International Centre for Radio Astronomy Research

Curtin University

The University of Western Australia
Achieve International Excellence

ICRAR is a partnership between Curtin University of Technology and The University of Western Australia

Criteria for Systems Choice

SKA PITF

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Top-level Power Requirements

- Sufficient
- Cost-effective
- Available/reliable
- Maintainable
- Scalable
- Logistically compatible with deployment schedule

But Also…

- Meet EMC requirements
- Carbon Neutral
- Safe!
- Compact & Modular
- Hot-Swappable (in many cases)
- Redundant (?)

Global Requirements

- “SKA will be a Renewable Energy Benchmark”
- Meet Schedule Constraints
  - development
  - Procurement
  - deployment
- Control maintenance costs
- Trade operating costs for Cap Investment
- Site-neutral as long as possible
- Manage entire product lifecycle

Criteria

- How Much?
  - Realistic load estimates & distribution size
- Where?
  - Real example siting probably needed
- When?
  - Development/construction/deployment schedule
- Who Pays?
  - Government incentives likely involved for Green Component

Non-functional issues

- Regulatory issues
  - EIS / Construction permits
  - Supplier licensing
  - Station licensing
- Political considerations
  - Green investment
    - Capital cost impact vs long-term cost savings
    - “moral” / PR benefits
  - Non-project infrastructure development
    - Required?
    - PR benefits?
- Uncertainty
  - Estimates
  - Schedule
  - Credibility

Guidelines to designers:

- EMC
  - Embedded power regulation is a key location for controlling EMI & crosstalk
  - => Ref to EMC plan & limit values
- Efficiency <> Cost
  - Minimum voltage headroom (LDO regulators, switched converters)
  - Minimum conversions
    - POU regulation
    - standard Bus voltages
    - Off-line/off-buss switchers
  - => Ref to project-level goals for efficiency (e.g. error budget)
- Reliability
  - Thermal survivability/accelerated aging
  - MTBF/MTTR vs availability requirements
  - Redundancy/hot swap technology
  - => Ref to project-level target availability

Reliability & Availability

“we don’t need to operate 24/7”

- Central core (50MW?)
  - Processing
  - Infrastructure
  - Antennas
- Arms
  - Antennas
- Remote cluster
  - Antennas
  - Processing
  - Local Processing

BUT… what are the loads?

- High availability
  - Supercomputer/storage
  - M&C
  - OHS
- Moderate to low
  - Antennas
  - ?

Power-loss Issues

- Restoration after outage:
  - Computer reboot time
  - FPGA board reload time
  - Telescope re-initialization/registration
  - M&C status recapture/update
  - Schedule reconfiguration
- DRM must account for down-time
- Cost-optimization requires adjusting power quality for the load point
- => several solutions

Monitor & Control

- Most power systems have M&C facilities… BUT isolated!
- SKA needs an INTEGRATED M&C system
  - Remote/autonomous control
  - Human attention span & detail comprehension
  - Probably hierarchical to make development tractable
- Facility controls system is as important (as hard) than system control
- Specification for integration with SKA facility control must be part of the power system requirements
  - …which means you must start working on defining architecture & interfaces soon!

Lightning & Grounding

- “ground” means different things to different people
  - Safety
  - Radiation plane
  - Lightning sink
- Fundamentally rely on soil conductivity to establish equipotential surface
- Geotechnical issue – deserts are DRY
- Consequence – observatory reticulation is by far the lowest impedance
  - Lightning issues – lateral currents may be serious
  - Localized potential points probably lower
  - Circulating currents (ionosphere) may need management

Life-time design costs

- Include maintenance & repair/spare costs in up-front investment
  - Long-term availability of parts
  - Cost of major maintenance events
    - Time/Data loss
    - Personnel availability
  - Provision of alternative emergency power
    - Mobile gen-sets…
- End-of-life cost & planning for replacements

