 3	Option 4	Option 5
Name	Single microgrid	3 separate microgrids	Numerous small microgrids linked by gas pipelines	Extend microgrids from existing generation assets	Remote AREA Power Supply (RAPS)
Description	Single electrical microgrid with powered by gas and centralized solar	Three electrical microgrids built around load centres	Three or more electrical microgrids linked by gas pipeline	Existing diesel generators leveraged to power adjacent existing large customers	Subsidised upgrade to individual RAPS scheme
Key components	• 120km reticulated underground cable (LV and MV) • Connecting all homes to an isolated microgrid • HW Load control • 3.4MW Synchronous Generator • Stage 2 0.5MW 0.5MWh Battery (Peaker Storage) 2MW Solar Farm • Stage Expansion of solar farm • 4.7MW S2G2E Facility (Ultra high efficient Power to Gas to Power fuel cell)	• 95km reticulated UG cable (LV/MV) • Smaller gen sets supplying each node (may require larger gensets to deal with LDC lack of diversity) - estimate 5MW gen • Three different generation centres • Supplies most customers	• 80 k UG gas pipeline (PE) • 30km reticulated UG cable (LV) • Smaller gen sets supplying each node (may require larger gensets to deal with LDC lack of diversity) - approx 5MW gen • Supplies MOST customers	• Utilise existing site infrastructu re • Build small LV network to supply limited customers with existing customer gensets	• Individ ual sites receive a subsidized more efficient, refreshed hybrid system (solar, diesel/gas generation, battery storage)

Pros	• Land acquisition may be challenging • Requires comms	• Allows for fast connection solution • Could provide a 100% renewable solution (through use of biogas/hydroge n)	• Inequi table - supplies 20% of customers by numbers • Req uires large site generation access at unknown cost • Not large enough for investor interest • High admin cost potential (metering, etc)
Cons	• Lower cost capex network • Able to be handled in small staged blocks	• High O&M and replacement on Gensets • Large generation losses due to inability to capture heat • Manufacturers unable to supply the right product for the territory	• No central infrastructu re required • Lower scheme regulation costs
• Network allows greater solar self-consumption • Higher reliability • Lower O&M and risk • Pathway to 80-100% renewables, lowering fuel costs • Future revenue upside for growth of vacant freehold lots	• Lower renewable uptake potential due to diversity • Poorer load utilisation due to load centre mismatch • Higher cost capex Gensets • Higher cost O&M for distributed gen • Governance challenges and networks	• Requires no subsidy • Low capex solution - using existing generation	• Similar solution to existing • High removal costs not currently included • ???) • Inequitable due to locational solar irradiance potential diversity • Low renewable potential

Cost	• $65M Capex • Network 32.3M • Generation 25.1M • Comms 3.6M • Other 3.6M • $1.3M Ongoing Opex	• $60M Capex • Network 27.3M • Generation 23.2M • Comms 3.6M • Ot • $2.8M Ongoing opex	• $70M Capex • Network 10.5M • Pipeline 11.1M • Generation 39.1M • Comms 3.6M • Other 6.0M • $ 2.5M Ongoing	• $15M Capex • $2M Ongoing opex (mostly fuel) • N small % of population	• $42M capex (frequent refresh) • Ongoing opex $2.7-$3.6M
Benefit (avoided fuel costs)	• $4.5 - $6M per annum savings	• $4.5 - $6M per annum savings	• $4 annum savings	• $1.6M annum savings	• $1.2M per annum savings
Renewable % potential	• Pathway to 80-100%	• Ma 60%	• >80%, likely 50-60%	• < 10%	• Max likely 30%-40%

For Option 5, this table (which has been distorted in transfer from PDF to Word) - CAPEX will be nothing like 42 million! Many installations are already quite new (in fact there are very few dating from 1995-8). There will be the need to ensure installations become modular (that is not have integrated inverter/chargers or MPPTs to allow ease of service – and to facilitate a common stock of replacement modules).

The issue of high energy users is addressed later in the document.

