Submission to Committee on the Northern Territory's Energy Future Inquiry into Key Challenges and Opportunities

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10th February 2014

INTRODUCTION AND SCOPE

1. This is a late submission and I appreciate its consideration at the discretion of the committee.

2. I am Dr Francis Clark; I hold a Bachelors Degree with Honours in Physics and a PhD in Mathematics, both from the University of Queensland. I have been professionally focused on Australian Electricity Systems since May 2010, first through a role at Adelaide University and more recently as a Research Fellow in Renewable Energy (part time) within the Centre for Renewable Energy at Charles Darwin University. I am especially interested in Electricity System Evolution.

3. My comments here (i) focus on solar-PV and associated electricity system evolution; (ii) are built around consideration of the Darwin-Katherine Integrated System (the DKIS), and; (iii) are focused broadly on key challenges and opportunities.

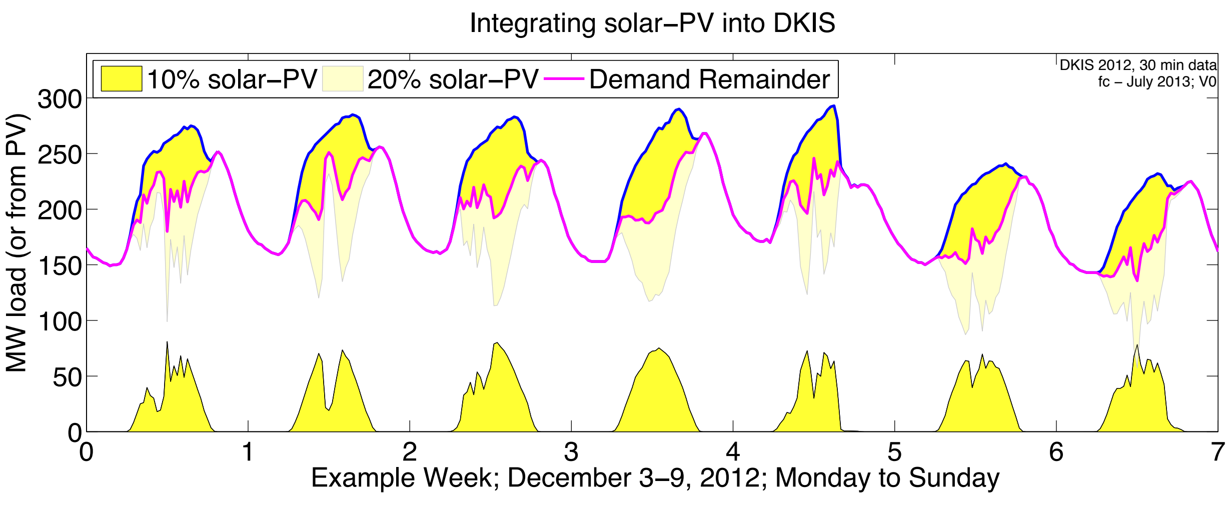

Figure 1a. Modelled solar-PV contributing to supply (or acting as negative load) in the peak load week of 2012 in the DKIS. See points 12-15 for further detail.

EXECUTIVE SUMMARY

4. Many issues around electricity system evolution generalise to the shift from a centralised system to an increasingly distributed system with more players, parts and complexity, but also more resilience, flexibility and cost effectiveness. In establishing settings for system evolution into the long term this is a key generality.

5. The further we try to look into the future on specific technologies, the more likely we will be wrong. I contend two areas where likely developments are clear and present: the first is ongoing additions of solar-PV into our systems; the second is use of the AS4755 Demand Response standard and associated technologies [1].

6. Most of the electricity generated in the DKIS is used for cooling. The storage of 'coolth' is relatively straightforward.

NARRATIVE COMMENTS

7. Electricity systems in the twentieth century grew and expanded with power becoming increasingly available and affordable. Driven by economies of scale, power stations became bigger and more centralised while the networks that transmit and distribute the electricity spread their copper tendrils ever further. Our electricity system has evolved such that supply is controlled while demand is not (much); when the demand changes the supply must adjust in lock-step. With the advent of mass air-conditioning, peak loads on hot afternoons require grid-system infrastructure to have a capacity that is not needed most of the time, which is expensive. The twentieth century model of electricity supply has essentially been broken in that we now have electricity becoming less affordable.

8. Solar-PV has the important property that it can be closely associated with loads and thus reduce network flows. Reducing network load can be extremely valuable if this occurs at times of peak demand. Analysis work presented below shows that this is indeed the case, to a point. Further, solar-PV 'behind the meter' effectively achieves the retail price while solar-PV electricity exported into the network generally has lesser value.

