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Environment Centre NT

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Scoping workshop on Australia-South East Asia grid connection to catalyse regional generation and distribution of renewable energy

WORKSHOP REPORT

Charles Darwin University, Darwin, Northern Territory, Australia. July 29th-30th 2013.

Partnering Institutions:

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Why connect electricity grids from Northern Australia to South East Asia?

An intercontinental grid interconnector will help to secure energy supplies for the region, reduce energy conflicts, address climate change and low carbon futures, maximise the regions' natural advantage of renewable resources, build regional partnerships and go some way to reducing energy poverty in the region.

Is grid interconnection between Northern Australia to South East Asia technically feasible?

Yes. It is possible to connect between Northern Australia and Indonesia/Timor Leste via High Voltage Direct Current (HVDC) subsea cable using existing technologies. However, there are significant challenges of ocean depth and distance, existing network capacity at either end, and grid stability issues that will require further investigation.

Are there enough renewable energy resources in the region to make this idea feasible?

There are significant world class, largely untapped, renewable energy resources in the region. Northern Australia has one of the largest solar resources in the world, whilst Indonesia and Timor have significant geothermal and tidal energy resources. A spatial regional renewable energy resource assessment should be undertaken to understand these resources better.

Is there a strong business case for grid interconnection?

It is unlikely that there is a strong business case for grid interconnection at this stage. There are numerous financial challenges relating to the costs of renewable energy and HVDC and network cabling. However, the costs of renewable energy are rapidly falling and as subsidies from fossil fuel energy sources are reduced such a project is likely to become more cost competitive

How much would regional grid interconnection cost?

A very rough back of the envelope estimate of the CAPEX of grid interconnection is $US8 billion. This is based on the current costs of HVDC cabling, network connections and 1000MW of solar power in northern Australia. Further economic analyses would need to be undertaken to determine a more realistic CAPEX .

What are the most likely routes and scale for grid interconnection?

The most economically and technically feasible route is likely to be between Darwin and West Timor and then across to eastern Java via HVDC cable and then a land cable across to Jakarta. This wwould connect to the energy load centre of Jakarta, with the capacity to deliver energy to Timor Leste also.

Laying HDVC deep sea cable

Why invest in renewable energy when oil and gas are being extensively developed in the region?

Addressing climate change requires moving away from fossil fuel based energy sources such as oil, gas and coal. It is important that energy futures for the region invest more in renewable energy in order to reduce greenhouse gas emissions. Energy security is also improved when there is a diversity of energy sources.

Would South-East Asian nations want to import renewable energy from Australia?

This is unknown. There remain geopolitical issues around energy sovereignty that the project will need to investigate further, and partnerships between countries are critical. However, Indonesia and nine other ASEAN countries are already working towards an ambitious ASEAN power grid action plan to interconnect electricity grids between the 10 countries by 2020.

'Energy security is improved when there is a diversity of energy sources.'

Are there grid stability risks that could occur from the intermittent power provided by renewable energy?

Yes, renewable energy has challenges with providing power 24 hours, 365 days of the year, but these are not unsolvable. Solutions would need to consider storage and or hybrid systems. Large scale grid interconnectivity also makes it easier to manage intermittency issues in a scenario where there are distributed renewable energy sources.

What would happen in the event of cable failure?

This is a risk that would need to be managed and how cables would be repaired should be properly investigated. A single HVDC cable is faced with risks of damage and failure such as from underwater earthquakes or mudslides, strong currents or anchor strikes.

Should the grid interconnection project be investigated further?

Yes. The general consensus from the workshop was that there were significant strategic imperatives for realising electricity grid interconnection between Northern Australia and South East Asia that should promote further research and investigation.

Executive Summary

The Workshop on "Interconnection of Electricity Grids between Northern Australia and Southeast Asia" was held at Charles Darwin University, Darwin, on 29 – 30 July 2013. The two-day Workshop scoped possibilities and challenges in integrating electricity grids in Northern Australia and Southeast Asia to enhance opportunities for the generation and distribution of renewable energy, improve energy security and cut energy poverty in the region.

The Workshop was organised by the Environment Centre NT and the Centre for Renewable Energy - Charles Darwin University and brought together over 25 experts and practitioners in the areas of renewable energy and energy markets, High Voltage Direct Current (HVDC) cables, policy makers and government officials from the Northern Territory, Indonesia and Timor Leste.

If constructed, the Australia-Asia Interconnector would be the longest and deepest subsea HVDC cable in the world, and the first to connect electrical grids between different continents (though other projects are underway).

'if constructed, the Australia-Asia Interconnector would be the longest and deepest subsea HVDC cable in the world'

The Workshop identified the following key issues that could be considered as important drivers for this ambitious but not unrealistic concept:

- Reducing emissions and tackling climate change
- Meeting rising energy demand in SE Asia
- Developing Northern Australia
- Addressing the inevitable depletion of non-renewable fossil fuel sources
- Realising the untapped world class renewable resources in the region
- Reducing the health and environmental impacts of coal, diesel and nuclear power
- Alleviating energy poverty
- Increasing energy security and reducing energy conflict risks
- Promoting energy cooperation for reduced energy conflicts
- Building regional partnerships
- Reducing the budgetary costs in Indonesia of major subsidies for diesel and electricity
- Falling costs of solar power and rising costs of fossil fuels

The Workshop also identified several key constraints that pose significant challenges to the realisation of the concept, split in to technical, financial, geopolitical and regulatory issues.

Solar power tower, Spain

Subsea HVDC cables technology is well developed and has been deployed throughout the world. The critical technical challenge to Australia - Asia grid interconnection is the depth of the ocean in the Timor Sea and distance between main areas of energy generation and energy demand. Different route options were discussed, with the most probable being from Darwin across to Timor, a distance of approximately 700 km depending upon the exact route chosen.

However, this would still require crossing the Timor Trench, which is a significant depth (around 2-3 km). It was noted that although it was not impossible to lay cables at such depths, it has not been done before. Laying a very long and heavy cable would place demands on existing submarine cable manufacturing facilities, be dependent on metals pricing such as copper and aluminium, and require very large cable laying vessels of which only 10 currently exist globally.

The region is also seismically active. The impacts on reliability of electrical supply due to a broken, or damaged, cable due to underwater earthquakes or mudslides, strong currents or anchor strikes would need to be assessed, including how a cable could be repaired. Significant concerns were identified for regional electrical grid stability that would arise from a failed cable.

Large infrastructure costs due to long distance transmission lines and associated technical challenges were also identified as a serious constraint. On the other hand, domestic energy markets in the region are characterised by mismatch between the demand and resource sites, making grid interconnection - which could promote renewable energy deployment an attractive option.

The Workshop pointed to an option of investing in domestic renewable energy in ASEAN nations which might make more economic sense than grid interconnection. It was noted that distributed photo-voltaic (PV) systems are growing in Indonesia in the domestic market and will be an important part of the energy mix in the future. However, an integrated grid could embrace the diversity of renewable energy resources along the route and provide an integrated regional energy hub. The solar resource, and land available for utility scale solar power plants, was identified as being of higher quality in the savanna and semi-desert regions of northern Australia than in equatorial Indonesia.

Furthermore, a HVDC cable was just one of various options of delivering renewable energy to Asia into the future. Other technologies such as solar fuels may develop further that could deliver better options from technical and economic standpoints. The region may also benefit from many renewable energy technologies which could deliver large scale energy supply in the region, most likely in the way of solar PV, concentrated solar thermal, geothermal and tidal.

The Workshop also raised concerns regarding the capacity of the electricity grid in Indonesia and Timor Leste to cope with new supply coming from a HVDC cable. The most feasible option to overcome this would be to connect to the higher load centre of Jakarta where AC networks are likely to be more robust. The likelihood of a multi-terminal interconnector delivering loads at different nodes was considered unlikely from a technical and economical point of view. However, provisions for a three terminal interconnector could provide electricity into Timor and Jakarta. Further work would need to be undertaken to consider AC network system capacity and system stability etc.

One of the greatest challenges from an economic perspective is finding finance to cover the potentially large CAPEX involved in the cable installation.

A very rough estimate for an Australia-Asia Interconnector and associated renewable energy generation was considered to be $8-10 billion, including 2000 km of HVDC subsea cable ($1-2 million per km), 1000Megawatt of solar PV and solar thermal ($2-3 million per MW), $18 million for Indonesian geothermal, and $18 million to upgrade or duplicate existing land AC transmission networks and $18 million for AC-DC converters and contingencies.

This challenge should be helped by reduced subsidies to fossil fuels and introduction of price on carbon in region. However, coal fired electricity in western Indonesia currently retails for 6c/kWh (approx) while Australian solar power exported to Java is unlikely to retail for under 30c/kWh at current infrastructure prices[1]. Accordingly, no business case exists in the short to medium term, and without significant government subsidies.

