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Appendix B – Scope of works

CSIRO

SUBMISSION TO

THE PARLIAMENTARY STANDING

COMMITTEE ON PUBLIC WORKS

Proposed Extension of Scope to the Pawsey High Performance Computing Centre and the Australian SKA Pathfinder (ASKAP) Radio Telescope Projects for the Provision of Sustainable Energy

June 2010

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Proposed Extension of Scope to the Pawsey Centre and ASKAP Projects for the Provision of Sustainable Energy

1.0 Introduction

The Pawsey High Performance Computing Centre project was referred in March 2010 to the Parliamentary Standing Committee on Public Works (PWC) for examination. A public hearing was conducted by the Committee at Bentley, Western Australia on 16 April 2010, at which the possibility to provide cooling to the Pawsey Centre through geothermal power was raised with the Committee.

The CSIRO Australian SKA Pathfinder (ASKAP) radio telescope project was submitted to the PWC in June 2008 and a hearing was held in Geraldton in October 2008. The ASKAP project was approved by the PWC and the work was approved by Parliament in December 2008. The ASKAP proposal outlined that the power generation system for the Murchison Radio-astronomy Observatory (MRO) was being constructed to enable a higher penetration renewable energy solution to be deployed for ASKAP when it became feasible to do so. During the PWC hearing it was raised that the ASKAP team were exploring mechanisms to provide more of the MRO power using solar technologies.

On 9 June 2010 the Prime Minister announced funding of $47.3 million through the Commonwealth Government's Education Investment Fund (EIF) Sustainability Round for the *Sustainable Energy for SKA* project. The project will support the construction in Western Australia of renewable energy infrastructure for the Pawsey Centre and for ASKAP at the Murchison Radio-astronomy Observatory.

The Square Kilometre Array (SKA) is a major international project currently under development by scientists from 50 institutions across 19 countries, with a project construction budget in excess of Euro 2 billion. The project involves the development, construction and operation of the world's largest radio telescope. Provision of energy for the data intensive SKA operation is a major challenge for the international project. Effective demonstration of renewable energy solutions for the SKA pathfinder projects the Pawsey Centre and ASKAP will strengthen Australia and New Zealand's bid for hosting the SKA.

The EIF funding enables CSIRO to take up options for renewable technology deployments described and foreshadowed in the Pawsey Centre and ASKAP PWC submissions. CSIRO is seeking the agreement of the Committee that the *Sustainable Energy for SKA* EIF-funded project be considered as an extension in the scope of the Pawsey Centre and ASKAP projects.

Approximately $20 million of the EIF grant awarded will be invested in a drilling program to access the hot sedimentary aquifer under the Perth basin to power an absorption chiller to meet the significant cooling requirements of the Pawsey Centre supercomputer and the heating/cooling requirements of the adjacent Australian Resources Research Centre (ARRC). The infrastructure will establish the Pawsey Centre as Australia's largest direct-heat geothermal demonstration site.

Approximately $27 million of EIF funding will be invested in infrastructure that will deliver a high renewable penetration hybrid power generation system, and will enable an energy efficient MRO control building to be constructed, as well as sophisticated geoexchange cooling to be developed and deployed for cooling ASKAP antenna electronics and the data processing system in the MRO control building.

2.0 Geothermal Infrastructure in Support of the Pawsey Centre

2.1 Background

The Pawsey Centre is a key part of the Federal Government's strategy to address the paucity of high ranked supercomputing systems in Australia. The supercomputer to be installed at Kensington will be at the forefront of facilities in Australia and will rank among the top twenty such facilities in the world at the time of its commissioning in 2013.

CSIRO will own and maintain the Pawsey Centre building. The supercomputer will be operated by iVEC, an unincorporated joint venture between CSIRO, Curtin University of Technology, Edith Cowan University, Murdoch University and the University of Western Australia.

The location of the proposed works is in Kensington, Perth on a CSIRO owned Greenfield site. It is situated adjacent to CSIRO's ARRC facility in Technology Park, Bentley approximately 6 km from the Perth CBD – see site map below.