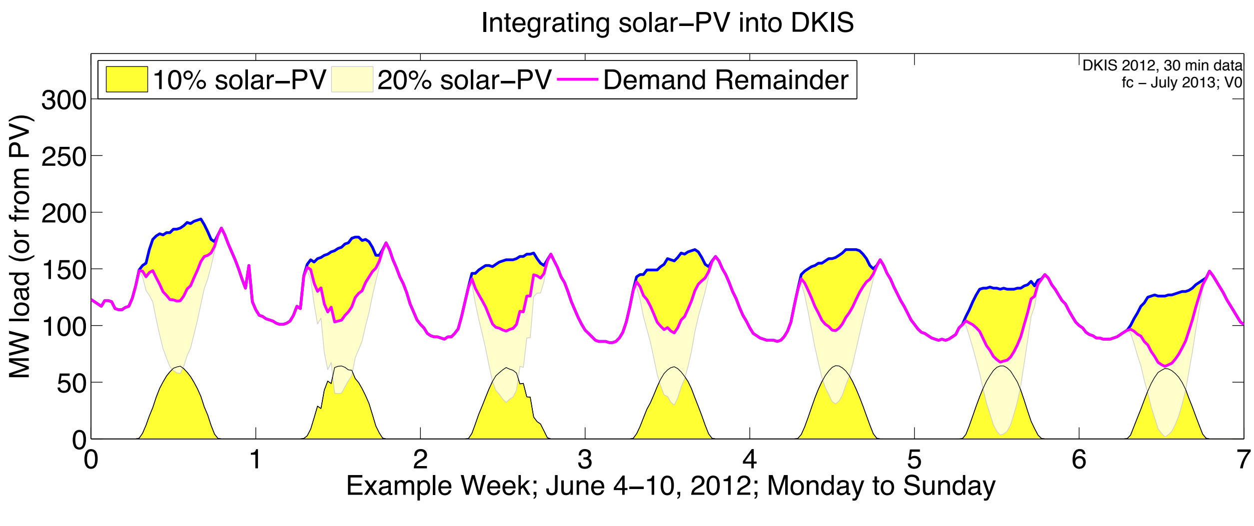

Figure 1b. Modelled solar-PV contributing to supply (or acting as negative load) in the Dry Season, DKIS, 2012. See points 12-15 for further detail.

9. Electricity from solar-PV, when available, is cheaper than network electricity (around five year payback 'behind the meter'). Solar-PV costs are decreasing; network electricity costs have been increasing. As time proceeds the penetration of solar-PV will increase. With more solar-PV the value of electricity from further solar-PV will decrease until a balance is established tracking to least cost electricity for the consumer. Good policy will broadly allow and encourage these dynamics to play out.

10. Mechanisms that can act to reduce peak network load can have very significant value (said to be around $3000 per kW of displaced peak load [1]). Three such mechanisms are clear now: (i) the storage of 'coolth' such as the 8.4 million litre tank of chilled water at CDU, (ii) Demand Response Enabled Devices including air conditioners and pool pumps, and (iii) the judicious placement of solar-PV.

11. Demand side flexibility mechanisms are valuable individually *and* able to usefully reinforce each other. These mechanisms become more important as the level of solar-PV increases. While a qualitative observation here, work proceeds on this point to establish quantitative results.

SOME NUMBERS AND RESULTS

12. To examine broadly how increasing levels of solar-PV might 'fit' into the DKIS system, I have over the last year analysed a one year series of DKIS system load data in conjunction with solar irradiance data (as recorded by BoM at Darwin Airport). This analysis does not address issues around 'system stability'; it does give a good high-level view of how solar-PV at different levels contributes to meeting demand.

13. The modelling work shows that 5 to 10% penetration of solar-PV into the DKIS (i.e. up to around 90 MW nameplate) is beneficial for the network utilisation dynamics, and that further steps to 15% and 20% would be detrimental without significant other changes. Specifically, at levels of solar-PV higher than 10% the peak demand on the network shifts into the early evening, and at around 20% there would be dry season days when solar-PV would be producing electricity equal to the total of system demand. This might represent an opportunity for an electricity intensive process to obtain cheap electricity; it certainly represents a challenge for system control.

