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Efficient Site Design

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Synopsis

The greatest spend in establishing new mobile radio/telecommunication sites is invariably in the real estate, the access, civil works, establishment of tower/building structures and power. Experience shows that this can equate to >90% of the capital cost. So why is this part of the project so often poorly considered in our build of radio infrastructure projects? This presentation deals with some lessons learned, oversights and pitfalls in establishing sites and some future strategies and building checklists to capture fundamentals of what we need.

- regulations governing site builds
- concept of right sizing
- number of sites growing
- concept of the value of a site and tower in real estate terms
- remoteness multiplier
- building site and tower structural survey databases
- practical trumps theoretical
- impact of increasing regulation (tickets, inductions, grinding pegs off, fencing)
- increasing environmentalism (managing aesthetics, radiation to public)
- checklist for site surveys

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Disclaimer

These are my views. All care, no responsibility.

No one can be an expert on everything.

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Inherent Value of a Site / Tower

a) It is Commercial Real Estate with an inherent commercial value (Value = x times the annualised Rate of return after costs. Typically, x will be 5.)

b) Value function of Captive market, location, (High Density to Remote, a bit like ACMA rates).

c) Exclusivity (I.E., is there only one site available).

d) Supply/Demand.

e) Coverage Profile.

f) Access.

g) Amenity (suitability for what you are trying to achieve. Is it an easy Landlord to deal with etc)

h) Facility (Is the tower suitable with capacity, is the equipment room suitable, is the Power supply and HVAC suitable with capacity)

i) Trade off between lease rather than own and operate.

SAT have built a database valuing sites to aid carriers when assessing the value of a site (Value = a+b+c+d+e+f+g+h+i).

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Regulations Governing Site Builds

Wind Loading / Structural Design

-AS 1170 Code upgraded in 2011, again in 2021
-2011 the wind-loading parameters became more stringent
-2021, (new wind region maps, region B and C have increased in size, C cyclonic and D extreme cyclonic)
This theme is likely to continue with recent Global events.

Steel Design

-AS 3995- Design of steel lattice towers and masts

Concrete Design

-AS 3600: 2018 Concrete Structures, Steel & Tendons

Electrical Design

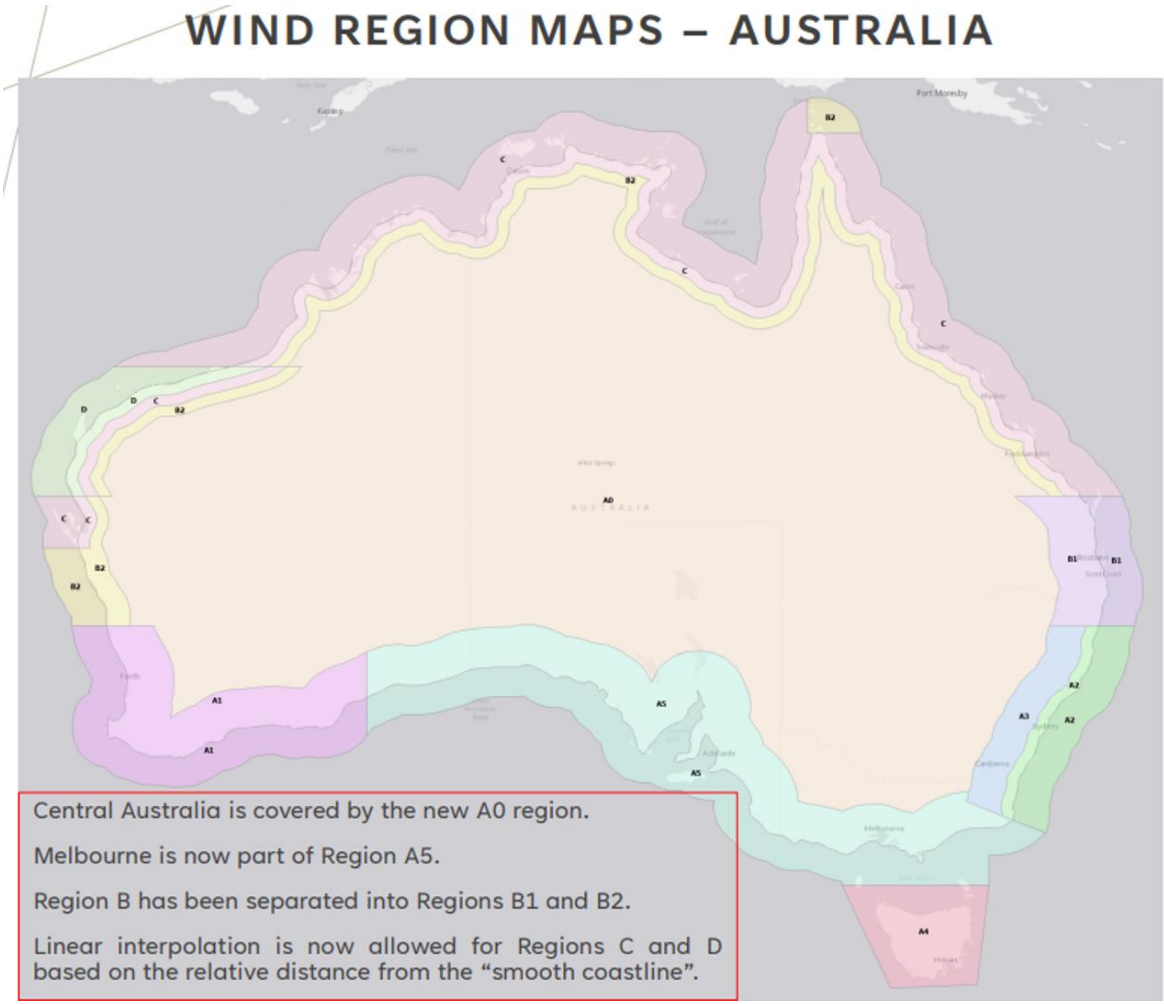
-AS/NZ 3000 - The Wiring rules
-AS 3010.1 Generating Sets.
-AS 45091 Australian Skills Qualification