The Workshop also noted the geopolitical and regulatory issues the grid interconnection could bring about. Indonesia's Electricity Law (Law # 30 - 2009) essentially prohibits importing electricity if local demand has not been filled (Article 39 'Cross-border Electricity Trade'). In addition to this will be the importance of engaging with state owned electricity generators, such as Power and Water Corporation in the Northern Territory and Perusahaan Listrik Negara (PLN) in Indonesia.

The Workshop agreed that further discussions and research projects are required to explore in more detail on the feasibility of such a concept. ASEAN-Australia Comprehensive Partnership Agreement (2014-19 phase) and the Science and Technology Cooperation Agreement were noted as two key institutional arrangements warranting investigating for government to government and technical discussions.

[1] This is very approximate and conservative, and other estimates have been lower (see presentation from workshop delivered by Andrew Blakers for a solar PV/pumped hydro plant).

Background

Dealing with the challenges of energy security, energy poverty and climate change facing South East Asia will require thinking in new ways about the development of critical energy infrastructure for the Twenty First Century. An interconnected regional grid tapping into utility-scale renewable energy is a long-term option in this Asian Century for reducing reliance on fossil fuels and associated pollution, buffering rising energy prices and reducing energy security risks. Grid integration via a subsea cable between Northern Australia and Southeast Asia offers the tantalising opportunity to stimulate regional renewable energy production, substantially cut energy poverty, and avoids the risks and escalating costs from fossil fuels and nuclear power.

The region has vast untapped world class renewable energy sources in the way of solar, tidal, and geothermal. However, the uptake of renewable energy in Northern Australia has been slow, limited by an abundance of natural gas and small energy markets. For example, less than 1% of the Northern Territory's current stationary energy production is from renewable sources. Indonesia and East Timor also possess potentially large renewable energy resources, but currently lack investment and integrated electricity grids to foster their development. Australia and Indonesia export and trade coal, oil, gas and uranium, why not also export and trade renewable energy?

'why not export and trade renewable energy?'

Context and rationale

Energy demand in South East Asia is rising almost twice as fast as the rest of the world, and is set to increase by 90% by 2030[2]. Of that mix, the greatest demand will come from electricity needs. Meeting this energy demand will be a serious security issue for the region. It is predicted by 2035 that most of Asia will be heavily dependent on energy imports[3]. Securing an adequate and reliable source of energy supply will be an ongoing challenge that if not managed intelligently and strategically will lead to potential regional energy conflicts.

The Fifth Assessment Report of the International Panel on Climate Change (IPCC) states the world has warmed by almost an average 1ºC and is on track with current policies to warm by 2-5.4ºC by 2100[4]. The primary cause of the observed changes in the Earth's climate are from human activities, mainly through the burning of fossil fuels such as coal, oil and gas, along with agriculture and land clearing emissions. Changes to our climate is leading to an increase in the frequency and severity of many extreme weather events, altering rainfall patterns, creating risks for human well-being, the economy and the environment. Stabilising the climate system will require substantial and sustained reductions of carbon dioxide (CO2) emissions.

Renewables are predicted to almost equal coal as the primary energy source by 2035[5]. Realising this economic opportunity is critical for the region, and should seek to maximise natural advantages. If the region continues along its current trajectory of fossil fuel based energy sources, greenhouse gas emissions will significantly rise in the region.

[2].International Energy Agency (2013) "South East Asia likely to play increasingly significant role in the world's energy markets", http://www.iea.org/newsroomandevents/news/2012/may/name,27338,en.html

[3].Ibid

[4]International Panel on Climate Change (2013) "Climate Change 2013: The Physical Science Basis, 5th Assessment Report" http://www.ipcc.ch

5. International Energy Agency, "World Energy Outlook 2013" http://www.worldenergyoutlook.org/

Inevitably ASEAN nations will adopt tougher emissions reduction policies and targets, raise investment and realign policy frameworks to support renewable energy, and place a price on carbon pollution. This will lead to rises in the cost of gas, oil and coal. Meanwhile, the costs of large scale renewable energy technologies continue to fall.

Australian deserts could provide a significant portion of power to ASEAN nations within a few decades. The regional energy transmission infrastructure required to create an Australia-Asia Interconnector could facilitate commercialisation of renewable energy in Indonesia and East Timor, particularly geothermal and solar, by deepening grid development and growing energy markets.

Return on investment would be potentially substantial over this Asian Century. Regional grid interconnection coupled with major investment in regional renewable energy generation would catapult Australia and ASEAN nations towards low carbon economies, alleviate Asian energy poverty, and enable reductions in regional greenhouse gas emissions.

Technical challenges and opportunities

Such a venture is ambitious but not unrealistic. Technological advances in HVDC cables and falling renewable energy costs may make an Australia-Asia Interconnector more of a realistic possibility in the next decade or two. There already exists over 20 HVDC sub-sea electricity cables around the world[6]. Renewable energy is exported undersea 580km from Norway to the Netherlands, and 290km from Tasmania to Victoria.

Iceland plans to send geothermal power to Scotland. The Desertec Africa-Europe initiative aims to send solar power 3000km from Algeria to industrial Germany. Energy loss through long distance transmission continues to fall as subsea HVDC cables increase in capacity.

Cumulative transmission losses over long distances will continue to fall due to innovations in cable design as larger boats are built to enable longer cables to be laid, and AC-DC conversion increases in efficiency. For example, the benchmark standard for high voltage sub-sea transmission has been predicted to increase from 400 kV to 600 kV within a decade[7]. Transmission losses are now as low as 15% per 1000km, including AC-DC conversion and conversion from land to sub-sea transmission.

The year 2022 will mark 150 years since the first telegraph submarine cable was laid between Darwin and Java in Indonesia, connecting Australia to the rest of the world[8]. Instantly it changed Australia's sense of identity, making communication between the isolated nation and the rest of the world possible in hours instead of weeks and months. For Northern Australia, the telegraph line helped speed up settlement and the growth of the pastoral and mining industries. Now 150 years later there lies a new opportunity for Australia's development and engagement with the region. Several options for grid interconnection between Northern Australia and Asia were considered, the most technically feasible and cost effective being from Darwin to West Timor to eastern Java.

This would cover a distance of 700 km (approx) from Darwin to West Timor and across the Timor Trench, which reaches a depth of approximately 1.6 to 3.3 kms deep[9]. The cable from Timor to eastern Java would measure approximately 1000km undersea, plus potentially an extra 900 km on land to Jakarta.

6.Wikipedia, "Submarine Power Cables" http://en.wikipedia.org/wiki/Submarine_power_cable.
7.Ian Burgwin, pers.comm. General Manager, Basslink Consulting, September 2013.
8.Huurdemann, A. (2003) "The worldwide history of telecommunications", John Wiley and Sons, New Jersey.
9 Wikipedia, "Timor Sea" http://en.wikipedia.org/wiki/Timor_Sea

To put this challenge in perspective, the deepest existing HVDC sub-sea cable is the SACOI cable which drops to 1,600m near Italy, and the longest is the NorNed cable stretching 580km along the bed of the Baltic Sea between Norway and the Netherlands. Such an idea poses significant technical, institutional, economic and social challenges.

Despite these challenges, the potential benefits of such a future should warrant further investigation. Increasingly, public acceptance of different energy sources is moving away from fossil fuels and shifting towards renewable energy.

If Australia is to seriously meet the sustainability challenges of the century it needs to explore such options, and shift from its current focus as an energy exporter of coal and natural gas.

Average annual solar radiation in northern Australia is 21-24 Megajoules/m² per day, much higher than the world average and compared to the solar resource through south east Asia[10]. Conversely Indonesia has the world's second largest geothermal resource. Tidal power hotspots also occur along the Indonesian archipelago and close to Darwin.

10. Geosciences Australia (2010), "Solar Energy" Australian Energy Resource Assessment http://www.ga.gov.au/image_cache/GA17057.pdf

The workshop

There has been emerging interest in the idea of Australia-Asia grid connectivity with several scoping projects underway looking at the idea in detail to map out some of the opportunities and challenges [11 12 13].

To build upon this work and give momentum to the idea, a workshop was held in Darwin, Northern Territory of Australia on 29 and 30 July 2013. Hosted by the Environment Centre NT and the Centre for Renewable Energy at Charles Darwin University it brought together over 25 experts and practitioners in the area of renewable energy and energy markets, HVDC cables, policy makers and government officials.

The workshop sought to scope possibilities and challenges in integrating electricity grids in Northern Australia and Southeast Asia to enhance opportunities for the generation and distribution of renewable energy, grow energy security and cut energy poverty.

