Solar PV
Briefing Note

Purpose:
The purpose of this note is to inform the Department of Energy and Climate Change of the potential impact of solar PV on transmission system operation and balancing.

Background:
Government incentives (such as Feed-In Tariffs introduced in 2010) created a strong economic case for individuals to invest in solar PV generation. According to Ofgem data around 1 GW had been installed up to April 2012.

Current Position:
Reduction in Feed-In Tariffs to solar PV is expected to reduce the rate of new installations.

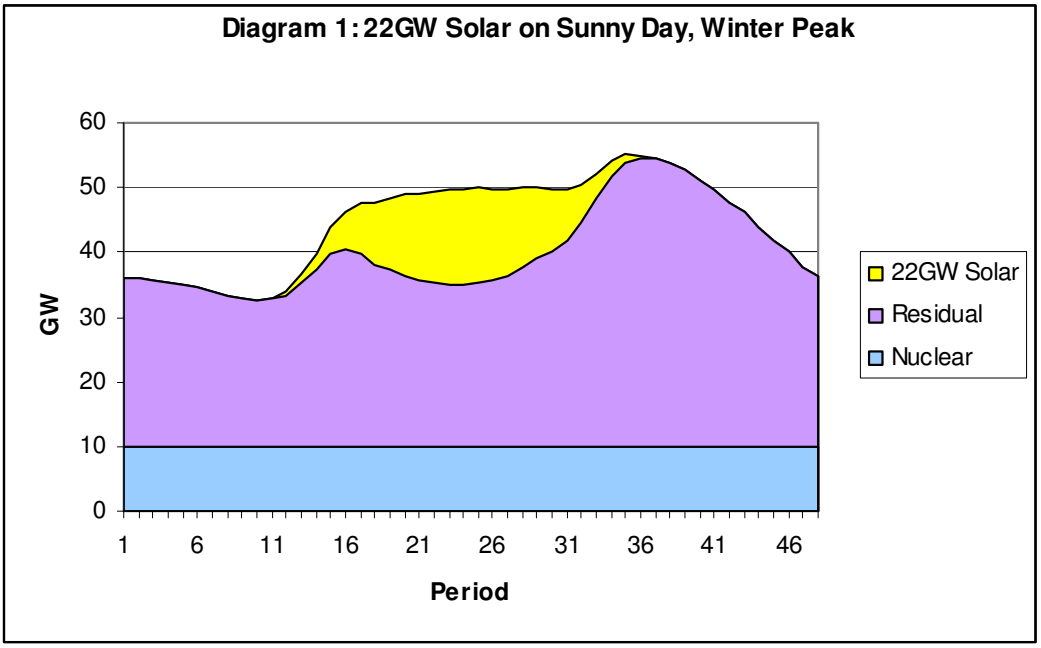
At present the system operator has neither the technical capability, nor the commercial arrangements to influence the output of solar PV. The new generation code will require a terminal on all installations to enable output to be reduced, but this still needs a communication channel for the system operator to use this facility, possibly via smart meters.

Potential Impact of Solar PV:
National Grid has undertaken some analysis to assess the potential impact of solar PV on transmission system operation and balancing at winter peak and summer minimum demand levels. For this analysis it is assumed that 22GW of solar PV is installed on the system, however it should be noted that the value of 22GW of solar PV is not consistent with any of National Grid's scenarios. It is also assumed that there is no means of controlling output of solar PV.

To establish how solar PV output would vary, assumptions have had to be made about where the panels are, the angle they are installed at and which way they face. This note has been based on analysis of the effect of the varying angle of the sun's rays, rather than experimental results.

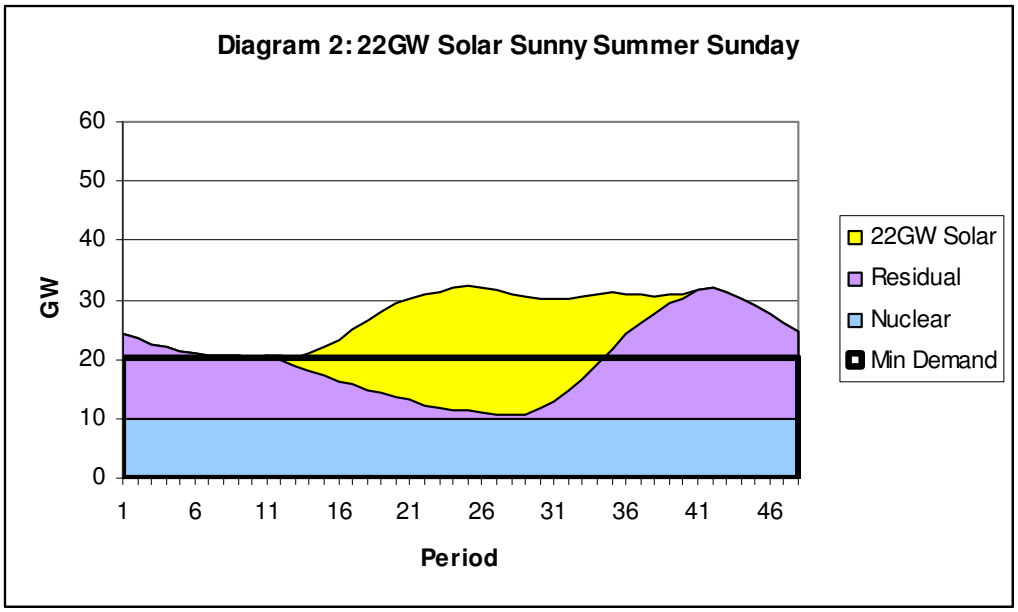
The following diagram shows the impact on a sunny day with winter peak demands.