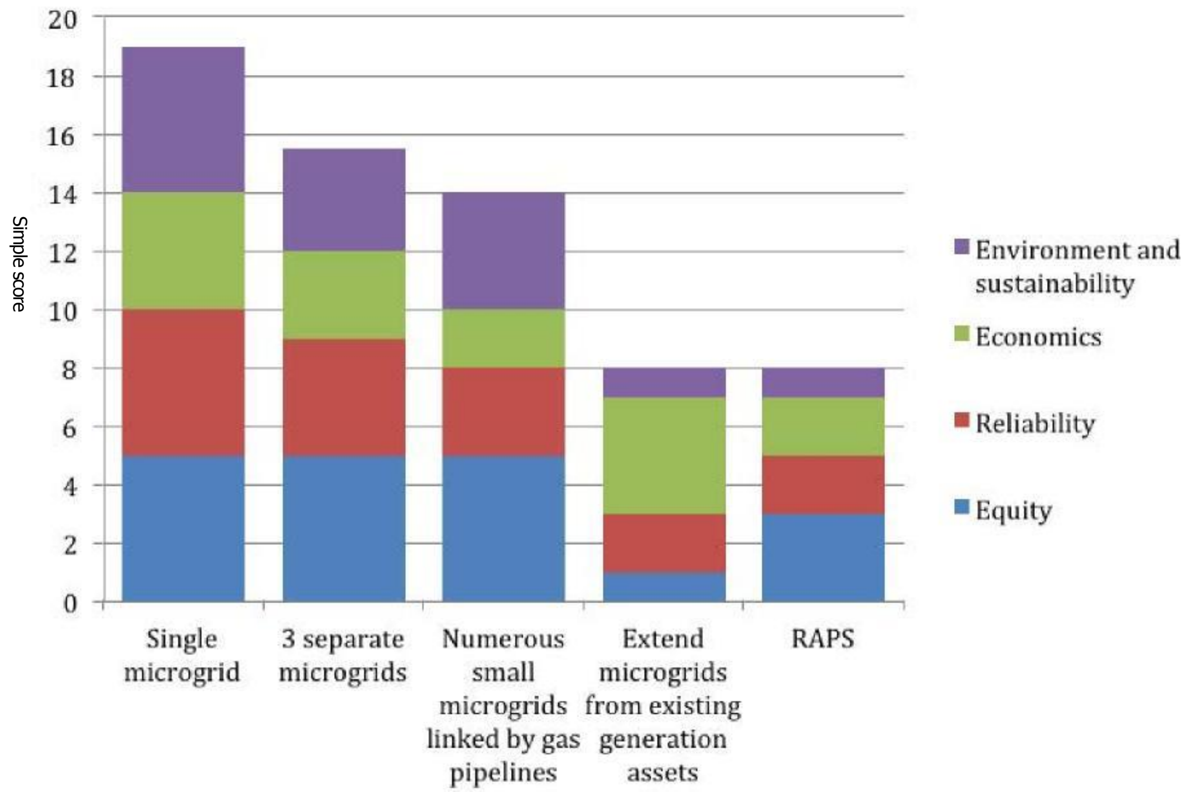


Fig 2.10 Options Assessment Chart

Assessment of Supply Options

Based on the assessment methodology listed above, the following scores and rankings were determined for the Supply Options.

Supply Option/ Success Criteria	Single microgrid	3 separate microgrids	Numerous small microgrids linked by gas pipelines	Extend microgrids from existing generation assets	RAPS
Equity	5	5	5	1	3
Reliability	5	4	3	2	2
Economics	4	3	2	4	2
Environment and sustainability	5	3.5	4	1	1

In this response we will only respond to Option 5, as we have responded to the other options in the earlier Sunverge response. The possible installation of two microgrids at the high-energy consumption sites of Cape Tribulation and Cow Bay are addressed later in the document.

Option 5

Properties with Hybrid RAPS (solar/generator) in Daintree Coast

Region	Private Dwellings	Commercial/ B&B	Other	Total **occupied** blocks	Total freehold blocks	Hybrid RAPS
Cape Tribulation	24	10	2	51	91	32
Thornton Beach	4	2		13	19	7
Diwan	57	14	2	114	150	83
Cow Bay	98	15	1	143	306	126
Kimberly	20	2	1	36	70	23
Forest Creek	39	1	1	52	116	41

These figures have been derived from current aerial photos and local knowledge. Refer to attached maps for more detailed breakdown. On inspection of the next series of maps, it is obvious that some version of Option 5 becomes the only sensible (and economic) approach given that a very high proportion of landholders already have some form of hybrid RAPS installed. Some RAPS systems are of very recent design and construction, a few are considerably older. **The cost of bringing these up** to an appropriate operating standard (for the property) would be a small fraction of the expected expenditure for even the cheapest grid option