The following report summarises some of the key questions identified, challenges and technologies that need investigation in a future feasibility study.

11. Blakers, A., Luther, J., and Nadolny, A. (2012) Asia Pacific Super Grid – Solar electricity generation, storage and distribution, Green 2 (4) pp.189-202
12.Taggart, S., James, G., Dong, Z. Zhaoyang, D., and Russell, C. (2012) "The future of renewables linked by a transnational asian grid" Proceedings of the IEEE, 100 (2)
13.Sue, K., Hussey, K., and Pittock, J., 2013. *Renewable energy export for the development of an Asia-Pacific Super Grid: Preliminary Review of Research Directions.* Canberra: Australian National University.

'If Australia is to seriously meet the sustainability challenges of the century it needs to explore such options, and shift from its current focus as an energy exporter of coal and natural gas.'

1.Opening Address
Vice Chancellor Professor Barney Glover of Charles Darwin University. Northern Territory Government

Good morning everyone,

As the Vice Chancellor of Charles Darwin University I would like to welcome you all here today, and I welcome the Hon. Minister Peter Chandler and the Consul of Indonesia Mr. Ade Padmo Sarwono.

Thank you for joining us, it is great to see so many experts here in the room, many of you that have travelled far and wide to be here today and tomorrow for what hopefully will be a great opportunity to build upon partnerships in our region and deliberate over some of the opportunities and challenges facing this part of the world.

Charles Darwin University has a very proud record of investing in renewable energy and energy efficiency measures. Those of you who have the chance to look around the campus here today will be able to witness that. We were one of the first organisations in Australia to develop chiller plant technology here at this Casuarina campus which supports our climate control across our buildings across campus. It was one of the largest chiller plants in the southern hemisphere, and provides an enormous benefit to the environment and to the university by using that chilled water technology for air conditioning our campus.

But it doesn't stop there, we also have a strong commitment to solar photovoltaic technology. If you were to wander around campus you will see our solar charging station which we opened just recently, and this provides charging capabilities for our 2 fully electric vehicles, our Nissan Leaf and our Mitisubishi i-Miev. Steve Tiele who heads our facilities management here at the University is doing a great job at converting our fleet of vehicles to hybrid technology. I think now we have converted our entire sedan fleet and are starting in to the four wheel drives. So we have a strong commitment to renewable energy in that sense, bringing our fleet into hybrid technology.

Later this year our new trade training facility will have a very significant integrated solar array built into that complex. So we are not just retro fitting as we are doing in our other existing buildings on campus, but we will be putting a very sophisticated solar array into that building. We will be looking to use it as a showpiece for renewable energy particularly for training, for developing the green skills necessary and for students to be exposed to the most important aspects of that green technology. I think that it is a wonderful opportunity for the University.

We will be doing even more, we did a major energy audit last year and that highlighted ways we could significantly lower our energy consumption. If you know a little bit about Charles Darwin University you will know in the past four years we have gone through a massive building phase on our campus, and if you look across the road you will see the Menzies Public health building going up. Although we are putting enormous new infrastructure on campus we have actually lowered our energy consumption this year to below 2009 levels. We are doing a lot to reduce energy demand on campus.

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As well we are working with some of the big energy users in the area such as the Darwin hospital, Casuarina shopping centre, the Darwin International Airport, the Department of Defence, to work together for various strategies in co-gen and other forms of energy we might use to support our campus. In addition of course we are working with Tenux on a trial tidal energy project, and hope that that goes forward.

We work very closely with the Northern Territory Power and Water utility up here, they support the University's Chair in Sustainable Engineering Charlie Fairfield, so there is a very strong connection there and we are working ways in which we can help them broker particularly remote off grid power generation and making that more sustainable.

So the projects the Centre for Renewable Energy are working on are worth mentioning. In the context of northern Australia there are significant challenges to the development of renewable energy, not just our sparse and dispersed population, not just about the remote context which means complex technologies can be a challenge to develop and maintain, not simply being cyclone prone, not simply the climatic conditions.

It is in general a difficult environment to introduce new technologies so I think the Centre for Renewable Energy has a very strong mandate to look at all of those circumstances and work with private industry and try and find ways to drive sustainability in northern Australia.

So it is an exciting time for the university, it is an exciting time in the region, and it is a wonderful opportunity you will have here over the next two days to explore connectivity between Northern Australia, Indonesia and Timor Leste. I think it is a wonderful opportunity to further cement something that is getting a great deal of attention from the Northern Territory government. I know the Chief Minister has spoken extensively about tri-partied linkages between East Indonesia, East Timor and Northern Australia. It is important to develop business linkages, and for education people to people linkages, so this sits nicely in this framework of looking at trade and building relationships between our countries. From that perspective I think it is a very welcome seminar.

I hope that you enjoy it, I hope you find it challenging. I am glad to hear that the technological and engineering side of things might be more advanced than we imagined, so perhaps the economics, the geopolitical and the regional issues can be worked through and hopefully we will see this as a major opportunity for the region. I thank you and I certainly thank Andrew Campbell and Stuart Blanch for the initiative of bringing this together today. I am looking forward to hearing the outcomes of your deliberations and hopefully we can continue the discussions and see that momentum build up from this workshop. I am sure equally the Northern Territory government will be interested to see what comes out of this workshop and how government can promote these ideas and relationship building in the region. So I commend the Centre for Renewable Energy and thank you very much. Enjoy your two days, and your deliberations, and hopefully you have a chance to have a look around this campus as well. Thank you.

2. Opening Address
Hon Peter Chandler MLA, Minister for Lands, Planning and Environment, Northern Territory Government

Ladies and Gentleman,

I would like to welcome you all here to Charles Darwin University this morning and to offer you my very best wishes for the work that will be conducted here over the next couple of days .This will be the first meeting of its kind between such a broad range of interests to scope the challenges and opportunities around connecting electricity grids between Northern Australia and Southeast Asia to catalyse the regional generation and distribution of renewable energy.

The Northern Territory Government, through the Research and Innovation Board, is happy to contribute to assist this event taking place because like everyone here we know the vision of today will hopefully one day become the reality of the future. Growth in both Asia and the Northern Territory over coming decades will require sustainable, affordable energy options.

Some of the delegates here today may recall the long-term vision shown by the CLP Government during the 1980s which saw them chart the distinctly radical course back then of replacing cheap, available diesel fuel for electricity generation with clean, green gas – piped across the Territory from fields in Central Australia.

The additional costs incurred at the time have been repaid repeatedly through reduced emissions coming out of the Territory's power generators. The increased focus in recent years on alternative sustainable energy sources make gatherings such as this one important to the development of innovative solutions to the Territory's and the region's electricity needs. While at this stage renewable energy contributes a small proportion of energy supply in Northern Australia, Indonesia and most SE Asian nations – this will not always be the case.

Technological innovation and increasing demand are driving down costs for solar power plants and High Voltage Direct Current cables, making grid interconnection to catalyse renewable energy in the region more commercially competitive with fossil fuels and nuclear power. The Top End and northern Western Australia are quite literally a global hotpsot for high solar irradiance.

Similarly, Indonesia possesses globally significant geothermal power resources associated with the meeting tectonic plates and volcanoes that are almost totally untapped. Indonesia alone has a population of approximately 230 million – with the major energy load centre based in Java.

Electricity grids are penetrating further into Asia as nations seek to reduce energy poverty and increase living standards and support manufacturing. This is particularly so in China.

A subsea HVDC cable is also to be built between Sumatra and Java. Similarly ... the grids in Northern Australia are remote, small and disconnected to grids in eastern and south-western Australia.
While innovative in a Top End context ... the subject matter behind this workshop is not new.

The first subsea High Voltage Direct Current cable was built in the 1950s. There are now more than 20 such cables globally, including the Basslink cable between Tasmania and Victoria (280 km), the NorNed cable between Norway and the Netherlands (580 km along the bed of the Baltic Sea), and a Norway-England cable of >700 km is being planned.'

Darwin is around 600km from the south coast of Timor, a distant equivalent to that of the NorNed HVDC cable. Conceivably cables could then extend westwards along the Indonesia Archipelago to the major electricity demand areas on Java.

The technology is there – what must be determined is how the technology can be adapted on a sustainable, commercially viable basis. The feasibility of maintaining a subsea HVDC cable across the deep and seismically active Java or Timor Trench needs much discussion and investigation.

What would happen if it broke? How long would it take to repair such a break? Would redundancy need to be built in to accommodate such circumstances? The Territory and the region both require base-load power. How will alternative energy sources that depend on tides or the sun be able to ensure that requirement?