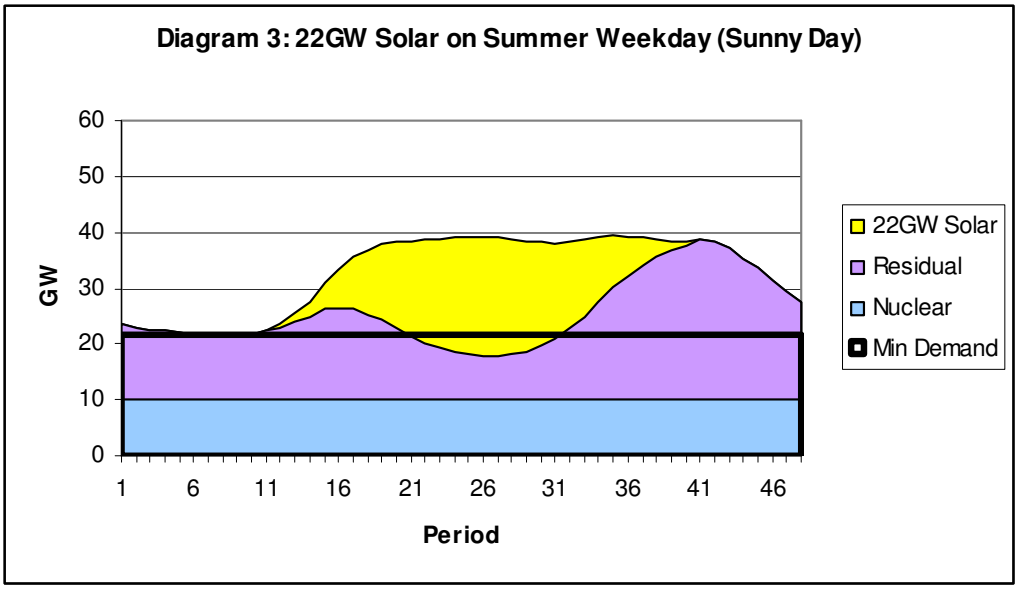
Diagram 1: 22GW Solar on Sunny Day, Winter Peak



The impact on winter peak is relatively limited due to the high demand and reduced solar generation with the lower angle of the sun in winter, which is likely to be further reduced by cloud cover on many days. The steep and prolonged demand increase as the darkness peak is approached is worth noting, but is no steeper than the current morning pickup.

The impact on summer minimum is more severe, as illustrated by the following diagrams showing the situation for a Sunday and a weekday.





In both cases the solar PV generation will net off demand and significantly lower the effective minimum demand on the system. Once again, there are prolonged ramps as the darkness peak is approached, but no steeper than currently experienced during the morning pick up. However, at the start of the ramp up, there could be no fossil generation synchronised apart from that providing frequency response. This will make the management of the ramp very difficult using plant that has just synchronised, wind, pumped storage and interconnectors.

The issue of “must run” plant is explored more closely in the following diagrams. It has been assumed that:

- There is 10GW of nuclear generation (or other generation that cannot be dispatched off).

- To maintain inertia, fault levels and HVDC commutation, Wind/Solar output must not exceed 60% of network demand. (This is using the limit established for the island of Ireland.)
- CCGT are required to provide frequency response
- Other reserve is provided by either standing reserve or varying inter-connectors.
- There is 30GW of installed wind generation.

