SKA Power Projections: Australian SKA Pathfinder musings ….

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30 October 2010

SKA WP2 PITF meeting

CSIRO

SKA Power

There are many issues for SKA power:

- Science requirements lead to instrument with dispersed ("remote") stations, a range of technical solutions
  - Some near grid (add renewables to grid)
  - Some near fuel resources (e.g. gas pipelines)
  - Some far from grid but near renewable sources (solar, wind, geoexchange)

- Quality of power issues
- Environmentally sensitive
- Cost – capital versus operating
- Etc etc ….

SKA Power

COST !

All these issues are basically cost in some sense

Range of potential power cost is very large.

100 MW (?) of power could cost something from <<50 million to >> 180 million € per year, ignoring issues of carbon credits etc.

So power costs alone could equal capital cost of SKA in as little as 10 years if we do not control it

SKA Power

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So power costs alone could equal capital cost of SKA in as little as 10 years if we do not control it

But you all know that – its all obvious.

SKA - Power

The good news:

An enormous number of references to power demand in so many of this weeks WP2 talks show acute awareness:

- Andy Faulkner with AA
- Duncan Hall
- Tim Cornwall
- Paul Alexander

All again showed numbers that were somewhere between intimidating and impossible in terms of potential consumption.

SKA - Power

The good news:

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The bad news:

To reiterate: SKA operating power costs alone could equal the capital cost of building the SKA in a few years.

SKA - Power

The good news:

An enormous number of references to power demand in so many of this weeks WP2 talks show acute awareness

The bad news:

To reiterate: SKA operating power costs alone could equal the capital cost of building the SKA in a few years.

We all know therefore:

We simply cannot build SKA on the old models especially when the additional constraint X is also considered.

What is constraint X ?

SKA - Power

Constraint X is simply :

A dominant criteria in powering the SKA will be the energy policies of the individual member countries of SKA Inc.

This will dominate how we build and power the SKA.

All questions of power will be determined by the combined energy policy that SKA Inc has to implement.

Technical issues are all manageable – very complex, but with appropriate optimisation (including configuration), solvable.

The technical solution(s) parameter space will be determined by Agency policies

SKA - Power

A dominant criteria in powering the SKA will be the energy policies of the individual member countries of SKA Inc.

This will be an integration of their individual policies into one for SKA Inc which covers the entire package of “carbon”

This could (will?) also include:

- material selection for construction
- manufacturing processes
- Distribution mechanisms
- Proper “whole of life” analysis
- Operating model

just as much as it will relate to the direct energy use

ASKAP Experience

Evolution of project power requirements:

1. Early (Concept) design phase

First order science drivers to basic specifications:

1. Numbers of antennas, size, estimate of what an antenna drive draws
2. Scale of the type of data reduction for– YY Gflops, with ZZ Watts/Mflop
3. Etc …..

Produces numbers: + 100 / - 50 % (and therefore scope iterations)

2. Mid (Critical) design phase

More specific characteristics as science requirements to specifications solidify operational aspects to:

1. Antenna drive characteristics – balanced/unbalanced, acceleration requirements, range of manufacturers specs, “type plate” maximums
2. Processing types – FPGA/GPU model, number, fibre driver chips, network characteristics etc

Produce numbers + 60 / - 30 %

- But conservatism can drive this up substantially !

ASKAP Experience II

3. Prototype (PRR) measured

1. Samples of bespoke equipment measured, start-up/inrush current characteristics
2. COTS specified, characteristics well understood
3. Specifics of efficiencies (building insulation etc) adequately known

Produce numbers + 15 / -10 %

4. Panic, start again.

ASKAP – surprised by how close the early numbers in the Concept period were to our current (Prototype level) estimates.