The NT already exports energy as LNG, oil and uranium to Asia, so why not solar-powered electricity too? As the price of fossil fuels slowly ramp up in Asian nations and as technology and falling costs make grid connection between Australia and Asia a real prospect to catalyse regional renewable energy, there will be increasing interest – and investment – in the proposal being discussed today.

I'm hopeful the discussions and workshops over the next two days go someway towards resolving these and other questions. Have fun working through these imponderables and good luck.

Workshop presenters.

3. Opening Address
Mr. Ade Padmo Sarwono, Consul of the Republic of Indonesia in Darwin

The Honorable Peter Chandler MLA, Minister for Lands, Planning and Environment, Northern Territory Government, Professor Barney Glover, Vice-Chancellor, Charles Darwin University,
Ladies and Gentlemen of the Workshop Speakers and Participants, Stuart Blanch, Director, Environment Centre NT.

I thank you for the invitation from the Environment Centre NT and Charles Darwin University to me to deliver remarks on the opening of this important workshop. The theme of this workshop indeed have touched upon Indonesia's –and also other Southeast Asia countries'- main priorities to developing their nations, providing electricity for the entire population, utilizing the untapped and underdeveloped renewable energy, as well as increasing energy security through a possible way of a regional interconnection.

Indonesia itself reached the electrification ratio as much as 76% in 2012. In the same year, there are 42% of Indonesia's population still using firewood as a replacement for electricity, which an indicative of an "energy shortage" and the crucial issue of sustainable energy in Indonesia. Facing this challenge, Indonesian government is currently focusing on the national management of natural gas as a top priority by committing to increase the share of renewable energy use, which is targeted to reach at least 17% by 2025.

In line with this goal, some programs under the National Energy Policy have been identified to support the development and utilization of renewable energy, which are still contributing a small proportion of energy supply although the potential renewable resources are numerous.

The technological innovation and increasing demand of energy are pushing down costs for renewable energy such as solar power plants and High Voltage Direct Current (HVDC) cables and making this renewable energy competitive to fossil fuels. Thus, there is possibility and more incentives for developing nations to develop renewable and environmental-friendly energy which later would reduce the risk of climate change.

In the wider region, Indonesia and other nine Southeast Asia countries under the ASEAN have been cooperating together to push the ambitious ASEAN power grid action plan, that is, to interconnect power lines in the 10 ASEAN Member States by 2020. This, of course, is not an easy task; however, the vision is there and all ASEAN Member States will increase all efforts in making the regional framework working effectively, including addressing other than technical matters, such as regulations, commercial, legal and technical standards, and other related matters.

The possibility of interconnecting grid between Australia and Southeast Asia will catalyse the future plan in the region on electrification including utilizing renewable energy.

I welcome the initiative of conducting this workshop and I hope this exercise will be a fruitful one in terms of exchanging ideas and identifying challenges lies ahead on the effort of catalysing regional generation and distribution of renewable energy in the region.

Thank you.

Participants at the scoping workshop. Charles Darwin University. July 29-30, 2013.

Workshop presentations

*The following are summaries of presentations given at the workshop. For full copies visit: http://*cre.cdu.edu.au/

1. An Australia-Asia Interconnector to catalyse regional renewable energy and grow energy security (Stuart Blanch and Rob Law, Environment Centre NT)

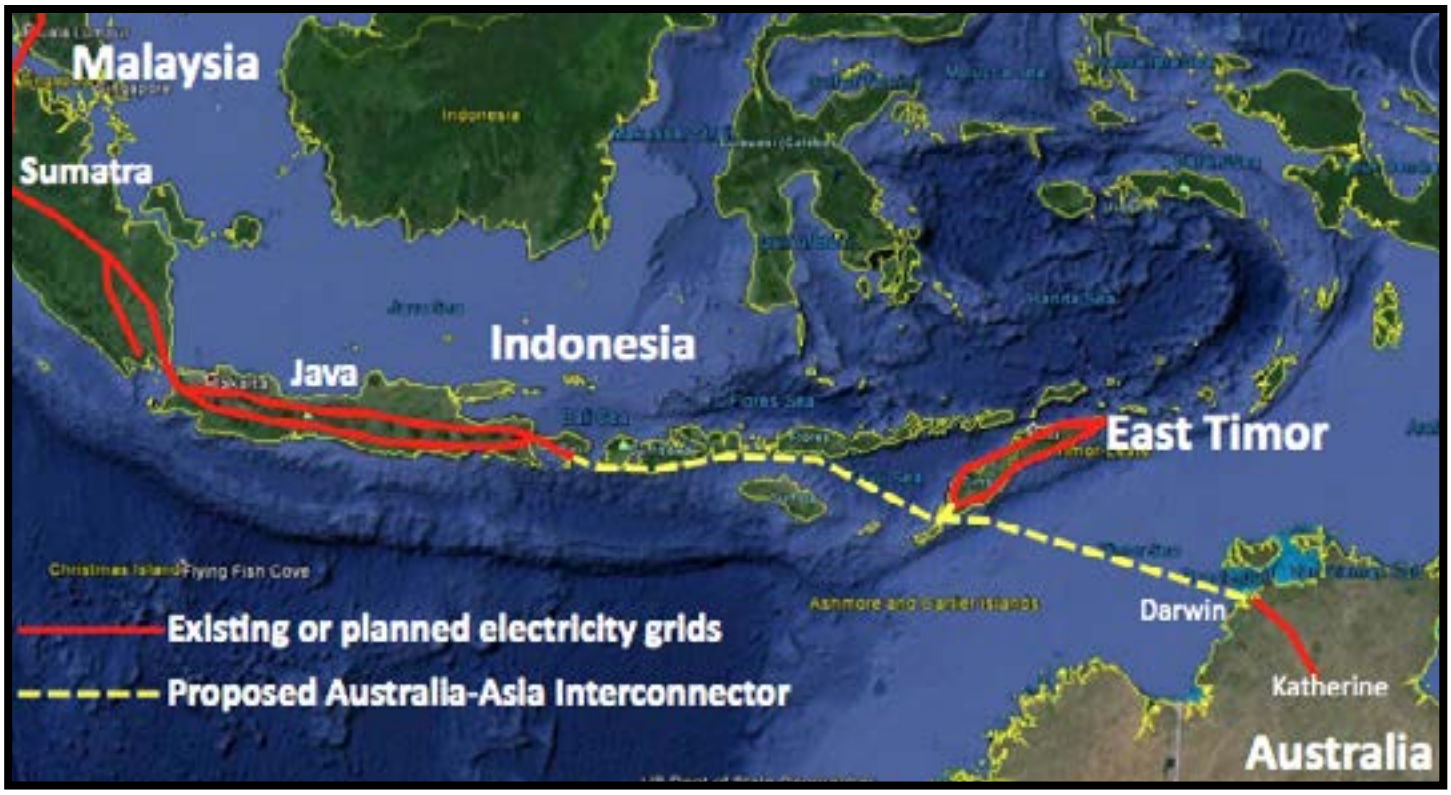
Dr. Stuart Blanch and Mr. Rob Law provided background and context for the workshop. They summarised existing submarine HVDC cables currently deployed around the world, of which there are currently more than 20 in operation, with the largest being the NOR-NED cable spanning 560km from Norway to the Netherlands, and the deepest being 1.6km from Sardinia to Italy.

There are also considerable untapped renewable resources in the region, particularly with solar and tidal in northern Australia and geothermal opportunities in SE Asia. Several different routes have been proposed in the past such as from Papua New Guinea to Cape York, West Papua to Gove, NT, Darwin to Timor and across to Java, and northern Western Australia to West Timor. It was argued that there are strong imperatives for investigating an interconnected regional grid based on renewable energy. These include addressing the increasing energy demand in SE Asia, improving energy security and reducing risks of energy conflict, curbing greenhouse gas emissions from fossil fuel use, technological innovations and falling costs of renewable energy, and building regional partnerships. There are however significant challenges that would need to be overcome such as the technical challenges associated with cable laying, grid stability and transmission loss issues, energy sovereignty and domestic energy policies, and building a strong business case and finding finance.

2. Renewable energy, water and an Australia-Asia electricity grid (Dr Jamie Pittock & Mr Keith Sue, Australian National University)

Dr Jamie Pittockdiscussed the planetary boundaries that society is currently overshooting, such as those driving widespread biodiversity loss, climate change, decline in available freshwater supplies. Setting the scene he discussed some of the challenges facing solar thermal plants that have high water requirements, as they often occur in arid regions with limited water resources available. A vision for large scale renewable exports may be based on important environmental drivers, but will face the challenge of becoming a competing land use in a water scarce northern Australia. He also detailed some of the competing visions that currently exist for an integrated regional electricity grid; the Beyond Zero Emissions 100% renewable stationary energy plan, the Desertec Australia project, the Greater Mekong sub region plan, and the ASEAN power grid.