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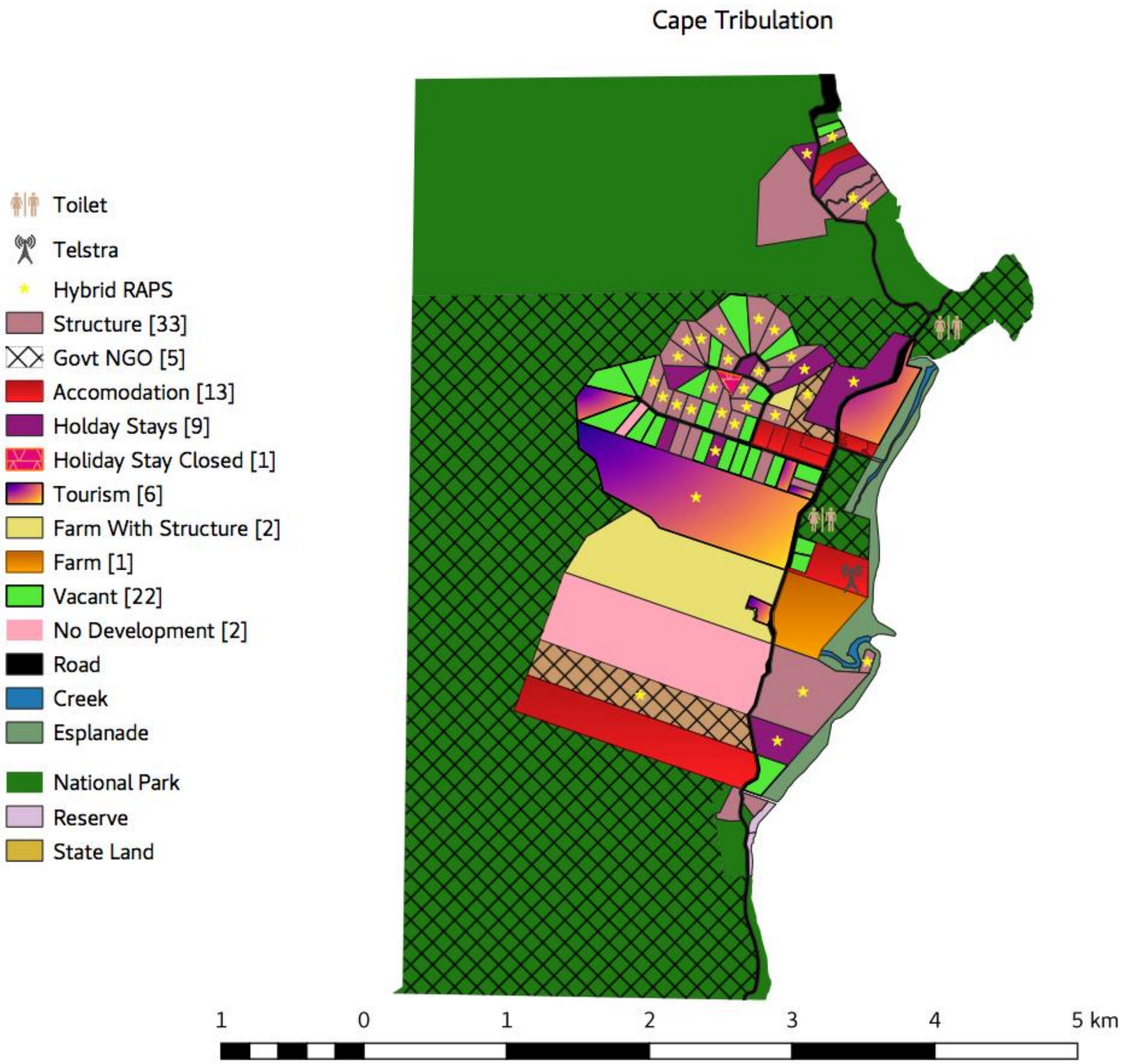