Guidelines

-issued by Clients. (Optus, Telstra, State Governments)
-Sustainability requirements (Power, disaster withstanding/ recovery)

Mandatory OHS

-Climbing, Safety, Fencing, increasing Public awareness, ARPANZA



Optimising / Right Sizing / Minimisation / Value Engineering

Sizing the tower height - (polynomial cost as a function of height), LOS, coverage area, consider reducing height, access, alternate tower type

Sizing the power can easily have quadruple to 10-fold ripple effect cost (6-10 dB cost in radio speak)

Earthing, lightning protection considerations

Critical point when uneconomic to connect to grid, definition of a solar site

Access and serviceability costs (track)

CapEx versus lease.

Optimising indoor/outdoor mix of equipment (move to outdoor)

Dissipating heat

Getting rid of PIM (Passive intermodulation)

Serviceability

Reliability Calculations

TOTAL COST OF OWNERSHIP MODEL/ANALYSIS.

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Electrical Design – Example

Adding 6 extra channels could add ~2 KW peak load onto the power system ⇒ requiring addition battery capacity ⇒ power AC to DC power upgrades ⇒ heightened max demand ⇒ additional cooling ⇒ transformer upgrade ⇒ transmission line upgrade

In limit 5 x the Peak Load capacity (note doesn't account for site autonomous power systems which can be much greater cost)

Equipment Load 	**AC/ DC Power Supply upgrades**	**Equipment Room Cooling upgrades**	**Max Demand upgrades add 10 kVA**	**Transformer upgrades**	**LV or HV Line upgrade**
~Peak 2 kVA ~Steady State 1.5 kVA Power consumption typically 300-400W per channel 2kW for 6 channels + peripherals (router, microwave)	Add charging ability 60A at 48V=~3kVA 	Add Max~5kVA Steady State ~2kVA Main 16 hrs, second summer 8 hrs day, DC fan 8 hrs winter less (30 KWhr) EER (high 3's) 		415/11,000V Upgrade by 10kVA	Maybe needs upgraded 

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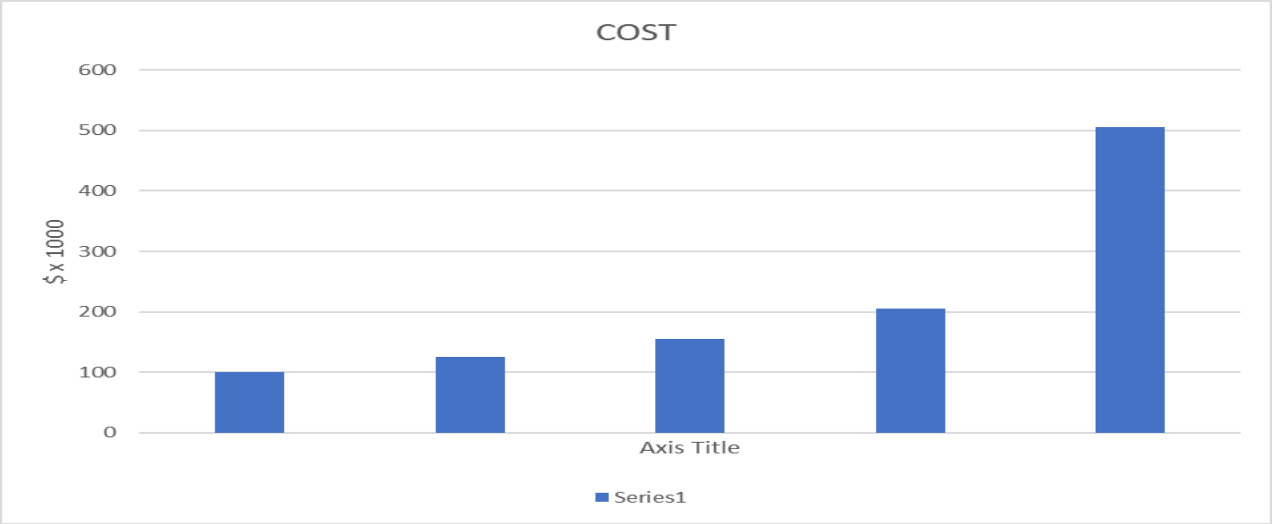
Real Cost of Power System Provisioning



Equip	$100K	$100K	$100K	$100K	$100K
DC Power Supply upgrades		$25K	$25K	$25K	$25K
Cooling upgrades			$15K+$15K	$15K+$15K	$15K+$15K
Transformer Upgrades				$50K	$50K
Power Line upgrades (example 2 Km's)					$300K
running total	**$100K**	**$125K**	**$155K**	**$205K**	**$505K**

Operating Expenditure (OpEx)

2kVA load equates to 2.2 x 24 x 365 kWhr/year = 19,272 kWhr or $3854.40 per year (at 20c / kWhr) RAW LOAD

Max Load ~10kVA

~ADMD load is more like 4kVA ~ $7708.80 per year (at 20c / kWhr) aggregate system

(typically, 2-10 times a domestic bill) - Not insignificant, not environmental.

Load Minimisation

How can we reduce the electrical load at a site.