Mr Keith Sue from the Australian National University delivered a presentation on the development of an ANU scoping paper on “Renewable Energy Export for the Development of an Asia-Pacific Super Grid”. He described four research clusters to advance the idea of an interconnected regional grid. These were: 1) Resources; Renewable Resource Availability and Spatial Analysis 2) Technical; Technical Feasibility of Generation and Transmission 3) Economic; Economic Feasibility and Market Integration and 4) Socio-political: Geopolitical and Strategic Benefits, Implications and Challenges. The end of the presentation outlined potential future directions and next steps involving project establishment, development of research clusters, and an initial research plan to be developed.



Existing, planned and proposed HVDC cables

3. Indonesia Energy Sector: Updates and Outlook towards Government's Energy Mix Policy Target in 2025 (Mr Joi Surya, Energy Nusantara)

Mr Joi Surya Dharma, founder of Energy Nusantara delivered a presentation on the projected energy mix of the Indonesian energy sector, focussing on current energy regulation and policy directions. He outlined the state of renewable energy in the country, the role of the state owned utility company Pertamina, and also described the electricity situation in Indonesia and interconnection plans with Malaysia. Fossil fuels of coal, oil and gas still make up the backbone of Indonesian energy supply, however Indonesian Energy Law 30 (2007) specifies a diversification of the energy mix to renewable energy, with a renewable energy target of 25% by 2025.

The challenge for renewable energy is that subsidies for oil, gas and electricity has been increasing over the last 5 years. A transformation paradigm for national energy management was proposed that would shift from a supply driven model with heavily subsidised fossil fuels to a demand driven model with highly diversified renewable energy of geothermal, wind, solar PV, waste to energy.

Regional electricity ratios were outlined showing low electricity ratios for eastern islands such as East Nusa Tenggara and Papua of less than 55% compared to 99% in Jakarta. Grid interconnection is happening at smaller scales between Indonesia and Malaysia such as an interconnector between Sumatra and Peninsula Malaysia, and West Kalimantan to Sarawak connector.

'HVDC technologies are continuing to evolve and remain the only way to cross large bodies of water.'

4. Lessons from Basslink's HVDC subsea cable between Tasmania and Victoria for potential grid interconnection between Northern Australian and SE Asian grids (Mr. Malcolm Eccles, Basslink Consulting Group)

Mr. Malcolm Eccles from Basslink Group gave a presentation on lessons learnt from the existing operational HVDC system between the Australian mainland and Tasmania. The cabling is a monopole configuration with 290km length submarine cable with a load of 500MW continuous and was first commissioned in 2006. Mr Eccles outlined the challenges of the project through the approvals stages in an environment where there was more community opposition than support and how these challenges were overcome. Construction and commission challenges were also detailed, and notably the challenges of dealing with a complex fragmented electricity market and a large number of stakeholders.

HVDC technologies are continuing to evolve and remain the only way to cross large bodies of water. For the Australia-Asia interconnector it was suggested the most likely route was from the north coast near Darwin across to the lower coast of Timor. Important issues that will need to be investigated further are where to connect and how strong the AC network is at that point, load loss from the AC network, water depth, seismic risk to cables, shore crossings and the economics.

5. Indonesian energy policy and opportunities and challenges for grid interconnection between Indonesia and Australia (Dr Ucok W. R. Siagian, Institut Teknologi Bandung, Indonesia)

Dr Ucok W.R. Siagian delivered a presentation on energy policy in Indonesia and the opportunities and challenges facing regional grid connection. Indonesian electricity demand growth will remain relatively high in the next 20-30 years and faces big challenges in meeting this demand. Indonesia's draft National Energy Policy released in 2012 aims to shift the energy resource paradigm from commodity into capital for national development, increase efficiency, conservation and protection of the environment, increase the share of new and renewable energies in the supply mix, and aims to secure energy supply for electricity and oil and gas for the short, medium and long term. Grid interconnection would need to consider the current regulations under "Cross Border Electricity Trade" Article 37-41 of Electricity Law No 30 -2009.

These laws reflect that energy demand is expected to be satisfied using domestic resources and that the Indonesian government is pursuing energy independence. However, there does exist the opportunity for grid interconnection between Australia and SE Asia, and Indonesia is active in establishing the ASEAN Energy cooperation, including regional power interconnection.

'Indonesian electricity demand growth will remain relatively high in the next 20-30 years and faces big challenges in meeting this demand.'

6. Grid development in China and East Asia, long distance UHVDC and CSP (Jerry Li, DESERT-EC foundation)

Dr Jerry Li, Coordinator of DESERTEC Foundation, outlined how the DESERTEC project is investigating an interconnected grid based on renewable energy in China and East Asia. The focus of this project is on long distance UHVDC cabling and strategic placement of Concentrated Solar Thermal plants in the region. Chinese deserts were noted as an important solar resource for the region and could meet the future electricity demand of China, Mongolia, Japan and Korea combined.

Also China are making considerable investment in grid development, and in the next eight years total investment in UHV cabling is estimated to be around USD 490 Billion. More broadly, Australia and China are two major centres of solar energy that can fill the energy demand of the whole Asia Pacific region. To achieve this will require deploying the best Concentrated Solar Plants and UHVDC technologies available. Australia has an advantage over Chinese deserts for CSP potential as they do not experience the same extremes as Chinese deserts. However China is making more progress in UHVDC deployment and further along in investigations into connecting to ASEAN. Thus there are important opportunities for collaboration between the two countries, and the availability of clean energy from Australia and China may accelerate the ASEAN power grid project and enhance the regions energy supply.

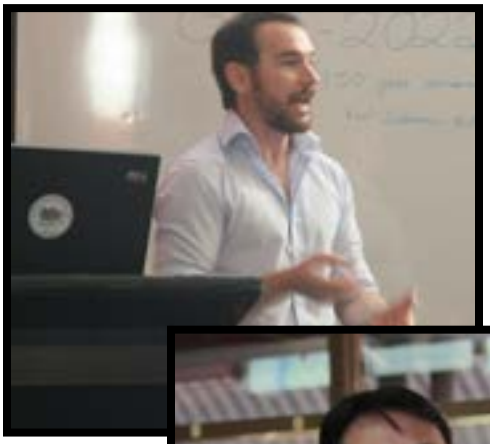
7. Asia Pacific Super Grid -Solar electricity generation, storage and distribution (Professor Andrew Blakers, Australian National University)

Professor Andrew Blakers from the Australian National University delivered a presentation on how an Asia Pacific super grid is technically and economically feasible now using existing technologies. A 2050 scenario was mapped out for the region whereby one third of electricity for SE Asian countries of Timor-Leste, Indonesia, Malaysia and Singapore comes from solar power in northern Australia. This could be achieved via large scale solar electricity transmitted via a “backbone” HVDC cable from northern Australia through SE Asia and competitive with locally produced solar electricity because of the high insolation levels in Australia.

The importance of hybrid systems using pumped hydro to overcome intermittency was emphasised. Prof. Blakers presented a potential model of a hybrid PV tracking array and pumped hydro storage plant located at Lake Argyle in Western Australia that could deliver approximately 100GW of power, 24 hours a day all through the year. Economic estimates of this scheme could deliver power to Jakarta at approximately 8 cents/kWhr, compared to the current 6 cents/kWhr from coal power. The capital required for a project would be large, estimated in the order of $500 billion. However, this is relative to the fact that Indonesia needs to invest $1000 billion in conventional power stations (coal and nuclear) in order to meet its energy needs in the next 40 years. Developing such a project would deliver energy security for the region and prepare for a carbon constrained world.

8. Grid interconnection between Asia and Australia to support carbon abatement (Mr. Stewart Taggart, Grenatec)

Mr. Stewart Taggart from Grenatec presented a scenario for a transnational Asian grid spanning from northern Australia right up into North East Asia. The approach outlined suggested using 'bundled' infrastructure of HVDC cables together with natural gas pipelines, and fibre optic cabling. The project used hourly climate data for a full year to estimate renewable energy generation in the region, electricity demand, generation capacity projected forward to the year 2025, and how this would all interact in an international market to demonstrate costs and benefits. Such a Pan-Asian Energy Infrastructure would address energy security issues, climate change and the need to reduce greenhouse gas emissions, and deepen energy market integration in the region. The conclusion from the Grenatec analysis presents a defensible case for deeper examination of the costs and benefits of an interconnected energy infrastructure for the region.