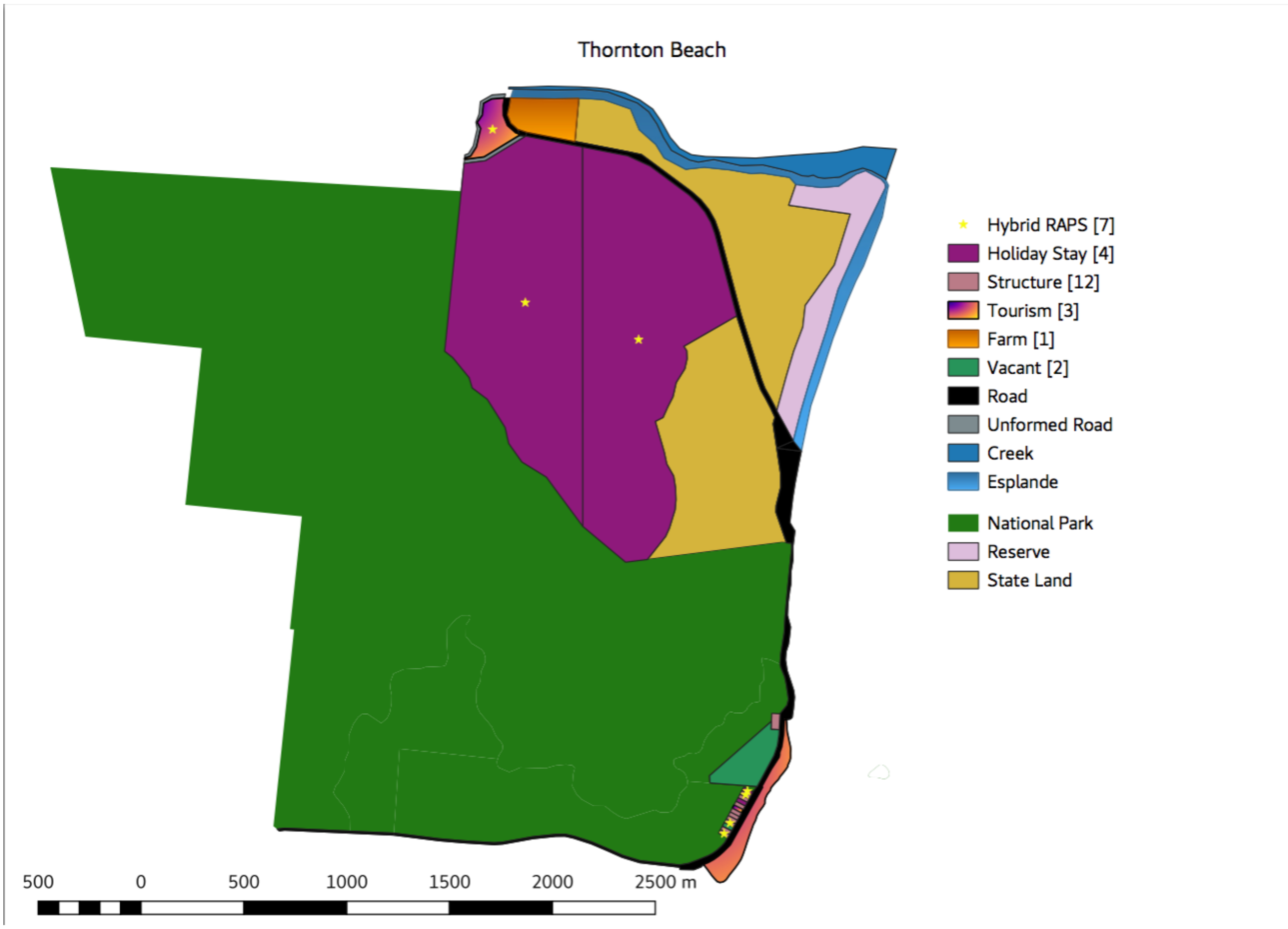
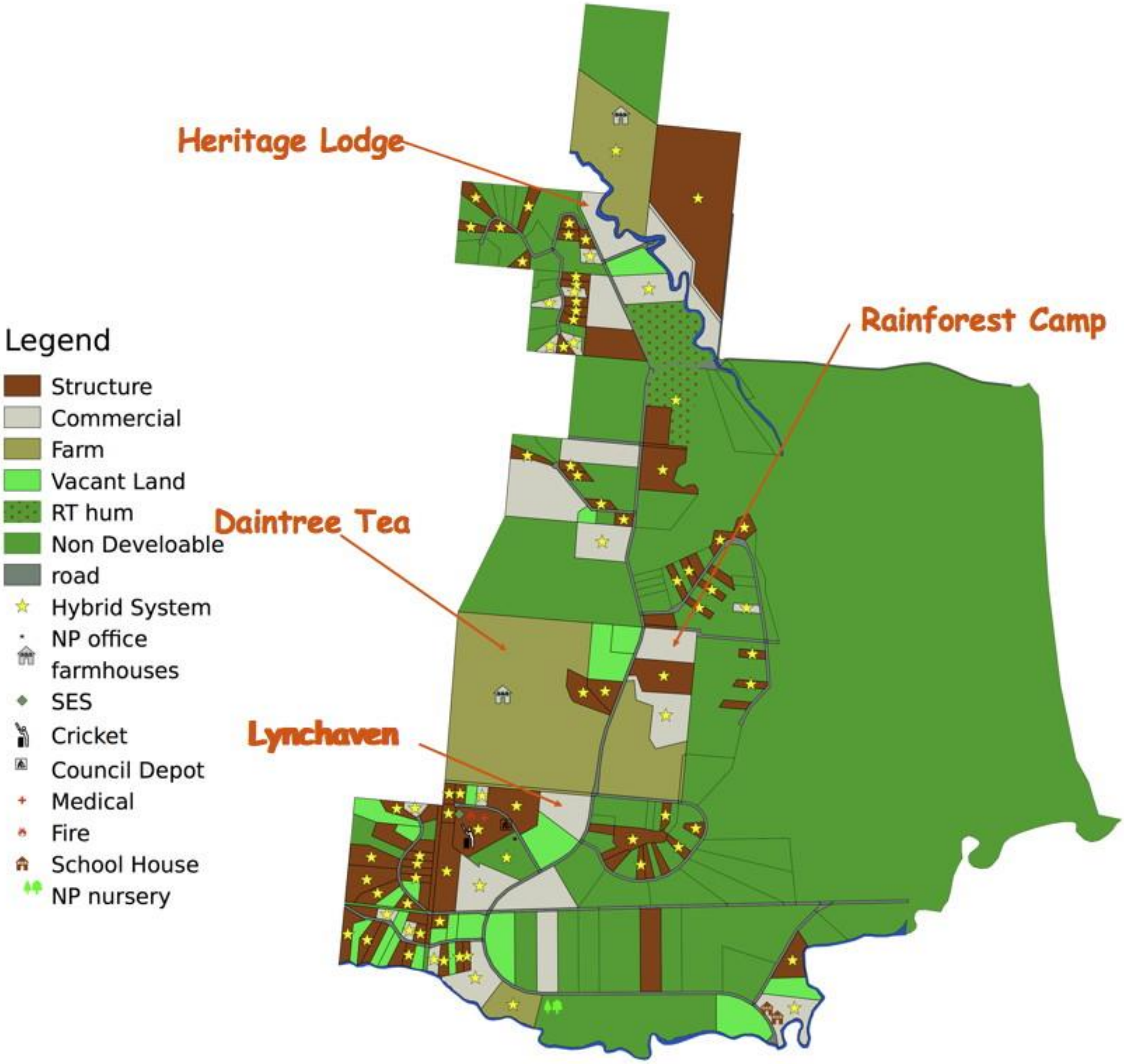

