CAERPHILLY COUNTY BOROUGH COUNCIL
CYNGOR BWRDEISTREF SIROL CAERFFILI

SUSTAINABLE DEVELOPMENT ADVISORY PANEL – 10TH APRIL 2014

SUBJECT: SOLAR FLARES AND SEVERE SPACE WEATHER

REPORT BY: ACTING DEPUTY CHIEF EXECUTIVE

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1. PURPOSE OF REPORT

1.1 To provide Members of the Sustainable Development Advisory Panel (SDAP) with information on the nature, occurrence and effect of solar flares and severe space weather, as requested at a meeting of the Panel.

2. SUMMARY

2.1 A solar flare is one of a number of different types of solar phenomena that together make up space weather. They are often, but not always, followed by a coronal mass ejection (CME).

2.2 Solar flares strongly influence the local space weather in the vicinity of the Earth. They can produce streams of highly energetic particles in the solar wind. CMEs can trigger geomagnetic storms that have been known to disable satellites and knock out terrestrial electric power grids for extended periods of time.

2.3 A well-documented 1989 storm had considerable impacts upon terrestrial infrastructure, most notably tripping the equipment protection relays of the Hydro-Quebec electricity network, resulting in loss of power for 9hrs across the Canadian province.

2.4 The 2013 UK National Risk Register has indicated the probability of the risk of Severe Space Weather as High rating. This means that this risk is considered highly likely to happen and have the highest impact if it does.

2.5 Current methods of flare prediction are problematic, and there is no certain indication that an active region on the Sun will produce a flare. A simple scheme of sunspot classification has been developed and is used as a starting point for flare prediction.

2.6 Space Weather Monitoring is critical to have forewarning of solar events as it enables engineering teams to go on standby and provide the context against which scientific advice and political decisions can be made.

3. LINKS TO STRATEGY

3.1 The Authority's work on sustainable Development supports the following strategies:

- "Living Better, Using Less", Sustainable Development Strategy, 2008.
- Emergency Management Plan
- Gwent Community Risk Register

4. THE REPORT

4.1 A solar flare is one of a number of different types of solar phenomena, including coronal mass ejections (CME's), solar radiation storms and solar radio bursts that together make up space weather. Although these solar phenomena are related in their common activity on the Sun, their size and interaction with the earth can vary and therefore the size of their respective terrestrial impacts may also vary.

4.2 A solar flare is a sudden brightening observed over the Sun's surface as a result of a large energy release. They are often, but not always, followed by a coronal mass ejection (CME). The flare ejects clouds of electrons, ions, and atoms through the corona of the Sun into space.

4.3 The frequency of occurrence of solar flares varies, from several per day when the Sun is particularly "active" to less than one every week when the Sun is "quiet", following the 11-year cycle. Large flares are less frequent than smaller ones.

4.4 Solar flares strongly influence the local space weather in the vicinity of the Earth. They can produce streams of highly energetic particles in the solar wind. These particles can impact the Earth's magnetoshhere and present radiation hazards to spacecraft and astronauts. CMEs can trigger geomagnetic storms that have been known to disable satellites and knock out terrestrial electric power grids for extended periods of time.

4.5 Solar flares were first observed on the Sun by Sir Richard Carrington and independently by Richard Hodgson in 1859 as localized visible brightenings of small areas within a sunspot group. The "Carrington Event" in 1859 is often described as the perfect storm because the largest CME's, radiation storms and solar flares ever recorded happened during this period.

4.6 **Impact on Earth**
When a CME is directed towards Earth and reaches it as an interplanetary CME (ICME), the shock wave of the traveling mass of solar energetic particles causes a geomagnetic storm that may disrupt Earth's magnetosphere.

4.7 Solar energetic particles can cause particularly strong aurorae in large regions around Earth's magnetic poles. These are also known as the *Northern Lights* (aurora borealis) in the northern hemisphere, and the *Southern Lights* (aurora australis) in the southern hemisphere. Coronal mass ejections, along with solar flares of other origin, can disrupt radio transmissions and cause damage to satellites and electrical transmission line facilities, resulting in potentially massive and long-lasting power outages.

4.8 **The risk posed by Severe Space Weather**
Each year the UK Government carries out a classified assessment of the risks of civil emergencies facing people in the UK and publishes its findings in the 'National Risk Register of Civil Emergencies' (NRR).

4.9 Within this reference document, published by the UK Government Cabinet Office, how serious the risk of an emergency is, depends both on the likelihood of it happening over the next five years, and on the consequences or impacts the people will feel if it does. The 2013 NRR has indicated the probability of the risk of Severe Space Weather as High rating. This means that this risk is considered highly likely to happen and have the highest impact if it does.

4.10 Assessment for the NNR is based on a "reasonable worst-case scenario". For severe space weather the reasonable worst-case scenario is based upon space weather of approximately the same magnitude as the Carrington Event of 1859, lasting for 1-2 weeks. The effects of solar activity of this magnitude are likely to be felt globally, although the severity of impact will vary with location.