Diagram 4: 22GW Solar: Sunny Summer Minimum

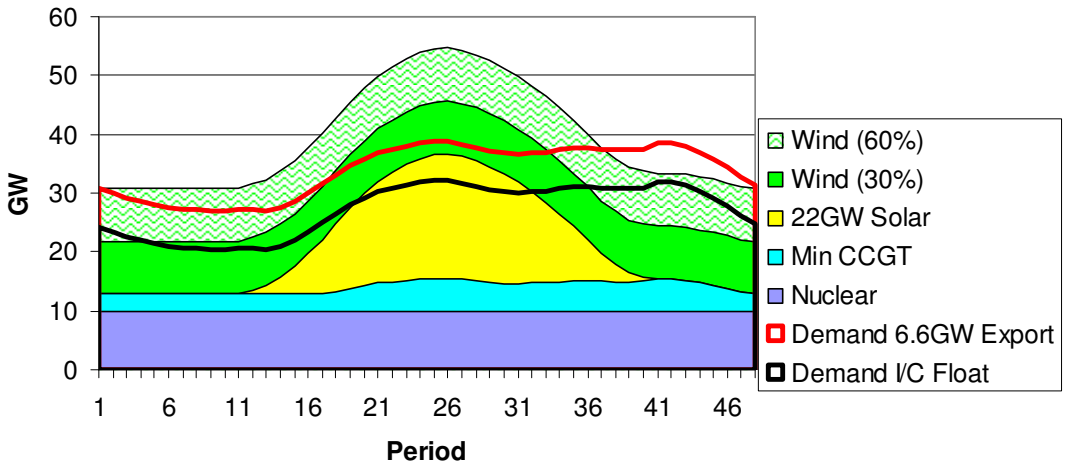


Diagram 5: 22GW Solar, Sunny Summer Weekday

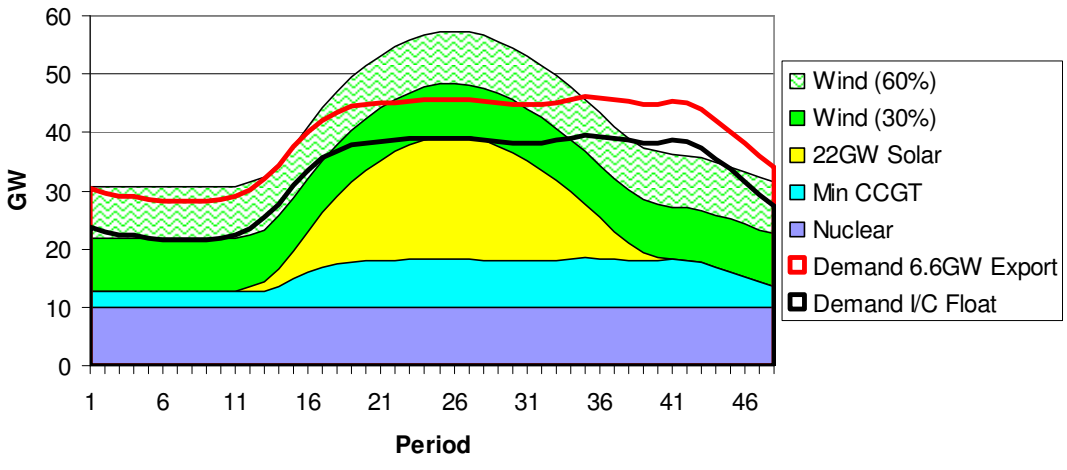


Diagram 4 shows that at around midday at the weekend (Summer minimum) solar PV, nuclear and the required level of CCGT generation will exceed the demand on the system. Whilst this could technically be accommodated by exporting to the continent or storage, it should not be assumed that all the interconnector capacity will be available or that other parties will be willing to buy the electricity at the other end. If the required export capacity on the interconnectors was not available and the operator was not able to reduce output from solar generation, then nuclear generation would have to be curtailed or shut down.

Key Conclusions

- Up to a penetration of around 10% of households or 10GW of generation, solar PV can be accommodated on the system without making the operation of the transmission system significantly more difficult. Beyond this level, it will exacerbate problems with regulating down

over summer weekend minimum and will increase the volume of wind generation constrained off. The construction of additional electricity storage would mitigate these problems.

- 22GW of Solar PV could theoretically be accommodated on the system assuming the interconnectors were in service, capacity to export could be secured and there was a purchaser on the continent. In reality, such an arrangement would not be robust against interconnector problems or losses of demand from the system and would not be acceptable.

- It is important to gain assurance that Solar PV installations comply with the relevant standards for frequency tolerance.

- The absolute ramp rates for "demand net of PV" are no greater than are currently experienced during the morning pick up. However, the challenge will be that they will start with little synchronised gas or coal plant apart from that carrying frequency response.

Key Considerations:

1. The following points (a-c) are made on the assumption that the system operator is unable to influence the output of solar PV. If a control mechanism/commercial arrangements were to be provided, these comments would no longer be applicable:
    a. With 22GW solar PV the system would require an unacceptable dependence on the ability to export over the interconnectors, or the construction of additional storage.
    b. It would be very difficult to meet the required ramp rates starting with almost no fossil plant on the system (except that required for frequency response)
    c. If solar is thought of as "negative demand" and its penetration was to reach 10% of homes (10GW), the effective demand at summer minimum would be reduced. This would exacerbate the problems of accommodating inflexible generation, intermittent generation and frequency response. Again, additional storage would mitigate this problem.
2. The impact on utilisation of wind plant is modest.
3. Should solar PV continue to grow, it will reach a point where it needs to be included within the demand forecasting process. It is not expected that this would be problematic.
4. The issue of solar PV tripping at low frequencies is being managed.

The way forward:

- Monitor the level of Feed in Tariff and the rate of new installation of solar PV
- Factor into the analysis any changes to the expected volumes of interconnection and/or storage available.
- Engage with DNOs as their networks are expected to be affected before the Transmission system.