Cape Tribulation
Toilet
Telstra
Hybrid RAPS
Structure [33]
Govt NGO [5]
Accomodation [13]
Holday Stays [9]
Holiday Stay Closed [1]
Tourism [6]
Farm With Structure [2]
Farm [1]
Vacant [22]
No Development [2]
Road
Creek
Esplanade
National Park
Reserve
State Land
1
0
1
2
3
4
5 km

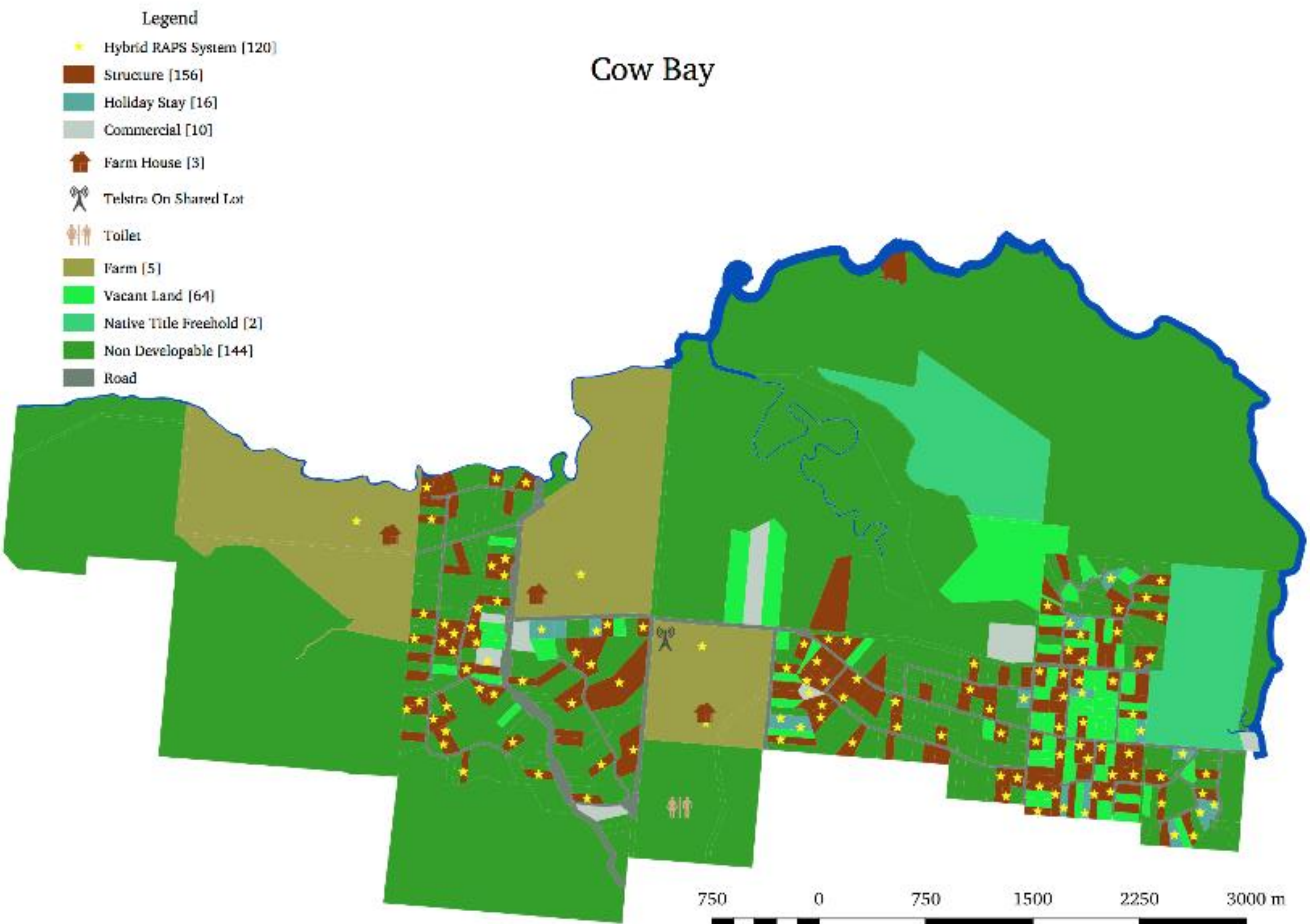


Thornton Beach