MRO - Power Generation and Cooling

CSIRO is strongly committed to maximising the use of renewable power sources

MRO Requirements for ASKAP, MWA etc :

- approximately 850+ kW, 24 hours, 365 days (1.1 MW peak)

- “medium” reliability (compared to DoD, communications, medical etc)

- major load is the electronics and processing (50 - 60 %)

- load variations dominantly due to diurnal cooling load

- RFI emission control to maintain pristine radio quiet site standards

“Demand side” management during design and operations planning critical

Working with Horizon Power (WA utility) to develop the design and supply model

MRO - Power Generation

Current Horizon Power design :

- 3 to 4 Scania diesels (up to 440 kVA each), 10% load tolerant
- initial 250 - 500 kW of photovoltaic cells
- (very) smart controller that balances
    - load
    - predicted load increases (communications from ASKAP control)
    - supply decreases (including predictive – cloud monitor)

- “short term” power storage using either 1MW flywheel or “supercaps”

Future:
Pursuing further options to significantly increase the penetration of renewable sources from 2012 onwards. Options include:
- more photovoltaic arrays
- solar thermal

Storage is key issue for renewables

MRO Power

MRO Scope:

1.Energy efficient central building design

2.Geothermal based building cooling
- 27 deg versus 45 deg air temperature improves efficiency of heat rejection

3.Geothermal based antenna cooling

4.Increase penetration of re-newables in power generation system in 2 phases:
1. Base system installed during 2011/12
2. Phase 2 – add more re-newables 2012/13, with storage

1.Pawsey HPC for SKA Science (Perth) – substantial cooling requirement for efficient cooling to the supercomputer

Horizon Power – Marble Bar hybrid station

Horizon (along with Power Corp and Sunpower) developed a fully integrated large scale isolated diesel solar hybrid power station:

- 4 diesels (N+2) – approximately 600 kW peak capacity

- 2,000 tracking solar panels in 3 rows (only one motor/actuator per row)

- 0.5 MW “flywheel” short term (5 – 30 second) power storage

- highly integrated and predictive control system

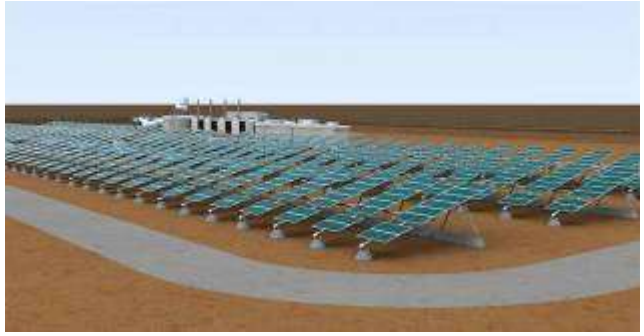
- very high solar penetration – achieving 100% !

Very likely that they will soon trial an operations model with the diesels turned off for periods of several hours per day.

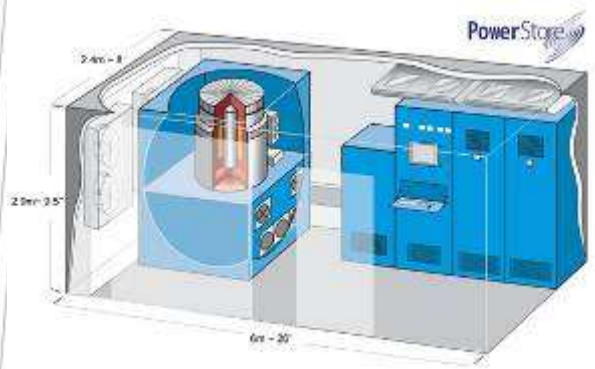
This sets an important demonstration of a step towards a 100% operations model able to deal with “typical” load variations in a renewable only mode.

Horizon Power – Marble Bar hybrid station

- **Worlds first High Penetration Solar/diesel Hybrid stations**
- **Largest single axis tracking arrays in Australia**
- **65% day time load from Solar energy (update: 100%)**
- **30% annual load from Solar energy (in a regulated req.)**
- **Approximately 300 kW demand plan (domestic 415 people)**
- **1.15 GWh renewable energy**
- **1150 Renewable Energy Certificates**
- **Diesel saving per year 405,000 litres**
- **Reduced annual $C0_2$ emissions by 1100 tons**