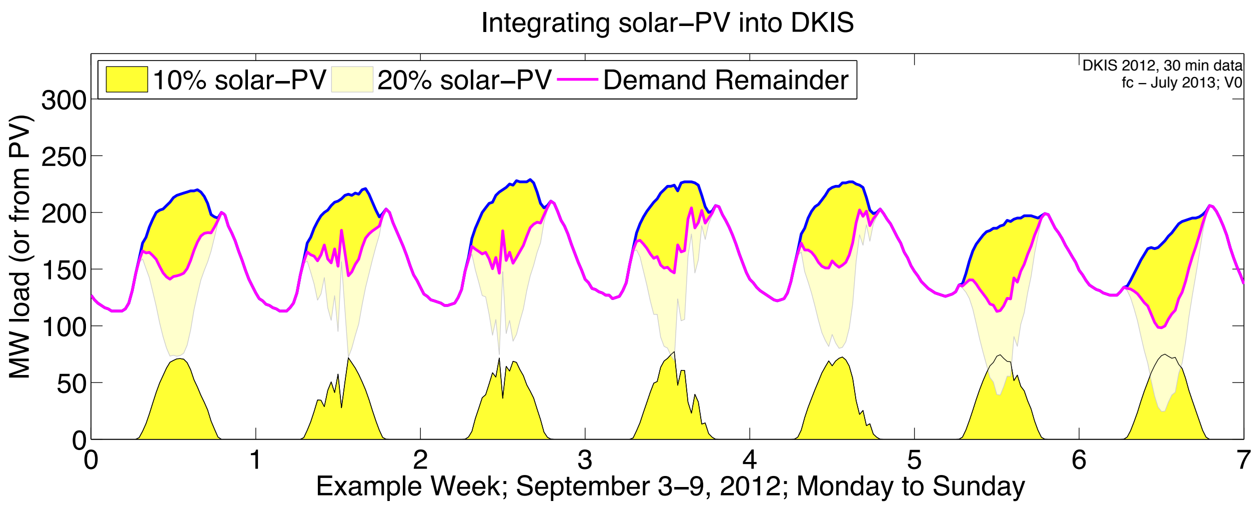

Figure 1c. Modelled solar-PV contributing to supply (or acting as negative load) in September, DKIS, 2012. See points 12-15 for further detail.

14. Current solar-PV in the DKIS is understood to produce less than half of one percent of total electricity. Like many 'rollout' processes solar-PV tends to follow a doubling behaviour, with a doubling period between one and two years. While this is speculating with numbers, it remains useful to note that even with a highly optimistic doubling period of twelve months, it would be early 2017 before we achieved 4% solar-PV penetration. IF such a trajectory were to occur -and-continue then DKIS could reach 20% renewable energy by 2020. I consider such an outcome unlikely because (i) a twelve month doubling period is optimistic in the first instance, and (ii) the continuation of this high rate past 10% penetration is doubly optimistic. My best guess, and I contend a reasonable rough estimate to base thinking around, is that DKIS will achieve 10% solar-PV penetration in 2020 or shortly after.

15. Figures showing the modelling work at 10% solar penetration for example weeks are shown as **Figures 1 a-d**. The December example week (Fig 1a) includes the 2012 peak load, and it is seen that the solar-PV contribution usefully contributes to supply on these hot days. **Figure 2** shows a summary view of how 5, 10, 15, and 20% solar-PV in the DKIS and associated with loads would change utilisation dynamics for the network.

MORE SPECIFIC SOLAR-PV COMMENTS

16. In assessing how much solar-PV can be integrated into our systems and how soon, there are two key high-level aspects. First, and somewhat simplified, we require the solar-PV to achieve capacity credit; that is, essentially, we require the solar-PV to contribute usefully at times when the network is serving peak loads. As above, we see in broad terms that this is achieved to 5% solar-PV penetration, with the general dynamics positive up to 10% (**Figure 2**). The second aspect is maintaining system stability (especially voltage and frequency regulation) in a system with significant solar-PV. While not in a position to make strong claims, I expect this issue can be managed with a transparent Ancillary Services Market.

17. Solar-PV can contribute electricity in at least four distinct ways. Before itemising these, it is reiterated that solar-PV is unlike most generation technologies in that it can effectively be placed with loads, and thus: (i) remove demand from the network, and (ii) effectively operate at retail level pricing (the so-called behind-the-meter model).