Hybrid RAPS [7]
Holiday Stay [4]
Structure [12]
Tourism [3]
Farm [1]
Vacant [2]
Road
Unformed Road
Creek
Esplande
National Park
Reserve
State Land
500
0
500
1000
1500
2000
2500 m

DIWAN

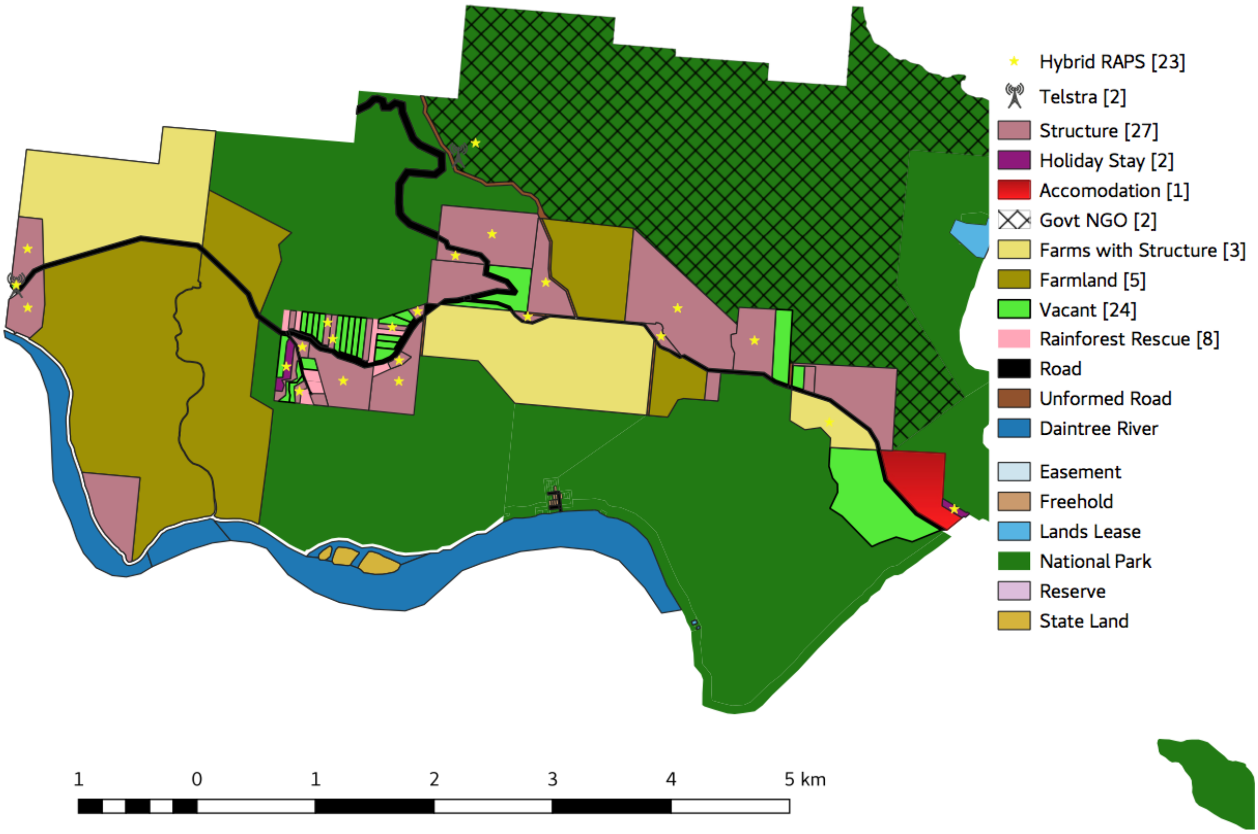


The properties indicated are the high energy users. Daintree Tea is an episodic high energy user (depending on harvest).