-Strip out what's not required (lights, auxiliaries, overkill Hot Standby - Duality)

-Smart management of devices (turn on and off, pick charging times)

-Optimise with duty cycles / batteries

-Build to demand not excess. (modular if necessary)

-Optimise and minimise cooling cycles, fans not A/C etc

-Location of equipment out of the sun with passive cooling skins/double skins

-Move Loads outside (growing theme with 3G/4G/5G and link ODU, all outdoor)

Winter / Alpine Climates

-As lots of sites are top of mountain

-Trickle heat (maybe use the residual heat from the equipment)

-Retain passive heat

-Minimise airflow

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Break even point between grid power and off site

Define ‘off grid’. Cost where TCI over x years is better than cost of connect plus kWhr expectation

-Typically, a 10-year TCI analysis +/-

-Derive a table of kWhr total cost versus off site and minimise as per previous steps

$200-300k not going to buy much… or unusual

On Grid Cost		Off Grid Cost
Cost to connect	<	CapEx of ‘Solar’ System
OpEx cost of electricity bill (increment with CPI+)		

Earthing and Lightning Protection

Protects People and Equipment

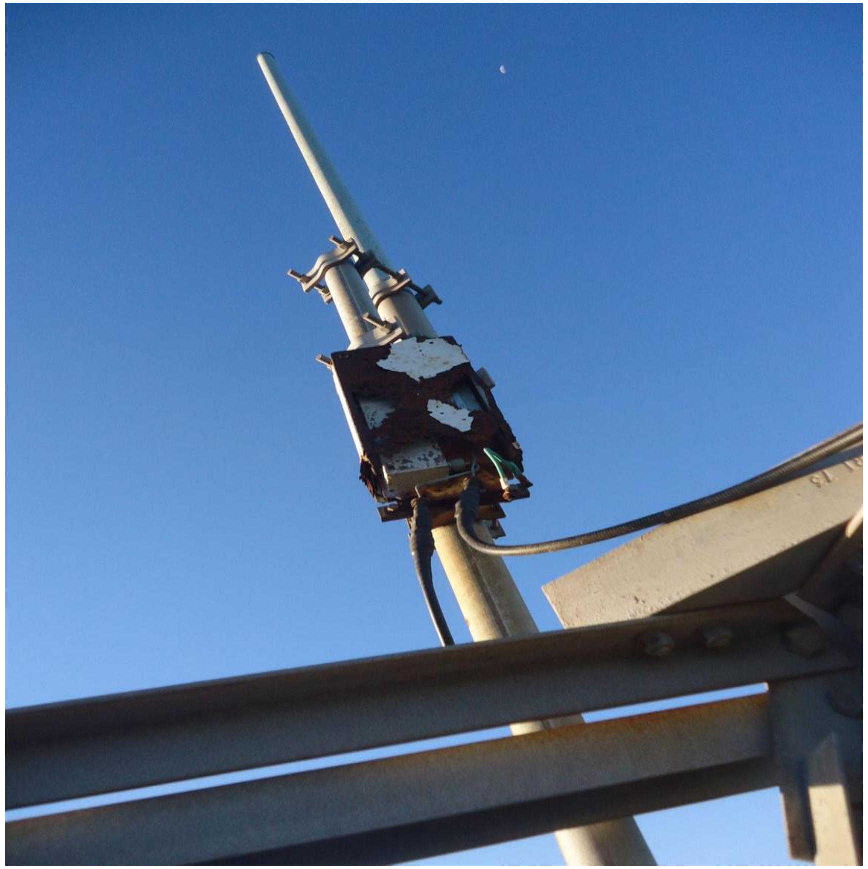
To define the nature of an LPS

-IEC 62305 risk assessment

-Soil resistivity

-Good Housekeeping, Earthing kits applied top and bottom, bends and into equip room (plus 10m intervals)

-No earth loops. Separate Comms and Electrical Earths



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Equipment Room Design

Continuing the example from above. Where do we put all this ‘stuff’.
Ie Footprint increase ~900%, Volume increase ~2300%

Our Outdoor half size 19’ equipment rack (600 x 600 x 1100) Include plinth 1000 x 1000 x 200	FOOTPRINT 1 m^2 VOLUMETRICALLY = 0.596 m^3
½ x 19’ rack for Mobile Radio Base station (600 x 600 x 1100) 1 x 19’rack for Power Supply System and batteries (600 x 600 x 1100) = equipment room, minimum 2400 x 2400 x 2400 (for erganomics) -concrete plinth to support equipment room (3000 x 3000 x 200) Outdoor area for mounting 2 split air conditioners (typically 600 x 600 x 300 each)	FOOTPRINT 9m^2 VOLUMETRICALLY = 14.4 m^3