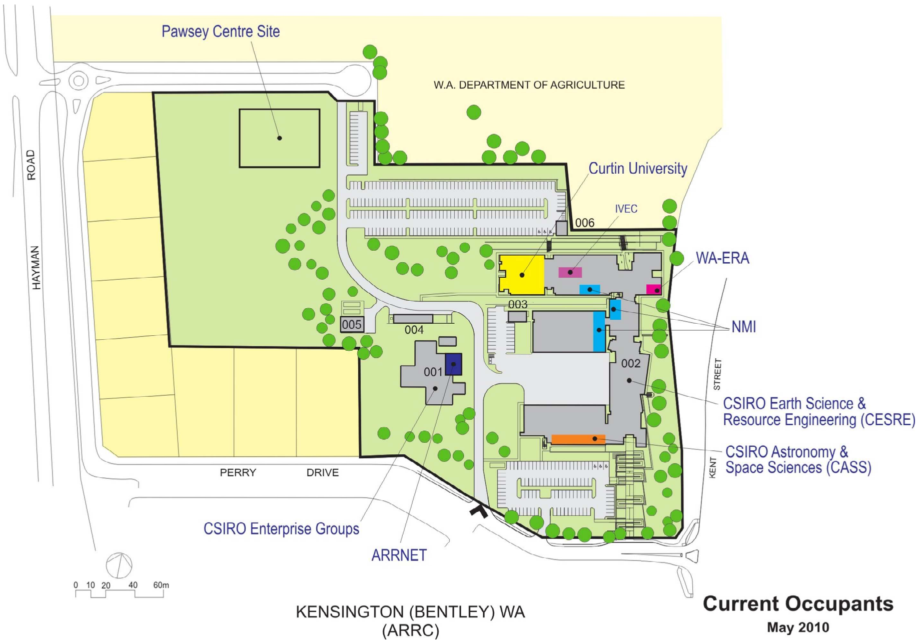

Figure 1. Site of the Pawsey Centre and ARRC facility

Recurrent operating costs associated with the Pawsey Centre will be significant, with electricity costs associated with running and cooling the supercomputer and associated infrastructure likely to exceed $5 million per annum. Of this total, up to 40% ($2 million pa) can be directly associated with the cost of cooling the Centre.

The geothermal component of this project aims to access the heat resource within the hot sedimentary aquifers within the Perth Basin to run off-the-shelf absorption chillers which will meet the cooling needs of the Pawsey Centre and the heating/cooling needs of the adjacent ARRC facility.

2.2 Objectives and Infrastructure Requirements

The objective of the geothermal component of the proposal is to establish the Pawsey Centre/ARRC as Australia's first large scale (10MW$_{th}$) direct heat geothermal demonstration site.

Other than CSIRO's cash contribution of $1.5 million for the acquisition of down-hole monitoring equipment for the exploration/research well, the proposed budget is directed exclusively towards the geothermal drilling program.

The drilling program proposes that three, 3km deep wells be drilled on the ARRC site:

- an exploration well to provide critical data (water temperature, flow rates and water chemistry) to inform the engineering design specifications for the production system; and
- a production "doublet" – geothermal extraction and re-injection wells.

The diagram below provides a generic schematic representation of a direct heat geothermal demonstrator, incorporating a slim-line exploration well, and extraction and reinjection production wells.