Legend
Hybrid RAPS System [120]
Structure [156]
Holiday Stay [16]
Commercial [10]
Farm House [3]
Telstra On Shared Lot
Toilet
Farm [5]
Vacant Land [64]
Native Title Freehold [2]
Non Developable [144]
Road
Cow Bay
750
0
750
1500
2250
3000 m

Forest Creek

Kimberley



Water heating as a load leveling technique appears to be a concern for the Sunverge options., Given that evacuated tube HWS are cheap and incredibly efficient even in this environment, even for institutional users with adequate roof space, there does not appear to be any justification for installing load levelling Providing adequate power for commercial establishments would not be all that problematical – as there are two groupings that could be served by a microgrid – Cow Bay "central" and Cape Tribulation "central" which have a sufficient concentration of high energy users to make such a facility practical. Outliers (farther than, say, 1 Km) where sufficient cleared land exists, could be assisted in installing appropriate facilities (for example with grants and interest-free loans).

Microgrids

Two small microgrids could service the high usage locales of Cape Tribulation and Western Cow Bay. Because both areas are close to cleared land that could host a solar array, cable runs would be quite short

Cape Tribulation "Central" This map identifies significant power users in the Cape Tribulation area- the legend is the same as for Map …Cleared areas suitable for solar arrays are designated with a square.

Cow Bay "central" Significant power users are indicated. The Discovery Centre is a relatively small load but because of location would have difficulty in using rooftop solar. MyPathways is also a small user. Possible locations for a solar array are indicated with a square. (Map error – MyPathways is actually the RACQ depot – a higher power user).

SUNVERGE - Option 5

Upgrade of individual hybrid supply options

This option needs a lot more installation generation compared to the other solutions which are leveraging the diversity of load between different units, of interest the 2016 Compass Research "Daintree Cape Tribulation Electricity Survey" indicated that the average generation is around 13kW (KW or KWH??) while the ADMD expected for both Ergon Energy and this study for collective MV/LV Distribution groups is around 4kVA.

Sunverge appears to be confused between KWH (total energy consumed) and KVA which is energy available subject to power factor. They are NOT equivalent. Average daily domestic power consumption, we suspect, ranges from 4 to 20 KWH.

Because of this factor both the diesel backup and solar/battery solution needs to be scaled up more than what would be needed for near self-sufficient grid connected systems to accommodate for the few days where load and or PV generation is much lower than expected. In addition in the Daintree the strong seasonal wet also significantly reduces PV potential while forcing customers to use diesel generation during these period.

Why always diesel? Yes, seasonal cloudy conditions do drastically reduce PV output, but for most households a 2KW inverter generator (Yamaha/ Honda) is quite adequate and efficient. (1KW for 7 hours is 7KWH!).

Only around 60% of the Daintree residential roofs are suitable for the very cost effective traditional string array systems, many roofs have some sort of shading which at one time or another will knock out an entire array.

Which can easily be corrected by clearing or use of micro inverters on each panel.

It is recommended that for the majority of the roofs that DC-DC converters be used to mitigate against this problem.

Maximum Power Point Trackers (MPPTs) are standard for all newer installations (and these are DC-DC converters with battery charging capabilities.) DC-DC converters tend to be only used in grid-tie systems.

Also, due to the high rainfall and dust from the local dirt roads, panel fouling will occur, therefore this option would mitigate against adversely impacting a whole string. This upgrade of the panels is reasonable as many systems now are a mismatch of different panel ages, sizes and manufactures making such systems suboptimal and prone to failure and long downtimes trying to sort out which system failed, in addition a clean cut is needed with respect to warranties as interfering without replacement of breakers and wiring will as Sunverge has seen in other projects cause contractual demarcation problems, especially around system performance. Having dedicated service capabilities in the area could also include panel cleaning services, as cleaning roof mounted arrays can be quite risky.
Replacement of old panel systems would be relatively cheap.

The Recommended solution for Residential properties (small B&B excluded) 15kVA Diesel Generator

Why 15 KVA??? 5KVA is generally regarded as adequate, and 2KV (inverter-generators) are more efficient. These should be coupled with a modern independent battery charger. There isn't much difference between a B&B and a normal family residence.

6kW PV Array (Either multiple MPPT for roofs with less than 10% shading OR DC-DC optimizers (Used for grid-connect)

DC coupled Battery System 12 – 14KWh (DC coupling due to efficiencies for most systems, or some newer AC coupled systems like the Tesla Powerwall 2, noting some concerns around liquid cooling and long term maintenance
with such systems).

The battery charger/panels/MPPT/inverter are ALL DC coupled – they have to be! Does Sunverge mean DC operation of devices such as fridges/lights? That would be far more efficient, but would require separate wiring. AGM lead acid would still be the preferred technology, provided it is maintained at a 30% discharge maximum.

It is unlikely that AGM lead acid batteries will be supplanted by lithium for off-grid use.

Critical to survival of stand -alone power systems in this environment is appropriate housing and vermin proofing of the electronics. See www.livingindaintree.org.au - power section.
Education of users is critical – use of AH metering . See www.livingindaintree.org.au - power section.