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Real Estate

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Lattice Tower Installation

Tower Modelling

-SpaceGas

-SAP

-Atena

-Tekla

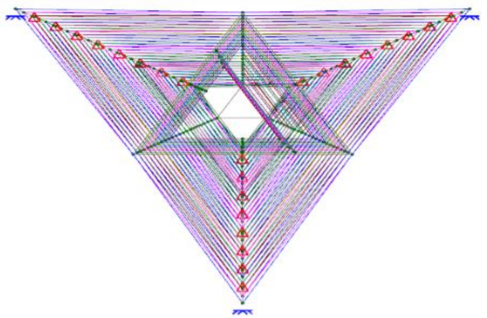
-Bentley

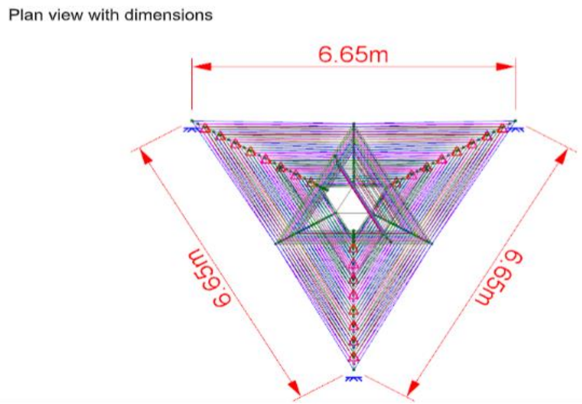
-CheckPole

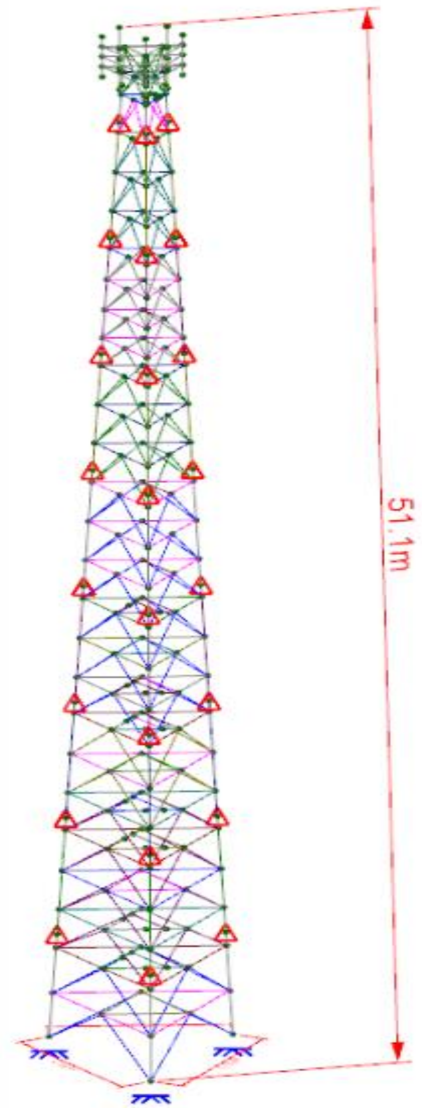
-RocPole

-Finite analysis/calculus based.

Pre loaded codes and antenna systems







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Dimensioning a Tower

-Height requirement

-Strength and loading requirement

(Antenna Matrix)

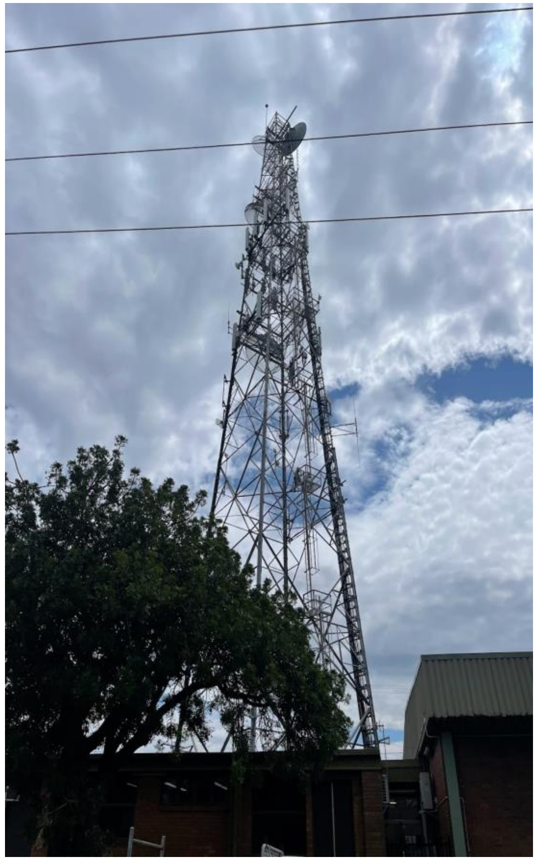
-Locating

-Foundation Design

-Installation

-Feeders

(ancillaries Hut, Power, Fence..)