Horizon Power – Power Corp flywheel

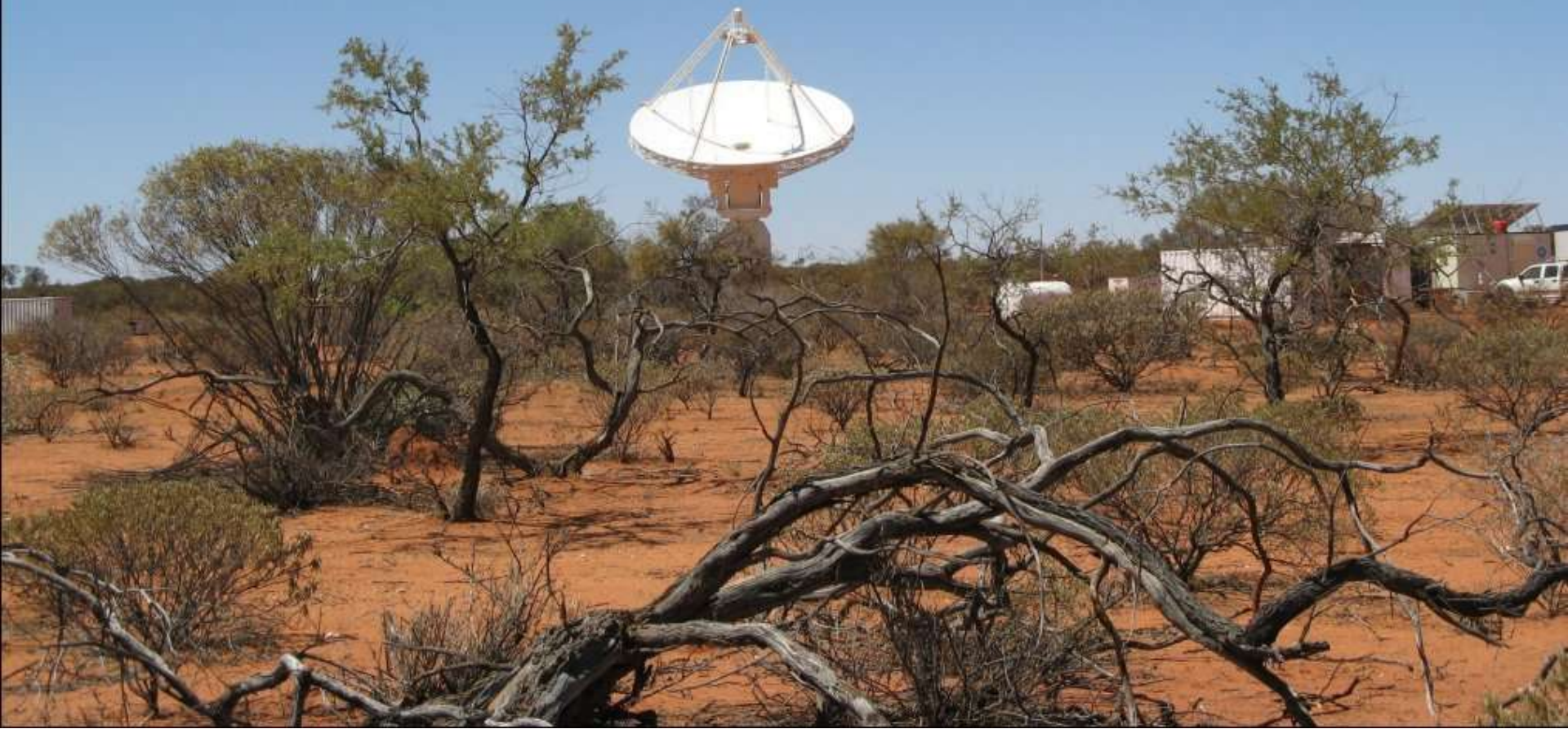


- Electrical - Kinetic - Electrical
- Rapid ‘Sink & Source’ of energy
- Rated Power 500kW
- Can Store 18 MJ or 18 MW sec
- ‘Park’ spinning reserve on the flywheel
- Fuel savings = 5yr pay back on flywheel
- Excellent transient response

Horizon Power – Marble Bar hybrid station

Horizon Power – Marble Bar hybrid station

We acknowledge the Wajarri Yamatji people as the traditional owners of the Observatory site.



Thank you

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