9. Hot, clean and complex: Unlocking Indonesia's geothermal power (Mr. Fitrian Ardiansyah, Australian National University)

Mr. Fitrian Ardiansyah from the Australian National University delivered a presentation on developing geothermal opportunities in Indonesia. Currently Indonesia has huge geothermal resources of an estimated 28,994MWe but development of these resources has been slow and is currently at 1,196MWe installed capacity. However, the Indonesian Government expects to have an additional 3,967 MW installed by the end of 2014. The presentation gave context to the electricity market in Indonesia, detailing demand by sector and region and presenting projections for electricity generation and greenhouse gas emissions under different energy scenarios. It presented some of the challenges in developing geothermal resources such as the need to expand the current grid infrastructure, existing tariffs at 9.7c/kWh, the cost of exploration and development, policy uncertainty and the overlapping of geothermal resources with forested areas (±60% in forest areas). The costs of coal are still cheaper compared to geothermal (highest cost of coal at US$7.5c/kWh compared to highest cost of geothermal at US$10c/kWh). To realise the geothermal opportunity, stronger supports and investment are required, and interconnection with other grid systems should lead to helping geothermal development.

10. Renewable energy resource assessment for Northern Australia (Dr. Tim Forcey, Beyond Zero Emissions)

Dr. Tim Forcey from Beyond Zero Emissions (BZE) delivered a presentation on two different studies modelling 100% renewable energy scenarios for Australia. The first study was the BZE 'Zero Carbon Australia Stationary Energy Plan' that outlined how Australia could produce 100% of its electricity with renewable energy and displace fossil fuel consumption.

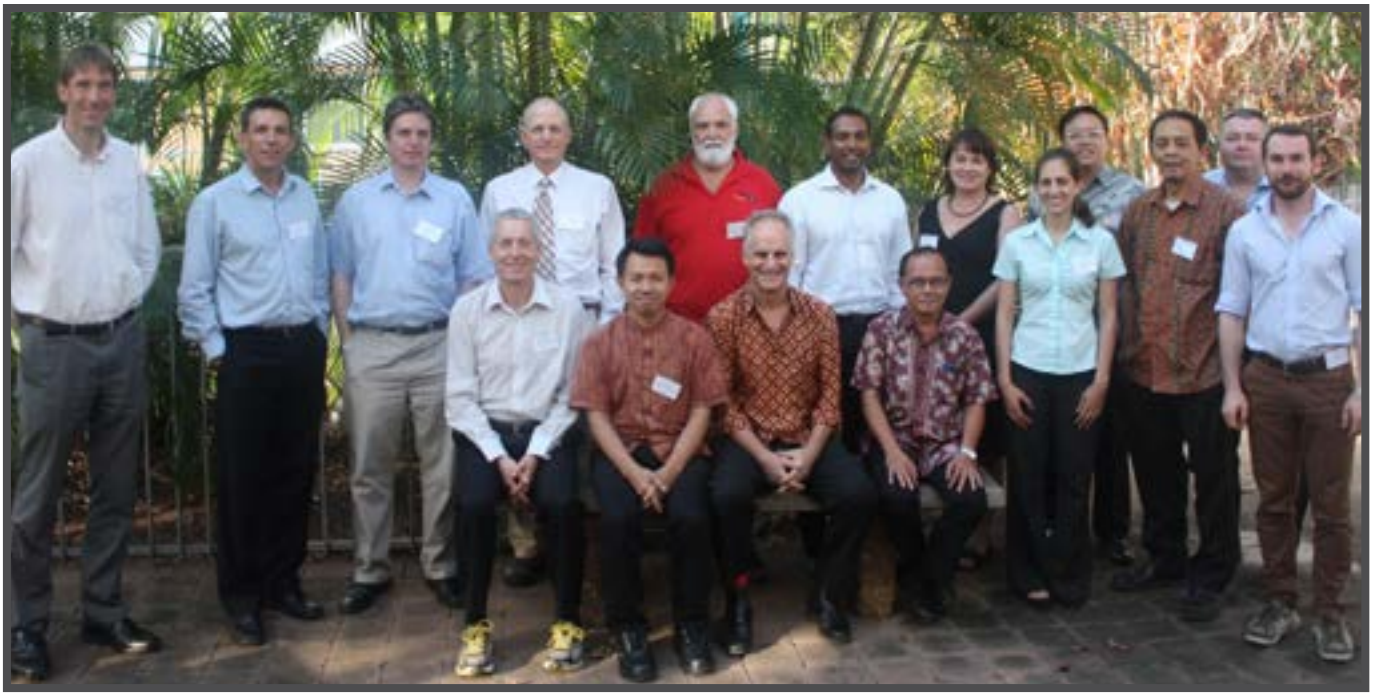
Also that the required facilities would not be that expensive and could be built in as little as 10 years were there the political and societal will to do so. In response to this plan the Australian Government directed the Australian Electricity Market Operator to conduct its own study into such a scenario. Similarly AEMO, who is actually responsible for operating the east coast electricity grid found no technological or operational barriers to supplying eastern Australia's electricity 100% from renewable energy. The presentation of these studies offered a potential model for how Northern Australia could produce and transmit significant amounts of renewable energy.

11. Developing a Road Map for grid interconnection between Northern Australia and SE Asia (Dr Geoff James, CSIRO)

The concluding presentation was delivered by Dr Geoff James from CSIRO who outlined the International Energy Agency (IEA) process for an Energy Technology Roadmap.

An energy roadmap is a "specialised type of strategic plan that outlines activities an organisation can undertake over specified time frames to achieve stated goals and outcomes".

It was important for the regional interconnected grid project to develop clear goals and maintain a very high level of interaction with key stakeholders. A roadmap can be broken down into four stages: Planning and Preparation, Visioning, Roadmap development, and Roadmap implementation and revision. A roadmap for the project would need to encompass all of the elements of the power system, covering traditional elements such as generation, transmission, distribution and load, and newer elements such as renewable generation, UHV network and energy storage and also non-technical elements such as governance structures. A roadmap would also map out potential problems and solutions in a matrix, and then develop implementation strategies that encourage shared goals and effective joint work between utilities, research institutes and government departments



Participants at the scoping workshop. Charles Darwin University. July 29-30, 2013.

Workshop discussions

Over the course of the workshop there were several small and large group discussions that mapped out some of the key issues to realising renewable based grid interconnection. The following is a short summary of the key opportunities and constraints facing grid interconnection.
Existing connections/collaborations

The project would build upon important connections and collaborations that have occurred in the past. These include:

- Trading links between Northern Australia and Indonesia going back at least 300 years
- Construction of an undersea telegraph cable between Darwin and Java in 1872
- Development of fibre optic cables between nations, including the proposed Australia- Sin gapore fibre optic submarine cable
- Bi and tri-national collaborations between Australia, Indonesia and East Timor on a range fronts such as asylum seekers, fisheries, oil and gas, research and military cooperation of
- Australia as a respected partner of ASEAN
- Existing energy export arrangements such as gas, uranium etc.
- West Indonesian grid currently being developed by the Indonesian government with ASEAN help
- Live cattle trade between Northern Australia and Indonesia
- Investment by Indonesia Government in pastoral lands in Northern Australia to grow food security

What are the key opportunities to come from grid interconnection?

The Asia-Pacific region has a real opportunity to develop this idea further. Such a venture will enable securing of energy supplies for the region, reducing energy conflicts, addressing climate change and low carbon futures, maximise the regions' natural advantage of renewable resources, and go some way to reducing energy poverty in the region.

The following points were highlighted as the obvious benefits and opportunities from realising grid interconnection based on renewable energy:

- **Tackling climate change**
  This was identified by many participants as a key driver and motivation for such a project. It was noted the critical importance and timeframes of reducing greenhouse gas emissions and moving away from fossil fuels in the region.

- **Meet rising energy demand in SE Asia**
  South East Asia energy demand is increasing at a rate twice that of the global rate, most of which is from electricity demand.

- **Develop Northern Australia**
  It was noted that during the 2013 election campaign, Northern Australia was a key focus for development, so the notion is likely to be a politically popular idea.

- **Untapped renewable resources**
  It was agreed that the region holds world class renewable energy resources, in par ticular the solar resources for Northern Australia are vast and largely untapped.

- **The impacts of coal**
  The diminishing public acceptance of coal as a form of energy, including the health impacts from coal fired power plants and mines were seen as an important driver.

- **Changing markets for energy**
  With international climate change policies encouraging the pricing of carbon and reducing subsidies for fossil fuel energy sources, the region is undergoing a transfor mation in energy markets

- **Poverty alleviation**
  It was initially pointed out the project could address energy poverty particularly east of Java. However to what degree such a project would deliver this was debat ed, noting that it is more about the 'spine, not the ribs' of an electricity network.

- **Energy security and reduced energy conflict risks**
  Providing an adequate and reliable source of energy will be an ongoing challenge for the region, and many ASEAN nations are likely to import energy.