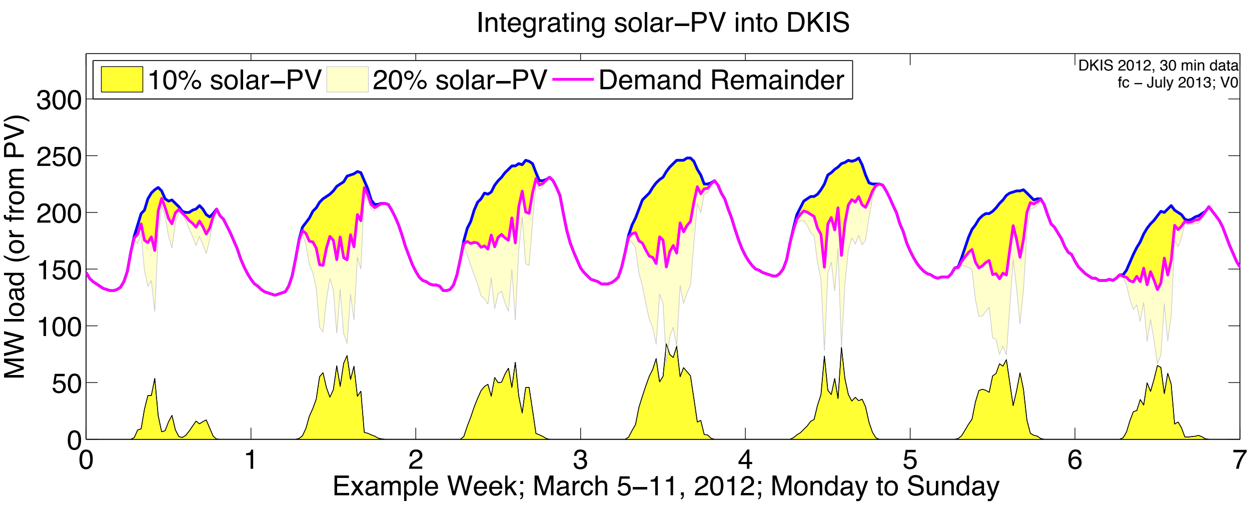

Figure 1d. Modelled solar-PV contributing to supply (or acting as negative load) in the Dry Season, DKIS, 2012. See points 12-15 for further detail.

18. First, there are small systems on residential roofs. It is true that there can be difficulties with voltage regulation at the street level, and there are also straightforward solutions. Ideally the one-for-one feed-in tariff currently enjoyed by residential solar-PV owners will not be suddenly and drastically reduced but will rather have a graduated retreat specified over a number of years, thus avoiding instability in this sector. With that caveat, this market can be expected to grow and mature for many years.

19. Second, for commercial and other premises where consistent daytime load exists system size can range 10 KW to 2 MW or more. This market is in its infancy, and where significant growth in solar-PV can be expected to occur. There are more than a couple of facilities where quite large solar-PV systems can be associated with daytime loads and thus achieve excellent economics.

20. Third, there can be large solar-PV farms operating in the wholesale market, feeding bulk electricity into the network (such as the Uterne system in Alice Springs). As these systems are competing for price in the wholesale electricity market, and because we can expect significant solar-PV to become embedded in the network (that is, 'behind-the-meter') it is not clear how soon or how strong such developments are likely to be. There are certainly advantages related to scale, the ability to ground mount, and the potential to have tracking systems.