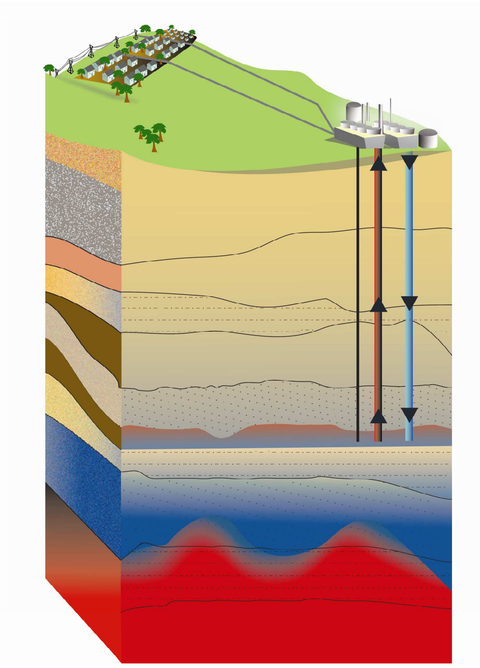

Figure 2. Schematic representation of a direct heat geothermal plant, incorporating a slim-line exploration well (black), and extraction (brown) and reinjection (blue) production wells.

The exploration well is critical as there are no hard data indicating water temperature (and chemistry) at depths of ~3 km in the Perth Basin – the proposed depth of the geothermal production wells.

This depth of drilling is based on data sourced from a ~800m Water Corporation bore adjacent to the ARRC site. Data recently acquired from re-logging this bore by the

WA Geothermal Centre of Excellence, suggest water temperatures of ~100^{O}C at a depth of 3km.

Current planning is based on a single deployment of a drill rig to minimise costs. In other words, all three wells will be drilled sequentially with minimal time delay between the exploration and production drilling programs – sufficient only to acquire the necessary engineering design specifications.

After acquiring the necessary design data from the exploration well, it is proposed that it be maintained at a depth of 1km as a research well to provide real time data on production well performance for R&D education & training purposes and as a test bed for down-hole monitoring equipment.

2.3 Budget

Infrastructure Item	**EIF Funding ($ million)**	**Other Funding ($ million)**
Exploration/Research Well	[redacted]	[redacted]
Production (extraction) Well	[redacted]	[redacted]
Production (re-injection) Well	[redacted]	[redacted]
Drilling Contingency	[redacted]	[redacted]
Down-hole Sensors	[redacted]	[redacted]
Project Management	[redacted]	[redacted]
Totals	**19.80**	[redacted]

3 Energy Management for the Murchison Radio-astronomy Observatory

3.1 Background

The Australian SKA Pathfinder (ASKAP) radio telescope will be an array of up to 36 parabolic dishes, each of 12 metres diameter. Phased array feed receivers at the focus of each dish will measure radio waves received from astronomical sources at frequencies between 800 MHz and 1700 MHz. The signals will be electronically combined in a data processing facility at the MRO, and transmitted to a large supercomputer at the Pawsey Centre that will further process the information.

The ASKAP telescope will deliver world-leading performance in a wide range of applications including cosmology, the study of transient radio sources, pulsar astronomy, and the study of the structure and magnetic field of our own galaxy.

ASKAP is being constructed in the Mid West of Western Australia at the Murchison Radio-astronomy Observatory (MRO). The MRO is approximately 315 km north east of Geraldton, on land within Boolardy Station pastoral lease (see Figure 3).