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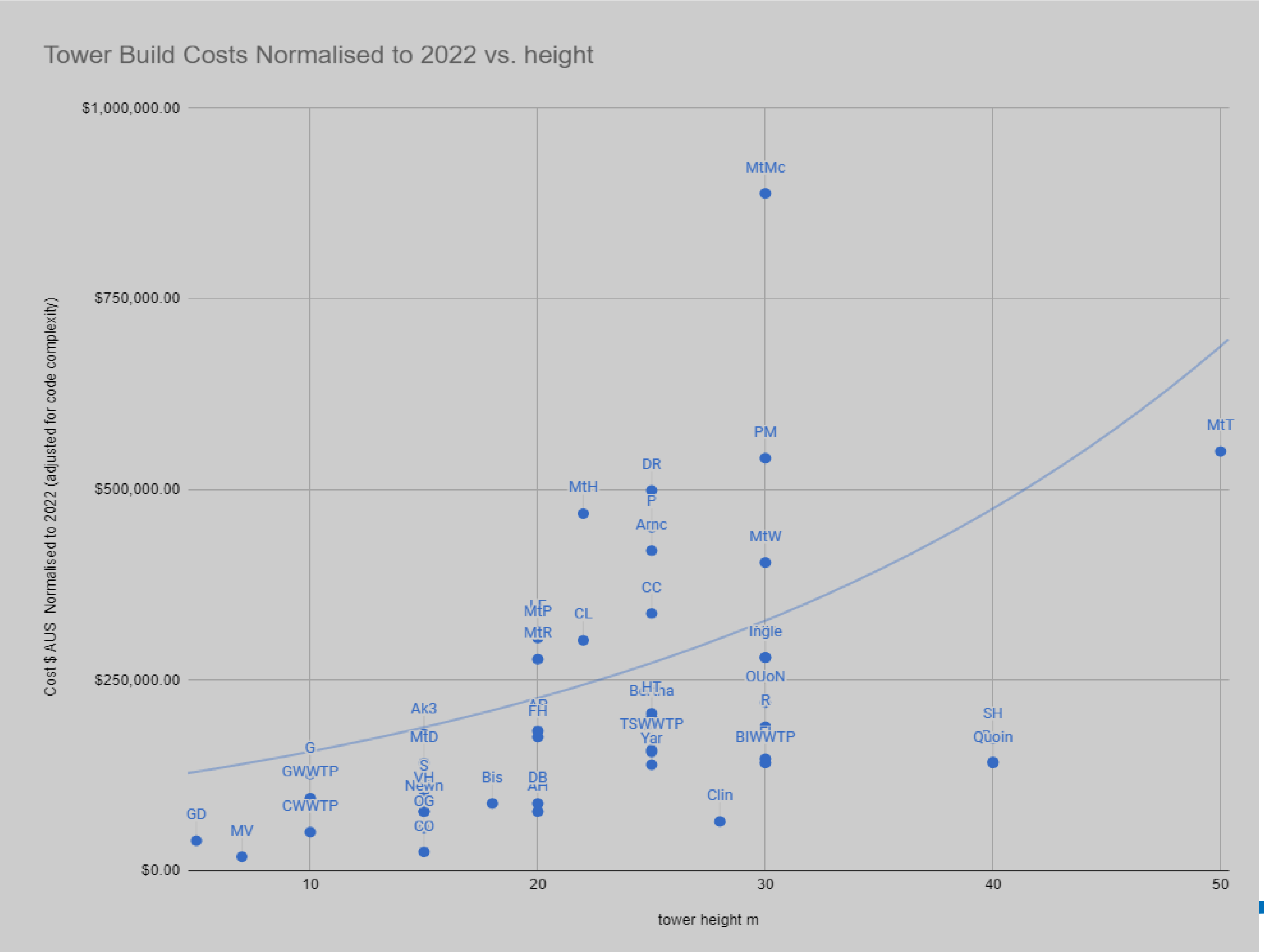
Benchmarking Costs

Extract from SAT database.

60 sites with detailed build costs.



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Standard / Hard / Extreme Difficulty

Extract from SAT database.

60 sites with detailed build costs.

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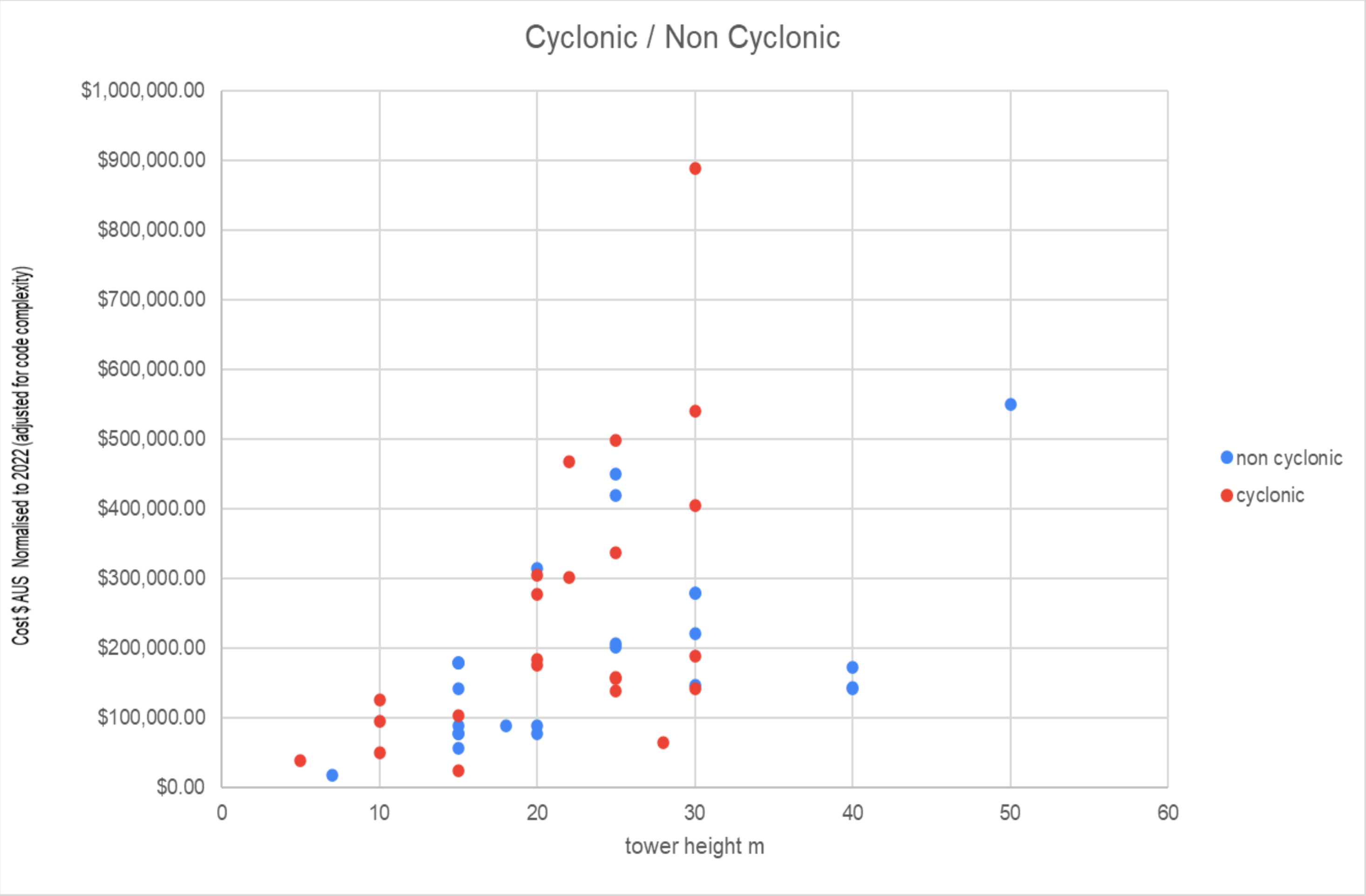
Cyclonic / Non-Cyclonic