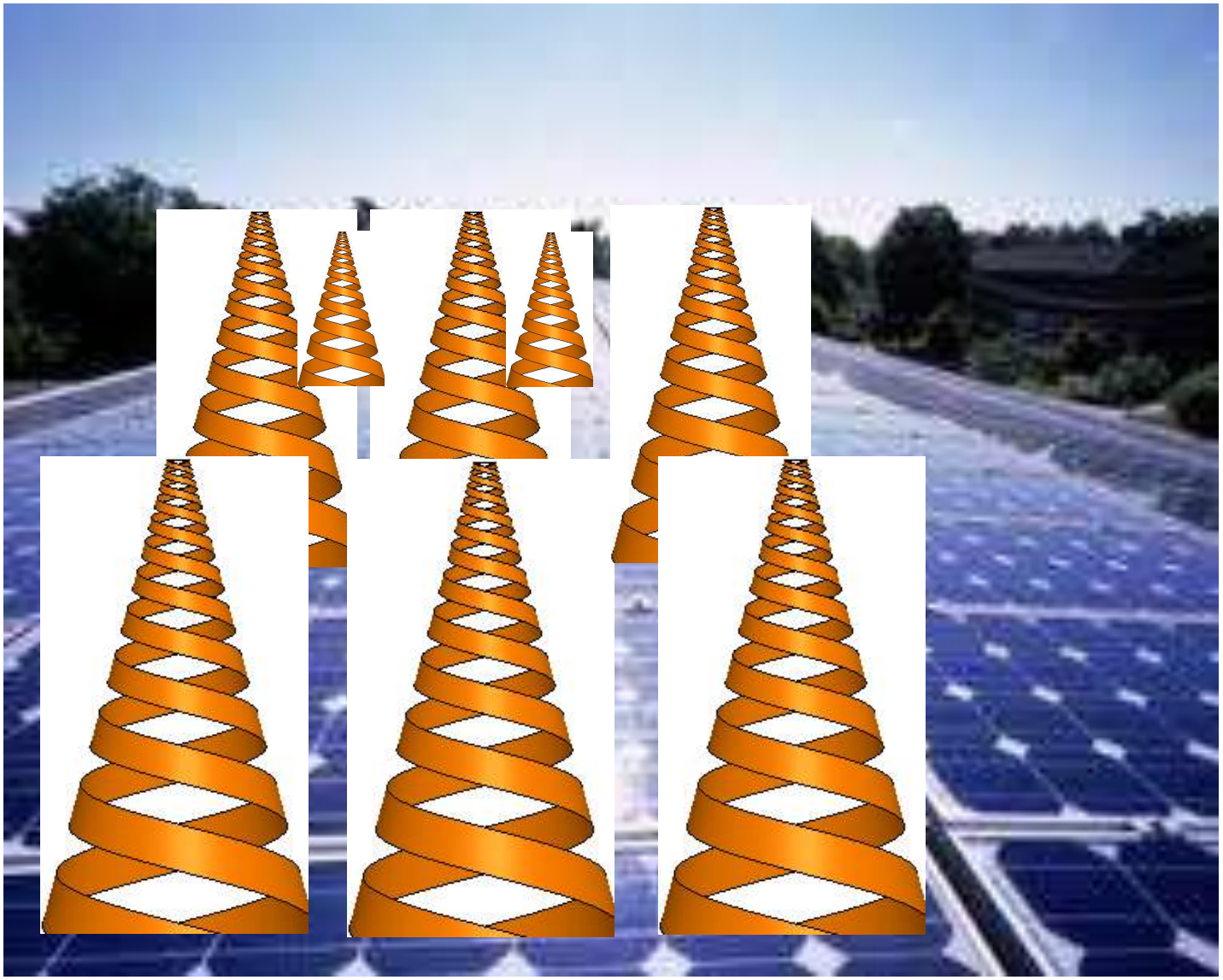
Likely Non-Issues

- 50 yr facility lifetime, non-commercial customer
  - approx. Marble Bar design lifetime (e.g.)
- Geographical diversity
  - Normal circumstance in these areas
- Dominance of RFI / EMC in power system design
  - “not a problem” if included at beginning
- “Soft” performance - cost targets for remote stations
  - …
- Relatively flat load versus time-of-day
  - Stable load is easier to support
- Simultaneous SKA operation and expansion
  - Modular design is standard

PITF roadmap to next stage

- DRM-level straw-man load estimate
  - Proj office publish “official” model
    - Optimization / analysis comparable
    - People happy to tell you what’s wrong with an assertion !
  - Key unknown is load of AA – all estimates seem confused here
  - Spell out (a few) different scenarios for comparison
    - Grid connect
    - Remote islands
    - Various levels of green penetration

One more crazy idea



Example islanded power system

- http://www.horizonpower.com.au/about_us/major_projects/New%20power%20stations%20at%20Marble%20Bar%20and%20Nullagine.html