- **Energy cooperation for reduced energy conflicts**
  Similarly, an interconnected grid could build relationships between nations and reduce potential for future energy conflicts.

What are the key constraints for grid interconnection?

Technical

Subsea HVDC cables technology is mature. More than 20 such cables exist globally. The greatest technical challenge for connecting Australia to Asia is the distance for connection and depth of the ocean in the Timor Sea. Different route options were discussed, the most feasible being from Darwin across to Timor, a distance of approximately 700 km depending upon the exact route chosen. However, this would still require crossing the Timor Trench, which is a significant depth (around 3 km). It was noted that it is not impossible to lay at such depths however it has not been done before. The greater distance however would be from Timor across to Java, a subsea cable of approximately 1000 km's.

Laying a very long and heavy cable (e.g. greater than 1000km at 6.5 tonnes per kilometre)[14] would require a very large boat compared to other subsea cable projects. More likely, several voyages by standard cable-laying vessels would be required, incurring additional costs and cable joins.

The region is seismically active. The impacts on reliability of electrical supply due to a broken, or damaged, cable would need to be assessed, including how a cable could be repaired.

It was also noted that there would be concern of an electricity connection disrupting electrical grid stability. Part of this concern would come from the mix of intermittent renewable energy supply and this would need to be addressed. In addition, a single HVDC cable connecting to Asia poses potentially high energy risks if failure occurs, such as if an underwater earthquake broke or damaged the cable.

14. The Basslink cable between Tasmania and Victoria weighs approximately 65 kg/m, personal communication from Malcolm Eccles, Managing Director, The Basslink Group, Melbourne.

Long distance transmission losses – and large infrastructure costs - were discussed in the context of whether investing in domestic renewable energy in ASEAN nations made more sense than grid interconnection between continents. It was noted that PV distribution is likely to continue to grow in Indonesia for domestic use. The challenge for the region however is that domestic energy markets may not match where the resources are and so grid interconnection could promote renewable energy deployment. Similarly it was pointed out that developments in HVDC cable have reduced transmission losses down to around five percent per 1000 km, excluding additional losses from AC-DC conversion.

Furthermore, a HVDC cable was just one option of delivering renewable energy to Asia into the future, and that other technologies may develop further that could deliver different options, such as solar fuels[15]. However, it was also expressed that many renewable energy technologies are ready to deliver large scale energy supply in the region, most likely in the way of solar PV, concentrated solar thermal and geothermal in Indonesia. One of the further challenges noted was the capacity of the electricity grid in Indonesia and Timor to cope with new supply imported by HVDC cable.

Further studies are needed in to the AC system capacity, system stability issues, and benefit cost studies of HVDC versus HVAC to determine optimum connection points. The most technically and economically feasible option would likely be a bipole connector between northern Australia and Java (see figure 1)[16] . There may however be also potential for a three terminal interconnector (a hybrid LCC/VSC) to deliver electricity in to Timor.

15. CSIRO (2013) "Solar Fuels Road Map" http://www.csiro.au/en/Organisation-Structure/Flagships/Energy-Flagship/Solar-Fuels-Road-Map.aspx
16. Personal communication from Ian Burgwin, Basslink Consulting Group, September 2013.

It is possible that subsea electric fields created by an HVDC undersea cable can increase the rate of corrosion of other subsea infrastructure, such as oil and gas rigs or pipelines, which would be a serious concern to their owners. Preventing this can require additional investment in cables with return conductors so that the seawater is not used as a conducting medium. This was the case, for example, when Basslink was constructed.

The current load for the existing Darwin to Katherine Integrated system is approximately 200MW, far less than currently in Indonesia. There is a risk of tripping this grid if the cable carrying the large supply of electricity (eg. 1000MW) to Indonesia fails, as the DKIS grid would not be able to accommodate the sudden excess in supply.

Financial

Wholesale electricity produced in western Indonesia from coal fired power stations currently costs around 6c/kWh, whilst the wholesale price of power generated from utility scale solar PV and solar thermal power plants should they be built in Northern Australia and exported to Indonesia is unlikely to cost less than 30c/kWh in the near future.

However, a presentation delivered by Andrew Blakers (see below) showed an example of pumped hydro and solar PV at Lake Argyle in Northern Australia could deliver electricity closer to 8c/kWh based on initial modelling. One of the greatest challenges from an economic perspective is finding finance to cover the potentially large CAPEX involved in the cable installation.

The workshop heard that sub-sea HVDC cables cost approximately $1-$2M per kilometre. However, the project is likely to attract significant private and public sector investment if it is shown to be commercially viable over the long term.

The role of subsidies for fossil fuels in Indonesia and Timor would be an important element in determining the economic viability of such a venture. It was noted that as the region moves to place a price on carbon, and public acceptance of fossil fuels diminishes the project is likely to be more realistic.

An important driver will be Indonesia's goal of achieving electrification of 93% of the nation by 2025. Currently only 76% of the nation is electrified. To achieve this it was estimated that over 500 power stations are needed, and a renewable energy target of 25% by 2025.

Geopolitical and regulatory issues

ASEAN-Australia Comprehensive Partnership Agreement (2014-19 phase) and the Science and Technology Cooperation Agreement were noted as two key institutional arrangements warranting investigating for government to government and technical discussions regarding studying the feasibility of an Australia-Asia Interconnector.
Indonesia's Electricity Law (Law # 30 - 2009) essentially prohibits importing electricity if local demand has not been filled (Article 39; 'Cross-border Electricity Trade'). In addition to this will be the importance of engaging with state owned electricity generators, such as Power and Water Corporation in the Northern Territory and Perusahaan Listrik Negara (PLN) in Indonesia.
It was recognised that there is a great opportunity for partnership building in the region through such a project, particularly between Australia, Indonesia and Timor Leste. This will require proper collaboration between Australia, Indonesia, East Timor and potentially other ASEAN nations that would be affected by an interconnected grid. It is unlikely that the interconnection will gain support as a standalone project, but rather it will be part of a regional strategy for clean energy supply, perhaps bundled with projects more focussed on local energy solutions for island populations in east Indonesia. There is a lot of room for imagination and innovation in the investment and business models that would combine multiple project in a way that can gain political support from all nations involved.

Connection points will be critical, determining the best pathway for an interconnecting cable. Will the cable run from Darwin to Timor, Darwin to Java, or some other route?

There will be different environmental, technical, financial and regulatory constraints for each option that would need thorough exploration.

There will also be important regulatory and technical issues surrounding the conversion points from direct current (DC) to alternating current (AC).

Another aspect that was discussed was that an electricity link should have the capacity for two way transmission. It was noted that the ambitious Desertec project connecting Europe to north Africa has largely been criticised for being too focussed on importing power into rich Western Europe, and not enough on producing renewable energy for poor north African nations. An electricity link between Australia and Asia would potentially incur less resistance if it provided value and benefits at both ends of the link. This may occur through being two way electricity trade or through other strategies such as offering some stake in solar farms built in northern Australia. However, importing electricity into Australia that was produced from coal fired generators, or potentially from nuclear power plants should they be built, was also seen as a risk for Australia.

Scale

A discussion was had around the scale of the project, and whether to frame the project in terms of connecting to a larger pan-Asian grid or connect to Asia in incremental stages (eg. Darwin to Timor Leste). Different approaches would have different challenges and opportunities. For example, connecting Australia to East Timor and East Indonesia may reduce the complexities of negotiation and finance requirements. However, this approach would be more likely to be considered energy aid rather than a market opportunity to meet the large energy demand from connecting to the much larger energy load in Java.

The project could become more economically viable if it was demand driven connecting Australia to Java, rather than supply driven focussing on the untapped renewable resources. However, it may be more realistic to approach the project in layers and stages rather than a grand design of a pan asian-Australia interconnected grid. It may be more feasible also for Eastern Indonesian islands to address their energy needs through distributed solar PV systems or geothermal, for individual islands rather than importing energy.

It was also noted the role of China in connecting to a pan-ASEAN grid from the north, and the opportunities this also provides for Australia. The question was posed of who would connect to Indonesia first, China or Australia, and whether Australia would realise the opportunity in time. Also, there may be issues that arise with some countries who seek to "block" this grid from happening due to energy independence policies.

Leadership and Partnerships

Positive leadership from government and business will be crucial to success of the project. To achieve this it was noted that it is important to develop a set of dialogues with industry, government departments and ministers, and institutions such as the IMF, ADB and the World Bank. A suggestion was made to develop an advocacy network of key people and decision makers to advance the project with coordinated objectives. Regional partnerships will be key, and should look to engage through the ASEAN – Australia Comprehensive Partnership process[17].