Extract from SAT database.

60 sites with detailed build costs.



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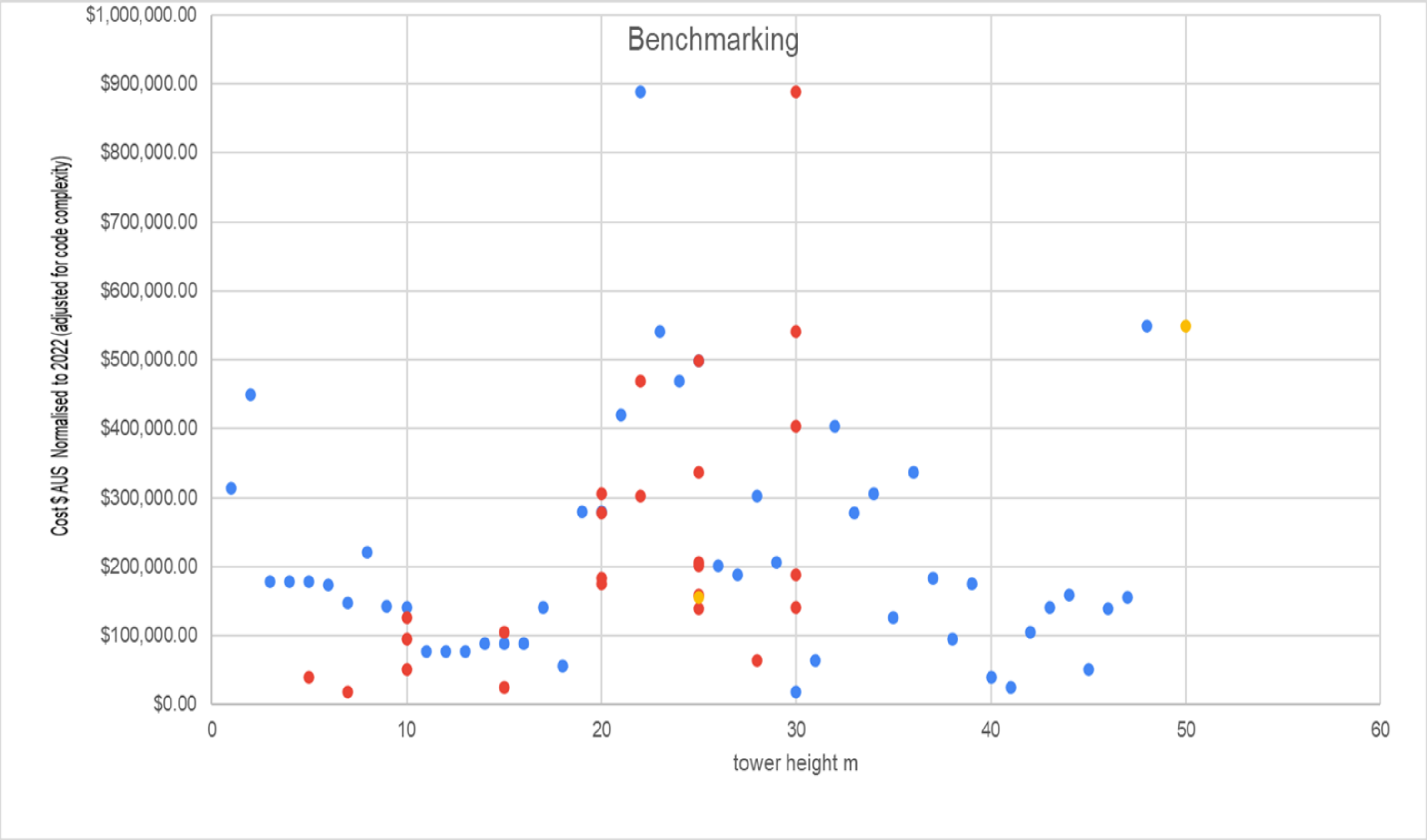
Pre 2011, 2011-2019, Post 2019

- -CPI multiplier applied
- -Normalising Multiplier of 2.11 applied pre-2011.
- -Normalising multiplier of 1.09 applied 2011-2021.