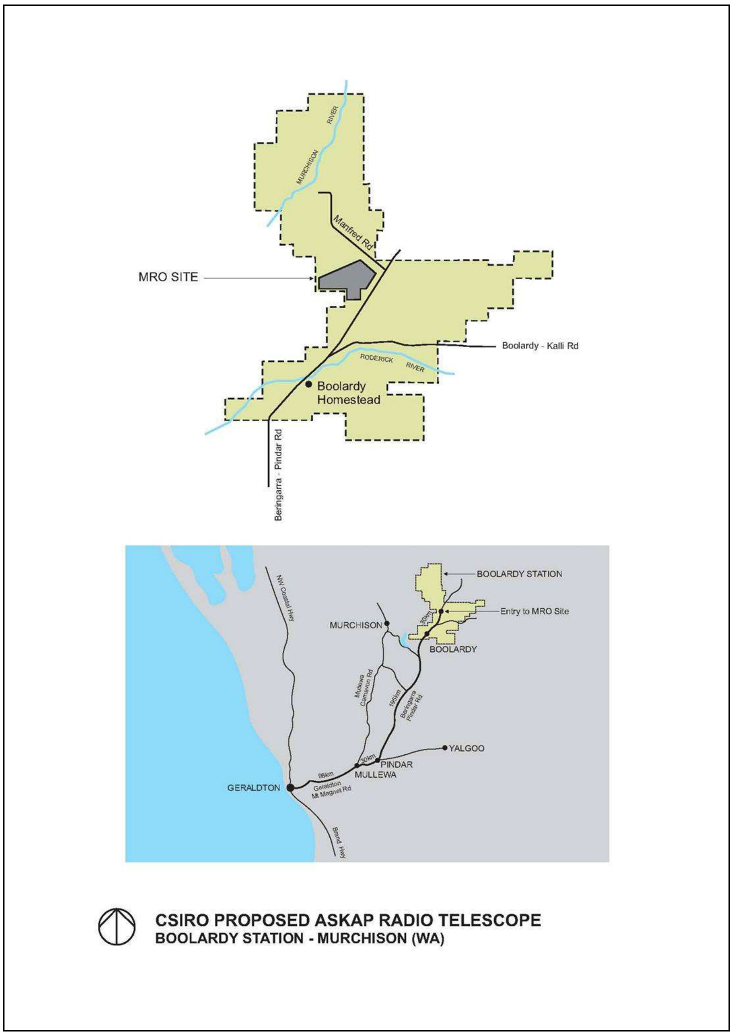

Figure 3. Site of the Murchison Radio-astronomy Observatory

The MRO is also Australia's candidate site for the international Square Kilometre Array radio telescope. Effective demonstration of renewable energy solutions at the MRO will strengthen Australia and New Zealand's bid for hosting the SKA.

3.2 Objectives and Infrastructure Requirements

The MRO is too remote for feasible provision of power through the grid. In order to minimise capital and operating expenses in power provision, there is a strong need for careful demand side management in the design of the telescope and support infrastructure. In addition, there is a need to provide as much power as possible through clean energy sources to minimise the carbon footprint of the operation.

The funding provided by EIF enables the ASKAP project to realise its stated goals in three important areas, which are outlined in more detail in the sections below:

- The development of remote power generation infrastructure that utilises renewable technologies to reduce reliance on traditional energy sources by over 50% (paragraphs 6, 160, 161 of 2008 PWC ASKAP submission), together with an underground power distribution network to minimise radio-frequency interference to the sensitive ASKAP receiver systems (paragraphs 162-165 of 2008 PWC ASKAP submission)
- The development and use of ground coupled cooling systems to cool the electronics in the ASKAP antennas and the data processing facility in the MRO control building. The EIF Sustainable Energy for SKA project provides funding for the project to deploy passive geoexchange cooling technology on the MRO (para 157 of 2008 PWC ASKAP submission
- The enhancement of the energy efficiency of the MRO control building through building techniques that reduce the power load whilst also preserving the radio-frequency interference integrity of the building (para 157 of ASKAP submission).

3.2.1 Power generation system

The peak power load of ASKAP and other facilities on the MRO is estimated to be of order 1 MW. CSIRO has been in negotiations with Horizon Power, a 100% WA Government owned company, regarding Horizon Power's provision of a solar/diesel hybrid power system to provide the energy requirements of the MRO. Horizon Power has proposed an initial investment by the company [redacted] in the initial power station infrastructure for ASKAP. The EIF funding provides $2.5 million to enhance the renewable component of the initial solar/diesel hybrid power station.

The proposed site for the power station is indicated in Figure 4. Clearing permits for the power station land have been obtained from WA Department of Environment and Conservation and, because the project goal has been to seek to enhance the renewable component, the clearing permit obtained includes sufficient land for the enhanced renewable deployment now possible with funding under EIF.