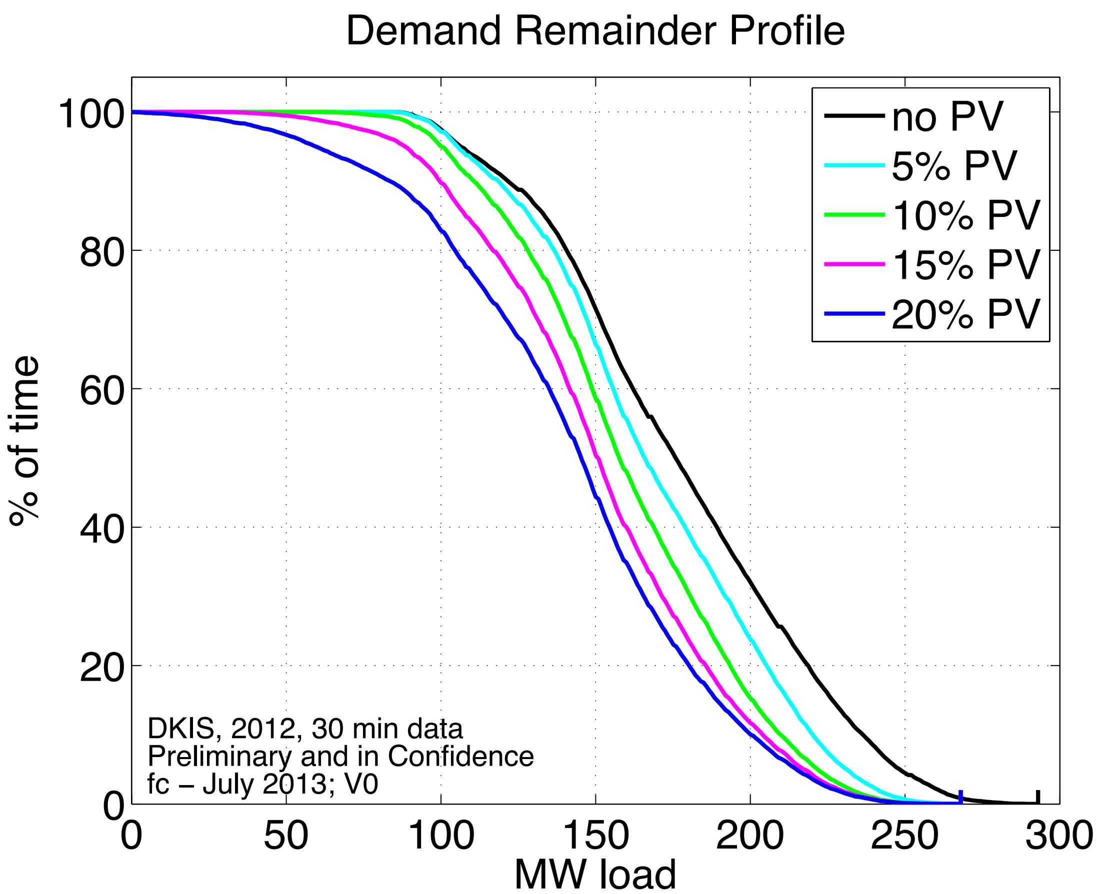

Figure 2. Solar-PV effect on system utilisation dynamics. The black trace shows the system load profile (load duration) for the entire year. As for the 'demand remainder' traces in Figures 1 a-d, the solar-PV supply at the various levels is treated as negative load before recalculating the load profile to give the cyan, green, magenta and blue traces. At 5% it is clear the solar-PV contributes dominantly at the high end while having little impact at the low end (improving system load factor), and this dynamic holds to around 10%. The 15% and 20% traces show much reduced contribution at the top end, while contributing significantly at the low end (deteriorating system load factor).

21. Fourth and finally, there is the use of solar-PV associated with diesel generators in remote systems. It has been clear for some time that the economics are favourable (see Green Energy Taskforce reports), and thus disappointing that progress in this area has been slow.

COLD THERMAL STORAGE SPECIFIC COMMENTS

22. Storage of coolth. In this tropical environment most of our electricity is used for cooling, especially air-conditioning, and particularly so at times of peak load. The storage of 'coolth' can be quite straightforward, requiring only implementation of well understood physical and engineering principles (as opposed to development of new technologies). Timelines vary: in the short term there are a number of facilities that could reasonably implement chilled water storage along the lines of the CDU system, especially if they can be assured of obtaining the financial benefit their infrastructure would bring to the system overall. This is an example of capital expenditure shifting from the central utility to players in the network, and is not dissimilar to the upfront cost of solar-PV. Also, the storage of coolth, like solar-PV, sits at a leaf node in the network and thus has a dual action as both storage and network management infrastructure.

23. Similarly and in the longer term we can anticipate district cooling systems to deliver significant economies.

CONCLUDING REMARKS

My key messages are:

24. Solar-PV is a here-and-now source of low cost electricity that can usefully and significantly increase its contribution to overall electricity supply. Continued liberalisation of the NT electricity market, judiciously undertaken, can be expected to facilitate this process. As the last century saw the development of electricity delivery as an essential utility service providing affordable electricity through a process of consolidation and centralisation on the supply side, this century will build on that heritage with developments on the demand side, including significant solar-PV and ‘storage’ embedded in the network.

25. In tropical environments much electricity is used for cooling, especially air-conditioning, and particularly so at times of peak load. The storage of 'coolth' can be quite straightforward. In relation to the Darwin-Katherine Integrated System (DKIS), significant further build of chilled water storage in the short-medium term can improve the system in a number of interrelated ways including: (i) reduced peak load, (ii) increased system resilience, (iii) reduced cost of electricity into the medium term, (iv) provision of significant demand side flexibility, that in time will enable (v) increased inclusion of cheap solar-PV energy and other 'renewable' resources.

26. I look forward to providing a more developed and quantitative submission building on the themes here when the committee comes to consider Renewable Electricity in more detail.

Francis Clark,
Darwin, 10th February 2014.

[1] htpp://consumersfederation.org.au/wp-content/uploads/2013/05/Smart-Appliance-Consultation-RIS.pdf