This option would be an extension to the existing supply model (no longer required) in Daintree and would involve: Individual sites receiving a subsidized, more efficient, refreshed hybrid system (solar, diesel/gas generation, battery storage) with no central infrastructure and lower scheme regulation costs. Similar solution to existing approach where each customer looks after their own supply, albeit with refreshed equipment similar to the scheme offered by the Queensland Government 20 years earlier

Absolutely correct!

It should be noted that high removal costs for existing equipment is not currently included in the analysis.

Why are removal costs considered to be high (removal of what? Batteries?} Makes little sense, especially as lead acid batteries are highly recyclable, which could offset costs.

This seen is not seen as favourable as it is:
-inequitable due to locational solar irradiance potential diversity, costly to maintain on an ongoing basis.

This is not true – and with a centralised support facility, would be cheap.

- unable to achieve significant renewable potential due to lack of diversity
-
- Sunverge have an obsession with "diversity" – in fact the renewable potential of Option 5 is very high – probably the highest estimate of cost per household for a total replacement of older system would be in the order of $40-$50,000 per household. It must be borne in mind that a significant number of properties have already invested in up-to-date solar RAPS systems, and probably would have little interest in this.

Conclusion and Recommendations

The report aims to provide a feasible pathway to an equitable, reliable, economically sound and environmentally sustainable energy supply for residents with the following recommendations.

Unfortunately, until a substantial load analysis of power usage in the region is carried out (including a wide sample of domestic as well as commercial use) the conclusions of this Sunverge report can only be considered to be highly speculative (and framed with the expectation that Sunverge may become a major contractor in the event of approval of this project.).

It should also be pointed out that Sunverge has considerably underestimated the number of properties now with Hybrid RAPS.

Sunverge also have an expectation that properties will be continuously occupied. From a recent on-ground survey of driveways, it is evident that, for example in Cow Bay, of 102 occupied blocks, 37 appear only to be intermittently occupied.

Recommendation 1

Who, exactly, are the "Key Stakeholders"?

Key stakeholders to support a staged approach to building a reliable, low-impact underground microgrid which is initially serviced by a mix of traditional gas generation and solar PV and leverages regional skills for real world operation

Recommendation 2

Key stakeholders to support, subsequent to the provision of reliable, low impact microgrid power, exploring options to increase the renewable generation of the system to approximately 80% through:

- first understanding the detailed load characteristics of n the whole system based on analysis of installed system (traditional) generation for a period of up to one year, then (based on actual system load data and detailed site investigation);
- implementing a plan to reliably increase renewable penetration and deploy innovative energy technologies including large scale, long term storage (e.g. solar to gas)

Recommendation 3

Key stakeholders to support establishing a mechanism to allow customers to benefit from sharing their excess solar production (similar to a Feed in Tariff scheme)

Recommendation 4

Key stakeholders to support implementing residential and business tariffs with a fixed and variable component similar to those offered to grid connected customers in regional Queensland

Recommendation 5

Key stakeholders explore options to encourage a public private partnership arrangement to the development of the microgrid solution

Recommendation 6

Key stakeholders to support and agree on the key principles for engineering solutions, tariff structures, subsidies and schemes, ownership, regulation and governance

Recommendation 7

Agree on funding for the development of a next stage detailed Microgrid pre-construction study with capable project proponent including detailed survey data, detailed engineering cost studies, pre-approvals and detailed project plan for Option 1. It is noted that the Queensland Government has made a commitment to provide $1M of funding for a study for renewable solutions for the Daintree and it is recommended that these funds be considered for the support of the pre-construction study for Option 1 as well as any other generation solutions which meet the requirements of providing equitable, reliable, economic and environmentally sustainable power.

The $1 million set aside for another energy survey could provide for a significant upgrade of existing RAPS or fund a microgrid for Cow Bay or Cape Tribulation.

Appendix 1

Region	freeh old	other tenure	hybrid power	buildings	holiday stays	acco m	touri sm	not tourist bus.	Gov / NGO	farm buildings	Farm land	vacant	non-developa ble	Total all blocks
Cape Trib	91	3	32	34	9	13	6	0	5	2	1	22	2	94
Thornton	19	1	7	10	4	0	3	0	0	0	1	2	0	20
Diwan	150	9	83	79	11	5	6	3	13	3	1	21	17	159
Cow Bay	306	4	126	154	20	3	2	1	5	3	2	64	56	310
Forest Ck	116	1	41	67	3	0	0	0	1	0	0	38	8	117
Kimberly	70	2	23	27	2	1	0	0	2	3	5	24	8	72
	642	16	273	327	36	9	8	4	21	9	8	147	89	658

484 occupied blocks

Analysis of settlement pattern for Daintree Coast. Oct 2018 This material has been developed from satellite date, aerial imagery, historical imagery, real estate listings, internet searches, local knowledge and on ground inspection..