Figure 4. The MRO, showing the locations of the MRO control building and the proposed site for the power generation system

ASKAP, as a radio telescope that operates 24/7, has an unusually flat electrical load profile. This presents particular challenges for renewable solar energy provision, due to the expense of energy storage required to enable overnight operation. The EIF funding provides a further $11 million in 2013 for implementation of a next-generation energy system to enhance the renewable penetration of the power generation system. The goal is to reduce reliance on traditional energy sources by >50%. Various options will be investigated over the next two years to determine the most appropriate technology to achieve this goal. One option is further photovoltaic cells and battery storage, but it is possible that technologies currently under prototyping development, such as solar thermal plants, may be deployable on this timescale. We expect, at this stage, that the land already set aside on the MRO for the power station will be sufficient for this next-generation deployment.

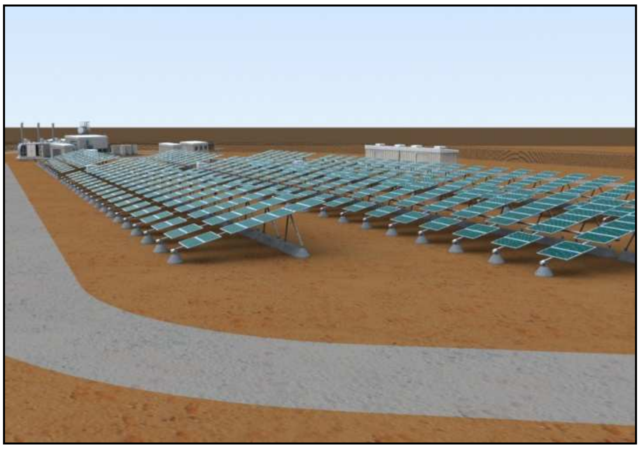

Figure 5. An artist's impression of a hybrid diesel/solar PV power station similar to the proposed initial power station for the MRO.

3.2.2 Demand-side management

Ground-coupled cooling system

CSIRO has been exploring with Direct Energy, an Australian start-up company, the potential for use of geoexchange direct heat pump cooling system for the ASKAP antenna electronics and the cooling requirements of the MRO control building. This technology has the potential to significantly reduce the power demand of the ASKAP system. Direct Energy is a co-investment partner in the *Sustainable Energy for SKA* project, and EIF funding of $3 million has been provided to fund the installation of geoexchange direct heat pump cooling at the MRO.

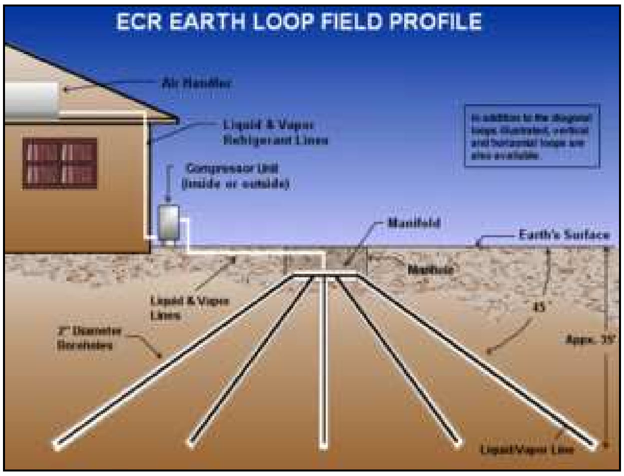

Figure 6. A schematic illustrating a direct heat pump geoexchange cooling system.

MRO control building

The MRO control building presents an unusual challenge. The intensive processing of raw ASKAP data required in the building is energy intensive and generates significant heat. On the other hand, the stringent radio-frequency screening requirements of the building, necessary to preserve the pristine radio-quiet environment of the MRO, limits traditional techniques of passive cooling such as enhanced free air flow. A design study has optimised the energy efficiency solutions for the MRO control building and EIF funding of $4.5 million has been provided to enable a building to be constructed that is sensitive to energy efficiency and yet meets the stringent radio-quietness constraints.