4.11 As part of its consideration and to allow appropriate planning to take place, the UK Government provides a 'Hazard and Threat Description'. For Severe Space Weather it is as follows:

- Two coastal electrical sub-stations serving approximately 100,000 customers, each are severely damaged and unable to supply electricity for two or more months.
- Consumers in these areas would experience an initial loss of supply, for up to half this period (i.e. for one month or more), until the local Distribution Network Operators and National Grid could arrange for alternative supplies such as interconnection to other substations, or deployment of mobile electricity generation.
- It is likely that rota-disconnections would be used in the affected areas for the rest of the period until the substation repairs were completed.
- Disruptions to satellite services for several days, including interruptions and degradations of GPS. This could result in casualties and fatalities as GPS is an integral component of modern automated dispatch systems used by the emergency services.
- Up to 2 weeks disruption to aviation as a result of:
  - an increase error rate in the electronics of flight control systems;
  - temporary loss of high frequency (HF) radio and satellite communication systems;
  - degradation of GPS augmentation services;
  - an increase in GPS horizontal and vertical error margins;
  - aircrew and passenger exposure to elevated levels of radiation (up to 10-20 millisievert (mSv)) in the course of a few hours more than once during the space weather event (the normal limit for members of the public is 1 mSv in excess from all sources of exposure).
- Temporary short-term (1hour) nationwide losses of wireless systems including mobile phones, internet and other related services.
- Increase in error rate in ground-based unprotected digital control systems, which are ubiquitous in modern technology (computers, internet systems, mobile phones etc.), for the duration of the storm.
- Impact upon civilian mobile satellite communication and satellite broadcasting systems. Terrestrial broadcasting should not be directly affected.

4.12 As indicated, the reasonable worst-case scenario assumes up to 2 coastal substations are affected. This is on the basis that low-density areas have fewer transformers to share the geomagnetic induced current (GIC) load and coastal areas are more vulnerable because of the build up of current on the sea/land boundary. A small number of power generator transformers may also be affected. In these circumstances, National Grid would take the machines offline in a controlled manner. This would be within their operating reserve and there would be minimal impact upon the end user.

4.13 Currently Finance, Communications and Energy sector dependencies upon satellite services are assessed to be low to medium, with no examples of 'catastrophic' dependency.

4.14 Airwave, the 'emergency services' communication system, which uses terrestrial ultra high frequency (UHF) radio signals, would not be significantly affected, except when using signal receivers with unprotected electrical components.

4.15 While storm impacts in the early to mid 20th century appear relatively benign, dependency upon technology vulnerable to space weather has pervaded most aspects of modern life and therefore the disruptive consequences of a severe solar storm could be very significant.

4.16 **Previous severe solar weather events**

A number of significant space weather events have been recorded since the first one in 1859. Although these have been lesser storms compared with the Carrington, many are estimated to be of the same order of magnitude.

The well-documented 1989 storm had considerable impacts upon terrestrial infrastructure, most notably tripping the equipment protection relays of the Hydro-Quebec electricity network, resulting in loss of power for 9hrs across the Canadian province.

A solar storm in 2003 interrupted the operation of 47 satellites, including 1 total loss, and caused the GPS augmentation system used by the aviation sector to go offline for more than a day.

4.17 **Prediction**
Current methods of flare prediction are problematic, and there is no certain indication that an active region on the Sun will produce a flare. However, many properties of sunspots and active regions correlate with flaring. For example, magnetically complex regions (based on line-of-sight magnetic field) called delta spots produce largest flares. A simple scheme of sunspot classification has been developed and is used as a starting point for flare prediction. The U S National Oceanic and Atmospheric Administration (NOAA) issues forecasts of this kind.

4.18 Space Weather Monitoring is critical to have forewarning of solar events as it enables engineering teams to go on standby and provide the context against which scientific advice and political decisions can be made. At present CME arrival time can be forecast with an accuracy of ± 6 -8 hours which, although far from precise, is useful for putting responders on standby; this can be expected to improve over the next few years. However, the geoeffectiveness of the CME cannot be judged and definitive forecasts issued until the CME reaches the primary satellite, thereby providing only 15 – 30 minutes' notice.

5. EQUALITIES IMPLICATIONS

5.1 There is no requirement for an Equalities Impact Assessment Questionnaire to be completed for this report, however Sustainable Development and Equalities interact on many levels and work done in one area often supports the other. Creating sustainable communities, employment and transport for example, is of benefit to all the residents of Caerphilly County borough, regardless of their individual circumstances or backgrounds.

6. FINANCIAL IMPLICATIONS

6.1 There are no financial implications associated with this report.

7. PERSONNEL IMPLICATIONS

7.1 There are no personnel implications.

8. CONSULTATIONS

8.1 The report has been sent to the consultees listed below and there are no consultation responses that have not been reflected within the report.

9. RECOMMENDATIONS

9.1 That Members of the Sustainable Development Advisory Panel note the information provided on Solar Flares and Severe Solar Weather.

10. REASONS FOR THE RECOMMENDATIONS

10.1 For the reasons set out in the report.

11. STATUTORY POWER

11.1 There are no current statutory powers.

Author:	Paul Cooke – Team Leader, Sustainable Development & Living Environment
Consultees:	Cllr Ken James - Cabinet Member for Regeneration, Planning and Sustainable Development Cllr Derek Havard – Vice Chair, Sustainable Development Advisory Panel Sandra Aspinall – Acting Deputy Chief Executive Sheryl Andrews – Emergency Planning Manager Ian Martin – Emergency Planning Officer