17. Australian Government , "Plan of Action to Implement the Joint Declaration on ASEAN-Australia cooperative partnership", http://www.dfat.gov.au/asean/plan_of_action.html

Presenters

Annex 1: Workshop Program

Time	Session
8.00am – 9.00am 8.30am – 9.30am	**Registration, coffee and tea** **Welcome** • Professor Andrew Campbell, Director, Research Institute for Environment and Livelihoods, Charles Darwin University • Dr Stuart Blanch, Director, Environment Centre NT, and University Fellow, Charles Darwin University **Official opening** • Ade Padmo Sarwono, Consul, Consulate of the Republic of Indonesia, Darwin • The Honourable Peter Chandler MLA, Minister for Lands, Planning and Environment, Northern Territory Government • Professor Barney Glover, Vice Chancellor, Charles Darwin University
9.30am – 10.30am	**Keynotes** **• Renewable energy, water and an Australia-Asia electricity grid** Dr Jamie Pittock and Mr Keith Sue, The Australian National University **• Indonesia Energy Sector: Updates and Outlook towards Government's Energy Mix Policy Target in 2025** Mr Joi Surya Dharma Founder and Chairman of Energy Nusantara, Indonesia's Leading Energy Network Deputy Head of Permanent Committee for Energy and Oil & Gas Infrastructure, Indonesian Chamber of Commerce and Industry Former Advisor to Parliament Member in Energy Commission of Indonesia House of Representatives
10.30am – 11.15am	**Break – Morning tea**
11.15am – 12.30pm	**Key constraints & opportunities to grid interconnection to grow regional renewable energy.** Facilitated small group discussions with report back, facilitated by Fitrian Ardiansyah, Rob Law, Ucok Siagian and Tim Forcey • How do you see grid interconnection happening? • What are the key constraints and opportunities? • Is it feasible from engineering, commercial & regulatory points of view? • What are the technological options? • Where could we get to by the end of the Workshop?
12.30pm – 1.30pm	**Lunch**
1.30pm -2.00pm 2.00pm -2.15pm	**Plenary session: Grid interconnection, energy policy and HVDC technology** **• Lessons from Basslink's HVDC subsea cable between Tasmania and Victoria for potential grid interconnection between Northern Australian and SE Asian grids** Malcolm Eccles, Managing Director, The Basslink Group **• Indonesian energy policy and opportunities and challenges for grid interconnection between Indonesia and Australia** Dr Ucok W. R. Siagian, Director, Energy Policy Research Centre, Institut Teknologi Bandung, Indonesia

2.15pm -2.30pm 2.30pm -2.45pm 2.45pm -3.00pm 3.00pm -3.30pm	• **Grid development in China and East Asia, long distance UHVDC and CSP** Jerry Li, Desertec Asia (via Skype) • **Asia Pacific Super Grid -Solar electricity generation, storage and distribution** Professor Andrew Blakers, The Australian National University • **Grid interconnection between Asia and Australia to support carbon abatement** Stewart Taggart, GRENATEC (video presentation). • **Panel Q & A** Facilitated by Mr Joi Surya Dharma and Dr Jamie Pittock
3.00pm – 3.30pm	**Break: Afternoon tea**
4.00pm – 5.30pm	**Panel Discussion: Why connect Southeast Asia and Northern Australian grids?** Facilitated by Geoff James and Malcolm Eccles • spatial and temporal trends in energy demand to 2050 • regional energy supply and demand • energy security and energy sovereignty issues • rapid transition to renewable energy • preferencing renewable energy over fossil fuels/nuclear
5.30pm -6.00pm	**Break**
6.00pm -7.00pm	**Drinks and Informal Discussions Venue: BBQ area, Research Institute for Environment and Livelihoods, Charles Darwin University.**
Time	**Session**
8.30am -9.00am	**Coffee and tea**
9.00am -9.30am	**Summary and discussion of Day 1** Facilitated by Andrew Campbell and Stuart Blanch
9.30am -9.45am 9.45am -10.00am 10.00am -10.15am 10.15am -10.30 am	**Plenary session: Renewable energy resources** • **Hot, clean and complex: Unlocking Indonesia's geothermal power** Fitrian Ardiansyah, Climate and Sustainability Specialist and PhD Scholar, The Australian National University • **Renewable energy resource assessment for Northern Australia** Tim Forcey, Beyond Zero Emissions. • **Developing a Road Map for grid interconnection between Northern Australia and SE Asia** Dr Geoff James, CSIRO Energy Technology • **Panel Q & A** Facilitated by Keith Sue and Ucok Siagian
10.30-11.00	Morning tea
11.00-12.30 pm	**Discussion: Next steps** Facilitated by Andrew Campbell and Stuart Blanch • Identifying key constraints and opportunities requiring feasibility study • Developing consortiums for research applications • Options for further engagement in government, research, engineering and community sectors • Future meetings and collaborations.
12.30-1.30 pm	Lunch
1.30 pm	Close meeting

Annex 2: Workshop Participants

Name	Organisational affiliation and contact information
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Annex 3: Workshop materials

All workshop presentations will be available at http://cre.cdu.edu.au/

Annex 4: Organising committee

The workshop was organised through the Environment Centre NT and the Centre for Renewable Energy, Charles Darwin University with partnering institutions of the Australian National University, CSIRO, Earth Systems, and UNO MS.

Annex 5: Workshop Flyer

Scoping Australia - Asia grid connection to grow regional renewable energy and energy security.

Workshop: JULY 29 - 30 2013

Charles Darwin University, Darwin, Northern Territory, Australia.

Solar power tower, Spain. Used with permission, Greenpeace.

Join with other experts and blue sky thinkers to identify key challenges in developing critical energy infrastructure for the Twenty First Century.

This workshop will scope possibilities and challenges in integrating electricity grids in Northern Australia and Southeast Asia to enhance opportunities for the generation and distribution of renewable energy, grow energy security and cut energy poverty.

The Top End of Australia's Northern Territory has untapped world class renewable energy sources (solar, tidal and possibly geothermal), but small energy markets and abundant natural gas. Less than 1% of the Territory's current stationery energy production is from renewable sources.

The context? Reducing energy poverty in southeast Asia, increasing energy security, cutting carbon pollution, catalysing utility scale renewable energy, and strengthening regional ties.

Indonesia and East Timor also possess potentially large renewable energy resources (geothermal, solar, tidal), but currently lack investment and integrated electricity grids to foster their exploitation.

Grid integration between Northern Australia and Southeast Asia offers the tantalising opportunity to stimulate regional renewable energy production, substantially cut energy poverty, and avoid the risks and escalating costs from fossil fuels and nuclear power.

An interconnected regional grid tapping into utility-scale renewable energy is a long-term option in this Asian Century for reducing reliance on fossil fuels and associated pollution, buffering rising energy prices and reducing energy security risks.

Technological advances in high voltage direct current (HVDC) cables and falling renewable energy costs make an Australia-Asia Electricity link a real possibility in the next decade or so.

The challenge? Work with experts and thought leaders from different disciplines to identify key questions, challenges and technologies that need investigation in a future feasibility study into constructing and maintaining a high voltage direct current (HVDC) subsea cable(s) between Northern Australia and Southeast Asia to catalyse generation and distribution of renewable energy.

Laying HVDC subsea cable

More than 20 HVDC subsea cables have been built globally since the 1950s, with many transmitting renewable energy long distances between islands and nations, with more than another dozen planned.

Key questions to be explored:

o **Business case:** is there a business case in the medium term, what's the likely cost of renewable energy produced, and when would it be cost competitive?

o **Technical and engineering:** is it feasible to transmit power across such long distances and across the Java Trench, can HVDC subsea cables maintain electrical supply under all contingencies, where would the link attach to existing grids?

o **Renewable energy resources:** how much renewable energy could be produced from the different sources across the region, what challenges does intermittency create?

o **Regulatory and political:** Do Southeast Asian nations want to import renewable energy from Australia, what are energy security concerns, what are the co-benefits of regional grid integration?

Who should attend?

Power distribution engineers, HVDC cable manufacturers, renewable energy experts, business and industry leaders with a passion to make big projects happen, energy economists, electricity grid managers, blue sky thinkers, energy market operators, community groups, oceanographers, energy policy experts, and international development practitioners.

Participants from Australia, Indonesia and East Timor in particular are urged to attend.

Funding support. Subject to eligibility, limited funding support may be available to assist key experts from Asia to travel to Darwin for the workshop.

To register your interest in participating in the workshop, recommend other participants, or propose a presentation, please contact:

Dr Stuart Blanch, Director, Environment Centre NT, Darwin, Northern Territory, Australia, on coordinator@ecnt.org or call +61 8 8941 7439.

Environment Centre NT | Charles Darwin University | Australian National University | CSIRO | UNO MS | Earth Systems