3.3 Budget

The Table below indicates a budget breakdown of the MRO component of the *Sustainable Energy for SKA* project. EIF funding, and other funding are indicated.

Infrastructure Item	**EIF funding ($million)**	**Other Funding ($million)**
MRO Control building	[redacted]	[redacted]
Geoexchange cooling at MRO	[redacted]	[redacted]
Power distribution network	[redacted]	[redacted]
1st stage power generation system	[redacted]	[redacted]
2nd stage renewable power generation system	[redacted]	[redacted]
Project management	[redacted]	
Performance monitoring/education	[redacted]	[redacted]
Total	**27.5**	[redacted]

4.0 Environmental Impact

Establishing the Pawsey Centre/ARRC as a geothermal demonstration site will confirm the long-held potential of the Perth Basin as a significant direct heat renewable energy source. If successful, the Pawsey Centre/ARRC deployment will provide proof-of-concept for much larger-scale exploitation of the Perth Basin hot, sedimentary aquifers and thus has the potential to significantly reduce the carbon footprint of the Perth metropolitan area. Specifically, the geothermal demonstrator will reduce energy consumption at the Pawsey Centre by up to 40%. Our plan includes provision for full environmental approvals to ensure that developments at the Pawsey Centre/ARRC showcase best-practice sustainable management of the aquifer resource within the Perth basin.

The energy management systems proposed for the MRO will reduce the carbon footprint of the radio astronomy operations at the MRO by over 50%, and thus will assist CSIRO to reach its goal of carbon neutrality. The development of sustainable energy solutions for the SKA pathfinders will also assist the international SKA program to develop energy efficient solutions for SKA deployment.

CSIRO has already obtained environmental approvals and clearing permits for the MRO land proposed for the power generation system, and is committed to follow a detailed Environmental Management Plan for the site.

This investment has the potential to cut energy costs by $5 million per year, and reduce Australia's carbon emissions by 12,000 tonnes per year - the equivalent of taking 6,000 cars off the road.

5.0 Community Impact

Performance monitoring data from the energy infrastructure is to be made available via a web-accessible interface to enable learning institutions to utilise the data in teaching and learning programs. The EIF funded infrastructure will thus have broad impact in the development of renewable energy technologies in Australia and overseas. It is estimated that the data generated will support more than 20 existing research groups in Australia, and has the potential to create more than 15 new research collaborations. In addition, construction of the infrastructure is expected to generate over 80 jobs for the duration of construction, including many in regional areas.

The EIF-funded renewable energy technologies proposed for the Pawsey Centre and ASKAP were described and flagged as options being pursued in the previous submissions on these projects to the PWC. The community have been consulted about the projects and submissions by members of the public on the projects were reviewed by the PWC.

6.0 Timing

The Table below indicates the key development milestones for the project.

Planned Project Milestone	Expected Completion Date of Project Milestone
Commissioning of MRO control building completed.	May 2011
Commencement of geothermal drilling program – exploration/research well, followed by production wells.	August 2011
Completion of geothermal drilling program and equipment installation down- hole.	November 2011
MRO power station and distribution network construction and commissioning completed.	December 2011
Commissioning of geoexchange cooling: antennae & central site completed.	March 2012
Installation commencement for next-generation renewable penetration technology at MRO.	March 2013
Installation of next-generation renewable penetration technology at MRO completed.	August 2013
Project completion.	December 2013

7.0 Conclusion

CSIRO has presented an outline of the infrastructure to be constructed under the *Sustainable Energy for SKA* EIF project. The EIF funding enables CSIRO to take up options for renewable technology deployments described and foreshadowed in the Pawsey Centre and ASKAP PWC submissions. The EIF funded infrastructure will have broad impact in the development of renewable energy technologies in Australia and overseas.

CSIRO is seeking the agreement of the Committee that the *Sustainable Energy for SKA* EIF-funded project be considered as an extension in the scope of the Pawsey Centre and ASKAP projects.