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Data

Height	Name	Foundations	Installation/Services	Tower Hardware	Total Cost
25	HT	26.79%	29.56%	43.65%	$ 201,588.00
25	R	20.31%	67.41%	12.28%	$ 206,797.34
30	AP	26.34%	71.18%	2.48%	$ 888,360.00
30	CL	16.63%	76.17%	7.21%	$ 541,200.00
22	PM	30.31%	64.98%	4.71%	$ 468,600.00
25	TSWWTP	18.02%	77.08%	4.90%	$ 498,960.00
30	Yar	6.68%	87.58%	5.74%	$ 404,481.00
20	MtR	38.19%	45.93%	15.89%	$ 277,585.00
20	MtP	43.22%	42.37%	14.41%	$ 305,406.95
10	MtH	60.95%	18.53%	20.52%	$ 126,896.00
25	Bertha	23.27%	65.41%	11.32%	$ 337,634.00
20	CWWTP	7.87%	84.23%	7.89%	$ 183,546.00
10	ST	46.23%	20.14%	33.62%	$ 95,172.00

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Foundation / Installation / Tower

Yellow = Tower Hardware $32,319

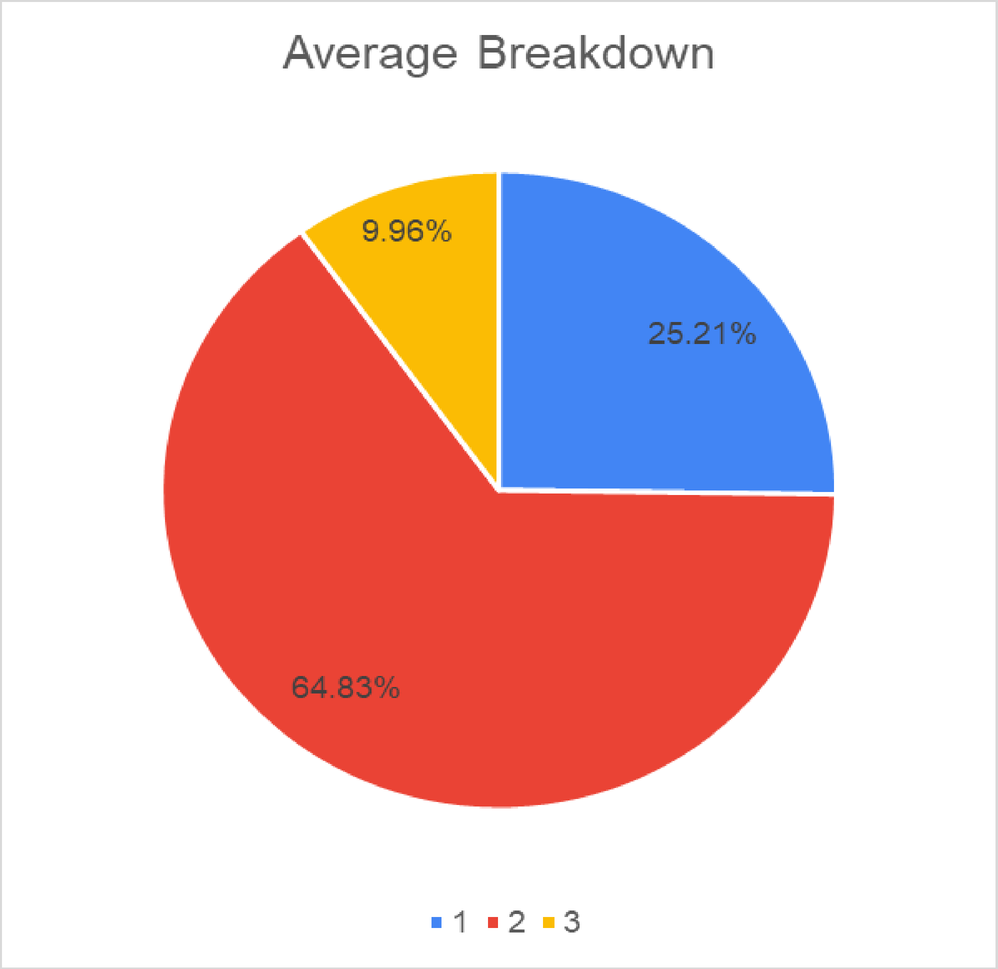
Blue = Foundation $81,772

Red = Installation $210,275

60 tower average

Medium tower height 21m

Average cost = $324,367



Aesthetics

Increasing environmentalism (managing aesthetics, radiation to public)

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Checklist for Site Surveys

- Regulations governing site builds
- Concept of right sizing.
- Number of sites growing.
- Concept of the value of a site and tower in real estate terms.
- Building site and tower structural survey databases.
- Practical trumps theoretical.
- Impact of increasing regulation (tickets, inductions, grinding pegs off, fencing)
- Increasing environmentalism (managing aesthetics, radiation to public,)

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Technology Improvements on Tower Loading

OLD		NEW	
10%	⌀3.7m antenna or above		
10%	⌀3m antenna	5%	⌀2.4m antenna or above
20%	⌀2.4m antenna	20%	⌀1.2m antenna
20%	⌀1.8m antenna	25%	⌀0.9m antenna
20%	⌀1.2m antenna	25%	⌀0.6m antenna
20%	⌀0.6m antenna	25%	⌀0.3m antenna

-Note benchmark for wind loading of 3.0m antenna in Australia in region ''a'' 3m = 20 kN (old AS 1170.2 code)
Use area ratio to adjust this up and down
-Similar improvement in capacity (2 Mbps gone to ~400 Mbps, 200-fold, reliability up, LSI up)

SITE SURVEY FORM www.satpty.com

Summary

SITE NAME:		ACMA ID or RFSNA ID
Date		
By		
Track General Condition	Access Track suitable for 4WD/2WD/Flatbed Truck/Crane/Concrete	Permissions / Keys required

Site Location

GPS LOG	Lat	Long	Comment
Tower Centre			
Compound Gate			
Access Waypoint 1 ( )			
Access Waypoint 2 ( )			
Access Gate			

detailed GPS access log taken

Structure Details

Structure type	☐ Building	Pole ☐			Tower ☐	
		wood ☐	Steel ☐	spun concrete☐	Lattice ☐	Guyed ☐
					3 leg☐	4 leg☐
Manufacturer			Model		☐ photograph nameplate	
Structure height	[..............................] (taken with a laser)					
Access / Ladder fitted	Access:				Ladder Yes ☐ No ☐	
Fall arrest fitted	Yes ☐ No ☐ Manufacturer ....Model .... Rating ....kN. Last inspected .... Current Yes/no					
Notes Amenity: Expectation on Loading: Suitability for new antennas: Condition of Tower / general Maintenance: Cable run:						

Documentation and Photos / Videos

Documents to Attain	Site Plan: Site Access Plan: Compound Plan: Compound Layout Foundation As built: Tower As built: Tower Structural Details: Structural Survey: Tower Shop Drawings: Equipment Room Fixation: Equipment Room Layout: Electrical Schematic: Earthing Diagram: Antenna Schedule: Feeder Schedule: Power Feed drawings: Solar Drawings: Generator Drawing: Geotechnical Assessment:	
Foundations / Guy Anchors inspected & Photographed		Completed ☐ Photograph any defects Comments:.. ....
Climb structure & record all defects In a separate report		Photograph defects & label locations on tower elevation dwg Use Highest Resolution Practical Completed ☐ Comments:.. ....
Check condition of galvanizing		new/ just off colour / tarnished and weathered/surface rust/severe rust
Check a sample of bolts for tightness		Check 5 random bolts on each face for tightness Completed ☐ Comments:..
Check antenna locations against drawings		Completed ☐ Update tower elevations ☐ (each antenna's to be shown only once on the elevations) Comments:.. ....
Check Antenna /Feeders for defects/damage		Completed ☐ (bent missing elements/corroded mounts/ torn radome covers/ODU earthing) Photograph any defects ☐ Comments:..

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Capture all available antenna details		Photograph Antenna nameplate ☐ (align antenna schedule & elevation dwgs) Update Antenna Schedule ☐
Check antenna against RCSMB		Provide updated info for RCSMB corrections (on the existing RCSMB document) Completed ☐
Inspect lightning protection		Grounding kits fitted at top & bottom of all RF feeders ☐ Surge arrestors fitted at gland plate ☐ Gland Plate grounded to site earth ☐ Highest point is a DC grounded Antenna or a lightning finial ☐ Comments:.. ....
Inspect Structure earthing connections		No corrosion/ mechanical damage/bolts are tight Completed ☐ Comments:..
Conduct a Site Earthing test		As per Site earth test method provided (3 pole 62% method) Indicative reading (A) (Ohms) .... (current probe at 20m & 50m from site boundary, voltage probe at 62% of current probe distance) If (A) is greater than 30 Ohms conduct a full test (10 tests out to 100m from site boundary) Final test result (Ohms) .... Record tests on provided spreadsheet ☐
Photograph each tower face and tower leg		Via Drone (typ 3-5 photos progressing up the face including photos showing the complete face to allow scaling of antenna heights) Completed ☐
Photograph the overall site layout		Via Drone (at least 2 photo's taken directly above the structure center, encompassing the complete site) Completed ☐
Photograph the cable ladder		Completed ☐ Type of cable support fitted [..]
Photograph the gland plate		Completed ☐
All RF feeders are labelled at the gland plate & antenna connection		Yes ☐ No ☐ Comments:.. ....
Is there a Geotechnical assessment		Yes ☐ No ☐
Review latest Structural assessment		Are all antenna included in the Structural assessment? Comments:.. ....
Tower Signage		Photograph all fitted signs ☐

Vegetation obstruction		Any antenna obstructed by nearby trees Yes ☐ (photograph) No ☐ Measure the vegetation heights for the closest trees in each cardinal direction N..............................E..............................S..............................W..............................
Aviation warning lights fitted. Power Feed:		Yes ☐ No ☐ Comments:..

POWER SYSTEMS

AC FEED TO SITE	1P / 3 Ph Meter Details: Photograph	11 KV Transformer spotted Photograph
SOLAR PANELS	Type: Qty: Array Size: Regulator Details: (Photograph all)	
GENERATOR	Type: Details: Mtce records: Photograph: Last Started: Photograph	
BATTERIES	Type: Strings: Total number: Date into service: Tested: Photograph	
OTHER (Wind, Fuel Cells, Water)		

Conclusions

Consider value engineering, right sizing, conservatism costs. Lack of considering the full engineering design can be costly particularly regarding the power and structural costs. easily able to blow out to typically 10x the Radio Network costs. This usually dominates the cost expectations for a network rollout

Power on Site

- Reduce equipment dimensioning (functionality, trunking example, capacity calculations, consumption, cooling requirement). Think about scalable upgrades when you need, modular.
- How can we reduce power footprints (passive cooling, double skins, out of the sun external placement, external heat sink, minimising kVA's of cooling, smart approach to Battery charging or generator operation)
- Strip back unnecessary equipment loads (lights, cold standby)
- With solar systems equate the Total Lifecycle Cost (x years), in terms of expectation of kWHr

Tower Loading

- Reducing antenna footprints and size with technology
- Dropping height where necessary, using logical locations for access. Leasing space rather than own and operate

Tower Building

- Survey site and confirm important parameters, (access, height required, antenna table to enable tower specification)
- Understand Geology (Geotech report), site layout restrictions (Parks, Heritage, boundary, footprint)

Real Estate Footprint and Loading

- Reducing real estate footprints and volume. Consider the lease model rather than site/tower own and operate

PROPERLY SURVEY THE SITE AND CAPTURE ALL THE RISKS, CAVEATS, PARAMETERS

“The problem with radio, is that it is too reliable”.

Thank you